THE UNIVERSITY OF OKLAHOMA

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PALYNOLOGY AND PALEOECOLOGY OF THE IRON POST COAL (PENNSYLVANIAN) OF OKLAHOMA

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PALYNOLOGY AND PALEOECOLOGY OF THE IRON POST COAL

(PENNSYLVANIAN) OF OKLAHOMA

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CHAPTER I

INTRODUCTION

This investigation of the Iron Post coal, the results of which are embodied in this report, was undertaken with the following objectives: 1) to describe the fossil spores and pollen contained in the underclays, the Iron Post coal seam, and the suprajacent roof shales in detail; 2) to establish the relationships between the fossils recovered; 3) to interpret the fossil assemblages and establish a spore successional history of the coal swamp; 4) to relate the spore successional history of the coal swamp to the associated cyclothemic unit. The Iron Post coal offers an excellent opportunity for such a study inasmuch as it is confined to a comparatively small area and the limits of the coal seam in both the southern and northern pinch-out areas are known.

Previous palynological studies of Oklahoma coals have been made by Morgan (1955), Wilson and Hoffmeister (1956, 1958), Higgins (1960), Davis (1961), and Clarke (1961). Studies of the several coals have, within these reports, through segment sampling, established spore succession within various coal seams.

Published palynological studies of the Iron Post coal consist of a generalized histogram and a brief paper on the stratigraphic ranges of several spore genera in the Cabaniss coals of Oklahoma, the Iron Post being one of them. Both papers are by Wilson and Hoffmeister (1956, 1958).

Stratigraphic Classification of the Des Moines Supergroup

(Middle Pennsylvanian) of Oklahoma

(Oklahoma Geological Survey)

after C. C. Branson, 1954

Northeastern Oklahoma	McAlester Basin
Marmaton Group	Marmaton Group
Holdenville shale	Holdenville formation
Lenapah limestone	
Nowata shale	
Oologah limestone	Wewoka formation
Labette formation	Wetumka shale
Fort Scott limestone	Calvin sandstone
Cabaniss Group	Cabaniss Group
Senora formation	Senora formation
Excello shale	
Breezy Hill limestone	
Kinnison shale	
Iron Post coal	
Unnamed or Lagonda shale	
Verdigris limestone	
Unnamed unit	
Croweburg coal	
Fleming coal	
Mineral coal	
Chelsea sandstone and Tiawah limestone	
Weir-Pittsburg coal	Secor coal
Krebs Group	Krebs Group
Boggy formation	Boggy formation
Savanna formation	Savanna formation
McAlester formation	
Hartshorne formation	

CHAPTER II

STRATIGRAPHY

Introduction

This dissertation is primarily concerned with the palynology of the Iron Post coal, its underclay and roof shales. These occur at the top of the Senora formation in outcrops and are apparently restricted to northeastern Oklahoma (see figure 1). Though only one coal seam, the Iron Post, is discussed here, Branson (1954) recognized 11 others within the Senora formation. The Iron Post cyclothem is referred to the upper portion of the Cabaniss group, middle Desmoinesian, and specifically includes the section defined by the Breezy Hill limestone at the top and the sandstone-shale deposits overlying the Verdigris limestone at the base. These basal deposits have been assigned to the Lagonda formation by some authors (Howe, 1956; Govett, 1960).

The units included in the above section were studied in an area extending some 62 miles in northeastern Oklahoma

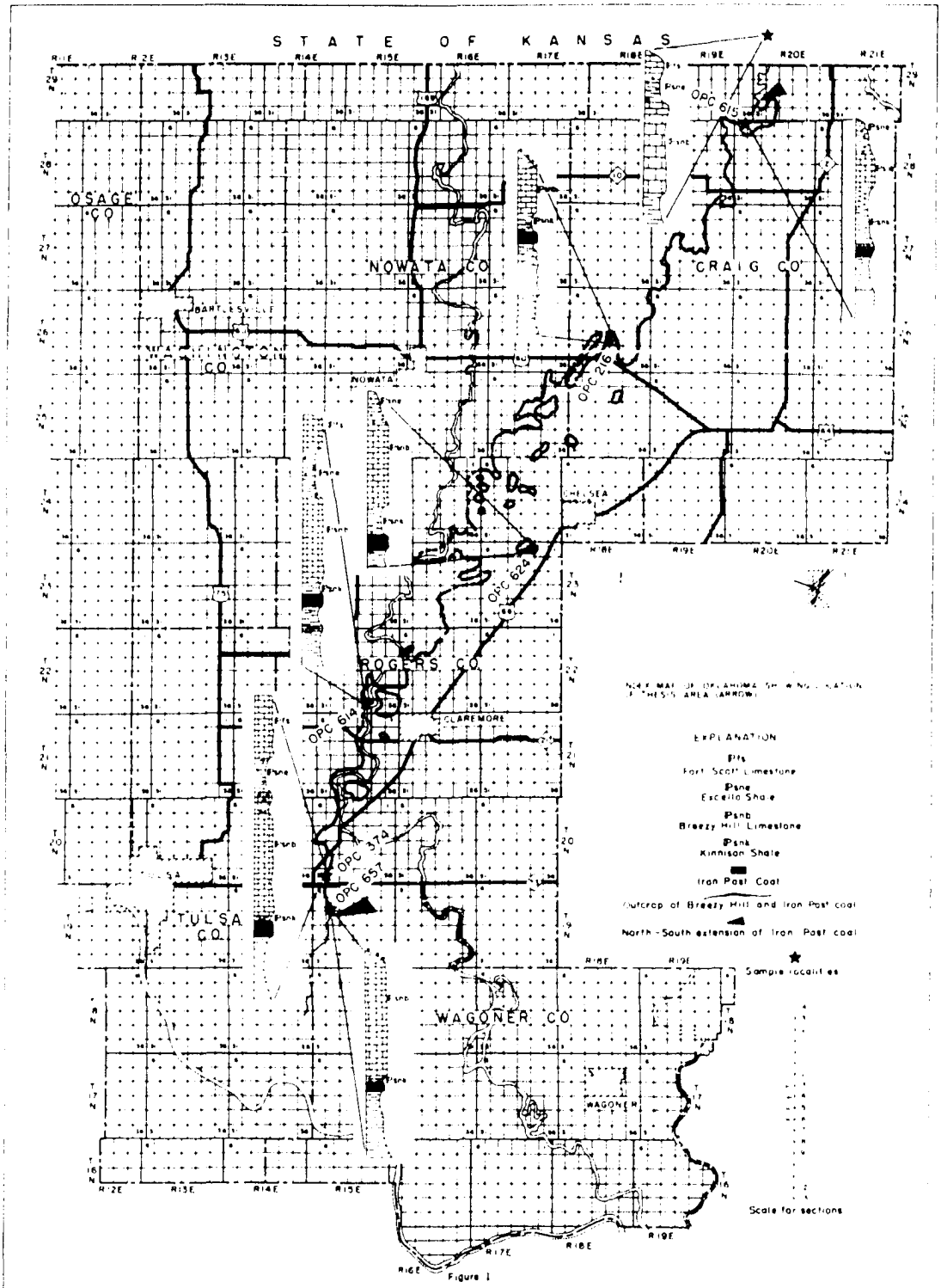

Figure 1

INDEX MAP
NORTHEASTERN OKLAHOMA
OF THE
BREEZY HILL LIMESTONE-IRON POST COAL OUTCROP

by
L. B. Gibson
1961

MILES

in a line running from northern Craig County to the extreme northwestern portion of Wagoner County, Oklahoma. These sediments are regarded as largely shelf deposits of the thicker sedimentary units of equivalent age found in the McAlester basin to the south.

For the most part the section is incompletely exposed. The Breezy Hill limestone is a resistant bed and is normally evident throughout the area. However, the immediately underlying shale, Iron Post coal and older sandstones and shales are covered and at many places necessarily must be excavated for sampling and observation.

The Senora Formation

The Senora formation was named, without a designated type locality, by Taff (1901, p. 4). Gould (1925) subsequently listed the site of the old post office of Senora, Okmulgee County, Oklahoma as the type locality. As originally defined, the formation included the sandstone and shale units lying between the Stuart shale (lower Cabaniss) below and the Calvin sandstone (basal Marmaton group) above. Branson (1956) defined the Senora formation as including that section lying between the Stuart shale below and the base of the Fort Scott formation above. Govett (1960)

employed the same usage. The discussion of this portion of the section as studied for this report is given below.

Unnamed Sandstone-Shale Unit
(The Lagonda member of some authors)

The sandstones and shales lying between the Verdigris limestone below and the Iron Post coal above are regarded as unnamed in this report. Some authors have referred to this unit as the Lagonda member, but as the type section for the sediments to which this term is applied is in Missouri, there is some question as to the validity of the usage in Oklahoma (C. C. Branson, personal communication).

In the southern portion of the outcrop area (sections OPC 374 and OPC 657, Wagoner County) shales predominate and exposures of shale up to 12 feet thick are encountered. These shales are blue-gray, locally silty, thinly laminated, noncalcareous and nonfossiliferous. Northward, this portion of the section becomes less well exposed and is arenaceous. Beginning in section OPC 624, northern Rogers County, the topmost 8 inches of the shale becomes arenaceous. In the next locality north, OPC 216, southern Craig County, the Iron Post coal is underlain first by a thin (8 inches) arenaceous, blue-gray shale which is followed by a somewhat massive, finely cross-bedded sandstone. This sandstone is weakly

calcareous in the topmost 1 foot level. In the northernmost section, OPC 615, northern Craig County, the unit thickens and is about equally divided between the nonfossiliferous shales and the finely cross-bedded sandstones. The nonmarine shales appear to be everywhere similar within the outcrop area in aspects of color, bedding, and composition.

Underclay

The sediment lying immediately beneath the Iron Post coal is a thin, blue-gray to yellow-gray, noncalcareous, locally silty to sandy clay. This material resulted from the weathering of the underlying shales. The thickness of these clays varies. In the central portion of the outcrop area, this zone is normally 2 inches thick, but is proportionately much thicker in the northern and southern portions of the area. In OPC 216, Craig County, the underclay measures 6 inches. In OPC 657, Wagoner County, the clay is 3 inches thick. These relatively thick underclays are devoid or essentially devoid of microspores.

The underclay is believed to represent an old soil profile (Stutzer and Noe, 1940). This being the case, thicknesses of the clay would appear to offer a rough measure of the relative amount of time a horizon had been subaerially

exposed. The fact that fossil plant roots are frequently found in situ here and that the sediment is at places non-calcareous are features supporting the contention that the underclays are fossil soil profiles. The underclay should therefore be recognized as representing a minor time break within the sections concerned. This break constitutes an additional minor disconformity aside from those normally considered to define the upper and lower limits of a cyclothem.

In the Iron Post coal, it appears that on the basis of the above features, the thicker underclays in sections OPC 216, Craig County and OPC 657, Wagoner County indicate that the clay horizons here were results of a longer subaerial exposure than elsewhere in the studied outcrop area. This becomes a more probable assumption because the sections are located in areas defining the southern and northern limits of the Iron Post coal.

Iron Post Coal

The Iron Post coal was named by Howe (1951, p. 2092) from exposures near Iron Post school, in the southeastern quarter of section 36, Craig County, Oklahoma. Howe (1956) referred the coal to the Lagonda formation and noted that it had been called the Fort Scott coal by other authors. The

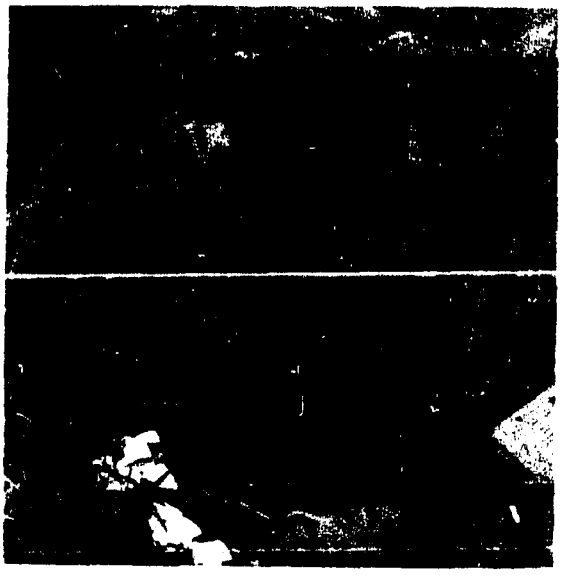

Figure 2. Exposure of the Iron Post coal, Kinnison shale and the lower portion of the Breezy Hill limestone. OPC 624, Rogers County

Figure 3. Exposure of the Breezy Hill limestone resting virtually upon the Iron Post coal. OPC 657, Wagoner County

Iron Post coal does not correlate with the Mulky coal of southeastern Kansas and Missouri as stated by Oakes (1944).

The coal varies between 6 and 15 3/4 inches in thickness, is bituminous, soft, blocky, and usually lustrous. It is thinnest in the northern (OPC 615, northern Craig County) and southern (OPC 657, northern Wagoner County) limits of the studied outcrop area. These sections represent the north-south extent of the Iron Post coal as exposures immediately beyond these localities do not contain the coal.

Microfossils were readily obtained from the coal section and only in section OPC 657, Wagoner County were any of the intervals barren or essentially so. As discussed in the section on paleontology, one level of this coal section (F) is represented almost entirely by leaf cuticle and wood fragments. The topmost coal, or coaly shale, is also represented by leaf cuticle and a scarcity of spores and pollen. These intervals are probably representative of local variations in the developmental cycle of the coal swamp. Elsewhere, the coal section appears not to have had these variations.

Kinnison Shale

The sediments lying between the Iron Post coal below and the Breezy Hill limestone above have been named the

Kinnison shale by Howe (1951, p. 2092-2093). Howe refers this unit to the Mulky formation. This assignment is not followed here because the terminology is not used in Oklahoma. Further, the designation does not indicate that developmentally the member is most related to the Senora formation as currently understood.

The Kinnison shale as exposed in most of the study area is blue gray. It becomes yellow or buff in the south. The shale is thinly laminated, locally iron stained, and varies between being noncalcareous and nonfossiliferous to calcareous and moderately fossiliferous. Generally, the shale is thinnest in the southern portion of the outcrop area. It measures 5 inches in section OPC 657, northern Wagoner County and increases to 13 inches in section OPC 614, Rogers County. From here south, the shale is nonmarine, nonfossiliferous and noncalcareous. Grab samples treated for microfossils proved to be barren. In the more northern sections from OPC 624, northern Rogers County to section OPC 615, northern Craig County, the Kinnison shale increases in thickness. This increase is accompanied by a thinning of the overlying Breezy Hill limestone (see figure 1). Accompanying this increase in thickness the lithology of the shale becomes calcareous and limy and locally fossiliferous.

The basal 10 inches of the shale in section OPC 624, Rogers County is calcareous but nonfossiliferous. At the next locality north, OPC 216, Craig County, it contains a basal 8-inch marine horizon containing abundant Desmoinesia muricatina. The remaining shale above this interval is barren and essentially noncalcareous. In the northernmost section, OPC 615, Craig County, the basal unit of the Kinnison shale is a 6-1/2-inch dark-gray, silty, abundantly fossiliferous coquinoid limestone or cap rock which also contains abundant wood fragments. The remaining shale section here is composed of a gray to yellow gray, thinly laminated shale which is calcareous and fossiliferous in the upper 2 foot level.

The fossils contained in the marine portions of the Kinnison shale are listed below according to the levels in which they occur (after Howe, 1956).

Basal limestone (cap rock), Kinnison shale

Echinoidea

Crinoid columnals

Brachiopoda

Derbyia crassa (Meek and Hayden, 1858) Waagen 1854 (minor)
Desmoinesia muricatina (Dunbar and Condra, 1932) Hoare (almost exclusively)
Spirifer sp. (very minor)

The upper calcareous Kinnison shale unit

Echinoidea

Crinoid columnals

Brachiopoda

Chonetes granulifer Owen

Bryozoa

Fenestrellina sp.

As the Kinnison shale is defined by the Iron Post coal at its base, the unit is not recognizable as such beyond the northern and southernmost extensions of the Iron Post coal (respectively sections OPC 615 and OPC 657). In these areas, the Iron Post coal is absent, and the Breezy Hill limestone is thicker here than in the outcrop area in which the Iron Post coal occurs.

Breezy Hill Limestone

The Breezy Hill limestone member was named by Pierce and Courtier (1937, p. 33) from exposures on Breezy Hill, near Mulberry, Crawford County, Kansas. In Kansas, the limestone, as described, lies immediately below the Fort Scott limestone. In Oklahoma, the top of the Breezy Hill does not correspond to the base of the Fort Scott and is everywhere separated from it by 3 to 4-1/2 feet of Excello shale. It is probably for this reason that Howe (1956, p. 84) refers to

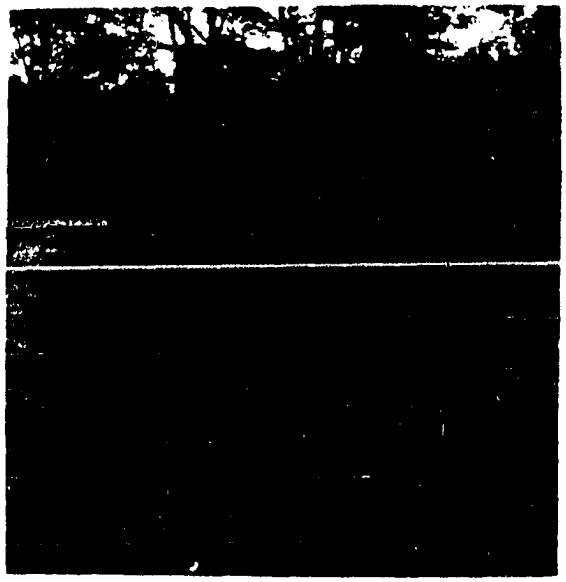

Figure 4. Exposure of the Breezy Hill limestone, showing its massive character. OPC 614, Rogers County

Figure 5. Exposure of the Iron Post coal, Breezy Hill limestone and Excello shale and lower Fort Scott. Verdigris River near Bird Creek, Rogers County

the Mulky formation all the beds from the top of the Iron Post coal to the top of the Mulky coal in Kansas. This division would have to be an artificial one in Oklahoma.

Within the studied outcrop area, the Breezy Hill limestone varies in thickness from about 3 feet minimum to about 10 feet maximum. The unit increases gradually to the south from section OPC 615, Craig County. From this locality, where the Breezy Hill measures 3 feet in thickness, the unit again increases in thickness across the state line in Kansas. The fossiliferous portion of the Kinnison shale and the limestone unit at the Craig County locality approximates the marine limestone thickness in the Kansas section.

The Breezy Hill limestone is composed of a dense bioclastic lime. It is extremely dense and megafossils do not weather easily from it. As a result most of the faunal components are known from various localities. The main known elements are compiled from various sources (Howe, 1956; Pierce and Courtier, 1937; Alexander, 1954).

Algae

Archaeolithophyllum sp.

Foraminifera

Fusulina expedita Alexander

Fusulina plena Alexander

Ptychocladia sp.

Echinodermata

Crinoid columnals

Brachiopoda

Antiquatonia portlockiana (Norwood and Pratten, 1855) Miloradovich

Composita sp.

Echinoconchus spp.

Linoproductus sp.

Reticulatis americana (Dunbar and Condra, 1932) Muir-Wood and Cooper

Bryozoa

Fenestrellina sp.

Rhombopora sp.

Unidentified bryozoan fragments

The above marine faunal elements and the fabric of the bioclastic limestone unit indicate that the Breezy Hill is a neritic deposit. That the unit was deposited in such an environment is further indicated by the presence of variable lithofacies within this relatively thin unit. In section OPC 374, Wagoner County, the top two feet of the limestone is highly cherty and this lithology is not duplicated elsewhere in the studied sections. However, the same lithofacies is duplicated in the unsampled section exposed at

Bird Creek, SE¼ Sec. 13, T. 20 N., R. 14 E., Rogers County. Southward at section OPC 657, Wagoner County, the top 15 inches of the Breezy Hill member is a silty, relatively soft, fossiliferous limestone composed largely of unidentifiable fossil fragments. In the illustrated Kansas section (see figure 1), the middle half of the unit is largely an algal limestone, and the top 1 foot of the section is a micro-coquina. The limestone unit is otherwise uniform lithologically within the studied area.

Excello Shale

The Excello shale was named by Searight and others (1953, p. 2748) and was subsequently described as a formation by Searight (1955, p. 35). This usage is not recognized in Oklahoma where the unit is considered as a member of the Senora formation (Govett, 1960). The Excello member includes the black, fissile, nodular (phosphatic) shales lying between the top of the Breezy Hill limestone and the base of the Fort Scott limestone.

The shale is incompletely exposed within the area studied in this report. Thicknesses vary from about 3 feet to 4½ feet. The larger measurements were obtained in sections OPC 374, Wagoner County and OPC 614, Rogers County where the

shale was observed in contact with the Fort Scott limestone.

Northward, in Kansas, the Excello contains the Mulky coal. This coal is nowhere in evidence in Oklahoma. As this shale unit initiates another coal cycle not developmentally part of the Iron Post cycle, the unit was not sampled for this report.

CHAPTER III

COLLECTIONS

Six sections of the Iron Post coal and associated sediments were measured and collected during the summers of 1959 and 1960. These sections are located in Craig, Rogers, and Wagoner Counties, Oklahoma. They were sampled in detail for microfossils and their positions within the outcrop area are shown in figure 1. The sections beyond the northernmost and southernmost extensions of the Iron Post coal were measured for comparative purposes and these are also figured. The sampled sections are listed below according to their north-south position in the outcrop area.

OPC 615: Gully off main creek east of county road, NW¼ NE¼ Sec. 6, T. 28 N., R. 19 E., Craig County, Oklahoma (modified after Howe, 1956).

Name of Unit	Descriptions	Thickness of Unit in Inches
Senora formation		
Breezy Hill limestone member		
	Limestone; yellow gray, compact, fossiliferous	36.5

Kinnison shale member	
Shale; yellow-gray, noncalcareous, non-fossiliferous in basal 36 inches; calcareous, fossiliferous in the top 24 inches	60.0
Cap rock	
Limestone; medium-gray, silty to sandy, fossiliferous, with woody fragments	6.5
Iron Post coal	
Bituminous, blocky	6.25
Unnamed shale member	
Underclay; blue-gray, silty, noncalcareous	2.0
Shale; light gray, non-calcareous, non-fossiliferous	3.5

OPC 216: Abandoned pit on the east side of county road, south of westerly flowing creek, NW¼ SW¼ Sec. 22, T. 26 N., R. 18 E., Craig County.

Name of Unit	Descriptions	Thickness of Unit in Inches
Senora formation		
Breezy Hill limestone member		
Limestone, yellow-gray, dense, fossiliferous		48.0
Kinnison shale member		
Upper shale; yellow-gray, noncalcareous		12.0
Lower shale; gray, calcareous, fossiliferous		8.0
Iron Post coal		
Bituminous, blocky		13.0
Ganister; light gray to white, silty, noncalcareous		1.0
Unnamed shale-sandstone member		
Clay-shale; gray, sandy, noncalcareous		6.0
Sandstone; buff, iron-stained, variably calcareous, with some fossil casts		48.0

OPC 624: Abandoned strip pit gained by private road south from county road leading west from Howard, Oklahoma, SE¼ SE¼ Sec. 3, T. 23 N., R. 17 E., Rogers County, Oklahoma.

Name of Unit	Descriptions	Thickness of Unit in Inches
Senora formation		
Breezy Hill limestone member		
	Limestone; yellow-gray, massive, coarsely crystalline, fossiliferous	88.5
Kinnison shale member		
	Shale, gray to yellow-gray, iron-stained, noncalcareous	22.0
	Shale; white to light gray, weakly calcareous, with some fossil casts	9.5
Iron Post coal		
	Bituminous, blocky	15.75
	Underclay; light gray, silty, noncalcareous	2.0
	Covered unnamed shale	Unknown

OPC 614: West bank of Verdigris River, NE¼ NW¼ NE¼ Sec. 34, T. 22 N., R. 15 E., Rogers County, Oklahoma.

Name of Unit	Descriptions	Thickness of Unit in Inches
Fort Scott formation		
	Blackjack Creek limestone	36.0
Senora formation		
Excello shale member		
	Shale; dark gray, thinly laminated, nodular	54.0
Breezy Hill limestone member		
	Limestone; yellow-gray, massive, hard, fossiliferous	90.0
Kinnison shale member		

	Shale; dark-gray, thinly laminated, non-calcareous to very weakly calcareous at top	13.0
Iron Post coal		
	Bituminous, blocky, dense	13.5
Unnamed shale unit		
	Underclay; blue-gray, mottled, noncalcareous	10.0
	Shale; light-gray, very thinly laminated, very weakly calcareous	12.0
	Limestone; gray, silty, fine-grained, nonfossiliferous	5.0
	Shale; light blue-gray, non-calcareous, nonfossiliferous	27.0

OPC 374: In road cut on new Route 66 east of Tulsa, west side of Spunky Creek, NE¼ NE¼ Sec. 6, T. 20 N., R. 15 E., Wagoner County, Oklahoma.

Name of Unit	Descriptions	Thickness of Unit in Inches
Fort Scott formation		
	Blackjack limestone member	54.0
Senora formation		
	Excello shale member	
	Shale; dark-gray, thinly laminated, iron-stained, nodular, non-fossiliferous	42.0
	Breezy Hill limestone member	
	Limestone, as below	12.0
	Shale parting, as above	16.0
	Limestone; light-gray, dense, fine-grained, hard, siliceous	17.0
	Limestone; light-gray, fossiliferous	91.0
	Kinnison shale member	
	Shale; light blue-gray, very weakly calcareous	7.0
	Iron Post coal	
	Bituminous, blocky	13.5
	Unnamed shale member	

Underclay; blue-gray, non-calcareous	2.0
Shale; blue-gray, slightly calcareous to non-calcareous, non-fossiliferous	84.0

OPC 657: Location 1.2 miles east of Wagoner-Tulsa County line on extension of 21st Street, SW¼ SW¼ SW¼ Sec. 8, T. 19 N., R. 15 E., Wagoner County, Oklahoma.

Name of Unit	Descriptions	Thickness of Unit in Inches
Senora formation		
Breezy Hill limestone member		
	Limestone, gray-yellow, medium compact, fossiliferous	127.5
Kinnison shale member ?		
	Shale; yellow-gray to brown, noncalcareous	5.0
Iron Post coal		
	Coaly shale; brown, non-calcareous, soft	3.0
	Coal; bituminous, blocky	6.0
Unnamed shale member		
	Underclay; yellow-gray, iron stained, noncalcareous	2.0
	Shale; yellow-gray to blue gray, thinly laminated, noncalcareous, non-fossiliferous	84.0
Covered interval		

The segment samples taken from the above sections are listed below. They are arranged in stratigraphic order, and labeled A, B, C, etc., from the basal sample upwards.

OPC 615, Craig County, Oklahoma

Sample Number	Lithology	Thickness and Position
OPC 615 E	coal	1" (0-1" below top)
OPC 615 D	coal	2" (1-3" below top)
OPC 615 C	coal	2" (3-5" below top)
OPC 615 B	coal	1 3/4" (basal coal)
OPC 615 A	underclay	2" (0-2" below coal)

OPC 216, Craig County, Oklahoma

Sample Number	Lithology	Thickness and Position
OPC 216 I	Roof shale	2" (0-2" above coal)
OPC 216 H	coal	1" (0-1" below top)
OPC 216 G	coal	2" (1-3" below top)
OPC 216 F	coal	2" (3-5" below top)
OPC 216 E	coal	2" (5-7" below top)
OPC 216 D	coal	2" (7-9" below top)
OPC 216 C	coal	2" (2" basal coal)
OPC 216 B	ganister	1" (0-1" below coal)
OPC 216 A	underclay	3" (1-4" below coal)

OPC 624, Rogers County, Oklahoma

Sample Number	Lithology	Thickness and Position
OPC 624 K	shale	2" (0-2" above coal)
OPC 624 J	coal	1" (0-1" below top)

OPC 624 I	coal	2" (1-3" below top)
OPC 624 H	coal	2" (3-5" below top)
OPC 624 G	coal	2" (5-7" below top)
OPC 624 F	coal	2" (7-9" below top)
OPC 624 E	coal	2" (9-11" below top)
OPC 624 D	coal	2" (11-13" below top)
OPC 624 C	coal	2" (13-15" below top)
OPC 624 B	coal	3/4" (basal 3/4" coal)
OPC 624 A	underclay	2" (0-2" below coal)

OPC 614, Rogers County, Oklahoma

Sample Number	Lithology	Thickness and Position
OPC 614 L	shale	2" (0-2" above coal)
OPC 614 K	coal	1" (0-1" below top)
OPC 614 J	coal	1½" (1-2½" below top)
OPC 614 I	coal	1½" (2½-4" below top)
OPC 614 H	coal	1½" (4-5½" below top)
OPC 614 G	coal	1½" (5½-7" below top)
OPC 614 F	coal	1½" (7-8½" below top)
OPC 614 E	coal	1½" (8½-10" below top)
OPC 614 D	coal	1½" (10-11½" below top)
OPC 614 C	coal	1½" (11½-13" below top)
OPC 614 B	coal	1½" (basal 1½" coal)
OPC 614 A	underclay	2" (0-2" below coal)

OPC 374, Wagoner County, Oklahoma

Sample Number	Descriptions	Thickness and Position
OPC 374 I	shale	2" (0-2" above coal)
OPC 374 H	coal	1" (0-1" below top)
OPC 374 G	coal	2" (1-3" below top)
OPC 374 F	coal	2" (3-5" below top)
OPC 374 E	coal	2" (5-7" below top)
OPC 374 D	coal	2" (7-9" below top)
OPC 374 C	coal	2" (9-11" below top)
OPC 374 B	coal	2" (basal 2" coal)
OPC 374 A	underclay	2" (0-2" below coal)

OPC 657, Wagoner County, Oklahoma

Sample Number	Descriptions	Thickness and Position
OPC 657 H	coaly shale	2" (0-2" above coal)
OPC 657 G	silty coal	1" (0-1" below top)
OPC 657 F	silty coal	1½" (1-2½" below top)
OPC 657 E	coal	2" (2½-4½" below top)
OPC 657 D	coal	2" (4½-6½" below top)
OPC 657 C	coal	2" (6½-8½" below top)
OPC 657 B	coal	3/4" (basal 3/4" coal)
OPC 657 A	underclay	2" (0-2" below coal)

CHAPTER IV

SAMPLE PREPARATION AND STUDY TECHNIQUES

Preparation

Laboratory methods used in this study are those, with minor variations, outlined by Wilson (1959a). Each sample was finely crushed, mixed thoroughly, and a 10-gram portion placed in a polyethylene beaker for acid treatment. Carbonate sediments were first treated for 6 hours with dilute (20%) hydrochloric acid, washed and returned to the beaker. The material was then covered with 52 percent hydrofluoric (HF) acid for 12 hours. The sample was washed in distilled water to remove the acid and then mixed with an equal volume of powdered potassium chlorate ($KClO_3$) and covered with concentrated nitric acid (HNO_3). After the initial vigorous reaction had ceased, additional nitric acid was added to the mixture which was then allowed to stand for 15 to 19 hours. The residues were again washed with a distilled water to remove the acid and treated with a saturated

solution of potassium carbonate (K_2CO_3) for 10 to 14 minutes. The solution was then diluted with distilled water and washed and centrifuged until the water was clear.

Shales and underclays were treated similarly except that additional hydrofluoric acid was periodically added, and that the sample was allowed to stand longer to aid in the dissolution of silicic minerals.

The stored residue was mixed in the preparation bottles and a portion withdrawn by dropper was placed in a watch-glass and stained with Saffranine O. Further processing proceeded by the methods outlined by Wilson (1959b). A total of 432 microslides (normally 8 for each sample) was prepared from the residues in this manner.

Study Procedure

The prepared slides were studied with the aid of an American Optical Microstar compound microscope, with 10X W.F. oculars, and 10X, 43X and 97X objectives. Each slide was traversed systematically. Each fossil to be photographed was ringed with glass marking ink. Notations of specimens so marked include sample number, slide number and ring number. For example, OPC 624D-1-2, refers to sample 624 in the Oklahoma Palynological Collections, level D of the sample

locality, slide number 1 of the preparation, ring 2 of the slide. The selected specimens were photographed with a Zeiss Photomicroscope, using Adox KB-14 film.

After specimens had been photographed and the prints mounted on cards and identified, assemblage counts were made. All slides prepared for each sample level were employed in the count to diminish the possibility of inadvertent sampling of the stained residue. Relative percentages of the various species present in each sample level were made and the results were plotted as histograms.

Statistical Limitations

As indicated previously, the statistics employed in this report consist largely of the representation of data in histogram form. What may be regarded by some as more sophisticated statistical analyses (Chi square tests, etc.) are not used in the successional analysis in this paper for various biological reasons and for restrictions imposed by the statistical methods available for use.

Statistical methods are useful (in problems such as the current one) only to the extent to which the biological assumptions upon which the methods are based are valid. Unfortunately, biological factors involved in coal-swamp

development are only partially known and most certainly values could not be assigned to them. Similarly, it would be almost impossible, at this stage, to allow for the effects of these biological variables in a statistical model. In a recent paper Gray and Guennel (1961) have attempted to establish a statistical model for the analysis of palynological data obtained from coal beds. The authors assumed that spore dispersal is more a function of chance than of geologic or bo ical factors. Most decidedly this is not true, and unqualified randomness, since it statistically implies unbiased dispersal, cannot be considered the operational factor responsible in spore and pollen dispersal within any living community (see Simpson and Roe, 1951). This is demonstrated for the Iron Post coal later in the discussion section.

Specifically, the biological-physical system of the coal-swamp community is such that one cannot assume true randomness in spore dispersal. In this sense, attempts at random statistics evaluation develops into no more than precise expressions of previous, naturally sampled (i.e. biased) populations of the coal-swamp plant community. The development and composition of the community was, in any given time interval, dependent upon and developed responsively to various environmental factors. Inherent bias in spore dispersal

is therefore predicated to environmental conditions, the structure of the plant community and various factors affecting preservation of the spores themselves. For this reason the presentation method employed in this paper avoids the use of more detailed statistical models. Such a treatment of successional phenomena must necessarily wait until a more complete understanding of the Pennsylvanian flora is available.

CHAPTER V

PALEONTOLOGY

Introduction

The spores and pollen of the underclays, Iron Post coal and roof shales consist of 75 species which are assigned to 26 previously described genera. Of this assemblage, 17 species and one genus are considered new although they are not here given new names.

Fossil preservation differs throughout the six sections collected segmentally within the outcrop area. Fossil preservation is poor to excellent, depending largely upon the location of the sample within the section. Spores recovered from underclays exhibit fair to poor preservation. This level is barren at places, as in section OPC 657, Wagoner County. The best spore preservation in the underclay is in sections located in the geographic center of the outcrop area, and the poorest is found in those sections located in the northern and southern limits of the studied area. Fossils

recovered from the coal intervals normally show excellent preservation except for those obtained in the upper levels of the southernmost locality (OPC 657, Wagoner County). Roof shales yield microfossils exhibiting good preservation except in the southernmost section where the spores are weathered. In the remaining sections, weathering is minor and only locally encountered.

The systematic taxonomy used in this paper is intended to be conservative and uses as a guide the results of Potonié and Kremp (1954, 1955), and as emended by Potonié (1956, 1958 and 1960) and partially emended by Bhardwaj (1955). The arrangement of taxa in these systems is artificial because the plant affinities and the phylogenies of the spores and pollen are largely unknown. This is particularly true for the Paleozoic forms. Generally artificial systems of classification attempt to assign forms with similar morphological structure to form generic groups regardless of their natural affinities.

Most workers agree that shape, germinal structure, and wall structure are features most useful in defining genera. Size and ornamentation are often important only at the specific level. The difficulty one encounters with the classification of Potonié and Kremp and the emendation by

Potonié is that many of these features are gradational and that they have been used upon occasion to define genera. In addition, the features are difficult to define precisely, and as a result, taxonomic assignments are often dependent upon word use or understanding of the individual worker. For example, it is often difficult to decide from the literature when a spine ceases to be a spine and becomes an apicula or a granule. Similar difficulties arise in defining verbally the visual differences between regularly arranged pits or microreticulae, foveati or punctae. All of these terms, however, serve as adjectival prefixes to generic names and specific references to these genera do not always offer a clear-cut decision. More importantly, these assignments do not sufficiently guarantee equating genetically significant characters into related natural groups.

The aim of classification is to arrive at a near-natural grouping. However, by considering details of only specific importance, there appears to be less chance of accomplishing this. For this reason the taxonomy employed here is conservative and only concedes to those emendations appearing distinctive and sufficiently well defined.

SPORAE DISPERSAE

Division TRILETES (Reinsch, 1881) emend. Potonié and Kremp, 1954

Subdivision Azonotriletes Luber, 1935

Series Laevigati (Bennie and Kidston, 1886) emend. Potonié and Kremp, 1954

Genus PUNCTATISPORITES (Ibrahim, 1932) emend. S., W., and B., 1944

Genotype: Punctatisporites punctatus (Ibrahim, 1932), Ibrahim, 1933

1932 Sporonites punctatus Ibrahim, in Pot., Ibr. and Loose, Neues Jahrbuch, Abt. B, vol. 67, p. 448, pl. 15, fig. 18

1933 Punctati-sporites punctatus (Ibrahim, 1932) Ibr., Sporenformen des Aegir-horizonts, p. 21, pl. 2, fig. 18

Potonié and Kremp (1955) revised the genus Punctatisporites by restricting to it those spherical species possessing granular, punctate or infragranular ornamentation. Accordingly, spherical forms previously referred to this genus but having short blunt spines or apiculae are summarily assigned to the genus Apiculatisporites. The emendation of

the genus on this basis is not followed here because the criteria are considered minor and would, in addition, suffer in interpretation from worker to worker. For example, some forms in which punctae are fine and close-set may appear granular and even apicular. As an illustration, it can be noted that P. triangularis is defined by Kosanke (1950) as being distinctly to indistinctly punctate, yet Potonié and Kremp (1955, p. 81) refer the form to Apiculatisporites. Although the existing classification is imperfect, it is recognized that the forms assigned to the genus Punctatisporites in the following section possess widely variable ornamentation and probably do not represent a natural group. The relative importance of these differences, however, must still be substantiated by additional data before a more meaningful emendation can be made.

PUNCTATISPORITES DENTATUS Wilson and Hoffmeister, 1956

Plate 1, fig. 5

Specimens referred to P. dentatus are rare in the assemblage counts of the Iron Post coal. It does not amount to more than 1.5 percent of the total assemblage in any level where encountered. The species is most abundant near the base of sections OPC 216, Craig County and OPC 614, Rogers

County and continues in the assemblage counts throughout the middle of this section. The species is absent in OPC 657, Wagoner County, in the extreme southern limit of the outcrop area. Scattered rare specimens occur in the remaining sections registering as fractions of a percent in the total assemblage counts. These are concentrated mostly in the middle and upper portions of the coal. All of the specimens referred to this species in the Iron Post coal possess fine short (0.5 by 1 or 2.0 microns) spines.

Described from the Croweburg coal of Oklahoma by Wilson and Hoffmeister (1956), the species has also been reported from the Secor (Higgins, 1960) and Rowe (Davis, 1961) coals of the same state. To date it has not been reported from outside the United States.

Figured specimen: Slide No. OPC 624J-8-4, Rogers County.

PUNCTATISPORITES LATIGRANIFER (Loose, 1932)

S., W., and B., 1944

Plate 1, fig. 1

1932 Sporonites latigranifer Loose, in Pot. Ibr. and Loose, Neues Jahrbuch, Abt. B, vol. 67, p. 452, pl. 19, fig. 54

1934 Granulati-sporites latigranifer (Loose, 1932) Loose, Inst. Palaobot. Arb., vol. 4, no. 3, p. 147

1944 Punctati-sporites latigranifer (Loose, 1932) S., W., and B., Illinois Geol. Survey, Rept. Invest. no. 91, p. 31.

Punctatisporites latigranifer is a relatively minor element in the spore assemblages of the Iron Post coal. It occurs most abundantly (to 6 percent of the total assemblage) in the basal 3 inches of coal in five of the sections sampled. Percentage values generally decrease up-section. It is most abundant and persistent in sections in the northern portion of the studied area, especially in OPC 216, Craig County, and becomes less common throughout the sections southward, eventually becoming absent in the southernmost sampled section OPC 657, Wagoner County. The percentage distribution of the species indicates that P. latigranifer was representative of a parent plant associated with the early development of the coal swamp community. The plant evidently remained rare and a variously successful minor vegetational component of the swamp plant community.

The specimens referred to this species from the Iron Post coal all possess close-set, fine spines, none of which

exceeds 1.5 microns in length. Under low power, these spines appear as pits or as fine granules.

The species has been reported from the McLeansboro group of Illinois (Kosanke, 1950) which according to the present system of stratigraphic nomenclature for the state (Kosanke et al., 1960) now includes the upper portion of the Kewanee group and the McLeansboro group. It has also been reported by Schemel (1951) from the Mystic coal of Iowa. The species has also been recorded from the Croweburg (Wilson and Hoffmeister, 1956), Rowe (Davis, 1961) and Secor (Clarke, 1961) coals of Oklahoma. Potonié and Kremp (1955) report the species from the upper Westphalian B horizon of the Ruhr basin of Germany, and Imgrund (1960) lists the species in the microflora of the lower red beds (Stephanian) of the Kaiping basin of China.

Figured specimen: Slide No. OPC 624D-3-2, Rogers County.

PUNCTATISPORITES MUNDUS Kosanke, 1950

Plate 1, fig. 2

Punctatisporites mundus is rare in the Iron Post coal. The species is scattered irregularly throughout various levels in the 6 sections examined and at most places at

values of less than 1 percent of the total assemblage. It is most abundant (1.5 percent) in the basal 1 inch coal level in section OPC 614 B, Rogers County. The species occurs too rarely and irregularly to define a pattern of distribution.

Kosanke (1950) reports the species from the upper part of the McLeansboro group of Illinois and Guennel (1958) records the species from the upper Pottsville of Indiana. The form has not been reported to date from the Pennsylvanian outside of Illinois and Indiana other than the species identified as P. punctatus by Alpern (1958) from the Stephanian of France. This species, from the description and illustration, appears to be more similar to P. mundus.

Figured specimen: Slide No. OPC 374F-3-1, Wagoner County.

PUNCTATISPORITES OBLIQUUS Kosanke, 1950

Plate 1, fig. 3

Specimens of P. obliquus are fairly common throughout all levels of the Iron Post coal. It may compose 20 percent of the total assemblage count in some levels. In the fossiliferous underclays, it may vary from 10 to slightly over 1 percent of the assemblage depending upon locality. In this level, P. obliquus is most common in the extreme northern

and southern sections of the outcrop area. Generally, larger percentage values for the species occur in the middle of the coal seam in all of the 6 sections examined. From this level, percentage proportions decrease to progressively lower values toward the top and base of the coal. Fossiliferous roof shales normally show a modest to obvious percentage increase of the species over the next lowest, or top coal, sample. The higher values of the species being concentrated in mid-section indicates that the parent plant was more favored by the environmental factors operative at the time of maximum swamp development and possible plant variety (Smith, 1961), and less adapted to conditions which existed in the early and late developmental stages of the swamp.

As indicated by Davis (1961), P. obliquus may, if orientation is such that the trilete is invisible, be mistaken for Laevigatosporites minutus or L. punctatus. However, in the Iron Post coal, the manner in which the species absorbed the staining medium was sufficiently selective to aid in resolving those cases which were in doubt.

The species is listed by Kosanke (1950) from the middle of the Tradewater group to the upper McLeansboro group of Illinois. This range is now referred to as extending from the lower portion of the Kewanee group to the upper

McLeansboro group of Illinois according to a recent revision of the stratigraphic nomenclature of the state (Kosanke et al., 1960). Guennel (1958) reported the species from the Pottsville coals of Indiana and Schemel (1951) listed it from the Mystic coal of Iowa. Wilson and Hoffmeister (1956) recorded it in the Croweburg coal of Oklahoma and Davis (1961) reported it from the Rowe and Clarke (1961) from the Secor coals of the same state. Potonié and Kremp (1955) listed the species from the middle Westphalian of the Ruhr basin of Germany.

Figured specimen: Slide No. OPC 624D-3-4, Rogers County.

PUNCTATISPORITES SETULOSUS Kosanke, 1950

Plate 1, fig. 4

Examples of P. setulosus are rare in the Iron Post coal. It appears in the assemblage counts of only five different levels as single specimens. These specimens occur in various levels of the sampled sections with no apparent regularity as to position in the seam.

Kosanke (1950) reported the species from the Caseyville and McLeansboro groups of Illinois (Atokan through Virgilian). This range is now (Kosanke et al., 1960)

referred to as extending from the base of the McCormick group through the McLeansboro group. The species is also reported from the Secor of Oklahoma (Higgins, 1960). In Europe, it has been recorded from the upper Westphalian B and middle C horizons of the Ruhr basin of Germany (Potonié and Kremp, 1955).

Figured specimen: Slide No. OPC 624G-1-2, Rogers County.

PUNCTATISPORITES TRIANGULARIS Kosanke, 1950

Plate 1, fig. 6

Punctatisporites triangularis is rare in the Iron Post coal and does not appear in any of the assemblage counts. The species was encountered while searching slide preparations for photographic specimens (OPC 374 H and OPC 614 G, Wagoner and Rogers Counties respectively).

Kosanke (1950) as per a recent revision of the stratigraphic nomenclature of Illinois (Kosanke et al., 1960) recorded the species as ranging stratigraphically from the uppermost portion of the Kewanee group to the lowermost portion of the McLeansboro group in this state. Wilson and Hoffmeister (1956) report the species from the Croweburg coal of Oklahoma. Potonié and Kremp (1955) list the species

from the Westphalian C horizon of the German Ruhr basin.

Figured specimen: Slide No. OPC 374H-2-10, Wagoner County.

Genus CALAMOSPORA S., W., and B., 1944

Genotype: Calamospora hartungiana Schopf, in S., W., and B., Illinois Geol. Survey, Rept. Invest. No. 91, p. 51, fig. 1

CALAMOSPORA BREVIRADIATA Kosanke, 1950

Plate 1, fig. 11

Of the Calamospora, C. breviradiata occurs most persistently throughout the Iron Post coal. It does not appear in excess of 20 percent in any of the assemblage counts. However, there is little change in percentage values throughout the various sampled coal levels, although it appears somewhat more commonly in the basal and upper quarters of each of the six coal-sections examined. The species is prominent in the underclays and roof shales. Values in the underclays may reach 15 percent of the total population count with somewhat smaller values for those underclays of sections in the northern and southern limits of the outcrop area. Percentage values of the species in roof shales are similar although there is a tendency for them to run higher

southward to section OPC 374, Wagoner County. The species is absent in the underclay and virtually so in the roof shale of the southernmost sampled section, OPC 657, Wagoner County. According to the stratigraphic and geographic distribution of the species, the parent plant evidently was a persistent and successful floral element throughout the developmental history of the coal swamp.

Kosanke (1950) recorded the species from the middle Kewanee group through the McLeansboro group of Illinois. In Oklahoma, Higgins (1960) and Davis (1961) reported, respectively, the species from the Weir-Pittsburg and Rowe coals. Schemel (1951) lists the species from the Mystic coal of Iowa. Potonié and Kremp (1955) recorded it from the middle Westphalian B horizon of the Ruhr basin. Imgrund (1960) reported specimens assigned to this species from beds of Stefanian age and the Westphalian D horizon of the Kaiping basin of China.

Figured specimen: Slide No. OPC 624K-1-7, Rogers County.

CALAMOSPORA DECORA Wilson and Hoffmeister, 1956

Plate 1, fig. 9

Calamospora decora is represented rarely by scattered occurrences in the six sections of the Iron Post coal

examined. In level C of section OPC 216, Craig County in the northern portion of the outcrop area, it approaches four percent of the total microflora. The presence of the species is otherwise expressed in the counts as fractions of a percent, and these are concentrated in the basal fourth of the examined sections.

The specimens encountered in the Iron Post coal range in size from 55 to 66 microns; this range is slightly less than the measurements reported by Wilson and Hoffmeister (1956). According to the literature, this species is to date geographically restricted to Oklahoma and stratigraphically to the Croweburg and Iron Post coals.

Figured specimen: Slide No. OPC 216D-1-1, Craig County.

CALAMOSPORA HARTUNGIANA Schopf, 1944

Plate 2, fig. 2

Specimens of C. hartungiana are a minor element of the Iron Post microflora. It is largely confined to the basal portions (levels A through C) of all sections examined except those located at the extreme northern (OPC 615, Craig County) and extreme southern (OPC 657, Wagoner County) limits of the outcrop area. This form is similar to C.

decora discussed previously but is larger and is ornamented by somewhat coarser granulae. The specimens from the Iron Post coal range in diameter from 70 to 105.6 microns, the larger measurement exceeding by slightly more than 5 microns the upper limit indicated by Schopf (1944).

According to Kosanke (1950) the stratigraphic range of the species extends from the middle Tradewater group throughout the McLeansboro group of Illinois. Current stratigraphic nomenclature of Illinois (Kosanke et al., 1960) now defines the basal limit of the stratigraphic range of the species by the Kewanee group. Schemel (1951) reported the species from the Mystic coal of Iowa and Wilson and Hoffmeister (1956) recorded the species from the Croweburg coal of Oklahoma. Specimens identified by Imgrund (1960) as C. hartungiana are reported from the Stephanian and upper Westphalian D horizons of the Kaiping basin of China. However, these forms are described as being punctate and not granular as indicated by Schopf (1944), and are probably not C. hartungiana. The species has also been recorded in the Stephanian of the Tura district of France (Alpern, 1958).

Figured specimen: Slide No. OPC 216F-1-1, Craig County.

CALAMOSPORA LIQUIDA Kosanke, 1950

Plate 1, fig. 8

Calamospora liquida occurs throughout all of the examined Iron Post coal sections. It is most common in some of the underclays and in all of the very basal portions (1 to 3 inches) of the coal sections. In these levels it may amount to 15 percent of the microflora. The species decreases upward to fractions of a percent in the middle portion of the seam, modestly increasing again in the uppermost portions. The species may account for 11 percent of the total microflora in the underclays. These values tend to become higher in the southern portion of the outcrop area (OPC 374, Wagoner County). C. liquida may be absent or barely exceed 2 percent of the total count in the roof shales. However, these values are normally greater than those for the topmost coal sample. The initial increase and subsequent mid-section decrease of the species suggests that the parent plant was important early in the development of the plant communities of the coal-swamp.

Kosanke (1950) reported this species as ranging stratigraphically from the lower portion of the Tradewater group to the upper portion of the McLeansboro group. According to the revised stratigraphic nomenclature of Illinois

(Kosanke et al., 1960) the range is now defined below by the Kewanee group. This species has not been recorded previously in Pennsylvanian coals outside of Illinois, other than a similar but doubtful form reported by Staplin (1960) from the Golata formation of Canada as C. cf. liquida.

Figured specimen: Slide No. OPC 374C-4-6, Wagoner County.

CALAMOSPORA MUTABILIS (Loose, 1932) S., W., and B., 1944

Plate 2, fig. 1

1932 Calimiti (?)-sporonites mutabilis, Loose, Neues Jahrbuch, Abt. B, vol. 67, p. 451, pl. 19, figs. 50a-c

1934 Calamiti (?)-sporites mutabilis (Loose, 1932) Loose, Inst. Palaobot. Arb., vol. 4, no. 3, p. 145

1944 Calamospora mutabilis (Loose, 1932) S., W., and B., Ill. Geol. Survey, Rept. Invest. No. 91, p. 52

A minor element in the Iron Post palynological assemblage, C. mutabilis nowhere exceeds in any level 6 percent of the total count. It occurs most abundantly (6 percent) in the basal 1-inch coal sample of section OPC 624, Rogers

County, and is stratigraphically most persistent in section OPC 614, Rogers County. Both sections are near the middle of the outcrop area. In all cases percentage values for the species diminish upward to mid-section or higher as fractions of a percent. The species is absent in locality OPC 216, northern Craig County and occurs in only level E of section OPC 374, Wagoner County near the southern limit of the outcrop area. The species is possibly representative of a vegetational element associated with the early development of the coal-swamp community as the form does not reappear at the top nor is it anywhere important in the top quarter of the coal sections studied. All of the specimens of C. mutabilis in the Iron Post coal measure between 80 and 127 microns.

Kosanke (1950) lists the species from the upper portion of the McCormick group to the lower portion of the McLeansboro group of Illinois. C. mutabilis has not been reported to date from Oklahoma. The species is reported from the Westphalian B and C horizons of the Ruhr basin of Germany according to Loose (1934) and Potonié and Kremp (1955), from the Productive Coal Measures of Scotland (Knox, 1952) and from the Stephanian of the Kaiping basin of China (Imgrund, 1960).

Figured specimen: Slide No. OPC 624D-1-3, Rogers County.

CALAMOSPORA PEDATA Kosanke, 1950

Plate 2, fig. 3

Calamospora pedata is one of the more persistent spores in the Iron Post coal. It is especially significant in the fossiliferous underclays and in the basal levels of the coal seam. Generally, proportional percentages show a decrease up-section to a mid-point and then again increase toward the top of the seam. This distribution is duplicated in all of the six sections examined. In the roof shales, the percentage of the species in total assemblage counts is greater than that at the top coal level. The occurrence of C. pedata in the roof shales is everywhere similar except for section OPC 216, Craig County, in the northern portion of the outcrop area. Here, the species does not appear until mid-section (E level), becomes most common in the topmost coal level and then decreases in the roof shale. From the percentage distributions of this species it appears to represent a plant associated with the early vegetational development of the coal-swamp community and later with the community extant at the time the swamp ceased to exist as an ecological

unit. This species occurs commonly folded in the spindle-shaped form illustrated and only infrequently appears spherical. The sizes encountered in the Iron Post coal range from 53 to 65 microns.

Kosanke (1950) reported C. pedata as ranging from about the middle of the Tradewater group to the middle of the McLeansboro group in Illinois. According to a revision of stratigraphic nomenclature applied to the Pennsylvanian of Illinois (Kosanke et al., 1960) the lower stratigraphic limit of the species is now regarded as the upper portion of the McCormick group. Schemel (1951) reported the species from the Mystic coal of Iowa. It has previously not been recorded from Oklahoma. Potonié and Kremp (1955) reported it from the middle Westphalian C horizon of the Ruhr basin of Germany.

Figured specimen: Slide No. OPC 374-1-7, Wagoner County.

CALAMOSPORA STRAMINEA Wilson and Kosanke, 1944

Plate 1, fig. 7

Specimens of C. straminea occur consistently in the Iron Post coal throughout most of the sections examined. The species appears to be most characteristic of the fossiliferous underclays and the basal quarters (the B, C and D

levels) of 5 of the 6 sections studied. In the sixth section (OPC 216, Craig County), in the northern portion of the outcrop area, the species is present in only the upper half of the coal. Generally, the form is represented by progressively smaller percentages in the total assemblage counts upward to about mid-section. This is normally followed by a modest but gradual increase in values to the top of the coal bed and fossiliferous roof shales. The distribution of C. straminea in the assemblage counts suggests that the parent plant was important in the early developmental stages of the coal-swamp community. This appears to be especially true for those sections near the middle of the outcrop area. Here the species may amount to 10 percent of the total population in the lower levels and the form is more persistent up-section. This distribution is less evident in the northern and southern sampled limits of the area.

Guennel (1958) assigned C. straminea to Punctatisporites on the basis of the species' possessing a relatively thick spore wall, and this feature was thought to differentiate the species from other Calamospora which are usually regarded as thin-walled. The emendation is not accepted in this paper as the feature seems to be of debatable value inasmuch as it appears to depend on the definition of what is

"too thick" or "too thin." In addition, Guennel retained C. obesus (Loose) S., W., and B., 1944 in Calamospora. This form is a thick-walled species lacking the numerous compression folds associated with species of Calamospora and should have, on the basis of the emendation, been referred to Punctatisporites also.

Kosanke (1960) recorded C. straminea from the Tradewater of Illinois, which as per Kosanke et al. (1960) confines the stratigraphic range of this species in that state to the section defined by the upper portion of the Kewanee group and the lower portion of the McLeansboro group. Guennel (1958) reported the species from the Pottsville coals of Indiana. It has also been listed from the Hardinsburg (late Mississippian) of Illinois (Hoffmeister, Staplin and Malloy, 1955). In Oklahoma, the species has been reported from the Croweburg (Wilson and Hoffmeister, 1956) and Secor (Higgins, 1960; Clarke, 1961) coals. To date, C. straminea has not been reported from Europe.

Figured specimen: Slide No. OPC 216E-1-2, Craig County.

CALAMOSPORA SP. A

Plate 2, fig. 4

Spores radial; trilete; originally spherical, typically folded and compressed tangentially to trilete area; trilete simple and relatively short, varying between 25.0 and 31.0 microns; trilete commissure bordered by thin (less than 0.5 microns), slightly raised lips; wall of spore 2.5 to 3.5 microns thick, levigate, typically with arcuate compression folds and tears. Diameter varies between 176.0 and 193.0 microns.

Typical specimen: Slide No. OPC 216F-3-3, Craig County, Oklahoma. Overall dimensions 124.5 by 193.0 microns.

This large species bears a superficial resemblance to Calamospora obesus (Loose, 1932) S., W., and B., 1944 from which it differs by being somewhat smaller and possessing a somewhat thinner spore wall. The species appears closely related to a form described as Calamostachys americana (Arnold, 1958). However, Arnold's species is much larger and is definitely a megaspore. Calamospora sp. A has a size range greater than that of other species designated as microspores of Calamospora. However, because the diameter of the species in no case has exceeded 200 microns and the spore wall may be considered relatively thin, the form is considered more

properly a microspore.

This species is rare in the population counts of the Iron Post coal. It is most common in sections OPC 374, Wagoner County and OPC 624, Rogers County, in the fossiliferous underclays and basal coal level of these sample localities. It nowhere exceeds 3.5 percent of the various assemblage counts. Although single specimens occur sporadically in 3 levels of section OPC 216, Craig County, it is absent in the population counts of sections OPC 615 and OPC 657, located respectively in the northernmost and southernmost limits of the outcrop area, and in section OPC 624, Rogers County, near the middle of the outcrop area.

CALAMOSPORA SP. B

Plate 1, fig. 10

Spores radial; trilete; originally spherical, typically with numerous, thin arcuate folds irregularly distributed; trilete simple, short, in almost all specimens obscured by folds; arms 5.0 to 7.0 microns long; spore wall thin, less than 0.5 microns, clear, levigate. Overall diameter consistently small and varying between 23.5 and 27.0 microns.

Typical specimen: Slide No. OPC 216E-3-2, Craig

County, Oklahoma. Overall dimensions 24.2 by 25.3 microns.

Calamospora sp. B as encountered in the Iron Post coal consistently measures 27 microns or less. This size feature and the consistent manner in which folds are developed on the spore body differentiate this species from C. parva Guennel (1958). The species is otherwise smaller by half than other small previously described species assigned to the genus.

The species occurs rarely in the assemblage counts of the Iron Post coal. It normally does not exceed 2 percent in any level, generally being represented by somewhat higher values near the base of the coal seam. The highest percentage value for the species is recorded in level A (5 percent) of section OPC 614, Craig County, located in the northernmost portion of the sampled area. The species, although of minor importance in the Iron Post coal, does appear most commonly associated with the early developmental stages of the coal-swamp.

Genus GRANULATISPORITES (Ibrahim, 1933) emend.
Potonié and Kremp, 1954

Genotype: Granulatisporites granulatus Ibrahim, 1933, Sporenformen des Aegirhorizonts des Ruhr-Reviers, p. 22, pl. 16, fig. 51

GRANULATISPORITES PIROFORMIS Loose, 1934

Plate 2, figs. 5, 6

1934 Granulatisporites piroformis Loose, Arb. Inst. Palaeobot. u. Petrog. Brennstein, vol. 4, p. 147, pl. 7, fig. 19

1955 Granulatisporites granularis Kosanke (1950) Pot. and Kr., Teil I, Palaeontographica, Abt. B, p. 60, pl. 12, fig. 152-156

The forms assigned to G. piroformis are minor in assemblage counts of the Iron Post coal though occurring rarely throughout most of the sampled levels. Percentages of this species do not exceed 8 percent in any of the counts. The higher values tend to be concentrated in the lower portions of the coal section. The species is absent from the population counts of the underclays in the northern half of the studied area and forms 8 percent of the total assemblage in these clays to the south. In the southernmost sample (OPC 657, Wagoner County) the species occurs only in the underclays. It is variously present in the roof shales, but is absent from these sediments in the southern portion of the sampled area. The distribution of the species appears to indicate that the parent plant was associated with the early vegetational development of the coal-swamp. As indicated

above, the writer is following the emendation of the species as proposed by Potonié and Kremp (1955) in referring G. granularis Kosanke (1950) to G. piroformis Ibrahim (1933). The separate names are assigned to forms which are very similar. The morphological differences as cited by the authors are minor and gradations in size often render assignment of the Iron Post specimens to either one or the other species doubtful.

Kosanke (1950) reported the species from the upper Carbondale and lower McLeansboro groups of Illinois. According to a recent revision of stratigraphic nomenclature of this state (Kosanke et al., 1960) the range is now defined by the upper portion of the Kewanee group and lower portion of the McLeansboro group. Schemel (1951) reported the species in the Mystic coal of Iowa. Wilson and Hoffmeister (1956) reported the species from the Croweburg coal of Oklahoma. Morgan (1955) and Clarke (1961) recorded the species (as G. granularis) respectively, from the Riverton and Secor coals of the same state. In Europe, the species has been listed as present in the Productive Coal Measures of Scotland (Knox, 1952), from the Westphalian B horizon of the Saar basin of Germany, and from the Visean Karaganda beds of Russia (Luber and Waltz, 1938). Imgrund (1960) listed the

species from the Visean, Lower Red beds of the Kaiping basin of China.

Figured specimens: Slide Nos. OPC216D-1-4, Craig County, and OPC 216E-1-20, Rogers County.

GRANULATISPORITES SPINOSUS Kosanke, 1950

Plate 2, figs. 7, 8

Granulatisporites spinosus is rare in the assemblage counts of the Iron Post coal and nowhere exceeds 4 percent of the microflora of any level where present. The species is absent from all underclay samples. Generally, it is most prevalent in the lower quarter of the coal seam and from here percentage values increase up-section. The rarity of the species and the irregular distribution of representative percentage values appear not to indicate a meaningful pattern. In the roof shales occurrence varies and the species may be absent (as in OPC 624, Craig County) or increase slightly with respect to the preceding top coal level. The species is absent from the southernmost section sampled in the outcrop area (OPC 657, Wagoner County).

The species has been transferred to the genus Anapiculatisporites by Potonié and Kremp (1955) on the basis of its triangular shape and prominent spines. The species

also bears resemblance to Acanthotriletes Naumova (1937). According to Potonié and Kremp (1955) the difference between Acanthotriletes and Anapiculatisporites is in the length and thickness of the spines. Because, as indicated previously, generic criteria based on gradational specific features must be regarded with caution, and because the status of both genera is in doubt, G. spinosus is retained in Granulatisporites.

This species is reported by Kosanke (1950) from the upper Tradewater group and the Carbondale group of Illinois. According to a recent revision of the stratigraphic nomenclature of this state (Kosanke et al., 1960) this range is now restricted to the upper Kewanee group. Schemel (1951) has listed the species from the Mystic coal of Iowa and Davis (1961) reported it from the Rowe coal of Oklahoma. Potonié and Kremp (1955) recorded the species from the lower Westphalian C horizon of the Ruhr basin of Germany. This report may be considered doubtful as the text figure of the specimen as figured by Potonié and Kremp (1955, p. 82) does not appear to be of Kosanke's species. The species figured shows few, short rounded spines or granules ornamenting the equatorial area and proximal surface. Kosanke's species possesses numerous definite slender and delicate spines.

Figured specimens: Slide Nos. OPC 624H-3-5, Rogers County; OPC 374F-4-3, Wagoner County.

GRANULATISPORITES VERRUCOSUS

(Wilson and Coe, 1940) S., W., and B., 1944

Plate 2, fig. 9

1940 Triquitrites verrucosus Wilson and Coe, Amer. Midland Naturalist, vol. 23, no. 1, p. 185, fig. 10

1944 Granulatisporites verrucosus (Wilson and Coe, 1940) S., W., and B., Ill. Geol. Survey, Rept. Invest. No. 91, p. 33

1958 non Triquitrites verrucosus Alpern, Girardeau and Trolard, Rev. Micropaleontologie, vol. 1, no. 2, p. 77, pl. 1, fig. 6

This species is rare in the population counts of the Iron Post coal. It is represented largely by one or two specimens in several scattered levels in four of the six examined sections. There is no apparent pattern in the distribution of the values. The species is absent in the two southernmost sections sampled in the outcrop area (OPC 374, OPC 657, Wagoner County).

Kosanke (1950) reported the species as occurring in

the Tradewater and Carbondale groups and the lower portion of the McLeansboro group of Illinois. As per Kosanke et al. (1960) this range is now defined by the upper portion of the McCormick group and the lower portion of the McLeansboro group. Guennel (1958) reported the species throughout the Pottsville group of Indiana. Wilson and Hoffmeister (1956) recorded the species from the Croweburg coal of Oklahoma and Davis (1961) and Clarke (1961) identified the species, respectively, in the Rowe and Secor coals of the same state. Potonié and Kremp (1955, 1956) did not list the species in their emendations nor is it otherwise reported from Europe.

Figured specimen: Slide No. OPC 216D-2-2, Craig County.

Genus RAISTRICKIA S., W., and B., 1944

Genotype: Raistrickia grovensis Schopf, 1944 in S., W., and B., Illinois Geol. Survey, Rept. Invest. No. 91, p. 55, fig. 3

RAISTRICKIA CRINITA Kosanke, 1950

Plate 2, fig. 10

Raistrickia crinita is a fairly persistent, although uncommon species in the Iron Post coal and the most abundant representative of the Raistrickia. The percentage value of

the species in population counts nowhere exceeds slightly more than 1 percent. The higher percentage values are most commonly encountered in the upper quarter of the coal section. The species appears more consistently in the roof shales than in the underclays. It was more frequently encountered in sections located in the northern half of the outcrop area and is less so throughout the sections southward. The species is absent from the assemblage counts of the southernmost section in the studied area (OPC 657, Wagoner County).

According to Kosanke (1950), as per Kosanke et al. (1960), the stratigraphic range of the species in Illinois is defined below by the upper portion of the McCormick group and above by the lower portion of the McLeansboro group. The species has been subsequently reported in Oklahoma by Wilson and Hoffmeister (1956) from the Croweburg coal. The species has not been reported from outside the United States to date.

Figured specimen: Slide No. OPC 624-3-5, Rogers County.

RAISTRICKIA CROCEA Kosanke, 1950

Plate 2, fig. 11

Specimens of R. crocea are rare in the Iron Post coal

and it appears in the assemblage counts of only 5 different levels. Occurrences appear mostly as single specimens in various levels of the sampled sections in the middle of the outcrop area (OPC 624, OPC 614, and OPC 374). The species occurs much too rarely and inconsistently to define a pattern of distribution.

Kosanke (1950) as in Kosanke et al. (1960) recorded this species from the upper portion of the Kewanee group of Illinois. Wilson and Hoffmeister (1956) report the species from the Croweburg coal of Oklahoma. The species' nearest European relative, R. saetosa (Loose, 1932) S., W., and B., 1944, is reported in the upper Westphalian B and lower Westphalian C horizons of the German Ruhr basin (Potonié and Kremp, 1955).

Figured specimen: Slide No. OPC 624K-1-2, Rogers County.

RAISTRICKIA IMBRICATA Kosanke, 1950

Plate 3, fig. 1

Raistrickia imbricata occurs in the population counts of only one sample level (OPC 614, Rogers County) of the Iron Post coal. The form was observed in only one other level (OPC 624-G, Rogers County) while examining slides in

search of photographic specimens.

This species had been assigned to the genus Apiculatisporites by Potonié and Kremp (1955). However, it possesses elongate spines which widen at their bases into keel-like structures which gradually merge with the spore surface producing rib-like features which give the spore, exclusive of the spines, a quasi-verrucose appearance. These spines are more in keeping with the variable spine expressions found in the genus Raistrickia and differ markedly from the delicate conical spiculae regarded as characterizing Apiculatisporites. The emendation of Potonié and Kremp is therefore not recognized in this paper.

Kosanke (1950) as per Kosanke et al. (1960) records the species from the upper portion of the Kewanee group of Illinois. Davis (1961) and Clarke (1961) report R. imbricata as rare in the Rowe and Secor coals of Oklahoma. It has not been reported to date outside of North America.

Figured specimen: Slide No. OPC 216F-3-4, Craig County.

RAISTRICKIA SOLARIA Wilson and Hoffmeister, 1956

Plate 3, fig. 6

Raistrickia solaria is the second most abundant

Raistrickia in the Iron Post coal but the proportion of the species in assemblage counts barely, on occasion, exceeds 1 percent. The species usually occurs scattered throughout various levels of 4 of the 6 sampled sections. In the northernmost section (OPC 615, Craig County) it occurs in only one level and it is absent in all of the population counts of the southernmost sampled section (OPC 657, Wagoner County). In the remaining four sections, the proportion of the species in population counts shows no well defined distribution pattern. The highest value (1.3 percent) for the species in these counts occurs in the fossiliferous underclays of OPC 614, Rogers County.

R. solaria was described from the Croweburg coal of Oklahoma, and Higgins (1960), Clarke (1961) and Davis (1961) recorded it, respectively, from the Weir-Pittsburg, Secor, and Rowe coals of the same state. To date the species has not been reported from Europe.

Figured specimen: Slide No. OPC 216D-1-2, Craig County.

RAISTRICKIA SP. A

Plate 3, figs. 7, 8, 9

Spores radial; spherical; trilete; rays with thin commissure and thin, slightly raised lips, extending to

four-fifths of the radius; projections sparse, tubular and terminated bluntly to slightly partate to more commonly flared, length 5.5 to 8.8 microns and of uniform length with each specimen, width 2.3 to 3.5 microns broad. Spines with prominent transverse regularly spaced striations. Spore wall 1 to 1.5 microns thick. Overall diameter 42 to 48 microns.

Typical specimen: Slide No. OPC 624E-4-2, Craig County, Oklahoma. Overall dimensions 42.9 by 46.2 microns.

Raistrickia sp. A is similar to the larger and more densely spinose R. saetosa (Loose, 1932) S., W., and B. (1944). It appears closely related to R. superba (Ibrahim, 1933) S., W., and B. (1944) from which it apparently differs by possessing fewer spines with prominent transverse striae or inner thickenings, and shorter trilete rays. It differs from R. crocea Kosanke (1950) in being smaller and in possessing relatively shorter and more bifid spines.

This species occurs rarely, largely as single specimens, in the assemblage counts of the Iron Post coal. The specimens tend mostly to occur in the middle portion of the sampled coal sections. The species is absent in the population counts of the southernmost section sampled (OPC 657, Wagoner County).

RAISTRICKIA SP. B

Plate 3, fig. 5

Spores radial; trilete; spherical; trilete rays obscured by dense processes but appear to extend 2/3 the radius. Processes variable, blunt to normally bulbously terminated, short, measuring 2.2 to 4.5 microns in length, 1.5 to 4.8 microns broad. Spore wall 1.7 to 2.3 microns thick. Overall diameter 28.0 to 36.0 microns.

Typical specimen: Slide No. OPC 216D-3-3, Craig County, Oklahoma. Overall dimensions 29.7 by 33.0 microns.

This species occurs in the population counts of only two levels of one sampled section (OPC 614, levels G and K, Rogers County) and was encountered only rarely while traversing slides in search of photographic specimens. The writer has found no previously described form similar to Raistrickia sp. B. At first glance the species superficially resembles Verrucosisporites due to the shortness of the numerous spines. It does not belong in this genus, however, as the ornamentation is definitely spinose.

RAISTRICKIA SP. C

Plate 3, fig. 4

Spores radial; trilete; spherical; trilete faint and obscured by processes. Processes short, blunt, mammillary,

length 4.5 to 5.5 microns, width 3.5 to 4.4 microns. Processes dimensionally uniform in given specimens. Overall diameter 36.0 to 41.0 microns.

Typical specimen: Slide No. OPC 624E-1-16, Rogers County, Oklahoma. Overall diameter 40.7 by 40.7 microns.

This species was observed in the population counts of three levels (level C, OPC 216, Craig County; levels C and E, OPC 624, Rogers County). It was encountered in only one other level (level D, OPC 614, Rogers County) while traversing slides in search of photographic specimens. There appears to be no described form similar to Raistrickia sp. C.

RAISTRICKIA ? SP. D

Plate 3, fig. 3

Spores radial; trilete; triangular; trilete rays long (16 to 22.5 microns) and extending 4/5 of radius; commissure thin with narrow (less than 1 micron) slightly raised lips; processes short, with variable, blunt to bulbous or inflated terminations, length 1.5 to 3.5 microns, width 1 to 2.5 microns. Smaller spines conical or apiculate in many specimens. Spore wall 1.3 to 1.5 microns thick. Overall diameter 45.5 to 53.0 microns.

Typical specimen: Slide No. OPC 624G-3-3, Rogers

County, Oklahoma. Overall diameter 48.5 by 51.7 microns.

The species is questionably referred to Raistrickia because of the triangular shape of the species. The shape and occasional conical or apiculate spines are suggestive of affinities to the spore group referred to as Anapiculatisporites Potonié and Kremp (1955). The species in shape and general ornamentation is broadly suggestive of some forms referred to Lophotriletes (Naumova, 1937) Potonié and Kremp (1955). However, because these genera have a doubtful status, the species is referred questionably in Raistrickia.

Raistrickia ? sp. D occurs rarely in the population counts of the Iron Post coal as single specimens. The species was encountered in the counts of 3 levels (level D of OPC 216, Craig County; level I, OPC 624, Rogers County, and level B of OPC 614, Rogers County). The species was otherwise encountered only rarely while traversing slides for photographic specimens.

Genus CONVOLUTISPORA Hoffmeister, Staplin and Malloy, 1955

Genotype: Convolutispora florida H., S., and M., 1955, Jour. Paleontology, vol. 29, p. 384, pl. 38, figs. 5 and 6

CONVOLUTISPORA FLORIDA H., S., and M., 1955

Plate 3, fig. 10

Specimens of C. florida are extremely rare in the Iron Post coal. It was encountered in the population counts of only one level (OPC 624 J, Rogers County) and in only one other level while traversing slides for photographic specimens (level H, OPC 624).

The species was originally described from the Hardinsburg formation (Chesterian) of Kentucky and has been reported from the Rowe (Davis, 1961) and Secor (Clarke, 1961) coals of Oklahoma.

Figured specimen: Slide No. OPC 624J-6-2, Rogers County.

Genus CONVERRUCOSISPORITES Potonié and Kremp, 1954

Genotype: Converrucosisporites triquetrus (Ibrahim, 1933) Pot. and Kr., 1955

1933 Verrucosi-sporites triquetrus Ibrahim, Sporenformen des Aegir-horizonts des Ruhr-Reviers, p. 26, pl. 7, fig. 61

1954 Converrucosisporites triquetrus (Ibr., 1933) Pot. and Kr., Teil I, Palaentographica, Abt. B, vol. 98, Lief 1-3, p. 65, pl. 13, fig. 191

CONVERRUCOSISPORITES MOSAICOIDES Potonie and Kremp, 1955

Plate 3, fig. 12

This species is rare in the examined sections of the Iron Post coal. It appears in the population counts of only 3 levels in different horizons of 4 of the 6 sections sampled. The species occurs as single specimens which tend to be concentrated in the lower half of the coal seam.

C. mosaicoides is absent from the population counts in the southernmost (OPC 657, Wagoner County) and northernmost (OPC 615, Craig County) sections. The specimens from the Iron Post coal do not exceed 25 microns in overall diameter, whereas Potonie´ and Kremp (1955) mentioned 30 microns or more as the diameter. Illustrations of the type, however, indicate that the diameter is approximately 23 microns. Other than this the species appears identical with C. mosaicoides Potonie´ and Kremp.

To date, this form has been recorded only from the lower portion of the Westphalian C horizon of the Ruhr basin of Germany and from the Stephanian of the Kaiping basin of China (Imgrund, 1960).

Figured specimen: Slide No. OPC 624D-3-3, Rogers County.

CONVERRUCOSISPORITES SULCATUS (Wilson and Kosanke, 1944) Potonié and Kremp, 1955

Plate 3, fig. 11

1944 Punctati-sporites sulcatus Wilson and Kosanke, Iowa Acad. Science, Proc., vol. 51, p. 331, fig. 4

1955 Converrucosisporites sulcatus (Wils. and Kos., 1944) Potonié and Kremp, Teil I, Palaeontographica, Abt. B, vol. 98, Liefg. 1-3, p. 64

Converrucosisporites sulcatus is very rare in the Iron Post coal. In population counts, the species appears in two sample levels in separate sections (level I, OPC 624 and level D, OPC 374) as single specimens. The species was encountered in only one other section (level G, OPC 614) while traversing slides for photographic specimens. In all cases, the specimens were encountered in the middle half of the coal section.

Reported occurrences of this species are confined to the northern portion of the western hemisphere. The form was described from the Des Moines of Iowa and has since been reported by Kosanke (1950) as per Kosanke et al. (1960) as ranging stratigraphically from the McCormick group through the McLeansboro group of Illinois. Guennel (1958) reported

the species from the Pottsville coals of Indiana. Schemel (1951) recorded it from the Mystic coal of Iowa. In Oklahoma the species is recorded from the Croweburg coal (Wilson and Hoffmeister, 1956), and from the Secor coal (Higgins, 1960; Clarke, 1961).

Figured specimen: Slide No. OPC 374D-1-4, Wagoner County.

Genus VERRUCOSISPORITES (Ibrahim, 1933) emend. Potonié and Kremp, 1954

Genotype: Verrucosisporites verrucosus (Ibrahim, 1932) Ibrahim, 1933

1932 Sporonites verrucosus Ibrahim in Pot., Ibr., and L., Neues Jahrbuch, Abt. B, vol. 67, p. 448, pl. 15, fig. 17

1933 Verrucosi-sporites verrucosus (Ibrahim, 1932) Ibrahim, Sporenformen des Aegirhorizonts, p. 25, pl. 2, fig. 17

1944 Punctatisporites verrucosus (Ibrahim, 1932) S., W., and B., Ill. Geol. Survey, Rept Invest. No. 91, p. 32.

1955 Verrucosisporites verrucosus (Ibrahim, 1932) Pot. and Kr., Teil I, Palaeontographica, Abt. B., vol. 98, p. 65, fig. 11, pl. 13, fig. 195

VERRUCOSISPORITES ? SP. A

Plate 3, fig. 2

Spores radial; trilete; spherical; trilete rays obscured by ornamentation but extend slightly in excess of 2/3 the radius; commissure thin with no raised lips. Ornamentation composed of low, generally oval to rounded thickenings measuring 4.5 to 7.8 microns in diameter; some project broadly to 2.5 to 3.5 microns beyond the equatorial outline; spore coat otherwise levigate. Spore wall 2.5 to 4.5 microns thick exclusive of verrucose projections.

Typical specimen: Slide No. OPC 624J-5-5, Rogers County, Oklahoma. Overall dimensions 66.0 x 71.5 microns.

The specific description is based upon only 3 specimens and is therefore referred questionably to Verrucosisporites. The assignment is also questionable as a few of the verrucose-like surface features tend to be broadly conical. This tendency emphasizes the gradational aspects of ornamentational features and, in the case of Verrucosisporites sp. A, is suggestive of possible affinity to Raistrickia. The species appears not to be related to any previously described form.

This species was encountered in the population counts of only one level (OPC 624 J) and was encountered

again only in this level and level F of the same section while traversing slides in search of specimens to photograph.

Genus SCHOPFITES Kosanke, 1950

Genotype: Schopfites dimorphus Kosanke, Ill. Geol. Survey, Bull. 74, p. 53, pl. 13, figs. 1-3

SCHOPFITES COLCHESTERENSIS Kosanke, 1950

Plate 4, fig. 3

Specimens of C. colchesterensis occur fairly consistently in the assemblage counts of the Iron Post coal. Although absent in some levels, the absences are mostly confined to the lower quarter of the coal section. The species may account for as much as 3.5 percent of the total population, but normally it is represented by values of less than 1 percent. The higher values occur in sections in the northern portion of the outcrop area (OPC 216, Craig County; OPC 624, Rogers County). Values diminish southward and these are scattered and become most rare in the southernmost sampled section (OPC 657, Wagoner County). Proportions of the species in population counts show consistently and progressively higher values up-section. The highest normally occur in the top fifth of the coal section. The species is present in the lower quarter and absent in the remaining

portions of the section of both the northernmost and southernmost sampled sections (respectively OPC 615, Craig County and OPC 657, Wagoner County). The species is normally absent in the underclays but it does occur in level A of OPC 624, Rogers County, near the middle of the outcrop area. Roof shales yield rare specimens in OPC 216, Craig County and OPC 624, Rogers County. The species is absent in the population counts in the roof shales of the remaining sections. S. colchesterensis in the Iron Post coal appears to have been representative of the plant community characterizing the late development or "maturation" of the coal swamp community in the center of the sampled area. The presence of the species lower in the coal section of the northernmost and southernmost sections is possibly indicative that conditions favorable for the parent plant occurred time-stratigraphically at a different time in these areas.

Kosanke (1950) described the species from No. 2 coal of the Carbondale formation of Illinois. It has been reported from the Croweburg coal of Oklahoma (Wilson and Hoffmeister, 1956) and from the Rowe and Secor coals of the same state by Davis (1961) and Clarke (1961). To date, the species has not been reported outside the mid-continental area of the United States, other than some of the illustrated

forms identified as Schopfites dimorphus Kosanke by Butterworth and Williams (1954) from the lower Carboniferous of England. These forms belong more probably to S. colchesterensis.

Figured specimen: Slide No. OPC 624K-1-5, Rogers County.

Series Muronati Potonie′ and Kremp, 1954

Genus MICRORETICULATISPORITES (Knox, 1950) emend. Potonie′ and Kremp, 1954

Genotype: Microreticulatisporites lacunosus (Ibrahim, 1933) Knox, 1950

1933 Reticulati-sporites lacunosus Ibrahim, Sporenformen des Aegirhorizonts, p. 36, pl. 6, fig. 50

1944 Punctati-sporites lacunosus (Ibrahim, 1933) S., W., and B., Ill. Geol. Survey, Rept. Invest. 91, p. 31

1950 Microreticulatisporites lacunosus (Ibrahim, 1933) Knox, 1950, Bot. Soc. Edinburgh, Trans., vol. 35, p. 320, fig. 240

The spores assigned to this genus from the Iron Post coal, M. fenestratus, M. foveatus, and M. quaesitus, present

a taxonomic problem discussed earlier in consideration of specific features as valid criteria in the erection of generic groups. The species in question are microreticulate. However, the forms are either alete or the triletes are barely visible, suggesting that they were nonfunctional. This feature would definitely exclude two of the species from Microreticulatisporites as emended by Potonie´and Kremp (1955). As emended, the genus was to serve as repository for spherical, trilete spores possessing reticulate ornamentation. Bhardwaj (1955) attempted to emend this group by proposing the generic name Foveolatisporites for some species assigned to Microreticulatisporites. The spores assigned to the genus are supposedly characterized by a spherical shape, indistinct trilete and ornamentation of foveolae or pits surrounded by extra reticulae. Microreticulatisporites is reserved for those otherwise similar spores with triangular shapes. The emendation of Bhardwaj is not followed in this paper as it returns again to the question of the validity in erecting generic taxa on features which are of specific importance. Bhardwaj (1955, p. 126) admits to the gradational feature of the faveolate ornamentation in mentioning that some species seem to combine the features of Foveolatisporites and Microreticulatisporites as emended. In addition,

there appears to be some doubt as to the validity of the proposal owing to a confusion among European workers as to the characteristics of M. fenestratus, the genotype of Foveolatisporites, and M. foveatus. These points will be more fully explained in the discussions concerning the individual species that follow.

MICRORETICULATISPORITES FENESTRATUS

(Kosanke and Brokaw, 1950) Potonie´and Kremp, 1955

Plate 4, fig. 5

1950 Punctati-sporites fenestratus Kosanke and Brokaw, in Kosanke, 1950, Ill. Geol. Survey, Bull. 74, p. 15, pl. 2, fig. 10

1954 non Microreticulatisporites fenestratus (Kos. and Brokaw, 1954) Butterworth and Williams, Ann. Mag. Nat. History, vol. 7, p. 755, pl. 17, fig. 1-3, text fig. 1-2

1955 Microreticulatisporites fenestratus (Kos. and Brokaw, 1950) Pot. and Kr., Teil I: Palaeontographica, Abt. B, vol. 98, Lief. 1-3, p. 98

1955 Foveolatisporites fenestratus (Kosanke, 1950) Bhardwaj, Palaeobotanist, vol. 4, p. 126, pl. 1, fig. 4

Microreticulatisporites fenestratus is uncommon in the assemblage counts of the Iron Post coal. The occurrences are usually scattered throughout the various levels. The tendency, however, is for the percentage values to be concentrated in the lower quarter of 4 of the 6 coal sections sampled. It occurs most abundantly (2 percent) in the B level, OPC 374, Wagoner County. The species is absent from the southernmost and northernmost sections (OPC 615, Craig County and OPC 657, Wagoner County) in the outcrop area. M. fenestratus is absent in the roof shales and is rare in the underclays; a single specimen appeared in the population count of the level A, OPC 374.

Kosanke and Brokaw (1950), in describing the species, noted that the spore appears alete and only through careful focusing is the trilete-mark faintly visible. In the Iron Post coal specimens the trilete was not visible through careful focusing. It appears that the species does not rightly belong in Microreticulatisporites as emended by Potonié and Kremp (1955), and should more aptly be assigned to a new genus representative of spheri al, microreticulate and alete spores. However, the species reported by Butterworth and Williams (1954) as M. fenestratus appears to be an incorrect identification of M. foveatus Kosanke, 1950. Bhardwaj (1955)

lists this identification in the synonomy of Foveolatisporites. As Bhardwaj was undoubtedly influenced by the European understanding of the morphological features of M. fenestratus (Kosanke, 1950) and does not mention having seen the holotype, and since, in addition, there appears to be a confusion in the European literature concerning the identification of M. fenestratus and M. foveatus, the species is retained in Microreticulatisporites Potonie' and Kremp (1955) and the status of Foveolatisporites is here considered in doubt.

Kosanke (1950) described M. fenestratus from the Herrin coal of Illinois and as per Kosanke et al. (1960) lists the stratigraphic range of the species in this state as extending from the McCormick group through the McLeansboro group. The species has been recorded in the Mystic coal of Iowa (Schemel, 1951). In Oklahoma, it is recorded by Clarke (1961) from the Secor coal. In Europe, Bhardwaj (1955) recorded the species from the lower Stephanian Göttelborner shales of the Saar basin.

Figured specimen: Slide No. OPC 374F-4-4, Wagoner County.

MICRORETICULATISPORITES FOVEATUS (Kosanke, 1950)

Plate 4, fig. 2

1950 Punctati-sporites foveatus Kosanke, Ill. Geol. Survey, Bull. 74, p. 17, pl. 1, fig. 6

1954 Microreticulatisporites fenestratus (Kosanke, 1950) Butterworth and Williams, Ann. Mag. Nat. History, vol. 7, p. 755, pl. 17, figs. 1-3

1955 Microreticulatisporites foveatus (Kosanke, 1950) Pot. and Kr., Teil I: Palaeontographica, Abt. B, vol. 98, Lief. 1-3, p. 98

1955 Foveolatisporites foveatus (Kosanke, 1950) Bhardwaj, Palaeobotanist, vol. 4, p. 126

Specimens of M. foveatus are fairly common in the Iron Post coal. The species appears most abundantly in the lower quarter of the sampled coal section and diminishes proportionately up-section. The highest percentage values are found in the basal inch of the coal, with a maximum (6 percent) in the basal coal level of section OPC 374, Wagoner County. The species is normally represented from mid-seam upward by single specimens. It is completely absent in the roof shales. Occurrence of the species in underclays is inconsistent, but percentage values of the species for this level exceed 1 percent in sections located near the middle

of the outcrop area. It is absent from the southernmost section in the outcrop area (OPC 657, Wagoner County). The percentage distributions of the species indicate that the parent plant of the spore was related to the flora associated with the early developmental stages of the coal-swamp.

The assignment of M. foveatus to Microreticulatisporites by Potonié and Kremp (1955) illustrates again difficulties encountered in establishing genera on characters of specific importance. The trilete rays, although normally visible, are obscure and contrast with the definite trilete marks in other species of Microreticulatisporites. Guided largely by size and ornamentation, Butterworth and Williams (1954) incorrectly assigned Lower Carboniferous spores to M. fenestratus (Kosanke, 1950), ignoring in their specimens the presence of arcuate rings circumscribing the trilete area. These markings clearly assign the specimens to M. foveatus (Kosanke, 1950) Pot. and Kr., 1955. This arcuate ring is somewhat suggestive of the circular line of concrescence about the trilete formed by the union of the inner and outer spore bodies of Vestispora Wilson and Hoffmeister (1956). In the Iron Post coal M. foveatus cannot be said to possess an inner spore body, but the species is distinct in the features discussed and it would appear that the form should be

assigned to a different genus. In attempting this, Bhardwaj (1955) assigned the species to Foveolatisporites. However, because of the morphological confusion implied in the cited synonymy, the proposal is considered questionable. Therefore, consistent with the conservative aims of this paper, the species is here retained in Microreticulatisporites.

M. foveatus was described by Kosanke (1950) from the lower Carbondale group of Illinois and subsequently listed from the upper McLeansboro group of the same state. According to a recent revision of the stratigraphic nomenclature of Illinois (Kosanke et al., 1960) the stratigraphic range of the species in this state is now considered to extend from the middle portion of the Kewanee group to the upper portion of the McLeansboro group. Davis (1961) and Clarke (1961) reported it as rare in the Rowe and Secor coals of Oklahoma. The species was recorded as M. fenestratus from the Westphalian C and D coal horizons of England by Butterworth and Williams (1954).

Figured specimen: Slide No. OPC 374D-1-5, Wagoner County.

MICRORETICULATISPORITES QUAESITUS (Kosanke, 1950)

Butterw. and Wil., 1954

Plate 4, fig. 4

1950 Punctati-sporites quaesitus Kosanke, Ill. Geol. Survey, Bull. 74, p. 17, pl. 2, fig. 2

1954 Microreticulatisporites quaesitus (Kosanke, 1950) Butterworth and Williams, Ann. Mag. Nat. History, vol. 7, p. 755

1955 Foveolatisporites quaesitus (Kosanke, 1950) Bhardwaj, Paleobotanist, vol. 4, p. 126

Specimens of M. foveatus are rare in the Iron Post coal and the species nowhere exceeds more than 1.7 percent of the various assemblage counts in which it is present. The species is limited to the basal portion of five of the six sections sampled. M. quaesitus occurs in the underclays of sections OPC 624, OPC 614 and OPC 374 located near the middle of the outcrop area. Most of the specimens are restricted to the basal 1 to 3 inches of coal. Single specimens occur sporadically in the mid-portion of the various sampled coal sections. The species is absent in the southernmost sampled section, OPC 657, Wagoner County.

Bhardwaj (1955) assigned the species to Foveolatisporites, but, as stated previously, because the status of

the genus is considered in doubt, the emendation is not followed here.

Kosanke (1955) described the species from the Herrin coal of Illinois and also reported it from the middle Tradewater group, the Carbondale group and lowermost portion of the McLeansboro group. As per Kosanke et al. (1960) the stratigraphic range of the species is now referred to as extending from the uppermost portion of the McCormick group through the Kewanee group of this state. Schemel (1951) reported the species from the Mystic coal of Iowa. M. quaesitus is also reported from England from coals equivalent in age to the Westphalian C to lower D horizons of continental Europe.

Figured specimen: Slide No. OPC 624I-1-1, Craig County.

Division ZONALES (Bennie and Kidston, 1886) emend. Potonié and Kremp, 1954

Subdivision Auritotriletes Potonié and Kremp, 1954

Series Auriculati (Schopf, 1938) emend. Potonié and Kremp, 1954

Genus TRIQUITRITES Wilson and Coe, 1940

Genotype: Triquitrites arculatus Wilson and Coe, 1940, Am. Midland Naturalist, vol. 23, no. 1, p. 185, fig. 8

TRIQUITRITES ADDITUS Wilson and Hoffmeister, 1956

Plate 4, figs. 8, 9

Specimens of T. additus are fairly common in five of the six sections of the Iron Post coal examined. It never exceeds 3 percent of the total population count in the various levels where it occurs. T. additus is most common in the basal quarter of the sections examined, decreasing upsection to one or two specimens in total population counts. The species is absent from the roof shales and is normally represented only by one or two specimens per assemblage in the underclays. Generally, the species is most common and persistent in sections in the northern portion of the outcrop area. This is especially the case in section OPC 624, Craig County. It is represented by only 3 specimens in level B, OPC 657, Wagoner County in the southernmost portion of the outcrop area. The distribution of the species in the population counts indicates that the species is representative of a plant associated with the early vegetational development

of the coal swamp. The importance of the plant apparently diminished as the swamp community developed although remaining most persistently in the northern portion of the area.

T. additus was described from the Croweburg coal of Oklahoma (Wilson and Hoffmeister, 1956) and has subsequently been reported from the Rowe coal (Davis, 1961) and the Secor coal (Higgins, 1960; Clarke, 1961) of the same state. Guennel (1958) recorded it from the Pottsville coals of Indiana. To date it has not been reported from outside the United States.

Figured specimens: Slide No. OPC 374F-1-11, Wagoner County; OPC 624D-1-23, Craig County.

TRIQUITRITES BRANSONII Wilson and Hoffmeister, 1956

Plate 4, fig. 11

This species is the most abundant form of the genus Triquitrites in the Iron Post coal and may account for as much as 11 percent of the assemblage of some levels. The distribution of the species in the various counts indicates that it is most abundant in the lower and less abundant in the middle portions of the sections sampled. Generally, the species proportion in the various assemblage counts decreases up-section to minimal values in the top quarter of the coal.

It is fairly common and may increase slightly over the preceding top coal sample in the roof shales. The species is quite common in the underclays and here it may account for as much as 9 percent of the total assemblage. T. bransonii is most abundant and persistent in the northernmost sampled section, OPC 624, Craig County, and is least abundant and persistent in the southernmost sampled section, OPC 657, Wagoner County. However, proceeding southward in the outcrop area, the higher percentage values for the species progressively shift up-section until in sections OPC 374 and OPC 657, the higher values appear in middle and then in the uppermost portions of the coal seam. The distribution of the percentage values clearly indicates that generally T. bransonii is representative of a plant which was associated with the initial and early developmental stages of the vegetational communities in the coal swamp. Further, it appears that favorable environmental conditions for the plant were established stratigraphically later in the southern portion of the studied area than they were in the north.

This species was described from the Croweburg coal of Oklahoma (Wilson and Hoffmeister, 1956) and has subsequently been reported from the Rowe (Davis, 1961) and Secor (Higgins, 1960; Clarke, 1961) coals of the same state.

Guennel (1958) recorded it from the Pottsville coals of Indiana. To date the species has not been reported from outside the continental United States.

Figured specimen: Slide No. OPC 624H-6-2, Craig County.

TRIQUITRITES cf. EXIGUUS Wilson and Kosanke, 1944

Plate 4, fig. 6

This small spore does not appear in the population counts of the Iron Post coal. It was encountered while traversing slides for photographic specimens in only two levels: level D, OPC 624, Craig County and level D, OPC 374, Wagoner County.

The species is tentatively assigned to T. exiguus because there were few specimens for comparison. Further, the apices appear less developed and more pointed in the Iron Post coal specimens.

T. exiguus was described from the Des Moines of Iowa by Wilson and Kosanke (1944). It has subsequently been reported from the Mystic coal of Iowa (Schemel, 1951), the Tradewater group and lower portion of the Carbondale group of Illinois (Kosanke, 1950), and from coals of the Pottsville series of Indiana (Guennel, 1958). In Oklahoma, it has been

reported by Wilson and Hoffmeister (1956) from the Croweburg coal and from the Rowe (Davis, 1961) and Secor (Clarke, 1961) coals. To date the species has not been reported from outside the United States.

Figured specimen: Slide No. OPC 624D-1-32, Craig County.

TRIQUITRITES INUSISTATUS Kosanke, 1950

Plate 4, fig. 10

The spores assigned to T. inusitatus occur only rarely in the Iron Post coal. The species is represented by one or two specimens in the assemblage counts of only five different levels. All of the specimens occur in the basal quarter of those sections located in or near the middle of the outcrop area. It is absent from sections in the extreme southern and northern limits of the studied area (respectively OPC 216, Craig County and OPC 657, Wagoner County) and from section OPC 614, Rogers County.

Potonié and Kremp (1954, p. 154) indicated that the spines developed at the apices of T. inusitatus are cause to remove the species from the genus Triquitrites as emended in their paper. Neves (1958, p. 7) proposed a new genus, Mooreisporites, for those species possessing apical spines,

and lacking thickened valvae at the apices. Potonie (1960, p. 56) recognized the genus and referred T. inusitatus to it. The emendation is not accepted here because the distinguishing feature appears too specific. To date only two described species have been assigned to the proposed new genus.

Kosanke (1950), as per Kosanke et al. (1960), recorded the species from the middle and lower portions of the Kewanee group of Illinois. Schemel (1951) listed it in the microflora of the Mystic coal of Iowa. It has been reported from the Croweburg (Wilson and Hoffmeister, 1956) and Secor (Clarke, 1961) coals of Oklahoma. The species reported by Staplin (1960, p. 18) from the Golata formation of Canada as T. cf. inusitatus definitely does not belong to the species. The species has otherwise not been reported outside the United States.

Figured specimen: Slide No. OPC 624C-5-4, Craig County.

TRIQUITRITES SPINOSUS Kosanke, 1943

Plate 4, fig. 7

This species is rare in the population counts of the Iron Post coal. It is represented in only four basal levels of two separate sections: a single specimen occurs in level

C. OPC 615, Craig County and is represented in levels C through E in section OPC 624, Craig County by 1 to 3 specimens. All of the occurrences are limited to the northern portion of the outcrop area.

Kosanke (1943) described the species from the Pittsburg coals of Ohio and subsequently (Kosanke, 1950), according to Kosanke et al. (1960), it has been reported to range stratigraphically from the Carbondale formation (upper Kewanee group) throughout the McLeansboro group in Illinois. To date, the species has not been reported from outside the United States except that Knox (1950) stated that her species T. papillosus may be conspecific with T. spinosus Kosanke. However, Potonié and Kremp (1955, p. 82) subsequently assigned T. papillosus (Knox, 1950) to their genus Pustulatisporites. Since T. spinosus clearly possesses the thickened valves characteristic of the genus Triquitrites the species has not been included in the synonymy of Pustulatisporites Potonié and Kremp, nor is it conspecific with T. spinosus.

Figured specimen: Slide No. OPC 624E-4-15, Craig County.

TRIQUITRITES TUMULUS Wilson and Hoffmeister, 1956

Plate 4, fig. 12

Triquitrites tumulus is not common in the Iron Post coal, and in population counts of the various levels in which it occurs, the species does not exceed 2.3 percent. The species is most common in the basal quarter of the coal seam and generally decreases to mid-section where representation becomes limited to single specimens. Normally, it is absent in the upper quarter of the coal although single specimens are encountered in the roof shales of sections OPC 614, Rogers County, and OPC 374, Wagoner County, in the southern portion of the outcrop area. The species otherwise is absent from the roof shales. In underclays, T. tumulus is represented only in those sections in the northern portion of the outcrop area. Here values may account for 1.5 percent of the total population. The form is absent in the southernmost sampled section, OPC 657, Wagoner County.

The species was described from the Croweburg coal of Oklahoma (Wilson and Hoffmeister, 1956). To date it has not been cited elsewhere.

Figured specimen: Slide No. OPC 624E-4-14, Craig County.

Subdivision Zonotriletes Waltz, 1935

Series Cingulati Potonié and Klaus, 1954

Genus LYCOSPORA (S., W., and B., 1944) emend. Potonié and Kremp, 1954

Genotype: Lycospora micropapillata (Wilson and Coe, 1940) S., W., and B., 1944

1940 Cirratriradites micropapillatus Wilson and Coe, Amer. Midland Naturalist, vol. 23, no. 1, p. 184, fig. 6

1944 Lycospora micropapillata (Wilson and Coe, 1940), S., W., and B., Illinois Geol. Survey, Rept. Invest. No. 91, p. 54

LYCOSPORA GRANULATA Kosanke, 1950

Plate 5, figs. 1, 2

The third most abundant species in the Iron Post coal is Lycospora granulata. It is present in all levels of the six sections sampled. Generally, the species proportion in total population counts commonly is high in the basal portion of the coal section. From this level values decrease to a minimum at mid-section and then again increase in the top quarter of the coal seam throughout the sampled area. In the top inch of the coal, values are proportionately less

than in the immediately preceding sample. The species is most common in sections located in or near the middle of the outcrop area and is at many places a decidedly dominant microfloral element in the basal and top quarters of the representative sections (OPC 624, OPC 614, OPC 374). L. granulata is most persistent and common throughout section OPC 374, northern Wagoner County, in the southern portion of the outcrop area. However, southward, the proportion of the species in the total microflora decreases rapidly. In the southernmost section, OPC 657, Wagoner County, it is a minor spore element and constitutes only 5 percent or less of the assemblages in the middle and top sample levels. The occurrence of the species in the underclays shows a decided relationship to sample location within the outcrop area. In those sections located at both the southern (OPC 657, Wagoner County) and northern (OPC 615, Craig County; OPC 216, Craig County) extremes of the area, the species is minor (1.3 percent or less of the total population). In or near the middle of the outcrop area, the species is common in the underclays and may account for 22 or more percent of the total microflora. In the roof shales, it is normally common and normally the percentage values are greater here than in the subjacent top coal level. This is particularly true for

those sections in the middle of the studied area. Some of the highest percentage values (27 percent in OPC 374, northern Wagoner County) appear in these levels.

L. granulata occurs at many places with L. pseudoannulata Kosanke discussed below. In many cases, however, it was difficult to separate the two species, as differentiation depends upon how well the annulus in L. pseudoannulata is developed. The writer, while traversing slides, has the rather distinct impression that the Iron Post forms can be relegated into a series with no annulus at one extreme and those with a clearly defined annulus at the other. Further, there are forms with gradational and intermediate flanges. This suggests that the end members in the gradational series are actually "processed species" or forms variously affected by the maceration technique employed. Because both L. granulata and L. pseudoannulata are distinguished by Kosanke on the presence or absence of an annulus, it appears that the two species may actually be conspecific; however, until this proposition can be demonstrated, the two morphological forms are treated separately in this paper.

Lycospora granulata was described from the Caseyville group of Illinois and subsequently reported from the Tradewater, Carbondale and lower McLeansboro of the same state

(Kosanke, 1950). According to the resent revision of the stratigraphic nomenclature of this state (Kosanke et al., 1960) the stratigraphic range of the species is now referred to as extending from the base of the McCormick group (Atokan) to the middle of the McLeansboro group (Missourian). Guennel (1958) recorded the species in the Pottsville coals of Indiana, and Schemel (1951) reported it from the Mystic coal of Iowa. Clarke (1961) recorded the species from the Secor coal in Oklahoma. In Europe the species has been reported from the upper Westphalian B zone in the German Ruhr basin (Potonie´and Kremp, 1956), and Imgrund (1960) recorded the species from the Westphalian D horizon and Stephanian of the Kaiping basin, China.

Figured specimens: Slide Nos. OPC 624D-1-9 and E-1-9, Craig County.

LYCOSPORA PSEUDOANNULATA Kosanke, 1950

Plate 5, fig. 3

Specimens in the Iron Post coal referred to L. pseudoannulata are fairly common. Generally, the species is most common in the basal quarter of the seam and the proportion in total population counts decreases up-section. This almost duplicates the distribution pattern of L. granulata. The form

is largely absent from the roof shales, and only in section OPC 614, Rogers County, is there an increase in the percentage value over that of the preceding level. It is either absent or is represented by single specimens in many of the underclay samples in the outcrop area; however, near the middle of the area it is fairly common to common in these clays. In OPC 624, Craig County, the form represents almost 20 percent of the total microflora of the underclay. In the southernmost sampled section, OPC 657, Wagoner County, the form is represented by only four specimens in sample level E.

As indicated in the previous discussion, the writer feels that possibly L. pseudoannulata and L. granulata are conspecific and that the two forms might well be products of maceration since the annulus of C. pseudoannulata is rather delicate and has been observed in various stages of destruction.

Kosanke (1950) records the species from the Caseyville (Atokan) formation through to the middle of the Spoon formation (mid Desmoinesian) of Illinois. Guennel (1958) reports it in the coals of the Pottsville series of Indiana. To date it has not been reported from Pennsylvanian coals in Oklahoma. Potonié and Kremp (1956) record the species from the upper Westphalian A horizon in the Ruhr basin.

Figured specimen: OPC 624D-3-12, Craig County.

LYCOSPORA CF. TORQUIFER (Loose, 1932)

Potonié and Kremp, 1956

Plate 5, fig. 6

1932 Sporonites torquifer Loose, in Pot., Ibr. and Loose, Neues Jahrbuch Beil., Abt. B, vol. 67, p. 450, pl. 18, fig. 43

1934 Reticulati-sporites torquifer (Loose, 1932) Loose, Inst. Palaob. Arb., vol. 4, no. 3, p. 154

1944 Granulatisporites torquifer (Loose, 1932) S., W., and B., Ill. Geol. Survey, Rept. Invest. No. 91, p. 12

1950 Microreticulatisporites torquifer (Loose, 1932) Knox, Bot. Soc. Edinburgh, Trans., vol. 35, p. 322, fig. 248

1956 Lycospora torquifer (Loose, 1932) Pot. and Kr., Teil II, Palaeontographica, Abt. B, vol. 99, Lief. 1-3, p. 104

Representatives of L. cf. torquifer are extremely rare in the Iron Post coal. The species appeared in the population counts of only one level, OPC 216D, Craig County,

and was encountered while traversing slides for photographic specimens in only two other levels: OPC 374 F, Wagoner County, and OPC 614 D, Rogers County.

Guennel (1958, p. 50) and Potonié and Kremp (1956, p. 104) indicated the similarity that this species bears to L. granulata Kosanke. As stated previously, the possibility exists that the species described in this paper may be forms made distinct through the maceration processes. The few specimens assigned to L. torquifer in the Iron Post coal may be compression variations of the other species of Lycospora. The specimens otherwise conform to the descriptions for the species given by Potonié and Kremp (1956).

It has been previously reported from North America only in the Rowe coal of Oklahoma (Davis, 1961). In Europe it is reported from the upper Westphalian B horizon of the Ruhr basin of Germany (Loose, 1934).

Figured specimen: Slide No. OPC 374F-4-3, Wagoner County.

LYCOSPORA SP. A

Plate 5, fig. 4

Spores radial; trilete; subtriangular to oval, lenticular; trilete rays distinct, bordered by raised lips, 1.1

microns in width, extending to equatorial margin; body wall thickness obscure but greater than 1 micron; triletes extend as thickened traces onto flange and many are agape centrally; central body distinct and surrounded by a narrow, slightly crenulate to serrate flange. Ornamentation of central body finely granular; granulae arranged in a crudely reticulate pattern; flange other than crenulation levigate to infragranular. Flange 2.0 to 3.6 microns wide; overall dimensions 43 to 53 microns (based on 10 specimens).

Typical specimen: Slide No. OPC 624J-5-3, Craig County, Oklahoma. Width of equatorial flange 2.2 to 3.3 microns; overall diameter 45.6 by 50.6 microns.

Lycospora sp. A is larger than other previously described forms. The narrow crenulate flange about the almost spherical central body, size, and granular ornamentation serve to distinguish the form from other Lycospora. Its closest described relative appears to be Lycospora cicatricosa (Ibrahim, 1932) Potonié and Kremp, 1956. Ibrahim's form is much larger, however, and apparently punctate.

This species is rare in the assemblage counts of the Iron Post coal, and appears only in five different levels. In the northern portion of the outcrop area, the species occurs as single or double specimens in the lower coal levels

(level D, OPC 624, Rogers County; levels A and B, OPC 614, Rogers County). In the south, the specimens are located near the top of the coal-section (level H, OPC 374, Wagoner County). The species is absent in the population counts in both the northernmost and southernmost sections in the outcrop area (respectively OPC 615 and OPC 216, Craig County, and OPC 657, Wagoner County).

LYCOSPORA ? SP. B

Plate 5, fig. 7

Spores radial; trilete; subtriangular to triangular; trilete distinct; rays 15 to 20 microns long, extending to margins of central body and continuing as thin, thickened subdued areas onto flange; commissure of rays thin and bordered by narrow (about 1 micron), slightly elevated lips. Rim or flange thickened, tapering gradually to outermost margin; ornamentation of central body 53 to 60 microns, flange width 3.5 to 7.8 microns, widest opposite triletes; overall dimensions 56 to 69 microns (based on 6 specimens).

Typical specimen: Slide No. OPC 374F-1-3, Wagoner County, Oklahoma. Dimensions of central body 55.0 by 57.2 microns; overall dimensions 60.5 by 68.7 microns.

This species is questionably referred to Lycospora

because the annulus or flange surrounding the central body is modest as in Lycospora (S., W., and B., 1944) emend. Potonié and Kremp, 1956, and satisfies the criteria of shape and general morphology established for the genus. The species is clearly not related to Cirratriradites, which is characterized by a prominent, normally serrate flange and the presence of foveal rings at the intersection of the trilete rays. The species resembles most of the generic characteristics of Stenozonotriletes (Naumova, 1937, 1939) emend. Potonié, 1958. This genus is characterized by being subtriangular to circular with a narrow flange or cingulum and a somewhat smoother ornamentation than Lycospora. Species assigned to Stenozonotriletes, however, do not have the pointed apices as in Lycospora ? sp. A described in this report and the flange or cingulum is described as evenly thickened and not tapered as in the Iron Post form. It is in these features that the species differs from those forms assigned to Stenozonotriletes. It appears that Lycospora ? sp. A may belong to a unique spore group as yet unassigned or named.

The species is rare in the Iron Post coal and appears in the population counts of three different levels in as many sections. All occurrences are limited to one or two specimens

in the lower portion of the coal seam. The species is in addition, confined to sections located near the middle of the outcrop area: level C, OPC 624, Craig County; level B, OPC 614, Rogers County; level C, OPC 374, northern Wagoner County.

LYCOSPORA ? SP. C

Plate 5, fig. 5

Spores radial; trilete; triangular, lenticular; trilete rays distinct, extending to margin of central body; rays with thin commissure with narrow (0.5 microns wide) slightly raised lips; central body distinct and triangular; thin flange conforms to central body shape, folded or flexed in many specimens. Central body and flange levigate. Central body 30 to 34 microns, overall diameter 39 to 48 microns (based on 7 specimens).

Typical specimen: Slide No. OPC 624K-2-1, Craig County, Oklahoma. Diameter of central body 33.0 by 33.0 microns; overall diameter 42.3 by 47.0 microns.

This species is questionably referred to Lycospora because the form is devoid of the ornamentation found in other species assigned to this genus. Assignment to Cirratriridites is not made because all the specimens possess

a relatively minor flange and lack foveal rings at the intersection of the rays. The form is again more angular apically and has a more uniform, tapering thin flange than in Stenozonotriletes. The form is most closely related to the species described as Stenozonotriletes minutus Ischenko (1950). It differs from it by being larger and having a relatively broader flange and more triangular central body. The species of Ischenko appears, by possessing a thin tapering flange, not to belong to the genus Stenozonotriletes as now recognized. However, Potonié and Kremp (1955, 1956) and Potonié (1958) did not reassign species of Russian genera. As currently understood neither Ischenko's species nor the Iron Post species could be referred to Stenozonotriletes and it probably belongs to an as yet unassigned and unnamed spore group.

Lycospora ? sp. C occurs rarely in the population counts of only five levels in the Iron Post coal. It is present as a single specimen in level K, OPC 624, Craig County, levels A, D, E, and L of OPC 614, Rogers County, and level I of OPC 374, Wagoner County. The species does not appear in the population counts of the southernmost or northernmost sampled sections.

Series Zonati Potonié and Kremp, 1954

Genus CIRRATRIRADITES Wilson and Coe, 1940

Genotype: Cirratriradites maculatus Wilson and Coe, 1940

CIRRATRIRADITES MACULATUS Wilson and Coe, 1940

Plate 5, fig. 8

1940 Cirratriradites maculatus Wilson and Coe, Amer. Midl. Naturalist, vol. 23, no. 1, p. 183, fig. 7

1956 non Cirratriradites saturni (Ibrahim, 1932) S., W., and B., emend. Pot. and Kr., Teil II, Palaeontographica, Abt. B, vol. 99, Lief. 4-6, p. 128

Cirratriradites maculatus occurs consistently, although rarely, in the population counts of the Iron Post coal and is present virtually in all levels of five of the six sampled sections. It is absent from the counts of the southernmost section, OPC 657, Wagoner County. Generally, percentage values for the species in population counts are low in the basal portion of the coal and increase up-section, being highest in the top 1 to 3 inches of the coal. The highest percentage recorded here is 2.8 percent of the total population (OPC 624, Rogers County). The species is

represented in underclays by valves up to 0.7 percent. In the southern portion of the outcrop area, the species is absent from this level (OPC 374, Wagoner County). C. maculatus is rare in the roof shales and is represented mostly by 2 or 3 specimens per assemblage count. The highest percentage value (1.3 percent) of the species in roof-shale assemblages is encountered in section OPC 374, Wagoner County.

Potonié and Kremp (1956) reassigned C. maculatus to C. saturni (Ibrahim) S., W., and B. In so doing, the authors had designated the latter as the genotype of Cirratriradites. The emendation was made, apparently, without having seen the holotype of C. maculatus. This is considered unfortunate because the two species are distinct and are so regarded in the present paper. Although the forms are obviously related, C. saturni has reticulate ornamentation, a wider, a more crenulate, lineated flange, and as indicated by Potonié and Kremp (1956, p. 128), normally with a single polar fovea at the intersection of the rays.

The species was described from the Des Moines of Iowa (Wilson and Coe, 1940) and subsequently, Kosanke (1950) listed the species in the lower and upper portions of the Tradewater group of Illinois, which as per Kosanke et al.

(1960) limits the stratigraphic range of the species in this state to the section defined by the upper portion of the McCormick group and the lower portion of the Kewanee group. The listing of C. saturni by Guennel (1958) from the Pottsville coals of Indiana appears to be this species and not C. maculatus. In Oklahoma, C. maculatus has been reported by Higgins (1960) from the Secor coal. The species reported as C. saturni by Davis (1961) from the Rowe coal of the same state is reticulate, and only superficially resembles the Iron Post form. The species has not been reported outside of North America other than the previously noted designation of Potonié and Kremp.

Figured specimen: Slide No. OPC 374H-4-4, Wagoner County.

Division MONOLETES Ibrahim, 1933

Subdivision Azonomonoletes Luber, 1935

Series Psilamonoleti V. D. Hammen, 1955

Genus LAEVIGATOSPORITES (Ibrahim, 1933) emend. S., W., and B., 1944

Genotype: Laevigatosporites vulgaris (Ibrahim, 1932) S., W., and B., 1944

1932 Sporenites vulgaris Ibrahim, Neues Jahrbuch, Beil., Abt. B, vol. 67, p. 448, pl. 15, fig. 16

1933 Laevigato-sporites vulgaris (Ibrahim, 1932) Ibrahim, in Pot. Ibr. and Loose, Sporenformen des Aegirhorizonts, p. 39-40, pl. 2, fig. 16; pl. 5, figs. 37-39

1944 Laevigato-sporites vulgaris (Ibrahim, 1932) S., W., and B., Illinois Geol. Survey, Rept. Invest. No. 91, p. 37

LAEVIGATOSPORITES DESMOINESIS (Wilson and Coe, 1940) S., W., and B., 1944

Plate 5, fig. 10

1940 Phaseolites desmoinensis Wilson and Coe, Amer. Midland Naturalist, vol. 23, no. 1, p. 183, fig. 4

1944 Laevigato-sporites desmoinensis (Wilson and Coe, 1940) S., W., and B., Illinois Geol. Survey, Rept. Invest. No. 91, p. 37

Laevigatosporites desmoinensis is uncommon in the assemblage counts of the Iron Post coal. Although it is represented by relatively low values, these are distributed

rather uniformly throughout most sampled levels. Although there is little variation in the stratigraphic distribution of the species, the relatively higher percentages tend to be concentrated in the upper and lower quarters of the coal section. Exceptions to this pattern of distribution are found in the southernmost and northernmost sections in the outcrop area (OPC 615, Craig County, and OPC 657, Wagoner County). Here, more than anywhere else, the basal quarters of the sections contain the highest percentage values of the species. Sporadic increases in the values within sections in or near the middle of the outcrop area (OPC 614, Rogers County; OPC 624, southern Craig County) are on the order of 4 to 6 percent and show no patterned distribution. The species is represented by values no higher than 1.5 percent in the underclays. This amount is approximated at all localities except in section OPC 657, Wagoner County. Here the species is absent. Roof shale distributions are similar but values may reach 2.3 percent of the total population. In the Iron Post coal, L. desmoinensis, on the basis of population-count percentages, indicates that the parent plant was a minor, although relatively persistent species throughout the development of the Iron Post coal swamp.

The species was described from Desmoinesian coal of

Iowa (Wilson and Coe, 1940). Kosanke (1950) reported the range of the species in Illinois as extending from the top of the Caseyville formation (Atokan) to near the top of the McLeansboro group (Missourian). It was reported by Guennel (1958) from the Pottsville coals of Indiana and by Schemel (1951) from the Mystic coal of Iowa. In Oklahoma, it was listed in the McAlester coal (Morgan, 1955), Croweburg coal (Wilson and Hoffmeister, 1956) the Rowe coal (Davis, 1961), and the Secor coal (Higgins, 1960; Clarke, 1961). In Europe, L. desmoinensis has been recorded from upper Westphalian A and lower Westphalian C zones of the Ruhr basin, and from the upper Westphalian C and Stephanian A zones of the Saar basin by Potonie´ and Kremp (1956). Luber and Waltz (1938) figured a similar species recovered from the Westphalian of the Donetz basin, Russia, and Knox (1950) listed the species from the lower Productive Coal Measures of Scotland (according to the emendations of Potonie´ and Kremp, 1956). The specimens assigned to this species from the Westphalian and Stephanian of China (Imgrund, 1960) should more probably be referred to L. medius.

Figured specimen: Slide No. OPC 624C-4-3, Craig County.

LAEVIGATOSPORITES LATUS Kosanke, 1950

Plate 5, fig. 10

1950 Laevigatosporites latus Kosanke, Ill. Geol. Survey Bull. 74, p. 29, pl. 5, fig. 11

1954 Latosporites latus (Kosanke, 1950) Potonié and Kremp, Geol. Jahrbuch, vol. 69, p. 165, pl. 16, fig. 67

Specimens assigned to L. latus occur rarely in the population counts of the Iron Post coal. The form is represented by one, or at the most three specimens per assemblage count in the various levels in which it occurs. Generally, L. latus is not regularly distributed, although there is a tendency for it to be more common in the upper third of the coal section in the northern portion of the outcrop area. In the southern portion of the area (OPC 374 and OPC 657, Wagoner County) it is most abundant in the lower third of the section.

Potonié and Kremp (1954) transferred L. latus to Latosporites, designating it as the genotype. Laevigatosporites and Latosporites are differentiated largely by shape, the latter being broadly oval or sub-spherical in proximal and distal views and hemispherical in equitorial view. As defined, Latosporites is represented by species

with levigate, infrareticulate or punctate ornamentation. L. latus is retained in Laevigatosporites in this paper as it is felt that the shape criterion in proximal and distal views is gradational with similar views of forms assigned to Laevigatosporites, and the inferred hemispherical equitorial view is suspect. Kosanke (1950, p. 29) described the genotype as being broadly oval in equitorial or longitudinal view and this differs markedly from the reconstructed hemispherical shape illustrated and described by Potonié and Kremp (1954, p. 165, pl. 16, fig. 67). The hypothetical shape (which does adequately describe L. robustus Kosanke, 1950) would appear to be a valid morphological criterion. However, Kosanke did not indicate this to be the case for the species, and further, if true it would be expected that mounted specimens would be predominantly of the hemispherical view. Because this is not the case and for the reasons given above, the species is retained in Laevigatosporites.

Kosanke (1950) described the species from the Stonefort formation of the lower Kewanee group of Illinois and reported it from coals in the upper and lower McLeansboro group of the same state. Guennel (1958) listed the species in the Minshall coals of the upper Pottsville group of Indiana. It has previously not been reported from the state

of Oklahoma. In Europe, Potonié and Kremp (1956) recorded it from the Westphalian B horizon of the Ruhr basin. Luber and Waltz (1938) reported the species from Westphalian A horizon of the Donetz basin (according to Potonié and Kremp, 1956). In Asia, Imgrund (1960) recorded the species in beds of Stephanian age from the Kaiping basin of China.

Figured specimen: Slide No. OPC 374B-4-3, Wagoner County.

LAEVIGATOSPORITES MEDIUS Kosanke, 1950

Plate 5, fig. 12

Laevigatosporites medius is uncommon in the Iron Post coal although persisting throughout the six sections in most levels. In population counts, the relative percentages of the species are highest in the lower half of the coal seam. These values generally decrease up-section. The species is most abundant and persists at higher values up-section more in the sections located in the northern portion of the outcrop area (OPC 615 and OPC 216, Craig County). Here the form may account for 5 to 7 percent of the total population. Generally, the decrease in percentages up-section is not reversed in the top inch of the coal seam. In the underclays, L. medius is most abundant (13 percent) in section OPC 615,

northern Craig County. In the remaining sections percentages in the total population of the underclays vary and the species may be absent or represented by as much as 2.3 percent. Roof shales carry the species in minor numbers, generally slightly in excess of 1 percent, with no well defined distribution pattern. The percentage distributions of the species appear to indicate that the parent plant of the spore was uncommon in the coal swamp community. It was most significant in the early stages of the developing swamp community and subsequently decreased in time to a much less prominent role. Apparently, the plant requirements were such that the initial developmental stages of the swamp were more favorable to it than the succeeding stages.

L. medius is characterized by size, and otherwise the form is similar to the larger L. desmoinensis. Some forms exceed the size limits noted by Kosanke (1950). It therefore appears at least possible that morphologically the spores are representative of the same plant species or at most are varieties of the same species.

In Illinois, the species ranges stratigraphically from the upper part of the Carbondale formation to the middle of the McLeansboro group (Kosanke, 1950). It is reported by Schemel (1951) from the Mystic coal of Iowa. Higgins (1961)

reported the species from the Secor coal and Davis (1961) from the Rowe coal of Oklahoma. In Europe, the species has been recorded from the upper Westphalian A and middle C horizons in the Ruhr basin and the Westphalian C horizon of the Saar basin of Germany (Potonié and Kremp, 1956). The species which Imgrund reported as occurring in the Westphalian D horizon and beds of Stephanian age in the Kaiping basin of China appears more closely related to L. medius than to L. desmoinensis.

Figured specimen: Slide No. OPC 374C-1-1, Wagoner County.

LAEVIGATOSPORITES MINIMUM (Wilson and Coe, 1940)

S., W., and B., 1944

Plate 5, fig. 14

1940 Phaseolites minimus Wilson and Coe, Amer. Midland Naturalist, vol. 18, no. 1 p. 183, fig. 6

1944 Laevigato-sporites minimus (Wilson and Coe, 1940) S., W., and B., Illinois Geol. Survey, Rept. Invest. No. 91, p. 37

Representatives of this species are rare in the Iron Post coal. The species is virtually confined to the basal

quarter of the coal seam. It is represented by higher percentage values in the lowermost level, and these values decrease rapidly up-section. The species nowhere exceeds 2.3 percent of the total population count in the various levels in which it occurs. Representative percentage values of the species tend to continue as fractions higher in the section southward in the outcrop area and it is stratigraphically most persistent in section OPC 374, Wagoner County. In underclays, L. minimus may attain as much as 4 and as little as 0.7 percent of the total population count. There is no trend in the distribution values for this level. The species is absent from the population counts of the roof shales. The distribution of the percentage values of this species indicates that the form is representative of a minor parent plant associated with the early developmental stages of the coal-swamp plant community.

The species was described from the Desmoinesian of Iowa (Wilson and Coe, 1940), and Kosanke (1950) found it to range from the upper portion of the McCormick group, and through the Kewanee and McLeansboro groups of Illinois. Guennel (1958) reported it from the Pottsville coals of Indiana, and Kosanke (1943) from the Pittsburg and Pomeroy coals of Ohio. Schemel (1951) listed it with the Mystic

coal microflora of Iowa. In Oklahoma, Wilson and Hoffmeister (1956) recorded it in the Croweburg, Davis (1961) in the Rowe, and Higgins (1960) and Clarke (1961) from the Secor coals. In Europe, Knox (1952) reported the species in the Productive Coal Measures of Scotland and in Germany (Potonié and Kremp, 1956) it was recorded from the middle Westphalian C horizons of the Ruhr and Saar basins.

Figured specimen: Slide No. OPC 216D-2-1, Craig County.

LAEVIGATOSPORITES MINUTUS (Ibrahim, 1933)

S., W., and B., 1944

Plate 5, fig. 13

1933 Punctato-sporites minutus Ibrahim, Sporenformen des Aegirhorizonts, p. 40, pl. 5, fig. 33

1944 Laevigato-sporites (Ibrahim, 1933) S., W., and B., Ill. Geol. Survey, Rept. Invest. No. 91, p. 37

1954 Punctatosporites minutus (Ibrahim, 1933) Pot. and Kr., Geol. Jahrbuch, vol. 69, p. 165, pl. 16, fig. 68

One of the more abundant species in the Iron Post

coal is L. minutus. Proportionate percentages of the form in total population counts may reach 25 percent in some levels. The species occurs in all sample levels of the six sections sampled in the study area. Generally, L. minutus is most abundant in the basal quarter of the coal seam, decreasing steadily up-section to 4 or 5 percent of the population count in the topmost 1 inch coal level. This distribution, however, is not duplicated in section OPC 374, Wagoner County, where the species shows only slight overall variation up-section and the higher percentage values are located in the top 3 inches of the coal seam. Percentage distributions of the species in underclays vary between 1.5 and approximately 5 percent in the northern portion of the outcrop area and increase to 10 percent in the southern and mid-portions of the area studied (OPC 614, Rogers County and OPC 374, Wagoner County). The underclays of the southernmost section (OPC 657, Wagoner County) are barren. Roof shales contain the species in values varying between 1 and 5 percent. The values are minimal for the species in these sediments in samples OPC 624 and OPC 614, Rogers County.

The species has been designated as the genotype of Punctatosporites by Potonié and Kremp (1954). The proposed emendation is defined on the basis of shape and ornamentation.

The granular ornamentation as described by Potonié and Kremp appears, in the Iron Post specimens, to be of close-set punctae which in oblique light exhibit a micropapillate or microgranular texture in the peripheral areas. The interpretation of whether the form is punctate or granular apparently has suffered the interpretations of various workers, and as indicated previously, emphasizes the danger encountered in recognizing generic features on the basis of ornamentation and predicating correct assignment to uniform interpretation of descriptive prefixes. For this reason, a conservative position is taken here and the species is retained in Laevigatosporites because the validity of the genus Punctatosporites is philologically in doubt.

The species has been recorded from Illinois (Kosanke, 1950). According to Kosanke et al. (1960) the range of the species now extends from the upper portion of the McCormick group to the top of the McLeansboro group. Schemel (1951) recorded it from the Mystic coal of Iowa. In Oklahoma, it has been reported as dominant in the Croweburg coal (Wilson and Hoffmeister, 1956), the McAlester coal (Morgan, 1955), and the Secor coal (Higgins, 1960; Clarke, 1961). In Europe the species is reported from the upper Westphalian B horizon of the Ruhr basin and the Westphalian C horizon of the Saar

basin (Potonie´and Kremp, 1956). It has also been reported from the Westphalian of the Donetz basin of Russia (Luber and Waltz, 1938, as per Potonie´and Kremp, 1956).

Figured specimen: Slide No. OPC 624C-1-4, Craig County.

LAEVIGATOSPORITES OVALIS, Kosanke, 1950

Plate 5, fig. 11

1950 Laevigatosporites ovalis Kosanke, Ill. Geol. Survey, Bull. 74, p. 29, pl. 5, fig. 7

1956 non Laevigatosporites vulgaris Ibrahim, 1932, Pot. and Kr., Teil II, Palaeontographica, Abt. B, vol. 99, Lief. 4-6, p. 139

Laevigatosporites ovalis is fairly common in the Iron Post coal. Representative percentages generally are higher in the lower quarter of the coal seam. These values gradually decrease to mid-section and increase again in the top coal level. This trend, however, is absent in section OPC 624, Rogers County. Here values do not exceed 3.5 percent and there is little variation vertically throughout the section. Values in the coal section vary between 10 and 0.5 percent. The underclays commonly yield the species in amounts ranging from 11 to 3 percent of the total population

count except in OPC 657, Wagoner County where this level is barren. The species is represented by higher values in those sections located in the northernmost portion of the outcrop area (OPC 615 and OPC 216, Craig County). Generally it exhibits higher values in the roof shales than in the preceding topmost coal sample. Although the distribution of the percentage values does not geographically describe a clear pattern it does seem that the spores represent a parent plant which was better adapted to the environment of the early developmental history of the coal swamp. Its importance diminished during mid-seam time and resumed somewhat the former status during the waning developmental stages of the swamp.

As indicated in the synonymy, Potonié and Kremp (1956) placed L. ovalis in synonymy with L. vulgaris (Ibrahim, 1932) Ibrahim 1933. The reported size range of L. vulgaris is 70 to 100 microns and Kosanke (1950) indicates the size of L. ovalis to be 45 to 65 microns. The diameter of the Iron Post specimens is 50 to 60 microns. Because differentiation of these laevigate spores is largely a matter of size and as L. ovalis falls well below the range given by Potonié and Kremp, their emendation is here not recognized. In addition, it is recognized that the species L. desmoinensis,

L. medius, L. latus, and L. ovalis comprise a closely, and probably naturally related group.

Kosanke (1950) reported the species in Illinois as ranging stratigraphically from the Caseyville formation (Atokan) through to the upper portion of the McLeansboro group. Guennel (1958) reported it as abundant in the Pottsville coals of Indiana. Schemel (1951) recorded it in the Mystic coal of Iowa. In Oklahoma, Morgan (1955) listed it from the Stigler and McAlester coals, Wilson and Hoffmeister (1956) in the Croweburg coal, Davis (1961) from the Rowe coal, and Higgins (1960) and Clarke (1961) from the Secor coal. The reports of the species in the Westphalian B and C horizons of the Ruhr basin and from the Westphalian C to Stephanian C horizons of the Saar basin by Potonié and Kremp (1956) are regarded as problematical due to their emendation.

Figured specimen: Slide No. OPC 624D-1-25, Rogers County.

LAEVIGATOSPORITES PUNCTATUS Kosanke, 1950

Plate 5, fig. 15

1950 Laevigatosporites punctatus Kosanke, Ill. Geol. Survey, Bull. 74, p. 30, pl. 5, fig. 3

1956 pars Laevigatosporites desmoinensis (Wilson

and Coe, 1940) Pot. and Kr., Teil II, Palaeontographica, Abt. B, vol. 99, p. 139

Laevigatosporites punctatus is fairly common in the Iron Post coal. Percentage values for the species in the various population counts vary from slightly in excess of 1 percent to 13 percent. Generally, the percentages are higher in the lower and upper quarters of the sampled sections, excepting sections OPC 615 and OPC 216 in the northern portion of the outcrop area. In these sections, values are higher than elsewhere in the area. In underclays, the species may account for less than 1 or more than 13 percent of the total assemblage count. The highest values are present in the underclays of the northernmost sampled section, OPC 615, Wagoner County. The species is absent in the underclays of the northern sections OPC 216 and OPC 624 and in the southernmost sample, OPC 657, Wagoner County. Intermediate percentages for this level are found in intervening sections. In roof shales, the species is uncommon and percentages exhibit higher values in the northern and southern extremes (1.5 to 4.7 percent) than for those sections in or near the middle of the outcrop area. Here the species is absent or rare (sections OPC 614 and OPC 624, Rogers County). The distribution of the species indicates a persistent, although

minor parent plant associated with the early and late developmental stages of the coal swamp. In addition, it appears to have been more important in the earliest developmental stages of the swamp in the northern portion of the outcrop area than in the southern portion.

Potonié and Kremp (1956) placed L. punctatus in synonomy with L. desmoinensis. The latter species is levigate and generally much larger whereas L. punctatus is smaller and obviously punctate. The two species definitely are not conspecific and the emendation is not recognized in this paper.

The species has been described and subsequently reported by Kosanke (1950) in Illinois from coals ranging stratigraphically from the upper portion of the McCormick group to the upper portion of the McLeansboro group. Guennel (1958) has reported the species from the Pottsville coals of Indiana. L. punctatus is also listed from the Mystic coal of Iowa and the Rowe (Davis, 1961) and Secor (Clarke, 1961) coals of Oklahoma. Reports of the species in Europe are confusing because of the emendation of Potonié and Kremp (1956), but the specimen reported by Loose (1934) from the Westphalian B and C horizons of the Ruhr basin appears to be L. punctatus.

Figured specimen: Slide No. OPC 374F-1-1, Wagoner County.

Genus VERRUCOSOSPORITES (Knox, 1952) emend. Potonié and Kremp, 1954

Genotype: Verrucososporites obscurus (Kosanke, 1950) Potonié and Kremp, 1954

1950 Laevigatosporites obscurus Kosanke, Ill. Geol. Survey, Bull. 74, p. 29, pl. 16, fig. 6

1954 Verrucososporites obscurus (Kosanke, 1950) Pot. and Kr., Geol. Jahrbuch, vol. 69, p. 116, pl. 16, fig. 69

Potonié and Kremp (1954) assigned those monolete spores possessing distinctive coarse verrucose ornamentation to Verrucososporites, removing them from the otherwise similar but levigate or modestly ornamented group now referred to the genus Laevigatosporites. Although the emendation is based on ornamentation, it does appear that the feature is sufficiently well defined and embraces a uniform morphologic group of species. This emendation of Potonié and Kremp is accepted in this paper.

VERRUCOSOSPORITES PSEUDOTHIESSENII Kosanke, 1950

Plate 5, fig. 16

1950 Laevigatosporites pseudothiessenii Kosanke, Ill. Geol. Survey, Bull. 74, p. 30, pl. 5, fig. 10

1956 Verrucososporites pseudothiessenii (Kosanke, 1950) Pot. and Kr., Teil II, Palaeontographica, Abt. B, vol. 99, Lief. 4-6, p. 144

The spores assigned to V. pseudothiessenii are most common in the Iron Post coal. The percentage values of the species in population counts in many cases exceed 25 percent. The form is present in almost all levels and values generally are minimal in the basal portion of the seam and increase gradually although rapidly to maxima in the upper and topmost levels of the coal. Generally, the species becomes most common in the upper half of the coal and values in the lower half are smaller by one fourth than the stratigraphically higher values. In the underclays, the species is minor and representative values vary between 1.5 and 5 percent in the assemblages. Generally, the values are highest in the areas at or near the northern and southern limits of the outcrop area (OPC 615, Craig County, and OPC 657, Wagoner County). The species is only absent in the barren

underclays of section OPC 657, Wagoner County. Roof shales characteristically contain relatively high percentages of the species. These values may duplicate those in the preceding top coal sample or may be slightly less. There is no apparent geographic trend in the distribution of values for this level. The general distribution of V. pseudothiessenii in the various levels indicates that the spore is representative of a plant which had assumed prominence in the middle and late developmental stages of the coal swamp. It remained temporarily prominent after the swamp had ceased to exist as an environmental unit. These factors would appear to indicate that the parent plant was more successfully adapted to the late "emergent" stages rather than to the earlier or more "submergent" stages of the swamp.

This species has been described by Kosanke (1950) from the Carbondale formation of Illinois and subsequently reported from the lower Kewanee group through to the lower portion of the McLeansboro group of the same state. It has been reported (Kosanke, 1952) from the Kittaming coals of Ohio. Kosanke (1950) also reported having seen the species in the Mystic coal of Iowa and in the Tebo and Lexington coals of Missouri. To date, the species has not been reported from Europe.

Figured specimen: Slide No. OPC 624D-1-14, Craig County.

Group Pollenites R. Potonié, 1931

Division SACCITES Erdtman, 1957

Subdivision Monosaccites (Chitaley, 1951) Potonié and Kremp, 1954

Series Triletesacciti Leschik, 1955

Genus SPENCERISPORITES Chaloner, 1951

Genotype: Spencerisporites radiatus (Ibrahim, 1932) Chaloner, 1951

1932 Sporonites radiatus Ibrahim, in Pot., Ibr. and Loose, Neues Jahrbuch, Beil. Abt. B, vol. 67, p. 449, pl. 16, fig. 25

1933 Zonales-sporites radiatus (Ibrahim, 1932) Ibr., Sporenformen des Aegir-horizonts, p. 28, pl. 3, fig. 25

1934 Triletes karozewskii Zerndt, Acad. Polonaise Science, Trav. Geol., no. 1, p. 27, pl. 31, fig. 3

1944 Triletes radiatus (Ibrahim, 1932) S., W., and B., Ill. Geol. Survey, Rept. Invest. No. 91, p. 24

1944 Endosporites (?) karczewskii (Zerndt, 1934) S., W., and B., ibid., p. 45

1946 Microsporites karczewskii (Zerndt, 1934) Dijkstra, Netherlands, Geol. Stichting, Meded., ser. C, sec. 3, no. 1, p. 64, pl. 4, fig. 40

1950 Triletes radiatus (Ibrahim, 1932) Horst, Bergbau und Energiewirtschaft, vol. 3, figs. 13-14

1951 Spencersiporites karczewskii (Zerndt, 1934) Chaloner, Ann. Mag. Nat. History, ser. 12, vol. 4, p. 862, figs. 1-2, 6-7

1954 Microsporites karczewakii (Zerndt, 1934) Dijkstra in Pot. and Kr., Geol. Jahrbuch, vol. 69, p. 170, pl. 17, figs. 78-79

1955 Microsporites radiatus (Ibr., 1932) Pot. and Kr., in Horst, Palaeontographica, Abt. B, vol. 98, no. 4-6, p. 192, pl. 18, fig. 15; pl. 19, fig. 16 a-b

1955 Endosporites (?) radiatus (Ibr., 1932) Dijkstra, Estudios Geol., vol. 11, no. 27-28, p. 342, pl. 45, fig. 54

1956 Microsporites radiatus (Ibr., 1932) Dijkstra, in Pot. and Kr., Palaentographica, Abt. B, vol. 99, nos. 4-6, p. 157, pl. 20, figs. 449-450

1959 Spencerisporites radiatus (Ibr., 1932) Chaloner, in Felix and Parks, Micropaleontology, vol. 5, no. 3, p. 359-364, pls. 1-2

SPENCERISPORITES CF. RADIATUS (Ibrahim, 1932) Chaloner, 1951

Plate 6, fig. 2

Spencerisporites cf. radiatus is rare in the population counts of the Iron Post coal. The maximum representative values do not exceed 1.5 percent. It is absent from all underclays and all roof shales except for the shales in section OPC 374, Wagoner County. The species is absent from section OPC 615, Craig County, in the northern portion of the outcrop area. There is a tendency for the species to be concentrated in the upper 1 to 3 inch coal level in the remaining five sections. In sections OPC 624 and OPC 614, Rogers County the species is represented by single specimens in mid-section. In section OPC 657, in the southern extreme of the outcrop area, the species occurs only in mid-section, immediately beneath a level in the coal characterized largely by fossil cuticle.

The Iron Post coal specimens tentatively assigned to S. radiatus (Ibrahim, 1932) Chaloner, 1951 have diameters

between 185 and 203 microns. The main difference between previously described species of Spencerisporites appears to be size. The Iron Post specimens are smaller than previously reported forms. Those recorded by Dijkstra (1955) as measuring between 252 and 343 microns appear to be the smallest reported. The size discrepancy between these and the Iron Post specimens, however, appears not to be too significant as proportionately the difference is no greater than size variations known in other spore groups. The width of the marginal flange in the Oklahoma forms is less than in others, but as indicated by Felix and Parks (1959, p. 364) this is widely variational and not considered significant. The rare Iron Post specimens are in many cases folded and torn, and details of the central spore body are therefore often obscured. For this reason and the above discrepancies, the species is tentatively assigned to S. radiatus.

Most of the reports concerning the stratigraphic range of S. radiatus have been cited in European papers. Dijkstra (1946) reported it from the Westphalian A, B, and C horizons and from the Namurian B and C horizons of the Pelazja beds of the Netherlands. He also (Dijkstra, 1955) reported it from the Carboniferous (Westphalian A and B) of Spain. In Germany Horst (1955) recorded it from the

Westphalian C horizon of the Ruhr basin and the Namurian and Westphalian A horizons of Silesia. In England, the species is recorded from beds equivalent in age to the continental Westphalian A horizon and the Farrington (Westphalian C or D equivalent) series (Chaloner, 1951). Potonié and Kremp (1956) reported it in the slide preparations of Knox of the Carboniferous (Westphalian A equivalent) of Scotland. Felix and Parks (1959) and Felix in the same publication (p. 359) reported the species from the Pottsville coals of Kentucky and sediments of Morrow age in the Texas and Oklahoma panhandle areas. They noted also that the species is common in North America but published reports are lacking. The form reported by Hacquebard and Barss (1957) from the Carboniferous of the Nahanni River area, Canada (Namurian A equivalent) as Microsporites macgregori appears closely allied to S. radiatus.

Figured specimen: Slide No. OPC 624J-3-2, Rogers County.

Genus ENDOSPORITES Wilson and Coe, 1940

Genotype: Endosporites ornatus Wilson and Coe, 1940, Amer. Midland Naturalist, vol. 23, p. 184, fig. 2

ENDOSPORITES MINUTUS Hoffmeister, Staplin and Malloy, 1955

Plate 6, fig. 5

The spores assigned to Endosporites minutus are very rare in the population counts of the Iron Post coal. A few scattered specimens occur in various levels of four of the six sections sampled. It is absent from the counts of sections OPC 615, Craig County and OPC 624, Rogers County. In the remaining four sections, the species nowhere amounts to more than 0.5 percent of the total populations. Most of the occurrences (single specimens) occur in the lower quarter of the coal except in section OPC 614, Rogers County where a single specimen was counted in the roof shale. The species is otherwise absent from the population counts in these shales. It is also absent from the underclay floras except for the two specimens counted in level A of section OPC 374.

The specimens from the Iron Post coal assigned to E. minutus agree well with the description and illustration given by Hoffmeister, Staplin and Malloy (1955). However, the trilete is not immediately visible if viewed distally. As can be seen from the illustrations given in this paper, the central body is strongly outlined and is an apparently distinctive feature of both the previously described forms

and the Iron Post specimens. The Oklahoma specimens (based on 16 specimens) all measure between 38 and 40 microns. This small form is probably related to E. circularis Guennel, 1958 which is characterized by a more prominent trilete and a rounded-triangular central body.

Endosporites minutus was originally reported from the Hardinsburg and Waltersburg formations (Upper Mississippian) of Kentucky and Illinois (Hoffmeister, Staplin and Malloy, 1955). To date this Oklahoma occurrence and the report from the Upper Carboniferous of England (Neves, 1958) are the only subsequent records on the species other than a similar form reported as Spore type A by Hacquebard and Barss (1957) from the Carboniferous (Namurian A equivalent) of Canada.

Figured specimens: Slide Nos. OPC 624E-4-1, Craig County; OPC 657E-5-1, Wagoner County.

ENDOSPORITES ORNATUS Wilson and Coe, 1940

Plate 6, figs. 3, 4

Endosporites ornatus is rare in the population counts of the Iron Post coal. The species is absent in the southernmost locality, OPC 657, Wagoner County, and is represented in only one level (C) of section OPC 374, Wagoner

County. It is present in two levels in the northernmost sections (level B, OPC 615; level I, OPC 216, both of Craig County). The species is most abundant in the remaining two sections near or in the central portion of the outcrop area. The form is stratigraphically most persistent in section OPC 614, Rogers County, and most abundant (2.3 percent) in level J of this section. Here the higher values tend to be concentrated in the upper quarter of the coal seam. The species occurs only sporadically in the lower three-quarters of these two sections. It is rare in the population counts of the underclays and is present in these sediments only as single specimens in sections OPC 624 and OPC 614, Rogers County. The occurrence in roof shales duplicates that of the underclays. There is no pattern defined by the occurrences except that in the central portion of the outcrop area the form was most important during the late developmental stages of the swamp.

Kosanke (1950) according to Kosanke et al. (1960) reported the stratigraphic range of this species in Illinois as extending from the upper portion of the McCormick group to the lower portion of the McLeansboro group. Kosanke (1943) reported the species from the Pittsburg and Pomeroy coals of Ohio and Guennel (1958) recorded it in the Pottsville

coals of Indiana. Schemel (1951) listed it with the microflora of the Mystic coal of Iowa. E. ornatus was described from the Desmoinesian of the same state (Wilson and Coe, 1940). Wilson and Hoffmeister (1956) reported it as abundant in the Croweburg coal of Oklahoma and Davis (1961) recorded it rarely from the Rowe coal of the same state. In Germany it is reported from the upper Westphalian B and lower Westphalian C horizons of the Ruhr basin (Potonié and Kremp, 1956). Bhardwaj (1957) recorded it from the Westphalian D horizon of the same area. In England Neves (1958) recorded it from the Lower Carboniferous (Namurian-Westphalian boundary) in North Staffordshire. Alpern (1958) reported it from the Stephanian of France.

Figured specimens: Slide Nos. OPC 614F-1-2, F-2-1 and F-3-1, Rogers County.

ENDOSPORITES PALLIDUS Schemel, 1950

Plate 6, fig. 6

Spores assigned to this species are very rare in the population counts of the Iron Post coal, and representative values do not exceed 1 percent of the counts in which it figures. Most occurrences are represented by single specimens. The species is absent from the counts of sections

OPC 615, OPC 216, Craig County and OPC 657, Wagoner County. Occurrences tend to be scattered throughout the remaining three sections. It is most common in section OPC 374, Wagoner County. Here it comprises 1 percent of the population of the underclay and is sporadically represented through the lower three-quarters of the coal section.

The Iron Post forms (on the basis of 8 specimens) all measure between 54 and 71 microns in diameter. The specimens agree well with the description and illustration given by Schemel (1951). The trilete rays are obscure and demand careful focusing for resolution and in some specimens a well defined germinal apparatus is lacking. This apparent tendency for no trilete to be developed is suggestive of a relationship with the spore group Enzonalasporites Leschik (1955).

The species was described by Schemel (1951) from a Lower Carboniferous coal of Utah, and subsequently it has been reported from the Upper Mississippian Hardinsburg formation of Kentucky (Hoffmeister, Staplin and Malloy, 1955). To date the Iron Post occurrence marks the first reference to this species in Pennsylvanian sediments. It has not been reported from outside the United States.

Figured specimen: Slide No. OPC 374H-4-5, Wagoner County.

Genus WILSONITES (Kosanke, 1950) Kosanke, 1959

Genotype: Wilsonites vesicatus Kosanke, 1959

1950 Wilsonia vesicatus Kosanke, Ill. Geol. Survey, Bull. 74, p. 54, pl. 14, figs. 1-3

1959 Wilsonites vesicatus (Kosanke, 1950) Kosanke, Jour. Paleontology, vol. 33, no. 4, p. 700

WILSONITES DELICATUS (Kosanke, 1950) Kosanke, 1959

Plate 6, figs. 8, 9

This relatively large spore, W. delicatus, is rare in the population counts of the Iron Post coal. The species is represented in all sections although representative percentages do not exceed 1.3 percent in any given level. Generally, it is most common in those sections located in the southern portion of the outcrop area, and higher values are normally found in the uppermost coal levels or in the roof shales. The species is represented in section OPC 615, Craig County, in the northernmost limit of the outcrop area, by a single specimen in level E. In section OPC 216, Craig County, the next locality south, the species is confined to the upper quarter of the section, with the highest value

(1.3 percent) representing the roof shale. In section OPC 624, Rogers County, the species occurs only in the lower quarter levels C and E of the coal section as individual specimens. From this section southward, W. delicatus appears stratigraphically more consistently. There is a tendency for the higher values to be concentrated in top levels of the sections. In the southernmost section, OPC 657, Wagoner County, an anomaly exists in that values are generally higher here in all levels than in the other five sections in the study area. The species is most common (1.3 percent of the total population) in level E, immediately below a mid-section horizon containing largely leaf cuticles and wood fragments. The species is here absent from the roof shales. W. delicatus is also absent from all underclays except for these sediments in section OPC 614, Rogers County.

This species is in most cases represented by pitted, folded and in some instances as torn specimens. The preservation is duplicated in all levels and is too consistent to be ascribed to the maceration technique employed. In addition, the central body is often indefinitely outlined due to the above factors. However, the forms agree with the descriptions of Kosanke, 1950 with regard to size, ornamentation, and general morphological features.

This species has, according to Kosanke (1950) as in Kosanke et al. (1960), a stratigraphic range extending from the Caseyville formation (Atokan) throughout the McLeansboro group (Missourian and Virgilian) in Illinois. Schemel (1951) listed the species from the Mystic coal of Iowa. The species has not otherwise been noted elsewhere in the literature.

Figured specimens: Slide Nos. OPC 657B-2-2, Wagoner County; OPC 216F-1-2, Craig County.

WILSONITES VESICATUS (Kosanke, 1950)

Kosanke, 1959

Plate 6, fig. 7

This species, although not abundant, is represented in almost all levels of the six sections sampled. It may amount to as much as 34.0 percent of the total population of some levels, although commonly the values are much less. The higher values are normally confined to the top fifth of the coal section. Minimal amounts are located basally and from here progressively increase up-section. The species is absent from the underclays of sections OPC 615, Craig County and OPC 374 and OPC 657, Wagoner County, and essentially so in section OPC 216, Craig County. It is rare in the clays of the remaining two sections located near the middle of the

outcrop area. W. vesicatus is absent from the roof shales in sections OPC 615, Craig County and OPC 657, Wagoner County, in the extreme northern and southern limits of the outcrop area. The remaining roof shales contain significant amounts of the species, the values of which are normally less, by half or more, than those of the uppermost coal samples. In section OPC 657, Wagoner County, the highest values representing the species are limited to the two levels immediately underlying a horizon containing much leaf cuticle and woody fragments (level F). The distribution of values indicates that the species was most important in the closing developmental stages of the coal swamp.

Kosanke (1950) recorded the species from the middle and upper portions of the McLeansboro group of Illinois. In Oklahoma, it has been reported from the Croweburg coal (Wilson and Hoffmeister, 1956), Rowe coal (Davis, 1961) and from the Secor coal (Higgins, 1960; Clarke, 1961). The species has not been reported to date from outside the United States.

Figured specimen: Slide No. OPC 624J-3-4, Rogers County.

Genus GUTHÖRLISPORITES Bhardwaj, 1954

Genotype: Guthörlisporites magnificus Bhardwaj, 1954, Neues Jahrbuch Geol. Palaontol., Monatshefte, vol. 11, p. 519, fig. 8

GUTHÖRLISPORITES SP. A

Plate 7, figs. 1, 2

Spores radial; trilete; central body circular; rays 8 to 12.5 microns long, simple, obscure; central body distinct, levigate with peripheral, and occasionally arcuate compression folds; bladder levigate to infrareticulate; sac and body wall thin, less than 1 micron. Diameter of central body 25 to 35 microns, overall diameter, 66 to 81 microns.

Figured specimens: Slide Nos. OPC 624K-1-6, Craig County; OPC 374H-4-8, Wagoner County, Oklahoma. Overall diameters respectively 67.3 microns and 81.4 microns.

The Iron Post specimens are not assigned to G. magnificus Bhardwaj in that the dimensions of the central body are larger and the overall sizes are smaller. The form is similar to Guthörlisporites sp. A reported by Davis (1961) from the Secor coal of Oklahoma. From descriptions and illustrations the species appears most closely related to G. velensis Bhardwaj (1957b, p. 130) described from the

Westphalian D horizon of the Ruhr basin of Germany.

The species is rare in the Iron Post coal and normally does not exceed 1.5 percent of the population for any given level in which it occurs. It is absent from the northernmost sections, OPC 615 and OPC 216, Craig County. The form, in the remaining four sections, tends to be concentrated in the upper quarter of the coal seam, although in sections OPC 624 and OPC 614, Rogers County, rare specimens occur randomly at mid-section. The species is absent from all underclays. It is present in roof shales in relative amounts varying between 0.3 and 4 percent. Generally, these values for the shale level increase southward in the study area. The distribution of values indicates that the species had been most important in the closing developmental stages of the coal swamp.

Genus VESTISPORA Wilson and Hoffmeister, 1956

Genotype: Vestispora profunda Wilson and Hoffmeister, 1956, Oklahoma Geol. Survey, Circ. no. 32, p. 27, pl. 2, figs. 16-19

VESTISPORA PROFUNDA Wilson and Hoffmeister, 1956

Plate 4, fig. 1

Vestispora profunda, although uncommon, is present

in virtually all levels. Proportionate values vary between 0.3 and 5.5 percent in the various population counts. V. profunda is represented generally by higher values in the basal quarter of the coal seam and relatively, these values diminish up-section to minima in the upper quarter. The highest values are confined to the basal coal levels (levels B and C). The species is fairly common in underclays in relative amounts varying between 0.3 and 4 percent except that this level, in OPC 657, Wagoner County, is barren. The highest value for these clays (4 percent) occurs in section OPC 374, Wagoner County. Roof shales yield the species in amounts ranging from 0.5 to 2.5 percent except in section OPC 615, Craig County and in the essentially barrer shale level of OPC 657, Wagoner County. Both sections are located, respectively, in the northernmost and southernmost extremes of the studied area. The higher values for the shale level are located in the southern half of the outcrop area.

V. profunda was described from the Croweburg coal of Oklahoma (Wilson and Hoffmeister, 1956) and has subsequently been reported by Clarke (1961) from the Secor coal of the same state. To date it has not been reported from outside the United States, although specimens now referred to the

genus, but as different species, are reported from sediments of Westphalian age in England and Germany (summarized in Potonié, 1960, p. 52). The form figured by Alpern (1958) from the Stephanian of France as Calamospora sp. (fig. 9, p. 50) belongs to Vestispora and appears similar to V. profunda.

Figured specimen: Slide No. OPC 216G-6-1, Craig County.

Series Aletesacciti Leschick, 1955

Genus FLORINITES S., W., and B., 1944

Genotype: Florinites antiquus Schopf, in S., W., and B., 1944, Ill. Geol. Survey, Rept. Invest. No. 91, p. 58, fig. 4

FLORINITES ELEGANS Wilson and Kosanke, 1944

Plate 7, fig. 4

Florinites elegans is extremely rare in the Iron Post coal. It occurs only in the population counts of two levels as single or double specimens: level G, OPC 614, Rogers County; level D, OPC 657, Wagoner County. It was encountered in only one other level (F of OPC 657) while traversing slides in search of photographic specimens. The overall diameter of the Iron Post specimens (on the basis of four individuals) ranges between 180.3 and 186.1 microns.

The species was described from Desmoinesian coals of Iowa (Wilson and Kosanke, 1944) and subsequently reported by Kosanke (1950), as in Kosanke et al. (1960), from the middle portion of the Kewanee group in Illinois. To date, these are the only known occurrences of the form.

Figured specimen: Slide No. OPC 657D-2-1, Wagoner County.

FLORINITES PARVUS Wilson and Hoffmeister, 1956

Plate 7, fig. 3

This species is rare in the populations of the Iron Post coal. It is absent from section OPC 615, northern Craig County. In the remaining five sections, it does not exceed 1.8 percent in any level in which it occurs. It is most persistent, stratigraphically, in section OPC 216, Craig County, and slightly less so in section OPC 374, Wagoner County. In these sections the higher values are concentrated in the upper quarter of the coal seam. In the remaining four sections, the species occurs irregularly in values registering tenths of a percent. There is otherwise no well defined pattern in the distribution of values.

F. parvus was described from the Croweburg coal of Oklahoma (Wilson and Hoffmeister, 1956). It has subsequently

been reported from the Rowe coal of the same state (Davis, 1961). To date the species has not been reported elsewhere.

Figured specimen: Slide No. OPC 657C-2-4, Wagoner County.

FLORINITES PELLUCIDUS (Wilson and Coe, 1940)

Wilson, 1958

Plate 7, fig. 5

1940 Endosporites pellucidus Wilson and Coe, Amer. Midland Naturalist, vol. 23, No. 1, p. 184, fig. 3

1958 Florinites pellucidus (Wilson and Coe, 1940) Wilson, Oklahoma Geol. Notes, vol. 18, p. 99

The most common member of Florinites in the Iron Post coal is F. pellucidus. It occurs in almost all but the basal levels of the six sections studied. Generally, relative values increase up-section to maxima in the top two coal levels of the seam. Here values may reach 6.3 percent of the total population. Generally, the values and stratigraphic persistence of the species is greater in the south than in the north. F. pellucidus is absent from all underclays except in section OPC 614, Rogers County. Values in the roof shales may reach 4 percent of the total population. The

values for this level are generally lower in the northern portion of the area than in the south.

In a personal conversation, L. R. Wilson stated that he is of the opinion that F. pellucidus is conspecific with F. antiquus Schopf (1944). From published descriptions and illustrations of both, the similarity is striking. Size discrepancies between the two described forms are small and the slight differences in central body and sac morphology may be considered as normal intraspecific variation. The identity of the two forms necessitates reassigning F. pellucidus as the genotype of Florinites but as this emendation necessitates a formal publication on the matter, the two specific epithets are treated separately here.

F. pellucidus was described from the Desmoinesian of Iowa (Wilson and Coe, 1940) and subsequently has been reported from the Rowe coal (Davis, 1961) and the Secor coal (Higgins, 1960; Clarke, 1961) of Oklahoma. F. antiquus was described from the Desmoinesian of Iowa (Schopf, in S., W., and B., 1944) and subsequently has been reported from the lower Pottsville coals of Indiana (Guennel, 1958). Stratigraphically, it is reported as extending from the upper portion of the Caseyville group to the middle portion of the McLeansboro group in Illinois (Kosanke, 1950). The species

has been also recorded from the Mystic coal of Iowa (Schemel, 1951). In Oklahoma, it has been noted in the McAlester coal (Morgan, 1955) and in the Croweburg coal (Wilson and Hoffmeister, 1956). In Europe F. antiquus is known from the Westphalian A and B horizons in the Ruhr basin (Potonié and Kremp, 1956) and from the Stephanian of France (Alpern, 1958).

Figured specimen: Slide No. OPC 624J-4-1, Rogers County.

FLORINITES SIMILIS Kosanke, 1950

Plate 7, fig. 6

The large specimens referred to F. similis are quite rare in the population counts of the Iron Post coal. It is absent from the counts of section OPC 216, Craig County. Occurrences are scattered throughout the remaining five sections although there is a tendency for the representative values to be concentrated in the upper half of the coal seam. Values here tend to run between 0.3 and 0.5 percent of the total population. The species occurs in only the underclays of section OPC 614, Rogers County. It normally is absent from the roof shales and occurs only rarely in these sediments in section OPC 614, Rogers County. There is no well

defined pattern in the distribution of values.

F. similis is reported from the middle McLeansboro coals in Illinois by Kosanke (1950). Schemel (1951) recorded a similar species, F. cf. similis, from the Mystic coal of Illinois. Neves (1958) recorded the species from the Upper Carboniferous Marine Shale (Namurian-Westphalian) of Yorkshire, England. To date it has not been recorded from continental Europe.

Figured specimen: Slide No. OPC 624D-1-20, Rogers County.

Subdivision Disaccites Cookson, 1947

Series Striatiti Pant, 1954

Genus ILLINITES (Kosanke, 1950) emend. Potonié and Klaus, 1954

Genotype: Illinites unicus Kosanke, 1950, Ill. Geol. Survey, Bull. 74, p. 51, pl. 1, figs. 1-4

ILLINITES UNICUS Kosanke, 1950

Plate 8, figs. 1, 2

Illinites unicus is uncommon in the population counts of the Iron Post coal. Representative values range between 0.3 and 1.8 percent of the various populations in which it occurs. Maxima normally occur in the basal coal levels and

from here values generally decrease up-section. In the southernmost and northernmost localities, the species appears in the top quarter of the coal seam. It tends to appear earlier and to be stratigraphically more persistent in the intervening sections. The species is present only in the underclays of section OPC 374, northern Wagoner County, and does not appear in the counts of the roof shales. According to the value distributions of the species, it appears that the form was associated with the early developmental stages of the swamp in or near the middle of the outcrop area and with the late developmental stages of the swamp in the peripheral areas.

This species is distinctive in possessing a trilete germinal structure. This feature usually is obscure in the Iron Post specimens. When present it is weakly developed and many forms exhibit a diamond shaped or V-shaped tear in the region. The specimens differ from Kosanke's species in this respect but the variation is considered minor since the forms otherwise conform to the published descriptions.

Kosanke (1950) recorded the species from the upper portion of the McLeansboro group of Illinois. Davis (1961) reported the species in the Rowe coal of Oklahoma. To date the species has not been listed from outside the United States.

Figured specimens: Slide Nos. OPC 347C-1-5, Wagoner County; OPC 216H-4-2, Craig County.

Series Monoradiati Bhardwaj, 1955

Genus SAHNISPORITES Bhardwaj, 1954

Genotype: Sahnisporites saarensis Bhardwaj, 1954, Neues Jahrbuch, Geol. Palaeon., Monatshefte, vol. 11, p. 522, fig. 12

SAHNISPORITES SP. A

Plate 8, fig. 8

Spores bilateral, bisaccate; prominent sulcus extending the length of the central spore body, parallel the equitorial axis; sulcus with moderately to slightly elevated lips; central body levigate; sac wall levigate externally to granular or irregularly reticulate internally. Overall diameter (based on three specimens) 101.3 to 105.6 microns. Overall diameter of inner spore body 67 to 72.3 microns.

Figured specimen: OPC 657C-2-3, Wagoner County, Oklahoma. Overall diameter 67.1 by 104.5 microns; dimensions of central spore body 55.0 by 71.5 microns.

This species appears smoother than the previously described forms assigned to Sahnisporites. The sac in

appearing to completely girdle the central body as well as the lack of a prominent open sulcus is characteristic. This form is more minutely ornamented and much larger than S. saarensis Bhardwaj. It is probably conspecific with the species described as Sahnisporites sp. A by Clarke (1961) from the Secor coal of Oklahoma.

This form is extremely rare in the Iron Post coal. It is represented as single specimens only in the population counts of two levels: level C, OPC 657, Wagoner County, and level G, OPC 624, Rogers County. Only one other specimen was encountered while traversing slides in search of photographic specimens (level G, section OPC 614, Rogers County).

Genus VESICASPORA Schemel, 1951

Genotype: Vesicaspora wilsonii Schemel, Amer. Midland Naturalist, vol. 46, p. 748, figs. 1, 3

VESICASPORA WILSONII Schemel, 1951

Plate 8, fig. 5

Vesicaspora wilsonii is a persistent and fairly common spore type in the Iron Post coal. Representative values range between 0.3 and 19.5 percent, and it occurs in virtually all levels sampled. The maxima tend to be concentrated in mid-section with minima relegated to the upper and lower

quarters of the coal seam in five of the six sections studied. In section OPC 657, Wagoner County, the maxima (19.5 percent) occurs at approximately mid-section, immediately below the level (F) yielding largely fossil cuticle and wood fragments. Generally, within the coal section, there is a general tendency for the values to increase southward within the outcrop area. The species is represented in the underclays by values ranging between 0.3 and 4 percent except for this barren level in OPC 657, Wagoner County. The values in this level also become progressively higher to the south. The species is present in roof shales in relative amounts ranging between 0.8 and 1.3 percent. The unit is practically barren in the southernmost section and the values for this level have no well-defined pattern in the remaining five sections. This species, according to the distribution of values, was a fairly common spore throughout the developmental period of the coal swamp. The parent plant, however, was most prominent during the time of maximum vegetational diversity which developed stratigraphically during mid-seam time.

This species was described from the Mystic coal of Iowa (Schemel, 1951) and has subsequently been reported from the lower Gondwana of India (Virkki, 1946, as reported by Potonié, 1958). A somewhat larger and different species

(Vesicaspora sp. A) has been described by Clarke (1961) from the Secor coal of Oklahoma. The species has otherwise not been reported elsewhere.

Figured specimen: Slide No. OPC 624E-3-2, Rogers County.

Series Sulcati Bhardwaj, 1955

Genus KOSANKEISPORITES Bhardwaj, 1955

Genotype: Kosankeisporites elegans (Kosanke, 1950) Bhardwaj, 1955

1950 Illinites elegans Kosanke, Ill. Geol. Survey, Bull. 74, p. 52, pl. 1, figs. 1-2

1955 Kosankeisporites elegans (Kos., 1950) Bhardwaj, Paleobotanist, vol. 4, p. 135-137, pl. 2, figs. 16a-d, 17

KOSANKEISPORITES ELEGANS (Kosanke, 1950) Bhardwaj, 1955

Plate 8, fig. 3, 4

This species is rare in the population counts of the Iron Post coal. Representative values range between 0.3 and 1.0 percent of the various populations with which it occurs. Within the coal section, the species appears most regularly in the upper quarter of the seam. It is absent in the coal

section of OPC 374, Wagoner County. Values are normally low and there appear to be no levels characterized by maxima in four of the six sections studied. In the sixth section, OPC 657, Wagoner County, the higher values are concentrated in the two basal coal levels with one specimen only in the topmost coal level. In the other sections single specimens may be found scattered in various levels. The species is absent from all underclays and is represented in the roof shales only in section OPC 614, Rogers County and in section OPC 374, Wagoner County, respectively, at 1.0 and 0.3 percent. There is otherwise no well developed pattern indicated for the distribution of values.

The Iron Post specimens referred to K elegans are consistently larger than Kosanke's forms and those reported by Bhardwaj. However, the overall sizes here (which range between 72.5 and 81.3 microns) are considered intraspecific variations. The form is otherwise morphologically the same.

This species was originally described from the upper portion of the McLeansboro group of Illinois. It has also been reported from the Secor coal of Oklahoma (Clarke, 1961). In Europe, Bhardwaj (1955) reported it from the Stephanian A and B horizons of the Saar basin in Germany. The species as yet has not been reported elsewhere.

Figured specimens: Slide Nos. OPC 624H-3-4, Rogers County; OPC 657C-4-7, Wagoner County.

KOSANKEISPORITES SP. A

Plate 8, figs. 6, 7

Spores bilateral; bisaccate; indistinct sulcus formed between bladders in equitorial view; sulcus oriented parallel greatest dimension of central body. Central body externally levigate, internally finely granular. Bladders levigate externally and coarsely reticulate to rugulate internally. Dimensions (on the basis of four specimens) of central body 49.5 to 69.3 microns; overall dimensions 96.5 to 104.5 microns.

Typical specimens: Slide Nos. OPC 657C-3-2, Wagoner County; OPC 624J-8-5, Rogers County. Overall dimensions respectively 67.1 by 100.1 microns and 61.6 by 100.5 microns.

This species has consistently larger measurements than those reported for the type species, K. elegans. It appears most closely allied to and is possibly conspecific with the species described as Kosankeisporites sp. A from the Secor coal of Oklahoma (Clarke, 1961).

This species figures rarely in the population counts of the Iron Post coal. It is present only in the counts of

level D, section OPC 216, Craig County as a single specimen. It was otherwise encountered only while searching for photographic specimens in the following sample levels and sections: OPC 657B, Wagoner County, and OPC 624J and B, Rogers County.

Genus PITYOSPORITES (Seward, 1914) Potonié and Klaus, 1954

Genotype: Pityosporites antarcticus (Seward, 1914) emend. Potonié and Klaus, 1954

1914 Pityosporites antarcticus Seward, British Antartic Exped., 1910, p. 23, pl. 8, fig. 45

1954 Pityosporites antarcticus (Seward, 1914) emend. Potonié and Klaus, Geol. Jahrbuch, vol. 68, p. 534-536

PITYOSPORITES CF. SCHAUBERGERI Potonié and Klaus, 1954

Plate 8, figs. 9, 10

The relatively large forms assigned to P. cf. schaubergeri figure rarely in the population counts of the Iron Post coal. Representative values exceed 0.3 percent of the populations with which it occurs only once (0.8 percent, level B, OPC 657, Wagoner County). The species is absent from section OPC 615, Craig County and appears only in the roof shale level of section OPC 614, Rogers County. It is

scattered elsewhere throughout various levels in the remaining sections. Most of the occurrences, however, tend to be concentrated in the lower third to half of the coal seam. The form is absent from all underclays. It is not represented in the roof shales except those of sections OPC 614, Rogers County, and OPC 374, Wagoner County.

The Iron Post specimens (on the basis of 12 different individuals) measure between 84.5 and 93.5 microns. These values exceed somewhat the higher value (70 microns) published by Potonié and Klaus. The Iron Post forms are most commonly oriented in polar view and these conform visually and morphologically to those illustrated and described by Potonié and Klaus. The lateral view of the spore appears more elliptical than the actual and reconstructed figures published of similar views. This is interpreted as due to uneven lateral compression and a rendering of a somewhat distorted view of the specimens from this aspect. The Oklahoma specimens otherwise conform rather well to the descriptions of the species.

P. schaubergeri was described from the Permian (Zechstein) of the Salz mountains area of Germany. It has apparently not been noted from the Pennsylvanian to date.

Figured specimens: Slide Nos. OPC 624D-1-13, F-1-7, Rogers County.

"PREPOLLEN"

Division PRECOLPATES Potonié and Kremp, 1954

Genus SCHOPFIPOLLENITES Potonié and Kremp, 1954

Genotype: Schopfipollenites ellipsoides (Ibrahim, 1932) Potonié and Kremp, 1954

1932 Sporonites ellipsoides Ibrahim, Neues Jahrbuch, Beil., Abt. B, vol. 67, p. 449, pl. 17, fig. 29

1933 Laevigato-sporites ellipsoides (Ibrahim, 1932) Ibrahim, Sporenformen des Aegir-horizonts, p. 40, pl. 4, fig. 29

1934 Punctato-sporites ellipsoides (Ibrahim, 1932) Loose, Inst. Palaeobot. Arb., vol. 4, no. 3, p. 158-159, pl. 7, fig. 35

1934 Sporonites ellipsoides (Ibrahim, 1932) Wicher, Inst. Palaeobot. Arb., vol. 4, no. 4, p. 185

1938 Monoletes ellipsoides (Ibrahim, 1932) Schopf, Ill. Geol. Survey, Rept. Invest., no. 50, p. 45, pl. 1, fig. 14; pl. 6, figs. 5-6

1954 Schopfipollenites ellipsoides (Ibrahim, 1932)

Potonié and Kremp, Geol. Jahrbuch, vol. 69, p. 180, pl. 19, figs. 89-92

SCHOPFIPOLLENITES ELLIPSOIDES (Ibrahim, 1932 Potonié and Kremp, 1954

Plate 7, fig. 7

Schopfipollenites ellipsoides figures rarely in the population counts of the Iron Post coal. It is absent from section OPC 615, northern Craig County. In the remaining five sections, the representative values range between 0.3 and 2.5 percent of the various assemblages with which it is associated. The species occurs irregularly throughout the coal sections, but the higher values tend to be concentrated in the lower quarter to half of the coal seam. Generally, values tend to be higher in this portion of the seam in the south than in the north, and it is most abundant in the southernmost section, OPC 657, Wagoner County. In this section, the highest values representing the species (2.5 percent) are found in that portion of the section lying below the level (F) represented largely by fossil cuticle and wood fragments. The species is absent from all underclays and roof shales.

The specimens assigned to the species S. ellipsoides

from the Iron Post coal measure less than the minimal diameters (330 to 380 microns) published by Schopf (1938). Other than size, however, the morphology and proportionate dimensions fit the descriptions well. In the case of megaspores, large dimensions make discrepancies appear greater than they are in a relative sense. The differences between the Iron Post specimens and those reported elsewhere are no greater, relatively, than size variations found in other spore groups. Dijkstra (1946) assigns specimens with minimal measurements at 250 microns to this species. Potonie´ and Kremp (1956) regard the shape as most important and mention only that the diameter exceeds 100 microns.

This species has been largely reported from Europe. In the United States, Schopf (1938) recorded it in the upper portion of the Kewanee group (Coal 6) of Illinois. Winslow (1959) figured several species identified from various coals throughout the Illinois Pennsylvanian section. Her illustrations (Plate 14, figures 5, 8, 9) included forms which are probably S. ellipsoides but no data concerning the stratigraphic distribution of the various spore types are given. In Germany, the stratigraphic range of the species is summarized by Potonie´ and Kremp (1955). It is listed by them as extending from the Westphalian B horizon through the C

horizon in the Ruhr basin. Bhardwaj (1957) later extended the range of the species in this area by reporting it from the lower Westphalian D horizon. Dijkstra (1946) previously recorded the species from the Westphalian B and C horizons of the Netherlands.

Figured specimen: Slide No. OPC 657B-3-1, Wagoner County.

Genus A

Plate 7, fig. 8

Spores ellipsoidal, bilateral; germinal apparatus unknown; bladder-like extensions adpolarly located; levigate, internally finely granular; spore wall thickness 11.5 to 15.8 microns; wall of bladder-like extensions 5.5 to 11.0 microns thick. Overall dimensions 356 to 457.2 microns (on the basis of three specimens).

Typical specimen: Slide No. OPC 216H-4-3, Craig County, Oklahoma. Overall dimensions 241.3 by 457.2 microns.

This species has not been found in the Iron Post material in other than a torn and fragmented condition. As a result, the morphology of the species is obscure.

This species is rare in the Iron Post coal. It occurs in the population counts of only level H, section OPC

216, Craig County, and was otherwise encountered only in level J of section OPC 624, Rogers County, while traversing slides in search of photographic specimens.

CHAPTER VI

DISCUSSION

Introduction

Results obtained from observations of the material examined during this study are divided roughly into three portions. The first is concerned with the spore and pollen succession in the Iron Post coal seam and interpretations regarding the succession. The second portion of the discussion concerns the environmental factors influencing succession. The third section deals with the results obtained from the accumulation of the palynological data. Before proceeding with the above topics, some botanical aspects regarding succession are first considered.

Data from the Iron Post coal show that distinctive palynological assemblages replaced one another in vertical succession. If it is assumed that succession followed normal ecological development, it must have proceeded in a mesarch direction. Studies of modern plant communities show

that successional rates vary in time and space. Also, these studies indicate that the order of community development may or may not be the same. Because of these variables, given areas may develop communities which may not be in the same developmental stage at the same time. Still another source of variation results from the new vegetational environments which are often caused by plant succession itself. Therefore, theoretically at least, it is expected that different sections of the same coal seam will not necessarily exhibit the same gross spore and pollen aspect. Interruptions or reversals of successional development, or local floral variations tend to further modify the vegetation of a given area.

The above facts seem to be explanations for successional changes in spores and pollen reported to date in previous works on the Pennsylvanian coals of Oklahoma (Wilson and Hoffmeister, 1956; Davis, 1961; Clarke, 1961). Smith (1961) has reported somewhat similar changes in the Carboniferous coals of England. Previously, the floral composition of ancient coal swamps was considered to have been relatively uniform over rather wide areas and was thought to have varied little through time (Giles, 1930). However, the present study indicates that this is not true and Pennsylvanian coal-swamp plant communities developed

rather definite successional aspects.

The spore spectra illustrated in the flare diagram (figure 9) summarizes the palynological succession of the Iron Post coal. The various sections are represented in their actual north-south position and each level is drawn to scale to show actual segment thicknesses. The fossils are represented as single species or as morphologically related groups. The arrangement of these groups in the diagram is designed to bring together those forms which produce the same or nearly the same pattern of distribution throughout the various sections studied. Fossil groups occurring rarely or scattered throughout various levels and defining no persistent pattern are not included.

Composition of the Iron Post Palynological Flora

Certain spores and pollen with similar successional distribution and morphology are illustrated together and are referred to as composite groups. The important groups referred to in the text in this manner include the Laevigatosporites minutus group, including L. minutus and L. punctatus, and the Laevigatosporites desmoinensis group which is composed of L. desmoinensis, L. ovalis, and L. medius. The Calamospora breviradiata group is composed of the following

species: C. breviradiata, C. liquida, C. straminea, and C. sp. B. The remaining groups discussed in this manner include the Triquitrites bransonii group which is composed of T. bransonii, T. additus, T. tumulus and T. spinosus and lastly the Wilsonites delicatus group which includes W. delicatus and W. vesicatus.

The composition of the Iron Post palynological flora is predominantly composed of spores of the genera Laevigatosporites, Calamospora, Lycospora, and Verrucososporites. When viewed from the aspect of related fossil groups, the Laevigatosporites breviradiata group, the spores of Lycospora, Verrucososporites pseudothiessenii, the Laevigatosporites minutus group and the L. desmoinensis group account for more than 65 percent of the total spore assemblage. Subsidiary elements include the Triquitrites bransonii group, the Wilsonites delicatus group, species of Florinites and Vesicaspora wilsonii. The remaining groups figured in the flare diagram are minor and locally assume only minor status in some intervals.

The palynological assemblage as a whole contains few saccate forms. Of these, the more important are mentioned above, and genera such as Endosporites, Illinites, Sahnisporites and Kosankeisporites, although present, are quite

rare and contribute little, either quantitatively or qualitatively, to the composition of the assemblages. For this reason, these spores are not figured in the flare diagram.

Successional Trends

It is evident, from the percentage values shown in the flare diagram (figure 9) that floral succession definitely occurred in the Iron Post coal-swamp. Also, this succession did not everywhere proceed in the same sequence nor apparently at the same rate within the area occupied by the swamp. Because of the irregularity of the trends, it is difficult to characterize the pattern. Therefore, only the main groups and important subsidiary elements are discussed in a manner utilizing the section as divided into three portions: the lower, middle, and upper thirds. The underclays and roof shales will be discussed separately.

The underclays of the Iron Post coal are characterized by spore suites dominated by the Calamospora breviradiata group, the Lycospora species, and only secondarily by the Laevigatosporites minutus and L. desmoinensis groups. The relative amounts in which these fossils are represented in the underclays varies with locality. The underclays are barren in the southernmost section, OPC 657, Wagoner County

and nearly barren in section OPC 216, southern Craig County. The Lycospora species are most common in the center of the outcrop area, and representation is minimal in the underclays of those sections located near the extremes of the study area. The Laevigatosporites minutus and L. desmoinensis groups are most important, relatively, in the areas where the Lycospora are least dominant. Of the subsidiary fossils, the Triquitrites bransonii group is most common in this level in the northern portion of the outcrop area, and representation decreases from here southward.

The dominant Lycospora-Calamospora-Laevigatosporites assemblage in the underclays changed with time in the Iron Post coal-swamp. In the basal third of the coal seam in the southernmost section (OPC 657, Wagoner County), the dominant spores are those of the Laevigatosporites minutus group, the L. desmoinensis group and the Calamospora breviradiata group. Importantly, the pollen Wilsonites and Vesicaspora became apparent. These secondary genera remain minor or are absent in the remaining sections. Northward, Lycospora is dominant in the basal third of the section OPC 624, northern Rogers County. The increase in Lycospora within this region follows a reduction in the spores of Laevigatosporites and Calamospora. Northward beyond the Rogers County section, Lycospora

is less abundant and there is a corresponding increase in the previously mentioned associated groups. In addition, Verrucososporites pseudothiessenii, although minor, became increasingly important in the upper portion of the coal northward in the outcrop area. The Triquitrites bransonii group is fairly common in the basal third of the seam in the north, but is increasingly less so in the south.

To summarize, the basal third of the coal seam may be characterized by a spore dominance of Lycospora species and the Calamospora breviradiata and Laevigatosporites minutus groups in the extreme localities of the outcrop area. In the south, important secondary pollen associates are the genera Wilsonites and Vesicaspora and in the north, the Triquitrites bransonii group and Punctatisporites obliquus compose the important subsidiary elements. In addition, the basal levels of the Iron Post coal contain minor elements which here attain their greatest importance (Microreticulatisporites, Granulatisporites and Calamospora pedata).

The middle third of the seam characteristically exhibits minimal values for Lycospora species and the Calamospora breviradiata group. In contrast, the Laevigatosporites minutus group becomes dominant in this portion of the seam except in the northern and southern extremes of the outcrop

area where it continues to decrease gradually. Verrucososporites pseudothiessenii becomes more important, reciprocating a decrease in the spores of Lycospora. In the southernmost section, OPC 657, Wagoner County, pollen of Wilsonites and Vesicaspora are dominants, a status not again duplicated elsewhere in the outcrop area. The middle third of the seam is further characterized by maxima developed by Punctatisporites obliquus and the Triquitrites bransonii group.

To summarize, the middle third of the seam is typified by the increasing prominence of Verrucososporites and the minimal occurrence of Lycospora species and the Calamospora breviradiata group. This is suggestive of favorable environmental factors for those plants that produced spores of the Laevigatosporites minutus group. The importance of the genera Wilsonites and Vesicaspora in the southernmost section, OPC 657, Wagoner County, may be due to its proximity to the pinch-out of the coal. If the parent plants of these spore genera were upland inhabitants then this would explain the abundance of the spores in the southernmost section. This location would allow either the encroachment of the upland floras, or the easier representation of them, established beyond the swamp region.

The upper third of the Iron Post coal is characterized

by the dominance of Verrucososporites pseudothiessenii, and in the central portion of the area, a sharp increase and then decrease in the spores of Lycospora. The Laevigatosporites minutus group remained at the same secondary levels during this time. The subordinate groups mentioned in the previous interval continue to decline except for the Triquitrites bransonii group. This subordinate group continued as an important minor element in the northern portion of the outcrop area. The interval is also characterized by a minor ascendancy of the spores of Wilsonites in the northern portion of the area. Similar increases are also indicated by the distribution of the genera Endosporites, Illinites, and Kosankeisporites. These elements are minor and do not figure in the flare diagram. However, as Wilsonites, they appear in the late stages of the coal-swamp spore succession. It might be conjectured that either the swamp area was better developed for the upland floras, or by a decline of the swamp flora owing to inundation, the upland spore-pollen rain was less masked than in the previous levels.

To summarize, the top third of the Iron Post coal is characterized by the spores of Verrucososporites and Lycospora. Other spores include those of the Calamospora breviradiata group with minor occurrences of the previously

discussed two groups of Laevigatosporites.

The spore flora of the roof shale is essentially the same as that of the top one-third of the coal seam. The predominant elements here are the spores of Lycospora and Verrucososporites pseudothiessenii as in the top coal level, with the exception of section OPC 216, Craig County. These groups compose 40 to 65 percent of the spore types in the sections located near the central portion of the outcrop area. The Calamospora breviradiata group and other elements comprise secondary associations. In the northern and southern portions of the area, spores of Lycospora are minor. The decrease in Lycospora is correlated with a continued relative abundance of the Laevigatosporites and Calamospora breviradiata groups. In this level, the pollen of Wilsonites increased or maintained the subordinate position developed in the preceding level.

At this point it should be stressed that the above comments are general, and actually do not include the various other fluctuations which are no less present in the subordinate and lesser groups. Actually, there are also fluctuations of the successional patterns within the major trends discussed, and these vary in amplitude and position within the levels. These fluctuations are interpreted as being due

to local, periodic changes in environmental factors. Since the fluctuations can at best be described as irregular, it can be visualized that through time, the environmental pattern in the swamp varied and shifted, alternately affecting some areas and not others. These minor fluctuations were probably a constant feature of the swamp throughout the time of its existence as an ecological unit.

Plant Affinities and Plant Succession

Plant affinities of spore groups have been described by various authors (Sen, 1958; Potonié, 1954; Couper, 1958; Chaloner, 1951, 1953; Wilson, 1960, and others). On the basis of these determinations, it is possible to assign some of the major spore types to known parent plants or plant groups. From these known affinities it is possible to roughly reconstruct the megaflora. It must be stressed, however, that the assignments apply to broad spore groups, and generally there is little information concerning individual species. Morphologically similar spore species placed within the same generic group may actually belong to different natural classes of plants. For this reason, some of the references below to parent plants are discussed as compound plant groups.

The major spore genus in the Iron Post coal is Lycospora. There seems little doubt that spores of this genus are microspores of Lepidodendron (Sen, 1958; Chaloner, 1953). The Calamospora breviradiata group is assigned to the combined Calamitales-Equisetales plant forms (Potonié, 1954). Kosanke (1950, p. 40) feels that the spores are predominantly of the Calamitales. The other prominent form in the Iron Post coal is Verrucososporites pseudothiessenii, which is believed to be a representative of the ancient fern group, the Protofilicales (Potonié, 1954). The remaining dominant groups include those of the genus Laevigatosporites. Both the ornamented and unornamented forms assigned to the genus are referred to the Equisetales (Potonié, 1954). Couper (1958) is of the opinion that some species of Laevigatosporites belong to the Filicales. There appears to be some doubt, however, that all of the species assigned to this genus were derived from equisetalian parent plants. S., W., and B. (1940, p. 36) indicate that these spores, in the sense that the genus is used in this paper, belong to at least three extinct orders of Paleozoic plants (Sphenophyllales, Pteridospermae and Filicales).

Of the important minor spore groups occurring in the Iron Post coal, Triquitites, Punctatisporites obliquus,

Wilsonites and Vesicaspora are most prominent. Of these, Triquitrites is referred to the Protofilicales, and Wilsonites, as well as the rare Florinites, is assigned to the Cordaitales (Potonié and Kremp, 1956). Vesicaspora is referred to the Pteridospermae by the same authors. Minor saccate genera not figuring in the flare diagram include Illinites, Kosankeisporites and Pityosporites. These all possess definite affinities to the Coniferales (Potonié, 1954). The relationship of Punctatisporites obliquus to a plant group is obscure. If the general assignments made by Potonié (1954) are to be strictly followed, the species would be assigned to the Equisetales.

On the basis of the above assignments, the major spore groups may be referred to parent plant genera or plant groups. With these, a general picture of megafossil succession may be constructed.

The underclays of the Iron Post coal may be visualized as having supported largely a Calamitales-Equisetales complex with Lepidodendron as a subdominant, especially in the central portion of the area. Secondary plant growth was mostly confined to the Equisetales-Calamitales-Filicales floral complex represented by the smooth Laevigatosporites group in the central portion of the area.

In the lower third of the coal seam, succession proceeded by increases in Lepidodendron and in the Equisetales-Calamitales flora in the central portion of the area, with a decrease in the last-named group in the peripheral areas. The Cordaitales and Pteridospermae were becoming established in the extreme southern portion of the area. The fern groups, represented by spores of the genera Granulatisporites and Triquitrites, assumed local importance as minor elements.

The middle third of the seam is marked by a decline in the Lepidodendraceae and by the establishment of the Equisetales-Calamitales group represented by the Laevigatosporites minutus group. In the southern portion of the area, the Cordaitales and the Pteridospermae became important local dominants, and in the north, the similar stratigraphic interval is occupied by the Equisetales and Protofilicales.

The upper third of the seam marked the firm establishment of the Protofilicales. Important subdominants include the Lepidodendraceae and the Calamitales-Equisetales flora in the central portion of the area. The Cordaitalean elements are minor in this interval, although they are significant in heralding the closing successional stages of the swamp.

The roof shales represent a vegetational complex similar to that of the preceding interval. The interval,

from a parent plant point of view, reflects a decline in the previously established dominants. This decline, as well as the increase in the upland floral elements (the Cordaitales and Coniferales) characterizes the final phases of the plant succession in the Iron Post coal swamp.

The treatment of succession in the preceding two sections has assumed that the spore groups represented in the Iron Post coal experienced little transport. This assumption of in situ deposition is strengthened by the common occurrence of unbroken tetrads of many of the species represented. The bladdered forms such as Wilsonites and Florinites were probably wind blown and their presence may be the result of some transport. However, the abundance of these in the southernmost locality suggests that the transported distance may have been short and that the parent vegetation was established in close proximity. The presence of Vestispora in the middle portion of the area is difficult to explain if the parent plant were not indigenous.

Cyclothemic deposits have long been recognized as shallow-water deposits (Weller, 1930, 1931). It is not surprising that the resulting sediments are variable, and alternate between marine and non-marine rocks. Within the area examined for this report, the Iron Post coal cycle is

initiated by decidedly shallow-water deposits. These deposits include the nonmarine cross-bedded sandstones and thin-bedded shales underlying the Iron Post coal. The floral succession reported in the coal section was initiated upon a weathered zone at the top of these underlying sediments. The early Equisetales-Calamitales-Filicales dominance in the underclays of the Iron Post coal probably indicates that succession developed under moist or wet conditions (Arnold, 1947, p. 141). These plants fared less well in the peripheral areas where soil conditions were probably less moist and submergent swamp conditions less frequent. The dominance of the Protofilicales during the late stages of the succession is probably related to a general lessening of the water content of the soil, at least during the time represented by the upper portion of the seam. The roof-shale level is interpreted as representing the demise of the coal swamp by either a rise in the water level and/or an increase in sedimentation. This interpretation is made on the basis of the regained dominance of the Equisetales-Calamitales-Lepidodendrales complex. In the extreme portions of the studied area, inundation arrived later, allowing the continuation here of the more mesically adapted Protofilicales, and in the south, allowed the encroachment of the upland

Cordaitales and Coniferales elements.

With the waning of the swamp, the area slowly subsided and the swamp was destroyed as an ecological unit. This interpretation is made because the overlying shales contained no fossil spores and pollen. A continuation of the subsidence allowed increasing amounts of first nonmarine and then marine sediments to accumulate. Ultimately, the return of shallow seas to the area resulted in the deposition of the neritic Breezy Hill limestone.

CHAPTER VII

STATISTICAL EVALUATIONS

The subject matter in this section is concerned with the spore and pollen frequencies obtained from the examined sections. The accumulations are represented as channel histograms (figures 6 and 7). These are constructed from a summation of spore and pollen frequencies in all levels. The object in presenting these data is to illustrate the qualitative and quantitative successional detail obtained in segment sampling (figure 9) as compared with the solely quantitative results obtained by treating the spore and pollen frequencies cumulatively. The accumulated frequencies represent each section as a single sample.

The accumulated spore and pollen frequencies in figures 6 and 7 show that the spores of Calamospora, Laevigatosporites and Lycospora are most common in the histograms of sections located near the geographical center of the outcrop area. Spores of Laevigatosporites are at their minima in

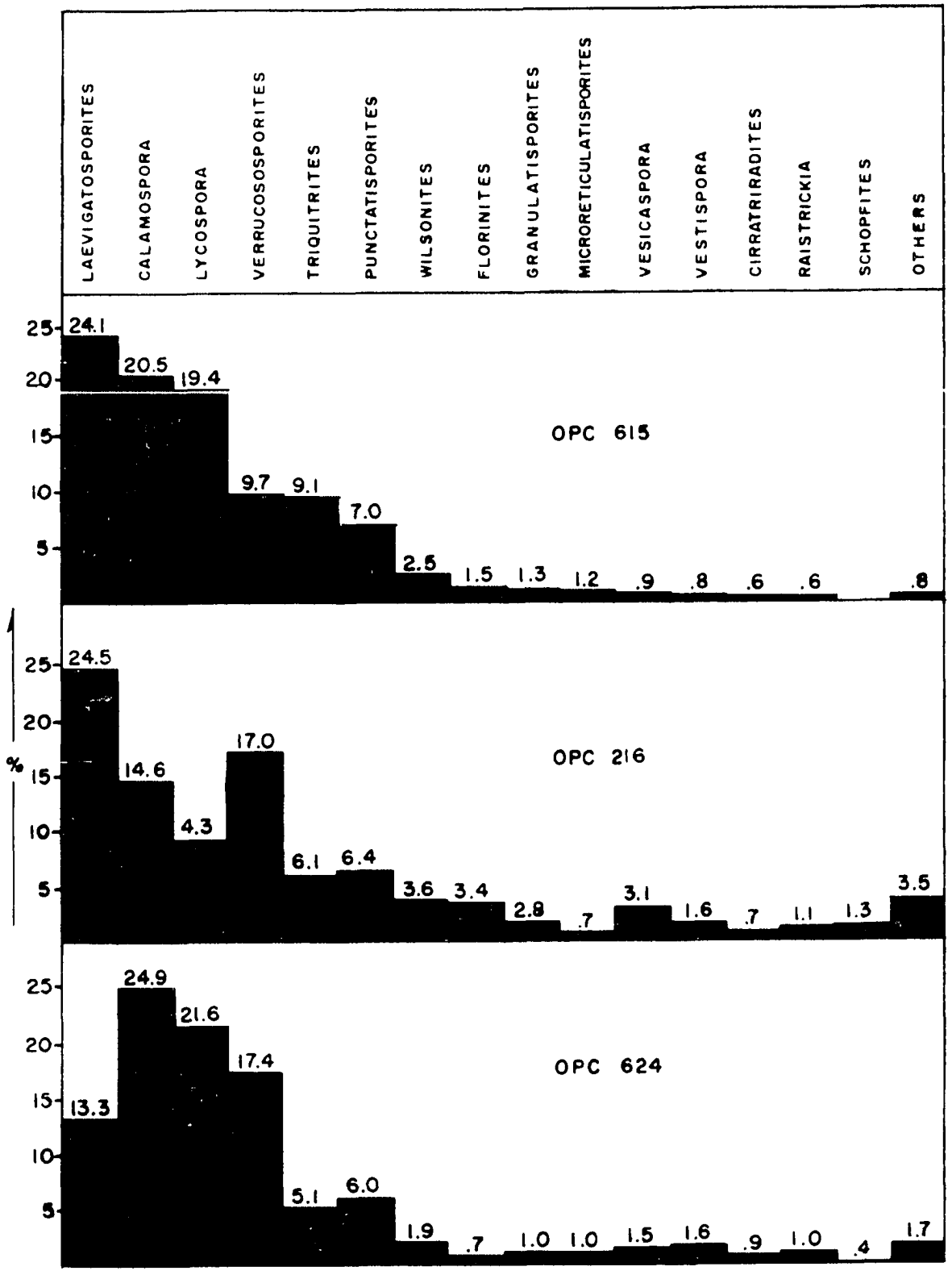

FIGURE 6. RELATIVE PERCENTAGES OF THE MORE COMMON GENERA OF THE IRON POST COAL AND SEDIMENTS. EACH HISTOGRAM REPRESENTS A SUMMATION OF VALUES FOR ALL LEVELS AT EACH SECTION LOCALITY.

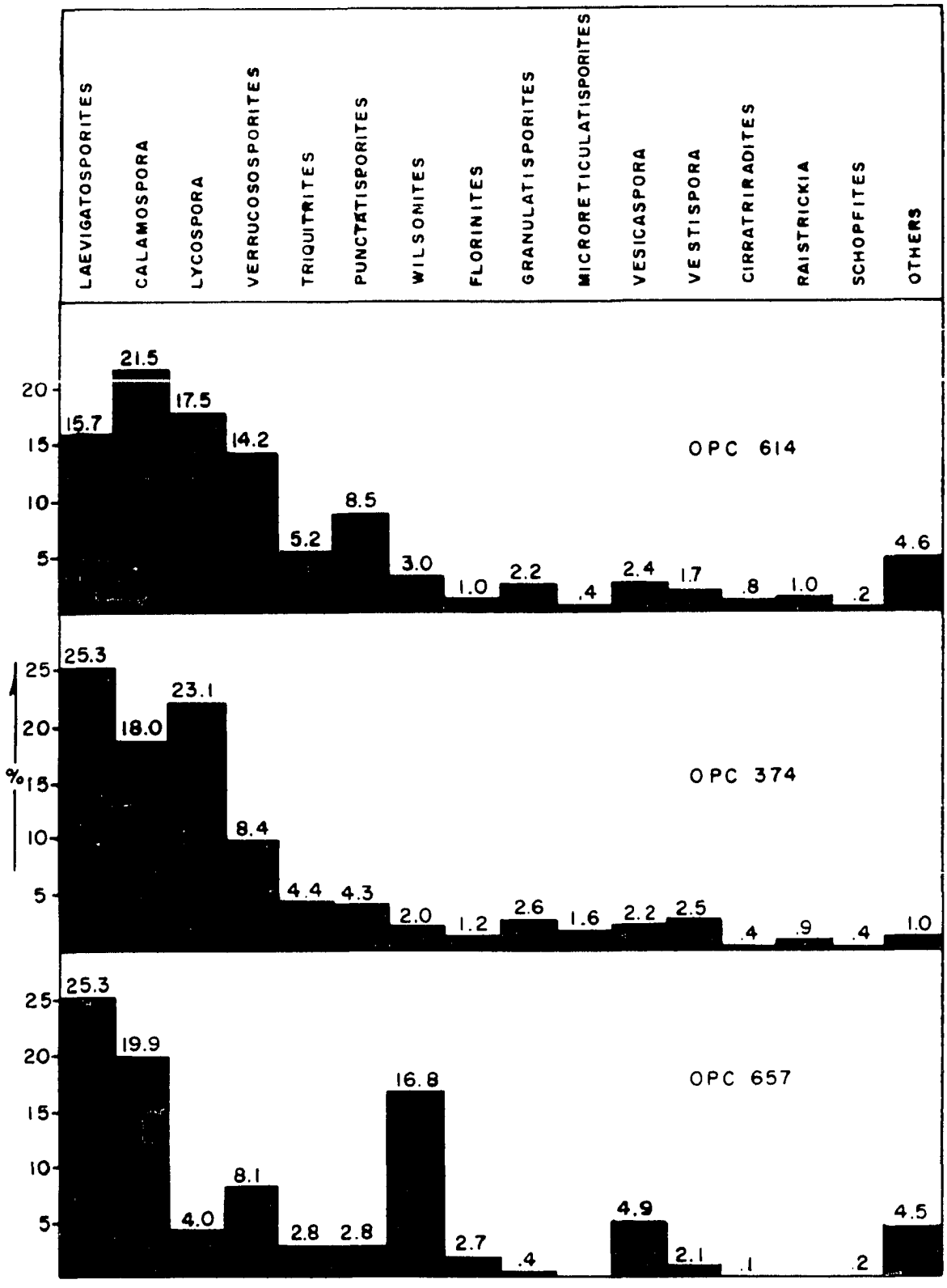

FIGURE 7. RELATIVE PERCENTAGES OF THE MORE COMMON GENERA OF THE IRON POST COAL AND SEDIMENTS. EACH HISTOGRAM REPRESENTS A SUMMATION OF VALUES FOR ALL LEVELS AT EACH SECTION LOCALITY.

the northern and southern extremes of the outcrop area. This distribution may support the possibility that in the central portion of the region, swamp conditions were maintained longer.

Spores of Verrucososporites, Triquitrites and Punctatisporites have major frequency fluctuations at all localities with the exception of section OPC 657 in Wagoner County. In this section the major fluctuations involve the pollen Wilsonites and Vesicaspora. The illustrated fluctuations within the represented sections produce different configurations and these illustrate no consistent pattern within the outcrop area. The differences between spore frequencies in the histograms are apparently related to ecological factors, but successional relationships between the spore groups are lost in the cumulative presentation. Differences in frequencies in the channel histograms are speculative. In addition, speculation on the differences would be more tenuous if the channel histograms represented a coal whose boundaries are unknown.

Figure 8 is a composite channel-sample histogram of the Iron Post coal seam. This histogram, constructed by averaging all of the spore and pollen frequencies of the channel sample histograms, represents the total palynological

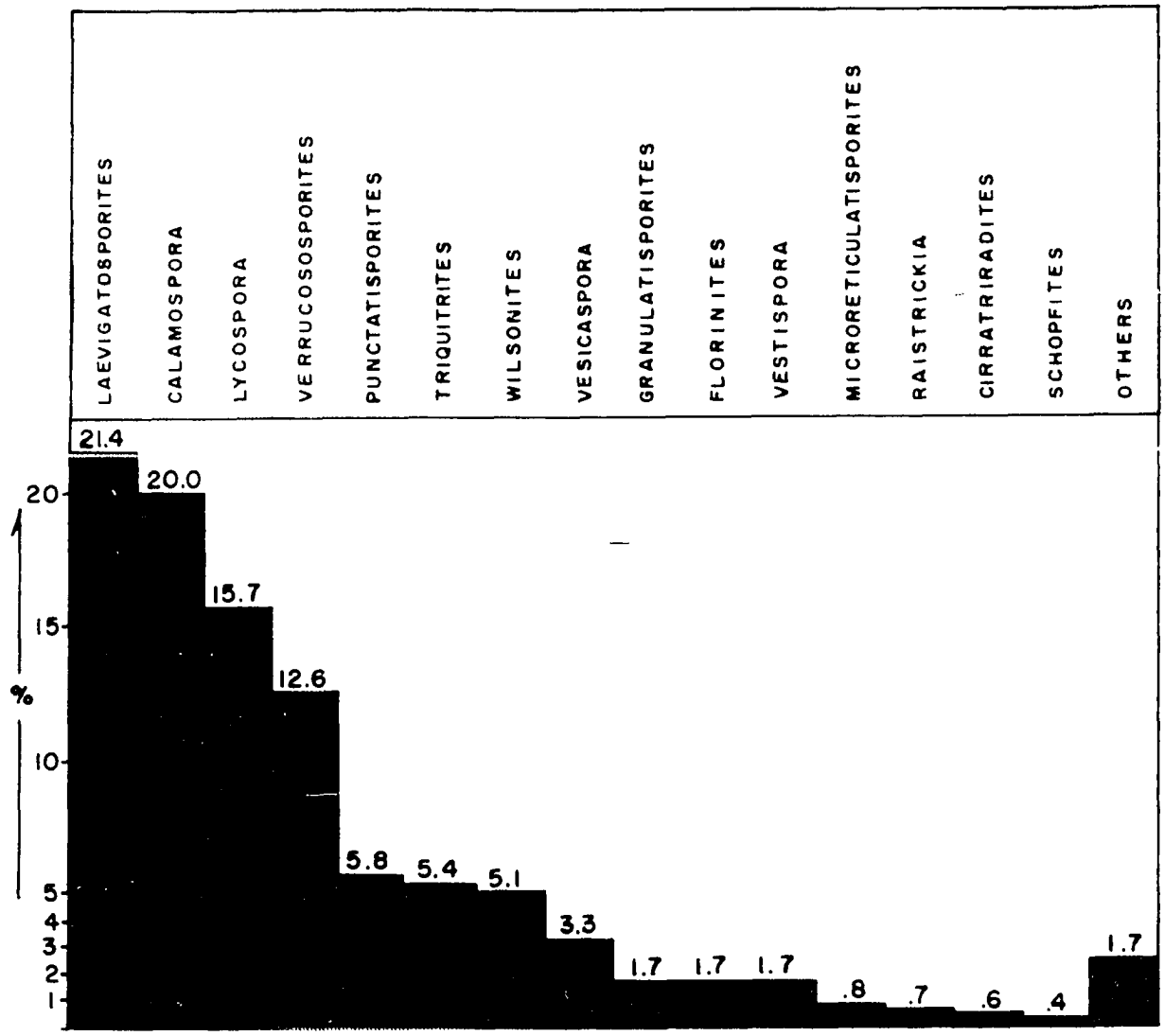

FIGURE 8. GRAPH SHOWING RELATIVE PERCENTAGES OF THE MORE COMMON GENERA IN THE IRON POST AND ASSOCIATED SEDIMENTS BASED ON DATA FROM 6 SECTIONS.

flora of the Iron Post coal. From it, little can be stated concerning the coal swamp ecology other than that certain spore types were relatively important.

Channel sample histograms are commonly used for correlation purposes. In a recent publication, Gray and Guennel (1961) presented a form of statistical analysis for the correlation of coal beds. The statistics proposed for correlation were based on data obtained from channel sampled sections. Basically their thesis is that spore dispersal was random and that distribution was not so much a question of biological or geological factors as it was a matter of chance. However, the present work indicates that dispersal is controlled more by biological factors than by chance and that spore accumulation and preservation is essentially a local phenomenon. The observations made in the present study concerning spore succession and its relationship to the geological factors indicates that spore dispersal and occurrence are not random. To further illustrate this point, a statistical test similar to the one employed by Gray and Guennel was run on the Iron Post data. The results are given in the following section.

The statistical method employed in this case concerns the Chi-square test. This test is designed to apply to

assumed binomial distributions and is based on the assumption that statistically, the universe being tested (in this case the spore population) is randomly distributed. Actually, the complexities involved in any biological system are many and interrelated, and it is difficult to determine qualitatively which factors should figure into any statistical model designed for fossil systems. Qualitative evaluation is especially difficult when one considers that many of the influencing factors have unmeasurable qualities in the geologic setting. It is felt that precise statistical treatment of fossil assemblage behavior must await the accumulation of more data on pollen and spore dispersal, preservation and distribution in time. However, since random statistics have been used on problems analagous to the current one, it was felt that a similar test should be made on the Iron Post coal data.

A Chi-square test simply represents a summation of the squares between observed and expected frequencies within two or more distributions to be compared, divided by the theoretical or expected frequencies within the supposed or assumed sample universe. In the case of the coal sections studied, all of the sampled sections are known to be the same coal, and the test is therefore to determine whether Chi-

square values are constant or nearly so for all of the accumulated assemblages involved. If Gray and Guennel (1961) are correct in assuming random dispersal, then a high degree of correlation between Chi-square values of spore frequencies in the Iron Post coal can be expected between compared sections. To make this comparison in the Iron Post coal, the most complete section which contains one of the largest and most abundant gross palynological flora was established as the standard to which the other remaining five sections were compared. The basis for this is the assumption that if dispersal is random, then any section within the outcrop area is just as likely as the next to contain a similar gross palynological flora. One then can assume that, if the beds are to correlate statistically (which geologically they do), then the Chi-square values computed by pairing assumed unknowns with the selected standard or expected frequency distribution, a test of the random dispersal thesis can be made. The calculations used in this test are outlined by Dixon and Massey (1951, p. 185). The computations illustrating the comparisons and resulting Chi-square values are shown in table 1. Selected values for Chi-square values with 10 degrees of freedom are listed in table 2. The values are computed from frequency values of the most significant 11 genera

in all sections examined for this study.

The intention of the Chi-square test is to measure the difference between expected and observed values. If the difference between the two sets of values is large, Chi-square will be large; if it is small, the Chi-square values will be small. In testing the significance of the calculated values, it is necessary to know whether these values are in each instance likely to indicate whether the various frequencies were drawn from the same population. For this one needs to know the degrees of freedom in the computation of Table 5. In the example here, this is equal to the number of units being compared minus 1 times the number of elements within the population being compared minus 1. In the Iron Post coal example the degrees of freedom are 10 (table 5).

In evaluating the results, it must also be decided what limits are to be placed on acceptance or nonacceptance of correlated values. The "acceptance levels" most frequently used in statistics are 5 and 1 percent (the p values in table 5). Translated, this means that, respectively, one would reject 5 and 1 percent of the valid comparisons; stated differently, this would mean one would require agreement in respectively, 95 and 99 percent of the units being compared. Table 5 also indicates that for any agreement level, agreement

will be denied if the actual Chi-square values exceed the probability of the p values.

The acceptance level once decided upon must be applied equally to all comparisons. Therefore, by evaluating the comparisons with respect to Chi-square values within 10 degrees of freedom in table 2, it is evident that by accepting a p value of 2.5 (probability of identity 97.5 percent), only two samples (OPC 216 and OPC 624) appear correlative with the standard. The remaining samples yield Chi-square values either too high or too low to be seriously considered correlative in a statistical sense. The hypothesis that the remaining sections are represented by identical parent populations, the representatives of which were randomly distributed, must be rejected.

As stated in a previous section, these differences could have been expected on a biological basis. The test does point out, however, that correlations based on frequencies of spores representing channel samples must be employed with extreme caution. Differences are undoubtedly the results of variations in succession and the quantitative accumulation of populations which had varied in composition, and time of duration. Therefore, correlation based upon statistical comparisons should be based on close sampling and in this

manner, variation may be allowed for and the effects more possibly interpreted.

Lastly, since the Iron Post swamp was, compared with other Pennsylvanian swamps, quite restricted, and as the coal seam is quite thin, successional variation may have been great. In more extensive and thicker coal deposits, more uniformity could possibly be expected. It is felt that such physically characterized units could maintain specific environments for a greater period. In such cases, random statistical methods applied to correlation may prove effective. However, these propositions are as yet unproved and one should still regard the application of random statistics to the correlation of palynological data with caution.

CHAPTER VIII

STRATIGRAPHIC CORRELATION OF THE IRON POST COAL

The Iron Post coal of Oklahoma is restricted to the northeastern portion of the state and extends for approximately 62 miles in a line running from the northern portion of Craig County to the extreme northwestern portion of Wagoner County. The correlation of the Iron Post coal with other coals on the basis of spores and pollen in common is only approximate because spore assemblages were subject to local and regional variations in ecology, and variable factors associated with preservation. Assemblage comparisons between the Iron Post coal of Oklahoma and four Illinois coals of approximately the same age are given below.

According to a recent publication (Kosanke et al., 1960) the Iron Post coal is supposedly correlative with the Kerton Creek and Roodhouse coals of Illinois. As Kosanke (1950) did not report on the palynological flora of the Kerton-Roodhouse coals, comparisons of the Iron Post coal of

Oklahoma and Illinois coals had to be made with those associated stratigraphically above and below the correlative horizon. The Springfield and Summum (No. 4) coals located above and the Colchester and DeKoven coals located below the Kerton Creek coal horizon are used in the comparison. A list of species illustrating the various spores common to these coals and the Iron Post coal is presented in table 3. Calculations indicating the comparative breakdown of species in common to each is given in table 4.

On the basis of the distribution of spores in common with Illinois and Oklahoma coals, the Summum coal, which is supposedly equivalent to the Mulky coal lying above the Breezy Hill limestone in Kansas (the Excello shale horizon in Oklahoma), contains the largest number of species in common with the Iron Post coal (73.9%). Almost 63 percent of the species from the Springfield coal (which would fall within the Fort Scott section in Oklahoma) occur in the Iron Post coal assemblage.

The floras in the coals located stratigraphically lower have fewer species in common with the Iron Post spore flora. The Colchester and DeKoven coals (according to Kosanke et al., 1960) correlate respectively with the Croweburg and Mineral coals of Oklahoma. The Colchester assemblage

has 46.2 percent of its species in common with the palynological assemblage of the Iron Post coal, whereas the stratigraphically older DeKoven coal has 56 percent in common. A larger spore assemblage in the DeKoven coal appears to be responsible for the large number of species in common with the Iron Post coal.

On the basis of the available data, the total palynological assemblage of the Iron Post coal is most similar to the stratigraphically younger Illinois coals than to the two older coals used in the comparison. Of the four compared, the spore flora of the Summum (No. 4) coal most closely resembles that of the Iron Post coal.

CHAPTER IX

SUMMARY

A summary of the results obtained from the palynological study of the underclays, Iron Post coal and roof shale deposits is listed below.

1. The Iron Post coal was formed in a slowly subsiding area in which initially nonmarine and ultimately marine sediments had accumulated.

2. During the existence of the swamp as an ecological unit, plant succession occurred within the swamp area.

3. Lateral variations in the palynological flora of the Iron Post coal are thought to reflect plant adaptation to environmental changes in the peripheral areas. These are possibly associated with a diminishing of swamp conditions in time.

4. The fluctuations in spore and pollen frequencies at similar levels in the coal seam cannot be used as correlative horizons because local variations in successional

stages and environment did not produce everywhere a uniform ecology in the swamp.

5. The demise of the swamp is associated with inundation of the swamp area. In this manner encroachment of upland floras into the area, or a destruction of a portion of the vegetation in the swamp allowed the spores and pollen of upland floras to be more easily represented in the fossil assemblages of the roof shales.

6. Fossil spores are probably indigenous and their dispersal and occurrence appears related to biological factors rather than to chance.

7. The use of random statistics in the analysis of palynological data for correlative purposes should be regarded with caution because spores and pollen are apparently not randomly distributed.

8. Correlation of coal seams by the use of floral succession should be based on close sampling to allow for variations in ecological factors.

9. The presentation of palynological assemblages in channel histogram form illustrates only gross aspects of the spore and pollen assemblages and the histograms are much less useful than segment sampling in demonstrating spore and pollen succession.

10. The palynological assemblage of the Iron Post coal most closely resembles that of the Summum (No. 4) coal of Illinois.

TABLE 1

COMPARATIVE SPORE FLORAS OF FOUR ILLINOIS COALS AND THE IRON POST COAL OF OKLAHOMA

Spore species common to both Illinois and Oklahoma coals		ILLINOIS				OKLAHOMA
		GROUPS				
		Kewanee				Cabaniss
		Spring-field	Summum (No. 4)	Col-chester	De-Koven	Iron Post
Punctatisporites	dentatus					X
	latigranifer					X
	mundus					X
	setulosus					X
	triangularis					X
Calamospora	decora					X
	liquida					X
	pedata					X
	sp. A					X
	sp. B					X
Granulatisporites	piroformis					X
Raistrickia	solaria					X
	sp. A					X
	sp. B					X
	sp. C					X
	sp. D					X
Convolutispora	florida					X
Converrucosisporites	mosaicoides					X
	sulcatus					X

TABLE 1--Continued

Spore species common to both Illinois and Oklahoma coals		ILLINOIS				OKLAHOMA
		GROUPS				
		Spring-field	Summum (No. 4)	Col-chester	De-Koven	Iron Post
Verrucosisporites	mosaicoides					X
Triquitrites	additus					X
	bransonii					X
	spinosus					X
	tumulus					X
Lycospora	pseudoannulata					X
	torquifer					X
	sp. A					X
	sp. B					X
	sp. C					X
Laevigatosporites	latus					X
Endosporites	minutus					X
	pallidus					X
Spencerisporites	sp. A					X
Wilsonites	delicata					X
	vesicatus					X
Guthörlisporites	sp. A					X
Vestispora	profunda					X
Florinites	elegans					X
	parvus					X
	similis					X
Illinites	unicus					X

TABLE 1--Continued

Spore species common to both Illinois and Oklahoma coals		ILLINOIS				OKLAHOMA
		GROUPS				
		Spring-field	Summum (No. 4)	Col-chester	De-Koven	Iron Post
Sahnisporites	sp. A					X
Vesicaspora	wilsonii					X
Kosankeisporites	elegans					X
	sp. B					X
Pityosporites	sp. A					X
Schopfipollenites	ellipsoides					X
Parasporites ?	sp. A					X
Punctatisporites	firmis				X	
	obliquus	X	X	X		X
	quasiarcuatus			X		
	reticuloides			X		
	verrucifer	X	X	X	X	
Calamospora	breviradiata	X	X	X	X	X
	flexilis	X		X		
	hartungiana	X		X	X	X
	mutabilis	X				X
	straminea	X			X	X
Granulatisporites	convexus		X	X	X	
	pallidus			X		
	spinosus	X		X		X
	verrucosus		X			X
Raistrickia	aculeolata			X		

TABLE 1--Continued

Spore species common to both Illinois and Oklahoma coals		ILLINOIS				OKLAHOMA
		GROUPS				
		Spring-field	Summum (No. 4)	Col-chester	De-Koven	Iron Post
Raistrickia	crinita	X	X			X
	crocea	X	X	X		X
	grovensis			X		
	irregularis			X		
	rubida			X		
Schopfites	colchesterensis			X		X
	dimorphus			X		
Microreticulatisporites	fenestratus	X	X		X	X
	foveatus			X	X	X
	quaesitus	X	X			X
Triquitrites	arculatus			X	X	
	crassus			X		X
	exiguus		X	X		X
	inusitatus			X	X	X
	protensus				X	
	pulvinatus	X	X	X	X	
Lycospora	brevijuga			X		
	granulata	X	X	X	X	X
	punctata	X	X	X	X	
Cirratriradites	annulatus	X	X	X		
	annuliformis	X	X	X		
	maculatus				X	X
Laevigatosporites	desmoinensis	X	X	X	X	X

TABLE 1--Continued

Spore species common to both Illinois and Oklahoma coals		ILLINOIS			OKLAHOMA	
		GROUPS				
		Spring-field	Summum (No.4)	Col-chester	De-Koven	Iron Post
Laevigatosporites	medius				X	X
	minutus	X	X	X	X	X
	minimus	X	X	X	X	X
	ovalis	X	X			
	robustus	X		X	X	
	punctatus	X	X	X	X	X
Verrucososporites	pseudothiessenii	X	X	X	X	X
Alatisporites	hexalatus	X		X	X	
	inflatus			X	X	
	trialatus	X		X		
	varius	X				
Endosporites	ornatus	X	X	X		X
Florinites	pellucidus		X	X	X	X

TABLE 2

COMPARATIVE DATA OF SPORE DISTRIBUTIONS IN FOUR ILLINOIS COALS AND THE IRON POST COALS OF OKLAHOMA

Comparative features	ILLINOIS			OKLAHOMA	
	GROUPS				
	Spring-field	Summum (No.4)	Col-chester	De-Koven	Iron Post
Number species reported	27	23	39	25	75
Species restricted	1	0	1	0	16
Species in common with the Iron Post coal compared with floral total	17 (62.9%)	17 (73.9%)	18 (46.2%)	14 (56.0%)	-- --
Species in common with the Iron Post coal compared with the floral total of the Iron Post coal	17 (22.7%)	17 (22.7%)	18 (24.0%)	14 (18.7%)	75 (100%)
Species in common with the Iron Post coal compared with the Iron Post species totals less those described as new species	17 (28.8%)	17 (28.8%)	18 (30.5%)	14 (23.7%)	59 (100%)

TABLE 3

SUMMARY COMPARISON OF PALYNOLOGICAL FLORAS OF THE IRON POST COAL AND THOSE PREVIOUSLY DESCRIBED FROM OTHER PENNSYLVANIAN COALS OF OKLAHOMA

Comparative features	GROUPS				
		CABANISS			KREBS
	Iron Post	Crowe-burg 1*	Secor (North) 2*	Secor (South) 3*	Rowe 4*
Species reported	75	48	45	103	78
Restricted species	16	5	3	46	19
Species occurring in the Iron Post	75	30	17	28	27
Percentage of species represented in Iron Post, relative to Iron Post	100%	40.0%	22.7%	37.3%	36.0%
Percentage proportion of individual floras represented in Iron Post	--	62.5%	37.7%	27.2%	34.6%

* 1 Wilson & Hoffmeister, 1956
2 Higgins, 1960
3 Clarke, 1961
4 Davis, 1961

TABLE 4

COMPUTED CHI-SQUARE VALUES FOR FIVE SECTIONS OF THE IRON POST COAL, USING AS A STANDARD OR EXPECTED THOSE VALUES ASSOCIATED WITH SECTION OPC 374, WAGONER COUNTY. SPORE TYPES NUMBERED FROM 1 THROUGH 11 REFER IN ORDER TO THE GENERA LAEVIGATOSPORITES, CALAMOSPORA, LYCOSPORA, VERRUCOSOSPORITES, TRIQUITRITES, PUNCTATISPORITES, WILSONITES, FLORINITES, GRANULATISPORITES, VESICASPORA AND VESTISPORA

CHI-SQUARE IS CALCULATED FROM THE FORMULA

$$X^2 = \frac{(f-F)^2}{F}$$

	Spore Types											Observed
	1	2	3	4	5	6	7	8	9	10	11	Sums
OPC 615 Observed (f)	24.1	20.5	19.4	9.7	9.1	7.0	2.5	1.5	1.3	.9	.8	96.8
OPC 374 Expected (F)	25.3	18.7	22.1	9.4	4.4	4.3	3.0	1.2	2.6	2.2	2.5	
Values	0.05	0.17	0.33	-	5.0	1.7	0.08	0.05	0.65	0.77	0.67	X^2 = 9.48
OPC 216 Observed (f)	24.8	14.6	9.8	17.0	6.1	6.4	3.6	3.4	2.8	3.1	1.6	93.2
OPC 374 Expected (F)	25.3	18.7	22.1	9.4	4.4	4.3	3.0	1.2	2.6	2.2	2.5	
Values	-	1.15	6.84	6.08	0.66	1.02	0.04	4.03	0.01	0.37	0.36	X^2 = 20.6
OPC 624 Observed (f)	13.3	24.9	21.6	17.4	5.1	6.0	1.9	0.7	1.0	1.5	1.6	95.0
OPC 374 Expected (F)	25.3	18.7	22.1	9.4	4.4	4.3	3.0	1.2	2.6	2.2	2.5	
Values	5.69	2.05	-	6.81	0.05	0.67	4.0	0.08	0.98	0.22	0.32	X^2 = 20.87
OPC 614 Observed (f)	15.7	21.5	17.6	14.2	5.2	8.5	3.0	1.0	2.2	2.4	1.7	93.0
OPC 374 Expected (F)	25.3	18.7	22.1	9.4	4.4	4.3	3.0	1.2	2.6	2.2	2.5	
Values	3.64	0.42	0.92	2.45	0.14	4.09	-	0.03	0.06	0.02	0.25	X^2 = 11.97
OPC 657 Observed (f)	25.3	19.9	4.0	8.1	2.8	2.8	16.8	2.9	0.4	9.9	2.1	95.0
OPC 374 Expected (F)	25.3	18.7	22.1	9.4	4.4	4.3	3.0	1.2	2.6	2.2	2.5	
Values	-	0.08	14.8	0.18	0.58	0.52	64.5	2.41	1.8	26.9	0.06	X^2 = 110.0

TABLE 5

SELECTED CHI-SQUARE VALUES FOR 10 DEGREES OF FREEDOM FOR USE IN CONJUNCTION WITH TABLE 4

X^2	15.9	18.3	20.5	23.2	25.2
p (Probability)	10.0%	5.0%	2.5%	1.0%	0.5%

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APPENDIX

PLATE 1

Figure

1. Punctatisporites latigranifer (Loose) S., W., and B.
   60.5 X 65.0 microns; Slide No. OPC 624D-3-2.

2. Punctatisporites mundus Kosanke
   58.0 X 71.0 microns; Slide No. OPC 374F-3-1.

3. Punctatisporites obliquus Kosanke
   35.6 X 35.6 microns; Slide No. OPC 624D-3-4.

4. Punctatisporites setulosus Kosanke
   69.3 X 73.1 microns; Slide No. OPC 624G-1-2.

5. Punctatisporites dentatus Wilson and Hoffmeister
   41.0 X 45.0 microns; Slide No. OPC 624J-8-4.

6. Punctatisporites triangularis Kosanke
   61.0 X 71.2 microns; Slide No. OPC 374H-2-10.

7. Calamospora straminea Wilson and Kosanke
   41.1 X 44.0 microns; Slide No. OPC 216E-1-2

8. Calamospora liquida Kosanke
   44.0 X 82.5 microns; Slide No. OPC 374C-4-6.

9. Calamospora decora Wilson and Hoffmeister
   51.7 X 55.0 microns; Slide No. OPC 216D-1-1.

10. Calamospora sp. B
    24.2 X 25.3 microns; Slide No. OPC 216E-3-2.

11. Calamospora breviradiata Kosanke
    53.9 X 53.9 microns; Slide No. OPC 624K-1-7.

PLATE 1

PLATE 2

Figure

1. Calamospora mutabilis (Loose) S., W., and B.
122.0 X 127.0 microns; Slide No. OPC 624D-1-3.

2. Calamospora hartungiana Schopf
93.5 X 105.6 microns; Slide No. OPC 216F-1-1.

3. Calamospora pedata Kosanke
38.5 X 54.0 microns; Slide No. OPC 374C-1-7.

4. Calamospora sp. A
124.5 X 193.0 microns; Slide No. OPC 216F-3-3.

5, 6. Granulatisporites piroformis Loose
(5) 28.6 X 33.0 microns; Slide No. OPC 216D-1-4.
(6) 30.0 X 31.0 microns; Slide No. OPC 216E-1-20.

7, 8. Granulatisporites spinosus Kosanke
(7) 27.5 X 28.0 microns; Slide No. OPC 374F-4-3.
(8) 23.1 X 27.5 microns; Slide No. OPC 624H-3-5.

9. Granulatisporites verrucosus (Wilson and Coe) S., W., and B.
20.3 X 20.3 microns; Slide No. OPC 216D-2-2.

10. Raistrickia crinita Kosanke
45.1 X 48.4 microns; Slide No. OPC 624E-3-5.

11. Raistrickia crocea Kosanke
41.8 X 49.5 microns; Slide No. OPC 624K-1-2.

PLATE 2

PLATE 3

Figure

1. Raistrickia imbricata Kosanke
   57.5 X 61.6 microns; Slide No. OPC 216F-3-4.

2. Verrucosisporites ? sp. A
   66.0 X 71.5 microns; Slide No. OPC 624J-5-5.

3. Raistrickia ? sp. D
   48.5 X 51.7 microns; Slide No. OPC 624G-3-3.

4. Raistrickia sp. C
   40.7 X 40.7 microns; Slide No. OPC 624E-1-16.

5. Raistrickia sp. B
   29.7 X 33.0 microns; Slide No. OPC 216D-3-3.

6. Raistrickia solaria Wilson and Hoffmeister
   46.5 X 52.8 microns; Slide No. OPC 624D-1-2.

7, 8, 9. Raistrickia sp. A
   (7) 42.9 X 46.3 microns; Slide No. OPC 624E-4-2, distal view
   (8) proximal view of the same specimen.
   (9) enlargement of the spines, same specimen.

10. Convolutispora florida Hoffmeister, Staplin and Malloy
   37.4 X 40.7 microns; Slide No. OPC 624J-6-2.

11. Converrusosisporites sulcatus (Wilson and Kosanke) Potonie´and Kremp
   36.8 X 40.7 microns; Slide No. OPC 374D-1-4.

12. Converrucosisporites mosaiccoides Potonie´and Kremp
   20.9 X 22.0 microns; Slide No. OPC 624D-3-3.

PLATE 3

1

3

2

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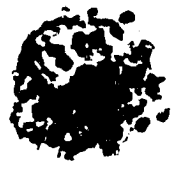

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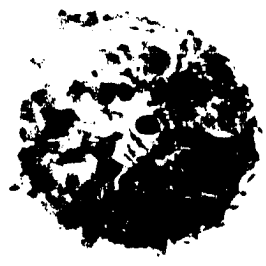

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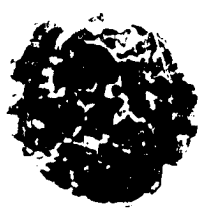

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PLATE 4

Figure

1. Vestispora profunda Wilson and Hoffmeister
   59.4 X 69.3 microns; Slide No. OPC 624E-1-2.

2. Microreticulatisporites foveatus (Kosanke) Potonié and Kremp
   69.3 X 74.8 microns; Slide No. OPC 374D-1-5.

3. Schopfites colchesterensis Kosanke
   77.0 X 79.2 microns; Slide No. OPC 624K-1-5.

4. Microreticulatisporites quaesitus (Kosanke) Butterworth and Williams
   35.2 X 39.6 microns; Slide No. OPC 624I-1-1.

5. Microreticulatisporites fenestratus (Kosanke and Brokaw) Potonie' and Kremp
   64.9 X 71.5 microns; Slide No. OPC 374F-4-4.

6. Triquitrites cf. exiguus Wilson and Kosanke
   27.5 X 28.5 microns; Slide No. OPC 624D-1-32.

7. Triquitrites spinosus Kosanke
   40.7 X 74.3 microns; Slide No. OPC 624E-4-15.

8, 9. Triquitrites additus Wilson and Hoffmeister
   (8) 44.0 X 44.0 microns; Slide No. OPC 624E-4-16.
   (9) 40.7 X 44.0 microns; Slide No. OPC 374F-1-11.

10. Triquitrites inusitatus Kosanke
    52.1 X 58.3 microns; Slide No. OPC 624C-5-4.

11. Triquitrites bransonii Wilson and Hoffmeister
    33.0 X 34.1 microns; Slide No. OPC 624H-6-2.

12. Triquitrites tumulus Wilson and Hoffmeister
    42.5 X 45.1 microns; 624E-4-14.

PLATE 4

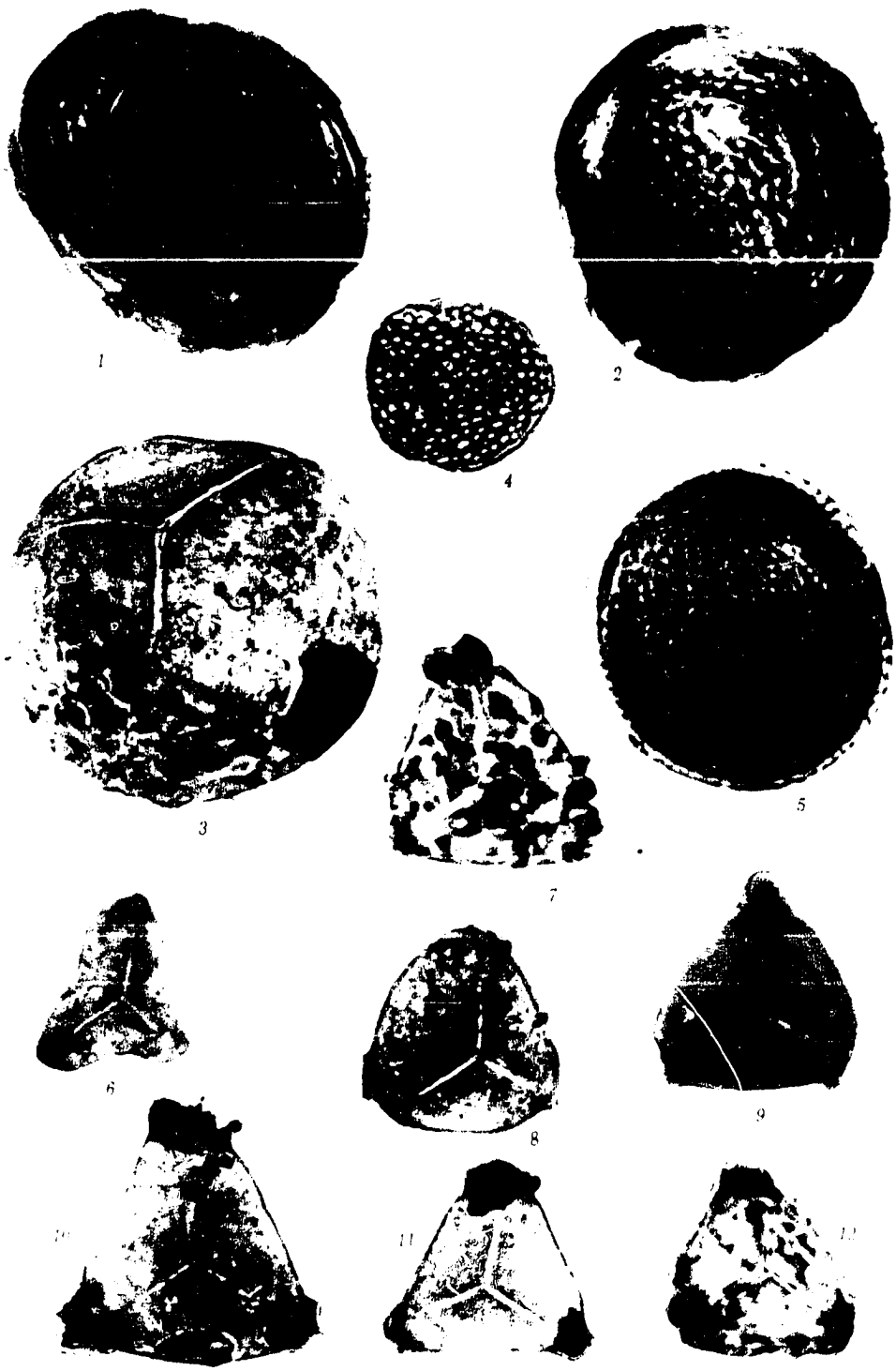

PLATE 5

Figure

1, 2. Lycospora granulata Kosanke
(1) 26.9 X 29.1 microns; Slide No. OPC 624D-1-9.
(2) 24.2 X 24.2 microns; Slide No. OPC 624E-1-9.

3. Lycospora pseudoannulata Kosanke
31.4 X 39.6 microns; Slide No. OPC 624D-3-12.

4. Lycospora sp. A
45.6 X 50.6 microns; Slide No. OPC 624J-5-3.

5. Lycospora ? sp. C
42.3 X 47.0 microns; Slide No. OPC 624K-2-1.

6. Lycospora cf. torquifer (Loose) Potonié and Kremp
33.0 X 34.1 microns; Slide No. OPC 374F-4-3.

7. Lycospora ? sp. B
60.5 X 68.7 microns; Slide No. OPC 374F-1-3.

8. Cirratriradites maculatus Wilson and Coe
82.5 X 82.5 microns; Slide No. OPC 374H-4-4.

9. Laevigatosporites desmoinensis (Wilson and Coe) S., W., and B.
45.1 X 60.9 microns; Slide No. OPC 624C-4-3.

10. Laevigatosporites latus Kosanke
52.3 X 56.1 microns; Slide No. OPC 374B-4-3.

11. Laevigatosporites ovalis Kosanke
36.9 X 55.9 microns; Slide No. OPC 624D-1-25.

12. Laevigatosporites medius Kosanke
23.6 X 45.7 microns; Slide No. OPC 374C-1-1.

13. Laevigatosporites minutus (Ibrahim) S., W., and B.
18.1 X 24.7 microns; Slide No. OPC 624C-1-4.

14. Laevigatosporites minimus (Wilson and Coe) S., W., and B.
19.0 X 20.3 microns; Slide No. OPC 216D-2-1.

Figure

15. Laevigatosporitas punctatus Kosanke
33.0 X 35.6 microns; Slide No. OPC 374F-1-1.

16. Verrucososporites pseudothiessenii (Kosanke) Potonie´and Kremp
27.9 X 33.5 microns; Slide No. OPC 624D-1-14.

PLATE 5

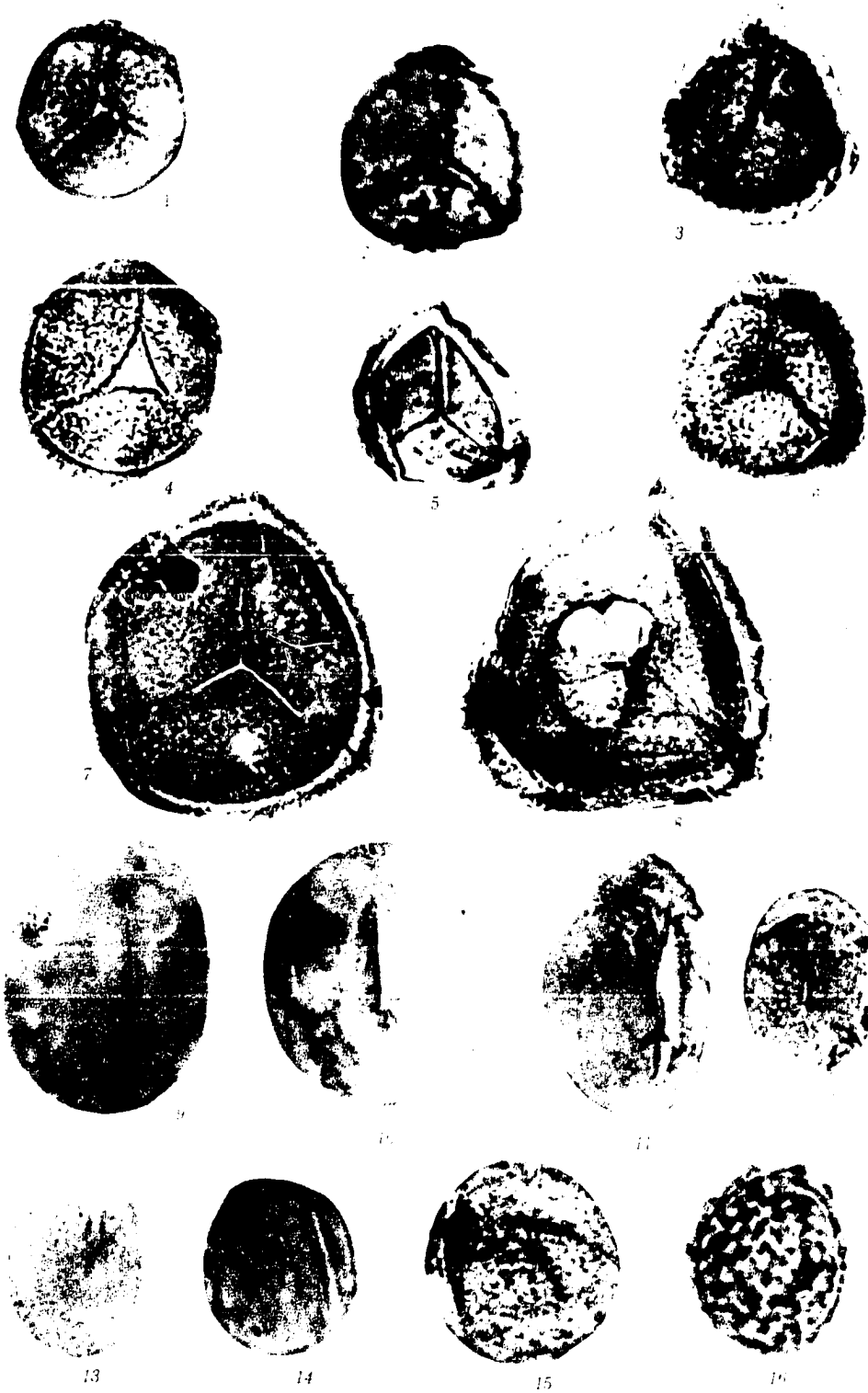

PLATE 6

Figure

1. Endosporites ornatus Wilson and Coe
   93.9 X 106.7 microns; Slide No. OPC 614F-3-1.

2. Spencerisporites cf. radiatus (Ibrahim) Chaloner
   11.68 X 182.9 microns; Slide No. OPC 624J-3-2.

3, 4. Endosporites ornatus Wilson and Coe
   (3) 81.3 X 86.4 microns; Slide No. OPC 624F-2-1.
   (4) 86.4 X 93.9 microns; Slide No. OPC 614F-1-2.

5. Endosporites minutus Hoffmeister, Staplin and Malloy
   38.1 X 38.1 microns; Slide No. OPC 657E-5-1.

6. Endosporites pallidus Schemel
   48.5 X 56.1 microns; Slide No. OPC 374H-4-5.

7. Wilsonites vesicatus (Kosanke) Kosanke
   70.4 X 72.6 microns; Slide No. OPC 624J-3-4.

8, 9. Wilsonites delicatus (Kosanke) Kosanke
   (8) 99.0 X 101.2 microns; Slide No. OPC 624D-1-22.
   (9) 111.8 X 127.0 microns; Slide No. OPC 657B-2-2.

PLATE 6

PLATE 7

Figure

1, 2. Cuthörlisporites sp. A
(1) 76.3 X 83.8 microns; Slide No. OPC 374H-4-8.
(2) 63.8 X 67.1 microns; Slide No. OPC 624K-1-6.

3. Florinites parvus Wilson and Hoffmeister
37.4 . 50.6 microns; Slide No. OPC 657C-2-4.

4. Florinites elegans Wilson and Coe
134.5 X 180.3 microns; Slide No. OPC 657D-2-1.

5. Florinites pellucidus (Wilson and Coe) Wilson
56.1 X 69.3 microns; Slide No. OPC 624J-4-1.

6. Florinites similis Kosanke
86.9 X 117.7 microns; Slide No. OPC 624D-1-20.

7. Schopfipollenites ellipsoides (Ibrahim) Potonié and Kremp
149.9 X 243.8 microns; Slide No. OPC 657B-3-1.

8. Genus A
241.3 X 457.2 microns; Slide No. OPC 216H-4-3.

PLATE 7

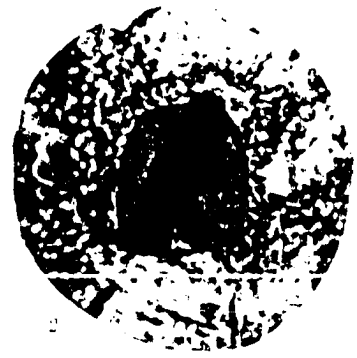

PLATE 8

Figure

1, 2. Illinites unicus Kosanke
(1) 53.9 X 61.5 microns; Slide No. OPC 374C-1-5.
(2) 45.1 X 61.5 microns; Slide No. OPC 216H-4-2.

3, 4. Kosankeisporites elegans (Kosanke) Bhardwaj
(3) 60.5 X 73.7 microns; Slide No. OPC 657C-4-7.
(4) 68.2 X 82.5 microns; Slide No. OPC 624H-3-4.

5. Vesicaspora wilsonii Schemel
31.9 X 40.7 microns; Slide No. OPC 624E-3-2.

6, 7. Kosankeisporites sp. A
(6) 67.1 X 100.1 microns; Slide No. OPC 657B-3-2.
(7) 61.6 X 100.1 microns; Slide No. OPC 624J-8-5.

8. Sahnisporites sp. A
67.6 X 104.5 microns; Slide No. OPC 657C-2-3.

9, 10. Pityosporites cf. schaubergeri Potonié and Klaus
(9) 59.4 X 89.1 microns; Slide No. OPC 624F-1-7.
(10) 60.5 X 92.4 microns; Slide No. OPC 624D-1-13.

PLATE 8

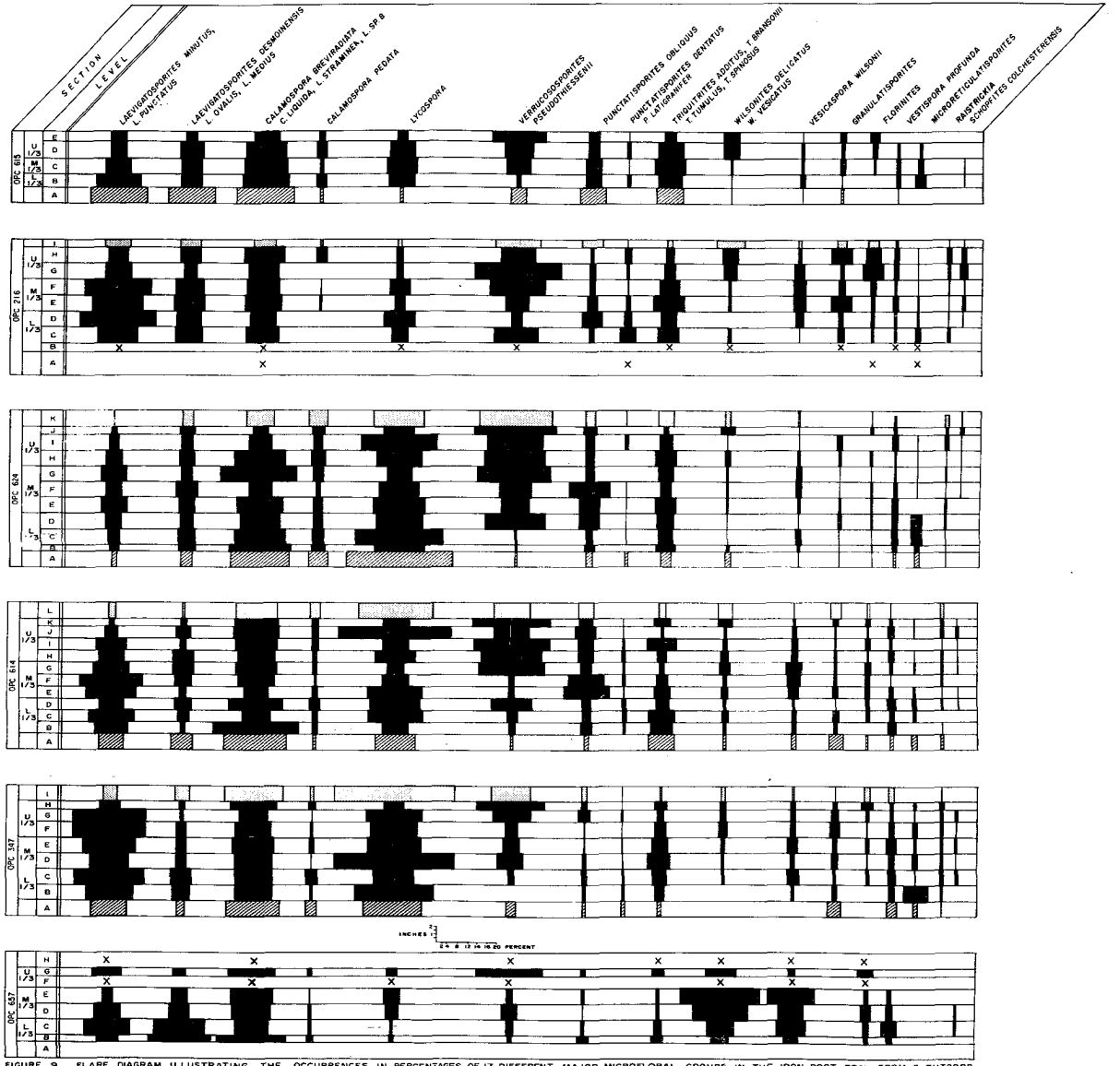

FIGURE 9. FLARE DIAGRAM ILLUSTRATING THE OCCURRENCES, IN PERCENTAGES, OF 17 DIFFERENT MAJOR MICROFLORAL GROUPS IN THE IRON POST COAL FROM 6 OUTCROP SECTIONS IN NORTHEASTERN OKLAHOMA. THE SECTIONS ARE SHOWN, FROM TOP TO BOTTOM, AS TO NORTH-SOUTH POSITION IN THE STUDY AREA. INTERVALS CONTAINING FEW OR NO MICROFOSSILS ARE INDICATED BY X'S. UNDERCLAY VALUES ARE REPRESENTED BY DIAGONAL RULING (▨) AND ROOF SHALE VALUES BY STIPPLE (▩).

Genus	Species	OPC 615 A	B	C	D	E	CUM %
PUNCTATISPORITES	DENTATUS					.3	TR
	LATIGRANIFER		1.8	0.5	1.0	0.6	0.7
	MUNDUS						
	OBLIQUUS	10.6	6.3	6.5	4.3	4.0	6.3
	SETULOSUS						
	TRIANGULARIS			0.3		0.3	0.1
CALAMOSPORA	BREVIRADIATA	9.3	7.8	10.8	10.5	8.3	9.3
	DECORA						
	HARTUNGIANA						
	LIQUIDA	4.3	8.5	3.6	3.8	0.8	4.2
	MUTABILIS		0.5	0.8		0.5	0.3
	PEDATA	1.0	3.8	1.3	4.3	2.0	2.4
	STRAMINEA	8.3	1.5	1.3	1.0	0.8	1.9
	SP. A				0.3		TR
	SP. B	4.3	0.8	0.8	0.8	0.5	2.4
GRANULATISPORITES	PIROFORMIS	1.0	0.3	1.5	0.8	0.8	0.8
	SPINOSUS		0.3	0.3	0.5	1.3	0.4
	VERRUCOSUS	0.3			0.3		0.1
RAISTRICKIA	CRINITA		0.3	0.8	0.8		0.3
	CROCEA						
	IMBRICATA						
	SOLARIA					0.8	0.1
	SP. A				0.3	0.3	0.1
	SP. B				0.3	0.3	0.1
	SP. C						
	SP. D						
CONVOLUTISPORA	FLORIDA						
CONVERRUCOSISPORITES	MOSAICOIDES						
	SULCATUS						
VERRUCOSISPORITES	SP. A						
SCHOPFITES	COLCHESTERENSIS		0.5	0.3			0.1
MICRORETICULATISPORITES	FENESTRATUS						
	FOVEATUS		3.0	1.0	1.0		1.0
	QUAESITUS		0.8	0.5			0.2
TRIQUITRITES	ADDITUS	0.8	0.8	1.0	0.8		0.6
	EXIGUUS						
	BRANSONII	9.0	8.5	10.5	9.3	3.8	8.2
	INUSITATUS						
	SPINOSUS				0.3		TR
	TUMULUS	0.8	0.3	0.5		0.3	0.3
LYCOSPORA	GRANULATA	1.3	16.8	14.3	17.0	29.0	15.6
	PSEUDOANNULATA	0.3	4.0	8.0	3.3	2.0	3.7
	TORQUIFER						
	SP. A				0.3		TR
	SP. B						
	SP. C				0.3		TR
CIRRATRIRADITES	MACULATUS		0.6	0.5	1.0	1.0	0.6
LAEVIGATOSPORITES	DESMOINENSIS	1.5	2.8	1.8	4.3	1.3	2.3
	LATUS					0.3	TR
	MEDIUS	10.0	2.5	3.8	2.5	1.5	4.0
	MINUTUS	0.6	11.3	7.0	4.0	6.0	9.7
	MINIMUS	3.3	1.0	0.5		0.8	1.1
	OVALIS	7.3	3.0	2.5	3.3	1.5	3.5
	PUNCTATUS	17.5	6.5	4.5	2.0	1.3	6.4
VERRUCOSOSPORITES	PSEUDOTHIESSENII	5.8	1.3	9.3	11.0	21.5	9.7
SPENCERISPORITES	SP. A						
ENDOSPORITES	MINUTUS						
	ORNATUS		0.8				0.1
	PALLIDUS						
WILSONITES	DELICATUS					0.3	TR
	VESICATUS		0.3	1.0	5.8	5.5	2.5
GUTHORLISPORITES	SP. A						
VESTISPORA	PROFUNDA	0.3	1.5	1.3	1.0		0.8
FLORINITES	ELEGANS						
	PARVUS						
	PELLUCIDUS			1.0	2.8	3.5	1.4
	SIMILIS				0.3	0.5	0.1
ILLINITES	UNICUS						
SAHNISPORITES	SP. A						
VESICASPORA	WILSONII	0.5	1.8	1.3	1.0	0.3	0.9
KOSANKEISPORITES	ELEGANS			0.3			TR.
	SP. A						
PITYOSPORITES	SP. A						
SCHOPFIPOLLENITES	ELLIPSOIDES						
GENUS A	SP.						
CUMULATIVE TOTAL		100.0	100.0	100.0	100.0	100.0	99.6*

Genus	Species	OPC 216 A	B	C	D	E	F	G	H	I	CUM %
PUNCTATISPORITES	DENTATUS			1.5	1.0	0.5		0.3	0.5		0.5
	LATIGRANIFER	X		6.3	2.5	1.8	0.5	1.0	1.5	0.5	2.0
	MUNDUS				0.3		0.3	0.3			0.1
	OBLIQUUS			1.8	8.5	4.5	3.0	2.5	1.5	4.3	3.8
	SETULOSUS			0.3							TR
	TRIANGULARIS										
CALAMOSPORA	BREVIRADIATA		X	8.3	5.5	10.0	9.5	9.8	12.5	6.0	8.8
	DECORA			4.0	0.8	0.5				0.3	0.8
	HARTUNGIANA		X	0.7	0.3		0.3				0.2
	LIQUIDA	X		4.5	3.3	3.3	2.3	1.0	1.0	0.5	2.3
	MUTABILIS										
	PEDATA					1.3	0.5		4.5	1.0	1.1
	STRAMINEA						0.3	1.5	1.8	1.3	0.6
	SP. A			0.5				0.3	0.5	0.3	0.2
	SP. B	X	X		1.8	0.8	1.0		0.3	0.8	0.6
GRANULATISPORITES	PIROFORMIS		X	3.0	2.3	3.0	1.3	1.3	3.0	1.8	2.2
	SPINOSUS		X		0.3	1.0	0.3		1.0	1.8	0.6
	VERRUCOSUS				0.5						TR
RAISTRICKIA	CRINITA			1.0	0.8	0.8	0.5	1.3	0.8	0.8	0.8
	CROCEA										
	IMBRICATA										
	SOLARIA						0.8	0.3	0.3		0.2
	SP. A			0.3					0.5		0.1
	SP. B										
	SP. C			0.3	0.3						TR
	SP. D										
CONVOLUTISPORA	FLORIDA										
CONVERRUCOSISPORITES	MOSAICOIDES		X								
	SULCATUS										
VERRUCOSISPORITES	SP. A										
SCHOPFITES	COLCHESTERENSIS				0.3	1.3	0.8	3.5	2.8	0.5	1.3
MICRORETICULATISPORITES	FENESTRATUS	X	X	0.7		0.3					0.1
	FOVEATUS		X	1.8	1.0	0.7		0.5	0.3		0.6
	QUAESITUS			0.3			0.3				TR
TRIQUITRITES	ADDITUS			2.0	2.8	2.3	3.0	1.5	0.5	0.5	1.7
	EXIGUUS										
	BRANSONII		X	3.0	2.3	7.8	4.0	2.0	3.0	2.8	5.5
	INUSITATUS			0.5							TR
	SPINOSUS										
	TUMULUS		X	2.5	1.5	1.8	0.8	0.3			0.9
LYCOSPORA	GRANULATA		X	5.5	12.3	3.0	3.0	2.8	16.0	25.0	9.0
	PSEUDOANNULATA			0.5		0.8	0.3				0.2
	TORQUIFER				0.3						TR
	SP. A										
	SP. B										
	SP. C										
CIRRATRIRADITES	MACULATUS			0.3	0.5	0.5		1.0	2.3	0.5	0.7
LAEVIGATOSPORITES	DESMOINENSIS			2.0	1.5	2.3	3.3	0.8	3.5	2.0	2.2
	LATUS					0.8	0.3		0.7	0.3	0.2
	MEDIUS			4.0	3.0	3.3	1.3	0.3	0.3	1.0	1.8
	MINUTUS		X	15.3	25.0	14.0	19.5	5.5	5.3	6.0	13.1
	MINIMUS			8.0	1.0	0.3			0.3		0.3
	OVALIS			5.0	5.5	7.0	4.5	4.0	4.0	5.0	5.0
	PUNCTATUS			1.0	5.5	6.5	7.0	4.0	2.3	4.8	4.5
VERRUCOSOSPORITES	PSEUDOTHIESSENII		X	17.5	4.0	9.3	22.0	34.0	13.3	18.3	17.0
SPENCERISPORITES	SP. A								0.5	0.5	0.1
ENDOSPORITES	MINUTUS			0.3							TR
	ORNATUS									0.3	TR
	PALLIDUS										
WILSONITES	DELICATUS						0.8		0.8	1.3	0.4
	VESICATUS		X	0.8		1.0		5.5	5.0	10.3	3.2
GUTHORLISPORITES	SP. A										
VESTISPORA	PROFUNDA		X	1.5	1.3	2.8	0.8	2.3	2.0	0.8	1.6
FLORINITES	ELEGANS										
	PARVUS				0.5	0.8	0.3	1.8	0.8	0.8	0.7
	PELLUCIDUS	X		0.8	0.5	1.0	1.8	6.3	4.5	4.0	2.7
	SIMILIS										
ILLINITES	UNICUS						0.5				TR
SAHNISPORITES	SP. A										—
VESICASPORA	WILSONII			0.3	3.5	5.5	5.8	3.8	1.5	1.3	3.1
KOSANKEISPORITES	ELEGANS								0.8		0.1
	SP. A										
PITYOSPORITES	SP. A					0.3	0.3		0.3		0.1
SCHOPFIPOLLENITES	ELLIPSOIDES			0.8		0.3			0.5	0.5	0.3
GENUS A	SP.								0.3		TR
CUMULATIVE TOTAL		X	X	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4*

Genus	Species	OPC 624 A	B	C	D	E	F	G	H	I	J	K	CUM %
PUNCTATISPORITES	DENTATUS							0.3	0.8	0.5			0.1
	LATIGRANIFER	0.8		0.5	0.5	0.5	0.3			0.3		0.3	0.3
	MUNDUS							[illegible]			0.5		TR
	OBLIQUUS	2.5	3.5	2.8	8.0	8.5	16.8	3.5	3.5	3.5	4.8	4.0	5.6
	SETULOSUS					0.3							
	TRIANGULARIS												
CALAMOSPORA	BREVIRADIATA	5.5	11.0	10.3	9.0	12.3	7.5	13.3	15.0	14.5	8.8	18.5	11.2
	DECORA												
	HARTUNGIANA		0.3	0.5									TR
	LIQUIDA	7.0	13.3	6.3	3.0	3.3	3.5	4.8	2.5	2.3	1.5	1.8	4.4
	MUTABILIS		6.3	1.5	1.0						0.8		0.9
	PEDATA	7.5	5.0	4.5	3.3	5.8	2.0	4.0	5.3	3.8	4.5	7.0	4.6
	STRAMINEA	10.5	5.3	4.8	3.3	1.8	3.8	2.5	1.5		1.5	1.3	3.3
	SP. A												
	SP. B	1.3			0.8	0.8	2.3	0.5					0.5
GRANULATISPORITES	PIROFORMIS	0.5	0.5	1.5	0.5	2.0	0.5	0.3	0.3	1.0			0.6
	SPINOSUS					0.3	0.3		0.3	1.0	1.0		0.2
	VERRUCOSUS		0.5							0.5			0.2
RAISTRICKIA	CRINITA	0.3	0.5	0.3	1.0	0.8	1.0	0.8	0.5	1.0	1.0	0.8	0.7
	CROCEA				0.3							0.3	TR
	IMBRICATA												
	SOLARIA				0.3		0.8	0.3				0.3	0.1
	SP. A					0.5				0.3			TR
	SP. B									0.3			TR
	SP. C			0.3		0.3							TR
	SP. D												
CONVOLUTISPORA	FLORIDA										0.3		TR
CONVERRUCOSISPORITES	MOSAICOIDES				0.3		0.5						TR
	SULCATUS									0.5			TR
VERRUCOSISPORITES	SP. A										0.3		
SCHOPFITES	COLCHESTERENSIS	0.5					0.3	0.5	0.3	0.5	1.8	0.3	0.4
MICRORETICULATISPORITES	FENESTRATUS			1.0									0.2
	FOVEATUS	1.8	1.3	2.8	0.3		0.3	0.5	0.3	0.3			0.7
	QUAESITUS	0.8		0.5									0.1
TRIQUITRITES	ADDITUS		0.5			1.0			0.3				0.1
	EXIGUUS												
	BRANSONII	4.5	5.8	3.5	4.8	5.8	4.0	4.6	7.5	3.3	1.8	6.3	4.7
	INUSITATUS			0.3	0.3								TR
	SPINOSUS			0.5	0.3	0.8							0.1
	TUMULUS		0.3	1.0		0.8	0.3	0.5	0.3				0.2
LYCOSPORA	GRANULATA	23.0	10.8	21.3	13.8	20.0	14.8	10.3	15.8	29.0	12.0	21.3	17.4
	PSEUDOANNULATA	19.5	9.8	4.5	3.8	1.5	1.8	1.3	2.0	0.8	0.3		4.1
	TORQUIFER												
	SP. A				0.5						0.3		TR
	SP. B			0.3									TR
	SP. C											0.3	TR
CIRRATRIRADITES	MACULATUS	0.8	0.5		0.8	1.0	1.0	0.5	0.8	2.8	1.5	0.5	0.9
LAEVIGATOSPORITES	DESMOINENSIS	0.5	2.8	1.0	1.5	2.8	1.3	1.0	4.0	2.0	1.8	2.3	1.9
	LATUS			0.3				0.3			0.3		TR
	MEDIUS	1.8	1.5	2.5	3.0	1.5	3.3	1.0	1.0	0.5	0.8	0.5	1.6
	MINUTUS	1.5	7.0	10.8	3.8	7.5	3.5	8.5	4.5	3.3	1.3	1.0	4.8
	MINIMUS		1.5	1.5	1.5		1.0		0.5				0.5
	OVALIS	3.0	2.8	3.0	2.8	2.3	4.5	3.0	1.5	2.5	3.8	1.5	2.9
	PUNCTATUS	0.3	3.0	2.3	2.3	2.5	2.8	1.0	1.3	0.5	1.5		1.6
VERRUCOSOSPORITES	PSEUDOTHIESSENII	1.5	1.3	1.8	24.5	10.8	12.3	50.0	24.0	22.5	33.5	29.5	17.4
SPENCERISPORITES	SP. A						0.3	0.3			1.5		0.2
ENDOSPORITES	MINUTUS												
	ORNATUS	0.3				0.5	1.8	0.3		0.3		0.3	0.3
	PALLIDUS						0.3						
WILSONITES	DELICATUS		0.3		0.3								TR
	VESICATUS	2.8	1.0	1.3	0.5	1.5	1.5	1.5	2.0	0.3	6.5	2.0	1.9
GUTHORLISPORITES	SP. A						0.3				0.5	0.3	TR
VESTISPORA	PROFUNDA	1.3	1.8	2.5	2.3	2.3	1.8	1.3	1.3	2.0	1.0	0.8	1.6
FLORINITES	ELEGANS												
	PARVUS					0.5							TR
	PELLUCIDUS	0.5	0.8		0.8	0.8	1.3	0.5	1.0		1.0	0.5	0.6
	SIMILIS			0.3	0.3						0.3		TR
ILLINITES	UNICUS			1.6	0.8	0.3	0.5	0.5	0.5		1.0		0.5
SAHNISPORITES	SP. A							0.3					TR
VESICASPORA	WILSONII	0.5	1.3	2.5	0.8	1.3	2.5	2.0	1.0	0.5	3.0	1.0	1.5
KOSANKEISPORITES	ELEGANS		0.3			0.3	0.3		0.3	0.3	0.5		0.2
	SP. A												
PITYOSPORITES	SP. A		0.3				0.3	0.3					TR
SCHOPFIPOLLENITES	ELLIPSOIDES			0.8							0.8		0.1
GENUS A	SP.												
CUMULATIVE TOTAL		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.5*

Genus	Species	OPC 614 A	B	C	D	E	F	G	H	I	J	K	L	CUM %
PUNCTATISPORITES	DENTATUS			0.3	1.3	0.5	0.3		0.3	0.3	0.3			0.3
	LATIGRANIFER		0.8	1.5	0.5	0.3	1.5	1.0	1.8	1.5	0.3	0.5		0.7
	MUNDUS		1.5							0.3		0.5		0.2
	OBLIQUUS	2.3	4.5	3.8	3.5	19.0	14.3	4.5	6.0	6.3	12.0	5.5	7.3	7.4
	SETULOSUS		0.3				0.3							TR
	TRIANGULARIS													
CALAMOSPORA	BREVIRADIATA	14.5	15.3	11.0	10.8	5.0	5.8	8.8	9.0	10.8	10.0	9.8	12.8	10.3
	DECORA			0.3	0.3									TR
	HARTUNGIANA			0.5										TR
	LIQUIDA	6.8	16.3	3.5	4.0	1.5	4.5	4.3	2.5	2.8	4.8	4.5	2.5	4.7
	MUTABILIS	2.0	2.5	0.8	0.8		0.8	0.5	0.8		0.8	0.5		0.8
	PEDATA	2.0	2.8	3.5	4.3	2.0	1.0	2.0	2.5	3.3	3.0	3.0	4.5	2.8
	STRAMINEA	2.8	7.3	1.0	1.5	1.0	2.3	0.8	0.8	1.0	0.8		1.8	1.7
	SP. A	1.0	1.0									1.8		0.3
	SP. B	0.5	0.8	1.3	1.5	1.8	1.3	0.8	1.0	0.5	0.3	0.3		0.6
GRANULATISPORITES	PIROFORMIS	5.5	1.3	1.8	0.5	1.8	0.5	1.0	0.8	0.8	0.3	0.8	2.0	1.4
	SPINOSUS			0.3		0.3	0.5	1.0	0.8	0.5	1.0	1.3	2.0	0.6
	VERRUCOSUS	0.5	0.3	0.3	0.3		0.5	0.5					0.3	0.2
RAISTRICKIA	CRINITA	0.3			0.3	0.3	0.3	0.3	0.8	0.3	1.0	1.8	1.0	0.5
	CROCEA						0.3							TR
	IMBRICATA	0.8												
	SOLARIA	1.3	0.3					0.3	0.3		0.3		0.3	0.2
	SP. A				0.3		0.3					0.3		0.1
	SP. B		0.5						0.3					0.1
	SP. C													
	SP. D											0.3		TR
CONVOLUTISPORA	FLORIDA													
CONVERRUCOSISPORITES	MOSAICOIDES													
	SULCATUS													
VERRUCOSISPORITES	SP. A													
SCHOPFITES	COLCHESTERENSIS				0.3	0.3		0.3	0.5	0.3	0.8	0.3		0.2
MICRORETICULATISPORITES	FENESTRATUS	1.0						0.3	0.3					0.1
	FOVEATUS	1.3		0.5	1.0	0.5		0.3			0.3	0.3		0.3
	QUAESITUS			0.3										TR
TRIQUITRITES	ADDITUS	0.8	0.8	1.0	0.5	0.3	0.3	0.3	0.3	0.5		0.3		0.4
	EXIGUUS													
	BRANSONII	0.8	7.3	7.3	3.0	3.5	3.8	1.5	3.0	2.3	1.0	5.8	3.0	4.1
	INUSITATUS													
	SPINOSUS													
	TUMULUS	1.5		1.8	1.5	2.3	0.5		0.5				0.3	0.7
LYCOSPORA	GRANULATA	13.5	7.5	13.3	15.5	20.0	6.5	4.5	13.5	8.8	22.5	9.0	19.0	12.8
	PSEUDOANNULATA	2.5	4.0	8.5	4.8	2.0	3.8	2.8	3.0	2.0	4.5	2.5	1.0	4.5
	TORQUIFER													
	SP. A	0.5		0.3			0.3						0.8	0.1
	SP. B		0.3											TR
	SP. C	1.5			0.3	0.3							0.3	0.2
CIRRATRIRADITES	MACULATUS	0.3	0.3		1.0	0.8	0.8	0.3	0.8	0.8	2.3	2.3	0.5	0.8
LAEVIGATOSPORITES	DESMOINENSIS	1.3	0.5	2.8	4.0	1.0	2.5	4.5	6.3	2.3	3.0	2.0	0.5	2.5
	LATUS							0.5			0.5		0.3	0.1
	MEDIUS	2.3		2.0	1.3	1.5	2.3	1.3	1.3	0.5	1.0			1.1
	MINUTUS	8.8	11.3	15.3	8.3	18.0	23.5	12.8	9.0	11.8	3.3	2.3	1.8	10.5
	MINIMUS	4.5		1.0	1.3	2.3	1.5	0.3						0.9
	OVALIS	5.5	1.8		2.0	1.0	1.5	2.0	0.5	0.5	2.0	1.8	2.0	1.7
	PUNCTATUS	1.0	1.5	2.8	2.3	2.3	2.0	1.3	1.3	0.5	1.8		0.3	1.4
VERRUCOSOSPORITES	PSEUDOTHIESSENII	0.8	2.8	4.3	16.3	2.8	3.0	25.8	24.0	30.8	13.8	31.3	14.8	14.2
SPENCERISPORITES	SP. A						0.3				0.5	1.3		0.2
ENDOSPORITES	MINUTUS												0.3	TR
	ORNATUS	0.3			0.3		4.0			0.5	2.3	0.3	0.5	0.7
	PALLIDUS		0.3											TR
WILSONITES	DELICATUS	0.5			0.3			0.5	0.3	0.3		0.3	0.5	0.2
	VESICATUS	0.8	1.3	2.8	1.5	2.8	2.5	4.0	2.8	2.3	2.0	5.5	6.0	2.8
GUTHORLISPORITES	SP. A					0.3		1.0	0.3		0.3		0.3	0.2
VESTISPORA	PROFUNDA	1.8	3.3	2.8	3.8	1.3	0.5	0.8	2.0	1.3	2.5	1.3	0.5	1.7
FLORINITES	ELEGANS							0.3						TR
	PARVUS			0.3		0.3								TR
	PELLUCIDUS			0.3	0.8	0.8	1.5	2.0	0.3	1.5	0.5	1.5	0.8	0.8
	SIMILIS	0.5		0.3					0.3	0.5			0.3	0.1
ILLINITES	UNICUS							1.3	0.3		0.3	0.3		0.2
SAHNISPORITES	SP. A													
VESICASPORA	WILSONII	1.5	1.5	1.5	0.8	4.0	5.5	6.3	2.8	2.5	0.8	1.8	1.3	2.4
KOSANKEISPORITES	ELEGANS			0.3								0.5	1.0	0.1
	SP. A													
PITYOSPORITES	SP. A												0.3	TR
SCHOPFIPOLLENITES	ELLIPSOIDES		1.0	1.8	0.3		0.5	0.5		0.3				0.3
GENUS A	SP.													
CUMULATIVE TOTAL		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6*

Genus	Species	OPC 374 A	B	C	D	E	F	G	H	I	CUM %
PUNCTATISPORITES	DENTATUS		0.3	0.3	0.3						0.1
	LATIGRANIFER	2.0	1.0	0.5		0.5	0.3	0.8	0.5	0.5	0.6
	MUNDUS		0.3			0.3	0.3				0.1
	OBLIQUUS	1.3	1.0	2.5	1.8	5.0	5.0	5.5	3.5	3.5	3.4
	SETULOSUS				0.3					0.3	TR
	TRIANGULARIS								0.3		TR
CALAMOSPORA	BREVIRADIATA	15.3	8.8	10.3	10.8	13.3	11.5	9.0	13.0	17.8	12.1
	DECORA			0.3	0.8	0.3		0.3	0.3		0.2
	HARTUNGIANA	0.5	0.3								0.1
	LIQUIDA	3.0	2.8	4.0	2.3	1.5	1.8	1.5	1.5	2.8	2.3
	MUTABILIS					0.3					
	PEDATA	4.5	1.0	5.0	0.3	2.5	0.8	0.5	2.5	1.8	2.0
	STRAMINEA	1.7	1.5		1.5	1.0	0.8	0.3		2.0	0.9
	SP. A	2.5	3.5	0.5				0.8			0.7
	SP. B	1.3	0.8	0.3				0.3	0.8	0.5	0.4
GRANULATISPORITES	PIROFORMIS	5.3	1.8	0.8	1.8	1.8	0.5	1.3	0.5		1.5
	SPINOSUS	1.3			0.8	0.8	3.8	1.8	2.0	0.3	1.1
	VERRUCOSUS										
RAISTRICKIA	CRINITA	0.3	0.8	0.8	0.8	0.5	0.5	0.5	1.3	0.3	0.6
	CROCEA							0.3			TR
	IMBRICATA										
	SOLARIA			0.8		0.3		0.3	0.5	0.3	0.2
	SP. A						0.3		0.3		TR
	SP. B										
	SP. C										
	SP. D										
CONVOLUTISPORA	FLORIDA										
CONVERRUCOSISPORITES	MOSAICOIDES					0.3					TR
	SULCATUS				0.5						TR
VERRUCOSISPORITES	SP. A										
SCHOPFITES	COLCHESTERENSIS			1.0	0.3	0.5	0.5	0.8	0.5	0.3	0.4
MICRORETICULATISPORITES	FENESTRATUS	0.3	2.0		0.3		0.3				0.5
	FOVEATUS	0.3	5.5	0.3	1.8	0.5	1.0	0.3	0.5		1.1
	QUAESITUS	0.5	1.8				0.3				0.3
TRIQUITRITES	ADDITUS	0.5	1.8	0.3	1.0	0.5	0.8		0.5		0.8
	EXIGUUS										
	BRANSONII	1.8	2.3	4.0	6.8	4.8	2.3	2.3	4.5	0.8	3.3
	INUSITATUS			0.3			0.3				TR
	SPINOSUS										
	TUMULUS	0.3	0.7	1.3	0.8	1.0				0.3	0.5
LYCOSPORA	GRANULATA	22.3	25.3	12.3	25.0	19.5	17.5	20.8	7.8	27.5	19.7
	PSEUDOANNULATA	0.5	6.5	3.8	2.8	1.3	1.8	1.3	1.3	0.5	2.3
	TORQUIFER					0.3					TR.
	SP. A								0.3		TR
	SP. B			0.5							TR
	SP. C									0.3	TR
CIRRATRIRADITES	MACULATUS			0.3	0.3	0.3	0.5	0.3	0.8	1.3	0.4
LAEVIGATOSPORITES	DESMOINENSIS	1.0	2.3	3.0	1.0	1.8	2.3	0.5	1.5	2.0	1.7
	LATUS		0.3	0.5	0.5					0.5	0.2
	MEDIUS			0.3	0.8	1.0	0.3	0.3		0.8	0.3
	MINUTUS	11.3	12.5	25.0	14.0	16.8	25.8	26.7	6.3	4.8	15.9
	MINIMUS	2.8	1.5	1.0	1.3	0.8	1.3	2.3	0.8		1.3
	OVALIS	2.7	5.3	5.0	3.0	1.8	1.8	0.8	1.5	3.3	2.8
	PUNCTATUS	3.0	6.5	3.0	1.3	4.3	3.8	3.6	1.8	1.6	3.1
VERRUCOSOSPORITES	PSEUDOTHIESSENII	4.3		2.8	10.8	6.8	6.5	10.0	26.8	15.6	9.4
SPENCERISPORITES	SP. A								0.8	0.3	0.1
ENDOSPORITES	MINUTUS	0.8		0.3							0.1
	ORNATUS			0.3							TR.
	PALLIDUS	1.0	0.5		0.3	0.3			0.3		0.2
WILSONITES	DELICATUS			0.3				0.3	0.3		0.1
	VESICATUS			1.0	1.3	1.8	3.8	2.8	3.5	2.8	1.9
GUTHORLISPORITES	SP. A								1.5	1.0	0.3
VESTISPORA	PROFUNDA	4.0	2.3	2.8	2.3	4.0	2.0	1.3	1.8	2.5	2.5
FLORINITES	ELEGANS										TR
	PARVUS							0.3	0.8	0.5	0.1
	PELLUCIDUS			0.5	0.3	1.0	0.5	1.0	4.3	2.5	1.1
	SIMILIS					0.3					TR
ILLINITES	UNICUS	0.3		0.6	0.5		0.8				0.2
SAHNISPORITES	SP. A										
VESICASPORA	WILSONII		1.3	5.0	2.3	4.0	2.0	2.0	2.0	0.8	2.2
KOSANKEISPORITES	ELEGANS									0.3	TR.
	SP. A										
PITYOSPORITES	SP. A			0.3			0.3			0.3	0.1
SCHOPFIPOLLENITES	ELLIPSOIDES			0.3							TR.
GENUS A	SP.										
CUMULATIVE TOTAL		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6

Genus	Species	OPC 687 A	B	C	D	E	F	G	H	CUM %
PUNCTATISPORITES	DENTATUS									
	LATIGRANIFER									
	MUNDUS									
	OBLIQUUS		4.5	1.0	5.0	0.8		2.8		2.8
	SETULOSUS									
	TRIANGULARIS									
CALAMOSPORA	BREVIRADIATA		10.0	5.5	5.3	8.5	X	11.8	X	8.2
	DECORA									
	HARTUNGIANA									
	LIQUIDA		10.5	3.5	2.8	1.8		0.6		3.8
	MUTABILIS		0.5	1.5	0.5	0.5				0.6
	PEDATA		2.0	1.8	1.8	1.0		2.0		1.7
	STRAMINEA		4.8	2.5	5.5	3.5		4.5	X	3.7
	SP. A									
	SP. B		1.8	1.5	4.0	2.0		1.0	X	2.0
GRANULATISPORITES	PIROFORMIS		2.0							0.4
	SPINOSUS									
	VERRUCOSUS									
RAISTRICKIA	CRINITA									
	CROCEA									
	IMBRICATA									
	SOLARIA							0.3		TR
	SP. A									
	SP. B									
	SP. C									
	SP. D									
CONVOLUTISPORA	FLORIDA									
CONVERRUCOSISPORITES	MOSAICOIDES									
	SULCATUS									
VERRUCOSISPORITES	SP. A									
SCHOPFITES	COLCHESTERENSIS			0.5	0.5					0.2
MICRORETICULATISPORITES	FENESTRATUS									
	FOVEATUS									
	QUAESITUS									
TRIQUITRITES	ADDITUS		0.6							0.1
	EXIGUUS									
	BRANSONII		3.3	3.3	1.5	1.3		4.3	X	2.7
	INUSITATUS									
	SPINOSUS									
	TUMULUS									
LYCOSPORA	GRANULATA		3.3	1.0	3.3	5.0	X	4.5	X	3.6
	PSEUDOANNULATA					1.0				0.2
	TORQUIFER									
	SP. A									
	SP. B									
	SP. C									
CIRRATRIRADITES	MACULATUS							0.3		TR
LAEVIGATOSPORITES	DESMOINENSIS		6.0	6.8	2.5	2.0		1.8		3.7
	LATUS		0.8	0.5		0.3				0.3
	MEDIUS		6.8	3.3	1.5	1.8		1.0		3.0
	MINUTUS		6.8	17.0	8.5	8.5	X	10.3	X	9.8
	MINIMUS		1.0	0.8	1.0					0.5
	OVALIS		11.3	10.3	4.5	2.8		2.5		6.2
	PUNCTATUS		2.0	1.5	1.6	2.6	X	1.5		1.8
VERRUCOSOSPORITES	PSEUDOTHIESSENII		2.0	3.3	6.0	2.6	X	28.8	X	8.0
SPENCERISPORITES	SP. A				0.8	0.3				0.1
ENDOSPORITES	MINUTUS			0.3		0.3				0.1
	ORNATUS									
	PALLIDUS									
WILSONITES	DELICATUS		0.8	1.5	1.3	1.3		0.8		1.0
	VESICATUS		6.8	9.7	20.8	30.5	X	11.5	X	15.8
GUTHORLISPORITES	SP. A							4.0		0.8
VESTISPORA	PROFUNDA		2.8	5.5	2.8	1.8				2.1
FLORINITES	ELEGANS				0.5					0.1
	PARVUS				0.5			0.6		0.2
	PELLUCIDUS		1.6	1.8	3.8	1.5	X	4.5	X	2.6
	SIMILIS							0.3		TR
ILLINITES	UNICUS		0.8	2.3	0.8	0.8		0.3		0.9
SAHNISPORITES	SP. A			0.3						TR.
VESICASPORA	WILSONII		8.8	11.8	10.8	19.6	X	2.5	X	9.9
KOSANKEISPORITES	ELEGANS		0.8	1.0				0.3		0.4
	SP. A									
PITYOSPORITES	SP. A			0.3	0.3					0.1
SCHOPFIPOLLENITES	ELLIPSOIDES		0.8	1.0	2.8	1.0				1.0
GENUS A	SP.									
CUMULATIVE TOTAL		0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.1*

TABLE 6 DATA OF THE VARIOUS SAMPLE LEVELS EXPRESSED IN PERCENTAGS. CUMULATIVE VALUES (*) DO NOT TOTAL 100 PERCENT DUE TO ROUNDING OF FRACTIONS AND THE NONINCLUSION OF VALUES WHICH AMOUNT TO LESS THAN 0.1 PERCENT (TR). OCCURRENCES OF SPECIES IN LEVELS SPARSELY FOSSILIFEROUS OR PRACTICALLY BARREN (X) ARE MERELY NOTED AND NOT INCLUDED IN THE CALCULATED TOTALS.