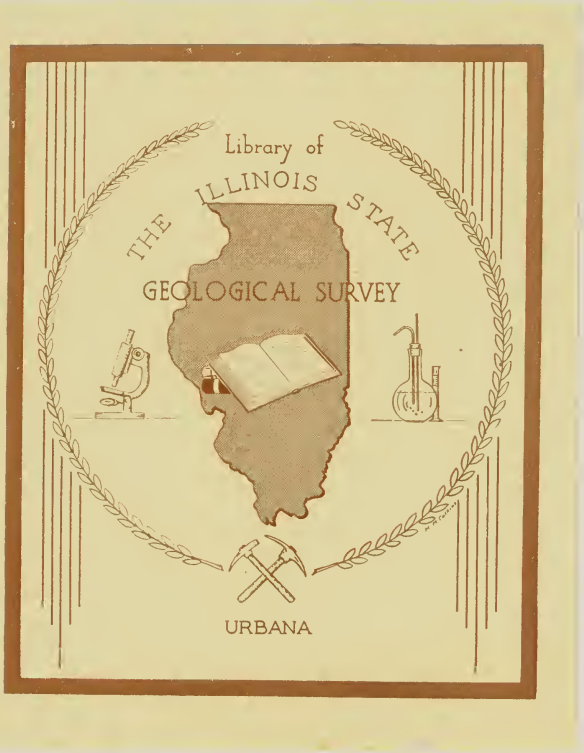

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PENNSYLVANIAN SPORES OF ILLINOIS AND THEIR USE IN CORRELATION

BY
ROBERT M. KOSANKE

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Topographic Mapping in Cooperation with the United States Geological Survey.

This report is a contribution of the Coal Division.

August 1, 1949

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ILLUSTRATIONS

PENNSYLVANIAN SPORES OF ILLINOIS
AND
THEIR USE IN CORRELATION

BY
R. M. KOSANKE

INTRODUCTION

THE TERM SPORE may be defined in a broad sense as a reproductive organ or body formed by plants, and in the animal kingdom by members of the Class Sporozoa of the Phylum Protozoa. The spores isolated from Illinois coal beds are all derived with a few possible exceptions from vascular plants.[1] All vascular plants produce spores or spore equivalents of which there are several types: homosporous spores, which are essentially the same size; male microspores and female megaspores of heterosporous plants; and male spores (microspores, prepollen, or pollen), and female gametophytes of primitive seed plants.

All vascular plants produce either homosporous spores or male microspores, or in more highly developed vascular plants, their equivalents. Megaspores are not produced by all vascular plants. For this reason, and because there are many more male spores produced than megaspores, the homosporous spores, microspores, and prepollen (small spores) have been selected for the investigation of their possible use in the correlation of Illinois coal beds.

The correlation of Illinois Pennsylvanian strata is a complex problem, as is attested by the numerous publications on the subject from the time of Worthen and his associates. Correlations using biological evidence have been of considerable value. The work of Dunbar and Henbest on the Fusulinidae, Schopf's megaspore publications, and Cooper's ostracod studies are examples. However, there still exist numerous perplexing coal correlation problems, and proved key beds are needed.

[1]Plants with definite conductive elements which are above the mosses and liverworts in the phylogenetic sequence.

There are more than 50 named coal beds in Illinois, and in addition there are a number of unnamed thin coal beds. The spore content of many of these coal beds has been extensively examined; other beds still need to be studied over a wider lateral distribution.

OBJECTIVES

The main objectives of this investigation were to determine the feasibility of correlating Illinois coal beds by means of plant spores, and to provide a paleobotanical basis for correlating as many of the coal beds as possible. In order to accomplish these objectives, it was first necessary to prepare and study the small spores from numerous coal beds, to identify old and describe new genera and species, and to determine the vertical and lateral distribution of each species.

Variation in the abundance of genera and species (both lateral and vertical), were also studied, as well as their zonation within portions of coal beds.

HISTORY OF SPORE STUDIES

The history of spore studies, given by various authors, is very complete. The following paragraphs give the more important contributions.

The presence of fossil plant spores was, in all probability, first observed by Mr. Henry Witham (1833, p. 50, Pl. 11, figs. 4 and 5). He employed William Nichol's method of thin sectioning to some cannel coal from Lancashire and noted " . . . . decided traces of organization." Witham stated that he was inclined to believe that these traces of organization might possibly be the remains of a monocotyledonous plant

(vessels). Witham declined to speculate, saying, " . . . . I shall not venture upon any conjecture respecting them." Bennie and Kidston (1886) pointed out that the traces of organization of Witham, drawn for Witham by W. MacGillivray, show many megaspores and not monocotyledonous vessels. It is also quite likely that numerous small spores were present in Witham's sections. His illustrations are shown at 100 × and on that basis many of the light colored areas measure from 60 to 100 microns, which is distinctly within the size range of small spores, and suggests the presence of small spores in Witham's sections.

From 1840 to 1855 there appeared a number of noteworthy papers on paleobotany and the origin of coal. Morris (1840) is credited by Bennie and Kidston (1886) to be the first to illustrate isolated fossil megaspores. Others who contributed were Bowman (1841), Phillips (1842), and E. W. Binney (1848). One of the most important contributions to the study of isolated plant remains found in coal was made by Franz Schulze in 1855. He discovered that coal could be macerated with chemicals (see page 9) without harm to the botanical ingredients. Thus almost 100 years ago there were known two methods (thin section and maceration) by which the botanical ingredients of coal could be studied microscopically. These methods with minor refinements are used to this day.

From 1855 to 1881 little happened that was directly related to the studies of spores from coal beds. Reinsch's publications of 1881 and 1884 are well known. Reinsch's publication in 1884 is an excellently illustrated two-volume work which has received considerable attention. Schopf, Wilson, and Bentall (1944) honored Reinsch with *Reinschospora.* Species of this genus were illustrated by Reinsch as were the now recognized genera: *Granulati-sporites, Triquitrites, Reticulati-sporites, Punctati-sporites, Raistrickia, Cirratriradites, Endosporites,* and possibly *Denso-sporites.* Reinsch also illustrated many megaspores. He believed that the organisms found in coal from Russia and Saxony were of algal origin, and that the flat expansion (flange) surrounding some of the spores was parasitic in origin.

James Bennie and Robert Kidston collaborated to publish an account of the spores of the Carboniferous of Scotland in 1886, Bennie's contribution being entirely geological, and Kidston's entirely botanical. Kidston did not favor Reinsch's theory that the organisms in coal were algal remains. Kidston believed the organisms in question to be spores, and that the flat expansion surrounding certain types of spores was an integral part of the spore on which it occurred.

The period following Bennie and Kidston's paper until 1931 was largely devoted to the "algal coals" (see Jeffrey 1910, Thiessen 1925, and Schopf, Wilson, and Bentall, p. 53, 1944) and the development of the thin-section method by Thiessen at the United States Bureau of Mines.

Numerous papers concerned with spores from Paleozoic coal deposits appearing between 1931 and the present have been of considerable aid in the present investigation. The authors and dates of publication are as follows: McCabe (1931), Potonie (1931), Loose (1932, 1934), Hartung (1933), Raistrick and Simpson (1933), Ibrahim (1933), Raistrick (1934-1935, 1937-1939), Wicher (1934a, 1934b), Florin (1936-1940, 1944), Paget (1936), Schopf (1936, 1938), Berry (1937), Knox (1938-1939, 1942), Millott (1939), Wilson and Coe (1940), Schopf, Wilson and Bentall (1944), Wilson and Kosanke (1944a), and Wilson (1944b). In addition to these papers, Olof H. Selling's paper (1946) has been helpful in understanding the spore types of certain modern pteridophytes.

PREPARATION OF COAL FOR MICROSCOPIC EXAMINATION

Coal is formed from plant remains which are progressively coalified and altered from their original state by increasing pressure, temperature, and the passage of time, resulting in the formation of coals of different

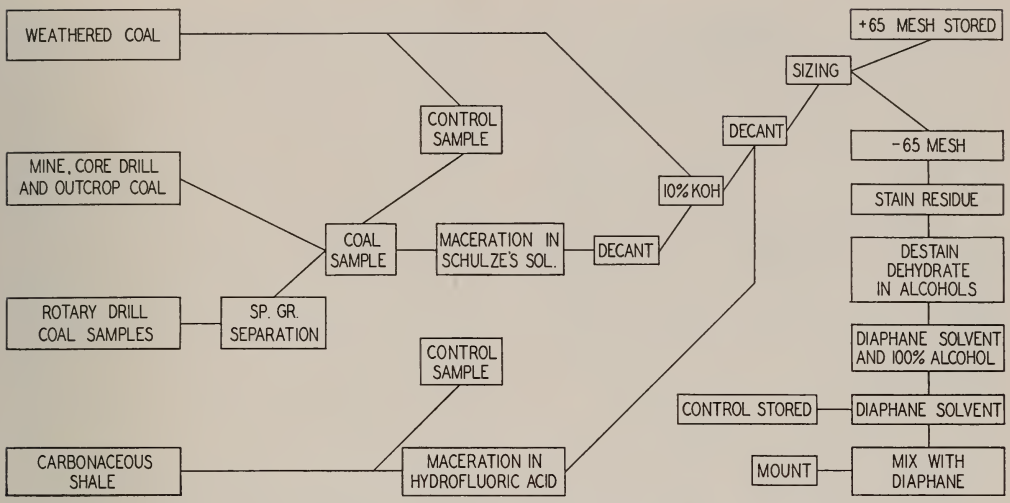

FIG. 1.—Outline of the procedure used in isolating the small spores for microscopic study.

ranks that range from brown coal to meta-anthracite. The Pennsylvanian coal beds in Illinois are high volatile bituminous coals of C and B rank, and are composed of at least two or more of the following ingredients: vitrain, clarain, durain, and fusain in variable proportions plus differing amounts of mineral matter and moisture.

Three methods of preparing coal for microscopic investigation of the botanical ingredients which are used in the United States are: the chemical maceration method, the thin-section method, and the serial microtome method. The thin-section method has been described by Thiessen, Sprunk, and O'Donnell (1938). The serial microtome method has been described by Jeffrey (1910). The maceration method has been described in part by various authors, but since it is the method used in this investigation it seems necessary to explain the process in detail and to record additional information which may be of help to others.

The maceration method was first described by Franz Schulze in 1855, and with modifications is widely used today not only for the maceration of coal, but by botanists for the maceration of modern plant tissues. It consists of two phases, the partial oxidation of coal and the dispersal of the humic matter. The resistant plant spores, cuticle, etc. are freed, and may be isolated for microscopic examination.

The partial oxidation of coal may be accomplished by a number of oxidizing agents, the most common of which is termed Schulze's solution. The solution is prepared by mixing one part of a saturated aqueous solution of $KClO_3$ with two or three parts of cold concentrated HNO_3, which in the presence of an oxidizable substance, in this case coal, reacts typically as follows:

$$2\,HNO_3 + KClO_3 \longrightarrow 2\,NO_2 + KCl + H_2O + [4\,O]$$

The coal is then placed in a beaker and covered with Schulze's solution. The oxidation of coal follows:

Coal + Oxygen (i.e. from Schulze's solution) $\longrightarrow$ partially oxidized coal, i.e. oxides of carbon, water, soluble acids, humic acids, etc.

As shown in figure 1, weathered samples of outcrop coal need no further oxidation, and the first phase of the maceration process is unnecessary. This is because the coal has been oxidized by nature.

Coaly or carbonaceous shales do not macerate readily with Schulze's solution, but maceration may be accomplished with hydrofluoric acid. Hydrofluoric acid has also proved helpful in the maceration of certain tough cannel coals.

The length of time necessary to prepare

coal for the second phase of the maceration process depends upon the rank and physical nature of the coal. Banded ingredients of Illinois coal beds do not oxidize at the same rate. Experiments have shown that in general the order of oxidation for a given coal sample is vitrain, clarain, durain, and fusain. The time necessary to oxidize different coal beds varies considerably. The maximum and minimum time generally required to complete the oxidation phase of the maceration process on non-weathered Illinois coal using a two-to-one Schulze's solution is as follows:

McLeansboro coals	6 to 50 hours
Carbondale coals	12 to 100 hours
Tradewater coals	36 to 140 hours
Caseyville coals	48 to 206 hours

The longest oxidation time required for any Illinois coal was that of the Reynoldsburg bed of Caseyville age. The length of time necessary to oxidize coal may be shortened by increasing the temperature of the mixture, or by increasing the strength of the solution.

Coals while still in Schulze's solution can be tested to determine whether or not they are ready for the second phase of the maceration process by placing a small portion of the partially oxidized coal in a beaker and washing it free of acid. The coal is then covered with a 10 percent solution of KOH; if a heavy brown liquid forms (release of the humic matter), a drop of this liquid is placed on a glass slide and examined microscopically for spores. If spores are present in abundance, the maceration is ready for the second phase. The remainder of the partially oxidized coal sample in Schulze's solution should be washed with H_2O until a pH of approximately 7 is reached. This may be accomplished either by siphoning or decanting with several changes of H_2O.

The second phase of the maceration may be expressed in the following manner:

$$\text{Partially oxidized coal} + H_2O + KOH \left\{ \begin{array}{l} \text{Soluble portion (salts of humic acids)} \\ \text{Insoluble portion (preserved botanic ingredients)} \end{array} \right.$$

The KOH solution usually used is 10 percent, but it is preferable to use as weak a solution as possible. Two or three percent solutions have given creditable results. The second phase of the maceration process is completed when abundant spores are present. The time necessary for the second phase may vary from 15 minutes to more than 12 hours. As shown in figure 1, the soluble humic matter is washed from the residue which is then ready for sizing.

The coal residue is divided into two fractions by screening with a standard 65-mesh Tyler screen, the openings of which are 0.0082 inch or 210 microns. The filtrate of this screening process, the minus 65-mesh material, contains the small spores and prepollens. Some of the larger spores which are included in this filtrate material may be small megaspores. After each screening, the screen should be carefully cleaned to avoid possible contamination from one screening operation to the next.

The spores contained in the minus 65-mesh screenings vary from light or pale yellow to dark brown. It is necessary to stain the material to obtain good photomicrographs and to study the minute structural details of the spore coat and appendages. The staining process is simply a matter of covering the residue with a concentrated aqueous solution of safranine Y (other stains may be used) from 10 to 12 hours. Warming the staining solution two to three hours is usually sufficient to stain the residue. When the staining process is completed, the surplus liquid is drained or decanted off and the residue dehydrated with alcohol as shown in figure 1. For glycerin jelly mounts, excess stain may be removed by several changes of H_2O. For diaphane mounts, the alcohol solution is mixed with a 50-50 solution of absolute alcohol and diaphane solvent, followed by pure diaphane solvent. The final mounting is accomplished by draining off the excess pure diaphane solvent, and mixing a portion of the residue with diaphane and mounting. Commercial diaphane is somewhat thin for mounting spores, and best results have been obtained by exposing the mixture of diaphane and residue to air, which slightly thickens the diaphane. The portion of the residue not used in preparing slides may be saved

in a storage bottle and covered with pure diaphane solvent. The cap of the storage bottle should be sealed with paraffin to prevent evaporation and ultimate drying up of the residue.

Rotary well cuttings of coal beds have provided a valuable source of samples for this investigation. Such coal samples also contain greater or less amounts of other strata from which the coal must be freed. The coal contained in rotary samples is first separated from non-coal material by washing the cuttings with warm water to remove drilling mud and other soft clayey material. The sample is then dried and the coal separated out as the float in CCl_4 with a specific gravity of 1.58. The CCl_4 is removed by air drying, and the coal is ready for the oxidation phase of the maceration process.

DESCRIPTIONS OF NEW GENERA AND SPECIES

Introduction

Nineteen genera of small spores, of which five are new, have been isolated from Illinois coal beds: *Cadiospora, Illinites, Schulzospora, Schopfites,* and *Wilsonia. Cadiospora, Illinites,* and *Schulzospora* are known only from Illinois; *Schopfites* from Illinois and Ohio; and *Wilsonia* from Illinois, Iowa, and Ohio. Several specimens which possess undescribed features and which may represent new genera, are not described because they are rare and hence of little value for correlative purposes. Critical examination of a sufficient number of forms to prepare complete description has not been possible.

The small-spore genera described prior to this report have been modified slightly by the many new species described. The new species which have been assigned to these genera have increased the generic size ranges, and additional minor morphologic features are recorded for some genera. This information is considered important in delineating the genera, but a revision of the genera has not been attempted.

Some 130 species have been identified from Illinois coal beds, of which 100 are

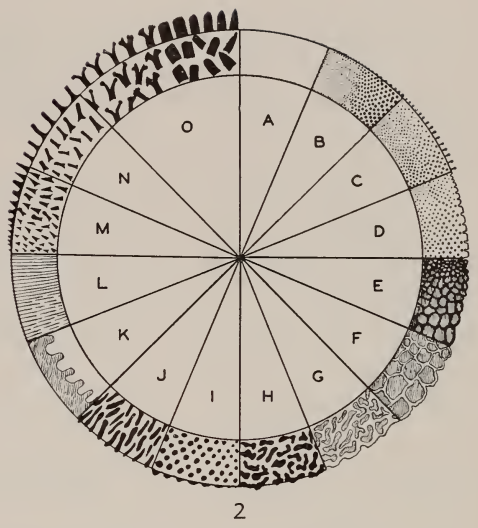

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FIG. 2.—Diagrammatic drawing of various types of spore coat ornamentation:

A. Levigate
B. Granulose
C. Papillate
D. Punctate
E. Punctate-Reticulate
F. Reticulate
G. Vermiculate
H. Obervermiculate
I. Verrucose
J. Rugose
K. Lobate
L. Striate
M. Spinose
N. Setaceous
O. Processes-Projections

new species. Additional new but rare and undescribed species are known, as has been noted. The species of spores described provide a working basis for the correlation of Illinois coal beds. New species have been constructed only when specimens were isolated in sufficient number for adequate description.

What constitutes a species is an ever present problem in paleontology, and perhaps even more so in micropaleobotany. The following characters have been of utmost importance in the construction of new species: shape, ornamentation, haptotypic structures, spore coat, and size. The various types of spore coat ornamentation are diagramatically illustrated in figure 2. The morphologic features of a radially symmetrical and bilateral spore are illustrated in figures 3 and 4. Table 1 records the generic characteristics for all of the

TABLE 1.—SUMMARY OF

Genus	Symmetry	Shape in Transverse Plane	Size in Microns	Ornamentation
Punctati-sporites (Pl. 1, Figs. 5–9; Pl. 2, Figs. 1–11) Description page 14	Radial	Round to sub-triangular	27.3 to 111	Punctate, papillate, reticulate-like, apiculate, verrucose, vermiculate, or setaceous
Granulati-sporites (Pl. 3, Figs. 1–11) Description page 19	Radial	Roundly triangular to triangular	25 to 85	Levigate, granulose, punctate, verrucose, spinose, setaceous, or reticulate (?)
Alati-sporites (Pl. 4, Figs. 1-5) Description page 23	Radial	Subtriangular	70 to 150	Bladder—Granulose or punctate Body—Levigate, granulose, punctate, or reticulate
Reticulati-sporites (Pl. 4, Figs. 6–7; Pl. 5, Figs. 1–2, 4–5) Description page 25	Radial	Round to oval or roundly triangular	40 to 126	Reticulate, body wall levigate to punctate
Laevigato-sporites (Pl. 5, Figs. 3, 6–11) Description page 27	Bilateral	Bean-shaped to suboval	14 to 150	Levigate, punctate, apiculate, verrucose, rugose, obvermiculate, mildly reticulate
Denso-sporites (Pl. 6, Figs. 1–11, Pl. 7, Figs. 1–2) Description page 31	Radial	Round or oval to subtriangular	25 to 100	Body—Levigate, granulose, punctate, reticulate, papillate, rugose, vermiculate Equatorial portion—as above
Cirratriradites (Pl. 7, Figs. 3–6) Description page 34	Radial	Round to sub-triangular	40 to 102	Levigate, granulose, punctate, or reticulate
Endosporites (Pl. 7, Figs. 7–9) Description page 36	Radial	Round	50 to 175	Bladder—Externally—Levigate, granulose or punctate Internally—Reticulate or punctate Body—Levigate or punctate
Triquitrites (Pl. 8, Figs. 1–5) Description page 37	Radial	Subtriangular to triangular	22 to 75	Levigate, granulose, mildly punctate, verrucose, spinose, or with blunt processes
Calamospora (Pl. 9, Figs. 1–5) Description page 40	Radial	Round	30 to 165	Levigate or mildly punctate
Reinschospora (Pl. 9, Figs. 6–7; Pl. 10, Figs. 1–2) Description page 42	Radial	Subtriangular to triangular	30 to 85	Body—Levigate, granulose, or punctate Equatorial flange—Spinose or setaceous which are single or partate
Lycospora (Pl. 10, Figs. 3–7) Description page 44	Radial	Round to sub-triangular	18 to 45	Levigate, granulose, punctate, or rugose
Raistrickia (Pl. 10, Figs. 8–9; Pl. 11, Figs. 1–8; Pl. 12, Fig. 1) Description page 45	Radial	Round to sub-triangular	37 to 90	Spinose or setaceous which are single or partate, or verrucose
Florinites (Pl. 12, Figs. 2–8) Description page 48	Bilateral (?)	Elliptical body (circular)	50 to 210	Bladder—Externally—Levigate, granulose, rugose Internally—Reticulate Body—Levigate, granulose, or faintly punctate
Cadiospora (Pl. 16, Fig. 1) Description page 50	Radial	Round	105 to 117.6	Punctate to granulose
Illinites (Pl. 1, Figs. 1–4) Description page 51	Radial, appears bilateral because of bladders. Bladders not inclined distally.	Oval to elliptical (body oval to circular)	56 to 70	Bladder—Externally—Levigate Internally—Coarsely punctate to reticulate Body—Levigate to granulose
Schopfites (Pl. 13, Figs. 1–4) Description page 52	Radial	Round	78 to 115	Proximal surface—Levigate Distal surface—Blunt to round projections
Schulzospora (Pl. 13, Figs. 5–8) Description page 53	Radial	Elliptical (body circular)	67 to 112	Bladder—Finely punctate Body—Finely punctate
Wilsonia (Pl. 14, Figs. 1–4) Description page 54	Radial	Round	69 to 98	Bladder—Externally—Levigate Internally—Reticulate Body—Levigate to granular

GENERIC CHARACTERS

Haptotypic Features and Bladder Membranes	Thickness of Spore Coat in Microns	Affinity
Trilete mark usually distinct, rays short or long, commissure and lips vary in prominence, arcuate markings present or absent, contact areas lacking	1.25 to 6.5	In part Pteriodospermic
Trilete, rays long, commissure distinct, lips not prominent, contact area present or absent	1 to 4.5	Filicales
Trilete, rays long, commissure distinct, lips poorly developed, contact areas lacking	Bladder—.75 to 2 Body—1.5 to 5	(?) Lycopodiales (?) Gymnospermic
Trilete, commissure and lips usually present, or covered by ornamentation, contact areas present or absent	Excluding muri—2 to 4	(?) Sphenophyllales (?) Hepaticae
Monolete linear suture, lips and arcuate marks present or absent	1 to 3.5	Filicinean (?) Calamarian
Trilete mark distinct or indistinct, rays variable in length, commissure and lips poorly developed	Proximal and distal surfaces—ca. 2 Equatorial portion—4.2 to 18.9	Unknown
Trilete, rays well developed, lips distinct, commissure thin but distinct, flange distinct	Flange thickness—up to 1.5 Body—2 to 3	Lycopodiales
Trilete, rays distinct and long, lips elevated usually, commissure variable, apical papillae present or absent	Bladder—very thin Body—up to 3	Cordaitalean
Trilete, rays long, lips and commissure present or absent	Variable due to thickened corners—1 to 9	(?) Filicales
Trilete, rays short to medium length, lips and commissure variable, contact areas absent or present	Generally 2 to 3 2 species up to 6	Calamarian (?) Sphenophyllales
Trilete, rays long, lips and commissure well developed	Less than 3	Unknown
Trilete, rays long, lips present or absent, commissure thin but distinct, equatorial ridge (arcuate) distinct, apical papillae present or absent	1 to 3	Lycopodiales
Trilete distinct or indistinct, rays short or long, lips usually poorly developed, contact areas present or absent	2 to 6	Filicales
Alete or trilete mark vestigial, possibly trilete in one species, distal surface largely or completely covered by bladder, proximal surface covered by bladder	Bladder—very thin Body—up to 2	Gymnospermic
Trilete, rays long, distinct arcuate ridge, lips and commissure distinct	6 to 8	Unknown
Proximal surface distinctly trilete, rays 10 to 12 microns long	Spore coat—less than 2 Bladders—1.5 to 2	Gymnospermic
Trilete, rays long, lips slightly developed, commissure thin or open	Proximally—3 Distally—4 to 5	Unknown
Trilete, rays relatively long, lips poorly developed, suture thin, body covered by bladder	Body and bladder—2	Unknown (Gymcspermic)
Trilete, rays long, lips elevated, suture thin. Distally bladder covers body and proximally the bladder covers the body in part to almost entirely	Bladder—1.5 to 2.2 Body—2 to 3	Gymnospermic

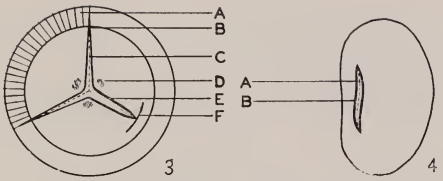

FIG. 3.—Diagrammatic drawing of a radially symmetrical spore illustrating:
A. Flange and striations
B. Ray of trilete mark
C. Original position of suture or commissure
D. Contact area
E. Lip
F. Arcuate (?) ridge

FIG. 4.—Diagrammatic drawing of bilateral spore illustrating:
A. Original position of monolete mark
B. Lip

small spore genera observed in Illinois coal beds. This table together with the plates illustrating species of the various genera will serve as a guide to the identification of genera.

GENUS PUNCTATI-SPORITES (Ibrahim, 1933) emend., S. W. and B., 1944

Plate 1, figures 5-9; Plate 2, figures 1-11; Plate 16, figures 3-4

More species are assigned to the genus *Punctati-sporites* than to any other small spore genus. The numerous species exhibit a wide variation in spore coat ornamentation, and it is possible that the plants which produced spores classified under this genus may represent more than one group. It is perhaps for this reason that the range of the genus covers all of the Pennsylvanian coal beds in Illinois. The genus is present but not dominant until McLeansboro time. The geographic distribution of the genus is extensive since it is known from the United States and Europe.

The following description of the genus is based on 31 previously described species and 16 species described in this report: the spores are radial, trilete, originally spherical to subtriangular in outline, and frequently obliquely compressed. The known size range is from 27.3 to more than 111 microns. The spore coat ornamentation is extremely variable and includes practically every known type. The tetrad mark is present (not known in *P. quaesitus*) and varies considerably as to its prominence. The rays may be short or long and extend to the margin of the spore wall. The commissure, arcuate markings, and lips may be present or absent. No contact areas are known to occur on species of this genus. The spore coat varies in thickness from 1 to 6.5 microns although most species range from two to four microns. There can be little question that the spores of *Crossotheca Hughesiana,* illustrated by Kidston, plates 25-28 (1906) are congeneric with *Punctati-sporites.* Thus at least some species of *Punctati-sporites* are of pteridospermic origin.

The new species of this report extend the maximum size range by about 30 microns, suggest the presence of arcuate markings, and confirm the presence of various other types of ornamentation. Eventually the genus will either have to be redefined or new genera established. Either change is impossible at the present time since the species of this genus in certain cases may represent immature forms of other existing genera, or these forms may represent transitional species. Additional information concerning species of this genus in connection with reproductive organs must be available.

The following are new species of the genus *Punctati-sporites* from Illinois coal beds:

1. *P. setulosus*
2. *P. fenestratus*
3. *P. foveosus*
4. *P. minutus*
5. *P. mundus*
6. *P. obliquus*
7. *P. orbicularis*
8. *P. provectus*
9. *P. verrucifer*
10. *P. foveatus*
11. *P. quaesitus*
12. *P. quasiarcuatus*
13. *P. reticuloides*
14. *P. triangularis*
15. *P. vagus*
16. *P. vermiculatus*

PUNCTATI-SPORITES SETULOSUS sp. nov.

Plate 2, figure 1

Description.—Spores are radial, trilete, and essentially spherical in shape. Frequently there is a small fold on the proximal surface of the spore coat. The holotype measures 73.5 × 73.5 microns, and the known size range is from 68 to 79 microns. The spore coat has numerous short blunt setae slightly more than 3 microns in length and from 1.5 to 2.5 microns in width. The setae cover both the proximal and distal surfaces. The trilete rays are distinct while the lips and commissure are faintly discernible on most specimens. One of the rays is frequently longer than the other two. The rays of the holotype vary in length from 16 to 24 microns. The spore coat averages 2 microns in thickness excluding the setae.

Holotype.—Maceration 500-C Slide 2, a coal bed at 227 to 228 feet (Shoal Creek?) in the Central Pipe Line—Liddle No. 1 well in Wabash County, Illinois.

Discussion.—This species is distinct from all known species of the genus by the presence of numerous short setae. These are suggestive of the ornamentation found in the genus *Raistrickia* excepting for the fact that the setae of *P. setulosus* are very short.

PUNCTATI-SPORITES FENESTRATUS sp. nov. Kosanke and Brokaw

Plate 2, figure 10

Description.—Spores are radial, trilete, spherical in shape and the outline is sometimes slightly crenulate due to folds. The holotype measures 77.7 × 79.8 microns and the known size range is from 68 to 85 microns. The spore coat is distinctly punctate, the punctations are closely spaced and do not exceed three microns. The pits are round to oval. The trilete mark is not distinct, in fact, the spores appear alete and only through careful focusing is it possible to discern the trilete mark. Some specimens suggest the presence of arcuate markings but it has not been possible to prove this point because of the ornamentation. The spore coat is from three to five microns thick.

Holotype.—Maceration 474-A Slide 3, No. 6 coal bed, Franklin County, Illinois.

Discussion.—*P. fenestratus* sp. nov. is similar to *P. foveatus* sp. nov. but distinct from it by having smaller and more closely spaced punctations. Further, the trilete mark is less distinct.

PUNCTATI-SPORITES FOVEOSUS sp. nov.

Plate 2, figure 3

Description.—Spores are radial, weakly trilete, spherical in shape and generally obliquely compressed. Holotype measures from 111 × 107 microns and the known size range is from 90 to 115 microns. The spore coat is covered with large punctations which suggests a transition type of ornamentation between punctate and reticulate types. The punctations or pits vary in width from two to 12 microns and penetrate the spore coat from 1.75 to 2.5 microns. The areas between pits average slightly more than four microns. The trilete mark is weakly developed and frequently difficult to observe owing to the ornamentation and oblique compression. The spore coat is often torn along one or more of the rays. The spore coat is usually at least three microns thick.

Holotype.—Maceration 486-B Slide 17, Friendsville coal bed, Wabash County, Illinois.

Discussion.—The large punctations certainly vaguely resemble the lacunae of some species of *Reticulati-sporites* but the sculpturing is definitely punctate. The relationship between the two types is clear. Knox's figure 113 (1938, p. 462) closely resembles this species although it appears to be slightly smaller in size.

PUNCTATI-SPORITES MINUTUS sp. nov.

Plate 16, figure 3

Description.—Spores are radial, trilete, originally spherical in shape with the spore coat variously folded. The holotype measures 29.4 × 28.7 microns and the known size range is from 27.3 to 32.5 microns. The spore coat is minutely punctate, but only with careful focusing and proper adjustment

of the iris diaphrams is it possible to distinguish the punctations. The trilete rays are distinct, the lips are slightly developed, and the commissure is thin. The rays average nine microns in length, and the spore coat is one to 1.5 microns thick.

Holotype.—Maceration 584 Slide 7, Woodbury (?) coal bed, Jasper County, Illinois.

Discussion.—This species is the smallest yet assigned to the genus *Punctati-sporites.* It resembles *P. parvipunctatus* Kosanke, 1943, but is smaller and has a thinner spore coat.

Punctati-sporites mundus sp. nov.

Plate 2, figure 8

Description.—Spores are radial, trilete, roundly triangular with occasional irregularly placed folds. The folds sometimes occur along the margin of the spore coat. The holotype measures 61 × 58.8 microns, and the known size range is from 54 to 72 microns. The spore coat is ornamented with medium sized punctations which are not always clearly evident. The trilete mark is distinct as are the lips and commissure. The rays are of relatively uniform length, measuring from 16 to 19 microns on the holotype. The spore coat measures from 2 to 2.5 microns in thickness.

Holotype.—Maceration 486-B Slide 17, Friendsville coal bed, Wabash County, Illinois.

Discussion.—*P. mundus* sp. nov. is very similar to Knox's type 7K, 1942, p. 101. *P. mundus* probably has a coarser ornamentation. A form conspecific with 7K has been observed in No. 8 coal bed in limited number.

Punctati-sporites obliquus sp. nov.

Plate 2, figure 5

Description.—Spores are radial, trilete, oval to spherical in outline and frequently obliquely compressed as exhibited by the holotype specimen. Folding of the spore coat occurs, often cresent-shaped, somewhat parallel to the margin of the spore coat. The holotype measures 34.6 × 39.8 microns and the known size range is from 31 to 46 microns. The spore coat is very minutely punctate and the punctations are closely spaced which tends to give the spore coat a minutely papillate ornamentation. The punctations are round and less than one micron in width. The trilete mark is distinct, with lips and commissure. The rays are not triangularly spaced as shown on the holotype specimen Pl. 2, fig. 5. The spore coat is 1.25 to 1.5 microns thick.

Holotype.—Maceration 603-B Slide 5, No. 2 coal bed, Fulton County, Illinois.

Discussion.—In some cases one of the trilete rays is indistinct. This tends to cause confusion in identification with a species of *Laevigato-sporites,* but by proper focusing usually a faint trace of the third ray can be detected.

Punctati-sporites orbicularis sp. nov.

Plate 2, figure 9

Description.—Spores are radial, trilete, originally spherical in shape and compressed into a disc. Folds are rare and the holotype specimen measures 37.8 × 37.8 microns, and the known size range is from 35 to 44 microns. The spore coat is finely punctate and the punctations are very closely spaced. The trilete mark and commissure are distinct. The lips are slightly developed. The rays are usually of uniform length and average 12 to 13 microns in length. The spore coat measures 2 to 2.5 microns in thickness which is relatively thick for spores of this size of the genus.

Holotype.—Maceration 542-A Slide 7, No. 8 coal, Peoria County, Illinois.

Discussion.—Spores of this type of character are common. *P. parvipunctatus* Kosanke from the Pomeroy coal bed in Ohio is similar in size and shape but is more finely punctate. *P. globosus* (Loose) S. W. and B., 1944, is also similar but appears to be larger and have a coarser ornamentation. Type B_6 of Raistrick and figs. 41 and 42 of Knox (1939) are also similar to *P. orbicularis* sp. nov.

PUNCTATI-SPORITES PROVECTUS sp. nov.

Plate 2, figure 11

Description.—Spores are radial, trilete, laterally compressed, spherical in outline with numerous irregularly distributed folds. The holotype measures 75.6 × 78.7 microns. The known size range is from 72 to 83 microns. The spore coat is characterized by fine to medium punctations. Occasionally folding of the spore coat occurs at the terminus of rays and results in what appears to be an incomplete arcuate ridge. The trilete rays, lips, and commissure are distinct. The rays are uniform length and on the holotype measure 27.3 microns in length. The spore coat is less than 2 microns in thickness.

Holotype.—Maceration 609 Slide 6, Wayside coal bed, Johnson County, Illinois.

Discussion.—*P. provectus,* the earliest known species of the genus from Illinois, is not abundant. The presence of folds (ridges) which may be arcuate in nature may be important from the standpoint of phylogeny.

PUNCTATI-SPORITES VERRUCIFER sp. nov.

Plate 2, figure 6

Description.—Spores are radial, trilete, roundly triangular in shape, obliquely or laterally compressed. The holotype measures 65 × 66 microns and the size range is from 60 to 74 microns. The spore coat is provided with numerous wart-like projections which are common to both proximal and distal surfaces. The wart-like projections measure up to 4 to 5 microns in diameter. The area between the projections is levigate. The trilete mark is often partially obscured by the ornamentation and the rays extend almost to the margin of the spore coat with a slight development of the lips. The spore coat exclusive of the projections measures from 1.75 to slightly over 2 microns. The thickness of the spore coat including projections where present ranges from 3 to 4.5 microns.

Holotype.—Maceration 520-A Slide 1, Bald Hill coal bed, Williamson County, Illinois.

Discussion.—*P. verrucifer* sp. nov. is similar to and possibly conspecific with Raistrick's type D_3. *P. firmus* (Loose) S. W. and B., 1944, is somewhat similar to the new species described here.

PUNCTATI-SPORITES FOVEATUS sp. nov.

Plate 1, figure 6

Description.—Spores are radial, trilete, spherical in shape and somewhat obliquely compressed. The holotype measures 73.5 × 73.5 microns and the known size range is from 67 to 84 microns. The spore coat is sharply punctate both proximally and distally. The pits are round to oval in outline and uniformly distributed. The trilete mark is frequently indistinct and often the spores of this species appear to be alete. The rays are short, only 12 to 15 microns in length. A ridge, possibly an arcuate ridge, surrounds the rays and some specimens have folds of the spore coat which are usually parallel to the outline of the spore. The spore coat is 2.5 to 4 microns thick.

Holotype.—Maceration 603-B Slide 6, No. 2 coal bed, Fulton County, Illinois.

Discussion.—This species is readily identified and has markings that might be classified as arcuate.

PUNCTATI-SPORITES QUAESITUS sp. nov.

Plate 2, figure 2

Description.—Spores are radial, probably trilete, spherical in outline and rarely folded. The holotype measures 35.7 × 37.8 microns, and the known size range is from 33 to 41 microns. The spore coat is punctate and the punctations are closely spaced and measure slightly in excess of 4 microns, in the largest diameter. The punctations are round to oval shaped. No definite trilete marks have been observed although faint lines suggestive of the mark have been observed on some specimens. The wall measures 2 microns in thickness.

Holotype.—Maceration 585-C Slide 4, No. 6 coal bed, Franklin County, Illinois.

Discussion.—This form is provisionally placed in the genus *Punctati-sporites* even though the trilete mark has not been def-

initely observed. It is similar to but smaller than Knox's type 1K (1942, p. 100).

PUNCTATI-SPORITES QUASIARCUATUS sp. nov.

Plate 1, figure 9

Description.—Spores are radial, trilete, originally spherical, compressed outline spherical to oval. The holotype measures 86 × 100.8 microns and the known size range is from 82 to 104 microns. The spore coat is distinctly punctate and the punctations are from 2 to 4.25 microns in diameter. The spore coat is thin for this size of spore. It measures 1.75 to 2.25 from the base of punctations to the inner wall and slightly more for the total thickness. The spores generally possess markings (arcuate?) which completely surround the tetrad scar. This marking is more in the nature of a fold rather than a ridge and in some cases does not connect all three rays of the tetrad. The rays, however, never pass beyond the marking.

Holotype.—Maceration 625-A Slide 2, Willis coal bed, Gallatin County, Illinois.

Discussion.—Species of *Punctati-sporites* which possess arcuate markings or even suggest their presence add a new character to the genus. It is possible that the folds or markings are of arcuate origin.

PUNCTATI-SPORITES RETICULOIDES sp. nov.

Plate 1, figure 7

Description.—Spores are radial, trilete, roundly triangular to spherical in shape and generally slightly obliquely compressed. Holotype measures 50.4 × 52.5 microns, and the known size range is from 45 to 61 microns. The spore coat is ornamented with punctations of varying size. Where several pits merge to form one large punctation the spore coat appears reticulate. The single pits or punctations vary in size from 1.75 to 2.5 microns and the larger punctations (several combined (?) punctations) have measured more than 5 microns. The trilete rays are always present although frequently not distinct because of the ornamentation. The rays range in length from 12 to 16 microns. The thickness of the spore coat is difficult to measure but probably does not exceed 2.5 microns.

Holotype.—Maceration 579-A Slide 1, No. 2 coal bed, Bureau County, Illinois.

Discussion.—*P. reticuloides* sp. nov. certainly approaches the reticulate ornamentation which characterizes the genus *Reticulati-sporites.* The ornamentation is, however, punctate, but further suggests a relationship with *Reticulati-sporites.*

PUNCTATI-SPORITES TRIANGULARIS sp. nov.

Plate 2, figure 7

Description.—Spores are radial, trilete, broadly roundly triangular, and with occasional folds. The holotype measures 63 to 65 microns, and the known size range is from 58 to 74 microns. The spore coat is indistinctly to distinctly punctate. The punctations are numerous and somewhat variable in size. The trilete mark is usually distinct and, due to oblique compression, it is frequently found at one side of the spore.

The rays are fairly uniform in length, ranging from 22 to 23.5 microns. The commissure is somewhat developed and the lips are almost lacking. The spore coat is more than 2 microns but less than 3 microns thick.

Holotype.—Maceration 474-A Slide 1, No. 6 coal bed, Franklin County, Illinois.

Discussion.—*P. triangularis* sp. nov. might be conspecific with *P. granifer* (Ibrahim) S. W. and B., 1944, however Ibrahim's description precludes this possibility since his species is not punctate.

PUNCTATI-SPORITES VAGUS sp. nov.

Plate 16, figure 4

Description.—Spores are radial, trilete, and spherical in shape; folding of the spore coat is rare except for an occasional peripheral fold. The holotype measures 65 × 63 microns, and the known size range is from 61 to 67 microns in the largest diameter. The spore coat is punctate and the punctations are about one micron in diameter. The trilete rays are rather vague although generally discernible on all speci-

mens. They average 20 to 21 microns in length without a pronounced commissure or lips. The spore coat is 2 to 3 microns thick.

Holotype.—Maceration 694 Slide 5, Shelbyville coal bed, Shelby County, Illinois.

Discussion.—This species is characterized by a vague trilete mark and does not appear to be closely related to any existing species of the genus.

PUNCTATI-SPORITES VERMICULATUS sp. nov.

Plate 2, figure 4

Description.—Spores are radial, trilete, nearly spherical in outline, and folding of spore coat is rare. The holotype measures 67 × 63 microns; the known size range is from 57 to 73 microns. The spore coat is vermiculate (spore coat inlaid somewhat like worm tracks) to reticulate. The vermiculate indentation extends from 2.5 microns to 3.2 microns into the spore coat. The trilete rays are usually not sharply defined due to the ornamentation. They are always present however, and rather long. The rays of the holotype measure from 24 to 28 microns in length. The commissure and lips are poorly developed. The spore coat including the ornamentation measures 5.5 to 6.5 microns.

Holotype.—Maceration 600 Slide 2, LaSalle coal bed, Bureau County, Illinois.

Discussion.—The term vermiculate most accurately describes the ornamentation of the spore coat. Perhaps this term should be used in connection with *P. grandiverrucosus* Kosanke, 1943.

GENUS GRANULATI-SPORITES (Ibrahim, 1933) emend., S. W. and B., 1944

Plate 3, figures 1-11

Schopf, Wilson, and Bentall recognized 15 species from pre-existing literature from which they gave their generic definition (1944, p. 32). Their conclusions are supported by the present investigation, and the following 11 new species add to our knowledge concerning the variation within the genus.

The 11 new species are:

1. *G. commissuralis*
2. *G. concavus*
3. *G. adnatus*
4. *G. convexus*
5. *G. grandis*
6. *G. levis*
7. *G. pallidus*
8. *G. granularis*
9. *G. aculeolatus*
10. *G. spinosus*
11. *G. pellucidus*

The following is a description of the genus: Spores are radial and trilete, subtriangular to triangular in transverse plane. The margin between the radii is either concave or convex, and the corners opposite the radii are generally rounded, but in some species they are bluntly pointed. Folding of the spore coat is frequently limited to the corners. The known size range is from 25 to 75 microns in the mean diameter. This extends the previously known size range by 30 microns. The ornamentation of the coat may be levigate, granulose, punctate, verrucose, spinose, setaceous or reticulate. The trilete rays are always long, usually two-thirds the distance to the spore wall, and in rare cases they extend to the spore wall. The commissure frequently is distinct, whereas the lips are usually not so distinct. The contact area, *area contagionis,* is known only in *G. adnatus* sp. nov. The spore coat is generally less than 2 microns thick but in *G. grandis* sp. nov. it is 4 to 4.5 microns thick. The only suggested affinity of the spores of this genus is with the Filicales.

In general, species of this genus are likely to be found in any portion of a coal bed. In a few exceptional instances certain species appear to be restricted to the lower portion of a particular coal bed. The genus is most abundant in Caseyville and lower Tradewater strata, reaching an abundance climax in the Babylon coal bed of Western Illinois. Throughout the remainder of Pennsylvanian beds in Illinois *Granulati-sporites* is present but never abundant.

Granulati-sporites commissuralis sp. nov.

Plate 3, figure 1

Description.—Spores are radial, triangular in outline, margin of spore wall between radii concave, corners opposite radii rounded. Holotype measures 29.5 × 26 microns, and the known size variance is from 26 × 34 to 25 × 33 microns. The spore coat is coarsely granulose and the granulations are closely spaced in most specimens. The tetrad mark is distinct and extends at least three-fourths the distance to the spore wall. The commissure is distinct, and the lips are slightly developed but broken in part by granulations. The spore coat is 1.5 to 2 microns thick.

Holotype.—Maceration 486-B Slide 22, Friendsville coal, Wabash County, Illinois.

Discussion.—This species is similar to the genotype *G. granulatus* (Ibrahim) S. W. and B., 1944, and may be conspecific with Raistrick's D_8 (1937, p. 911) which was illustrated but not named. It differs from *G. granulatus* in that the granulations are larger and the rays are longer. The rays also appear to be somewhat longer than Raistrick's D_8.

Granulati-sporites concavus sp. nov.

Plate 3, figure 4

Description.—Spores are radial, subtriangular in outline, margins between radii strongly concave, corners opposite radii rounded. Holotype measures 55 × 58.8 microns, and the known size variance is about 6 microns more or less than that of the holotype. The margin of the spore coat between the radii parallels the radii for a considerable distance, and ranges in width from 22 to 24 microns. The spore coat is levigate and the tetrad mark extends at least three-fourths of the distance to the spore wall; the lips and commissure are distinct. Spore coat is less than 2 microns thick.

Holotype.—Maceration 318 Slide 10, "Ditney" coal bed from New Haven diamond drill core, White County, Illinois.

Discussion.—This species is similar to *G. pellucidus* sp. nov. and is found in association with *Reinschospora* which further suggests a relationship between the two genera. However, there exists little similarity of the spore bodies of the two species.

Granulati-sporites adnatus sp. nov.

Plate 3, figure 9

Description.—Spores are radial, roundly triangular in outline, margin of the spore wall between radii concave, corners opposite radii broadly rounded. Spores are laterally compressed and the holotype measures 35 × 36 microns while the known size range of this species is 32 to 39 microns. The spore coat is levigate distally and proximally except for an area adjacent to the tetrad scar. This area is somewhat thicker and appears slightly granulose under high magnification. The tetrasporic mark is distinct and extends at least three fourths of the distance to the spore wall. The lips are well developed and there is a definite *area contagionis.* The spore coat is uniformly slightly less than 2 microns thick except at the contact area.

Holotype.—Maceration 573 Slide 8, Coal 20 feet below the Carlinville limestone (No. 8 coal), Macoupin County, Illinois.

Discussion.—This species has an *area contagionis* which has not previously been reported present in this genus. This species is strikingly similar to Raistrick's D 14, and also illustrated by Knox (1938, p. 459). However, they illustrate no *area contagionis* and on this basis it is not possible to consider their form conspecific with *G. adnatus* sp. nov.

Granulati-sporites convexus sp. nov.

Plate 3, figure 6

Description.—Spores are radial, subtriangular in outline, margins between radii convex and corners opposite radii rounded. The holotype measures 61 × 60 microns and the known size range is about plus or minus 7 microns of that given for the holotype. The spore coat is levigate but when examined with an oil immersion objective the spore coat is finely granulose. The tetrad

mark is present and the lips are poorly developed. The rays of the tetrad extend three fourths of the distance to the spore wall. The spore coat is 1 to 1.5 microns thick.

Holotype.—Maceration 543-C Slide 8, No. 5 coal, Fulton County, Illinois. This species appears to be slightly more abundant in western Illinois than in southern Illinois No. 5 coal.

Discussion.—This species is somewhat similar to *G. deltoides* (Ibrahim), S. W. B., 1944; however it is smaller and the tetrad rays do not extend to the margin of the spore wall.

GRANULATI-SPORITES GRANDIS sp. nov.

Plate 3, figure 10

Description.—Spores are radial, subtriangular in outline, margin of the spore wall between radii strongly concave, corners opposite radii rounded although the spore is laterally compressed. The holotype measures 74 × 84 microns and specimens are known to range from 66 to 75 microns and 75 to 86 microns. The spore coat is essentially levigate although when viewed with oil immersion lens a fine granulation may be observed. The tetrasporic mark is distinct, rays extend almost to the margin of the spore wall, and the lips are definite. There appears to be a thickening which may be a super development of lips or equivalent to an *area contagionis*. The spore coat is 4 microns thick between the radii; opposite the radii it frequently measures more than 4.5 microns in thickness. This slight thickening of the spore coat opposite the radii suggests a resemblance to the genus *Triquitrites*. However, the thickening is so slight that it seems unwise to consider this point further.

Holotype.—Maceration 490-A Slide 8, McCleary's Bluff coal (3½ inches), Wabash County, Illinois. This species has been observed only in the above mentioned coal.

Discussion.—Morphologically this species must be classified as a member of the genus *Granulati-sporites*. It is much larger than any previously described species of this genus, but this fact merely extends the size range of the genus. It is similar in construction to *G. levis* sp. nov. but is larger and the spore wall is much thicker.

GRANULATI-SPORITES LEVIS sp. nov.

Plate 3, figure 5

Description.—Spores are radial, subtriangular to triangular in outline, margin of the spore wall between radii slightly concave or convex, corners opposite radii bluntly pointed, generally laterally compressed. Diameter is generally 48 × 50 microns and the spore coat is levigate. The tetrasporic mark is distinct, frequently torn open, and extends two-thirds to three-fourths the distance to the spore wall. The lips are distinct and thick, thinning toward the apex of the radii. The spore wall is uniformly 2 microns thick.

Holotype.—Maceration 500-B Slide 2, Central Pipe Line-Liddle No. 1 (Friendsville Coal), Wabash County, Illinois.

Discussion.—This species is known at present only from the upper McLeansboro group from Illinois.

GRANULATI-SPORITES PALLIDUS sp. nov.

Plate 3, figure 3

Description.—Spores are radial, subtriangular in outline, margin of the spore wall between radii slightly concave, corners opposite radii broadly rounded, in some instances flattened, and spore body is laterally compressed but not to the degree of most species of this genus. Average diameter measures 38 × 38 microns the size ranging from 35 to 42 microns. The corners opposite the radii measure 14 to 20 microns in width in the lateral plane. The spore coat is distinctly granulose on both proximal and distal sides of the spore. The granulations are numerous and closely spaced, which gives the spore a rough appearance. The tetrasporic mark is distinct, the rays usually extend two thirds the distance to the spore wall, and lips are somewhat developed. The spore coat is uniformly 1.5 to 2.1 microns thick.

Holotype.—Maceration 587 Slide 1,

Battery Rock coal, Hardin County, Illinois. The geological range is from the Wayside coal to the basal portion of No. 2 coal bed.

Discussion.—*G. granulatus* (Ibrahim), S. W. and B., 1944, differs from *G. pallidus* sp. nov. in being smaller in size, without pronounced corners and, judging from Ibrahim's illustration (Plate 6, fig. 51), apparently has larger granulations, which are not as closely spaced as those of *G. pallidus* sp. nov.

Granulati-sporites granularis sp. nov.

Plate 3, figure 2

Description.—This form is strikingly similar to *G. pallidus* sp. nov. except for overall size and size of granulations. This species consistantly measures 4 to 7 microns less than *G. pallidus* sp. nov. and the granulations are smaller and are somewhat more closely spaced.

Holotype.—Maceration 596-A Slide 1, Grape Creek No. 6 coal bed, Vermilion County, Illinois. This species is known to occur throughout Illinois No. 6 coal bed.

Discussion.—*G. granularis* sp. nov. is similar to but distinct from *G. pallidus* sp. nov. A difference is apparent when one closely examines these two forms, and they are separated geologically. This species may be a transition form of *G. pallidus*.

Granulati-sporites aculeolatus sp. nov.

Plate 3, figure 8

Description.—Spores are radial, triangular in outline, margin of spore wall is slightly convex between radii, corners opposite radii are bluntly pointed. The holotype measures 28.5 × 31 microns exclusive of the setae, and the known size range of this species is 25 × 28 to 33 × 34 microns. The spore coat is characterized by numerous blunt setae. The setae range in length from 3 to 3.5 microns and average slightly more than 1 micron in width. At the juncture of the setae with the spore coat, the setae are somewhat wider. The setae on the proximal surface are irregularly placed but on the distal side they are uniformly placed and spaced 2 to 2.5 microns apart. The tetrasporic mark frequently extends three-fourths the distance to the spore wall and on occasion is split open. Lips may be seen with careful focusing.

Holotype.—Maceration 625-A Slide 3, Willis coal, Gallatin County, Illinois.

Discussion.—This species is similar to *Granulati-sporites microsaetosus* (Loose), S. W. and B., 1944, excepting for the following: the setae are longer and not regularly spaced on the proximal side as illustrated by Loose (pl. 18, fig. 40). Also the spore wall margin between the radii in G. *microsaetosus* apparently is concave and the corners opposite them are broadly rounded.

Granulati-sporites spinosus sp. nov.

Plate 3, figure 7

Description.—Spores are radial, triangular in outline, margin of spore wall between radii convex, corners opposite radii bluntly pointed. Holotype measures 31 × 30 microns, and the known size range of the mean diameter of this species is from 26 to 38 microns. The spore coat is characterized by numerous sharp spines which completely cover the distal and all of the proximal side except an area surrounding the tetrad mark in some specimens. The spines are almost 4 microns long and 1.5 microns wide. The tetrad mark extends nearly to the spore wall and lips are slightly developed.

Holotype.—Maceration 579-A Slide 1, No. 2 coal, Bureau County, Illinois.

Granulati-sporites pellucidus sp. nov.

Plate 3, figure 11

Description.—Spores are radial, triangular in outline, margin of spore wall distinctly concave between radii, corners opposite radii are rounded. The holotype measures 48 × 48 microns and the size variance ranges from 44 to 53 microns. The spore coat is levigate and the tetrasporic mark is well over three-fourths the distance to the margin of the spore wall. The tetrasporic mark is most unusual in that it is 5 to 6 microns wide. The spore coat is

thin and measures less than 1 micron thick.

Holotype.—Maceration 486-A Slide 4, Friendsville Coal, Wabash County, Illinois.

Discussion.—In many respects it greatly resembles the body of *Reinschospora magnifica* sp. nov. without the flange although it is somewhat smaller in size. However, no specimens or even fragments of specimens were found of *Reinschospora.*

GENUS Alati-sporites (Ibrahim, 1933) emend., S. W. and B., 1944

Plate 4, figures 1-5

The genotype *A. pustulatus (Sporonites pustulatus,* Ibrahim 1932) Ibrahim 1933, is to date the only described species of the genus according to Schopf, Wilson, and Bentall (1944) since they considered type D_5 of Raistrick (1934-1935 and 1937) conspecific with *A. pustulatus.* It is difficult to prove this point because the genotype spore coat is reticulate and Raistrick's illustrations are not clear in this respect. Raistrick's D_5 is probably a separate and distinct species but only through examination of photomicrographs or the type material can this be determined. The following are new species from Illinois coal beds:

1. *A. hexalatus*
2. *A. inflatus*
3. *A. punctatus*
4. *A. triangularus*
5. *A. varius*

The following is a description of the genus: Spores are radial, trilete, spore body subtriangular in outline, and the interradial area generally concave, although *A. inflatus* sp. nov. is sometimes slightly convex and the corners round to bluntly pointed. The bladders (wings) number three or six with one or two bladders to each interradial area. The bladders are extremely variable in appearance because they are frequently folded and sometimes this folding can cause a form with three bladders to appear to possess four, five, or six bladders. The known size range—the overall measurement in the mean diameter—is from about 70 to 150 microns. The known spore coat ornamentation varies from levigate, granulose, punctate to reticulate. The bladder ornamentation is known to be either granulose or punctate. The trilete rays always extend at least three-fourths the distance to the margin of the spore coat and generally to the margin or very close to it. Lips are not usually developed and the commissure is frequently distinct. The spore coat ranges in thickness from 1.5 to 5 microns, the bladders are usually 0.75 to 2 microns thick. The affinity of spores of this genus is unknown. There exist two possibilities on the basis of our knowledge at the present time. *Spencerites* Scott, an isolated cone genus, is an eligulate homosporous cone classified with the Lycopodiaceae. According to Scott, *S. majusculus* is winged but quite different from *S. insignus,* " . . . for in *S. majusculus* each spore has three wings . . . . " It appears as though in *S. insignus,* the wing is not divided into three parts. Scott's illustration (1898, pl. 15, fig. 18-C) shows a spore of *S. majusculus* which is suggestive of *Alati-sporites* except that the trilete rays are short and the three bladders are tightly crowded against each other lengthwise. Certain species of the modern genera *Podocarpus, Pherosphaera* and possibly *Microcachrys* have three wings. These are however all southern hemisphere conifers. Thus the available evidence is meager that the affinity of *Alati-sporites* is possibly Lycopodiaceae, less likely gymnospermic.

The vertical geological distribution of *Alati-sporites* is from lower Tradewater (Willis coal bed) through No. 5 coal bed in the Carbondale group and in the upper McLeansboro group. Two points of interest noticed in regard to the distribution of the genus are: (1) *Alati-sporites* is more abundant in western Illinois in the Carbondale strata and more abundant in southeastern Illinois in the McLeansboro strata and (2) the genus has been observed only in the upper half of the various coal beds.

Alati-sporites hexalatus sp. nov.

Plate 4, figure 5

Description.—Spores are radial, body is subtriangular in outline, margins between

radii are slightly concave and the corners are slightly rounded. Overall diameter of the holotype is 76.5 × 78.6 microns and the spore body measures 53.1 × 55.2 microns. There are two bladders between each radii which are arranged so that the corners of the spore body are not covered. The spore body is levigate although it appears very finely granulose under oil immersion. The bladders are finely granulose. On the proximal surface of the spore body there are scattered several round papillae. The trilete mark extends to the margin of the spore wall and the lips and commissure are not well developed. The spore coat is 1.5 to 2 microns thick and the bladders about one micron thick.

Holotype.—Maceration 519-A Slide 1, Dekoven coal bed, Williamson County, Illinois.

Discussion.—In some forms it is difficult to be certain whether there are five or six bladders because one of the bladders may not be clearly divided to the spore body. Pollen grains from the modern genus *Podocarpus* upon occasion display unusual conditions when a species which normally has two bladders may possess three or four bladders. This is thought to be due to the failure of the mother cell to divide into four pollen grains after the second division. In some forms, one of the two bladders divides resulting in three bladders; in other forms the two bladders divide resulting in four bladders of equal proportions. Whichever occurs, the body of the grain is larger than that of normal pollen grains of the species in question. This merely illustrates that there may exist some variance in the normal bladder number.

Alati-sporites inflatus sp. nov.

Plate 4, figure 2

Description.—Spores are radial, body is subtriangular in transverse plane, subspherical in outline including bladder. Margin of body wall between radii generally is slightly convex or slightly concave and the corners are broadly rounded. Overall diameter of holotype is 120.4 × 129.6 microns and the known size range is from 120 × 123 microns to 148.7 × 150 microns. The three bladders of the holotype vary in the longest diameter from 87.1 microns to 93.4 microns. The bladders extend over the proximal side of the spore body 8 to 15 microns and about the same distance distally. The bladders are almost devoid of folds and appear inflated. The juncture of the bladder and the spore body is somewhat irregular but in general follows the outline of the spore body. The spore coat is levigate with a few minor small round thickened areas scattered on the proximal surface. The bladders (perisporial) are about 1 micron thick and sharply granulose. The trilete mark extends nearly to the margin of the spore wall, the lips and commissure are somewhat developed.

Holotype.—Maceration 543-C Slide 6, No. 5 coal bed, Fulton County, Illinois.

Alati-sporites punctatus sp. nov.

Plate 4, figure 4

Description.—Spores are radial, spore body is subtriangular in transverse plane, overall transverse outline is irregularly ovate to almost round. The margin of the spore wall between radii is generally convex and the corners are somewhat bluntly pointed. The overall measurement of the holotype is 102 × 98.75 microns while the spore body is 78.6 × 76.5 microns. The bladders vary in length from 70 to 80 microns and from 25.5 to 29.7 microns in width. The bladders overlap on the spore body about 5 microns. The known size range of the spore body in the mean diameter is from 70.5 to 79 microns. The spore coat is obvermiculate (as observed on undermacerated material) to punctate (on overmacerated material) and the bladders are finely granulose. Trilete mark extends nine-tenths the distance to the spore wall and the lips and commissure are not developed. The spore coat is 4 to 5 microns thick and the bladders are 0.75 to 1.25 microns thick and greatly folded to appear sometimes as though there were more than three bladders. By focusing up and down it is possible to prove the existence of no more than three bladders.

Holotype.—Maceration 576 Slide 4, coal bed below the New Haven limestone, Gallatin County, Illinois.

Discussion.—This species is similar to *A. pustulatus* (Ibrahim) Ibrahim, 1933, but the spore coat is not reticulate, the bladders are variously folded, and there is a difference in size between the two species.

ALATI-SPORITES TRIALATUS sp. nov.

Plate 4, figure 3

Description.—Spores are radial, body is subtriangular in outline, margins of spore wall between radii concave in transverse plane, corners broadly rounded. There are three bladders which are usually not greatly folded. Overall diameter of holotype is 90.3 × 98.2 microns and the spore body measures 55.2 microns × 64.8 microns. The bladders range in length from 65.8 to 67 microns and overlap the spore body as much as 13 microns. The known spore body range in the mean diameter is from 50 to 65 microns. The spore coat is levigate and the bladders are punctate. The bladders are sometimes connected as shown on plate 4, figure 3. Notice the lower left corner which illustrates this point and that in effect there are two bladders: one interradial between two rays, and one which is deeply dissected and at the other ray. The spore coat varies in thickness from 2 to more than 4 microns. The bladders are as much as 2 microns thick.

Holotype.—Maceration 543-B Slide 20, No. 5 coal bed, Fulton County, Illinois.

A. VARIUS sp. nov.

Plate 4, figure 1

Description.—Spores are radial, body is somewhat triangular, margins between radii are concave, corners are broadly rounded and there are three bladders, each folded, giving the appearance of six bladders. The overall diameter of the holotype is 116.8 × 128.5 microns, and the spore body measures 72.25 × 84.8 microns. The bladders range from 85 to 91.3 microns in length and overlap the spore body proximally and distally as much as 10 to 11 microns. The juncture of the bladders with the spore coat is somewhat crenulate. The spore coat is levigate and the bladders are punctate. The tetrad mark extends nearly to the margin without extensive lip or commissure development. The spore wall is 2 to 3 microns thick and the bladders are 1 to 2 microns thick.

Holotype.—Maceration 543-B Slide 7, No. 5 coal bed, Fulton County, Illinois.

Discussion.—*A. varius* sp. nov. is similar to *A. inflatus* sp. nov. except for size and folding of the bladders.

GENUS RETICULATI-SPORITES (Ibrahim, 1933) emend., S. W. and B., 1944

Plate 4, figures 6-7; Plate 5, figures 1-2, 4-5

Reticulati-sporites is rarely abundant in Illinois, excepting for certain coal beds in the upper McLeansboro, particularly the LaSalle and New Haven. It is known to occur also in the Carbondale, Tradewater, and Caseyville groups in a somewhat discontinuous pattern which is of value for correlation studies. There are seven named species which are described and illustrated; they are listed by Schopf, Wilson, and Bentall (1944), from European literature as well as about a dozen forms of Raistrick and Knox from Britain which are illustrated and described to some extent but not given binomial names. Six new species, the first from the United States are:

1. *R. adhearens*
2. *R. irregularis*
3. *R. lacunosus*
4. *R. muricatus*
5. *R. scrobiculatus*
6. *R. splendens*

Several additional new species are known to occur but owing to the lack of sufficient specimens are not described at this time.

The following is a description of the genus based on the seven previously published species plus the six new species here described: Spores are radial, strongly to weakly trilete and in some cases apparently alete. In outline the spores are generally round although some species are oval or roundly triangular which may be due to compression. Folding of the spore coat is

not common. The known size ranges from 40 to 126 microns. The spore coat is always reticulate and in some forms the body wall is also punctate. The haptotypic structures are variously developed on different species. The trilete mark, lips, and commissure may be present or absent. When present they are frequently covered in part by the muri of the reticulate ornamentation. The spore coat or coats, if the reticulate structures are perisporal, vary in thickness. Excluding the muri the spore coat generally is from 2-4 microns thick and somewhat thicker in several species. Little is known of the affinity of the spores of *Reticulati-sporites*. Suggested relationships of the trilete forms with *Sphenophyllum* and the alete forms with Hepaticae spores must await further information.

Reticulati-sporites adhearens sp. nov.

Plate 5, figure 2

Description.—Spores are radial, oval to round with the marginal outline wavy due to the muri. The holotype measures 88 × 92.4 microns and the known size ranges from 82 to 97 microns. The spore coat is reticulate with large lacunae frequently measuring more than 20 microns in width. The muri are 3-5 microns in width and 4-6 microns high. Folding of the muri is common. A definite trilete mark, lip, and sometimes commissure are present. The rays are at least 22 microns in length. There is an *area contagionis* which covers the area between the rays on the proximal surface. This area is marked by numerous round projections. The spore coat is 2-3 microns thick exclusive of the muri.

Holotype.—Maceration 519-B Slide 7, Dekoven coal bed, Williamson County.

Discussion.—The *area contagionis* is a new character for the genus and the thickening by round blunt projections is unusual, but distinctive.

Reticulati-sporites irregularis sp. nov.

Plate 5, figure 1

Description.—Spores are radially symmetrical, compressed into a disc-like shape without folds. The holotype measures 88.2 × 86.1 microns and the known size range is from 80 to 126 microns. The spore coat is reticulate and the lacunae vary in size and shape from rectangular to round and in size from about 2 microns to 12 microns. The muri range in thickness from less than 2 microns to 4-5 microns thick. The spore coat is variously thickened due to its reticulate ornamentation. No haptotypic structures have been observed.

Holotype.—Maceration 144 Slide 1, "Sub-Babylon" coal bed above the Pennsylvanian-Mississippian contact, Fulton County, Illinois.

Discussion.—The known size variation is very large and yet specimens have been observed throughout the size range although most of the specimens are less than 110 microns. The trilete mark has not been observed and thus this species is known only from the alete condition. The reticulations are vaguely suggestive of those of *R. facetus* (Ibrahim), S. W. and B., 1944, although this species is considerably smaller in size.

Reticulati-sporites lacunosus sp. nov.

Plate 5, figure 5

Description.—Spores are radial, subspherical in outline and the muri frequently folded. The holotype measures 86 × 92 microns and the known size variance is from 80 to 101 microns. The spore coat is reticulate with extremely large lacunae and high muri. The lacunae measure 20 to more than 40 microns in width and the muri are frequently 8 to 10 microns high. The trilete mark is always present but frequently is not distinct in that it is covered by the muri. The holotype trilete mark is about the average condition. The rays are usually over 22 microns in length. The spore coat is more than 2 microns thick.

Holotype.—Maceration 625-B Slide 9, Willis coal bed, Gallatin County, Illinois.

Discussion.—This species is usually found abundantly in the lower half of the coal bed, suggesting that the parent plant was an early member of the plant community.

RETICULATI-SPORITES MURICATUS sp. nov.

Plate 4, figure 7

Description.—Spores are radial, body is essentially spherical, the outline is irregularly crenulate due to the large muri. The overall diameter measures 84 × 91.2 microns and the known size range is from 81.9 to 96.6 microns. The spore coat is reticulate with large lacunae and thin but long muri. The lacunae are up to 20 microns in width and average 10 to 12 microns. The muri are 8 to 10 microns high and about 2 microns wide. They are frequently folded and twisted. The trilete mark, lips, and commissure are present and distinct. The rays of the holotype range in length from 23 to 31.5 microns. The spore coat ranges from 2 to 4 microns in thickness exclusive of the muri.

Holotype.—Maceration 600 Slide 2, LaSalle coal bed, Bureau County, Illinois.

Discussion.—This species is distinctly an upper McLeansboro form, usually fairly abundant and easily recognized. As in *R. splendens* sp. nov., the muri traverse the trilete rays.

RETICULATI-SPORITES SCROBICULATUS sp. nov.

Plate 4, figure 6

Description.—Spores are radial and essentially spherical in outline. The holotype measures 109 × 111 microns, and the known size diameter is from 102 to 116 microns. The spore coat has two types of ornamentation: one, the reticulate type and the other a very definite punctate condition between the muri. The lacunae are very large and regular and measure over 50 microns in width. The muri measure 4 to 5 microns in width and are about 3 microns high. The trilete mark, lips, and commissure are distinct. The rays of the holotype range in length from 30 to 40 microns. The spore coat exclusive of the muri measures slightly more than 3 microns.

Holotype.—Maceration 574 Slide 14, Shoal Creek coal bed, Bond County, Illinois.

Discussion.—The punctate ornamentation is so distinct that the reticulate condition appears indistinct when compared with other species of the genus.

RETICULATI-SPORITES SPLENDENS sp. nov.

Plate 5, figure 4

Description.—Spores are radial, and spherical to subtriangular in outline without folds. The holotype measures 58.27 × 56.7 microns, and the known size variation is from 53 to 61 microns. The spore coat is reticulate with widely spaced lacunae on both proximal and distal surfaces. The reticulate ridges (muri) may be as much as 2 microns wide and 6 microns high and the lacunae may be as much as 12 microns in length. The tetrasporic mark is distinct as are the lips and commissure. The rays vary in length from 14 to more than 20 microns in length. The apex of the rays is frequently difficult to see due to the reticulate ridges which apparently traverse the rays. The spore coat is more than 2 microns thick and when joined by a ridge (muri) it is as much as 8 microns thick.

Holotype.—Maceration 587 Slide 18, Battery Rock Coal bed, Hardin County, Illinois. This species is known to occur in the Wayside and "Sub-Babylon" coal beds through the Tarter and Willis coal beds of lower Tradewater age.

Discussion.—*R. splendens* proves that the reticulate ridges (muri) are formed after the second division of the spore mother cell, because the ridges traverse the trilete rays.

GENUS LAEVIGATO-SPORITES (Ibrahim, 1933) emend., S. W. and B., 1944

Plate 5, figures 3, 6-11; Plate 16, figures 2, 6

Spores of the genus *Laevigato-sporites* are known to occur in Illinois in coal beds ranging from the Caseyville group throughout the entire Pennsylvanian. The genus is also known to occur in almost every coal of Pennsylvanian age that has been studied in the United States and Europe. Furthermore, Berry (1937) reports its presence in the Permian of Ohio, and Wilson and Webster (1946) report that similar forms

exist in the "American Mesozoic and Tertiary coals." In addition to the five modern genera listed by Wilson and Webster, Olof Selling (1946) lists 20 other genera of pteridophytes from Hawaii which are definitely monolete and thus of the *Laevigato-sporites* type. Selling's excellent monograph establishes without question the existence of numerous modern monolete bilateral spores. Apparently monolete bilateral spores originated in very early Pennsylvanian time and may possibly have a continuous range to the present day. The first known definite occurrence of spores of this type in Illinois is in Reynoldsburg coal bed. A fragment of a spore coat which may be of this type has been observed in the Wayside coal bed (lower in the section). The thin coal beds of the upper Mississippian should be searched for spores of the *Laevigato-sporites* type. If spores of this type are not found, there was a tremendous floral change between Pennsylvanian and Mississippian time. The probability of this change is supported by the fact that *Laevigato-sporites* is generally the dominant small spore type throughout the Pennsylvanian of Illinois.

The parent plant or plants of the spores classified under the genus *Laevigato-sporites* are unknown. It is surprising that so little is known in view of the abundance of spores of this type. The spores of a calamarian fructification (Reed, 1938) and of *Zeilleria,* a fern (Florin, 1937), are possibly of this type. Suggested affinities based on modern plants strongly indicate a relationship with the pteridophytes.

The spores of the genus *Laevigato-sporites* are perhaps the easiest to identify generically. This is because they possess a monolete mark and bilateral symmetry. Classification of the ornamented forms is generally readily accomplished. However, classification of the levigate forms presents a perplexing problem. The known size range of the genus is from 14 microns in *L. Thiessenii* to 150 microns in *L. robustus* sp. nov. In the size range of slightly under 20 microns to 30 microns there are two species: *L. minimus* and *L. minutus. L. minimus* is levigate and readily distinguished from *L. minutus,* which is punctate, providing overmaceration has not reduced the ornamentation. There appears to be a continuous size range of the levigate forms from 40 to almost 150 microns, and the known maximum range of the ornamented species in 127 microns in *L. vulgaris.* There are six described species, two of which are known to occur in Illinois coal beds. They are *L. desmoinensis* and *L. vulgaris.* The latter is described as levigate to faintly punctate and the other as levigate. It is natural that species identification might be somewhat confusing. However, judging from illustrations, *L. vulgaris* has a much coarser spore coat and on this basis species separation has been made. Schopf, Wilson, and Bentall, 1944, considered Loose's *L. vulgaris* forma *minor, maior* and *maximus,* 1934, synonymous with *L. vulgaris* (Ibrahim) Ibrahim, 1933. If so, automatically the size range of the species is extended to that of *L. vulgaris* forma *maximus* which is 122 microns. Specimens from Illinois which are considered to be conspecific have measured more than 127 microns in the longest diameter.

The following new species have been observed in Illinois coal beds:

1. *Laevigato-sporites latus*
2. *L. medius*
3. *L. obscurus*
4. *L. ovalis*
5. *L. pseudothiessenii*
6. *L. punctatus*
7. *L. robustus*

The following description of the genus *Laevigato-sporites* is based upon the previously described species and the seven new species mentioned above: spores are bilateral, monolete, bean-shaped to broadly bean-shaped, sometimes approaching an oval shape (*L. latus* sp. nov.); elongate oval to broadly oval in plane of longitudinal symmetry, round or oval in transverse plane. Folding occurs in certain species without definite patterns. The known size range from 14 to 150 microns in longest diameter. Ornamentation levigate, punctate, apiculate, verrucose, obvermiculate to faintly reticulate. Suture always monolete and linear, which is less than half to three-

fourths the total length of the spore. The suture is usually distinct but may be hidden by folds or ornamentation. The lips and small arcuate ridges may be present or absent. The spore coat may range in thickness from around 1 micron to 3.5 microns.

Laevigato-sporites latus sp. nov.

Plate 5, figure 11

Description.—Spores are bilateral, monolete, broadly bean to oval shaped in the plane of longitudinal symmetry, oval to round in transverse plane. The holotype measures 63 × 54.6 microns, and the known size variance is from 57 to 66 microns in the longest plane. The spore coat is levigate and the monolete mark is distinct, slightly opened, with lips. The monolete mark is less than half the length of the spore. The spore coat is 1.5 to 2 microns thick.

Holotype.—Maceration 490-A Slide 6, McCleary's bluff coal bed (3½″), Wabash County, Illinois.

Discussion.—*L. latus* sp. nov. is distinct from all known species in that it is almost as wide as long and also the monolete mark is less than half the length of the spore.

Laevigato-sporites medius sp. nov.

Plate 16, figure 2

Description.—Spores are bilateral, monolete, elongate to oval in the plane of longitudinal symmetry. The spore coat frequently exhibits minor folds but major folds are rare. The holotype measures 42.1 × 28.3 microns and the known size range is from 36 to 43 microns in length and from 25 to 29 microns in width. The monolete suture averages 25 microns in length. The lips and suture are distinct, and the spore coat appears levigate although it obviously is minutely granular when critically examined. The spore coat is 2 to 2.5 microns thick.

Holotype.—Maceration 578 Slide 5, Scottville coal bed, Macoupin County, Illinois.

Discussion.—This species is intermediate in size between the small species of the genus and *L. ovalis* sp. nov.

Laevigato-sporites obscurus sp. nov.

Plate 16, figure 6

Description.—Spores are bilateral, monolete, broadly oval in outline, and rarely folded. The holotype measures 32 × 29.4 microns and the known size range is from 28 to 34 microns in the largest diameter. The outline of the spore is irregular due to the sculpturing of the spore coat which is punctate. The punctations are distinct when viewed with low magnification, but are obscure when viewed with high magnification. The monolete suture is usually two-thirds to three-fourths the length of the body and somewhat distorted by the ornamentation. The lips are slightly elevated and the suture is well defined. The spore coat is 2 to 2.25 microns thick.

Holotype.—Maceration 576 Slide 14, New Haven coal bed, Gallatin County, Illinois.

Discussion.—This species is closely related to *L. thiessenii* Kosanke, 1943, and *L. pseudothiessenii* sp. nov. It differs from these two species in the type of ornamentation, and is larger than *L. thiessenii* Kosanke, 1943.

Laevigato-sporites ovalis sp. nov.

Plate 5, figure 7

Description.—Spores are bilateral, monolete, bean shaped to oval in the plane of longitudinal symmetry. Folding of the spore coat is very rare. The holotype measures 63 × 46.2 microns. Thus the width of the spore is about three-fourths of the total length. The known size range is from 45 to 65 microns. The spore coat is distinctly levigate, the monolete mark is half the length of the spore or more and the suture is frequently open. Distinct lips may be observed by focusing to proper adjustment under high magnification. The spore coat is 2 to 2.5 microns in thickness.

Holotype.—Maceration 501-A Slide 1, coal bed at 85 to 87 feet in the Skiles-Price No. 1 well in Wabash County, Illinois.

Discussion.—*L. ovalis* sp. nov. is distinct from *L. desmoinensis* (Wilson and Coe), S. W. and B., 1944, in being shorter and

wider, with a thicker spore coat and definite lips.

Laevigato-sporites pseudothiessenii sp. nov.

Plate 5, figure 10

Description.—Spores are bilateral, monolete, elongate to oval in the plane of longitudinal symmetry, round or oval in transverse plane. The outline in both longitudinal and transverse planes is broken by the sculpturing of the spore coat. The holotype measures 37.8 × 29.4 microns. The known size range is from 26 to 46 microns in the longitudinal plane. The ornamentation is various depending upon the degree of maceration. In general, the spore coat is verrucose to obvermiculate and sometimes appears reticulate. The monolete tetrad mark extends well over half the length of the spore. The spore varies in thickness, due to ornamentation, from 1.5 to 3.5 microns.

Holotype.—Maceration 543-D Slide 4, No. 5 coal bed, Fulton County, Illinois. The known range of the species is from the Upper Tradewater (Dekoven coal bed) to lower middle McLeansboro (upper Scottville coal bed).

Discussion.—*L. pseudothiessenii* is distinct from *L. thiessenii* due to larger size and slight differences in ornamentation. The two species are similar in many respects, and are probably from closely related parent plants. The writer has observed this species from the middle Kittaning coal bed in Ohio, the Mystic coal bed of Iowa, the Tebo and Lexington coal beds from Missouri, and in Indiana from No. VII coal bed to No. III coal bed. Thiessen was the first to observe and illustrate this species (1932, page 22, figures 14 B-C).

Laevigato-sporites punctatus sp. nov.

Plate 5, figure 3

Description.—Spores are bilateral, monolete, oval to broadly bean-shaped in longitudinal plane. Holotype measures 44 × 35.7 microns, and the known size variation in the long axis is from 35 to 51 microns. The spore coat is distinctly punctate, the monolete mark is over half the length of the spore, and the lips are poorly developed. The spore coat is 1.25 to 2 microns in thickness.

Holotype.—Maceration 625-A Slide 1, Willis coal bed, Gallatin County, Illinois. *L. punctatus* is known to occur from the lower Tradewater throughout the Carbondale.

Discussion.—Spores of this type are at the present assigned to the genus *Laevigatosporites* sp. nov. on the basis of the monolete scar and because their symmetry is not radial but bilateral. However, the symmetry is not as strongly bilateral as in most other species of the genus. *L. punctatus* may be distinguished from small forms of *L. vulgaris* (Ibrahim) Ibrahim, 1933, on the basis of a more sharply punctate ornamentation.

Laevigato-sporites robustus sp. nov.

Plate 5, figure 9

Description.—Spores are bilateral, monolete, broadly bean shaped. Small folds of spore coat are common and occur almost anywhere either proximally or distally. The holotype measures 101.8 × 73.5 microns, and the known size range is from 79.8 to 150 microns in the longest diameter whereas the average range is from about 85 to 120 microns. The spore coat is distinctly levigate, and the monolete mark is usually one-half to two-thirds the length of the spore. The lips are usually not distinct and the suture is sometimes open. The spore coat is 1.5 to 2 microns thick.

Holotype.—Maceration 574 Slide 8, coal bed below the Shoal Creek coal bed, Bond County.

Discussion.—The size range of 79.8 to 150 in the longest diameter may well include at least two species based on size range. However, it is necessary to name the forms and it is doubtful that it will be possible to delineate species properly until spores of this type are found within reproductive organs. Raistrick's type B may be conspecific with *L. robustus* sp. nov.

GENUS Denso-sporites (Berry, 1937) emend., S. W. and B., 1944

Plate 6, figures 1-11; Plate 7, figures 1-2

The genus *Denso-sporites* has an interesting and important geological range in Illinois. So far as is known, it is restricted entirely to Tradewater and Caseyville groups. Maximum abundance is attained in the Reynoldsburg coal bed, upper Caseyville, and the youngest *Denso-sporites* horizon is the Dekoven coal bed, upper Tradewater.

Thiessen's "splint microspores" were species of *Denso-sporites,* and he found this type of spore abundantly preserved in splint coals. The resulting idea that splint coal was derived from a specific type of vegetation does not appear valid. If this were true one might expect to find splint spores wherever splint coal is encountered. Also, the range of splint coal would be identical with the range of "splint microspores." In Illinois, this is not true; in fact the Reynoldsburg coal bed is not truly a splint coal and yet it contains more "splint microspores" than any other Illinois coal bed. Figures 1-2, Plate 15, illustrate this point. There is little information concerning splint coal in Illinois; however it is known that splint coal does occur above the range of the "splint microspores." The parent plants of *Denso-sporites* contributed to splint coal but it is probable that splint coal was formed in more than one way and from more than one type of vegetation.

The following are new species of *Denso-sporites:*

1. *D. sinuosus*
2. *D. glandulosus*
3. *D. granulosus*
4. *D. lobatus*
5. *D. reynoldsburgensis*
6. *D. ruhus*
7. *D. sphaerotriangularis*
8. *D. triangularis*

The following description of the genus *Denso-sporites* is based on six previously described species and the species mentioned above: Spores are radial, trilete; isolated compressed forms are round, oval to subtriangular in transverse plane. In vertical thin-section they are "dumbbell" shaped as seen on plate 15, figure 1. The known size range is from 27 to 100 microns. The proximal-distal portions of the spore coat may be levigate, granulose, punctate, papillate, apiculate, rugose, to vermiculate. The equatorial portion of the spore coat may be levigate, granulose, punctate, nearly reticulate, rugose, apiculate and frequently irregularly thickened. The trilete mark may be indistinct, distinct, or even absent if the proximal area of the spore coat is poorly preserved. The rays may be limited to the proximal area or extend into the thicker equatorial portion of the spore coat. The spore coat is always characterized by the proximal-distal portion which is thin and the equatorial portion which is much thicker and frequently opaque. The parent plants of *Denso-sporites* are unknown. In some cases, the equatorial portion of the spore coat resembles a flange which remotely resembles the spore genus *Cirratriradites.*

Denso-sporites sinuosus sp. nov.

Plate 6, figures 1-2

Description.—Spores are radial, trilete, roundly triangular to oval in outline and frequently obliquely compressed. The holotype (figure 1) measures 39.9 × 46.2 microns and the known size range is from 36 to 48 microns. The proximal and distal portions of the spore coat are minutely punctate. The thicker equatorial portion is nearly opaque with ridges arranged so as to appear reticulate to wavy. Figures 1-2, plate 6, illustrate this feature. The trilete mark is usually visible although indistinct in some forms. The rays are not known to extend beyond the proximal portion of the spore coat. The proximal and distal portions of the spore coat are thin but the equatorial portion averages about 10.5 microns in thickness. Over 50 percent of the spore coat is of the equatorial type as viewed transversely.

Holotype.—Maceration 587 Slide 12, Battery Rock coal bed, Hardin County, Illinois.

Discussion.—The ornamentation of the

thicker equatorial portion of the spore coat is characteristic of this species. Figure 1, plate 6, is in focus to show the trilete mark and ornamentation whereas figure 2 illustrates the triangular outline of some specimens.

Denso-sporites glandulosus sp. nov.

Plate 6, figure 3

Description.—Spores are radial, trilete (?), originally spheroid, and frequently compressed to a suboval shape in the transverse plane. The holotype measures 27.3 × 35.7 microns, and the known size range is from 25 to 38 microns. The proximal and distal portions of the spore coat are minutely granulose as seen with the aid of oil immersion, and there are also scattered about a number of stalked glandulose structures which extend also on the thicker equatorial portion of the spore coat. The glandulose projections average about 4.2 microns in length, 1-2 microns at the apex, and usually much less at the base because the projections are knobbed. A faint mark, probably the trilete mark, has been observed. The proximal and distal portions of the spore coat do not exceed 2 microns and the equatorial portion is 4.2 to 7.8 microns in thickness.

Holotype.—Maceration 144 Slide 5, "Sub-Babylon" coal bed, Fulton County, Illinois.

Discussion.—The glandulose nature of the entire spore coat is distinctive of this species. The glandulose projections are similar in shape to those of *Lyginopteris oldhamia.*

Denso-sporites granulosus sp. nov.

Plate 6, figure 8

Description.—Spores are radial, trilete, oval to round in transverse outline and with occasional folds on the proximal surface of the spore. The holotype measures 52.5 × 48.3 microns and the known size variation is from 45 to 56 microns. The proximal surface of the spore coat is covered with small blunt granulose structures. The equatorial area is opaque with minor spine-like projections located at the equator of the spore. A few pits have been observed in the opaque area. The trilete mark is not prominent and the rays sometimes extend into the equatorial portion of the spore coat. The rays average about 16.8 microns in length. The proximal and distal portions of the spore coat are less than 2 microns in thickness while the equatorial portion varies from 7.6 to 12.6 microns which may in part be due to oblique compression. A direct transverse measure of the holotype reveals that over 40 percent of the spore is the equatorial portion of the spore coat.

Holotype.—Maceration 625-A Slide 6, Willis coal bed, Gallatin County, Illinois.

Discussion.—*D. granulosus* sp. nov. is similar in size and shape to *D. densus* Berry, 1937; however, the proximal-distal portion of the spore coat is definitely granulose. Type A, of Raistrick (1947, page 911), is somewhat similar to *D. granulosus* sp. nov.

Denso-sporites lobatus sp. nov.

Plate 6, figures 4-5

Description.—Spores are radial, thought to be trilete and oval to roundly triangular, as viewed in transverse plane. The holotype (figure 4) measures 37.8 × 44.1 microns and the known size variation is from 34 to 55 microns. The proximal and distal portions of the spore coat are actually vermiculate, appearing reticulate when not in perfect focus. The equatorial portion of the spore coat is not a homogeneous opaque structure but rather consists of an essentially opaque area and a definitely translucent area which extends beyond the opaque area to the margin of the spore wall. The peripheral margin of the opaque area of the equatorial portion of the spore coat is sharply lobed to nearly clefted, thus the margin is irregular in outline although the apexes somewhat parallel the outline of the spore coat in transverse plane. The trilete mark has not been definitely observed, probably due to the ornamentation of the proximal and distal portions of the spore coat. However, a faint mark has been observed on several specimens which suggests the presence of a trilete mark. The proxi-

mal-distal portions of the spore coat are estimated to be 2 microns thick; the equatorial portion ranges from 8.4 to 10.5 microns in thickness and comprises about 42 percent of the spore coat.

Holotype.—Maceration 625-A Slide 1, Willis coal bed, Gallatin County, Illinois.

Discussion.—Figure 4, plate 6 illustrates an oval outline as contrasted with the somewhat triangular outline of figure 5. Figure 4 illustrates the ornamentation of the proximal-distal portion of the spore which appears reticulate, and figure 5 illustrates the vermiculate type of ornamentation. This feature is entirely dependent upon the focusing of the microscope.

Denso-sporites reynoldsburgensis sp. nov.

Plate 6, figures 9-11

Description.—Spores are radial, trilete and roundly triangular as viewed in transverse plane. The tetrad, plate 6, figure 9, shows the spore to be subtriangular at right angles to the transverse plane. The holotype (figure 10) measures 39.9 × 44.6 microns, and the known size range is from 36 to 47 microns. The proximal and distal surfaces are slightly granular as viewed under high dry magnification. With oil immersion this portion of the spore coat is either minutely granulose or punctate, probably granulose. The juncture of this portion of the spore coat with the equatorial portion is marked by ridge or fold which completely surrounds the center area. Due to compression, a portion of the equatorial area overlaps on the distal side of the central area. The thicker equatorial portion of the spore coat is essentially opaque with a few minor pits or punctations, and minor folding of this area of the spore coat is shown on plate 6, figures 10-11. This species is definitely derived from tetrahedral tetrads and the tetrad mark may be weakly or strongly preserved on isolated specimens as shown in figures 10-11, plate 6. The rays do not extend into the equatorial portion of the spore coat. The rays of the holotype vary in length from 10.5 to 12.6 microns in length. The proximal-distal portion of the spore coat is less than 2 microns thick and the equatorial portion averages 8.4 microns in thickness. A direct transverse measure of the holotype reveals that more than 39 percent of the spore is the equatorial portion of the spore coat.

Holotype.—Maceration 618 Slide 21, Reynoldsburg coal bed, Johnson County, Illinois.

Discussion.—This species is similar to but certainly not conspecific with *D. annulatus* (Loose) S. W. and B., 1944.

Denso-sporites ruhus sp. nov.

Plate 6, figure 6

Description.—Spores are radial, trilete (?), oval in transverse outline and with occasional minor folds of the spore coat. The holotype measures 42 × 52.5 microns, and the known size range is from 42 to 53 microns. The proximal and distal portions of the spore coat are punctate. The thicker equatorial portion of the spore coat is somewhat irregularly thickened and the margin of the spore coat is rough in appearance. The trilete mark is indistinct to absent on most specimens. The proximal and distal portions of the spore coat are thin, not more than from 1.75 to 2 microns thick. The equatorial portion of the spore coat varies in thickness from 8.4 to 10.5 microns.

Holotype.—Maceration 587 Slide 13 Battery Rock coal bed, Hardin County Illinois.

Discussion.—This species is somewhat similar to fig. 1 (Pagent, 1936) but probably not conspecific with it. *D. ruhus* sp. nov. is characterized by its rather coarse ornamentation.

Denso-sporites sphaerotriangularis sp. nov.

Plate 6, figure 7

Description.—Spores are radial, trilete and roundly triangular in outline and lacking folds, except at the inner margin of the thick wall. At this point minor folds may be distinguished. The holotype measures 48.3 × 50.4 microns, and the known size range is from 46 to 59 microns. The proxi-

mal and distal portions of the spore coat are covered with large widely spaced papillations. The equatorial portion of the spore coat is thickest at the inner margins as shown by its nearly opaque nature. At the outer margin this portion is translucent. There is a sharp contrast between the nearly opaque and translucent portions. The nearly opaque portion is irregular in outline due to its structure which is composed of a number of small plicating sheets. The trilete rays are faintly present and extend into the thick equatorial portion of the spore coat. The entire length of the rays, including that portion extending into the equatorial area, varies from 16 to 18 microns. As viewed transversely, the proximal and distal walls of the spore coat are thin, certainly less than 2 microns. The equatorial portion of the spore coat including the nearly opaque and the translucent area measures between 12.5 and 14.7 microns on the holotype specimen. A direct transverse measure of the holotype reveals that more than 63 percent of the spore is the equatorial portion of the spore coat.

Holotype.—Maceration 520-A Slide 2, Bald Hill coal bed, Williamson County, Illinois.

Denso-sporites triangularis sp. nov.

Plate 7, figure 1

Description.—Spores are radial, faintly trilete, outline in transverse plane is subtriangular and lacking in folds although some specimens show the equatorial area compressed over a portion of the proximal and distal portions of the spore coat. The holotype measures 58.8 × 58.8 microns and the known size range is from 52 to 65 microns. The proximal and distal areas of the spore coat are granulose to vermiculate. The thicker equatorial area is variously ornamented. In part it is punctate and the margin has a few spines at which point the spore coat is translucent. Only faint lines resembling the tetrad mark have been observed. The proximal-distal portion of the spore coat is thin, not over 2 microns in thickness. The thicker equatorial portion varies from 12.6 microns between the corners to 18.9 microns at the corners. About 55 percent of the total spore coat is that of the equatorial portion.

Holotype.—Maceration 144 Slide 3, "Sub-Babylon" coal bed, Fulton County, Illinois.

GENUS Cirratriradites Wilson and Coe, 1940

Plate 7, figures 3-6

Cirratriradites is rarely abundant in Illinois coal beds. The two known exceptions are the coal beds between the Babylon and Delwood coal beds of the Tradewater group and No. 5 coal bed of the Carbondale group. The known range is from the base of the Tradewater (the Babylon coal bed) to below No. 8 coal bed in the McLeansboro group. The known range is not continuous, since some of the coal beds within this range appear to lack the genus. *C. difformis* and *C. rotatus,* which are new species from the Tradewater group, are of particular value for correlation purposes because of their abundance and restricted range.

The following description of the genus *Cirratriradites* is based on 14 established species and four new species: spores are radial, trilete, with a definite flange, originally roundly oblate and for this reason when compressed only minor folds are evident. In transverse plane the spore body is round to subtriangular and the flange may be triangular, due to the extention of the rays, or almost round. The known size range is from 40 to 102 microns. The ornamentation of the spore coat is levigate, granulose, punctate, or reticulate. Some species have distal ridges which may enclose one to four or more areas in an unusual type of ornamentation. The flange is frequently radially striate and in some species the flanges have radially arranged processes. The trilete rays are usually strongly developed, as are the lips, whereas the commissure is often sharply developed but thin. As reported by Schopf, Wilson, and Bentall (1944), the affinity of the spores of this genus is unknown although they are thought to be related to the lycopods. However, known microspores of *Lepidostrobus* do not

have the flange development although some isolated spores of *Lycospora* described later in this report approach more closely a flange development than has been previously known.

Cirratriradites annuliformis sp. nov. Kosanke and Brokaw

Plate 7, figure 6

Description.—Spores are radial, trilete, nearly round to roundly triangular in transverse plane and with a definite equatorial flange. Folding of the spore body is rare; the flange may or may not possess minor folds. The holotype measures 84 × 82 microns, and the known size range is from 76 to 90 microns. The spore coat is minutely punctate (as viewed under oil immersion) and the periphery of the flange is irregular, being minutely toothed. The flange is definitely not radially striate and appears to originate slightly to the proximal and distal sides of the equator of the spore. The spore coat of the holotype, exclusive of the flange, measures 73.5 × 71.4 microns. The thin distal areas surrounded by ridges may be present or absent. The trilete mark is usually distinct and extends to the periphery of the flange. The spore coat measures 2 to 3 microns in thickness and the flange is 1 to 1.25 microns in thickness.

Holotype.—Maceration 596-A Slide 8, Grape Creek No. 6 coal bed, Vermilion County, Illinois.

Discussion.—The portion of the flange which extends beyond the spore body is rather small when contrasted to other species of the genus. This may or may not be due to the fact that the flange originates slightly to the proximal and distal sides of the equator.

Cirratriradites annulatus sp. nov. Kosanke and Brokaw

Plate 7, figure 4

Description.—Spores are radial, trilete, roundly triangular in transverse plane, with a definite equatorial flange. Folding of the spore body is rare and only minor folds of the flange are known. The holotype measures 89.2 × 98.6 microns, and the known size range is from 84 to 102 microns. The body of the spore measures 65.1 × 67.2 microns. The spore coat is sharply punctate and the punctations vary in size from less than 1 micron to almost 2 microns. The spore coat frequently has on its distal surface, opposite the center of the trilete mark, a series of ridges which may enclose four or more areas. The flange is minutely radially striate. The trilete mark is distinct and extends to the periphery of the flange. The commissure is not developed although the lips are distinct. The spore coat is over 2 microns thick and the flange is very thin.

Holotype.—Maceration 540-C Slide 6, No. 6 coal bed, Fulton County, Illinois.

Discussion.—This species was first observed in No. 5 coal bed by A. L. Brokaw. It is now known to be present in No. 6 coal and its range has been traced into the lower part of the McLeansboro group.

Cirratriradites difformis sp. nov.

Plate 7, figure 3

Description.—Spores are radial, trilete, subtriangular to round in transverse plane, with a definite large equatorial flange. Occasionally the flange is folded or slightly twisted. The holotype measures 63 × 53.5 microns and the known size range is from 52 to 68 microns. The spore coat is mildly reticulate with ridges at the periphery of the spore coat which anastomose in groups and extend into the flange. The area between the ridges of the flange is usually open but occasionally it is filled by the matrix of the flange or a reticulate network. The spore body of the holotype measures 31.5 × 31.5 microns. The trilete mark is usually distinct and extends beyond the body of the spore and into the outer margin of the flange in most cases. The commissure and lips are only slightly developed. The spore coat is about two microns in thickness and the flange is much less although somewhat variable.

Holotype.—Maceration 625-B Slide 7, Willis coal bed, Gallatin County, Illinois.

Cirratriradites rotatus sp. nov.

Plate 7, figure 5

Description.—Spores are radial, trilete, roundly triangular in outline and have a definite equatorial flange consisting of numerous radially arranged processes. The spore coat is rarely folded although occasionally it is obliquely compressed. The holotype measures 50.4 × 50 microns, and the known size range is from 46 to 58 microns. The spore coat is coarsely punctate to reticulate and the flange processes appear to originate slightly to the proximal and distal sides of the equator, at which point the spore coat is reticulate. The processes are forked at the tip and frequently anastomosing. There appears to be a thin flange matrix joining the processes and when missing it is thought to be due to preservation or maceration. The spore body of the holotype measures 27.3 × 34.6 microns. The flange varies in width from 8 to 13 microns. The trilete mark is distinct, the commissure is thin and the lips are sharply defined. The spore coat is less than 3 microns thick, the flange processes are about 2 microns thick, and the matrix of the flange is very thin.

Holotype.—Maceration 625-B Slide 7, Willis coal bed, Gallatin County, Illinois.

Discussion.—This small spore is similar to the megaspore, *Triletes rotatus* Bartlett, 1928, in the formation of the processes in the flange.

GENUS Endosporites Wilson and Coe, 1940

Plate 7, figure 7-9

Endosporites ranges throughout most of the coal beds in Illinois. It is rarely abundant except for several horizons in upper McLeansboro coal beds and from the Murphysboro through the Dekoven coal beds of upper Tradewater age. Identification of species is commonly difficult because of a badly folded perisporial bladder. *E. vesicatus* sp. nov. and *E. plicatus* sp. nov. have proved of value in correlating coal beds of the McLeansboro group. Additional species are known to occur in Illinois but because of insufficient specimens only three new species are described.

The following description of the genus *Endosporites* is based on eight established species and three new species: spores are radial, trilete, with a perisporial bladder, and laterally compressed in fairly good proximal-distal orientation. The bladder is generally plicated and occasionally the exosporial body may be slightly folded. The size range is from 50 to 175 microns for American species of the genus. Schopf, Wilson, and Bentall (1944) include a doubtful species, *E.* (?) *karczewskii* (Zerndt) S. W. and B., 1944, transferred from *Triletes* which would extend the size range to 300 microns. The bladders may be ornamented externally by being levigate to granular to punctate, or internally by coarse punctations or by being reticulate. The exosporial body may be levigate or punctate. The trilete rays are distinct, and extend either to the periphery of the exosporial body or at least two-thirds the distance to it. The lips are frequently elevated and the commissure may be thin or wide. Apical papillae may be present or absent. The perisporial bladder is usually membraneous and the exosporial body is considerably thicker but probably does not exceed three microns. There is little doubt that spores of this genus are closely related to the Cordaitaleans.

Three new species from Illinois coal beds are:

1. *E. formosus*
2. *E. vesicatus*
3. *E. plicatus*

Endosporites formosus sp. nov.

Plate 7, figure 9

Description.—Spores are radial, trilete, roundly triangular in outline in transverse plane with a distinct perisporial bladder. The holotype measures 117.6 × 105 microns; the exosporial body wall measures 63 × 54.6 microns and the known size range is from 101 to 122 microns. Folding of the bladder and the body wall is common. The

exosporial body wall is punctate while the internal bladder ornamentation is coarsely punctate to finely reticulate. The trilete rays are distinct and extend to the margin of the body wall. Occasionally, the folding of the bladder may appear as extensions of the rays. The lips are elevated and the commissure is thin but distinct. A thickening of the bladder may correspond to arcuate ridges. The exosporial wall is not over two microns in thickness and the bladder is much less.

Holotype.—Maceration 490-A Slide 5, McCleary's Bluff coal bed (3½ inches), Wabash County, Illinois.

Discussion.—*E. formosus* is distinct from *E. angulatus* Wilson and Coe, 1940, based on size and ornamentation. It is distinct from *E. ornatus* Wilson and Coe, 1940, based on shape and ornamentation.

Endosporites vesicatus sp. nov.

Plate 7, figure 8

Description.—Spores are radial, trilete, originally spherical in transverse plane with exceptionally large bladders. The bladders (perisporial) appear to be inflated and variously folded; frequently they are folded over the exosporial body wall which itself is rarely folded. The holotype measures 73.5 × 136.5 microns, and originally must have measured at least 130 × 130 microns. The exosporial body measures 44 × 52.5 microns and the maximum size observed measured 148 microns (including bladder) in the largest diameter. The exosporial body is minutely punctate to finely reticulate. The trilete mark is fairly distinct and the lips are slightly elevated while the commissure is thin but clearly marked. The rays extend at least three-fourths of the distance to the margin of the exosporial body, and apical papillae are usually present. The exosporial body does not exceed 2 microns in thickness and the bladder is about 1 micron thick.

Holotype.—Maceration 542-B Slide 1, No. 8 coal bed, Peoria County, Illinois.

Discussion.—This species is characterized by large folded bladders and the presence of apical papillae.

Endosporites plicatus sp. nov.

Plate 7, figure 7

Description.—Spores are radial, trilete, spherical in transverse plane with a small perisporial bladder. Folding of the exosporial body and bladder is common and the folds are usually parallel to the outline and are most numerous at the juncture of the perisporial and exosporial coats. The holotype measures 86.1 × 81.4 microns and the known size range is from 78 to 99 microns. The exosporial body measures 63 × 56.7 microns, and is punctate with distinct apical papillae. The internal bladder ornamentation is punctate to finely reticulate. The trilete mark is distinct and extends from two-thirds to three-fourths of the distance to the margin of the exosporial body. The commissure is frequently wide and the lips are elevated. The exosporial wall is 1.75 to 2.25 microns in thickness; the bladders are about 1 micron thick.

Holotype.—Maceration 573 Slide 6, No. 8 coal bed, Macoupin County, Illinois.

Discussion.—The presence of apical papillae and a small bladder characterize this species.

GENUS Triquitrites Wilson and Coe, 1940

Plate 8, figures 1-8

Triquitrites has a long vertical range, but is an important spore genus in Illinois coal beds. It has been isolated from almost all macerations that have been run. The genus had periods of numerical abundance in upper Tradewater and middle McLeansboro time.

Triquitrites has been observed in almost all the Pennsylvanian coal beds studied in the United States and in Europe, and is readily recognized, which is a definite asset in the correlation of coal beds. Specific identification is likewise easy to establish, and the new species described in this report expand the known types of ornamentation and arcuate thickenings.

The following description of the genus *Triquitrites* is based on six previously described species and seven new species: Spores

are radial, trilete, elliptical to oval in vertical plane, subtriangular to triangular in transverse plane. The interradial margin varies from concave to convex. The spores are usually compressed in good proximal-distal orientation. Folding of the spore coat is relatively rare, but folding or overlapping of the arcuate thickenings is common where the thickenings are pronounced. The known size range is from 22 to 75 microns. The ornamentation of the spore coat varies from levigate, granulose, mildly punctate, verrucose, spinose, to blunt projections or processes. The trilete rays are usually distinct and extend at least two-thirds the distance to the margin of the spore wall and in most species the rays extend three-fourths the distance. The lips and commissure may be moderately developed or almost lacking. The spore coat is characterized by extremes in variation due to the universal presence of thickened corners opposite the rays. The spore coat, exclusive of the thickened corners, varies in thickness from 1 to 9 microns. The parent plant of *Triquitrites* is unknown. It is thought possible by Schopf, Wilson, and Bentall (1944) to be related possibly to the filicineans. It has been noted that an increase in the abundance of prepollens sometimes is associated with increase in the abundance of *Triquitrites*. This may be of ecological importance.

The following are new species isolated from Illinois coal beds:

1. *T. angulatus*
2. *T. crassus*
3. *T. discoideus*
4. *T. inusitatus*
5. *T. pulvinatus*
6. *T. priscus*
7. *T. protensus*

Triquitrites angulatus sp. nov.

Plate 8, figure 8

Description.—Spores are radial, trilete, triangular in transverse plane, margin between rays is slightly concave or convex, and the corners opposite the rays are extremely wide and thickened. The holotype measures 71.9 to 70.9 microns, and the known size range is from 66 to 75 microns. The arcuate thickenings are perhaps the most extreme of any species of the genus, and appear to be connected to each other by a thickened line on the proximal surface. The arcuate thickenings of the holotype vary in length from 33 to 42 microns and in width up to 8 microns. The ornamentation is levigate on both the proximal and distal surfaces. The trilete mark is distinct, the lips are slightly elevated, and the commissure is thin. The spore coat is 2.25 to 3.5 microns in thickness exclusive of the arcuate thickenings.

Holotype.—Maceration 520-A Slide 3, Bald Hill coal bed, Williamson County, Illinois.

Discussion.—*T. angulatus* sp. nov. is the largest species of the genus thus far observed and is characterized by an unusual development of the arcuate thickenings.

Triquitrites crassus sp. nov.

Plate 8, figure 6

Description.—Spores are radial, trilete, subtriangular in outline, interradial margins generally slightly convex, and have arcuate thickenings. The holotype measures 66.1 × 67.2 microns, and the known size range is from 61 to 73 microns. The arcuate thickenings appear to originate on the proximal surface and surround the apex of the rays. The widest thickening measured on the holotype was 14.7 microns, and the length averaged 16.8 microns. The spore coat is levigate with widely scattered blunt projections on both proximal and distal surfaces. The trilete rays are distinct, and extend at least three-fourths the distance to the margin of the spore wall. The lips are slightly elevated and the commissure is distinct. The spore coat varies in thickness due to the projections; however, exclusive of the projections, the spore coat ranges from 5.2 to 9 microns.

Holotype.—Maceration 574 Slide 21, Shoal Creek coal bed, Bond County, Illinois.

Discussion.—The thick spore coat and projections help characterize *T. crassus* sp. nov.

Triquitrites discoideus sp. nov.

Plate 8, figure 3

Description.—Spores are radial, trilete, roundly triangular in transverse plane, interradial margins convex, and have definite arcuate thickenings. The holotype measures 71.4 × 67.2 microns and the known size range is from 63 to 74.5 microns. The arcuate thickenings measure 4.2 microns wide and 16.8 microns long. They appear to originate at the equator of the spore. The spore coat is ornamented with short broad spine-like projections which may be irregularly placed on both proximal and distal surfaces. The trilete rays are sharply defined and extend nearly to the margin of the spore wall. The lips are thin but elevated and the commissure is thin but distinct. The spore coat, exclusive of projections and arcuate thickenings, varies in thickness from 3.6 to 4.2 microns.

Holotype.—Maceration 542-B Slide 3, Trivoli No. 8 coal bed, Peoria County, Illinois.

Discussion.—*T. discoideus* sp. nov. is abundantly present in a number of McLeansboro coal beds.

Triquitrites inusitatus sp. nov.

Plate 8, figure 7

Description.—Spores are radial, trilete, triangular in transverse plane, and the margin between rays is essentially straight. The thickening (?) opposite the rays is unusual since it is a series of several processes which are projections of the spore coat. The holotype measures 65.1 × 67.2 microns exclusive of the corner processes, and the known size range is from 60.5 to 73 microns. The processes (arcuate thickenings?) vary in width since commonly two processes appear to be fused whereas in length they average slightly more than eight microns. The spore coat is levigate to minutely granular. The trilete mark, lips, and commissure are distinct. The rays of the holotype vary in length from 15 to 17 microns. The spore coat varies in thickness from two to three microns.

Holotype.—Maceration 603-C Slide 4, No. 2 coal bed, Fulton County, Ilinois.

Discussion.—*T. inusitatus* sp. nov. is characterized by unusual processes (arcuate thickenings?). The processes appear to be projections of the spore coat.

Triquitrites pulvinatus sp. nov.

Plate 8, figure 1

Description.—Spores are radial, trilete, and subtriangular in transverse plane. The interradial margin is slightly convex, and the arcuate thickenings are large and cushion-like in appearance. The holotype measures 46.2 × 46.2 microns, and the known size range is from 41.5 to 52.6 microns. The arcuate thickenings of the holotype vary in length from 16.8 to 21.5 microns and in width from three to four microns beyond the body cavity. The spore coat is essentially levigate with a few scattered small punctations present on some specimens. The trilete rays are distinct and extend almost to the margin of the spore wall. The lips are elevated and the commissure is pronounced. The spore coat ranges in thickness from 2 to 2.75 microns.

Holotype.—Maceration 628-A Slide 4, Murphysboro coal bed, Saline County, Illinois.

Discussion.—*T. pulvinatus* is characterized by cushion-like arcuate thickenings. This species is somewhat similar to *T. tribullatus* (Ibrahim) S. W. and B., 1944, but it is slightly different in shape and the arcuate thickenings are shorter in length.

Triquitrites priscus sp. nov.

Plate 8, figure 4

Description.—Spores are radial, trilete, and subtriangular in transverse plane. The interradial margins are concave, and the arcuate thickenings are distinct. The holotype measures 40.5 to 40.5 microns, and the known size range is from 36 to 45 microns. The length of the arcuate thickenings of the holotype varies from 20.4 to 21.4 microns and the width is less than half the length. The spore coat has coarse-

ly but widely scattered punctations. The trilete rays are distinct and extend more than three-fourths of the distance to the margin of the spore wall. The lips are slightly elevated and the commissure is distinct. The spore coat is more than 2 microns in thickness.

Holotype.—Maceration 587 Slide 13, Battery Rock coal bed, Hardin County, Illinois.

Discussion.—*T. priscus* sp. nov. is the first species of the genus recognized from the Caseyville group in Illinois.

Triquitrites protensus sp. nov.

Plate 8, figure 2

Description.—Spores are radial, trilete, and triangular in transverse plane. The interradial margins are slightly concave or convex and have arcuate thickenings. The overall measurement of the holoytype is 37.8 × 36.5 microns, and the known size range is from 33.5 to 39 microns. The arcuate thickenings appear to originate from the proximal side of the spore equator and their total width is 10.5 microns of which 4.2 microns extend beyond the body cavity. The length of the thickenings is the same as the width, 10.5 microns. The spore coat is levigate, but frequently small fragments of debris are found clinging to the proximal and distal surfaces. The trilete rays are fairly distinct and the lips are slightly elevated. The commissure may or may not be clearly visible. The rays extend almost to the margin of the spore wall. The spore coat varies in thickness from 2 to 3 microns.

Holotype.—Maceration 519-B Slide 1, Dekoven coal bed, Williamson County, Illinois.

Discussion.—The thickenings of *T. protensus* sp. nov. are distinct from those of all other known species of the genus.

GENUS Calamospora S. W. and B., 1944

Plate 9, figures 1-5

Calamospora is present in almost every coal bed in Illinois. It is abundantly present in the coal beds of Tradewater, Carbondale, and McLeansboro age. Maximum abundance is recorded from the Jamestown and Cutler coal beds of southern Illinois. *Calamospora* is present in moderate abundance in the Seville, Rock Island, No. 2, No. 5, Shoal Creek, and LaSalle coal beds.

The genus is readily identified with one exception: mildly ornamented species of *Punctati-sporites* might possibly be confused with *Calamospora.*

Identification of species is not always easy because of lack of ornamentation. Also it is thought that the spores of the genus are not readily segregated into restricted generic relationships. Thus *Calamospora* appears to be a somewhat generalized form, possibly representing several types of parent plants. Hartung's (1933) work suggested the Calamarian relationship for which spores of this type have been placed in the genus *Calamospora.* Arnold (1945) described a fructification, *Bowmanites,* which was heterosporous, and both megaspores and microspores are of the *Calamospora* type. Certainly Arnold's small spores of this fructification (figs. 5 and 9) are referrable to *Calamospora.*

Description of the genus *Calamospora* is characterized as follows, based on eight previous species and five new species: Spores are radial, trilete, originally spherical in shape, and variously folded. The known size range is from 30 to 165 microns. The ornamentation is in general levigate. The trilete rays may extend from one-fourth to more than two-thirds the distance to the margin of the spore coat. The lips may be greatly developed or lacking, and the commissure may be thin or wide. The *area contagionis* may be present or absent. The spore coat is usually very thin, 2 to 3 microns, and translucent. Two species have spore coats up to 6 microns thick. Species with thin spore coats usually are folded.

It is possible that *C. obesus* (Loose) comb. nov. S. W. and B., 1944, and *C. flava* sp. nov. are megaspores. The only basis for this is their thick spore coats, 5 to 6 microns. However, this thickness is

much in excess of the other species. These two species are generally smaller than the thin walled species *C. perrugosus* (Loose) S. W. and B., 1944. However, in light of Thompson's (1927) works this is not an important consideration.

The following are new species:

1. *C. breviradiata*
2. *C. flava*
3. *C. flexilis*
4. *C. liquida*
5. *C. pedata*

Calamospora breviradiata sp. nov.

Plate 9, figure 4

Description.—Spores are radial, trilete, originally spherical, and have folds generally parallel to the margin of the spore. The holotype measures 57.7 × 65.1 microns and the known size range is from 52 to 71 microns. The trilete rays are short and those of the holotype vary in length from 8 to 16 microns. The lips are distinct and elevated while the commissure is thin and attenuate. The *area contagionis* is developed. The spore coat is levigate and is not over two microns thick.

Holotype.—Maceration 579-B Slide 1, No. 2 coal bed, Bureau County, Illinois.

Discussion.—*C. breviradiata* sp. nov. is characterized by relatively short rays and highly developed lips. Also the presence of the *area contagionis* is important although not a feature restricted to this species.

Calamospora flava sp. nov.

Plate 9, figure 2

Description.—Spores are radial, trilete, spherical, and have occasional minor folds. The holotype measures 107.1 × 119.7 microns and the known size range is from 98 to 123 microns. The trilete rays of the holotype vary in length from 27.3 to 33.6 microns. The lips are very thin and elevated. Folds frequently are associated with the lip, and are possibly due to compression of the thick spore coat. The commissure when visible is thin. The spore coat is levigate, yellow, and 3.5 to 5.2 microns thick.

Holotype.—Maceration 538-F Slide 8 (Macoupin coal bed?) diamond-drill core, Jefferson County, Illinois.

Discussion.—*C. flava* sp. nov. is distinct from *C. obesus* (Loose) S. W. and B., 1944, although there can be little doubt that they are closely related.

Calamospora flexilis sp. nov.

Plate 9, figure 5

Description.—Spores are radial, trilete, spherical to roundly triangular and have occasional folds frequently running parallel with the rays. The holotype measures 69.3 × 64 microns, and the known size range is from 58 to 70 microns. The trilete rays of the holotype vary in length from 14 to 17 microns. The lips are slightly developed and elevated, however they are partly obscured by folds. The commissure is thin but definite. The spore coat is levigate, appearing minutely punctate due to minor irregularities of the spore coat. The spore coat is 2 microns thick.

Holotype.—Maceration 625-A Slide 1, Willis coal bed, Gallatin County, Illinois.

Discussion.—*C. flexilis* sp. nov. is characterized by its shape and folds associated with the rays.

Calamospora liquida sp. nov.

Plate 9, figure 1

Description.—Spores are radial, trilete, spherical, and have numerous plications of the spore coat. The holotype measures 81.6 × 84 microns, and the known size range is from 76 to 94 microns. The plications are numerous and somewhat parallel to the outline of the spore. The trilete rays of the holotype are distinct and vary in length from 26.2 to 31.5 microns. The lips are moderately developed and definitely elevated. The commissure is usually thin but distinct. The *area contagionis* is not present. The spore coat is levigate and translucent. It is less than 2 microns in thickness which probably accounts for the numerous plications.

Holotype.—Maceration 574 Slide 12,

Shoal Creek coal bed, Bond County, Illinois.

Discussion.—*C. liquida* sp. nov. is similar to *C. hartungiana* Schopf, but lacks the *area contagionis*. Further, the plications are not generally of major dimensions. *C. liquida* sp. nov. is probably conspecific with Knox's type B_3 (1938, p. 458).

Calamospora pedata sp. nov.

Plate 9, figure 3

Description.—Spores are radial, trilete, originally spherical. Compression usually results in one major fold. The holotype measures 44.1 × 70.3 microns; before compression it probably measured about 65 × 65 microns. The known size range is from 41 to 75 microns. The trilete rays vary in length from 21 to 27.3 microns. The lips are generally lacking or very small. The commissure is thin but distinct. The spore coat is levigate, yellow, and varies in thickness from 2 to 3 microns.

Holotype.—Maceration 542-C Slide 3, No. 8 coal bed, Peoria County, Illinois.

Discussion.—*C. pedata* sp. nov. is characterized by long trilete rays and singular fold.

GENUS Reinschospora Schopf, Wilson, and Bentall, 1944

Plate 9, figures 6-7; Plate 10, figures 1-2

Reinschospora has been observed in relatively few Illinois coal beds. Its vertical geological range has thus far proved limited and it is therefore of importance for correlation studies. Fragments of *Reinschospora* have been isolated from the Willis and Tarter coal beds of lower Tradewater age. Complete specimens have been found irregularly from the Scottville and higher coal beds in the McLeansboro group. Perfect specimens are very rare due to the delicate nature of the flange. *Reinschospora* is never abundant although it averages one specimen per slide in the coal below the New Haven Limestone at the type locality and in a coal bed below this horizon (Ditney coal bed) in the diamond drill core from New Haven. *Reinschospora* appears to have been present in greater abundance in southern and southwestern Illinois than anywhere else in the state, which is in contrast to the distribution of *Alati-sporites*. *Reinschospora bellitas* Bentall is known from the Angle and Battle Creek coal beds of southern Tennessee. Brokaw has recognized the presence of the genus in the McLeansboro group from Illinois.

The following description of the genus *Reinschospora* is based on the two previously described species and three new species described in this report: Spores are radial and trilete, and are subtriangular to triangular in transverse plane excluding the fimbriate flange. This is shortest at the corners of the radii and results in an overall outline which is subspherical in transverse plane. The spines or setae of the flange are either united or separate. In one species the spines are partate and have round knobs at the apex of the spines. Folding of the spore body is rare except for the corners of *R. magnifica* sp. nov. The known size range is from 30 to 85 microns including the flange. The body ornamentation varies from levigate, granulose to punctate. The trilete rays, lips and commissure are usually well marked, and the spore coat is under 3 microns. The affinity of this genus is unknown. There seems little doubt that it is closely related to the spore genus *Granulati-sporites* as pointed out by Schopf, Wilson, and Bentall (1944, page 53). Specimens lacking the flange and therefore referrable to *Granulati-sporites* were recorded by Bentall and the same condition exists in certain Illinois coal beds. Many of these cases have proved, under oil immersion, to be merely *Reinschospora* with the flange removed. However, numerous specimens observed confirm Bentall's findings.

Reinschospora magnifica sp. nov.

Plate 10, figure 2

Description.—Spores are radial, subtriangular in outline exclusive of setae-like flange. The margin between radii is concave, and the corners opposite radii are

broadly rounded. Spore body is flattened to eliptical in lateral profile and the corners frequently folded. Holotype measures 64.2 × 71.5 microns including flange and the known size variance is 60 × 69 to 70 × 78 microns. The spore coat is levigate except when viewed under oil immersion and then it appears finely granulose. The setae which radiate from the proximal side of the spore are separate and distinct and vary in length from 4 microns at the corners to 12 microns midway between the radii. The setae at this point are embedded as much as 12.5 microns into the spore coat and are thus almost 25 microns in their entire length. At the corners opposite the radii the entire length of the setae is 10 microns. Individual seta measure slightly over 1 micron in width and are usually blunt or very slightly tapering at the apex. There are usually more than 50 setae between the extremities of 2 rays of the tetrad scar. Due to the short setae at the corners and longer setae between the radii, the entire outline of the spore is subspherical. The trilete rays extend well over three-fourths the distance the margin of the spore wall and are distinct. Lips are usually poorly developed and commissure sometimes distinct.

Holotype.—Maceration 536-A Slide 1, diamond-drill core (Shoal Creek coal), Franklin County, Illinois.

Discussion. — Without question this species is similar to *R. bellitas* Bentall, 1944. It differs in having shorter setae which are not united and broader corners opposite the radii, which are frequently folded.

Reinschospora triangularis sp. nov.

Plate 9, figures 6-7

Description.—Spores are radial and triangular in outline exclusive of spinate flange. Margin between radii slightly convex, corners opposite radii pointed. Spore body flattened to elliptical in lateral profile and in contrast to *R. magnifica* sp. nov. the corners are rarely folded. Holotype measures 74 × 74 microns and the known size variance is 66 × 66 to 78 × 79 microns. The spore coat is levigate but appears slightly granulose under oil immersion lens. The spines opposite the radii extend 5 to 6 microns beyond the spore wall. The spines midway between the radii, frequently partate with round knobs at the apex up to 12.6 microns long, 1 to 1.5 wide at the base, extend as much as 7.3 microns into the spore coat just above the equator of the spore on the proximal side. The outline of the spore including the flange is subspherical. The trilete rays, lips and commissure are distinct and extend nearly to the margin of the spore wall.

Holotype.—Maceration 573 Slide 2, coal bed 20 feet below Carlinville limestone, No. 8 coal, Macoupin County, Illinois. It is also present in the Ditney coal bed, the New Haven coal bed, and Brokaw observed this species in a coal of the Bogota cyclothem.

Reinschospora punctata sp. nov.

Plate 10, figure 1

Description.—Spores are radial and triangular in outline, exclusive of fimbriate flange. The margin of the spore wall between radii is very slightly concave. The corners opposite radii are pointed and frequently folded to appear round. Holotype measures 67.5 × 67 microns and the known size variance is about plus or minus 7 microns from the holotype. The spore coat is distinctly punctate. The flange originates slightly to the proximal side of the spore equator and is longest between the radii. It is composed of less than 50 fimbriate elements between radii, which appear, in some forms, to be used terminally as well as laterally. The longest fimbriate elements measure 12 microns, opposite the radii 3.5 to 5 microns, and they are embedded into the spore coat only a few microns in contrast to *R. magnifica* sp. and *R. triangularis* sp. nov. The trilete rays extend almost to the spore wall and the lips and commissure are present.

Holotype.—Maceration 572 Slide 4, Upper Scottville coal, Macoupin County, Illinois.

Discussion.—This species is greatly similar to *R. bellitas* Bentall, 1944, but is

readily distinguished from it by the punctate ornamentation of the spore coat.

GENUS Lycospora S. W. and B., 1944

Plate 10, figures 3-7

Lycospora is one of the more important small spore genera in Illinois coal beds. It is known to occur in every coal bed below the Trivoli No. 8 coal bed. The fact that no species of *Lycospora* have been isolated from No. 8 and younger coal beds indicates a major floral change in middle McLeansboro time in Illinois. The elimination of the plants represented by the spores of *Lycospora* is of extreme importance and may indicate either a step of organic evolution owing to changes in environment or to senility. Whatever the cause of the lack of *Lycospora* in upper McLeansboro beds, it is of great value for correlation purposes.

Our knowledge of the spores contained in fructifications of *Lepidostrobus* clearly indicates a close relationship with the isolated spores of *Lycospora*. Therefore, the presence of *Lycospora* is taken to indicate the presence of arborescent lepidodendrids.

The following description of the genus *Lycospora* is based on four previously published species and five new species: Spores are radial, trilete, round to subtriangular in transverse plane, usually greatly compressed with or without folds, and with an equatorial ridge. The known size range is from 18 to 45 microns. The surface ornamentation may be nearly levigate, granulose, punctate to rugose. The trilete rays are distinct and generally extend nearly to or to the margin of the spore coat. Lips may be absent or present, and when present they are usually elevated. The commissure may be thin but is generally distinct. The equatorial ridge is usually fairly well developed and in one species, in which it is greatly developed, it almost reaches flange-like proportions. The spore coat is thin and translucent. Apical papillae are present in *L. brevijuga* sp. nov.

The following are new species:

1. *Lycospora brevijuga*
2. *L. parva*
3. *L. punctata*
4. *L. granulata*
5. *L. pseudoannulata*

Lycospora brevijuga sp. nov.

Plate 10, figure 5

Description.—Spores are radial, trilete, roundly triangular in transverse plane, without folds, and have a definite but small equatorial ridge. The holotype measures 35.7 × 38.8 microns, and the known size range is from 32 to 41 microns. The trilete rays are distinct and extend to the periphery of the spore coat. The lips are small but elevated, and the commissure is distinct and wide. The spore coat is mildly punctate and 2 microns thick, apical papillae present.

Holotype.—Maceration 603-C Slide 7, No. 2 coal bed, Fulton County, Illinois.

Discussion.—*L. brevijuga* sp. nov. is characterized by long rays and a very small equatorial ridge. It may be conspecific with type D_1, Knox (1938, p. 459), if apical papillae are present.

Lycospora parva sp. nov.

Plate 16, figure 5

Description.—Spores are radial, trilete, roundly triangular in transverse plane, and are usually without body folds except at the periphery of the body adjacent to the flange. The flange is similar in construction to that of *L. brevijuga* sp. nov. and is slightly wider. The holotype measures 26.2 × 29.4 microns, and the known size range is from 25.1 to 32.5 microns. The rays are 8 to 10.5 microns long and extend almost to the flange. The lips are elevated and the commissure is thin. The ornamentation of the spore coat is minutely punctate and is discernible only with the proper adjustment of light, substage, and iris diaphragms. The spore coat is 1.5 to 2.25 microns thick.

Holotype.—Maceration 591-B Slide 5, Danville No. 7 coal bed, Vermilion County, Illinois.

Discussion.—This species is obviously closely related to *L. pusillus* (Ibrahim) S.

W. and B., 1944, but is smaller in diameter and has a narrower flange.

Lycospora punctata sp. nov.

Plate 10, figure 3

Description.—Spores are radial, trilete, compressed to a lenticular shape in lateral profile, subtriangular in transverse plane, and have a slightly expanded equatorial ridge. The holotype measures 36.7 × 38 microns, and the known size range is from 30 to 42 microns. The trilete rays are distinct, and extend almost to the equatorial ridge. The ridge is 2 to 3 microns in width. The spore coat is often folded at the juncture of the ridge and the periphery of the spore coat. The lips are elevated and the commissure is thin. The spore coat is punctate and between 1 to 2 microns thick.

Holotype.—Maceration 474-A Slide 4, No. 6 coal bed, Franklin County, Illinois.

Discussion.—*L. punctata* sp. nov. is similar in construction to *L. pseudoannulata* sp. nov. They are separated by body ornamentation.

Lycospora granulata sp. nov.

Plate 10, figures 4, 6

Description.—Spores are radial, trilete, spherical to subtriangular in transverse plane, without folding of the spore coat, and have a small equatorial ridge. Spores are laterally compressed but often not in good proximal-distal orientation. Tetrad groups are frequently found in most macerations. The holotype (figure 6) measures 31.5 × 37.8 microns, and the known size range is from 30 to 41 microns. The trilete rays are distinct with greatly elevated lips and a thin commissure. The rays extend to the margin of the spore wall. The spore coat is coarsely granulose and 2 or more microns thick.

Holotype.—Maceration 519-A Slide 14, Dekoven coal bed, Williamson County, Illinois.

Discussion.—*L. granulata* sp. nov. is characterized by coarse granulations and greatly developed lips.

Lycospora pseudoannulata sp. nov.

Plate 10, figure 7

Description.—Spores are radial, trilete, roundly triangular in transverse plane, have minor folds, and a greatly expanded equatorial ridge appearing to resemble a flange. The holotype measures 39.7 × 42 microns, and the known size range is from 30 to 42 microns. The trilete rays are distinct, the lips are developed and elevated, and the commissure is definite. The spore coat is granulose, and the flange-like equatorial ridge is levigate with numerous small perforations which are best observed when using an oil immersion objective. The spore coat is more than 2 and less than 3 microns thick, and minor folds occur at the juncture of the equatorial ridge and the spore coat.

Holotype.—Maceration 587 Slide 17, Battery Rock coal bed, Hardin County, Illinois.

Discussion.—*L. pseudoannulata* sp. nov. is characterized by its greatly developed equatorial ridge.

GENUS Raistrickia S. W. and B., 1944

Plate 10, figures 8-9; Plate 11, figures 1-8; Plate 12, figure 1

Raistrickia is rarely abundant in Illinois coal beds, but it is important for correlation purposes. Species of the genus are known to be present in all of the coal beds of the Caseyville and Tradewater groups, and in most of the coal beds in the Carbondale and McLeansboro groups. The No. 2 and No. 7 coal beds contain more specimens of *Raistrickia* than any other coal bed in Illinois, though they are not truly abundant even in these two coal beds.

Perfect specimens of *Raistrickia* are rare, due to their ornamentation. The spines or setae are often folded or twisted. However, no trouble has yet been experienced in differentiating species.

Plant microfossils classified under the genus *Raistrickia* are closely related to the spores of *Senftenbergia plumosa,* as pointed out by Schopf, Wilson, and Bentall (1944). It seems reasonable to expect that

at least some of the spores of *Raistrickia* are filicinean in origin and possibly from the family Schizaeaceae.

The following description of the genus *Raistrickia* is based on seven previously published species and nine new species: Spores are radial, trilete, and round to subtriangular in transverse plane. The known size range is from 37 to 90 microns. The ornamentation is usually spinose, setaceous, or coarsely verrucose. The spines or setae vary considerably in length, width, and shape. Further, the apex of the spines or projections of some species are variously partate. The trilete rays may be distinct or inconspicuous, short or long, and the rays and commissure are usually poorly developed. One species may possess an *area contagionis*. The spore coat varies in thickness from two to six microns.

The following are new species from Illinois coal beds:

1. *Raistrickia aculeata*
2. *R. protensa*
3. *R. crinita*
4. *R. crocea*
5. *R. imbricata*
6. *R. irregularis*
7. *R. pilosa*
8. *R. prisca*
9. *R. rubida*

Raistrickia aculeata sp. nov.

Plate 10, figure 9

Description.—Spores are radial, trilete, originally spherical, and with numerous long, slightly tapering blunt spines. The dimensions of the holotype spore body are 65.1 × 69.3 microns and the known size range is from 62 to 74 microns. The trilete rays are inconspicuous owing to numerous spines. The rays range in length from 19 to 23 microns. The lips and commissure are poorly developed. The spore coat varies in thickness from 2 to 2.5 microns. The spines are numerous and closely spaced. They vary in length from 7.3 to 10.5 microns and in width from 2 to 2.7 microns. Minor folding of the spore is a common feature.

Holotype.—Maceration 490-A Slide 5, McCleary's Bluff coal bed (3½ inches) Wabash County, Illinois.

Discussion.—*R. aculeata* sp. nov. is characterized by numerous long, narrow, tapering, blunt spines.

Raistrickia protensa sp. nov.

Plate 11, figures 1-3

Description.—Spores are radial, trilete, round in transverse plane, and have characteristic club-shaped, partate projections. The spore coat occasionally has minor folds and the projections are frequently folded or twisted. The dimensions of the holotype spore body are 58.8 × 60.9 microns, and the known size range is from 54.5 to 63.8 microns. The trilete rays are definite and those of the holotype vary in length from 18.5 to 22. The lips are thin and poorly developed. The commissure is either narrow or wide. The spore coat is usually more than 2 and less than 3 microns thick. The club-like projections, when viewed in a median transverse plane, have one major division, each division minutely divided, resulting in as many as 5 divisions and 6 papillate knobs. The club-like projections vary in length from 12.5 to 17.9 microns. In width the projections are narrowest at their base and vary from 4 to 7 microns, and at the apex of those in true median section, from 12 to 14.7 microns. Irregularities in the shape of the projections is thought to be due to folding, preservation, or overmaceration.

Holotype.—Maceration 474-A Slide 8, No. 6 coal bed, Franklin County, Illinois.

Discussion.—Partate spines or projections within the genus *Raistrickia* are thought to indicate a rather close relationship between species sharing this unique feature.

Raistrickia crinita sp. nov.

Plate 11, figure 7

Description.—Spores are radial, trilete, roundly triangular in transverse plane, and have numerous blunt to tapering spines. The holotype spore body dimensions are 61.9 × 58.3 microns, and the known size

range is from 54 to 67 microns. The trilete rays are very long, at least three-fourths of the distance to the margin of the spore wall. The lips are poorly developed. Many specimens are torn along the rays and are variously folded. Compressed forms rarely show good proximal-distal orientation. The many spines are often wider midway from their base to the apex. Although they taper toward the apex, they are not sharply pointed. The spines are numerous, closely spaced, and range in length from 7.7 to 9.5 microns. The maximum width at their thickest portion does not exceed 4 microns. The spore coat ranges in thickness from more than 2 microns to less than 3.5 microns.

Holotype.—Maceration 544 Slide 9, No. 7 coal bed, Fulton County, Illinois.

Discussion.—*R. crinita* sp. nov. is characterized by long rays roundly triangular in transverse plane, and numerous closely spaced spines which taper to a blunt point.

Raistrickia crocea sp. nov.

Plate 11, figure 6

Description.—Spores are radial, trilete, round in transverse plane, and have scattered ribbon-like projections which are minutely partate at the apex. The holotype spore body dimensions are 69.3 × 73.5 and the known size range is from 63 to 77 microns. The trilete rays are not usually sharply defined, and the rays average about 23 microns in length. The lips and commissure are thin and not greatly developed. The ribbon-like projections are 11.5 × 15.7 microns in length and from 7.3 to 9.4 microns in width. The projections are flattened, and occasionally twisted. The apex of each projection is partate, giving rise to as many as 6 spines measuring slightly over a micron in length and about half a micron in width. The spore coat is thin, yellow, usually not more than 2 microns thick, and it is frequently folded parallel to the periphery of the spore coat.

Holotype.—Maceration 603-C Slide 1, No. 2 coal bed, Fulton County, Illinois.

Discussion.—*R. crocea* sp. nov. is related to the other partate spine species of *Raistrickia.* The spines differ from those of the other species in that they are ribbon-like in appearance.

Raistrickia imbricata sp. nov.

Plate 11, figure 8

Description.—Spores are radial, trilete, roundly triangular to oval in transverse plane, and have numerous imbricating bluntly pointed spines. The overall dimensions of the holotype are 56.7 × 67.2, and the known size range is from 54.1 to 68.3 microns. The trilete rays are distinct even though occasional spines overlap the rays. The rays of the holotype vary in length from 13 to 18 microns. The lips are clearly visible and slightly elevated. The commissure is usually thin but definite. The spore coat is densely covered with many bluntly pointed spines which vary in length from 3 to 6.5 microns and in width from 2 to 4.2 microns. The spore coat is 2 to 3 microns thick, rarely folded although the spines are frequently folded.

Holotype.—Maceration 500-D Slide 3, No. 6 coal bed, Wabash County, Illinois.

Discussion.—*R. imbricata* sp. nov. is characterized by numerous bluntly pointed spines.

Raistrickia irregularis sp. nov.

Plate 11, figure 5

Description.—Spores are radial, trilete, subtriangular in transverse plane, and have blunt spines which appear to be somewhat irregular in width. The holotype overall dimensions are 71.4 × 71.4 microns, and the known size range is from 66 to 77 microns. The trilete rays are distinct and long, measuring from 21 to 28 microns in length. The lips are moderately thick and elevated. The commissure is usually clearly demarcated. The blunt spines vary in length from 4.4 to 7.2 microns and in width from 3.1 to 10.5 microns. The spore coat varies in thickness from 3 to 4 microns.

Holotype.—Maceration 603-B Slide 6, No. 2 coal bed, Fulton County, Illinois.

Discussion.—*R. irregularis* sp. nov. is characterized by long rays, and blunt spines

which appear to vary considerably in width. It is possible that the spines are of variable width because originally they were somewhat lenticular in cross-section rather than round. Thus in optical vision of an isolated spore, the spines on the flattened lenticular side will be wide while an end view of the same spine will be narrow.

Raistrickia pilosa sp. nov.

Plate 11, figure 4

Description.—Spores are radial, trilete, round to roundly triangular in transverse plane, with long spines, and a relatively small spore body. The spore body of the holotype measures 39.9 × 40.3 microns, and the known size range is from 37 to 43 microns. The trilete rays are long but generally inconspicuous due to the spines. The lips and commissure are poorly developed. The spines average in length about one-fourth the diameter of the spore body (10.5 × 12.6 microns) and in width the spines measure from 2 to 3 microns. The spore coat averages 2 microns in thickness.

Holotype.—Maceration 544 Slide 2, No. 7 coal bed, Fulton County, Illinois.

Discussion.—*R. pilosa* sp. nov. is characterized by a small spore body, long narrow spines, and long trilete rays.

Raistrickia prisca sp. nov.

Plate 10, figure 8

Description.—Spores are radial, trilete, roundly triangular in transverse plane, and have numerous blunt spines. The overall dimensions of the holotype are 52.5 × 54.6 microns, and the known size range is from 48 to 57.8 microns. The trilete rays range in length from 14 to 20 microns. The lips are distinct although thin and somewhat elevated, and the commissure is definite. An area adjacent to the rays on the proximal surface has numerous dot-like thickenings which may be an *area contagionis*. The spore coat, on the proximal and distal surfaces, is covered with many spine-like projections which range in length from 2 to more than 6 microns and up to 4.2 microns in width. The spore coat ranges in thickness from 2 to more than 3 microns.

Holotype.—Maceration 609 Slide 1, Wayside coal bed, Johnson County, Illinois.

Discussion.—*R. prisca* sp. nov. is closely related to *R. grovensis* Schopf, 1944. It differs from *R. grovensis* by the presence of a thickened area *(area contagionis?),* elevated lips, and is somewhat larger in size.

Raistrickia rubida sp. nov.

Plate 12, figure 1

Description.—Spores are radial, trilete, roundly triangular in transverse plane, and have short blunt projections. The overall dimensions of the holotype are 65.1 × 65.1 microns, and the known size range is from 61 to 69 microns. The trilete rays vary in length from 12.6 to 18 microns. The lips are absent or poorly developed and the commissure is frequently wide. The short blunt projections vary in width from 3.5 to 6 microns and in length from 3.1 to 5.2 microns. The spore coat is unusually thick, measuring 4.2 to 5.8 microns, and of a brownish color. Folding of the spore coat is unknown.

Holotype.—Maceration 574 Slide 19, Shoal Creek coal bed, Bond County, Illinois.

Discussion.—*R. rubida* sp. nov. is characterized by a thick spore coat, and short thick blunt projections. This species is similar to and may be conspecific with type D_6, Knox (1938, p. 459).

Genus Florinites S. W. and B., 1944

Plate 12, figures 2-8

The genus *Florinites* is represented in all of the Pennsylvanian groups in Illinois. It was most abundant during upper Tradewater and lower Carbondale time, that is from No. 1 coal bed through No. 2 coal bed. A period of limited abundance has been noted in middle McLeansboro time, No. 8 coal bed.

Florinites appears to have considerable value for correlative purposes, though it is known that additional species and possibly a genus remains to be described. Additional

information is needed before this important descriptive work can be undertaken.

There appears to be little doubt that *Florinites* is of gymnospermic origin. However, Hoskins and Cross (1946) report the presence of abundant pollen grains of the *Florinites* type in the pollen chamber of *Pachytesta vera*. Florin (1944) illustrates the pollen grains of *Lebachia piniformis, L. hypnoides, Ernestiodendron filiciforme, Walchianthus crassus, W. cylindraccus, Ullmannia frumentaria,* and *U. Bronnii*. There certainly exists a similarity between *Lebachia* and *Ernestiodendron* with *Florinites*.

The following description of the genus *Florinites* is based on three previously published species and three new species here described: Pollen grains appearing bilateral, in part possibly derived from tetrahedral tetrads. Grains are usually broadly elliptical in outline owing to bladder; body spherical, enclosed by the bladder except for a portion of the distal side. The body is often sharply folded. The known size range, length including bladders, is from 50 to 210 microns. The body of the grain is levigate, granulose, or faintly punctate. The external bladder ornamentation is levigate to granulose, but internally the bladder is reticulate. The trilete mark may be absent, faintly present, or distinct. The spore coat of the body is generally less than 3 microns thick and the bladder usually less than 2 microns in thickness.

The following are new species of the genus *Florinites:*

1. *Florinites diversiformis*
2. *F. similis*
3. *F. triletus*

Florinites diversiformis sp. nov.

Plate 12, figure 5

Description.—Pollen grains are bilateral with a vestigial tetrad mark. They are elliptical in transverse plane, including bladders. The body was originally spherical so that when compressed it forms folds at right angles to the long axis of the grains. The folds occur on the distal side at the terminus of the bladder on the body. The holotype measures 94.5 × 134.4 microns, and the known size range is from 91 to 98 microns in width, and from 126 to 139 microns in length. The body of the holotype measures 75.6 microns in width, and 65 microns in length. A trace or vestigial remnant of the tetrad mark is generally discernible. The body of the grain is dark yellow to light brown in color in contrast to the pale yellow bladder. The body is levigate, the external portion of the bladder is levigate, but reticulate internally. The internal bladder reticulations are small, measuring 1 to 1.75 microns in diameter. The bladder overlaps the body on the distal surface in a crescent pattern on either side of the spore body in the long axis from 13 to 15 microns at the maximum. The body of the grain is 2 to 2.5 microns thick, and the bladder is 1.5 to 2 microns thick.

Holotype.—Maceration 618 Slide 2, Reynoldsburg coal bed, Johnson County, Illinois.

Discussion.—*F. diversiformis* sp. nov. is characterized by a vestigial tetrad mark, the extension of the bladder of the grain somewhat on the distal surface, and a distinct body.

Florinites similis sp. nov.

Plate 12, figure 2

Description.—Pollen grains are bilateral, apparently alete, and elongate elliptical in transverse plane including bladder. The body was originally spherical but due to compression the body is sharply folded. The holotype overall dimensions are 92.4 × 132.7 microns, and the known size range is from 88 to 97 microns in width and 124 to 142 microns in length. The body of the holotype measures 63 × 75.6 microns. The body of the grain is minutely granulose, and the bladder is levigate externally, reticulate internally. The internal bladder reticulations range in diameter from 1 to 3 microns. The spore coat of the body is less than 2 microns in thickness, and the bladder ranges in thickness from less than 1 micron to 2 microns where thickened by reticulations. The bladder is sometimes folded or torn.

Holotype.—Maceration 542-C Slide 2, No. 8 coal bed, Peoria County, Illinois.

Discussion.—*F. similis* is intermediate in size between the smaller *F. antiquus* Schopf, and *F. elegans* Wilson and Kosanke, 1944, which is considerably larger. It is similar in shape and construction to *F. elegans*.

Florinites triletus sp. nov.

Plate 12, figures 3-4

Description.—Pollen grains are bilateral, trilete, and elliptical in transverse plane including bladder. The body was originally spherical and folded around its periphery. The holotype overall dimensions are 52.9 × 65.1 and the known size range is from 49 to 69 microns. The body of the holotype measures 33.6 × 27.3 microns and the known size range is from 25 to 36 microns. Trilete rays are distinct on the proximal surface of the body and average about 8.4 microns in length. Lips are indistinct or absent, and the suture 1 to 1.5 microns in width. The body of the grain is minutely punctate, and the bladder is levigate externally and finely reticulate internally. The body of the grain is 1 to 2 microns thick, and the bladder is variously thickened due to reticulations, but even so it does not exceed 1 to 1.5 microns.

Holotype.—Maceration 574 Slide 3, Shoal Creek coal bed, Bond County, Illinois.

Discussion.—*Florinites triletus* sp. nov. is provisionally classified under *Florinites*. The presence of a definite trilete mark is contrary to the original description of the genus by Schopf, Wilson, and Bentall (1944). Only a limited number of specimens were found and it is expected that eventually a final decision can be made as to the proper taxonomic treatment of this form.

GENUS Cadiospora gen. nov.

Plate 16, figure 1

The generic name *Cadiospora* is proposed for spores of the following character: Spores are radial, trilete, originally spherical or slightly pyramidal on the proximal surface, usually flattened in fairly good proximal-distal orientation, and have strongly developed arcuate ridges. The lips are thick and prominent on all specimens. The known size range is from 105 to 111.3 by 100 to 117.6 microns, based on measurements of 25 specimens. The trilete rays range in length from 39 to 46.2 microns when not shortened by folding or twisting. The lips range in thickness from 3 to 5 microns on either side of the suture. The spore coat ranges in thickness from 6 to 8 microns.

The characters mentioned above strongly suggest a relationship with the megaspore genus *Triletes* (Reinsch) Schopf as illustrated by Schopf (1938) except that the new genus is at least 180 microns smaller than any known species of *Triletes*. Further, the lips of *Cadiospora* gen. nov. display the largest development of that structure known to spores of a comparable size. This new genus may represent a megaspore of unusually small size, in line with the views of Thompson (1927).

Regardless of the type of spore represented, its vertical distribution in Illinois is limited to the upper McLeansboro group, and therefore it is of importance in correlation studies.

Cadiospora magna sp. nov.

Plate 16, figure 1

Description.—The genotype measures 117.6 × 111.3 microns, as oriented in plate 16, figure 1. The trilete rays vary in length from 40 to 44 microns. The suture is distinct and the lips vary in thickness from 4 to 5 microns on either side of the suture. The lips appear to continue as thickenings in association with the arcuate ridge. The apex of the rays (trilete aperture) is open or closed. The rays divide at the terminus of the rays and interradially become the arcuate ridge. The spore coat is minutely punctate to finely granulose, and measures 6 to 8 microns in thickness. Frequently small fragments of unmacerated coal appear to cling to the spore coat.

Genotype.—Maceration 600 Slide 15,

La Salle coal bed, Bureau County, Illinois.

Discussion.—This species in overall appearance resembles the megaspore species *Triletes fulgens* Zerndt, 1937; however, it is less than one third the minimum size range of Zerndt's species, and it has a relatively thin wall for a megaspore. Also Zerndt's illustration (1937) lacks the lip development so characteristic of *Cadiospora magna* sp. nov.

GENUS ILLINITES gen. nov.

Plate 1, figures 1-4

The generic name *Illinites* is here proposed for prepollens of the following character: Grains have radial body symmetry, and an overall shape which viewed proximally or distally is oval to elliptical owing to two oppositely placed bladders. Trilete mark is distinct and is on the proximal surface, which appears to lack a clearly defined cap or exine. The trilete mark is functional and not vestigial. The bladders are not inclined distally as in *Pityosporites* or modern pollen, and are as wide as or wider than the body. A false furrow or sulcus is the result of the bladder's overlapping the body of the grain. The known size range in the longest diameter is 56 to 70 microns. The known body ornamentation is levigate or granulose and the bladders are levigate externally and coarsely punctate to reticulate internally. The prepollens are probably of gymnospermic origin.

Gymnospermic prepollens with functional triradiate apertures represent a transitional stage between the trilete vascular spores and pollen tube development in modern conifer pollen. For this reason, and because the bladders do not appear to be inclined distally and lack furrows, a new genus is established. In an earlier publication, Kosanke (1947) considered the pollen in question to be members of the genus *Pityosporites,* which now seems unappropriate. The early pollens present in Pennsylvanian deposits may prove of great help in understanding climatic conditions. Although they do not appear in abundance, they should receive proper taxonomic treatment.

Pityosporites has been considered indicative of xerophytic upland flora. The similarity of *Pityosporites* and *Illinites* suggests that the latter may be associated with xerophytic climatic conditions. If so, the geographic location of uplands in or adjacent to Illinois presents a problem. Pennsylvanian uplands in this area are thought to have existed in the Ozarks and Kansas. The winged nature of *Illinites* gen. nov. is an adaptation for wind dispersal, and since the genus is rarely present, it is suggested that its origin may have been somewhat removed from the place of deposition.

ILLINITES UNICUS sp. nov.

Plate 1, figures 3-4

Description.—The body of the grain has a triradial symmetry which appears bilateral because of two bladders arranged opposite each other. The grains are compressed and oval-shaped as viewed from either proximal or distal side. The body is round to oval, being oval at right angles to the transverse plane. The bladders almost encircle the body but are not much broader than the body in a transverse plane. The genotype (in the longest diameter) measures 63 microns, and at right angles to this measurement, 42 microns. The body measures 32.5 $\times$ 42 microns, and the bladders overlap all but 16.8 microns of the body at the center of the proximal and distal sides. The known size variance in the longest diameter is 56 to 70 microns. The body of the grain is finely granulose, and the bladders are levigate externally and the internal bladder ornamentation is finely reticulate. The trilete mark is distinct, and the rays measure 10 to 12 microns in length. The pollen coat is less than 2 microns thick, and the bladders are thin except where thickened by internal reticulations. There seems little doubt but that this species is related to the coniferous pollen.

Genotype.—Maceration 494 Slide 15, 10-inch coal bed exposed in Coffee Creek, Wabash County, Illinois. This horizon

may be above the Shoal Creek coal bed of western Illinois which also contains this species.

Discussion.—This species is characterized by a distinct trilete mark, two bladders, and the lack of a clearly defined cap and furrow. This species is similar to *Parasporites maccabei* Schopf, 1938, even to the shortening of one ray, but it is about one-fourth the size and shaped differently.

Illinites elegans sp. nov.

Plate 1, figures 1-2

Description.—The grains have an ellipsoid shaped body in transverse section, and two large bladders placed opposite each other. The grains are compressed in excellent proximal-distal orientation which results in a certain amount of folding and overlapping of the bladders. The bladders nearly surround the body and are somewhat wider than the body, which may be due to compression. The holotype measures 51.4 × 63 microns in the overall dimensions and the body measures 29.4 × 46.2 microns. The bladders overlap the body except for 6 to 7 microns in the center of the proximal-distal surfaces. The known size range in the largest diameter is from 56 to 67 microns. The body is levigate, externally the bladders are levigate, and the internal bladder ornamentation is coarsely punctate to finely reticulate. The trilete mark is distinct and presumed to be functional. The rays average 12 microns in length. The coat is at least 2 microns thick and the bladders are 1.5 to more than 2 microns thick.

Holotype.—Maceration 490-A Slide 5, McCleary's Bluff coal bed (3½ inches), Wabash County, Illinois.

Discussion.—This species shares the distinctive trilete mark with the previous species in addition to the wings; however, the bladders overlap the body to a greater extent. The bladders are larger and the body is shaped differently.

GENUS Schopfites gen. nov.

Plate 13, figures 1-4

The generic name *Schopfites* is proposed for spores of the following character: Spores are radial, trilete, originally spherical, and flattened owing to compression in poor proximal-distal orientation. *Schopfites* ranges in diameter from 78 to 115 microns. The proximal surface is distinctly levigate for approximately four-fifths of the area. In some specimens the entire proximal surface is levigate. The distal surface of the spore is ornamented by a mass of closely spaced, imbricating, blunt to round projections. The projections range in length from 2 to 12 microns. The spore coat is up to 3 microns thick on the proximal side, and thickens to 4 microns at the juncture of the two types of ornamentation. It is rather difficult to measure accurately the distal thickness of the spore coat because of the ornamentation. Folding of the spore coat is rare except on the thinner proximal surface. The trilete mark is plainly visible and in one species it is frequently broken open. The lips and commissure may be developed or rather thin.

The origin of the distal portion of the spore coat can hardly be haptotypic in view of the definition of this term by Wodehouse (1935). It is possible that the levigate portion of the spore coat might be due to the contact with its other members of the tetrad, and thus haptotypic in origin.

Schopfites is commonly found in the No. 2 coal bed in Illinois, and is characteristically restricted to the lower portion of the bed. A similar distribution has been noted from one maceration from Ohio. The spores from the Ohio coal beds are not well enough known to make a long range correlation on the basis of one maceration.

The following two species are from Illinois coal beds and the first serves as the genotype:

1. *S. dimorphus* sp. nov.
2. *S. colchesterensis* sp. nov.

Schopfites dimorphus sp. nov.

Plate 13, figures 1-3

Description.—Spores are radial, trilete, spherical, and somewhat flattened in poor proximal-distal orientation. The spores

vary in size from 78 to 115 microns. The proximal surface is distinctly levigate for approximately four-fifths of the area. The distal surface is covered with a mass of imbricating, blunt to round projections. This dimorphic type of spore coat readily assures rapid identification of the genus. The projections of the distal surface range in length from 3 to 12 microns, and in width from 3 to 15 microns. The proximal surface of the spore coat is usually at least 3 microns thick, and thickens toward the juncture of the two types of ornamentation. The distal surface is at least 4 microns thick, but may be more since it is difficult to measure the exact thickness due to the ornamentation. The trilete mark is plainly visible and the rays range in length from 30 to 35 microns. The lips are only slightly developed.

Genotype.—Maceration 537-L_3 Slide 5, No. 2 coal bed, Franklin County, Illinois.

Discussion.—*Schopfites dimorphus* sp. nov. has proved a good guide fossil for the Illinois No. 2 coal bed. It is readily identified and is usually abundant enough to have value for correlative purposes.

Schopfites colchesterensis sp. nov.

Plate 13, figure 4

Description.—Spores are radial, trilete, originally spherical to ovoid in outline, and are usually flattened in poor proximal-distal orientation. The holotype dimensions are 78.1 × 90.3 microns. The proximal surface is essentially levigate while the distal area is covered with blunt projections. The juncture of the two types of ornamentation is somewhat irregular, and frequently some projections extend well onto the proximal surface. The projections are variable in width and shape. They range in width from 2 to 12 microns, and in length from 2 to 4 microns. The spore coat is 3 microns thick on the proximal surface and thickens distally to 4+ microns on the distal surface, exclusive of the projections. The trilete mark is distinct and from 18 to 20 microns in length. The spore coat is frequently broken along the suture line. The lips are mildly elevated.

Holotype.—Maceration 603-C Slide 7, No. 2 coal bed, Fulton County, Illinois.

Discussion.—*S. colchesterensis* sp. nov. is smaller in size than *S. dimorphus* sp. nov., the distal projections are shorter, and not as closely spaced.

Genus Schulzospora gen. nov.

Plate 13, figures 5-6

The generic name *Schulzospora* is proposed for spores of the following character: Spores are radial and appear bilateral owing to the presence of an elliptical bladder. Spores are distinctly trilete and the body is spherical and greatly compressed in good proximal-distal orientation. The spores range in size from 67 to 83 microns in width and from 90 to 112 microns in length. The body ranges from 60 to 75 microns in diameter. The mode of attachment of the bladder to the body is a somewhat perplexing problem because the ornamentation of the body and bladder are identical. On the basis of 19 isolated specimens available for study it is thought that the bladder completely surrounds the body of the spore, a condition difficult to visualize. In shape *Schulzospora* closely resembles *Florinites,* but differs in the attachment of the bladder to the body. *Schulzospora* is generally distinct from present recognized genera.

Although *Schulzospora* is not abundant, it is useful in the correlation of the Battery Rock coal bed, because in Illinois it appears to be restricted to this coal bed. The description is given in the hope that additional information from other spore studies might help clarify the actual type of attachment of the bladder to the body of the spore. The affinity is unknown, possibly gymnospermic.

The following species serves as the genotype.

Schulzospora rara sp. nov.

Plate 13, figures 5-8

Description.—Spores are radial, trilete, and elliptical in transverse plane including

bladder. The body is spherical, and folding of bladder and body is rather common. The holotype dimensions are 81.9 × 109.2 microns, and the known range in the largest diameter is from 80 to 112 microns. The body dimensions of the holotype are 73.5 × 73.5 microns and the known range is from 60 to 75 microns. The bladder and body both appear to be finely punctate. The trilete rays are usually at least 20 microns in length. The lips are poorly developed, and the suture is generally well marked. The spore coat is frequently broken open along the suture lines. The spore coat and bladder appear to be thin, not exceeding 2 microns.

Genotype.—Maceration 587 Slide 8, Battery Rock coal bed, Hardin County, Illinois.

Discussion.—*S. rara* sp. nov. is a rare but rather important floral member of the Battery Rock coal bed. Additional specimens for the study of this genus might be found in the Main Nolin coal bed of western Kentucky if chart No. 6 of the subcommittee on Pennsylvanian correlations is correct.

GENUS Wilsonia gen. nov.

Plate 14, figures 1-4

The generic name *Wilsonia* is proposed for prepollens of the following character: Grains are radial, trilete, and body and bladder are round in transverse plane. They are usually flattened in good proximal-distal orientation. Folding of the bladder is common and folding of the body occasionally occurs. The known size range is from 69 to 98 microns including the bladder. The bladder covers all of the distal portion of the body. The proximal portion of the body is either completely covered by the bladder or largely covered by it. *Wilsonia* is related to *Endosporites* differing in that the body is indistinct as shown by examination of plate 14, figure 1. Contrast this indistinct body with *Endosporites* plate 7, figures 7 to 9. Internal bladder reticulation appears to be a common feature of conifer pollen grains. There appears to be a slight peripheral bladder thickening in *Wilsonia delicatus* sp. nov. which may or may not be due to the internal bladder ornamentation. The rays extend at least three-fourths the distance to the body margin, the lips are elevated, and the commissure is usually thin. The body wall is 2 to 3 microns thick, and the bladder ranges in thickness from 1.5 to 2.2 microns.

Wilsonia has been isolated from coal beds in Illinois, Iowa, and Ohio. It occurs in the No. 6 and LaSalle and other coal beds in Illinois, but is not numerically abundant.

The following new species are from Illinois coal beds and the first described served as the genotype.

Wilsonia vesicatus sp. nov.

Plate 14, figures 1-3

Description.—Grains are radial, trilete, and round in transverse plane including bladder, which covers the body distally and proximally. Folding of bladder and body is usually adjacent to the rays. The overall dimensions are 79.8 × 75.6 microns and the body measures 52.5 × 46.2 microns. The known overall size range is from 69 to 81 microns, and the known size range of the body is from 42 to 54.5 microns. The trilete mark is distinct and the rays extend to the margin of the body wall. Folding of the bladder membrane makes the rays appear to extend beyond the body. Suture thin, lips elevated and prominent. Bladder levigate externally, reticulate internally. Body apparently essentially levigate to granulose. The body wall is 2 to 2.5 microns thick and the bladder 1.5 to 2 microns thick.

Genotype.—Maceration 600 Slide 2, LaSalle coal bed, Bureau County, Illinois.

Discussion.—*Wilsonia vesicatus* sp. nov. is thought to be of gymnospermic origin, since the bladder in many respects resembles certain coniferous pollen described by Florin (1944).

Wilsonia delicata sp. nov.

Plate 14, figure 4

Description.—The grains are radial, trilete, and round in transverse plane in-

cluding the bladder which covers the distal and a large portion of the proximal surface of the body. The body is spherical, and folding of the bladder membrane and body is common. The overall dimensions of the holotype are 92.4 × 86.1 microns; the body dimensions are 56.7 × 52.5 microns. The known overall size range is from 81 to 98 microns, and that of the body is from 52 to 61 microns. The trilete rays are distinct, and extend nearly to the margin of the body wall. The lips are greatly elevated, and the suture is very thin. The bladder externally is essentially levigate, and internally it is distinctly reticulate. The body is levigate to minutely granulose. The bladder appears to be somewhat thickened at the periphery of the bladder. The body is 2 to 3 microns thick, the bladder is 1.5 to 2.25 microns thick.

Holotype.—Maceration 540-C Slide 8, No. 6 coal bed, Fulton County, Illinois.

Discussion.—*Wilsonia delicata* sp. nov. differs from *W. universica* sp. nov. in being larger in size, having somewhat shorter rays, and in having less of the proximal side of the body covered by the bladder.

LOCATIONS OF COAL SAMPLES

Figure 5 indicates the 47 counties in Illinois from which samples of coal beds have been collected and macerated. Geographic locations are listed by county and maceration number. Rotary and diamond-drill holes usually contained several coal bed samples listed as A, B, C, etc. and the names of these coal beds are not given.

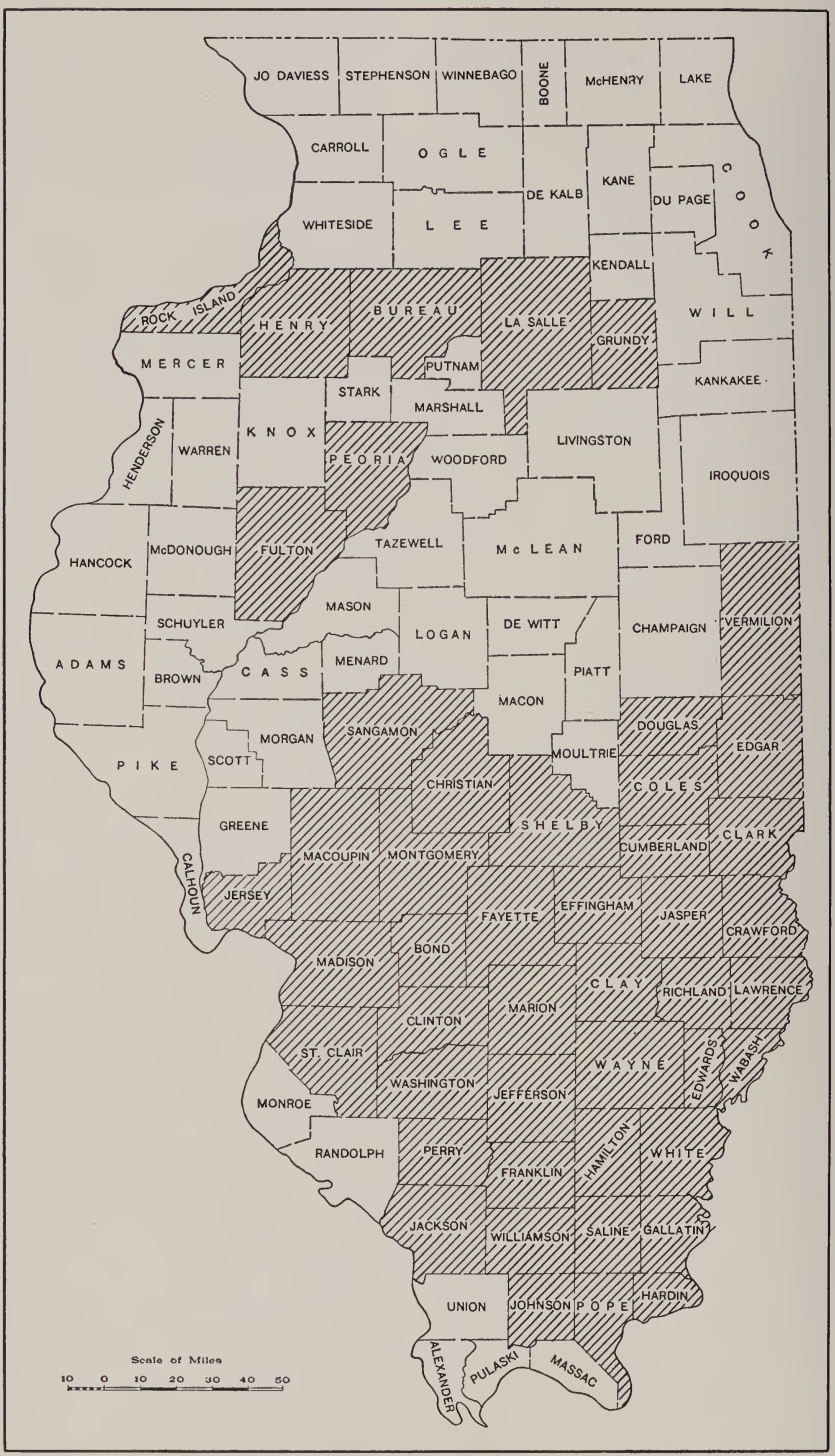

FIG. 5.—Illinois counties from which coal samples were collected.

Geographic Locations

County	Maceration Number	Type[a]	Coal	Location					
				Quarter Sec.			Sec.	T.	R.
Bond	561	DD		NW	NE	NE	17	6N	3W
	574	OU	Shoal Creek	SE	SW	SE	28	4N	4W
Bureau	579 A-C	SU	No. 2			NW	33	16N	11E
	600	OU	LaSalle	SE	SW	NW	33	16N	11E
Christian	670 A-C	DD	No. 6	NE	NE	NE	12	12N	3W
Clark	601	OU	"Merom SS."		NE	SW	2	11N	12W
Clay	563 A-C	TD		NE	SE	NW	23	5N	5E
	564 A-D	TD		SW	SW	SW	14	5N	5E
	569 A-D	TD		SE	SE	SE	10	4N	5E
Clinton	689	OU	Shoal Creek			SW	2	3N	4W
Coles	641 A-D	TD		NE	SE	NW	25	12N	7E
	666 A-G	TD		NE	SW	SE	10	13N	7E
	669 A-O	TD		NW	SW	SE	10	11N	7E
Crawford	485 A-E	TD		NEc	SW	SW	15	5N	11W
Cumberland	484 A-M	TD		SE	NE	SW	8	9N	9E
Douglas	586 A-D	DD		NE	NE	SE	27	16N	10E
Edgar	610	OU	Broulette (?)			NW	28	14N	10W
	612 A-C	OU	Flannigan (?)		NW	NE	2	14N	11W
	695 A-H	DD		SW	SW	SE	32	16N	12W
Edwards	471 A-E	TD		NE	NE	NE	17	3S	14W
	620 A-B	TD		SW	SE	SW	20	2S	14W
	621 A-D	TD		NW	NE	SE	18	1N	10E
	622 A-C	TD		NW	NW	SW	28	1S	14W
Effingham	605	OU	Watson			SW	1	6N	5E
Fayette	473 A-F	TD		SW	SW	NE	29	5N	3E
	510	TD		NW	NW	NE	23	9N	1E
	512 A-B	TD		NW	SE	NE	22	8N	3E
Franklin	474 A-D	TD		NE	NW	SW	21	7S	3E
	507 A-B	DD	5-A	NE	SW	SE	1	5S	2E
	522 A-F	DD	Cutler	SE	SE	SW	2	5S	2E
	533 A-C	DD		SE	NW	NE	16	6S	1E
	534 A-D	DD		SE	NW	NE	16	6S	1E
	535	DD	Davis	SE	NW	NE	16	6S	1E
	536 A-F	DD		SE	NW	NE	16	6S	1E
	537 A-R	DD		SE	NW	SE	27	6S	2E
	545 A-E	DD			SW	NE	29	7S	3E
	546 A-J	DD		NE	NE	NE	30	6S	3E
	548 A-H	DD		SE	NW	NE	16	6S	1E
	551 A-H	DD		SE	NE	NE	14	5S	2E
	553 A-F	DD			SW	NW	6	7S	3E
	554 A-H	DD		SE	NE	NE	18	5S	2E
	555	DD	Jamestown	SW	NW	NE	16	6S	1E
	556 A-B	DD		NW	SE	SW	10	6S	1E
	585 A-C	DD	No. 6	SW	NE	SW	3	6S	1E
	593 A-C	SU	No. 6	NE	NE	NE	25	7S	2E
	594 A-C	TD		NW	SE	NW	1	6S	2E
	693 A-G	DD		NE	SW	SE	18	7S	4E
	698 A-C	TD		NW	NW	SW	5	5S	3E
Fulton	144	OU	"Sub-Babylon"	NE	NE	SE	2	5N	1E
	523 A-B	OU	Babylon	NW	NE	NE	14	7N	1E
	524 A-F	OU	No. 6	SE	NE	NE	1	7N	4E
	525 A-B	OU	Wiley	NE	NW	NE	16	4N	3E
	527 A-B	OU	Upper Delong	NE	NW	SW	19	5N	2E
	528 A-B	OU	Rock Island		SW	SW	23	6N	1E
	540 A-C	OU	No. 6	SE	NE	NE	1	7N	4E
	541	OU	No. 4		NW	NE	3	3N	2E
	543 A-D	OU	No. 5		NW	NE	3	3N	2E
	588	OU	Babylon	NW	NE	NE	14	7N	1E
	592	OU	Greenbush	SE	NW	NE	21	6N	1E
	599 A-B	OU	Rock Island		SW	SW	23	6N	1E
	602	OU	Pope Creek	SE	SW	SE	11	7N	1E
	603 A-C	OU	No. 2	NE	NW	NE	16	4N	3E
	604 A-B	OU	Tarter	NW	NW	SE	19	5N	2E

GEOGRAPHIC LOCATIONS—(Continued)

County	Maceration Number	Type[a]	Coal	Location					
				Quarter Sec.			Sec.	T.	R.
Gallatin	570	TD		NE	SE	NW	11	8S	10E
	576	OU	New Haven	NE	NE	NW	19	7S	10E
	624	OU	Willis		NE	SW	30	10S	9E
	625 A-B	SM	Willis		NW	SE	30	10S	9E
	633 A-B	OU	5-A	SE	SW	SE	17	9S	8E
Grundy	580	ST	No. 2				12	33N	8E
	611	ST	No. 2		SE	SE	9	33N	8E
Hamilton	472 A-E	TD		NE	NE	SE	1	4S	5E
	581	TD		SW	NE	SW	19	5S	5E
	582	TD		NE	NW	NE	15	5S	7E
Hardin	587	MD	Battery Rock				27	11S	10E
Henry	589	SU	Rock Island	NE	NW	SE	3	16N	1E
	626	SU	Rock Island		NE	NE	33	14N	1E
Jackson	549	MD	Murphysboro		NW	NW	36	7S	4W
	550	MD	Murphysboro			NW	30	7S	2W
	608	OU	Murphysboro	SW	NE	SE	21	7S	3W
Jasper	584	OU	Woodbury			SW	31	8N	9E
	613	OU	Gila (?)	SW	SW	SW	29	8N	8E
	614	OU	Gila (?)	SW	SW	SW	29	8N	8E
	615	OU	Gila (?)	NE	NE	SW	28	8N	8E
	616	OU	Gila (?)	NE	NE	SW	28	8N	8E
Jefferson	479 A-F	TD		SE	NW	NE	36	4S	3E
	513 A-B	TD		NE	NE	SE	36	2S	4E
	538 A-F	DD				c SE	4	4S	1E
	557 A-G	DD		NE	NE	SW	3	4S	1E
	558 A-I	DD		SW	SW	SE	16	4S	1E
	559	DD		NW	NE	SW	29	3S	1E
	560 A-B	DD		SW	SW	SE	22	4S	1E
Jersey	463	OU	Summum No. 4	NW	SW	SE	16	7N	10W
Johnson	609	OU	Wayside	NE	NW	NE	4	11S	2E
	618	MD	Reynoldsburg			SW	32	11S	4E
LaSalle	567	ST	No. 2		NW	NE	25	33N	4E
Lawrence	585	TD		NW	SW	NW	13	3N	11W
Macoupin	571	OU	Upper Scottville	SE	NW	SW	16	12N	9W
	572	OU	Upper Scottville	SE	NW	SW	16	12N	9W
	573	OU	No. 8	SW	NE	SW	7	12N	8W
	575	OU	No. 8	NW	SE	SW	10	11N	8W
	577	OU	Carlinville	SE	NE	NW	26	12N	8W
	578	OU	Scottville	SW	NW	NW	16	12N	9W
	688	OU	Macoupin		NE	NW	2	9N	7W
Madison	511 A-C	TD		SW	NW	SE	3	3N	6W
	617 A-C	DD		NE	NE	SE	29	6N	5W
	643 A-D	DD		SE	SE	NE	28	6N	5W
Marion	699 A-J	TD		NE	NE	SE	21	4N	4E
Montgomery	697	DD	Shoal Creek (?)	NW	SW	NW	36	9N	5W
Peoria	542 A-C	OU	No. 8			SW½	3	8N	5E
Perry	690	OU	Jamestown	NW	NW	NE	7	6S	2W
	692	OU	Cutler		SW	SW	34	5S	4W
Pope	629	OU	Battery Rock		SE	SW	6	11S	6E
Richland	477 A-C	TD		SE	SE	NW	31	3N	9E
Rock Island	627	SU	Rock Island	NW	SE	SW	1	16N	1W
St. Clair	565 A-C	ST	Jamestown	SW	SW	SE	33	1S	7W
Saline	355–69	SU	Harrisburg No. 5	NW	NE	SE	15	9S	6E
	518 A-B	OU	Davis		NE	NW	21	10S	5E
	552 A-F	DD			SE	NW	5	8S	7E
	607	OU	Jamestown	NW	SW	NW	30	9S	5E
	628 A-B	OU	Murphysboro (?)	NE	SE	NW	27	10S	6E
	632	OU	Jamestown	NW	SW	NW	30	9S	5E
	709	OU	Delwood		NW	NW	3	10S	6E
Sangamon	371-74	OU	Springfield No. 5	SE	NE	SE	21	16N	5W
	630	DD	No. 5				15	14N	4W

GEOGRAPHIC LOCATIONS—(Concluded)

County	Maceration Number	Type[a]	Coal	Location					
				Quarter Sec.			Sec.	T.	R.
Shelby	665	TD		NE	NE	NW	12	10N	6E
	694	SU	Shelbyville	NE	SW	NE	33	12N	4E
	710	OU	Trowbridge			NW	14	10N	6E
Vermilion	514	OU	No. 7	SW	SW	SW	15	19N	12W
	515	OU	No. 6		NE	SW	14	18N	11W
	531	ST	No. 6	NW	SW	NE	16	19N	11W
	532 A-B	OU	No. 7	NE	SW	SE	12	19N	12W
	590 A-D	ST	No. 7	SW	NE	NW	7	19N	11W
	591 A-D	OU	No. 7	NE	NW	NE	18	19N	11W
	595 A-C	OU	No. 6		NE	SW	14	18N	11W
	596 A-D	OU	No. 6		NE	SW	14	18N	11W
	597 A-B	OU	No. 6		NE	NE	7	19N	11W
Wabash	486 A-C	SU	Friendsville	NW	NE	NE	29	2S	13W
	487 A-D	SU	Friendsville	NW	SW	SW	13	1N	13W
	490	OU	3½" McCleary's Bluff	NW	SW	SW	29	2S	13W
	494 A-B	OU	Shoal Creek (?)		NW	NE	11	2S	13W
	500 A-F	TD		NW	NW	SW	26	1N	13W
	501 A-B	TD		NE	NW	SW	19	1N	12W
	504 A-J	TD		SW	SW	SW	17	1S	12W
	508 A-K	TD			NE	SE	3	1S	13W
	516 A-M	TD		SW	SW	SE	22	3S	14W
	517 A-L	TD		SE	SW	SE	16	1S	12W
	583	TD	No. 5	NE	SE	NW	27	2S	13W
Washington	509 A-B	TD		SW	NW	NW	26	3S	3W
Wayne	478 A-G	TD		SW	NW	SE	29	2S	9E
White	318	DD	Ditney		NE	NW	18	7S	10E
	475 A-D	TD		NE	SW	SE	31	3S	14W
	476 A-C	TD		SE	SE	NW	27	6S	9E
Williamson	519 A-B	OU	Dekoven		NW	SW	13	10S	4E
	520 A-B	OU	Bald Hill		NW	SE	25	10S	4E
	640	OU	Stonefort		NW	SE	25	10S	4E
	691	OU	Bankston		NE	NE	24	9S	4E

[a] DD Diamond-drill
TD Rotary-drill
SU Underground mine
ST Strip mine
MD Mine dump
OU Outcrop

CORRELATION OF ILLINOIS COAL BEDS

The main objective of this investigation was to explore the value of fossil spores, found mainly in coal beds, as guide fossils for correlation purposes. Because little previous work had been done in this field it was important to know (1) whether or not spores occur in sufficient abundance to be useful, and (2) whether the evolution and succession of Pennsylvanian plants was rapid enough to produce important changes in spore population between the time represented by successive beds or groups of beds. In this connection it may be pointed out that the spore distribution chart (in pocket) records the presence of 130 species assigned to 19 genera. Spores were abundant in nearly all of the coal samples macerated. The facts that genera and species are numerous, and that 67 out of 130 species have restricted ranges, and 33 other species are restricted to Pennsylvanian groups in Illinois or have important geologic ranges, indicate relatively rapid plant succession and evolutionary changes. These spores therefore seem to fulfill the requirements of satisfactory guide fossils.

These conclusions could not be reached until the spore population of numerous coal beds had been determined. It was necessary, therefore, to sample numerous coal beds and obtain fossil collections from several samples from which lists were compiled. The usefulness of the spores as guide fossils was indicated fairly early in the studies, after which the compilation of fossil lists representative of the various coal beds seemed of greater importance than the demonstration of their usefulness. At the same time the additional evidence added weight to the conclusion previously reached.

In the following pages the fossil spores characteristic of most of the coal beds in the Pennsylvanian system of Illinois are listed by coal bed. It is evident that a vast amount of fossil material is available. It was scarcely necessary to assemble special evidence that evolutionary changes and plant succession were of sufficient importance to provide many species of spores of restricted ranges. Actually the matter of prime interest came to be the identification of the spores characteristic of the different coal beds or unit groups of Pennsylvanian beds.

In carrying on the census of spore population it was necessary to obtain collections from the same bed at as many localities as time and opportunity permitted. The identification of these beds had to be made by other criteria than by means of spores. This was not difficult in the Carbondale group because the coal beds have been traced almost continuously for many miles, and it was possible to collect from the same bed from localities in northern, western, and southern Illinois. In some cases this was also true for eastern Illinois. The Caseyville and Tradewater coals and particularly the upper McLeansboro coals could not be identified with equal certainty except for relatively short distances. In general it appears that tentative correlations that have been made in the past were frequently found not to possess the requirements of stratigraphic relationship demanded by standards imposed in these studies. When there was uncertainty as to correctness of correlation, even though general agreement in fossil population existed, only the probability of stratigraphic agreement was suggested. Eventually the amount of evidence was considerable and the validity of the suggestions became increasingly more probable.

Some collections from a particular coal bed were made at only one locality. It is necessary to know what effect samples of a particular coal bed from only one locality will have in correlation. The available evidence strongly indicates that the characteristic spores are present in each maceration, but in some cases the abundance ratios vary in the same bed from two widely separated geographic localities. Exceedingly rare species of spores have not been used as guide fossils and this tends to minimize

a potential source of error in the correlation of coal beds. In working well-known coal beds a start was usually made at the type locality or area for which the bed was named. The type locality usually provided the stratigraphic evidence for identification of the bed elsewhere.

CASEYVILLE GROUP

The Caseyville group, formerly called the lower Pottsville, is best known from exposures in southern Illinois. It is the oldest Pennsylvanian group in Illinois, and is thought to correspond to the upper part of the Morrow series of the Midcontinent region, the upper part of the lower half of the Pottsville of the eastern United States, and the upper part of the Namurian B and the lower half of the Namurian C of Europe.

Weller (1940) reported a maximum thickness of more than 400 feet for the strata of the Caseyville group in Hardin and Pope counties. It is characterized by two massive cliff-forming sandstones, the Battery Rock and the Pounds, which in places contain well-rounded quartz pebbles. Within the Caseyville group there are three coal beds which have been named the Wayside, Battery Rock, and the Reynoldsburg in the order from oldest to youngest. The Wayside is a member of the Lusk formation; the Battery Rock coal bed lies between the Battery Rock and Pounds sandstones; and the Reynoldsburg coal bed lies between the Pounds and Grindstaff sandstones. The Caseyville group, according to Weller, Henbest, and Dunbar (1942), extends to the base of the Grindstaff sandstone.

Wayside Coal Bed

Spores are rather numerous in the Wayside coal bed, but the number of species is small. Three forms which probably represent new species are not described because each is a single occurrence, and only nine genera have been identified. The Wayside coal bed can be identified from its spore content because *Lycospora pseudoannulata* sp. nov. averages 70 to 75 percent of the total spore content, and because *Punctati-sporites provectus* sp. nov. is restricted to this coal bed. It is important to record the absence of the following genera: *Alati-sporites, Laevigato-sporites, Cirratriradites,* and *Schulzospora* gen. nov. The following genera and species are present in maceration 609, NE. ¼ NW. ¼ NE. ¼ sec. 4, T. 11 S., R. 2 E., Johnson County, Illinois:

1. *Punctati-sporites provectus* sp. nov.
2. *Granulati-sporites pallidus* sp. nov.
3. *Reticulati-sporites splendens* sp. nov.
4. *Denso-sporites reynoldsburgensis* sp. nov.
5. *D. ruhus* sp. nov.
6. *Triquitrites priscus* sp. nov.
7. *Lycospora pseudoannulata* sp. nov.
8. *L. micropapillatus* (Wilson and Coe) S. W. and B., 1944
9. *Raistrickia prisca* sp. nov.

In addition to the above species, forms referrable to *Wilsonia* gen. nov., *Endo-sporites,* and *Punctati-sporites* need to be described when sufficient good specimens are found.

Battery Rock Coal Bed

The spore content of the Battery Rock and Wayside coal beds are similar with respect to the small number of species identified. Only 11 species have been identified from the Battery Rock coal bed and nine of these are new.

Schulzospora gen. nov. and *Denso-sporites sinuosus* have been observed only in this coal bed. Generally eight percent of the total spore content is *Schulzospora* gen. nov. The dominant species is *Lyco-spora pseudoannulata* sp. nov.; however, it is less abundant than in the Wayside. *Denso-sporites* is more abundant than in the Wayside and there are four species present in contrast to two for the Wayside. *Granulati-sporites pallidus* sp. nov. has become a prominent member of the flora.

The following important genera have not been observed from the Battery Rock coal bed: *Alati-sporites, Reinschospora, Cirratriradites,* and *Wilsonia* gen. nov. The following genera and species have been identified from this coal bed, maceration 587, Hardin County, Illinois:

1. *Granulati-sporites pallidus* sp. nov.
2. *Reticulati-sporites splendens* sp. nov.
3. *Denso-sporites sinuosus* sp. nov.
4. *D. lobatus* sp. nov.

5. *D. reynoldsburgensis* sp. nov.
6. *D. ruhus* sp. nov.
7. *Triquitrites priscus* sp. nov.
8. *Lycospora pseudoannulata* sp. nov.
9. *L. micropapillatus* (Wilson and Coe) S. W. and B., 1944
10. *Raistrickia prisca* sp. nov.
11. *Schulzospora rara* sp. nov.

In addition to the species listed above, forms belonging to *Calamospora and Punctati-sporites* have been observed but are not described because of the lack of adequate good specimens to warrant description.

Reynoldsburg Coal Bed

Spores are numerically abundant in the Reynoldsburg coal bed, and 11 genera including 15 species are recognized. The Reynoldsburg coal bed at the single locality sampled is characterized by a dominance of *Denso-sporites reynoldsburgensis* sp. nov. which comprises 65 percent of the total spore content. Further, *D. indignabundus* (?) (Loose) S. W. and B., 1944, and *Lycospora pellucidus* (Wicher) S. W. and B., 1944, appear to be restricted to this bed. *Lycospora,* the dominant genus of the Battery Rock and Wayside coal beds, is subdominant, representing only 20 percent of the total spore content. Nevertheless it is an important genus for correlating the Reynoldsburg coal bed because four species of the genus are known to be present, or two more than are found in either the Battery Rock or the Wayside coal beds. The presence of species of the genus *Laevigato-sporites* is of utmost importance because it is the first occurrence of the genus in Pennsylvanian time in Illinois, and because spores of this type are known to the present day. The following important genera have not been observed in the Reynoldsburg: *Alati-sporites, Cirratriradites, Reinschospora,* and *Schulzospora.* The following genera and species have been identified from the Reynoldsburg coal bed, maceration 618, SW. ¼ sec. 32, T. 11 S., R. 4 W., Johnson County, Illinois:

1. *Granulati-sporites pallidus* sp. nov.
2. *G. granulatus* Ibrahim, 1933
3. *G. gibbosus* (Ibrahim) S. W. and B., 1944
4. *Reticulati-sporites splendens* sp. nov.
5. *Laevigato-sporites ovalis* sp. nov.
6. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
7. *Denso-sporites reynoldsburgensis* sp. nov.
8. *D. indignabundus* (?) (Loose) S. W. and B., 1944
9. *Triquitrites priscus* sp. nov.
10. *L. pseudoannulata* sp. nov.
11. *L. granulata* sp. nov.
12. *L. micropapillatus* (Wilson and Coe) S. W. and B., 1944
13. *L. pellucidus* (Wicher) S. W. and B., 1944
14. *Florinites diversiformis* sp. nov.
15. *Florinites antiquus* Schopf, 1944

The addition to the species listed above, five species of the following genera have been observed in very limited numbers and are not described: *Endosporites, Calamospora, Punctati-sporites,* and *Wilsonia* gen. nov.

Conclusions

The spores of three Caseyville coal beds have been examined. Spores from 13 genera have been identified, and of these, seven species and one genus are restricted to the Caseyville coal beds. *Laevigato-sporites* and *Florinites* appear for the first time in the Pennsylvanian of Illinois in the Reynoldsburg coal bed. *Alati-sporites, Cirratriradites,* and *Reinschospora* (which are present in the Tradewater group) have not been found in Caseyville coal beds.

The Wayside, Battery Rock, and Reynoldsburg coal beds, of Caseyville age, have a distinctive spore population which should enable the identification of coal beds at these horizons outside of Illinois. Attempts at correlation of the Caseyville coal beds and "lower Pennsylvanian" beds of western Illinois have led to the conclusion that the "Sub-Babylon"[1] coal bed exposed near Tarter Bridge in Fulton County, sec. 2, T. 5 N., R. 1 E., and the Babylon coal bed are younger and therefore may be of early Tradewater age. Correlation of Illinois Caseyville coal beds with those of western Kentucky has not been attempted.

TRADEWATER GROUP

The Tradewater group, formerly called upper Pottsville, is known from outcrops in southern, western, and northern Illinois. Recent publications place the top of the Tradewater group at the bottom of the

[1] A 2 to 3 inch coal bed called the "Sub-Babylon" coal bed by Schopf in maceration notes. It lies above the Mississippian strata and below the Babylon coal bed.

Palzo and Isabel sandstones in southern and western Illinois: Cady (1942) and Weller, Henbest, and Dunbar (1942). The base of the group in southern Illinois, according to Weller, Henbest, and Dunbar (1942), is at the bottom of the Grindstaff sandstone. In western Illinois the Tradewater group has been included in the Pottsville formation by Moore, Wanless, Weller, et al., (1944); and Cooper (p. 16, 1946) includes the beds from the Tarter to the base of the Carbondale in this group. The Tradewater group is thought to compare with the Lampasas series of the Midcontinent region, the upper Pottsville of eastern United States, and with the upper half of the Namurian C and all of the Westphalian A and B of Europe.

The maximum thickness of Tradewater strata in southern Illinois, according to Weller (1945) is 445 feet, in western Illinois 100 feet, and in central Illinois it is thought to be possibly as much as 600 feet. This group includes a number of sandstones, shales, coal beds, and two marine limestones, the Curlew and Stonefort in southern Illinois, and the Seville and Seahorne limestones in western Illinois.

"Sub-Babylon" Coal Bed

The oldest Pennsylvanian coal bed of western Illinois is termed the "Sub-Babylon," as is mentioned earlier in this report. It lies below the Babylon coal bed and above the Mississippian strata. A collection and maceration by Schopf and another collection at the same locality and maceration by the author have provided numerous spores. Ten genera and 13 species have been identified. Three are new species described in this report.

The coal bed appears to be characterized by *Reticulati-sporites irregularis* sp. nov. and *Denso-sporites glandulosus* sp. nov., since they appear restricted to this bed. Furthermore, other species appear for the first time in this coal bed, as shown on the spore distribution chart (pocket).

The following species have been identified from the "Sub-Babylon" coal bed, maceration 144, NE. ¼ NE. ¼ SE. ¼ sec. 2, T. 5 N., R. 1 E., Fulton County, Illinois:

1. *Granulati-sporites pallidus* sp. nov.
2. *Reticulati-sporites irregularis* sp. nov.
3. *Laevigato-sporites desmoinensis* (Wilson and Coe) S. W. and B., 1944
4. *L. minutus (Ibrahim)* S. W. and B., 1944
5. *Denso-sporites glandulosus* sp. nov.
6. *D. granulosus* sp. nov.
7. *D. triangularis* sp. nov.
8. *Triquitrites priscus* sp. nov.
9. *Calamospora mutabilis* (Loose) S. W. and B., 1944
10. *Lycospora punctata* sp. nov.
11. *L. granulata* sp. nov.
12. *L. pseudoannulata* sp. nov.
13. *Raistrickia prisca* sp. nov.

In addition to the above listed species, undescribed species of *Endosporites, Granulati-sporites,* and *Calamospora* are present in very limited number. A single fragment of a spore coat indicates the presence of the genus *Punctati-sporites.* Important genera not present include *Alati-sporites, Cirratriradites, Reinschospora,* and *Florinites.*

The "Sub-Babylon" coal bed is believed to be early Tradewater in age because of the presence of species of the genus *Laevigato-sporites* and because of the general spore content listed above and illustrated on the spore distribution chart (in pocket). The spore content of this bed differs from the Caseyville coal beds.

Babylon Coal Bed

The spores of the Babylon coal bed indicate a vast change in the flora when compared with those of the Caseyville coal beds. Twelve genera are known to be present and 18 species have been identified. The Babylon coal bed can be readily differentiated by plant spores from the coal beds above and below. Eight species appear for the first time in the Babylon coal bed as do two genera. *Laevigato-sporites* is the dominant genus for the first time in the Pennsylvanian of Illinois. *Granulati-sporites* is subdominant with 18 percent of the total spore content belonging to this genus, the largest percentage this genus attains in the Pennsylvanian in Illinois. *Cirratriradites* appears for the first time and makes up 10 percent of the total spore content.

The Babylon coal bed exposed along Spoon River north of Babylon in Fulton County was for one reason or another as-

signed to the position of the Battery Rock coal bed, but more recently (Moore, Wanless, Weller, et al., 1944) to the position of the Reynoldsburg coal bed. The plant spores of these two coal beds lack similarity, indicating that the beds are not equivalent. In all probability the sequence in a complete section including both western and southern Illinois would be as follows:

Tradewater Group
- Babylon coal bed
- "Sub-Babylon" coal bed

Caseyville Group
- Reynoldsburg coal bed
- Battery Rock coal bed
- Wayside coal bed

Therefore, the oldest Pennsylvanian strata in southern Illinois are of Caseyville age, and in western Illinois are of Tradewater age.

The following species have been identified from macerations 523 and 588, Fulton County, Illinois:

1. *Punctati-sporites quasiarcuatus* sp. nov.
2. *Granulati-sporites pallidus* sp. nov.
3. *G. granulatus* Ibrahim, 1933
4. *G. gibbosus* (Ibrahim) S. W. and B., 1944
5. *G. verrucosus* (Wilson and Coe) S. W. and B, 1944
6. *Reticulati-sporites splendens* sp. nov.
7. *Laevigato-sporites robustus* sp. nov.
8. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
9. *L. minutus* (Ibrahim) S. W. and B., 1944
10. *Denso-sporites granulosus* sp. nov.
11. *Cirratriradites maculatus* Wilson and Coe, 1940
12. *Endosporites* sp.
13. *Triquitrites pulvinatus* sp. nov.
14. *Calamospora straminea* Wilson and Kosanke, 1944
15. *Lycospora pseudoannulata* sp. nov.
16. *L. micropapillatus* (Wilson and Coe) S. W. and B., 1944
17. *Florinites diversiformis* sp. nov.
18. *F. antiquus* Schopf, 1944
19. *"Spherites"**

Willis and Tarter Coal Beds

The Willis coal bed from Gallatin County (Schneider's Mine—NW. ¼ SE. ¼ sec. 30, T. 10 S., R. 9 E.) is correlated by plant spores with the Tarter coal bed in Fulton County (NW. ¼ NW. ¼ SE. ¼ sec. 19, T. 5 N., R. 2 E.). This correlation is in agreement with that made by Wanless (1939), Henbest and Dunbar (1944), Moore, Wanless, Weller et al. (1944) and Cooper (1946).

* Refers to a type of spore which is to be described in a later publication by another author.

The following list of genera and species have been isolated and identified from both beds with two exceptions which are indicated in the list:

1. *Punctati-sporites quasiarcuatus* sp. nov.
2. *P. sulcatus* Wilson and Kosanke, 1944
3. *Granulati-sporites pallidus* sp. nov.
4. *G. aculeolatus* sp. nov.
5. *G. deltiformis* S. W. and B., 1944
6. *Alati-sporites trialatus* sp. nov.*
7. *Reticulati-sporites splendens* sp. nov.
8. *R. lacunosus* sp. nov.
9. *Laevigato-sporites ovalis* sp. nov.
10. *L. punctatus* sp. nov.
11. *L. robustus* sp. nov.
12. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
13. *L. minimus* (Wilson and Coe) S. W. and B., 1944
14. *L. minutus* (Ibrahim) S. W. and B., 1944
15. *Denso-sporites granulosus* sp. nov.
16. *D. lobatus* sp. nov.
17. *D. sphaerotriangularis* sp. nov.
18. *Cirratriradites annuliformis* sp. nov.
19. *C. differmis* sp. nov.
20. *C. rotatus* sp. nov.
21. *C. maculatus* Wilson and Coe, 1940
22. *Endosporites angulatus* Wilson and Coe, 1940
23. *Triquitrites* sp.
24. *Calamospora flexilis* sp. nov.
25. *C. straminea* Wilson and Kosanke, 1944
26. *C. microrugosus* (Ibrahim) S. W. and B., 1944
27. *Reinschospora* (fragment)**
28. *Lycospora granulata* sp. nov.
29. *L. pseudoannulata* sp. nov.
30. *L. micropapillatus* (Wilson and Coe) S. W. and B., 1944
31. *Raistrickia prisca* sp. nov.
32. *Florinites antiquus* Schopf, 1944
33. *"Spherites"* sp.

The occurrence of a single form of *Alati-sporites trialatus* sp. nov. in the Tarter bed and a fragment of *Reinschospora* sp. in the Willis bed is considered a minor discrepancy, in view of the similarity in relative abundance of the more numerous forms. The dominant spore genus is *Laevigato-sporites* which comprises 39 percent of the spore content of the Tarter bed and 35 percent of the spore content of the Willis bed. The subdominant genus is *Cirratriradites* which comprises 26 percent of the spore content of the Tarter bed and 27 percent of the spore content of the Willis bed. The remaining genera are equally abundant in the two areas investigated.

* One specimen observed in the Tarter coal bed out of over 5000 examined.

** One fragment of a specimen of this genus observed from the Willis coal bed.

Delwood and Pope Creek Coal Beds

The Delwood coal bed in the NW. ¼ NW. ¼ sec. 3, T. 10 S., R. 6 E., Saline County, is correlated by plant spores with the Pope Creek coal bed in the SE. ¼ SW. ¼ SE. ¼ sec. 11, T. 7 N., R. 1 E., Fulton County, Illinois. This correlation is in agreement with that by Wanless (1939), Weller, Henbest, and Dunbar (1942), Moore, Wanless, Weller et al. (1944), and Cooper (1946).

Spores are not as abundant as in the Willis and Tarter coal beds. The following list includes genera and species which are present in both the Delwood and Pope Creek coal beds unless otherwise indicated:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. reticuloides* sp. nov.
3. *P. sulcatus* Wilson and Kosanke, 1944
4. *Granulati-sporites pallidus* sp. nov.
5. *G. verrucosus* (Wilson and Coe) S. W. and B., 1944
6. *Laevigato-sporites punctatus* sp. nov.
7. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
8. *L. minimus* (Wilson and Coe) S. W. and B., 1944
9. *L. minutus* (Ibrahim) S. W. and B., 1944
10. *L. ovalis* sp. nov.
11. *Denso-sporites sphaerotriangularis* sp. nov.*
12. *D. lobatus* sp. nov.**
13. *Cirratriradites difformis* sp. nov.
14. *C. rotatus* sp. nov.
15. *C. maculatus* Wilson and Coe, 1940
16. *Endosporites angulatus* Wilson and Coe, 1940
17. *E. ornatus* Wilson and Coe, 1940*
18. *Triquitrites priscus* sp. nov.
19. *T. pulvinatus* sp. nov.
20. *Calamospora straminea* Wilson and Kosanke, 1944
21. *Lycospora granulata* sp. nov.
22. *L. pseudoannulata* sp. nov.
23. *L. micropapillatus* (Wilson and Coe) S. W. and B., 1944
24. *Florinites antiquus* Schopf, 1944
25. *"Spherites"* sp.

In addition to the above listed genera and species, a fragment of a spore was observed in the Pope Creek coal bed which probably is referable to the genus *Raistrickia.*

The dominant spore genus for the Delwood and Pope Creek coal beds is *Laevigato-sporites* which comprises 45 percent of the total spore content. *Lycospora* is the next in abundance with about 15 percent of the total spore content being divided among three species of the genus. The Pope Creek and Delwood coal beds may be differentiated from the Willis and Tarter coal beds by the presence of *Punctati-sporites fenestratus* sp. nov., *P. reticuloides* sp. nov., increased abundance of *Laevigato-sporites* and *Lycospora,* and reduced numbers of *Cirratriradites.*

* Observed only in the Delwood coal bed.
** Observed only in the Pope Creek coal bed.

Rock Island (No. 1) Coal Bed

The Rock Island coal bed from Pryce Mine (NW. ¼ SE. ¼ SW. ¼ sec. 1, T. 16 N., R. 1 W.), Rock Island County, Werner Mine (NE. ¼ NW. ¼ SE. ¼ sec. 3, T. 16 N., R. 1 E.), Henry County, and Buggos and White Mine (sec. 33, T. 14 N., R. 1 E.), Henry County, is correlated with a coal bed which crops out in sec. 23, T. 6 N., R. 1 E., Fulton County, Illinois.

The following genera and species have been observed from all of the above locations unless otherwise noted:

1. *Punctati-sporites decorus* Wilson and Kosanke, 1944
2. *P. fenestratus* sp. nov.
3. *P. quasiarcuatus* sp. nov.
4. *P. sulcatus* Wilson and Kosanke, 1944
5. *Granulati-sporites pallidus* sp. nov.
6. *G. verrucosus* (Wilson and Coe) S. W. and B., 1944*
7. *Laevigato-sporites desmoinensis* (Wilson and Coe) S. W. and B., 1944
8. *L. minutus* (Ibrahim) S. W. and B., 1944
9. *L. ovalis* sp. nov.
10. *L. punctatus* sp. nov.
11. *L. vulgaris* (Ibrahim) Ibrahim, 1933
12. *Denso-sporites lobatus* sp. nov.
13. *D. sphaerotriangularis* sp. nov.
14. *D. triangularis* sp. nov.
15. *Cirratriradites maculatus* Wilson and Coe, 1940
16. *C. annuliformis* sp. nov.*
17. *Endosporites ornatus* Wilson and Coe, 1940
18. *Triquitrites pulvinatus* sp. nov.
19. *Calamospora straminea* Wilson and Kosanke, 1944
20. *C. pedata* sp. nov.
21. *C. liquida* sp. nov.
22. *C. flexilis* sp. nov.
23. *Lycospora pseudoannulata* sp. nov.
24. *L. granulata* sp. nov.
25. *Raistrickia* sp.**
26. *Florinites antiquus* Schopf, 1944
27. *"Spherites"* sp.

* Observed only in the samples from Rock Island and Henry counties.
** One specimen observed in the sample from Fulton County.

There is a little doubt that the coal samples from the localities mentioned above are from the same coal bed. The No. 1 coal bed can be readily distinguished from the Delwood and Pope Creek coal beds. The dominant spore genus of the No. 1 coal bed is *Laevigato-sporites,* since 45 percent of the total spore content is that genus. *Calamospora, Punctati-sporites,* and *Denso-sporites* are important spore genera. *Lycospora,* important in the coal beds below and above the No. 1 coal bed, is almost lacking.

Murphysboro Coal Bed

The Murphysboro coal bed has been examined for spore content from the following localities in Jackson county: south of Sato, SW. ¼ NE. ¼ SE. ¼, sec. 21, T. 7 S., R. 3 W.; south of Ava, NW. ¼ NW. ¼, sec. 36, T. 7 S., R. 4 W.; and a sample from a mine dump of the abandoned Brinker Mine near Oraville. The spore content differs from that of the Rock Island coal bed, as can be seen in the spore distribution chart, and therefore the two beds are considered distinct. A coal bed occurring below the Curlew Limestone in the NE. ¼ SE. ¼ NW. ¼, sec. 27, T. 10 S., R. 6 E., Saline County, has a spore content similar to that of the Murphysboro coal bed and is tentatively correlated with the latter. There are some differences, possibly owing to insufficient collections from Saline County. *Denso-sporites* which is present from the base of the Pennsylvanian through the Rock Island coal bed, appears to be absent in both Jackson and Saline counties.

The following genera and species are known to be present in both Jackson and Saline counties unless otherwise noted:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. sulcatus* sp. nov.
4. *P. quaesitus* sp. nov.*
5. *Granulati-sporites verrucosus* (Wilson and Coe) S. W. and B., 1944
6. *G. pallidus* sp. nov.
7. *G. aculeolatus* sp. nov.*
8. *Reticulati-sporites lacunosus* sp. nov.
9. *Laevigato-sporites desmoinensis* (Wilson and Coe) S. W. and B., 1944
10. *L. ovalis* sp. nov.
11. *L. minutus* (Ibrahim) S. W. and B., 1944
12. *L. minimus* (Wilson and Coe) S. W. and B., 1944
13. *L. punctatus* sp. nov.
14. *L. vulgaris* (Ibrahim) Ibrahim, 1933**
15. *Cirratriradites maculatus* Wilson and Coe, 1940
16. *Endosporites ornatus* Wilson and Coe, 1940
17. *Triquitrites pulvinatus* sp. nov.
18. *T. exiquus* Wilson and Kosanke, 1944
19. *T. arculatus* Wilson and Coe, 1940
20. *Calamospora straminea* Wilson and Kosanke, 1944
21. *C. liquida* sp. nov.
22. *C. hartungiana* Schopf, 1944
23. *C. flexilis* sp. nov.**
24. *Lycospora granulata* sp. nov.
25. *L. brevijuga* sp. nov.
26. *L. punctata* sp. nov.
27. *L. micropapillatus* (Wilson and Coe) S. W. and B., 1944
28. *L. pseudoannulata* sp. nov.
29. *Raistrickia aculeolata* Wilson and Kosanke, 1944
30. *Florinites antiquus* Schopf, 1944

The Murphysboro coal bed is readily differentiated from the Rock Island coal bed below and the Bald Hill above by a sharp increase in abundance of *Lycospora* and lack of *Denso-sporites.* Species differences are shown in the spore distribution chart.

Bald Hill Coal Bed

The Bald Hill coal bed is described by Cady (1926). The coal collected for the investigation was from Williamson County just north of Stonefort in a road-cut in sec. 25, T. 10 S., R. 4 E. Wanless (1939) has suggested that the Bald Hill coal bed is approximately equivalent to the Upper DeLong coal bed of western Illinois. One sample of the DeLong coal bed from the NE. ¼ NW. ¼ SW. ¼ sec. 19, T. 5 N., R. 2 E., Fulton County, was prepared, but only a few long-ranging genera and species were obtained from a poor maceration. The Bald Hill coal bed can readily be identified by plant spores, differing from the Murphysboro coal bed by the presence of a restricted form, *Triquitrites angulatus* sp. nov., and four species which appear for the first time in Illinois. The four species are *Punctati-sporites verrucifer* sp. nov., *Reticulati-sporites adhearens* sp. nov., *Triquitrites crassus* sp. nov., and *Florinites elegans* Wilson and Kosanke.

* Absent in samples from Jackson County.
** Absent in samples from Saline County.

The following species have been identified from the Bald Hill coal bed:

1. *Punctati-sporites verrucifer* sp. nov.
2. *P. sulcatus* Wilson and Kosanke, 1944
3. *P. decorus* Wilson and Kosanke, 1944
4. *Granulati-sporites pallidus* sp. nov.
5. *G. verrucosus* (Wilson and Coe) S. W. and B., 1944
6. *G. deltiformis* S. W. and B., 1944
7. *Reticulati-sporites adhearens* sp. nov.
8. *Laevigato-sporites ovalis* sp. nov.
9. *L. punctatus* sp. nov.
10. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
11. *L. minimus* (Wilson and Coe) S. W. and B., 1944
12. *L. minutus* (Ibrahim) S. W. and B., 1944
13. *L. vulgaris* (Ibrahim) Ibrahim, 1933
14. *Denso-sporites sphaerotriangularis* sp. nov.
15. *Triquitrites angulatus* sp. nov.
16. *T. crassus* sp. nov.
17. *T. exiquus* Wilson and Kosanke, 1944
18. *T. arculatus* Wilson and Coe, 1940
19. *Calamospora straminea* Wilson and Kosanke, 1944
20. *C. hartungiana* Schopf, 1944
21. *Lycospora brevijuga* sp. nov.
22. *L. granulata* sp. nov.
23. *Raistrickia aculeolata* Wilson and Kosanke, 1944
24. *Florinites elegans* Wilson and Kosanke, 1944

Stonefort Coal Bed

The Stonefort coal bed exposed on Stonefort Hill in the NW. ¼ SE. ¼ sec. 25, T. 10 S., R. 4 E., Williamson County, was macerated and the spores identified. The coal bed lies below the Stonefort limestone and above the Bald Hill coal bed as illustrated by Henbest (1928). The coal bed has a maximum thickness of 14 inches and is without partings.

Spores are abundant in the Stonefort coal bed, which may be distinguished from the Bald Hill coal bed below and the Davis coal bed above by several guide species, and the apparent lack of *Denso-sporites* and *Granulati-sporites*. In this latter respect it is somewhat similar to the Murphysboro coal bed.

The following list of genera and species is from the Stonefort coal bed at the location given above:

1. *Punctati-sporites decorus* Wilson and Kosanke, 1944
2. *P. firmus* (Loose) S. W. and B., 1944
3. *Reticulati-sporites adhearens* sp. nov.
4. *Laevigato-sporites punctatus* sp. nov.
5. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
6. *L. vulgaris* (Ibrahim) Ibrahim, 1933
7. *L. ovalis* sp. nov.
8. *L. latus* sp. nov.
9. *L. minutus* (Ibrahim) S. W. and B., 1944
10. *L. minimus* (Wilson and Coe) S. W. and B., 1944
11. *Endosporites ornatus* Wilson and Coe, 1940
12. *Triquitrites protensus* sp. nov.
13. *T. crassus* sp. nov.
14. *T. pulvinatus* sp. nov.
15. *Calamospora hartungiana* Schopf, 1944
16. *C. straminea* Wilson and Kosanke, 1944
17. *Lycospora punctata* sp. nov.
18. *L. granulata* sp. nov.
19. *L. pseudoannulata* sp. nov.
20. *Raistrickia aculeolata* Wilson and Kosanke, 1944
21. *R. crinita* sp. nov.
22. *Florinites elegans* Wilson and Kosanke, 1944
23. *F. antiquus* Schopf, 1944
24. *"Spherites"* sp.

Davis and Wiley Coal Beds

The Davis coal bed of western Kentucky and southern Illinois is correlated by similarity of spore contents with the Wiley coal bed of Fulton County, although there are some minor discrepancies. This correlation is in agreement with Wanless (1939). The type locality is in Union County, Kentucky, where the bed was originally called the "4-foot coal" by Owen (1856). In 1857, he called the 4-foot coal bed the No. 5 coal bed of Kentucky. This coal bed was named the Davis or No. 6 coal bed by Lee (1916), who gives two measured sections of the coal from the Davis Mine, Union County, Kentucky, in which the coal bed is 3 feet 9 3/4 inches and 3 feet 10 inches thick. One of the two sections measured by Lee includes a bony clay parting in the upper portion of the bed and both appear to have "marcasite" layers ½ inch thick. The Davis coal bed is known from outcrop and small mining operations in southern Illinois. In western Illinois the Wiley coal bed lies between the Greenbush coal bed and the Seahorne limestone, and ranges in thickness from less than one foot to two feet. Its exposure near Wiley, Fulton County, Illinois, is in the SW. ¼ NW. ¼, sec. 11, T. 7 N., R. 2 E.

The following genera and species have been isolated from the Davis coal bed, maceration 518 A-B, Saline County, and from the Wiley coal bed, maceration 525

A-B, Fulton County, unless otherwise noted:

1. *Punctati-sporites sulcatus* Wilson and Kosanke, 1944
2. *P. foveatus* sp. nov.*
3. *P. quasiarcuatus* sp. nov.**
4. *Granulati-sporites pallidus* sp. nov.
5. *G. spinosus* sp. nov.*
6. *Alati-sporites hexalatus* sp. nov.
7. *A. trialatus* sp. nov.*
8. *Reticulati-sporites lacunosus* sp. nov.
9. *Laevigato-sporites desmoinensis* (Wilson and Coe) S. W. and B., 1944
10. *L. minutus* (Ibrahim) S. W. and B., 1944
11. *L. minimus* (Wilson and Coe) S. W. and B., 1944
12. *L. punctatus* sp. nov.
13. *L. ovalis* sp. nov.
14. *Denso-sporites triangularis* sp. nov.
15. *Cirratriradites maculatus* Wilson and Coe, 1940
16. *C. annuliformis* sp. nov.**
17. *Endosporites ornatus* Wilson and Coe, 1940
18. *Triquitrites pulvinatus* sp. nov.
19. *T. inusitatus* sp. nov.
20. *T. crassus* sp. nov.
21. *T. exiquus* Wilson and Kosanke, 1944
22. *Calamospora breviradiata* sp. nov.
23. *C. hartungiana* Schopf, 1944
24. *C. straminea* Wilson and Kosanke, 1944
25. *Lycospora punctata* sp. nov.
26. *L. granulata* sp. nov.
27. *L. micropapillatus* (Wilson and Coe) S. W. and B., 1944
28. *Raistrickia irregularis* sp. nov.
29. *R. aculeolata* Wilson and Kosanke, 1944
30. *Florinites antiquus* Schopf, 1944

Laevigato-sporites, Lycospora, and *Calamospora* are the most abundant genera, and the presence of five species which appear to originate in this bed helps to characterize the Davis and Wiley coal beds.

Dekoven and Greenbush Coal Beds

The Dekoven coal bed of western Kentucky and southern Illinois was correlated by Wanless (1939) with the Greenbush coal bed of Warren County in western Illinois, a correlation corroborated by fossil plant spores. The Dekoven type locality is in Union County, Kentucky, and the bed was originally called the "3-foot coal" by Owen (1856). In 1857, he called the 3-foot coal the No. 6 coal bed of Kentucky. This coal bed was named the Dekoven coal bed by Lee (1916) for an opening at Dekoven. According to Lee (1916), the Dekoven coal at the type locality measured 44 inches in thickness but it generally did not exceed three feet elsewhere. This coal bed locally has been called the "Gas" coal since it has been used in the production of gas.

The Greenbush coal bed is named from an exposure in a ravine tributary to Swan Creek in the E. ½ sec. 24, T. 8 N., R. 1 W., Greenbush Township, Warren County, Illinois, and additional exposures are known from Fulton County, Illinois.

The following genera and species have been identified from the Dekoven coal bed, maceration 519 A-B, Williamson County, and Greenbush coal bed, maceration 592, Fulton County, unless otherwise noted:

1. *Punctati-sporites foveatus* sp. nov.
2. *P. fenestratus* sp. nov.
3. *P. firmus* (Loose) S. W. and B., 1944
4. *P. verrucifer* sp. nov.*
5. *Granulati-sporites aculeolatus* sp. nov.
6. *Alati-sporites hexalatus* sp. nov.
7. *Laevigato-sporites punctatus* sp. nov.
8. *L. ovalis* sp. nov.
9. *L. robustus* sp. nov.
10. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
11. *L. minutus* (Ibrahim) S. W. and B., 1944
12. *L. minimus* (Wilson and Coe) S. W. and B., 1944
13. *L. vulgaris* (Ibrahim) Ibrahim, 1933
14. *L. pseudothiessenii* sp. nov.
15. *Denso-sporites sphaerotriangularis* sp. nov.
16. *Cirratriradites maculatus* Wilson and Coe, 1940
17. *Triquitrites inusitatus* sp. nov.
18. *T. pulvinatus* sp. nov.
19. *T. protensus* sp. nov.
20. *T. arculatus* Wilson and Coe, 1940
21. *Calamospora breviradiata* sp. nov.
22. *C. straminea* Wilson and Kosanke, 1944
23. *C. hartungiana* Schopf, 1944
24. *Lycospora granulata* sp. nov.
25. *L. punctata* sp. nov.
26. *Florinites antiquus* Schopf, 1944

The Dekoven and Greenbush coal beds are readily differentiated from the coal beds below and above. *Laevigato-sporites, Triquitrites,* and *Lycospora* are the most abundant genera represented. *Triquitrites* reaches its maximum abundance, and *Laevigato-sporites pseudothiessenii* sp. nov. apparently originated at this time and is a dominant member of the flora throughout the Carbondale and early McLeansboro time.

Conclusion

Spores occur abundantly in the coal beds

* Observed only in Wiley coal bed.
** Observed only in Davis coal bed.

* Two specimens found only in the Dekoven coal bed.

of the Tradewater group and many guide fossils are present. Eighteen species of small spores appear restricted to the coal beds of this group. The genus *Densosporites* is not known to occur in coal beds of post-Tradewater age in Illinois. *Wilsonia* gen. nov. has not been seen in the coal beds examined of Tradewater age, but does occur in the older Carbondale and McLeansboro coal beds. The genera and species distribution is illustrated in chart 1 (in pocket).

CARBONDALE GROUP

The Carbondale group includes the strata from the base of the Palzo sandstone to the top of the Herrin No. 6 coal bed in southern Illinois, and from the base of the Isabel sandstone to the top of the Herrin No. 6 coal bed in western Illinois. The Carbondale group is thought to correlate with the middle third of the Des Moines series of the Midcontinent (Cooper, 1946), and with the Westphalian C of Europe. The thickness of the group does not exceed 400 feet according to Weller (1945), and in many places is much less. It is characterized by three persistent coal beds, the Nos. 2, 5, and 6 which are known to be present in southern, central, and northern Illinois. The distribution of the No. 4 coal bed is less extensive than these beds, and the 5-A coal bed is essentially restricted to southeastern Illinois.

In contrast to the Tradewater group, limestones are more prominent and there appears to be considerable similarity in the succession separating successive coal beds.

No. 2 Coal Bed

The type locality of the Colchester (No. 2) coal bed is at Colchester, T. 5 N., R. 4 W., McDonough County. The No. 2 coal bed in northern Illinois has been called the LaSalle No. 2, or Third Vein, coal bed. In southern Illinois, a thin, more or less indefinitely located coal bed above the Palzo sandstone has been correlated as the No. 2 coal bed by Wanless (1939) and by Weller and Wanless (1939).

The Colchester (No. 2) coal bed of western Illinois and LaSalle (No. 2) of northern Illinois are a continuous bed and the same spores are found in both areas. A coal bed 2 feet 8 inches thick from a diamond-drill core in Franklin County, sec. 27, T. 6 S., R. 2 E., at a depth of 789 feet is identified as the No. 2 coal bed on the basis of its spore content. The following is a generalized description of the coal beds and other strata encountered in the Carbondale group of this core:

	Depth		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Base of McLeansboro	638	10		
Top of Herrin (No. 6) coal bed	638	10		
5-A coal bed	665	5½	to 665	7½
Top of Harrisburg (No. 5) coal bed	685	0		
No. 4 coal bed (?)	766	10	to 767	8
No. 2 coal bed	789	0	to 791	8
Bone and shale	791	8	to 792	2
Pyrite lens	792	2	to 793	3
Underclay	793	3	to 794	11
Siltstone	794	11	to 802	0
Sandstone (Palzo ?, upper 28′ impure)	802	0	to 860	0
Gray shale	860	0	to 868	5
Black shale	868	5	to 870	6
Top of the Dekoven coal bed	870	6		

If the sandstone below coal No. 2 and above the Dekoven coal beds is the Palzo sandstone, the total thickness of the Carbondale strata in this drill hole is 221 feet 2 inches, since the base of Palzo sandstone is considered to be the base of the Carbondale group.

Another diamond-drill core from sec. 16, T. 6 S., R. 1 E., Franklin County, has a thin coal bed which has been identified by spores as the No. 2 coal bed. The following is a generalized description of the coal beds and other strata for a short distance above and below No. 2 coal bed:

	Depth		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Base of McLeansboro	562	5¼		
Top of Herrin (No. 6) coal bed	562	5¼		
Top of Harrisburg (No. 5) coal bed	613	0		
Coal horizon	683	9	to 674	1
Coal No. 4 (?)	702	0	to 704	6
Limestone, fossiliferous	778	6	to 779	4
Shale, fossiliferous	779	4	to 781	7
Limestone, fossiliferous	781	7	to 782	0

	Depth		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Coal bed No. 2	782	0	to 782	10
Underclay and clay	782	10	to 786	9
Limestone (underclay limestone)	786	9	to 789	9
Siltstone	789	9	to 791	½
Sandstone (corrected depth by marker)	792	6	to 793	6
Shale	793	6	to 810	0
Siltstone	810	0	to 815	5
Gray shale	815	8	to 818	0
Black shale	818	0	to 818	8
Top of Dekoven coal bed	818	8		

If the one-foot sandstone at 792 feet 6 inches represents the Palzo sandstone, the total thickness of the Carbondale strata in this drill hole is 231 feet.

The following genera and species have been identified from Fulton (maceration 603), Bureau (maceration 579), and Grundy (maceration 580, 611) counties in northern Illinois, and from Franklin County (maceration 536-G, 537-L) in southern Illinois unless otherwise noted:

1. *Punctati-sporites obliquus* sp. nov.
2. *P. verrucifer* sp. nov.*
3. *P. foveatus* sp. nov.
4. *P. quasiarcuatus* sp. nov.**
5. *P. reticuloides* sp. nov.
6. *Granulati-sporites convexus* sp. nov.
7. *G. pallidus* sp. nov.
8. *G. spinosus* sp. nov.
9. *Alati-sporites hexalatus* sp. nov.**
10. *A. trialatus* sp. nov.
11. *Laevigato-sporites ovalis* sp. nov.
12. *L. pseudothiessenii* sp. nov.
13. *L. punctatus* sp. nov.
14. *L. robustus* sp. nov.
15. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
16. *L. minimus* (Wilson and Coe) S. W. and B., 1944
17. *L. minutus* (Ibrahim) S. W. and B., 1944
18. *Cirratriradites annuliformis* sp. nov.
19. *C. annulatus* sp. nov.
20. *Endosporites ornatus* Wilson and Coe, 1940
21. *Triquitrites crassus* sp. nov.
22. *T. inusitatus* sp. nov.
23. *T. pulvinatus* sp. nov.
24. *T. arculatus* Wilson and Coe, 1940
25. *T. exiquus* Wilson and Kosanke, 1944*
26. *Calamospora breviradiata* sp. nov.
27. *C. flexilis* sp. nov.
28. *C. hartungiana* Schopf, 1944
29. *Lycospora brevijuga* sp. nov.
30. *L. punctata* sp. nov.
31. *L. granulata* sp. nov.
32. *Raistrickia crinita* sp. nov.
33. *R. crocea* sp. nov.
34. *R. irregularis* sp. nov.
35. *R. pilosa* sp. nov.
36. *R. rubida* sp. nov.
37. *R. aculeolatus* Wilson and Kosanke, 1944
38. *R. grovensis* Schopf, 1944
39. *Florinites antiquus* Schopf, 1944
40. *Schopfites dimorphus* sp. nov.
41. *S. colchesterensis* sp. nov.
42. *Wilsonia* sp.
43. *"Spherites"* sp.

* Not observed in northern Illinois No. 2 coal bed.
** Not observed in southern Illinois No. 2 coal bed.

The list of genera and species isolated from the No. 2 coal bed indicates an abundant and diversified flora. The publications of Noé, Janssen, and others describing the plant compressions in the ironstone nodules above the No. 2 coal bed in northern Illinois likewise record an abundant and diversified flora in post No. 2 time.

Statistical counts of the small spores isolated from the No. 2 coal bed show that *Lycospora* and *Laevigato-sporites* are dominant, and that *Calamospora* is next in numerical importance. Thirty-eight to 42 percent of the total spore content is distributed between three species of *Lycospora.* Twenty-seven to 33 percent of the total spore content is distributed between seven species of *Laevigato-sporites,* and 10 to 14 percent of the spore population is found in three species of *Calamospora.* The other 10 genera and 28 species comprise the remaining 11 to 25 percent of the spore content.

The diversified flora of No. 2 coal bed apparently consisted largely of three groups of plants represented by the three most abundant genera of small spores. This is probably true even though the spore output per plant of the lycopsids is thought to be rather high. The parent plant of *Laevigato-sporites* is unknown but it is reasonable to expect fructifications bearing spores of this type to be present in the ironstone concretions from the Francis Creek shale which lies above the No. 2 coal bed in northern Illinois.

Three samples were generally taken (top, middle, and bottom) from each collection of No. 2 coal bed, regardless of the thickness.

As stated, the No. 2 coal bed in western, northern, and southern Illinois has a similar spore content. It has also been noted that the thin No. 2 coal bed from southern Illinois contains essentially the same floral ele-

ments in approximately the same abundance as the thicker No. 2 coal bed from western and northern Illinois. The zonation of *Schopfites* in the lower portion of the bed and *Alati-sporites* in the upper third of the bed was observed in No. 2 coal bed in southern Illinois.

The floral development of No. 2 coal bed is of considerable interest because the bed is widespread, and therefore to account for the zonation of various genera significant changes must have occurred in the flora during the period of accumulation of the bed. The parent plants of the following genera of spores are considered as early invaders since they have been isolated from the bottom third of the bed:

1. *Punctati-sporites*
2. *Granulati-sporites*
3. *Laevigato-sporites*
4. *Cirratriradites*
5. *Endosporites*
6. *Triquitrites*
7. *Calamospora*
8. *Lycospora*
9. *Raistrickia*
10. *Florinites*
11. *Schopfites*
12. *Wilsonia*

The middle third of the bed contains the same genera listed above except that *Schopfites* is very rare and *Laevigato-sporites, Lycospora,* and *Punctati-sporites* have materially increased in abundance. The upper third of the bed apparently lacks *Schopfites,* and *Alati-sporites* appears to be restricted to this portion of the coal bed. *Laevigato-sporites* and *Calamospora* reach their maximum abundance but *Lycospora* is much less abundant than in the middle and lower thirds of the bed. The No. 2 coal bed is readily identified by plant spores as indicated by the following species which are restricted to this bed in the samples studied: *Punctati-sporites reticuloides* sp. nov., *Schopfites dimorphus* sp. nov., and *S. colchesterensis* sp. nov. In addition, nine species appear to originate or terminate their geological range with the No. 2 coal bed, and these are indicated on the genera and species list of the coal bed and in the spore distribution chart.

Summum (No. 4) Coal Bed

The Summum (No. 4) coal bed, near Summum, Illinois, according to Wanless (1939), is exposed in Woodland Township (T. 3 N., R. 2 E.), Fulton County. Here the No. 4 coal bed is overlain by a black shale which contains large calcareous concretions. In Greene and Jersey counties the No. 4 coal bed is overlain by black shale and the Hanover limestone (Wanless, 1939, Payne, 1942). Wanless (1939) believes the calcareous concretions in Fulton and Peoria counties are at the same position as the Hanover limestone. The coal bed below the Hanover limestone contains the same small spore population as the Summum (No. 4) coal bed, and the two beds are therefore correlated.

The Summum (No. 4) coal bed appears to be represented in southern Illinois by a coal bed in Williamson County lying below the Harrisburg (No. 5) bed. However, additional comparative studies of the No. 4 coal bed from both western and southern Illinois are necessary before a definite correlation is made. Abundance variations and genera and species zonations must be clearly understood before attempting to extend the known distribution of the bed.

The species content of this bed is small when compared with that of either No. 2 or No. 5 coal beds possibly because of the small number of samples examined.

The following genera and species have been identified from the No. 4 coal bed in Fulton and Jersey counties (macerations 541 and 463):

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. verrucifer* sp. nov.
4. *P. quaesitus* sp. nov.
5. *Granulati-sporites convexus* sp. nov.
6. *G. verrucosus* (Wilson and Coe) S. W. and B., 1944
7. *Laevigato-sporites pseudothiessenii* sp. nov.
8. *L. punctatus* sp. nov.
9. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
10. *L. minimus* (Wilson and Coe) S. W. and B., 1944
11. *L. minutus* (Ibrahim) S. W. and B., 1944
12. *Cirratriradites annuliformis* sp. nov.
13. *C. annulatus* sp. nov.
14. *Endosporites ornatus* Wilson and Coe, 1940
15. *Triquitrites pulvinatus* sp. nov.
16. *T. exiquus* Wilson and Kosanke, 1944
17. *Calamospora breviradiata* sp. nov.
18. *Lycospora granulata* sp. nov.

19. *L. punctata* sp. nov.
20. *Raistrickia crinita* sp. nov.
21. *R. crocea* sp. nov.
22. *Florinites antiquus* Schopf, 1944

Triquitrites exiquus Wilson and Kosanke, 1944, is not known to be present above this horizon in Illinois, and *Alati-sporites* has not been observed in the No. 4 coal bed although is known to be present in beds above and below. When *Alati-sporites* is present in a coal bed it has always been found in either the upper one-half to one-third of the bed. Its apparent absence in the No. 4 bed suggests that the swamp vegetation did not reach that stage of late floral development which is marked by the appearance of *Alati-sporites* in the upper part of other coal beds.

The dominant genus in the Summum coal bed is *Lycospora* followed closely by *Laevigato-sporites*. The remaining genera appear, on the basis of relative abundance, to be minor elements of the flora.

Harrisburg-Springfield (No. 5) Coal Bed

The Harrisburg (No. 5) coal bed (Cady, 1916) from southern Illinois has long been correlated with the Springfield (No. 5) coal bed (Worthen, 1883) from Sangamon County and western Illinois, a relationship which is substantiated by similarity in their small spore content. Arnold Brokaw[2] likewise correlated the Harrisburg and Springfield (No. 5) coal beds. Brokaw's results are included in the present discussion in addition to further information obtained by the author from additional coal samples.

The No. 5 coal bed is second in commercial importance in Illinois to the No. 6 coal bed, below which it occurs from 20 to 125 feet. In areas where either the No. 6 or 5 coal bed is missing, it is important to know which is present in constructing maps delineating the structure and distribution of the workable beds. The plant spores observed include guide fossils for the identification of the No. 5 coal bed.

The following genera and species have been isolated and identified from the above coal bed:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. verrucifer* sp. nov.
4. *P. quaesitus* sp. nov.
5. *Granulati-sporites convexus* sp. nov.
6. *G. spinosus* sp. nov.
7. *Alati-sporites inflatus* sp. nov.*
8. *A. trialatus* sp. nov.
9. *A. varius* sp. nov.
10. *Laevigato-sporites ovalis* sp. nov.
11. *L. pseudothiessenii* sp. nov.
12. *L. punctatus* sp. nov.
13. *L. robustus* sp. nov.
14. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
15. *L. minimus* (Wilson and Coe) S. W. and B., 1944
16. *L. minutus* (Ibrahim) S. W. and B., 1944
17. *L. vulgaris* (Ibrahim) Ibrahim, 1933
18. *Cirratriradites annuliformis* sp. nov.
19. *C. annulatus* sp. nov.
20. *Endosporites* sp.
21. *E. ornatus* Wilson and Coe, 1940
22. *Triquitrites pulvinatus* sp. nov.
23. *T.* sp.
24. *Calamospora breviradiata* sp. nov.
25. *C. hartungiana* Schopf, 1944
26. *C. multabilis* (Loose) S. W. and B., 1944
27. *C. flexilis* sp. nov.
28. *Lycospora punctata* sp. nov.
29. *L. granulata* sp. nov.
30. *Raistrickia crocea* sp. nov.
31. *R.* sp.
32. *Florinites* sp.
33. *Schopfites* sp.
34. *"Spherites"* sp.

Two species of *Alati-sporites* appear to be restricted to the No. 5 coal bed, *A. inflatus* sp. nov. and *A. varius* sp. nov. *A. trialatus* sp. nov., *Granulati-sporites convexus* sp. nov. and *Raistrickia crocea* sp. nov. have not been observed in coal beds above this horizon. All of these forms are guide fossils of this coal bed.

Alati-sporites reached its maximum abundance in Illinois at this time, but this abundance is most notable in western Illinois, where 10 percent of the total spore content consists of the genus. In southern Illinois *Alati-sporites* rarely exceeds three percent of the total spore content. It has not been observed in the lower third of the bed in either southern or western Illinois, and is present only rarely in the middle third of the bed. *Laevigato-sporites* is the dominant genus, since frequently 45 to 50 percent of the spore content is assigned to the genus. *Laevigato-sporites pseudothiessenii* sp. nov.

[2] An unpublished master's thesis on No. 5 coal bed which was worked out in conjunction with the Illinois Geological Survey and the Department of Geology, University of Illinois, 1942.

* Known only from the Springfield (No. 5) coal bed.

and *L. minutus* (Ibrahim) S. W. and B., 1944, are most comon and six other species of the genus are present. The genus *Lycospora* is next in numerical importance and its abundance varies from 20 to 30 percent. It may be somewhat more abundant in southern Illinois. *Calamospora, Cirratriradites,* and *Punctati-sporites* follow successively in line of numerical importance.

It is sometimes difficult to identify the No. 6 and 5 coal beds in portions of southern Illinois where only rotary logs are available for study. However when samples of coal from these rotary holes are available, it is possible to identify the beds. In the Engle-Waddle No. 1 well in Wabash County (fig. 6) the interval between No. 6 and No. 5 coal beds attains the somewhat unusual thickness of 125 feet; hence the base of the black shale representing the position of the No. 5-A bed about 65 feet below No. 6 bed would probably have been identified as the position of the No. 5 coal bed had not the identity of the No. 5 at 125 feet below the No. 6 been determined by means of fossil spores.

No. 5-A Coal Bed

Cady (1916, p. 45) recorded the presence of a coal bed in Williamson and Saline counties which stratigraphically was between the No. 5 and No. 6 coal beds. In 1919, Cady numbered this coal the 5-A bed and correlated it with the Briar Hill (Kentucky No. 10) coal bed. This coal bed is thin, and in some places divided by one or two shale partings.

The 5-A coal bed is readily differentiated from either the No. 5 or 6 coal beds, and most certainly differs from the Grape Creek coal bed of Vermilion County with which it has been correlated by Wanless (1939).

The following genera and species have been identified from the 5-A coal bed from Gallatin (maceration 633 A-B) and Franklin counties (maceration 507 A-B):

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. verrucifer* sp. nov.
4. *P. quaesitus* sp. nov.
5. *P.* sp.
6. *Granulati-sporites granularis* sp. nov.
7. *Laevigato-sporites ovalis* sp. nov.
8. *L. pseudothiessenii* sp. nov.
9. *L. punctatus* sp. nov.
10. *L. robustus* sp. nov.
11. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
12. *L. minutus* (Ibrahim) S. W. and B., 1944
13. *Triquitrites pulvinatus* sp. nov.
14. *Calamospora breviradiata* sp. nov.
15. *C. hartungiana* Schopf, 1944
16. *C.* sp.
17. *Lycospora punctata* sp. nov.
18. *L. granulata* sp. nov.
19. *Raistrickia protensa* sp. nov.
20. *R. crinita* sp. nov.
21. *R.* sp.
22. *Florinites* sp. Schopf, 1944
23. *Schopfites* sp.
24. Gen. Nov.*

Granulati-sporites granularis, Raistrickia protensa sp. nov., and the new form listed as a new genus on the genera and species list all are unknown from the coal beds below 5-A. *Schopfites* is not known to occur above this horizon.

No. 6 Coal Bed

The Herrin (No. 6) coal bed from Franklin and Fulton Counties in southern and western Illinois and the Grape Creek coal bed from Vermilion County in eastern Illinois are correlated as the same bed on the basis of their content of small spores. Samples from these three respective counties have been investigated as well as collections from various other counties.

The following genera and species have been identified from the No. 6 coal bed from each of the three counties mentioned above except as noted:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. triangularis* sp. nov.
4. *P. quaesitus* sp. nov.
5. *P.* sp.
6. *Granulati-sporites granularis* sp. nov.**
7. *Laevigato-sporites pseudothiessenii* sp. nov.
8. *L. punctatus* sp. nov.
9. *L. robustus* sp. nov.
10. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
11. *L. minimus* (Wilson and Coe) S. W. and B., 1944
12. *L. minutus* (Ibrahim) S. W. and B., 1944
13. *L. medius* sp. nov.
14. *Cirratriradites annuliformis* sp. nov.
15. *C. annulatus* sp. nov.
16. *Endosporites ornatus* Wilson and Coe, 1940

* A new genus of bladdered grains abundant in Iowa, which is being described by L. R. Wilson, is also present in Illinois.

** Has not been observed below the blue band.

17. *E.* sp.
18. *Triquitrites protensus* sp. nov.*
19. *T. pulvinatus* sp. nov.
20. *T. spinosus* Kosanke, 1943
21. *T.* sp.
22. *Calamospora breviradiata* sp. nov.
23. *C. hartungiana* Schopf, 1944
24. *C.* sp.
25. *Lycospora punctata* sp. nov.
26. *L. granulata* sp. nov.
27. *Raistrickia protensa* sp. nov.
28. *R. crinita* sp. nov.
29. *R. imbricata* sp. nov.
30. *R. aculeolata,* 1944**
31. *R. grovensis* Schopf, 1944
32. *Florinites* sp.
33. *Wilsonia delicata* sp. nov.
34. *"Spherites"* sp.
35. Gen. nov. (see 5-A coal bed)

The correlation of the Grape Creek coal bed with the Herrin (No. 6) coal bed is based upon the presence of the same genera at all localities investigated (Table 2). Although two species discrepancies are recorded, both are exceedingly rare. *Granulati-sporites* has not been found below the blue band in any of the coals examined, which is the only genus zonation observed. This is in contrast to the conspicuous zonation in both the No. 2 and No. 5 coal beds.

The No. 6 coal bed is readily identified and may be distinguished from the beds below and above it by its spore content. *Punctati-sporites triangularis* sp. nov., and *Wilsonia delicata* sp. nov. are known only from No. 6 and coal beds above. *Raistrickia protensa* sp. nov. and *R. grovensis* Schopf, 1944, are known only from No. 6 and coal beds below, while *R. imbricata* sp. nov. is known only from the No. 6 coal bed.

Genera distribution and abundance variations have been determined for the various benches of the coal bed (Table 2). *Laevigato-sporites* and *Lycospora* are of approximately equal dominance in Franklin and Vermilion counties with each genus comprising 30 to 35 percent of the total spore content, the two thus comprising 60 to 70 percent of the total population. In these two counties *Punctati-sporites* is next in numerical importance with approximately 13 percent for Franklin County and eight percent for Vermilion County. In Fulton County, from the type Brereton cyclothem exposure (maceration 524, 540) only the top four inches above the upper shale parting has *Laevigato-sporites* and *Lycospora* as the dominant genera, with 25 to 30 percent of the spore population recorded for each of the genera. However, *Punctati-sporites* comprises 20 to 25 percent of the total spore population. Below the upper four inches, *Punctati-sporites* is dominant and *Laevigato-sporites* and *Lycospora* are subdominant with 15 to 20 percent of the total population for each genus. Below the blue band, *Wilsonia* gen. nov. reaches a maximum abundance for the genus.

It is therefore possible that whereas the coal bed from three counties contains the same genera and, with minor exceptions, the same species, there exists a considerable variation in the abundance of the genera in Fulton County as contrasted to Franklin and Vermilion counties. This suggests that the No. 6 coal bed in Fulton County is derived more largely from the parent plants of *Punctati-sporites* than No. 6 coal bed in Franklin and Vermilion counties.

Laevigato-sporites pseudothiessenii sp. nov. is the most abundant species of the genus in Franklin and Vermilion counties and usually it comprises two-thirds to three-fourths of all the species of the genus. In Vermilion County it makes up 66 percent of the genus and 26 percent of all species counted. The proportions are somewhat higher in Franklin County. In Fulton County the proportions are entirely different since *L. pseudothiessenii* sp. nov. is not the most abundant species of the genus. It is only 14 percent of the species of *Laevigato-sporites* and is less than three percent of all the species counted. Both *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944, and *L. minutus* (Ibrahim) S. W. and B., 1944, exceed *L. pseudothiessenii* sp. nov. in abundance.

Lycospora granulata sp. nov. makes up over 90 percent of species of the genus and 36 percent of the total of all species in Vermilion County. It is somewhat less abundant in Franklin County where it is slightly exceeded in quantity by *L. pseudothiessenii* sp. nov. At the type Brereton cyclothem exposure in Fulton County *Lyco-*

* Has not been observed from Franklin County (Herrin).
** Has not been observed from Vermilion County (Grape Creek).

TABLE 2.—DISTRIBUTION AND ABUNDANCE OF GENERA IN NO. 6 COAL BED

In percentage of total specimens counted

Genera	I			II			III		
	A	B	C	A	B	C	A	B	C
Punctati-Sporites	9–10	8–9	30–35	8–9	15–20	40–45	5–6	10–15	20–25
Granulati-Sporites				½–1	½–1		2–3		½–1
Laevigato-Sporites	40–45	40–45	15–20	30–35	30–35	15–20	45–50	40–45	25–30
Cirratriradites	1–2	½–1	2–3	1–2	½–1	3–4	2–3	½–1	½–1
Endosporites			½–1	½–1			2–3	1–2	5–6
Triquitrites	3–4	½–1	2–3	1–2	1–2	3–4	5–6	½–1	½–1
Calamospora	3–4	2–3	6–7	4–5	5–6	9–10	2–3	4–5	9–10
Lycospora	35–40	40–45	15–20	45–50	40–45	15–20	25–30	30–35	25–30
Raistrickia	1–2		5–6	4–5	3–4	½–1	4–5	2–3	
Florinites					½–1		½–1		3–4
Wilsonia	½–1	½–1	10–15	½–1	½–1	½–1	½–1	½–1	½–1
"Spherites"		½–1			½–1	½–1	½–1		
Gen. Nov.		½–1		½–1			½–1		½–1

I. COAL BELOW THE BLUE BAND
II. COAL BETWEEN BLUE BAND AND UPPER SHALE PARTING
III. COAL ABOVE UPPER SHALE PARTING TO TOP OF BED

A. GRAPE CREEK NO. 6 COAL BED (eastern Illinois)
B. HERRIN NO. 6 COAL BED (southern Illinois)
C. HERRIN NO. 6 COAL BED (western Illinois)

spora-granulata sp. nov. comprises 69 percent of the genus, but only 14 percent of the total spore content. *Punctati-sporites obliquus* sp. nov. is the dominant species of the genus in all three counties mentioned in this discussion; however, it is less than three percent of the total spore content in Vermilion County, not more than five percent in Franklin County, whereas it is the dominant species in Fulton County where it is 29 percent of the spore content.

It appears from the foregoing that in the three areas under consideration there were differences in the relative abundance of various plants. Further studies in these three areas should help to establish the validity of the differences indicated by the studies.

The No. 6 coal bed ranks first in commercial importance in Illinois because of its thickness, quality, wide geographic distribution and favorable mining conditions. It is the uppermost member of the Carbondale group and is an excellent key bed in many counties of the State, partly because of its benched character and association with the Herrin limestone. A persistent parting, the blue band, is usually found in the lower portion of the bed although occasionally it is found as high as the middle of the bed. In addition to the blue band, one to three shale partings less widely distributed are known to be present.

The usual sequence of strata above the coal is gray shale, black shale, and limestone but the coal bed may be overlain by any one of these, and in some localities because of Pennsylvanian erosion and subsequent deposition, sandstone or siltstone rests directly upon the coal bed with the normal caprock, gray and black shale, being "cut out."

The strata below the coal bed usually contains a well developed underclay although this is locally replaced by shale, sandstone, or siltstone. In many places toward the base of the underclay limestone nodules appear locally representing a transition zone which may develop into an underclay limestone. The underclay limestone is usually non-fossiliferous, but the core of a drill-hole located near the center of the SE. ¼ sec. 4, T. 4 S., R. 1 E., Jefferson County, contained marine fossils at the base of limestone. In southern Illinois the underclay limestone may locally be absent.

It is apparent from the discussion preceding (see also fig. 6) that the strata adjacent to the No. 6 coal bed are somewhat variable. Variations of the sort mentioned may in some instances result in uncertainty in the identification of a coal bed when made

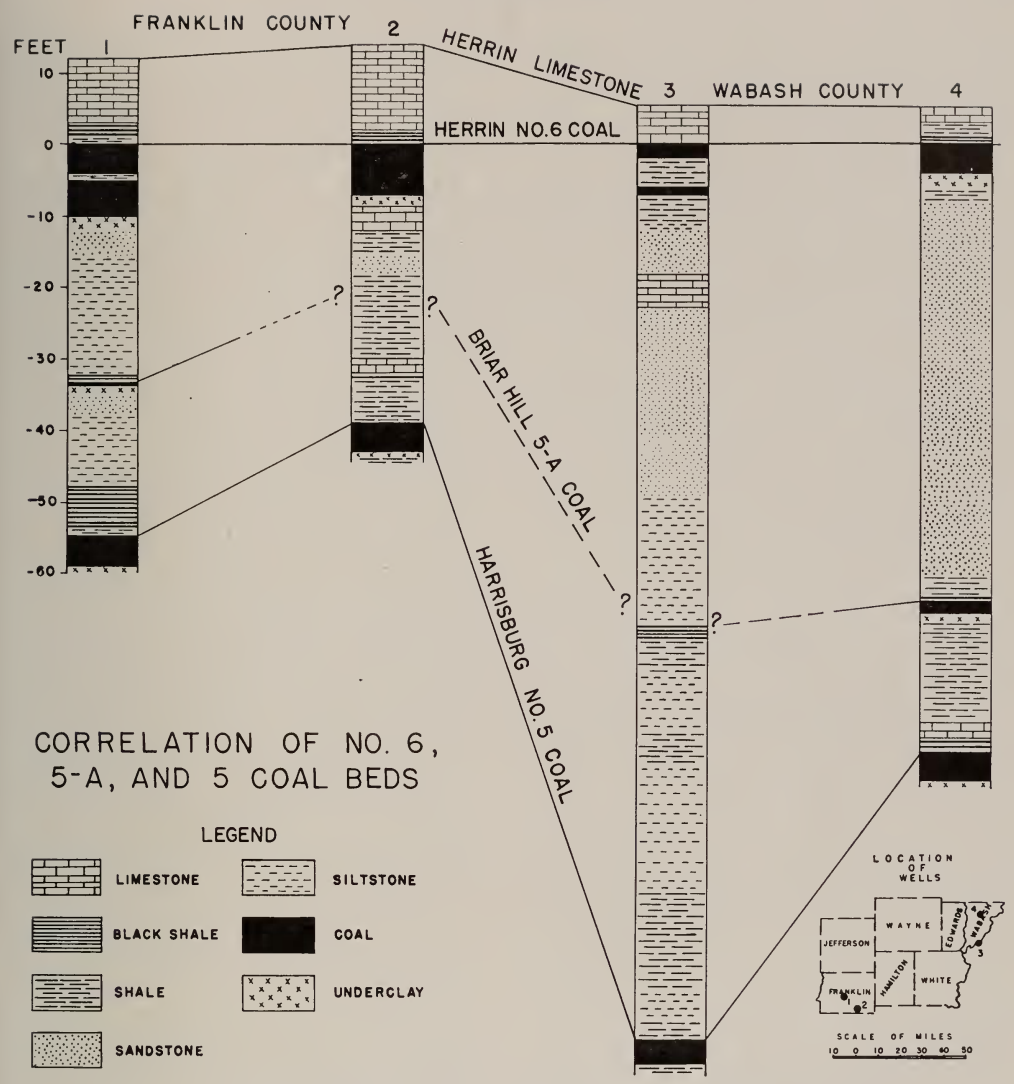

Fig. 6.—Correlation of coal beds with the aid of spores from rotary-drill samples.

by non-biologic means, even in areas where the structure is well established by core drilling and mining operations. However, these variations in the succession of strata materially increase in importance in less well drilled areas.

A correlation chart (fig. 6) has been prepared on the basis of the identification of Nos. 6, 5-A, and 5 coal beds by spores obtained from rotary drill-hole cuttings in Wabash and Franklin counties for a comparison of the strata in these two counties from a short distance above the top of the Carbondale group to a position a short distance below the No. 5 coal bed. There is a considerable difference in the succession and the usefulness of spores for purposes of identification of the coal beds.

Conclusions

The coal beds of the Carbondale group can be differentiated from each other and from the coal beds of the older Tradewater and younger McLeansboro groups by means of their spore population. There are 13 genera and 56 species of spores present in the coal beds investigated. In addition, there are two new genera and several new

species which are represented by a few specimens. These have not been described, but the new genera are to be described by another author from an area where more abundant specimens have been found. Ten species are restricted to the five coal beds of this group and 21 species either originate or terminate their geologic range in the Carbondale group.

McLEANSBORO GROUP

The term McLeansboro was first applied by DeWolf (1910) as a formational name for rocks which overlie No. 6 coal bed in Illinois. Jon A. Udden's description (1906) of the cores of the borings at Delafield and Elm Grove in Hamilton County was used as representative of the McLeansboro succession. Weller (1940) raised the McLeansboro formation to the rank of a group and introduced new formational units on a cyclothem basis.

The McLeansboro formation according to DeWolf included all Pennsylvanian strata above No. 6 coal bed. Spore studies, on the other hand, provide evidence in agreement with that produced by Dunbar and Henbest (1942) that there was a major change in fauna and flora shortly after the beginning of McLeansboro deposition but prior to accumulation of the Trivoli (No. 8) coal bed. Evidence indicates that the Carbondale group should extend beyond the position of the present conventional upper boundary, at the top of No. 6 coal bed, to the position of the paleontologic change. The Carbondale-McLeansboro boundary at such a position would conform essentially to the Des Moines-Missouri boundary of the Midcontinent region. This matter is discussed further in comments on the plant spores of the No. 8 coal bed.

The maximum thickness of McLeansboro strata appears to be more than 1200 feet in central and eastern Illinois (Weller, 1945). These strata are believed to be equivalent to the upper third of the Des Moines series, all of the Missouri, and possibly a portion of the Virgil series of the Midcontinent region, also to the upper Allegheny and all of the Conemaugh of eastern United States and possibly to the Westphalian D and lower Stephanian of Europe.

The McLeansboro group contains numerous prominent marine limestones, many thin and more or less lenticular coal beds, a predominant amount of shale, siltstone, and sandstone strata. In the shale beds particularly there are numerous layers of well preserved (not fragmentary) plant compression fossils. Conglomerates and variegated shale beds, although of local occurrence and not prominent members of the McLeansboro sediments, have fairly definite stratigraphic positions and geographic distribution.

Cooper (1946, p. 27) remarks: "As indicated in the stratigraphic summary the correlation of Illinois coal beds above the Shoal Creek limestone with those of the Midcontinent are uncertain and those indicated on the chart (fig. 2) are tentative and approximate, based on the analysis of the ostracode faunas that have been studied to date." Certainty of correlation and the sequence of the coal beds based on spore studies above the Shoal Creek are in doubt because the coal beds are lenticular, making it necessary to study numerous samples in order to include all of the coal beds that would be present in a composite section. While many coal beds have been studied, our information is still believed to be incomplete. Therefore, the sequence of beds for this portion of the McLeansboro section is regarded as tentative and subject to change in the light of additional information. The coal beds which have been studied contain many guide fossils indicating rapid changes in the plant life. These guide fossils are essential if it is going to be possible to correlate the coal beds of this section. Present indications suggest that the fossil spores promise to play an important role in the solution of the many correlation problems of the upper McLeansboro section in Illinois.

Jamestown Coal Bed

The Jamestown coal bed lies between the Herrin and the Jamestown limestones.

Samples of this coal bed that have been examined are from the NW. ¼ NW. ¼ NE. ¼ sec. 7, T. 6 S., R. 2 W., Perry County, SW. ¼ SW. ¼ SE. ¼ sec. 33, T. 1 S., R. 7 W., St. Clair County, and NW. ¼ SW. ¼ NW. ¼ sec. 30, T. 9 S., R. 5 E., Saline County.

A section compiled by Cady[3] of the Perry County exposure records the Jamestown limestone as ½ inch thick, fossiliferous, with a light gray soft shale above it. Between the limestone and the Jamestown coal, there are eight inches of soft shale which is carbonaceous toward the base. The coal bed is six inches thick and is underlain by 48 inches of shale with a few limestone concretions at the base. Below this bed, there are 24 inches of limestone lenses interbedded with shale, and the Herrin limestone lies below. The sample from St. Clair County is from the United Electric Red Ray strip mine, sec. 33, T. 1 S., R. 7 W. The coal bed is three to four inches thick with a lenticular pyrite parting ½ inch from the top. Field notes by Cady and Spotti record ½ inch of carbonaceous shale above the coal bed and below the Jamestown limestone which is one foot thick. The Saline County samples are from an Illinois Central Railroad cut along the Edgewood-Vienna branch, sec. 30, T. 9 S., R. 5 E.

The spore content of the Jamestown coal bed is apparently characterized by few species, but eight genera have been identified, which suggests some diversity of floral elements. The following genera and species have been observed in the coal bed:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. quaesitus* sp. nov.
3. *P. sulcatus* Wilson and Kosanke, 1944
4. *Granulati-sporites* sp.
5. *Laevigato-sporites pseudothiessenii* sp. nov.
6. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
7. *L. minutus* (Ibrahim) S. W. and B., 1944
8. *Endosporites ornatus* Wilson and Coe, 1940
9. *Triquitrites spinosus* Kosanke, 1943
10. *Calamospora breviradiata* sp. nov.
11. *C. hartungiana* Schopf, 1944
12. *Lycospora granulata* sp. nov.
13. *L. punctata* sp. nov.
14. *L. parva* sp. nov.
15. *Raistrickia crinita* sp. nov.

[3] Field Notes.

A variation was noted in the abundance of genera across the southern part of Illinois from St. Clair County on the southwestern side to Saline County on the southeastern side. *Punctati-sporites* and *Laevigato-sporites* are more abundant in Saline County but *Calamospora* and *Lycospora* are more abundant in St. Clair County. Numerically, *Lycospora* is the most abundant genus, averaging 33 to 36 percent of the total spore population. *L. granulata* sp. nov. is the most abundant species. *Laevigato-sporites* is next in abundance and *L. minutus* (Ibrahim) S. W. and B., 1944, and *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944, share approximately 20 to 23 percent of the 25 percent recorded for the genus. *L. pseudothiessenii* sp. nov. is rare, in contrast to the No. 6 coal bed, the first coal bed below the Jamestown. *Punctati-sporites* and *Calamospora* average 18 to 20 to 15 to 18 percent of the total spore population respectively. The remaining genera and species are minor elements of the spore population numerically.

Bankston Coal Bed

The Bankston coal bed is exposed near Bankston at the roadside east of the Allensy crossing of the Illinois Central Railroad in the NE. ¼ NE. ¼ sec. 24, T. 9 S., R. 4 E., Williamson County. The coal bed lies several feet above the Bankston Fork limestone, and is badly weathered. Spores were extracted from the coal, but only after several attempted macerations. The coal had been oxidized by weathering so that the acid oxidation phase of the maceration process was unnecessary.

The Bankston coal bed has been identified in several diamond-drill cores from Franklin County. Samples of two cores of this coal bed from Franklin were macerated (maceration 536 E, from a drill-hole in SE. ¼ NW. ¼ NE. ¼ sec. 16, T. 6 S., R. 1 E., and maceration 537 F, from a drill-hole in SE. ¼ NW. ¼ SE. ¼ sec. 27, T. 6 S., R. 2 E.).

The following genera and species have been identified from the Bankston coal bed at the discovery locality and from the diamond-drill holes mentioned above:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. orbicularis* sp. nov.
3. *P. obliquus* sp. nov.
4. *P. quaesitus* sp. nov.
5. *P. latigranifer* (Loose) S. W. and B., 1944
6. *Laevigato-sporites latus* sp. nov.
7. *L. ovalis* sp. nov.
8. *L. pseudothiessenii* sp. nov.
9. *L. punctatus* sp. nov.
10. *L. robustus* sp. nov.
11. *L. minutus* (Ibrahim) S. W. and B., 1944
12. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
13. *Cirratriradites annuliformis* sp. nov.
14. *Endosporites ornatus* Wilson and Coe, 1940
15. *Triquitrites protensus* sp. nov.
16. *T. pulvinatus* sp. nov.
17. *T. spinosus* Kosanke, 1943
18. *Calamospora breviradiata* sp. nov.
19. *C. pedata* sp. nov.
20. *C. mutabilis* (Loose) S. W. and B., 1944
21. *Lycospora granulata* sp. nov.
22. *L. punctata* sp. nov.
23. *L.* sp.
24. *Wilsonia delicata* sp. nov.
25. Gen. Nov. (see 5-A coal bed)

The most abundant species is *Lycospora punctata* sp. nov. which comprised 25-28 percent of the total spore content. The genus *Lycospora* is the most abundantly represented genus making up 35 to 36 percent of the total spore content. *Punctati-sporites* is next in numerical importance with 20 to 21 percent of the total spore population. *P. latigranifer* is the most abundant species; it averages about 19 percent of the total spore population. *Calamospora* represents 16 to 18 percent of the spore population and *C. mutabilis* (Loose) S. W. and B., 1944, is most important with 13 to 14 percent. *Laevigato-sporites* represents 14 to 15 percent and *L. minutus* (Ibrahim) S. W. and B., 1944, is the most abundant species with 9 to 10 percent of the spore population. *L. pseudothiessenii* sp. nov. is exceedingly rare, in contrast with its abundance in No. 6 and the Cutler coal. *Punctati-sporites orbicularis* sp. nov. and *P. latigranifer* (Loose) S. W. and B., 1944, are not known to occur below this bed.

Cutler Coal Bed

The name Cutler was applied by Bell, Ball, and McCabe (1931) to a coal bed exposed in the vicinity of Cutler, Perry County, Illinois. Stratigraphically the Cutler coal bed occupies part of the succession between the Cutler limestone above and the Galum limestone below in the vicinity of Cutler. In some places in southern Illinois, as in Franklin County, the Bankston coal bed lies a few feet below the Cutler bed. A sample of the Cutler coal bed from the SW. ¼ SW. ¼ sec. 34, T. 5 S., R. 4 W., Perry County, Illinois, has been macerated and the spores identified. A coal bed commonly encountered in diamond drilling in Franklin County lies at the position of the Cutler coal bed of Perry County. Three such cores of this bed from Franklin County have been examined for spores: maceration 536-D, 458 feet 2 inches to 460 feet 9½ inches, SE. ¼ NW. ¼ sec. 16, T. 6 S., R. 1 E.; maceration 537-E, 518 feet 8 inches to 520 feet 9½ inches, SE. ¼ NW. ¼ SE. ¼ sec. 27, T. 6 S., R. 2 E.; and maceration 553-D, 426 to 427 feet, SW. ¼ NW. ¼ sec. 6, T. 7 S., R. 3 E.

The Cutler coal bed is commonly the thickest McLeansboro coal bed in Franklin County, but the bed is variable in thickness, ranging from less than 1 to slightly less than 3 feet. The coal bed is composed of normal bright banded coal and is not benched by shale or clay partings. However, lenses of pyrite have been observed.

The following genera and species have been observed in Perry and Franklin counties unless otherwise noted:

1. *Punctati-sporites triangularis* sp. nov.
2. *P. orbicularis* sp. nov.
3. P. sp.*
4. *P. latigranifer* (Loose) S. W. and B., 1944
5. *Granulati-sporites granularis* sp. nov.
6. *G.* sp.
7. *Laevigato-sporites pseudothiessenii* sp. nov.
8. *L. punctatus* sp. nov.
9. *L. minutus* (Ibrahim) S. W. and B., 1944
10. *L. ovalis* sp. nov.
11. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
12. *L. robustus* sp. nov.
13. *Cirratriradites annuliformis* sp. nov.**
14. *Endosporites ornatus* Wilson and Coe, 1940
15. *Triquitrites spinosus* Kosanke, 1943
16. *T. pulvinatus* sp. nov.
17. *T.* sp.
18. *Calamospora breviradiata* sp. nov.
19. *C. hartungiana* Schopf, 1944
20. *Lycospora parva* sp. nov.

* Not observed in Perry County sample.
** Not observed in maceration 553-D.

21. *L. granulata* sp. nov.
22. *L. punctata* sp. nov.
23. *Raistrickia crinita* sp. nov.
24. *R. pilosa* sp. nov.*
25. *"Spherites"* sp.
26. Gen. nov. (see 5-A coal bed)*

The dominant genus is *Lycospora,* and *L. parva* sp. nov. is the most abundant species. This species usually represents about 40 percent of the total spore content. *L. granulata* sp. nov. and *L. punctata* sp. nov. are somewhat variable in abundance but always represent five to 10 percent of the total spore population each. Thus *Lycospora* represents 50 to 60 percent of the total spore population. The two coal bed cores, macerations 536-D and 537-E, were divided equally into four samples each. Separate macerations of each of the samples revealed that *Lycospora* is dominant throughout the entire bed. *Laevigato-sporites* represents 28 to 33 percent of the total spore population, and when considering the bed as a whole *L. pseudothiessenii* sp. nov. is the most abundant species for it represents 16 percent of the total spore population. However, this abundance is restricted to the upper half of the bed in macerations 536-D and 537-E. The upper half of the bed contains 26 to 27 percent of *L. pseudothiessenii* sp. nov. but the bottom half contains only five to seven percent of the total spore population and *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944, *L. minutus* (Ibrahim) S. W. and B., 1944, and *L. punctatus* sp. nov. become important numerically. In a diamond-drill core from Franklin County, maceration 553-D, the Cutler coal bed is only one foot thick. It contained 28 percent *L. pseudothiessenii* sp. nov. and this suggests the possibility that only the upper half of the coal bed is present. The only evidence of genus zonation is the restriction of *Cirratriradites* to the lower three-fourths of the bed. This further suggests that only the upper portion of the Cutler coal bed is present in maceration 553-D since *Cirratriradites* appears to be lacking.

The remainder of the spore population is of minor numerical importance when considering the coal bed as a whole, except that *Punctati-sporites* represents six to seven percent of the spore population and *Calamospora* three to five percent.

* Not observed in Perry County sample.

Danville (No. 7) Coal Bed

The No. 7 coal bed is the lowermost coal bed of the McLeansboro group in Vermilion County, and is believed to be absent in southern Illinois by Wanless (1939) and Weller and Wanless (1939). Cady (1942, p. 10) suggests that the Cutler coal bed of southern Illinois may be equivalent to the Danville (No. 7) coal bed.

One of the following coal beds in southern Illinois may be the equivalent of Danville No. 7 coal bed: Jamestown, Bankston, Cutler, and even the first Cutler-rider coal bed. Genera and many species discrepancies exist between the spores of the No. 7 coal bed and those of the Jamestown and of the Bankston coal beds. Furthermore, the rarity of *Laevigato-sporites pseudothiessenii* sp. nov. in these two beds from southern Illinois contrasts markedly with its prominence in the No. 7 bed. The Cutler coal bed appears to lack the genus *Wilsonia* gen. nov., but only one specimen of this genus has been isolated in the No. 7 bed. Species discrepancies are more numerous, particularly species of minor numerical importance. Genera and species of numerical importance in the two beds are essentially identical. The first Cutler-rider coal bed has two genera discrepancies of minor numerical importance and many species discrepancies. The dominant genus is *Laevigato-sporites* as contrasted to *Lycospora* in the No. 7 and Cutler beds. The evidence seems to indicate the equivalence of the Cutler coal bed and No. 7 bed of the Danville district.

Two column samples and one random sample of the Danville (No. 7) coal bed from Vermilion County (macerations 514, 590 A-D, and 591 A-D) contained the following genera and species:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. orbicularis* sp. nov.
4. *P. triangularis* sp. nov.
5. *P. latigranifer* (Loose) S. W. and B., 1944
6. *P.* sp.
7. *Granulati-sporites commissuralis* sp. nov.
8. *G. verrucosus* (Wilson and Coe) S. W. and B., 1944

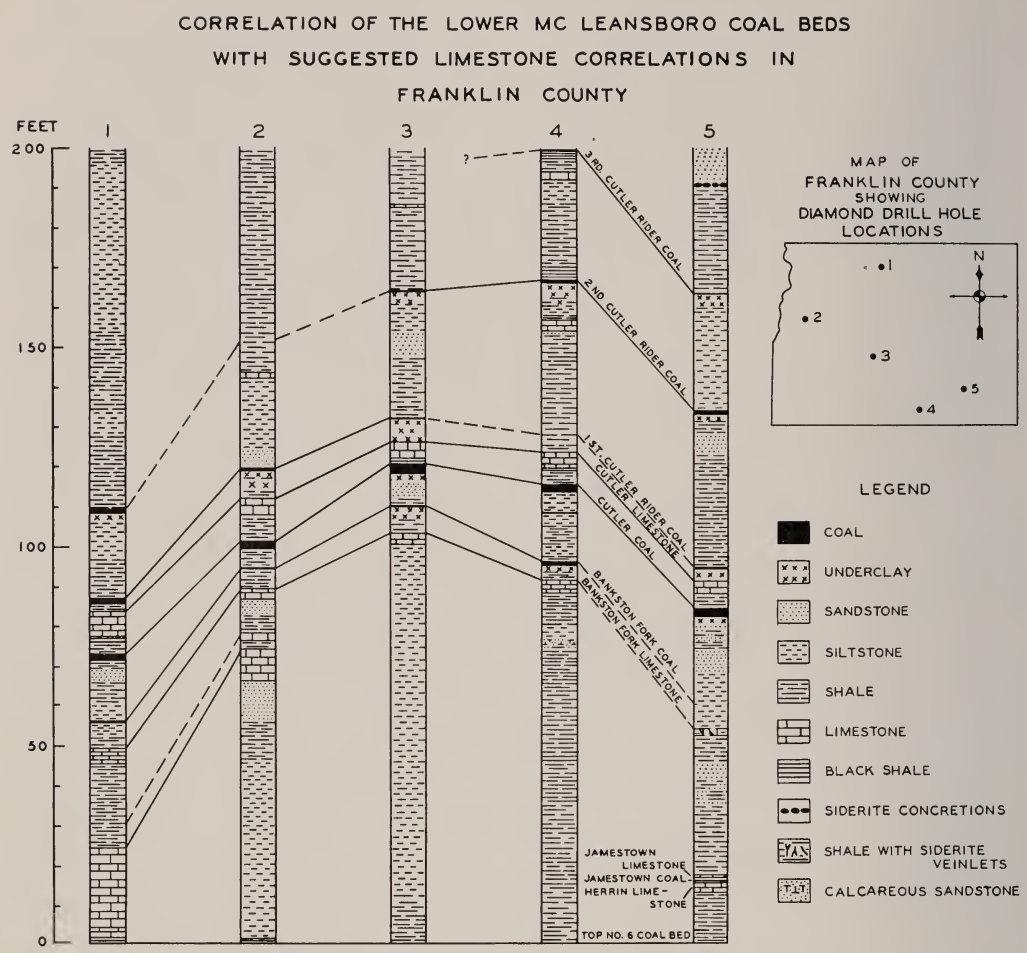

FIG. 7.—Correlation by plant spores of lower McLeansboro coal beds.

9. *Laevigato-sporites ovalis* sp. nov.
10. *L. pseudothiessenii* sp. nov.
11. *L. punctatus* sp. nov.
12. *L. minutus* (Ibrahim) S. W. and B., 1944
13. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
14. *Cirratriradites annuliformis* sp. nov.
15. *Endosporites ornatus* Wilson and Coe, 1940
16. *Triquitrites spinosus* Kosanke, 1943
17. *Calamospora breviradiata* sp. nov.
18. *Lycospora parva* sp. nov.
19. *L. granulata* sp. nov.
20. *L. punctata* sp. nov.
21. *Raistrickia crinita* sp. nov.
22. *R. pilosa* sp. nov.
23. *"Spherites"* sp.
24. *Wilsonia delicata* sp. nov.
25. Gen. Nov. (see 5-A coal bed)

The dominant genus is *Lycospora* with 55 to 57 percent of the spore population. *L. parva* sp. nov., and *L. granulata* sp. nov., and *L. punctata* sp. nov. represent 30, 15, and 10 to 12 percent of the spore population respectively. *Laevigato-sporites,* with 23 to 26 percent of the spore population, is next in numerical importance. *Laevigato-sporites pseudothiessenii* sp. nov. and *L. minutus* (Ibrahim) S. W. and B., 1944, represent 14 to 16 and 9 to 10 percent of the spore population respectively, while the remaining species of the genus are rare. *Punctati-sporites* represents 10 to 12 percent of the spore population and only *P. triangularis* sp. nov. is important numerically with six to eight percent.

The Cutler-rider Coal Beds

There are three thin coal beds within 90 feet above the Cutler limestone in Franklin, Williamson, and Saline counties (fig. 7). The presence of all three of these coal beds in a single diamond-drill core is rare except in T. 7 S. and 8 S., R. 3 and 4 E.

These three coal beds, each usually less than 1 foot thick, have been known from drilling records for some time. The beds are lenticular and the identity of any one or two coal beds when less than three are present may be uncertain. Plant spores have provided a means of identifying these beds and since they are otherwise unnamed they are tentatively referred to as the 1st, 2nd, and 3rd Cutler-rider coal beds respectively in order above the Cutler limestone (fig. 7).

The 1st Cutler-rider coal bed, observed by Bell, Ball, and McCabe (1931) along Galum Creek, Perry County, Illinois, but not named, usually lies one to 10 feet above the Cutler limestone. It usually is overlain by black or gray shale although occasionally by a thin sandstone which in turn is overlain by shale. The underclay is well developed and ranges in thickness from one to six feet.

The 2nd Cutler-rider coal bed lies at an interval of from 30 to 56 feet above the Cutler limestone. This coal bed is usually associated with black shale, with gray shale intervening between the black shale and coal bed in some places. The underclay is well developed being one to four feet thick, with underclay limestone commonly present.

The 3rd Cutler-rider coal bed, which is very thin, lies 62 to 90 feet above the Cutler limestone. The coal is capped by gray to dark gray shale. The underclay is poorly developed in contrast to the 1st and 2nd Cutler-rider coal beds. Where present the underclay is thin, and where absent the coal overlies gray shale.

The 1st and 2nd Cutler-rider coal beds are probably represented by two coal beds exposed along the Illinois Central Railroad cut in sec. 24, T. 9 S., R. 4 E., Williamson County.

The following genera and species have been identified from the 1st Cutler-rider coal bed in each of the diamond-drill cores illustrated in fig. 7:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. quaesitus* sp. nov.
4. *P. triangularis* sp. nov.
5. *P.* sp.
6. *Granulati-sporites verrucosus* (Wilson and Coe) S. W. and B., 1944
7. *G.* sp.
8. *Laevigato-sporites ovalis* sp. nov.
9. *L. punctatus* sp. nov.
10. *L. pseudothiessenii* sp. nov.
11. *L. robustus* sp. nov.
12. *L. minutus* (Ibrahim) S. W. and B., 1944
13. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
14. *Cirratriradites annuliformis* sp. nov.
15. *Endosporites ornatus* Wilson and Coe, 1940
16. *Triquitrites protensus* sp. nov.
17. *Calamospora breviradiata* sp. nov.
18. *C. liquida* sp. nov.
19. *C. hartungiana* Schopf, 1944
20. *C.* sp.
21. *Lycospora granulata* sp. nov.
22. *L. parva* sp. nov.
23. *L. punctata* sp. nov.
24. *Raistrickia crinita* sp. nov.
25. *Wilsonia* sp.

A new species of *Triquitrites* with a distinctive reticulate spore coat was observed in maceration 353-C, Franklin County, but because of its single occurrence it has not been described. The most abundant species is *Laevigato-sporites minutus* (Ibrahim) S. W. and B., 1944, which comprises 20 to 23 percent of the total spore population and *L. pseudothiessenii* sp. nov. is next in numerical importance with 14 to 15 percent. The genus *Laevigato-sporites* contains 40 to 43 percent of the spore population and *Lycospora* is next numerically with 15 to 20 percent. *L. punctata* sp. nov. and *L. parva* sp. nov. represent 9 to 10 percent and seven to nine percent respectively but *L. granulata* sp. nov. is rare. *Endosporites ornatus* Wilson and Coe, 1940, represents nine to 11 percent of the spore population and the remaining genera and species are of minor numerical importance.

The following genera and species have been observed from all of the 2nd Cutler-rider coal beds examined from Franklin County:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. orbicularis* sp. nov.
4. *P. latigranifer* (Loose) S. W. and B., 1944
5. *Laevigato-sporites ovalis* sp. nov.
6. *L. pseudothiessenii* sp. nov.
7. *L. robustus* sp. nov.
8. *L. minutus* (Ibrahim) S. W. and B., 1944
9. *L. vulgaris* (Ibrahim) Ibrahim, 1933
10. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
11. *Cirratriradites annuliformis* sp. nov.
12. *Endosporites ornatus* Wilson and Coe, 1940

13. *Triquitrites spinosus* Kosanke, 1943
14. *T.* sp.
15. *Calamospora breviradiata* sp. nov.
16. *Lycospora granulata* sp. nov.
17. *L. parva* sp. nov.
18. *L. punctata* sp. nov.
19. *Raistrickia aculeata* sp. nov.
20. *R. crinita* sp. nov.
21. *Wilsonia vesicatus* sp. nov.
22. *"Spherites"* sp.
23. Gen. Nov. (see 5-A coal bed)

Laevigato-sporites is numerically the most important genus since 54 to 57 percent of the total spore content is ascribed to the genus. *L. minutus* (Ibrahim) S. W. and B., 1944, and *L. pseudothiessenii* sp. nov. represent 31 and 21 percent respectively whereas the remaining species of the genus are rather rare. Species of *Lycospora* represent 32 percent of the spore population with *L. granulata* sp. nov., *L. parva* sp. nov., and *L. punctata* sp. nov. representing 16, 13, and 3 percent respectively. The remainder of the genera and species are of minor numerical importance.

Although this coal bed is not definitely identified outside the Franklin County area it may be equivalent to the Scottville coal bed of Payne (1942). The reason for suspecting equivalence of these two beds is that the lowest range of *Wilsonia vesicatus* sp. nov. and the highest range of gen. nov. (see 5-A coal bed species list) is known in both of these beds.

The following genera and species have been identified from the 3rd Cutler-rider coal bed, macerations 693-C and 545-A, from Franklin County:

1. *Punctati-sporites fenestratus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. orbicularis* sp. nov.
4. *P. latigranifer* (Loose) S. W. and B., 1944
5. *Laevigato-sporites latus* sp. nov.
6. *L. ovalis* sp. nov.
7. *L. punctatus* sp. nov.
8. *L. minutus* (Ibrahim) S. W. and B., 1944
9. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
10. *Endosporites formosus* sp. nov.
11. *E. plicatus* sp. nov.
12. *E. vesicatus* sp. nov.
13. *Triquitrites pulvinatus* sp. nov.
14. *Calamospora breviradiata* sp. nov.
15. *C.* sp.
16. *Florinites* sp.
17. *Wilsonia vesicatus* sp. nov.

Endosporites is the dominant genus for the first time in the Pennsylvanian of Illinois with 45 percent of the spore content belonging to the genus. *E. formosus* sp. nov. and *E. plicatus* sp. nov. and *E. vesicatus* sp. nov. represent 41 and three and one percent respectively of the spore population. *Laevigato-sporites* contains 25 percent of the spore population with *L. minutus* (Ibrahim) S. W. and B., 1944, *L. ovalis.* sp. nov., *L. punctatus* sp. nov. representing 10, seven and five percent respectively, while *L. latus* sp. nov. and *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944, are rare. *Punctati-sporites orbicularis* sp. nov. represents 13 percent of the spore population and the remaining species of the genus represent five percent. Species of *Calamospora* represent seven percent of the spore population.

The absence of *Laevigato-sporites pseudothiessenii* sp. nov. from this coal bed indicates that the 2nd Cutler-rider coal bed is the upper limit of the species. *Lycospora* is likewise missing, indicating that the 3rd Cutler-rider coal bed lies above the Scottville and below the No. 8 coal beds.

Scottville Coal Bed[4]

The coal bed called the Scottville coal bed by Payne (1942) lies 35 feet 6 inches below the Scottville limestone in the SW. ¼ NW. ¼ NW. ¼ sec. 16, T. 12 N., R. 9 W., Macoupin County.

The coal bed is characterized by an abundance of *Lycospora* with *L. granulata* sp. nov. and *L. parva* sp. nov., and *L. punctata* sp. nov. comprising 20, 20, and 10 percent of the total spore population respectively. The genus *Laevigato-sporites* contains 36 to 43 percent of the total spore population and *L. pseudothiessenii* sp. nov. represents 23 to 25 percent of this total. *L. medius* sp. nov. contains five to six percent of the total spore population and *L. minutus* (Ibrahim) S. W. and B., 1944, eight to 10 percent while *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944, and *L. latus* sp. nov. are minor elements insofar as abundance is concerned. This is the highest stratigraphic position in which *L. pseudothiessenii* sp. nov. is an important component of the spore population. It is note-

[4] In an earlier publication (1947) the author used the name First coal bed below the Scottville as suggested by Ball in a manuscript on the Geology of the Carlinville quadrangle. Payne's original name is used in this report.

worthy that *Punctati-sporites* is uncommon, which is in direct contrast to its abundance in the very thin Upper Scottville coal bed about 30 feet higher in the section.

The following genera and species have been observed in the Scottville coal bed (maceration 578):

1. *Punctati-sporites* sp.
2. *Granulati-sporites granulatus* Ibrahim, 1933
3. *G.* sp.
4. *Laevigato-sporites latus* sp. nov.
5. *L. pseudothiessenii* sp. nov.
6. *L. medius* sp. nov.
7. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
8. *L. minutus* (Ibrahim) S. W. and B., 1944
9. *Cirratriradites annuliformis* sp. nov.
10. *Endosporites plicatus* sp. nov.
11. *Triquitrites spinosus* Kosanke, 1943
12. *Calamospora breviradiata* sp. nov.
13. *Lycospora punctata* sp. nov.
14. *L. granulata* sp. nov.
15. *L. parva* sp. nov.
16. *Raistrickia* sp.
17. *Wilsonia vesicatus* sp. nov.
18. *"Spherites"* sp.
19. Gen. nov. (see 5-A coal bed)

Upper Scottville Coal Bed[5]

The Upper Scottville coal bed, a lenticular 1 to 2 inch bed, is exposed in the SE. ¼ NW. ¼ SW. ¼ sec. 16, T. 12 N., R. 9 W., Macoupin County, about 5 feet 6 inches below the Scottville limestone. This thin coal bed has great correlative significance because two specimens of *Lycospora granulatus* sp. nov. and one of *Laevigato-sporites pseudothiessenii* sp. nov. were observed. This coal bed is the highest stratigraphic position known for either species. *Reinschospora punctatus* sp. nov. has not been observed from any other coal bed to date.

The flora of the coal bed was diversified, eight genera of spores being represented. On the other hand, only 10 species have been identified. The diversified spore content of this thin bed suggests that had the bed developed to several feet in thickness, many additional species of spores would be present in the coal bed.

The following genera and species are known from the Upper Scottville coal bed (macerations 571 and 572):

1. *Punctati-sporites orbicularis* sp. nov.
2. *P.* sp.
3. *Granulati-sporites commissuralis* sp. nov.
4. *Laevigato-sporites pseudothiessenii* sp. nov.
5. *L. minutus* (Ibrahim) S. W. and B., 1944
6. *Endosporites plicatus* sp. nov.
7. *Calamospora breviradiata* sp. nov.
8. *Reinschospora punctata* sp. nov.
9. *Lycospora granulata* sp. nov.
10. *Wilsonia vesicatus* sp. nov.

The dominant genus is *Punctati-sporites* which constitutes 70 to 80 percent of the total spore content of the coal bed. *Punctati-sporites orbicularis* sp. nov. is the dominant species comprising 65 to 75 percent of the total spore content. All other species are essentially minor elements of the flora.

Trivoli (No. 8) Coal Bed

The Trivoli (No. 8) coal bed at the exposure near Trivoli in the SW. ½ sec. 3, T. 8 N., R. 5 E., Peoria County, is 26 to 28 inches thick. It is overlain by eight to 12 inches of black shale followed by the Trivoli limestone, which is about 24 inches thick.

Dunbar and Henbest (1942, pp. 30, 31) record that one of the important faunal breaks in the Pennsylvanian is represented by the change in the Fusulinidae of the Trivoli as compared with those found in lower beds. They recommend (p. 31) placing the Carbondale - McLeansboro boundary at the base of the Trivoli cyclothem, thus making the Trivoli limestone the first marine limestone of Missourian age in Illinois.

The small spores also indicate that an important floral break separates the plants of No. 8 coal bed and those of earlier age. *Lycospora,* which has a continuous range from the basal Pennsylvanian, is absent from No. 8 coal bed and from all coal beds above this horizon which have been investigated. It is rarely present in the thin Upper Scottville coal bed, but is the dominant genus of the Scottville coal bed. *Laevigato-sporites pseudothiessenii* sp. nov. has a known range from the top of the Dekoven coal bed to the Upper Scottville bed.

The disappearance of the genus *Lycospora* and of *Laevigato-sporites pseudothiessenii,* a long ranging species as noted above, is the evidence of a decided floral change at

[5] In an earlier publication (1947) the author used the name Scottville for this bed as suggested by Ball (see previous footnote).

approximately the same position indicated by Dunbar and Henbest (1942). Thus the faunal and floral evidence favors placing the Carbondale-McLeansboro boundary at a position higher than that to which it is conventionally assigned. Were this done its approximate position could probably be most conveniently mapped as the base of Trivoli sandstone. However, it might be difficult to trace and identify this bed, particularly in outcrop.

The following genera and species have been identified from the outcrop of the Trivoli (No. 8) coal bed near Trivoli (maceration 542 A-C), Peoria County, Illinois:

1. *Punctati-sporites setulosus* sp. nov.
2. *P. grandiverrucosus* Kosanke, 1943
3. *P. orbicularis* sp. nov.
4. *P. verrucifer* sp. nov.
5. *P. obliquus* sp. nov.
6. *P.* sp.
7. *Granulati-sporites adnatus* sp. nov.
8. *G. commissuralis* sp. nov.
9. *G. levis* sp. nov.
10. *G. concavus*
11. *Reticulati-sporites* sp.
12. *Laevigato-sporites desmoinensis* (Wilson and Coe) S. W. and B., 1944
13. *L. minimus* (Wilson and Coe) S. W. and B., 1944
14. *L. minutus* (Ibrahim) S. W. and B., 1944
15. *L. ovalis* sp. nov.
16. *L. robustus* sp. nov.
17. *Endosporites plicatus* sp. nov.
18. *E. vesicatus* sp. nov.
19. *Triquitrites crassus* sp. nov.
20. *T. discoideus* sp. nov.
21. *Calamospora hartungiana* Schopf, 1944
22. *C. liquida* sp. nov.
23. *C. pedata* sp. nov.
24. *C. breviradiata* sp. nov.
25. *Reinschospora triangularis* sp. nov.
26. *Raistrickia aculeata* sp. nov.
27. *Florinites antiquus* Schopf, 1944
28. *F. similus* sp. nov.
29. *F.* sp.

Usually 30 to 35 percent of the total spore population is represented by the genus *Punctati-sporites* and more than 25 percent by *P. orbis* sp. nov. *Calamospora* usually comprises 20 to 23 percent and *C. breviradiata* sp. nov. usually comprises 12 percent of the total spore population respectively. *Laevigato-sporites* usually contains 15 to 20 percent of the total spore population distributed among the five species listed above. *Florinites* usually represented 12 to 15 percent and *Florinites antiquus* Schopf, 1944, averages over 10 percent of the total spore population respectively. The remaining genera and species listed above are minor elements of the flora.

A coal bed less than one foot thick lying 18 feet below the Carlinville coal bed and about 20 feet below the Carlinville limestone in the SW. ¼ NE. ¼ NE. ¼ sec. 7, T. 12 N., R. 8 W., Montgomery County, and NW. ¼ SE. ¼ SW. ¼ sec. 10, T. 11 N., R. 8 W., Macoupin County, is correlated with the Trivoli No. 8 coal bed. There is surprisingly slight variation in abundance of species between the localities. A minor discrepancy is the absence of *Granulati-sporites adnatus* sp. nov. in Montgomery and Macoupin counties. This species, however, never exceeds one-half of one percent of the total spore population at the type locality and might be present in less abundance elsewhere and be difficult to detect.

Ditney Coal Bed

The type locality of the Ditney coal bed is known from an exposure in Ditney Hills, Warrick County, Indiana. The bed lies five to 15 feet above the distinctive West Franklin limestone. The Ditney coal bed is believed to be the same as the coal bed penetrated nine feet above the top bench of the West Franklin limestone at a depth of 334 feet in the New Haven core, NE. ¼ NE. ¼ NW. ¼ sec. 18, T. 7 S., R. 10 E., White County, Illinois.

The spore content of the Ditney coal bed in the New Haven core is almost identical with that of the Trivoli No. 8 coal bed of western Illinois. Only *Granulati-sporites adnatus* sp. nov., present in the Trivoli, appears to be absent in the Ditney, and only *Laevigato-sporites medius* sp. nov., present in the Ditney, appears to be lacking in the Trivoli coal bed. Although these two coal beds lie at about the same if not the same horizon, proof of their actual identity is still insufficient.

The Ditney coal bed has been identified by spores from rotary well samples in Wabash County. Two such wells are the Lenghorn-Helm No. 30 well, SW. ¼ SW. ¼ SE. ¼ sec. 22, T. 3 S., R. 14 W., maceration 516-A (470-472 feet) and the Horton-Carson No. 1 well in the SE. ¼ SW. ¼ SE. ¼

sec. 16, T. 1 S., R. 12 W., maceration 517-A (180-182 feet).

Carlinville Coal Bed

The Carlinville coal bed is known from one exposure in the SE. ¼ NE. ¼ NW. ¼ sec. 26, T. 12 N., R. 8 W., Macoupin County. It is a thin coal less than two inches thick and lies one to two feet below the Carlinville limestone and thus about 18 feet above the No. 8 coal bed.

The following genera and species have been identified from the Carlinville coal bed from the above mentioned locality:

1. *Punctati-sporites orbicularis* sp. nov.
2. *P. obliquus* sp. nov.
3. *P.* sp.
4. *Granulati-sporites commissuralis* sp. nov.
5. *G.* sp.
6. *Reticulati-sporites muricatus* sp. nov.
7. *Laevigato-sporites ovalis* sp. nov.
8. *L. minutus* (Ibrahim) S. W. and B., 1944
9. *L. minimus* (Wilson and Coe) S. W. and B., 1944
10. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
11. *Endosporites vesicatus* sp. nov.
12. *E. formosus* sp. nov.
13. *Triquitrites spinosus* Kosanke, 1943
14. *T. discoideus* sp. nov.
15. *Calamospora liquida* sp. nov.
16. *C. hartungiana* Schopf, 1944
17. *C. breviradiata* sp. nov.
18. *Florinites antiquus* Schopf, 1944
19. *F.* sp.
20. *Wilsonia* sp.

The spore content of this coal bed is similar to that of the No. 8 coal bed with the following exceptions: (1) the presence of the genus *Wilsonia;* (2) the presence of *Reticulati-sporites muricatus* sp. nov.; (3) *Laevigato-sporites minutus* (Ibrahim) S. W. and B., 1944, is the most abundant species with 20 to 25 percent of the spore population; and (4) *Laevigato-sporites* is the most abundant genus since 35 to 38 percent of the total spore population is found in three species. *Calamospora hartungiana* Schopf, 1944, *Endosporites formosus* sp. nov. and *Punctati-sporites orbicularis* sp. nov. comprise about 10 percent each of the total spore population.

Macoupin Coal Bed

The name Macoupin is used to designate the six-inch coal bed below an exposure of the Macoupin limestone in the NE. ¼ NW. ¼ sec. 2, T. 9 N., R. 7 W., Macoupin County. The following genera and species have been obtained from a sample of this bed at the above mentioned locality:

1. *Punctati-sporites setulosus* sp. nov.
2. *P. orbicularis* sp. nov.
3. *P. latigranifer* (Loose) S. W. and B., 1944
4. *P.* sp.
5. *Granulati-sporites commissuralis* sp. nov.
6. *Laevigato-sporites ovalis* sp. nov.
7. *L. minutus* (Ibrahim) S. W. and B., 1944
8. *Endosporites formosus* sp. nov.
9. *E. vesicatus* sp. nov.
10. *Triquitrites discoideus* sp. nov.
11. *T.* sp.
12. *Calamospora breviradiata* sp. nov.
13. *C. flava* sp. nov.
14. *C. liquida* sp. nov.
15. *C. pedata* sp. nov.
16. *C. hartungiana* Schopf, 1944
17. *Raistrickia* sp.
18. *Florinites similis* sp. nov.

Calamospora is the most abundant genus with approximately 32 percent of the spore population. *C. hartungiana* Schopf, 1944, *C. liquida* sp. nov., and *C. flava* sp. nov. represent 10, 10, and six percent of the spore population respectively. *C. flava* sp. nov. is the most important since it is readily recognized and appears restricted to this bed. *Laevigato-sporites* is represented by *L. ovalis* and *L. minutus* (Ibrahim) S. W. and B., 1944, which accounts for 18 and 10 percent of this spore population. *Punctati-sporites* represents about 24 percent of the spore population which is divided equally among the species listed above. The remaining genera and species are not numerically important.

The Macoupin limestone, according to Simon and Cady,[6] lies between the Carlinville and Shoal Creek limestone. Identification of the Macoupin coal bed outside the type area will not be possible until samples from closely spaced localities have been examined to determine the lateral abundance variations of the spore population. A coal bed core obtained from a diamond-drill core at 303 feet 10 inches to 304 feet 2 inches located in Jefferson County (maceration 538-F) contains *Calamospora flava* sp. nov. which indicates similarity in stratigraphic position.

[6] "Stratigraphic position of the Shoal Creek and Carlinville limestones in southwestern Illinois," paper presented to the Paleontology and Stratigraphy Section, Annual Meeting of Geological Society of America, Chicago, Dec. 1946.

Shoal Creek Coal Bed

The name Shoal Creek coal bed is here applied to the 2 to 3-inch coal bed exposed at the locality where the Shoal Creek limestone was originally described in the SW. ¼ sec. 2, T. 3 N., R. 4 W., Clinton County. The coal bed is lenticular and lies immediately below black shale. The coal bed as observed elsewhere is usually at least 10 feet below the black shale.[7] This relationship has posed the question as to whether or not there might exist two coal beds, one immediately below and one 10 feet or so below the black shale. Present evidence indicates that there is but one coal bed between the Macoupin and the Shoal Creek limestones.

Samples from near the type locality in the SE. ¼ SW. ¼ SE. ¼ sec. 28, T. 4 N., R. 4 W., Bond County contained the following genera and species:

1. *Punctati-sporites setulosus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. orbicularis* sp. nov.
4. *P.* sp.
5. *Granulati-sporites levis* sp. nov.
6. *Reticulati-sporites scrobiculatus* sp. nov.
7. *Laevigato-sporites ovalis* sp. nov.
8. *L. robustus* sp. nov.
9. *L. obscurus* sp. nov.
10. *L. minutus* (Ibrahim) S. W. and B., 1944
11. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
12. *Endosporites formosus* sp. nov.
13. *E. plicatus* sp. nov.
14. *Triquitrites crassus* sp. nov.
15. *T. discoideus* sp. nov.
16. *Calamospora liquida* sp. nov.
17. *C. hartungiana* Schopf, 1944
18. *C. mutabilis* (Loose) S. W. and B., 1944
19. *Raistrickia aculeata* sp. nov.
20. *R. rubida* sp. nov.
21. *Florinites similis* sp. nov.
22. *F. triletus* sp. nov.
23. *Illinites unicus* sp. nov.

Laevigato-sporites minutus (Ibrahim) S. W. and B., 1944, is the dominant small spore representing 38 to 40 percent of the spore population and the total percentage of the genus varies from 45 to 48 percent. *Endosporites, Punctati-sporites, Illinites* gen. nov., *Florinites,* and *Raistrickia* represent 10, 9, 8, 8, and 7 percent of the total spore population. The remaining genera listed above are rare in occurrence.

There is evidence from the fossil spores that the Shoal Creek coal bed may correlate with coal beds encountered in certain diamond-drill holes as follows: coal bed at 284 feet 8 inches to 285 feet 10 inches, located near the center of the SE. ½ sec. 4, T. 4 S., R. 1 E., Jefferson County (maceration 538-C); coal bed at 84 feet 6 inches to 85 feet in the SE. ¼ NW. ¼ NE. ¼ sec. 27, T. 6 S., R. 2 E., Franklin County (maceration 536-A). It is also possible that this same bed is present in a rotary well at 227 feet to 228 feet in the NW. ¼ NW. ¼ SW. ¼ sec. 26, T. 1 N., R. 13 W., Wabash County (maceration 500-C). The presence of six specimens of *Reinschospora magnifica* sp. nov. in maceration 536-A remains unexplained. *Reticulati-sporites scrobiculatus* sp. nov., *Florinites triletus* sp. nov., and *Illinites unicus* sp. nov. appear to be restricted to this bed.

[7] Personal communication, J. A. Simon.

New Haven Coal Bed

The name New Haven is used here to designate the 1½-inch coal bed which lies below the New Haven limestone at the exposure in the NW. ¼ sec. 19, T. 7 S., R. 10 E., at New Haven, Gallatin County, Illinois.

The spore content of this bed is rather significant because the presence of many specimens of *Reticulati-sporites muricatus* sp. nov. suggests a relationship with the LaSalle coal bed while the presence of *Laevigato-sporites obscurus* sp. nov. suggests a relationship with the Shoal Creek coal bed. *Reinschospora triangularis* sp. nov. and *Alati-sporites punctatus* sp. nov. present in this bed are not known to occur in either the LaSalle or Shoal Creek coal beds. *Alati-sporites punctatus* sp. nov. is known only from this bed in the McLeansboro group.

The New Haven limestone has been identified as the equivalent of the Shoal Creek limestone of western Illinois by Wanless (1939), Moore, Wanless, and Weller, et al. (1944), and others. Present spore studies do not definitely either prove or fail to prove the accuracy of these correlations. The spore content may represent marginal flora of one or both of these beds or represent an intermediate bed with a transitional flora.

The limestone in the New Haven dia-

mond-drill core (NE. ¼ NE. ¼ NW. ¼ sec. 18, T. 7 S., R. 10 E., White County) at 108 feet to 114 feet has been thought to be the New Haven. Unfortunately no coal is present below the limestone but a hydrofluoric maceration of black shale has yielded a few spores which do not suggest a relationship with the New Haven coal bed. Thus the stratigraphic position of this bed based on plant spores is uncertain.

The following genera and species have been observed from this bed:

1. *Punctati-sporites setulosus* sp. nov.
2. *P. obliquus* sp. nov.
3. *P. orbicularis* sp. nov.
4. *P. sulcatus* Wilson and Kosanke, 1944
5. *P. grandiverrucosus* Kosanke, 1943
6. *P.* sp.
7. *Granulati-sporites commissuralis* sp. nov.
8. *Alati-sporites punctatus* sp. nov.
9. *Reticulati-sporites muricatus* sp. nov.
10. *Laevigato-sporites obscurus* sp. nov.
11. *L. robustus* sp. nov.
12. *L. minutus* (Ibrahim) S. W. and B., 1944
13. *Endosporites formosus* sp. nov.
14. *Triquitrites* sp.
15. *Calamospora* sp.
16. *Reinschospora triangularis* sp. nov.
17. *Raistrickia* sp.

Laevigato-sporites, with about 30 percent of the spore population, is the most abundant genus. *L. obscurus* sp. nov. represents 23 to 24 percent of the spore population and thus the remainder of the species of the genus is not abundant. *Punctati-sporites* with 22 to 24 percent of the spore population is next in numerical importance. *P. grandiverrucosus* Kosanke, 1943, and *P. orbicularis* sp. nov. represent nine and seven percent respectively, and the remaining species are not of numerical importance. *Reticulati-sporites muricatus* sp. nov., *Alati-sporites punctatus* sp. nov. and *Reinschospora triangularis* sp. nov. represent 14, 12, and 12 percent, respectively, of the spore population. The remaining genera and species are rare.

McCleary's Bluff Coal Bed

The name McCleary's Bluff is used here to designate a three-inch coal bed exposed along the Wabash River Bluff in the NW. ¼ SW. ¼ SW. ¼ sec. 29, T. 2 S., R. 13 W., Wabash County. The stratigraphic position of this bed is uncertain although it appears to lie below the Friendsville coal bed. This bed is included because many excellently preserved spores were present, five of which serve as types. The following forms have been observed in this bed at the above mentioned locality:

1. *Punctati-sporites setulosus* sp. nov.
2. *P. orbicularis* sp. nov.
3. *Granulati-commissuralis* sp. nov.
4. *G. grandis* sp. nov.
5. *G. levis* sp. nov.
6. *Laevigato-sporites latus* sp. nov.
7. *L. ovalis* sp. nov.
8. *L. minutus* (Ibrahim) S. W. and B., 1944
9. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
10. *L. minimus* (Wilson and Coe) S. W. and B., 1944
11. *Endosporites formosus* sp. nov.
12. *Triquitrites* sp.
13. *Calamospora hartungiana* Schopf, 1944
14. *C.* sp.
15. *Raistrickia aculeata* sp. nov.
16. *Wilsonia* sp.
17. *Illinites elegans* sp. nov.
18. *I.* sp.

Laevigato-sporites accounts for 66 to 68 percent of the spore population, and *L. ovalis* sp. nov. and *L. minutus* (Ibrahim) S. W. and B., 1944, each average about 30 percent. *Endosporites formosus* sp. nov., *Punctati-sporites orbicularis* sp. nov., and *Calamospora* represent 12, eight, and eight percent of the spore population, respectively. *Illinites elegans* sp. nov. which represents about three percent of the spore population appears restricted to this bed.

Friendsville Coal Bed

The Friendsville coal bed is thought by Wanless (1939) to be equivalent to the LaSalle or Lower Bogata coal beds. However, present studies indicate that it does not correlate with the LaSalle coal bed, maceration 600. Comparison with the Lower Bogata coal bed has not been made, hence its relation with the Friendsville and LaSalle coal beds on the basis of spore content is unknown.

The Friendsville coal bed appears to be lenticular and has a known maximum thickness of 42 inches in a mine now abandoned, located in the NW. ¼ NE. ¼ NE. ¼ sec. 29, T. 2 S., R. 13 W. Coal from this mine and that from a mine located near Friendsville in the NW. ¼ SW. ¼ SW. ¼ sec. 13, T. 1 N., R. 13 W. contain essentially

the same genera and species of small spores and are correlated as the same bed.

The following genera and species have been identified from samples of the above two mines unless otherwise noted:

1. *Punctati-sporites foveosus* sp. nov.
2. *P. mundus* sp. nov.
3. *P. obliquus* sp. nov.
4. *P. orbicularis* sp. nov.
5. *P. grandiverrucosus* Kosanke, 1943
6. *P.* sp.
7. *Granulati-sporites commissuralis* sp. nov.
8. *G. levis* sp. nov.
9. *G. pellucidus* sp. nov.
10. *Laevigato-sporites ovalis* sp. nov.
11. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
12. *L. minutus* (Ibrahim) S. W. and B., 1944
13. *L. minimus* (Wilson and Coe) S. W. and B., 1944
14. *Cirratriradites* sp.*
15. *Endosporites formosus* sp. nov.
16. *Triquitrites discoideus* sp. nov.
17. *T.* sp.
18. *Calamospora hartungiana* Schopf, 1944
19. *C.* sp.
20. *Raistrickia aculeata* sp. nov.
21. *R. rubida* sp. nov.
22. *Florinites* sp.

Punctati-sporites foveosus sp. nov., *P. mundus* sp. nov. and *Granulati-sporites pellucidus* sp. nov. appear restricted to this bed. *Laevigato-sporites minimus* (Wilson and Coe) S. W. and B., 1944, *Triquitrites discoideus* sp. nov., and *Raistrickia rubida* sp. nov. are not known to occur above this horizon.

LaSalle Coal Bed

The LaSalle coal bed underlying the LaSalle limestone is represented by a sample collected in the SW. ¼ SW. ¼ NW. ¼ sec. 33, T. 16 N., R. 11 E., Bureau County. It contains abundant spores, some of which are restricted to the coal bed.

The coal at the above locality is exposed in a small ravine along the north wall of Illinois valley. The coal bed is overlain by black shale, and is five feet below the La Salle limestone.

The following genera and species are known from the LaSalle coal bed:

1. *Punctati-sporites orbicularis* sp. nov.
2. *P. verrucifer* sp. nov.
3. *P. vermiculatus* sp. nov.
4. *P. latigranifer* (Loose) S. W. and B., 1944
5. *P. sulcatus* Wilson and Kosanke, 1944
6. *Granulati-sporites levis* sp. nov.
7. *Reticulati-sporites muricatus* sp. nov.
8. *Laevigato-sporites ovalis* sp. nov.
9. *L. latus* sp. nov.
10. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
11. *Triquitrites spinosus* Kosanke, 1943
12. *T.* sp.
13. *Calamospora breviradiata* sp. nov.
14. *C. liquida* sp. nov.
15. *C. hartungiana* Schopf, 1944
16. *C.* sp.
17. *Raistrickia aculeata* sp. nov.
18. *Florinites similis* sp. nov.
19. *Cadiospora magna* sp. nov.
20. *Illinites unicus* sp. nov.
21. *Wilsonia vesicatus* sp. nov.

Laevigati-sporites represents 25 to 30 percent and *Punctati-sporites* 20 to 22 percent of the total spore population. *Laevigato-sporites ovalis* sp. nov. is the most abundant species and it comprises 16 to 18 percent of the total spore population. *Calamospora, Reticulati-sporites,* and *Cadiospora* comprise about 10 percent each of the total spore population. The other species are minor elements of the spore population so far as abundance is concerned.

Punctati-sporites vermiculatus sp. nov. is restricted to this bed. *Cadiospora magna* sp. nov. is illustrated as restricted to this bed on the spore distribution chart, but is probably present in at least one of the coal beds not here reported. The LaSalle coal bed is further characterized by several species whose known range ends with this bed, as illustrated on the spore distribution chart. There should be little difficulty in identifying this coal bed if it is found elsewhere.

Upper McLeansboro Coal Beds

The upper McLeansboro coal beds receive attention in the following pages in what is believed to be their order of deposition. Coal samples which are thought to come from beds equivalent to the Cohn, Bogata, Newton, and Gila coal beds respectively were recovered from rotary-drill holes. These coal samples were prepared and examined, but the results are not included here because samples from the type sections have not been studied.

Spore studies indicate considerable changes in the spore population from coal bed to coal bed. This supports the probability that a systematic study of all of the

* A fragment of a spore undoubtedly referable to this genus was observed in maceration 487, but none were found in maceration 486, both of which are from Wabash County.

coal beds would greatly enlarge the understanding of the stratigraphy of the upper part of the McLeansboro group in Illinois.

Shelbyville Coal Bed

The name Shelbyville has been designated for the coal bed mined in the vicinity of Shelbyville, Illinois, which is represented by a sample from the Kingston Mine located in the NE. ¼ SW. ¼ NE. ¼ sec. 33, T. 12 N., R. 4 E., Shelby County. This contains the following genera and species:

1. *Punctati-sporites vagus* sp. nov.
2. *Laevigato-sporites ovalis* sp. nov.
3. *L. punctatus* sp. nov.
4. *L. minutus* (Ibrahim) S. W. and B., 1944
5. *L. vulgaris* (Ibrahim) Ibrahim, 1933
6. *Endosporites formosus* sp. nov.
7. *E. vesicatus* sp. nov.
8. *E. plicatus* sp. nov.
9. *E.* sp.
10. *Calamospora liquida* sp. nov.
11. *C. mutabilis* (Loose) S. W. and B., 1944
12. *Raistrickia aculeata* sp. nov.
13. *Florinites* sp.

Only six genera and 13 species have been observed in the coal bed but all occur abundantly. *Endosporites* accounts for 39 to 41 percent of the spore population. *E. formosus* sp. nov., *E. vesicatus* sp. nov., *E. plicatus* sp. nov., and *E.* sp. makes up 16, 13, 5 to 6, and 5 to 6 percent of the spore population respectively. *Laevigato-sporites* contains four species which represent 30 percent of the spore population. *L. minutus* (Ibrahim) S. W. and B., 1944, *L. punctatus* sp. nov., *L. ovalis* sp. nov., and *L. vulgaris* (Ibrahim) Ibrahim, 1933, represent 11, 8, 6, and 5 percent respectively of the spore population. *Punctati-sporites vagus* sp. nov. represents 16 percent of the spore population. The remaining genera and species are of minor importance. The small number of genera together with the presence of *Punctati-sporites vagus* sp. nov. and the abundance of the genus *Endosporites* characterize this bed.

Trowbridge Coal Bed

The name Trowbridge designates the coal bed exposed northwest of Trowbridge in the NW. ¼ sec. 14, T. 10 N., R. 6 E., Shelby County, Illinois. The following genera and species have been observed from this bed:

1. *Punctati-sporites* sp.
2. *Granulati-sporites levis* sp. nov.
3. *Reticulati-sporites muricatus* sp. nov.
4. *Laevigato-sporites robustus* sp. nov.
5. *L. minutus* (Ibrahim) S. W. and B., 1944
6. *Endosporites formosus* sp. nov.
7. *Triquitrites spinosus* Kosanke, 1943
8. *Calamospora liquida* sp. nov.
9. *Illinites* sp.
10. *Wilsonia* sp.

Only ten species are known to be present in this coal bed although spores are abundant. *Endosporites formosus* sp. nov. is dominant, and represents about 80 percent of the total spore population. *Laevigato-sporites robustus* sp. nov. accounts for 13 percent of the spore population. The remaining spores identified in the coal bed are of minor numerical importance.

E. formosus sp. nov., the dominant spore, helps to identify the bed and *L. robustus* sp. nov., which is abundantly present, appears to be absent in the Shelbyville coal bed. This and other differences in the spores of the two beds make it seem probable that the Shelbyville and Trowbridge are different beds.

Woodbury Coal Bed (?)

The type Woodbury cyclothem of Newton and Weller (1937) is exposed along Webster Creek in the SE. ¼ sec. 32, T. 9 N., R. 8 E., Jasper County. The spores of the Woodbury coal bed exposed at the type locality are unknown. An exposure of a four and one-half inch coal bed in the SW. ¼ sec. 31, T. 8 N., R. 9 E., thought to be at the same stratigraphic position, provided the following genera and species:

1. *Punctati-sporites setulosus* sp. nov.
2. *P. minutus* sp. nov.
3. *P. firmus* (Loose) S. W. and B., 1944
4. *Granulati-sporites commissuralis* sp. nov.
5. *G. grandis* sp. nov.
6. *G. gibbosus* (Ibrahim) S. W. and B., 1944
7. *Laevigato-sporites ovalis* sp. nov.
8. *L. minutus* (Ibrahim) S. W. and B., 1944
9. *L. desmoinensis* (Wilson and Coe) S. W. and B., 1944
10. *Endosporites formosus* sp. nov.
11. *E. vesicatus* sp. nov.
12. *Triquitrites* sp.
13. *Calamospora liquida* sp. nov.
14. *C. hartungiana* Schopf, 1944
15. *Raistrickia aculeata* sp. nov.
16. *Illinites unicus* sp. nov.
17. *"Spherites"* sp.

In addition to the species listed above it is believed that at least one new species of

Punctati-sporites is present in very limited numbers.

The dominant species is *Punctati-sporites minutus* sp. nov. which makes up 77 to 79 percent of the spore population. The next most abundant species is *Endosporites formosus* sp. nov. with 7 percent, and the remaining species are of minor numerical importance. There is little doubt that this coal bed is at a different stratigraphic position than the Trowbridge coal bed as seen by comparing the genera and species lists of the two coal beds. *Endosporites formosus* sp. nov., the dominant spore of the Trowbridge coal bed, is replaced numerically by *Punctati-sporites minutus* sp. nov.

Watson Coal Bed

The name Watson is applied to the coal bed exposed southwest of Watson in the SW. ¼ sec. 1, T. 6 N., R. 5 E., Effingham County, Illinois. The following genera and species have been observed from this bed:

1. *Punctati-sporites minutus* sp. nov.
2. *P.* sp.
3. *Granulati-sporites levis* sp. nov.
4. *G.* sp.
5. *Laevigato-sporites latus* sp. nov.
6. *L. robustus* sp. nov.
7. *L. minutus* (Ibrahim) S. W. and B., 1944
8. *Endosporites formosus* sp. nov.
9. *E. vesicatus* sp. nov.
10. *Triquitrites* sp.
11. *Calamospora liquida* sp. nov.
12. *C. hartungiana* Schopf, 1944
13. *Wilsonia* sp.

Punctati-sporites minutus sp. nov. is the dominant spore with 74 to 77 percent of the spore population. In this respect this coal bed is very similar to the coal bed described earlier as the Woodbury (?) bed. However, *Laevigato-sporites minutus* (Ibrahim) S. W. and B., 1944, represents about 10 percent of the spore population of the Watson bed and it is exceedingly rare in the Woodbury (?) bed. Further differences between the two beds can be seen by a comparison of species lists of the respective beds.

McLeansboro Coal and Limestone Beds in Southern and Southwestern Illinois

A cross-section diagram of the McLeansboro coal beds and limestones from Franklin to Macoupin counties (in pocket) was prepared from data supplied by outcrops, and from diamond, rotary, and churn drill holes. Spore analyses from Franklin, Jefferson, Clinton, Bond, and Macoupin counties are the basis for the suggested correlation.

The No. 6 coal bed (top of bed is the Carbondale-McLeansboro boundary) is continuous the entire length of the traverse except for a short distance in Bond and Madison counties where it is "cut out." The Herrin limestone overlying No. 6 coal bed is also continuous. The coal beds and limestones, from the Bankston Fork limestone to the 3rd Cutler-rider coal bed, are restricted to Franklin, Jefferson, and possibly Washington counties. However, preliminary spore studies suggest a possible correlation between the Cutler coal bed and the No. 7 coal bed of Macoupin and Madison counties. Thus the Piasa and Cutler limestones are possibly to be correlated. The 2nd Cutler-rider coal bed and the Scottville coal bed have similar spore contents, but the 3rd Cutler-rider coal bed is younger than the Upper Scottville coal. The No. 8 coal bed of Macoupin County is present in all of the counties southward into Franklin County where it is notably continuous. The Macoupin and Shoal Creek coal beds of Macoupin County are thought to be present in Franklin and Jefferson counties as indicated in the diagram. The traverse crosses the Duquoin monoclinal flexure in Jefferson County and at the foot of the monoclinal flexure there are five limestones and three coal beds above the Shoal Creek limestone.

The interval from the top of No. 6 coal bed to the Shoal Creek limestone thickens 175 feet from Macoupin to Franklin County. One hundred feet of this thickening is between No. 6 and No. 8 coal beds. In general the limestones thicken westward toward the margin of the basin.

Conclusions on the McLeansboro Coal Beds

The coal beds of the McLeansboro group that have been examined can be differentiated from each other and distinguished from the coal beds of older age by means of the small spores which they contain. Sixteen genera and 74 species have been identified from the beds of McLeansboro age. Thirty-

five of these 74 species are restricted to the McLeansboro coal beds. The two new genera which were also present in some of the Carbondale coal beds, and are not described (see pages 64 and 73), are rarely found in the McLeansboro beds.

DISCUSSION

This investigation was primarily an exploration of the small spore content of the various coal beds in Illinois and of the value of these spores in the correlation of coal beds. But in addition, much information was obtained concerning the plant succession from bottom to top of a number of coal beds, and the influence of geographic distribution of samples of a particular bed on the abundance variation in spore population.

The causes of geographic variations in abundance of the spore population are not understood. Ecological factors such as climate, physiographic features, or regional factors may have been important. Among the climatic factors which might produce lateral variations in plant population are differences in temperature, atmospheric moisture, and light, but these are thought to have been relatively uniform. The direction of prevailing winds is unknown, and changes in direction and strength during the time of coal accumulation might have been important. Among physiographic features which appear more likely to influence the floral composition are topographic variations, especially toward marginal areas. A regional factor of importance might be changes of humic accumulation in the soil.

Bench zonation of particular genera and species in certain coal beds points to plant succession.[8] The ecesis[9] and migration of plants upon Pennsylvanian soil (underclay) may have been rapid. It is not yet known whether or not the primary plant invaders were herbaceous or arborescent forms. The restriction of some genera and species to either the upper or basal portions of coal beds points to possible primary and climax communities.

[8] The replacement of a group of plants, which occupy a common habitat, by another group of plants (Nichols, 1923).

[9] The actual establishment of a plant in a new location.

Summary

Nineteen genera and 130 species of spores have been identified from the coal beds investigated from 47 counties in Illinois. Five of the genera and 100 of the species are described in this report. These new genera and species together with forms previously described provide a working basis for the correlation of the coal beds of Illinois. Twenty-eight species are at the present known to be restricted to one or another single coal bed, 16 species appear to be restricted to two coal beds, and 23 species on the basis of present information are restricted to three coal beds. In addition to these restricted species several genera and many species have significant ranges which are invaluable in correlation studies.

The vertical distribution of isopores, microspores, and prepollen in Illinois coal beds as observed in this investigation provides a means of specific identification of coal beds. Correlations have been made and are indicated in the text.

ACKNOWLEDGMENTS

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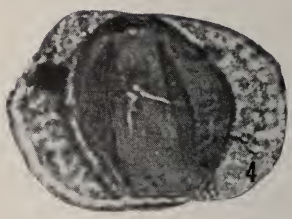
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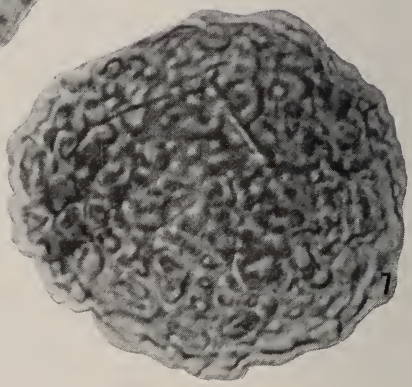
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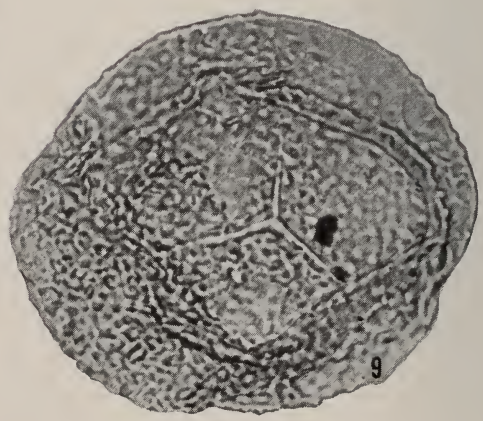
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PLATE 1

FIGS. 1.-2.—*Illinites elegans* sp. nov. holotype, maceration 490-A Slide 5, McCleary's Bluff coal bed, Wabash County, Illinois. Fig. 1—oil immersion photomicrograph. Fig. 2—same specimen water immersion photomicrograph showing trilete mark. Specimen dimensions are 51.4 × 63 microns.

FIG. 3.—*I. unicus* sp. nov. holotype, maceration 494 Slide 15, Shoal Creek coal bed (?), Wabash County, Illinois, illustrating bladder ornamentation, body, and trilete mark. Specimen dimensions are 42 × 63 microns.

FIG. 4.—*I. unicus* sp. nov. maceration 574 Slide 23, Shoal Creek coal bed, Bond County, Illinois, dimensions are 44.1 × 65.1 microns.

FIG. 5.—*Punctati-sporites latigranifer* (Loose) S. W. and B., 1944, maceration 536-A Slide 2, Shoal Creek coal bed (?), Franklin County, Illinois, dimensions are 69.3 × 60.9 microns.

FIG. 6.—*P. foveatus* sp. nov. holotype, maceration 603-B Slide 6, No. 2 coal bed, Fulton County, Illinois, dimensions are 73.5 × 73.5 microns.

FIG. 7.—*P. reticuloides* sp. nov. holotype, maceration 579-A Slide 1, No. 2 coal bed, Bureau County, Illinois, dimensions are 50.4 × 52.5 microns.

FIG. 8.—*P. latigranifer* (Loose) S. W. and B., 1944.

FIG. 9.—*P. quasioarcuatus* sp. nov. holotype, maceration 625-A Slide 2, Willis coal bed, Gallatin County, Illinois, dimensions are 86 × 100.8 microns.

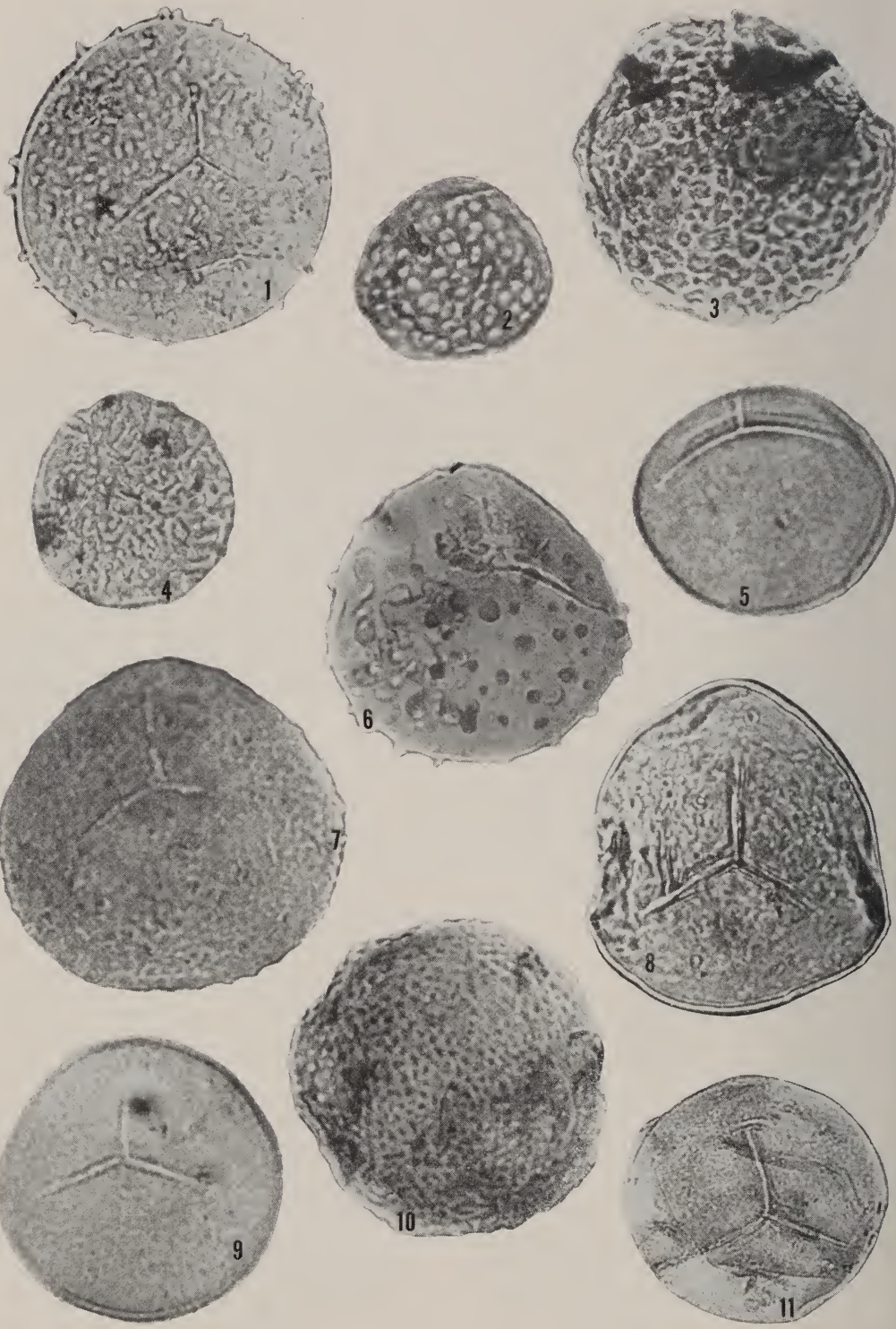
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PLATE 2

FIG. 1.—*Punctati-sporites setulosus* sp. nov. holotype, maceration 500-C Slide 2, Shoal Creek coal bed (?), Wabash County, Illinois, dimensions are 73.5 × 73.5 microns.

FIG. 2.—*P. quaesitus* sp. nov. holotype, maceration 585-C Slide 4, No. 6 coal bed, Franklin County, Illinois, dimensions are 35.7 × 37.8 microns.

FIG. 3.—*P. foveosus* sp. nov. holotype, maceration 486-B Slide 17, Friendsville coal bed, Wabash County, Illinois, dimensions are 111 × 107 microns.

FIG. 4.—*P. vermiculatus* sp. nov. holotype, maceration 600 Slide 2, La Salle coal bed, Bureau County, Illinois, dimensions are 67 × 63 microns.

FIG. 5.—*P. obliquus* sp. nov. holotype, maceration 603-B Slide 5, No. 2 coal bed, Fulton County, Illinois, dimensions are 34.6 × 39.8 microns.

FIG. 6.—*P. verrucifer* sp. nov. holotype, maceration 520-A Slide 1, Bald Hill coal bed, Williamson County, Illinois, dimensions are 65 × 66 microns.

FIG. 7.—*P. triangularis* sp. nov. holotype, maceration 474-A Slide 1, No. 6 coal bed, Franklin County, Illinois, dimensions are 63 × 65 microns.

FIG. 8.—*P. mundus* sp. nov. holotype, maceration 486-B Slide 17, Friendsville coal bed, Wabash County, Illinois, dimensions are 61 × 58.8 microns.

FIG. 9.—*P. orbicularis* sp. nov. holotype, maceration 542-A Slide 7, No. 8 coal bed, Peoria County, Illinois, dimensions are 37.8 × 37.8 microns.

FIG. 10.—*P. fenestratus* sp. nov. holotype, maceration 474-A Slide 3, No. 6 coal bed, Franklin County, Illinois, dimensions are 77.7 × 79.8 microns.

FIG. 11.—*P. provectus* sp. nov. holotype, maceration 609 Slide 6, Wayside coal bed, Johnson County, Illinois, dimensions are 75.6 × 78.7 microns.

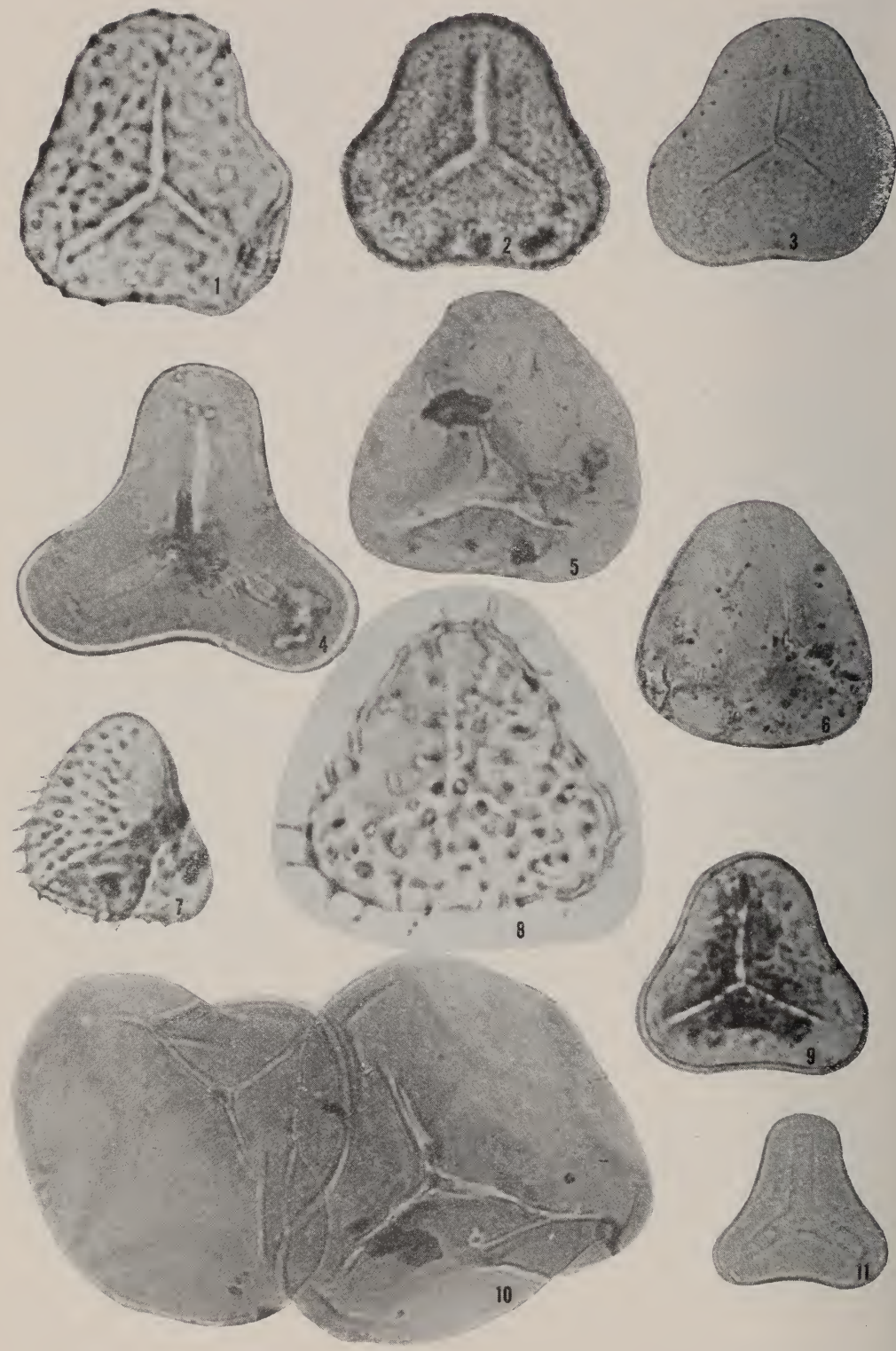
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PLATE 3

FIG. 1.—*Granulati-sporites commissuralis* sp. nov. holotype, maceration 486-B Slide 22, Friendsville coal bed, Wabash County, Illinois, dimensions are 29.5 × 26 microns.

FIG. 2.—*G. granularis* sp. nov. holotype, maceration 596-A Slide 1, No. 6 coal bed, Vermilion County, Illinois, dimensions are 33.6 × 33.6 microns.

FIG. 3.—*G. pallidus* sp. nov. holotype, maceration 587 Slide 1, Battery Rock coal bed, Hardin County, Illinois, dimensions are 38 × 38 microns.

FIG. 4.—*G. concavus* sp. nov. holotype, maceration 318 Slide 10, Ditney coal bed, White County, Illinois, dimensions are 55 × 58.8 microns.

FIG. 5.—*G. levis* sp. nov. holotype, maceration 500-B Slide 2, Friendsville coal bed, Wabash County, Illinois, dimensions are 48 × 50 microns.

FIG. 6.—*G. convexus* sp. nov. holotype, maceration 543-C Slide 8, No. 5 coal bed, Fulton County, Illinois, dimensions are 61 × 60 microns.

FIG. 7.—*G. spinosus* sp. nov. holotype, maceration 579-A Slide 1, No. 2 coal bed, Bureau County, Illinois, dimensions are 31 × 30 microns.

FIG. 8.—*G. aculeolatus* sp. nov. holotype, maceration 625-A Slide 3, Willis coal bed, Gallatin County, Illinois, dimensions are 28.5 × 31 microns, exclusive of setae.

FIG. 9.—*G. adnatus* sp. nov. holotype, maceration 573 Slide 8, No. 8 coal bed, Macoupin County, Illinois, dimensions are 35 × 36 microns.

FIG. 10.—*G. grandis* sp. nov. holotype specimen right side, maceration 490-A Slide 8, McCleary's Bluff coal bed, Wabash County, Illinois, dimensions are 74 × 84 microns.

FIG. 11.—*G. pellucidus* sp. nov. holotype, maceration 486-A Slide 4, Friendsville coal bed, Wabash County, Illinois, dimensions are 48 × 48 microns.

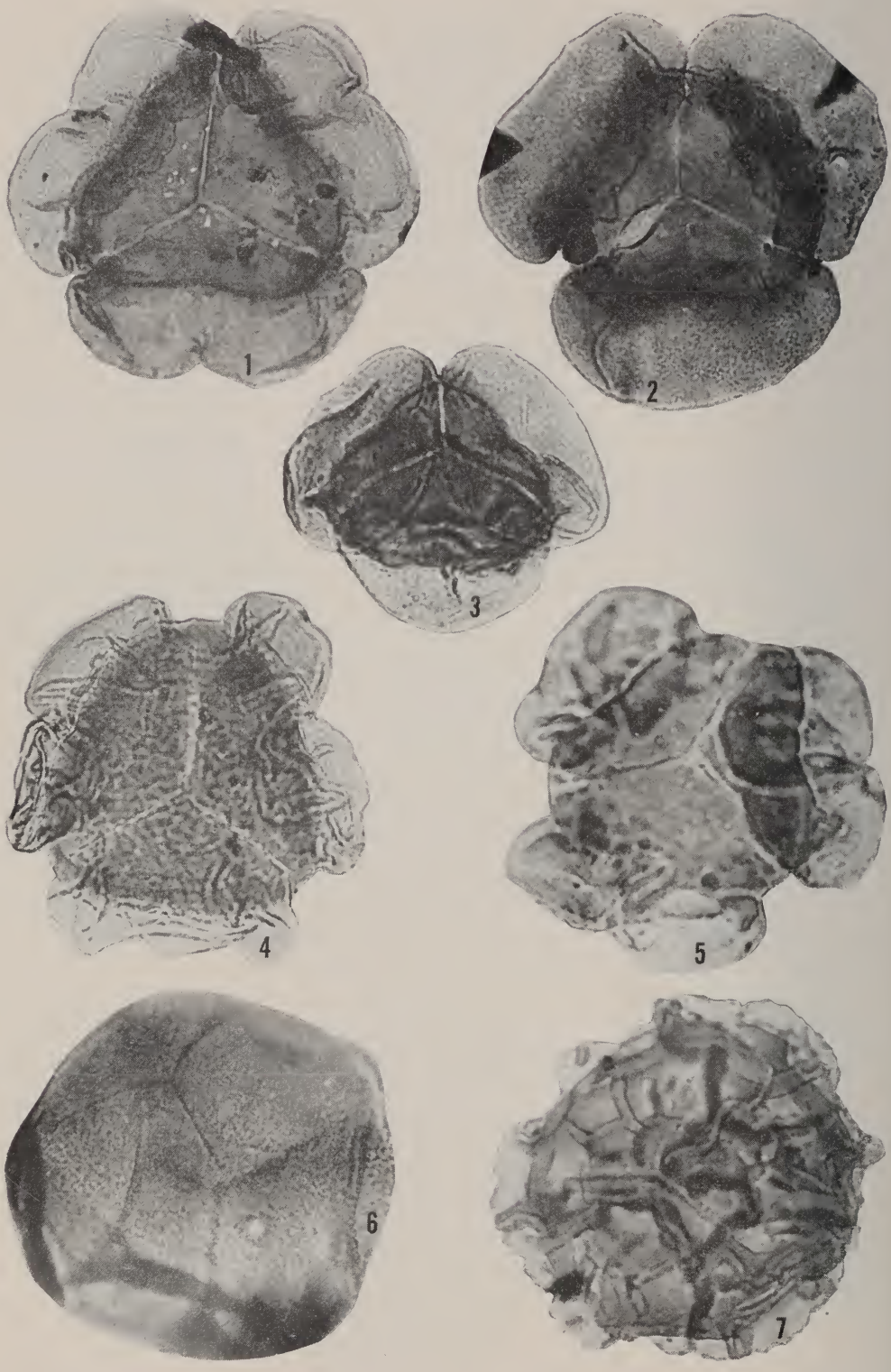
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PLATE 4

FIG. 1.—*Alati-sporites varius* sp. nov. holotype, maceration 543-B Slide 7, No. 5 coal bed, Fulton County, Illinois, dimensions including bladders are 116.8 × 128.5 microns.

FIG. 2.— *A. inflatus* sp. nov. holotype, maceration 543-C Slide 6, No. 5 coal bed, Fulton County, Illinois, dimensions including bladders are 120.4 × 129.6 microns.

FIG. 3.—*A. trialatus* sp. nov. holotype, maceration 543-B Slide 20, No. 5 coal bed, Fulton County, Illinois, dimensions including bladders are 90.3 × 98.2 microns.

FIG. 4.—*A. punctatus* sp. nov. holotype, maceration 576 Slide 4, New Haven coal bed, White County, Illinois, dimensions including bladders are 102 × 98.7 microns.

FIG. 5.—*A. hexalatus* sp. nov. holotype, maceration 519-A Slide 1, Dekoven coal bed, Williamson County, Illinois, dimensions including bladders are 76.5 × 78.6 microns.

FIG. 6.—*Reticulati-sporites scrobiculatus* sp. nov. holotype, maceration 574 Slide 14, Shoal Creek coal bed, Bond County, Illinois, dimensions are 109 × 111 microns.

FIG. 7.—*R. muricatus* sp. nov. holotype, maceration 600 Slide 2, LaSalle coal bed, Bureau County, Illinois, dimensions are 84 × 91.2 microns.

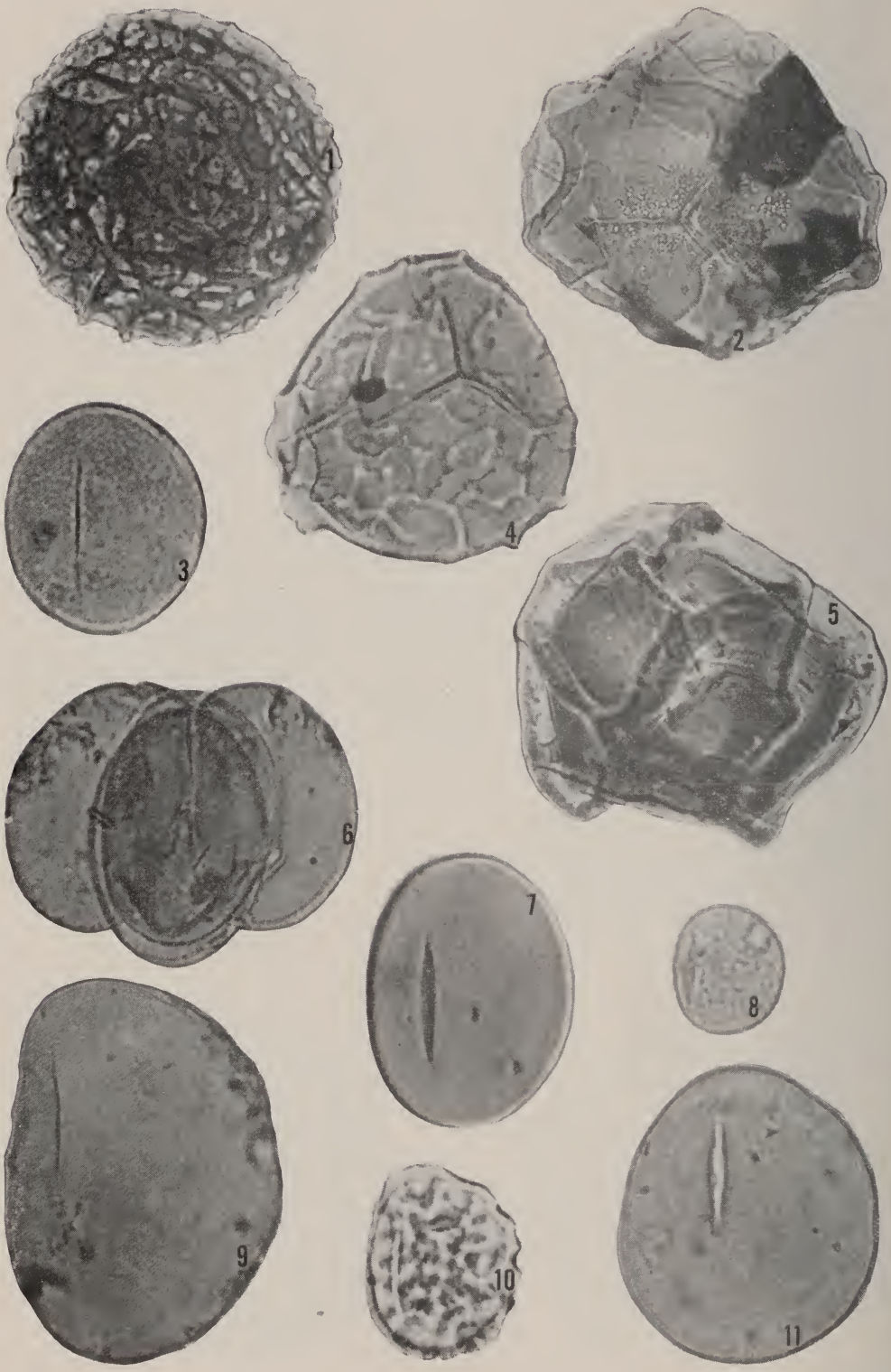
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PLATE 5

FIG. 1.—*Reticulati-sporites irregularis* sp. nov. holotype, maceration 144 Slide 1, "Sub-Babylon" coal bed, Fulton County, Illinois, dimensions are 88.2 × 86.1 microns.

FIG. 2.—*R. adhearens* sp. nov. holotype, maceration 519-B Slide 7, Dekoven coal bed, Williamson County, Illinois, dimensions are 88 × 92.4 microns.

FIG. 3.—*Laevigato-sporites punctatus* sp. nov. holotype, maceration 625-A Slide 1, Willis coal bed, Gallatin County, Illinois, dimensions are 44 × 35.7 microns.

FIG. 4.—*Reticulati-sporites splendens* sp. nov. holotype, maceration 587 Slide 18, Battery Rock coal bed, Hardin County, Illinois, dimensions are 58.2 × 56.7 microns.

FIG. 5.—*R. lacunosus* sp. nov. holotype, maceration 625-B Slide 9, Willis coal bed, Gallatin County, Illinois, dimensions are 86 × 92 microns.

FIG. 6.—*Laevigato-sporites ovalis* sp. nov. showing tetrad, maceration 577 Slide 1, Carlinville coal bed, Macoupin County, Illinois.

FIG. 7.—*L. ovalis* sp. nov. holotype, maceration 501-A Slide 1, coal bed at 85′ to 87′ in the Skiles-Price No. 1 well, Wabash County, Illinois, dimensions are 63 × 46.2 microns.

FIG. 8.—*L.* cf. *minutus* (Ibrahim) S. W. and B., 1944, maceration 486-B Slide 12, Friendsville coal bed, Wabash County, Illinois, dimensions are 24.7 × 20 microns.

FIG. 9.—*L. robustus* sp. nov. holotype, maceration 574 Slide 8, Shoal Creek coal bed, Bond County, Illinois, dimensions are 101.8 × 73.5 microns.

FIG. 10.—*L. pseudothiessenii* sp. nov. holotype, maceration 543-D Slide 4, No. 5 coal bed, Fulton County, Illinois, dimensions are 37.8 × 29.4 microns.

FIG. 11.—*L. latus* sp. nov. holotype, maceration 490-A Slide 6, McCleary's Bluff coal bed, Wabash County, Illinois, dimensions are 63 × 54.6 microns.

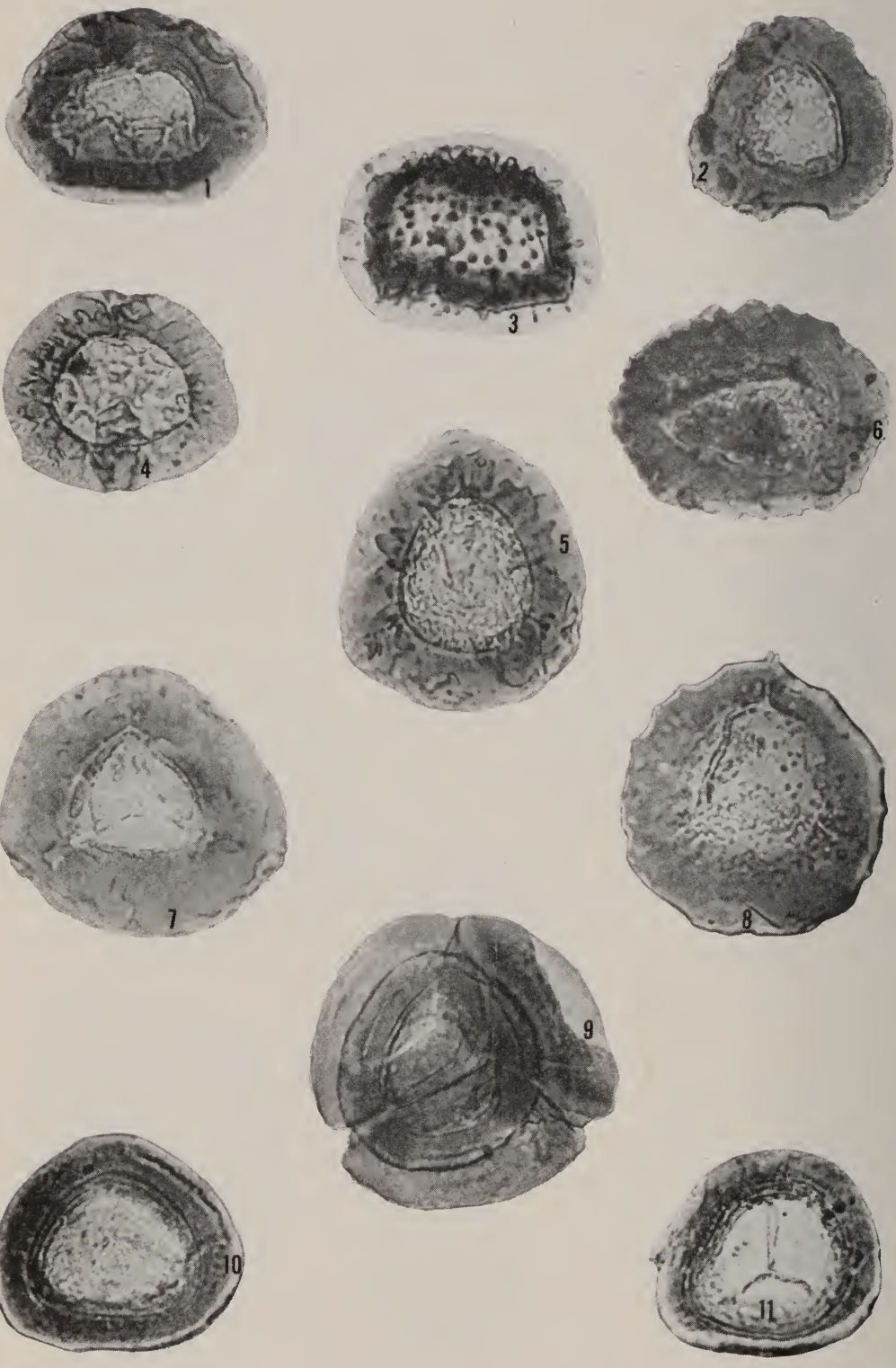
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PLATE 6

FIG. 1.—*Denso-sporites sinuosus* sp. nov. holotype, maceration 587 Slide 12, Battery Rock coal bed, Hardin County, Illinois, dimensions are 39.9 × 46.2 microns.

FIG. 2.—*D. sinuosus* sp. nov. paratype, maceration 587 Slide 6, Battery Rock coal bed, Hardin County, Illinois, dimensions are 39.9 × 40.9 microns.

FIG. 3.—*D. glandulosus* sp. nov. holotype, maceration 144 Slide 5, "Sub-Babylon" coal bed, Fulton County, Illinois, dimensions are 27.3 × 35.7 microns.

FIG. 4.—*D. lobatus* sp. nov. holotype, maceration 625-A Side 1, Willis coal bed, Gallatin County, Illinois, dimensions are 37.8 × 44.1 microns.

FIG. 5.—*D. lobatus* sp. nov. paratype, maceration 625-A Slide 1, Willis coal bed, Gallatin County, Illinois, dimensions are 54.6 × 50.4 microns.

FIG. 6.—*D. ruhus* sp. nov. holotype, maceration 587 Slide 13, Battery Rock coal bed, Hardin County, Illinois, dimensions are 42 × 52.5 microns.

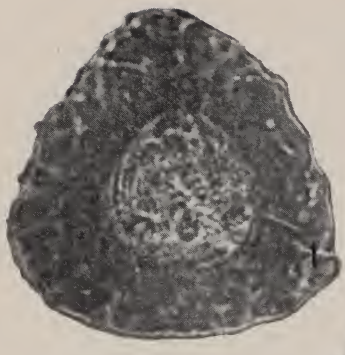
FIG. 7.—*D. sphaerotriangularis* sp. nov. holotype, maceration 520-A Slide 2, Bald Hill coal bed, Williamson County, Illinois, dimensions are 48.3 × 50.4 microns.

FIG. 8.—*D. granulosus* sp. nov. holotype, maceration 625-A Slide 6, Willis coal bed, Gallatin County, Illinois, dimensions are 52.5 × 48.3 microns.

FIG. 9.—*D. reynoldsburgensis* sp. nov., tetrad showing four spores derived from spore mother cell, maceration 618 Slide 20, Reynoldsburg coal bed, Johnson County, Illinois.

FIG. 10.—*D. reynoldsburgensis* sp. nov. holotype, maceration 618 Slide 21, Reynoldsburg coal bed, Johnson County, Illinois, dimensions are 39.9 × 44.6 microns.

FIG. 11.—*D. reynoldsburgensis* sp. nov. paratype, maceration 618 Slide 19, Reynoldsburg coal bed, Johnson County, Illinois, dimensions are 37.9 × 41 microns.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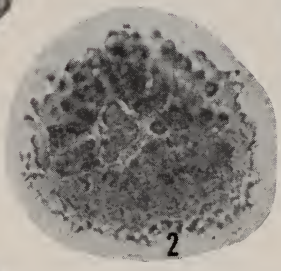
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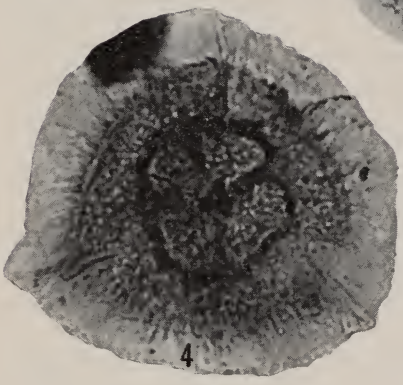
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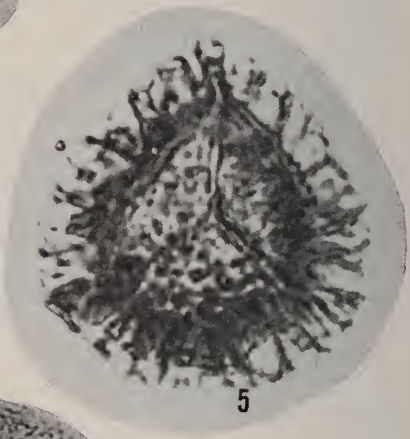
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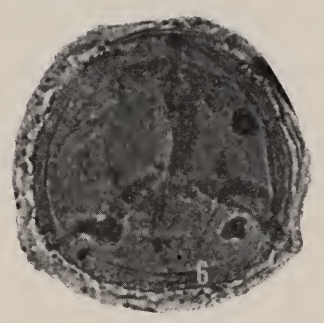
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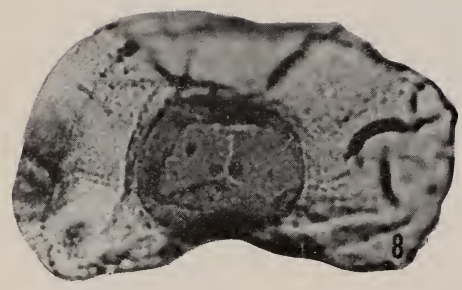
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PLATE 7

FIG. 1.—*Denso-sporites triangularis* sp. nov. holotype, maceration 144 Slide 3, "Sub-Babylon" coal bed, Fulton County, Illinois, dimensions are 58.8 × 58.8 microns.

FIG. 2.—*D. indignabundus* (?) (Loose) S. W. and B., 1944, maceration 618 Slide 2, Reynoldsburg bed, Johnson County, Illinois, dimensions are 70.3 × 77.1 microns.

FIG. 3.—*Cirratriradites difformis* sp. nov. holotype, maceration 625-B Slide 7, Willis coal bed, Gallatin County, Illinois, dimensions are 63 × 53.5 microns.

FIG. 4.—*C. annulatus* sp. nov. holotype, maceration 540-C Slide 6, No. 6 coal bed, Fulton County, Illinois, dimensions are 99.2 × 98.6 microns.

FIG. 5.—*C. rotatus* sp. nov. holotype, maceration 625-B Slide 7, Willis coal bed, Gallatin County, Illinois, dimensions are 50.4 × 50 microns.

FIG. 6.—*C. annuliformis* sp. nov. holotype, maceration 596-A Slide 8, No. 6 coal bed, Vermilion County, Illinois, dimensions are 84 × 82 microns.

FIG. 7.—*Endosporites plicatus* sp. nov. holotype, maceration 573 Slide 6, No. 8 coal bed, Macoupin County, Illinois, dimensions are 86.1 × 81.4 microns.

FIG. 8.—*E. vesicatus* sp. nov. holotype, maceration 542-B Slide 1, No. 8 coal bed, Peoria County, Illinois, dimensions are 73.5 × 136.5 microns.

FIG. 9.—*E. formosus* sp. nov. holotype, maceration 490-A Slide 5, McCleary's Bluff coal bed, Wabash County, Illinois, dimensions are 117.6 × 105 microns.


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PLATE 8

FIG. 1.—*Triquitrites pulvinatus* sp. nov. holotype, maceration 628-A Slide 4, Murphysboro coal bed, Saline County, Illinois, dimensions are 42.2 × 46.2 microns.

FIG. 2.—*T. protensus* sp. nov. holotype, maceration 519-B Slide 1, Dekoven coal bed, Williamson County, Illinois, dimensions are 37.8 × 36.5 microns.

FIG. 3.—*T. discoideus* sp. nov. holotype, maceration 542-B Slide 3, No. 8 coal bed, Peoria County, Illinois, dimensions are 71.4 × 67.2 microns.

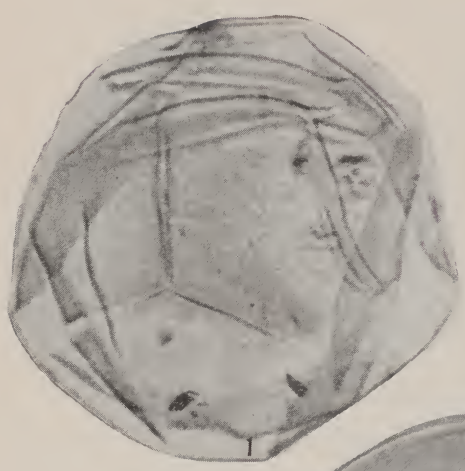
FIG. 4.—*T. priscus* sp. nov. holotype, maceration 587 Slide 13, Battery Rock coal bed, Hardin County, Illinois, dimensions are 40.5 × 40.5 microns.

FIG. 5.—*T. spinosus* Kosanke, 1943, maceration 600 Slide 1, LaSalle coal bed, Bureau County, Illinois, dimensions are 50 × 51.5 microns.

FIG. 6.—*T. crassus* sp. nov. holotype, maceration 574 Slide 21, Shoal Creek coal bed, Bond County, Illinois, dimensions are 66.1 × 67.2 microns.

FIG. 7.—*T. inusitatus* sp. nov. holotype, maceration 603-C Slide 4, No. 2 coal bed, Fulton County, Illinois, dimensions exclusive of corner processes are 65.1 × 67.2 microns.

FIG. 8.—*T. angulatus* sp. nov. holotype, maceration 520-A Slide 3, Bald Hill coal bed, Williamson County, Illinois, dimensions are 71.9 × 70.9 microns.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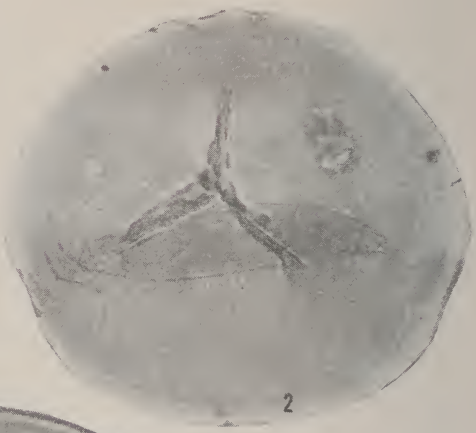
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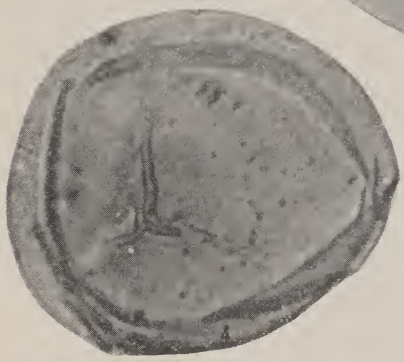
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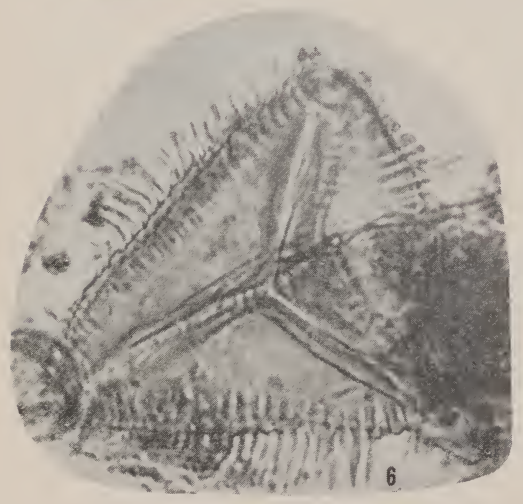
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PLATE 9

FIG. 1.—*Calamospora liquida* sp. nov. holotype, maceration 574 Slide 12, Shoal Creek coal bed, Bond County, Illinois, dimensions are 81.6 × 84 microns.

FIG. 2.—*C. flava* sp. nov. holotype, maceration 538-F Slide 8, Macoupin coal bed (?), Jefferson County, Illinois, dimensions are 107.1 × 119.7 microns.

FIG. 3.—*C. pedata* sp. nov. holotype, maceration 542-C Slide 3, No. 8 coal bed, Peoria County, Illinois, dimensions are 44.1 × 70.3 microns.

FIG. 4.—*C. breviradiata* sp. nov. holotype, maceration 579-B Slide 1, No. 2 coal bed, Bureau County, Illinois, dimensions are 57.7 × 65.1 microns.

FIG. 5.—*C. flexilis* sp. nov. holotype, maceration 625-A Slide 1, Willis coal bed, Gallatin County, Illinois, dimensions are 69.3 × 64 microns.

FIG. 6.—*Reinschospora triangularis* sp. nov. holotype, maceration 573 Slide 2, No. 8 coal bed, Macoupin County, Illinois, dimensions are 74 × 74 microns.

FIG. 7.—*R. triangularis* sp. nov. holotype, portion of holotype specimen as viewed with oil immersion showing spines. One spine inked in black illustrates the partate nature with knobs at the apex. Dotted line below spine indicates origin of spine in spore body. The line below the specimen is 20 microns in length.


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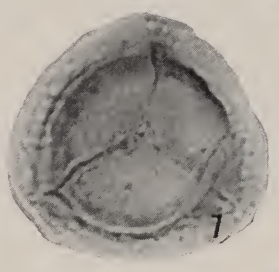
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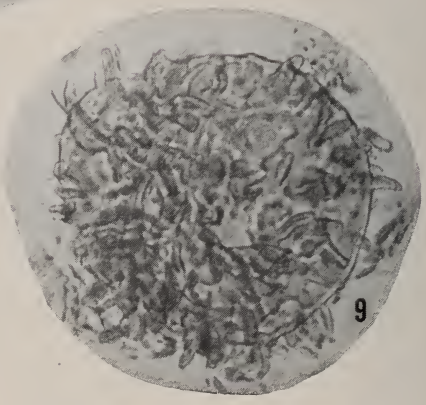
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PLATE 10

FIG. 1.—*Reinschospora punctata* sp. nov. holotype, maceration 572 Slide 4, Upper Scottville coal bed, Macoupin County, Illinois, dimensions are 67.5 × 67 microns.

FIG. 2.—*R. magnifica* sp. nov. holotype, maceration 536-A Slide 1, Shoal Creek coal bed, Franklin County, Illinois, dimensions including flange are 64.2 × 71.5 microns.

FIG. 3.—*Lycospora punctata* sp. nov. holotype, maceration 474-A Slide 4, No. 6 coal bed, Franklin County, Illinois, dimensions are 36.7 × 38 microns.

FIG. 4.—*L. granulata* sp. nov. maceration 603-B Slide 8, No. 2 coal bed, Fulton County, Illinois, a tetrad of spore which is rather common in the isolated spores of *Lycospora*.

FIG. 5.—*L. brevijuga* sp. nov. holotype, maceration 603-C Slide 7, No. 2 coal bed, Fulton County, Illinois, dimensions are 35.7 × 38.8 microns.

FIG. 6.—*L. granulata* sp. nov. holotype, maceration 519-A Slide 14, Dekoven coal bed, Williamson County, Illinois, dimensions are 31.5 × 37.8 microns.

FIG. 7.—*L. pseudoannulata* sp. nov. holotype, maceration 587 Slide 17, Battery Rock coal bed, Hardin County, Illinois, dimensions are 39.7 × 42 microns.

FIG. 8.—*Raistrickia prisca* sp. nov. holotype, maceration 609 Slide 1, Wayside coal bed, Johnson County, Illinois, overall dimensions are 52.5 × 54.6 microns.

FIG. 9.—*R. aculeata* sp. nov. holotype, maceration 490-A Slide 5, McCleary's Bluff coal bed, Wabash County, Illinois, spore body dimensions are 65.1 × 69.3 microns.

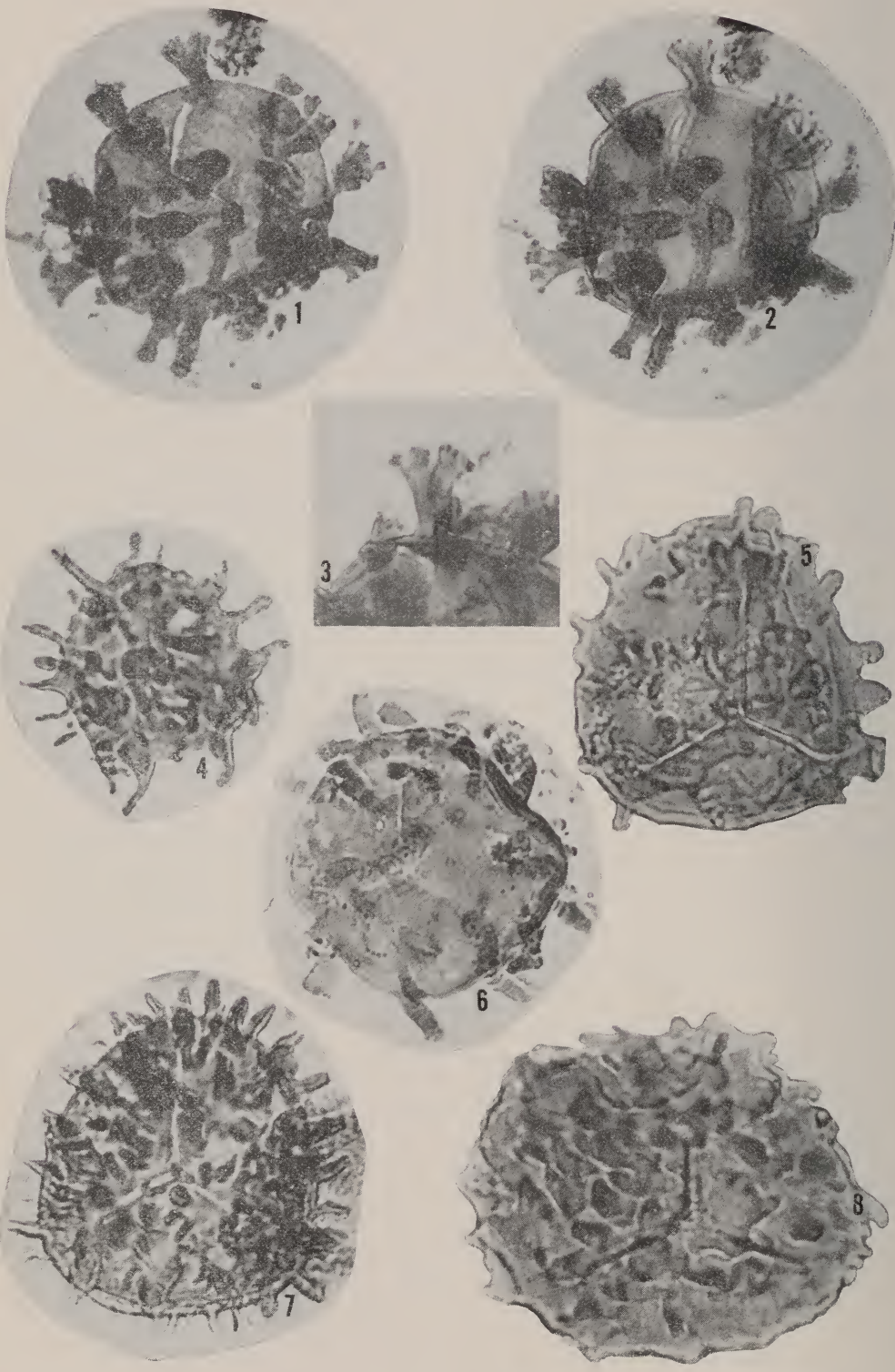
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PLATE 11

FIG. 1.—*Raistrickia protensa* sp. nov. holotype, maceration 474-A Slide 8, No. 6 coal bed Franklin County, Illinois, spore body dimensions are 58.8 × 60.9 microns. Specimen focused to illustrate trilete mark, lips, and commissure.

FIG. 2.—Same specimen as in fig. 1, but focused to show projection opposite left ray.

FIG. 3.—Oil immersion photomicrograph of projection from fig. 2, the projection is 15.2 microns in length from the margin of the spore coat to the apex. Note the partate nature and knobs at the apex of the projections.

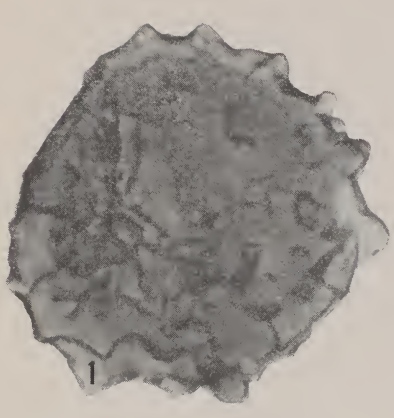
FIG. 4.—*R. pilosa* sp. nov. holotype, maceration 544 Slide 2, No. 7 coal bed, Fulton County, Illinois, body dimensions are 39.9 × 40.3 microns.

FIG. 5.—*R. irregularis* sp. nov. holotype, maceration 603-B Slide 6, No. 2 coal bed, Fulton County, Illinois, overall dimensions are 71.4 × 71.4 microns.

FIG. 6.—*R. crocea* sp. nov. holotype, maceration 603-C Slide 1, No. 2 coal bed, Fulton County, Illinois, spore body dimensions are 69.3 × 73.5 microns.

FIG. 7.—*R. crinita* sp. nov. holotype, maceration 544 Slide 9, No. 7 coal bed, Fulton County, Illinois, spore body dimensions are 61.9 × 58.3 microns.

FIG. 8.—*R. imbricata* sp. nov. holotype, maceration 500-D Slide 3, No. 6 coal bed, Wabash County, Illinois, overall dimensions are 56.7 × 67.2 microns.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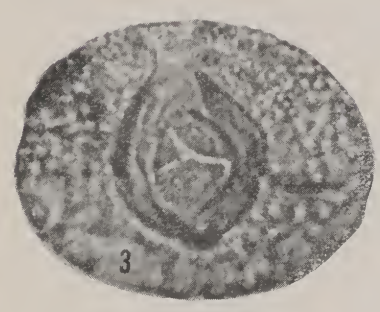
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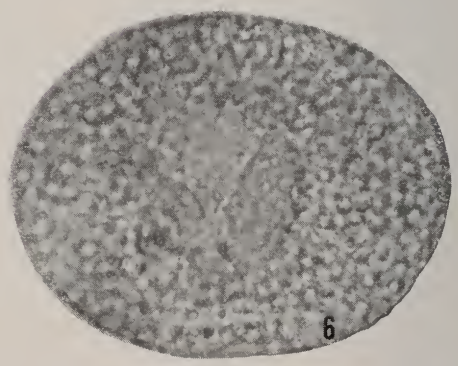
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PLATE 12

FIG. 1.—*Raistrickia rubida* sp. nov. holotype, maceration 574 Slide 19, Shoal Creek coal bed, Bond County, Illinois, overall dimensions are 65.1 × 65.1 microns.

FIG. 2.—*Florinites similis* sp. nov. holotype, maceration 542-C Slide 2, No. 8 coal bed, Peoria County, Illinois, overall dimensions are 92.4 × 132.7 microns.

FIG. 3.—*F. triletus* sp. nov. holotype, maceration 574 Slide 3, Shoal Creek coal bed, Bond County, Illinois, overall dimensions are 52.9 × 65.1 microns. Specimen focused to illustrate partial overlap of bladder on spore body distally, and trilete mark.

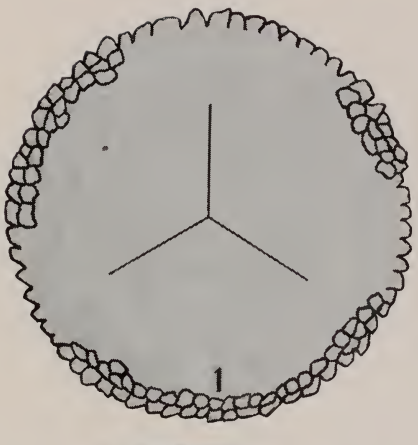
FIG. 4.—Same specimen as in fig. 3, focused to illustrate reticulate bladder ornamentation.

FIG. 5.—*F. diversiformis* sp. nov. holotype, maceration 618 Slide 2, Reynoldsburg coal bed, Johnson County, Illinois, dimensions are 94.5 × 134.4 microns.

FIG. 6.—*F. antiquus* Schopf, 1944, maceration 519-A Slide 15, Dekoven coal bed, Williamson County, Illinois, dimensions are 65 × 84.1 microns. Proximal surface to illustrate complete overlap of the body by the bladder.

FIG. 7.—*F. antiquus* Schopf, 1944, maceration 604-B Slide 7, Tarter coal bed, Fulton County Illinois, dimensions are 56.7 × 73.5 microns. Notice folding of central body.

FIG. 8.—*F. antiquus* Schopf, 1944, maceration 519-B Slide 8, Dekoven coal bed, Williamson County, Illinois, dimensions are 53 × 73.5 microns. View to illustrate distal side of body in part devoid of bladder membrane.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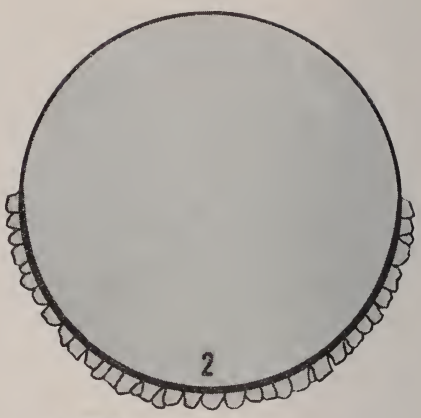
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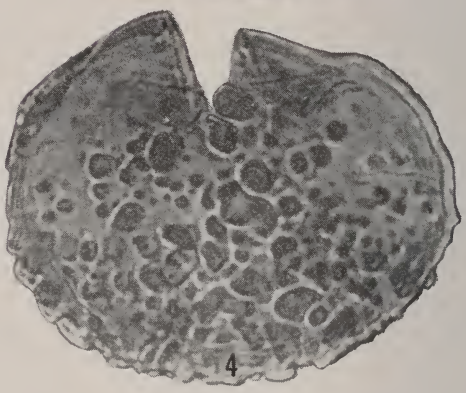
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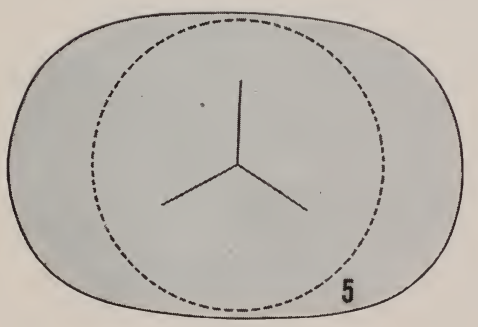
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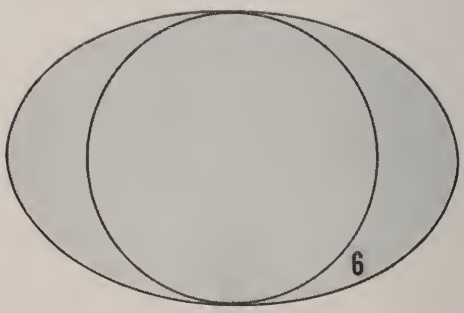
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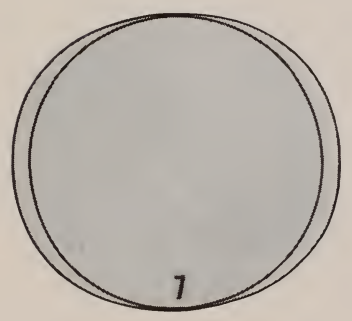
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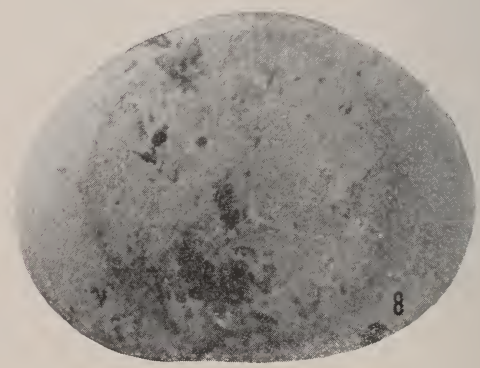
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PLATE 13

FIG. 1.—*Schopfites dimorphus* sp. nov. reconstructed drawing of genotype, maceration 537-L_3 Slide 5, No. 2 coal bed, Franklin County, Illinois, diameter 113.2 microns. Drawing illustrating the external transverse plane.

FIG. 2.—*S. dimorphus* sp. nov. drawing of longitudinal section illustrating levigate proximal surface and ornamented distal surface. Distal portion of spore coat exclusive of ornamentation is thicker than proximal portion of spore coat.

FIG. 3.—*S. dimorphus* sp. nov. genotype photomicrograph, maceration 527-L_3 Slide 5, No. 2 coal bed, Franklin County, Illinois, dimensions are 105 × 113.2 microns.

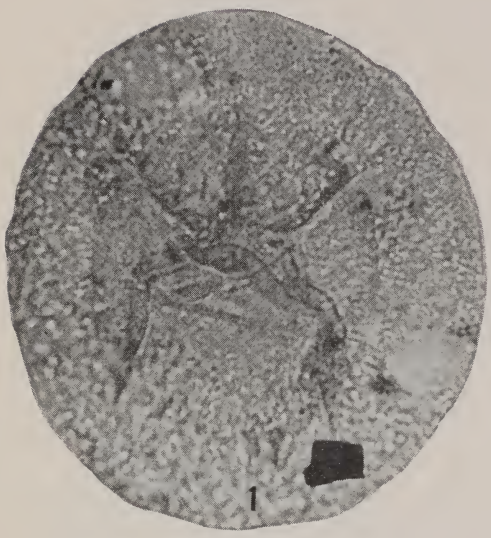
FIG. 4.—*S. colchesterensis* sp. nov. holotype, maceration 603-C Slide 7, No. 2 coal bed, Fulton County, Illinois, dimensions are 78.1 × 90.3 microns.

FIG. 5.—*Schulzospora rara* sp. nov. reconstructed drawing of genotype, maceration 587 Slide 8, Battery Rock coal bed, Hardin County, Illinois, dimensions are 81.9 × 109.2 microns. Drawing illustrating the external transverse plane.

FIG. 6.—Longitudinal section of fig. 5 illustrating complete bladder overlap of the body.

FIG. 7.—Cross-section of fig. 5 illustrating spherical body and bladder overlap.

FIG. 8.—*Schulzospora rara* sp. nov. genotype, maceration 587 Slide 8, Battery Rock coal bed, Hardin County, Illinois, dimensions are 81.9 × 109.2 microns.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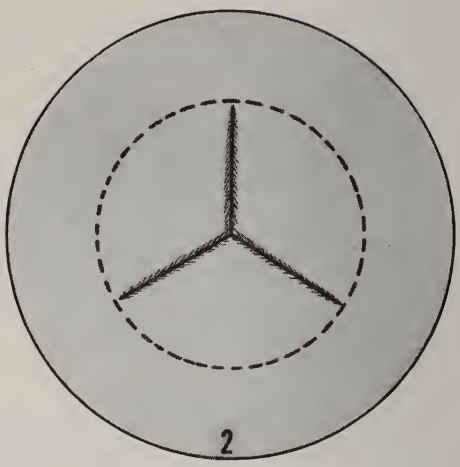
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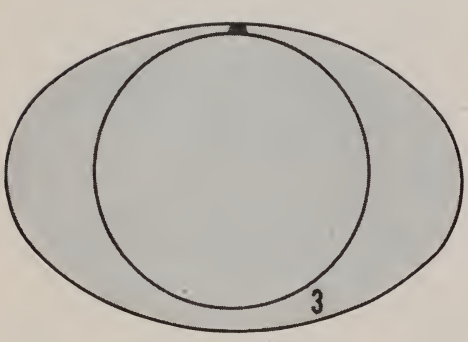
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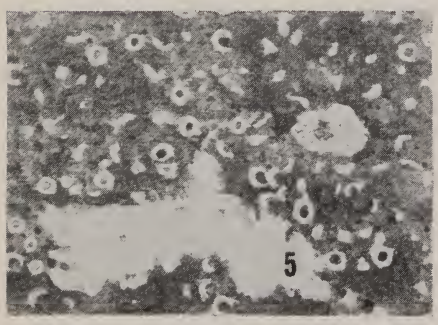
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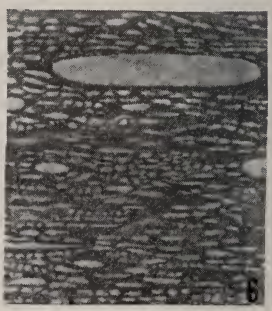
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PLATE 14

FIG. 1.—*Wilsonia vesicatus* sp. nov. genotype, maceration 600 Slide 2, LaSalle coal bed, Bureau County, Illinois, overall dimensions are 79.8 × 75.6 microns.

FIG. 2.—Reconstruction of a transverse proximal view of the genotype *W. vesicatus*.

FIG. 3.—*Diagrammatic* cross-section of fig. 2 illustrating the bladder which overlaps the circular body.

FIG. 4.—*W. delicata* sp. nov. holotype, maceration 540-C Slide 8, No. 6 coal bed, Fulton County, Illinois, overall dimensions are 92.4 × 86.1 microns.

FIGS. 5-6.—Thin section of cannel coal from Witham (1833, Pl. 11, figs. 4 and 5) believed to be the first thin sections of coal ever made. Fig. 5 is a transverse section and fig. 6 a cross-section illustrating megaspores and possibly small spores. 100×.


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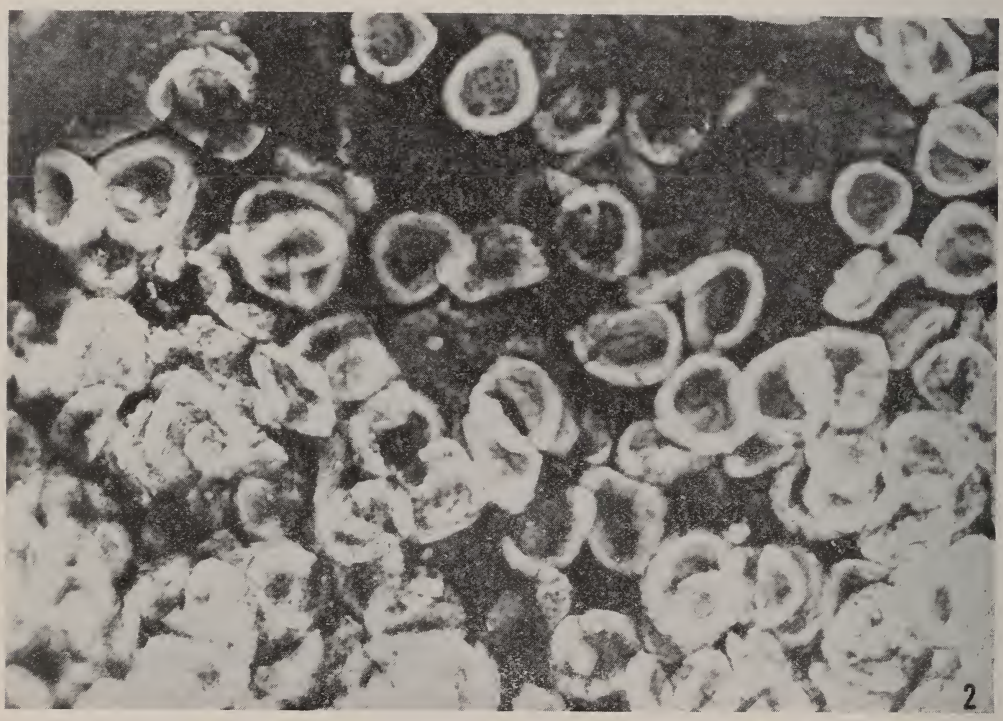
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PLATE 15

FIG. 1.—Thin cross-section of the Reynoldsburg coal from Johnson County, Illinois. The section contains numerous bands of anthraxylon, some attritus, opaque matter, and spores. Many of the spores are of the genus *Denso-sporites* which in cross-section appear dumb-bell shaped. 350×.

FIG. 2.—A thin horizontal section of the Reynoldsburg coal from Johnson County, Illinois. The section contains many ("splint spores") spores of *Denso-sporites reynoldsburgensis*. 350×.

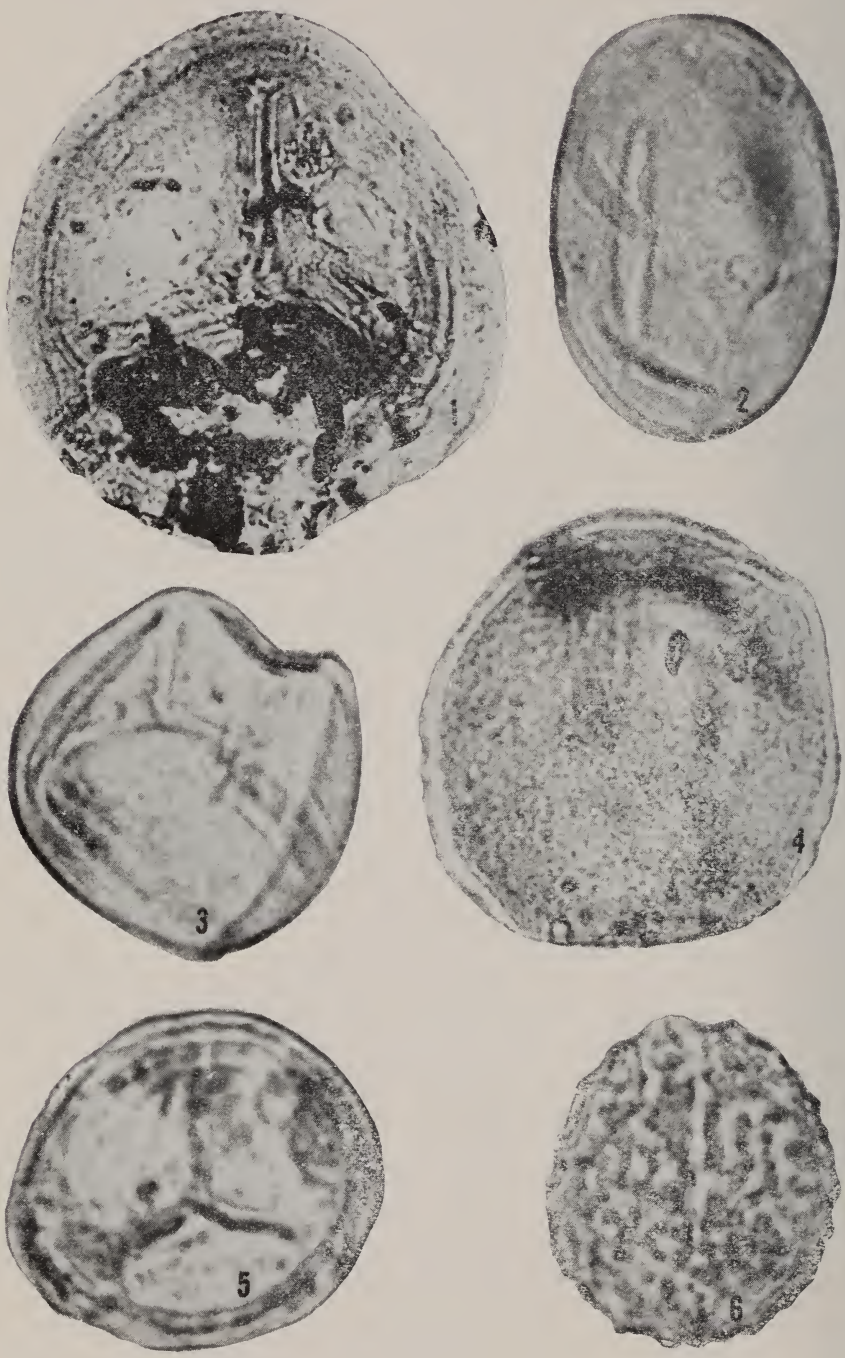
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PLATE 16

FIG. 1.—*Cadiospora magna* sp. nov. genotype, maceration 600 Slide 15, LaSalle coal bed, Bureau County, Illinois, dimensions are 117.6 × 111.3 microns.

FIG. 2.—*Laevigato-sporites medius* sp. nov. holotype, maceration 578 Slide 5, Scottville coal bed, Macoupin County, Illinois, dimensions are 42.1 × 28.3 microns.

FIG. 3.—*Punctati-sporites minutus* sp. nov. holotype, maceration 584 Slide 7, Woodbury coal bed (?), Jasper County, Illinois, dimensions are 29.4 × 28.7 microns.

FIG. 4.—*P. vagus* sp. nov. holotype, maceration 694 Slide 5, Shelbyville coal bed, Shelby County, Illinois, dimensions are 65 × 63 microns.

FIG. 5.—*Lycospora parva* sp. nov. holotype, maceration 591-B Slide 5, No. 7 coal bed, Vermilion County, Illinois, the overall dimensions are 26.2 × 29.4 microns.

FIG. 6.—*Laevigato-sporites obscurus* sp. nov. holotype, maceration 576 Slide 14, New Haven coal bed, Gallatin County, Illinois, dimensions are 32.5 × 29.4 microns.

REFERENCES

Arnold, Chester A., 1944, A heterosporous species of *Bowmanites* from the Michigan coal basin: Am. Jour. Botany, vol. 31, no. 8, pp. 466-469.

Bartlett, Harley Harris, 1928, Fossils of the Carboniferous coal pebbles of the glacial drift at Ann Arbor: Michigan Acad. Sci. Papers, vol. 9, pp. 11-28.

Bell, Alfred H., Ball, Clayton, and McCabe, Louis, 1931, Geology of the Pinckneyville and Jamestown Areas, Perry County, Illinois: Illinois Geol. Survey, Illinois Petroleum 19, pp. 1-22.

Bennie, James and Kidston, Robert, 1886, On the occurrence of spores in the Carboniferous Formation of Scotland: Royal Physical Soc. of Edinburgh Proc., vol. 9, pp. 82-117.

Berry, Willard, 1937, Spores from the Pennington coal, Rhea County, Tennessee: Am. Midland Naturalist, vol. 18, no. 1, pp. 155-160.

Binney, E. W., 1848, On the origin of coal: Manchester Lit. Philos. Soc. Mem. and Proc., vol. 8.

Bowmann, J. E., 1841, On the origin of coal and the geological conditions under which it was produced: Manchester Geol. Soc. London Trans., pp. 38-46.

Cady, G. H., 1916, Coal resources of district 6: Illinois Geol. Survey, Illinois Coal Min. Inv., Bull. 15, p. 45.

Cady, G. H., 1919, Coal resources of district 5: Idem, Bull. 19, p. 20.

Cady, G. H., 1926, The areal geology of Saline County: Illinois Acad. Sci. Trans., vol. 19, pp. 250-272.

Cooper, C. L., 1946, Pennsylvanian Ostracodes of Illinois: Illinois Geol. Survey Bull. 70, 177 pp.

DeWolf, F. W., 1910, Studies of Illinois coal: Illinois Geol. Survey Bull. 16, p. 181.

Dunbar, Carl O., and Henbest, Lloyd G., 1942, Pennsylvanian Fusulinidae of Illinois: Illinois Geol. Survey Bull. 67, 218 pp.

Erdtman, G., 1943, An introduction to Pollen Analysis: Chronica Botanica, Waltham, Massachusetts, 239 pp.

Florin, Rudolf, 1936, On the structure of the pollen grains in the Cordaitales: Svensk bot. tidsk., vol. 30, no. 3, pp. 624-651.

Florin, Rudolf, 1937, On the morphology of the pollen grains in some Paleozoic pteridosperms: Idem, vol. 31, no. 3, pp. 305-338.

Florin, Rudolf, 1938-40, 1944, Die Koniferen des Oberkarbons und des unteren Perms: 1 Heft, pp. 1-62, pls. 1-30, 1938; 2 Heft, pp. 63-122, pls. 31-74, 1939; 3 Heft, pp. 123-173, pls. 75-110, 1939; 4 Heft, pp. 175-241, pls. 111-150, 1939; 5 Heft, pp. 243-263, pls. 151-166, 1940; 6 Heft, pls. 167-172, 1944; 7 Heft, 1944; Paleontographica, vol. 85, Abt. B.

Hartung, W., 1933, Die Sporenverhältnisse der Calamariaceen: Inst. Paläobot. u. Petrog. der Brennsteine Arb., vol. 3, no. 3, pp. 95-149.

Henbest, Lloyd G., 1928, Fusulinellas from the Stonefort limestone member of the Tradewater formation: Jour. Paleontology, vol. 2, no. 1, pp. 70-85.

Hoskins, J. H. and Cross, A. T., 1943, Monograph of the paleozoic cone genus *Bowmanites* (Sphenophyllales): Am. Midland Naturalist, vol. 30, no. 1, pp. 113-163.

Ibrahim, Ahmet Can, 1933, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Dissertation, Berlin; privately pub. 1933, by Konrad Triltsch, Wurzburg, 47 pp.

Jeffrey, Edward C., 1910, The nature of some supposed algal coals: Am. Acad. Arts Sci. Proc., vol. 46, no. 12, pp. 273-290.

Kidston, Robert, 1906, On the microsporangia of the Pteridospermeae, with remarks on their relationship to existing groups; Royal Soc. London Philos. Trans., B, vol. 198, pp. 413-446.

Knox, E. M., 1938, The spores of Pteridophyta, with observations on microspores in coals of Carboniferous age: Bot. Soc. Edinburgh Trans. and Proc., vol. 32, no. 3, pp. 438-466.

Knox, E. M., 1939, The spores of Bryophyta compared with those of Carboniferous age: Idem, vol. 32, no. 4, pp. 477-487.

Knox, E. M., 1942, The microspores in some coals of the productive Coal Measures in Fife: Inst. Min. Eng. Trans., London, vol. 10, no. 4, pp. 98-112.

Kosanke, R. M., 1943, The characteristic plant microfossils of the Pittsburgh and Pomeroy coals of Ohio: Am. Midland Naturalist, vol. 29, no. 1, pp. 119-132.

Kosanke, R. M., 1947, Plant microfossils in correlation of coal beds: Jour. Geology, vol. LV, no. 3, pp. 280-284.

Lee, Wallace, 1916, Geology of the Kentucky Part of the Shawneetown Quadrangle: Kentucky Geol. Survey, ser. 4, vol. 4, part 2, 73 pp.

Loose, Friederich, 1932, Beschreibung von Sporenformen aus Flöz Bismarck; in Potonie, R., Sporenformen aus den Flözen Ägir und Bismarck des Ruhrgebietes: Neues Jahrb., Beilage-Band 67, Abt. B, pp. 449-452.

Loose, Friederich, 1934, Sporenformen aus dem Flöz Bismarck des Ruhrgebietes: Inst. Paläobot. u. Petrog. d. Brennsteine Arb., vol. 4, no. 3, pp. 127-164.

McCabe, Louis C., 1931, Some plant structures of coal: Illinois Acad. Sci. Trans. 24, no. 2, pp. 321-326.

MILLOTT, J. O'N., 1939, The microspores in the coal seams of North Staffordshire. Part 1—the grit—ten foot coals: Inst. Min. Eng. Trans. (London), vol. 96, pp. 317-353. (Reprinted in Colliery Guardian, vol. 158 (4074): pp. 151-153; Ibid. (4075): pp. 200-204, Jan. and Feb. 1939.)

MOORE, WANLESS, WELLER, et al., 1944, Correlation of Pennsylvanian Formations of North America: Geol. Soc. America Bull., vol. 55, pp. 657-706.

MORRIS IN PRESTWICK, 1840, On the geology of Coalbrook Dale: Geol. Soc. London, Trans. II, ser. 2, vol. 5.

NEWTON, WILLIAM A., and WELLER, J. MARVIN, 1937, Stratigraphic studies of Pennsylvanian outcrops in part of southeastern Illinois: Illinois Geol. Survey Rept. Inv. 45, 31 pp.

NICHOLS, G. E., 1923, A working basis for the ecological classification of plant communities. Ecol. vol. 4, p. 167.

OWEN, DAVID DALE, 1856, Report of the geological survey in Kentucky, made during the years 1854 and 1855; First Geological Survey Kentucky, 416 pp., Frankfort, Kentucky.

OWEN, DAVID DALE, 1857, Third report of the geological survey in Kentucky, made during the years 1856 and 1857: First Geol. Survey Kentucky, 589 pp., Frankfort, Kentucky.

PAGET, R. F., 1936, The correlation of coal seams by microspore analysis; The seams of Warwickshire: Inst. Min. Eng. Trans. London, vol. 92, no. 2, pp. 59-88. (In part reprinted in Colliery Guardian, vol. 153 (3954), pp. 654-663, 1936. Discussion in Colliery Guardian (3955-3956) pp. 748-750, 797-798, 1936).

PAYNE, J. N., 1942, Structure of Herrin (No. 6) coal bed in Macoupin County, Eastern Greene and Jersey, Southeastern Scott and Southern Morgan and Sangamon Counties, Illinois: Illinois Geol. Survey Circ. 88.

PHILLIPS, J., 1842, On the microscopic structure of coal: Brit. Assoc. Adv. Sci. Rept., Part 2, pp. 47-48.

POTONIE, R., 1931, Zur Mikroskopie der Braunkohle. Tertiäre Blütenstaubformen (1'ste mitteilung): Braunkohle, Jg. 30, no. 16, pp. 325-333.

RAISTRICK, A. and SIMPSON, J., 1933, The microspores of some Northumberland coals, and their use in the correlation of coal seams: Inst. Min. Eng. Trans. (London), vol. 85, no. 4, pp. 225-235.

RAISTRICK, A., 1934, The correlation of coal seams by microspore content. Pt. I—the seams of Northumberland: Inst. Min. Eng. Trans. (London), vol. 88, no. 3, pp. 142-153.

RAISTRICK, A., 1935, The microspore analysis of coal: Naturalist, 1935, pp. 145-150.

RAISTRICK, A., 1937, The microspores of coal and their use in correlation: Congres pour l'avancement des etudes de stratigraphie Carbonifere, Heerlen, 1935, Compte rendu, vol. 2, pp. 909-917.

RAISTRICK, A., 1938, The microspore content of some Lower Carboniferous coals: Leeds Geol. Assoc. Trans. vol. 5, no. 4, pp. 221-226.

RAISTRICK, A., 1939, The correlation of coal seams by microspore content, Pt. II—The Trencherbone seam, Lancashire, and the Busty seams, Durham: Inst. Min. Eng. Trans. (London), vol. 97, pp. 425-431. (In part reprinted in Colliery Guardian, vol. 158 (4094), pp. 1059-1061, June 1939.)

REED, FREDDA D., 1938, Notes on some plant remains from the Carboniferous of Illinois, Bot. Gazette, vol. 100, no. 2, pp. 324-335.

REINSCH, P. F., 1881, Neue Untersuchungen über die Mikrostruktur der Steinkole des Carbon, der Dyas und Trias, Leipzig, Verlag T. O. Weigel.

REINSCH, P. F., 1884, Micro-Palaeophytologia formationis carboniferae: vol. 1. Continens Trileteas et Stelideas. Erlangae, Germania. Theo. Krische, pp. VII + 80, pls. 1-66.

SCHOPF, J. M., 1936, The paleobotanical significance of plant structure in coal: Illinois State Acad. Sci. Trans. (1935), vol. 28, no. 2, pp. 106-110.

SCHOPF, J. M., 1938, Spores from the Herrin (No. 6) coal bed in Illinois: Illinois Geol. Survey Rept. Inv. 50, 73 pp.

SCHOPF, J. M., WILSON, L. R., and BENTALL, RAY, 1944, An annotated synopsis of paleozoic fossil spores and the definition of generic groups: Illinois Geol. Survey Rept. Inv. 91, 72 pp.

SCHULZ, FRANZ, 1855, Über das Vorkommen wohlerhaltener Zellulose in Braunkohle and Steinkohle: Ber. K. Akad. Wiss. Berlin, pp. 676-678.

SCOTT, D. H., 1898, On the structure and affinities of fossil plants from the Paleozoic rocks. —II. On *Spencerites,* a new genus of lycopodiaceous cones: Royal Soc. London Philos. Trans., ser. B, vol. 189, pp. 83-106.

SELLING, OLAF H., 1946, Studies in Hawaiian pollen statistics, Part I, The spores of the Hawaiian Pteriodophytes: Bishop Museum Special Publication 37, Honolulu, Hawaii, 87 pp.

THIESSEN, R., 1925, Origin of the boghead coals: U. S. Geol. Survey Prof. Paper 132, pp. 121-135.

THIESSEN, R. (Fieldner, A. C., Davis, J. D., Thiessen, R., Kester, E. B., Selvig, W. A., Reynolds, D. A., Jung, F. W., Sprunk, G. C.) 1932, Carbonizing properties and constitution of Pittsburgh bed coal from

Edenborn Mine, Fayette County, Pa.: U. S. Bur. Mines Tech. Paper 525, 60 pp.

Thiessen, R., 1932, Carbonizing properties and constitution of No. 6 coal bed from West Frankfort, Franklin County, Illinois: U. S. Bur. Mines Tech. Paper 524, 60 pp.

Thiessen, R., Spiunk, G. C., and O'Donnel, H. J., 1938, Preparation of thin sections of coal: U. S. Bur. Mines Inf. Circ. 7021, pp. 1-8.

Thompson, R. B., 1927, Evolution of the seed habit in plants: Royal Soc. Canada Trans. ser. 3, vol. 21, pp. 229-272.

Udden, Jon, 1906, The Delafield drill core; and the Elm Grove Coal Company's boring: Illinois Geol. Survey Bull. 4, pp. 203-211.

Wanless, Harold R., 1939, Pennsylvanian correlations in the Eastern Interior and Appalachian coal fields: Geol. Soc. America Spec. Papers 17, 130 pp.

Weller, J. Marvin, and Wanless, Harold R., 1939, Correlation of mineable coals of Illinois, Indiana and Western Kentucky: Am. Assoc. Petroleum Geologists Bull., vol. 23, no. 9, pp. 1374-1392.

Weller, J. Marvin, 1940, Geology and oil possibilities of extreme southern Illinois: Illinois Geol. Survey. Rept. Inv. 71, 71 pp.

Weller, J. Marvin, Henbest, Lloyd G., and Dunbar, Carl O., 1942, *In* Pennsylvanian Fusulinidae of Illinois, Dunbar, Carl O., and Henbest, Lloyd G., Illinois Geol. Survey Bull. 67, pp. 9-28.

Weller, J. Marvin, 1945, Geologic map of Illinois, Illinois Geol. Survey.

Wicher, Carl A., 1934a, Sporenformen der Flammkohle des Ruhrgebietes: Inst. Paläobotanik u. Petrog. der Brennsteine Arb, vol. 4, no. 4, pp. 165-212.

Wicher, Carl A., 1934b, Uber abortiverscheinungen bei fossilen sporen und ihre Phylogenetische Bedeutung: Idem, vol. 5, no. 3, pp. 87-96.

Wilson, L. R., and Coe, E. A., 1940, Descriptions of some unassigned plant microfossils from the Des Moines series of Iowa: Am. Midland Naturalist, vol. 23, no. 1, pp. 182-186.

Wilson, L. R., and Kosanke, R. M., 1944a, Seven new species of unassigned plant microfossils from the Des Moines series of Iowa: Iowa Acad. Sci. Proc., vol. 51, pp. 329-333.

Wilson, L. R., 1944b, Spores and pollen as microfossils: Bot. Review, vol. 10, no. 8, pp. 499-523.

Wilson, L. R., and Webster, Ruth M., 1946, Plant microfossils from a Fort Union coal of Montana: Am. Jour. Botany, vol. 33, no. 4, pp. 271-278.

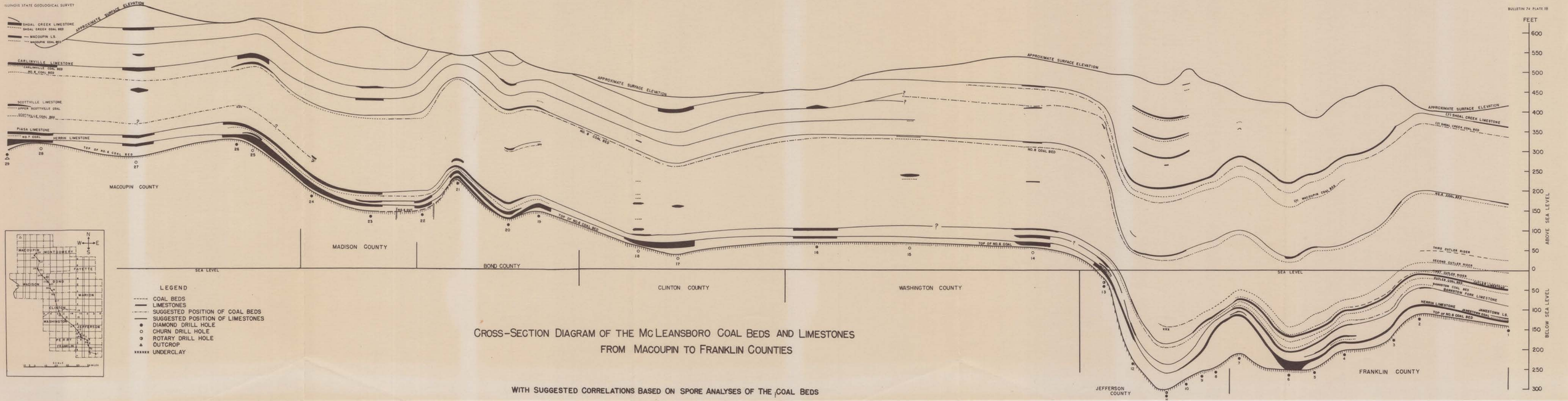
Witham, Henry T. M., 1833, The internal structure of fossil vegetables found in the Carboniferous and oolitic deposits of Great Britain: Adam and Charles Black; Edinburg, and Longman, Rees, Orme, Grown, Green and Longman, London, 84 pp.

Wodehouse, R. P., 1935, Pollen grains: McGraw-Hill, New York and London, 574 pp.

Zerndt, Jan., 1937, Les mégaspores du bassin houiller Polonais; Deuxieme partie: Acad. polonaise des Sci. et des Lettres, Comité des publications Silésiennes—Travau Géol., no. 3, pp. 1-78.

ILLINOIS STATE GEOLOGICAL SURVEY

BULLETIN 74 PLATE 18



LEGEND

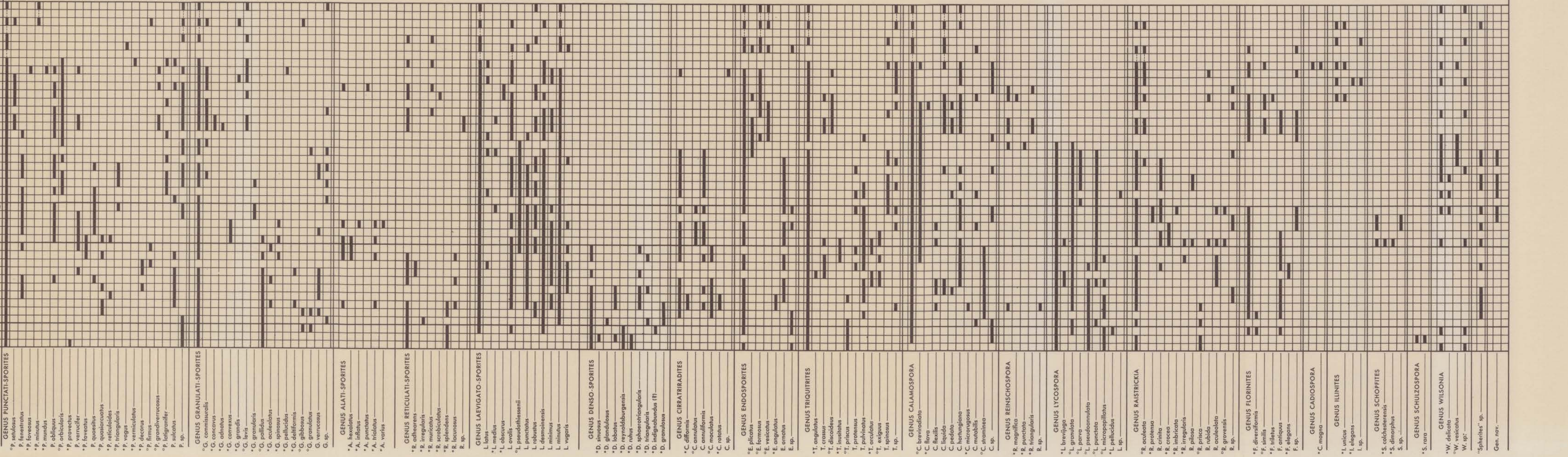
- COAL BEDS
- LIMESTONES
- SUGGESTED POSITION OF COAL BEDS
- SUGGESTED POSITION OF LIMESTONES
- DIAMOND DRILL HOLE
- CHURN DRILL HOLE
- ROTARY DRILL HOLE
- OUTCROP
- UNDERCLAY

CROSS-SECTION DIAGRAM OF THE MCLEANSBORO COAL BEDS AND LIMESTONES FROM MACOUPIN TO FRANKLIN COUNTIES

WITH SUGGESTED CORRELATIONS BASED ON SPORE ANALYSES OF THE COAL BEDS

SPORE DISTRIBUTION CHART

PENNSYLVANIAN SYSTEM ILLINOIS	COAL BEDS			
	SOUTHERN	WESTERN SOUTHWESTERN	NORTHERN	CENTRAL SOUTHEASTERN
McLeansboro				Watson
				Woodbury (?)
				Trowbridge
				Shelbyville
			LaSalle	
				Friendsville
				McCleary's Bluff
				New Haven
		Shoal Creek		
		Macoupin		
		Carlinville		
				Ditney
		Trivoli (No. 8)		
	3rd Cutler Rider			
		Upper Scottville		
		Scottville		
	2nd Cutler Rider			
	1st Cutler Rider			
				Danville (No. 7)
	Cutler			
	Bankston			
	Jamestown			
Carbondale	Herrin (No. 6)	Herrin (No. 6)		Grape Creek (No. 6)
	Briar Hill (No. 5-A)			
	Harrisburg (No. 5)	Springfield (No. 5)		
		Summum (No. 4)		
	No. 2	Colchester	No. 2	
Tradewater	DeKoven	Greenbush		
	Davis	Wiley		
	Stonefort			
	Bald Hill			
	Murphysboro			
			Rock Island	
	Delwood	Pope Creek		
	Willis	Tartar		
		Babylon		
		Sub-Babylon		
Caseyville	Reynoldsburg			
	Battery Rock			
	Wayside			



* Spores of restricted range useful in correlating coal beds.
° Spores restricted to groups or with important geological ranges.