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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

PALYNOLOGY OF THE MINERAL COAL (PENNSYLVANIAN) OF OKLAHOMA AND KANSAS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

JAMES B. URBAN

Norman, Oklahoma

1962

PALYNOLOGY OF THE MINERAL COAL (PENNSYLVANIAN) OF OKLAHOMA AND KANSAS

APPROVED BY

DISSERTATION COMMITTEE

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PALYNOLOGY OF THE MINERAL COAL (PENNSYLVANIAN) OF OKLAHOMA AND KANSAS*

INTRODUCTION

This palynological investigation of the Mineral coal was begun in the summer of 1960 with the following objectives: (1) identify previously described palynological taxa and describe any new taxa that might be encountered; (2) relate affinities whenever possible; (3) examine the possible ecological implications of the spore flora spectra; and (4) investigate correlation procedure employed with coal seams. The Mineral coal lends itself well to such a study because the preservation of the fossil material is in general excellent, the coal is sufficiently persistent to allow successional development, and the lateral extent is sufficient to point out geographical variation.

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*The National Science Foundation gave financial aid under Grant No. G6589.

Published palynological studies of the Mineral coal (Wilson and Hoffmeister, 1956 and 1958) are generalized and deal with the stratigraphic ranges of spore genera in the Cabaniss coals of Oklahoma.

Acknowledgments

Dr. L. R. Wilson, Professor of Geology at The University of Oklahoma, directed this dissertation.

Dr. C. C. Branson, Director of the School of Geology, The University of Oklahoma, gave suggestions.

The following persons served on the doctoral committee: Dr. G. Goodman, Department of Botany, and Dr. E. A. Frederickson, Dr. C. A. Merritt, and Dr. R. W. Harris, School of Geology.

Dr. B. S. Venkatachala, Birbal Sahni Institute of Lucknow, India, discussed various palynological concepts.

To my wife, a special debt of gratitude is owed.

STRATIGRAPHY

The Mineral coal received its name from that of the town of Mineral in northwestern Cherokee County, Kansas (Pierce and Courtier, 1937). In that area it has been the most important strip-mined coal, but is now second in importance to the Weir-Pittsburg bed (Howe, 1956). Locally this coal has been variously termed "Weir-Pittsburg upper," "Lightning Creek," "Baxter," "22-inch," "top vein," and "upper seam." The first two names have been used in publications, but have since been proved not representative of the coal bed for which they were intended (Pierce and Courtier, 1937). In Oklahoma the Mineral coal has been referred to locally as "the Welch coal" due to its proximity to the town of Welch, Oklahoma.

The southernmost occurrence of the coal bed is in Craig County, Oklahoma, approximately three miles south of the studied section OPC 621. From that locality it extends northward and eastward through Cherokee, Crawford, Labette, and Bourbon Counties of Kansas, and into Missouri (fig. 1).

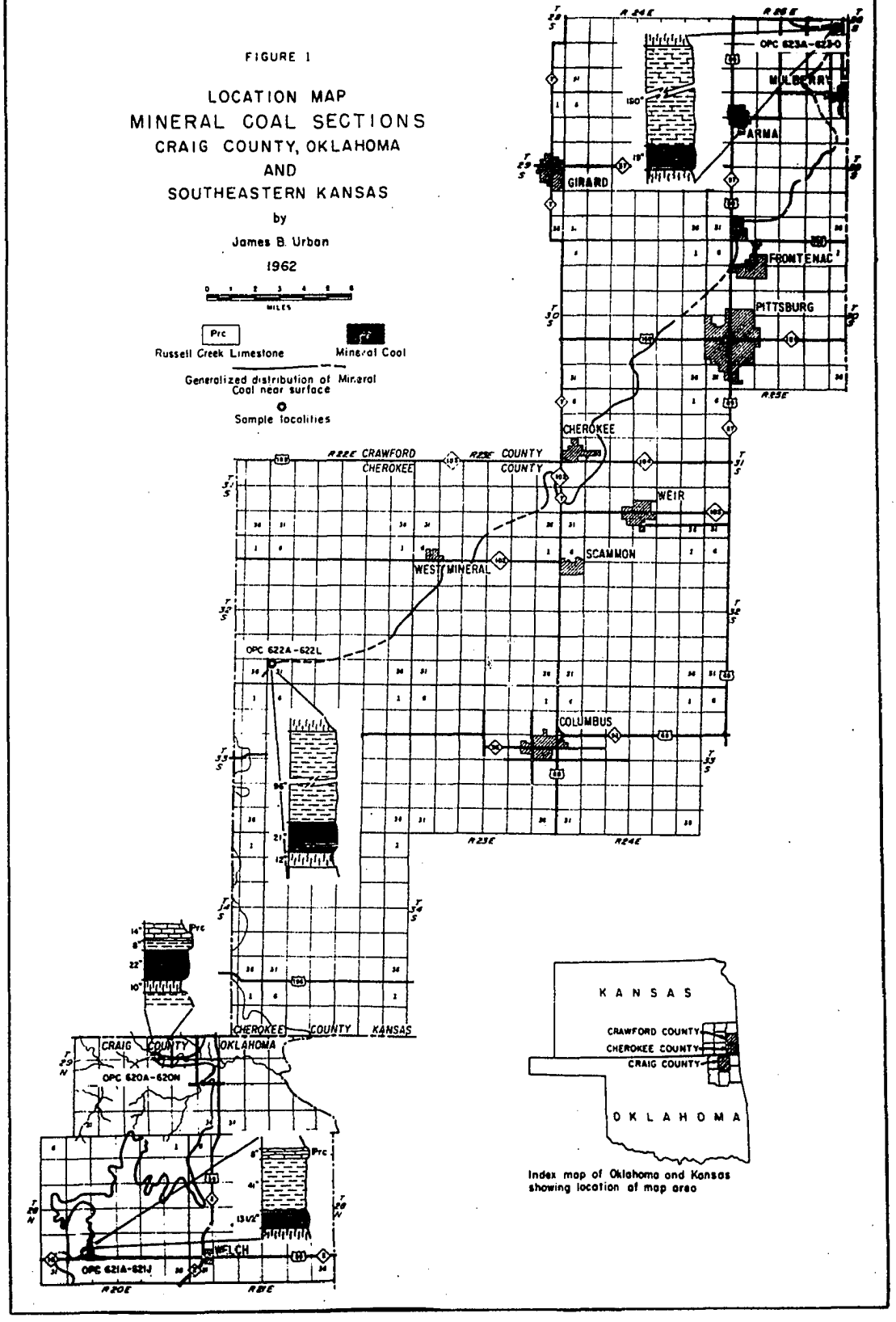
FIGURE 1

LOCATION MAP
MINERAL COAL SECTIONS
CRAIG COUNTY, OKLAHOMA
AND
SOUTHEASTERN KANSAS

by

James B. Urban

1962



Index map of Oklahoma and Kansas showing location of map area

It is believed to be equivalent to the DeKoven (No. 7) coal of western Kentucky, the Dekoven coal of southeastern and southwestern Illinois, and the Greenbush coal of northern Illinois (Kosanke et al., 1960).

According to the Oklahoma system of stratigraphic nomenclature the Mineral coal is in the lower part of the Senora Formation of the Cabaniss Group. In Craig County, Oklahoma, the coal is a few inches to three or four feet beneath the Russell Creek Limestone. This limestone is readily observed around strip pits in the waste heaps.

In Kansas the Senora is classified as the Cabaniss Formation. In isolated places in southeastern Cherokee County, according to Howe (1956), the Russell Creek Limestone is present. The Kansas sections studied by the writer did not have the limestone cap rock. These sections (OPC 622 and OPC 623) are overlain by a black, carbonaceous, calcareous shale that is highly fossiliferous and contains phosphatic nodules. This, according to Howe (1956), is the "normal" sequence where the limestone is absent.

Underclays are present beneath all four sampled coal sections and varied from 10 to 12 inches in thickness. The underclay beneath the coal at Mulberry, Kansas, (OPC 623) contains numerous plant impressions.

The coal varies from a feather edge at one locality observed by the writer in northern Craig County, Oklahoma, to a maximum reported thickness of 32 inches in Cherokee County, Kansas (Howe, 1956). Howe also listed the general thickness of the coal as 18 to 24 inches. Three of the sections sampled by the writer were within this "average" whereas the fourth and southernmost section (OPC 621) from SW¼ SE¼ sec. 28, T. 28 N., R. 20 E., west of Welch, Oklahoma, is only 13½ inches thick.

Stratigraphic Classification of the Des Moines Supergroup (Middle Pennsylvanian) of Northeastern Oklahoma and Southeastern Kansas

Modified from C. C. Branson, 1962

Oklahoma Platform	Kansas
Marmaton Group	Marmaton Group
Holdenville Shale	Holdenville Shale
Lenapah Limestone	Lenapah Limestone
Nowata Shale	Nowata Shale
Altamont Limestone	Altamont Limestone
Bandera Shale	Bandera Shale
Pawnee Limestone	Pawnee Limestone
Labette Formation	Labette Formation
Fort Scott Limestone	Fort Scott Limestone
Cabaniss Group	Cherokee Group
Senora Formation	Cabaniss Formation
	Mulky coal
Iron Post coal	
Bevier coal	
	Wheeler coal
Croweburg coal	Croweburg coal
	Fleming coal
Mineral coal	Mineral coal
	Scammon coal
Tebo coal	Tebo coal
Weir-Pittsburg coal	Weir-Pittsburg coal
Krebs Group	Krebs Formation
Boggy Formation	
Savanna Formation	
McAlester Formation	
Hartshorne Formation	

COLLECTIONS

Four sections of Mineral coal from different localities (fig. 1) were measured and collected during the summer of 1960. Channel samples were taken of the coal plus two inches each of the underclay and roof shales. The coal samples were taken generally as a one-inch segment at the base with the remainder divided into two-inch segments except where certain lithologic peculiarities exist and then the sample was divided according to the lithology. Each section was assigned an Oklahoma Palynological Collection (OPC) number and the unused part of the sample is now in the collection of the Oklahoma Geological Survey, Norman, Oklahoma. In addition to the section number, the samples were designated alphabetically A, B, C, etc., from the underclay upward through the coal and into the roof shale.

TABLE 1

SECTIONS OF THE MINERAL COAL AND POSITION OF SEGMENT SAMPLES

OPC 621: 250 yards northwest of Grandview School House, dug out of a ditch running south out of an abandoned strip pit; SW¼ SE¼ sec. 29, T. 28 N., R. 20 E.

Lithology	Thickness (inches)
Limestone, silty, fossiliferous, tan	8.0
Shale, blocky, calcareous, tan	41.0
Mineral coal	12.5
Underclay	10.0

Sample No.	Lithology	Thickness of bed (inches)	Measurement above base of coal (inches)
OPC 621 J	shale	2	13.5-15.5
OPC 621 I	coal	1	12.5-13.5
OPC 621 H	coal	2	10.5-12.5
OPC 621 G	coal	2	8.5-10.5
OPC 621 F	coal	2	6.5- 8.5
OPC 621 E	coal	2	4.5- 6.5
OPC 621 D	coal	2.5	2.0- 4.5
OPC 621 C	coal	1	1.0- 2.0
OPC 621 B	coal	1	0.0- 1.0
OPC 621 A	underclay	2	below coal

TABLE 1--Continued

OPC 620: East bank of Russell Creek on the farm of Mrs. Leep, NE¼ SW¼ sec. 15, T. 29 N., R. 20 E.

Lithology	Thickness (inches)
Limestone, silty, fossiliferous, tan	14.0
Shale, fissile, calcareous, tan	8.0
Mineral coal	22.0
Underclay	10.0

Sample No.	Lithology	Thickness of bed (inches)	Measurement above base of coal (inches)
OPC 620 N	shale	2	22.0-24.0
OPC 620 M	coal	1	21.0-22.0
OPC 620 L	coal	2	19.0-21.0
OPC 620 K	coal	2	17.0-19.0
OPC 620 J	coal	2	15.0-17.0
OPC 620 I	coal	2	13.0-15.0
OPC 620 H	coal	2	11.0-13.0
OPC 620 G	coal	2	9.0-11.0
OPC 620 F	coal	2	7.0- 9.0
OPC 620 E	coal	2	5.0- 7.0
OPC 620 D	coal	2	3.0- 5.0
OPC 620 C	coal	2	1.0- 3.0
OPC 620 B	coal	1	0.0- 1.0
OPC 620 A	underclay	2	below coal

TABLE 1--Continued

OPC 622: Pittsburg-Midway Coal Company pit in the C NW¼ sec. 34, T. 32 S., R. 22 E. near Hallowell, Cherokee County, Kansas.

Lithology	Thickness (inches)
Fleming coal	18.0
Underclay	12.0
Shale, fissile, calcareous, fossiliferous, phosphatic nodules, black	180.0
Mineral coal	19.0
Underclay	not measured

Sample No.	Lithology	Thickness of bed (inches)	Measurement above base of coal (inches)
OPC 622 L	shale	2	19.0-21.0
OPC 622 K	coal	1	18.0-19.0
OPC 622 J	coal	2	16.0-18.0
OPC 622 I	coal	2	14.0-16.0
OPC 622 H	coal	2	12.0-14.0
OPC 622 G	coal	2	10.0-12.0
OPC 622 F	coal	2	8.0-10.0
OPC 622 E	coal	2	6.0- 8.0
OPC 622 D	coal	2	4.0- 6.0
OPC 622 C	coal	2	2.0- 4.0
OPC 622 B	coal	2	0.0- 2.0
OPC 622 A	underclay	2	below coal

TABLE 1--Continued

OPC 623: Bench on the east side of the high wall of an abandoned strip pit 2½ miles north of Mulberry, Crawford County, Kansas.

Lithology	Thickness (inches)
Fleming coal	9.0
Underclay	32.0
Shale, fissile, calcareous, phosphatic, black	96.0
Mineral coal	21.0
Underclay	12.0

Sample No.	Lithology	Thickness of bed (inches)	Measurement above base of coal (inches)
OPC 623 M	shale	2	21.0-23.0
OPC 623 L	coal	2	19.0-21.0
OPC 623 K	coal	2	17.0-19.0
OPC 623 J	coal	2	15.0-17.0
OPC 623 I	coal	2	13.0-15.0
OPC 623 H	coal	2	11.0-13.0
OPC 623 G	coal	2	9.0-11.0
OPC 623 F	coal	2	7.0- 9.0
OPC 623 E	coal	2	5.0- 7.0
OPC 623 D	coal	2	3.0- 5.0
OPC 623 C	coal	2	1.0- 3.0
OPC 623 B	coal	1	0.0- 1.0
OPC 623 A	underclay	2	below coal

SAMPLE PREPARATION AND STUDY

Laboratory techniques used in this research are essentially those outlined by Wilson (1959b). Each sample was crushed and thoroughly mixed. A 10-gram portion from each sample was placed in a polyethylene beaker and covered with hydrofluoric acid (52 percent) for 24 hours. Residues were washed with water to remove the acid. The residues were then mixed with an equal volume of dry powdered potassium chlorate and covered with concentrated nitric acid. After standing 10 to 14 hours (each sample checked as to progress) the residues were again washed until free of acid. They were then treated with a saturated solution of potassium carbonate 5 to 25 minutes depending upon progress of maceration. The potassium carbonate was then removed by washing with distilled water. The residue was stored in an aqueous solution containing a few drops of acetic acid as a preservative.

The fossil material was stained with Bismark Brown at the time the slides were prepared. Two hundred and forty-

five microscope slides (five from each sample) were prepared from the residues.

The slides were studied with the aid of a Leitz Ortholux compound binocular microscope using 12x periplan oculars and 40x and 90x objectives. The latter (oil immersion) objective had a numerical aperture of 1.35. Each slide was examined by systematic horizontal traverses. Microfossils selected for photographing were ringed with glass-marking ink.

Notations regarding specimens refer to sample, slide, and ring numbers. For example, OPC 620 E 3-1 refers to the samples of section 620 of the Oklahoma Palynological Collection, level E of the sampled section, and ring number 1 of the third slide prepared from level E. The selected specimens were photographed with a Zeiss Photomicroscope on 35 mm Adox KB-14 film. Prints were made by enlargment on single-weight, Kodabromide No. 5 paper.

Assemblage counts were made after identifications were completed. A total of 250 fossils was counted from each level, using all five slides from each level to give random sampling. Relative percentages of species from each level were calculated and the results plotted as histograms.

PALEONTOLOGY

The fossil spore-pollen flora of the Mineral coal encountered in this study consists of 29 genera and 76 species. Four genera and 11 species are considered to be undescribed. Slides containing the newly described types as well as all other specimens figured are on file in the Oklahoma Geological Survey repository.

The preservation of the fossil material is generally good except the lower part of OPC 620, which shows great deterioration. The underclays and roof shales of all four sections were barren.

The system of taxonomic classification employed in this study is intended to be a modification of the general taxonomic practices of the present day. The emendation work of Schopf, Wilson, and Bentall (1944) serves as the fundamental reference for this classification. A close analysis was made of the emendation work of Potonié and Kremp (1954) which was further emended by Potonié (1956, 1958, 1960),

partially modified by Bhardwaj (1955), and numerous other authors. Each taxonomic transfer is analyzed and discussed. The writer has employed a conservative approach because of the tendency in some palynological literature to overlook the species as the fundamental taxonomic unit.

SPORAE DISPERSAE

Anteturma Sporites H. Potonié, 1893

FUNGUS SPORE SP. A

Plate 7, figure 13

Spore chain bilateral, spores 3 to 4 in number, non-aperturate; overall length 45 microns; average cell size approximately 12x12 microns; cell walls less than 1 micron thick, surface laevigate, constrictions between cells thickened; some spores tend to become biseriate at top of chain.

This spore was noted in level F of OPC 622.

Figured specimen: OPC 622 F 2-4

Anteturma Sporites H. Potonié, 1893

Turma Triletes Reinsch, 1881

Subturma Azonotriletes Luber, 1935

Infraturma Laevigati (Bennie and Kidston, 1886), R. Potonié, 1956

Genus PUNCTATISPORITES (Ibrahim, 1932) emend. Schopf, Wilson and Bentall, 1944

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

1932 Sporonites punctatus Ibrahim, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B., vol. 67, p. 448, pl. 15, fig. 18.

1933 Punctati-sporites punctatus (Ibrahim, 1932), Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers. Würzburg, Konrad Triltsch, p. 21, pl. 2, fig. 18.

1944 Punctati-sporites punctatus (Ibrahim, 1932), Schopf, Wilson and Bentall, Illinois Geol. Survey, Rept. Invest., No. 91, p. 31.

The use of the Schopf, Wilson and Bentall emendation of the genus Punctatisporites, rather than that of Potonié and Kremp, causes the assignment of some species to the Infraturma Laevigati to be rather dubious. They would perhaps be more properly placed in the Infraturma Apiculati.

PUNCTATISPORITES cf. P. AUREUS (Loose, 1934), Schopf, Wilson and Bentall, 1944

Plate 1, figure 1

1934 Reticulati-sporites aureus Loose,

Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, no. 3, p. 155, pl. 7, fig. 24.

1944 Punctati-sporites aureus (Loose, 1934), Schopf, Wilson and Bentall, Illinois Geol. Survey, Rept. Invest. 91, p. 31.

The species is a rare element of the Mineral coal spore flora. It was recorded in only two of the four sections (OPC 620 and OPC 623) and the percentage values of the species were insignificant (see fig. 1).

Potonié and Kremp (1954) transferred this species to the genus Cyclogranisporites. The writer is of the opinion that the genus Cyclogranisporites is established on characteristics that are too gradational and variable to be of generic rank. Consequently, the species is retained within Punctatisporites according to the emendation of Schopf, Wilson and Bentall, 1944.

Potonié and Kremp (1955) reported the species from the Ruhr region as ranging from upper Westphalian B to middle Westphalian C. Bhardwaj (1957) listed the species from the Saar coals ranging through the Stephanian B and C. Imgrund (1960) reported the species from the lower Permian of the Kaiping Basin of China. The figured specimen does not, however, appear to conform to the specific diagnosis. This

species has not been reported from Oklahoma prior to this time.

Figured Specimen: OPC 623 B 5-8

PUNCTATISPORITES LATIGRANIFER (Loose, 1932),
Schopf, Wilson and Bentall, 1944
Plate 1, figure 3

1932 Sporonites latigranifer Loose, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 452, pl. 19, fig. 54.

1934 Granulati-sporites latigranifer (Loose, 1932), Loose, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, no. 3, p. 147.

1944 Punctati-sporites latigranifer (Loose, 1932), Schopf, Wilson and Bentall, Illinois Geol. Survey, Rept. Invest. 91, p. 31.

Punctatisporites latigranifer was noted in all four sections. The occurrence is minor, with a maximum abundance in OPC 623 of 1.2 percent.

Potonié and Kremp (1955) transferred this species to the genus Apiculatisporis. As previously stated, the writer is not in agreement with the establishment of genera on the

basis of exine ornamentation of such a variable nature. P. latigranifer illustrates well the difficulty of such assignment. In many cases grana and minute apiculae occur on the same specimen. Generic assignment according to ornamentation could quite possibly result in this species' being placed in either Cyclogranisporites or Apiculatisporis or both. Certainly when an individual grain can exhibit such variation, a generic assignment on such characters is dubious. Therefore, the writer does not accept this transfer.

Kosanke (1950) reported the species from the upper part of the Kewanee Group and throughout the McLeansboro Group of Illinois. Schemel (1951) reported the species from the Mystic coal of Iowa. P. latigranifer has been recorded from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Rowe (Davis, 1961), Secor (Clarke, 1961), Tebo (Ruffin, 1961), and Iron Post (Gibson, 1961). Potonié and Kremp (1955) reported the species from the upper Westphalian B horizon of the Ruhr Basin of Germany. Imgrund (1960) listed the species from the lower red beds (Stephanian) of the Kaiping Basin of China.

Figured specimen: OPC 621 B 3-2

PUNCTATISPORITES MINUTUS Kosanke, 1950

Plate 1, figure 7

P. minutus is a rare species in three of the studied sections (OPC 620, OPC 621, and OPC 622).

Only in the last section does it occur with any regularity, being present in four levels of the section. The maximum abundance figure is 0.8 percent.

Kosanke (1950) reported the species as occurring in the uppermost part of the McLeansboro Group of Illinois. Bhardwaj and Venkatachala (1957) recorded this species from the lowermost Permian of the Pfalz district, Bavaria.

Figured specimen: OPC 620 D 1-5

PUNCTATISPORITES OBESUS (Loose, 1932),
Potonié and Kremp, 1955

Plate 1, figure 2

1932 Sporonites obesus Loose,
in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 451, pl. 19, fig. 49.

1934 Laevigati-sporites obesus (Loose, 1932),
Loose, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, no. 3, p. 145.

1955 Punctatisporites obesus (Loose, 1932), Potonié and Kremp, Palaeontographica, Abt. B, vol. 98, p. 43, pl. 11, fig. 124.

This form is represented by a single occurrence in the northern Craig County, Oklahoma, section (OPC 621).

Potonié and Kremp (1955) reported P. obesus from the middle to the upper Westphalian B of the Ruhr region. Horst (1943) recorded the species ranging from the Namurian A to the Westphalian A of Mährisch-Ostrau and upper Silesia.

Figured specimen: OPC 621 E-2-2

PUNCTATISPORITES ORBICULARIS Kosanke, 1950

Plate 1, figure 8

This species is a minor element of the spore flora. It is present in all four sections with a maximum abundance of 0.8 percent in OPC 620.

Potonié and Kremp (1955) placed this species in the genus Cyclogranisporites. This placement is not deemed necessary by the writer and the transfer is not recognized. Kosanke (1950) reported the species from the coals of the upper part of the Kewanee Group through the upper part of the McLeansboro Group of Illinois. P. orbicularis has been recorded in Oklahoma from the Croweburg coal (Wilson and

Hoffmeister, 1956) and Rowe coal (Davis, 1961).

Potonié and Kremp (1955) recorded the species in the Westphalian B and C of the Ruhr region and Westphalian D of the Saar.

Figured specimen: OPC 620 L 3-1

PUNCTATISPORITES VERRUCIFER Kosanke, 1950

Plate 1, figure 6

P. verrucifer is present in three of the studied sections (OPC 620, OPC 622, and OPC 623). These occurrences are too minor to have any particular significance. Potonié and Kremp (1955) transferred this species to the genus Apiculatisporis. For reasons previously stated, this transfer is not recognized. Kosanke (1950) listed the species as occurring throughout the Kewanee Group of Illinois. In Oklahoma, P. verrucifer has been recorded from the Rowe coal (Davis, 1961) and Secor coal (Clarke, 1961).

Figured specimen: OPC 623 B 5-13

PUNCTATISPORITES SP. B (of Clarke, 1961)

Plate 1, figure 4

Spores radial; trilete; oval to circular in equatorial view; diameter 54 to 58 microns; known variation, 52 to 70 microns; ray length two-thirds the radius; wall 3-4

microns thick, granular, grana less than 1 micron wide, shows some anastomosing to give a slightly rugate appearance.

This species is rare in the Mineral coal assemblage and was observed in only one level (B) of section OPC 623. This form appears to be conspecific with P. sp. B of Clarke and P. sp. B of Ruffin.

Figured specimen: OPC 623 B 4-7

PUNCTATISPORITES species

Plate 1, figure 5

Spores radial; trilete; circular to subtriangular in equatorial view; diameter 57x60 microns, known variation 41 to 60 microns; ray length equal to the radius length; commissure may be slightly thickened; wall 1-3.2 microns thick, laevigate.

The wall thickness is quite variable in these forms, which may indicate that they represent different natural species that are morphologically similar. These forms are rare in the Mineral coal assemblage and were not encountered in the counts. Several specimens were observed during preliminary scanning and descriptive work.

Figured specimen: OPC 621 F 2-1

Genus CALAMOSPORA Schopf, Wilson, and Bentall, 1944

Genotype: Calamospora hartungiana Schopf, 1944 in Schopf, Wilson and Bentall.

CALAMOSPORA BREVIRADIATA Kosanke, 1950

Plate 1, figure 11

C. breviradiata was not noted in OPC 620 but was observed in the other three sections. It occurs in a single level, in the center of the coal seam, at OPC 621 and it has an abundance of 0.4 percent. It occurs in the topmost level (K) of OPC 622 with a maximum value of 2.4 percent and in OPC 623 the species is present throughout the section with a maximum value of 1.6 percent in the upper part of the section.

This species is reported ranging from the middle part of the Kewanee Group to the upper part of the McLeansboro Group of Illinois (Kosanke, 1950). Schemel (1951) recorded the species from the Mystic coal in Iowa. C. breviradiata has been reported from the following Oklahoma coals: Weir-Pittsburg (Secor?) (Higgins, 1960), Rowe (Davis, 1961), Croweburg (Wilson and Hoffmeister, 1956), Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961).

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 Stephanian C and the Westphalian D horizon of the Kaiping Basin of China. The specimen figured by Imgrund is of doubtful specific assignment. Bhardwaj (1957) listed the species as occurring in the Saar coals of Stephanian C age. Bhardwaj and Venkatachala (1957) recorded the species from the Stephanian C of the Pfalz district.

Figured specimen: OPC 622 J 1-9

CALAMOSPORA FLEXILIS Kosanke, 1950

Plate 1, figure 13

C. flexilis is present throughout all four sections. It has its highest relative percentage value in the bottom two samples of OPC 620 and OPC 621. The distribution in the remainder of these two sections is of a smaller value and remains fairly constant. OPC 622 shows a minimum value for the species at the bottom and a general increase to a maximum value of (5.1 percent) at the top. OPC 623 shows a fluctuation of values with no progressive trend indicated.

Kosanke (1950) described C. flexilis with a range from the middle of the McCormick Group to the middle of the Kewanee Group in Illinois. Guennel (1958) reported the

species from the Pottsville coals in Indiana. The species has been recorded from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Rowe (Davis, 1961), Secor (Clarke, 1961) and Tebo (Ruffin, 1961).

Figured specimen: OPC 623 B 1-7

CALAMOSPORA HARTUNGIANA Schopf, 1944

in Schopf, Wilson and Bentall

Plate 2, figure 1

The species is rare in the Mineral assemblage. It was recorded in two of the four sections (OPC 621 and OPC 622). Only in the latter was it observed during the assemblage counts. The other occurrence was noted during preliminary identification work.

Kosanke (1950) listed the stratigraphic range of the species as from the basal part of the Kewanee Group throughout the McLeansboro Group of Illinois. Schemel (1951) reported the species from the Mystic coal of Iowa.

Wilson and Hoffmeister (1956) recorded the species from the Croweburg coal and Gibson (1961) reported it from the Iron Post 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. The species has also been recorded in the Stephanian of the Tura district of France (Alpern, 1958). Bhardwaj (1957) reported the species from the Stephanian A horizon of the Saar coals.

Figured specimen: OPC 621 F 4-1

CALAMOSPORA MICRORUGOSA (Ibrahim, 1932)

Schopf, Wilson and Bentall, 1944

Plate 1, figure 9

1932 Sporonites microrugosus Ibrahim, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 447, pl. 14, fig. 9.

1933 Laevigati-sporites microrugosus (Ibrahim) Ibrahim Sporenformen des Aegirhorizonts des Ruh. Reviers: Konrad Triltsch, Würtzburg, p. 18, pl. 1, fig. 9.

1944 Calamospora microrugosa (Ibrahim, 1932) Schopf, Wilson and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 52.

C. microrugosa was noted in all four of the sections. The species was persistent only in OPC 622, being present throughout most of the section.

Kosanke (1950) reported C. microrugosa from the

middle of the McCormick Group of Illinois. The species has been recorded from the following Oklahoma coals: Rowe (Davis, 1961), and Secor (Clarke, 1961).

Potonié and Kremp (1955) reported the species from Westphalian B and C of the Ruhr region. Horst (1943) listed it from Mährisch-Ostrau and Upper Silesia ranging from Namurian to Westphalian A. Naumova (1937) recorded the species from the Karaganda Basin in the Lower Carboniferous.

Luber and Waltz (1938) listed the species from the Karaganda Basin and the Westphalian of the Donetz Basin. Imgrund (1960) reported it from the Lower Permian of the Kaiping Basin of China. Bhardwaj and Venkatachala (1957) reported it from the Stephanian C of the Pfalz district.

Figured specimen: OPC 623 B 2-1

CALAMOSPORA cf. C. PALLIDA (Loose, 1932),
Schopf, Wilson and Bentall, 1944
Plate 1, figure 10

1932 Sporonites pallidus Loose, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 449, pl. 18, fig. 31.

1933 Punctati-sporites pallidus (Loose, 1932),

Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 21.

1934 Punctati-sporites pallidus (Loose, 1932), Loose, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, p. 146.

1944 Calamospora pallidus (Loose, 1932), Shopf, Wilson and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 52.

C. pallida has the greatest abundance of all Calamospora species in the Mineral coal. With the exception of OPC 620, the general distribution of this species in the individual sections is from a minimum value at or near the bottom to a maximum near the middle and gradually declining toward the top with occasional resurgences. OPC 620 has this same pattern if the bottom three levels are omitted.

Potonié and Kremp reported the range of this species as being from upper Westphalian A to middle Westphalian C of the Ruhr region. This is the first occurrence known to the writer from other than European localities.

Figured specimen: OPC 622 C 3-4

CALAMOSPORA SAARIANA Bhardwaj, 1957

Plate 2, figure 2

This species was noted in OPC 622 and OPC 623. Its

distribution is irregular with no particular trend indicated. However, its occurrence in only these two sections may be significant in the interpretation of the swamp ecology. This possibility will be considered elsewhere.

Bhardwaj (1957) described the species from the Saar coals and listed the range as Stephanian A. Bhardwaj and Venkatachala (1957) listed the species from the Stephanian C of the Pfalz district.

Figured specimen: OPC 622 F 3-2

CALAMOSPORA STRAMINEA Wilson and Kosanke, 1944

Plate 1, figure 12

The species is a minor element in the Mineral coal assemblage and occurs uncommonly. It has a maximum percentage value of 3.8 in level B of OPC 620.

Guennel (1958) assigned C. straminea to Punctatisporites due to the possession of a relatively thick spore wall. The forms observed by the writer do exhibit folds typical of Calamospora; therefore the transfer is not recognized.

Wilson and Kosanke (1944) described the species from the Des Moines Supergroup of Iowa. Kosanke (1950) recorded it from the upper part of the Kewanee Group and the lower

part of the McLeansboro Group of Illinois. Guennel (1958) reported the species from the Pottsville coals of Indiana. Hoffmeister, Staplin and Malloy (1955) listed it from the Hardinsburg (late Mississippian) of Illinois. C. straminea has been recorded from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Weir-Pittsburg (Secor?) (Higgins, 1961), Secor (Clarke, 1961). To date, the species has not been reported from Europe.

Figured specimen: OPC 622 C 4-5

Infraturma Apiculati (Bennie and Kidston, 1886)
Potonié and Kremp, 1954

Genus GRANULATISPORITES (Ibrahim, 1933)
emend. Schopf, Wilson and Bentall, 1944

Genotype: Granulatisporites granulatus Ibrahim, 1933, Sporenformen des Aegirhorizonts des Ruhr-Reviers, Würzburg, Konrad Triltsch, p. 22, pl. 6, fig. 51.

Genus GRANULATISPORITES COMMISSURALIS Kosanke, 1950

Plate 3, figure 14

G. commissuralis is present in small numbers in all four sections. Only in sections OPC 620 and OPC 621 does it attain any persistence. In these two sections it is present

only in minor amounts (maximum of 1.2 percent).

Potonié and Kremp (1955) placed this species in the genus Lophotriletes. The genus Lophotriletes is defined on ornamentation. According to their definition the species of Granulatisporites are granular and those assigned to Lophotriletes are apiculate. The writer feels that these types of ornamentation are highly gradational and variable and certainly should not be considered as significant generic characters.

Kosanke (1950) described the species from the uppermost Kewanee Group through the McLeansboro Group. Morgan (1955) reported G. commissuralis from the McAlester coal of Oklahoma and Davis (1961) reported it from the Rowe coal. Potonié and Kremp (1955) reported the species from the middle Westphalian B of the Ruhr region. Bhardwaj (1957) recorded it from the Stephanian C of the Saar region. Bhardwaj and Venkatachala (1957) listed the species from the Stephanian C of the Pfalz district.

Figured specimen: OPC 621 F 1-4

GRANULATISPORITES CONVEXUS Kosanke, 1950

Plate 3, figure 12

G. convexus is present in three sections, but absent

from OPC 622. It has somewhat variable distribution and low percentage values (maximum of 1.6 percent).

Potonié and Kremp (1955) transferred this species to Leiotriletes, which is characterized by a laevigate spore coat. Kosanke (1950) described the species as having a "finely granulose" spore coat. The writer, therefore, does not accept this transfer.

Kosanke (1950) reported the species from the Kewanee Group of Illinois. Potonié and Kremp reported the species from middle to upper Westphalian D of the Ruhr region.

Figured specimen: OPC 623 C 4-2

GRANULATISPORITES DELTIFORMIS Wilson and Coe (1940), Schopf, Wilson and Bentall, 1944

Plate 3, figure 11

1940 Triquitrites deltoides Wilson and Coe, Amer. Midland Naturalist, vol. 23, no. 1, p. 185, fig. 9.

1944 Granulatisporites deltiformis Schopf, Wilson and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 32.

1944 non. Granulati-sporites deltoides (Ibrahim), Schopf, Wilson, and Bentall.

OPC 623 was the only section in which this species

was noted. It was observed in two levels during the assemblage counts with values of 0.4 percent.

Wilson and Coe (1940) described this species from the Des Moines Supergroup of Iowa. Guennel (1958) reported it from the Pottsville coals of Indiana. To date, it has been recorded from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Weir-Pittsburg (Secor?) (Higgins, 1960), and Rowe (Davis, 1961).

Figured specimen: OPC 623 E 8-6

GRANULATISPORITES LEVIS Kosanke, 1950

Plate 3, figure 10

G. levis is the most persistent and abundant species of the genus Granulatisporites. It is present in all four sections. The distribution is rather sporadic in OPC 620, but is more persistent in the other sections, and has greatest uniformity of abundance in OPC 623.

Potonié and Kremp transferred this species to Leiotriletes. The genus Leiotriletes is not recognized in this paper for reasons previously stated.

Kosanke (1950) described the species from the upper part of the McLeansboro Group of Illinois. Bhardwaj and Venkatachala (1957) reported the species from the Stephanian

C of the Pfalz district.

Figured specimen: OPC 621 G 2-2

GRANULATISPORITES MICROSAETOSUS (Loose, 1932), Schopf, Wilson and Bentall, 1944

1932 Sporonites microsaetosus Loose, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 450, pl. 18, fig. 40.

1933 Setosi-sporites microsaetosus (Loose, 1932), Loose, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, no. 3, p. 148.

1944 Granulati-sporites microsaetosus (Loose, 1932), Schopf, Wilson, and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 33.

This species was observed in only one section (OPC 622) and was encountered only in the two upper levels. The writer suggests this distribution may be indicative of a local geographic or ecologic condition.

Potonié and Kremp (1955) transferred this species to the genus Lophotriletes. In keeping with previously stated opinions, this transfer is not recognized. Guennel (1958) reported the species in the Pottsville coals of Indiana. In

Oklahoma the species has been reported to be in abundance in both the Weir-Pittsburg (Secor?) coal (Higgins, 1960) and the Tebo coal (Ruffin, 1961).

Figured specimen: OPC 621 C 4-2

GRANULATISPORITES PARVUS (Ibrahim, 1932),
Schopf, Wilson and Bentall, 1944
Plate 3, figure 15

1932 Sporonites parvus Ibrahim, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 448, pl. 15, fig. 21.

1933 Punctati-sporites parvus (Ibrahim, 1932), Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 21, pl. 2, fig. 21.

1934 Reticulati-sporites parvus (Ibrahim, 1932), Loose, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, p. 154, pl. 7, fig. 13.

This is a minor element of the Mineral coal assemblage. It is listed in three sections (OPC 621, OPC 622, and OPC 623), but it was observed during the counts from only two levels of OPC 622 with a maximum value of 0.8 percent.

Potonié and Kremp (1955) placed Granulatisporites

pallidus Kosanke, 1950, in synonomy with G. parvus. The writer does not agree with this synonomy and believes that the two species are distinct entities. Potonié and Kremp (1955) reported the species from the Westphalian B and lower Westphalian C of the Ruhr region. Horst (1943) reported the species as ranging from Namurian A to Westphalian A or Mährisch-Ostrau and Upper Silesia.

The species has been recorded from the following Oklahoma coals, Weir-Pittsburg (Secor?) (Higgins, 1960) and Rowe (Davis, 1961).

Figured specimen: OPC 621 C 4-2

Genus CONVERRUCOSISPORITES Potonié and Kremp, 1954

Genotype: Converrucosisporites triquetris (Ibrahim, 1933), Potonié and Kremp, 1954.

1933 Verrucosi-sporites triquetris Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 26, fig. 61.

1944 Granulati-sporites triquetris (Ibrahim, 1933), Schopf, Wilson, and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 33.

1954 Converrucosisporites triquetris Ibrahim (1933), Potonié and Kremp, Palaeontographica, Abt. B, vol.

98, p. 65, pl. 13, fig. 191.

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

Plate 3, figure 13

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

1955 Converrucosisporites sulcatus (Wilson and Kosanke, 1944), Potonié and Kremp, Teil I, Palaeontographica, Abt. B, vol. 98, p. 64.

C. sulcatus was noted in three sections, being absent from OPC 622 and it was observed in the upper part of OPC 621 and OPC 623. This distribution is in keeping with that of numerous species, which is indicative of a relatively late beginning of a "typical" coal swamp succession at OPC 620.

C. sulcatus was described by Wilson and Kosanke (1944) from the Des Moines Supergroup of Iowa. Kosanke (1950) reported it ranging from the uppermost part of the McCormick Group to the upper part of the McLeansboro Group of Illinois. Schemel (1951) recorded it from the Mystic coal of Iowa. Guennel (1958) reported it from the Pottsville coals of Indiana. The species has been recorded from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956),

Weir-Pittsburg (Secor?) (Higgins, 1960), Secor (Clarke, 1961), Iron Post (Gibson, 1961) and Tebo (Ruffin, 1961).

Figured specimen: OPC 623 B 3-7

Genus VERRUCOSISPORITES (Ibrahim, 1933), emend. Potonié and Kremp, 1955

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

1932 Sporonites verrucosis Ibrahim, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 448, pl. 15, fig. 17.

1933 Verrucosis-sporites verrucosus (Ibrahim, 1932), Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 26, pl. 2, fig. 17.

1944 Punctati-sporites verrucosus (Ibrahim, 1932), Schopf, Wilson and Bentall, Ill. Geol. Survey Rept. Invest. 91, p. 32.

1950 Verrucoso-sporites verrucosus (Ibrahim, 1932), Knox, Botanical Soc. Edinburgh, Trans., vol. 35, p. 319, fig. 230.

1955 Verrucosisporites verrucosus (Ibrahim, 1932),

Potonié and Kremp, Palaeontographica, Abt. B., vol. 98, p. 69, figs. 196-199.

VERRUCOSISPORITES cf. V. FIRMUS (Loose, 1934), Potonié and Kremp, 1955

Plate 3, figure 19

1934 Verrucosi-sporites firmus Loose, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, no. 3, p. 154, pl. 7, fig. 30.

This form was observed from only one level (K) of OPC 623 during preliminary scanning and descriptive work. Although several specimens were noted, it did not occur in the assemblage counts.

Potonié and Kremp (1955) reported this species from the upper Westphalian B of the Ruhr region.

Higgins (1960) reported V. firmus from the Weir-Pittsburg (Secor?) coal of Oklahoma.

Figured specimen: OPC 623 K 4-2

VERRUCOSISPORITES cf. V. DONARII Potonié and Kremp, 1955

Plate 3, figure 20

V. donarii was recorded from all four sections. It was found from only one level, in the upper part of OPC 620.

The other sections show it originating at or near the bottom and becoming more persistent through the sections northward.

Potonié and Kremp reported this form from the Westphalian B of the Ruhr region. Bhardwaj and Venkatachala (1957) recorded this species from the Stephanian C of the Pfalz district.

Figured specimen: OPC 623 B 8-2

VERRUCOSISPORITES GRANDIVERRUCOSUS

(Kosanke, 1943), comb. nov.

Plate 3, figure 18

1943 Punctatisporites grandiverrucosus Kosanke, Amer. Midland Naturalist, vol. 29, p. 127, pl. 3, fig. 4.

Kosanke (1943) described this species as "very characteristically verrucosely sculptured."

The species was recorded in only one section (OPC 622). It is rare in the Mineral coal assemblage, but enough specimens are available to study the diagnostic characters of the species and to recommend its transfer from the genus Punctatisporites to Verrucosisporites.

Figured specimen: OPC 622 F 1-2

Genus ANAPICULATISPORITES SPINOSUS (Kosanke, 1950), Potonie and Kremp, 1955

Plate 3, figure 17

1950 Granulatisporites spinosus Kosanke, Ill. Geol. Survey, Bull. 74, p. 22, pl. 3, fig. 7.

1955 Anapiculatisporites spinosus (Kosanke, 1950), Potonié and Kremp, Palaeontographica, Abt. B., vol. 98, p. 82.

A. spinosus was recorded in all four sections. It is present in the lower half of OPC 620 and OPC 621 although in minor numbers. The species is present throughout OPC 622 and 623 and shows a trend to increase in abundance toward the top.

This distribution closely corresponds to that of Densosporites and it is here suggested that they may have occupied similar ecologic situations.

Kosanke (1950) recorded this species from the upper part of the Kewanee Group of Illinois. Schemel (1951) recorded the species from the Mystic coal of Iowa. The species has been reported from the Rowe coal (Davis, 1961) and Iron Post coal (Gibson, 1961) of Oklahoma. Potonié and Kremp (1955) reported the species from the Westphalian C of the Ruhr Basin of Germany.

Figured specimen: OPC 623 K 1-2

Genus RAISTRICKIA Schopf, Wilson and Bentall, 1944

Genotype: Raistrickia grovensis Schopf, 1944 in Schopf, Wilson and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 55, fig. 3.

RAISTRICKIA ACULEATA Kosanke, 1950

Plate 2, figure 4

This species is present in all four sections and exhibits a distribution pattern paralleling that of Verrucosisporites donarii. It is present in the upper part of OPC 620 and the lower part of the other three sections and is more abundant in the northern sections.

Kosanke (1950) reported the species in the McCormick, Kewanee, and McLeansboro Groups of Illinois. There is no prior occurrence known to the writer.

Figured specimen: OPC 623 B 3-4

RAISTRICKIA ACULEOLATA Wilson and Kosanke, 1944

Plate 2, figure 3

R. aculeolata has a distribution pattern similar to that of Raistrickia aculeata in both occurrence and percentage

values.

The species was described from the Des Moines Supergroup of Iowa (Wilson and Kosanke, 1944). Kosanke (1950) reported it from the upper part of the McCormick Group through the Kewanee Group of Illinois. Schemel (1951) reported R. aculeolata from the Mystic coal of Iowa. Guennel (1958) reported the form in the Pottsville coals of Indiana. The species has been recorded from the following Oklahoma coals: Weir-Pittsburg (Secor?) (Higgins, 1960) and Rowe (Davis, 1961). Bhardwaj (1957) reported the species from the Stephanian C horizon of the Saar coals.

Figured specimen: OPC 623 B 7-4

RAISTRICKIA CRINITA? Kosanke, 1950

Plate 2, figure 9

A single specimen referred to this species was recorded in level 0 of OPC 622.

Kosanke (1950) reported the range of the species in Illinois as from the upper part of the McCormick Group to the lower part of the McLeansboro Group. The species has been recorded from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Iron Post (Gibson, 1961) and Tebo (Ruffin, 1961). The species has not been reported from

outside the United States to date.

Figured specimen: OPC 622 D 1-5

RAISTRICKIA CROCEA Kosanke, 1950

Plate 2, figure 6

R. crocea was observed in OPC 620 and OPC 623. The latter occurrence was in a single level (D). It is listed from four levels in the upper half of OPC 620.

Kosanke (1950) recorded the species from the upper portion of the Kewanee Group of Illinois. The species has been reported from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961).

Figured specimen: OPC 620 H 3-7

RAISTRICKIA cf. R. GROVENSIS Schopf, 1944,

in Schopf, Wilson and Bentall

Plate 2, figure 7

This species is rare in the Mineral coal assemblage, being recorded from levels of both OPC 620 and OPC 621. It is present in levels D and E of OPC 623.

Raistrickia grovensis was described from the Herrin (No. 6) coal bed of Illinois (Schopf, in Schopf, Wilson and Bentall, 1944). Kosanke (1943) reported the form from the

Pittsburgh coal of Ohio and (1950) from the Kewanee Group of Illinois. The species has been recorded from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956) and Rowe (Davis, 1961).

Figured specimen: OPC 621 E 2-1

RAISTRICKIA IRREGULARIS Kosanke, 1950

Plate 2, figure 10

The species is present in OPC 620, OPC 622, and OPC 623. Only in the last section does it attain any persistence, being present throughout the lower half. It has a stratigraphic distribution similar to that of R. aculeata and R. aculeolata.

Potonié and Kremp (1955) transferred this form to Apiculatisporis. This writer believes that the species exhibits typical Raistrickian ornamentation and therefore the transfer is not recognized.

Kosanke (1950) reported this species from the lower part of the Kewanee Group of Illinois. It has been previously noted in the Secor coal (Clarke, 1961). No European occurrence is reported.

Figured specimen: OPC 623 B 5-12

RAISTRICKIA SPINOSOSAETOSA (Loose, 1932),
Schopf, Wilson and Bentall, 1944
Plate 2, figure 5

1932 Sporonites spinososaetosus Loose, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 452, pl. 19, fig. 55.

1933 Apiculati-sporites spinososaetosus (Loose), Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 24.

1934 Apiculati-sporites spinososaetosus (Loose, 1932), Loose, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, no. 3, p. 153.

R. spinosososaetosus is a minor element of the Mineral coal assemblage but is present sporadically in all four sections.

Potonié and Kremp (1955) transferred this species to the genus Apiculatisporis. They noted that some projections are flat-topped, but indicated that they believed they were broken. The writer has observed this same feature and believes this to be a consistent character.

The species has not been previously recorded from the United States. Potonié and Kremp (1955) reported the

range of the species as upper Westphalian B to middle Westphalian C.

Figured specimen: OPC 623 C 3-13

Infraturma Murornati Potonié and Kremp, 1954

Genus CONVOLUTISPORA Hoffmeister, Staplin, and Malloy, 1955

Genotype: Convolutispora florida Hoffmeister, Staplin and Malloy, 1955, Jour. Paleontology, vol. 29, p. 384, pl. 38, figs. 5 and 6.

CONVOLUTISPORA sp. A

Plate 2, figure 12

Spores radial; trilete; circular in equatorial profile, originally spherical; trilete rays simple, four-fifths the radius; lips may be slightly thickened; spore wall thin, approximately 1.5 microns; spore coat ornamented with anastomosing vermiculate ridges 2-4 microns high and 2-6 microns wide, irregularly jointed to form a semi-reticulate or lacunate sculpture; holotype 49.2 microns in diameter, known size variation 42 to 53 microns.

This species is rare in the Mineral coal assemblage. It is present in level H of OPC 620 and level H of OPC 621.

Figured specimen: OPC 620 H 4-1

Genus RETICULATISPORITES (Ibrahim, 1933) emend. Schopf, Wilson and Bentall, 1944

Genotype: Reticulatisporites reticulatus (Ibrahim, 1932), Ibrahim, 1933, p. 33-34, pl. 1, fig. 3.

1932 Sporonites reticulatus Ibrahim in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 56, p. 447, pl. 14, fig. 3.

1933 Reticulati-sporites reticulatus (Ibrahim, 1932), Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 19, pl. 1, fig. 8.

RETICULATISPORITES LACUNOSUS Kosanke, 1950

Plate 2, figure 8

R. lacunosus was noted in three sections (OPC 620, OPC 621, and OPC 622). It is most persistent in OPC 620 where it occurs in the lower five samples with a maximum abundance of 5.8 percent. The preservation of spores in this particular level (C) is poor and only resistant types like R. lacunosus are recognizable. This fact may explain the apparent great abundance of the species. A similar

situation exists in level I of OPC 621. These samples had few well-preserved and identifiable forms other than Reticulatisporites and Vestispora.

R. lacunosus was described by Kosanke (1950) and listed from the upper part of the McCormick Group to the lowermost part of the Kewanee Group. In Oklahoma the species has been reported from the Weir-Pittsburg (Secor?) (Higgins, 1960) and the Secor (Clarke, 1961) coals.

Figured specimen: OPC 620 E 5-1

Turma Zonales (Bennie and Kidston, 1886, Ibrahim 1933) emend. R. Potonié, 1956

Subturma Auritotriletes Potonié and Kremp, 1954

Infraturma Auriculati (Schopf), R. Potonié, 1960

Genus TRIQUITRITES Wilson and Coe, 1940

Genotype: Triquitrites arculatus Wilson and Coe, 1940, Amer. Midland Naturalist, vol. 23, p. 185, fig. 8.

TRIQUITRITES ADDITUS Wilson and Hoffmeister, 1956

Plate 3, figure 7

This species is present in all four sections, but it is a minor element in OPC 620 and OPC 621. In OPC 622 and

OPC 623 it has greatest percentage values in the bottom levels of each; gradually it decreases in abundance toward the center of the sections. There it disappears from the counts.

This species was described from the Croweburg coal (Wilson and Hoffmeister, 1956). Guennel (1958) reported it from the Pottsville coals of Indiana. In addition to the Croweburg coal from which it was originally described, T. additus has been recorded from the following Oklahoma coals: Weir-Pittsburg (Secor?) (Higgins, 1960), Rowe (Davis, 1961), Secor (Clarke, 1961), Iron Post (Gibson, 1961) and Tebo (Ruffin, 1961).

Figured specimen: OPC 623 C 2-3

TRIQUITRITES BRANSONII Wilson and Hoffmeister, 1956

Plate 3, figures 4, 5

T. bransonii is the most abundant representative of the genus in the Mineral coal. It is present in all four sections. In OPC 620 it first appears midway through the section and continues to the top. The pattern in the other three sections is reversed. The species is present in the bottom levels and goes out midway through the sections. The writer suggests this species may be one of the pioneer

elements of Pennsylvanian coal swamp development.

T. bransonii was described from the Croweburg coal (Wilson and Hoffmeister, 1956). Guennel (1958) reported it from the Pottsville coals of Indiana. In addition to the Croweburg, the species has been reported from the following Oklahoma coals: Weir-Pittsburg (Secor?) (Higgins, 1960), Rowe (Davis, 1961), Secor (Clarke, 1961), Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961).

Figured specimens: OPC 620 H 2-7, OPC 623 D 6-1

TRIQUITRITES DIVIDUUS Wilson and Hoffmeister, 1956

Plate 3, figure 6

T. dividuus is present in the following three sections: OPC 620, OPC 621, and OPC 623. The distribution is somewhat irregular but coincides with the distribution of T. bransonii.

T. dividuus was described from the Croweburg coal (Wilson and Hoffmeister, 1956). Guennel (1958) reported it from the Pottsville coals of Indiana. In addition to the Croweburg, the species has been recorded in the following Oklahoma coals: Weir-Pittsburg (Secor?) (Higgins, 1960), Rowe (Davis, 1961), Secor (Clarke, 1961), and Tebo (Ruffin, 1961).

Figured specimen: OPC 623 B 2-15

TRIQUITRITES EXIGUUS Wilson and Kosanke, 1944

Plate 3, figure 8

The species is rare in the Mineral coal assemblage but is present in all four sections. Its distribution is coincident with that of the other species of Triquitrites.

T. exiguus was described from coals of the Des Moines Supergroup of Iowa by Wilson and Kosanke (1944). It has subsequently been reported from the Mystic coal of Iowa (Schemel, 1951), the upper part of the McCormick Group and the lower part of the Kewanee Group of Illinois (Kosanke, 1950), and from the Pottsville Series of Indiana (Guennel, 1958). In Oklahoma, it has been reported from the following coals: Croweburg (Wilson and Hoffmeister, 1956), Rowe (Davis, 1961), Secor (Clarke, 1961), and Iron Post (Gibson, 1961). To date the species has not been reported from outside the United States.

Figured specimen: OPC 620 H 1-3

TRIQUITRITES INUSITATUS Kosanke, 1950

Plate 3, figure 1

The species is rare in the Mineral coal assemblage. It is present in OPC 620, OPC 621, and OPC 623, and its

range coincides with the distribution of the other species of Triquitrites.

Neves (1958) established the genus Mooreisporites with T. inusitatus Kosanke as its type. It is here contended that the presence of "the club like projections" is a specific rather than a generic character.

Kosanke (1950) reported T. inusitatus from the lower part of the Kewanee Group of Illinois.

Schemel (1951) reported it from the Mystic coal of Iowa. In Oklahoma, the species has been recorded from the following coals: Croweburg (Wilson and Hoffmeister, 1956), Secor (Clarke, 1961), Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961).

Figured specimen: OPC 623 B 5-1

TRIQUITRITES PRAETEXTUS Wilson and Hoffmeister, 1956

Plate 3, figure 2

T. praetextus is rare in the Mineral coal assemblage and was observed only in OPC 622, and OPC 623 sections during the statistical counts.

The species was originally described from the Croweburg coal of Oklahoma by Wilson and Hoffmeister (1956). T. praetextus has also been reported from the Tebo coal by

Ruffin (1961).

Figured specimens: OPC 622 C 5-4

TRIQUITRITES PROTENSUS Kosanke, 1950

Plate 3, figure 9

T. protensus was observed in three sections, OPC 620, OPC 621, and OPC 623. It is a minor element of the Mineral coal assemblage.

Kosanke (1950) reported the species as occurring in Illinois from the upper McCormick Group through the McLeansboro Group. Higgins (1960) recorded the species from the Weir-Pittsburg (Secor?) coal of Oklahoma.

Figured specimen: OPC 623 D 6-3

TRIQUITRITES TUMULUS Wilson and Hoffmeister, 1956

Plate 3, figure 3

T. tumulus was observed in four levels, two in OPC 621 and two in OPC 623. It is a rare element and coincides with the distribution of all the other species of Triquitrites.

The species was described from the Croweburg coal of Oklahoma (Wilson and Hoffmeister, 1956). Gibson (1961) reported it from the Iron Post coal of Oklahoma.

Subturma Zonotriletes Waltz, 1935

Infraturma Cingulati Potonié and Klaus, 1954

Genus DENSOSPORITES (Berry, 1937) emend.
Schopf, Wilson and Bentall, 1944

Genotype: Densosporites covensis (Berry, 1937) emend. Schopf, Wilson and Bentall, 1944.

1937 Densosporites covensis Berry, Amer. Midland Naturalist, vol. 18, p. 147, fig. 11.

1944 Densosporites covensis (Berry, 1937) emend. Schopf, Wilson and Bentall, Ill. Geol. Survey, Rept. of Invest. 91, p. 39.

DENSOSPORITES ANULATUS (Loose, 1932),
Schopf, Wilson and Bentall, 1944
Plate 5, figures 1, 2

1932 Sporonites anulatus Loose, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 451, pl. 18, fig. 44.

1934 Zonales-sporites annulatus (Loose, 1932), Loose, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, no. 3, p. 15.

This species is rare in the Mineral coal assemblage.

Although it was noted in all four sections, it was most abundant in OPC 623.

Potonié and Kremp (1955) established the genus Anulatisporites on this species. The writer believes that their concept of Densosporites is fundamentally incorrect and that actually this species is similar to the concept of Densosporites. Therefore, the transfer is not recognized. Hacquebard and Barss reported the species from South Nahanni River coal of Canada. Potonié and Kremp (1956) recorded the species from middle Westphalian B to middle Westphalian C of the Ruhr region.

Figured specimens: OPC 620 D 5-1, OPC 620 D 3-2

Genus DENSOSPORITES GRANULOSUS Kosanke, 1950

Plate 5, figures 5, 6

D. granulosus is the most abundant species of the genus in the Mineral coal assemblage. In OPC 620 and OPC 621 it is present in the middle of the sections. In OPC 622 and OPC 623 it is first noted midway through the sections and increases, in both cases, to become the dominant element of the spore flora at the top.

Kosanke (1950) reported this species from the upper McCormick Group of Illinois.

Figured specimens: OPC 623 L 6-1, OPC 622 E 2-4

DENSOSPORITES SPHAEROTRIANGULARIS Kosanke, 1950

Plate 5, figures 3, 4

D. sphaerotriangularis is present in all four sections. Its distribution in OPC 620 and OPC 621 is somewhat sporadic but parallels the distribution of the other species of the genus. It is an abundant element in OPC 622 and OPC 623 where it also coincides with the distribution of D. granulosus and D. anulatus.

Kosanke (1950) reported this species from the uppermost McCormick Group and the lower part of the Kewanee Group. This is the first known occurrence of the species in an Oklahoma coal.

Figured specimens: OPC 623 L 6-1, OPC 622 E 2-4

Genus CADIOSPORA Kosanke, 1950

Genotype: Cadiospora magna Kosanke, 1950, Ill. Geol. Survey Bull. 74, p. 30, pl. 16, fig. 1.

CADIOSPORA SP. A

Plate 4, figure 5

Spores radial; trilete; circular to subtriangular in equatorial view; diameter 92x87.4 microns. Known variation 82 to 127 microns; rays simple, length approximately one-half

the spore radius, slightly elevated, and lips may be as much as 14 microns wide; proximal wall folds at ends of trilete to give impression of an arcuate ridge; wall 8 to 12 microns thick, laevigate to punctate.

The form is laevigate when well preserved, but over-macerated or poorly preserved forms become increasingly punctate.

This species is present in the two sections OPC 620 and OPC 621. In OPC 621 it occurs in a single level (I). It is present in the bottom four levels of OPC 620 with a maximum abundance figure of 5.2 percent in level F.

Figured specimen: OPC 620 D 4-1

CADIOSPORA SP. B

Plate 4, figure 4

Spores radial; trilete; circular to subtriangular in equatorial view; diameter 138x131.5 microns, known variation 92 to 140 microns; rays simple, one-fourth to one-third the spore radius, commissure in many cases slightly protruding and open at the top giving appearance of well-developed lips; folding of wall frequently gives appearance of arcuate ridges at ends of trilete radii; wall 5-12 microns thick, proximal laevigate, distal vermiculate, vermiculae ramose, 2-16

microns wide, may be confined to distal or slightly encroaching upon proximal.

Species B differs from Sp. A in being vermiculate. This species has a distribution similar to Cadiospora Sp. A. It is present in one level (G) of OPC 621. In OPC 620 it is present in the lower four levels and has a maximum abundance figure of 4.0 percent in level E.

Figured specimen: OPC 620 D 5-2

CADIOSPORA SP.

Plate 4, figure 6

Spores radial; trilete; circular in equatorial view; diameter 75 microns; rays simple, 27 to 30 microns in length, commissure slightly open; proximal wall folded on one side and appearing as a double wall; wall 3-9 microns thick, proximal punctate in trilete interradial areas, remainder laevigate.

This form was recorded as a single specimen from level B of OPC 623. The description is not intended as a new specific description but as a supplementary diagnosis for reference of specimens that future workers might find.

Figured specimen: OPC 623 B 5-3

Genus LYCOSPORA Schopf, Wilson and Bentall, 1944

Genotype: Lycospora micropapillata (Wilson and Coe, 1940) Schopf, Wilson and Bentall, 1944, p. 54.

1940 Cirratriradites micropapillatus Wilson and Coe, Amer. Midland Naturalist, vol. 23, p. 184, fig. 6.

LYCOSPORA GRANULATA Kosanke, 1950

Plate 5, figures 8, 9, 10

L. granulata is one of the four more conspicuous elements of the Mineral coal assemblage. It is present in all four sections. The distribution in OPC 620 is irregular, but this is in keeping with other abnormalities present in that section.

Kosanke (1950) described the species from the Dekoven coal bed of Illinois and listed it as ranging from the middle McCormick Group through the lower McLeansboro Group. Guennel (1958) recorded the species from the Pottsville coals of Indiana. Schemel (1951) reported it from the Mystic coal of Iowa.

L. granulata has been reported from the following Oklahoma coals: Rowe (Davis, 1961), Secor (Clarke, 1961), and Iron Post (Gibson, 1961).

Figured specimens: OPC 623 E 2-6, OPC 623 G 2-4, OPC 623 E 1-11

Infraturma Zonati Potonié and Kremp, 1954

Genus CIRRATRIRADITES Wilson and Coe, 1940

Genotype: Cirratriradites maculatus Wilson and Coe, 1940, p. 183, fig. 7.

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

1956 non Cirratriradites saturni (Ibrahim, 1932), Schopf, Wilson and Bentall, emend. Potonié and Kremp, Teil II, Palaeontographica, Abt. B, vol. 99, pl. 4-6, p. 128.

CIRRATRIRADITES CRASSUS Wilson and Hoffmeister, 1956

Plate 4, figure 3

This species is rare in the Mineral coal assemblage and is present only in sections OPC 622 and OPC 623.

Wilson and Hoffmeister, 1956, described the species from the Croweburg coal of Oklahoma and its occurrence in the Mineral coal is its second report.

Figured specimen: OPC 622 E 2-1

CIRRATRIRIDITES SATURNI (Ibrahim, 1932), Schopf, Wilson, and Bentall, 1944

Plate 4, figures 1, 2

1932 Sporonites saturni Ibrahim, in Potonié, Ibrahim

and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 448, pl. 15, fig. 14.

1933 Zonales-sporites saturni (Ibrahim, 1932), Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 30, pl. 2, fig. 14.

C. saturni is rare in the Mineral coal assemblage and is found only in sections OPC 621 and OPC 623.

Potonié and Kremp (1956) placed C. maculatus in synonymy with C. saturni and thereby made C. saturni the genotype of Cirratriradites. Unfortunately, Potonié and Kremp made this recommendation without seeing the type specimen of C. maculatus. Examination of a paratype, supplied by Dr. Potonié and in the Oklahoma Palynological Collection, with C. maculatus convinces the writer the two are not conspecific. Accordingly, C. maculatus is retained as the genotype. The writer is of the opinion that C. annulatus Kosanke is synonymous with C. saturni, but will not recommend synonymy without having seen the type of the former.

Guennel (1958) reported the species from the Pottsville coals of Indiana. The only previous report of the species in Oklahoma was made by Davis (1961), who found it in the Rowe coal.

Potonié and Kremp (1955) reported the species from upper Westphalian B and middle Westphalian (of the Ruhr region and Westphalian D of the Saar).

Genus REINSCHOSPORA Schopf, Wilson and Bentall, 1944

Genotype: Reinschospora speciosa (Loose, 1934), Schopf, Wilson and Bentall, 1944.

1934 Alati-sporites speciosus Loose, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, no. 3, p. 151, pl. 7, fig. 1.

1943 Triletes (Zonales) speciosus Loose, Horst, Diss., plates 38 and 39.

1944 Reinschospora bellitas Bentall in Schopf, Wilson and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 53, fig. 2.

REINSCHOSPORA TRIANGULARIS Kosanke, 1950

Plate 2, figures 11, 13

R. triangularis is a rare element in the Mineral coal assemblage, but it is present in all four sections. It has an abundance of 1.2 percent in level F of OPC 621.

The specimens observed in the Mineral coal cause some doubt as to the specific diagnosis of Kosanke (1950). The writer has noted the "spines" continuing on the distal

side. They were observed to extend from each of the corners to a juncture at the center of the distal side. Cloe examination of Kosanke's figure 6 suggests that the specimen figured by him also possessed this character. An indication of these distal spines can be seen along the triradiate mark. The writer has also observed that the "spines" do not arise from an insertion along an edge but are simply projections of the spore wall in a subequatorial position. The "blunt ends" of the bifurcating spines are believed to be an optical illusion created when the top of a spine is curved parallel to the optical axis of the microscope. The spines are highly variable in shape, varying from simple apiculae to long tubular projections with club-shaped and serrate ends.

Figured specimens: OPC 622 C 2-2, OPC 622 C 5-2

Kosanke (1950) reported this species from the middle McLeansboro Group of Illinois.

Turma Monoletes Ibrahim, 1933

Subturma Azonomonoletes Luber, 1935

Genus LAEVIGATOSPORITES (Ibrahim, 1935) emend. Schopf, Wilson, and Bentall, 1944

Genotype: Laevigatosporites vulgaris (Ibrahim, 1932), Ibrahim, 1933.

1932 Sporonites vulgaris Ibrahim, in Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 448, pl. 15, fig. 16.

1933 Laevigato-sporites vulgaris (Ibrahim, 1932) Ibrahim, Sporenformen des Aegirhorizonts des Rurh-Reviers: Konrad Triltsch, Würtzburg, p. 39-40, pl. 2, fig. 16, pl. 5, figs. 37, 39.

The genus Laevigatosporites involves several complex taxonomic problems. The type species Laevigatosporites vulgaris (Ibrahim, 1932) was redescribed by Ibrahim, 1933, as being oval to elliptical, laevigate to punctate, simple monolete dehiscence mark, and ranging in size from 40 microns to 100 microns. The Schopf, Wilson and Bentall (1944) emendation recognized this diagnosis and extended it to include other types of exine ornamentation as apiculate, rugate, or reticulate. They considered the shape, thickness of wall, and dehiscence structure to be characters of generic rank. Ornamentation types were considered to be specific characters.

Potonié and Kremp, 1956, emended the genus to include only those forms having laevigate to infrapunctate exines. Species were then delimited on the basis of size. The writer tested the size range determination by a size-frequency study

of the spores of Laevigatosporites of OPC 623. The results of this size-distribution study are shown in figure 2 and suggest that a correlation between stratigraphy and size groups exists in OPC 623. The size limits of the species were chosen on the basis of the stratigraphic distribution of the size groups. This study is not intended to suggest similar size limits be imposed upon species of Laevigatosporites in other areas, but that a similar approach can be useful in different stratigraphic sections.

L. ovalis Kosanke, 1950, is placed in synonymy with L. vulgaris Ibrahim, 1933 (p. 140) "Kosanke 1950, Taf. 5, fig. 7, bildet eine L. ovalis ab. welche sich nach Fotografie und Beschreibung nicht von L. vulgaris unterscheiden läbt. Auch die ± lang Dehiszenzmarke ("half of the length of the spore") gehört zur Variationsbreite des Kreises. Kosanke bringt denn auch keine genügende Differentialdiagnose."

The description of Kosanke gave a size range of L. ovalis from 45 to 65 microns, whereas Potonié and Kremp gave the size range of L. vulgaris as 70 to 100 microns. Holotype 69.5 microns.

Potonié and Kremp also placed L. punctatus Kosanke, 1950, in synonymy with L. desmoinensis Wilson and Coe. L. desmoinensis was described by Wilson and Coe as being smooth

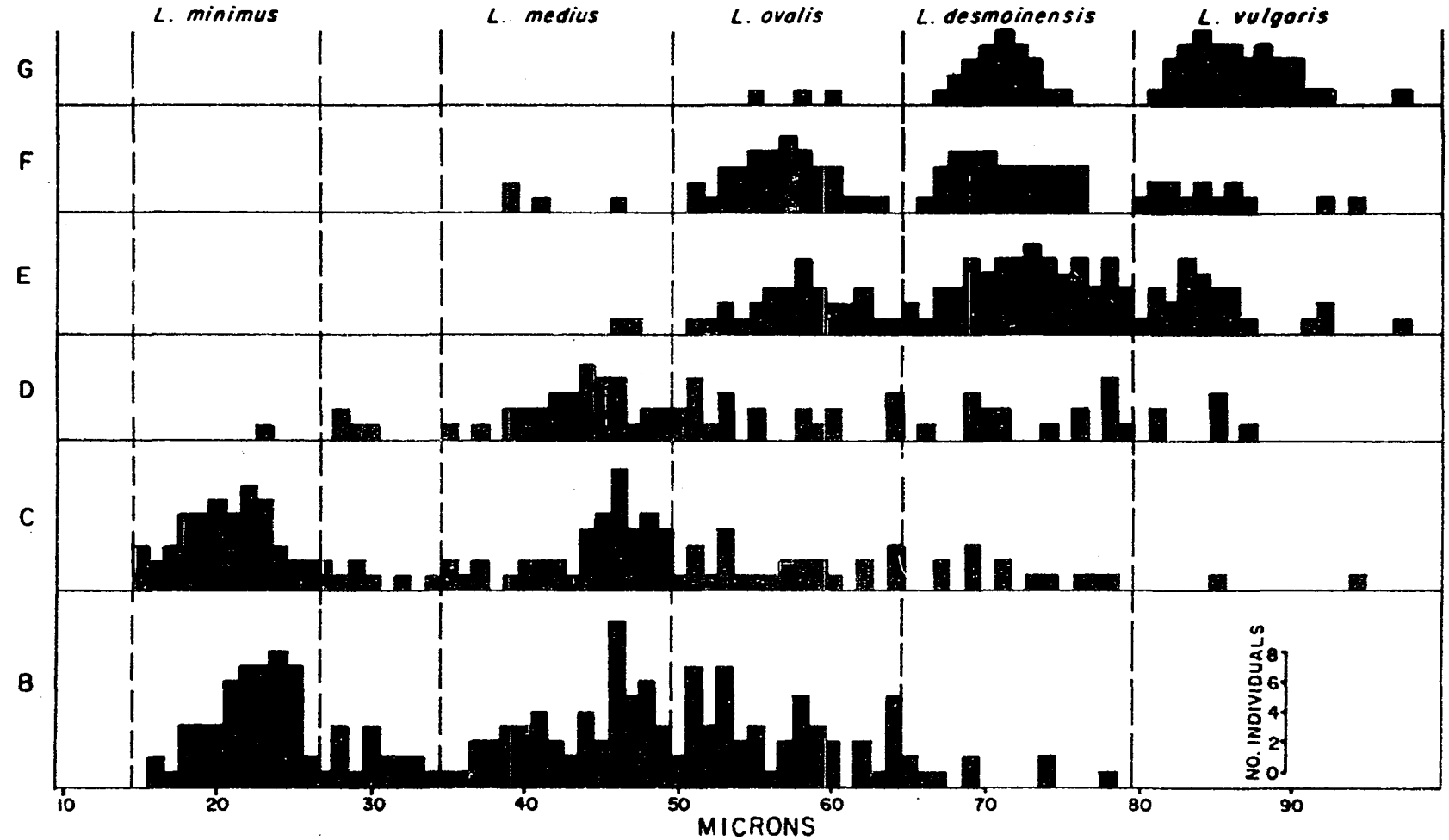


FIGURE 2. HISTOGRAMS SHOWING SIZE-FREQUENCY DISTRIBUTION OF SMOOTH FORMS OF LAEVIGATOSPORITES IN SIX SUCCESSIVE VERTICAL SAMPLES OF OPC 623.

and was used as a category of Potonie and Kremp representative of the size range 45 to 75 microns. Kosanke (p. 30) described the spore coat of L. punctatus as . . . . "distinctly punctate . . . ." According to the emendation of Potonié and Kremp, L. punctatus is without a generic assignment. It cannot be assigned to Punctatosporites as suggested by Guennel (1958, p. 78), because Potonié and Kremp describe the genus Punctatosporites as being characterized by granular ornamentation.

The present findings and the inconsistencies of Potonié and Kremp force a rejection of their emendation of the smooth Laevigatosporites. Further, the writer believes the ambiguity of the genus Punctatosporites being characterized by granular ornamentation is misleading and confusing. It is also doubted that exine ornamentation as variable and gradational as granulate, punctate, and tuberculate should be used as the basis for the separation of genera as Punctatosporites and Tuberculatosporites. These are also rejected as not necessary for taxonomic clarity. Further difficulty exists in the Laevigatosporites latus and L. robustus types. Potonié and Kremp (1955) established the genus Latosporites and designated L. latus (Kosanke, 1950) as the holotype. Forms of this genus are characterized as being elongate in a

polar direction. They are otherwise morphologically similar to the smooth forms of Laevigatosporites. The writer noted that in OPC 620 all the smooth forms of Laevigatosporites above 30 microns were referable to the L. latus and L. robustus types. Other ornamented fossils of similar morphological structure showed evidence of having been subjected to severe preservation conditions and can be mistaken as distinct species. Further substantiation of this conclusion was observed in other coal sections. In certain levels in which preservation was poor, the L. latus and L. robustus types were present. It is here suggested that in the Mineral coal these forms should be referred to L. medius, L. ovalis, L. desmoinensis, and L. vulgaris according to size limits determined in a well-preserved specimen, and that this conclusion be investigated in other stratigraphic sections.

LAEVIGATOSPORITES DESMOINENSIS (Wilson and Coe, 1940), Schopf, Wilson and Bentall, 1944

Plate 7, figure 2

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

1944 Laevitato-sporites desmoinensis Wilson and Coe, 1940), Schopf, Wilson and Bentall, Ill. Geol.

Survey, Rept. Invest. 91, p. 37.

L. desmoinensis is an abundant element in the Mineral coal assemblage and is persistent. Its greatest abundance is in the lower half of the section and it decreases upward.

The species was described from the What Cheer coal of Iowa (Wilson and Coe, 1940). Kosanke (1950) reported the species in Illinois as ranging from the middle part of the McCormick Group to near the top of the McLeansboro Group. 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 has been found occurring in the following coals: McAlester (Morgan, 1955), Croweburg (Wilson and Hoffmeister, 1956), Weir-Pittsburg (Secor?) (Higgins, 1960), Rowe (Davis, 1961), Secor (Clarke, 1961), and Iron Post (Gibson, 1961).

Potonié and Kremp reported the species ranging from upper Westphalian A to lower Westphalian C of the Ruhr region and upper Westphalian C to Stephanian A of the Saar Basin. Luber and Waltz (1938) listed it from the Westphalian of the Donetz Basin of Russia. Knox (1952) recorded it from the Westphalian A and B of Scotland. Bhardwaj and Venkatachala (1957) reported the species from the Stephanian C of the Pfalz district.

Figured specimen: OPC 623 D 1-1

LAEVIGATOSPORITES MEDIUS Kosanke, 1950

Plate 7, figure 12

L. medius exhibits a distribution similar to that of L. desmoinensis. It has a maximum relative abundance value of 25.7 percent in level B of OPC 621.

Kosanke (1950) reported the species from the upper part of the Kewanee Group and the middle of the McLeansboro Group. Schemel (1951) recorded L. medius from the Mystic coal of Iowa. Guennel (1958) reported it from the Pottsville coals of Indiana. L. medius has been recorded from the following Oklahoma coals: Weir-Pittsburg (Secor?) (Higgins, 1961), Rowe (Davis, 1961), and Iron Post (Gibson, 1961). Potonié and Kremp reported this species ranging from the upper Westphalian A to middle Westphalian C of the Ruhr region and Westphalian C of the Saar Basin. Bhardwaj and Venkatachala (1957) listed the species from Stephanian C of the Pfalz district.

Figured specimen: OPC 621 C 2-8

LAEVIGATOSPORITES MINIMUS (Wilson and Coe, 1940), Schopf, Wilson and Bentall, 1944

Plate 7, figure 10

1940 Paseolites minimus Wilson and Coe, Amer. Midland Naturalist, vol. 18, p. 183, fig. 5.

1944 Laevigato-sporites minimus (Wilson and Coe, 1940), Schopf, Wilson and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 37.

This species has a distribution coincident with the other smooth species of Laevigatosporites. The species is present in all four sections but is more sporadic than the other species.

L. minimus was first reported from the Des Moines Supergroup of Iowa by Wilson and Coe (1940). Kosanke (1943) reported it from the Pittsburgh and Pomeroy coals of Ohio, and (1950) from the upper part of the McCormick Group through the McLeansboro Group of Illinois. Schemel (1951) reported it from the Mystic coal of Iowa. Guennel (1958) reported it from the Pottsville coals of Indiana. In Oklahoma the species has been reported from the Croweburg coal (Wilson amd Hoffmeister, 1956), Weir-Pittsburg (Secor?) coal (Higgins, 1960), Rowe coal (Davis, 1961), and Tebo coal (Ruffin, 1961)

Potonié and Kremp reported the species from the middle Westphalian C of the Ruhr region and Westphalian C to Stephanian C of the Saar Basin. Knox (1952) recorded it between Westphalian A and B of Scotland. Bhardwaj and

Venkatachala (1957) from the Stephanian C of the Pfalz district.

Figured specimen: OPC 620 J 2-12

LAEVIGATOSPORITES OVALIS Kosanke, 1950

Plate 7, figure 4

L. ovalis is the most persistent of the smooth-walled species of Laevigatosporites. It is present in all levels in the four sections. The maximum abundance is 27 percent in level M of OPC 620.

Potonié and Kremp (1956A) placed L. ovalis in synonymy with L. vulgaris on the basis of a morphological similarity of the monolete dehiscence mark. This fact is not consistent with their arbitrary size splitting of the genus. L. ovalis was originally described as having a size range of 45 to 65 microns. L vulgaris was described as varying in size from 75 to 100 microns. This and other inconsistencies (see previous discussion of the genus Laevigatosporites) caused the writer to disregard this transfer.

Kosanke (1950) gave the range of L. ovalis as the upper part of the McCormick Group through the upper part of the McLeansboro Group of Illinois. Schemel (1951) reported it from the Mystic coal of Iowa. Guennel (1958) reported it

from the Pottsville coals of Indiana. In Oklahoma, it has been reported from the following coals: Stigler and McAlester (Morgan, 1955), Croweburg (Wilson and Hoffmeister, 1956), Weir-Pittsburg (Secor?) (Higgins, 1960), Rowe (Davis, 1961), Secor (Clarke, 1961), Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961).

Figured specimen: OPC 623 B 7-5

LAEVIGATOSPORITES VULGARIS (Ibrahim, 1932),
Schopf, Wilson and Bentall, 1944
Plate 7, figure 1

L. vulgaris is present in three of the studied sections (OPC 620, OPC 621 and OPC 623). Its absence in OPC 621 may be related to the geographic location of that section near the southern limits of the coal.

Potonié and Kremp reported this species from the Ruhr region ranging from upper Westphalian A to middle Westphalian C and Stephanian C. Imgrund recorded the species from the lower Permian of the Kaiping Basin of China.

Figured specimen: OPC 622 F 5-6

LAEVIGATOSPORITES MINUTUS (Ibrahim, 1933),
Schopf, Wilson, and Bentall, 1944
Plate 7, figure 14

1933 Punctatosporites minutus Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 40, pl. 5, fig. 33.

1944 Laevigato-sporites minutus (Ibrahim, 1933) Schopf, Wilson and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 37.

L. minutus is present in all four of the sections. The distribution of this speces indicates that it was a pioneer element of the spore flora. The writer interprets resurgences of this species and certain other species as being indicative of a reestablishment of earlier swamp conditions.

Potonié and Kremp (1954) attempted to reinstate the genus Punctatosporites. They redefined the genus as being characterized by granular ornamentation. In keeping with the opinions previously stated, the writer believes ornamentation should be considered a specific character and the fossils should be retained in Laevigatosporites.

Kosanke (1950) reported this species ranging from the lower part of the McCormick Group through the upper part of the McLeansboro Group in Illinois. Schemel (1951) reported it from the Mystic coal of Iowa. In Oklahoma, the species has been reported from the following coals: McAlester (Morgan, 1955), Croweburg (Wilson and Hoffmeister, 1956),

Weir-Pittsburg (Secor?) (Higgins, 1960), Rowe (Davis, 1961), Secor (Clarke, 1961), Iron Post (Gibson, 1961) and Tebo (Ruffin, 1961).

Potonié and Kremp reported the species from the upper Westphalian B of the Saar Basin. Luber and Waltz (1938) listed the species throughout the Westphalian of the Donetz Basin of Russia.

Figured specimen: OPC 620 J 1-6

LAEVIGATOSPORITES PYGMÄUS Imgrund, 1960, comb. nov.

Plate 7, figure 11

1956 Punctatisporites pygmäus Potonié and Kremp, Palaeontographica, Teil II, vol. 99, Abt. B, p. 142.

1960 Punctatisporites pygmäus Imgrund, Geologischen Landesanstalten, Bundesrepublic Deutschland, Geologisches Jahrbuch, vol. 77, p. 175, table 16, fig. 100-113.

This occurrence is the first record of this species in other than European or Asian coals. It is a persistent element in all four sections and has a maximum relative abundance of 19.6 percent in level B of OPC 622. The dis-

tribution of the species suggests that it may be an element, of marginal swamp areas. Potonié and Kremp (1956a) listed this species as belonging to the genus Punctatosporites. They referred to the species as having been described in the dissertation of R. Imgrund, 1952. According to the international rules the dissertation did not constitute a valid publication. Potonié and Kremp did not describe nor figure the form so the valid publication date must be considered as that of Imgrund, 1960.

Imgrund described the species from the lower Permian of the Kaiping Basin of China.

Figured specimen: OPC 623 B 7-8

LAEVIGATOSPORITES GLOBOSUS Schemel, 1951

Plate 7, figure 3

L. globosus was noted in all four of the studied sections. It is present in the highest relative percentage of all species in the Mineral coal assemblage. The distribution of this species indicates that it was a pioneer element in the Mineral coal swamp spore flora. Fluctuations of relative percentages of this species are considered by the writer to be significant of ecological shifts and reestablishment of the swamp.

Potonié and Kremp transferred this species to Latosporites. They described the genus as being laevigate to infrareticulate whereas Schemel described the . . . "surface of spore densely and minutely punctate. . ." Certainly this transfer is not consistent with their generic diagnosis and therefore the recommendation is not accepted.

Schemel (1951) described this species from the Mystic coal of Iowa. Guennel (1958) reported it from the Pottsville coals of Indiana. Wilson and Hoffmeister (1956) recorded it from the Croweburg coal of Oklahoma.

Figured specimen: OPC 620 J 2-15

LAEVIGATOSPORITES SP. A

Plate 7, figures 5, 8

Spores bilateral; monolete; oval to circular in profile, oval to circular in equatorial view; monolete simple, approximately one-half the diameter; wall thin, less than 0.5 micron, surface densely spinose, spines 0.5 to 1.5 microns in length and less than 0.5 microns in width at the base; diameter of holotype 14.4x17.5. Known variation 11-19 microns in maximum diameter.

The original shape was probably spherical. This is indicated by the lack of preferred orientation of the monolete

mark. Some spores are folded with the folds parallel to the circumference.

This species is present in all four of the studied sections. It is most persistent in OPC 622 and seems to coincide with the distribution of the other species of Laevigatosporites.

Figured specimens: OPC 622 H 3-4, OPC 620 L 2-5

GENUS A SP. A

Plate 7, figures 6, 7, 9

Spores bilateral; monolete; oval to circular in profile, oval to circular in equatorial view; distal in many cases more strongly arched than proximal; monolete simple, one-half to two-thirds the spore body length; wall 2-3 microns thick on distal, thins abruptly at proximal to less than 1 micron; exine granular, grana approximately 1 micron in diameter, less than 1 micron high, irregularly spaced, few closer than 1 micron apart, may be clustered to appear nearly rugate, proximal ornamentation may be somewhat finer than distal; outline in many grains appears ragged. Holotype 48.3x37 microns, known variations 26 to 52 microns in length.

This species is a persistent element in all four of the studied sections. In level J of OPC 620 it has a relative

abundance of 23.4 percent. The distribution closely coincides with that of Laevigatosporites.

Figured specimens: OPC 620 J 1-8, OPC 620 J 1-16, OPC 620 J 2-8

GENUS B SP. A

Plate 7, figures 15, 16

Spores bilateral; monolete; oval to circular in profile, oval to circular in equatorial view; monolete simple, approximately two-thirds the spore body length; wall 1 to 1.5 microns thick, laevigate to infrapunctate; original shape globular to near spherical, swollen (umbonal) areas adjacent to suture; compression in most cases results in cracks along the circumference due to tension. Known size range 87 to 131 microns in length. Holotype 110.4x90 microns.

This species is present in all four of the studied sections. Its relative abundance was not a high value in any case (maximum 2.4 percent, level J, OPC 623), but it was observed in most of the samples.

Figured specimens: OPC 620 D 1-10, OPC 623 D 2-4

Anteturma Pollenites R. Potonié, 1931

Turma Saccites Erdtman, 1947

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

Infraturma Triletesaccites Leschik, 1955

Genus SPENCERISPORITES Chaloner, 1951

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

1932 Sporonites radiatus Ibrahim, in Potonié, Ibrahim and Loose, Neues Jahrbuch, für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 449, pl. 16, fig. 25.

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

1944 Triletes radiatus (Ibrahim, 1932) Schopf, Wilson and Bentall, Ill. Geol. Survey, Rept. Invest. 91, p. 24.

1944 Endosporites (?) karczewskii (Zerndt, 1934) Schopf, Wilson, and Bentall, 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 Spencerisporites karczewskii (Zerndt, 1934), Chaloner, Ann. Mag. Nat. History, ser. 12, vol. 69, p. 170, pl. 17, figs. 78-79.

1955 Microsporites radiatus (Ibrahim, 1932), Potonié and Kremp, 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 (Ibrahim, 1932), Dijkstra, Estudios Geol., vol. 11, no. 27-28, p. 342, pl. 45, fig. 54.

1956 Microsporites radiatus (Ibrahim, 1932), Dijkstra, in Potonié and Kremp, Palaeontographica, Abt. B, vol. 99, no. 4-6, p. 157, pl. 20, figs. 449-450.

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

SPENCERISPORITES cf. S. RADIATUS (Ibrahim, 1932), Chaloner, 1951

Plate 5, figure 14

The form present in the Mineral coal assemblage may be a new species. The central body is not distinct in the forms observed to date. More forms must be studied before describing a new species.

Dijkstra (1946) reported the species from the Westphalian A, B, and C and from the Namurian B and C of the Pelazja beds of the Netherlands. Dijkstra (1955) also reported it from the Westphalian A and B of Spain. Horst (1955) recorded it from the Westphalian C of the Ruhr Basin and the Namurian and Westphalian A of Märisch-Ostrau and Upper Silesia. Chaloner (1951) reported the species from Westphalian A and C of England. Potonié and Kremp (1956) reported it from the Westphalian of Scotland. Felix and Parks (1959) reported it from the Pottsville coals of Kentucky and from strata of Morrowan age from the Oklahoma-Texas panhandle areas.

Figured specimen: OPC 621 E 1-2

Genus WILSONITES (Kosanke, 1950)

emend. Kosanke, 1959

Genotype: Wilsonites vesicatus (Kosanke, 1950), Kosanke, 1959, Jour. Paleontology, vol. 33, p. 700.

1950 Wilsonia vesicatus Kosanke, Ill. Geol. Survey,

Bull. 74, p. 54, pl. 14, figs. 1-3.

1959 Wilsonites vesicatus (Kosanke, 1950), Kosanke, 1959, Jour. Paleontology, vol. 33, p. 700.

WILSONITES VESICATUS (Kosanke, 1950), Kosanke, 1959

Plate 6, figure 6

W. vesicatus was recorded from all four of the studied sections. It has its greatest relative abundance in OPC 620. The writer believes that this is related to a peculiar geographical location (see conclusions).

The species was reported by Kosanke (1950) from the middle and upper McLeansboro Group of Illinois. W. vesicatus has been listed from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Weir-Pittsburg (Secor?) (Higgins, 1960), Rowe (Davis, 1961), Secor (Clarke, 1961), Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961).

Figured specimen: OPC 620 H 2-8

GENUS C SP. A

Plate 6, figures 9, 10, 11

Spores radial; trilete; monosaccate; oblately flattened circular to rounded triangular in equatorial outline, total diameter of holotype 52.9x43.7 microns, known variation

40 to 70 microns, in maximum diameter; central body 41x34.3 microns; wall about two microns thick; saccus width 11 to 15 microns, attached at equatorial margin and entire proximal face, appears as thickened lips of trilete, saccus densely granular, grana less than 0.5 microns in height and width; trilete simple, equal to radius length in mature specimens; central body coarsely punctate; area of saccus beneath saccus is wrinkled to vermiculate.

Two characteristic features of this species are readily observed: (1) the distal ornamentation simulates the pattern of the cerebrum of the brain and (2) the equatorial margin of the central body is rather indefinite due to the juncture of the saccus appearing similar to secondary folding.

This species is present in all four of the studied sections. It is most abundant in OPC 620, a situation which is considered by the writer to be related to its peculiar geographical location as discussed later.

Figured specimens: Holotype, OPC 620 H 5-7,
OPC 620 J 2-1, OPC 620 E 2-3

GENUS D SP. A

Plate 6, figures 2, 5, 7

Spores radial, trilete; monosaccate; oblately flattened, circular to elongate oval in equatorial outline; total

diameter of holotype 90x69.5 microns, known variation 43-90 microns, wall thin, less than 1 micron but variable, thickened at equatorial margin; saccus width 16 to 18 microns, attached only at equator and this juncture with central body forms a thickened rim, saccus infrareticulate, surface laevigate; trilete simple and in many specimens quite faint, generally one-half the radius; central body densely papillate, papillae quite short and of irregular size.

This species is extremely variable in outline and in many cases appears bisaccate. The equatorial thickening of the central body and the surface ornamentation is characteristic. Flattening of the form results in a second "ring" outside the rim of attachment, a condition which is due to folding of the central body (see paratype figure).

The species is in the Mineral coal assemblage and was noted in only two sections (OPC 622 and OPC 623). It is slightly more abundant in the lower part of OPC 622.

Figured specimens: Holotype: OPC 622 C 2-4,
OPC 623 B 7-10, OPC 623 B 2-5

Genus VESTISPORA Wilson and Hoffmeister, 1956

Genotype: Vestispora profunda Wilson and Hoffmeister, 1956, Okla. Geol. Survey, Circ. 32, p. 27, pl. 2, figs. 16-19.

VESTISPORA PROFUNDA Wilson and Hoffmeister, 1956

Plate 4, figures 7, 8

This species is present in all four of the studied sections. Two of the abundance percentages listed for the species are quite misleading. In level C of OPC 620 and level I of OPC 621 the percentages are 27.9 and 31.8 respectively. These abundances appear due to the preservation factor. Little could be identified from these levels other than Vestispora, Reticulatisporites, and Laevigatosporites.

V. profunda was originally described from the Croweburg coal, Oklahoma (Wilson and Hoffmeister, 1956). It has also been reported from the additional Oklahoma coals: Secor (Clarke, 1961) Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961).

Figured specimen: OPC 623 B 7-7

GENUS SCHULZOSPORA Kosanke, 1950

Genotype: Schulzospora rara Kosanke, 1950, Ill. Geol. Survey, Bull. No. 74, p. 53, pl. 13, figs. 5-8.

SCHULZOSPORA cf. S. RARA Kosanke, 1950

Plate 5, figure 13

S. rara was noted in all four sections, but is an extremely rare element. It was recorded in only five levels

in the four sections.

Kosanke (1950) reported the species from the lower part of the McCormick Group of Illinois. The species has not been previously recorded in Oklahoma coals and the writer is not aware of it elsewhere in the literature.

Figured specimen: OPC 623 B 4-3

Infraturma Aletesacciti Leschik 1955

Genus FLORINITES Schopf, Wilson and Bentall, 1944

Genotype: Florinites antiquus Schopf, 1944, in Schopf, Wilson and Bentall, p. 58, fig. 4.

FLORINITES PELLUCIDUS (Wilson and Coe, 1940), Wilson, 1960

Plate 6, figures 1, 3, 4

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

1960 Florinites pellucidus (Wilson and Coe, 1940), Wilson, Okla. Geol. Survey, Okla. Geol. Notes, vol. 20, p. 29.

This species is a dominant element in all four of the studied sections. The distribution is at a maximum in the

center of the coal seam, and decreases up and down section.

Wilson (personal oral communication) is of the opinion that F. antiquus Schopf, 1944, and F. pellucidus (Wilson and Coe, 1944), Wilson, 1960, are conspecific.

F. pellucidus was originally described from the Des Moines Supergroup of Iowa by Schopf (in Schopf, Wilson and Bentall, 1944).

Kosanke (1950) reported F. antiquus ranging from the middle of the McCormick Group to the middle of the McLeansboro Group of Illinois. Schemel (1951) reported the species from the Mystic coal of Iowa. Guennel (1958) lists F. antiquus as occurring in the Pottsville coals of Indiana. In Oklahoma, F. antiquus has been reported from the McAlester coal (Morgan, 1955) and the Croweburg coal (Wilson and Hoffmeister, 1955). F. pellucidus has been reported from the following Oklahoma coals: Weir-Pittsburg (Secor?) (Higgins, 1960), Rowe (Davis, 1961), Secor (Clarke, 1961), Iron Post (Gibson, 1961).

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). Bhardwaj (1957) listed F. antiquus from the Westphalian C of the Saar Basin.

Figured specimens: OPC 623 E 10-6, OPC 622 G 3-2, OPC 622 J 1-2

Subturma Disaccites Cookson 1947

Infraturma Disaccitrileti Leschik, 1955

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

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

ILLINITES UNICUS Kosanke, 1950

Plate 6, figure 8

I unicus was recorded from only two levels (F and K) of OPC 622.

Kosanke (1950) recorded the species from the upper McLeansboro Group of Illinois. In Oklahoma, the species has been recorded from the Rowe coal (Davis, 1961), and Iron Post coal (Gibson, 1961).

Figured specimen: OPC 622 F 1-3

Infraturma 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 (Kosanke, 1950) Bhardwaj, Paleobotanist, vol. 4, p. 135-137, pl. 2, figs. 16 a-d, 17.

KOSANKEISPORITES ELEGANS (Kosanke, 1950), Bhardwaj, 1955

Plate 6, figure 12

K. elegans was recorded in all four sections, but was noted only in the counts from OPC 621.

Kosanke (1960) originally described this species from the upper McLeansboro Group of Illinois. In Oklahoma, K. elegans has been reported from the Secor coal (Clarke, 1961), Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961). Bhardwaj (1955) reported the species from the Stephanian A of the Saar Basin in Germany.

Figured specimen: OPC 623 I 6-3

Subturma Polysaccites Cookson, 1947

Genus ALATISPORITES Ibrahim, 1933

Genotype: Alatisporites pustulatus (Ibrahim, 1932),

Ibrahim, 1933.

1932 Sporonites pustulatus Ibrahim, in Potonié, Ibrahim, and Loose, Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 448, pl. 14, fig. 12.

1933 Alatisporites pustulatus (Ibrahim, 1932), Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 33, pl. 1, fig. 12.

ALATISPORITES HEXALATUS Kosanke, 1950

Plate 5, figures 11, 12

A. hexalatus was recorded from all four sections. The distribution is through the middle of the section in all four cases.

This species was described from the No. 5 coal bed, middle part of the Kewanee Group of Illinois (Kosanke, 1950). In Oklahoma it has been reported from the following coals: Weir-Pittsburg (Secor?) (Higgins, 1960), Secor (Clarke, 1961), and Tebo (Ruffin, 1961). Guennel (1958) described A. pottsvillensis from the Pottsville coals of Indiana. The writer believes this to be conspecific with A. hexalatus but will not place them in synonymy without having seen the types.

Alpern (1958) illustrated a form which he refers to a new species A. splendidus from the Stephanian of Lorraine. The writer suggests that this form may also be conspecific with A. hexalatus Kosanke.

Figured specimens: OPC 620 G 1-1, OPC 621 G 2-4

ALATISPORITES INFLATUS Kosanke, 1950

Plate 5, figure 7

This species was recorded from three sections (OPC 620, OPC 621, and OPC 623). It is abundant only in OPC 620 and its distribution coincides with that of A. hexalatus.

Kosanke (1950) described this species from the No. 5 coal bed, middle part of the Carbondale Group of Illinois. There is no other reported occurrence of this species known to the writer.

Figured specimen: OPC 623 K 1-14

"PREPOLLEN"

Turma Precolpates Potonié and Kremp, 1954

Genus SCHOPFIPOLLENITES Potonié and Kremp, 1954

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

1932 Sporenites ellipsoides Ibrahim, in Potonié,

Ibrahim and Loose: Neues Jahrbuch für Mineralogie, Geologie, Paläontologie, Beilage, Abt. B, vol. 67, p. 449, pl. 17, fig. 29.

1933 Laevigato-sporites ellipsoides (Ibrahim, 1932), Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Konrad Triltsch, Würtzburg, p. 40, pl. 4, fig. 29.

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

1934 Sporonites ellipsoides (Ibrahim, 1932) Wicher, Inst. Palaeobot. u. Petrog. Brennstiene, Arbeiten, vol. 4, no. 4, p. 185.

1938 Monoletes ellipsoides (Ibrahim, 1932), Schopf, Ill. Geol. Survey, Rept. Invest. 50, p. 45, pl. 1, fig. 14; pl. 6, figs. 5-6.

1954 Schopfipollenites ellipsoides (Ibrahim, 1932), Potonié and Kremp, Geologisches Landesanstalten, Bundesrepublik Deutschlands Geol. Jahrbuch, vol. 69, p. 180, pl. 19, figs. 89-92.

SCHOPFIPOLLENITES ELLIPSOIDES (Ibrahim, 1932),

Potonié and Kremp, 1954

Plate 6, figure 13

S. ellipsoides was recorded from all four of the studied sections, but is a rare element of the Mineral assemblage. Schopf (1958) reported this species in the upper part of the Kewanee Group (Coal No. 6 of Illinois). Winslow (1959) figured several species identified from various coals throughout the Illinois Pennsylvanian section. The species has been reported quite extensively from Europe and Potonié and Kremp (1955) summarized the range as Westphalian B through C in the Ruhr Basin. Bhardwaj (1957) extended the range of the species in the Ruhr to Westphalian D. Dijkstra (1946) previously recorded the species from the Westphalian B and C of the Netherlands.

Figured specimen: OPC 621 C 4-1

DISCUSSION

Data for this study of the Mineral coal spore flora have been obtained in two ways: (1) identification of taxonomic entities contained as fossils in the coal and (2) assemblage counts plotted as histograms. The latter technique involves counting 250 specimens in each stratigraphic level. The counts of each species are computed and then plotted as relative percentages in each sample level (table 1). Analysis of these data indicates that certain species of some genera have complementary distribution patterns. These were combined and plotted as 16 spore floral groups (fig. 3).

The stratigraphic sections are presented in their relative north-south geographic position and each level is drawn to scale to indicate segment thickness. The graphic illustrations are designed to illustrate subtle changes of the spore flora in response to ecologic shifts. Relative percentage histograms of the common genera of the Mineral coal are used to indicate general spore flora distribution and trends.

TABLE 2

INDEX FOR SPECIES COMBINATION HISTOGRAMS
ILLUSTRATED ON FIGURE 3

(Numbers represent the adjacent combination of species)

Index Number		Species Combination
1.	Laevigatosporites	globosus
	L.	minutus
	L.	pygmäus
	L.	Sp. A
2.	Laevigatosporites	minimus
	L.	medius
	L.	ovalis
	L.	desmoinensis
	L.	vulgaris
3.	Florinites	pellucidus
4.	Densosporites	granulosus
	D.	sphaerotriangularis
	D.	anulatus
5.	Lycospora	granulata
6.	Genus A	Sp. A
7.	Calamospora	breviradiata
	C.	flexilis
	C.	hartungiana
	C.	microrugosa
	C.	pallida
	C.	saariana
	C.	straminea
8.	Triquitrites	additus
	T.	bransonii
	T.	dividuus
	T.	exiguus
	T.	inusitatus
	T.	praetextus
	T.	protensus
	T.	tumulus

TABLE 2--Continued

Index Number		Species Combination
9.	Anapiculatisporites	spinosus
10.	Granulatisporites	commissuralis
	G.	convexus
	G.	deltiformis
	G.	levis
	G.	microsaetosus
	G.	parvus
11.	Verrucosisporites	donarii
12.	Raistrickia	aculeata
	R.	aculeolata
	R.	crinita
	R.	crocea
	R.	grovensis
	R.	irregularis
	R.	spinososaetosa
13.	Alatisporites	hexalatus
	A.	inflatus
14.	Wilsonites	vesicatus
15.	Cadiospora	Sp. A
	C.	Sp. B
	C.	Sp.
16.	Genus C	Sp. A

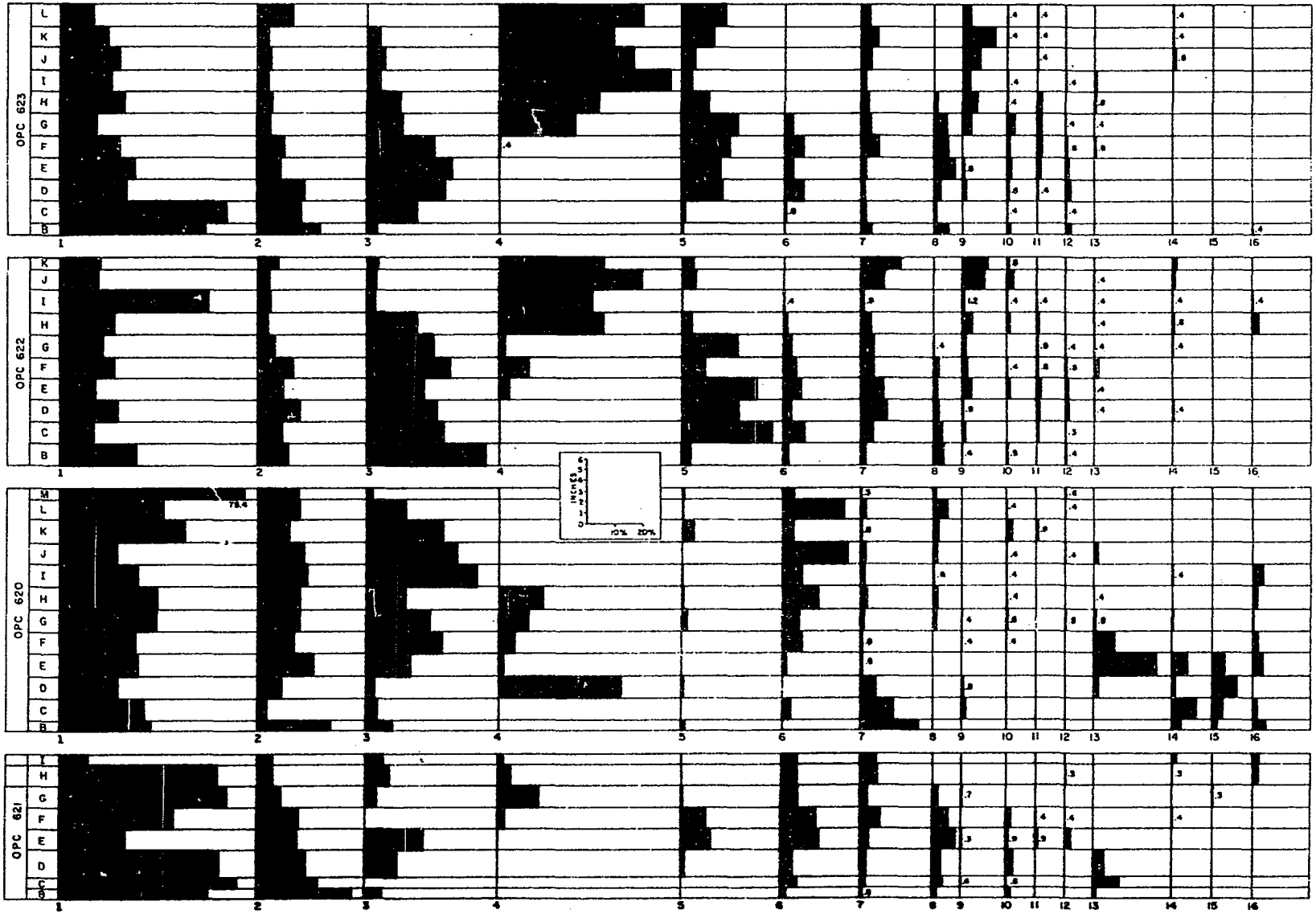


FIGURE 3. HISTOGRAMS ILLUSTRATING RELATIVE PERCENTAGES OF 16 SPORE FLORA GROUPS IN FOUR SECTIONS OF MINERAL COAL. SECTIONS FROM TOP TO BOTTOM ARE NORTH TO SOUTH GEOGRAPHICALLY. UNDERCLAYS AND ROOF SHALES ARE UNFOSSILIFEROUS.

The spore flora of the Mineral coal consists primarily of species of four genera: (1) Laevigatosporites, (2) Florinites, (3) Densosporites and (4) Lycospora. These four genera also show the principal succession trends.

The three principal elements of the Mineral coal swamp succession continuum are interpreted by the writer as being Laevigatosporites, Florinites, and Densosporites. Laevigatosporites is believed to be one of the pioneer elements of spore flora succession. Florinites and Lycospora seem to follow Laevigatosporites and may actually be the last elements of "normal" swamp succession. Densosporites may not be the end member of normal swamp succession, but rather an inhabitant of an ecologic condition created by factors outside the swamp tending to modify the swamp proper. This opinion is formulated by analysis of the spore distribution of figure 3 in conjunction with lithologic differences noted in the samples. The section at Mulberry, Kansas (OPC 623) is increasingly shaly from a point midway in the section to the top. The same is true of the section OPC 622 near Hallowell, Kansas. This latter section is more striking in that it was exceedingly difficult to determine the separation between coal and shale. The Leep farm section (OPC 620), Craig County, Oklahoma, offers the most convincing support

of this theory. That portion of the section containing Densosporites is quite silty whereas the upper part is the more typical coal. The top of this section is abruptly terminated by a thin marine shale (8 inches) and the Russell Creek Limestone. The writer has observed an outcrop of the Mineral coal approximately one-half mile south of OPC 620 in which the coal is interspersed with lenses of shale. The section consists of a basal one to two inches of coal overlain by a series of intermingled stringers of coal and shale with approximately two inches of coal at the top immediately subjacent to the Russell Creek Limestone. The shaly part of this latter section is interpreted as being equivalent to the silty part of OPC 620 where Densosporites occurs.

OPC 621
Craig County, Oklahoma

Section OPC 621 is near the southern limit of the Mineral coal. This is probably near the edge of the ancient Mineral coal swamp and would be expected to have a great amount of variation in the succession of the spore flora. The ornamented forms of Laevigatosporites indicate two stages of succession at this point. These forms are quite abundant at the base of the section but show a marked drop in level E.

Florinites pellucidus and Lycospora granulata have maximum percentage values at this point. The ornate Laevigatosporites then increase toward the top, possibly indicating reestablishment. Level I should be discounted in the detailed analysis due to the poor preservation of the spores. No specimens are identifiable except Vestispora and Reticulatisporitas. The smooth Laevigatosporites show a maximum abundance at the base with a gradual decrease toward the top. The absence of Florinites from two levels is difficult to explain. It may indicate that Florinites was absent in this geographical location and that its representation in the spore assemblage is dependent upon transporting factors. Triquitrites shows maximum abundance about mid-section and a gradual decrease and extinction at level H. The presence of Alatisporites, also a saccate form, may indicate the proximity of a nearby upland flora. The advent of Densosporites is interpreted by the writer as being indicative of an influx of sediment into the swamp, for reasons explained previously. The entire section of OPC 621 is typified by Laevigatosporites and may be interpreted as having remained in the early stages of swamp succession during the entire history.

OPC 620
Craig County, Oklahoma

The successional pattern in OPC 620 is unlike that of the other three sections; it is reversed. The fact that this section is 15 miles north of OPC 621 suggests that a local geographic condition is responsible for the different spore elements in the lower part of the section. The ornamented Lavigatosporites show with only minor fluctuations a general increase from bottom to top. The smooth forms of Laevigatosporites show a sudden influx at the bottom followed by a marked decrease and gradual return to a fairly constant value. Florinites has a bimodal distribution in this section with high abundances occurring in the lower and the upper halves of the section. Densosporites shows a rather striking abundance in level D only to decrease abruptly and then begin a gradual increased recurrence and abruptly disappears at level I. Calamospora has its greatest abundance in the basal part of this section. Cadiospora is also a prominent form in the basal part of this section and is especially noteworthy because it occurs only in a single level of one other section. Genus C (a saccate spore) is also present in the basal part and is fairly persistent in the lower two-thirds of the section. The presence of Alatisporites

and Wilsonites suggests close proximity of an upland flora, because these were probably airborne spores or pollen and are not normally abundant in the coals.

This section is dominated by Laevigatosporites with Florinites as an important secondary element.

OPC 622
Cherokee County, Kansas

Both ornamented and unornamented forms of Laevigatosporites show a rather consistent range of values starting with moderate abundance at the bottom and a general decrease toward the top. Florinites has its greatest abundance in the lower part of the section and decreases gradually toward the top. Lycospora has its greatest abundance in section OPC 622 and shows a distribution pattern similar to that of Florinites. Calamospora exhibits its greatest abundance in this section and its distribution parallels that of Florinites and Lycospora. Anapiculatisporites is present with a distribution similar to that of Densosporites. Densosporites shows a sudden influx in level F then decreases but returns in great abundance to the top of the coal.

Section OPC 622 is characterized by Laevigatosporites, Florinites, and Densosporites. Lycospora is an important subsidiary element.

OPC 623
Crawford County, Kansas

Both ornamented and unornamented forms of Laevigatosporites have maximum abundance at the base of the section and gradually decrease upward. Florinites is a minor element at the base but increases rapidly to a maximum in level E. It shows a gradual decrease from that level upward and is absent in the uppermost level. Lycospora is almost as abundant as Florinites in this section but shows a somewhat different distribution in that it occurs at the top. Calamospora is fairly uniform throughout this section. Triquitrites is abundant in the lower half of the section and Anapiculatisporites reaches prominence in the upper half of the section. Densosporites appears a little below the center of the section and is the most prominent element throughout the top half.

This section is characterized by Laevigatosporites and Densosporites. Florinites and Lycospora are important secondary elements.

Conclusions

The spore flora occurs in patterns and associations of species which would indicate that plant succession was a factor in the coal swamp development. It is obvious when

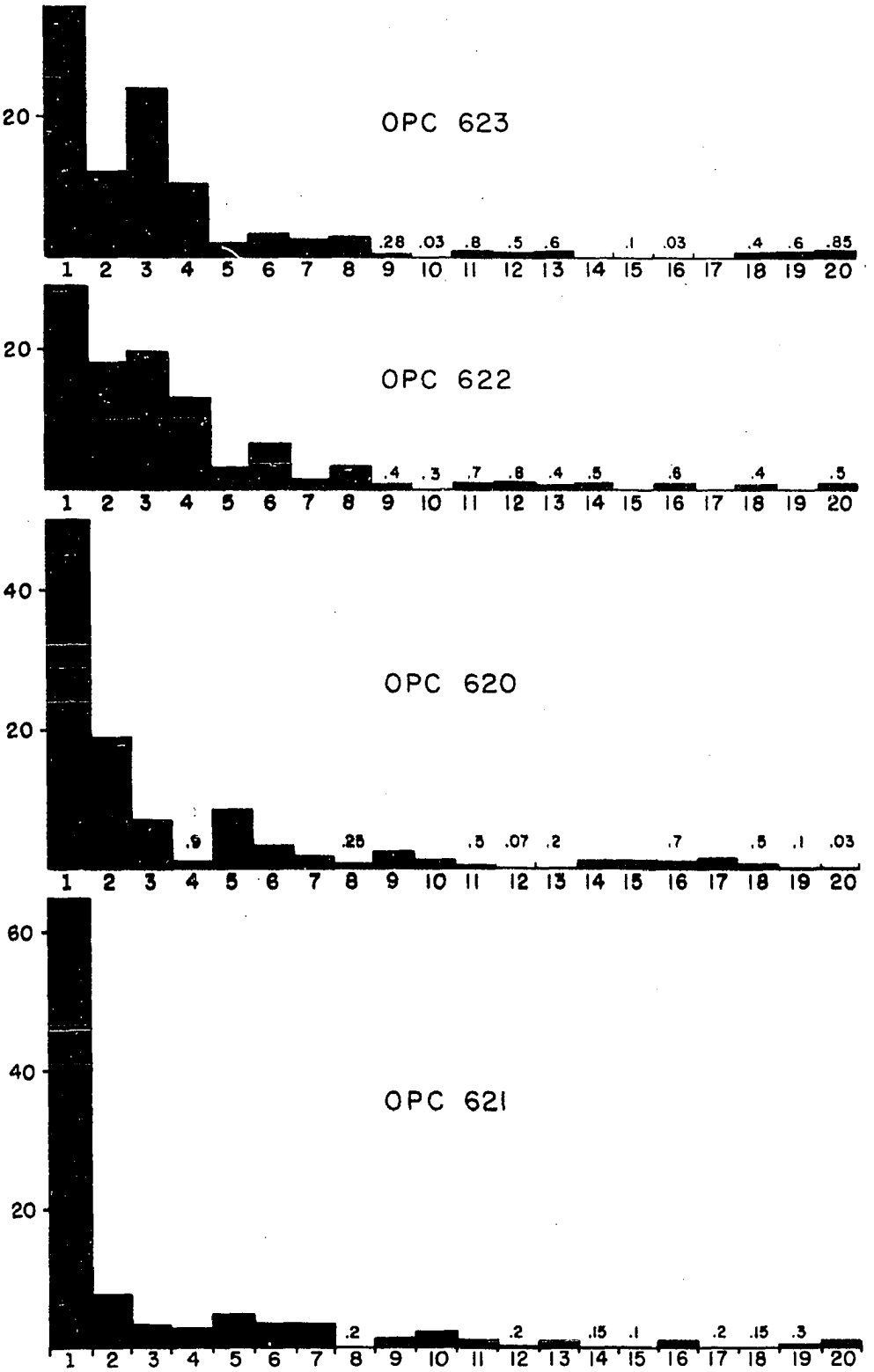


FIGURE 4. RELATIVE PERCENTAGES OF COMMON GENERA IN EACH SECTION OF MINERAL COAL. Refer numbers to figure five.

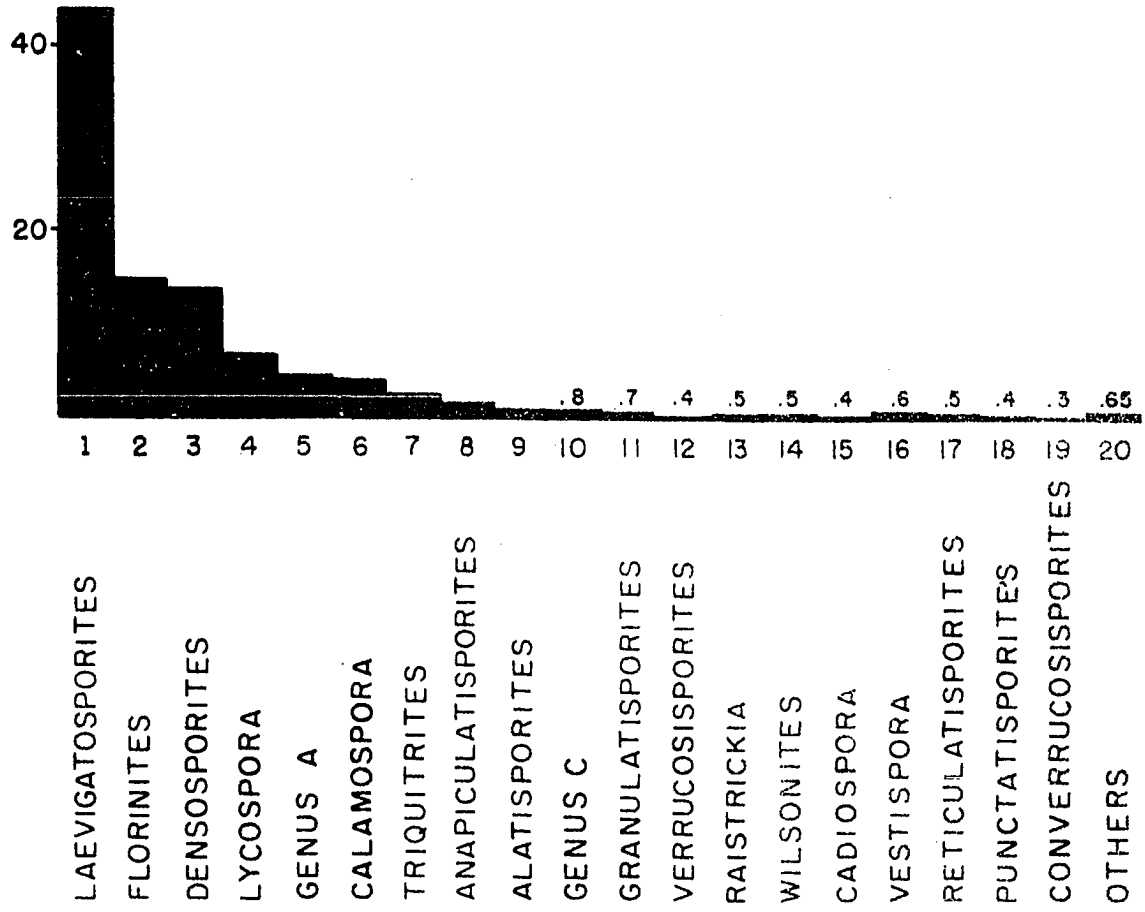


FIGURE 5. RELATIVE PERCENTAGE OF COMMON GENERA IN ALL SECTIONS OF MINERAL COAL.

studying the distribution of the spores over the extent of the Mineral coal seam that this succession existed at different stages in the coal swamp. The northernmost section shows a more complete successional picture and the stages are progressively younger to the south. The spore patterns appear to be related to geographic location. Sedimentation in the northern parts of the swamp may have begun somewhat earlier than those to the south. Those coals in the south also have indications of successional repetition during their developmental history. The repetition is probably coincident with their marginal position which would subject them to minor fluctuations of swamp condition.

Densosporites appears to be related to abnormal circumstances in the developmental history of the coal swamp. Evidence suggests that Densosporites is dependent upon an influx of clastic sediment to modify the typical swamp environment.

AFFINITIES

The predominant spore genus in the Mineral coal is Laevigatosporites. Schopf, Wilson and Bentall (1944) stated that this group of spores was related to three plant orders (Sphenophyllales, Pteridospermae, and Filicales). Kosanke (1960) suggested that some members may possess calamarian relationships. Potonié (1954) reported these spores to have relationship with the Equisetales and Couper (1958) considered some of the species referable to the Filicales.

Florinites pellucidus has been reported by Wilson (1960) from the strobilus of Cordianthus shuleri of the Cordaitales. Chaloner (1962) reported Densosporites from the lycopod fructification Sporangiostrobis. Chaloner (1953) and Sen (1958) have shown Lycospora to have affinity with Lepidostrobus, also a lycopod.

Calamospora is related to plants of the Sphenopsida. Hartung (1933) related the genus to the calamarians. Kosanke (1950) was of the opinion that spores of this genus are

predominantly from the genus Calamites.

They have been related to the Noeggerathiales by Potonié (1954), Equisetites by Couper (1958), Calamostachys by Arnold (1958), and questionably to Bowmanites by Mamay (1959).

Potonié and Kremp (1956) referred Triquitrites to the Protofilicales. Schopf, Wilson, and Bentall referred spores of Granulatisporites to the ferns.

Of the more important minor spore-flora elements, the following affinities have been reported: Wilsonites (Potonié, 1954) to the Cordaitales, Alatisporites (Potonié, 1954) questionably to the Cordaitales and Raistrickia to the filicineans and to Senftenbergia in particular (Radforth, 1938).

STRATIGRAPHIC CORRELATION OF THE MINERAL COAL

The Mineral coal has an extensive lateral distribution. It is known in northern Oklahoma, southeastern Kansas, and the northwestern part of Missouri. This study has shown the importance of an understanding of the successional trends of a spore flora and their relationship to the distribution if fossil spores are to be used in coal seam correlation. Species comparisons between the Mineral coal of Oklahoma and Kansas and six other coals of approximately the same age are shown in the following table (table 4).

Kosanke et al. (1960) indicated that the Mineral coal is supposedly correlative with the Dekoven and Greenbush coals of Kentucky and Illinois. Kosanke (1950) has reported the spore flora of the Greenbush coal and his list of species is used in this comparison of spore floras. The Mineral coal spore flora is here compared with those of the Greenbush coal, Davis, Wiley, and the Colchester coal beds of Illinois. The latter seam is stratigraphically above the Mineral coal

whereas the Davis-Wiley beds are lower.

The Colchester coal of Illinois has the greatest number of species (18) in common with the Mineral coal. Wilson and Hoffmeister (1956) indicated that the Colchester is correlative with the Croweburg coal. This apparently contradictory evidence is explained by a comparison of the relative percentages of species in common which is based on the number of species in the compared coal. The Greenbush coal has 57.7 percent of its species in common with the Mineral coal and the Colchester has 40.9 percent. Quite probably the paucity of species in the Greenbush coal (26) as compared with 43 in the Colchester explains this percentage difference. From these data, the writer is of the opinion that the Mineral coal flora is probably correlative with that of the Greenbush coal of Illinois.

In Oklahoma, the Mineral coal has a spore flora more like that of Croweburg coal than the tebo or Iron Post coals.

TABLE 4

SPORE SPECIES COMMON TO BOTH ILLINOIS AND OKLAHOMA COALS

Species		Illinois coals			Oklahoma coals			
		*DW	GB	CC	T	C	IP	M
Punctati-sporites	aureus							x
	dentatus					x	x	
	globosus				x			
	latigranifer				x	x	x	x
	minutus							x
	mundus						x	
	obesus							x
	obliquus			x	x	x	x	
	orbicularis					x		x
	provectus				x			
	quasiarcuatus	x		x				
	reticuloides			x				
	setulosus						x	
	triangularis					x	x	
	verrucifer		x	x				x
	Sp. A (Ruffin, 1961)				x			
	Sp. B (Ruffin, 1961)				x			x
	Sp.							x
Calamospora	breviradiata	x	x	x	x	x	x	x
	decora					x	x	
	flexilis			x		x		x
	hartungiana	x	x	x		x	x	x
	liguida						x	
	microrugosa							x
	mutabilis						x	
	pallida							x
	parva				x			
	pedata						x	
	saariana							x
	straminea	x	x			x	x	x
	Sp. A (Ruffin, 1961)				x			
	Sp. B (Gibson, 1961)						x	
	Sp. A (Gibson, 1961)						x	

TABLE 4--Continued

Species		Illinois coals			Oklahoma coals			
		*DW	GB	CC	T	C	IP	M
Granulati-sporites	aculeolatus				x			
	adnatus				x	x		
	commissuralis							x
	convexus				x			x
	deltiformis					x		x
	granularis				x	x		
	gibbosus				x			
	levis							x
	microsaetosus				x			x
	microspinosus				x			
	mosaicus				x			
	pallidus				x			x
	parvus				x			x
	piroformis					x	x	
	verrucosus				x	x	x	
Converrucosi-sporites	mosaicoides						x	
	sulcatus	x			x	x	x	x
	Sp. A (Ruffin, 1961)				x			
Verrucosi-sporites	difficilis				x			
	donarii							x
	firmus		x					x
	grandiverrucosus							x
	Sp. A (Gibson, 1961)						x	
	Sp. A (Ruffin, 1961)				x			
	Sp. B (Ruffin, 1961)				x			
Anapiculati-sporites	spinosus	x		x				x
Raistrickia	aculeata					x		x
	aculeolata	x		x	x			x
	crinita			x	x	x	x	x
	crocea			x	x	x	x	x
	grovensis			x		x		x
	imbricata				x			
	irregularis	x		x				x

TABLE 4--Continued

Species		Illinois coals			Oklahoma			
		*DW	GB	CC	T	C	IP	M
Raistrickia (continued)	pilosa			x	x			
	prisca					x		
	rubida			x				
	solaria				x	x	x	
	spinososaetosa							x
	Sp. A (Ruffin, 1961)				x			
	Sp. B (Gibson, 1961)						x	
	Sp. C (Gibson, 1961)						x	
	Sp. D (Gibson, 1961)						x	
	Sp. A (Gibson, 1961)						x	
Schopfites	colchesterensis			x		x	x	
	dimorphis			x				
Convoluti-spora	florida				x		x	
	Sp. A (Ruffin, 1961)				x			
	Sp. B (Ruffin, 1961)				x			
	Sp. A (Urban, 1962)							x
Reticulati-sporites	lacunosus	x						x
	muricatus				x			
Triquitrites	additus				x	x	x	x
	arculatus		x	x		x	x	
	bransonii				x	x	x	x
	crassus	x		x	x	x	x	
	discoideus					x		
	dividuus				x	x		x
	exiquus	x		x		x	x	x
	inusitatus	x	x	x	x	x	x	x
	praetextus				x	x		x
	protensus		x					x
	pulvinatus	x	x	x				
	spinosus						x	
	tumulus					x	x	x

TABLE 4--Continued

Species		Illinois coals				Oklahoma		
		*DW	GB	CC	T	C	IP	M
Densosporites	anulatus							x
	granulosus							x
	sphaerotriangularis		x					x
	triangularis	x						
Cadiospora	magna				x			
	Sp. A (Ruffin, 1961)				x			
	Sp. A (Urban, 1962)							x
	Sp. B (Urban, 1962)							x
	Sp. (Urban, 1962)							x
Lycospora	brevijuga			x		x		
	granulata	x	x	x	x		x	x
	micropapillata	x						
	pseudoannulata						x	
	punctata	x	x	x				
	torquifer						x	
	Sp. A (Gibson, 1961)				x		x	
	Sp. B (Gibson, 1961)						x	
	Sp. C (Gibson, 1961)						x	
	Sp. A (Ruffin, 1961)				x			
Cirra-triradites	annulatus			x	x			
	annuliformis	x		x				
	crassus					x		x
	intermedius					x		
	maculatus	x	x				x	
	saturni							x
	pseudoannulatus					x		
	punctatus					x		
Spenceri-sporites	radiatus						x	x
Reinschospora	triangularis							x
Laevigato-sporites	desmoinensis	x	x	x		x	x	x
	globosus					x		x
	latus						x	

TABLE 4--Continued

Species		Illinois coals				Oklahoma		
		*DW	GB	CC	T	C	IP	M
Laevigato-sporites (continued)	medius						x	x
	minimus	x	x	x	x	x	x	x
	minutus	x	x	x	x	x	x	x
	ovalis	x	x	x	x	x		x
	pseudothiessenii		x	x		x		
	punctatus	x	x	x	x		x	
	pygmäus							x
	robustus		x	x	x			
	vulgaris		x					x
	Sp. A (Urban, 1962)							x
New Genus A	Sp. A (Urban, 1961)							x
New Genus B	Sp. A (Urban, 1961)							x
Foveolati-sporites	fenestratus		x				x	
	foveatus	x	x	x	x		x	
	quaesitus						x	
Wilsonites	delicatus					x	x	
	vesicatus				x		x	x
	Sp.			x				
Endosporites	minutus						x	
	ornatus	x		x	x	x	x	
	pallidus						x	
	Sp. A (Ruffin, 1961)				x			
Vestispora	profunda				x	x	x	x
	Sp. A (Ruffin, 1961)				x			
Schulzospora	rara							x
Guthörli-sporites	Sp. A (Gibson, 1961)						x	
Florinites	antiquus	x	x	x		x		
	elegans						x	

TABLE 4--Continued

Species		Illinois coals			Oklahoma			
		*DW	GB	CC	T	C	IP	M
Florinites (continued)	parvus				x	x		
	pellicidus				x		x	x
	similis						x	
Illinites	unicus						x	x
Kosankei-sporites	elegans				x		x	x
	Sp. B (Gibson, 1961)						x	
Sahnisporites	Sp. A (Gibson, 1961)						x	
Vesicaspora	wilsonii						x	
Alisporites	Sp. A (Ruffin, 1961)				x			
Pityosporites	Sp. A (Gibson, 1961)						x	
Platysaccus	Sp. A (Ruffin, 1961)				x			
Schopfi-pollenites	ellipsoides				x		x	x
	ovatus				x			
Genus A	(Gibson, 1961)						x	
Genus A	(Ruffin, 1961)				x			
Genus B	(Ruffin, 1961)				x			
Genus C	(Ruffin, 1961)				x			
Genus D	(Ruffin, 1961)				x			
Genus C	(Urban, 1962)							x
Genus D	(Urban, 1962)							x
Alatisporites	hexalatus	x	x	x	x			x
	inflatus							x
	trialatus	x		x				
	varius				x			
	Sp. A (Ruffin, 1961)				x			

*DW - Davis and Wiley coals (Kosanke, 1950)
GB - Greenbush and Dekovan (7) coals (Kosanke, 1950)
CC - Colchester (2) coal (Kosanke, 1950)
T - Tebo coal (Ruffin, 1961)
C - Croweburg coal (Wilson and Hoffmeister, 1956)
IP - Iron Post coal (Gibson, 1961)
M - Mineral coal (Urban, 1962)

TABLE 5

SUMMARY OF SPORE DISTRIBUTION IN THREE ILLINOIS COALS AND FOUR OKLAHOMA COALS

Comparison	Illinois			Oklahoma			
	*DW	GB	CC	T	C	IP	M
Species reported	30	26	43	71	48	75	76
Restricted species	3	--	3	32	7	30	28
Species and percentage in common with Mineral coal	16 (21.1)	15 (19.7)	18 (23.7)	26 (34.2)	26 (34.2)	24 (32.4)	-- --
Species and percentage in common with Mineral coal	16	15	18	26	26	24	--
Percentage of compared coal	(53.3)	(57.7)	(40.9)	(36.6)	(54.2)	(32.0)	--

*DW - Davis and Wiley coals (Kosanke, 1950)
GB - Greenbush and Dekoven (7) coals (Kosanke, 1950)
CC - Colchester (2) coal (Kosanke, 1950)
T - Tebo coal (Ruffin, 1961)
C - Croweburg coal (Wilson and Hoffmeister, 1956)
IP - Iron Post coal (Gibson, 1961)
M - Mineral coal (Urban, 1962)

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APPENDIX

PLATE 1

1. Punctatisporites aureus
72x66 microns OPC 623 B 5-8

2. Punctatisporites obesus
95.7 microns OPC 621 E 2-2

3. Punctatisporites latigranifer
66.7 microns OPC 621 B 3-2

4. Punctatisporites Sp. B
58x54 microns OPC 623 B 3-2

5. Punctatisporites Sp. A
47x41 microns OPC 621 F 2-1

6. Punctatisporites verrucifer
39x27.6 microns OPC 623 B 5-13

7. Punctatisporites minutus
23 microns OPC 620 D 1-5

8. Punctatisporites orbicularis
36 microns OPC 620 L 3-1

9. Calamospora microrugosa
116x85 microns OPC 623 B 2-1

10. Calamospora pallida
54x50 microns OPC 622 C 2-4

11. Calamospora breviradiata
72x66 microns OPC 622 J 1-9

12. Calamospora straminea
38x35 microns OPC 622 C 4-5

13. Calamospora flexilis
55 microns OPC 623 B 1-7

PLATE 1

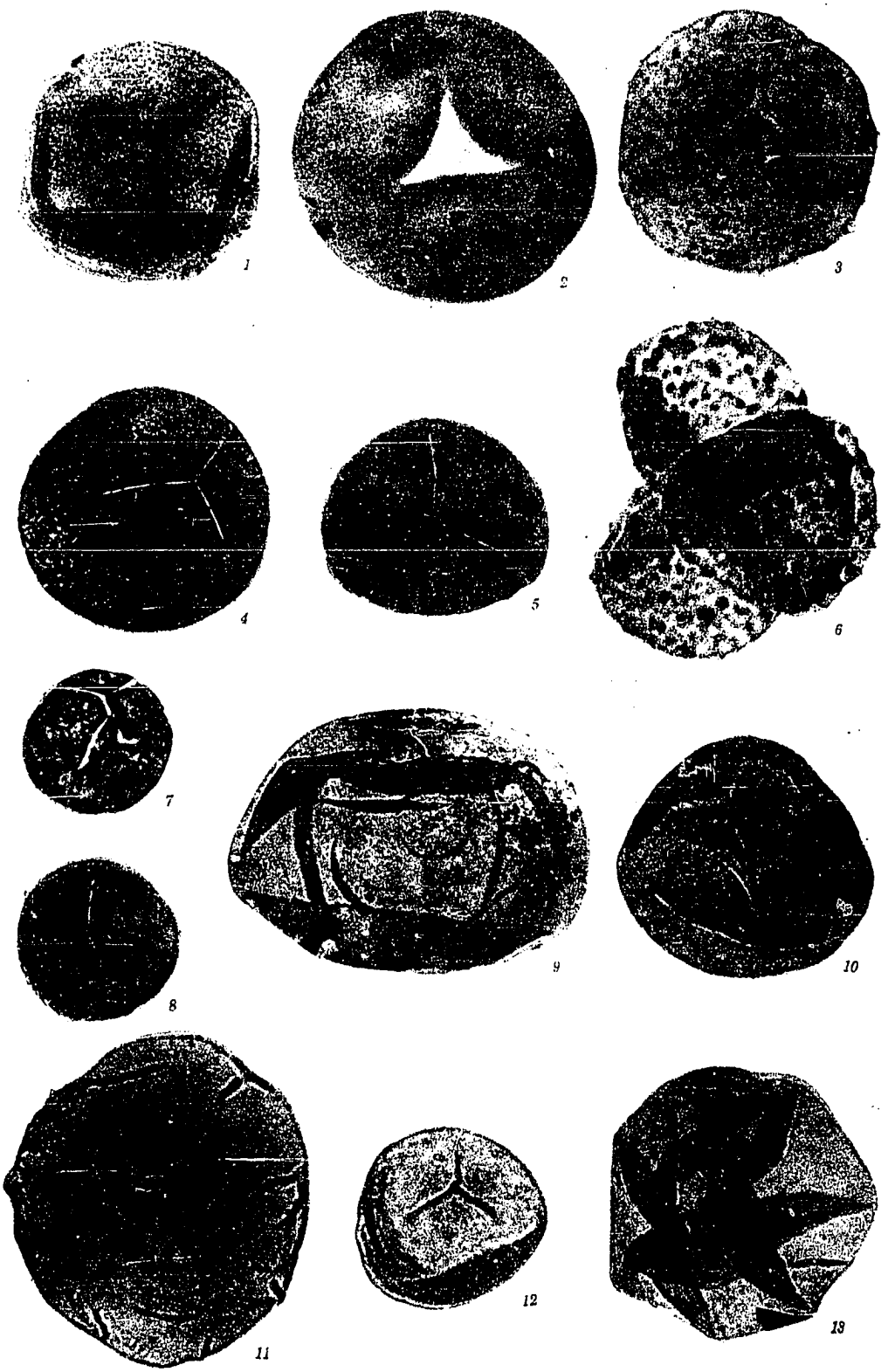


PLATE 2

1. Calamospora hartungiana
90x77 microns OPC 621 F 4-1

2. Calamospora saariana
106x94 microns OPC 622 F 3-2

3. Raistrickia aculeolata
36.8x34.5 microns OPC 623 B 7-4

4. Raistrickia aculeata
46 microns OPC 623 B 3-4

5. Raistrickia spinososaetosa
56x49 microns OPC 623 C 3-13

6. Raistrickia crocea
41x37 microns OPC 620 H 3-7

7. Raistrickia grovensis
56x53 microns OPC 621 E 2-1

8. Reticulatisporites lacunosus
91x84 microns OPC 620 E 5-1

9. Raistrickia crinita
49x41 microns OPC 622 D 1-5

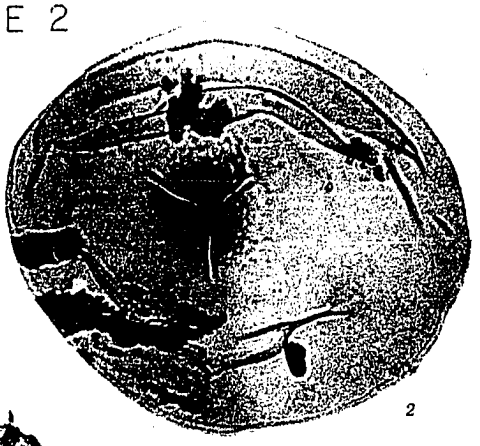
10. Raistrickia irregularis
57x55 microns OPC 623 B 5-12

11,13. Reinschospora triangularis
59x53 microns OPC 622 C 2-2
57.5x52.9 microns OPC 622 C 5-2

12. Convolutispora Sp. A
43.7 microns OPC 620 H 4-1

PLATE 2

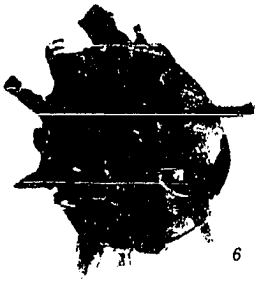

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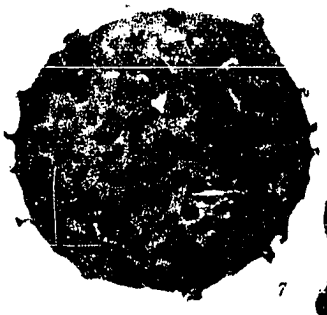

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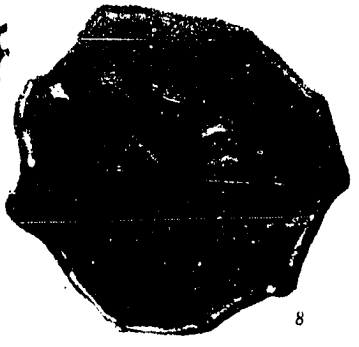

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PLATE 3

1. Triquitrites inusitatus
62x60 microns OPC 623 B 5-1

2. Triquitrites praetextus
42x40 microns OPC 622 C 5-4

3. Triquitrites tumulus
45x43 microns OPC 623 D 8-7

4,5. Triquitrites bransonii
29.9x32.2 microns OPC 620 H 2-7
34.5x23 microns OPC 623 D 6-1

6. Triquitrites dividuus
40x38 microns OPC 623 B 2-15

7. Triquitrites additus
49x41 microns OPC 623 C 2-3

8. Triquitrites exiguus
29x24 microns OPC 620 H 1-3

9. Triquitrites protensus
35x34 microns OPC 623 D 6-3

10. Granulatisporites levis
39x38 microns OPC 621 G 2-2

11. Granulatisporites deltiformis
25x22 microns OPC 623 E 8-6

12. Granulatisporites convexus
60x58 microns OPC 623 C 4-2

13. Converrucosisporites sulcatus
29x25 microns OPC 623 B 3-7

14. Granulatisporites commissuralis
28x27 microns OPC 621 F 1-4

15. Granulatisporites parvus
36x33 microns OPC 621 C 4-2

16. Granulatisporites microsaetosus
20.7 microns OPC 622 J 2-10

17. Anapiculatisporites spinosus
29x28 microns OPC 623 K 1-2

18. Verrucosisporites grandiverrucosus n. comb.
55.2 microns OPC 622 F 1-2

19. Verrucosisporites firmus
53x52 microns OPC 623 K 4-2

20. Verrucosisporites donarii
53x47 microns OPC 623 B 8-2

PLATE 3

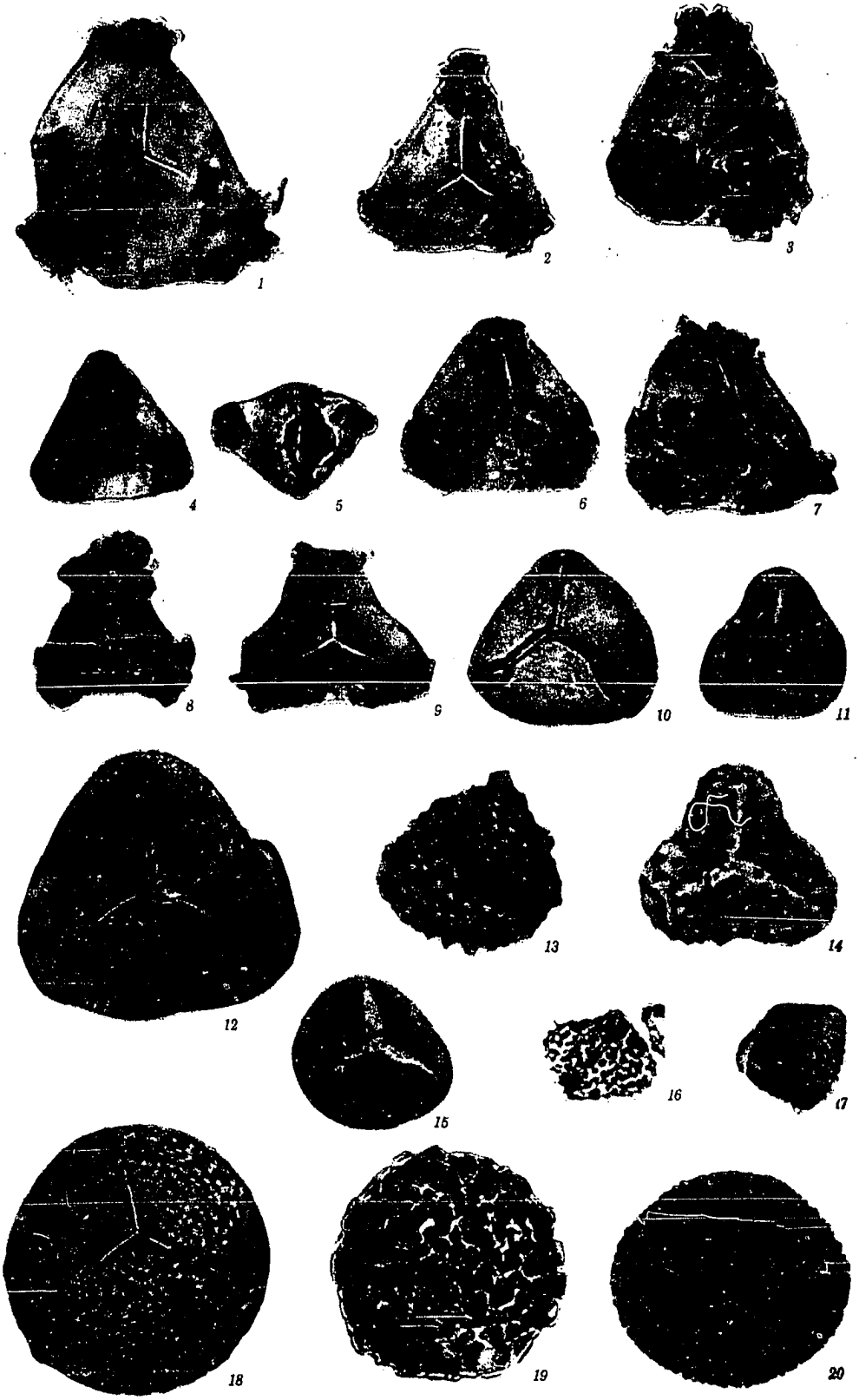


PLATE 4

1,2. Cirratriradites saturni
74x65 microns OPC 621 E 3-1
76 microns OPC 621 F 3-3

3. Cirratriradites crassus
78x70 microns OPC 622 E 2-1

4. Cadiospora Sp. B
138x131 microns OPC 621 H 5-2

5. Cadiospora Sp. A
92x87.4 microns OPC 620 D 4-1

6. Cadiospora Sp.
80x72 microns OPC 623 B 5-3

7,8. Vestispora profunda
80x73.6 microns OPC 623 B 7-7
78.2 microns OPC 623 B 5-15

PLATE 4



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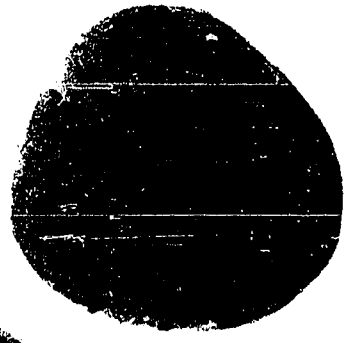
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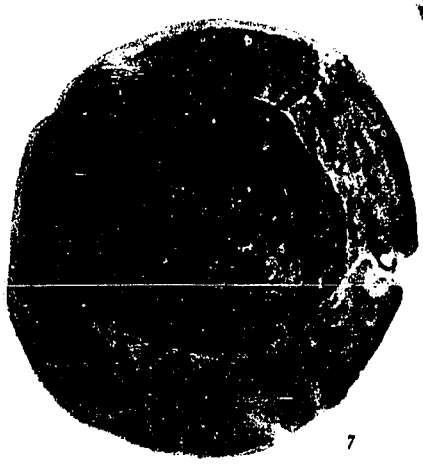
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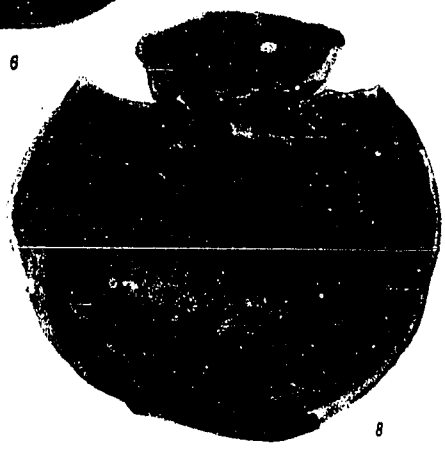
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PLATE 5

1,2. Densosporites anulatus
82 microns OPC 620 D 5-1
60x53 microns OPC 620 D 3-2

3,4. Densosporites sphaerotriangularis
47 microns OPC 620 K 1-4
46x40 microns OPC 623 K 2-10

5,6. Densosporites granulosus
43x42 microns OPC 623 L 6-1
48 microns OPC 622 E 2-4

7. Alatisporites inflatus
99x78 microns OPC 623 K 1-14

8,9,10. Lycospora granulata
29x27 microns OPC 623 E 2-6
31x29 microns OPC 623 G 2-4
42x36 microns OPC 623 E 1-11

11,12. Alatisporites hexalatus
44x42 microns OPC 620 G 1-1
60 microns OPC 621 G 2-4

13. Schulzospora rara
115x87 microns OPC 623 B 4-3

14. Spencerisporites radiatus
370x350 microns OPC 621 E 1-2

PLATE 5


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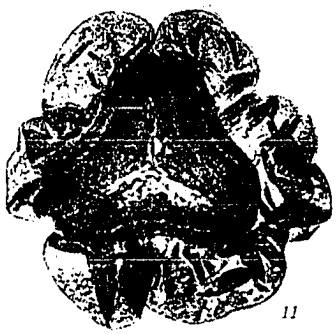

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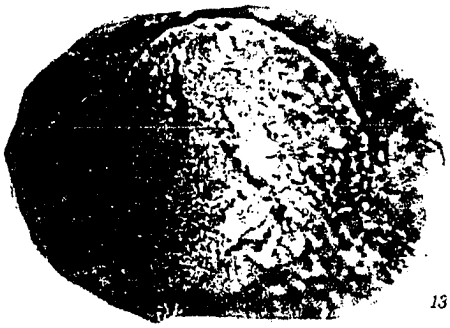



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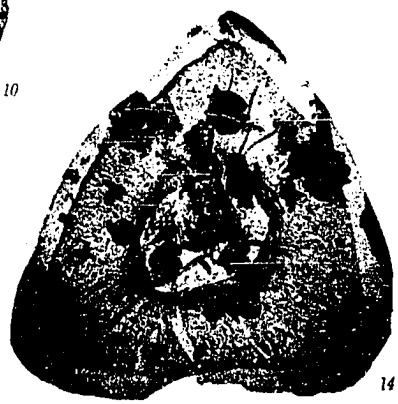

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PLATE 6

1,3,4. Florinites pellucidus
36x48.3 microns OPC 623 E 10-6
60x30 microns OPC 622 G 3-2
80.5x64.4 microns OPC 622 J 1-2

2,5,7. Genus D Sp. A
50.6x32.2 microns OPC 623 B 7-10
90x69.5 microns OPC 622 C 2-4
43x37 microns OPC 623 B 2-5

6. Wilsonites vesicatus
66.7x64.4 microns OPC 620 H 2-8

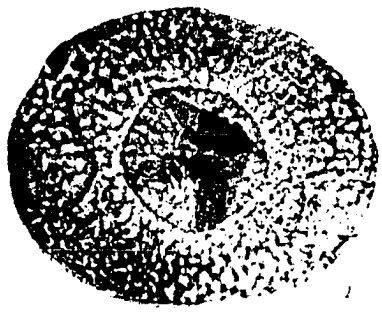
8. Illinites unicus
61.9x50.6 microns OPC 622 F 1-3

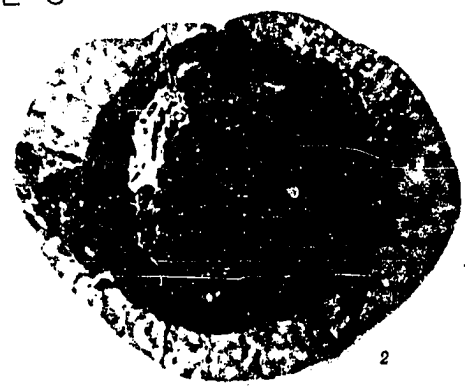
9,10,11. Genus C Sp. A
52.9x41.4 microns OPC 620 E 2-3
52.9x43.7 microns OPC 620 H 5-7
44 microns OPC 620 J 2-1

12. Kosankeisporites elegans
92x69 microns OPC 623 I 6-3

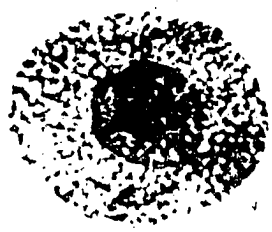
13. Schopfipollenites ellipsoides
171x98 microns OPC 621 C 4-1

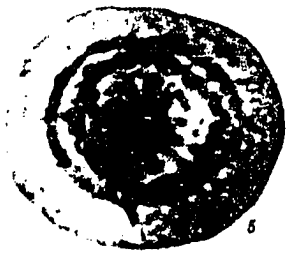
PLATE 6

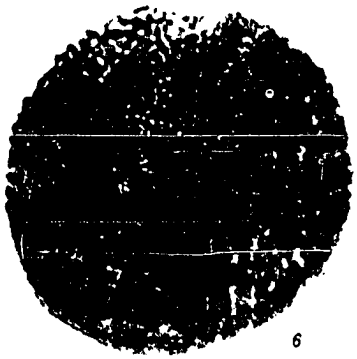

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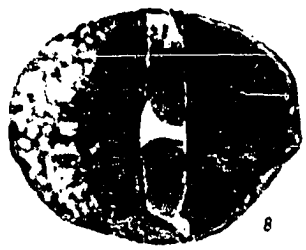

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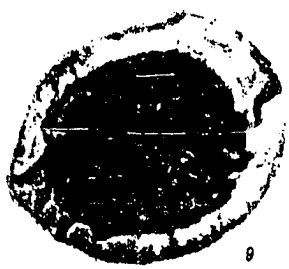

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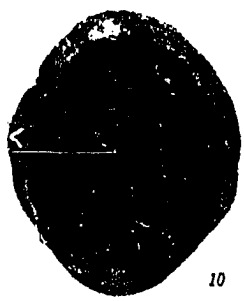

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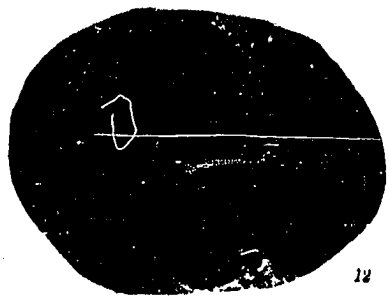

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PLATE 7

1. Laevigatosporites vulgaris
80x48 microns OPC 622 F 5-6

2. Laevigatosporites desmoinensis
89x49 microns OPC 623 D 1-1

3. Laevigatosporites globosus
32 microns OPC 620 J 2-15

4. Laevigatosporites ovalis
50x35 microns OPC 623 B 7-5

5,8. Laevigatosporites Sp. A
16.1x13 microns OPC 620 L 2-5
15x11.5 microns OPC 622 H 3-4

6,7,9. Genus A Sp. A
38 microns OPC 620 J 1-8
48.3x37 microns OPC 620 J 2-8
39x30 microns OPC 620 J 1-16

10. Laevigatosporites minimus
26x18 microns OPC 620 J 2-12

11. Laevigatosporites pygmäus
20.4x12.3 microns OPC 623 B 7-8

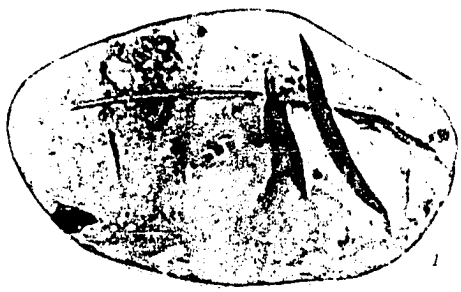
12. Laevigatosporites medius
28x24 microns OPC 621 C 2-8

13. Fungus spore
36x12 microns OPC 622 F 2-4

14. Laevigatosporites minutus
24x20.7 microns OPC 620 J 2-10

15,16. Genus B Sp. A
110.4x90 microns OPC 623 D 2-4
111x82 microns OPC 620 D 1-10

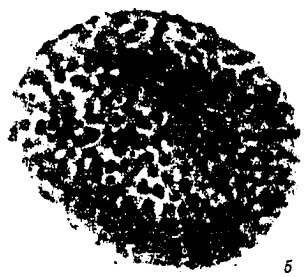
PLATE 7


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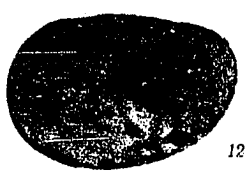

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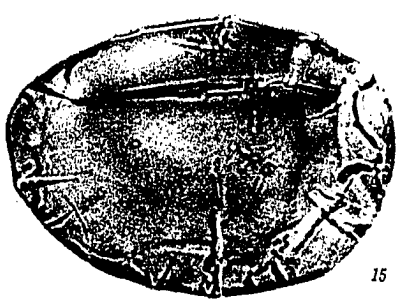

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TABLE 3. RELATIVE ABUNDANCES IN PERCENT OF SPORE SPECIES IN EACH LEVEL
(Occurrences of less than 0.1 percent are indicated by tr.)

	OPC 621								OPC 620												OPC 622										OPC 623										
	B	C	D	E	F	G	H	I	B	C	D	E	F	G	H	I	J	K	L	M	B	C	D	E	F	G	H	I	J	K	B	C	D	E	F	G	H	I	J	K	L
Punctatisporites aureus																	.4														tr.			.4								
latigranifer	tr.		tr.		.4												.4		.4					.8							.4			.8	1.2						
minutus					.4						tr.			1.2					.4								.8	.4	.8	.4											
obscurus				tr.																																					
orbicularis					.4						.9		.4	.8		.8			tr.											.4			tr.	tr.		.4	.4			.4	.4	
verrucifer																	tr.								.4						tr.					4					
sp. B																															tr.										
sp.				tr.	tr.										tr.														tr.												
Calamospora breviradiata					.4																						.4		1.2	2.4	.4	.4				.4			1.6	
flexilis	.4	1.6	1.0	.7	.8	3	.7		5.0	2.9			.4		.8	.8	1.2	.8	.8		.8	1.6	2.0	1.2		1.9	1.2		1.2	5.1	1.6	.4		.8	2.3		1.2		.4	2.4	1.2
hartungiana					tr.																				.4				tr.	2.0											
microrugosa						3		1.9	8.1		.4												.8	1.6	.4	.4		.4	2.0	2.8	tr.	.4	tr.								
pallida	.4	4	.3	2.3	5.5	2.0	5.3	3.8	3.8	5.9	4.7	.8	.4	1.6	1.5	.8	.8		1.2	.3	1.2	2.3	6.1	4.4	3.9	1.9	2.0	.4	2.7	4.7	2.0	.8	1.2	.4	4.2	4.0	1.2	2.0	2.8	2.0	2.0
saariana																							.4		tr.	.4			.8	1.6		tr.	.4				.4		.4	
straminea			1.0						3.8	2.9												.7	tr.	.8															.4	
Granulatisporites commisurnilis	1.2		.7	.3	tr.									.4				.8	.4		.4								.4											
convexus		.4	.7	.3	1.6								.4			.4	4	.4														tr.							.4	
deltiformis																															.4			tr.		.4				.4
levis	.4	.4	.9	.3		tr.								.4	.4			1.2						.4	.4		1.2	.4	.4		.9	.4	.8	1.6	1.2	.8					
microsaetosus																													2.0	.4											
parvus		tr.																			.4			.8								tr.									
Converrucosisporites sulcatus		.7	.3		.8	.3													1.2	.3											5.6	.4		.4						
Verrucosisporites donarii		tr.		.9	.4													.8				1.0	1.2	1.6	.8	.8	1.2	.4			tr.		.4	1.2	1.5	1.2	1.2		.4	.4	.4
firmus																																								tr.	
grandiverrucosus																									tr.		.8														
Anapiculatisporites spinosus		.4		3		.7				1.5	8		.4	.4							.4	1.6	.8	3.6	2.4	1.9	4.1	1.2	8.2	9.1			1.2	.8		3.2	4.7	2.6	6.4	12.0	3.1
Raistrickia aculeata		tr.	tr.	9															tr.			.3		.4		.4					1.2	.4				.4					
aculeolata				1.0	tr										tr.				tr		.4		.8	.4	.8						.8	tr.	.4			tr.					
crinita																																									
crocea														4	tr.		.4		4				tr.											.4							
grovensis				tr.																														.4	.4						
irregularis		tr.		tr.	.4		.3				tr								tr.	3 .3	tr.	tr.	tr.								..			.4	.4	.4	tr.			tr.	
spinonassetosa				3										.4									.4	.4								tr.			.4					
Convolutispora sp. A							.6								tr.																									
Reticulatisporites lacunosus			3				1.0	20.8	.6	5.8	3.0	4.7	7.2																									.4			
Triquitrites additus		.8	3											.4				.4			1.2	2.3	.8	.4	.4	.4					2.0	.4	.4	.4						
bransonii	1.9	2.8	1.7	8.3	5.9	1.3								1.2	.7	.4	1.9	1.6	4.3	1.0	2.0	1.3		.8	1.6						.8	.4	2.0	6.3	5.0	5.2	1.6			
dividuus		4	1.3												.8	.4			.4	.7											1.9	.4	tr.		.4					
exiguus						1.0									tr.				.8		.4													.4						
inusitatus															.4			.4			.4		.4								.8									
praetextus																			tr.			tr.	1.2	.8	.4						tr.	tr.	tr.	8						
protenaus			.3		1.6														.4														tr.							
tumulus				.3	.4																										.4		.4							
Densosporites anulatus						.7					1.3				1.2										tr.											1.2	1.2		.4	tr.	.8
granulosus				tr.	2.4	9.8	3.3				37.3	1.6	5.6	10.1	12.4									2.8	7.9	17.2	34.6	28.5	42.9	32.8					.4	18.8	25.2	43.2	32.6	35.2	42.7
sphaerotriangularis						3.9	1.0				7.6		tr.	.4	1.6	tr.								1.3	2.8	5.0	3.3	6.4	8.6	5.1						7.6	9.8	10.0	15.2	6.0	8.2
Cadiospora sp. A									1.3	2.9	5.2	.8																												
sp. B						.3		1.9	.8	tr.	3.4	4.0																													
sp																															tr.									
Lycospora granulata		tr.	1.3	10.3	7.8	.3			1.3		.8			2.0	.8	.4		4.4	.4	.7	2.8	32.3	20.4	27.0	8.4	20.1	3.7	tr.	5.0	4.0	.8	1.2	15.6	14.2	17.5	20.4	10.2	4.0	4.8	12.0	16.1
Cirratriradites crassus																																								
saturni				.7	tr.																		.4	tr.							tr.				.4	tr.				
Reinschospora triangularis					1.2																	.3		tr.					tr.									.4	tr.
Laevigatosporites desmoinensis		.7	1.0	3.7	3.5	2.6	2.3	1.9	5.6		4.3	4.3	3.2	4.5	3.1	3.9	1.9	3.6	2.4	.3	2.0	2.3	5.4	2.8	5.1	.8	1.2	2.7	1.2	3.2	3.2	1.2	4.4	1.0	3.1	.4	3.5		2.0	.8	.8
globosus	30.7	29.3	21.3	13.6	18.7	46.7	23.0	5.7	30.4	26.7	19.5	27.3	15.2	9.1	5.4	3.5	5.0	12.0	5.1	44.4	3.2	5.3	6.6	5.2	7.0	5.3	9.8	10.5	6.2	10.3	37.8	27.8	12.8	23.4	16.4	11.2	22.0	17.6	19.8	17.2	11.0
medius	25.7	15.4	12.0	4.0	6.3	1.3	1.0		.6		.8	2.8	3.2	5.4	1.6	1.9	2.0	5.1	1.6.3	9.3	3.2	2.0	2.4	.4	.8			.4	.3	.6	16.6	7.6	3.6	.4	1.2	.4		2.0	.8	.8	.7
minimus	1.2	3.1	.6		2.0	2.9	.3		4.4		.9		1.2	.3	2.0	6.2	2.4	.8	2.3			.7		.8		1.6	.4			.8	4.0	1.2	.4					.4		
minutus	12.7	24.0	25.0	8.0	11.7	10.5	32.2	3.8		2.9	.9	.4	11.6	22.6	26.6	18.0	15.0	19.6	17.4	19.4	2.8	4.3	6.6	2.0	5.9	6.8	7.8	41.8	6.2	3.6	12.7	20.7	9.2	3.6	5.4	2.0	1.2	.8	1.6	.4	1.2
ovalis	7.3	2.8	4.0	6.7	3.1	1.6	2.0	3.8	8.8	1.5	2.3	7.1	4.4	5.3	5.8	8.6	6.2	2.8	6.7	2.7	6.0	4.0	6.6	6.0	3.9	3.1	1.2	1.2	2.7	2.8	7.6	2.8	7.2	3.6	4.2	3.2	.4	1.2	1.2	1.2	11.0
pygmäus	9.2	6.4	10.0	1.0	9.8	2.0			1.9				.4	2.8	2.7	6.6	.4	13.2	13.4	11.6	19.6	2.0	6.2	4.8	5.9	1.1	.4	.4	.8		1.6	11.2	2.0							
vulgaris									6.3	1.5	.9	7.5	2.4	.8	.4	1.6	4	.4					.8		2.4	2.3			.4				.4		1.2	.8	1.6	8	.4	1.2	
sp. A		.4		.3			.7												1.2		1.2		.8	.4	.4		.8											.4			
Genus A sp. A	1.9	4.7	4.0	13.5	12.5	5.9	5.7	5.7		2.9		1.6	7.2	6.1	12.7	7.0	23.4	5.6	21.7	4.0	2.0	7.6	2.8	6.4	4.7	3.0	1.6	.4				.8	6.8	3.2	6.9	3.2					
Genus B sp. A				.3		tr.		1.9			.9	.8	tr.	tr.									tr.	.4	tr.	tr.	tr.	.4					tr.	tr.	.8	tr.	tr.	.8	2.4			
Spenceriasporites radiata																																			.8						
Wilsonites vesicatus					.4	tr.	.3	1.9	3.2	8.8	1.3	5.2		.4	tr.	.4				tr.			.4	tr.		.4	.8	.4	1.2	1.6								.8	.4	.4
Genus C sp. A							1.7	1.9	4.4	1.5		3.8	2.0	.4	1.8	3.1	tr.								tr.		2.5	.4			.4								tr.	
Genus D sp. A																					.4	tr.		tr.				.4		tr.									
Vestispora profunda		.4		1.0	1.2		.3	31.8		27.9	.4				.4				.8		.4	.3	.4	.8			.4		.8	1.3	1.2	.8	.4	1.2	.4	tr.	.4			
Schulzospora rara		.8	.3									.4									tr.										tr.									
Florinites pellucidus	7.0	tr.	11.7	21.0	tr.	4.2	8.7	7.5	9.9	4.4	3.4	16.2	30.0	23.1	14.3	39.7	32.6	27.6	14.3	2.4	42.8	27.8	25.4	20.6	30.1	24.2	18.2	3.5	3.9	4.3	3.6	17.5	28.0	30.5	24.1	12.8	12.2	4.8	6.4	4.8	
Illinites unicus																									tr.					.4											
Kosankeisporites elegans		.4			.4	.3	.3								tr.								tr.				tr.										tr.			
Alatisporites hexalatus						.7	6.0	3.8			1.7	.8	6.0	.4	.4		1.5						.4	.4	2.0	.4	.4	.4	.4						tr.	.8	.4	.8	1.2		
inflatus						.3	3.3					11.9	1.8	.4	tr.																								tr.	
Schopfipollenites ellipsoides								1.9					.4								2.0			.4							.4									