STATE OF ILLINOIS 1970
DEPARTMENT OF REGISTRATION AND EDUCATION

Correlation and Palynology of Coals in the Carbondale and Spoon Formations (Pennsylvanian) of the Northeastern Part Of the Illinois Basin

Russel A. Peppers

BULLETIN 93

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA, ILLINOIS 61801

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Topographic mapping in cooperation with the United States Geological Survey.

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Manuscript submitted for printing July 31, 1969

CORRELATION AND PALYNOLOGY OF COALS IN THE CARBONDALE AND SPOON FORMATIONS (PENNSYLVANIAN) OF THE NORTHEASTERN PART OF THE ILLINOIS BASIN

Russel A. Peppers

Abstract

Palynological investigations of about 240 coal samples from the Carbondale and Spoon Formations (Pennsylvanian), primarily from the northeastern part of the Illinois Basin, reveal that the occurrence and relative abundance of certain spore taxa are useful in the identification and correlation of these coals and associated strata. The data obtained clarify the geologic ranges of the plant microfossils in the strata of the Kewanee Group.

The coal members most extensively sampled were the Colchester (No. 2), Lowell, Summum (No. 4), Springfield (No. 5), Herrin (No. 6), and Danville (No. 7) Coals, mainly from Livingston, Grundy, LaSalle, and Edgar Counties, Illinois. Other coals analyzed for their spore content included one tentatively correlated with the Rock Island (No. 1) Coal; one tentatively correlated with the Murphysboro Coal; the Wiley, DeKoven, and Seelyville Coals; one thin, uncorrelated coal below the No. 2 Coal; a coal tentatively assigned to the Abingdon Coal; the Cardiff and Shawneetown Coals; an unnamed Indiana coal between the Houchin Creek (IVa) and Springfield (V) Coals; and the Briar Hill (No. 5A), Spring Lake, Jamestown, and Allenby Coals. A total of 57 sample sites are represented.

Of the 59 spore genera and 221 species differentiated, four genera and 35 species are proposed as new and are formally described and named. In addition, one genus is described that is probably a fungus. New spore taxa include six species of *Raistrickia,* two of *Hymenospora, Vestispora, Punctatisporites, Granulatisporites, Lophotriletes, Apiculatisporis,* and *Dictyotriletes,* and one each of *Leiotriletes, Cyclogranisporites, Anapiculatisporites, Schopfites, Maculatasporites, Microreticulatisporites, Reticulatisporites, Camptotriletes, Triquitrites, Indospora,*

Cirratriradites, *Perotriletes*, *Pileatisporites*, *Distortisporites*, and *Balteosporites*. The last three are new genera. The spore genus *Kewaneesporites* also is erected to accommodate two previously described species of *Punctatisporites*, *P. reticuloides*, and *P. patulus*, which are emended. *Trihyphaecites* is proposed as the generic name of a microfossil that is probably fungal in origin. *Punctatisporites transenna* Peppers, 1964, is placed in synonymy with *P. vermiculatus*. The genus *Kosankeisporites* and the species *K. elegans* and *Laevigatosporites robustus* are emended. *Elaterites triferens*, previously described from coal ball petrifactions, is recorded from a coal maceration for the first time.

Despite variations in the composition of spore assemblages within the same coal, individual coals of the Carbondale and Spoon Formations can be differentiated. Conspicuous changes in the spore floras occur between the No. 2 and Lowell Coals, between the Lowell (and equivalent coals) and the No. 4 Coals, between the No. 5 and No. 5A Coals, and between the No. 5A and No. 6 Coals. The No. 4 and No. 5 Coals are the most difficult to distinguish from each other by spore analysis.

The spore populations of the coals of the Carbondale and Spoon Formations are markedly dominated by *Lycospora* except in the interval between and including the Lowell and No. 5 Coals and in a thin coal (Abingdon (?) Coal) below the No. 2 Coal. In those coals *Laevigatosporites* is more abundant or almost as abundant as *Lycospora*. *Thymospora* is a very significant part of the spore assemblage in the interval from the No. 4 Coal to the No. 5A Coal.

Distinct changes occur in the composition of spore assemblages in the No. 2, Lowell, and No. 4 Coals as the coals are traced from the west and onto the LaSalle Anticlinal Belt and the gentle Ancona-Garfield structure along the western flank of the belt. During part of the Pennsylvanian Period the LaSalle Anticlinal Belt, especially the Ancona-Garfield structure, probably was high enough to have affected the depth of the water table, salinity, and drainage patterns while the No. 2, Lowell, and No. 4 Coals were being deposited. These changes in environmental conditions had a noticeable influence on the geographic and stratigraphic distribution of the spore-bearing plants of the coal swamp floras.

The names Cardiff Coal and Spring Lake Coal are reintroduced and type sections are proposed for them. As the type section of the Summum (No. 4) Coal has been destroyed by strip-mine operations, an alternate type section is designated. The erroneous stratigraphic position for the Shawneetown Coal given when its type section was described is corrected, as is the spelling of the Seelyville Coal.

INTRODUCTION

The delineation and correlation of individual coal members, essential to studies of Pennsylvanian stratigraphy and coal resources, are difficult or impossible where outcrop, mine, or drill hole information is scarce, especially in areas of rapid stratigraphic transitions. To help resolve some of these difficulties, Kosanke (1950) used small spores to establish a framework of correlation for the important Illinois coals. Because of the comprehensive nature of this significant contribution, the number of samples included was small in relation to the area and thickness of strata considered. More detailed investigations of the fossil spore flora of Illinois have become necessary as the need for more precise stratigraphic correlation increases.

A brief discussion of previous investigations of Pennsylvanian palynology in Illinois was given by Peppers (1964, p. 11). Literature dealing with Pennsylvanian small spores from many parts of the world is so voluminous that no attempt will be made to discuss it here.

The small plant spores of Pennsylvanian age from coals of the upper part of the Spoon Formation and from the Carbondale

Formation of the Illinois Basin are described in this report. The Carbondale coals are geographically the most extensive and economically the most important in Illinois.

The Carbondale and Spoon Formations form the Kewanee Group of Illinois, the Carbondale at the top and the Spoon at the base (text fig. 1). The Carbondale Formation is defined (Kosanke et al., 1960) as including strata between the base of the Colchester (No. 2) Coal and the top of the Danville (No. 7) Coal. Although most of the coal samples were obtained from the Carbondale, several coals from the upper part of the Spoon Formation were included because two cored sections in Livingston County encountered thin coals a few feet below the No. 2 Coal, and it seemed worth while to include them in this investigation.

In a study of strippable coal reserves, Smith (1968) described the stratigraphy and distribution of the various coals in the area that were most extensively sampled for this investigation.

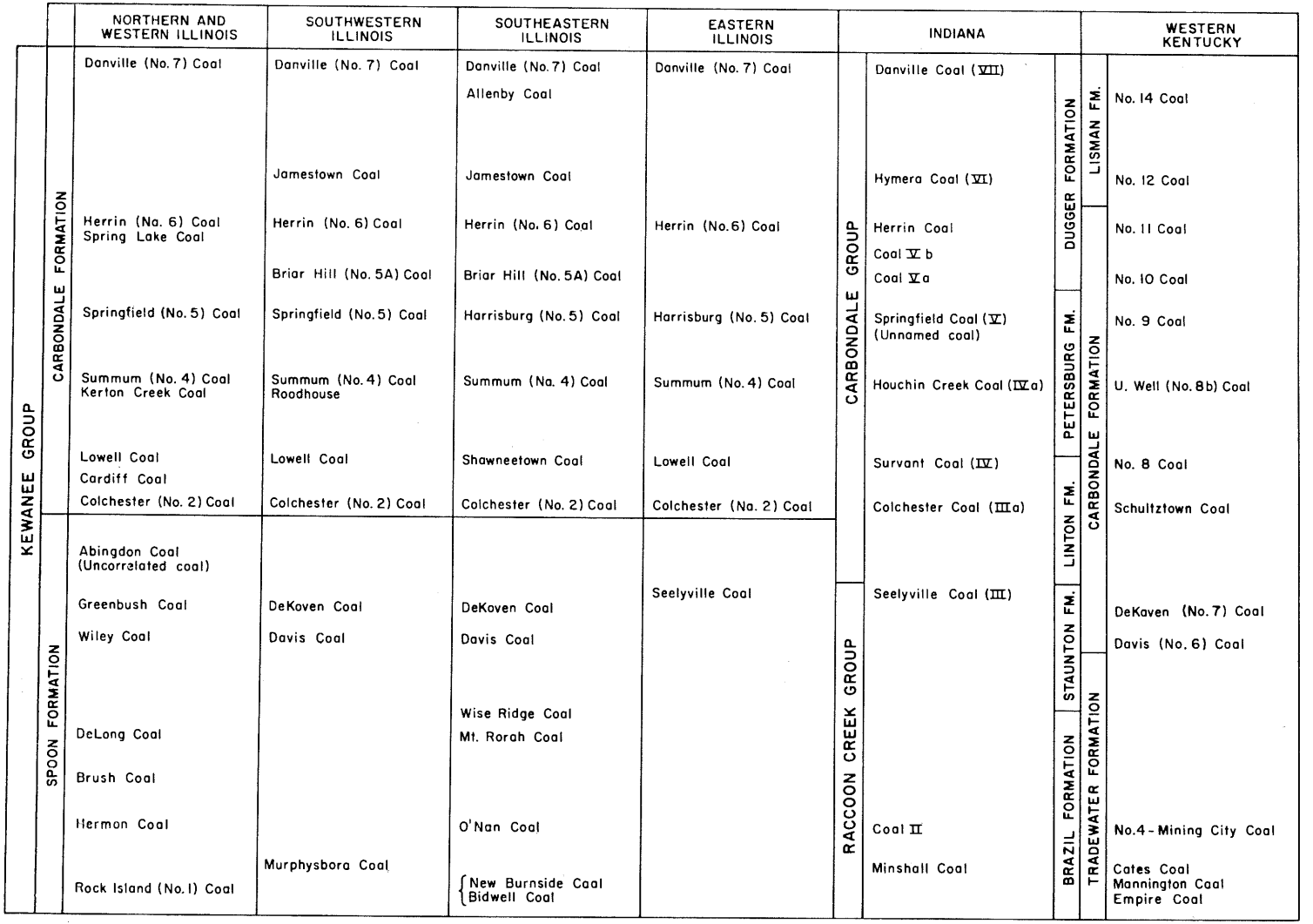
The area from which the coals were sampled is shown in text figures 2 and 3. Most of the samples were obtained from LaSalle, Livingston, Grundy, Kankakee, and Edgar Counties in the northeastern and eastern portions of the Illinois Basin. Other sample localities in Fulton, McDonough, Logan, Tazewell, Marshall, Bureau, Vermilion, Saline, Franklin, and Gallatin Counties of Illinois and in Vigo and Vermillion Counties of Indiana were selected for stratigraphic control and for the purpose of comparing spore assemblages over considerable lateral distances. Type localities of coal members were sampled where possible. About 240 benched samples from 57 localities (text figs. 2 and 3; table 1) were used in the investigation.

A very important aim of this study was to correlate coal members in northeastern Illinois by means of their spore contents, especially in the Wilmington area of southeastern Grundy County and northwestern Livingston County. In this area, four coals that lie above the No. 2 Coal have been exposed in strip pits and underground mines. The No. 2 Coal, the Cardiff Coal, and the uppermost coal have been mined. The four coals are separated by a relatively few feet of strata, none of them useful in correlation. All but a few feet of strata overlying the uppermost coal have been truncated and covered by glacial drift. The coals have been difficult to trace eastward or westward because of erosion, lack of drill hole information and outcrops, and rapid changes in stratigraphic sequence. The rapid changes in environments of deposition are especially apparent for the three coals between the more persistent No. 2 Coal and the uppermost coal. All three were deposited in a narrow channel-like depression that trends northeast-southwest.

The description of the small spore assemblages from a large number of samples provided new data concerning the geologic ranges of spores in the Carbondale and Spoon coals. Reliability of certain spore taxa for stratigraphic correlation could be tested because of the large number of samples studied.

Although Kosanke (1950) reported on the spores of most of the coals studied for this report, numerous spore taxa not previously reported from strata of Illinois were encountered because so many macerations were studied. This was predictable because even minor variations in environmental conditions from place to place in the same coal swamp would influence the areal distribution of the spore-bearing plants. The vertical or geologic ranges of some of these newly reported spores make them useful in the correlation of coals.

The palynology of coals from places in Illinois not previously sampled also forms part of this study. Spores from coals in Livingston, Kankakee, Marshall, Logan, and Tazewell Counties are here reported for the first time, as are spore assemblages of some coals from counties included in earlier palynological investigations. Samples from some of these areas have been only lately obtainable. Many coal samples from Livingston and LaSalle Counties were made available from the Northern Illinois Gas Company's recently obtained diamond drill cores. Several other sets of samples have become accessible through relatively



Text Fig. 1 — Coal members of the Kewanee Group (Pennsylvanian) of Illinois and equivalent coals of Indiana and Kentucky. (Adapted from Kosanke et al., 1960, Wier and Powell, 1967, and Wayne, Johnson, and Keller, 1966.)

recent drilling by coal companies in Edgar, Livingston, and other counties and from strip mine operations in northwestern Kankakee County.

In addition, the spore content of several coals that had not previously been fully investigated is here given in detail. The coals include one directly below the No. 2 Coal and tentatively correlated with the Abingdon Coal (referred to herein as the Abingdon (?) Coal); and the Lowell Coal, Shawneetown Coal, Survant Coal (IV) of Indiana, and the 2A coals (name discontinued) of southern Illinois that are, at least in part, probably all correlative. Also included in this interval between the No. 2 and No. 4 Coals is a locally developed channel coal, the Cardiff Coal, found in the vicinity of Cardiff and Clarke City. Guennel (1952, p. 27-28) reported on the small spores of the Survant Coal (IV) of Indiana but only as to genera. Described here for the first time are the spores from an unnamed coal between the Houchin Creek Coal (IVa) and the Springfield Coal (V) of Indiana and those from the Spring Lake Coal.

Acknowledgments

Dr. Robert M. Kosanke of the U. S. Geological Survey critically read this manuscript and made many valuable suggestions, especially concerning the spore taxonomy. Professor Donald P. Rogers of the University of Illinois Botany Department checked the construction of new names of spore taxa. I am most grateful for their help.

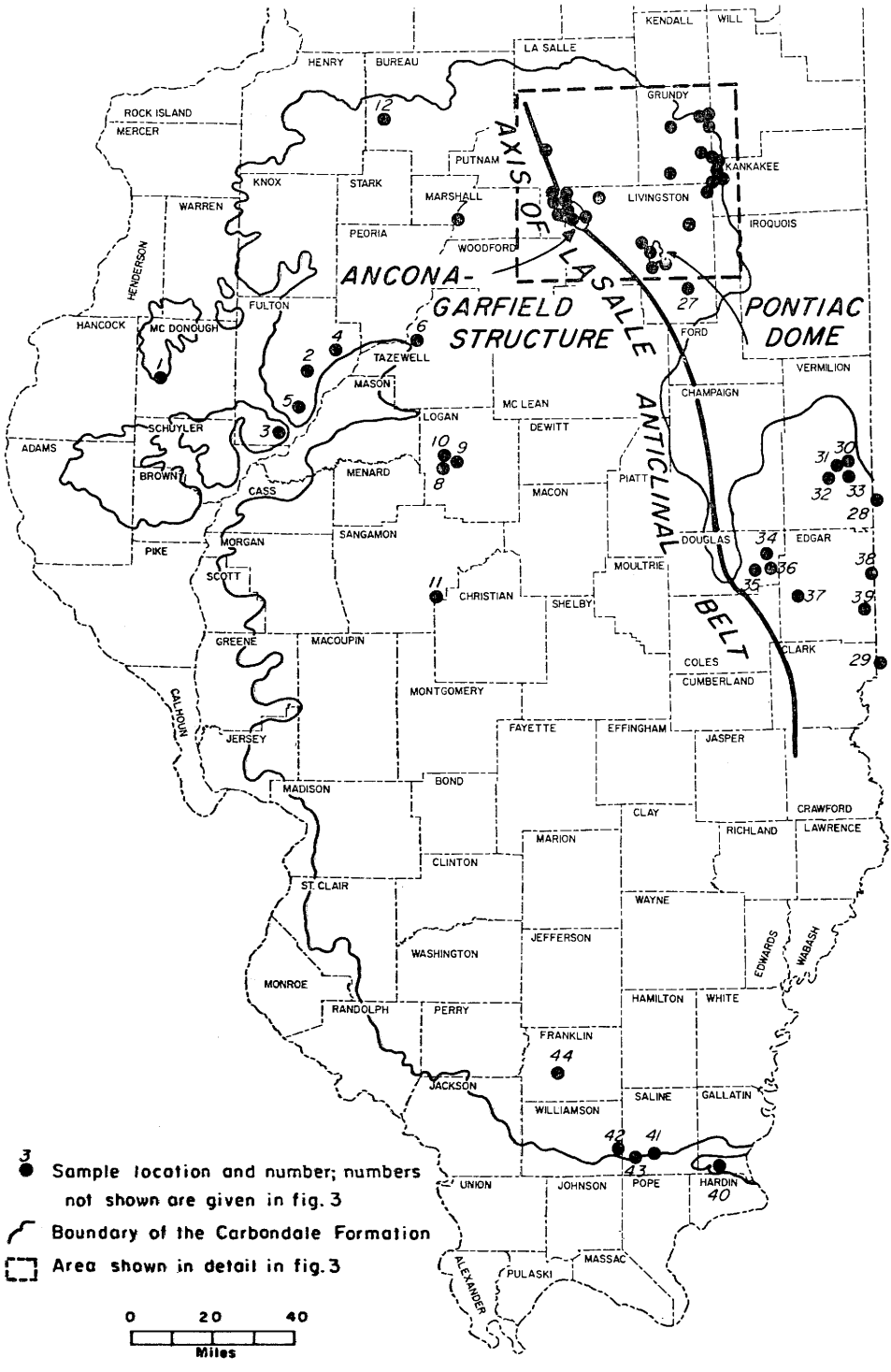
PREPARATION TECHNIQUES

The techniques used in preparing the coal macerations studied are essentially the same as those described by Kosanke (1950) and Peppers (1964). Although coal samples processed as early as 1945 were used, results obtained did not differ significantly from spore analyses of coals prepared in more recent years because the maceration procedure at the Illinois State Geological Survey has been only slightly modified since that time. In any case, maceration techniques everywhere are often altered to adapt them to the inherent composition of the coal and the extent to which it has been weathered.

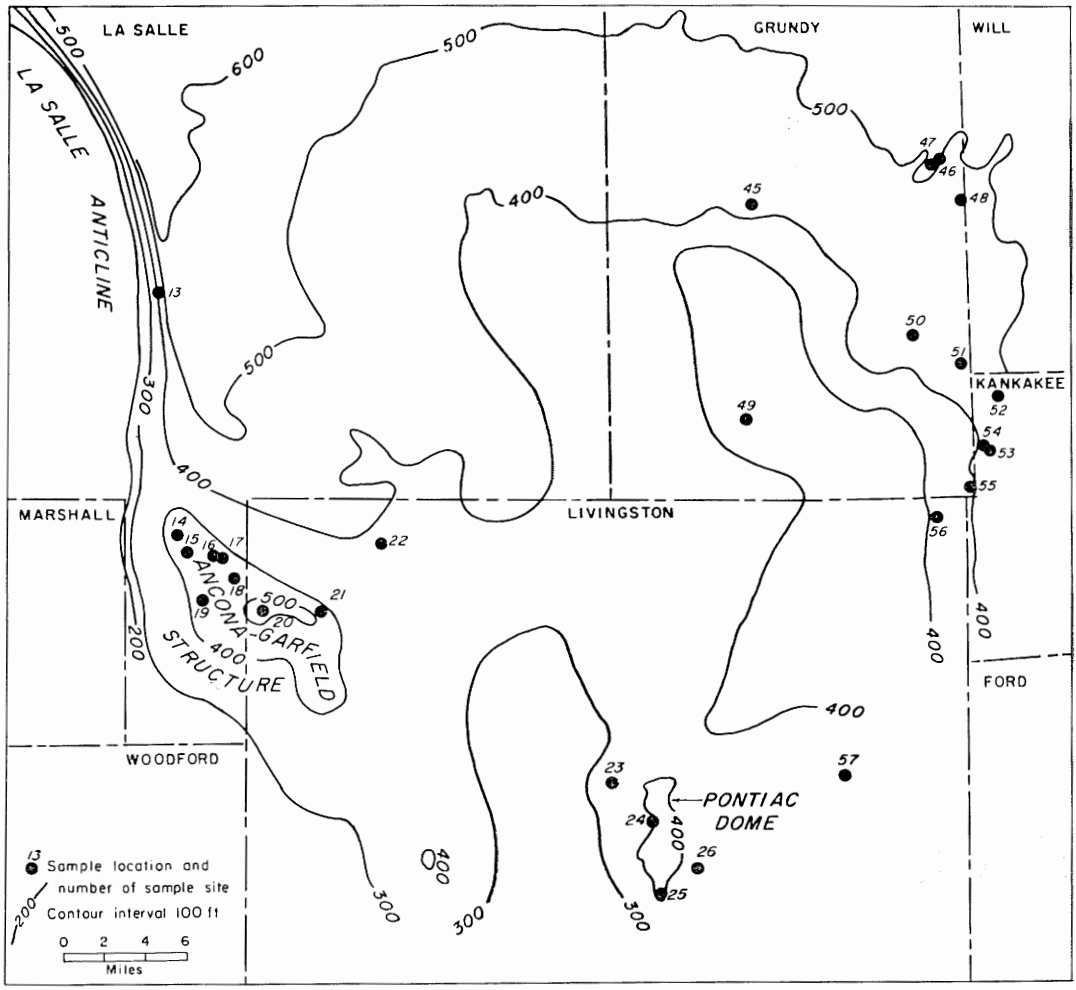
Relatively thick bench samples of the coals were taken because the primary purpose of this study was correlation of coals rather than paleoecological investigation of coal deposition. Coals of sufficient thickness were divided into two or more benches that were designated by letters suffixed to their maceration numbers. Whenever possible, the upper and lower boundaries of benches were chosen along such natural stratigraphic breaks as shale, clay, or pyrite bands. If no spores were found in the original maceration, or if those present were poorly preserved or abnormally thin, the coal samples, when still available, were reprocessed. Maceration numbers followed by "RR" indicate these remacerated samples.

Many coal samples were selected for maceration from diamond drill cores, many of them recently drilled and made available to the Illinois Geological Survey. A ribbon sample of 50 to 100 grams was cut from the coal cores with a carborundum blade saw. A mechanical rock splitter was used to reduce the outcrop samples to a weight of 50 to 100 grams for easy handling. The rock splitter also reduced the size of the several rotary churn samples carefully collected from wells drilled specifically for coal tests. All the samples were then broken with a hammer until the maximum fragment size was about 5 millimeters (mm).

To oxidize the coal, Schulze's solution (1 part saturated solution of potassium chlorate to 2 parts concentrated nitric acid) was added until the sample was completely covered. The sample was allowed to stand for a period of from a few minutes to as much as 4 days, depending on the freshness of the sample. Some highly



Text Fig. 2 — **Sample sites and major structures** in the area of the report. Outline shows the boundary of the Carbondale Formation. Boxed area is shown in detail in text figure 3.



Text Fig. 3 — Detail of figure 2 showing sample sites in the northeastern portion of the Illinois Basin and the structure on top of the Colchester (No. 2) Coal. (After Smith, 1967.)

weathered outcrop samples and some of the older core samples of relatively high-sulfur coal that had been exposed to the air for many years were already so well oxidized that Schulze's solution was not required. After most of the chemical action had ceased and the coal felt soft when stirred with a rod, water was added and decanted until the pH was neutral.

About 100 milliliters (ml) of 5 percent solution of potassium hydroxide was next added to dissolve the humic matter. A drop of the residue was immediately examined under a microscope; if the botanic constituents appeared to be well separated, water was added. Water could be added to many samples within 5 minutes, but it was necessary to keep a few samples in potassium hydroxide solution for up to 2 hours. Adding and decanting of water continued until all the dissolved humic matter had been removed.

The macerated residue was sieved with a 65-mesh Tyler screen to separate the material coarser than 210 microns (μ) from the fine residue that contained the small spores. The coarse fraction was stored in alcohol and glycerin in 50 ml bottles for future reference. A small portion of the fine fraction was centrifuged in a solution of zinc chloride (specific gravity 2) and an approximately 2 percent solu-

TABLE 1 — GEOGRAPHIC LOCATION, THICKNESS, AND DEPTH OF COAL SAMPLES

Sample site	Type of sample*	Maceration	Coal in order of stratigraphic occurrence at each site	Thickness in outcrop or drill core (in.)	Depth to top of coal sample (ft.)	(in.)	Location				
							Quarter	Sec.	Twp.	Range	County
1	OU	1386-B 1386-A	No. 2 No. 2	top 12 bottom 12			W½ NE SW	12	5 N	4 W	McDonough
2	OU	1405-C 1405-B 1405-A	No. 4 No. 4 No. 4	top 18 middle 16 bottom 18			SW NE SE	35	6 N	3 E	Fulton
3	OU	1406-C 1406-B 1406-A	No. 4 No. 4 No. 4	top 22 middle 23 bottom 18			Cen. NE	15	3 N	2 E	Fulton
4	ST	1408-C 1408-B 1408-A	No. 5 No. 5 No. 5	top 19 middle 20 bottom 20			N½ SW SE	36	7 N	4 E	Fulton
5	OU	525-A 525-B	Wiley Wiley	top 5 bottom 6			NE NW NE	16	4 N	3 E	Fulton
6	ST	1392	No. 5	58			Center	1	24 N	5 W	Tazewell
7	MD	1393	No. 7	±26			SE SW SW	23	12 N	9 E	Marshall
8	DD	1415 722-A 722-B 722-C 722-D	No. 7 No. 5 No. 5 No. 5 No. 5	13.8 24 24 23 0.6	65 153 155 157 159	3.5 7.5 7.5 7.5 6.5	NE SW NE	7	19 N	3 W	Logan
9	DD	1399-G 1399-F 1399-E 1399-D 1399-C 1399-B 1399-A	Uncorrelated[a] Lowell Lowell Uncorrelated[a] No. 2 No. 2 No. 2	0.5 6.5 6.5 0.3 13 11.5 3.8	174 252 252 266 308 309 310	0.5 0 6.5 11.5 4 5 5.2	SE SW SW	5	19 N	3 W	Logan
10	DD	1412	No. 6	25	157	8	NE NW SW	31	20 N	3 W	Logan

(continued on next page)

TABLE 1 — Continued

Sample site	Type of sample*	Maceration	Coal in order of stratigraphic occurrence at each site	Thickness in outcrop or drill core (in.)	Depth to top of coal sample (ft.)	(in.)	Location: Quarter	Sec.	Twp.	Range	County
11	DD	630	No. 5	37	292	7	NE NW NE	15	14 N	4 W	Sangamon
12	SU	1398	No. 6	53	50	0	NE SE SE	23	16 N	6 E	Bureau
13	OU	1190 1377	Lowell	6			SE SW	8	32 N	2 E	LaSalle
14	DD	1396-B	No. 4	4.5	152	10	NW NW SE	10	30 N	2 E	LaSalle
		1396-A	No. 4	6.5	153	2.5					
15	DD	1275-AA	Spring Lake	8	89	8	SW SW NW	15	30 N	2 E	LaSalle
		1275-A	Lowell	2	161	9					
		1275-D	No. 2	10.5	211	3.5					
		1275-E	No. 2	12.2	212	2					
		1275-F	No. 2	11	213	2.2					
16	DD	1395-B	No. 4	5	93	2	NW SW SE	14	30 N	2 E	LaSalle
		1395-A	No. 4	2.8	93	7					
		1296	No. 2	27.5	151	0.5					
17	DD	1276-A	No. 4	10.5	94	10.5	SW SE SE	14	30 N	2 E	LaSalle
18	DD	1227-A	No. 2	9.5	175	2	SW SE SW	24	30 N	2 E	LaSalle
		1227-B	No. 2	10	175	11.5					
		1227-C	No. 2	8.5	176	9.5					
19	DD	1279-AA	No. 5	0.1	141	6	SE SE SE	27	30 N	2 E	LaSalle
		1279-A	No. 4	10	163	11					
		1279-B	No. 4	7	164	9					
		1279-C	No. 4	8	165	4					
		1279-D	Lowell	6	184	11.5					
		1279-E	Lowell	1.8	186	0.8					
		1279-F	No. 2	12	224	0					
		1279-G	No. 2	12	225	0					
20	DD	1230-A	No. 4	10.5	95	0.8	SE SE NE	31	30 N	3 E	Livingston
		1230-B	No. 4	10.2	95	11.3					

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TABLE 1 — Continued

Sample site	Type of sample*	Maceration	Coal in order of stratigraphic occurrence at each site	Thickness in outcrop or drill core (in.)	Depth to top of coal sample (ft.) (in.)	Location				
						Quarter	Sec.	Twp.	Range	County
		1230-CC	No. 2	22	155 3					
		1230-C	No. 2	7.5	155 3					
		1230-D	No. 2	7.4	155 10.5					
		1230-E	No. 2	7.2	156 5.9					
21	DD	1234-A	Spring Lake	3.5	78 4	NE NW SE	34	30 N	3 E	Livingston
		1234-B	No. 4	0.5	129 2.2					
		1234-C	No. 4	6	129 3.5					
		1234-D	No. 4	6.4	129 9.5					
		1234-E	No. 4	7	130 3.9					
		1234-F	No. 4	2.5	[b]					
22	ST	1418-C	No. 7	8	20 0	NW NW NE	18	30 N	4 E	Livingston
		1418-B	No. 7	10	20 8					
		1418-A	No. 7	8	21 6					
23	DD	1384-W	No. 7	1.5	152 11.5	SW SW SW	7	28 N	6 E	Livingston
		1384-V	No. 7	6.5	153 1					
		1384-U	No. 7	6.8	153 7.5					
		1384-T	No. 7	7.2	154 2.3					
		1384-S	No. 7	7	154 10					
		1384-R	No. 7	1	155 7					
		1384-Q	No. 6	2	187 7.5					
		1384-P	No. 6	2.8	187 9.5					
		1384-O	No. 6	3	188 0.3					
		1384-N	Lowell	4	294 10					
		1384-M	Lowell	4.5	295 2					
		1384-L	Lowell	5	295 6.5					
		1384-K	Lowell	3	295 11.5					
		1384-J	No. 2	5.5	337 11.5					
		1384-I	No. 2	5.2	338 5					
		1384-H	No. 2	3.8	338 10.2					
		1384-G	Abingdon (?)	2.5	342 2					
		1384-F	Abingdon (?)	2.5	342 4.5					
		1384-E	Uncorrelated [c]	1	344 7					
		1384-D	Uncorrelated	2	344 8					
		1384-C	Uncorrelated	2	344 10					

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TABLE 1 — Continued

Sample site	Type of sample*	Maceration	Coal in order of stratigraphic occurrence at each site	Thickness in outcrop or drill core (in.)	Depth to top of coal sample (ft.)	(in.)	Location: Quarter	Sec.	Twp.	Range	County
		1384-B	Uncorrelated[d]	3	358	5.8					
		1384-A	Uncorrelated	3.8	358	8.8					
24	DD	1402-G	Lowell	3	267	8	SW SW SW	21	28 N	6 E	Livingston
		1402-F	Lowell	8	268	0.3					
		1402-E	Lowell	8.5	268	8.8					
		1402-D	Lowell	1.5	269	7.3					
		1402-C	No. 2	9.2	308	9.8					
		1402-B	No. 2	12.8	309	7					
		1402-A	No. 2	5	310	10.8					
25	DD	1387-J	No. 7	13	126	11.8	SW SW NE	9	27 N	6 E	Livingston
		1387-I	No. 7	13	128	0.8					
		1387-H	No. 7	13	129	1.8					
		1387-G	No. 7	13.8	130	2.8					
		1387-F	Lowell	8	215	9					
		1387-E	Lowell	8	216	5					
		1387-D	Lowell	5.5	220	5					
		1387-C	Lowell	6.5	220	10.5					
		1387-B	No. 2	5	247	0					
		1387-A	No. 2	5	247	5					
26	DD	1401-D	No. 2	5	302	10	NW NW NE	2	27 N	6 E	Livingston
		1401-C	No. 2	5	303	3					
		1401-B	Wiley	4	327	2					
		1401-A	Wiley	5.5	327	6					
27	DD	726-Aa	No. 5	12.8	240	0	SW NW SW	1	26 N	7 E	Livingston
28	ST	1464-C	Seelyville (III)	top 18			NW NW NW	21	18 N	10 W	Vermillion (Indiana)
		1464-B	Seelyville (III)	middle 9							
		1464-A	Seelyville (III)	bottom 31							
29	DD	1509-M	Unnamed	10.5	343	0	SW NE SW	11	12 N	10 W	Vigo (Indiana)
		1509-L	Unnamed	8	343	10.5					
		1509-K	Unnamed	9.5	344	6.5					

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TABLE 1 — Continued

Sample site	Type of sample*	Maceration	Coal in order of stratigraphic occurrence at each site	Thickness in outcrop or drill core (in.)	Depth to top of coal sample (ft.)	(in.)	Location: Quarter	Sec.	Twp.	Range	County
		1509-J	Houchin Creek (IVa)	6.5	357	2					
		1509-I	Houchin Creek (IVa)	7.5	357	8.5					
		1509-H	Houchin Creek (IVa)	11.5	358	4					
		1509-G	Survant (IV)	10	419	9.2					
		1509-F	Survant (IV)	8.8	420	7.2					
		1509-E	Survant (IV)	11	421	4					
		1509-D	Survant (IV)	5.5	434	4.8					
		1509-C	Survant (IV)	7.2	434	10.3					
		1509-B	Survant (IV)	9.5	435	5.5					
		1509-A	Colchester (IIIa)	1	453	9					
30	ST	590-A	No. 7	top 12			SW NE NW	7	19 N	11 W	Vermilion
		590-B	No. 7	upper middle 18							
		590-C	No. 7	lower middle 24							
		590-D	No. 7	bottom 9							
31	DD	1447	Jamestown	18	126	0	NW NW SE	14	19 N	12 W	Vermilion
32	SU	1356	No. 7	68	125	0	NE NW NW	27	19 N	12 W	Vermilion
33	SU	1354	No. 6	84	125	0	SE NE NE	30	19 N	11 W	Vermilion
34	SU	1355	No. 6	77	211	0	NW NE SE	36	16 N	10 E	Douglas
35	DD	924-A	No. 7	4	161	8	NW NW NW	14	15 N	10 E	Douglas
		924-B	No. 6	22	225	3					
36	DD	982-A	No. 6	9	133	9	NW NW NW	8	15 N	14 W	Douglas
		982-B1	No. 5	13.5	156	2					
		982-B2	No. 5	13	157	3.5					
		982-C1	No. 2	3	229	7					
		982-C2	No. 2	6.2	230	0					
		982-D1	Uncorrelated[c]	1	238	6					
		982-D2	Uncorrelated	1.2	238	7.3					
		982-E	Uncorrelated[c]	11	240	1					
		982-F	Uncorrelated[c]	10.5	258	7.5					
37	TD	1267	No. 2	60[e]	140	0	SW NW SW	17	14 N	13 W	Edgar

(continued on next page)

TABLE 1 — Continued

Sample site	Type of sample*	Maceration	Coal in order of stratigraphic occurrence at each site	Thickness in outcrop or drill core (in.)	Depth to top of coal sample (ft.)	(in.)	Location				
							Quarter	Sec.	Twp.	Range	County
38	DD	1404-HH	No. 7	12.5	30	8	SW SW NW	20	15 N	10 W	Edgar
		1404-GG	No. 7	4.8	31	8.5					
		1404-FF	No. 7	12.3	32	3.3					
		1404-EE	No. 7	6.3	33	6.5					
		1404-DD	No. 7	10	34	2.8					
		1404-CC	No. 6	6.5	138	4					
		1404-BB	No. 6	5.8	138	10.5					
		1404-AA	No. 6	6.8	139	4.3					
		1404-Z	No. 5	3.5	152	5					
		1404-Y	No. 5	2.5	152	8.5					
		1404-X	No. 5	11.5	154	0					
		1404-W	No. 5	11.5	154	11.5					
		1404-V	No. 5	15.8	155	11					
		1404-U	No. 5	4.3	158	0					
		1404-T	No. 4	3.5	238	1.5					
		1404-S	No. 4	3	238	5					
		1404-R	Lowell	14	268	1.5					
		1404-Q	Lowell	13	269	3.5					
		1404-P	Lowell	6.5	270	5					
		1404-O	Lowell	14.5	271	0.5					
		1404-N	No. 2	1.3	314	8.5					
		1404-M	No. 2	5.8	314	10.5					
		1404-L	No. 2	11	315	5.3					
		1404-K	Abingdon (?)	4	317	8					
		1404-J	Abingdon (?)	5.5	318	0					
		1404-I	Abingdon (?)	4.5	318	5.5					
		1404-H	Uncorrelated [c]	1.0	397	5					
		1404-G	Murphysboro	12	456	8					
		1404-F	Murphysboro	19.2	457	8.2					
		1404-E	Murphysboro	2.2	459	3.5					
		1404-D	Murphysboro	6	459	5.8					
		1404-C	Murphysboro	6.2	460	0.8					
		1404-B	Murphysboro	14	460	7					
		1404-A	Murphysboro	3.2	461	11					

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TABLE 1 — Continued

Sample site	Type of sample*	Maceration	Coal in order of stratigraphic occurrence at each site	Thickness in outcrop or drill core (in.)	Depth to top of coal sample (ft.)	(in.)	Location				
							Quarter	Sec.	Twp.	Range	County
39	DD	876	No. 7	32	308	7	NW NW NE	1	13 N	11 W	Edgar
		877	No. 7	32	311	3					
		878	No. 6	25	416	9.5					
		879	No. 5	26	439	1					
		880	No. 5	21.5	441	6					
		880-A	No. 4	15.8	499	9					
		881-A	Lowell	11.8	548	10					
		881	Lowell	8	559	2					
40	DD	1378-R	No. 5A	12	48	6	NE NW NE	19	10 S	9 E	Gallatin
		1378-Q	No. 5A	12	49	6					
		1378-P	No. 5A	12	50	6					
41	ST	1454-D	Shawneetown	top 6.5			SE NE NW	9	10 S	6 E	Saline
		1454-C	Shawneetown	upper middle 7.5							
		1454-B	Shawneetown	lower middle 7							
		1454-A	Shawneetown	bottom 11							
42	DD	1381-L	Shawneetown	7	106	6	SE SE NE	2	10 S	5 E	Saline
		1381-K	Shawneetown	8.8	107	1					
		1381-J	Lowell (?)	6.5	116	2					
		1381-I	Lowell (?)	7.5	116	8.5					
		1381-H	No. 2	6.6	195	6					
		1381-G	No. 2	6.8	196	0.6					
		1381-F	DeKoven	13.8	229	7.8					
		1381-E	DeKoven	16	230	9.5					
		1381-D	DeKoven	13.5	232	1.5					
		1381-C	Davis	15.5	249	7.8					
		1381-B	Davis	20.5	250	11.3					
		1381-A	Davis	14.2	252	7.8					
43	OU	607	Jamestown (?)	6			NW SW NW	30	9 S	5 E	Saline
44	DD	537-F	Allenby	0.3	532	9.5	SE NW SE	27	6 S	2 E	Franklin
		537-L	Lowell	32	789	0					
45	OU	1508-B	Lowell	1			NE SW NW	20	33 N	7 E	Grundy

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TABLE 1 — Continued

Sample site	Type of sample*	Maceration	Coal in order of stratigraphic occurrence at each site	Thickness in outcrop or drill core (in.)	Depth to top of coal sample (ft.) (in.)	Location				
						Quarter	Sec.	Twp.	Range	County
46	ST	951	Uncorrelated [e]	3.5		SE SE NE	11	33 N	8 E	Grundy
		950-B	No. 1	3.8						
		950-A	No. 1	3						
		949	No. 1	1.5						
47	DD	1160	Murphysboro	5	53 3	NW SE	11	33 N	8 E	Grundy
48	ST	1414	No. 6	±36		SE SE NE	24	33 N	8 E	Grundy
49	DD	1242-A	No. 6	top [f] 6.4	119 1	NE NW NE	18	31 N	7 E	Grundy
		1242-B	No. 6	upper middle 0.2						
		1242-C	No. 6	lower middle 6						
		1242-D	No. 6	bottom 2.2						
	TD	1413-B	No. 6	13	119 1					
		1413-A	No. 2	13	214 5					
50	TD	1246	No. 2	40	133 5	NE NW NW	27	32 N	8 E	Grundy
51	ST	1249-A	No. 4	top 13.3		SW	1	31 N	8 E	Grundy
		1249-B	No. 4	middle 13.3						
		1249-C	No. 4	bottom 13.3						
52	ST	723-A	No. 2	top 10.5		NE NW	8	31 N	9 E	Kankakee
		723-B	No. 2	middle 10.5						
		723-C	No. 2	bottom 10.5						
53	ST	1133-B1	No. 4	top 19		SE NW SE	19	31 N	9 E	Kankakee
		1133-B2	No. 4	middle 19						
		1133-B3	No. 4	bottom 19						
		1133-A1	Lowell (?) [e]	top 8						
		1133-A2	Lowell (?)	bottom 2.8						
		1133-C1	Cardiff	top 19						
		1133-C2	Cardiff	middle 19						
		1133-C3	Cardiff	bottom 19						
		1133-E	Uncorrelated	7.5						
		1133-D	No. 2	29						

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TABLE 1 — Concluded

Sample site	Type of sample*	Maceration	Coal in order of stratigraphic occurrence at each site	Thickness in outcrop or drill core (in.)	Depth to top of coal sample (ft.)	(in.)	Location: Quarter	Sec.	Twp.	Range	County
54	DD	954-Aa	No. 4	12	51	8	NW NW SE	19	31 N	9 E	Kankakee
		954-Ab	No. 4	22.5	52	8					
		954-Ac	No. 4	22.5	54	6.5					
		954-B	Lowell (?) [c]	2.6	61	8					
		954-C	Lowell (?) [c]	11	62	9					
		954-Da	Cardiff	11	65	11					
		954-Db	Cardiff	18.5	66	10					
		954-Dc	Cardiff	9.5	68	4.5					
		954-Dd	Cardiff	7	69	2					
		954-Ea	No. 2[g]	top 2.5	70	5.5					
		954-Eb	No. 2	upper middle 4.5							
		954-Ec	No. 2	middle 3.5							
		954-Ed	No. 2	lower middle 3.5							
		954-Ee	No. 2	bottom 3							
55	TD	1143-A	No. 4	19	65	4	NW NE SE	36	31 N	8 E	Grundy
		1143-B	Cardiff (?)	33	109	10					
		1143-C	No. 2	38	168	3					
56	TD	1034-A	Cardiff (?)	48	91	6	SW SW SE	2	30 N	8 E	Livingston
		1034-B	No. 2	39	174	10					
57	TD	962-A	Cardiff (?)	43	218	8	NE NE SE	12	28 N	7 E	Livingston
		962-B	No. 2	7	303	1					

* DD = diamond drill core; TD = rotary drill cuttings; SU = underground mine; ST = strip mine; MD = mine dump; OU = outcrop.

[a] Coal too thin to contain spore assemblages that could be compared with those from a coal of "normal" thickness.

[b] Core disturbed; position of 1234-F within coal is not known.

[c] Coal contains poorly preserved spores.

[d] Coal contains spore assemblage unlike that of any previously studied coals.

[e] Represents interval in which cuttings were recovered and is not true thickness of coal.

[f] 14.9 inches of badly broken core represent coal 37 inches thick at 119 feet 1 inch to 122 feet 2 inches.

[g] 17 inches of badly broken core represent coal 34.5 inches thick at 70 feet 5.5 inches to 73 feet 4 inches.

tion of hydrochloric acid to isolate any mineral matter from the botanic remains. The zinc chloride solution was removed by repeated centrifuging. The sample was subjected to ultrasonic vibrations for about 5 seconds to disperse the particles. Finely divided organic matter was removed from some of the samples by centrifuging them for 1 minute or less and pouring off the suspended matter. Part of the residue was stored in alcohol and glycerin in a small vial, and another portion was stained by placing it in safrinin Y solution for about two hours, after which alcohol was added and decanted until all the water had been removed.

A small representative portion of the spore residue in a final solution of 50 percent absolute alcohol and 50 percent xylene was mixed with liquid Canada balsam to be mounted on slides. The prepared slides were placed in a warming oven at a temperature of 105° F for at least 5 days. The stained residues not used for slides were stored in small vials sealed with paraffin.

The spore slides were first examined with a Spencer Microstar microscope at a magnification of 100× to record the various taxa in each sample. To determine the relative abundance of spores in each maceration, 300 identified specimens were counted at a magnification of 430×. The total percentages of spores in coals that had been divided into benches were computed by adding percentages weighted according to the thickness of the individual benches. For example, the percentage of spores from a 12-inch thick bench sample would account for 66.7 percent of the total distribution of spores in a coal that had a total thickness of 18 inches. The occurrence and average relative abundance of spore genera and species in the coals investigated are shown in the spore distribution charts preceding the taxonomy section. More detailed observations were made, especially on new taxa, with a Leitz Ortholux microscope at magnifications of up to 980× by using an oil immersion objective. The Ortholux microscope was also employed for taking photomicrographs in which 120 mm Adox R 14 film was used.

All materials, including reference coal samples (kept in plastic bags), coarsely and finely macerated residues, and slides, are stored at the Illinois State Geological Survey, Urbana, Illinois.

DISCUSSION OF SPORE ASSEMBLAGES AND CORRELATION OF COALS

Spoon Formation

Although most of this investigation is concerned with coals of the Carbondale Formation, small spore assemblages of several coals of the underlying Spoon Formation were studied for comparison with assemblages from Carbondale coals. An attempt was made, also, to determine the stratigraphic position of several coals, samples of which were recovered from diamond drill core sections in northeastern Illinois, that lie between the base of the Pennsylvanian and the Colchester (No. 2) Coal.

Rock Island (No. 1) Coal

The No. 1 Coal, the oldest coal in the Spoon Formation, was first named by Worthen (1868, p. 6) in his generalized section of the Coal Measures of northern and western Illinois. In 1870 he described as the type locality of the No. 1 Coal an exposure along the Spoon River about 1 mile southwest of Seville in Fulton County. Worthen and Shaw (1873, p. 221, 229-232) correlated the coal mined at Rock Island with the No. 1 Coal. Wanless (1957, p. 72, 201) redescribed the type section and formally designated the coal as the Rock Island (No. 1) Coal. Kosanke et al. (1960) defined the Rock Island (No. 1) Coal as the basal member of the Spoon Formation.

Kosanke (1950, p. 66-67) investigated the small spores of the Rock Island (No.

1) Coal from Rock Island, Henry, and Fulton Counties.

Culver (1923, p. 134-138), in his description of the strata below the Colchester (No. 2) Coal, noted the presence of several thin, lenticular coals that are locally of minable thickness where they were deposited in channel-like depressions.

Two of these bodies of coal, which trend northeast-southwest and occur 20 to 30 feet below the No. 2 Coal in Aux Sable Township (T. 34 N., R. 8 E.) were essentially removed by strip mining. Culver (1923, p. 135) used the name "Goose Lake Coal," presumably in reference to one of these channel coals mined at Jugtown at an early date. No type locality or description was given, and, unfortunately, no samples are presently available.

In his investigation of clays, Doehler (1957) found two thin coals separated by clay in the Illinois Clay Products pit in the northern half of sec. 11, T. 33 N., R. 8 E., near Goose Lake, Grundy County (sample site 46). Whether either of these coals is equivalent to the "Goose Lake Coal" of Culver is not known. The upper coal, about 3.5 inches thick, is discontinuous, but the lower, more persistent coal varies in thickness from 1.5 to 6.75 inches in the pit. The coals, which are somewhat weathered and contain abundant fusain, dip toward the south.

Megaspores isolated from coarse residues of the two coal macerations were examined by Winslow (1959, p. 89). The lower coal was sampled at its greatest thickness (macerations 950-A and 950-B) and yielded megaspores that occur in the Willis and No. 1 Coals and in a coal formerly called "Sub-Babylon" (name now discontinued). The upper coal (maceration 951) was found to contain only *Monoletes*, a very wide-ranging spore.

During the present investigation, the fine residues of the macerated upper coal, the entire thickness of the lower coal where it is thinnest in the clay pit (maceration 949), and the top 3.75 inches (maceration 950-B) of the lower coal at its maximum observed thickness were examined. Some of the samples yielded no small spores and others only a few very poorly preserved, stratigraphically long-ranging spores. The bottom 3 inches (maceration 950-A) of the lower coal contains most of the spores sufficiently well preserved to identify. The spores of maceration 950-A listed below probably represent only a relatively small portion of the original small spore flora.

Calamospora sp.
Cyclogranisporites sp.
Raistrickia sp.
Reticulatisporites lacunosus
R. sp.
Triquitrites exiguus
Crassispora plicata
Lycospora granulata
L. punctata
Densosporites cf. *lobatus*
D. triangularis
Laevigatosporites globosus
L. medius
L. ovalis
Wilsonites vesicatus
Endosporites globiformis
Florinites antiquus
F. millotti
Alatisporites trialatus

Because the spores were so poorly preserved, a statistical count of the miospores from this sample would not have been very meaningful. The dominant spore genus is probably *Laevigatosporites*, in which *L. globosus* accounts for most of the genus and *L. ovalis* and *L. medius* the remainder. *Lycospora* is the second most abundant genus and specimens of *Densosporites* were frequently encountered.

Although the evidence is not as positive as would be desired, the lower of the two coals in the Goose Lake clay pit is tentatively correlated with the Rock Island (No. 1) Coal because the upper coal is probably older than the Seahorne Limestone Member, for W. A. White (personal communication, 1967) suggested that the mineralogy of the greenish clay unit at the top of the clay pit is typical of the underclay found just below the Seahorne Limestone. Furthermore, the megaspores investigated by Winslow (1959) indicated an age no younger than Rock Island (No. 1) Coal, and the small spores would not support an age as old as the Willis Coal because, even

though the quite well preserved specimens of *Densosporites* are fairly abundant, no specimens of the closely related *Radiizonales difformis* and *R. rotatus* were observed. These two species are considered diagnostic fossils of the Willis-Tarter and Delwood – Pope Creek Coals. In the Spoon Formation only the Rock Island (No. 1) Coal has as high a frequency of *Densosporites* as was observed in maceration 950-A. Reference macerations of the No. 1, Willis, Pope Creek, DeLong, and Mt. Rorah Coals were examined, and the spore assemblage from the lower coal at the Goose Lake clay pit was found to compare most closely with that of the No. 1 Coal.

Murphysboro Coal Member

The Murphysboro Coal was first named and described by Worthen (1868, p. 11-12) at its type locality (Wanless, 1956, p. 9) in the vicinity of the town of Murphysboro, Jackson County. Kosanke (1950, p. 67), on the basis of spore analyses, differentiated stratigraphically the Murphysboro and Rock Island (No. 1) Coals and suggested that the Murphysboro Coal lies above the No. 1 Coal. Wanless (1956) tentatively correlated the Murphysboro Coal with the No. 1 Coal of Illinois and the Minshall Coal of Indiana. Kosanke et al. (1960) indicated that the Murphysboro, Litchfield, and Assumption Coals are only approximately correlative with the No. 1 Coal. Type exposures of the Litchfield and Assumption Coals are in mines that are now abandoned.

The palynology of the Murphysboro Coal sampled from four localities in southern Illinois was reported by Kosanke (1950, p. 67), and Guennel (1952, p. 31) examined the small spore flora of the Minshall Coal of Indiana.

About a quarter of a mile south of the Goose Lake clay pit in Grundy County, a diamond drill core encountered a 5-inch thick coal (maceration 1160, sample site 47) at a depth of 53 feet 3 inches. The coal is questionably correlated with the Murphysboro Coal of southern Illinois. The following spore taxa were observed in maceration 1160:

Leiotriletes adnatoides
L. parvus
Punctatisporites aerarius
P. minutus
P. nahannensis
P. obliquus
P. vermiculatus
Calamospora breviradiata
C. flexilis
C. hartungiana
C. pedata
C. straminea
Granulatisporites pallidus
G. cf. *parvus*
Cyclogranisporites cf. *aureus*
C. micaceus
C. minutus
Verrucosisporites sifati
Lophotriletes commissuralis
L. cf. *granoornatus*
L. ibrahimi
L. mosaicus
L. rarispinosus
Anapiculatisporites grundensis
A. spinosus
Pustulatisporites crenatus
Apiculatisporis abditus
A. setulosus
Acanthotriletes aculeolatus
A. sp. 1
Raistrickia crocea
R. cf. *fibrata*
R. irregularis
Convolutispora sp. 1
Microreticulatisporites harrisonii
M. sulcatus
Reticulatisporites lacunosus
Vestispora fenestrata
V. foveata
V. wanlessii
Triquitrites additus
T. cf. *additus*
T. exiguus
T. minutus
T. protensus
T. pulvinatus
Ahrensisporites guerickei
Crassispora plicata
Lycospora brevijuga
L. granulata
L. punctata
L. subjuga
Murospora kosankei
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. punctatus
L. vulgaris

Columinisporites ovalis
Wilsonites vesicatus
Hymenospora paucirugosa
Endosporites globiformis
Paleospora fragila
Florinites antiquus
F. millotti
Vesicaspora wilsonii

Macerations of the Murphysboro Coal studied by Kosanke (1950) contained several species, given below, that were not observed in maceration 1160.

Calamospora liquida
Triquitrites arculatus
Lycospora micropapillatus
Cirratriradites maculatus
Laevigatosporites minimus

Lycospora and *Laevigatosporites*, the two most abundant genera in maceration 1160, are almost equally represented, with 19 and 18.3 percent, respectively, of the spore flora. *Punctatisporites* (12.7 percent), an unusually high frequency of *Endosporites* (9 percent) for this part of the Pennsylvanian, *Granulatisporites* (8.3 percent), and *Florinites* and *Calamospora* (both 6.7 percent) are important constituents in the spore assemblage. *Triquitrites* (4.7 percent), *Wilsonites* (4.3 percent), *Cyclogranisporites* (3 percent), and *Vesicaspora wilsonii* (2.7 percent) make up most of the remaining portion of the spore flora.

The coal of maceration 1160 is quite unique in that, although it is only 5 inches thick, it contains a large variety of spore genera and species that are numerically more evenly represented in the assemblage than is usual in the Illinois coals. The large number of small specimens of several spore taxa present also is unusual. For example, some specimens morphologically like *Vestispora fenestrata* measured only 55 microns (μ) instead of the usual 65μ to 85μ. The coal represented by maceration 1160 may have been deposited in a local environment, perhaps in an abandoned stream channel, that was unlike the more widespread area of deposition in the southern part of the Illinois Basin.

The absence of certain spore taxa from maceration 1160 and the over-all nature of the assemblage would eliminate from consideration its correlation with coals in the Abbott Formation. Macerated residues of the DeLong Coal (macerations 527-A and 527-B) of the Spoon Formation from Fulton County that contained only a few identifiable long-ranging spores (Kosanke, 1950, p. 67), and residues of its equivalent, the Mt. Rorah Coal (macerations 520-A and 520-B) of Williamson County (Kosanke, 1950, p. 67-68), could not be correlated with maceration 1160.

The spore assemblage of maceration 1160 is dissimilar to that of the lower coal (tentatively correlated with the No. 1 Coal) found in the Goose Lake clay pit about a quarter of a mile to the north. However, the coal might be equivalent to the upper discontinuous coal near the top of the pit, which failed to yield spores. Because of the southerly dip of the strata in that area, the upper coal, which is only about 5 feet below the top of the pit, would be considerably deeper to the south.

The spore population of maceration 1160 compares most closely with that of the Murphysboro Coal, which, according to Kosanke (1950), contains spores that permit its differentiation from the Rock Island (No. 1) Coal. More specifically, it is most similar to a coal (macerations 628-A and 628-B) found below the Curlew Limestone Member in T. 10 S., R. 6 E., Saline County, that Kosanke (1950, p. 67) thought was correlative with the Murphysboro Coal. The spore assemblage of 1160 also compares favorably with that of the lower part of a coal 138 feet below the No. 2 Coal between depths of 456 feet 8 inches and 461 feet 11 inches in Edgar County (sample site 38), which from other evidence is tentatively considered the equivalent of the Minshall Coal of Indiana. An unusually high abundance of *Endosporites* was found in this coal and in macerations 1160, 628-A, and 628-B. Guennel (1958, p. 31) pointed out that the Minshall Coal has a significantly large proportion of *Endosporites*. Even after reassignment of the percentage of *Florinites pellucidus* that was classified as *Endosporites pellucidus* at the time of Guennel's report, the genus still accounts for 12.4

percent of the spore population in the Minshall Coal.

The Murphysboro Coal is probably equivalent to the Minshall Coal and occurs above the Rock Island (No. 1) Coal.

Davis and Wiley Coal Members

The name Davis was introduced, but not defined, by D. D. Owen (1856, p. 41) in referring to a coal that was the sixth of eight workable coals of the "Upper Coal Measures" of Union County, Kentucky. Because the coal has a nearly uniform thickness of 4 feet in that area, Owen also called it the "4-foot coal." Later (1857) he called it the No. 5 Coal of Kentucky. Lee (1916, p. 19) designated the Davis as the No. 6 Coal of Kentucky and defined it as the coal from the Davis Mine half a mile east of DeKoven in Union County, Kentucky.

The Wiley Coal of western Illinois was named and described by Wanless (1931, p. 801-812) from an outcrop near the town of Wiley in Fulton County. The correlation of the Davis and Wiley Coals suggested by Wanless (1939, p. 14, 17) was confirmed by Kosanke (1950, p. 68) through the use of small spores.

A coal (macerations 1401-A and 1401-B) 9.5 inches thick that lies 23.5 feet below the No. 2 Coal in a core from sec. 2, T. 27 N., R. 6 E., Livingston County (sample site 26), is probably correlative with the Wiley Coal even though there are some discrepancies in the spore assemblages. This is the only coal in the study area that was assigned to the Davis-Wiley stratigraphic interval. As maceration 1401-B from the top 4 inches of the coal yielded only a few poorly preserved spores, it was not studied in detail. For comparison of spore assemblages, the Davis Coal of southern Illinois was sampled from a core from Saline County (sample site 42). The coal, 50.25 inches thick, was divided into lower, middle, and upper benches (macerations 1381-A, 1381-B, 1381-C). Macerations (525-A and 525-B) of the Wiley Coal from an outcrop in Fulton County (sample site 5) studied by Kosanke (1950, p. 68-69) also were examined.

The following small spores have been identified from the Davis and Wiley Coals and maceration 1401-A. Those that occur in the Davis Coal are marked with an asterisk, those found in the Wiley Coal are marked with a dagger, and those present in maceration 1401-A are indicated by a double dagger.

Leiotriletes adnatoides†
L. cf. *adnatus*†
Punctatisporites decorus†
*P. minutus**†‡
P. nahannensis†
P. orbicularis†
*Calamospora breviradiata**†‡
C. hartungiana†‡
C. minuta†
*C. mutabilis**†
C. straminea†
*Elaterites triferens**†‡
Granulatisporites granularis†‡
G. pannosites†
Cyclogranisporites cf. *aureus**‡
C. microgranus†
C. staplini†
Verrucosisporites microtuberosus†
*Anapiculatisporites spinosus**†‡
*Apiculatisporis lappites**
*Acanthotriletes aculeolatus**†‡
*Raistrickia breveminens**
R. carbondalensis†
R. crocea‡
*R. subcrinita**†‡
*Microreticulatisporites sulcatus**†‡
Reticulatisporites sp. 1†
Vestispora colchesterensis‡
*V. fenestrata**†‡
*V. laevigata**†
Triquitrites additus‡
T. cf. *additus**†‡
*T. bransonii**†‡
T. exiguus†‡
T. spinosus‡
*Mooreisporites inusitatus**†‡
*Crassispora plicata**†‡
*Lycospora granulata**†‡
*L. punctata**†‡
Cadiospora magna†
*Densosporites sphaerotriangulus**
*D. triangularis**
*Cirratriradites annulatus**†‡
*C. annuliformis**
*Laevigatosporites desmoinensis**†‡
*L. globosus**†‡
*L. medius**†
*L. minutus**†‡
*L. ovalis**†‡
*L. punctatus**†‡

*L. vulgaris**†*
*Thymospora pseudothiessenii**†‡*
*Wilsonites vesicatus**†‡*
*Hymenospora paucirugosa***
*Endosporites globiformis**‡*
*Florinites antiquus**†‡*
F. millotti†*
F. similis†‡*
*Vesicaspora wilsonii**†‡*
*Alatisporites trialatus***

Kosanke (1950, p. 69) listed several species found in the Davis and Wiley Coals that were not encountered during this investigation.

Granulatisporites pallidus
Raistrickia aculeolata
R. irregularis
Reticulatisporites lacunosus
Vestispora foveata
Triquitrites crassus
T. pulvinatus
Lycospora micropapillatus
Cirratriradites maculatus
Laevigatosporites minimus
Alatisporites hexalatus

Except for being about 20μ larger, *Reticulatisporites lacunosus* is morphologically the same as the species I designated *Reticulatisporites* sp. 1. Kosanke's *Laevigatosporites minimus*, not found in any samples considered in this investigation, may actually be overmacerated specimens of *L. minutus*. *Cirratriradites annulatus*, which was recognized from my macerations, and Kosanke's *C. maculatus* are morphologically very similar.

The stratigraphic range of *Thymospora pseudothiessenii* is extended downward from the DeKoven to the Davis Coal, in which it had previously been considered absent.

The foregoing two lists make it apparent that a number of species occur in both the Davis and Wiley Coals, but many other species occur in only one. However, the latter spores are all accessory or rarely occurring forms, many of which are represented by only one or two specimens. The fact that several species were not common to the coals from northwestern and southern Illinois is not totally unexpected for samples that are geographically so widely separated. The two coal swamps may not have been connected and may have existed only approximately at the same time. The Davis Coal is much thicker than the Wiley and may represent a different environment of deposition. Consideration should also be given to the fact that the upper 4 inches of maceration 1401 could not be analyzed because the spores were so poorly preserved.

In general, the macerations of the Davis and DeKoven Coals contain an abundance of opaque organic fragments and plant microfossils that are not as well preserved as those of the No. 2 Coal. The spore assemblage of the Wiley Coal was better preserved, probably because of its slightly lower rank.

The distribution percentages of the most abundant spores compare quite closely in the Davis and Wiley Coals. The most abundant genus is *Lycospora*, which makes up 51 to 65 percent of the assemblage. Although it is difficult to draw any conclusions about the vertical distribution of the spore population, it appears that *Lycospora* decreases in abundance toward the top of the coal. *Laevigatosporites* (10 to 12 percent), in which *L. minutus* is the most common species, and *Calamospora* (6 to 14 percent) are second and third in numerical importance. *C. breviradiata,* which composes the largest share of the genus, is most abundant toward the top of the coal. *Triquitrites* (4 to 7 percent), *Vesicaspora wilsonii* (3 to 6 percent), *Florinites antiquus* (2 to 6 percent), *Crassipora plicata* (2 to 5 percent), and *Thymospora pseudothiessenii* (about 2 percent) are all rather well represented.

DeKoven Coal Member

Owen (1856) referred to a "3-foot coal" that occurs above the "4-foot coal," his informal name for the Davis Coal. A year later he designated the "3-foot coal" as the No. 6 of Kentucky, but it remained for Lee (1916, p. 30) to assign the name DeKoven to this coal in describing the four coals of greatest economic importance in the Carbondale Formation of Kentucky. The name was taken from DeKoven Station, Union County, Kentucky.

Wanless (1931, p. 188, 192) described and named the Greenbush Coal of western Illinois from exposures in a tributary to Swan Creek in Warren County, Illinois. In 1939 he correlated it with the DeKoven Coal of western Kentucky and southern Illinois, and spore analyses of these two coals by Kosanke (1950, p. 69) supported this conclusion.

The only sample of the DeKoven Coal macerated for this report was taken from a core from Saline County, Illinois (sample site 42), in which it occurs about 17 feet above the Davis Coal. The DeKoven, which is about 43 inches thick, was divided for maceration into three benches (macerations 1381-D, 1381-E, 1381-F). Neither the DeKoven nor Greenbush Coal was encountered in any of the stratigraphic sections of northeastern Illinois.

The following spore taxa were found in the DeKoven Coal from Saline County.

Punctatisporites minutus
P. orbicularis
Calamospora breviradiata
C. hartungiana
C. mutabilis
C. straminea
Elaterites triferens
Cyclogranisporites cf. *aureus*
Lophotriletes rarispinosus
Anapiculatisporites spinosus
Acanthotriletes aculeolatus
Raistrickia breveminens
R. crocea
R. irregularis
R. subcrinita
Microreticulatisporites sulcatus
Vestispora fenestrata
V. laevigata
Triquitrites cf. *additus*
T. bransonii
T. crassus
T. exiguus
T. protensus
T. spinosus
T. sp. 1
Mooreisporites inusitatus
Crassispora plicata
Lycospora granulata
L. punctata
Densosporites triangularis
Cirratriradites annulatus
C. annuliformis
Laevigatosporites globosus
L. medius
L. minutus
L. ovalis
L. punctatus
L. vulgaris
Thymospora pseudothiessenii
Wilsonites vesicatus
Endosporites globiformis
Florinites antiquus
F. similis
Vesicaspora wilsonii

Spores that were not observed in macerations 1381-D, 1381-E, and 1381-F but were recorded by Kosanke (1950, p. 69) from the DeKoven and Greenbush Coals are listed below.

Converrucosisporites verrucifer
Verrucosisporites firmus
Vestispora foveata
Triquitrites arculatus
T. pulvinatus
Densosporites sphaerotriangularis
Laevigatosporites desmoinensis
L. minimus
Alatisporites hexalatus

As in the Davis Coal, the dominant spore genera are *Lycospora* and *Laevigatosporites*, which compose about 53 and almost 20 percent, respectively, of the small spore population. *Laevigatosporites minutus* (12.5 percent) and *L. punctatus* (7.3 percent) account for most of the latter genus. *Florinites antiquus* (9.7 percent), *Thymospora pseudothiessenii* (7.3 percent), and *Calamospora breviradiata* (4.2 percent) also are important components of the spore assemblage. *Lycospora* apparently decreases in quantity while *Thymospora pseudothiessenii* increases at the top of the coal as it does in the Davis Coal. *Florinites antiquus* becomes especially abundant in the upper bench of the coal, where it reaches 19 percent. Although Kosanke (1950, p. 69) found that *Triquitrites* reaches its maximum abundance in the samples of DeKoven Coal he studied, less than 1 percent was found in macerations 1381-D, 1381-E, and 1381-F.

A greater abundance of *Florinites* and about twice as many *Laevigatosporites* and *Thymospora pseudothiessenii* occur in the DeKoven as in the Davis. *Calamospora* probably is not as abundant and *Vesicaspora* probably is rare in the DeKoven Coal

compared to its occurrence in the Davis Coal, but not enough samples of these two coals have been studied as yet to confirm this. The DeKoven Coal lacks *Granulatisporites* (sensu Potonié and Kremp, 1954) but is present in the Davis Coal.

*Seelyville Coal Member**

The name Seelyville Coal Member was formally designated by Kosanke et al. (1960, p. 33) to replace the name Coal III of Indiana in eastern Illinois. Mines in the vicinity of Seelyville, Vigo County, Indiana, are the type locality. The coal is now called Seelyville Coal (III) in Indiana.

Guennel (1952, p. 26-27) included the Seelyville Coal, which he divided into a total of 18 benches from six localities, in his study of spore genera of coals of Allegheny age in Indiana.

The Indiana Seelyville Coal (III) from a strip mine (sample site 28) in Vermillion County, Indiana, where it is 58 inches thick, was benched into three samples and macerated (macerations 1464-A, 1464-B, and 1464-C). The macerations contain rather poorly preserved spores and a large quantity of fine opaque organic matter. The following miospore species were observed.

Punctatisporites minutus
P. nahannensis
Calamospora breviradiata
C. hartungiana
C. mutabilis
C. straminea
Elaterites triferens
Granulatisporites granularis
G. cf. *parvus*
Schopfites colchesterensis
S. dimorphus
Anapiculatisporites spinosus
Raistrickia subcrinita
Reticulatisporites sp. 1
Vestispora fenestrata
V. foveata
Triquitrites cf. *additus*
T. bransonii
T. exiguus
T. protensus
Crassispora plicata
Lycospora granulata
L. paulula
L. punctata
Densosporites sphaerotriangularis
D. triangularis
Cristatisporites alpernii
Cirratriradites annulatus
Laevigatosporites globosus
L. medius
L. minutus
L. ovalis
L. punctatus
Thymospora pseudothiessenii
Torispora securis
Wilsonites vesicatus
Endosporites globiformis
E. plicatus
Florinites antiquus
F. similis
Vesicaspora wilsonii
Alatisporites trialatus

Lycospora, forming almost 66 percent of the total spore assemblage, is by far the dominant genus and is followed by *Laevigatosporites*, which accounts for 11.5 percent. These figures compare quite closely with those of Guennel (1952, p. 25), who reported 56.4 percent and 11.5 percent (including *Thymospora pseudothiessenii*), respectively, for these two genera. A diminution of *Lycospora* is found toward the top of the Seelyville. Only 2.2 percent *Calamospora* and 2.7 percent *Florinites* and *Endosporites* together were calculated from macerations 1464-A, 1464-B, and 1464-C, whereas Guennel reported 10.2 percent for the last two genera. *Densosporites*, which was found only in the lower half of the coal makes up 1.7 percent of the spore population. *Triquitrites* and *Anapiculatisporites*, being minor constituents of the spore flora, account for 1.7 percent and 0.7 percent, respectively. *Alatisporites*, which is very rare, was found in the lower bench, contrary to the usual occurrence of this taxon in the upper portions of a coal.

The presence of *Schopfites* in the Seelyville Coal helps distinguish it from older coals. *Granulatisporites*, *Torispora*, *Cristatisporites*, and *Endosporites plicatus* are found in the Seelyville Coal but are absent from the DeKoven Coal. Spore taxa found in the DeKoven but not in the Seelyville are *Lophotriletes*, *Acanthotriletes*, and four stratigraphically widespread and easily

* The name formally adopted for this coal by Kosanke et al. (1960) was misspelled "Seeleyville." It is here corrected to "Seelyville."

recognized species — *Mooreisporites inusitatus*, *Cirratriradites annuliformis*, *Laevigatosporites vulgaris*, and *Microreticulatisporites sulcatus*. Of all the species of *Raistrickia* that occur in the DeKoven, only *R. subcrinita* is found in the Seelyville. The Seelyville Coal possesses more *Densosporites* and *Laevigatosporites globosus* but fewer *L. minutus* than does the DeKoven Coal.

Uncorrelated Coal

A diamond drill core in sec. 7, T. 28 N., R. 6 E., Livingston County (sample site 23), recovered three thin coals within a thick clay sequence below the Colchester (No. 2) Coal. The clay interval is probably the Cheltenham Clay, whose stratigraphic age varies from place to place. The first coal (macerations 1384-F and 1384-G), 2 feet below the No. 2 Coal, will be discussed under the section dealing with the Abingdon (?) Coal. The second coal (macerations 1384-C, 1384-D, and 1384-E), which, like the first one, is 5 inches thick, lies 5 feet 5 inches below the No. 2 Coal and was found to be barren of identifiable spores. The third coal (macerations 1384-A and 1384-B), which is not correlated with any named coal, lies about 19 feet 3 inches below the No. 2 Coal and yielded a variety of well preserved spores, which are listed below.

Leiotriletes adnatoides
Punctatisporites aerarius
P. minutus
P. obliquus
Calamospora breviradiata
C. minuta
C. mutabilis
Elaterites triferens
Granulatisporites granularis
G. pannosites
G. cf. *parvus*
Cyclogranisporites microgranus
C. staplini
Verrucosisporites compactus
V. donarii
V. firmus
V. microtuberosus
Schopfites carbondalensis
S. colchesterensis
Distortisporites illinoiensis
Lophotriletes cf. *granoornatus*
Anapiculatisporites spinosus
Apiculatisporis abditus
A. frequentisporites
A. lappites
A. setulosus
Raistrickia breveminens
R. crocea
R. irregularis
R. lacerata
R. subcrinita
Convolutispora fromensis
Dictyotriletes densoreticulatus
Camptotriletes bucculentus
Triquitrites additus
T. cf. *additus*
T. bransonii
T. exiguus
T. pulvinatus
Mooreisporites inusitatus
Crassispora plicata
Lycospora granulata
L. punctata
L. subjuga
Densosporites triangularis
Laevigatosporites globosus
L. medius
L. minutus
L. ovalis
L. vulgaris
Tuberculatosporites robustus
Thymospora pseudothiessenii
Wilsonites vesicatus
Hymenospora paucirugosa
Endosporites globiformis
E. plicatus
Paleospora fragila
Florinites antiquus
Alatisporites hexalatus
A. trialatus
Trihyphaecites triangulatus

The two most abundant genera in the coal are *Laevigatosporites* and *Lycospora*, which account for 49.6 percent and 27.8 percent, respectively, of the flora. By far the largest percentage of *Laevigatosporites* is *L. globosus* (38.1 percent). Other rather common taxa are *Punctatisporites* (12.6 percent), *Crassispora plicata* (9.8 percent), *Thymospora pseudothiessenii* (4.7 percent), and *Anapiculatisporites spinosus* (3.7 percent). As is often characteristic of these taxa, *Laevigatosporites globosus*, *Anapiculatisporites spinosus*, and *Crassispora plicata* increase greatly in abundance in the upper bench of coal at the expense of *Lycospora* and *Laevigatosporites minutus*.

This coal, 6.75 inches thick, could not be correlated with any other coal studied

during this investigation. The presence of *Schopfites* places it above the DeKoven, or Greenbush, Coal. It can be distinguished from the DeKoven and Seelyville Coals by its smaller percentage of *Lycospora*; by its greater percentage of *Laevigatosporites globosus*, *Crassispora plicata*, and *Anapiculatisporites spinosus*; and by the absence of *Cirratriradites*. The uncorrelated coal possesses *Tuberculatosporites robustus*, *Paleospora fragila*, *Verrucosisporites*, and *Apiculatisporis*, which are all missing in the DeKoven and Seelyville Coals. *Camptotriletes*, *Convolutispora*, *Mooreisporites inusitatus*, *Cyclogranisporites*, and *Lophotriletes* are found in the uncorrelated coal but not in Seelyville Coal. Several species of *Raistrickia* are found in the uncorrelated coal but only one in the Seelyville. The former also contains *Schopfites* and *Granulatisporites*, which are both missing from the DeKoven Coal.

Abingdon (?) Coal Member

A coal that occurs only a few feet below the No. 2 Coal was found at two localities (sample sites 23 and 38). This coal may be the equivalent of the Abingdon Coal and is designated Abingdon (?) Coal in this report. Culver (1925, p. 75) named the Abingdon Coal for one occurring below the No. 2 Coal that had been mined near Abingdon, Knox County, in western Illinois. A coal sample from the type area in Knox County, which was designated by Weller et al. (1942, p. 1589), was macerated but failed to yield spores because the outcrop was extremely weathered.

At sample site 23 (macerations 1384-F and 1384-G), the Abingdon (?) Coal is separated from the No. 2 Coal by 3 feet of underclay, and at sample site 38 (macerations 1404-I, 1404-J, and 1404-K) the interval of underclay between the two coals is 16 inches. The spores identified in these macerations are well preserved, and their number and variety indicate a diverse flora. Species from both sites are listed below.

Leiotriletes adnatoides
L. levis
L. notatus
L. parvus
Punctatisporites aerarius
P. edgarensis
P. minutus
P. nahannensis
P. obliquus
P. cf. *pseudolevatus*
Calamospora breviradiata
C. flava
C. hartungiana
C. straminea
Granulatisporites granularis
G. cf. *parvus*
Cyclogranisporites cf. *aureus*
C. micaceus
C. microgranus
C. staplini
Verrucosisporites microtuberosus
V. cf. *verus*
Schopfites colchesterensis
S. dimorphus
Lophotriletes cf. *granoornatus*
L. mosaicus
L. pseudaculeatus
L. rarispinosus
Anapiculatisporites spinosus
Apiculatisporis abditus
A. lappites
A. setulosus
Acanthotriletes aculeolatus
Raistrickia breveminens
R. carbondalensis
R. cf. *fibrata*
R. irregularis
R. lacerata
R. solaria
R. subcrinita
Microreticulatisporites sulcatus
Reticulatisporites lacunosus
R. sp. 1
Camptotriletes bucculentus
Vestispora colchesterensis
V. fenestrata
V. foveata
Triquitrites additus
T. cf. *additus*
T. bransonii
T. crassus
T. exiguus
T. minutus
T. protensus
T. pulvinatus
T. sculptilis
T. spinosus
Mooreisporites inusitatus
Crassispora plicata
Lycospora brevijuga
L. granulata
L. punctata
L. subjuga
L. torquifer
Densosporites sphaerotriangularis

D. triangularis
Cirratriradites annulatus
C. annuliformis
Laevigatosporites globosus
L. medius
L. minutus
L. ovalis
L. punctatus
L. vulgaris
Thymospora pseudothiessenii
Torispora securis
Wilsonites delicatus
W. vesicatus
Endosporites globiformis
E. plicatus
Florinites antiquus
F. grandis
F. similis
Vesicaspora wilsonii
Alatisporites trialatus
Trihyphaecites triangulatus

In the eastern part of the study area, the small spore flora of the Abingdon (?) Coal (macerations 1404-I, 1404-J, 1404-K) is 57.4 percent *Laevigatosporites*; *L. minutus* accounts for 42.4 percent of the genus. Macerations 1384-F and 1384-G, which are actually from a coaly shale 5 inches thick, show a higher percentage of *Lycospora* (59.8 percent) and a lower percentage of *Laevigatosporites* (30.1 percent) although *L. minutus* is still well represented with 26.9 percent of the total spore frequency. *Crassispora* (6 percent) is fairly common in macerations 1384-F and 1384-G. The absence from those macerations of a number of spore taxa, including the two stratigraphically useful genera, *Schopfites* and *Densosporites*, is probably due to the thinness and shaly nature of the coal interval.

The Abingdon (?) Coal is palynologically much like the No. 2 Coal, but it has a smaller percentage of *Lycospora* and *Florinites* and a markedly larger percentage of *Laevigatosporites minutus*. *Reinschospora, Tuberculatosporites, Hymenospora, Paleospora, Punctatisporites decorus, Granulatisporites livingstonensis, Converrucosisporites subverrucosus, Verrucosisporites compactus, V. firmus*, and *Vestispora laevigata*, which are usually found in the No. 2 Coal, were not found in the Abingdon (?) Coal.

Carbondale Formation

Colchester (No. 2) Coal Member

The Colchester (No. 2) Coal is the basal member of the Carbondale Formation of Illinois (Kosanke et al., 1960, p. 34). It is the most widespread coal in the Illinois Basin and probably is not only the most widely traceable but also one of the most economically important coals in North America. In Illinois it attains its maximum thickness of about 4 feet in the western and northern part of the state, where it is extensively mined.

Worthen (1868, p. 11) introduced the name Colchester for a coal in McDonough County and designated it Coal No. 2, along with the lower coal at Murphysboro, the coal at Morris in Grundy County, and the lowest seam at LaSalle. Wanless (1939, p. 25, 101) correlated the No. 2 Coal with Coal IIIa of Indiana, the Whitebreast Coal of Iowa, the Schultztown Coal of Kentucky, and tentatively with the Lower Kittanning Coal of Ohio and Pennsylvania. Wanless (1955, p. 1790) later extended the correlation to include the Croweburg Coal of Missouri and the Henryetta–Broken Arrow Coal of Oklahoma. The type locality for the Colchester (No. 2) Coal was listed by Wanless (1956) as being in secs. 12 and 13, T. 5 N., R. 4 W., McDonough County, Illinois. Kosanke et al. (1960) extended the name Colchester (No. 2) Coal Member to the No. 2 Coal wherever it occurs in Illinois.

The spores of No. 2 Coal and its equivalents have been more widely studied than those of any other coal in North America. Kosanke (1950, p. 70-73) described the small spore assemblages of the No. 2 Coal in Illinois and reported an abundant and diversified flora. He also traced the zonation and succession of some of the spores from the base of the coal to the top. Guennel (1952, p. 26-27) reported on the spore genera from three samples of the Coal IIIa of Indiana. Wilson and Hoffmeister (1956) studied the spore assemblage, which consists of 48 species from nine localities, of the Croweburg Coal in

Oklahoma and concluded (p. 36), "... the closest correlation of the Croweburg Coal with the Illinois sequence is the Colchester Coal . . . ." The palynology of the Lower Kittanning and several other coals of early Allegheny age in Columbiana, Ohio, was carried out by Denton (1957). In 1966 Habib discussed the spore and pollen assemblages in the Lower Kittanning Coal of western Pennsylvania and related the vertical and geographic distribution of the spores to depositional facies. From 15 sample sites, 140 species were recorded. Gray (1967) also studied the plant microfossils of the Lower Kittanning Coal in the northern Appalachian Coal Field of eastern Ohio and western Pennsylvania. The distribution of spores in 2-inch increment samples of the Henryetta Coal from a mine in Okmulgee County, Oklahoma, was described by Meyers (1967).

According to W. H. Smith (1966, personal communication), the coal (maceration 537-L) at a depth of 789 feet to 791 feet 8 inches, described from a cored section in Franklin County as the No. 2 Coal, is actually the Lowell Coal. Kosanke (1950, p. 70), who included this coal in his study of the No. 2 Coal, may have listed some of the spores from the Lowell Coal with those of the No. 2 Coal. The No. 2 Coal was cut out by a thick sandstone unit, and the Lowell Coal was developed to an abnormal thickness. Reexamination of maceration 537-L supports this more recent interpretation.

In the present investigation, 50 samples of the No. 2 Coal from 23 Illinois localities, plus one sample of the correlative Colchester Coal (IIIa) of Indiana, were macerated and analyzed for their spore content. The coal was divided into several benches unless it was too thin or had already been sampled as one unit, as in the case of rotary drill cutting samples. The plant microfossils of the No. 2 Coal from the area of the type locality in McDonough County (sample site 1, macerations 1386-A and 1386-B), where it is 24 inches thick, are being reported for the first time. The coal there yielded 96 taxa, the maximum number found at any single locality of the No. 2 Coal. As was obvious from previous palynological studies of the No. 2 Coal or its equivalents, the spore flora is a rich and varied one. The following spores were found during this study.

Leiotriletes adnatoides
L. gracilis
L. levis
L. notatus
L. pseudolevis
Punctatisporites aerarius
P. decorus
P. minutus
P. nahannensis
P. obliquus
P. orbicularis
P. cf. *pseudolevatus*
P. vermiculatus
P. sp. 1
Calamospora breviradiata
C. flava
C. hartungiana
C. minuta
C. mutabilis
C. pedata
C. straminea
Elaterites triferens
Granulatisporites granularis
G. livingstonensis
G. pannosites
G. cf. *parvus*
G. sp. 1
Cyclogranisporites cf. *aureus*
C. breviradiatus
C. micaceus
C. microgranus
C. minutus
C. staplini
C. sp. 1
Converrucosisporites subverrucosus
Verrucosisporites compactus
V. donarii
V. firmus
V. microtuberosus
V. verrucosus
V. sp. 1
Schopfites carbondalensis
S. colchesterensis
S. dimorphus
S. cf. *dimorphus*
Kewaneesporites reticuloides
Lophotriletes commissuralis
L. copiosus
L. cf. *granoornatus*
L. mosaicus
L. pseudaculeatus
L. rarispinosus
L. sp. 1
Anapiculatisporites grundensis
A. spinosus

Pustulatisporites crenatus
P. sp. 1
Apiculatisporis abditus
A. lappites
A. setulosus
Acanthotriletes dimorphus
Raistrickia aculeolata
R. breveminens
R. carbondalensis
R. crinita
R. crocea
R. dispar
R. cf. *fibrata*
R. irregularis
R. lacerata
R. lowellensis
R. pilosa
R. pontiacensis
R. solaria
R. subcrinita
R. superba
R. sp. 1
R. sp. 3
Convolutispora cf. *florida*
C. fromensis
C. sp. 2
Spackmanites cf. *facierugosus*
Maculatasporites punctatus
Microreticulatisporites sulcatus
Dictyotriletes densoreticulatus
D. distortus
D. cf. *reticulocingulum*
Reticulatisporites lacunosus
R. sp. 1
Camptotriletes bucculentus
C. triangularis
Knoxisporites rotatus
Vestispora colchesterensis
V. fenestrata
V. foveata
V. laevigata
V. profunda
V. pseudoreticulata
Triquitrites additus
T. cf. *additus*
T. cf. *arculatus*
T. bransonii
T. crassus
T. desperatus
T. dividuus
T. exiguus
T. minutus
T. protensus
T. pulvinatus
T. sculptilis
T. spinosus
T. subspinosus
T. trigonappendix
T. sp. 1
Mooreisporites inusitatus
Indospora boletus
Grumosisporites cf. *rufus*
Crassispora plicata
Lycospora brevijuga
L. granulata
L. paulula
L. punctata
L. subjuga
L. torquifer
Cadiospora fithiana
C. magna
Densosporites cf. *lobatus*
D. sphaerotriangularis
D. triangularis
Cristatisporites alpernii
Vallatisporites sp. 1
Cirratriradites annulatus
C. annuliformis
Reinschospora magnifica
R. triangularis
Savitrisporites asperatus
S. majus
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. punctatus
L. vulgaris
Tuberculatosporites robustus
Thymospora pseudothiessenii
Torispora securis
Wilsonites delicatus
W. vesicatus
Perotriletes parvigracilus
Hymenospora multirugosa
H. paucirugosa
Endosporites globiformis
E. plicatus
Paleospora fragila
Florinites antiquus
F. grandis
F. similis
F. visendus
Vesicaspora wilsonii
*Complexisporites chalonerii**
Alatisporites hexalatus
A. punctatus
A. trialatus

The first and second most abundant spore genera in the No. 2 Coal are *Lycospora* and *Laevigatosporites*, respectively, except in a small area in the vicinity of the Ancona-Garfield structure in LaSalle and Livingston Counties (text fig. 4). This assemblage (shown by bar diagrams in text fig. 5), in which *Laevigatosporites* is plentiful and occasionally dominant, will be discussed later. The great dominance of

* Occurrence of the single specimen observed may be due to contamination of sample.

Lycospora in the No. 2 Coal and its equivalents in this study agrees with the findings of Kosanke (1950), Guennel (1952), Wilson and Hoffmeister (1956), Habib (1966), and Meyers (1967). Gray (1967) obtained similar results with three samples of the Lower Kittanning Coal, but at six other localities *Laevigatosporites* was dominant, followed closely by *Lycospora.*

The rather low number (about 52 percent) of *Lycospora* and rather high percentage of *Laevigatosporites* (about 31 percent) in the spore assemblage at the type area of the No. 2 Coal (macerations 1386-A and 1386-B) is probably due to differential corrosion of the spores in the weathered outcrop samples. A second maceration of the samples gave results similar to those obtained the first time. The sample with the most *Lycospora*, 83 percent, is a rotary drill cutting sample (maceration 1413-A from sample site 49) and thus is probably not as representative of the coal as many of the other samples. After allowances are made for the doubtful accuracy in the percentages recorded from these samples, the No. 2 Coal typically contains 54 to 76 percent *Lycospora. Laevigatosporites*, away from the Ancona-Garfield structure, ranges from 31.4 percent at the type outcrop to 4.7 percent in the rotary drill cutting sample 1413-A, but averages 10 to 20 percent. *Laevigatosporites minutus* accounts for most of the genus except in the Ancona-Garfield area, in the type No. 2 Coal sample, and at sample site 52, where *L. globosus* is numerically the most important. *L. ovalis* and *L. medius* are not numerically significant but were found in most of the samples.

A diminution of *Lycospora* generally occurs from the bottom to the top of the coal. *Laevigatosporites globosus* usually markedly increases in frequency in the upper bench of coal, and its abundance varies considerably, from "not observed" in maceration 1413-A to 19.5 percent outside the Ancona-Garfield area. The peak occurrence of *L. minutus* is usually, but not always, in the bottom part of the coal. Maceration 1227-B (sample site 18) is the only bench sample in which the species was not noted. *Crassispora plicata*, which was observed in all the macerations, is the third most abundant taxon and, except in the Ancona-Garfield area, averages 6 to 12 percent. The smallest representation, 0.7 percent, was found where the coal is only 7 inches thick (maceration 962-B, sample site 57). *Florinites* ranges from less than 1 to 7.8 percent of the assemblage but averages about 4 percent. *Thymospora pseudothiessenii* accounts for less than 1 to 6.3 percent. *Punctatisporites*, in which *P. minutus* is the most common species, averages 3 to 5 percent of the miospore flora but ranges from less than 1 to 8.6 percent. Other small spore genera frequently encountered but not numerically important include *Calamospora*, *Triquitrites*, *Anapiculatisporites*, *Schopfites*, *Cirratriradites*, *Verrucosisporites*, *Vestispora*, *Raistrickia*, and *Wilsonites.*

The No. 2 Coal (maceration 1133-D, sample site 53) from a strip mine near Clarke City in northeastern Illinois contains an unusually large (40.7) percentage of *Laevigatosporites minutus* and only 19.3 percent of *Lycospora.* The proportion of *Endosporites* in this assemblage is much larger (6.3 percent) than has been recorded from any other sample of the No. 2 Coal. Directly above the No. 2 Coal is an interval, 7.5 inches thick, of coal bands interbedded with shale. The spore assemblage obtained from the maceration (1133-E) of these uncorrelated coal bands between the No. 2 and Cardiff Coals is similar to that of the underlying No. 2 Coal, as indicated by the poor representation of *Lycospora* (8.7 percent) and the abundance of *Laevigatosporites minutus* (51.7 percent). These samples are from the locality where the channel-deposited Cardiff Coal occurs directly above the 7.5 inches of interbedded coal and shale, and where the No. 4 Coal is present at the abnormally short distance of 30 to 40 feet above the No. 2 Coal. It seems likely that the local environment that resulted in deposition of the Cardiff and No. 4 Coals within such a short interval also had an influence on the coal swamp flora of the No. 2 Coal.

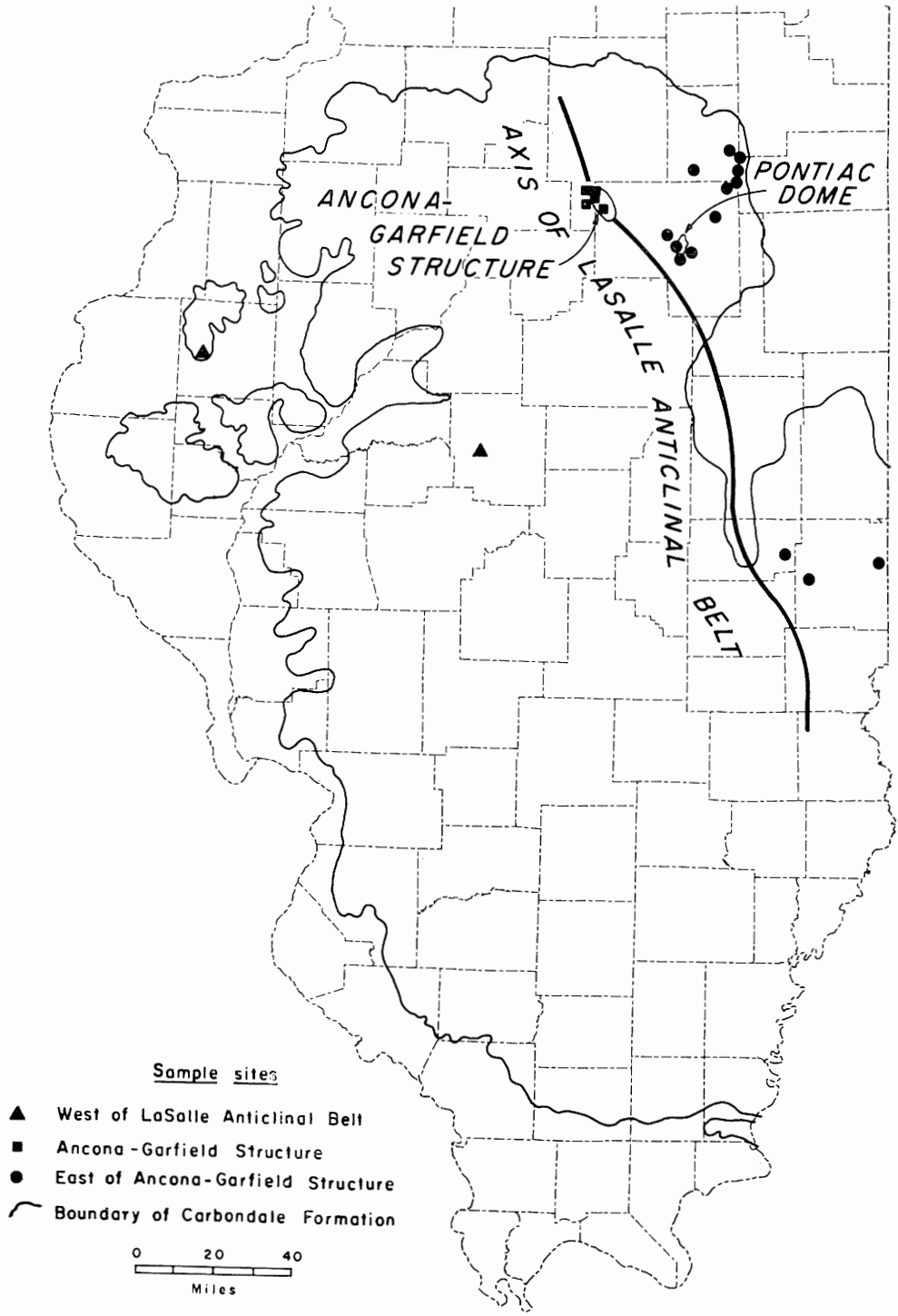
One specimen of *Complexisporites* was observed in the No. 2 Coal in the basal portion of the coal (maceration 954-Ee, sample site 54) sampled from a core drilled in the same northeast-southwest oriented basin as the strip mine already mentioned in connection with macerations 1133-D and 1133-E. This single occurrence of *Complexisporites* may be due to the unique local environment or to contamination of the sample. That the cored sample was somewhat disturbed is indicated by the fact that 35 inches of coal were reported but only 17 inches were recovered and macerated. The earliest occurrence of *Complexisporites* is probably in the No. 4 Coal or one slightly younger, as in the case of macerations 954-B, 1133-A1, and 1133-A2.

In contrast to the single specimen of *Spackmanites* cf. *facierugosus* found in the No. 2 Coal of Illinois (maceration 1402-C, sample site 24), Habib (1966) and Gray (1967) found numerous specimens in the probably equivalent Lower Kittanning Coal in Ohio and Pennsylvania. In the Illinois Basin, this species is rarely found below the No. 4 Coal, but, it has been found in the considerably older Pope Creek Coal Member of the Abbott Formation.

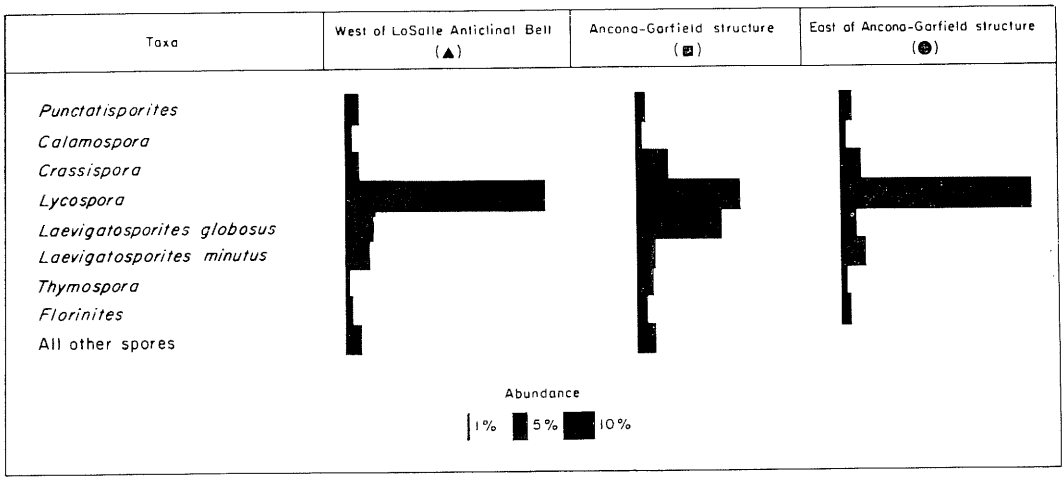
The presence of *Densosporites* in a coal in the Illinois Basin has been used as a diagnostic indication that the coal is at least as old as the Spoon Formation or older than the No. 2 Coal. During this investigation, *Densosporites* was found in 11 macerations of the No. 2 Coal from eight different localities. Although *Densosporites* has been recorded from coals equivalent to the No. 2 Coal in the Eastern Appalachian Coal Province, this is the first published account of the occurrence of the genus in the No. 2 Coal of Illinois. Several specimens of the genus have been observed in the Schultztown Coal Member at its type locality in western Kentucky (Gray and Taylor, 1967). Wilson and Hoffmeister (1956) and Meyers (1967) did not report *Densosporites* from the McAlester and Henryetta Coals of Oklahoma, but Cross and Schemel (1951, p. 128) placed the upper limit of *Densosporites* slightly above the Pottsville-Allegheny boundary in West Virginia. This is supported by the investigations of Habib (1966) and Gray (1967), who found considerable numbers of specimens of *Densosporites* in the Lower Kittanning Coal of Ohio and Pennsylvania. In Illinois, *Densosporites* in the No. 2 Coal is apparently restricted to the eastern portion of the state, generally east of the axis of the LaSalle Anticlinal Belt.

Effect of Ancona-Garfield Structure on Spore Assemblage

The Ancona-Garfield structure occurs in southern LaSalle County and the northwestern part of Livingston County (T. 30 N., Rs. 2 and 3 E.) and was one of the sites explored for gas storage reservoirs by the Northern Illinois Gas Company. This structure is an asymmetrical anticline at whose crest are the Ancona and Garfield Domes (Buschbach and Bond, 1967, p. 22). The spore assemblage of the No. 2 Coal in the vicinity of the Ancona-Garfield structure is distinctly different from that in the No. 2 Coal from other parts of the Illinois Basin (text figs. 4 and 5). At sample sites 15, 16, 18, 19, and 20 (macerations 1275-D, 1275-E, 1275-F, 1296, 1227-A, 1227-B, 1227-C, 1279-F, 1279-G, and 1230-CC), the No. 2 Coal sampled from cores drilled in the area of the structure contains unusually low amounts (22 to 42.7 percent) of *Lycospora*. *Lycospora* is still the most abundant taxon in maceration 1279, in which it makes up 36 percent. *Crassispora*, which ranks second with 24.7 percent, is more abundant here than in any of the other samples of the No. 2 Coal studied. *Laevigatosporites*, which is third in abundance, contributes 19.5 percent of the spore assemblage. In macerations 1275-D, 1275-E, 1275-F, 1227-A, 1227-B, and 1227-C, the *Lycospora* percentage is unusually low, making up less than half the spore population, whereas *Laevigatosporites* becomes the most important genus and accounts for 45 to 47 percent of the spore population. Most of the high percentage of the latter is due to



Text Fig. 4 — Sites from which the Colchester (No. 2) Coal was sampled and major structures related to spore distribution. Major spore taxa are shown in text figure 5.



Text Fig. 5 — Relative abundance of small spore taxa in the Colchester (No. 2) Coal. Symbols in headings refer to sample sites in figure 4.

a distinct increase in *L. globosus* in the upper or both upper and lower benches. In the Ancona-Garfield area, *Crassispora* averages 6 to 7 percent, except in macerations 1279-F and 1279-G, where it is in great profusion. *Thymospora pseudothiessenii* (2 to 11 percent), *Florinites antiquus* (1.3 to 6.4 percent), and *Punctatisporites* (0.5 to 6.7 percent) make up most of the rest of the miospore assemblage in the area. *Lycospora* is most abundant in the middle bench of the coal, and *Laevigatosporites* attains its maximum frequency in the top bench or top and middle benches. Although not restricted exclusively to the No. 2 Coal in the area of the Ancona-Garfield structure, *Reinschospora*, *Torispora*, and *Alatisporites* appear to be more frequently encountered there; only one specimen of *Lophotriletes* was found in the area. A similar structure near Pontiac (sample sites 23 and 26) had no noticeable influence on the composition of the plant microfossil population of the No. 2 Coal.

Habib (1966, p. 662-663) found that the assemblages characterized by *Densosporites* and an abundance of *Punctatisporites obliquus* and *Laevigatosporites globosus* occurred where the Lower Kittanning Coal of Pennsylvania is overlain by marine and restricted marine facies. He concluded that the presence of this assemblage reflected changes in salinity due to proximity to the sea and to changes in the level of the water table.

The assemblage rich in *Laevigatosporites globosus* in the Ancona-Garfield area of Illinois is overlain by marine or nonmarine, gray, plant-bearing shale at sample sites 15 and 19 and by black, fissile, marine shale at sample site 18. However, the No. 2 Coal (maceration 1404-L, 1404-M, and 1404-N) in Edgar County, which is also overlain by a black, fissile, marine shale, yielded a small proportion (2 percent) of *Laevigatosporites globosus*.

If the Ancona-Garfield structure were topographically high during deposition of the No. 2 Coal, a coal swamp flora of a composition different from that of the surrounding environment might be expected. The structure is genetically closely related to the LaSalle Anticlinal Belt, which shows evidence of only minor activity during Pennsylvanian time (Clegg, 1965, p. 82-94). No appreciable thinning of the No. 2 Coal or associated strata is evident over the structure. However, even minor structural movement of the Ancona-Garfield structure during Pennsylvanian time, resulting in only a few feet of difference in elevation relative to the regional topography, could have influenced the level of the water table, salinity of the water, water

currents, and other factors that would have had an effect on the composition of the coal swamp flora growing on the structure.

Differentiation of No. 2 Coal

The No. 2 Coal can easily be distinguished from the Abingdon (?), Seelyville, and DeKoven Coals below by spore analysis because the No. 2 Coal has a much more diverse spore assemblage. Genera found in the No. 2 Coal but apparently absent from the DeKoven include *Schopfites*, *Leiotriletes*, *Granulatisporites*, *Apiculatisporis*, *Reticulatisporites*, *Hymenospora*, and *Camptotriletes*. In addition, the DeKoven Coal lacks *Tuberculatasporites robustus*, *Paleospora fragila*, *Triquitrites minutus*, and a number of species of *Raistrickia*. *Florinites* is more abundant in the DeKoven Coal than in the No. 2 Coal.

Punctatisporites and *Densosporites* are more abundant in the Seelyville Coal than in the No. 2 Coal. Spore genera present in the No. 2 Coal but apparently lacking in the Seelyville Coal include *Leiotriletes*, *Cyclogranisporites*, *Verrucosisporites*, *Lophotriletes*, *Apiculatisporis*, *Microreticulatisporites*, *Dictyotriletes*, *Reticulatisporites*, *Cadiospora*, *Reinschospora*, *Tuberculatosporites*, *Hymenospora*, and *Paleospora*.

As the Abingdon Coal was not identified with certainty in this report, no attempt is made to contrast in detail its spore assemblage with that of the No. 2 Coal.

Lowell and Cardiff Coal Members and Equivalents

In the interval between the Colchester (No. 2) and Summum (No. 4) Coals, one or two coals have been described from different parts of the Illinois Basin. The coals have been variously named the Lowell, Cardiff, Shawneetown, and 2A (name discontinued) Coals in Illinois, Coal IV in Indiana, No. 8 Coal in Kentucky, and the Bevier Coal in Missouri. Although the thickness of the Lowell Coal and its equivalents and their exact distance above the No. 2 Coal is erratic, the coal or coal horizons can be traced over a more extensive area than had previously been realized. The Lowell Coal has not been reported, however, in northwestern Illinois west of the Illinois River. Two separate coals are commonly found between the No. 2 and No. 4 Coals in many parts of the Illinois Basin, especially in the southern and eastern parts. At the localities where the two coals were sampled for this study, the interval between them varies from 8 inches at sample site 19 to about 12 feet at sample site 29. I was not able at this time to determine palynologically or by other means whether the Lowell Coal of northern Illinois is equivalent to the lower or upper coal in other parts of the Illinois Basin or to a combination of the two coals.

The Lowell Coal was named and described by Willman and Payne (1942, p. 102-103, p. 300) from an exposure at the high bank on the south side of the Vermilion River in sec. 8, T. 32 N., R. 2 E., LaSalle County (sample site 13). Here the Lowell Cyclothem contains a shaly coal 6 inches thick and a marine limestone. In the same report, Willman and Payne stated that the Lowell Coal may be equivalent to the Bevier Coal of Missouri and the Linton Coal of Indiana. Kosanke et al. (1960, p. 42) proposed the name Tonica Cyclothem "... for the lower Liverpool strata wherever the Lowell Cyclothem is well enough developed to be named ...." Smith (1961, p. 13) applied the name Lowell to a coal or coaly zone 30 to 40 feet above the No. 2 Coal in Madison, Macoupin, and Jersey Counties and also correlated it with the Bevier Coal of Missouri.

Harrison (1951, p. 15) referred to two thin coals between the No. 2 and No. 4 Coals in Gallatin and White Counties of southern Illinois as the No. 2A Coals. He reported that the interval between the two coals varied from 8 to 16 feet and that their position was distinctly indicated in about 70 percent of the electric logs from White County. The name No. 2A Coal was also used by Siever (*in* Wanless, 1956) for these two coals in southern and eastern Illinois. The name No. 2A Coal was discarded by Kosanke et al. (1960, p. 34).

The name Shawneetown Coal Member was proposed by Kosanke et al. (1960, p. 34-35) for the lower of the two coals formerly called No. 2A, whereas the name actually had been intended to be applied to the upper coal. In the Union Colliery Company drill hole 28, located in the NW¼ SW¼ NW¼, sec. 23, T. 9 S., R. 9 E., Gallatin County, which serves as the type section, the depth of the Shawneetown was erroneously listed as 543 feet 10 inches. The probable position of the uppermost of the two coals was given as 504 feet 11 inches. However, according to J. A. Simon (1962, personal communication), the coal at 543 feet 10 inches is actually the No. 2 Coal, and the 26-inch coal at 482 feet 7 inches is the Shawneetown Coal and was the coal intended to represent the type Shawneetown as originally defined. The error made in Kosanke et al. (1960) in defining the Shawneetown Coal is here formally corrected. The coal horizon reported at 504 feet 11 inches is probably the position of the lower coal and is not formally named.

The name Cardiff Coal, which was introduced by Cady (1915, p. 35, 101, 102), had been discontinued but is here re-introduced for the coal as defined by Cady (1915; 1952, p. 60) and for its equivalents. The Cardiff Coal Member is the first coal that lies a few feet, generally not over 10, above the No. 2 Coal in the vicinity of Cardiff. At a few places in that vicinity the Cardiff lies on top of the No. 2 Coal. The name is derived from the village of Cardiff in secs. 22 and 23, T. 30 N., R. 8 E., Livingston County. The type locality is the mines within a mile of the village. There the coal, which had been called the "big vein," was found in a northeast-southwest trending channel, attained a thickness up to 12 feet, and has been essentially mined out. According to Cady (1915, p. 35), a similar channel-deposited coal was reported near Clarke City, 6 or 7 miles north of Cardiff.

The coal from the type section of the Lowell Coal (sample site 13) was sampled and macerated (macerations 1190, 1377). The Shawneetown Coal is represented by a sample (macerations 1454-A, 1454-B, 1454-C, and 1454-D, sample site 41) from a coal in sec. 9, T. 10 S., R. 6 E., Saline County, that had been exposed in the highwall of a strip mine, and another from a diamond drill core (macerations 1381-K and 1381-L, sample site 42) in sec. 2, T. 10 S., R. 5 E., Saline County. The latter sample is of the upper coal of the two that were formerly called No. 2A. The lower of the two coals also was sampled and macerated (macerations 1381-I and 1381-J, sample site 42). A thick lenticular coal a few feet above the No. 2 Coal, thought to be equivalent to the Cardiff Coal, was sampled from a strip mine (macerations 1133-C1, 1133-C2, and 1133-C3, sample site 53) in Kankakee County in the vicinity of Clarke City and from a diamond drill core and several rotary drill holes (sample sites 54 through 57). Two coals, one 22.5 inches thick (macerations 1509-B, 1509-C, and 1509-D, sample site 29) and one 29.75 inches thick (macerations 1509-E, 1509-F, and 1509-G, sample site 29) between the Colchester (IIIa) and Houchin Creek (IVa) Coals of Indiana were sampled from a core from Vigo County, Indiana (sample site 29). They are considered to be upper and lower benches of the Survant Coal (IV) of Indiana.

The Lowell Coal of northern Illinois is correlated by spores with the interval of the Survant Coal (IV) of Indiana and the two coals formerly called the 2A Coals of southern Illinois. Whether the Lowell Coal is equivalent to the upper, lower, or both coal seams of this interval could not be resolved by spore analysis during this investigation. The Cardiff Coal is palynologically somewhat similar to the Lowell Coal but may not necessarily be correlative with it, as will be discussed later.

Guennel (1952, p. 27-28) reported on the palynology of coals mined as the Survant Coal (IV) of Indiana from five mines but identified only three of the coals as definitely belonging to that coal interval.

A list of small spore species observed in the various macerations of the Lowell, Cardiff, and equivalent coals follows. Taxa

found in the two thin coals tentatively called Lowell (?) Coal (sample sites 53 and 54) that do not appear in the other coals of this interval are not listed because these coals have not yet been definitely correlated.

Leiotriletes adnatoides
L. cf. *adnatus*
*L. gracilis**
L. levis
L. notatus
L. parvus
*L. pseudolevis**
L. sp. 1
Trivolites laevigata
Punctatisporites aerarius
P. curviradiatus
P. decorus
P. edgarensis
P. kankakeensis
P. minutus
P. nahannensis
P. obliquus
P. orbicularis
P. sp. 1
Calamospora breviradiata
C. flava
C. hartungiana
C. mutabilis
C. pedata
C. straminea
C. sp. 1
Elaterites triferens
Granulatisporites granularis
G. livingstonensis
G. pallidus
G. pannosites
G. cf. *parvus*
Cyclogranisporites aureus
C. cf. *aureus*
C. breviradiatus
C. micaceus
C. microgranus
*C. minutus**
C. staplini
Converrucosisporites subverrucosus
C. sp. 1
Verrucosisporites compactus
V. donarii
V. firmus
V. microtuberosus
V. microverrucosus
*V. papulosus**
V. sifati
V. verrucosus
Schopfites carbondalensis
S. colchesterensis
S. dimorphus
S. cf. *dimorphus*
Distortisporites illinoiensis
Lophotriletes commissuralis
L. cf. *granoornatus**
L. ibrahimi
L. microsaetosus
L. mosaicus
L. pseudaculeatus
L. rarispinosus
L. sp. 1
L. sp. 2
*Anapiculatisporites grundensis**
A. spinosus
Apiculatisporis abditus
A. lappites
A. setulosus
Acanthotriletes aculeolatus
A. dimorphus
Pileatisporites aequus
Raistrickia cf. *aculeata*
R. aculeolata
R. breveminens
R. carbondalensis
R. cf. *clavata*
R. crinita
R. crocea
R. dispar
R. cf. *fibrata*
R. grovensis
R. irregularis
R. lacerata
R. lowellensis
R. pilosa
R. pontiacensis
R. protensa
R. solaria
R. subcrinita
R. superba
R. sp. 2
R. sp. 3
Maculatasporites punctatus
*Microreticulatisporites hortonensis**
M. cf. *lunatus*
M. sulcatus
Dictyotriletes cf. *reticulocingulum*
Reticulatisporites lacunosus
R. pseudomuricatus
R. reticulatus
R. sp. 2*
Camptotriletes bucculentus
C. triangularis
Knoxisporites rotatus
*Vestispora colchesterensis**
V. fenestrata
V. foveata
V. laevigata
*V. profunda**
Triquitrites additus
T. cf. *additus*
T. cf. *arculatus*
T. bransonii
T. crassus
T. dividuus
T. exiguus

* Found in the Cardiff but not in the Lowell or equivalent coals.

T. minutus
T. protensus
T. pulvinatus
T. sculptilis
T. cf. *sculptilis**
T. spinosus
T. subspinosus
T. trigonappendix
T. sp. 1
Mooreisporites inusitatus
*Indospora stewarti**
Grumosisporites cf. *rufus*
Crassispora plicata
Lycospora brevijuga
L. granulata
L. paulula
L. punctata
L. subjuga
L. torquifer
Murospora kosankei
Densosporites sphaerotriangularis
*D. triangularis**
Cirratriradites annulatus
C. annuliformis
*Reinschospora magnifica**
R. triangularis
Savitrisporites majus
S. sp. 1
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. punctatus
L. vulgaris
Tuberculatosporites robustus
Thymospora pseudothiessenii
Torispora securis
Wilsonites delicatus
W. vesicatus
Perotriletes parvigracilus
Hymenospora multirugosa
H. paucirugosa
Endosporites globiformis
E. plicatus
Paleospora fragila
Florinites antiquus
F. millotti
F. similis
Vesicaspora wilsonii
Alatisporites hexalatus
A. punctatus
A. trialatus
Trihyphaecites triangulatus

Lowell Coal Member

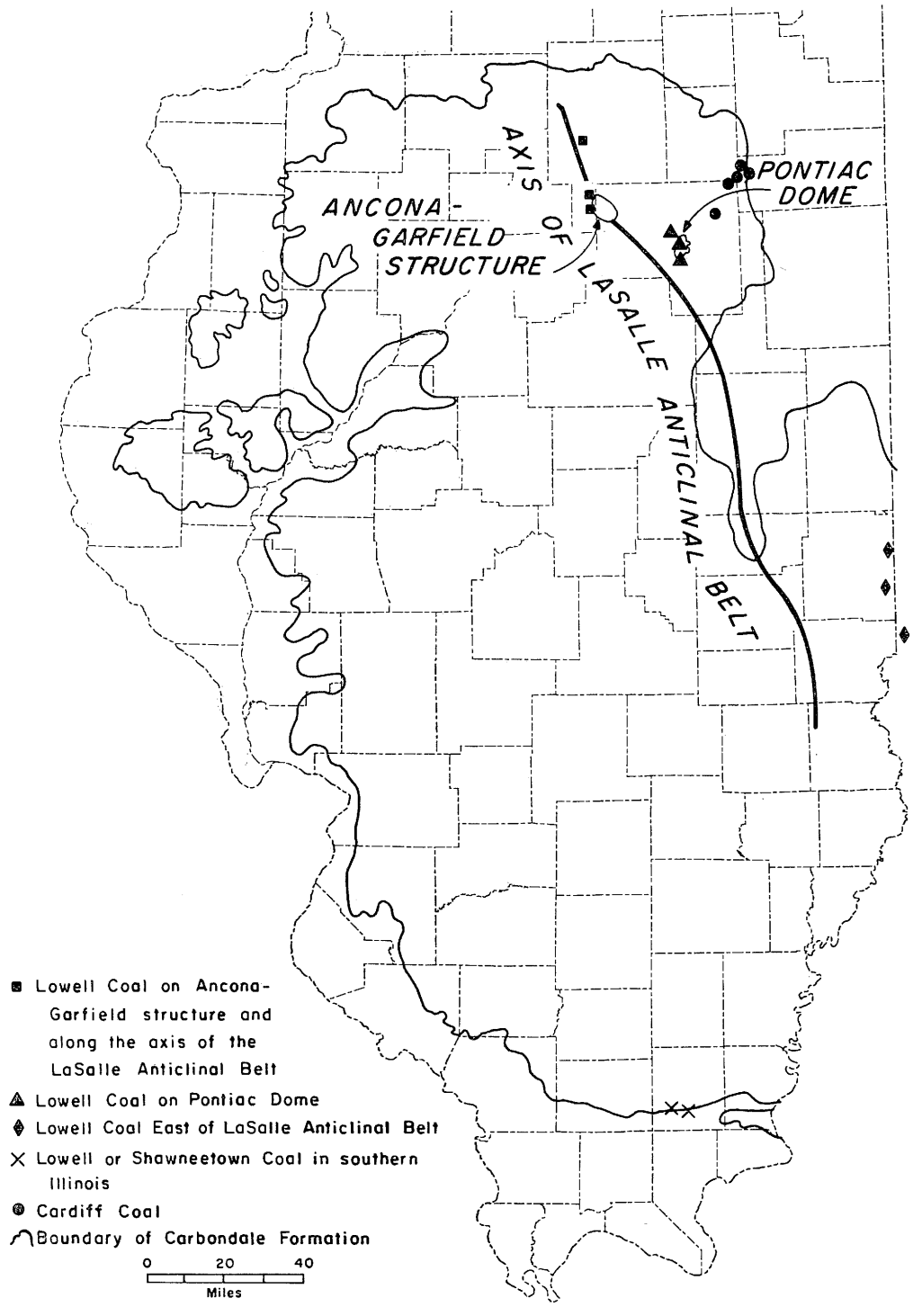
Spore data from the Lowell Coal interval are based on the study of 54 bench samples from 18 localities. Where sampled, the Lowell Coal or its equivalents varies in thickness from 2 inches (maceration 1274-A, sample site 15) to 48 inches (maceration 1404-O through 1404-R, sample site 38). The Lowell Coal contains a diverse flora of usually well preserved small spores. The coal (macerations 1402-D, 1402-E, 1402-F, and 1402-G, sample site 24) with the largest number of taxa recorded (107) is from a core near the town of Pontiac.

Text figure 6 shows the relation of the major structures to the sample sites of the Lowell, Cardiff, and equivalent coals. In figure 7 the relative abundance of the spore taxa in these coals is indicated by bar diagrams. The spore assemblages of the Lowell Coal at the type section (sample site 13) and from two cores drilled on the Ancona-Garfield structure nearby (sample sites 15 and 19) were found to have some differences when compared with the assemblages from the Lowell in other parts of the state. These assemblages and those from the Cardiff Coal will be discussed in greater detail later.

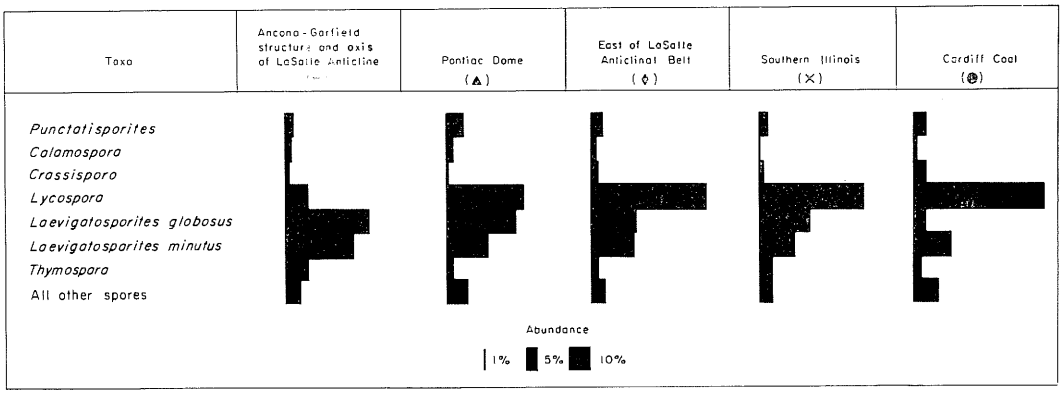
In the region of the Pontiac and Ancona-Garfield structures and westward, the most abundant genus is *Laevigatosporites*, with *Lycospora* second, but east of the LaSalle Anticlinal Belt and in southern Illinois *Lycospora* is the dominant genus. In the western sector, *Laevigatosporites* makes up 47 to 50.3 percent and *Lycospora* accounts for 27.4 to 36 percent of the miospore assemblage. *Laevigatosporites globosus* ranges from 22.1 to 36.4 percent and *L. minutus* from 11.4 to 21.9 percent. Other spore taxa not uncommonly observed in this region include *Punctatisporites* (5 to 9.9 percent), *Apiculatisporis* (1.8 to 5.2 percent), *Calamospora* (1.9 to 3 percent), *Thymospora* (1.1 to 3 percent), *Crassispora* (0.3 to 2 percent), and *Triquitrites* (0.8 to 1.6 percent). *Punctatisporites edgarensis* is apparently restricted to this western region. No relation between relative abundance of spore taxa and the vertical position within the coal was observed.

East and south of the Pontiac Dome (text figure 4), *Lycospora* with 41.2 to 54.9 percent and *Laevigatosporites* with 26.7 to

* Found in the Cardiff but not in the Lowell or equivalent coals.



Text Fig. 6 — Sites from which the Lowell, Cardiff, and equivalent coals were sampled and major structures related to spore distribution. Major spore taxa are shown in text figure 7.



Text Fig. 7 — Relative abundance of small spore taxa in the Lowell, Cardiff, and equivalent coals. Symbols in headings refer to sample sites in figure 6.

41.8 percent rank first and second in the Lowell and Shawneetown Coals and in the interval of the Survant Coal (IV) of Indiana. *Laevigatosporites globosus* constitutes 9.0 to 26.6 percent and *L. minutus* 9.7 to 24.7 percent of the small spore population. The latter reaches its numerical peak at the bottom or middle of the coal. Maceration 1508-B (sample site 45), which contains an unusually small amount (9 percent) of *L. globosus*, may not be very representative because it was prepared from a 1-inch thick fragment of coal, found in stream gravel, that had washed out of a coal only 1.5 inches thick that is exposed along a stream. The extremely weathered coal sampled from the stream bank outcrop failed to yield recognizable spores. *Punctatisporites* (2 to 8.7 percent), *Thymospora* (1.9 to 6.1 percent), *Crassispora* (0.3 to 5.7 percent), and *Calamospora* (0.5 to 2.2 percent) are the most frequently encountered of the remaining genera.

The only part of the Illinois Basin where marine limestone has been found thus far in the Lowell Cyclothem (W. H. Smith, 1967, personal communication) is the type locality of the Lowell (macerations 1190 and 1377, sample site 13) and in the vicinity of the Ancona-Garfield structure (macerations 1275-A, 1279-D, and 1279-E). The macerations from the type section actually represent a shaly coal zone 6 inches thick. Maceration 1275-A is from a 2-inch thick, very carbonaceous zone that was obtained from a core (sample site 15). Another cored section from the Ancona-Garfield region (sample site 19) displayed a coal (maceration 1279-D) 6 inches thick and a bony coal (maceration 1279-E) 1¾ inches thick separated from each other by an 8-inch thick siltstone zone. The Lowell Coal interval in this local environment is characterized by a very low frequency of *Lycospora*, such as was recorded from macerations 1190 and 1377 (15.3 percent), maceration 1275-A (5 percent), maceration 1279-D (6 percent), and maceration 1279-E (17.7 percent). *Laevigatosporites minutus* is the most abundant species (46 percent) in macerations 1190 and 1377, but *L. globosus* is the dominant species, making up 52 percent of the spore assemblage in maceration 1275-A and 47.5 percent in macerations 1279-D and 1279-E. *Thymospora pseudothiessenii* (7.5 to 16.7 percent), *Punctatisporites* (1.8 to 6 percent), *Calamospora* (up to 3.7 percent), and *Triquitrites* (0.3 to 2.4 percent) constitute most of the remainder of the plant microfossils. In the area overlain by marine facies, the coal swamp probably was invaded by the sea before sufficient time had elapsed for the establishment of a plant community rich in *Lycospora*-bearing lepidodendrids.

Lowell (?) Coal Member

Two thin coals, tentatively correlated with the Lowell but here considered sep-

arately because of the uncertainty of the correlation, were found in a shale interval between the Cardiff and No. 4 Coals in the "multiple seam area" in western Kankakee County. The coals were sampled from a diamond drill core (macerations 954-B and 954-C, sample site 54) and from a strip mine about one-third of a mile to the southeast (macerations 1133-A1 and 1133-A2, sample site 53). The coals of macerations 954-C and 1133-A are about 11 inches thick and the latter is only about 5 feet below the No. 4 Coal and 4 feet above the Cardiff Coal. A shale band 1 inch thick occurs 2.75 inches above the base of the coal of 1133-A. Coal of maceration 954-B is only 2.6 inches thick and lies about 10 inches above 954-C.

The macerations of these coals are characterized by a very high frequency of *Laevigatosporites minutus*, which ranges from 29.3 to 43.3 percent. *Laevigatosporites* and *Lycospora*, with 33 to 43 percent and 39 to 43 percent, respectively, are about equally well represented in the spore assemblages except in maceration 954-B. That maceration contains a very high proportion of *Laevigatosporites* (64.3 percent) at the expense of *Lycospora*, which accounts for only 13.3 percent of the spore population. *Thymospora pseudothiessenii* (7 percent) and *Calamospora* (3 percent) are fairly common in maceration 954-C, whereas *Crassispora* (9.1 percent) and *Punctatisporites* (5.9 percent) are common in macerations 1133-A1 and 1133-A2.

No exact correlation of these thin coals was made because the small number of taxa identified in maceration 954-C suggests poor preservation of the spores. The coals, therefore, were not included on the spore distribution charts (text figs. 10 and 11). The percentage of *Lycospora* reported may be abnormally low because *Lycospora* is less resistant to decomposition than *Laevigatosporites*. Probably macerations 954-C and 1133-A1 and 1133-A2 are correlative. The coals are thought to be approximately equivalent to the upper part of the Lowell Coal depositional sequence because it, too, has a high proportion of *Laevigatosporites*. The rather common occurrence (5.7 percent) of *Endosporites* and absence of *Thymospora pseudothiessenii* in maceration 954-B suggest an affinity with the Cardiff Coal, but the presence of *Complexisporites chaloneri* and *Kewaneesporites reticuloides* in macerations 954-B, 1133-A1, and 1133-A2 points to an affinity with the No. 4 Coal.

Survant Coal (IV) of Indiana

Two coals of the Coal IV interval of Indiana sampled from a diamond drill core in Vigo County, Indiana (macerations 1509-B through 1509-G, sample site 29), are correlated by spore analysis with two Illinois coals in the same interval from a core in Saline County, Illinois (macerations 1381-I through 1381-L, sample site 42).

Where Coal IV is mined, a medial parting that is often present may be equivalent to the intervening shale unit where two separate coals are developed. For example, a diamond drill core in sec. 12, T. 14 N., R. 10 W., Vigo County, Indiana, shows a shale parting about 2 inches thick that occurs 17.5 inches below the top of the coal. In section 33 of the same township, a shale interval of 3 feet 5 inches separates the upper and lower benches of Coal IV, and in other parts of Vigo County the shale interval attains a thickness of at least 20 feet.

Cardiff Coal Member

As mentioned in the introduction of this report, the stratigraphy in the Wilmington area of Kankakee County is quite complex because of the occurrence of at least four coals stratigraphically separated by only a few feet of shale. In this "multiple seam area" the Cardiff Coal is traced from a strip mine (sample site 53), where it is 57 inches thick and only a few feet above the No. 2 Coal, and a diamond drill core sample (sample site 54) southwest to sample sites 55, 56, and 57 (macerations 1143-B, 1034-A, and 962-A from rotary drill holes)

in southern Grundy and northeastern Livingston Counties. The spore assemblages from the coal in the three drill holes closely resemble those from the Cardiff Coal in the strip mine to the northeast. However, the coal recovered from the rotary samples is correlated with the Cardiff Coal to the northeast with some reservation because of the unusually large interval between this coal and the No. 2 Coal where the samples were taken. The coal of maceration 962-A lies almost 81 feet above the No. 2 Coal.

With a few exceptions, the small spore population of the Cardiff Coal is similar to that of the Lowell Coal east of the axis of the LaSalle Anticlinal Belt. The abundance of *Lycospora* in the Cardiff is as low as 45.6 percent, although it does get up to 62.3 percent, somewhat higher than has been found in the Lowell of the eastern or southeastern part of the Illinois Basin. *Laevigatosporites globosus*, which is not as abundant in the Cardiff Coal as in the Lowell, ranges from 2 to 5.3 percent, and *L. minutus* varies erratically from 11.3 to 21 percent. *Laevigatosporites* decreases in abundance from the bottom of the coal toward the top, whereas *Lycospora* increases. Although *Endosporites* is rare in two samples (macerations 1143-B and 1034-A), it makes up 4 to 5 percent of the spore assemblage in the other three sample localities, and one of the macerations (1133-C2, sample site 53) from the middle bench of the Cardiff Coal had 13 percent *Endosporites*.

The relative scarcity of *Endosporites* in macerations 1143-B and 1034-A may be explained by the fact that the sample chips recovered from rotary drilling do not represent the coal as well as a face or diamond drill core sample. *Crassispora plicata* and *Densosporites* are encountered a little more frequently in the Cardiff than in the typical Lowell Coal.

The Cardiff Coal is interpreted as an earlier abandoned channel phase of deposition of the Lowell Coal. It may actually be a little older than the Lowell Coal of other parts of the Illinois Basin because the spore assemblage has some aspects of the No. 2 Coal assemblage. This is not surprising, as Cady (1915, p. 35) reported that the Cardiff Coal in places rests on top of the No. 2 Coal. On the other hand, the ecological conditions in a coal swamp forest growing in a narrow channel-like depression must have been somewhat different from conditions in a more shallow, wide depression. Therefore, the differences in spore content that exist between the Cardiff and more typical Lowell Coal may be more of a reflection of the differences in environment rather than in geologic age.

Differentiation of Lowell and Equivalents

The spore assemblages of the Lowell Coal, Shawneetown Coal, and Coal IV of Indiana resemble that of the No. 2 Coal more closely than that of any other coal, but they can be distinguished by spore analysis. Generally the Lowell has a lower percentage of *Lycospora* than the No. 2. Except in the Cardiff Coal, *Crassispora* and *Florinites antiquus* have never been found to exceed 4 percent and 1.7 percent, respectively, whereas in the No. 2 Coal, they almost always exceed that amount.

Schopfites and *Apiculatisporis lappites* are less frequently encountered in the No. 2 Coal than in the Lowell. Although the abundance of these two taxa in the Lowell Coal is not reflected in the relative percentage because of their scarcity compared with other taxa, the number of specimens per slide counted in a Lowell maceration may be 4 or 5 times the number on a slide of the No. 2 Coal maceration.

Pustulatisporites crenatus, *Punctatisporites vermiculatus*, and *Cadiospora* have not been found in the Lowell, but they occur in the No. 2 Coal. *Verrucosisporites sifati*, *Distortisporites*, and *Murospora* are easily identified spores that are recorded from the Lowell but not from the No. 2 Coal.

Summum (No. 4) Coal Member

The first reference in the literature to the No. 4 Coal in Illinois was that of Lesquereux (1866, p. 213) when he described the section of Pennsylvanian strata near

Shawneetown, Illinois. A coal occurring in the Summum Cyclothem near Peoria in Fulton County was called the No. 4 by Wanless (1931, p. 182, 192). He pointed out that his No. 4 Coal was not the same as Worthen's (1870) coal No. 4 of northwestern Illinois, which is actually equivalent to the Springfield (No. 5) Coal. In 1939, Wanless correlated the No. 4 Coal with the Houchin Creek Coal (IVa) of western Indiana, Upper Well (No. 8b) and Goshen Coals of western Kentucky, Mulky Coal of Missouri, and Fort Scott Coal of Kansas and Oklahoma. The exposure in sec. 3, T. 4 N., R. 2 E., Fulton County, was proposed by Wanless (1956, p. 10) as the type locality of the Summum Coal, and he later (1957, p. 204) described the stratigraphic section in detail. (The township number, however, should have been 3 N. instead of 4 N.) The rocks of the type section have since been destroyed by strip mine operations, but a sample of the coal that had been collected there about 20 years ago was macerated for this study. Apparently it had weathered in the outcrop, and it failed to yield any spores.

A proposed alternate type section of the Summum (No. 4) Coal and Summum Cyclothem is about one-third of a mile west of Morning Star School along a tributary of Big Creek in SW¼ NE¼ SE¼ sec. 35, T. 6 N., R. 3 E., Fulton County. Macerated residues (macerations 1405-A, 1405-B, and 1405-C, sample site 2) of the No. 4 Coal, which is 52 inches thick, contains well preserved spores. Another exposure of the No. 4 Coal in a roadcut, near Kerton Creek in the center NE¼ sec. 15, T. 3 N., R. 2 E., Fulton County (sample site 3) also was sampled for spore analysis. The bottom 18-inch thick bench (maceration 1406-A) contained rather well preserved spores, but the upper 45 inches of coal was too badly weathered to be of any value.

In the Wilmington area of western Kankakee County and eastern Grundy County, a coal generally 65 to 85 feet above the No. 2 Coal has been extensively strip mined. At sample site 53 it is only about 40 feet above the No. 2. The identification and stratigraphic relations of this coal have been in doubt for some time because diagnostic strata above the coal have been removed by erosion and because the thick glacial drift prevents good exposures. Bradley (1870, p. 194), in discussing the Pennsylvanian strata of Grundy County, stated that the outcrops are so scattered and the beds so discontinuous that he was unable to depict the stratigraphy in a general geologic section. However, he did identify as "Coal No. 4" of the Illinois Valley section a coal at an old mine in sec. 20, T. 33 N., R. 7 E., which is about 10 miles northwest of present strip mining activity. The coal was called the Sparland (No. 7) Coal by Cady (1915, p. 34), but later Cady and others (1952, p. 5) tentatively correlated it with the Summum (No. 4) Coal. As a result of the present investigation, the coal is correlated by means of spores with the No. 4 Coal.

Kosanke (1950, p. 72-73) reported on the small spore genera and species from two samples of the No. 4 Coal from Fulton and Jersey Counties. Guennel (1952, p. 28) studied the spore genera in two samples of the Houchin Creek Coal (IVa) from Parke and Greene Counties, Indiana. In this investigation, 30 macerations from 15 sample localities were analyzed. The most diverse miospore flora, which includes 80 species, occurs in the coal (macerations 1249-A, 1249-B, and 1249-C) that was sampled at site 51. The spore genera and species observed in the No. 4 Coal are recorded in the following list.

*Leiotriletes adnatoides**
L. levis
*L. notatus**
*Punctatisporites aerarius**
P. decorus
P. cf. *gracilirugosus*
P. kankakeensis
P. minutus
P. nahannensis
P. obliquus
P. orbicularis
P. cf. *pseudolevatus*
P. vermiculatus
P. sp. 1
Calamospora breviradiata
C. flava
C. hartungiana

* Found only east of the Ancona-Garfield structure.

C. minuta
C. mutabilis
*C. pedata**
C. straminea
Elaterites triferens
Granulatisporites granularis
*G. pallidus**
G. pannosites
G. cf. *parvus*
Cyclogranisporites breviradiatus
C. micaceus
C. microgranus
C. staplini
Converrucosisporites subverrucosus
Verrucosisporites microtuberosus
*V. papulosus**
V. cf. *papulosus**
V. sifati
Schopfites colchesterensis
S. dimorphus
S. cf. *dimorphus*
*Distortisporites illinoiensis**
Kewaneesporites reticuloides
Lophotriletes commissuralis
L. cf. *granoornatus*
L. pseudaculeatus
L. rarispinosus
Anapiculatisporites spinosus
Apiculatisporis abditus
A. lappites
A. setulosus
Acanthotriletes dimorphus
Raistrickia crinita
R. crocea
R. cf. *fibrata*
R. grovensis
R. irregularis
R. subcrinita
Spackmanites cf. *facierugosus*
Maculatasporites punctatus
Microreticulatisporites sulcatus
*Dictyotriletes densoreticulatus**
D. distortus
D. cf. *falsus**
D. cf. *reticulocingulum*
Reticulatisporites reticulatus
R. sp. 1
Camptotriletes triangularis
Vestispora colchesterensis
V. fenestrata
V. foveata
V. laevigata
Triquitrites additus
T. cf. *additus**
T. bransonii
T. crassus
T. desperatus
*T. dividuus**
T. exiguus
T. minutus
T. protensus
T. pulvinatus
T. spinosus
T. subspinosus
T. trigonappendix
T. truncatus
T. sp. 1
Mooreisporites inusitatus
Crassispora plicata
Lycospora brevijuga
L. granulata
L. punctata
L. subjuga
Cadiospora fithiana
C. magna
Cirratriradites annulatus
C. annuliformis
*Reinschospora triangularis**
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. punctatus
L. vulgaris
Thymospora pseudothiessenii
Torispora securis
Wilsonites delicatus
W. vesicatus
Perotriletes parvigracilus
Hymenospora multirugosa
H. paucirugosa
Endosporites globiformis
E. plicatus
Paleospora fragila
Florinites antiquus
F. grandis
F. millotti
F. similis
F. visendus
Vesicaspora wilsonii
Kosankeisporites elegans
Complexisporites chalonerii
*Alatisporites trialatus**
Trihyphaecites triangulatus

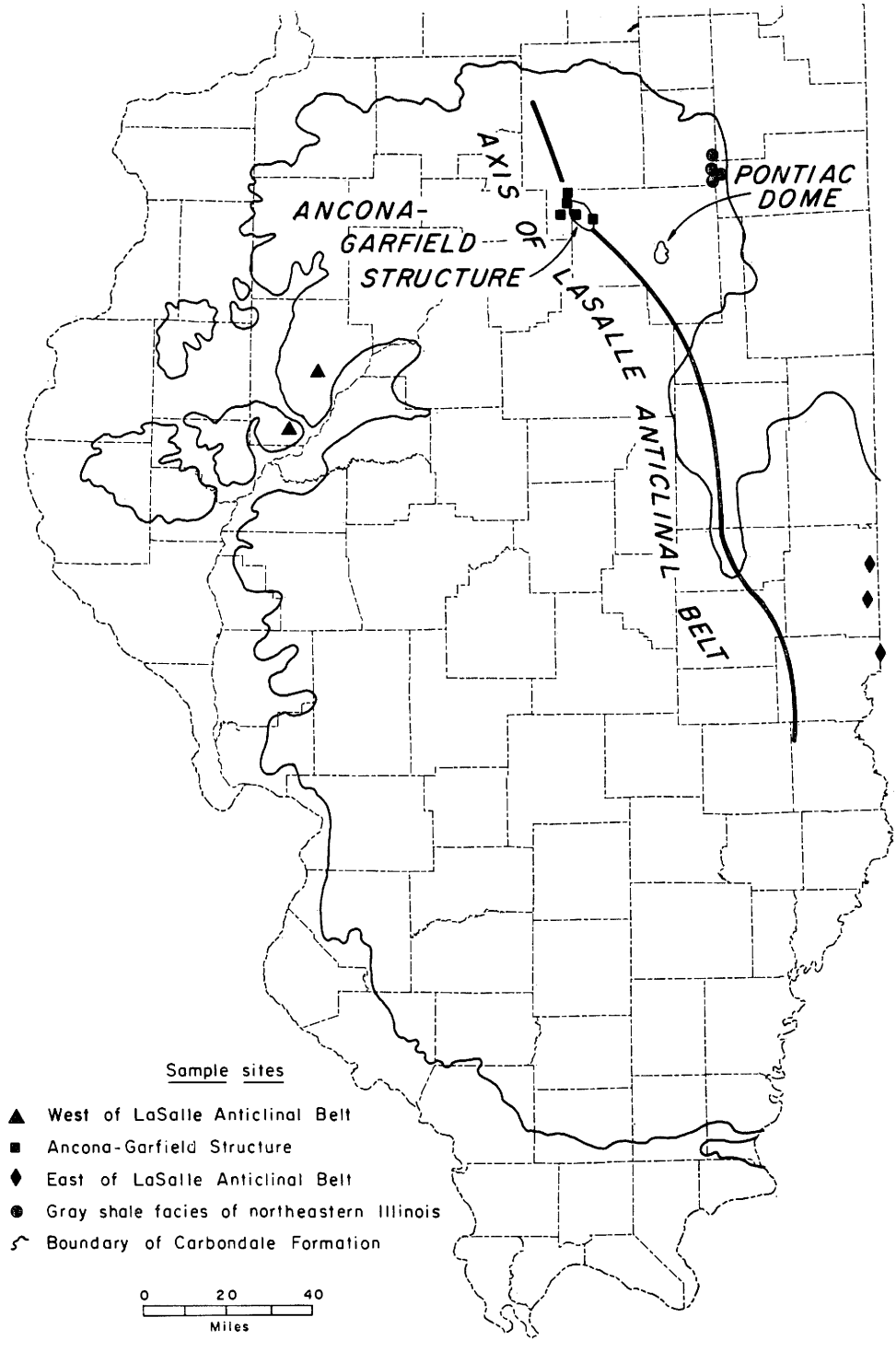
Species occurring in the No. 4 Coal listed by Kosanke (1950) but not observed in my macerations are given below.

Granulatisporites convexus
G. verrucosus
Punctatisporites verrucifer
Laevigatosporites minimus

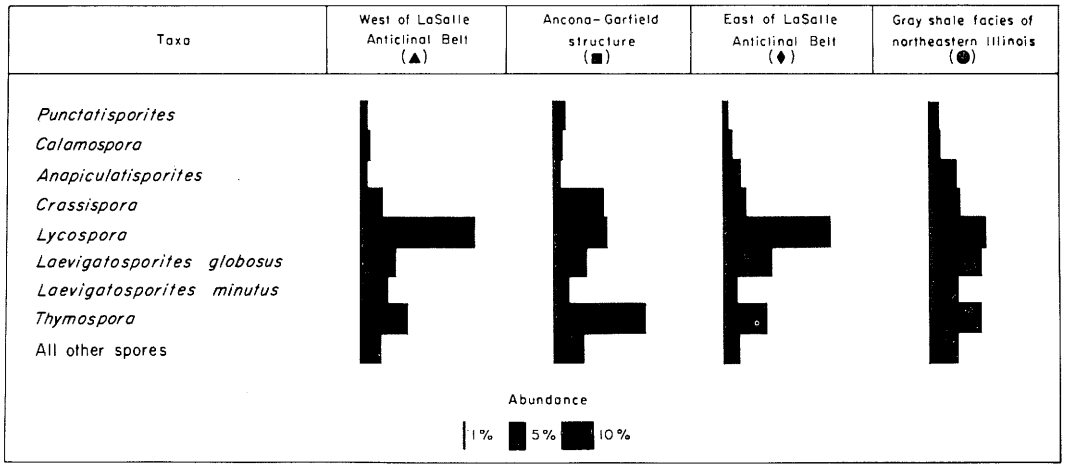
Spore Distribution and Major Structures

Some minor variations in the occurrence and relative abundance of taxa were found in the spore assemblages as the No. 4 Coal was traced onto the Ancona-Garfield structure (text figs. 8 and 9) and to the north-

* Found only east of the Ancona-Garfield structure.



Text Fig. 8 — Sites from which the Summum (No. 4) Coal was sampled and major structures related to spore distribution. Major spore taxa are shown in text figure 9.



Text Fig. 9 — Relative abundance of small spore taxa in the Summum (No. 4) Coal. Symbols in headings refer to sample sites in figure 8.

eastern part of the study area where the coal is overlain by gray shale rather than the typical black shale. With the exception of these two areas, *Lycospora* is the dominant genus, constituting 27 to 47.7 percent of the spore population, and *Laevigatosporites* is subdominant with 12 to 34 percent. Maceration 1406-A represents only the bottom 18 inches of a 63-inch thick section of the No. 4 Coal and appears to be equivalent to the lower bench of the nearest complete column sample (macerations 1405-A, 1405-B, and 1405-C).

Laevigatosporites minutus is the most abundant species of the genus west of the LaSalle Anticlinal Belt and is most abundant in the bottom bench of coal. *L. globosus* is the best represented species of the genus east of the LaSalle Anticline except in maceration 880-A (sample site 39) where *Thymospora* is more abundant than *Laevigatosporites*. *Thymospora*, which averages 16.2 to 24.4 percent of the assemblage, and *Crassispora*, which varies from 3.8 to 20.1 percent, rank third and fourth in abundance. The delicate nature of the spore coat of *Crassispora* and differences in degree of preservation might help explain the considerable variation in its abundance. *Anapiculatisporites spinosus* (2.7 to 9.8 percent), an easily recognizable and stratigraphically useful spore, in most areas has its greatest frequency at the top or middle bench of the coal. Other genera rather well represented include *Calamospora* (0.7 to 6.5 percent), *Punctatisporites* (0.4 to 4.2 percent), *Vesicaspora* (less than 1 to 3.3 percent), *Triquitrites* (0.2 to 1.7 percent), and *Florinites* (0.2 to 1.1 percent). *Alatisporites* and *Reinschospora* have been found in the No. 4 Coal only east of the Ancona-Garfield structure regardless of whether they are directly overlain by black or by gray shale facies. *Anapiculatisporites spinosus* is more abundant to the east of the LaSalle Anticlinal Belt. Here, too, were observed most of the specimens of *Reticulatisporites* and *Dictyotriletes*.

The spore assemblages from the No. 4 Coal (macerations 1230-A, 1230-B, 1276-A, 1279-A, 1279-B, 1395-A, 1395-B, 1234-B through 1234-F, 1396-A, and 1396-B) in the region of the Ancona-Garfield structure (sample sites 20, 17, 19, 16, 21, and 14) are generally rather poorly preserved. Maceration 1276-A includes only the top 10.5 inches of a bony coal 21.5 inches thick. In the Ancona-Garfield area, *Thymospora pseudothiessenii* ranks first in spore frequency with 24.5 to 42.8 percent, followed by *Lycospora* (12.4 to 22 percent) and *Laevigatosporites* (15.2 to 22.9 percent), which are about equally represented. *Crassispora plicata*, which is most numerous toward the bottom of the coal, accounts for 14 to 21.0 percent of the

spore flora. *Laevigatosporites minutus* usually decreases in abundance toward the top of the coal, whereas *L. globosus* and *Thymospora pseudothiessenii* increase toward the top. Macerations 1396-A and 1396-B that are from a coal only 11 inches thick at the edge of the Ancona-Garfield structure probably represent only the early part of coal deposition because *Laevigatosporites minutus* (17.7 percent), which occurs mostly in the lower part of the coal, is dominant over *L. globosus* (6.3 percent), and *Thymospora pseudothiessenii* is less frequently encountered (4.5 percent) than is usually the case. Most of the remainder of the spore assemblage in the region of the Ancona-Garfield structure is made up of *Punctatisporites* (1.3 to 7.3 percent), *Calamospora* (0.7 to 7.3 percent), *Triquitrites* (1.8 to 2 percent), and *Vesicaspora* (0.6 to 2 percent).

In southeastern Grundy County and western Kankakee County, the No. 4 Coal (macerations 954-Aa, 954-Ab, 954-Ac, 1133-B1, 1133-B2, 1133-B3, 1249-A, 1249-B, and 1249-C, sample sites 54, 53, and 51) is directly overlain by marine gray shale facies. *Laevigatosporites* is the most frequently encountered genus (27.8 to 38.5 percent), followed by *Lycospora* (17.2 to 21.3 percent) or *Thymospora* (24.9 percent). *Laevigatosporites globosus* (15.4 to 27 percent) increases, whereas *L. minutus* (3.2 to 17 percent) decreases in numerical importance toward the top of the coal, and *Lycospora* becomes most abundant in the middle bench of coal. *Anapiculatisporites spinosus* is an important component, contributing 6.6 to 13.9 percent to the spore population. Other spore taxa of decreasing abundance are *Punctatisporites* (0.2 to 4.4 percent), *Calamospora* (2.7 to 3.9 percent), *Vesicaspora* (1.8 to 2.8 percent), *Triquitrites* (0.8 to 2.4 percent), and *Granulatisporites* (0.7 to 2.4 percent).

Differentiation of No. 4 Coal

The No. 4 Coal can be readily differentiated from the Lowell Coal below by spore analysis. *Thymospora pseudothiessenii, Anapiculatisporites spinosus*, and *Crassispora plicata* are more abundant in the No. 4 than in the Lowell Coal. *Laevigatosporites minutus, Schopfites*, and *Apiculatisporis lappites* are more common in the Lowell than in No. 4 Coal. *Kosankeisporites, Complexisporites*, and *Cadiospora* have not been found in the Lowell Coal, but are present in No. 4 Coal. *Lophotriletes* cf. *granoornatus*, present in the No. 4 Coal, was not found in the Lowell Coal but occurs in the Cardiff Coal, which may not be synchronous in deposition with the Lowell. *Kewaneesporites* is found in the No. 4 Coal, but not in the Lowell except in the two thin coals (macerations 1133-A and 954-B) in the "multiple seam area" tentatively correlated with the Lowell. As mentioned in the discussion of the Lowell Coal, the palynology of these two coals seems to indicate an age more or less intermediate to the Lowell and No. 4 Coals.

A large number of species that have been observed in the Lowell are apparently absent from the No. 4 Coal. These include *Verrucosisporites donarii, Reticulatisporites lacunosus, Punctatisporites edgarensis, Cyclogranisporites aureus, C.* cf. *aureus, Lophotriletes mosaicus, Murospora kosankei, Tuberculatosporites robustus, Triquitrites sculptilis, Lycospora paulula, Raistrickia carbondalensis, R. dispar, R. lacerata, R. lowellensis, R. pilosa, R. solaria*, and *Savitrisporites*. No densospores have been found in any coal in Illinois above the Lowell Coal.

Unnamed Coal of Indiana

At sample site 29 in Vigo County, Indiana, an unnamed coal (macerations 1509-K, 1509-L, and 1509-M) 27 inches thick was found in a diamond drill core 14 feet 5 inches above the Houchin Creek Coal (IVa) (macerations 1509-H, 1509-I, and 1509-J) and 27 feet 3 inches below the Springfield Coal (V). The coal is overlain by 16 feet of claystone and underlain by gray shale. Unlike most Pennsylvanian coals, this coal has no underclay. Another coal in a similar stratigraphic position was encountered in several other diamond drill holes in Vigo County, but it is not known to occur in Illinois. The unnamed coal,

which was sampled from only one locality, was found to contain the following species.

Leiotriletes adnatoides
L. levis
L. notatus
Punctatisporites decorus
P. minutus
P. orbicularis
Calamospora breviradiata
C. flava
C. hartungiana
C. mutabilis
C. straminea
Granulatisporites granularis
G. cf. *parvus*
Cyclogranisporites breviradiatus
C. microgranus
C. staplini
Verrucosisporites microtuberosus
V. verrucosus
Schopfites colchesterensis
S. dimorphus
Lophotriletes commissuralis
L. pseudaculeatus
L. rarispinosus
Anapiculatisporites spinosus
Apiculatisporis abditus
A. lappites
A. setulosus
Raistrickia breveminens
R. carbondalensis
R. crinita
R. crocea
R. lowellensis
R. subcrinita
Spackmanites cf. *facierugosus*
Microreticulatisporites sulcatus
Reticulatisporites reticulatus
Knoxisporites rotatus
Vestispora fenestrata
V. foveata
V. laevigata
Triquitrites cf. *additus*
T. bransonii
T. exiguus
T. minutus
T. protensus
T. spinosus
T. subspinosus
Mooreisporites inusitatus
Crassispora plicata
Lycospora granulata
L. punctata
L. subjuga
Cirratriradites annulatus
C. annuliformis
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. vulgaris
Thymospora pseudothiessenii
Torispora securis
Wilsonites vesicatus
Endosporites globiformis
E. plicatus
Paleospora fragila
Florinites antiquus
F. millotti
F. similis
Vesicaspora wilsonii
Complexisporites chalonerii

Lycospora (38.7 percent), *Laevigatosporites* (31.6 percent), and *Thymospora* (10.3 percent) rank first, second, and third in spore abundance. About equally represented with 14.4 percent and 12.6 percent, respectively, are *Laevigatosporites globosus*, which decreases in frequency toward the top of the coal, and *L. minutus*, which increases toward the top. *Lycospora* also shows an increase toward the top of the coal. *Calamospora* (5 percent), *Punctatisporites* (4.7 percent), *Crassispora* (3.4 percent), *Endosporites* (2.2 percent), and *Triquitrites* (1.2 percent) account for most of the remaining spores in the microfossil assemblage.

As the unnamed coal was sampled from only one locality, the criteria for distinguishing it palynologically from the underlying and overlying coals are not well established. However, some tentative conclusions are offered. The spore assemblage in the unnamed coal is very similar to that of the older Summum (No. 4) Coal. *Crassispora plicata*, *Anapiculatisporites spinosus*, and *Thymospora pseudothiessenii* are more common in the No. 4 Coal than in the unnamed coal. *Endosporites* is apparently better represented in the unnamed coal. *Raistrickia carbondalensis* and *R. lowellensis*, which appear in the unnamed coal, are absent in the No. 4 Coal. No specimens of *Hymenospora* have been found in the unnamed coal.

The unnamed coal differs from the Springfield (No. 5) Coal of Illinois by the greater abundance of *Crassispora plicata*, *Anapiculatisporites spinosus*, and *Thymospora pseudothiessenii* in the latter. *Laevigatosporites minutus* and *Endosporites* are not as frequently encountered in the No. 5

Coal as in the unnamed coal. *Reinschospora*, *Cadiospora*, *Alatisporites*, *Hymenospora*, and *Trihyphaecites*, which were all identified from the No. 5 Coal, have not been observed in the unnamed coal. *Reticulatisporites reticulatus*, *Raistrickia carbondalensis*, *R. lowellensis*, *Florinites millotti*, and *Complexisporites chalonerii* have been found in the unnamed coal but are apparently absent from the No. 5 Coal.

Springfield (No. 5) Coal Member

The Springfield (No. 5) Coal, called Harrisburg (No. 5) Coal in southern Illinois, is one of the most widespread coals and has been extensively mined in the central part of the Springfield area, and in the southern and western parts of the Illinois Basin. Worthen (1866, p. 53) was the first to use the designation No. 5 for this coal, and in 1883 he called it the Springfield Coal for the underground mines near Springfield, Illinois. At that early date, there were already seven coal mines in this coal within a few miles of Springfield. Exposures in coal mines in that vicinity were later designated the type area by Wanless (1956, p. 10).

The Springfield (No. 5) Coal has long been correlated with the Harrisburg (No. 5) Coal of southern Illinois, which had been named by Shaw and Savage (1912, p. 7). Cady (1916, p. 21) correlated it with the No. 9 Coal of western Kentucky, the Petersburg or Alum Cave (No. V) Coal (now called Springfield Coal (V)) of Indiana, the Summit Coal of Missouri, and the coal between the Upper and Lower Fort Scott Limestone of Kansas. Its exact equivalent in the Appalachian Coal Field had not been determined at that time. Moore et al. (1944, p. 657-706) correlated the Middle Kittanning Coal of Ohio and Pennsylvania with the No. 6 Coal of Illinois. Data obtained from the palynological investigation of the Middle Kittanning Coal by Gray (1967) and on the No. 5 and No. 6 Coals indicate that the Middle Kittanning is palynologically more similar to the No. 5 Coal than it is to the No. 6 Coal of Illinois. However, it is recognized that a considerable distance from one sedimentary basin to another is involved.

Correlation of the Springfield (No. 5) and Harrisburg (No. 5) Coals was carried out by Brokaw (1942), who was the first to investigate their small spore content. The correlation was corroborated by Kosanke (1950, p. 73-74) in his study of the spores of additional coal samples. Guennel (1952, p. 28) reported on the spore genera of the Springfield Coal (V) of Indiana from eight sample localities in Indiana. In the present investigation, 21 bench samples from nine localities were examined in detail for their spore content. The most diverse spore flora occurs in macerations 722 and 1404, from which 64 taxa were identified. Maceration 726a, which was prepared from only the top half of a coal 25.5 inches thick, was the only portion of that coal analyzed because the spores in the maceration of the bottom half of the coal were too poorly preserved to be considered.

The following species of microfossils were observed in the Springfield (No. 5) Coal.

Leiotriletes adnatoides
L. cf. *atshanensis*
L. levis
Punctatisporites aerarius
P. curviradiatus
P. decorus
P. edgarensis
P. minutus
P. nahannensis
P. obliquus
P. orbicularis
P. vermicularis
Calamospora breviradiata
C. hartungiana
C. minuta
C. mutabilis
C. pedata
C. straminea
Elaterites triferens
Granulatisporites granularis
G. livingstonensis
G. pannosites
G. cf. *parvus*
Cyclogranisporites breviradiatus
C. microgranis
C. staplini
Verrucosisporites donarii
Schopfites colchesterensis

S. dimorphus
Distortisporites illinoiensis
Kewaneesporites reticuloides
Anapiculatisporites spinosus
Apiculatisporis abditus
A. lappites
A. setulosus
Acanthotriletes dimorphus
Raistrickia crinita
R. crocea
R. irregularis
R. subcrinita
Spackmanites cf. *facierugosus*
Maculatasporites punctatus
Microreticulatisporites lunatus
M. sulcatus
Reticulatisporites lacunosus
Vestispora fenestrata
V. foveata
V. laevigata
Triquitrites additus
T. cf. *additus*
T. bransonii
T. crassus
T. exiguus
T. minutus
T. protensus
T. pulvinatus
T. cf. *sculptilis*
T. spinosus
Mooreisporites inusitatus
Crassispora plicata
Lycospora brevijuga
L. granulata
L. punctata
L. subjuga
Cadiospora fithiana
Cirratriradites annulatus
C. annuliformis
Reinschospora triangularis
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. punctatus
L. vulgaris
Thymospora pseudothiessenii
Torispora securis
Wilsonites delicatus
W. vesicatus
Hymenospora paucirugosa
Endosporites globiformis
E. plicatus
Paleospora fragila
Florinites antiquus
F. similis
Vesicaspora wilsonii
Alatisporites hexalatus
A. punctatus
A. trialatus
Trihyphaecites triangulatus

Additional species were recorded from the No. 5 Coal by Kosanke (1950), but not observed during this study.

Granulatisporites convexus
Punctatisporites verrucifer
Calamospora flexilis
Laevigatosporites minimus
Alatisporites inflatus
A. varius

Statistical analysis of the spore assemblages indicates that since several genera are of approximately equal frequency, the genus that is dominant varies among *Laevigatosporites*, *Lycospora*, and *Thymospora* from one locality to another. *Thymospora* is the most abundant in three macerations (726Aa, 982B, 1234, and 1392) and has a range of 15.9 to 41 percent. *Laevigatosporites* is most common in three sets of macerations (722-A, 722-B, 722-C, 1404-V, 1404-W, 1404-X, 1408-A, 1408-B, and 1408-C) and ranges from 10.7 to 28.3 percent. *L. globosus* (4.7 to 24.8 percent), which usually increases in prominence toward the top of the coal, is the most abundant species of *Laevigatosporites*. The combined total of all the monolete spores (*Thymospora* and *Laevigatosporites*) averages about 40 percent and ranges from 37.7 to 47.7 percent of the spore assemblage, not including maceration 726Aa, which is only the top half of the coal. *Lycospora* is the major genus at two sample localities (macerations 630, 879, and 880) and varies from 11 to 32.9 percent of the small spore assemblage. *Crassispora plicata* and *Anapiculatisporites spinosus* are important components of the spore flora and account for 9.5 to 21 percent and 1.8 to 13.3 percent, respectively. Most of the rest of the spore assemblage is made up of *Punctatisporites* (1.9 to 8.3 percent), *Calamospora* (1.3 to 3.8 percent), and *Vesicaspora* (0.3 to 2.8 percent). Kosanke (1950, p. 73) found that *Laevigatosporites* (which included *Thymospora* at that time) was the dominant genus in his samples, 45 to 50 percent of the spores being assigned to that genus. Guennel (1952, p. 28) found a slightly higher frequency (62.3 percent) for the genus in the Springfield Coal (V) of Indiana.

Palynological differentiation of the No. 5 and No. 4 Coals is rather difficult. The relative abundance of spore taxa in the two coals is too similar to be of much value in differentiation. *Alatisporites* and *Reinschospora*, which are fairly commonly found but not abundant in the No. 5 Coal, have been found in the No. 4 Coal only east of the Ancona-Garfield structure. The single species *Alatisporites trialatus* is the only species of *Alatisporites* thus far observed in the No. 4 Coal, whereas *A. punctatus*, *A. hexalatus*, and *A. trialatus* occur frequently in the No. 5 Coal. No specimens assignable to *Dictyotriletes* and only one specimen of *Reticulatisporites*, *R. lacunosus*, were recorded from the No. 5 Coal. *Reticulatisporites* and *Dictyotriletes* were found rather consistently in the No. 4 Coal east of the Ancona-Garfield structure but no specimen was identified as *R. lacunosus*. Although rare in number, several species of *Verrucosisporites* are present in the No. 4 Coal, but only *V. donarii*, which is apparently absent from the No. 4 Coal, has been found in the No. 5 Coal.

Taxa present in the No. 4 Coal but absent from the No. 5 Coal are *Lophotriletes*, *Complexisporites*, *Kosankeisporites*, *Dictyotriletes*, *Hymenospora multirugosa*, *Florinites visendus*, *Raistrickia* cf. *fibrata*, and *Schopfites* cf. *dimorphus*.

Briar Hill (No. 5A) Coal Member

The name Briar Hill Coal was introduced by Glenn (1912, p. 38) who stated that the No. 10 Coal of Union County, Kentucky, is known as the Briar Hill Coal. Cady (1916, p. 45) mentioned a thin coal appearing between the No. 5 and No. 6 Coals in drill holes in Williamson and Saline County. He later (1919, p. 20, 79) listed it as the No. 5A Coal and concluded that it is probably the same coal as the Briar Hill Coal of Kentucky. The type area of the Briar Hill (No. 5A) Coal was designated by Wanless (1956, p. 10) as T. 9 N., R. 7 E., Saline County, but should have read T. 9 S.

The small spores of the No. 5A Coal from Gallatin and Franklin Counties were studied by Kosanke (1950, p. 74).

The Briar Hill (No. 5A) Coal Member was not encountered in the northeastern portion of the Illinois Basin, but macerations of a lower, middle, and upper bench (macerations 1378-P, 1378-Q, and 1378-R) of the No. 5A Coal from a core in Gallatin County were studied for the purposes of comparison and continuity. The spores recorded from those macerations are given below.

Punctatisporites minutus
P. obliquus
Calamospora breviradiata
C. hartungiana
Elaterites triferens
Granulatisporites granularis
Cyclogranisporites staplini
Schopfites dimorphus
Raistrickia crinita
R. crocea
R. irregularis
R. subcrinita
Microreticulatisporites sulcatus
Vestispora fenestrata
Triquitrites bransonii
T. pulvinatus
T. spinosus
Mooreisporites inusitatus
Crassispora plicata
Lycospora brevijuga
L. granulata
L. punctata
Cirratriradites annuliformis
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. vulgaris
Thymospora pseudothiessenii
Torispora securis
Hymenospora paucirugosa
Endosporites globiformis
Paleospora fragila
Florinites antiquus
Vesicaspora wilsonii

Kosanke discovered the following species in his samples of the No. 5A Coal that are not listed above.

Punctatisporites verrucifer
Raistrickia protensa

Lycospora and *Thymospora pseudothiessenii* rank first and second in abundance in maceration 1378 with 58 percent and 26.6 percent, respectively. *Lycospora* increases in dominance toward the

top of the coal at the expense of *Thymospora*. *Crassispora plicata* (4.9 percent), *Laevigatosporites minutus* (3.9 percent), *Calamospora breviradiata* (2.1 percent), *Vesicaspora wilsonii* (1.8 percent), *Punctatisporites minutus* (1.6 percent), and *Laevigatosporites globosus* (1.4 percent) account for most of the remaining spore population.

The No. 5A Coal is readily distinguished from the No. 5 Coal on the basis of its spore content. Because of the small number of samples of the No. 5A Coal examined, some spore taxa presently regarded as absent may turn up as additional macerations are studied. The No. 5A Coal has a higher percentage of *Lycospora* and a lower percentage of *Laevigatosporites*, especially *L. globosus*, than does the No. 5 Coal. *Crassispora plicata* also is not as abundant in the No. 5A Coal. Among the taxa present in the No. 5 Coal, but absent from the No. 5A Coal are *Cadiospora*, *Wilsonites*, *Reinschospora*, *Alatisporites*, *Apiculatisporis*, *Anapiculatisporites*, *Verrucosisporites*, *Cirratriradites annulatus*, *Lycospora subjuga*, *Triquitrites additus*, and *T.* cf. *additus*. In the No. 5A Coal, the only species of *Calamospora* recorded are *C. breviradiata* and *C. hartungiana*. *Granulatisporites granularis* is the only species that represents the genus in the No. 5A Coal.

Spring Lake Coal Member

A coal designated as unit 43, 11 to 17 feet below the No. 6 Coal, was described by Willman and Payne (1942, p. 130, 295) from outcrops along the Vermilion River and its tributaries in LaSalle and Livingston Counties. They found that the coal reached a maximum thickness of 2 feet 6 inches near the north end of Eagle Creek in the SE¼ SE¼ sec. 22, T. 31 N., R. 3 E., LaSalle County, where it was strip mined. Cady (1948, p. 5) called unit 43 of Willman and Payne (1942) the Spring Lake Coal, named from Spring Lake 1 mile west of Streator. The name Spring Lake Coal, which has not been used since its introduction, is adopted here, and geologic section 20 (outcrop on east bank of the Vermilion River at greenhouse, SE¼ SW¼ SW¼ sec. 23, T. 31 N., R. 3 E.) described by Willman and Payne (1942, p. 295) is designated the type section.

Two diamond drill core samples of the Spring Lake Coal from the region of the Ancona Dome have been macerated and studied for their spore content. At sample site 15, sec. 15, T. 30 N., R. 2 E., the coal (maceration 1275-AA) is 8 inches thick and 38 feet above the No. 4 Coal, and at sample site 21, sec. 34, T. 30 N., R. 3 E., the coal (maceration 1234-A) is 3½ inches thick and about 51 feet above the No. 4 Coal. The No. 6 Coal is not present in either of the cores. The following genera and species of spores, which are well preserved, were identified from the Spring Lake Coal.

Punctatisporites minutus
P. obliquus
Calamospora breviradiata
C. hartungiana
Granulatisporites pallidus
Cyclogranisporites breviradiatus
C. staplini
Lophotriletes commissuralis
L. copiosus
Apiculatisporis abditus
Raistrickia crinita
R. subcrinita
Spackmanites cf. *facierugosus*
Microreticulatisporites sulcatus
Camptotriletes bucculentus
Vestispora fenestrata
V. foveata
Triquitrites exiguus
Mooreisporites inusitatus
Crassispora plicata
Lycospora brevijuga
L. granulata
L. punctata
L. subjuga
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. vulgaris
Thymospora pseudothiessenii
Wilsonites delicatus
W. vesicatus
Endosporites globiformis
Florinites antiquus
F. grandis
F. visendus

The spore assemblages of the Spring Lake Coal are characterized by a preponderance of *Lycospora* that amounts to about 79 percent of the spore population. *Wilsonites* and *Crassispora* are about equally well represented, and each account for about 5 percent. *Laevigatosporites* with 3.7 percent ranks third in importance.

The Spring Lake Coal is distinguished from the No. 5A Coal below by its higher frequency of *Thymospora pseudothiessenii*, *Lycospora,* and *Laevigatosporites*. *Wilsonites*, which is rather common in the Spring Lake Coal, is absent in the No. 5A Coal. Only one species of *Triquitrites* — *T. exiguus* — was found in the Spring Lake Coal. Taxa appearing in the No. 5A Coal but absent in the Spring Lake Coal include *Schopfites*, *Cirratriradites*, *Hymenospora*, *Paleospora fragila*, and *Vesicaspora wilsonii.*

The Spring Lake differs palynologically from the No. 6 Coal above by the large number of genera and species not observed in the Spring Lake but present in the No. 6 Coal. These include *Leiotriletes*, *Murospora*, *Cirratriradites*, *Anapiculatisporites*, *Verrucosisporites*, *Vesicaspora wilsonii*, *Lophotriletes* cf. *granoornatus*, *Granulatisporites granularis*, *G.* cf. *parvus*, *Lycospora paulula*, and *Paleospora fragila.*

Herrin (No. 6) Coal Member

The Herrin (No. 6) Coal Member is the most extensively mined coal in Illinois. The No. 6 Coal was among the coals Lesquereux (1866, p. 213) numbered in presenting the section of Pennsylvanian strata near Shawneetown, Illinois. Worthen (1870, p. 93) described a coal that he called the No. 6 in his report of the geology of Fulton County. The No. 6 Coal of the Murphysboro-Herrin area of southern Illinois was formally named the Herrin Coal (No. 6) by Shaw and Savage (1912, p. 6), and the type sections were designated as being in the mines in the vicinity of Herrin.

The No. 6 Coal of Illinois has been correlated with the No. 11 Coal of Kentucky, the Mystic Coal of Iowa, and the Lexington Coal of Missouri (Wanless, 1939, p. 19-20). Wanless (1939) also correlated the No. 6 Coal with the Hymera Coal (VI) of Indiana, but present correlations indicate the Hymera is equivalent to the Jamestown Coal of Illinois. He also suggested that the No. 6 might be equivalent to the Middle Kittanning Coal of Ohio, but he concluded that the clay partings that occur in both coals are not reliable for correlation across such a distance. Spore analyses of the Illinois coals and the Middle Kittanning Coal (Gray, 1967) indicate that the No. 4 Coal or the No. 5 Coal, more likely the latter, may be correlative with the Middle Kittanning Coal.

Small spores of the No. 6 Coal were investigated by Kosanke (1950, p. 74-77) from Christian, Fulton, and Vermilion Counties. Guennel (1952, p. 29-30) studied the relative distribution of spore genera from six samples of the Hymera Coal (VI) of Indiana.

Sixteen macerated samples from 11 localities in the area of this report were studied. The most diverse plant microfossil flora was observed in macerations 1404-AA, 1404-BB, and 1404-CC from sample site 38, which contained at least 74 identifiable species. Maceration 982-A (sample site 36) represents only the top 9 inches of a coal 86 inches thick, and only 14.6 inches of the coal of maceration 1242 was recovered from a cored sample of the No. 6 Coal that was reported by drillers to be 37 inches thick. The spores in maceration 1242-D are so poorly preserved that no statistical count was made of that portion of the coal.

The following genera and species have been identified from the Herrin (No. 6) Coal.

Leiotriletes adnatoides
L. levis
L. notatus
L. pseudolevis
Punctatisporites aerarius
P. decorus
P. edgarensis
P. minutus

P. nahannensis
P. obliquus
P. cf. *pseudolevatus*
P. vermiculatus
Calamospora breviradiata
C. flava
C. hartungiana
C. mutabilis
C. pedata
C. straminea
Elaterites triferens
Granulatisporites granularis
G. pallidus
G. pannosites
G. cf. *parvus*
G. verrucosus
Cyclogranisporites cf. *aureus*
C. breviradiatus
C. micaceus
C. microgranus
C. staplini
Verrucosisporites donarii
V. sifati
Kewaneesporites reticuloides
Lophotriletes commissuralis
L. cf. *granoornatus*
L. mosaicus
L. rarispinosus
Anapiculatisporites spinosus
Pustulatisporites sp. 1
Apiculatisporis abditus
A. setulosus
A. sp. 1
Raistrickia cf. *aculeata*
R. aculeolata
R. breveminens
R. crinita
R. crocea
R. cf. *fibrata*
R. grovensis
R. irregularis
R. lacerata
R. lowellensis
R. pilosa
R. pontiacensis
R. subcrinita
R. superba
R. sp. 3
Spackmanites cf. *facierugosus*
Microreticulatisporites sulcatus
Vestispora fenestrata
V. foveata
V. laevigata
V. profunda
Triquitrites additus
T. cf. *additus*
T. bransonii
T. crassus
T. desperatus
T. exiguus
T. minutus
T. protensus
T. sculptilis
T. cf. *sculptilis*
T. spinosus
T. subspinosus
T. sp. 1
Mooreisporites inusitatus
Indospora stewarti
Crassispora plicata
Lycospora brevijuga
L. granulata
L. paulula
L. punctata
L. subjuga
L. torquifer
Cadiospora fithiana
Murospora kosankei
Cirratriradites annulatus
C. annuliformis
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. punctatus
L. ovalis
L. vulgaris
Thymospora pseudothiessenii
Torispora securis
Wilsonites delicatus
W. vesicatus
Perotriletes parvigracilus
Endosporites globiformis
Paleospora fragila
Florinites antiquus
F. grandis
F. millotti
F. similis
Vesicaspora wilsonii
Alatisporites trialatus

In addition to the above taxa, Kosanke (1950, p. 74-75) reported six other spores as occurring in the No. 6 Coal.

Punctatisporites triangularis
Laevigatosporites minimus
L. punctatus
Triquitrites pulvinatus
Raistrickia protensa
R. aculeolata

Lycospora, which makes up from 59.3 to 77.3 percent of the spore assemblage, is by far the most commonly occurring genus in the No. 6 Coal. *Laevigatosporites* (6.7 to 16.3 percent) ranks second in abundance at five localities (exclusive of maceration 982-A) and *Crassispora* (8 to 15.2 percent) holds that rank at four localities. *Laevigatosporites minutus* is the prominent species of *Laevigatosporites*, making up 2

to 8.7 percent of the composite spore population. *Punctatisporites* with 1.1 to 9 percent, *Calamospora* with 0.3 to 9.7 percent, and *Thymospora pseudothiessenii* with 0.3 to 6.1 percent are rather well represented in the assemblage. Kosanke and Guennel recorded a higher percentage (30 to 45 percent) of *Laevigatosporites* in the coal than I found.

The No. 6 Coal can be differentiated from the No. 5A Coal by spore analysis. The No. 5A Coal is characterized by a higher frequency of *Thymospora pseudothiessenii* than the No. 6 Coal and by the presence of *Schopfites*. Among the taxa present in the No. 6 Coal but not found in the No. 5A Coal are *Leiotriletes*, *Lophotriletes*, *Apiculatisporis*, *Anapiculatisporites*, *Verrucosisporites*, *Murospora*, *Triquitrites minutus*, *T. additus*, *T.* cf. *additus*, *Cirratriradites annulatus*, *Lycospora paulula*, and *L. subjuga*. In the No. 5A Coal, *Granulatisporites* and *Cyclogranisporites* are represented by only one species, *G. granularis* and *Cyclogranisporites staplini*, whereas several species of the two genera occur in the No. 6.

As the No. 5A Coal is not everywhere present and the No. 5 Coal is the next coal below that is persistent, it may be necessary to distinguish the No. 5 and No. 6 Coals from each other. The No. 5 Coal possesses a much greater abundance of *Laevigatosporites globosus* and *Thymospora pseudothiessenii*, whereas the No. 6 Coal contains about twice as many specimens of *Lycospora* as the No. 5 Coal. *Alatisporites* is less frequently observed in the No. 6 Coal, which contains the single species *A. trialatus*, than in the No. 5 Coal in which *A. trialatus*, *A. hexalatus*, and *A. punctatus* are found. *Anapiculatisporites spinosus* is present in significant numbers in the No. 5 Coal, but is rare in the No. 6 Coal. *Murospora* and *Lycospora paulula* are present in the No. 6 Coal but absent in the No. 5 Coal. In contrast, *Schopfites*, *Reinschospora*, *Hymenospora paucirugosa*, and *Endosporites plicatus*, which are absent in the No. 6 Coal, are found in the No. 5 Coal.

Jamestown Coal Member

The Jamestown Coal Member is a thin coal between the Brereton Limestone Member below, and the Conant Limestone Member above. The name Jamestown was applied by Bell et al. (1931, p. 3) just to the limestone overlying a coal in the vicinity of Pinckneyville and Jamestown. The type section of the Jamestown strata near the town of Jamestown in Perry County was established by Wanless (1939, p. 17, 19, 88), who applied the name Jamestown to the coal. The name of the limestone was changed by Kosanke et al. (1960, p. 35) to Conant Limestone Member, and the coal retained the name Jamestown. The Jamestown Coal is found in southern Illinois and is the same as the No. 12 Coal of western Kentucky (Wanless, 1939, p. 19) and the Hymera Coal (VI) of Indiana.

A thin coal (maceration 1447, sample site 31) sampled from a diamond drill core in southern Vermilion County, Illinois, is tentatively correlated with a coal (maceration 607, sample site 43) identified as the Jamestown Coal in Saline County. The coal of maceration 1447 is 18 inches thick and lies about 8 feet below the Danville (No. 7) Coal. This same coal is present in several other cores drilled in secs. 14, 23, and 24, T. 19 N., R. 12 W., but maceration 1447 provided the best preserved spore assemblage. In general, macerations of the Jamestown Coal yield abundant angular opaque particles, perhaps fusain, and rather poorly preserved spores. Kosanke (1950, p. 78-79) reported on the spores from several macerated samples of the Jamestown from southern Illinois, including the coal of maceration 607, which was remacerated for this report.

The following miospores have been identified from macerations 607 and 1447.

Punctatisporites minutus
P. nahannensis
P. orbicularis
Calamospora breviradiata
C. hartungiana
C. mutabilis
Elaterites triferens
Granulatisporites granularis

G. pallidus
Cyclogranisporites breviradiatus
C. minutus
Raistrickia crinita
Microreticulatisporites sulcatus
Vestispora fenestrata
Triquitrites bransonii
Mooreisporites inusitatus
Crassispora plicata
Lycospora granulata
L. punctata
Cirratriradites annulatus
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. vulgaris
Thymospora pseudothiessenii
Wilsonites vesicatus
Endosporites globiformis
Florinites antiquus
F. visendus
Vesicaspora wilsonii
Complexisporites chalonerii

Two other species were reported from the Jamestown by Kosanke (1950, p. 79).

Triquitrites spinosus
Lycospora parva

The most abundant spore genera in the Jamestown Coal are *Lycospora*, which varies from 45 to 55.7 percent, *Laevigatosporites* with 8.7 to 21.7 percent, and *Crassispora* with 13.7 to 20.7 percent. *Laevigatosporites minutus*, which accounts for 6.3 to 16 percent of the composite spore population, is numerically the most important species of *Laevigatosporites*. *Vesicaspora wilsonii* (2 to 4 percent), *Thymospora pseudothiessenii* (2 to 4 percent), *Endosporites globiformis* (0.3 to 5.3 percent), and *Punctatisporites* (0.7 to 7 percent) constitute most of the remainder of the small spore flora.

The Jamestown and underlying No. 6 Coal can be differentiated palynologically, but more samples of the Jamestown should be studied to substantiate the criteria presented here. *Lycospora* is more abundant and *Crassispora* is less abundant in the No. 6 Coal than in the Jamestown. Although *Vesicaspora wilsonii* never reaches a very high proportion in any of the Illinois coals, it is better represented in the Jamestown than in the No. 6 Coal. *Complexisporites* has been found in the Jamestown, but not in the No. 6 Coal. The Jamestown lacks a large number of spore genera and species that are normally found in the No. 6 Coal. Among these are *Leiotriletes*, *Lophotriletes*, *Apiculatisporis*, *Verrucosisporites*, *Lycospora paulula*, *L. subjuga*, *Granulatisporites* cf. *parvus*, *Triquitrites additus*, *T.* cf. *additus*, *T. minutus*, *T. sculptilis*, and all species of *Raistrickia* found in the No. 6 Coal except *R. crinita*.

Allenby Coal Member

The Allenby Coal Member is a thin coal apparently restricted to southern Illinois where it overlies by a few feet the Bankston Fork Limestone Member. The name of the coal was changed from Bankston to Allenby by Kosanke et al. (1960, p. 35). The type locality proposed by Wanless (1939, p. 14) is in the roadside east of a railroad crossing in sec. 24, T. 9 S., R. 4 E., Williamson County. He stated that it is probably equivalent to the No. 14, or Baker, Coal of western Kentucky.

The small spores from three samples of the Allenby Coal were investigated by Kosanke (1950, p. 79-80). One of these macerations (537-F, sample site 44) was re-examined for this report because of the changes made in spore taxonomy and classification since that time and in order to present as completely as possible the distribution of spores in all the coals of the Carbondale Formation. No samples of the Allenby Coal were encountered in northern Illinois. The following spores were observed in maceration 537-F.

Punctatisporites minutus
P. orbicularis
Calamospora breviradiata
C. mutabilis
C. pedata
Lophotriletes cf. *granoornatus*
Vestispora fenestrata
Triquitrites bransonii
T. protensus
T. spinosus
Crassispora plicata
Lycospora granulata
L. punctata
Cirratriradites annulatus
Laevigatosporites desmoinensis

L. minutus
L. ovalis
L. vulgaris
Thymospora pseudothiessenii
Endosporites globiformis
Florinites antiquus

The spore flora of the Allenby Coal is characterized by a profusion (up to 37.3 percent) of *Crassispora plicata*, which is second in abundance only to *Lycospora* (46.7 percent). *Laevigatosporites* accounts for 12 percent of the spore population and is made up almost entirely of *L. minutus*.

The Allenby Coal is differentiated palynologically from the underlying Jamestown Coal by its larger number of *Crassispora plicata* and smaller number of *Thymospora pseudothiessenii* and *Endosporites globiformis*. Taxa present in the Jamestown Coal but not found in the Allenby include *Granulatisporites*, *Cyclogranisporites*, *Vesicaspora wilsonii*, *Mooreisporites inusitatus*, *Microreticulatisporites sulcatus*, and *Laevigatosporites globosus*.

Danville (No. 7) Coal Member

The Danville (No. 7) Coal Member is a quite widespread and persistent coal in northern Illinois and has been mined in several places, including the vicinity of Sparland in Marshall County, but it is most extensively mined near Danville, where it attains a thickness of 4 to 7 feet. The coal thins to the west and southwest. The term No. 7 was first applied to a coal by Lesquereux (1866, p. 213), who included "coal traces No. 7" in his stratigraphic section of Shawneetown, Illinois. Worthen (1870, p. 102) mentioned Coal No. 7 in describing the geology of Fulton County, and Bradley (1870, p. 250-251) assigned the name Danville to the No. 7 Coal that was being mined near Danville, Vermilion County, Illinois. It is interesting to note that the coal was being strip mined there at that early date. The type locality of the Danville (No. 7) Coal, formerly designated by Wanless (1956, p. 11), is in E½ sec. 7, T. 19 N., R. 11 W., Vermilion County. Kosanke et al. (1960, p. 35) extended the name Danville (No. 7) Coal Member to northern and western Illinois, replacing the name Sparland (No. 7) Coal, a coal mined at Sparland in Marshall County. The name was also extended into southern Illinois to replace the name Cutler Coal, which was used by Bell et al. (1931).

Small spore genera and species of the No. 7 Coal of Vermilion County and the Cutler Coal of southern Illinois, now accepted as equivalent to the Danville (No. 7) Coal, were studied by Kosanke (1950, p. 80-82). Guennel (1952, p. 31) investigated the spore content of 14 benches of Coal VII from five localities in Indiana. In the present investigation, 28 bench samples of the No. 7 Coal from 10 sites were macerated and analyzed. The thickness of the coal sampled varies from 4 inches (maceration 924-A, sample site 35) in Douglas County to 68 inches (maceration 1356, sample site 32) in Vermilion County. The locality from which the maximum number of 66 taxa were identified is sample site 23 (macerations 1384-R through 1384-W) in Livingston County.

The spores, which are generally well preserved, found in the No. 7 Coal are listed below.

Leiotriletes cf. *atshanensis*
L. gracilis
L. levis
L. notatus
L. parvus
L. pseudolevis
Punctatisporites aerarius
P. decorus
P. minutus
P. nahannensis
P. obliquus
P. orbicularis
P. vermiculatus
Calamospora breviradiata
C. flava
C. flexilis
C. hartungiana
C. mutabilis
C. pedata
C. straminea
Elaterites triferens
Granulatisporites granularis
G. livingstonensis
G. pannosites
G. cf. *parvus*
G. sp. 1
Cyclogranisporites cf. *aureus*
C. breviradiatus

C. staplini
Verrucosisporites donarii
V. microtuberosus
V. sp. 1
Kewaneesporites reticuloides
Lophotriletes commissuralis
L. cf. *granoornatus*
L. rarispinosus
Pustulatisporites sp. 1
Apiculatisporis abditus
A. setulosus
Raistrickia cf. *aculeata*
R. aculeolata
R. breveminens
R. crinita
R. crocea
R. cf. *fibrata*
R. grovensis
R. irregularis
R. pilosa
R. subcrinita
R. sp. 2
Convolutispora fromensis
Microreticulatisporites harrisonii
M. sulcatus
Dictyotriletes danvillensis
D. densoreticulatus
Vestispora fenestrata
V. laevigata
Triquitrites additus
T. cf. *additus*
T. cf. *arculatus*
T. bransonii
T. crassus
T. dividuus
T. exiguus
T. minutus
T. protensus
T. spinosus
T. subspinosus
Crassispora plicata
Lycospora brevijuga
L. granulata
L. paulula
L. punctata
L. subjuga
L. torquifer
Cadiospora fithiana
Cirratriradites annulatus
C. annuliformis
C. tenuis
Reinschospora magnifica
R. cf. *magnifica*
R. triangularis
Balteosporites minutus
Laevigatosporites desmoinensis
L. globosus
L. medius
L. minutus
L. ovalis
L. punctatus
L. vulgaris
Tuberculatosporites robustus
Thymospora pseudothiessenii
Torispora securis
Wilsonites delicatus
W. vesicatus
Perotriletes parvigracilus
Hymenospora multirugosa
H. paucirugosa
Endosporites globiformis
E. plicatus
Paleospora fragila
Florinites antiquus
F. similis
Vesicaspora wilsonii
Kosankeisporites elegans
Complexisporites chalonerii
Alatisporites trialatus
Trihyphaecites triangulatus

Spore taxa recorded by Kosanke (1950) but not observed in my macerations are listed below.

Punctatisporites latigranifer
P. triangularis
Granulatisporites verrucosus
Lycospora parva

The dominant spore genus in the Danville (No. 7) Coal is *Lycospora*, which averages about 67 percent and has a range of 60.8 to 74.7 percent of the spore assemblage. The second most abundant genus at six localities is *Punctatisporites*, which ranges from 4.7 to 14.8 percent; second at three localities is *Crassispora*, which varies from 0.7 to 15.8 percent; and at one locality *Laevigatosporites* is second, having a range of 1.6 to 16.1 percent of the spores. Other spore taxa not uncommonly encountered in the No. 7 Coal include *Calamospora* (1.2 to 6 percent) and *Thymospora* (0.3 to 10.7 percent). *P. minutus* easily makes up the highest proportion of *Punctatisporites*. *L. minutus* constitutes the most frequent species of *Laevigatosporites*, except in macerations 1404-DD through 1404-HH (sample site 38) and 876 and 877 (sample site 39) in which *L. globosus* is the most frequently noted species. *Lycospora* generally decreases in abundance toward the top of the coal.

A unique and interesting assemblage has been found at the top of the No. 7 Coal at sample sites 38 and 39 in Edgar County. It is characterized by the presence of numerous small specimens of *Reinschospora*,

which are otherwise absent from the No. 7 Coal. Also present are several species, such as *Balteosporites minutus*, *Microreticulatisporites harrisonii*, *Dictyotriletes danvillensis*, and *Cirratriradites tenuis*, that are not found elsewhere in the No. 7 Coal. Only in these macerations does *Laevigatosporites globosus* become so abundant that it outnumbers *L. minutus*, and *Laevigatosporites* becomes the second most numerous genus.

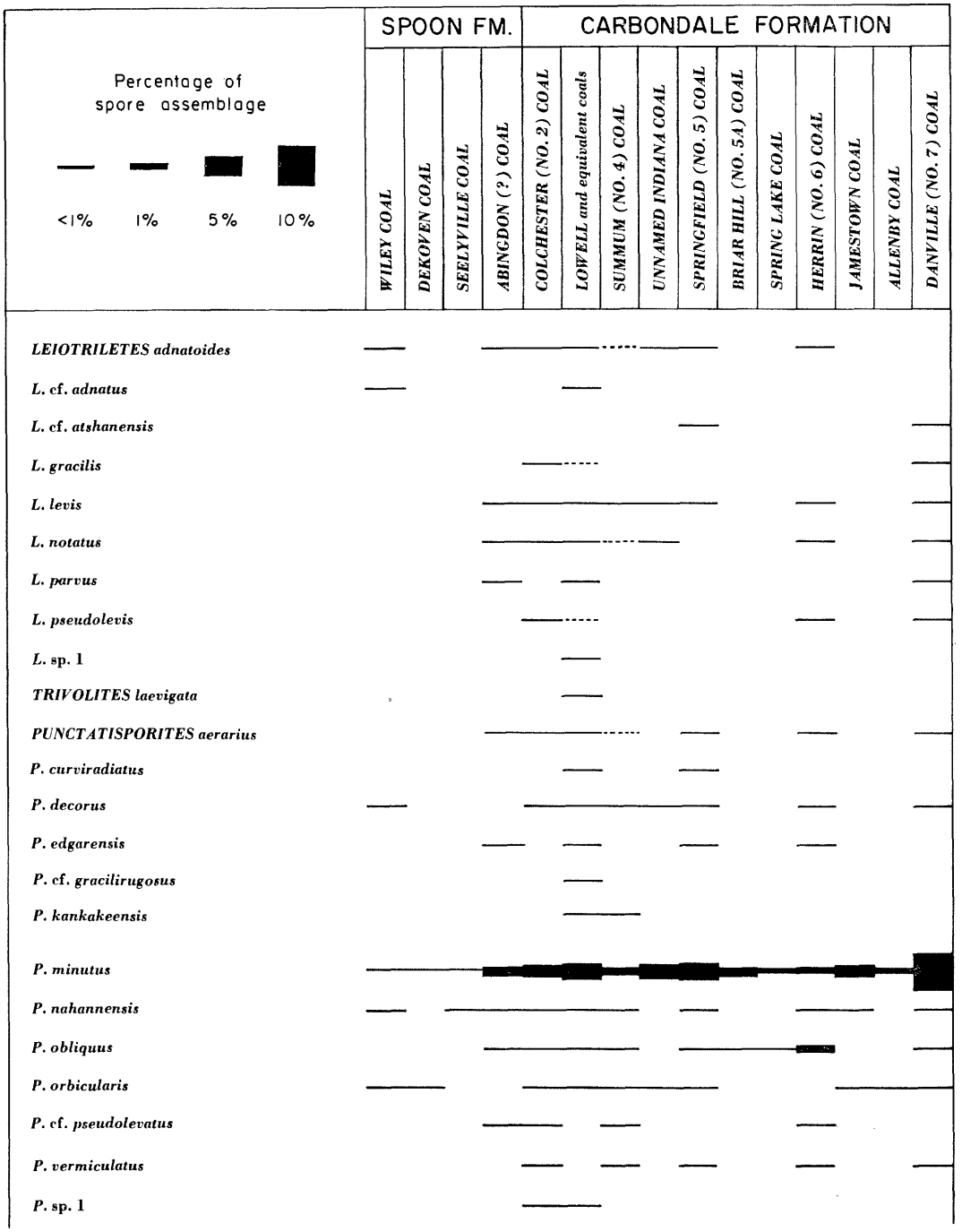
The No. 7 Coal can be easily differentiated on the basis of spore analysis from the No. 6 Coal according to the following criteria. The No. 7 Coal contains *Dictyotriletes*, *Tuberculatosporites robustus*, *Hymenospora paucirugosa*, *H. multirugosa*, *Kosankeisporites elegans*, and *Complexisporites chalonerii*, all of which are absent from the No. 6 Coal. Spores present in the No. 6 Coal but missing from the No. 7 Coal are *Mooreisporites inusitatus*, *Murospora kosankei*, *Cyclogranisporites microgranus*, and *Anapiculatisporites spinosus*. An interesting relation exists between the two small species *Laevigatosporites minutus* and *Punctatisporites minutus*. In the No. 7 Coal, *P. minutus* outnumbers *L. minutus* at all localities except site 36, where the coal is only 4 inches thick. In the No. 6 Coal, *L. minutus* had a higher frequency than *P. minutus* at all localities.

The Allenby and Jamestown Coals, which underlie the No. 7, differ from the No. 7 Coal by having a slightly lower percentage of *Lycospora* and a higher percentage of *Punctatisporites* and *Crassispora*. The Allenby and Jamestown Coals have a much less diverse spore flora than the No. 7 Coal by lacking *Leiotriletes*, *Apiculatisporis*, *Cadiospora*, *Verrucosisporites*, *Reinschospora*, *Torispora securis*, *Perotriletes*, *Hymenospora*, *Paleospora fragila*, *Punctatisporites decorus*, *Granulatisporites* cf. *parvus*, *Lophotriletes rarispinosus*, *Triquitrites minutus*, *Tuberculatosporites robustus*, *Cirratriradites annuliformis*, and other taxa.

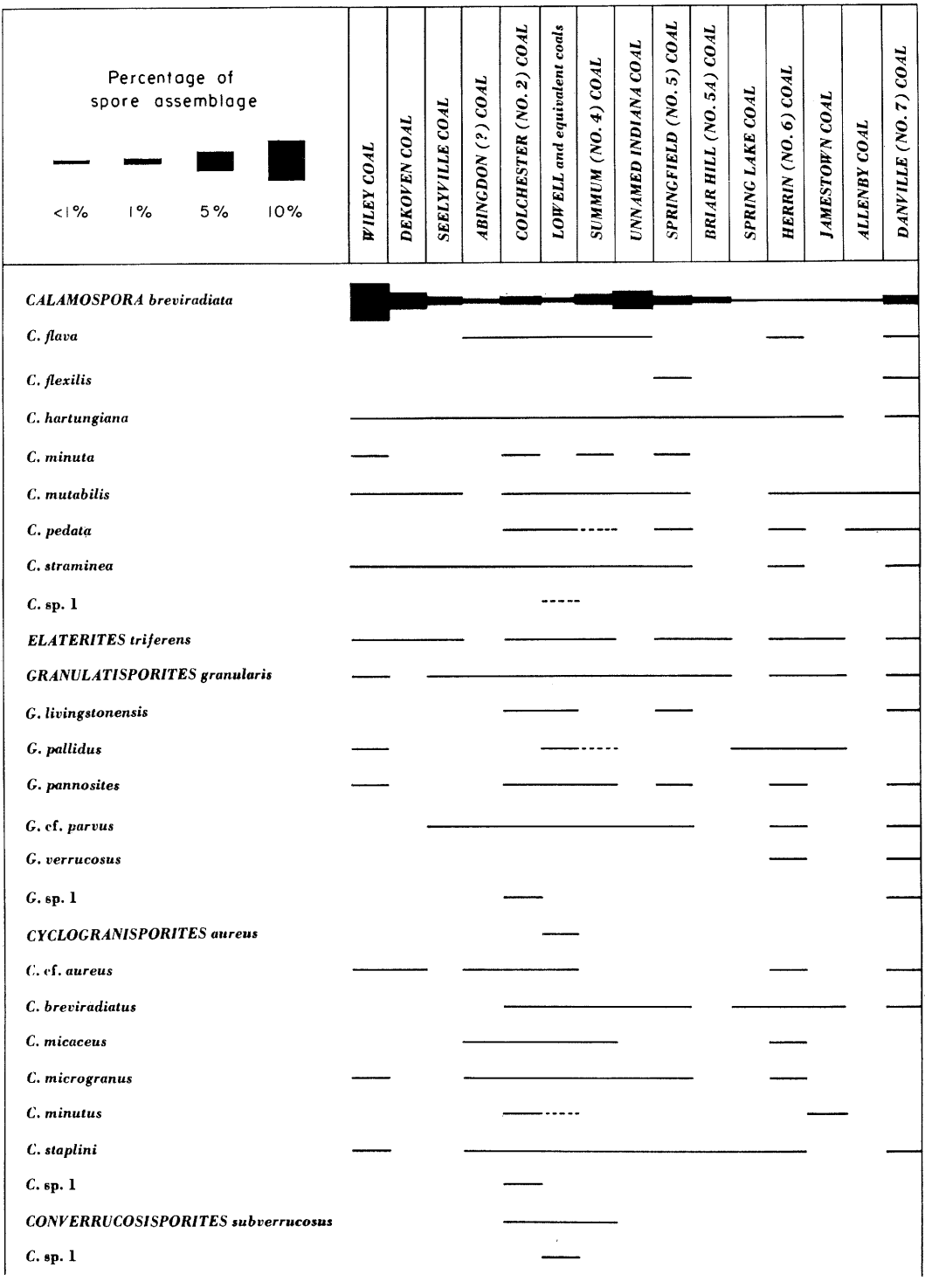
SPORE DISTRIBUTION CHARTS

The stratigraphic distribution of all the spore genera and species identified in this investigation is diagrammed in two spore distribution charts (text figs. 10 and 11). Abundance of the taxa in the various coals is indicated by the thickness of the bars on the charts.

Coals tentatively identified as Rock Island (No. 1) and Murphysboro were studied but, for two reasons, were not included in the charts. First, only one sample of each was analyzed, and, second, the stratigraphic interval between these coals and the Wiley Coal contains several other coals that were not investigated.

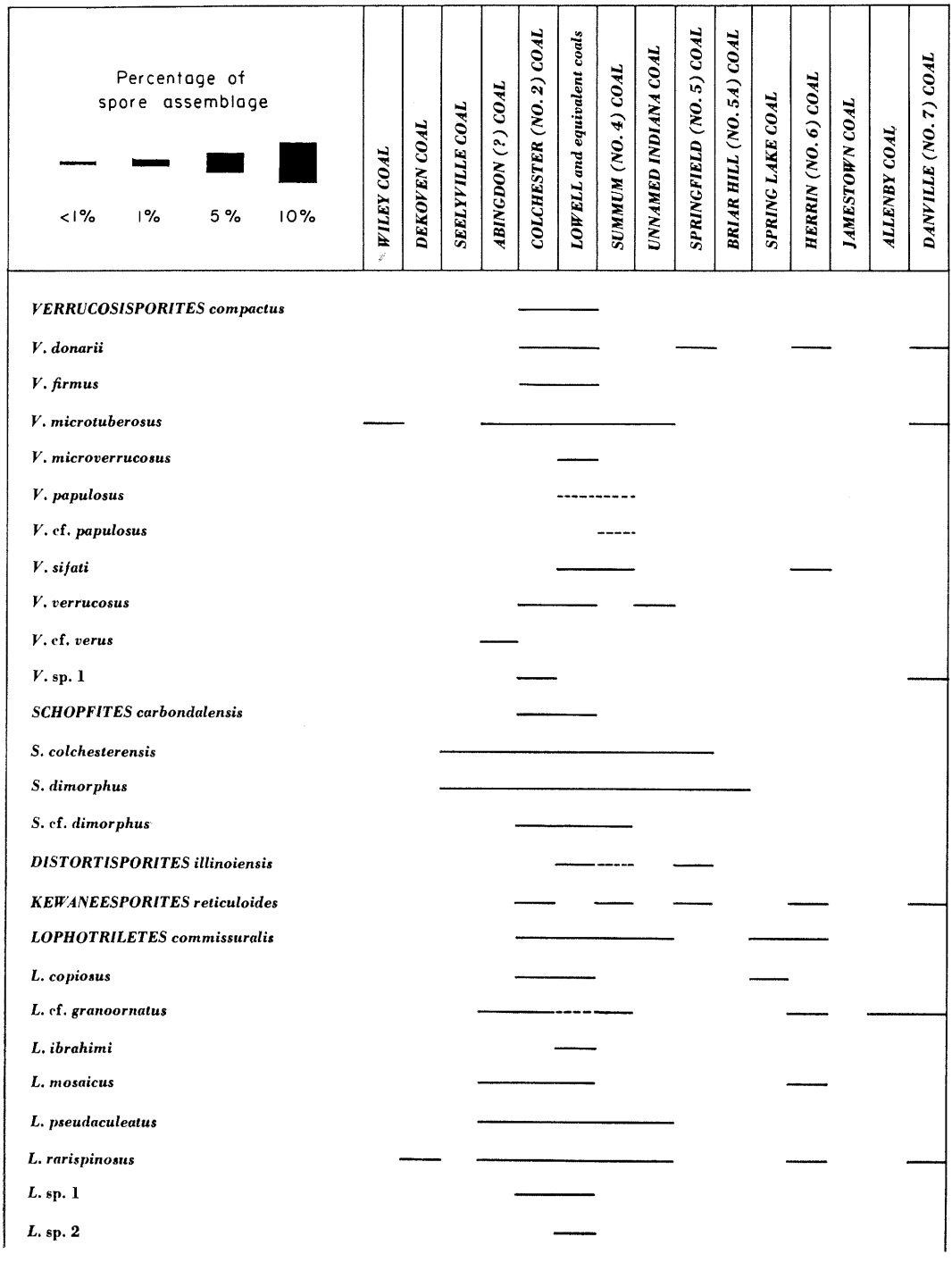


Text Fig. 10 — Stratigraphic distribution and relative abundance of small spore species in coals of the Carbondale Formation and the upper part of the Spoon Formation. Dashed line in the Summum (No. 4) Coal column indicates the spore is found in the No. 4 east of the Ancona-Garfield structure only. Dashed line in the Lowell and equivalents column indicates the spore is found in the Cardiff Coal, which may not be exactly equivalent to the Lowell Coal.



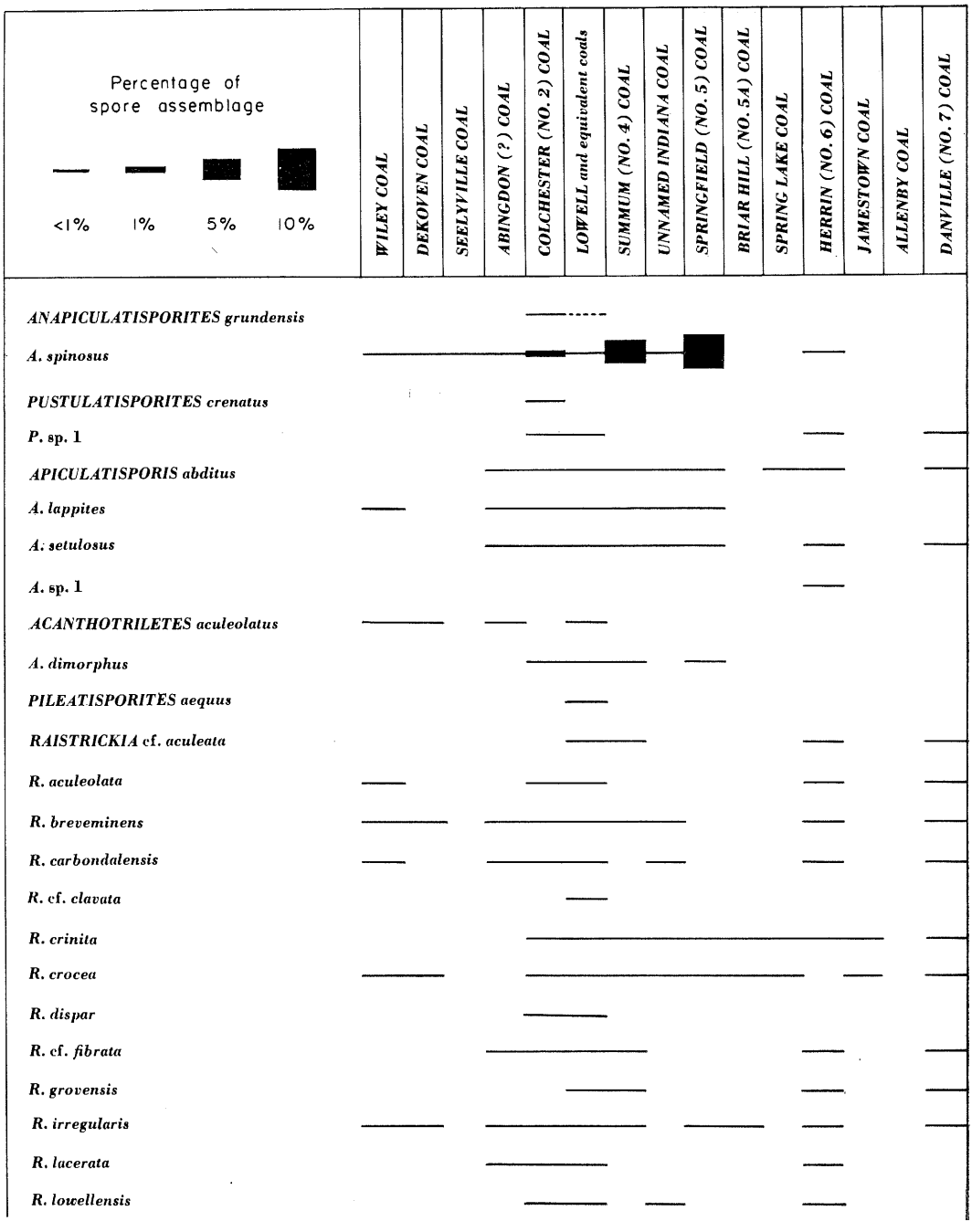
Text Fig. 10 — (continued)

Dashed line in the Summum (No. 4) Coal column indicates the spore is found in the No. 4 east of the Ancona-Garfield structure only. Dashed line in the Lowell and equivalents column indicates the spore is found in the Cardiff Coal, which may not be exactly equivalent to the Lowell Coal.



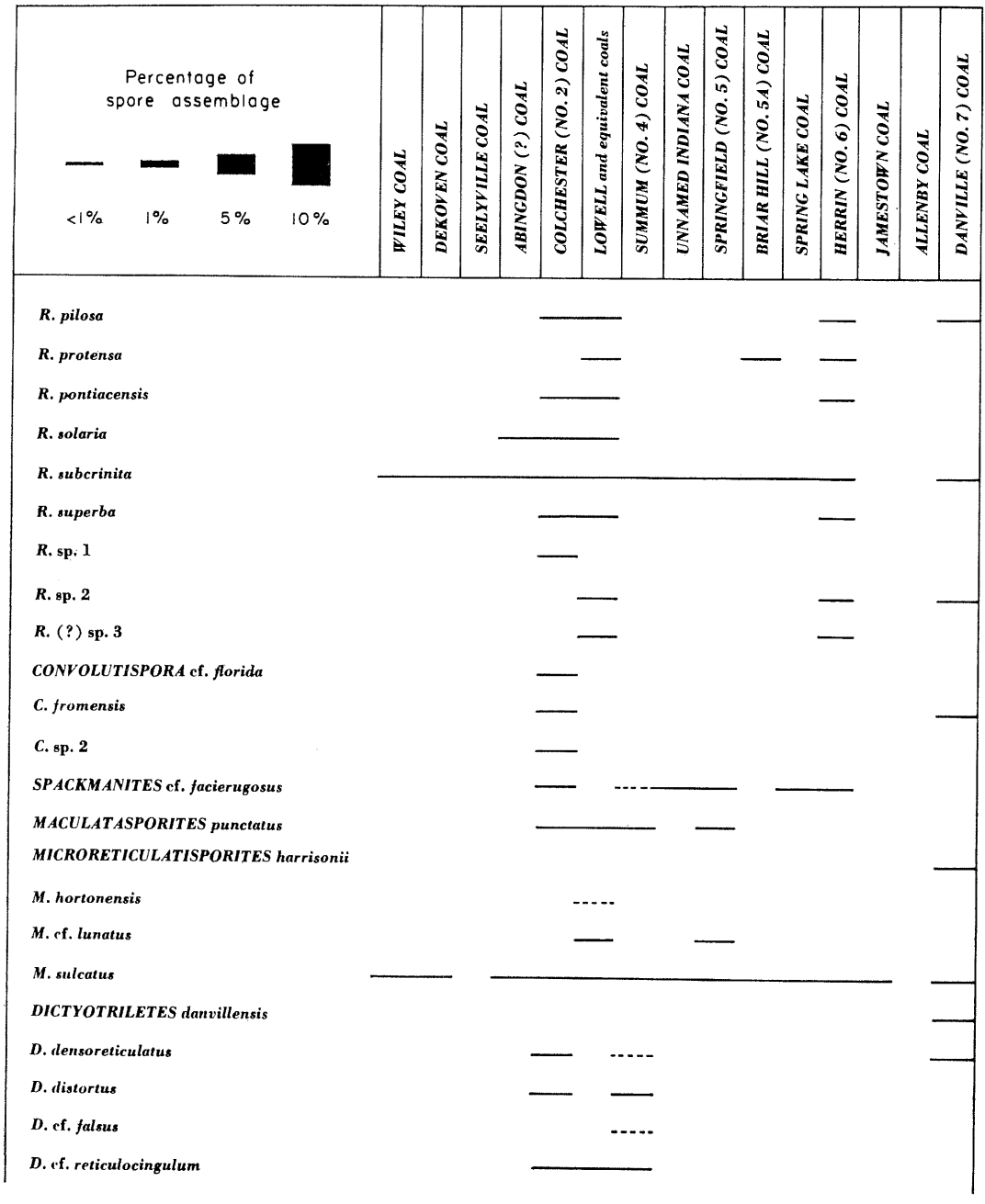
Text Fig. 10 — (continued)

Dashed line in the Summum (No. 4) Coal column indicates the spore is found in the No. 4 east of the Ancona-Garfield structure only. Dashed line in the Lowell and equivalents column indicates the spore is found in the Cardiff Coal, which may not be exactly equivalent to the Lowell Coal.



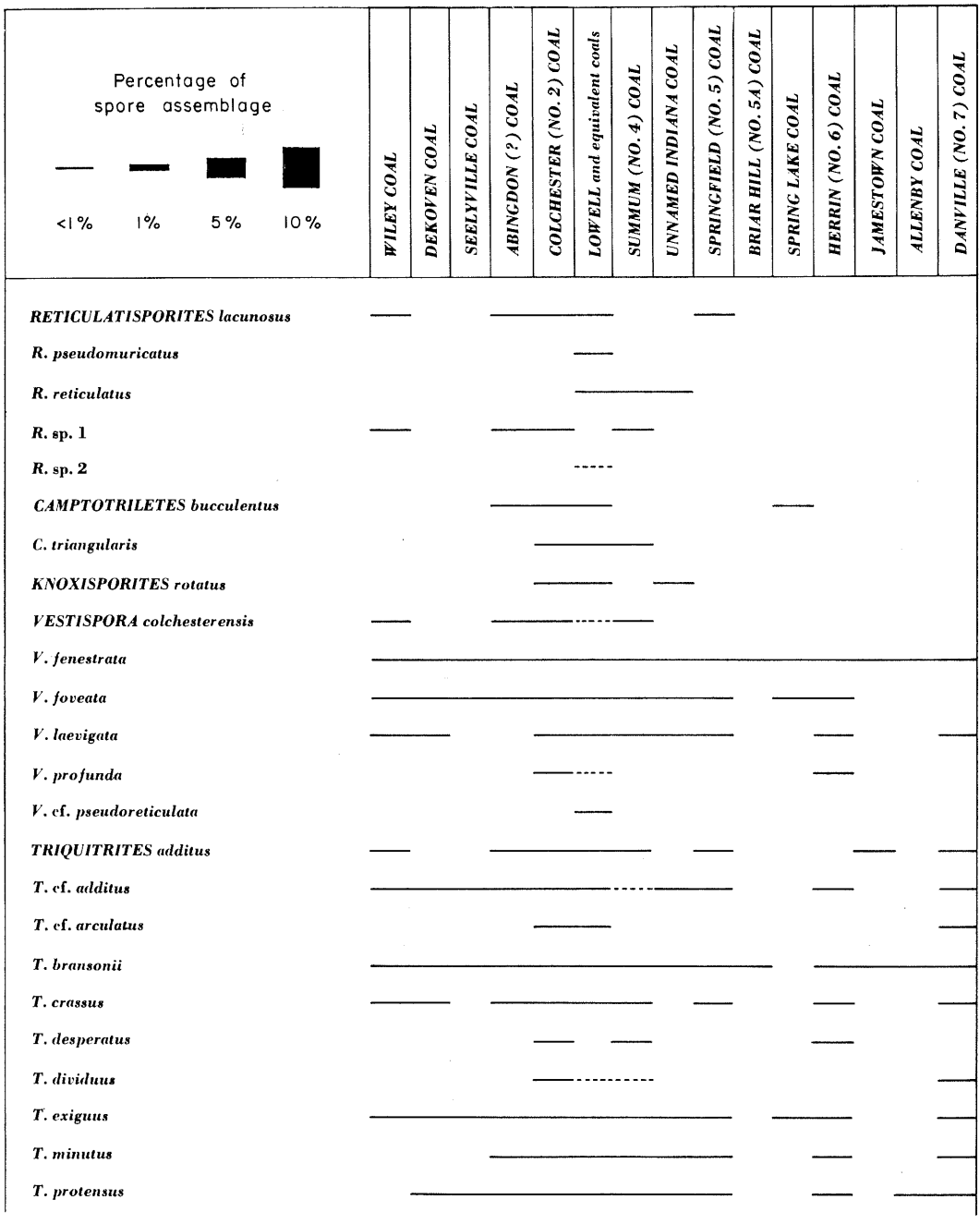
Text Fig. 10 — (continued)

Dashed line in the Lowell and equivalents column indicates the spore is found in the Cardiff Coal, which may not be exactly equivalent to the Lowell Coal.



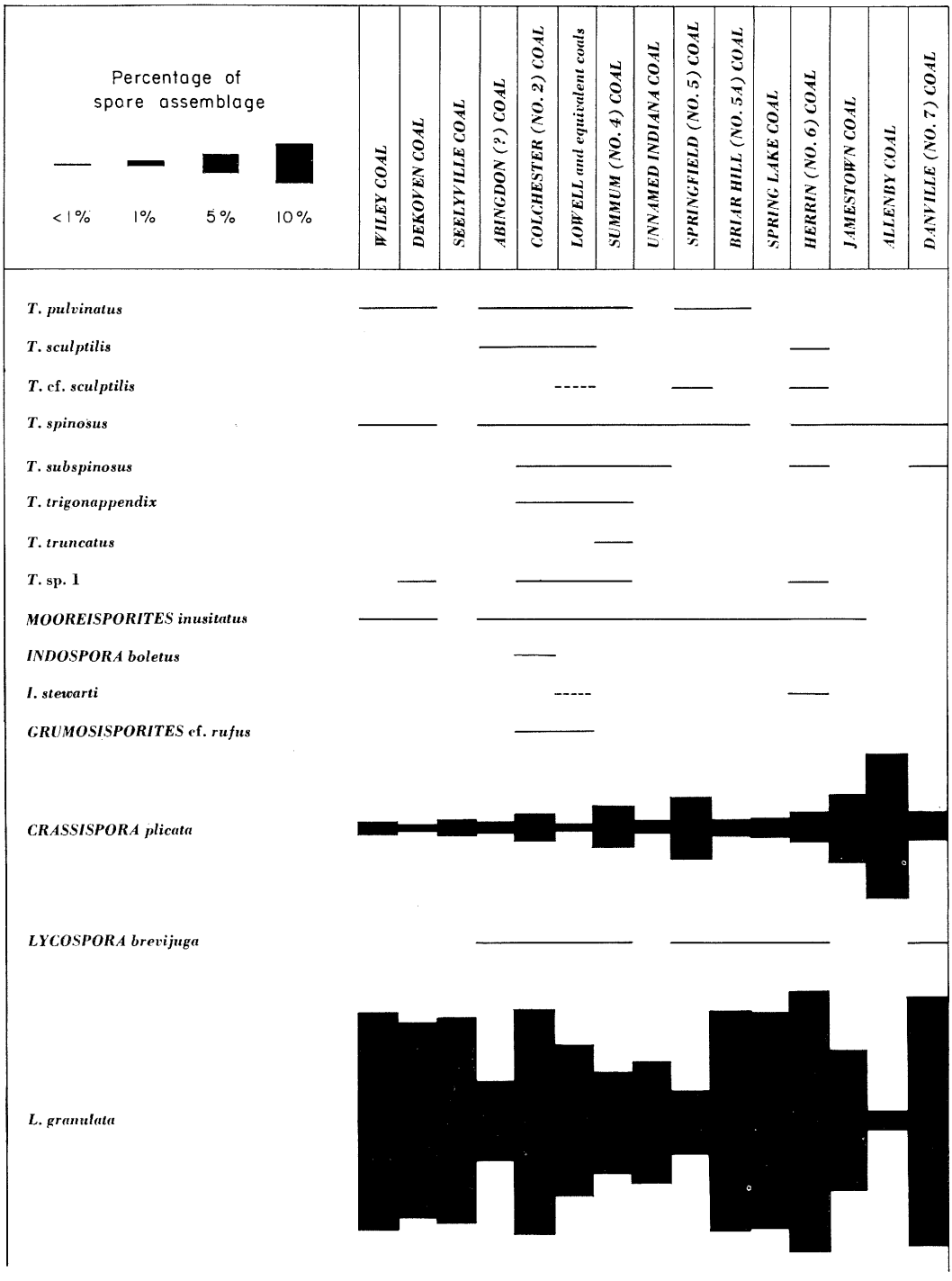
Text Fig. 10 — (continued)

Dashed line in the Summum (No. 4) Coal column indicates the spore is found in the No. 4 east of the Ancona-Garfield structure only. Dashed line in the Lowell and equivalents column indicates the spore is found in the Cardiff Coal, which may not be exactly equivalent to the Lowell Coal.



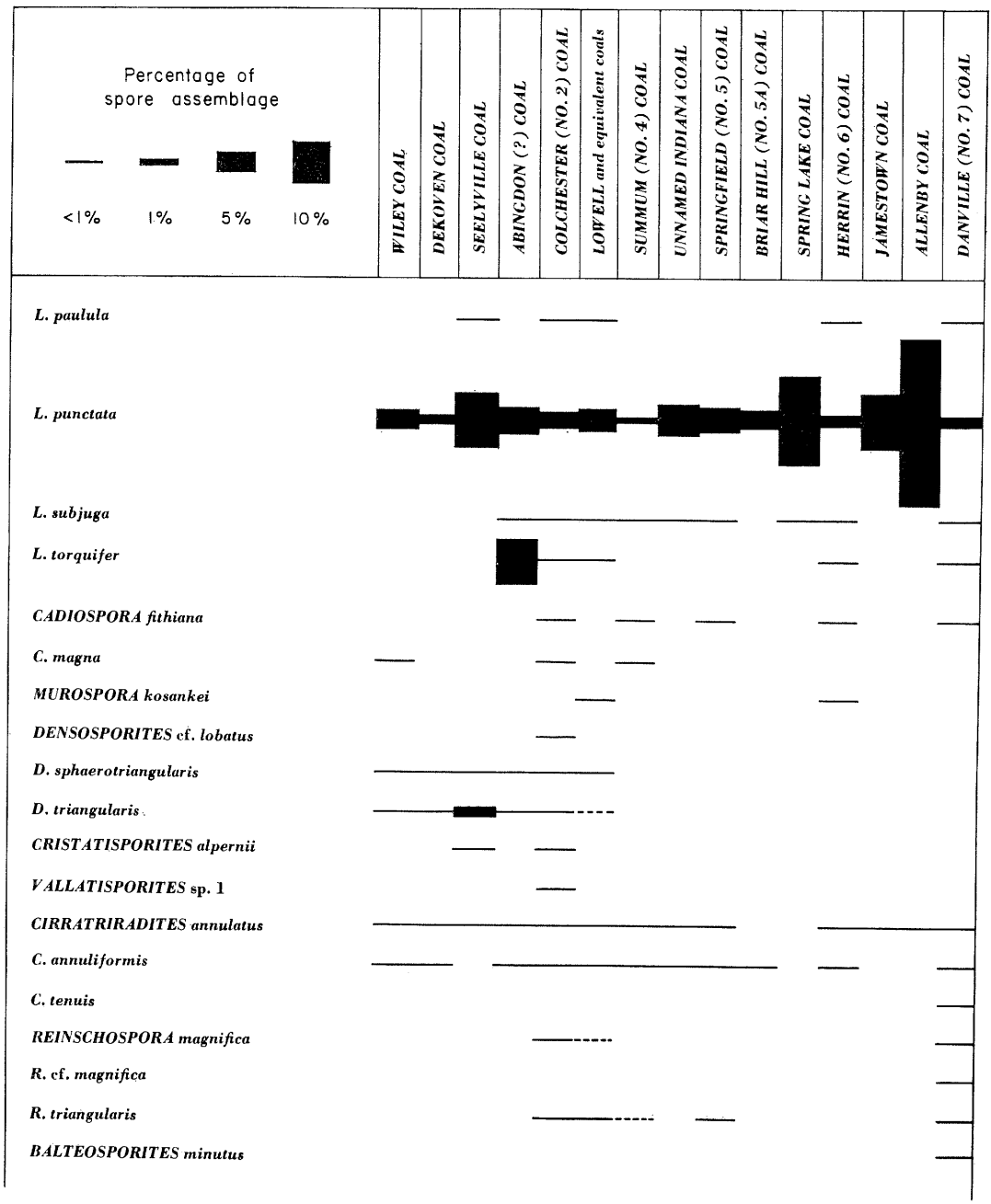
Text Fig. 10 — (continued)

Dashed line in the Summum (No. 4) Coal column indicates the spore is found in the No. 4 east of the Ancona-Garfield structure only. Dashed line in the Lowell and equivalents column indicates the spore is found in the Cardiff Coal, which may not be exactly equivalent to the Lowell Coal.



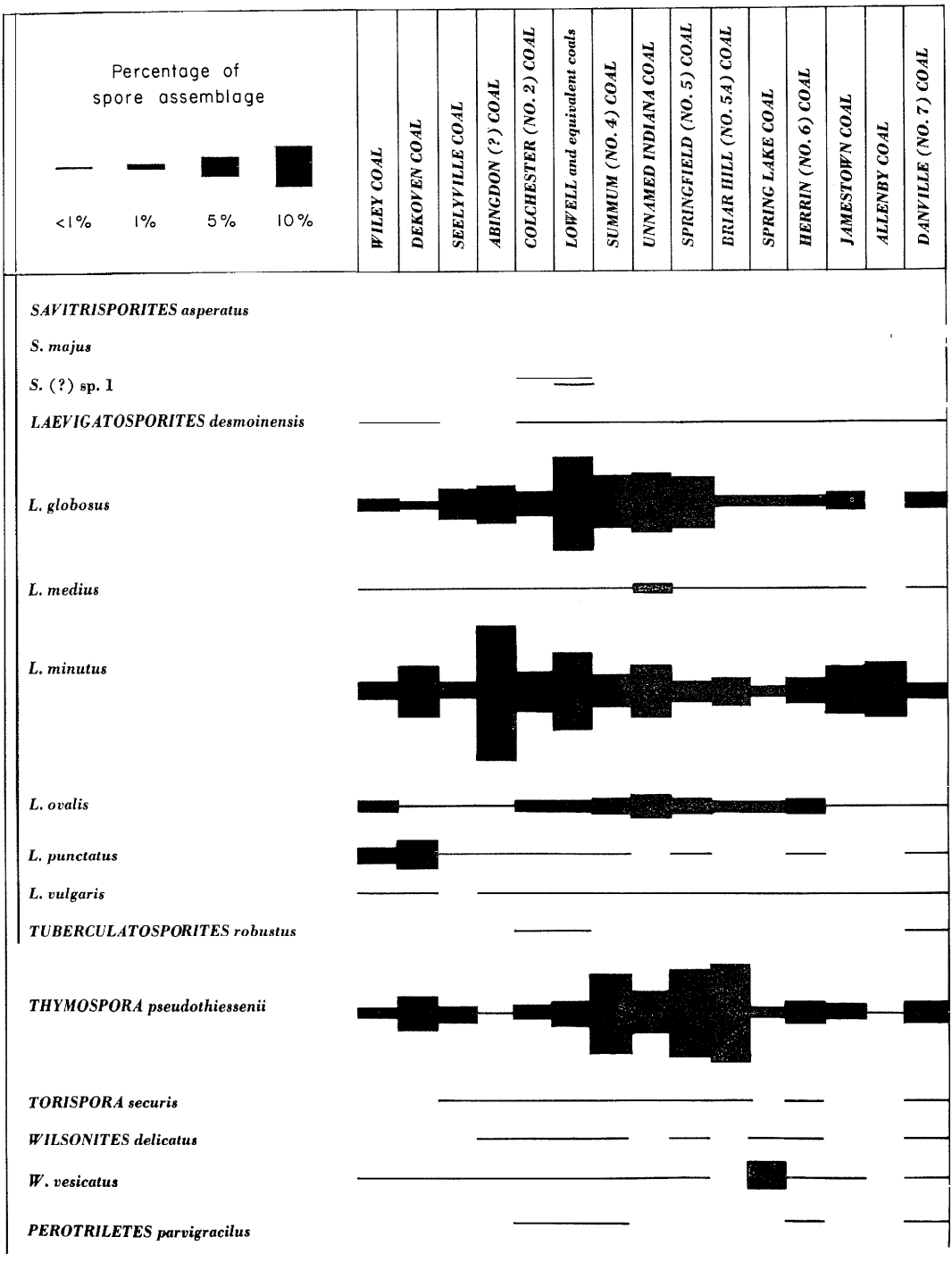
Text Fig. 10 — (continued)

Dashed line in the Lowell and equivalents column indicates the spore is found in the Cardiff Coal, which may not be exactly equivalent to the Lowell Coal.

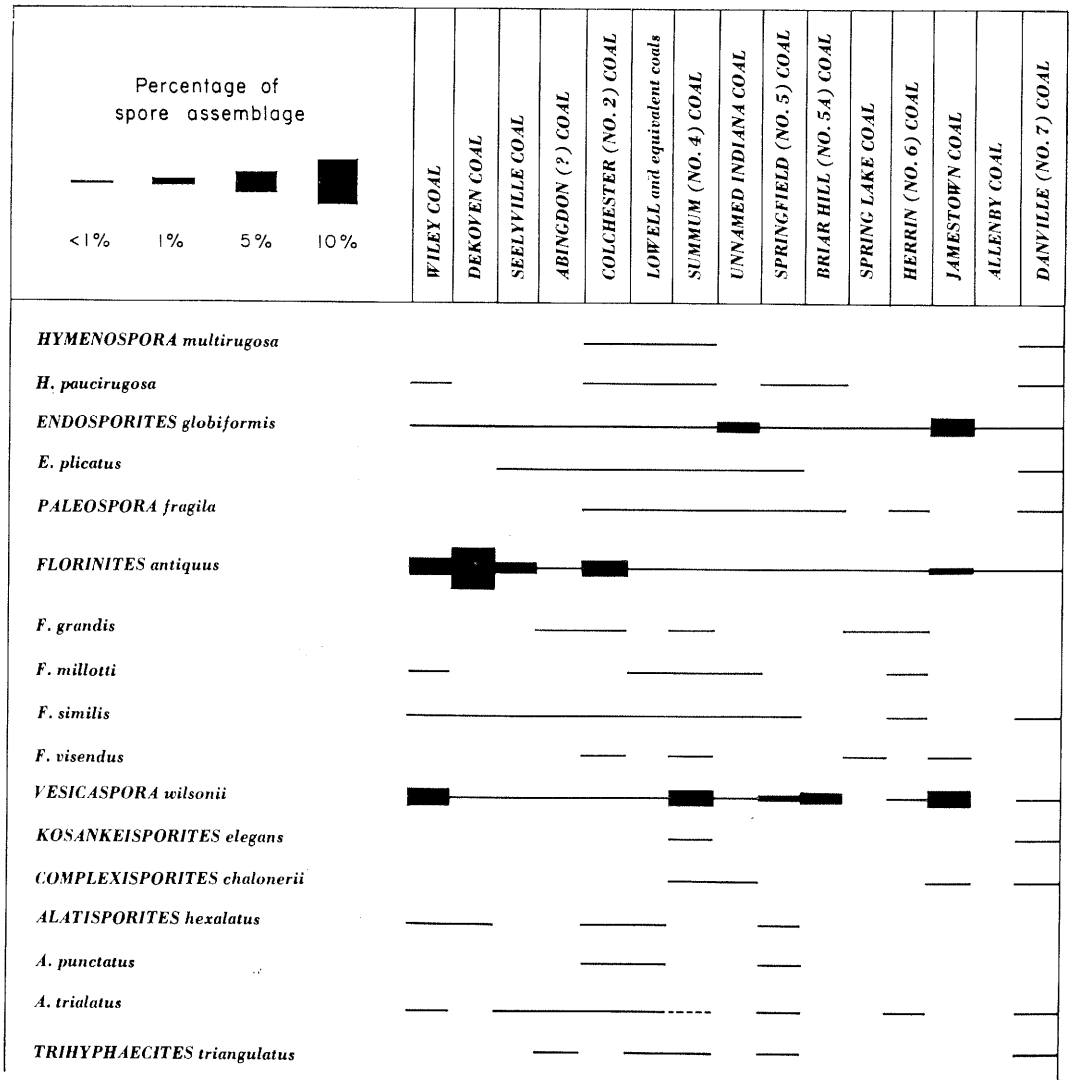


Text Fig. 10 — (continued)

Dashed line in the Summum (No. 4) Coal column indicates the spore is found in the No. 4 east of the Ancona-Garfield structure only. Dashed line in the Lowell and equivalents column indicates the spore is found in the Cardiff Coal, which may not be exactly equivalent to the Lowell Coal.

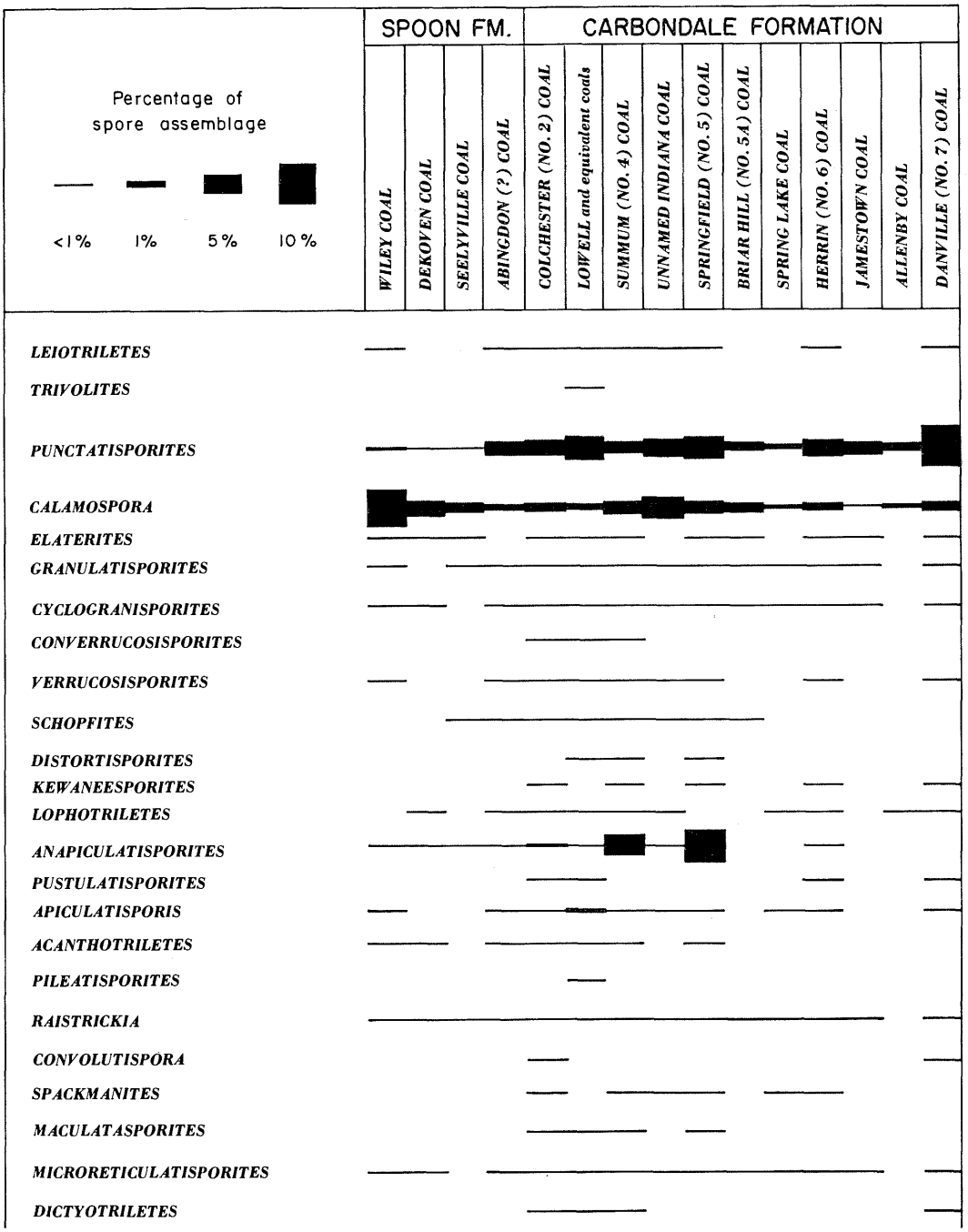


Text Fig. 10 — (continued)

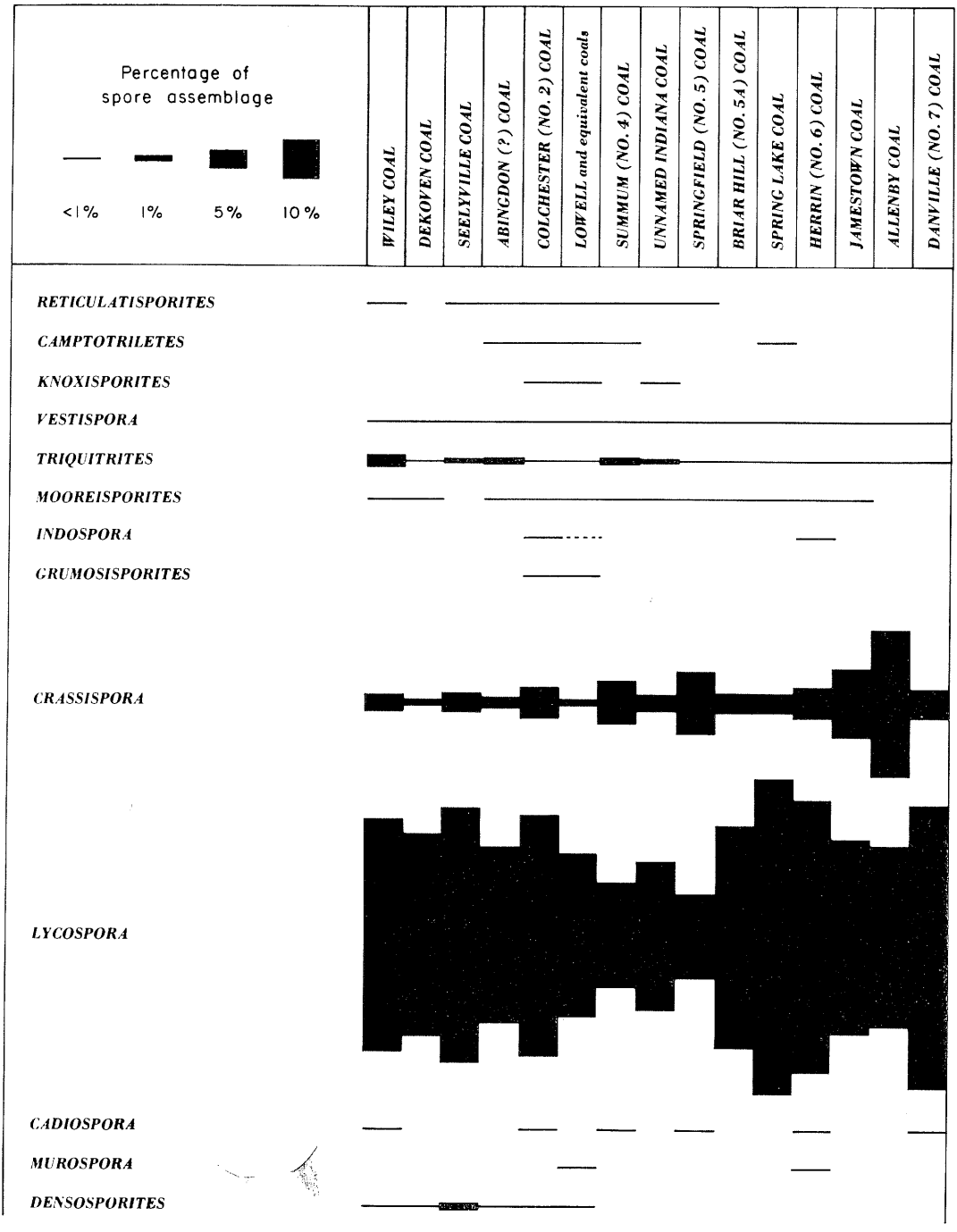


Text Fig. 10 — (concluded)

Dashed line in the Summum (No. 4) Coal column indicates the spore is found in the No. 4 east of the Ancona-Garfield structure only.

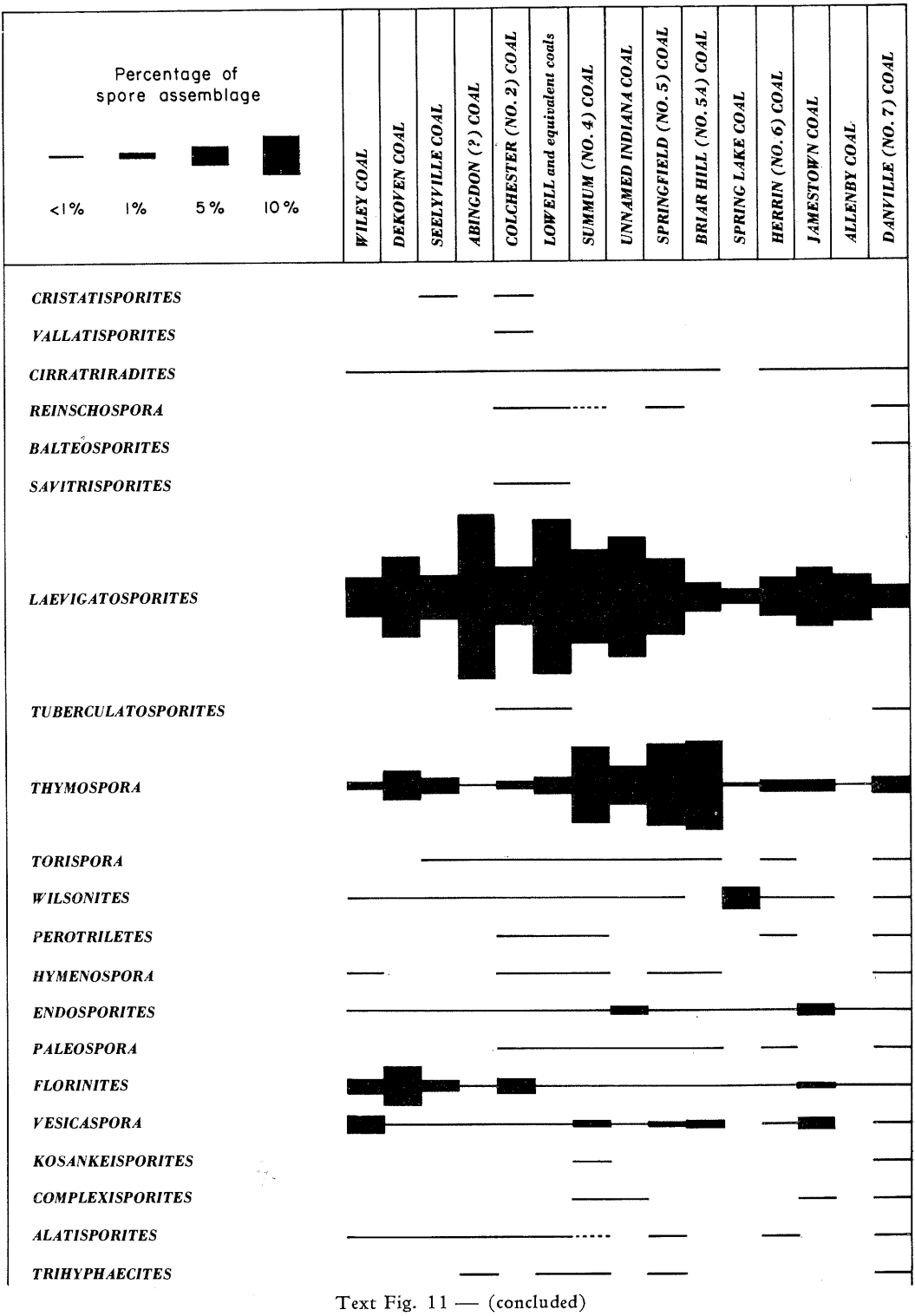


Text Fig. 11 — Stratigraphic distribution and relative abundance of small spore genera in coals of the Carbondale Formation and the upper part of the Spoon Formation.



Text Fig. 11 — (continued)

Dashed line in the Lowell and equivalent coals column indicates the spore is found in the Cardiff Coal, which may not be exactly equivalent to the Lowell Coal.



Text Fig. 11 — (concluded)

Dashed line in the Summum (No. 4) Coal column indicates the spore is found in the No. 4 east of the Ancona-Garfield structure only.

TAXONOMY

Of a total of 59 small spore genera and 221 species differentiated during the course of this investigation, 4 genera and 35 species are proposed as new and are formally described and named. One genus and four species have been emended and four new combinations have been proposed. A number of taxa that had previously been described from other areas are recorded from the Illinois Basin for the first time. Twenty-two species that are probably new to the literature were given number designations because not enough specimens were observed to warrant assigning formal epithets to them. One genus and species of a microfossil probably of fungal affinities are formally described and named.

The slides of the type specimens, with the specimens circled in ink, are deposited in the paleobotanical collection of the Illinois Geological Survey. The mechanical stage of a Spencer microscope (serial number 417297) was used to find the coordinate locations of the illustrated specimens on the slides.

Maceration numbers followed by (RR) indicate samples remacerated when no spores were found in the original maceration or the spores present were poorly preserved.

Genus LEIOTRILETES (Naumova) Potonié and Kremp, 1954

Type species. — *Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, 1954.

Leiotriletes adnatoides Potonié and Kremp, 1955

Plate 1, figure 1

Discussion.—*Leiotriletes adnatoides* was transferred to *Granulatisporites* by Smith and Butterworth (1967) because their specimens were finely granulate under oil immersion objective. However, the Illinois specimens are not as distinctly granulate as those of Smith and Butterworth (pl. 3, figs. 12-14), being more like the specimen shown by Potonié and Kremp (1955, fig. 14). Under oil immersion objective, portions of the exine are levigate, whereas other portions appear slightly granulate.

Occurrence. — Murphysboro and Wiley Coals; Abingdon (?) through No. 5 Coals; and No. 6 Coal.

Leiotriletes cf. *adnatus* (Kosanke) Potonié and Kremp, 1955

Plate 1, figure 2

Discussion. — Proper focusing on the spore exine permits sharper delineation of the thickened triangular area at the apex than is discernible in the illustration. This taxon, which is almost 10μ smaller than *Leiotriletes adnatus*, may actually be a new species, but not enough specimens were found to resolve this question.

Occurrence. — Wiley and Lowell Coals.

Leiotriletes pseudolevis sp. nov.

Plate 1, figures 3-4

Diagnosis. — The small spores are radial, trilete, and triangular in outline. The spores, which often show minor folding, have straight to slightly concave or convex interradial sides. The commissure, which is distinct but not split wide open, possesses rays that extend almost to the spore equator. Along the rays are elevated ridges, up to 6μ wide at the spore apex, that taper in width toward the radial corners. They extend one-half to two-thirds the length of the rays, which, in addition, may possess narrow folds or lips. The triradiate ridges are

flat on top and have sharp, distinct outer edges. The spore coat, about 1μ thick, is levigate even under oil immersion objective. Dimensions (7 specimens): size range, 36.4 to 43.2μ; median, 39.3μ.

Holotype. — Plate 1, figure 3; negative 7750; Colchester (No. 2) Coal, maceration 1402-C, slide 5, coordinates, 144.3 × 47.5; size, 36.4 by 36.1μ.

Paratype. — Plate 1, figure 4; negative 7845; Herrin (No. 6) Coal, maceration 1242-A, slide 12, coordinates, 124.2 × 51.5; size, 38.0 by 36.4μ.

Comparison. — *Leiotriletes pseudolevis* is a form between species of *Leiotriletes*, in which interradial ridges are not sharply delineated or are lacking, and *Latipulvinites kosankii* Peppers, 1964, which possesses strongly developed, well differentiated triradiate ridges. *L. adnatoides* Potonié and Kremp, 1955, is more convex in outline than *L. pseudolevis* and the ridges along its rays are not as well developed. The commissure of *L. adnatoides*, unlike that of *L. pseudolevis*, is commonly torn open. *L. gracilis* Imgrund, 1960, differs from *L. pseudolevis* in its smaller size. *L. levis* (Kosanke) Potonié and Kremp, 1955, is distinguished by having more rounded, shoulder-like thickening in the interradial areas. *L. pseudolevis* somewhat resembles *L.* sp. A Hacquebard, 1957, and *L.* sp. A Habib, 1966.

Etymology. — The specific epithet suggests the gross similarity between this taxon and *Leiotriletes levis*.

Occurrence. — No. 2, No. 6, and No. 7 Coals.

Leiotriletes levis (Kosanke)
Potonié and Kremp, 1955
Plate 1, figure 5

1966 *Ahrensisporites vagus* Habib, p. 640, pl. 106, fig. 5.

Discussion. — The kyrtomes of *Ahrensisporites vagus* were characterized by Habib (1966, p. 640) as being best developed in the interradial area and traceable to the radial corners " . . . where, however, it is distinguished occasionally only with oil magnification . . . ." The kyrtomes of *Ahrensisporites* are developed on the distal surface, but the illustration of the holotype of *A. vagus* (Habib, 1966, pl. 106, fig. 5) shows these thickened structures apparently on the proximal surface. Occasionally specimens of *Leiotriletes levis* are compressed in such a way that the interradial thickened portions of the exine have pulled away from the suture, sometimes to even a greater extent than is depicted on the spore illustrated in this report, to produce pseudokyrtomes.

Occurrence. — Abingdon (?) through No. 5 Coals; No. 6 and No. 7 Coals.

Leiotriletes notatus Hacquebard, 1957
Plate 1, figure 6

Occurrence.—Abingdon (?) Coal through the unnamed coal between No. 4 and No. 5 Coals; No. 6 and No. 7 Coals.

Leiotriletes gracilis Imgrund, 1960
Plate 1, figure 7

Discussion.—The taxon designated *Granulatisporites* sp. 2 (Peppers, 1964) is assigned to this species.

Occurrence. — No. 2, Cardiff, and No. 7 Coals.

Leiotriletes parvus Guennel, 1958
Plate 1, figure 8

Occurrence. — Murphysboro, Abingdon (?), Lowell, and No. 7 Coals.

Leiotriletes cf. *atshanensis* Singh, 1964
Plate 1, figure 9

Discussion. — This spore with short rays resembles the one illustrated by Singh (1964, pl. 44, fig. 11), but the Illinois specimens have a maximum diameter of 53μ, larger than the size range of 35 to 45μ given for the species by Singh. They also are similar to the specimen assigned to *Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, 1955, by Alpern (1959, pl. 1, fig. 18).

Occurrence. — No. 5 and No. 7 Coals.

Leiotriletes sp. 1
Plate 1, figure 10

Description. — The miospore is radial, trilete, and roundly triangular in transverse plane. Its interradial sides are concave to slightly convex, and its corners are broad and well rounded. The distinct commissure possesses rays that are straight, lack lips, and extend about two-thirds the distance to the corners. The exine, which is levigate, is slightly thicker and darker in the area of the suture. The spore coat is about 1μ thick.

Figured specimen. — Negative 7730; Lowell Coal, maceration 1387-D, slide 7, coordinates, 122.5 $\times$ 40.0; size, 37.4 by 35.8μ.

Occurrence. — Lowell Coal.

Genus TRIVOLITES Peppers, 1964

Type species.—*Trivolites laevigata* Peppers, 1964.

Trivolites laevigata Peppers, 1964
Plate 1, figure 11

Occurrence. — Lowell Coal.

Genus PUNCTATISPORITES (Ibrahim) Potonié and Kremp, 1954

Type species. — *Punctatisporites punctatus* Ibrahim, 1933.

Punctatisporites curviradiatus Staplin, 1960
Plate 1, figure 12

Discussion.—*Punctatisporites curviradiatus* and *P. atrifucatus* Staplin, 1960, could be conspecific. As the size difference between the former (27 to 43μ) and the latter (45 to 54μ) is not significantly great, a continuous series in size might actually be represented. The only other distinguishing feature of *P. curviradiatus* seems to be the "off-polar compression and resultant apparent curvature of two sutures" (Staplin, 1960, p. 7).

Occurrence. — Lowell and No. 5 Coals.

Punctatisporites cf. *pseudolevatus* Hoffmeister, Staplin, and Malloy, 1955
Plate 1, figure 13

Occurrence.—Abingdon (?), No. 2, No. 4, and No. 6 Coals.

Punctatisporites aerarius Butterworth and Williams, 1958
Plate 1, figure 14

Discussion.—The maximum size of 95μ given by Butterworth and Williams (1958, p. 360) is increased here to include spores of up to 110μ.

Occurrence. — Murphysboro, Abingdon (?) through No. 4 Coals; No. 5, No. 6, and No. 7 Coals.

Punctatisporites nahannensis Hacquebard and Barss, 1957
Plate 1, figure 15

Discussion.—*Cyclogranisporites* sp. Butterworth and Williams (1958, pl. 1, fig. 20) is probably this same taxon.

Occurrence. — Murphysboro and Wiley Coals; Seelyville Coal through No. 4 Coal; and No. 5, No. 6, Jamestown, and No. 7 Coals.

Punctatisporites edgarensis sp. nov.
Plate 1, figures 16-17

Diagnosis. — The miospores are radial, trilete, and are roundly triangular in overall transverse plane, but they generally have an undulating margin. They are commonly in good proximal-distal orientation. The rays, one-half to two-thirds the length of the spore radius, are straight and lined with lips 1 to 2μ wide. The commissure may be split open. On the distal surface are large, low, often inconspicuous ridges and verrucae. Where the thickened portions are close together, the grooves be-

tween produce a sculpture that could be considered vermiculate. Ridges and verrucae are not sharply bounded, and they tend to merge with the rest of the spore coat. Except for the distal irregularities in thickness, the exine is levigate under high dry objective, but under oil immersion objective is seen to be infrapunctate. The spore coat, 5 to 12μ thick, is sometimes slightly thicker at the corners opposite the rays. Dimensions (21 specimens): 90 to 152.8μ in maximum diameter; median, 130.7μ.

Holotype. — Plate 1, figure 16; negative 7782; Lowell Coal, maceration 1402-D, slide 21, coordinates, 138.5 × 55.7; size, 121.9 by 113.8μ.

Paratype. — Plate 1, figure 17; negative 7846; Herrin (No. 6) Coal, maceration 1404-CC, slide 35, coordinates, 129.7 × 35.5; size, 123.5 by 120.9μ.

Comparison. — *Punctatisporites edgarensis* most closely resembles *P. sinuatus* (Artuz) Neves, 1961, except that the former has a more triangular shape and is not as strongly folded. The broad verrucae on *P. edgarensis* are restricted to the distal surface and are less distinct than on *P. sinuatus*. *P. edgarensis* also compares closely with *P. obesus* (Loose) Potonié and Kremp, 1955, except for the low ridges and verrucae on the distal surfaces of the former.

Etymology.—The species name refers to Edgar County, Illinois.

Occurrence. — Abingdon (?), Lowell, No. 5, and No. 6 Coals.

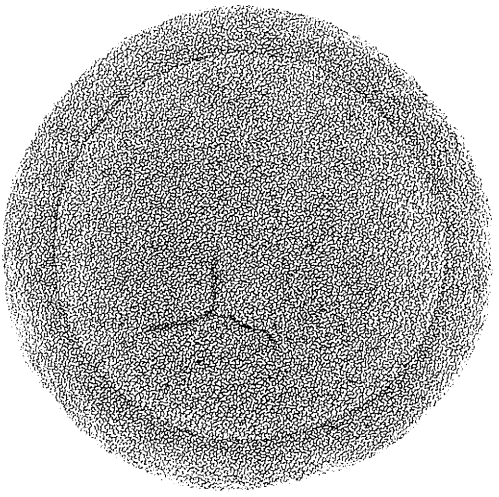
Punctatisporites decorus
Wilson and Kosanke, 1944
Plate 2, figure 1

Occurrence.—Wiley Coal; No. 2 through No. 5 Coals; No. 6 and No. 7 Coals.

Punctatisporites kankakeensis sp. nov.
Text figure 12; plate 2, figures 2-3

Diagnosis. — The miospores are radial, trilete, and circular in transverse plane. Most are in good proximal-distal orientation and seldom secondarily folded. The distinct trilete rays are simple, straight, and extend about one-third the length of the spore radius. The spore coat appears levigate, but under oil immersion objective it can be observed to be very finely punctate to granulate. The exine thickness, 5.5 to 7.5μ, is considerable for the spore size. Dimensions (8 specimens): size range, 47.1 to 71.5μ in maximum diameter; median, 61.8μ.

Holotype. — Plate 2, figure 2; negative 7606; Summum (No. 4) Coal, maceration 1133-A1, slide 2, coordinates, 139.0 × 44.0; size, 65.3 by 65.0μ.



Text Fig. 12 — Diagrammatic reconstruction of the holotype of *Punctatisporites kankakeensis* sp. nov.

Paratype. — Plate 2, figure 3; negative 7385; Summum (No. 4) Coal, maceration 1405-A, slide 9, coordinates, 122.9 × 49.1; size, 49.1 by 47.1μ.

Comparison. — *Punctatisporites kankakeensis* is distinguished by its great thickness, short trilete rays, and very fine ornamentation. The well defined circumscribing line poleward to the spore margin (text fig. 12) denotes the inside margin of the spore wall and is not to be interpreted as a cingulum or separate structure. Focusing up and down through the spore reveals that the spores are very thick.

Etymology. — The species name refers to Kankakee County, Illinois.

Occurrence. — Lowell and No. 4 Coals.

Punctatisporites minutus (Kosanke) Peppers, 1964

Occurrence. — From below the Wiley Coal to above the No. 7 Coal.

Punctatisporites obliquus Kosanke, 1950

Discussion.—Miller (1966, p. 224-228) erected the genus and species *Circlettisporites dawsonensis* for spores somewhat similar to *P. obliquus*. Wilson and Venkatachala (1967, p. 363-365) emended the species and transferred it and *Punctatisporites obliquus* to *Leschikisporis* Potonié, 1958. The main basis for separating *Leschikisporis* from similar taxa is its possession of two rays in a straight, or nearly straight, line and a third ray at nearly 90 degrees from the other two. I do not believe that this feature is of enough significance to warrant establishing a different genus to accommodate these forms. *P. obliquus* is therefore retained under *Punctatisporites*. Also see discussion under *Laevigatosporites globosus* Schemel, 1951.

Occurrence. — Murphysboro Coal; Abingdon (?) Coal through No. 4 Coal; No. 5 Coal through No. 6 Coal; and No. 7 Coal.

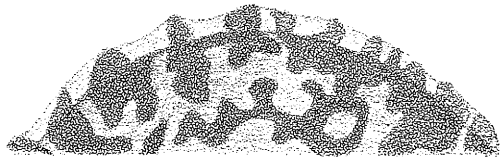
Punctatisporites orbicularis Kosanke, 1950
Plate 2, figure 4

Occurrence.—Wiley and DeKoven Coals; No. 2 through No. 5 Coals; and Jamestown through No. 7 Coals.

Punctatisporites vermiculatus
Kosanke, 1950
Text figure 13; plate 2, figures 5-6

1964 *Punctatisporites transenna* Peppers, p. 33, pl. 4, figs. 18 and 19.

Discussion.—Re-examination of the holotypes and other specimens of *Punctatisporites vermiculatus* and *P. transenna* has resulted in the conclusion that the latter is a junior synonym of the former. *P. vermiculatus* displays considerable variation in ornamentation — from coarsely punctate to pseudoreticulate or vermiculate, depending upon the proportion of negative sculpture to the rest of the spore coat.



Text Fig. 13 — Diagrammatic detail of portion of holotype of *Punctatisporites vermiculatus* Kosanke, 1950.

Figured specimens. — Plate 2, figure 5; negative 7376; Springfield (No. 5) Coal, maceration 630, slide 24, coordinates, 144.2 × 49.4; size, 52.0 by 41.0μ. Plate 2, figure 6; negative 7935; same specimen as figure 5, under oil immersion objective.

Occurrence. — Murphysboro Coal; No. 2 through No. 4 Coals; No. 5, No. 6, and No. 7 Coals.

Punctatisporites cf. *gracilirugosus*
Staplin, 1960
Plate 2, figure 7

Discussion. — This spore conforms to the description of *Punctatisporites gracilirugosus* except that it is larger (65μ) than those in the size range of 44μ to 50μ reported by Staplin.

Occurrence. — No. 4 Coal.

Punctatisporites sp. 1
Plate 2, figure 8

Description. — The miospore is radial, trilete, and roundly triangular in transverse plane. The distinct trilete rays lack lips and extend about two-thirds the distance to the spore equator. The exine, which is levigate, is about 5μ thick.

Figured specimen. — Negative 7654; Lowell Coal, maceration 1384-K, slide 5, coordinates, 126.5 × 36.0; size, 60.8 by 51.8μ.

Occurrence. — No. 2 and Lowell Coals.

Genus CALAMOSPORA
Schopf, Wilson, and Bentall, 1944

Type species. — *Calamospora hartungiana* Schopf, 1944 (*in* Schopf, Wilson, and Bentall, 1944).

Calamospora breviradiata Kosanke, 1950

Discussion. — Spores similar to those designated *Calamospora multiplicata* Habib, 1966, were included under *C. breviradiata* because it is difficult to differentiate between the two species. The criss-cross disposition of the folds on *C. multiplicata* were considered a distinguishing characteristic, setting it apart from *C. breviradiata.* Although folding of specimens of *C. breviradiata* generally occurs parallel to the spore margin, this is not always the case. *C. saariana* Bhardwaj, 1957a, is probably synonymous with *C. breviradiata.*

Occurrence.—No. 1 Coal; Wiley through No. 7 Coals.

Calamospora flava Kosanke, 1950

Occurrence. — Abingdon (?) through the unnamed coal between the No. 4 and No. 5 Coals; No. 6 and No. 7 Coals.

Calamospora flexilis Kosanke, 1950
Plate 2, figure 9

Occurrence. — Rare; Murphysboro, No. 5, and No. 7 Coals.

Calamospora minuta Bhardwaj, 1957a
Plate 2, figure 10

Discussion. — Except for its smaller size, *Calamospora minuta* is very similar to *C. breviradiata* Kosanke, 1950, and may actually be conspecific with it. According to Bhardwaj (1957a, p. 80) *C. minuta* is differentiated from *C. breviradiata* by its thicker exine. However, one of the specimens he illustrated (1957a, pl. 22, fig. 9) possesses numerous folds and has the appearance of being quite thin. *C. straminea* Wilson and Kosanke, 1944, is approximately the same size as *C. minuta,* but the latter exhibits more pronounced labra and intratecta.

Occurrence. — No. 2, No. 4, and No. 5 Coals.

Calamospora hartungiana Schopf
(*in* Schopf, Wilson, and Bentall, 1944)
Plate 2, figure 11

Discussion.—The contact areas of *Calamospora hartungiana* vary from rather light to dark. *C. elliptica* Habib, 1966, is probably conspecific with *C. hartungiana.*

Occurrence.—Murphysboro Coal to the No. 7, with the exception of the Allenby Coal.

Calamospora mutabilis (Loose)
Schopf, Wilson, and Bentall, 1944
Plate 2, figure 12

Discussion. — The spores referred to *Calamospora mutabilis* apparently conform more closely to the description by Potonié and Kremp (1955, p. 49) than that of Smith and Butterworth (1967, p. 135).

Occurrence. — Wiley Coal through the No. 7 Coal, except for the Abingdon (?), No. 5A, and Spring Lake Coals.

Calamospora pedata Kosanke, 1950
Plate 2, figure 13

Discussion. — *Punctatisporites calvus* Staplin, 1960, var. *calvus* and *P. calvus* var. *macrocalvus* Staplin, 1960, appear to be conspecific with *Calamospora pedata.*

Occurrence. — Murphysboro Coal; No. 2 through No. 4 Coals; No. 5, No. 6, Allenby, and No. 7 Coals.

Calamospora straminea
Wilson and Kosanke, 1944

Occurrence. — From below Wiley Coal through No. 5 Coal; No. 6, and No. 7 Coals.

Calamospora sp. 1
Plate 2, figure 14

Description. — *Calamospora* sp. 1 is radial, trilete, and roundly triangular in transverse plane. The commissure is distinct, open, and without lips. The trilete rays are 26 to 30μ long. The contact areas are slightly thicker and darker than the rest of the exine, which is levigate and about 2μ thick.

Figured specimen. — Negative 7558; Cardiff Coal; maceration 1133-C1 (RR),

slide 5, coordinates, 124.3 × 41.0; size, 91.0 by 89.4μ.

Occurrence. — Rare; found only in the Cardiff Coal.

Genus ELATERITES Wilson, 1943

Type species. — *Elaterites triferens* Wilson, 1943.

Elaterites triferens Wilson, 1943
Plate 3, figures 1-3

Description. — The small spores are radial, trilete, and possess a circular body. The conspicuous trilete rays are 12 to 15μ in length and are bordered by lips up to 2.5μ wide. The distinct, sharply outlined, thickened, and darkened circular contact areas are often marked at their equatorial margins by arcuate ridges. The body, or exospore, is less than 1μ thick. Closely attached to the body on many specimens is a thin, contorted perispore that occasionally possesses at least one elater. The elaters are usually closely appressed to the spore body and tightly coiled. The elaters and perisporium, both of which are less than 1μ thick, are slightly scabrate. A triangular "truss" on the distal side is rarely present. Dimensions (20 specimens): size range of exospore, 55.3 to 84.5μ in diameter; median, 74.8μ.

Figured specimens. — Plate 3, figure 1; negative 7836; Colchester (No. 2) Coal, maceration 1275-D, slide 11, coordinates, 124.5 × 45.0; size of body, 76.7 by 66.6μ. Plate 3, figure 2; negative 7837; Colchester (No. 2) Coal, maceration 1275-D, slide 12, coordinates, 141.9 × 40.3; size of body, 82.5 by 73.5μ. Plate 3, figure 3; negative 7807; Colchester (No. 2) Coal, maceration 1246, slide 12, coordinates, 140.0 × 33.3; detached body; size, 74.1 by 61.8μ.

Discussion.—*Elaterites triferens* has been described from coal ball material by Wilson (1943, 1963), and the presence of these spores in a calamitean cone from a coal ball from the same locality as the type material was noted by Baxter and Leisman (1967). The present study is apparently the first to report *E. triferens* from coal macerations.

Occurrence.—Wiley and Seelyville Coals; No. 2 through No. 4 Coals; No. 5, No. 5A, No. 6, Jamestown, and No. 7 Coals.

Genus GRANULATISPORITES (Ibrahim) Schopf, Wilson, and Bentall, 1944

Type species. — *Granulatisporites granulatus* Ibrahim, 1933.

Granulatisporites cf. *parvus* (Ibrahim) Potonié and Kremp, 1955
Plate 3, figures 4-5

Discussion. — Although it was not discussed by Potonié and Kremp (1955, p. 59), several of their illustrations display a thickened interray portion of the exine that is characteristic of my specimens. Bhardwaj (1957a, p. 82-83) stated that *Granulatisporites parvus* has a thickened and dense interray exine. The spores designated *G. piroformis* Loose, 1934, by Wilson and Hoffmeister (1956, pl. 2, fig. 1) and *Granulatisporites* sp. 1 by Gray (1967, pl. 15, fig. 23) are probably this same taxon.

Occurrence.—Seelyville through No. 5 Coals; No. 6 and No. 7 Coals.

Granulatisporites livingstonensis sp. nov.
Plate 3, figures 6-7

Diagnosis. — The miospores are radial, trilete, and triangular in transverse plane. They possess straight to slightly concave or convex sides and well rounded corners. The rays are distinct, straight, and extend about three-fourths the distance to the corners. On each side of the commissure are conspicuous elevated lips or triradiate ridges that are up to 5μ wide. The lips show a decrease in width from the apex toward the ends of the rays near the corners. The upper surface of the ridges is levigate, but the radial margins are ragged. The proximal and distal surfaces of the exine are covered with grana of unequal sizes that produce an over-all rough

appearance. In lateral view, most of the grana have rounded ends, but bacula and coni with blunt ends are occasionally encountered. In end view, the grana are circular to irregular in shape or even elongate. They average 1 to 2μ in diameter and height but are occasionally 3.5μ in diameter, and they are crowded so closely that there is no room for grana of equal size between them. Approximately 40 to 55 grana can be counted at the spore periphery. The exine is 1.5 to 2μ thick. Dimensions (5 specimens): size range, 40.3 to 45.2μ in maximum diameter; median, 41μ.

Holotype. — Plate 3, figure 6; negative 7929; Lowell Coal, maceration 1402-F, slide 10, coordinates, 134.2 × 32.7; size, 41.3 by 39.3μ.

Paratype. — Plate 3, figure 7; negative 7722; Lowell Coal, maceration 1402-G, slide 7, coordinates, 127.2 × 31.5; size, 40.6 by 38.0μ.

Comparison. — *Granulatisporites livingstonensis* most nearly resembles *G. pannosites* sp. nov., but the former is more triangular, thicker, smaller, and has better developed lips or triradiate ridges. *Lophotriletes* cf. *granoornatus* Artuz, 1957, has larger, more widely spaced ornaments, most of which are coni.

Etymology. — The specific epithet refers to Livingston County, Illinois.

Occurrence. — No. 2, Lowell, No. 5, and No. 7 Coals.

Granulatisporites pannosites sp. nov.
Plate 3, figures 8-9

Diagnosis. — The miospores are radial, trilete, and roundly triangular to triangular in transverse plane. They have convex interradial sides and well rounded corners, but minor folding is common. The spores are usually somewhat obliquely compressed so that the suture is displaced toward the interradial side that is rather straight. The other two sides are strongly convex. The distinct rays of the suture are straight, occasionally bifurcated, and extend two-thirds to three-fourths the distance to the corners. On each side of the commissure, which is usually split open, are lips or triradiate ridges up to 3.5μ wide. The lips are levigate on their upper surfaces, but their interradial margins are uneven. The proximal and distal surfaces of the spore coat have a very ragged appearance as they are covered with grana of various sizes that are irregularly distributed on the same specimen. They average 1μ in diameter and height but vary from less than 1μ to occasionally up to 3μ. The grana in vertical section are mostly well rounded, occasionally truncated or cone shaped. In end view they are circular, oval, or very irregular in shape. The number of grana that protrude beyond the margin varies from 15 to about 40. The exine is about 1μ thick. Dimensions (20 specimens): size range, 48.8 to 61.8μ in maximum diameter; median, 55μ.

Holotype. — Plate 3, figure 8; negative 7401; Springfield (No. 5) Coal, maceration 722-C, slide 6, coordinates, 140.3 × 46.6; size, 61.0 by 56.0μ.

Paratype. — Plate 3, figure 9; negative 7440; Summum (No. 4) Coal, maceration 1143-A (RR), slide 17, coordinates, 140.5 × 38.5; size, 58.5 by 55.3μ.

Comparison. — *Planisporites* ? sp. A Habib, 1966, is similar to this taxon but is larger and has ornaments that are more cone shaped.

Etymology. — The species name refers to the ragged (*pannosus*) nature of the exine.

Occurrence. — Murphysboro and Wiley Coals; No. 2 through No. 4 Coals; No. 5, No. 6, and No. 7 Coals.

Granulatisporites pallidus Kosanke, 1950
Plate 3, figure 10

Occurrence.—Murphysboro, Wiley, Lowell, and No. 4 Coals; Spring Lake Coal through Jamestown Coal.

Granulatisporites granularis Kosanke, 1950
Plate 3, figure 11

Occurrence.—Wiley Coal to No. 7 Coal except for DeKoven, Spring Lake, and Allenby Coals.

Granulatisporites verrucosus
Wilson and Coe, 1940

Occurrence. — No. 6 and No. 7 Coals.

Granulatisporites sp. 1
Plate 3, figure 12

Description. — The small spore is radial, trilete, and triangular in transverse plane. The trilete rays are distinct, slightly sinuous, and extend about three-fourths the distance to the corners. A triangular, dark, and thick contact area is present. The exine is covered with widely spaced, rounded grana of irregular size and distribution that are 1 to 2.5μ in diameter. The grana appear to be embedded in the spore coat, as they project little beyond the outer spore wall. The exine is about 1μ thick.

Figured specimen. — Negative 7624; Danville (No. 7) Coal, maceration 1384-S, slide 20, coordinates, 137.6 × 49.2; size, 26.7 by 25.4μ.

Occurrence. — No. 2 and No. 7 Coals.

Genus CYCLOGRANISPORITES
Potonié and Kremp, 1954

Type species. — *Cyclogranisporites leopoldi* (Kremp) Potonié and Kremp, 1954.

Cyclogranisporites minutus Bhardwaj, 1957a
Plate 3, figure 13

Occurrence.—Murphysboro, No. 2, Cardiff, and Jamestown Coals.

Cyclogranisporites aureus (Loose) Potonié and Kremp, 1955
Plate 3, figure 14

Occurrence. — Lowell Coal.

Cyclogranisporites cf. *aureus* (Loose) Potonié and Kremp, 1955
Plate 3, figure 15

Discussion. — This is the same taxon as the one described and illustrated by Bhardwaj (1957a, p. 84; pl. 22, figs. 27 and 28).

Occurrence.—Murphysboro, Wiley, DeKoven, Abingdon (?), No. 2, Lowell, No. 6, and No. 7 Coals.

Cyclogranisporites micaceus Imgrund, 1960
Plate 3, figure 16

Occurrence. — Murphysboro Coal; Abingdon (?) through No. 4 Coals; No. 6 Coal.

Cyclogranisporites breviradiatus sp. nov.
Plate 4, figures 1-3

Diagnosis. — The miospores are radial, trilete, and originally spherical in transverse plane but when compressed are irregularly folded or torn. The trilete suture is usually not visible owing to the folding of the spores. The rays, 10 to 20μ in length, extend less than one-third the length of the spore radius and lack lips. The exine is covered with small, uniformly distributed grana less than 0.5μ in diameter and height. The individual grana can be discerned only by use of oil immersion objective. They are so closely packed that some areas of the exine appear punctate. More than 200 grana extend beyond the spore margin. Occasional specimens display loosely attached circular and irregularly distributed verrucae that are 1 to 2μ in diameter. The exine is 2.5 to 3μ thick. Dimensions (18 specimens): size range, 79.3 to 110.5μ in maximum diameter; median, 97.5μ.

Holotype. — Plate 4, figure 1; negative 7881; Lowell Coal, maceration 1402-E, slide 21, coordinates, 141.9 × 48.0; size, 94.3 by 72.5μ.

Paratype. — Plate 4, figure 2; negative 7381; Summum (No. 4) Coal, maceration 1405-A, slide 11, coordinates 137.9 × 39.5; size, 100.8 by 97.5μ. Plate 4, figure 3; negative 7928; same specimen shown in figure 2 under oil immersion objective.

Comparison.—*Planisporites ovatus* Knox, 1950, is oval, possesses a trilete suture that is usually open, and has a larger size range (up to 150μ) than *Cyclogranisporites breviradiata*. *Punctatisporites callosus* Artuz, 1957, resembles *C. breviradiatus*, but most of its spore surface is unornamented, often infrapunctate to infracticulate, and has longer trilete rays. *C. microgranus* Bhardwaj, 1957a, is coarser grained and smaller than *C. breviradiatus*. The latter is also larger and has shorter trilete rays than *Punctatisporites globulosus* Habib, 1966. *C. breviradiatus* is larger, has shorter rays, and less distinct and smaller grana than *C. multigranus* Smith and Butterworth, 1967.

Etymology. — The specific name refers to the short rays displayed by this taxon.

Occurrence. — No. 2 through No. 5 Coals; Spring Lake through Jamestown Coals; and No. 7 Coal.

Cyclogranisporites microgranus
Bhardwaj, 1957a
Plate 4, figure 4

Discussion. — Although he makes no mention of it under the diagnosis of this species, Bhardwaj (1957a, p. 84-85) states in his description and comparison that a characteristic feature is the usual occurrence of one ray that is smaller than the other two. This feature was noticed on only a few of the Illinois specimens.

Occurrence. — Wiley Coal; Abingdon (?) through No. 5 Coal; and No. 6 Coal.

Cyclogranisporites staplini Peppers, 1964, comb. nov.
Plate 4, figure 5

1964 *Punctatisporites staplini* Peppers, p. 35; pl. 5, figs. 5 and 6.

Discussion. — *Punctatisporites staplini* seems to have an ornamentation intermediate to that of *Cyclogranisporites* and *Cyclobaculisporites*, a genus that Bhardwaj (1955, p. 123) proposed to accommodate circular spores with baculate ornamentation. However, *Cyclobaculisporites* is not valid because Bhardwaj defined as the type species for the genus *Verrucosisporites grandiverrucosus* (Kosanke) Smith et al., 1964, which is definitely verrucose rather than baculate.

Occurrence. — Wiley Coal; Abingdon (?) through No. 6 Coals; and No. 7 Coal.

Cyclogranisporites sp. 1
Plate 4, figure 6

Description. — The miospore is radial, trilete, and circular in transverse plane. The commissure, which is open, has rays that are straight, without lips, and about half as long as the spore radius. The spore coat is covered with circular grana, 1.5 to 2μ in diameter that are quite uniform in size and distribution. They are 1.5 to 2μ apart, and about 100 project around the spore circumference. The exine is 3.3μ thick.

Figured specimen. — Negative 7642; Colchester (No. 2) Coal, maceration 1413-A, slide 12, coordinates, 142.0 $\times$ 39.1; size, 82.6 by 80.3μ.

Occurrence. — No. 2 Coal.

Genus CONVERRUCOSISPORITES
Potonié and Kremp, 1954

Type species.—*Converrucosisporites triquetrus* (Ibrahim) Potonié and Kremp, 1954.

Converrucosisporites subverrucosus
Bhardwaj, 1957a
Plate 4, figure 7

Occurrence. — No. 2 through No. 4 Coals.

Converrucosisporites sp. 1
Plate 4, figure 8

Description. — The miospores are radial, trilete, and roundly triangular in transverse plane. The distinct trilete rays are straight and almost reach the spore margin. Folds or lips about 1μ wide occur along the rays. Verrucae, which are generally

restricted to the distal surface, average 3μ in diameter, but may be up to 4.5μ in diameter. They are, at the most, only 1μ long, and they project only slightly beyond the margin. The exine is about 1μ thick.

Figured specimen. — Negative 7485; Lowell Coal, maceration 1190, slide 4, coordinates, 133.4 × 41.8; size, 49.7 by 40.6μ.

Occurrence. — Lowell Coal.

Genus VERRUCOSISPORITES (Ibrahim) Smith and Butterworth, 1967

Type species.—*Verrucosisporites verrucosus* (Ibrahim) Ibrahim, 1933.

Verrucosisporites donarii
Potonié and Kremp, 1955
Plate 4, figure 9

Occurrence. — No. 2 and Lowell Coals; No. 5, No. 6, and No. 7 Coals.

Verrucosisporites compactus Habib, 1966
Plate 4, figure 10

Comparison. — *Verrucosisporites compactus* is very similar in appearance to *V. cerosus* (Hoffmeister, Staplin, and Malloy) Butterworth and Williams, 1958, but the latter is found in Mississippian or Lower Carboniferous rocks.

Occurrence. — No. 2 and Lowell Coals.

Verrucosisporites sifati (Ibrahim) Smith and Butterworth, 1967
Plate 4, figure 11

Occurrence. — Lowell, No. 4, and No. 6 Coals.

Verrucosisporites papulosus Hacquebard, 1957
Plate 4, figure 12

Occurrence. — Cardiff and No. 4 Coals.

Verrucosisporites cf. *papulosus* Hacquebard, 1957
Plate 4, figure 13

Discussion.—This spore resembles those illustrated by Playford (1963, pl. 3, figs. 1-2). It is about 20μ larger than the other Illinois specimen assigned in this report to this species.

Occurrence. — No. 4 Coal.

Verrucosisporites firmus (Loose) Potonié and Kremp, 1955
Plate 4, figure 14

Discussion. — Smith et al. (1964, p. 1073) stated, ". . . the status of this species is clearly unsatisfactory and requires further investigation." They noted that the holotype figured by Potonié and Kremp (1955, pl. 13, fig. 203) suggests the presence of large, angular, loosely distributed verrucae, whereas another specimen (pl. 13, fig. 204) shows closely spaced pila-shaped projections. This variation in ornamentation has been observed on my specimens and is thought to be a function of the degree of preservation and maceration. Considering the small range in size (60 to 70μ) given by Potonié and Kremp, it seemed reasonable to assign the Illinois spores to this species even though they are less than 60μ in diameter (45 to 58.5μ, including ornamentation).

Occurrence. — No. 2 and Lowell Coals.

Verrucosisporites cf. *verus* (Potonié and Kremp) Smith et al., 1964
Plate 4, figure 15

Discussion. — This spore is similar to *Verrucosisporites microtuberosus* and *V. sinensis* except for its larger size and more numerous verrucae. It is ornamented with closely spaced verrucae not exceeding 2μ in width or height. Approximately 120 verrucae are visible along the spore margin.

Occurrence. — Abingdon (?) Coal.

Verrucosisporites verrucosus (Ibrahim) Ibrahim, 1933
Plate 4, figure 16

Occurrence. — No. 2, Lowell, and the unnamed coal between the No. 4 and No. 5 Coals.

Verrucosisporites microtuberosus (Loose) Smith and Butterworth, 1967
Plate 4, figure 17

Discussion. — This species and *Verrucosisporites sinensis* Imgrund, 1960, must be morphologically very closely related. The latter, according to Imgrund (1960, p. 162), possesses approximately 90 verrucae, 3 to 5μ in diameter, around the spore margin. Bhardwaj (1957a, p. 90), in emending *V. sinensis*, reported that re-examination of the original specimens led him to conclude that up to 120 projections, never exceeding 2μ, are placed around the spore margin. Imgrund's description of the ornamentation of *V. sinensis* approximates that of *V. microtuberosus*, which, as stated by Smith et al. (1964, p. 1074) and Smith and Butterworth (1967, p. 150), consists of 70 to 100 verrucae not exceeding 2μ in height or breadth projecting from the periphery.

Occurrence. — Wiley Coal; Abingdon (?) through the unnamed coal between the No. 4 and No. 5 Coals; and No. 7 Coal.

Verrucosisporites microverrucosus Ibrahim, 1933
Plate 5, figure 1

Discussion. — This specimen compares closely with the spore illustrated by Smith et al. (1964, pl. II, fig. 7) and Smith and Butterworth (1967, pl. 5, fig. 14) as *Verrucosisporites microverrucosus*. No circular forms were observed.

Occurrence. — Lowell Coal.

Verrucosisporites sp. 1
Plate 5, figure 2

Description. — The miospore is radial, trilete, and subcircular in transverse plane. The trilete rays are distinct and equal in length to about two-thirds the spore radius. On the proximal and distal surfaces are circular verrucae 3 to 4μ in diameter and about 1.5μ in height. They are closely spaced and almost touch each other at their bases. Extending beyond the spore periphery are 18 verrucae. The spore coat is about 1μ thick.

Figured specimen. — Negative 7627; Danville (No. 7) Coal, maceration 1415, slide 11, coordinates, 140.5 × 37.2; size, 35.1 by 33.2μ.

Occurrence. — No. 2 and No. 7 Coals.

Genus SCHOPFITES Kosanke, 1950

Type species. — *Schopfites dimorphus* Kosanke, 1950.

Schopfites carbondalensis sp. nov.
Plate 5, figures 3-4

Diagnosis. — The miospores are radial, trilete, and circular to oval in over-all transverse plane, but the margin is somewhat irregular because of ornamentation. They are rarely folded. The trilete rays are generally indistinct because of the dense ornamentation and poor proximal-distal orientation. The commissure lacks lips, and the rays, which are slightly sinuous, extend two-thirds to three-fourths the distance to the spore margin. The distal surface and all except a third of the proximal surface are covered with closely spaced, irregularly shaped verrucae. They are more or less flat topped except where spines are present. The verrucae average 4μ in diameter but reach a maximum of about 8μ. They extend 2 to 3μ above the rest of the spore surface. Scattered among the verrucae, especially along their lateral margins, are minute, sharp coni. Their length and breadth, which are about equal, are less than 1μ, so they generally can be seen only under oil immersion objective. The proximal and distal surfaces are about 3μ and 4μ thick, respectively. Dimensions (14 specimens): size range, 40.6 to 51.4μ in maximum diameter, including verrucae; median, 46.2μ.

Holotype. — Plate 5, figure 3; negative 7518; Colchester (No. 2) Coal, maceration 1386-B, slide 14, coordinates, 144.3 × 47.2; size, 44.9 by 40.3μ.

Paratype. — Plate 5, figure 4; negative 7893; Colchester (No. 2) Coal, maceration

954-Ee, slide 22, coordinates, 122.3 × 45.4; size, 46.2 by 42.9μ.

Comparison. — *Schopfites colchesterensis* Kosanke, 1950, and *S. dimorphus* Kosanke, 1950, are larger than *S. carbondalensis*. *S. saarensis* Bhardwaj, 1957a, is ornamented entirely with coni, and *S. laterales* Singh, 1964, although about the same size as *S. carbondalensis*, has rounded verrucae and lacks coni.

Etymology. — The species name refers to the Carbondale Formation (Pennsylvanian) of Illinois.

Occurrence. — No. 2 and Lowell Coals.

Schopfites colchesterensis Kosanke, 1950

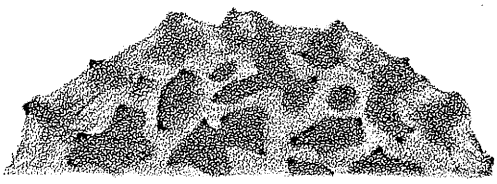
Occurrence. — Seelyville through No. 5 Coals.

Schopfites dimorphus Kosanke, 1950

Occurrence.—Seelyville through No. 5A Coals.

Schopfites cf. *dimorphus* Kosanke, 1950
Text figure 14; plate 5, figure 5

Description.—The small spores are radial, trilete, circular in transverse plane, and are generally in good proximal-distal orientation. The simple rays of the suture are



Text Fig. 14 — Diagrammatic detail of portion of *Schopfites* cf. *dimorphus* Kosanke, 1950.

straight and extend one-half to two-thirds the distance to the spore margin. Except in the area of the rays, the spore surface is covered with low, irregularly shaped verrucae that are 2 to 4μ in diameter. Some of the smaller verrucae are connected by low, irregular ridges. Along the margins of the larger verrucae are sharp coni, 1 to 3μ in diameter and height. The exine is 2.5 to 4μ thick. Dimensions (10 specimens): size range, 41.3 to 97.5μ in maximum diameter; median, 84.5μ.

Figured specimen. — Negative 7204; Summum (No. 4) (?) Coal, maceration 954-Ac, slide 7, coordinates, 132.7 × 40.2; size, 75.7 by 73.5μ.

Discussion. — This taxon, which differs from the typical specimens of *Schopfites dimorphus* by its possession of coni, may actually represent corroded, immature, or overmacerated specimens of *S. dimorphus*.

Occurrence. — No. 2 to No. 4 Coals.

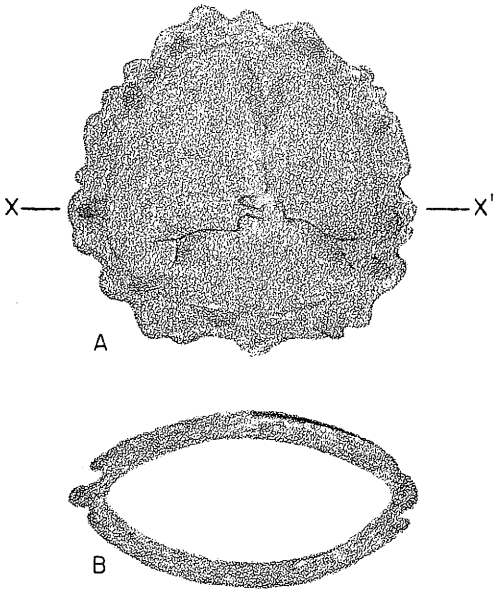
Genus DISTORTISPORITES gen. nov.

Type species. — *Distortisporites illinoiensis* sp. nov.

Diagnosis. — The generic name *Distortisporites* is proposed for spores having the following characteristics. The spores are radial, trilete, and roundly triangular in transverse plane when well oriented, but they are practically always distorted or folded. The trilete rays, some of which are sinuous, are rather distinct when not obscured by folding. They usually bifurcate at the ends, and lips, not often present, are poorly developed. The proximal and distal surfaces are generally levigate, but the margin is characterized by a series of low verrucae that are often poorly developed. Verrucae are irregularly placed and occasionally overlap on the proximal or distal surfaces. The spore exine is thick in relation to spore size. The known size range is 43 to 68μ.

Discussion. — *Distortisporites* is characterized by its distorted orientation and possession of verrucae generally limited to the margin. Only one well oriented specimen was observed. A rather definite line distinguishes the inner wall of the exine (text fig. 15). Careful focusing demonstrates that the spores are thick walled and that the outer equatorial portion is not a separate structure, or cingulum. The surface of the equatorial portion is on the same plane as the central portion of the spore.

Comparison.—Distortisporites has a general appearance similar to *Clavispora* Bhardwaj and Venkatachala, 1961, but the latter is larger, more strongly ornamented and is distinctly divided into a central body and an equatorial zone, or cingulum.



Text Fig. 15 — Diagrammatic reconstruction of the holotype of *Distortisporites illinoiensis* sp. nov. (A) View of proximal surface. (B) Cross section through spore along X-X'.

Etymology. — The generic name refers to the distorted or deformed (*distortus*) nature of the spore exine.

Distortisporites illinoiensis sp. nov.
Text figure 15; plate 5, figures 6-8

Diagnosis. — The miospores are radial, trilete, and, when well oriented, are roundly triangular in transverse plane. Ornamentation gives them a scalloped margin. The spores are almost always contorted and folded. The trilete rays, which are rather distinct when not obscured by folding, generally lack lips, but when present they are not more than 1μ wide. The rays are sometimes sinuous, usually bifurcated at the ends, and they extend at least three-fourths the distance to the spore margin. The proximal and distal surfaces are levigate, even under oil immersion objective. Extending completely around the margin are verrucae that average 3μ high and 5μ wide, occasionally up to 8.5μ wide. Verrucae may slightly overlap on the proximal or distal surface. Some are poorly developed and appear to merge with one another. Between 20 and 25 verrucae can be counted at the margin. The exine between the verrucae is 3 to 4μ thick. Dimensions (15 specimens): size range, 43.2 to 68.3μ in maximum diameter; median, 55.3μ.

Holotype. — Plate 5, figure 6; negative 7735; Lowell Coal, maceration 1402-D, slide 9, coordinates, 132.3 × 45.8; size, 55.9 by 55.3μ exclusive of verrucae.

Paratypes. — Plate 5, figure 7; negative 7787; Lowell Coal, maceration 1404-Q, slide 7, coordinates, 131.1 × 54.4; size, 55.3 by 51.4μ. Plate 5, figure 8; negative 7897; Lowell Coal, maceration 1387-E, slide 2, coordinates, 135.8 × 50.8; size, 68.3 by 45.5μ.

Occurrence. — Lowell, No. 4, and No. 5 Coals.

Etymology. — The species is named for the state of Illinois.

Genus KEWANEESPORITES gen. nov.

Type species.—Kewaneesporites reticuloides (Kosanke, 1950) comb. nov.

Diagnosis. — The generic name *Kewaneesporites* is proposed for miospores having the following characteristics. The small spores are radial, trilete, and circular or oval to roundly triangular in transverse plane. The trilete rays are rather distinct unless obscured by ornamentation, and they extend three-fourths or more the length of the spore radius. Lips, if present, are poorly developed. The proximal and distal surfaces are ornamented with verrucose projections that are piliferous (clavate), slightly obvermiculate, or crater-like. The ornaments are rather widely to closely spaced and are somewhat reduced in size and number in the region of the suture. Covering each projection on their free surfaces is a thin, transparent, and levigate membrane. The spore exine is 1

to 2μ thick. The known size range is 27 to 58μ, not including ornamentation.

Discussion. — The genus *Kewaneesporites* is distinguished from other spore genera by the presence of a thin membrane covering each of the strongly verrucose to clavate projections. The absence of the outer membrane in some specimens may result from overmaceration or poor preservation, or may reflect the degree of spore maturity.

Etymology. — This genus is named for the Kewanee Group (Pennsylvanian) of Illinois.

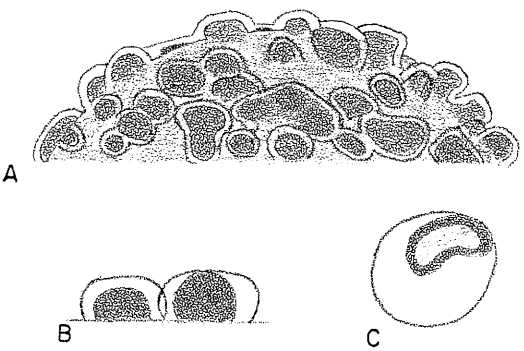
Kewaneesporites reticuloides (Kosanke, 1950) emend. and comb. nov.

Text figure 16; plate 5, figures 9-15

1950 *Punctatisporites reticuloides* Kosanke, p. 18; pl. 1, fig. 7.

Description. — The miospores are radial, trilete, and circular, oval, or roundly triangular in outline. The trilete rays are moderately distinct and simple, extending three-fourths or more the length of the spore radius. The proximal and distal surfaces are covered with verrucose projections that in vertical section are most often semicircular but occasionally are expanded at the ends to take the shape of pila. In end view, the verrucae are circular to oval or slightly obvermiculate, but in practically all specimens there is some evidence of development toward a crater shape, which probably indicates that at least some of the verrucae are hollow. The crater-like ornaments have flattened rims, and the cavity varies from indistinct to large and conspicuous. A thin, transparent membrane surrounds and extends 1 to 2μ beyond each of the projections. The outer membrane is usually absent around the largest projections. The projections are either widely distributed or so closely spaced that they touch one another, but they are reduced in size and number in the region of the trilete suture. The projections are from less than 1 to 10μ wide and up to 5μ long. About 25 to 35 projections extend beyond the spore margin. The exine is about 1μ thick. Dimensions (22 specimens): size range, 26 to 47μ in maximum diameter (not including ornamentation); median, 39μ.

Holotype. — Plate 5, figure 9 (re-illustrated from Kosanke, 1950, pl. 1, fig. 7); negative 7914; size, 47.8 by 45.5μ (not including ornamentation).



Text Fig. 16 — Diagrammatic details of *Kewaneesporites reticuloides* (Kosanke, 1950) emend. and comb. nov. (A) Portion of holotype. (B) View of projections in cross section. (C) Plan view of projection with crater-like rim and outer membrane.

Additional figured specimens. — Plate 5, figure 10; negative 7908; Summum (No. 4) Coal, maceration 1405-A, slide 11, coordinates, 139.5 × 45.0; size, 40.0 by 39.0μ. Plate 5, figure 11; negative 7907; Springfield (No. 5) Coal, maceration 722-B, slide 16, coordinates, 139.0 × 34.6; size, 42.3 by 39.5μ. Plate 5, figure 12; negative 7840; Danville (No. 7) Coal, maceration 1384-U, slide 11, coordinates 139.0 × 55.0; size, 39.0 by 37.1μ. Plate 5, figure 13; negative 7937; Herrin (No. 6) Coal, maceration 1398, slide 2, coordinates, 122.5 × 36.1; size, 41.3 by 39.0μ. Plate 5, figure 14, negative 7922; Danville (No. 7) Coal, maceration 877, slide 9, coordinates, 126.1 × 51.8; size, 35.1 by 32.5μ; high focus. Plate 5, figure 15; negative 7923; same specimen as shown in figure 14 but in low focus.

Discussion. — The crater-like projections, which are a unique feature of *Kewaneesporites reticuloides*, and the extremely variable development of the outer thin membrane make the sculpture of this species difficult to interpret. Specimens

vary from those that possess well developed crater-like verrucae but lack an outer membrane to those in which "cratering" of the verrucae is inconspicuous or absent but have a membrane (pl. 5, figs. 9-10). Between these two extremes are spores that, with careful focusing, show a thin, transparent membrane formed over a darker crater-like structure (pl. 5, fig. 11; text fig. 16C). The outer membrane on the holotype (pl. 5, fig. 9) is narrow and inconspicuous.

Occurrence.—No. 1 Coal; No. 2 through No. 4 Coals; No. 5, No. 6, and No. 7 Coals.

Kewaneesporites patulus (Peppers) emend. and comb. nov.

1964 *Punctatisporites patulus* Peppers, p. 32; pl. 4, figs. 12-13.

Discussion. — The membrane extending beyond the spore margin was incorrectly interpreted (Peppers, 1964, p. 32) as a continuous, scalloped, flange-like structure around the entire spore. This appears to be the case where the projections are so closely packed that the membranes tend to merge. However, the fact that the outer membranes individually enclose the projections can be demonstrated by focusing on the verrucae in end view near the center of the spore.

Comparison. — *Kewaneesporites patulus* differs from *K. reticuloides* by being thicker and by possessing longer and more piliferous projections that are rarely hollow. *K. patulus* is from strata of younger Pennsylvanian age (upper part of Mattoon Formation) than *K. reticuloides.*

Occurrence. — Henshaw Formation of western Kentucky.

Genus LOPHOTRILETES (Naumova) Potonié and Kremp, 1954

Type species. — *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp, 1954.

Lophotriletes commissuralis (Kosanke) Potonié and Kremp, 1955
Plate 5, figure 16

Occurrence.—Murphysboro, No. 2 Coal through the unnamed coal between the No. 4 and No. 5 Coals; Spring Lake, No. 6, and No. 7 Coals.

Lophotriletes microsaetosus (Loose) Potonié and Kremp, 1955
Plate 5, figure 17

Occurrence. — Uncorrelated coal between Cardiff and No. 4 Coals.

Lophotriletes cf. *granoornatus* Artuz, 1957
Plate 5, figures 18, 23

Description. — The spores are radial, trilete, and roundly triangular in transverse plane. They have convex sides and well rounded corners and are usually folded. The distinct trilete rays are straight, usually split open, and extend about three-fourths the distance to the spore periphery. The exine is darker and thicker adjacent to the commissure. Lips are absent, but folds along the commissure may simulate lips. Coni are evenly distributed over the distal surface but are rare on the proximal surface. They are generally sharply pointed but occasionally rounded on the ends, as seen along the margin, and are circular to oval in end view. They are quite variable in size, up to 2.5μ long and from less than 1μ to 3.5μ in diameter, with 2.5μ as the average. The coni, which are rather widely spaced, number from 25 to 35 at the spore margin. The exine is about 1μ thick. Dimensions (34 specimens): size range, 34.1 to 52.6μ in maximum diameter; median, 42.6μ.

Figured specimens. — Plate 5, figure 18; negative 7442; Summum (No. 4) Coal, maceration 1249-A, slide 20, coordinates, 142.4 $\times$ 44.0; size, 38.7 by 34.8μ. Plate 5, figure 23; negative 7443; Summum (No. 4) Coal, maceration 1249-A, slide 10, coordinates, 136.5 $\times$ 27.1; size, 42.3 by 40.0μ.

Discussion.—The Illinois specimens are assigned to *Lophotriletes granoornatus* with some reservation because they resemble the photomicrograph by Artuz (1957, fig. 13a) but are dissimilar to his drawing (1957, fig. 13b). However, the Illinois specimens seem to conform more closely to the specimens illustrated by Artuz than

to those figured by Smith and Butterworth (1967, pl. 6, figs. 3-4). The size, shape, and distribution of the ornaments were not included in Artuz's description, and although he classified the spore under *Lophotriletes*, which is defined as having cone-shaped projections, Artuz referred to the ornaments of *L. granoornatus* as grana. No mention was made of a darkened exine in the region of the laesurae, but the photograph appears to show such a feature.

Occurrence. — Murphysboro, Abingdon (?), No. 2, Cardiff, No. 4, No. 6, Allenby, and No. 7 Coals.

Lophotriletes mosaicus Potonié and Kremp, 1955
Plate 5, figures 19, 24

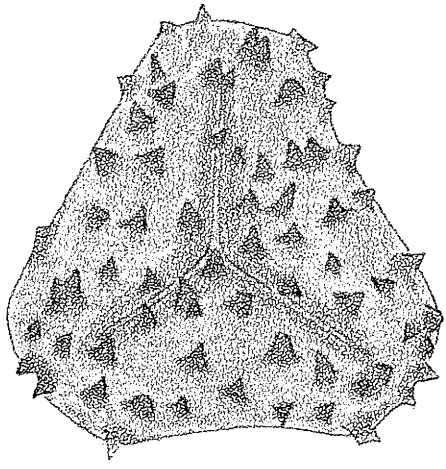
Discussion. — According to Potonié and Kremp (1955, p. 75), the coni on *Lophotriletes mosaicus* are 1.5 to 2μ long; however, it appears from their illustrations (pl. 14, figs. 227-228) that they could be up to 3μ long, as on my specimens. This is the same taxon as the one designated *Granulatisporites* sp. 6 by Peppers (1964, pl. 6, fig. 21).

Occurrence. — Murphysboro Coal; Abingdon (?) through Lowell Coals; and No. 6 Coal.

Lophotriletes rarispinosus sp. nov.
Text figure 17; plate 5, figures 20-22

Diagnosis. — The trilete miospores are radial, triangular in transverse plane, and have straight to slightly interradial sides and rounded corners. The trilete rays are distinct, extend at least three-fourths the distance to the periphery, and are usually split open. Adjacent to the commissure, the exine is often thicker and darker, but lips are not present. The exine is ornamented with wide-based spines or coni that give the exine the appearance of being somewhat verrucose. The flattened basal portion of the spines rises gently to rounded peaks that are usually surmounted by sharp points. The coni, which display considerable variation in size, are less than 1 and up to 4μ, usually 3μ, in diameter at their bases and are up to 2.5μ, usually 2μ, high. They are widely separated, and 18 to 25 extend beyond the spore margin. The exine is about 1μ thick. Dimensions (25 specimens): size range, 19.5 to 28.3μ in maximum diameter, exclusive of ornamentation; median, 25.4μ.

Holotype. — Plate 5, figure 20; negative 7882; Colchester (No. 2) Coal, maceration 1384-H, slide 19, coordinates 139.8 × 43.2; size, 26.0 by 25.4μ.



Text Fig. 17 — Diagrammatic reconstruction of the holotype of *Lophotriletes rarispinosus* sp. nov.

Paratypes. — Plate 5, figure 21; negative 7621; Colchester (No. 2) Coal, maceration 1267, slide 10, coordinates, 125.9 × 35.2; size, 26.7 by 23.4μ. Plate 5, figure 22; negative 7501; Colchester (No. 2) Coal, maceration 1386-A, slide 18, coordinates, 137.9 × 45.0; size, 25.7 by 22.8μ.

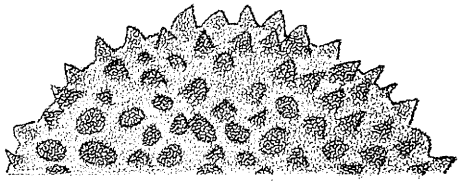
Comparison. — *Lophotriletes rarispinosus* has broader based, more sparsely distributed coni than *L. microsaetosus* (Loose) Potonié and Kremp, 1955, and *L. novicus* Singh, 1964. *L. microsaetosus* is larger than *L. rarispinosus*, attaining up to 40μ in diameter. *L. novicus* has coni aggregated at the corners. *L. interruptus* Habib, 1966, possesses less broadly based coni and is slightly smaller (28 to 38μ) than *L. rarispinosus*. The exine of *L. interruptus* is apparently not thickened adjacent to its rays.

Etymology. — The specific epithet is derived from the sparse (*rarus*) arrangement of spines.

Occurrence. — Murphysboro Coal; DeKoven Coal; Abingdon (?) Coal through the unnamed coal between No. 4 and No. 5 Coals; No. 6 and No. 7 Coals.

Lophotriletes copiosus sp. nov.
Text figure 18; plate 5, figures 25-26

Diagnosis. — The small spores are radial, trilete, and triangular in transverse plane and have gently concave to straight sides and well rounded corners. They usually have secondary folds. The straight trilete rays are simple and extend two-thirds to three-fourths the distance to the spore margin. The commissure is somewhat obscured by the ornamentation of the spore coat. The proximal and distal surfaces are covered with evenly distributed, rather closely spaced coni. The coni are usually sharply pointed, but occasionally they have rounded or truncated ends. In plan view they are circular to oval. The width at their bases and their length, which are about equal, measure 2 to 3μ. The coni are 2 to 3μ apart, but occasionally two are joined at their bases. Approximately 40 to 65 coni protrude beyond the spore periphery. The exine is about 1μ thick. Dimensions (6 specimens): size range, 42.3 to 55.3μ in maximum diameter, exclusive of ornamentation; median, 46.5μ.



Text Fig. 18 — Diagrammatic detail of a portion of the holotype of *Lophotriletes copiosus* sp. nov.

Holotype. — Plate 5, figure 25; negative 7581; Lowell (?) Coal between Cardiff and Summum (No. 4) Coals, maceration 954-B, slide 19, coordinates, 141.0 × 46.0; size, 55.3 by 55.3μ.

Paratype. — Plate 5, figure 26; negative 7888, uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 17, coordinates, 124.2 × 35.3; size, 48.8 by 44.9μ.

Comparison. — *Lophotriletes copiosus* can be distinguished from other species of *Lophotriletes* by the number and small size of the coni. *L. copiosus* resembles *Azontriletes parviverrucosus* Waltz (*in* Luber and Waltz, 1941), except that the latter has more concave sides, and its ornamentation consists of round tubercles rather than coni.

Etymology. — The specific epithet refers to the abundance (copiosus) of small coni.

Occurrence. — No. 2 Coal; uncorrelated coal bands (maceration 1133-E) between No. 2 Coal and Cardiff Coal; Lowell (?) Coal (maceration 954-B) between Cardiff and No. 4 Coals; and Spring Lake Coal.

Lophotriletes ibrahimi (Peppers) Pi-Radondy and Doubinger, 1968
Plate 6, figure 1

Occurrence. — Murphysboro and Lowell Coals.

Lophotriletes pseudaculeatus Potonié and Kremp, 1955
Plate 6, figure 2

Occurrence.—The Abingdon (?) Coal through the unnamed coal between the No. 4 and No. 5 Coals.

Lophotriletes sp. 1
Plate 6, figure 3

Description. — The small spore is radial, trilete, triangular in outline, and has concave interradial sides and well rounded, broad corners. The trilete rays are simple, straight, and equal in length to about three-fourths the spore radius. Coni, which are restricted principally to the distal surface, have blunt ends and are 4 to 5μ in diameter and 2 to 3μ high. Rounded verrucae are also present. Many of the projections are connected at their bases by low ridges.

About 15 projections extend beyond the spore margin. The spore coat is about 1.5μ thick.

Figured specimen. — Negative 7754; uncorrelated coal bands between the No. 2 and Cardiff Coals, maceration 1133-E, slide 15, coordinates, 139.3 × 45.1; size, 35.0 by 32.8μ, not including coni.

Occurrence. — No. 2 Coal; uncorrelated coal bands between No. 2 Coal and Cardiff Coal; Lowell Coal.

Lophotriletes sp. 2
Plate 6, figure 4

Description. — The miospore, which is radial and trilete, is triangular in outline and possesses straight interradial sides and well rounded corners. The straight trilete rays lack lips and extend about three-fourths the distance to the radial corners. The spines, which are sharply pointed, average 2.5μ in width and 3μ in length, and are widely spaced. About 12 coni project beyond the spore margin. The exine is about 1μ thick.

Figured specimen. — Negative 7861; Lowell Coal, maceration 1402-F, slide 15, coordinates, 126.1 × 39.0; size, 38.4 by 35.1μ.

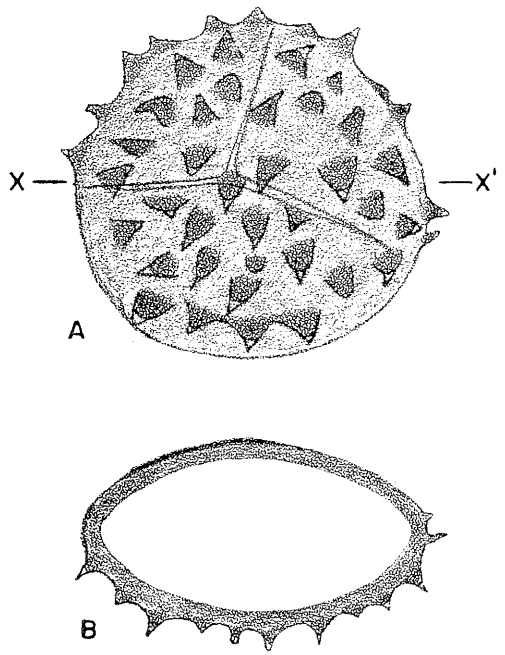
Occurrence. — Lowell Coal.

Genus ANAPICULATISPORITES
Potonié and Kremp, 1954

Type species. — *Anapiculatisporites isselburgensis* Potonié and Kremp, 1954.

Anapiculatisporites grundensis sp. nov.
Text figure 19; plate 6, figures 5-6

Diagnosis. — The miospores are radial, trilete, and roundly triangular in transverse plane and are usually twisted or folded in compression. The trilete rays are distinguished by elevated, slightly contorted lips about 1μ wide. The proximal surface is levigate, but the distal surface is covered except along the interradial margins, with cone-like spines that are widely separated. Individual coni are longer than are the diameters of their bases, and some are bent. They are 2 to 3μ long and up to 2μ wide at their bases. The spore margin has 15 to 20 spines extending beyond it when the spore is obliquely compressed. The exine is thick (1.5 to 2μ) in comparison to the spore size. Dimensions (12 specimens): size range, 19.5 to 23.7μ in maximum diameter, exclusive of spines; median, 20.8μ.



Text Fig. 19 — Diagrammatic reconstruction of the holotype of *Anapiculatisporites grundensis* sp. nov. (A) View from distal surface. (B) Cross section through spore along X-X'.

Holotype. — Plate 6, figure 5; negative 7793; Murphysboro Coal, maceration 1160 (RR), slide 1, coordinates, 133.1 × 38.3; size, 22.8 by 17.2μ.

Paratype. — Plate 6, figure 6; negative 7924; Murphysboro Coal, maceration 1160 (RR), slide 9, coordinates, 141.5 × 44.0; size, 20.5 by 20.2μ.

Comparison.—*Anapiculatisporites grundensis* is similar in over-all appearance to *Pustulatisporites vergrandis* Upshaw and Creath, 1965, except that their specimens have pustules on the proximal and distal surfaces that are only 0.5μ long, possess a differentiated contact area, and are larger (22 to 33μ in diameter). *Apiculatisporis baccatus* (Hoffmeister, Staplin, and Malloy) var. *pauciverrucosus* Staplin, 1960,

has sutures that are not prominent, and, the spore illustrated by Staplin seems to have larger, more closely spaced verrucae. *Apiculatisporis levis* Balme and Hennelly, 1956, has smaller, more numerous spines than are found on *Anapiculatisporites grundensis* and has a darkened contact area.

Etymology. — The species is named for Grundy County, Illinois.

Occurrence.—Murphysboro, No. 2, and Lowell Coals.

Anapiculatisporites spinosus (Kosanke) Potonié and Kremp, 1955

Discussion. — *Anapiculatisporites hispidus* Butterworth and Williams, 1958, is most probably a synonym of *A. spinosus.*

Occurrence. — Wiley through No. 5 Coals; No. 6 Coal.

Genus PUSTULATISPORITES
Potonié and Kremp, 1955

Type species. — *Pustulatisporites pustulatus* Potonié and Kremp, 1955.

Pustulatisporites crenatus Guennel, 1958
Plate 6, figure 7

Discussion. — Except for minor differences, *Pustulatisporites crenatus* and *Punctatisporites verrucifer* Kosanke, 1950, are similar. The projections on *Pustulatisporites crenatus* are apparently more pointed than those on *Punctatisporites verrucifer*, and the former is smaller (35 to 52μ) than the latter (60 to 74μ).

Occurrence. — Murphysboro and No. 2 Coals.

Pustulatisporites sp. 1
Plate 6, figure 8

Description. — The spores are radial, trilete, triangular in transverse plane, and have straight to convex interradial sides and well rounded corners. The rather distinct trilete rays are straight and extend about two-thirds the distance to the corners. The exine is covered with protuberances that are verrucose to baculate, but in a few specimens coni with rounded ends are present. In plan view the projections are circular to subcircular, 2.5 to 3.5μ high and in diameter, and 2 to 3μ apart. Projecting beyond the spore wall, which is about 2μ thick, are 30 to 40 protuberances. Dimensions (5 specimens): size range 37 to 54μ.

Figured specimen. — Negative 7886; Danville (No. 7) Coal, maceration 1384-V, slide 12, coordinates, 125.6 × 38.7; size, 40.6 by 39.0μ.

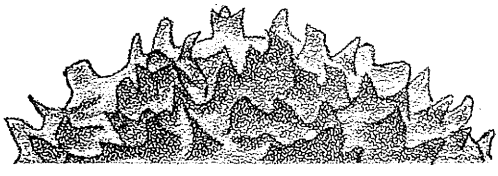
Occurrence. — No. 2, Lowell, No. 6, and No. 7 Coals.

Genus APICULATISPORIS
Potonié and Kremp, 1956

Type species. — *Apiculatisporis aculeatus* (Ibrahim) Smith and Butterworth, 1967.

Apiculatisporis frequentispinosus sp. nov.
Text figure 20; plate 6, figures 9-10

Diagnosis. — The miospores are radial, trilete, and roundly triangular to elliptical in transverse plane. The simple rays are straight, partially obscured by ornamentation, and extend about three-fourths the distance to the spore margin. The exine is covered by closely spaced spines that average 3μ in length but have a range of 1 to 5μ. The basal diameter of the spines is about equal to their length. The spines are sharply pointed or slightly rounded on the ends and are often connected at their bases by low, narrow ridges that make an almost reticulate pattern. Spines possessing truncated ends are rare. Between 25 and 32 spines extend beyond the spore margin. The spore coat is about 3μ thick. Dimensions (9 specimens): size range, 53.6 to 63.4μ in maximum diameter, excluding spines; median, 55.6μ.



Text Fig. 20 — Diagrammatic detail of a portion of the holotype of *Apiculatisporis frequentispinosus* sp. nov.

Holotype. — Plate 6, figure 9; negative 7827; uncorrelated coal bands between the Colchester (No. 2) Coal and Cardiff Coal, maceration 1133-E, slide 28, coordinates, 137.8 × 46.4; size, 58.5 by 52.0μ.

Paratype. — Plate 6, figure 10; negative 7752; uncorrelated coal bands between Colchester (No. 2) Coal and Cardiff Coal, maceration 1133-E, slide 7, coordinates, 133.7 × 57.9; size, 56.9 by 48.8μ.

Comparison. — *Apiculatisporis abditus* (Loose) Potonié and Kremp, 1955, has longer, less pointed spines that are not as crowded and are not connected at the base as are those of *A. frequentispinosus*.

Etymology. — The specific epithet suggests the crowded (*frequens*) nature of the spines on the spore surface.

Occurrence. — Uncorrelated coal bands (maceration 1133-E) between No. 2 and Cardiff Coals.

Apiculatisporis abditus (Loose)
Potonié and Kremp, 1955
Plate 6, figures 11-13

Discussion. — *Apiculatisporis abditus* shows considerable variation in size of spines and is quite similar to *Raistrickia irregularis* Kosanke, 1950. The spines on *R. irregularis* are more abundant on the distal than on the proximal surface and generally are longer.

Occurrence. — Murphysboro Coal; Abingdon (?) through No. 5 Coals; Spring Lake, No. 6, and No. 7 Coals.

Apiculatisporis lappites sp. nov.
Text figure 21; plate 6, figures 14-15

Diagnosis. — The spores are radial, trilete, circular to oval in transverse plane, and many are folded. The rays are simple, extend to the spore margin, and are somewhat obscured by the ornamentation. The exine is covered with closely packed, sharply pointed spines, most of which are curved. They are about 1μ long and less than 0.5μ wide at their bases, but a few spines are up to 1.5μ long. Thirty to 40 can be counted projecting beyond the spore periphery. The exine is less than 1μ thick. Dimensions (45 specimens): size range, 10.4 to 16.3μ in maximum diameter not including ornamentation; median, 13.3μ.

Holotype. — Plate 6, figure 14; negative 7926; Lowell Coal, maceration 1387-F, slide 16, coordinates, 138.8 × 52.3; size, 15.0 by 13.6μ (not including spines).

Paratype. — Plate 6, figure 15; negative 7934; Lowell Coal, maceration 1387-D, slide 14, coordinates, 135.3 × 44.0; size, 15.3 × 12.7μ.

Text Fig. 21 — Diagrammatic detail of a portion of the holotype of *Apiculatisporis lappites* sp. nov.

Comparison. — *Apiculatisporis lappites* is distinguished by its small size and closely packed spines. Except for its smaller size and slightly shorter spines, *A. lappites* resembles *Acanthotriletes echinatoides* Artuz, 1957.

Etymology. — The species name refers to the spore's resemblance to a bur (*lappa*).

Occurrence. — Wiley Coal; Abingdon (?) through No. 5 Coals.

Apiculatisporis setulosus (Kosanke)
Potonié and Kremp, 1955
Plate 6, figure 16

Occurrence. — Murphysboro Coal; Abingdon (?) through No. 5 Coals; No. 6 and No. 7 Coals.

Apiculatisporis sp. 1
Plate 6, figure 17

Diagnosis. — The miospore is radial, trilete, and oval in transverse plane. The trilete rays are indistinct, straight, and almost reach the spore margin. A dark area that extends outward from the proximal pole about one-third the length of the radius is made up of closely spaced grana, about 1μ in diameter. The exine is ornamented, mostly on the distal surface, with sharply pointed or truncated spines 2 to 3μ in diameter and about 3μ long. Approximately 36 spines project beyond the

spore margin. The spore coat is about 1μ thick.

Figured specimen. — Negative 7649; Herrin (No. 6) Coal, maceration 1404-CC, slide 19, coordinates, 125.3 × 37.9; size, 35.8 by 32.5μ.

Comparison. — *Apiculatisporis* sp. 1 is similar in over-all appearance to *Anaplanisporites stipulatus* Jansonius, 1962, except that the latter has wart-like protuberances that are smaller than the spines of *Apiculatisporis* sp. 1.

Occurrence. — No. 6 Coal.

Genus ACANTHOTRILETES (Naumova) Potonié and Kremp, 1954

Type species. — *Acanthotriletes ciliatus* (Knox) Potonié and Kremp, 1954.

Acanthotriletes aculeolatus (Kosanke) Potonié and Kremp, 1955
Plate 6, figure 18

Occurrence.—Murphysboro, Wiley, De-Koven, Abingdon (?), and Lowell Coals.

Acanthotriletes dimorphus Habib, 1966
Plate 6, figure 19

Occurrence. — No. 2, Lowell, and No. 4 Coals; No. 5 Coal.

Acanthotriletes sp. 1
Plate 6, figure 20

Description. — The small spore is radial, trilete, and roundly triangular in transverse plane. The rather indistinct trilete rays extend about two-thirds the distance to the equator. The proximal and distal surfaces are covered with sharply pointed, occasionally truncated spines that almost touch at their bases. They are about 3μ long and 1.5μ wide. Approximately 40 spines project beyond the spore wall, which is about 1μ thick.

Figured specimen. — Negative 7707; Murphysboro Coal, maceration 1160 (RR), slide 19, coordinates, 131.7 × 49.1; size, 38.7 by 32.5μ.

Comparison.—This species may be conspecific with *Azonotriletes parvispinus* Luber, 1941, but a comparison with Luber's drawing is difficult to make.

Occurrence. — Murphysboro Coal.

Genus PILEATISPORITES gen. nov.

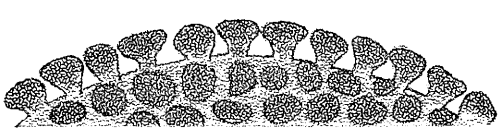
Type species. — *Pileatisporites aequus* sp. nov.

Diagnosis. — The generic name *Pileatisporites* is proposed for miospores having the following characteristics. The spores are radial, trilete, triangular in transverse plane, and have straight, or nearly straight, interradial sides and well rounded corners. The proximal and distal surfaces are covered with nearly equidimensional pileiform, or mushroom-shaped, projections. In plan view the pilei are circular to subcircular. The known size range is 61 to 69μ.

Comparison.—*Pileatisporites* differs from *Lophotriletes*, *Granulatisporites*, *Apiculatisporis*, *Converrucosisporites*, and other triangular ornamented miospores by possessing pileiform projections (text fig. 22). *Pileatisporites* differs from *Tricidarisporites* Sullivan and Marshall, 1966, by being ornamented on the proximal as well as distal surface and by having pilei of almost equal dimensions.

Pileatisporites aequus sp. nov.
Text figure 22; plate 6, figures 21-23

Diagnosis. — The miospores are radial, trilete, triangular in outline, and have straight to slightly concave or convex sides and well rounded corners. Secondary folding of the exine is common. The straight



Text Fig. 22 — Diagrammatic detail of a portion of the holotype of *Pileatisporites aequus* sp. nov.

trilete rays are fairly distinct, extend about three-fourths the distance to the corners, and lack lips. The commissure is frequently torn open. The proximal and distal surfaces of the spore coat are covered with pileiform projections that are made

up of a stalk and a cap. In end view the pilei are subcircular. They are of uniform size and distribution and are so closely packed that the pilei almost touch each other. The entire length of the projections is about 1μ, whereas the pileate portion is 0.5 to 1μ in diameter. Approximately 130 to 150 can be counted projecting beyond the spore margin. The exine is about 1μ thick. Dimensions (5 specimens): size range, 61.4 to 69.2μ in maximum diameter, including ornamentation.

Holotype. — Plate 6, figure 21; negative 7788, Lowell Coal, maceration 1404-Q, slide 24, coordinates, 139.9 × 31.0; size, 61.4 by 59.2μ. Plate 6, figure 23; negative 7920; holotype under oil immersion objective.

Paratype. — Plate 6, figure 22; negative 7619, Lowell Coal, maceration 1404-Q, slide 10, coordinates, 125.0 × 49.2; size, 65.3 by 56.2μ.

Etymology. — The species name is derived from the almost equal (*aequus*) size and distribution of the pileiform ornaments.

Occurrence. — Lowell Coal.

Genus Raistrickia
Schopf, Wilson, and Bentall, 1944

Type species. — *Raistrickia grovensis* Schopf, Wilson, and Bentall, 1944.

Raistrickia cf. *aculeata* Kosanke, 1950
Plate 7, figure 1

Discussion. — The spores assigned to this species have slightly shorter spines than those described by Kosanke (1950).

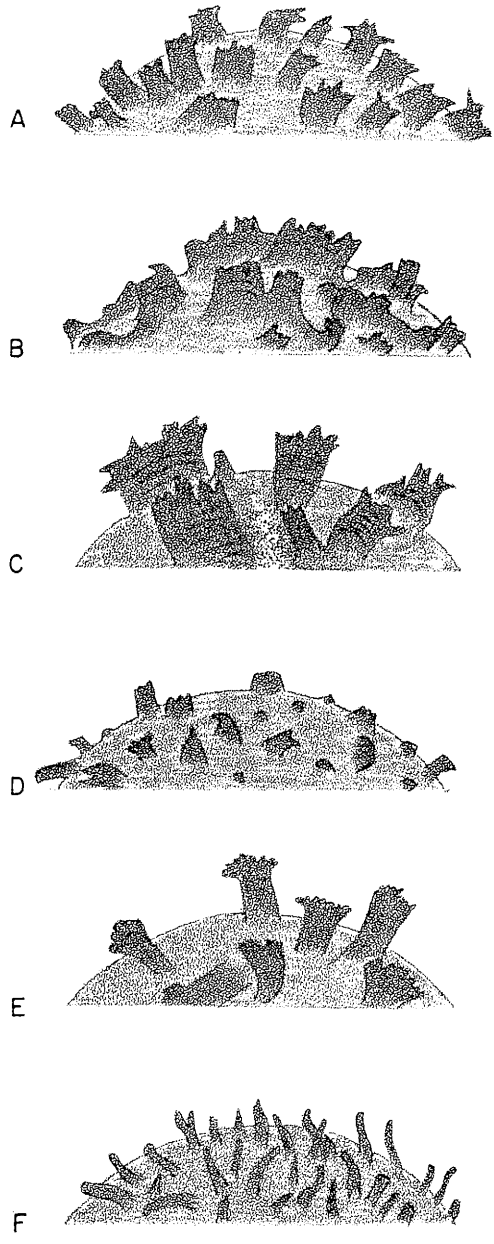
Occurrence. — Lowell, No. 4, No. 6, and No. 7 Coals.

Raistrickia aculeolata
Wilson and Kosanke, 1944
Plate 7, figure 2

Occurrence. — Wiley, No. 2, Lowell, No. 6, and No. 7 Coals.

Raistrickia breveminens sp. nov.
Text figure 23A; plate 7, figures 3-4

Diagnosis. — The small spores are radial, trilete, and circular, elliptical, or roundly triangular in outline. Very few are folded. The rays are distinct, straight, and extend two-thirds to three-fourths the distance to the spore margin. On each side



Text Fig. 23 — Diagrammatic details of portions of the holotypes of (A) *Raistrickia breveminens* sp. nov. (B) *R. carbondalensis* sp. nov. (C) *R. lacerata* sp. nov. (D) *R. dispar* sp. nov. (E) *R. lowellensis* sp. nov. (F) *R. subcrinita* sp. nov.

of the commissure are lips about 1.5μ wide. The proximal and distal surfaces are ornamented with processes of diverse forms that generally are wider than long and have straight to slightly tapered sides. Setae, which are not uncommon, are generally not more than 1.5 times as long as they are wide. Club-shaped projections are rare. Occasionally interspersed among the major processes are narrow, small, irregularly shaped or spinose projections.

Most of the major projections are distinctly partate or lacerated on the ends. They are elliptical in end view, and under oil immersion objective cross striations can be observed on some of the projections. They are up to 7μ long and 8.5μ wide, with 5μ as an average length and width, except for the narrow spinose projections that may be 2μ or less in width. The projections are quite uniformly distributed and closely spaced, so that almost the entire surface of some specimens is covered. Projecting beyond the periphery are 18 to 30 processes. The exine is 1.5 to 2.5μ thick. Dimensions (21 specimens): size range, 53.0 to 74.8μ in maximum diameter, exclusive of ornamentation; median, 60.5μ.

Holotype. — Plate 7, figure 3; negative 7891; Colchester (No. 2) Coal, maceration 1034-B (RR), slide 19, coordinates, 135.3 $\times$ 51.4; size, 65.0 by 60.0μ.

Paratype. — Plate 7, figure 4; negative 7892; Colchester (No. 2) Coal, maceration 1404-N, slide 10, coordinates, 144.6 $\times$ 50.7; size, 55.3 by 50.1μ.

Comparison. — *Raistrickia breveminens* is distinguished from other species of the genus by its short, wide processes with lacerated ends. *R. fibrata* (Loose) Schopf, Wilson, and Bentall, 1944, has narrower and shorter processes that are only occasionally partate. *R. kentuckiensis* Peppers, 1964, and *R. lowellensis* sp. nov. are smaller and have proportionately longer processes.

Etymology. — The specific epithet suggests the short (*brevis*) projections (*eminens*) that characterize this spore.

Occurrence.—Wiley and DeKoven Coals; Abingdon (?) Coal through the unnamed coal between No. 4 and No. 5 Coals; No. 6 and No. 7 Coals.

Raistrickia carbondalensis sp. nov.
Text figure 23B; plate 7, figures 5-6

Diagnosis. — The miospores are radial, trilete, and circular to elliptical in transverse plane. Secondary folds are common. The straight rays, which are often obscured by ornamentation or folding, are without lips and extend at least three-fourths the length of the spore radius. The exine is covered with setae that are partate at the ends and average 5μ long and 4μ wide but may be up to 7μ long and 6μ wide. Club-shaped projections, spines, and coni also may be present but are rare and may represent broken setae. Many projections are joined near their bases by low ridges, which may form a somewhat reticulate pattern. Between the major processes minute spines may rise from the ridges. The major projections are far enough apart to allow additional projections of equal size between them. From 20 to 33 projections can be counted beyond the spore margin. The spore coat is 1.5 to 2.5μ thick. Dimensions (15 specimens): size range, 58.5 to 78.0μ; median, 68.3μ.

Holotype. — Plate 7, figure 5; negative 7655; Lowell Coal, maceration 1384-N, slide 20, coordinates, 130.9 $\times$ 44.6; size, 67.6 by 61.8μ.

Paratype. — Plate 7, figure 6; negative 7831; uncorrelated coal bands between the Colchester (No. 2) Coal and Cardiff Coal, maceration 1133-E, slide 19, coordinates, 124.2 $\times$ 35.5; size, 70.5 by 64.7μ.

Comparison.—*Raistrickia carbondalensis* resembles *R. solaria* Wilson and Hoffmeister, 1956, except that the former has projections that are smaller, more widely spaced, and often connected at the base by ridges.

Etymology. — The species name is derived from the Carbondale Formation (Pennsylvanian) of Illinois.

Occurrence. — Wiley Coal; Abingdon (?) through Lowell Coals; unnamed coal between the No. 4 and No. 5 Coals.

Raistrickia cf. *clavata* (Hacquebard) Playford, 1963
Plate 7, figure 7

Discussion. — This spore is referred to *R. clavata* with some reservation because the Carbondale Formation is much younger than the Mississippian Horton Group of Nova Scotia from which this species was first described. The spore is ornamented with characteristically large mushroom-shaped projections and conforms in other ways to the description given by Hacquebard and Playford.

Occurrence. — Lowell Coal.

Raistrickia crinita Kosanke, 1950
Plate 7, figure 8

Occurrence. — No. 2 through Jamestown Coals; No. 7 Coal.

Raistrickia cf. fibrata (Loose) Schopf, Wilson, and Bentall, 1944
Plate 7, figure 9

Occurrence. — Murphysboro Coal; Abingdon (?) through No. 4 Coals; No. 6 and No. 7 Coals.

Raistrickia grovensis Schopf, Wilson, and Bentall, 1944
Plate 7, figure 10

Occurrence. — Lowell, No. 4, No. 6, and No. 7 Coals.

Raistrickia crocea Kosanke, 1950
Plate 7, figure 11

Comparison.—This species may be conspecific with *Raistrickia saetosa* (Loose) Schopf, Wilson, and Bentall, 1944.

Occurrence.—Murphysboro, Wiley, and DeKoven Coals; No. 2 through No. 5A Coals; No. 6 and No. 7 Coals.

Raistrickia lacerata sp. nov.
Text figure 23G; plate 7, figures 12-13

Diagnosis. — The miospores are radial, trilete, and roundly triangular to oval in polar view. The rays of the suture are distinct, straight, and extend one-half to two-thirds the distance to the spore periphery. Lips when present are about 1μ wide. The spore coat is ornamented with three kinds of projections. The most conspicuous are large setaceous processes that have straight or slightly tapered or expanded sides. They are up to 10.5μ wide and 13μ long. Distinctly club-shaped or fan-shaped processes, both of which are very rare, are usually longer than wide, but their length does not exceed 1.5 times their width. Many setae are wider than they are long. The ends are flat but distinctly partate. The secondary subdivisions on the ends may be up to 3μ long, and some of them have tertiary, minute spines. The major processes are loosely set so that 8 to 12 may extend beyond the margin. Cross striations on the projections can be seen under oil immersion objective. The second kind of projection consists of narrow (1 to 4μ wide) setae that in most specimens are as long as the major processes. They are quite irregular in shape, having sharply pointed to expanded ends that are not partate. They are not as numerous as the larger projections and number six or less at the spore periphery. The third set of ornaments, well rounded verrucae about 3μ in diameter and height that are loosely scattered between the setaceous processes, may be absent on some specimens. The exine is 2 to 3μ thick. Dimensions (22 specimens): size range, 45.8 to 74.8μ in maximum diameter; median, 61.8μ.

Holotype. — Plate 7, figure 12; negative 7667; Colchester (No. 2) Coal, maceration 1246, slide 20, coordinates, 141.1 $\times$ 39.0; size, 65.0 by 62.4μ.

Paratype. — Plate 7, figure 13; negative 7231; Cardiff Coal, maceration 1034-A, slide 8, coordinates 129.2 $\times$ 39.3; size, 64.0 by 54.6μ.

Comparison. — *Raistrickia lacerata* is distinguished by its large setaceous processes, which have well lacerated ends. *R. crocea* Kosanke, 1950, *R. saetosa* (Loose) Schopf, Wilson, and Bentall, 1944, and *R. superba* (Ibrahim) Schopf, Wilson, and Bentall, 1944, have narrower setae in rela-

tion to length. *R. breveminens* has more numerous and smaller setae than *R. lacerata.*

Etymology. — The specific epithet refers to the distinctly lacerated (*lacer*) ends on the processes.

Occurrence. — Abingdon (?) through Lowell Coals; No. 6 Coal.

Raistrickia irregularis Kosanke, 1950
Plate 7, figures 14-15

Discussion. — The processes of *Raistrickia irregularis* vary in spacing and numbers. In the holotype (Kosanke, 1950, pl. 11, fig. 5) and in figure 14, the processes are relatively widely spaced, whereas the spore in figure 15 possesses closely spaced processes. Twenty processes extend beyond the periphery of the spore in figure 14, and 29 can be counted around the margin of the spore in figure 15. As in *Apiculatisporis abditus*, the processes are more numerous on the distal than on the proximal surface.

Occurrence.—Murphysboro, Wiley, and DeKoven Coals; Abingdon (?) through No. 4 Coals; No. 5, No. 5A, No. 6, and No. 7 Coals.

Raistrickia solaria
Wilson and Hoffmeister, 1956
Plate 7, figure 16

Occurrence. — Abingdon (?) through Lowell Coals.

Raistrickia dispar sp. nov.
Text figure 23D; plate 8, figures 1-2

Diagnosis. — The small spores are radial, trilete, and roundly triangular to oval in outline. Minor folds are common. The rays, which are indistinct owing to the ornamentation, extend two-thirds to three-fourths the distance to the spore margin. Lips about 1μ wide on either side of the commissure are present. The spore coat is covered with moderately closely spaced projections of various shapes and sizes. Setae, the most common kind of projection, have truncated ends and sides that are either tapered or parallel. The height and width of the individual setae at their bases are about equal. Narrow, pointed spines, verrucae, and coni are often present. The coni may be wider at their bases than they are high. Occasionally on the ends of the setae or coni are one or two spines not more than 1μ long. The projections are 2 to 6μ wide at their bases, and they average 4μ long, but may be as much as 7μ. About 20 to 30 ornaments extending beyond the spore margin can be counted. The spore coat is 1 to 2μ thick. Dimensions (10 specimens): size range, 47.8 to 61.8μ in maximum diameter exclusive of ornamentation; median, 54.6μ.

Holotype. — Plate 8, figure 1; negative 7479; Lowell Coal, maceration 1190, slide 6, coordinates, 138.5 $\times$ 49.4; size, 53.0 by 49.4μ.

Paratype. — Plate 8, figure 2; negative 7890; Colchester (No. 2) Coal, maceration 1402-A, slide 15, coordinates, 134.5 $\times$ 35.4; size, 58.5 by 52.3μ.

Etymology. — The specific name refers to the diverse (*dispar*) morphology of the ornamentation on this taxon.

Occurrence. — No. 2 and Lowell Coals.

Raistrickia lowellensis sp. nov.
Text figure 23E; plate 8, figures 3-4

Diagnosis. — The miospores are radial, trilete, circular in transverse plane, and possess secondary folds. The straight rays are rather distinct, extend two-thirds to three-fourths the length of the spore radius, and have lips about 1μ wide. The proximal and distal sides are ornamented with rather loosely set, ribbon-like processes. They range from setaceous to club- or fan-shaped in lateral view and have partate ends. A few processes branch into two major subdivisions at the base, near the middle, or near the end. Transverse striations can be observed on some projections when viewed under oil immersion objective. Individual processes are longer than they are wide and vary from 5 to 10μ in length and from 3 to 4.5μ in width. Spines on the partate ends are 1 to 2μ long and vary in number from 1 to at least 6. Beyond the spore periphery, 12 to

22 processes can be counted. The spore coat is not more than 1μ thick. Dimensions (16 specimens): size range, 32.8 to 50.4μ in maximum diameter; median, 45.6μ.

Holotype. — Plate 8, figure 3; negative 7656; Lowell Coal, maceration 1384-N, slide 11, coordinates, 123.1 × 44.1; size, 46.5 by 43.9μ.

Paratype. — Plate 8, figure 4; negative 7510; Colchester (No. 2) Coal, maceration 1386-A, slide 4, coordinates, 143.3 × 45.0; size, 48.8 by 42.3μ.

Comparison. — *Raistrickia lowellensis* most closely resembles *R. crocea* Kosanke, 1950, but is smaller and has smaller projections. Major branching of processes is also found in *R. protensa* Kosanke, 1950, but it has a larger diameter and larger projections than *R. lowellensis*. *R. kentuckiensis* Peppers, 1964, is thicker and has more numerous projections that are not as ribbon-like. *R. superba* (Ibrahim) Schopf, Wilson, and Bentall, 1944, has processes that are often conical and lack fan-shaped projections that have major branches. The specimen of *R. superba* illustrated by Potonié and Kremp (1955, fig. 263) may be somewhat like *R. lowellensis*, but it is not like the holotype or the description of *R. superba* given by Ibrahim or Potonié and Kremp. *R. aculeolata* Wilson and Kosanke, 1944, is larger and lacks fan-shaped projections.

Etymology. — This species is named for the Lowell Coal of Illinois.

Occurrence. — No. 2 and Lowell Coals, the unnamed coal between the No. 4 and No. 5 Coals, and No. 6 Coal.

Raistrickia subcrinita sp. nov.
Text figure 23F; plate 8, figures 5-6

Diagnosis. — The miospores are radial, trilete, and roundly triangular in outline. The interradial sides are well rounded, and secondary folds are common. The trilete rays are straight, and extend about two-thirds the length of the spore radius. The commissure is lined with fairly distinct lips about 1μ wide. The exine is covered with rather evenly distributed projections, mostly spines, that are close together, but enough space exists between them for additional ones. Most of the projections, which are often bent, have tapered to gently rounded ends. A few processes are truncated, cone shaped, or possess ends that are pointed, swollen, or subdivided. They average 4 to 6μ long and 1 to 2.5μ wide. As many as 40, but more commonly 25 to 30, can be counted projecting beyond the spore margin. Dimensions (25 specimens): size range, 46.2 to 68.3μ in maximum diameter; median, 58.5μ.

Holotype. — Plate 8, figure 5; negative 7824; Summum (No. 4) Coal, maceration 1405-B, slide 12, coordinates, 136.8 × 41.2; size, 48.8 by 47.5μ.

Paratype. — Plate 8, figure 6; negative 7826; coal bands between Colchester (No. 2) Coal and Cardiff Coal, maceration 1133-E, slide 16, coordinates, 122.9 × 41.7; size, 46.2 by 42.3μ.

Comparison. — This species was assigned to *Raistrickia* rather than *Acanthotriletes* because only an occasional projection is sharply pointed. *Raistrickia subcrinita* is comparable to *R. crinita* Kosanke, 1950, but is thinner and has smaller projections than the latter. *R. aculeata* Kosanke, 1950, is more nearly circular and has longer spines.

Etymology. — The species name suggests its general similarity to *Raistrickia crinita*.

Occurrence. — Wiley through No. 7 Coals, with the exception of the Jamestown and Allenby Coals.

Raistrickia pilosa Kosanke, 1950
Plate 8, figure 7

Occurrence. — No. 2, Lowell, No. 6, and No. 7 Coals.

Raistrickia protensa Kosanke, 1950

Occurrence. — Lowell, No. 5A, and No. 6 Coals.

Raistrickia pontiacensis sp. nov.
Plate 8, figure 8

Diagnosis. — The miospores are radial, trilete, and circular to oval in outline. The commissure is usually distinct but may be

partially obscured by the coarse ornamentation. The rays are straight, simple, and about equal in length to two-thirds the spore radius. The exine is set with large, rounded projections that usually extend beyond the spore wall a distance greater than their width. In plan view they are subcircular. They average 6μ long and 5μ wide but reach 10μ long and 8.5μ wide. Their ends are well rounded but occasionally slightly expanded. Two projections are sometimes connected at their bases. Approximately 12 to 15 projections extend beyond the spore margin. The spore coat is about 1.5μ thick. Dimensions (11 specimens): size range, 44.2 by 62.4μ in maximum diameter, not including verrucae; median, 53.3μ.

Holotype. — Plate 8, figure 8; negative 7729; Lowell Coal, maceration 1387-D, slide 9, coordinates, 142.0 × 34.4; size, 56.2 by 51.7μ.

Etymology. — The species is named for the town of Pontiac in Livingston County, Illinois.

Occurrence. — No. 2, Lowell, and No. 6 Coals.

Raistrickia superba (Ibrahim) Schopf, Wilson, and Bentall, 1944
Plate 8, figure 9

Occurrence. — No. 2, Lowell, and No. 6 Coals.

Raistrickia sp. 1
Plate 8, figure 10

Description. — The miospore is radial, trilete, and subcircular in outline. The trilete rays lack lips and are equal in length to about three-fourths the spore radius. The exine is crowded with spinose and setaceous projections that have pointed, blunted, and occasionally bifurcated ends. The projections, which appear subcircular in end view, are about 4μ long and 2 to 3μ wide. About 54 projections extend beyond the spore coat, which is about 1μ thick.

Figured specimen. — Negative 7718; Colchester (No. 2) Coal, maceration 1402-B, slide 10, coordinates, 138.4 × 51.6; size, 52.0 by 43.2μ.

Comparison. — Except for the nearly circular shape of *Raistrikia* sp. 1, it is similar to *R. subcrinita* sp. nov.

Occurrence. — No. 2 Coal.

Raistrickia sp. 2
Plate 8, figure 11

Description.—The small spore is radial, trilete, and roundly triangular in transverse plane. The indistinct trilete rays are straight and lack lips. The exine displays long club-shaped or setaceous projections that are up to 11μ long and 6.5μ wide but average 7μ and 3μ, respectively. Some of the longer projections are greatly expanded near their ends. Short verrucose projections, which are 2 to 3μ in length and diameter, also are present. As seen under oil immersion objective, the projections are cross triated. They are moderately spaced, and approximately 32 extend beyond the spore margin. The spore coat is about 2μ thick.

Figured specimen. — Negative 7636; Danville (No. 7) Coal; maceration 1418-A, slide 16, coordinates, 125.0 × 32.7; size, 59.2 by 52.0μ.

Occurrence. — Lowell, No. 6, and No. 7 Coals.

Raistrickia (?) sp. 3
Plate 8, figure 12

Description. — The miospore is radial, trilete, and circular in outline. The distinct commissure is open and does not possess lips. The trilete rays are straight and extend about two-thirds the distance to the spore equator. The distal surface of the exine is covered with closely packed, elongate projections that display slightly tapered sides and well rounded ends. They are about 6.5μ long and have a maximum width of about 3.5μ. Some are bent, and occasionally two or more are joined at their bases. Most of the projections are weakly cross striated when viewed under oil immersion objective. The spore coat is about 4μ thick.

Figured specimen. — Negative 7605; Lowell Coal, maceration 1404-O, slide 7, coordinates, 131.0 × 40.3; size, 76.1 by 71.5μ not including ornamentation.

Occurrence. — No. 2, Lowell, and No. 6 Coals.

Genus CONVOLUTISPORA
Hoffmeister, Staplin, and Malloy, 1955

Type species. — *Convolutispora florida* Hoffmeister, Staplin, and Malloy, 1955.

Convolutispora cf. *florida*
Hoffmeister, Staplin, and Malloy, 1955
Plate 8, figure 13

Discussion. — A spore encountered in the Colchester (No. 2) Coal is assigned to *Convolutispora florida* with reservation because only one specimen was observed. It is apparent from the illustrations of Hoffmeister, Staplin, and Malloy (1955, pl. 38, figs. 6 and 7) that there must be considerable variation in the morphology of this species.

Occurrence. — No. 2 Coal.

Convolutispora fromensis
Balme and Hassell, 1962
Plate 8, figure 14

Occurrence. — No. 2 and No. 7 Coals.

Convolutispora sp. 1
Plate 8, figure 15

Description. — The small spore is radial, trilete, and subcircular in outline. The indistinct trilete rays are straight and extend about three-fourths the distance to the spore margin. Irregularly shaped ridges and verrucae that are on the spore surface are widely spaced, have rounded crests, and are up to 8μ wide and 3μ tall. About 14 ridges project beyond the spore margin. The exine is about 1μ thick.

Figured specimen. — Negative 7706; Murphysboro Coal, maceration 1160 (RR), slide 20, coordinates, 129.9 × 35.1; size, 37.4 by 35.2μ.

Occurrence. — Murphysboro Coal.

Convolutispora sp. 2
Plate 8, figure 16

Description. — The miospore is radial, trilete, and subcircular in outline. The suture is indistinct. The exine, which is 1.5μ thick, is covered with irregular obvermiculate ridges about 3.5μ in height.

Figured specimen.—Negative 7502; Colchester (No. 2) Coal, maceration 1386-A, slide 16, coordinates, 126.9 × 31.8; size, 51.7 by 45.5μ.

Comparison. — *Convolutispora* sp. 2 is quite similar to the specimen described by Hoffmeister, Staplin, and Malloy (1955) as *Convolutispora* type A.

Occurrence. — No. 2 Coal.

Genus SPACKMANITES Habib, 1966

Type species. — *Spackmanites ellipticus* Habib, 1966.

Discussion. — Loose (1934, p. 155) described the species *Reticulatisporites facierugosus* as having a granulate to reticulate surface and an irregular, crenate outline. He considered it to be questionably trilete. Butterworth and Williams (1954, p. 754) assigned the species to *Verrucososporites*, but they reported that "no sutures have been observed with certainty, though what is probably a very short triradiate mark is sometimes seen at the centre of the spore." Habib (1966) erected the trilete genus *Spackmanites* to accommodate the species. He stated that the trilete mark is " . . . usually short or may even be represented only by a triangular gap in the exine; usually can be seen only with careful focusing." The Illinois specimens of *Spackmanites* did not show any trilete suture except on possibly one specimen. Gray (1967) reported three species (spores C, D, and F on his pl. 18) from the Middle Kittanning Coal of the northern Appalachian Coal Field that probably would be assigned to *Spackmanites* even though no sutures were observed on the specimens he described earlier (Gray, 1965).

Except for the presence of a trilete mark, which is usually difficult to see, this genus

greatly resembles the Triassic genus *Enzonalasporites* Leschik, 1955. Leschik (1955) and Klaus (1960) interpreted *Enzonalasporites* as an alete, saccate microspore enclosing a separate, usually distinct membrane. Clarke (1965, p. 302), who felt that the genus is not cavate, thought that the ridges of *E. vigens*, the type species, are better developed at the equator than on the central area, thus giving the effect of an equatorial extension.

Although considerable difference exists in geologic age, there is little doubt that the spores reported from the Keuper (Triassic) of Europe, from the Westphalian of Germany and England, and from the Pennsylvanian of Illinois, Ohio, and Pennsylvania are morphologically very closely related.

Spackmanites cf. *facierugosus* (Loose) Habib, 1966

Plate 8, figures 17-20

1934 *Reticulatisporites facierugosus* Loose, p. 155, pl. 7, fig. 26.

1954 *Verrucososporites facierugosus* (Loose, 1934) Butterworth and Williams, p. 754, pl. 18, fig. 6.

Description. — The miospores are radial, alete, and circular in transverse plane. They are generally well oriented and seldom folded. The exoexine is composed of closely spaced rod- or club-shaped setae radially arranged outward from the endexine to which they are attached. A thinner equatorial zone extending beyond the endexine is produced where the setae are viewed lengthwise. A central, darker portion where the setae are viewed on end is delineated by the margin of the inner membrane. The setae gradually expand in width toward the ends, which are sometimes minutely pitted or subdivided two or more times. The projections are 3 to 8μ long, with 5μ being the most common, and are up to 4μ wide at the ends. In end view, the setae are extremely irregular in shape, somewhat contorted, and may appear to be pitted. They are so closely spaced that individual elements along the margin are difficult to distinguish, even with careful focusing. The levigate endexine is usually obscured by the exoexine but sometimes can be discerned under oil immersion objective. It is less than 1μ thick and is often folded. Dimensions (14 specimens): over-all size range, 36.1 to 60.8μ in maximum diameter; median, 45.5μ; endexine size range, 32 to 39μ.

Figured specimens. — Plate 8, figure 17; negative 7608; Herrin (No. 6) Coal, maceration 878, slide 1, coordinates, 136.4 $\times$ 51.0; size, 36.1 by 35.7μ. Plate 8, figure 18; negative 7910; Summum (No. 4) Coal, maceration 1133-B2 (RR), slide 1, coordinates, 143.5 $\times$ 40.5; size, 43.9μ in maximum diameter, endexine 35.8 by 31.9μ. Plate 8, figure 19; negative 7905; Colchester (No. 2) Coal, maceration 1402-C, slide 5, coordinates, 134.8 $\times$ 43.5; size, 53.0 by 49.7μ. Plate 8, figure 20; negative 7927; same specimen as negative 7905 but under oil immersion objective.

Discussion. — The species *Reticulatisporites facierugosus* was first described by Loose as having a granulate to reticulate spore surface. His drawing (1934, fig. 26) of the holotype, although quite small, seems to illustrate a rather finely ornamented spore. The specimen photographed by Butterworth and Williams (1954, pl. XVIII, fig. 6) also appears to be finely ornamented, but their drawing (fig. 3) of the same taxon shows somewhat coarser bacula. They described the species as being reticulate or microreticulate in general appearance. The specimen illustrated by Habib (1966, pl. 105, fig. 19) that was assigned to *Spackmanites facierugosus* more closely resembles the Butterworth and Williams drawing than the photograph. The Illinois specimens probably conform more closely to the original description of the species given by Loose, the photograph of Butterworth and Williams, and the species *Spackmanites ellipticus* Habib, 1966. It is unfortunate that no photograph of the holotype of *S. facierugosus* is available.

Occurrence. — No. 2 Coal; No. 4 to No. 5 Coals; Spring Lake and No. 6 Coals.

Genus MACULATASPORITES Tiwari, 1964

Type species.—Maculatasporites indicus Tiwari, 1964.

Maculatasporites punctatus sp. nov.
Plate 8, figures 21-22

Diagnosis. — The miospores are radially symmetrical, alete, and circular in transverse plane. The exoexine is deeply perforated by circular to elliptical, occasionally slightly vermiculate, pits. In high focus the exine appears reticulate. The lacunae are 2 to 4μ in maximum diameter, and are about 3μ apart. At the periphery can be counted 25 to 30 lacunae. The outer spore coat, which is 4 to 5μ thick, appears levigate between the lacunae under oil immersion objective. The levigate endexine is usually not visible because the exoexine is very thick. Elliptical lacunae are often oriented so that their long dimensions parallel the spore periphery. Dimensions (8 specimens): size range, 36 to 45.5μ in maximum diameter; median, 41.5μ; endexine size range, 29 to 35μ.

Holotype. — Plate 8, figure 21; negative 7415; Springfield (No. 5) Coal, maceration 1408-B, slide 3, coordinates 135.2 × 45.5; size, 40.0 by 40.0μ; endexine, 31.2 by 30.9μ.

Paratype. — Plate 8, figure 22; negative 7810; Colchester (No. 2) Coal, maceration 1246, slide 12, coordinates, 137.3 × 49.0; size, 42.3 by 39.3μ.

Comparison.—Maculatasporites indicus Tiwari, 1964, which ranges up to 65μ in diameter is larger than *M. punctatus*. The former is also more loosely reticulate, with a larger proportion of the exine surface in lacunae. *M. irregularis* Tiwari, 1964, also is larger than *M. punctatus* and possesses muri that give the appearance of bacula, thus resembling *Spackmanites* cf. *facierugosus*. *M. punctatus* most closely resembles *M. minimus* Segroves, 1967, but the latter is more coarsely reticulate or punctate and intrapunctate.

Discussion. — Tiwari (1964) did not note the presence of an endexine in his description of the genus, perhaps because of poor preservation of the specimen or the great thickness and intense ornamentation of its exoexine. The other features, however, that are common to the spores described by Tiwari and the Illinois material seemed to warrant assigning this species to *Maculatasporites*. Segroves (1967), who considered *Maculatasporites* an acritarch rather than a spore, noted the presence of a thin-walled inner body in his specimens.

Etymology. — The species name refers to the punctate spore coat.

Occurrence. — No. 2 through No. 4 Coals; No. 5 Coal.

Genus MICRORETICULATISPORITES (Knox) Potonié and Kremp, 1954

Type species. — *Microreticulatisporites lacunosus* (Ibrahim) Knox, 1950.

Microreticulatisporites harrisonii sp. nov.
Plate 9, figure 1

Diagnosis. — The small spores are radial, trilete, triangular in transverse plane, and have straight to slightly concave interradial sides and well rounded corners. Most of the spores possess minor folds. The distinct rays are straight, extend about two-thirds the length of the spore radius, and lack lips. The exine in the region adjacent to the laesurae is darker than the rest of the spore coat. The proximal and distal surfaces are finely reticulate. The lacunae are 0.5 to 1μ in diameter and of uniform size and distribution. The muri are about 0.5μ in width and height. Approximately 60 lacunae can be counted at the periphery. The exine is 1μ thick. Dimensions (5 specimens): size range, 28.3 to 33.8μ in maximum diameter.

Holotype. — Plate 9, figure 1, negative 7931; Murphysboro Coal, maceration 1160 (RR), slide 16, coordinates, 135.5 × 34.3; size, 33.8 by 30.9μ.

Comparison. — *Microreticulatisporites concavus* Butterworth and Williams, 1958, is more coarsely reticulate and is generally larger (32 to 52μ) than *M. harrisonii*.

Etymology. — The species is named in honor of John A. Harrison, former coal petrographer of the Illinois Geological Survey.

Occurrence. — Murphysboro and No. 7 Coal.

Microreticulatisporites hortonensis Playford, 1963
Plate 9, figure 2

Occurrence. — Cardiff Coal.

Microreticulatisporites cf. *lunatus* (Knox) Knox, 1950
Plate 9, figure 3

Occurrence. — Lowell and No. 5 Coals.

Microreticulatisporites sulcatus (Wilson and Kosanke) Smith and Butterworth, 1967
Plate 9, figure 4

Discussion.—Wilson and Kosanke (1944, p. 331) gave the known size range for this species as 30 to 40μ; subsequently Wilson and Hoffmeister (1956, pl. 1, fig. 11) increased the size to 52μ. Specimens encountered in this study range up to 55μ in maximum diameter.

Occurrence.—Murphysboro Coal; Wiley through No. 7 Coals, with the exception of the Seelyville and Allenby Coals.

Microreticulatisporites nobilis (Wicher) Knox, 1950
Plate 9, figure 5

Discussion.—*Microreticulatisporites novicus* Bhardwaj, 1957a, was differentiated by Bhardwaj from *M. nobilis* on the basis of the former's possessing wavy rays and muri that are more pointed. These two species would be difficult to distinguish since the same specimen of *Microreticulatisporites* may display pointed as well as rounded muri.

Occurrence. — Uncorrelated coal bands (maceration 1133-E) between the No. 2 and Cardiff Coals.

Genus DICTYOTRILETES (Naumova) Potonié and Kremp, 1954

Type species.—*Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp, 1954.

Discussion.—Potonié and Kremp (1954, p. 144) in their emendation of *Dictyotriletes* failed to mention the absence of a reticulum on the proximal surface, but their illustrations (pl. 8, figs. 29-30) of the genus show none present. Smith and Butterworth (1967, p. 144) emended *Dictyotriletes* to include many species of *Reticulatisporites* that possess a wide cingulum. This emendation is not followed in the present report because it seems desirable to keep the reticulate spores with a wide cingulum, such as *Reticulatisporites*, separate from those having a very narrow or no cingulum, such as *Dictyotriletes*.

Dictyotriletes danvillensis sp. nov.
Plate 9, figures 6-7

Diagnosis. — The miospores are radial, trilete, and in transverse plane are roundly triangular with well rounded corners and strongly convex interradial sides. They are generally in good proximal-distal orientation. The rays extend to the spore margin and are distinct, especially when bordered by elevated lips or folds as is frequently the case. Lips when present are up to 2μ wide on either side of the commissure. The proximal surface is levigate, and the distal surface is perforated by large punctations or lacunae. The circular to oval lacunae are rather uniformly distributed, 2 to 2.5μ in diameter and 2 to 4μ apart. Areas between the lacunae are flat, not peaked. The 70 to 80 lacunae at the periphery give the spore margin a notched appearance. The exine is 3 to 4μ thick. Dimensions (10 specimens): size range, 45.5 to 57.5μ in maximum diameter; median, 54.9μ.

Holotype. — Plate 9, figure 6; negative 7818; Danville (No. 7) Coal, maceration 1404-HH, slide 14, coordinates, 133.2 × 53.7; size, 55.3 by 54.3μ.

Paratype. — Plate 9, figure 7; negative 7820; Danville (No. 7) Coal, maceration 876 (RR), slide 16, coordinates, 143.9 × 39.2; size, 52.7 by 48.1μ.

Comparison. — *Dictyotriletes danvillensis* is distinguished from other species of *Dictyotriletes* by its relatively small, widely

spaced lacunae, which are on the distal surface only.

Discussion. — Although the size of the lacunae of *Dictyotriletes danvillensis* generally conforms to that found on species of *Microreticulatisporites*, this species was placed with *Dictyotriletes* because of the absence of a reticulum on the proximal surface. The erection of a new genus to accommodate this taxon does not seem warranted at this time.

Etymology. — *Dictyotriletes danvillensis* is named for the Danville (No. 7) Coal of Illinois.

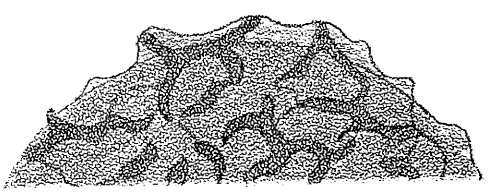
Occurrence. — No. 7 Coal.

Dictyotriletes densoreticulatus
Potonié and Kremp, 1955
Plate 9, figure 8

Occurrence. — No. 2, No. 4, and No. 7 Coals.

Dictyotriletes distortus sp. nov.
Text figure 24; plate 9, figures 9-11

Diagnosis. — The miospores are radial, trilete, and circular to oval in outline. The distinct rays are straight, about two-thirds the length of the spore radius, and lack lips. Muri on the proximal and distal sides



Text Fig. 24 — Diagrammatic detail of a portion of the holotype of *Dictyotriletes distortus* sp. nov.

delineate lacunae that are 5μ in maximum width. The muri are 2 to 3μ high and very irregular in thickness, from less than 1 up to 2.5μ, with 1.5μ as the average. In polar view, the spores appear almost obvermiculate because the muri are greatly contorted and occasionally possess gaps so that some lacunae are not completely bordered. Extending slightly beyond the spore periphery at right angles are 15 to 20 mural ridges. The spore coat is about 1μ thick. Dimensions (5 specimens): size range, 32 to 39μ in maximum diameter, including muri.

Holotype. — Plate 9, figure 9; negative 7527; Colchester (No. 2) Coal, maceration 1386-B, slide 19, coordinates, 131.9 × 41.0; size, 36.1 by 34.1μ. Plate 9, figure 11; negative 7936; holotype under oil immersion objective.

Paratype. — Plate 9, figure 10; negative 7825; Summum (No. 4) Coal, maceration 1405-B, slide 12, coordinates, 136.9 × 43.0; size, 32.5 by 30.9μ.

Comparison. — *Dictyotriletes distortus* differs from *Reticulatisporites areolatus* Guennel, 1958, which it most closely resembles, by having greatly distorted muri that are sometimes unconnected. The latter also has slightly larger lacunae and higher muri that extend farther beyond the periphery.

Etymology. — The specific epithet is derived from the distorted (*distortus*) nature of the muri.

Occurrence. — No. 2 and No. 4 Coals.

Dictyotriletes cf. *falsus*
Potonié and Kremp, 1955
Plate 9, figure 12

Occurrence. — No. 4 Coal.

Dictyotriletes cf. *reticulocingulum* (Loose)
Smith and Butterworth, 1967
Plate 9, figure 13

Comparison. — This taxa is similar to the specimen illustrated by Smith and Butterworth (1967, pl. 11, fig. 27). Forms resembling Smith and Butterworth's figures 28 and 29 of the same taxa were not encountered in the Illinois coals.

Occurrence. — No. 2, Lowell, and No. 4 Coals.

Genus RETICULATISPORITES (Ibrahim)
Ibrahim, 1933

Type species. — *Reticulatisporites reticulatus* (Ibrahim) Ibrahim, 1933.

Reticulatisporites lacunosus Kosanke, 1950
Plate 9, figure 14

Occurrence. — No. 1, Wiley, Abingdon (?), No. 2, Lowell, and No. 5 Coals.

Reticulatisporites reticulatus (Ibrahim) Ibrahim, 1933
Plate 9, figure 15

Discussion.—Potonié and Kremp (1955, p. 112) stated that *Reticulatisporites muricatus* Kosanke, 1950, at present cannot be differentiated from *R. reticulatus*. However, the holotype of *R. muricatus* (Kosanke, 1950, pl. 4, fig. 7) displays muri that possess peculiar crenulated outer margins that are not present in *R. reticulatus*. Guennel (1958, p. 82) also pointed out that *R. muricatus* has taller muri than *R. reticulatus*. It is difficult to tell how *R. reticuliformis* Ibrahim, 1933, can be distinguished from *R. reticulatus*, unless perhaps the former has longer rays.

Occurrence. — Lowell Coal through the unnamed coal between No. 4 and No. 5 Coals.

Reticulatisporites pseudomuricatus sp. nov.
Plate 9, figures 16-17

Diagnosis. — The miospores are radial, trilete, and circular to elliptical in outline, except for a ruffled or undulated cingulum. Many are somewhat contorted or folded. The trilete rays are distinct except where obscured by muri, are at least three-fourths the length of the radius of the spore cavity, and possess elevated lips about 1μ wide on either side of the commissure. The lacunae measure 13 to 17μ in maximum width, and the muri are 3 to 4μ thick and 8 to 11μ high at the spore margin. The number of muri extending beyond the periphery as darkened ridges varies from 13 to 19. The cingulum is thickened along the periphery. Dimensions (9 specimens): size range, 45.5 by 58.5μ in maximum diameter, exclusive of muri; median, 48.8μ.

Holotype. — Plate 9, figure 16; negative 7637; Lowell Coal, maceration 1404-R, slide 4, coordinates, 127.9 × 39.2; size, 52.0 by 48.8μ, excluding muri, and 61.4 by 57.9μ, including muri.

Paratype. — Plate 9, figure 17; negative 7791; Lowell Coal, maceration 1404-Q, slide 22, coordinates, 141.5 × 32.0; size, 53.0 by 51.7μ, exclusive of muri, and 61.8 by 61.8μ, including muri.

Comparison.—*Reticulatisporites pseudomuricatus* resembles quite closely *R. muricatus* Kosanke, 1950, except that the latter is considerably larger (81.9 to 96.6μ).

Occurrence. — Lowell Coal.

Reticulatisporites sp. 1
Plate 9, figure 18

Description. — The spores are radial, trilete, and subcircular in outline. The rays are simple and extend about two-thirds the length of the spore radius. The muri are thin (1 to 2μ) and short (4 to 7.5μ). The lacunae vary in size from 13 to 23μ in maximum dimension and number 8 to 10 around the spore margin. The two specimens observed measure 48 and 49μ in maximum diameter.

Figured specimen. — Negative 7387; Summum (No. 4) Coal, maceration 1405-A, slide 20, coordinates, 137.7 × 31.3; size, 52.0 by 45.8μ, not including muri.

Discussion. — This species is most likely the same as the one referred to *Dictyotriletes mediareticulatus* (Ibrahim) Potonié and Kremp, 1955, by Guennel (1958, p. 84). He reported that his specimens were a little smaller than the size range of 50 to 80μ indicated by Potonié and Kremp and questioned whether two distinct size groups exist. These spores probably should be differentiated from *D. mediareticulatus*, not only because of their size, but because the latter apparently has smaller, more numerous lacunae. *R.* sp. 1 might be the same taxon as *R.* sp. Butterworth and Williams, 1958 (pl. 2, figs. 5-6).

Occurrence. — Wiley, Abingdon (?), No. 2, and No. 4 Coals.

Reticulatisporites sp. 2
Plate 9, figure 19

Description. — The small spore is radial, trilete, and roundly triangular in outline. The trilete rays, which are rather

indistinct, extend about two-thirds the distance to the spore margin and possess lips that are about 1μ wide. The proximal and distal surfaces are reticulate. The muri, 3 to 4μ wide, are sinuous and make about 18 arcs around the spore equator.

Figured specimen. — Negative 7559; Cardiff Coal, maceration 1133-C1 (RR), slide 4, coordinates, 127.0 × 46.0; size, 50.4 by 47.1μ.

Comparison. — This spore is very similar to the one illustrated by Butterworth and Williams (1958, pl. 2, fig. 7) and designated *Reticulatisporites* sp.

Occurrence. — Cardiff Coal.

Genus CAMPTOTRILETES (Naumova) Potonié and Kremp, 1954

Type species. — *Camptotriletes corrugatus* (Ibrahim) Potonié and Kremp, 1954.

Camptotriletes bucculentus (Loose) Potonié and Kremp, 1955
Plate 9, figure 20

Occurrence.—Abingdon (?) Coal through Lowell Coal; Spring Lake Coal.

Camptotriletes triangularis sp. nov.
Text figure 25; plate 10, figures 1-2

Diagnosis. — The miospores are radial, trilete, and triangular in transverse plane and have convex interradial sides and well rounded corners. The simple trilete rays are distinct, straight, and extend about two-thirds the distance to the corners. The distal spore surface is set with relatively widely spaced, low anastomosing, obvermiculate ridges 3 to 4μ wide. About 12 to 15 arcs can be counted at the spore margin. The exine is about 1μ thick. Dimensions (9 specimens): size range, 36.1 to 48.8μ in maximum diameter.

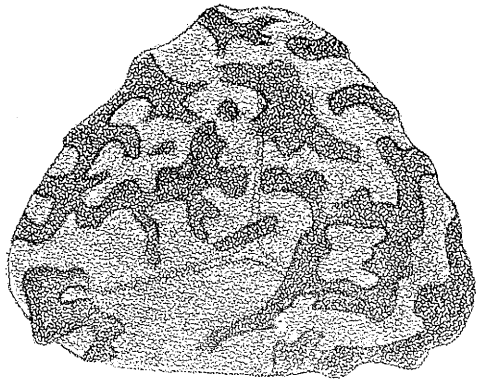
Holotype. — Plate 10, figure 1; negative 7829; uncorrelated coal bands between the Colchester (No. 2) Coal and Cardiff Coals, maceration 1133-E, slide 28, coordinates, 144.8 × 31.2; size, 45.5 by 39.7μ.

Paratype. — Plate 10, figure 2; negative 7470; Summum (No. 4) Coal, maceration 1234-F, slide 19, coordinates, 126.2 × 47.0; size, 35.8 by 34.1μ.

Comparison. — *Camptotriletes triangularis* resembles *Grumosisporites verrucosus* (Butterworth and Williams) Smith and Butterworth, 1967, but the former is triangular, has more widely spaced obvermiculate ridges, and lacks an intexine.

Etymology.—The species name suggests the triangular shape of the spore.

Occurrence. — No. 2 through No. 4 Coals.



Text Fig. 25 — Diagrammatic reconstruction of the holotype of *Camptotriletes triangularis* sp. nov.

Genus KNOXISPORITES (Potonié and Kremp) Neves, 1961

Type species. — *Knoxisporites hageni* Potonié and Kremp, 1954.

Knoxisporites rotatus Hoffmeister, Staplin, and Malloy, 1955
Plate 10, figure 3

Comparison. — The spore illustrated here is like that shown by Hoffmeister, Staplin, and Malloy (1955, pl. 37, fig. 13).

Occurrence. — No. 2 and Lowell Coals and the unnamed coal between the No. 4 and No. 5 Coals.

Genus VESTISPORA (Wilson and Hoffmeister) Wilson and Venkatachala, 1963b

Type species. — *Vestispora profunda* Wilson and Hoffmeister, 1956.

Vestispora colchesterensis sp. nov.
Plate 10, figures 4-5

Diagnosis. — The miospores are radial, trilete, and circular in transverse plane. Secondary folding of the spore coat is common. The straight, trilete rays are usually open, lack lips, and are 18 to 24μ long. The operculum is 33 to 43μ in diameter. The exine is covered with linear, more or less parallel costae 1 to 2μ wide that sometimes branch. A weakly defined reticulum is often developed, especially in the region of the poles. Observed under oil immersion objective, the exine is very finely punctate to granulose between the costae. The outer wall is 1 to 2μ thick. The inner membrane or endexine is levigate, less than 1μ thick, and 52 to 60μ in diameter. Dimensions (11 specimens): size range, 70.9 to 95.2μ; median, 81.3μ.

Holotype. — Plate 10, figure 4; negative 7694; Colchester (No. 2) Coal, maceration 1387-B, slide 5, coordinates, 136.0 × 38.0; size, outer wall, 95.2 by 91.0μ; endexine, 71.5 by 65.0μ.

Paratype. — Plate 10, figure 5; negative 7809; Colchester (No. 2) Coal, maceration 1246, slide 20, coordinates, 144.5 × 44.5; size, outer wall, 75.4 by 71.5μ; operculum, 42.3 by 32.5μ.

Comparison. — *Vestispora colchesterensis* may be the same species as the one designated *Vestispora* sp. by Wilson and Venkatachala, 1963b. *Vestispora colchesterensis* has thinner, less distinct, and more abundant costae than *V. costata* (Balme) Bode (*in* Smith and Butterworth, 1967) and *V. tortuosa* (Balme) Spode (*in* Smith and Butterworth, 1967). *V. magna* (Butterworth and Williams) Spode (*in* Smith and Butterworth, 1967) and *V. pseudoreticulata* Spode (*in* Smith and Butterworth, 1967) have a secondary reticulum that is lacking in *V. colchesterensis.*

Etymology. — The species is named after the Colchester (No. 2) Coal of Illinois.

Occurrence. — Wiley, Abingdon (?), No. 2, Cardiff, and No. 4 Coals.

Vestispora fenestrata
(Kosanke and Brokaw)
Wilson and Venkatachala, 1963b

Occurrence. — Recorded in all the coals studied for this report.

Vestispora foveata (Kosanke)
Wilson and Venkatachala, 1963b

Occurrence. — Murphysboro, Wiley through No. 5 Coals; Spring Lake and No. 6 Coals.

Vestispora laevigata
Wilson and Venkatachala, 1963b
Plate 10, figure 6

Occurrence.—Wiley and DeKoven Coals; No. 2 through No. 5 Coals; No. 6 and No. 7 Coals.

Vestispora profunda
Wilson and Hoffmeister, 1956
Plate 10, figure 7

Occurrence. — No. 2, Cardiff, and No. 6 Coals.

Vestispora cf. *pseudoreticulata* Spode
(*in* Smith and Butterworth, 1967)
Plate 10, figure 8

Comparison. — The Illinois spores resemble the specimen illustrated by Smith and Butterworth (1967, pl. 25, fig. 14) but the Illinois spores have a more weakly defined reticulum and their intexine is more distinct.

Occurrence. — No. 2 Coal.

Vestispora wanlessii sp. nov.
Plate 10, figures 9-10

Diagnosis. — The miospores are radial, trilete, and circular in transverse plane and have a rather smooth margin. They are usually obliquely compressed. The trilete rays are quite distinct, straight, and about 20μ long. The operculum is about 35μ in diameter. The outer spore wall is ornamented with a poorly defined reticulum in

which the muri and lacunae are generally elongate parallel to the spore margin, but in the region of the operculum they are more equidimensional. The muri and lacunae are about 3μ wide. The outer spore wall is about 3μ thick. The inner membrane or endexine is levigate, thin, and about 65μ in diameter. Dimensions (4 specimens): size range, 80.9 to 96.5μ in maximum diameter; median, 87μ.

Holotype. — Plate 10, figure 9; negative 7796; Murphysboro Coal, maceration 1160 (RR), slide 20, coordinates, 135.8 × 40.2; size, 88.7 by 83.9μ.

Paratype. — Plate 10, figure 10; negative 7797; Murphysboro Coal, maceration 1160 (RR), slide 17, coordinates, 128.7 × 52.5; size, 85.5 by 78.0μ.

Comparison.—*Vestispora wanlessii* most clearly resembles *V. profunda* Wilson and Hoffmeister, 1956, but it is thicker and has a less well defined reticulum. The muri are broader and more like rounded ridges than the net-like muri of *V. profunda.*

Etymology. — The species is named for Professor H. R. Wanless of the University of Illinois.

Occurrence. — Murphysboro Coal.

Genus TRIQUITRITES (Wilson and Coe) Schopf, Wilson, and Bentall, 1944

Type species. — *Triquitrites arculatus* Wilson and Coe, 1940.

Triquitrites additus
Wilson and Hoffmeister, 1956
Plate 10, figure 11

Discussion. — A wide variation in morphology occurs in *Triquitrites additus*, as indicated by Wilson and Hoffmeister (1956, p. 24). I included forms having a maximum diameter of 30μ even though a size range of 35 to 45μ was given by Wilson and Hoffmeister. *T. cuspidatus* Bhardwaj, 1957a, may be in part conspecific with *T. additus.*

Occurrence. — Murphysboro and Wiley Coals; Abingdon (?) through No. 4 Coals; No. 5, No. 6, and No. 7 Coals.

Triquitrites cf. *additus*
Wilson and Hoffmeister, 1956
Plate 10, figure 12

Occurrence.—Murphysboro Coal; Wiley through No. 5 Coals; No. 6 and No. 7 Coals.

Triquitrites desperatus
Potonié and Kremp, 1956
Plate 10, figure 13

Occurrence. — No. 2, No. 4, and No. 6 Coals.

Triquitrites minutus Alpern, 1958
Plate 10, figure 14

Occurrence. — Murphysboro Coal; Abingdon (?) through No. 5 Coals; No. 6 and No. 7 Coals.

Triquitrites pulvinatus Kosanke, 1950
Plate 10, figure 15

Occurrence.—Murphysboro, Wiley, and DeKoven Coals; Abingdon (?) through No. 4 Coals; No. 5 and No. 5A Coals.

Triquitrites dividuus
Wilson and Hoffmeister, 1956
Plate 10, figure 16

Occurrence. — No. 2 through No. 4 Coals; No. 7 Coal.

Triquitrites exiguus
Wilson and Kosanke, 1944
Plate 10, figure 17

Occurrence. — No. 1 and Murphysboro Coals; Wiley through No. 5 Coal; Spring Lake, No. 6, and No. 7 Coals.

Triquitrites protensus Kosanke, 1950
Plate 10, figure 18

Discussion. — The size range of 33.5 to 39μ indicated by Kosanke (1950, p. 40) for *T. protensus* is extended to include spores as small as 29μ.

Occurrence. — Murphysboro; DeKoven through No. 5 Coals; No. 6, Allenby, and No. 7 Coals.

Triquitrites truncatus
Bhardwaj and Kremp, 1955
Plate 10, figure 19

Occurrence. — No. 4 Coal.

Triquitrites bransonii
Wilson and Hoffmeister, 1956
Plate 10, figure 20

Occurrence. — All coals studied from Wiley through No. 7 Coals except for the Spring Lake Coal.

Triquitrites cf. *arculatus*
(Wilson and Coe)
Schopf, Wilson, and Bentall, 1944
Plate 11, figure 1

Discussion. — Only four specimens assigned to this taxon were encountered. Except for the small size (22.8 to 32.5μ) they are very similar to the holotype illustrated by Wilson (1958, pl. I, fig. 8).

Occurrence. — No. 2, Lowell, and No. 7 Coals.

Triquitrites sculptilis Balme, 1952
Plate 11, figures 2-3

Discussion. — *Triquitrites sculptilis* displays great variation in ornamentation on its exine from poorly defined irregular thickenings (pl. 11, fig. 2) to large blunt or rounded verrucae (pl. 11, fig. 3). The projections, which often extend beyond the interradial sides, may be joined by ridges or may be segregated. A reticulum, is occasionally present but is usually poorly developed. *Ahrensisporites velensis* Bhardwaj, 1957b, may represent an extreme development of the irregular thickenings in *T. sculptilis* and does compare closely with a specimen he designated *T. sculptilis* (Bhardwaj, 1957b, pl. 24, fig. 60).

Occurrence. — Abingdon (?), No. 2, Lowell, and No. 6 Coals.

Triquitrites cf. *sculptilis* Balme, 1952
Plate 11, figures 4-5

Description. — The trilete miospores are radial, triangular in transverse plane, and have rather broad corners and straight to slightly convex interradial sides. The trilete rays, which are distinct, extend almost to the auriculae and possess lips less than 1μ wide. The auriculae vary greatly in length, from 6 to 18μ, and are up to 6μ wide. They are irregular in shape but tend to have sharply angular projections. The proximal surface of the exine is levigate, but the distal surface is distinguished by an irregular, sometimes discontinuous reticulum whose muri are less than 1μ wide. The lacunae are generally 6 to 9μ in diameter. The spore coat is 1 to 1.5μ thick. Dimensions (4 specimens): 26.7 to 37.4μ in maximum diameter; median, 30.9μ.

Figured specimens. — Plate 11, figure 4; negative 7652; Herrin (No. 6) Coal, maceration 1398, slide 5, coordinates, 137.6 $\times$ 47.9; size, 37.4 by 32.5μ. Plate 11, figure 5, negative 7557; Cardiff Coal, maceration 1133-C1 (RR), slide 9, coordinates, 125.1 $\times$ 48.0; size, 26.7 by 23.4μ.

Comparison. — *Triquitrites* cf. *sculptilis* has more sharply pointed and narrower muri than the typical specimens of *T. sculptilis*. The former has an equatorial outline that is more angular, especially at the auriculae.

Occurrence. — Cardiff, No. 5, and No. 6 Coals.

Triquitrites spinosus Kosanke, 1943

Occurrence. — Wiley through No. 7 Coals, with the exception of the Seelyville and Spring Lake Coals.

Triquitrites crassus Kosanke, 1950
Plate 11, figure 6

Discussion. — Within *Triquitrites crassus* are included several forms whose ornamentation is reduced to rather low, inconspicuous, interconnected processes. These forms grade into those that have exines densely covered with blunt, rounded, or sharply pointed ends.

Occurrence. — Wiley and DeKoven Coals, Abingdon (?) through No. 4 Coals, and No. 5, No. 6, and No. 7 Coals.

Triquitrites trigonappendix (Loose) Schopf, Wilson, and Bentall, 1944
Plate 11, figure 7

Occurrence. — No. 2 through No. 4 Coals.

Triquitrites subspinosus sp. nov.
Plate 11, figures 8-9

Diagnosis. — The trilete miospores are radial, triangular in transverse plane, and possess straight interradial sides and prominent auriculae. The distinct trilete rays are simple, straight, and extend up to, or nearly up to, the auriculae. The auriculae, which strongly project beyond the corners, generally originate somewhat poleward on the proximal side and may be slightly imbricate or digitate. They are up to 14μ long and 7.5μ wide but average 10μ and 6μ, respectively. The distal surface is set with low, rather indistinct, sharp to rounded spines that are connected by irregular and poorly defined ridges. The spore coat is about 1μ thick. Dimensions (14 specimens): size range, 32 to 47.8μ in maximum diameter; median, 36.4μ.

Holotype. — Plate 11, figure 8; negative 7372; Summum (No. 4) Coal, maceration 1405-B, slide 19, coordinates, 129.0 $\times$ 47.0; size, 34.8 by 32.5μ.

Paratype. — Plate 11, figure 9; negative 7483; Lowell Coal, maceration 1190, slide 5, coordinates, 124.5 $\times$ 53.2; size, 36.4 by 34.8μ.

Comparison. — *Triquitrites subspinosus* is most like *T. perornatus* Pi-Radondy and Doubinger, 1968, but the former has much more prominent auriculae and its ornamentation is not as well developed as that of *T. perornatus*. *T. subspinosus* is also comparable to *T. spinosus*, but has much more prominent auriculae and its spines may not be obvious without considerable focusing up and down.

Etymology. — The species name suggests the small spines with which the spores are ornamented.

Occurrence. — No. 2 Coal through the unnamed coal between No. 4 and No. 5 Coals; No. 6 and No. 7 Coals.

Triquitrites sp. 1
Plate 11, figure 10

Description.—The small spore is radial, trilete, triangular in transverse plane, and has straight to slightly convex interradial sides. The commissure, which is distinct, is open and lacks lips. The rays are about two-thirds the length of the spore radius. Auriculae, which are well developed, are about 13μ wide and 7μ long. The distal surface of the spore coat is ornamented with verrucae and flattened spines, many of which are connected by narrow ridges. The exine is about 2.5μ thick.

Figured specimen. — Negative 7417; Summum (No. 4) Coal, maceration 1405-B, slide 7, coordinates, 123.4 $\times$ 38.2; size, 52.0 by 48.8μ.

Occurrence. — DeKoven, No. 2, Lowell, No. 4, and No. 6 Coals.

Genus MOOREISPORITES Neves, 1961

Type species. — *Mooreisporites fustis* Neves, 1958.

Mooreisporites inusitatus (Kosanke) Neves, 1961
Plate 11, figure 11

Occurrence. — Wiley through Jamestown Coals, with the exception of the Seelyville Coal.

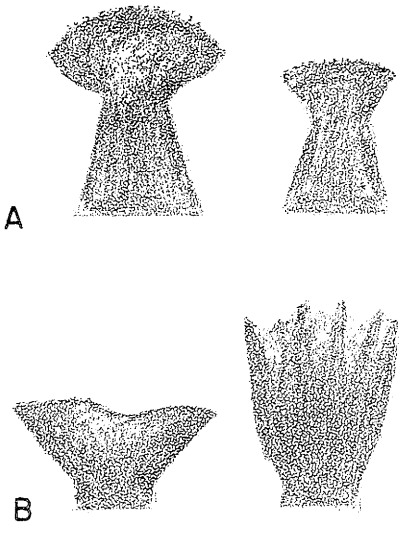
Genus INDOSPORA Bhardwaj, 1960

Type species. — *Indospora clara* Bhardwaj, 1960.

Indospora boletus sp. nov.
Text figure 26A; plate 11, figures 12-13

Diagnosis. — The miospores are radial, trilete, and triangular in transverse plane and have straight, interradial sides. The trilete rays are distinct, straight, and extend at least three-fourths the distance to the corners. The commissure is usually split open and lacks lips, but the exine adjacent to the commissure is often slightly thicker and darker than the rest of the exine. The

ends of the distal triradiate ridge project 3 to 4μ beyond the spore margin at the corners. The arms of the ridge are approximately 1.5μ wide near the radial corners and gradually widen toward the distal pole where a triangular area, or pad, is often formed at the juncture of the three arms. The ridge, which is raised about 1.5μ above the distal surface, is very



Text Fig. 26 — Comparison of projections on (A) *Indospora boletus* sp. nov. and (B) *Indospora stewarti* Peppers, 1964.

finely granulate or punctate as viewed under oil immersion objective. The proximal and distal spore surfaces are ornamented with mushroom-shaped projections that are up to 3.5μ high. The caps of the pila are 2 to 3μ in diameter and about half as high. The surface of the caps is very finely granulate under oil immersion objective. The projections are well separated but are concentrated principally near the interradial sides. About 14 to 20 projections extend beyond the spore periphery. The exine between the projections is levigate and less than 1μ thick. Dimensions (8 specimens): size range, 26.0 to 30.9μ in maximum diameter, exclusive of triradiate ridges; median, 28.0μ.

Holotype. — Plate 11, figure 12; negative 7919; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 46, coordinates, 144.0 × 28.0; size, 26.0 by 26.0μ.

Holotype. — Plate 11, figure 13; negative 7702; Colchester (No. 2) Coal, maceration 1133-D (RR), slide 11, coordinates, 130.1 × 35.0; size, 30.9 by 29.3μ.

Comparison. — *Indospora boletus* is differentiated from other species of *Indospora* by its mushroom-shaped projections.

Etymology. — The specific epithet (*boletus*) refers to its mushroom-shaped projections.

Occurrence. — No. 2 Coal and uncorrelated coal bands between No. 2 and Cardiff Coals.

Indospora stewarti Peppers, 1964
Text figure 26B

Occurrence. — Cardiff and No. 6 Coals.

Genus AHRENSISPORITES
(Potonié and Kremp) Horst, 1955

Type species.—*Ahrensisporites guerickei* Horst, 1955.

Ahrensisporites guerickei Horst, 1955
Plate 11, figure 14

Occurrence. — Murphysboro Coal.

Genus GRUMOSISPORITES
Smith and Butterworth, 1967

Type species. — *Grumosisporites verrucosus* (Butterworth and Williams) Smith and Butterworth, 1967.

Grumosisporites cf. *rufus*
(Butterworth and Williams)
Smith and Butterworth, 1967
Plate 11, figure 15

Discussion. — Although lacking any evidence of an intexine and not quite large enough (43.6μ) to fall within the size range of 48 to 68μ reported by Smith and Butterworth (1967, p. 231) for this species, the Illinois spore resembles their illustrations and descriptions.

Occurrence. — No. 2 and Lowell Coals.

Genus CRASSISPORA (Bhardwaj) Bhardwaj, 1957b

Type species. — *Crassispora ovalis* (Bhardwaj) Bhardwaj, 1957b.

Crassispora plicata Peppers, 1964
Plate 11, figures 16-19

Discussion. — *Crassispora plicata* was described (Peppers, 1964) as having coni present on the distal surface and around the spore margin but absent from the proximal surface. Figure 17 (pl. 11) of this report is a photomicrograph in which the distal surface that is ornamented with coni is in focus; figure 18 shows the proximal surface in focus. This arrangement of coni and the presence of apical papillae, which was noted for the first time in this genus, were considered important in erecting *C. plicata*. Concentric folding around the equatorial margin was thought to be a typical feature of *C. plicata*. No crassitudinous thickening of the exoexine, perhaps owing to lack of preservation, was observed. Sullivan (1964, p. 375-376) in describing *Crassispora* from his material mentioned the presence of apical papillae and the absence of coni on the proximal surface in all species of *Crassispora*, although Bhardwaj had not recognized either characteristic. If this is true, then *C. plicata* may be synonymous with *C. ovalis* or *C. kosankei* (Potonié and Kremp, 1955) Bhardwaj, 1957b.

Sullivan (1964, p. 376) noted that the dimensions of *C. kosankei* from the Edgehills Coal, England, span the interval between the size limits of the species *C. kosankei* (65 to 85μ) and *C. ovalis* (45 to 55μ). He doubted whether they should be retained as separate entities. The size range of *C. plicatus* observed in the Carbondale coals of Illinois varies from about 32 to 76μ. The maximum dimension of 200 specimens from a sample of No. 5 Coal (maceration 1408-B) ranged from 33.8 to 69.2μ and had a median of 48.2μ. Descriptions of other species of *Crassispora* have been based principally on size and development of the crassitudo. The weak nature of the spore exoexine and differences in preservation and effects of maceration processes result in extreme variations in size, ornamentation, folding, and nature of the crassitudo. Spores similar to those I interpreted as being overmacerated or poorly preserved specimens of *Crassispora* were later put in *Cappasporites* Urban, 1966, when he erected that genus. *Crassispora* from the coals of the Carbondale Formation exhibit many variations, from well preserved specimens (pl. 11, fig. 16) to those in which the exoexine has been almost or completely removed (pl. 11, fig. 19) so that the spore resembles *Cappasporites distortus*. Spores resembling *C. distortus* were found in all Carbondale coals and in practically all the macerations studied and were classified as *Crassispora plicata*, because most of the samples were analyzed before 1966.

Occurrence. — No. 1 through No. 7 Coals.

Genus LYCOSPORA Schopf, Wilson, and Bentall, 1944

Type species. — *Lycospora micropapillatus* (Wilson and Coe) Schopf, Wilson, and Bentall, 1944.

Lycospora brevijuga Kosanke, 1950

Discussion. — Smith and Pierart (Pierart et al., 1964, p. 1061) considered *L. brevijuga* a variation of *Lycospora pusilla* (Ibrahim) Schopf, Wilson, and Bentall, 1944.

Occurrence. — Abingdon (?) through No. 4 Coals; No. 5 through No. 6 Coals; No. 7 Coal.

Lycospora granulata Kosanke, 1950

Comparison. — The specimens referred to *Lycospora granulata* by Smith and Butterworth (1967, pl. 20, figs. 1-3) are coarser grained than the Illinois specimens and probably should not be assigned to this taxon.

Occurrence. — No. 1 through No. 7 Coals.

Lycospora pauluia Artuz, 1957
Plate 11, figure 20

Discussion. — The spores of this species encountered in Illinois are generally triangular, but a number of circular and intermediate forms have been observed. *Lycospora rotundus* Bhardwaj, 1957a, with its round to oval rather than roundly triangular shape, resembles *L. paulula*. Perhaps these two species are synonyms. *Lycospora subtriquetrus* (Luber) Potonié and Kremp, 1956, is similar except for its narrower cingulum and larger size. The specimen illustrated by Kremp (1951, pl. 15b, fig. 3) and designated *Lycospora* sp. can most likely be placed with *L. paulula*.

Occurrence. — Seelyville, No. 2, Lowell, No. 6, and No. 7 Coals.

Lycospora punctata Kosanke, 1950

Discussion. — Smith and Pierart (Pierart et al., 1964, p. 1061) observed that this species might be synonymous with *Lycospora pellucida* (Wicher) Schopf, Wilson, and Bentall, 1944.

Occurrence. — No. 1 through No. 7 Coals.

Lycospora subjuga Bhardwaj, 1957b
Plate 11, figure 21

Discussion. — The Illinois spores most closely resemble the one illustrated by Bhardwaj, 1957b (pl. 25, fig. 84).

Occurrence. — Abingdon (?) through No. 5 Coals; Spring Lake, No. 6, and No. 7 Coals.

Lycospora torquifer (Loose)
Potonié and Kremp, 1956
Plate 11, figure 22

Comparison. — *Lycospora torquifer* was interpreted as having grana that in size are intermediate to *L. granulata* and *L. paulula* Artuz, 1957.

Occurrence. — Abingdon (?) through Lowell Coals; No. 6 and No. 7 Coals.

Genus CADIOSPORA Kosanke, 1950

Type species. — *Cadiospora magna* Kosanke, 1950.

Cadiospora fithiana Peppers, 1964
Plate 11, figure 23

Occurrence. — No. 2, No. 4, No. 5, No. 6, and No. 7 Coals.

Cadiospora magna Kosanke, 1950
Plate 12, figure 1

Occurrence. — Wiley, No. 2, and No. 4 Coals.

Genus MUROSPORA Somers, 1952

Type species. — *Murospora kosankei* Somers, 1952.

Murospora kosankei Somers, 1952
Plate 12, figures 2-3

Occurrence. — Lowell and No. 6 Coals.

Genus DENSOSPORITES (Berry)
Butterworth, Jansonius, Smith, and Staplin, 1964

Type species. — *Densosporites covensis* Berry, 1937.

Densosporites triangularis Kosanke, 1950
Plate 12, figures 4-5

1966 *Densosporites oblatus* Habib, p. 641-642, pl. 106, figs. 12, 14.

Discussion.—*Densosporites triangularis* as observed in the lower part of the Carbondale Formation and upper part of the Spoon Formation shows a variation in number of spines from only one, several as seen on the holotype, to many. Several large, indistinct verrucae or rounded spines can be seen on the distal portion of the central body. Vermiculae and pits in the thick cingulum also show variation, from being rather indistinct in well preserved spores to being prominent features that dissect and even produce a ragged, uneven margin on other specimens. The

minimum size of 52μ for this species given by Kosanke (1950, p. 34) is changed to include specimens down to 45μ in diameter.

Occurrence. — No. 1 through Cardiff Coals.

Densosporites cf. *lobatus* Kosanke, 1950
Plate 12, figure 6

Occurrence. — No. 1 and No. 2 Coals.

Densosporites sphaerotriangularis
Kosanke, 1950

Occurrence. — Wiley through Lowell Coals.

Genus CRISTATISPORITES
(Potonié and Kremp)
Butterworth, Jansonius, Smith, and Staplin, 1964

Type species. — *Cristatisporites indignabundus* (Loose) Potonié and Kremp, 1954.

Cristatisporites alpernii
Staplin and Jansonius, 1964
Plate 12, figure 7

Occurrence.—Seelyville and No. 2 Coals.

Genus VALLATISPORITES Hacquebard, 1957

Type species. — *Vallatisporites vallatus* Hacquebard, 1957.

Vallatisporites sp. 1
Plate 12, figure 8

Description. — The miospore is radial, trilete, and roundly triangular in transverse plane, but has a crenulate margin. The trilete rays are rather distinct because of the well developed elevated lips, but the commissure is not visible. The rays extend as far as the inner margin of the zona. The intexine is visible. The proximal surface of the central area is covered with puncta that are less than 1μ in diameter. The central area on the distal side is covered with large, low, flat verrucae of irregular shape. The zona, which has a width less than half the spore radius, gradually thins toward the equator. The proximal surface is punctate adjacent to the central area, but the number of punctae decreases toward the equator of the zona. The zona contains abundant, randomly distributed vacules that produce an incised margin at the equator.

Figured specimen. — Negative 7668; Colchester (No. 2) Coal, maceration 1246, slide 16, coordinates, 143.7 × 43.7; size, 55.3 by 50.1μ.

Occurrence. — No. 2 Coal.

Genus CIRRATRIRADITES
Wilson and Coe, 1940

Type species. — *Cirratriradites maculatus* Wilson and Coe, 1940.

Cirratriradites annulatus
Kosanke, 1950

Occurrence. — Wiley through No. 5 Coals; No. 6 through No. 7 Coals.

Cirratriradites annuliformis
Kosanke and Brokaw, *in* Kosanke, 1950
Plate 12, figure 9

Occurrence. — Wiley and DeKoven Coals; Abingdon (?) through No. 5A Coals; No. 6 and No. 7 Coals.

Cirratriradites tenuis sp. nov.
Plate 12, figures 10-11

Diagnosis. — The spores are radial, trilete, and triangular in outline when viewed in good proximal-distal orientation. Most of them are folded, and may be highly contorted and torn. The spore body is triangular and possesses two series of major folds. One group of folds accompanies the trilete rays and passes through the corners of the body, extending into the flange, which is also folded. The other group consists of three folds, each of which is parallel to one of the interradial sides on the distal surface. The commissure, which

extends to the body margin, cannot be seen on most spores. The exine is levigate to finely punctate under oil immersion objective but is rather coarsely punctate adjacent to the trilete rays. The flange, which is attached to the body at the region of the interradial folds, is plicated and is usually flat, broad, and truncated at the corners. It extends 7 to 15μ beyond the periphery of the body. The surface of the flange is finely punctate under oil immersion objective, and along the margin are broad-based, sharply pointed spines, 1 to 2μ long. The body and flange are 1μ or less thick. Dimensions (21 specimens): size range, 73.1 to 105.6μ in maximum diameter, including the flange; median, 87.8μ; 57 to 89.9μ in maximum diameter excluding the flange; median, 68.3μ.

Holotype. — Plate 12, figure 10; negative 7822; Danville (No. 7) Coal, maceration 876 (RR), slide 14, coordinates, 142.3 × 50.0; size, 96.2 by 83.2μ, including flange; 72.5 by 71.5μ, excluding flange.

Paratype. — Plate 12, figure 11; negative 7867; Danville (No. 7) Coal, maceration 876 (RR), slide 3, coordinates, 141.2 × 39.5; size, 77.4 by 68.3μ, including flange; 58.5 by 49.4μ, excluding flange.

Comparison.—*Cirratriradites tenuis* may be the same species as *Cirratriradites* sp. illustrated by Butterworth and Williams (1958, pl. LXIII, fig. 53).

Etymology. — The specific epithet is derived from the thin (*tenuis*) nature of the spore coat.

Occurrence. — No. 7 Coal.

Genus REINSCHOSPORA
Schopf, Wilson, and Bentall, 1944

Type species. — *Reinschospora bellitas* Bentall (*in* Schopf, Wilson, and Bentall, 1944).

Reinschospora magnifica Kosanke, 1950
Plate 12, figure 12

Occurrence. — No. 2, Cardiff, and No. 7 Coals.

Reinschospora cf. *magnifica*
Kosanke, 1950
Plate 12, figure 13

Discussion. — Referred to this species are spores resembling *Reinschospora magnifica* but measuring as little as 36μ in maximum diameter, which is considerably smaller than the size range of 60 by 69μ to 70 by 78μ given by Kosanke (1950, p. 43). *R.* cf. *magnifica* is particularly common in macerations 876 and 1404-HH, both from the top of the No. 7 Coal. These macerations contain spore assemblages unique in other ways, and perhaps the small size of these spores is a reflection of peculiar ecological conditions rather than evidence for erecting a new taxon.

Occurrence. — No. 7 Coal.

Reinschospora triangularis
Kosanke, 1950
Plate 12, figure 14

Occurrence. — No. 2 through No. 4 Coals; No. 5 and No. 7 Coals.

Genus BALTEOSPORITES gen. nov.

Type species. — *Balteosporites minutus* sp. nov.

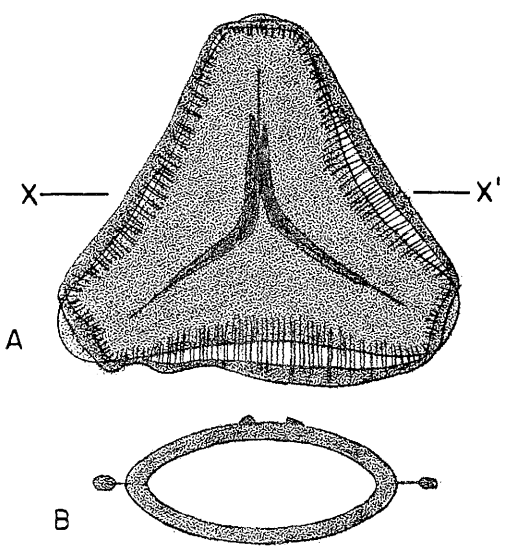
Diagnosis. — The generic name *Balteosporites* is proposed for miospores having the following characteristics. The spores are radial and trilete and have bodies that are triangular in transverse plane and concave interradial sides. A fimbriate flange extends equatorially beyond the spore margin. Fimbriae are attached on the proximal surface and are longest midway between the radial corners. They gradually become shorter toward the corners, where they are greatly reduced. Equatorial to and attached to the fimbriae is a narrow, ribbon-like band that completely circumscribes the spore. This structure is widest midway between the radial corners and gradually decreases in width toward the corners, which on most specimens it slightly overlaps on the proximal side. The known size range is 24.4 to 32.5μ.

Comparison. — *Balteosporites* compares most closely with *Reinschospora* but differs from it by possessing a ribbon-like band circumscribing the fimbriate flange. This band is not formed by the fusion of some of the fimbriae, as sometimes occurs in *Reinschospora*, but is a distinct, integral structure.

Etymology.—The generic name (*balte*) is derived from the presence of a belt-like structure that encircles the spore.

Balteosporites minutus sp. nov.
Text figure 27; plate 12, figures 15-16

Diagnosis. — The miospores are radial and trilete. The triangular body has concave sides and narrow but rounded corners. The rays of the indistinct trilete suture extend about three-fourths the distance to the corners and possess labra up to 1.5μ wide. An equatorial fimbriate flange extends beyond the spore margin. The fimbriae radiate from the proximal spore surface, and at the point of greatest concavity of the interradial sides they are embedded into the spore coat about 1.5μ. The margin of the spore where the roots of the fimbriae are embedded is thicker than the rest of the exine. The fimbriae are very fine, thin, transparent, and separated from each other. They vary in length from up to 5μ midway between the radial points of the body to less than 1μ near the corners. The fimbriae are less than 1μ wide and number 25 to 30 along each side. Circumscribing and attached to the fimbrial flange is a solid, ribbon-like structure. It is up to 2.5μ wide midway between the corners and gradually decreases in width to about 1μ near the corners. The band on most specimens slightly overlaps the body toward the poles at the corners on the proximal side. The body, which is about 1μ thick, is finely granulate under oil immersion objective. Dimensions (5 specimens): size range, 24.4 to 32.5μ total maximum diameter; median, 29μ.



Text Fig. 27 — Diagrammatic reconstruction of the holotype of *Balteosporites minutus* sp. nov. (A) View of proximal surface. (B) Cross section through spore along X-X'.

Holotype. — Plate 12, figure 16; negative 7921; Danville (No. 7) Coal, maceration 1404-HH, slide 11, coordinates, 133.3 × 50.5; size, 32.5 by 29.3μ in total diameter.

Paratype. — Plate 12, figure 15; negative 7815; Danville (No. 7) Coal, maceration 1404-HH, slide 9, coordinates, 142.8 × 35.2; size, 29.3 by 25.7μ in total diameter.

Occurrence. — No. 7 Coal.

Genus SAVITRISPORITES Bhardwaj, 1955

Type species. — *Savitrisporites triangulus* Bhardwaj, 1955.

Discussion.—Bhardwaj (1955, p. 127), in erecting the genus *Savitrisporites*, described a thickening of the angles as one of the diagnostic characteristics, but in a later publication he provisionally assigned *S. majus* Bhardwaj, 1957a, to this genus even though it possesses no angular thickenings. Alpern felt that his new species *Dictyotriletes camptotus* (1958, p. 57) and *D. cingulatus* (1959, p. 145) did not conform to *Savitrisporites* because they lack angular thickenings, so he placed them with *Dictyotriletes*. Sullivan (1964, p. 373), in discussing what he believed is the congeneric relation of *Savitrisporites* and *Callisporites* Butterworth and Williams, 1958, concluded that "the slightly

thickened angles mentioned by Bhardwaj (1955, p. 127) is hardly a character worthy of generic distinction."

Savitrisporites asperatus Sullivan, 1964
Plate 12, figure 17

Occurrence. — No. 2 Coal.

Savitrisporites majus Bhardwaj, 1957a
Plate 12, figure 18

Discussion. — *Dictyotriletes camptotus* Alpern, 1958, is probably a synonym of *Savitrisporites majus*. The specimen of *D. camptotus* illustrated by Peppers (1964, pl. 2, fig. 7) should be placed with *Savitrisporites* and perhaps assigned to *S. majus* except that the distal ornamentation is not as strongly reticulate as that in the spores illustrated by Bhardwaj (1957a, pl. 24, figs. 11-12).

Occurrence. — No. 2 and Lowell Coals. It probably also occurs in the higher Pennsylvanian coals of Illinois (Peppers, 1964).

Savitrisporites? sp. 1
Plate 12, figure 19

Description. — The miospore is radial, trilete, and roundly triangular in transverse plane. The radial corners are not appreciably thickened. The distinct trilete rays are straight, two-thirds to three-fourths the length of the radius, and are split open. The proximal surface of the exine is levigate, but the distal surface is reticulate. The lacunae average 6.5μ in diameter, and the muri, which are low, are up to 4.5μ wide. About 14 arcs of muri extend beyond the margin. The exine is 1μ thick.

Figured specimen. — Negative 7589; Lowell Coal, maceration 1404-O, slide 5, coordinates, 132.2 $\times$ 53.0; size, 45.5 by 43.9μ.

Occurrence. — Lowell Coal.

Genus LAEVIGATOSPORITES (Ibrahim) Schopf, Wilson, and Bentall, 1944

Type species. — *Laevigatosporites vulgaris* (Ibrahim) Ibrahim, 1933.

Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall, 1944

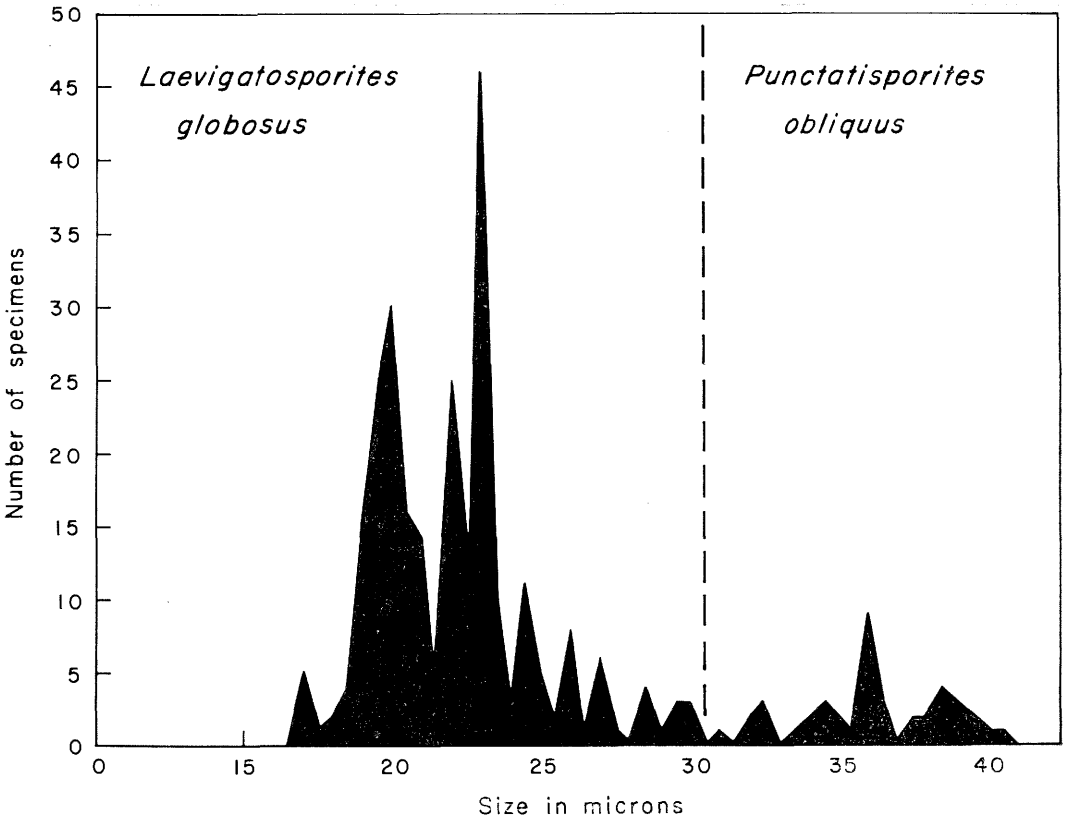
Occurrence.—Murphysboro through De-Koven Coals; No. 2 through No. 7 Coals.

Laevigatosporites globosus Schemel, 1951
Plate 12, figure 20

Discussion. — It is difficult to differentiate for stratigraphic purposes the four species, *Laevigatosporites globosus*, *L. punctatus* Kosanke, 1950, *Punctatisporites orbicularis* Kosanke, 1950, and *P. obliquus* Kosanke, 1950, because of their similarity in shape and ornamentation. Schemel (1951, p. 746) noted that there is difficulty in distinguishing between specimens of *L. globosus* and *P. obliquus*. He further stated, "If the nature of the suture cannot be discerned, it may be problematical to which species, and genus, certain specimens belong." Habib (1966, p. 633) felt, "Except for only a slight difference in size range, the two species are very similar and perhaps should be considered conspecific. The true nature of the suture of either species is in doubt."

The sutures vary from monolete in *Laevigatosporites punctatus*, to monolete or trilete in *L. globosus*, and to trilete with rays of almost equal length in *Punctatisporites orbicularis*. According to the original diagnoses, the size ranges are: *L. punctatus* — 35 to 51μ, *L. globosus* — 19 to 30μ, *P. obliquus* — 31 to 46μ, and *P. orbicularis* — 35 to 51μ. Under oil immersion objective the ornamentation of the last three species is almost the same except for the slightly coarser ornamentation on *P. orbicularis*. *P. orbicularis* is also slightly thinner.

To help resolve the problem of differentiating between *Punctatisporites obliquus* and *Laevigatosporites globosus*, the maximum diameters of 100 specimens falling within the morphologic limitations of the two species were measured from three macerations (1143-C, 1404-Q, and 1404-HH). Diameters were plotted (text fig.



Text Fig. 28 — Comparison of size distribution of *Laevigatosporites globosus* Schemel, 1951, and *Punctatisporites obliquus* Kosanke, 1950.

28) to show distribution of specimens in size increments of 0.5μ. The diagram shows two main groupings. Most specimens lie in the size range 16.5 to 30μ; a second, smaller group between 32 and 41μ occurs. Although difficult to separate morphologically during routine analyses, both species appear to be represented. For the purpose of this report the specimens that are 30μ or smaller were classified as *L. globosus* and those larger than 30μ as *P. obliquus*. In addition to the difference in size, *L. globosus* commonly has a thicker exine in relation to its size, and it is generally more elliptical than *P. obliquus*. *L. globosus* typically displays one long suture and a vestigial perpendicular suture that seems to plunge into the spore exine away from the longer suture.

Laevigatosporites punctatus is monolete, more elliptical, and is somewhat more coarsely ornamented than the three species discussed above. Some specimens of *L. punctatus* are very difficult to distinguish from poorly preserved or overmacerated specimens of *Thymospora pseudothiessenii*.

The species described by Alpern (1958), *Speciosporites minor*, *S. minutus*, *S. triletoides*, *Crassosporites triletoides*, and *C. punctatus*, are apparently gradational with *Punctatisporites obliquus* or *Laevigatosporites globosus*. Alpern, Doubinger, and Liabeuf (1967) helped clarify the morphology and classification of the small monolete spores, including *Laevigatosporites*, *Punctatosporites*, *Speciosporites*, and *Thymospora*, which they compared by examining material from which many of the species were originally described.

Occurrence. — No. 1 through Jamestown Coals; No. 7 Coal.

Laevigatosporites medius
Kosanke, 1950
Plate 12, figure 21

Occurrence.—No. 1 Coal; Wiley through Jamestown Coals; No. 7 Coal.

Laevigatosporites minutus (Ibrahim) Schopf, Wilson, and Bentall, 1944

Occurrence.—Wiley through No. 7 Coals.

Laevigatosporites ovalis
Kosanke, 1950

Occurrence. — No. 1 through No. 7 Coals.

Laevigatosporites punctatus
Kosanke, 1950
Plate 12, figure 22

Occurrence.—Murphysboro through No. 4 Coals; No. 5, No. 6, and No. 7 Coals.

Laevigatosporites vulgaris
(Ibrahim) Ibrahim, 1933
Plate 12, figure 23

Occurrence.—Murphysboro Coal; Wiley and DeKoven Coals; Abingdon (?) through No. 7 Coals.

Genus TUBERCULATOSPORITES

Type species. — *Tuberculatosporites anicystoides* Imgrund, 1960.

Tuberculatosporites robustus (Kosanke) emend. and comb. nov.
Plate 13, figures 1-2

1950 *Laevigatosporites robustus* Kosanke, p. 30, pl. 5, fig. 9.
1966 *Tuberculatosporites spinoplicatus* Habib, p. 644, pl. 107, figs. 1-3.

Diagnosis. — The spores are bilateral, monolete, bean-shaped, and have a periphery that appears to be slightly upturned or downturned. The distinct suture, which extends about two-thirds the spore length, is bordered on each side by lips up to 3μ in width. The commissure is opened or closed. On the spore surface are widely and unevenly distributed bristle-like setae that may or may not extend beyond the spore margin. The maximum observed extension beyond the spore margin is 8μ. The spore margin in most specimens is angularly deflected where it intersects the setae. The setae, which may number up to about 30 around the spore margin, are narrow, hair-like in the central regions of the spore, and gradually expand in width toward or beyond the spore margin. They are up to 30μ long and 8μ wide at their ends, which are ragged. The setae are straight, curved, or somewhat sinuous, and the thin ones are cross striated, producing a beaded appearance. Channelized thin areas or small folds on the spore exine reflect setae that have been torn out or completely eroded. The exine, about 1μ thick, under oil immersion objective is levigate between the setae. Dimensions (32 specimens): size range, 93 by 62μ to 182 by 120μ; median, 124 by 81μ.

Holotype.—Kosanke, 1950, pl. 5, fig. 9.

Figured specimens. — Plate 13, figure 1; negative 7913; New Haven Coal, maceration 574, slide 8, coordinates, 144.7 × 33.4; size, 101.8 by 73.5μ. Plate 13, figure 2; negative 7622; Colchester (No. 2) Coal, maceration 1230-C, slide 15, coordinates, 137.7 × 40.3; size, 123.5 by 81.3μ.

Discussion. — The holotype illustrated by Kosanke shows only vague evidence of setae, which could easily be mistaken for small folds.

Occurrence.—No. 2, Lowell, and No. 7 Coals.

Genus THYMOSPORA
Wilson and Venkatachala, 1963a

Type species. — *Thymospora thiessenii* (Kosanke) Wilson and Venkatachala, 1963a.

Thymospora pseudothiessenii (Kosanke) Wilson and Venkatachala, 1963a

Occurrence.—Wiley through No. 7 Coals.

Genus TORISPORA (Balme)
Alpern, Doubinger, and Horst, 1965

Type species. — *Torispora securis* (Balme) Alpern, Doubinger, and Horst, 1965.

Discussion. — Many Illinois coals contain spores of the genus *Torispora* that are more coarsely verrucose than the typical specimen of *Torispora securis* illustrated in this report. Ornamentation probably grades from granulose or weakly verrucose to strongly verrucose (*Torispora verrucosus* Alpern, 1958), as in *Thymospora pseudothiessenii* (Wilson and Venkatachala, 1963c).

Torispora securis (Balme)
Alpern, Doubinger, and Horst, 1965

Occurrence.—Seelyville through No. 5A Coals; No. 6 and No. 7 Coals.

Genus COLUMINISPORITES Peppers, 1964

Type species. — *Columinisporites ovalis* Peppers, 1964.

Columinisporites ovalis Peppers, 1964
Plate 13, figure 3

Occurrence. — Murphysboro Coal.

Genus WILSONITES (Kosanke)
Kosanke, 1959

Type species.—*Wilsonites vesicatus* (Kosanke) Kosanke, 1959.

Wilsonites delicatus (Kosanke)
Kosanke, 1959
Plate 13, figure 4

Occurrence. — Abingdon (?) through No. 4 Coals; No. 5, Spring Lake, No. 6, and No. 7 Coals.

Wilsonites vesicatus (Kosanke)
Kosanke, 1959

Occurrence. — No. 1 through No. 5 Coals; Spring Lake through Jamestown Coals; No. 7 Coal.

Genus PEROTRILETES (Erdtman)
ex Couper, 1953

Type species. — *Perotriletes granulatus* Couper, 1953.

Discussion.—Couper (1953) described the genus *Perotriletes* from Upper Jurassic strata of New Zealand. Balme and Hassell (1962) erected the genus *Diaphanospora* to accommodate spores of comparable morphology from Upper Devonian rocks. Although they recognized that the forms they placed in *Diaphanospora* could also be placed, on a morphologic basis, in *Perotriletes*, they concluded that since " . . . no spores with perispores have been found in Permian and Triassic sediments in Australia . . . it is considered that a distinct genus is necessary for the Upper Devonian species." Hughes and Playford (1961) assigned to *Perotriletes* two species they described from the Lower Carboniferous of Spitsbergen. *Hymenospora* (Neves, 1961), another morphologically similar taxon was described from the Namurian of England. Assignment of the Illinois species *Perotriletes parvigracilus*, *Hymenospora multirugosa*, and *H. paucirugosa* to their respective genera, therefore, was made with some uncertainty.

Perotriletes parvigracilus sp. nov.
Plate 13, figures 5-7

Diagnosis. — The miospores are radial, trilete, and oval in transverse plane. The rather distinct commissure is usually open and possesses lips up to 1μ wide. Two of the rays, which are generally longer than the third, extend about two-thirds the distance to the spore margin. The spore coat of the body is about 2μ thick and is probably levigate. The enclosing perispore is attached to the body at the proximal surface and is translucent and thin, being less than 0.5μ thick. It is characterized by abundant small folds, most of which are on the distal side. The perispore in most specimens extends 1 to 2μ, but in a few up to 4μ, beyond the margin of the body. It is levigate under high dry objective but is minutely punctate under oil immersion objective. A few widely scattered

grana, about 1μ in diameter, generally occur on the proximal and distal surfaces of the perispore. Dimensions (10 specimens): size range, 42.5 to 52.3μ; median, 45.5μ.

Holotype. — Plate 13, figure 5; negative 7789; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 37, coordinates, 130.1 × 42.2; size, 45.8 by 40.6μ.

Paratypes. — Plate 13, figure 6; negative 7832; Lowell Coal, maceration 1404-Q, slide 22, coordinates, 123.3 × 44.1; size, 47.5 by 40.0μ; focus on proximal side. Plate 13, figure 7; negative 7833; focus on distal side.

Etymology. — The specific epithet refers to its small (*parvus*) and thin (*gracilus*) perispore.

Occurrence. — No. 2 through No. 4 Coals; No. 6 and No. 7 Coals.

Genus HYMENOSPORA Neves, 1961

Type species. — *Hymenospora palliolata* Neves, 1961.

Discussion. — See discussion of genus *Perotriletes*.

Hymenospora multirugosa sp. nov.
Plate 13, figures 8-9

Diagnosis. — The miospores are radial, trilete, and circular to roundly triangular in transverse plane, but the margin is often slightly contorted owing to minor folding. The spores are differentiated into a central body and an enveloping perispore. The perispore is closely fixed, especially on the proximal side, which often results in the formation of a triradiate mark on the perispore. The body, about three-fourths the radius of the saccus, is circular to roundly triangular, distinct, and about 1μ thick. It is probably levigate, but the ornamentation cannot be determined with certainty because it is concealed by the perispore. The trilete rays are fairly distinct and are at least two-thirds the length of the spore radius. The commissure is bordered on both sides by elevated irregular labra about 1μ wide. Rays on the body are straight, but where the suture is formed on the perispore, the rays are wavy and split open. The perispore is externally levigate, but is finely infrapunctate to infrareticulate. Individual punctations can be discerned only under oil immersion objective. The proximal and, more especially, the distal surfaces are set with abundant, narrow, anastamosing folds or rugae. Occasionally the raised portions of the folds are more verrucose in shape. Folds are denser toward the poles but extend out beyond the body area, sometimes to the margin of the perispore, which then becomes uneven. The perispore lacks a limbus and is rather thick (about 1μ). Dimensions (16 specimens): over-all size range, 35.8 to 45.8μ in maximum diameter; median, 42μ; size range of body, 29.3 to 39μ in maximum diameter; median, 33.5μ.

Holotype. — Plate 13, figure 8; negative 7839; Danville (No. 7) Coal, maceration 1384-U, slide 12, coordinates, 125.6 × 43.1; size, over-all diameter 39.0 by 35.1μ; body, 32.5 by 29.3μ.

Paratype. — Plate 13, figure 9; negative 7900; Cardiff Coal, maceration 1133-C1 (RR), slide 18, coordinates, 129.5 × 50.7; size, over-all diameter 39.0 by 35.8μ; body, 28.6 by 30.9μ.

Comparison. — *Hymenospora multirugosa* is smaller, has a more distinct body, and has more folds than *H. paucirugosa* sp. nov. *H. multirugosa* is like *H. caperata* Felix and Burbridge, 1967, except that it has an infrapunctate to infrareticulate outer membrane and its commissure possesses lips. Species of *Hymenospora* are morphologically similar to some species that have been assigned to *Diaphanospora* Balme and Hassell, 1962. The perispore of *D. ricinata* Balme and Hassell, 1962, is unornamented and that of *D. perplexa* Balme and Hassell, 1962, is infragranulate. *D. cingulata* Guennel, 1963, has a body ornamented with grana of two different sizes. *D. reticulata* Guennel, 1963, is more triangular, and its perispore is more coarsely punctate.

Etymology. — The specific epithet refers to the many (*multi*) folds (*ruga*) on its perispore.

Occurrence.—No. 2 through No. 4 Coals; No. 7 Coal.

Hymenospora paucirugosa sp. nov.
Plate 13, figures 10-13

Diagnosis. — The spores are radial, trilete, and circular to roundly triangular or elliptical in outline. Many are folded. The spores are divided into a circular to roundly triangular, indistinct body and a rather thick enveloping perispore. The latter is closely attached to the body, especially on the proximal surface where a trilete mark is usually formed on the perispore. Larger specimens seldom display any evidence of a body. The trilete rays are distinct and show considerable variation in form. They are usually three-fourths as long as the radius of the body, but they may reach the margin. Occasionally one ray is much shorter than the other two, and the ends may bifurcate. The commissure is distinct and is bordered on both sides by elevated lips about 2μ wide. The body is probably levigate. The perispore is externally levigate but finely infrapunctate to infrareticulate with punctations so small that oil immersion objective is required to differentiate them. The central portions of the proximal and, more especially, the distal sides are set with small anastamosing folds. The perispore lacks a limbus and is 1μ or less thick. Dimensions (40 specimens): over-all size range, 55.3 to 82.6μ in maximum diameter; median, 67.3μ.

Holotype. — Plate 13, figure 10; negative 7901; Colchester (No. 2) Coal, maceration 954-Ee, slide 18, coordinates, 137.6 $\times$ 36.3; over-all size, 65.0 by 62.1μ; body, 54.0 by 54.0μ.

Paratypes. — Plate 13, figure 11; negative 7903; Cardiff Coal, maceration 954-Dd, slide 7, coordinates, 129.6 $\times$ 50.1; size (perispore), 74.1 by 62.1μ. Plate 13, figure 12; negative 7638; Lowell Coal, maceration 1404-R, slide 18, coordinates, 142.9 $\times$ 44.0; over-all size, 78.7 by 71.5μ; body, 63.4 by 62.8μ. Plate 13, figure 13; negative 7902; Summum (No. 4) Coal, maceration 1249-B, slide 11, coordinates, 123.1 $\times$ 40.0; size (perispore), 68.3 by 65.3μ.

Discussion. — The holotype (fig. 10) and the specimen illustrated in figure 12 display an indistinct central body. Figure 13 shows a perispore with a thin, circular portion toward the center that marks the position of the missing central body. The most typical form, in which there is no evidence of a spore body, is depicted in figure 11. The unnamed spore, Spore sp. A, illustrated by Habib (1966, pl. 107, fig. 4) probably should be assigned to *Hymenospora paucirugosa.*

Etymology. — The species name refers to the relatively few (*pauci*) number of folds (*ruga*) found in this taxon compared with *Hymenospora multirugosa.*

Occurrence. — Murphysboro and Wiley Coals; No. 2 through No. 4 Coals; No. 5, No. 5A, and No. 7 Coals.

Genus ENDOSPORITES
Wilson and Coe, 1940

Type species. — *Endosporites ornatus* Wilson and Coe, 1940.

Endosporites globiformis (Ibrahim)
Schopf, Wilson, and Bentall, 1944
Plate 13, figure 14

Discussion. — As pointed out by Habib (1966, p. 647), Chaloner (1953, p. 104-108) compared specimens of microspores from *Lepidostrobus zea* and found that if they were dispersed they would be classified as several species of *Endosporites.* The specimens from coals of the Carbondale Formation fell within the size range of 80 to 130μ for the maximum over-all diameter given by Chaloner and may or may not display indistinct apical papillae on the spore body. Chaloner stated that interradial papillae may be observed on the spore body of a number of specimens but might not be recognized because of incomplete development or concealment by the sac.

Occurrence. — No. 1 and Murphysboro Coals; Wiley through No. 7 Coals.

Endosporites plicatus Kosanke, 1950
Plate 13, figure 15

1966 *Endosporites grandicorpus* Habib, p. 647, pl. 107, figs. 11-12.

Discussion.—Although circular in overall outline, the holotype of *Endosporites plicatus*, which is somewhat thin, does have angular extensions on the bladder opposite the rays. Another specimen of this taxon on the same slide as the holotype is a little thicker and more angular. This species, as observed from many coals and other Pennsylvanian rocks throughout Illinois, varies in shape from circular to quite angular. Many spores of the kind designated as *E. grandicorpus* have been observed, and the construction of a new species had been considered until the holotype of *E. plicatus* and other specimens from the same maceration were examined in detail. Part of the variation in the shape of these spores is probably due to different degrees of maturity, preservation, and compaction.

Occurrence. — Seelyville through No. 5 Coals; No. 7 Coal.

Genus PALEOSPORA Habib, 1966

Type species. — *Paleospora fragila* Habib, 1966.

Paleospora fragila Habib, 1966
Plate 13, figure 16

Occurrence. — Murphysboro Coal; No. 2 through No. 5A Coals; No. 6 and No. 7 Coals.

Genus FLORINITES
Schopf, Wilson, and Bentall, 1944

Type species.—*Florinites antiquus* Schopf (*in* Schopf, Wilson, and Bentall, 1944).

Florinites antiquus Schopf
(*in* Schopf, Wilson, and Bentall, 1944)
Plate 13, figure 17

Occurrence. — No. 1 and Murphysboro Coals; Wiley through No. 7 Coals.

Florinites grandis Kalibová, 1964
Plate 14, figure 1

Occurrence. — Abingdon (?), No. 2, Lowell (?), No. 4, Spring Lake, and No. 6 Coals.

Florinites similis Kosanke, 1950
Plate 14, figures 2-3

Description. — The pollen grains are bilateral, trilete, and elliptical to almost circular in outline. A saccus encloses the spore body except for a small area on the distal surface. The sharply defined body is also elliptical to circular and is strongly folded, especially around the periphery. Folds occur on the distal and proximal surfaces of the body, and folds on the distal surface that transect the rays do not disturb the rays. The trilete rays are distinct when the body is not excessively torn or folded. The sutures, which are often open, lack lips, but occasional narrow folds along either side may resemble lips. Two of the rays are long, one-half to two-thirds of the radius of the body, but the third ray is only one-fourth the radius or less and is almost at right angles to the other two. The surface of the body is minutely granulate to punctate under oil immersion objective. The body is about 1μ thick. The saccus is externally levigate but infrapunctate to infrareticulate. The lacunae are from less than 1 to 3μ in diameter and are largest away from the body. The saccus is often folded or torn. Dimensions (30 specimens): size range, saccus length 97 to 172μ; saccus width, 64 to 104μ; body, maximum diameter, 55 to 78μ.

Holotype. — Kosanke, 1950, p. 116-117, pl. 12, fig. 2.

Figured specimens. — Plate 14, figure 2; negative 7726; Cardiff Coal, maceration 954-Dd, slide 10, coordinates, 144.5 × 53.2; size, saccus, 119.3 by 95.2μ; body, 73.5 by 62.4μ. Plate 14, figure 3; negative 7725; Cardiff Coal, maceration 954-Dd, slide 15, coordinates 139.0 × 39.5; size, saccus, 113.1 by 103.7μ; body, 74.8 by 69.2μ.

Discussion. — Pollen grains conforming to the description of *Florinites similis*, ex-

cept for the presence of trilete rays, were assigned to this species. Kosanke (1950, p. 49) stated that *F. similis* is apparently alete. The holotype does not reveal any haptotypic features because the body is torn and folded; however, several specimens from a remacerated sample from which the holotype had been selected displayed the same kind of rays characteristic of the specimens examined for this study and resembled the holotype in all other respects. A well defined bladder-free area on the distal side of the body was seldom observed on my specimens.

Florinites similis is very similar in overall appearance to the type species *Guthoerlisporites magnificus* described by Bhardwaj in 1954. According to him, these isospores possess a body that is free of the saccus on the proximal surface. Bhardwaj (1955, p. 132), in his reconstruction of *Guthoerlisporites*, stated, "In view of the well-developed trilete mark borne by the central body it seems that the proximal side of the body is free, the bladder covering the distal side." Bhardwaj also stated that *Florinites* lacks a distinct trilete mark; however, several species of *Florinites* possessing a well developed trilete mark have been described. The pollen grain with a well developed trilete mark and a distinct body outline, assigned to *F. similis* and illustrated as figure 3 of plate 14, shows where part of the saccus has been torn free from the proximal surface of the spore body. Some specimens in which the body has been completely removed still show a scar made by the trilete rays, indicating that the saccus extends over the proximal surface of the body. As the presence of a well developed trilete mark was apparently cited by Bhardwaj as evidence of a bladder-free proximal side, it is thought that *G. magnificus* and *Florinites similis* may be morphologically very similar.

Guennel (1958) illustrated from the Minshall Coal of Indiana a pollen grain he assigned to *Guthoerlisporites magnificus*. He concluded that perhaps the taxon should be placed with *Endosporites* because he felt that the folding of the body wall, absence of a limbus, and presence of short tecta were insignificant grounds for establishing the genus *Guthoerlisporites*.

Florinites similis and *Guthoerlisporites* also bear some similarity to *Potonieisporites novicus* Bhardwaj, 1954, the type species of the monolete genus, especially the drawing of the holotype of *P. novicus* (Bhardwaj, 1954, fig. 10) and the photographs of the two diplotypes (Bhardwaj, 1955, pl. 2, figs. 13-14) in all of which the suture is angularly deflected in the middle but lacks a third ray. The straight suture shown in the diagrammatic sketches of *P. novicus* (Bhardwaj, 1954, fig. 9; 1955, fig. 11), however, is unlike the suture found in *F. similis*. Nygreen and Bourn (1967, p. 325-332) described the morphological transitions from *Potonieisporites* to *Guthoerlisporites*, *Nuskoisporites*, and *Candidspora*.

Occurrence. — Wiley through No. 5 Coals; No. 6 and No. 7 Coals.

Florinites millotti
Butterworth and Williams, 1954
Plate 14, figure 4

Occurrence.—No. 1, Murphysboro, and Wiley Coals; uncorrelated coal bands between the Cardiff and No. 2 Coals; Lowell Coal through the unnamed coal between No. 4 and No. 5 Coals; No. 6 Coal.

Florinites visendus (Ibrahim)
Schopf, Wilson, and Bentall, 1944

Occurrence. — No. 2, No. 4, Spring Lake, and Jamestown Coals.

Genus VESICASPORA (Schemel)
Wilson and Venkatachala, 1963d

Type species. — *Vesicaspora wilsonii* (Schemel) Wilson and Venkatachala, 1963d.

Vesicaspora wilsonii (Schemel)
Wilson and Venkatachala, 1963d
Plate 14, figure 5

Occurrence.—Murphysboro Coal; Wiley through No. 5A Coals; No. 6, Jamestown, and Danville Coals.

Genus KOSANKEISPORITES (Bhardwaj, 1955) emend.

1955 *Kosankeisporites* Bhardwaj, p. 135-137, pl. 2, figs. 16-17.

Type species. — *Kosankeisporites elegans* (Kosanke, 1950) emend.

Diagnosis. — The bisaccate prepollen grains are bilaterally symmetrical, elliptical, and haploxylonoid to slightly diploxylonoid in over-all outline when viewed in good proximal-distal orientation. The body of most specimens is elliptical but in others is circular. On the proximal surface are four or five distinct, occasionally obscure striae or rugulae that are more or less straight and parallel and run in a longitudinal direction. The length of the striae almost equals body length, and bifurcation of the striae is rare. The striated area is enclosed by a circular groove just inside, and more or less parallel to, the periphery of the body. The commissure at the proximal pole of the body is wider and more distinct than the striae. One of the three rays is generally less than half the length of the other two, which may extend outward and join the circular groove. The apex of the three rays is often ruptured, producing a small triangular area. The surface of the body is levigate to finely granulate.

On the distal side of the body is a sulcus formed between two crescent-shaped folds that extends almost the entire width of the body. The width of the folds, which varies, is from 2 to 9μ. The two opposite sacci overlap onto the body except for a narrow portion at the center of the proximal and distal sides. Saccus attachment on the distal side is slightly beyond or in the region of the folds on either side of the sulcus. The area of overlap on the proximal surface is indistinct. When the prepollen is viewed in lateral position, the sacci are slightly inclined distally. The length of the sacci from the ends to where they are attached to the body is usually less than their width. The semicircular to crescent-shaped sacci are as wide or wider than the body. They are externally levigate but infrareticulate. The known size range in longest dimension is 48 to 84μ.

Discussion. — Bhardwaj (1955) proposed the genus *Kosankeisporites* to accommodate *Illinites elegans*, which displays striae on the proximal cap, but he interpreted the trilete suture as part of the striated pattern.

Kosankeisporites elegans (Kosanke) emend.

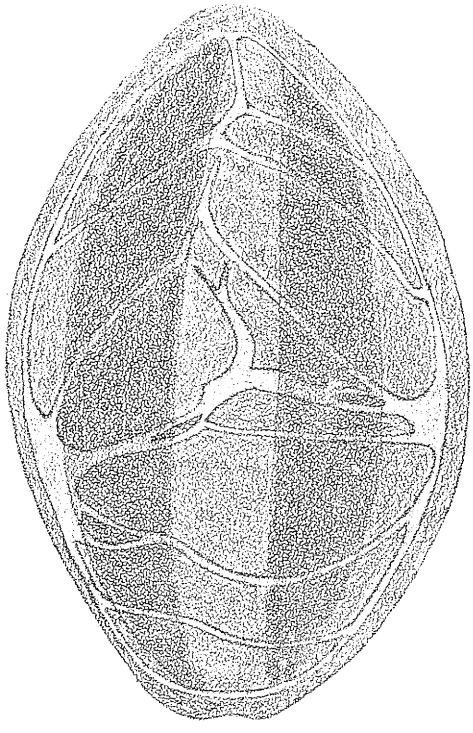
Text figure 29; plate 14, figures 6-8

1950 *Illinites elegans* Kosanke, p. 52, pl. 1, figs. 1-2.

1955 *Kosankeisporites elegans* (Kosanke) Bhardwaj, p. 137, pl. 2, figs. 16-17.

Diagnosis. — The trilete, bisaccate, prepollen grains are elliptical to somewhat haploxylonoid in transverse plane and most specimens are in good proximal-distal orientation. The body is strongly elliptical so that its longest dimension is transverse to the length of the entire prepollen grain. On the proximal surface are four or five distinct longitudinal striae that are more or less parallel but bifurcate occasionally. A circular groove just inside the periphery is often observed and limits the extent of the longitudinal striae. A distinct trilete mark is present toward the center of the proximal surface. Two of the rays are considerably longer than the third ray and may extend to the circular groove to which it joins. On the distal surface, transverse to the longitudinal axis of the grain are two strongly developed crescent-shaped folds. The exine, 1 to 2μ thick, is levigate. On opposite ends of the body the two approximately semicircular sacs are attached distally near or just beyond the folds on either side of the sulcus. The extent of the overlap of sacci on the proximal side is difficult to discern, but the body is probably about two-thirds covered. Some specimens in which the body is missing show striae on the sacci except for a narrow gap about 6μ wide at the center. In lateral view the sacci are slightly inclined distally. The sacci, 1μ or less thick, are levigate and infrareticulate with lacunae up to 3μ in diameter. Dimensions (8 specimens): size range, total length, 56 to 85μ (medi-

an, 64μ); body width, 42 to 52μ (median, 46μ); body length, 31 to 48.8μ (median, 35.8μ); saccus length, 25 to 35.1μ (median, 29.3μ); saccus width, 43 to 50μ (median, 46.2μ); sulcus width, 6 to 13μ (median, 7.2μ).



Text Fig. 29—Diagrammatic detail of the proximal surface of the holotype of *Kosankeisporites elegans* (Kosanke, 1950) emend.

Holotype. — Plate 14, figure 6 (re-illustrated from Kosanke (1950, p. 94-95, pl. 1, figs. 1-2); negative 7918; body under oil immersion objective.

Additional figured specimens. — Plate 14, figure 7; negative 7911; New Haven Coal, maceration 574, slide 40, coordinates, 139.2 × 56.4; size, 62.8 by 45.5μ. Plate 14, figure 8; negative 7912; same specimen as figure 7 to show trilete suture.

Discussion.—Bhardwaj (1955) described the striae on the body of *Kosankeisporites elegans* but interpreted the trilete suture as being part of the striated pattern. It is concluded here that this species possesses a trilete suture as originally described by Kosanke because a trilete groove is always near the proximal pole of the body, and it is generally more conspicuous and wider than the other striations. The specimen illustrated in plate 14, figures 7 and 8, clearly depicts a trilete suture.

Occurrence. — No. 4 and No. 7 Coals.

Genus COMPLEXISPORITES Jizba, 1962

Type species. — *Complexisporites polymorphus* Jizba, 1962.

Complexisporites chalonerii Habib, 1966
Plate 14, figure 9

Description.—The trilete, bisaccate prepollen grains are bilaterally symmetrical, and elliptical or haploxylonoid in polar view. The body on some specimens is circular but generally ellipsoid so that the longitudinal dimension that is parallel to the pollen length is shorter than the body width. The proximal surface of the body is characterized by four or five longitudinal, more or less straight and parallel striations that extend almost the entire length of the body. Striae are seldom branched and are circumscribed by a circular groove just inside the body margin. The commissure, which is usually split open, is distinct and near the center of the body. One of the three rays is usually shorter than the other two, which extend as far as, and join, the circular groove. A sulcus is formed between two crescent-shaped folds on the distal side of the body. The body, 1 to 2μ thick, is finely granulate. The two opposing sacci overlap the body on the distal side in or slightly beyond the region of the sulcus folds. The amount of overlap on the proximal surface is difficult to determine because of the fine ornamentation of the sacci. At the region of attachment, the more or less semicircular sacs are about as wide as the body and are wider than their longitudinal dimension. In lateral view the sacci are slightly inclined distally. The sacci, 1μ or less thick, are levigate and finely infrareticulate with lacunae that are less than 3μ in diameter. Dimensions (20 specimens): size range,

total length, 48 to 73μ (median, 63μ); width, 32 to 52μ (median, 42μ); body length, 26 to 42μ (median, 39μ); body length (in direction parallel to total length), approximately eight-tenths as long as body width; saccus length, 23 to 42μ (median, 29μ); saccus width, 4 to 13μ, depending on compression.

Figured specimen.—Negative 7909; Danville (No. 7) Coal, maceration 1384-R, slide 13, coordinates, 139.3 × 33.3; size, 65.0 by 43.2μ.

Discussion. — Habib (1966, p. 650) described the species as having a straight longitudinal suture. Most of the Illinois specimens that I observed show that the suture, which is trilete, consists of long rays that form almost a straight line except for a medial flexure and a third ray almost perpendicular to the other two.

Occurrence.—No. 4 Coal, the unnamed coal between No. 4 and No. 5 Coals; Jamestown and No. 7 Coals.

Genus ALATISPORITES (Ibrahim) Schopf, Wilson, and Bentall, 1944

Type species. — *Alatisporites pustulatus* (Ibrahim) Ibrahim, 1933.

Alatisporites trialatus Kosanke, 1950
Plate 14, figure 10

Occurrence. — No. 1 and Wiley Coals; Seelyville through No. 4 Coals; No. 5, No. 6, and No. 7 Coals.

Alatisporites hexalatus Kosanke, 1950
Plate 14, figure 11

Discussion. — Assigned to this species are spores similar to *Alatisporites hexalatus*, but which possess five rather than six bladders.

Occurrence. — Wiley, DeKoven, No. 2, Lowell, and No. 5 Coals.

Alatisporites punctatus Kosanke, 1950
Plate 14, figure 12

Discussion. — On some specimens of *Alatisporites punctatus* the bladders are folded in the middle in such a way as to give the appearance of two bladders along one interradial side. A peculiarity of this species, not encountered on the spores described by Kosanke (1950, p. 24), is the occasional formation of obvermiculate ridges into looped or crater-shaped protuberances on the spore body.

Occurrence. — No. 2, Lowell, and No. 5 Coals.

Genus TRIHYPHAECITES gen. nov.

Type species. — *Trihyphaecites triangulatus* sp. nov.

Diagnosis. — The generic name *Trihyphaecites* is proposed for a plant microfossil having the following characteristics. The fossils are composed of radially symmetrical, triangular to roundly triangular bodies that give rise to septate hyphae from each of the corners. Septae are also present at the corners where the hyphae are joined to the body. The hyphae may consist of one segment with a well rounded terminal end or may be of several segments in which the terminal end is either well rounded or broken. The fossils generally possess minor folds and are slightly torn. They are levigate and about 1μ thick. The triangular central body is generally thicker than the hyphae. Known size range from one corner to the opposite side of the triangular body is 32.2 to 48.8μ.

Discussion. — The genus *Trihyphaecites* is characterized by its triangular body with septate hyphae at each of the corners. These plant fossils may be fungal spores.

Trihyphaecites triangulatus sp. nov.
Plate 14, figures 13-16

Diagnosis. — The plant microfossils are made up of radially symmetrical, triangular to roundly triangular bodies that possess septate hyphae at each of the corners, which also are septate. The hyphae may consist of a single segment with a well rounded terminal end or numerous segments in which the terminal segment is rounded or broken. Hyphae are unbranched and septae are thick and pronounced. The triangular body and hyphae

are about 1μ thick, are levigate under oil immersion objective, and possess minor folds. Dimensions (19 specimens): size range of triangular body, 32.5 to 48.8μ in maximum diameter (median, 41.3μ); width of hyphae at corners, 10.4 to 26.0μ (median, 15.6μ).

Holotype. — Plate 14, figure 13; negative 7755; uncorrelated coal bands between Cardiff and Colchester (No. 2) Coals, maceration 1133-E, slide 8, coordinates 144.5 × 45.1; maximum diameter of triangular body, 38.4μ.

Paratypes. — Plate 14, figure 14; negative 7418; Springfield (No. 5) Coal, maceration 630, slide 25, coordinates 138.5 × 43.8; maximum diameter of triangular body, 35.8μ. Plate 14, figure 15; negative 7460; Springfield (No. 5) Coal, maceration 1392, slide 8, coordinates, 131.4 × 40.5; maximum diameter of largest triangular body, 42.3μ. Plate 14, figure 16; negative 7690; Abingdon (?) Coal, maceration 1404-I, slide 4, coordinates, 125.6 × 53.1; maximum diameter of triangular body, 38.4μ.

Occurrence. — Abingdon (?) Coal; uncorrelated coal bands between No. 2 and Cardiff Coals; Lowell, No. 4, No. 5, and No. 7 Coals.

SUMMARY

Correlation of Coals

The palynologic scrutiny of coals of the Carbondale Formation and the upper part of the Spoon Formation in Illinois reported here provided solutions to specific correlation problems in the northeastern part of the Illinois Basin.

A thin coal occurring in a clay pit near Goose Lake in Grundy County is tentatively correlated with the No. 1 Coal. The spore assemblage in another coal found about a quarter of a mile to the south is probably younger than the coal in the clay pit. It contains a spore assemblage resembling that of the Murphysboro Coal of southern Illinois and the Minshall Coal of Indiana, but not the No. 1 Coal. This supports Kosanke's belief (1950) that the Murphysboro is younger than the No. 1 Coal and is not correlative to it.

A coal lying a few feet below the No. 2 Coal in a diamond drill core from southern Livingston County is the only coal in the northeastern part of the Illinois Basin that is correlated with the Wiley Coal. Another hole drilled a few miles to the northwest contained three coals below the No. 2 Coal, the lowermost of which yielded well preserved spores. However, the coal was not identified as the assemblage was unlike that of any known coal. The first coal below the No. 2 Coal from the same cored section was correlated with a coal from another core in Edgar County, about 100 miles to the southeast. It is referred to as the Abingdon (?) Coal, but with reservation because comparison with the spore assemblage in the Abingdon Coal at its type outcrop was not possible, the outcrop being extremely weathered.

Spores were used to correlate the Lowell and Shawneetown Coals and the interval of the two coals formerly called the "2A" Coals (name now discontinued) of southern Illinois and the Survant Coal (IV) of Indiana. The Lowell Coal and its equivalents vary in thickness. They are absent in some places, in others are merely a smut streak, or they may form either one thick coal or two rather thick benches separated by a shale interval that varies from a few inches to almost 16 feet thick. The stratigraphic distance above the No. 2 Coal also varies considerably. Because of the close similarity of their spore contents, the two coal benches could not be differentiated by spore analysis. The Lowell Coal of northern Illinois, therefore, may be equivalent to the lower, the upper, or to a combination of the two coal seams.

The Cardiff Coal was deposited in a long, narrow channel in western Kankakee and northeastern Livingston County, and occurs in approximately the same interval as the Lowell Coal. However, the spore content of the two coals is somewhat differ-

ent. Either the Cardiff Coal was deposited slightly earlier than the Lowell Coal, or it was laid down synchronously with Lowell deposition but under dissimilar environmental conditions existing in the narrow channel basin.

A coal whose identity has been in doubt for many years occurs generally 40 to 85 feet above the No. 2 Coal and has been extensively mined in Kankakee and Grundy Counties. In this investigation its spore content indicated correlation with the No. 4 Coal.

Of the 59 small spore genera and 221 species identified, 4 genera and 35 species are new and are formally named and described. Other previously described spore taxa are recorded from the Illinois Basin for the first time. *Punctatisporites vermiculatus* Kosanke, 1950, and *P. transenna* Peppers, 1964, are placed in synonymy. Two species of *Punctatisporites, P. reticuloides* and *P. patulus* were emended and placed in the newly erected genus *Kewaneesporites*. The genus *Kosankeisporites* Bhardwaj, 1955, and the species *K. elegans* and *Laevigatosporites robustus* Kosanke, 1950, also are emended.

Although many of the coals investigated had already been considered in previous spore studies, new palynologic data were obtained because of the large number of coal samples used in this investigation. The Colchester (No. 2) Coal, the Lowell Coal and its equivalents, the Summum (No. 4), Springfield (No. 5), Herrin (No. 6), and Danville (No. 7) Coal Members were the most extensively sampled and studied. Other coals investigated include one tentatively identified as the Rock Island (No. 1) Coal, a coal tentatively identified as the Murphysboro Coal, the Wiley, DeKoven, and Seelyville Coals, one thin uncorrelated coal below the No. 2 Coal, the Abingdon (?), Cardiff, and Shawneetown Coals, an unnamed coal between the No. 4 and No. 5 Coals, the Briar Hill (No. 5A), Spring Lake, Jamestown, and Allenby Coals.

The spore contents of the Seelyville, Abingdon (?), the Lowell and its equivalents, the unnamed coal between the No. 4 and No. 5 Coals, and the Spring Lake Coal are reported in detail for the first time.

Spore Distribution

The occurrence and relative abundance of spore taxa proved useful in differentiating and correlating the coals (text figure 10). The most noticeable changes in the composition of the spore assemblages of the Carbondale coals take place between the No. 2 and Lowell Coals, the Lowell Coal and No. 4 Coal, between No. 5 and No. 5A Coals, and between No. 5A and No. 6 Coals. The No. 4 and No. 5 Coals are the most difficult to distinguish from each other by spore analysis.

Lycospora is by far the dominant genus in the Carbondale and upper Spoon coals, except in the interval including the Lowell, No. 4, and No. 5 Coals. There, *Laevigatosporites*, consisting mainly of *L. globosus* and *L. minutus*, is generally more abundant than *Lycospora. Thymospora pseudothiessenii* is a significant part of the spore population between the No. 4 and No. 5A Coals, and the presence of *Anapiculatisporites spinosus* in relatively large numbers characterizes the No. 4 and No. 5 Coals. *Crassispora* is rather common in the No. 5, Jamestown, and Allenby Coals, whereas *Punctatisporites* reaches its maximum frequency of about 10 percent in the No. 7 Coal.

Influence of Structure on Distribution

A special relation between the spore distribution of the No. 2, Lowell, and No. 4 Coals and the structural features of the northeastern part of the Illinois Basin was noted. In the No. 2 Coal, *Lycospora* decreases considerably in abundance, and *Laevigatosporites globosus* and *Crassispora* increase as the coal is traced from the west and east onto the Ancona-Garfield structure, which is a gentle anticline along the axis of the LaSalle Anticlinal Belt. Specimens of *Reinschospora*, *Torispora*, and *Densosporites* are more commonly observed on the Ancona-Garfield structure

than elsewhere in the state. The presence of *Densosporites* in the No. 2 Coal is apparently restricted to that portion of the Illinois Basin east of the axis of the LaSalle Anticlinal Belt.

Laevigatosporites globosus and *L. minutus* together make up about two-thirds of the small spore assemblage in the Lowell Coal on the Ancona-Garfield structure and at the type section of the coal on the steep western flank of the LaSalle Anticlinal Belt just to the north of the Ancona-Garfield structure. *Lycospora* is relatively uncommon. On the anticlinal belt and east and south of it, *Lycospora* increases and *Laevigatosporites* diminishes in importance.

In the No. 4 Coal, *Thymospora* and *Crassispora* become more plentiful and *Lycospora* becomes less abundant on the Ancona-Garfield structure. *Alatisporites* has not been noted in the No. 4 Coal west of the Ancona-Garfield structure nor in southern Illinois, but the genus is found with regularity in the coal east of the structure.

An explanation of the unique composition of the spore assemblages in the coals on the Ancona-Garfield structure may be in the relation of the coal to the underlying structural framework and resultant geomorphology. Other evidence shows that the LaSalle Anticline was not very active during Pennsylvanian time (Clegg, 1965, p. 82-94), and the strata between the No. 2 and No. 6 Coals display no appreciable thinning over the anticlinal belt or even over the Ancona-Garfield structure. Most of the structural development of the LaSalle Anticlinal Belt took place before and after Pennsylvanian time, but there was minor activity during Pennsylvanian time. It is proposed that the LaSalle Anticlinal Belt, and more particularly the Ancona-Garfield structure, were sufficiently elevated in comparison to adjacent areas to have had some influence on the environment and composition of the coal swamp flora. Perhaps variations in the flora reflect differences in the water level, salinity, and drainage patterns, as pointed out by Spackman et al. (1966), Habib (1966), and Habib et al. (1966) in their discussions of the recent peat deposits of southwestern Florida. Also, as *Lycospora* was generally found to decrease in abundance while *Thymospora* and *Laevigatosporites globosus* increase in abundance toward the top of the No. 2, Lowell, and No. 4 Coals, the coal swamps may have formed over the Ancona-Garfield structure in the later stages of coal swamp development.

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PLATES AND EXPLANATIONS

PLATE 1

(Magnification 500× unless otherwise stated)

FIGURE

1. *Leiotriletes adnatoides* Potonié and Kremp, 1955; Lowell Coal, maceration 1190, slide 10; 31.9 by 31.9μ; p. 80.
2. *Leiotriletes* cf. *adnatus* (Kosanke) Potonié and Kremp, 1955; Lowell Coal, maceration 1190, slide 2; 26.0 by 23.7μ; p. 80.
3. *Leiotriletes pseudolevis* sp. nov., holotype; Colchester (No. 2) Coal, maceration 1402-C, slide 5; 36.4 by 36.1μ; p. 80.
4. *Leiotriletes pseudolevis* sp. nov., paratype; Herrin (No. 6) Coal, maceration 1242-A, slide 12; 38.0 by 36.4μ; p. 80.
5. *Leiotriletes levis* (Kosanke) Potonié and Kremp, 1955; Danville (No. 7) Coal, maceration 1404-HH, slide 14; 46.5 by 39.0μ; p. 81.
6. *Leiotriletes notatus* Hacquebard, 1957; Herrin (No. 6) Coal, maceration 1355, slide 1; 42.3 by 39.7μ; p. 81.
7. *Leiotriletes gracilis* Imgrund, 1960; Colchester (No. 2) Coal, maceration 982-C2, slide 8; 26.0 by 23.1μ; p. 81.
8. *Leiotriletes parvus* Guennel, 1958; Cardiff Coal, maceration 1133-C1 (RR), slide 18; 23.4 by 22.8μ; p. 81.
9. *Leiotriletes* cf. *atshanensis* Singh, 1964; Springfield (No. 5) Coal, maceration 982-B1, slide 3; 53 by 46.8μ; p. 81.
10. *Leiotriletes* sp. 1; Lowell Coal, maceration 1387-D, slide 7; 37.4 by 35.8μ; p. 82.
11. *Trivolites laevigata* Peppers, 1964; Lowell Coal, maceration 1279-E, slide 17; 33.2 by 29.9μ; p. 82.
12. *Punctatisporites curviradiatus* Staplin, 1960; Springfield (No. 5) Coal, maceration 726-Aa, slide 19; 45.5 by 42.6μ; p. 82.
13. *Punctatisporites* cf. *pseudolevatus* Hoffmeister, Staplin, and Malloy, 1955; Summum (No. 4) Coal, maceration 1249-C, slide 2; 55.3 by 48.8μ; p. 82.
14. *Punctatisporites aerarius* Butterworth and Williams, 1958; Abingdon (?) Coal, maceration 1404-K, slide 10; 106.3 by 80.9μ; p. 82.
15. *Punctatisporites nahannensis* Hacquebard and Barss, 1957; Herrin (No. 6) Coal, maceration 1242-A, slide 13; 54.3 by 52.3μ; p. 82.
16. *Punctatisporites edgarensis* sp. nov., holotype; Lowell Coal, maceration 1402-D, slide 21; 121.9 by 113.8μ; p. 82.
17. *Punctatisporites edgarensis* sp. nov., paratype; Herrin (No. 6) Coal, maceration 1404-CC, slide 35; 123.5 by 120.9μ; p. 82.


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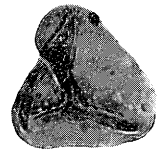
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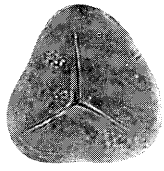
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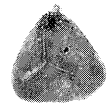
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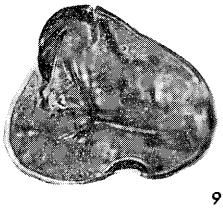
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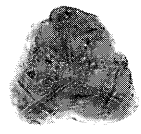
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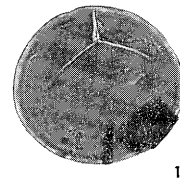
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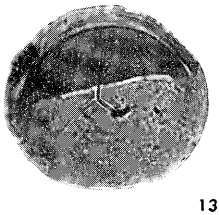
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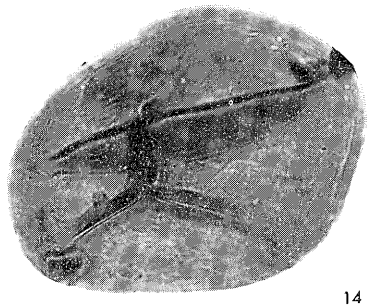
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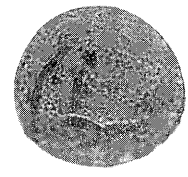
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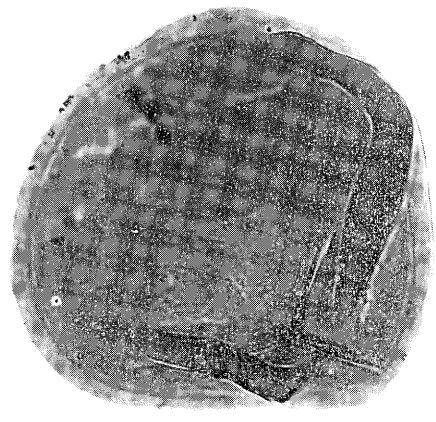
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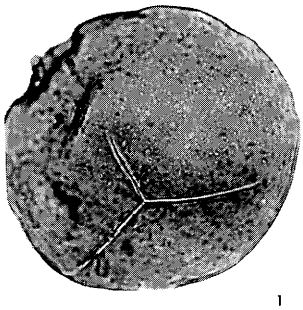
PEPPERS — PENNSYLVANIAN SPORES

PLATE 2

(Magnification 500× unless otherwise stated)

FIGURE

1. *Punctatisporites decorus* Wilson and Kosanke, 1944; Colchester (No. 2) Coal, maceration 954-Ee, slide 25; 80.6 by 76.4μ; p. 83.
2. *Punctatisporites kankakeensis* sp. nov., holotype; uncorrelated Summum Coal, maceration 1133-A1, slide 2; 65.3 by 65.0μ; p. 83.
3. *Punctatisporites kankakeensis* sp. nov., paratype; Summum (No. 4) Coal, maceration 1405-A, slide 9; 49.1 by 47.1μ; p. 83.
4. *Punctatisporites orbicularis* Kosanke, 1950; Lowell Coal, maceration 1404-P, slide 6; 35.4 by 34.8μ; p. 84.
5. *Punctatisporites vermiculatus* Kosanke, 1950; Springfield (No. 5) Coal, maceration 630, slide 24; 52.0 by 41.0μ; p. 84.
6. *Punctatisporites vermiculatus* Kosanke, 1950; same specimen shown in figure 5, but at 1000× magnification; p. 84.
7. *Punctatisporites* cf. *gracilirugosus* Staplin, 1960; Summum (No. 4) Coal, maceration 1396-B, slide 10; 65.0 by 59.5μ; p. 84.
8. *Punctatisporites* sp. 1; Lowell Coal, maceration 1384-K, slide 5; 60.8 by 51.8μ; p. 84.
9. *Calamospora flexilis* Kosanke, 1950; Murphysboro Coal, maceration 1160 (RR), slide 13; 64.4 by 58.5μ; p. 85.
10. *Calamospora minuta* Bhardwaj, 1957a; Summum (No. 4) Coal, maceration 1405-C, slide 8; 33.8 by 33.5μ; p. 85.
11. *Calamospora hartungiana* Schopf (*in* Schopf, Wilson, and Bentall, 1944); Summum (No. 4) Coal, maceration 1405-B, slide 20; 75.1 by 64.4μ; p. 85.
12. *Calamospora mutabilis* (Loose) Schopf, Wilson, and Bentall, 1944; Lowell Coal, maceration 1404-P, slide 14; 134.9 by 123.5μ; p. 85.
13. *Calamospora pedata* Kosanke, 1950; Springfield (No. 5) Coal, maceration 726-Aa, slide 18; 68.9 by 51.0μ; p. 85.
14. *Calamospora* sp. 1; Cardiff Coal, maceration 1133-C1 (RR), slide 5; 91.0 by 89.4μ; p. 85.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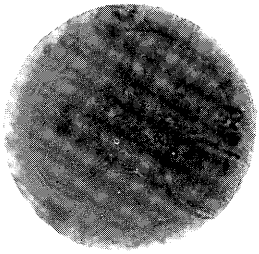
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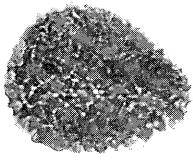
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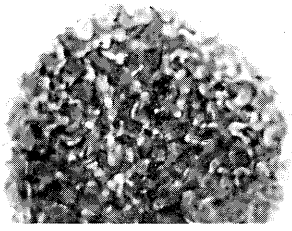
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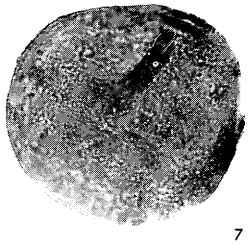
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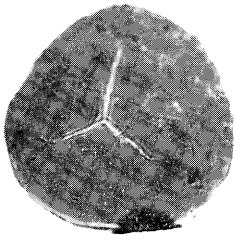
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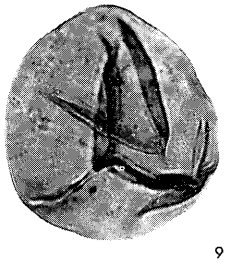
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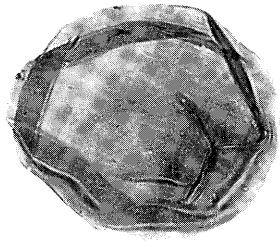
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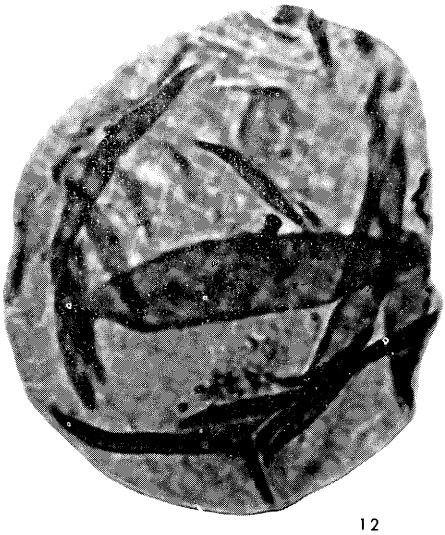
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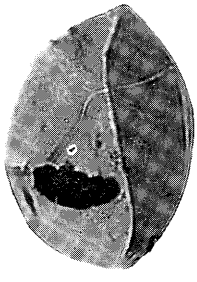
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PEPPERS — PENNSYLVANIAN SPORES

PLATE 3

(Magnification 500× unless otherwise stated)

FIGURE

1. *Elaterites triferens* Wilson, 1943; Colchester (No. 2) Coal, maceration 1275-D, slide 11; body, 76.7 by 66.6μ; p. 86.

2. *Elaterites triferens* Wilson, 1943; Colchester (No. 2) Coal, maceration 1275-D, slide 12; body, 82.5 by 73.5μ; p. 86.

3. *Elaterites triferens* Wilson, 1943; Colchester (No. 2) Coal, maceration 1246, slide 12; completely detached body, 74.1 by 61.8μ; p. 86.

4. *Granulatisporites* cf. *parvus* (Ibrahim) Potonié and Kremp, 1955; Colchester (No. 2) Coal, maceration 1246, slide 6; 33.5 by 32.5μ; p. 86.

5. *Granulatisporites* cf. *parvus* (Ibrahim) Potonié and Kremp, 1955; Colchester (No. 2) Coal, maceration 954-Ee, slide 22; 37.8 by 32.5μ; p. 86.

6. *Granulatisporites livingstonensis* sp. nov., holotype; Lowell Coal, maceration 1402-F, slide 10; 41.3 by 39.3μ; magnification 1000×; p. 86.

7. *Granulatisporites livingstonensis* sp. nov., paratype; Lowell Coal, maceration 1402-G, slide 7; 40.6 by 38.0μ; p. 86.

8. *Granulatisporites pannosites* sp. nov., holotype; Springfield (No. 5) Coal, maceration 722-C, slide 6; 61.0 by 56.0μ; p. 87.

9. *Granulatisporites pannosites* sp. nov., paratype; Summum (No. 4) Coal, maceration 1143-A (RR), slide 17; 58.5 by 55.3μ; p. 87.

10. *Granulatisporites pallidus* Kosanke, 1950; Murphysboro Coal, maceration 1160 (RR), slide 6; 42.3 by 39.3μ; p. 87.

11. *Granulatisporites granularis* Kosanke, 1950; Lowell Coal, maceration 1190, slide 6; 27.6 by 26.0μ; p. 87.

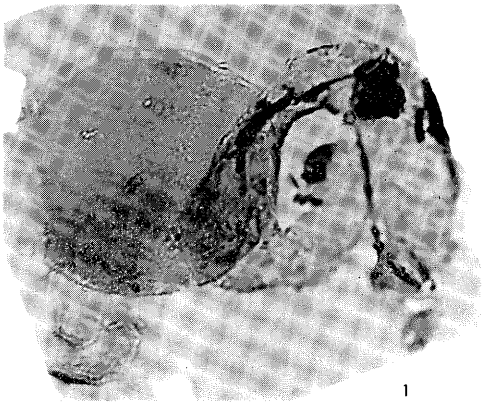
12. *Granulatisporites* sp. 1; Danville (No. 7) Coal, maceration 1384-S, slide 20; 26.3 by 25.4μ; p. 88.

13. *Cyclogranisporites minutus* Bhardwaj, 1957a; Colchester (No. 2) Coal, maceration 954-Ea, slide 15; 33.5 by 29.3μ; p. 88.

14. *Cyclogranisporites aureus* (Loose) Potonié and Kremp, 1955; Lowell Coal, maceration 1190, slide 11; 59.5 by 48.8μ; p. 88.

15. *Cyclogranisporites* cf. *aureus* (Loose) Potonié and Kremp, 1955; Colchester (No. 2) Coal, maceration 954-Ea, slide 18; 84.8 by 74.8μ; p. 88.

16. *Cyclogranisporites micaceus* Imgrund, 1960; Herrin (No. 6) Coal, maceration 1412, slide 11; 64.4 by 57.5μ; p. 88.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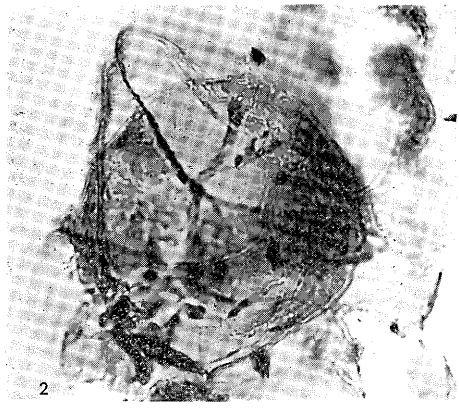
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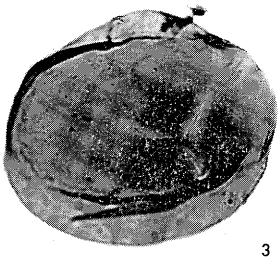
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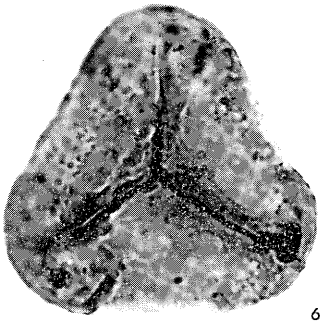
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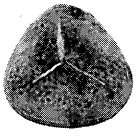
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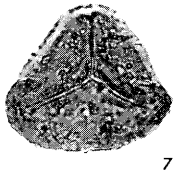
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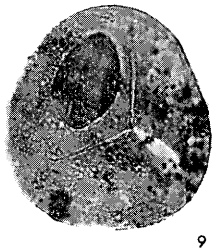
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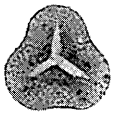
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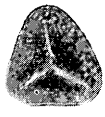
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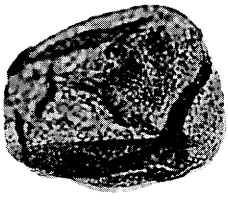
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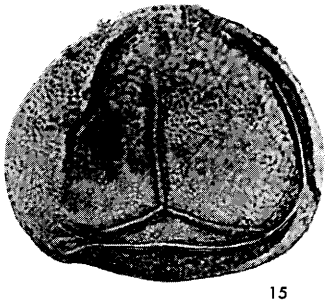
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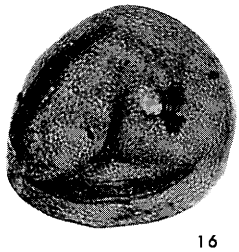
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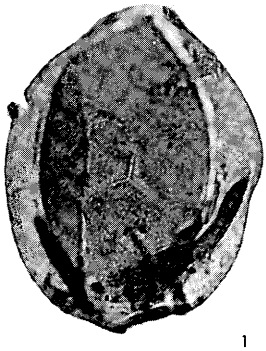
PEPPERS — PENNSYLVANIAN SPORES

PLATE 4

(Magnification 500× unless otherwise stated)

FIGURE

1. *Cyclogranisporites breviradiatus* sp. nov., holotype; Lowell Coal, maceration 1402-E, slide 21; 94.3 by 72.5μ; p. 88.
2. *Cyclogranisporites breviradiatus* sp. nov., paratype; Summum (No. 4) Coal, maceration 1405-A, slide 11; 100.8 by 97.5μ; p. 88.
3. *Cyclogranisporites breviradiatus* sp. nov., portion of spore wall of specimen in figure 2; paratype at 1000× magnification; p. 88.
4. *Cyclogranisporites microgranus* Bhardwaj, 1957a; Lowell Coal, maceration 1404-O, slide 17; 50.4 by 50.4μ; p. 89.
5. *Cyclogranisporites staplini* Peppers, 1964, comb. nov.; Springfield (No. 5) Coal, maceration 726-Aa, slide 8; 52.0 by 47.8μ; p. 89.
6. *Cyclogranisporites* sp. 1; Colchester (No. 2) Coal, maceration 1413-A, slide 12; 82.6 by 80.3μ; p. 89.
7. *Converrucosisporites subverrucosis* Bhardwaj, 1957a; Colchester (No. 2) Coal, maceration 982-C2, slide 13; 41.6 by 31.3μ; p. 89.
8. *Converrucosisporites* sp. 1; Lowell Coal, maceration 1190, slide 4; 49.7 by 40.6μ; p. 89.
9. *Verrucosisporites donarii* Potonié and Kremp, 1955; Colchester (No. 2) Coal, maceration 982-C1, slide 19; 43.9 by 42.3μ; p. 90.
10. *Verrucosisporites compactus* Habib, 1966; Colchester (No. 2) Coal, maceration 1386-B, slide 16; 43.9 by 38.0μ; p. 90.
11. *Verrucosisporites sifati* (Ibrahim) Smith and Butterworth, 1967; Lowell Coal, maceration 1404-O, slide 7; 92.0 by 74.8μ; p. 90.
12. *Verrucosisporites papulosus* Hacquebard, 1957; Cardiff Coal, maceration 1133-C1 (RR), slide 11; 46.5 by 45.5μ; p. 90.
13. *Verrucosisporites* cf. *papulosus* Hacquebard, 1957; Summum (No. 4) Coal, maceration 1133-B1 (RR), slide 20; 71.8 by 60.8μ; p. 90.
14. *Verrucosisporites firmus* (Loose) Potonié and Kremp, 1955; Colchester (No. 2) Coal, maceration 1386-B, slide 16; 53.6 by 52.0μ; p. 90.
15. *Verrucosisporites* cf. *verus* (Potonié and Kremp) Smith et al., 1964; Abingdon (?) Coal, maceration 1404-K, slide 19; 109.2 by 91.0μ; p. 90.
16. *Verrucosisporites verrucosus* (Ibrahim) Ibrahim, 1933; Colchester (No. 2) Coal, maceration 1246, slide 13; 61.8 by 61.8μ; p. 90.
17. *Verrucosisporites microtuberosus* (Loose) Smith and Butterworth, 1967; Cardiff Coal, maceration 1133-C1 (RR), slide 18; 77.0 by 74.1μ; p. 91.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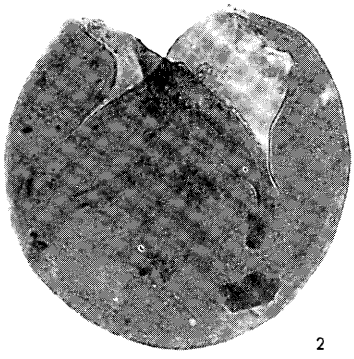
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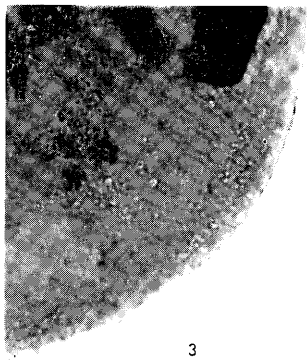
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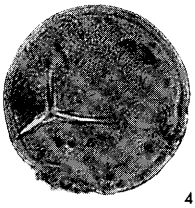
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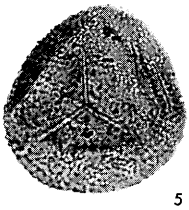
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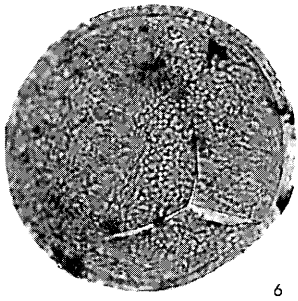
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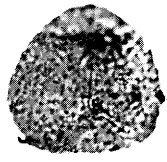
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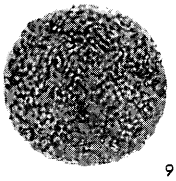
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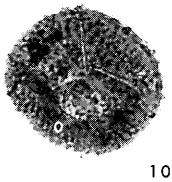
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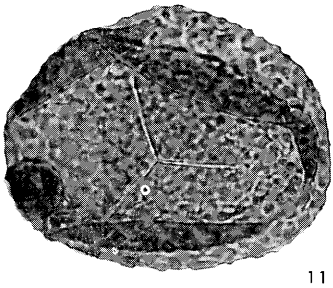
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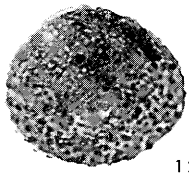
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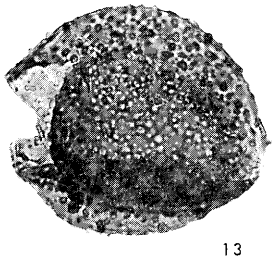
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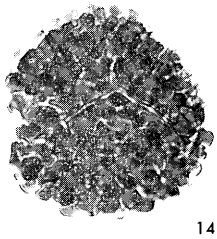
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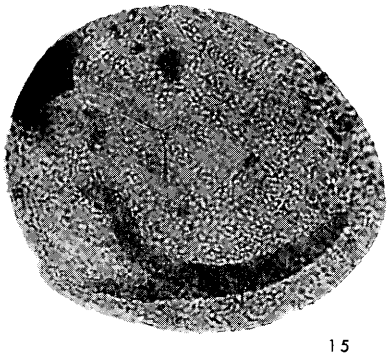
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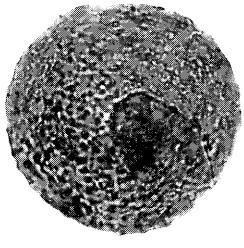
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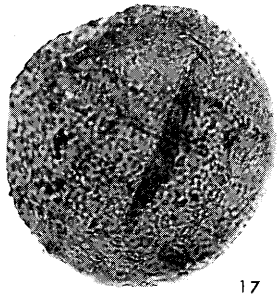
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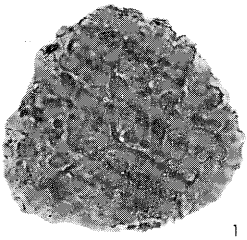
PEPPERS — PENNSYLVANIAN SPORES

PLATE 5

(Magnification 500× unless otherwise stated)

FIGURE

1. *Verrucosisporites microverrucosus* Ibrahim, 1933; Lowell Coal, maceration 1402-F, slide 17; 62.8 by 58.5μ; p. 91.
2. *Verrucosisporites* sp. 1; Danville (No. 7) Coal, maceration 1415, slide 11; 35.1 by 33.2μ; p. 91.
3. *Schopfites carbondalensis* sp. nov., holotype; Colchester (No. 2) Coal, maceration 1386-B, slide 14; 44.9 by 40.3μ; p. 91.
4. *Schopfites carbondalensis* sp. nov., paratype; Colchester (No. 2) Coal, maceration 954-Ee, slide 22; 46.2 by 42.9μ; p. 91.
5. *Schopfites* cf. *dimorphus* Kosanke, 1950; Summum (No. 4) (?) Coal, maceration 954-Ac, slide 7; 75.7 by 73.5μ; p. 92.
6. *Distortisporites illinoiensis* sp. nov., holotype; Lowell Coal, maceration 1402-D, slide 9; 55.9 by 55.3μ; p. 93.
7. *Distortisporites illinoiensis* sp. nov., paratype; Lowell Coal, maceration 1404-Q, slide 7; 55.3 by 51.4μ; p. 93.
8. *Distortisporites illinoiensis* sp. nov., paratype; Lowell Coal, maceration 1387-E, slide 2; 68.3 by 45.5μ; p. 93.
9. *Kewaneesporites reticuloides* (Kosanke) comb. nov., holotype; Colchester (No. 2) Coal, maceration 579-A, slide 1; 52.5 by 50.4μ; p. 94.
10. *Kewaneesporites reticuloides* (Kosanke) comb. nov.; Summum (No. 4) Coal, maceration 1405-A, slide 11; 40.0 by 39.0μ; p. 94.
11. *Kewaneesporites reticuloides* (Kosanke) comb. nov.; Springfield (No. 5) Coal, maceration 722-B, slide 16; 42.3 by 39.5μ; p. 94.
12. *Kewaneesporites reticuloides* (Kosanke) comb. nov.; Danville (No. 7) Coal, maceration 1384-U, slide 11; 39.0 by 37.1μ; p. 94.
13. *Kewaneesporites reticuloides* (Kosanke) comb. nov.; Herrin (No. 6) Coal, maceration 1398, slide 2; 41.3 by 39.0μ; magnification 1000×; p. 94.
14. *Kewaneesporites reticuloides* (Kosanke) comb. nov.; Danville (No. 7) Coal, maceration 877, slide 9; 35.1 by 32.5μ; high focus, magnification 1000×; p. 94.
15. *Kewaneesporites reticuloides* (Kosanke) comb. nov.; same specimen shown in figure 14 but low focus; p. 94.
16. *Lophotriletes commissuralis* (Kosanke) Potonié and Kremp, 1955; Summum (No. 4) (?) Coal, maceration 954-Ab, slide 22; 26.0 by 25.4μ; p. 95.
17. *Lophotriletes microsaetosus* (Loose) Potonié and Kremp, 1955; uncorrelated coal between Cardiff and No. 4 Coals, maceration 1133-A1 (RR), slide 12; 29.6 by 28.6μ; p. 95.
18. *Lophotriletes* cf. *granoornatus* Artuz, 1957; Summum (No. 4) Coal, maceration 1249-A, slide 20; 38.7 by 34.8μ; p. 95.
19. *Lophotriletes mosaicus* Potonié and Kremp, 1955; Colchester (No. 2) Coal, maceration 1386-A, slide 20; 31.9 by 30.6μ; p. 96.
20. *Lophotriletes rarispinosus* sp. nov., holotype; Colchester (No. 2) Coal, maceration 1384-H, slide 19; 26.0 by 25.4μ; p. 96.
21. *Lophotriletes rarispinosus* sp. nov., paratype; Colchester (No. 2) Coal, maceration 1267, slide 10; 26.7 by 23.4μ; p. 96.
22. *Lophotriletes rarispinosus* sp. nov., paratype; Colchester (No. 2) Coal, maceration 1386-A, slide 18; 25.7 by 22.8μ; p. 96.
23. *Lophotriletes* cf. *granoornatus* Artuz, 1957; Summum (No. 4) Coal, maceration 1249-A, slide 10; 42.3 by 40.0μ; p. 95.
24. *Lophotriletes mosaicus* Potonié and Kremp, 1955; Herrin (No. 6) Coal, maceration 924-B, slide 13; 36.4 by 35.4μ; p. 96.
25. *Lophotriletes copiosus* sp. nov., holotype; uncorrelated coal between Cardiff and Summum (No. 4) (?) Coals, maceration 954-B, slide 19; 55.3 by 55.3μ; p. 97.
26. *Lophotriletes copiosus* sp. nov., paratype; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 17; 48.8 by 44.9μ; p. 97.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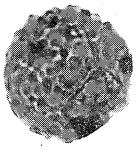
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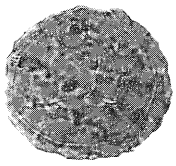
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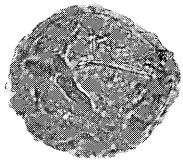
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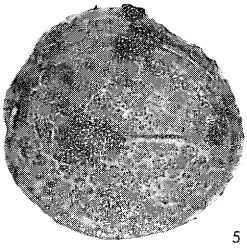
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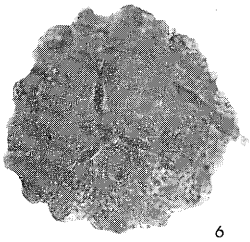
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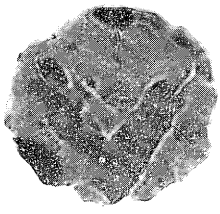
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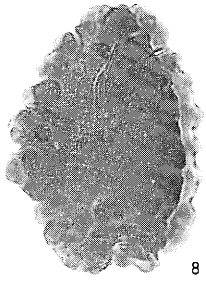
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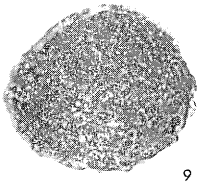
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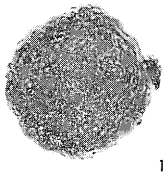
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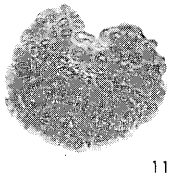
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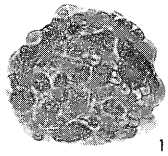
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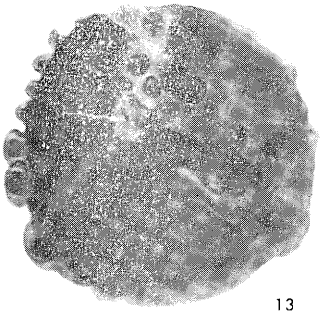
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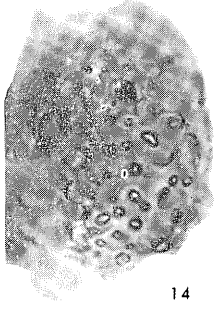
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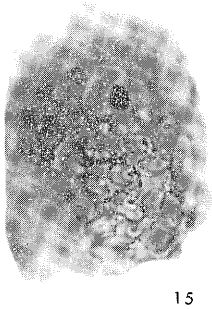
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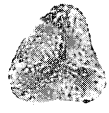
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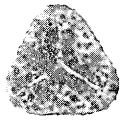
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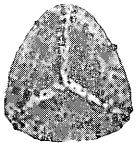
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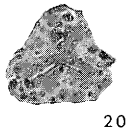
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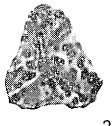
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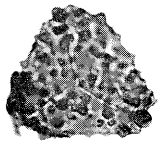
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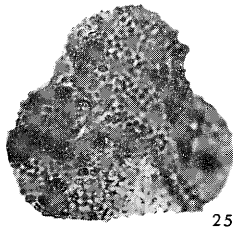
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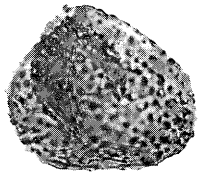

26

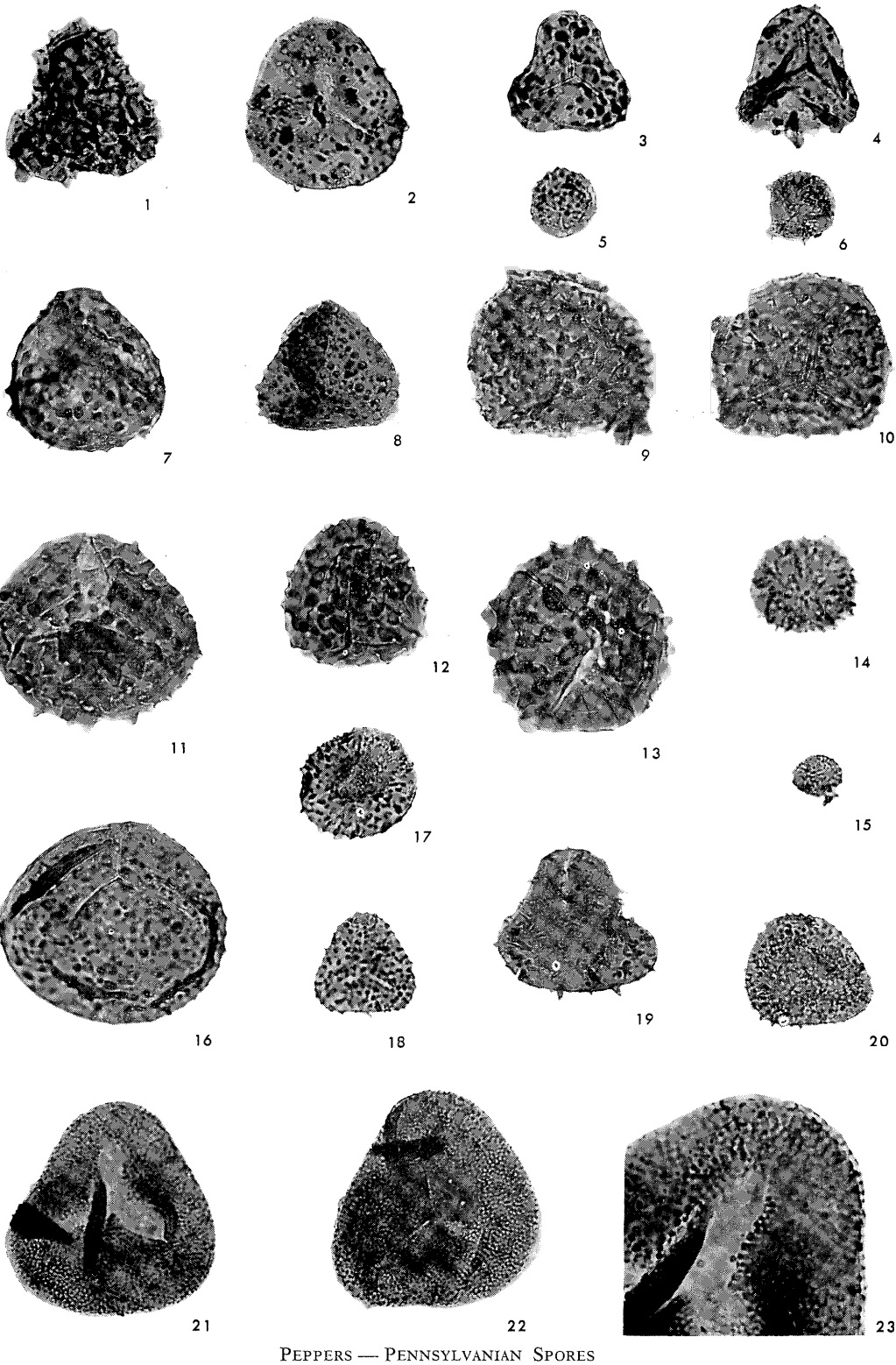
PEPPERS — PENNSYLVANIAN SPORES

PLATE 6

(Magnification 500× unless otherwise stated)

FIGURE

1. *Lophotriletes ibrahimi* (Peppers) Pi-Radondy and Doubinger, 1968; Murphysboro Coal, maceration 1160, slide 13; 43.6 by 41.9μ; p. 97.
2. *Lophotriletes pseudaculeatus* Potonié and Kremp, 1955; Abingdon (?) Coal, maceration 1384-G, slide 21; 50.4 by 46.2μ; p. 97.
3. *Lophotriletes* sp. 1; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 15; 35.0 by 32.8μ; p. 97.
4. *Lophotriletes* sp. 2; Lowell Coal, maceration 1402-F, slide 15; 38.4 by 35.1μ; p. 98.
5. *Anapiculatisporites grundensis* sp. nov., holotype; Murphysboro Coal, maceration 1160 (RR), slide 1; 22.8 by 17.2μ; p. 98.
6. *Anapiculatisporites grundensis* sp. nov., paratype; Murphysboro Coal, maceration 1160 (RR), slide 9; 20.5 by 20.2μ; p. 98.
7. *Pustulatisporites crenatus* Guennel, 1958; Colchester (No. 2) Coal, maceration 1386-B, slide 18; 49.4 by 46.2μ; p. 99.
8. *Pustulatisporites* sp. 1; Danville (No. 7) Coal, maceration 1384-V, slide 12; 40.6 by 39.0μ; p. 99.
9. *Apiculatisporis frequentispinosus* sp. nov., holotype; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 28; 58.5 by 52.0μ; p. 99.
10. *Apiculatisporis frequentispinosus* sp. nov., paratype; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 7; 56.9 by 48.8μ; p. 99.
11. *Apiculatisporis abditus* (Loose) Potonié and Kremp, 1955; Herrin (No. 6) Coal, maceration 1242-A, slide 20; 62.1 by 56.6μ; p. 100.
12. *Apiculatisporis abditus* (Loose) Potonié and Kremp, 1955; Summum (No. 4) Coal, maceration 1405-A, slide 12; 48.4 by 43.9μ; p. 100.
13. *Apiculatisporis abditus* (Loose) Potonié and Kremp, 1955; Lowell Coal, maceration 1404-P, slide 17; 56.2 by 52.0μ; p. 100.
14. *Apiculatisporis lappites* sp. nov., holotype; Lowell Coal, maceration 1387-F, slide 16; 15.0 by 13.6μ; magnification 1000×; p. 100.
15. *Apiculatisporis lappites* sp. nov., paratype; Lowell Coal, maceration 1387-D, slide 14; 15.3 by 12.7μ; p. 100.
16. *Apiculatisporis setulosus* (Kosanke) Potonié and Kremp, 1955; Colchester (No. 2) Coal, maceration 1386-A, slide 2; 68.3 by 61.8μ; p. 100.
17. *Apiculatisporis* sp. 1; Herrin (No. 6) Coal, maceration 1404-CC, slide 19; 35.8 by 32.5μ; p. 100.
18. *Acanthotriletes aculeolatus* (Kosanke) Potonié and Kremp, 1955; Abingdon (?) Coal, maceration 1404-J, slide 14; 29.9 by 29.3μ; p. 101.
19. *Acanthotriletes dimorphus* Habib, 1966; Summum (No. 4) Coal, maceration 1405-B, slide 15; 43.6 by 40.6μ; p. 101.
20. *Acanthotriletes* sp. 1; Murphysboro Coal, maceration 1160 (RR), slide 19; 38.7 by 32.5μ; p. 101.
21. *Pileatisporites aequus* sp. nov., holotype; Lowell Coal, maceration 1404-Q, slide 24; 61.4 by 59.2μ; p. 101.
22. *Pileatisporites aequus* sp. nov., paratype; Lowell Coal, maceration 1404-Q, slide 10; 65.3 by 56.2μ; p. 101.
23. *Pileatisporites aequus* sp. nov., detail of exine of holotype; magnification 1000×; p. 101.



PEPPERS — PENNSYLVANIAN SPORES

PLATE 7

(Magnification 500× unless otherwise stated)

FIGURE

1. *Raistrickia* cf. *aculeata* Kosanke, 1950; Lowell Coal, maceration 1190, slide 6; 66.6 by 61.8μ; p. 102.

2. *Raistrickia aculeolata* Wilson and Kosanke, 1944; Danville (No. 7) Coal, maceration 924-A, slide 12; 55.3 by 53.6μ; p. 102.

3. *Raistrickia breveminens* sp. nov., holotype; Colchester (No. 2) Coal, maceration 1034-B (RR), slide 19; 65.0 by 60.0μ; p. 102.

4. *Raistrickia breveminens* sp. nov., paratype; Colchester (No. 2) Coal, maceration 1404-N, slide 10; 55.3 by 50.1μ; p. 102.

5. *Raistrickia carbondalensis* sp. nov., holotype; Lowell Coal, maceration 1384-N, slide 20; 67.6 by 61.8μ; p. 103.

6. *Raistrickia carbondalensis* sp. nov., paratype; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 19; 70.5 by 64.7μ; p. 103.

7. *Raistrickia* cf. *clavata* (Hacquebard) Playford, 1963; Lowell Coal, maceration 1377, slide 13; 49.4 by 48.8μ; p. 104.

8. *Raistrickia crinita* Kosanke, 1950; Danville (No. 7) Coal, maceration 1384-U, slide 14; 55.9 by 51.4μ; p. 104.

9. *Raistrickia* cf. *fibrata* (Loose) Schopf, Wilson, and Bentall, 1944; Colchester (No. 2) Coal, maceration 1227-A, slide 6; 43.9 by 40.0μ; p. 104.

10. *Raistrickia grovensis* Schopf, Wilson, and Bentall, 1944; Lowell Coal, maceration 1413-B, slide 12; 47.8 by 43.9μ; p. 104.

11. *Raistrickia crocea* Kosanke, 1950; Lowell Coal, maceration 1404-Q, slide 17; 70.9 by 61.8μ; p. 104.

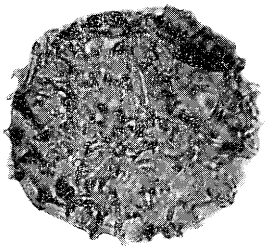
12. *Raistrickia lacerata* sp. nov., holotype; Colchester (No. 2) Coal, maceration 1246, slide 20; 65.0 by 62.4μ; p. 104.

13. *Raistrickia lacerata* sp. nov., paratype; Cardiff (?) Coal, maceration 1034-A, slide 8; 64.0 by 54.6μ; p. 104.

14. *Raistrickia irregularis* Kosanke, 1950; Springfield (No. 5) Coal, maceration 726-Aa, slide 6; 52.0 by 48.8μ; p. 105.

15. *Raistrickia irregularis* Kosanke, 1950; Colchester (No. 2) Coal, maceration 1402-B, slide 16; 63.4 by 59.8μ; p. 105.

16. *Raistrickia solaria* Wilson and Hoffmeister, 1956; Colchester (No. 2) Coal, maceration 1402-C, slide 3; 74.8 by 65.0μ; p. 105.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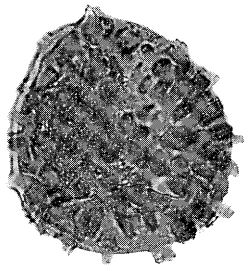
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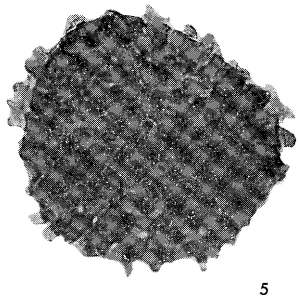
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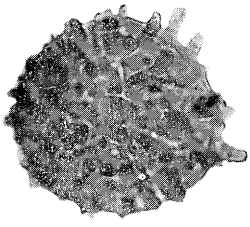
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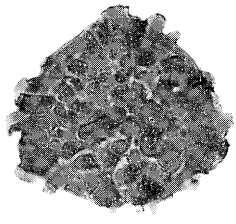
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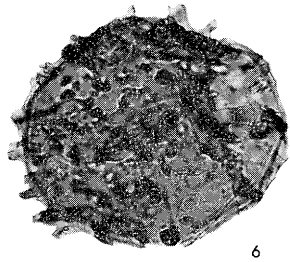
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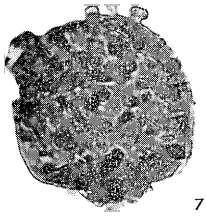
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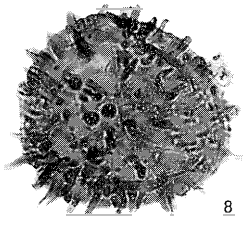
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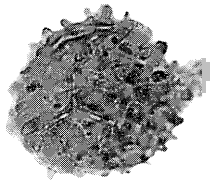
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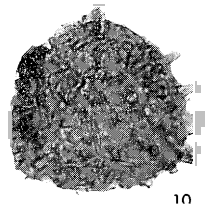
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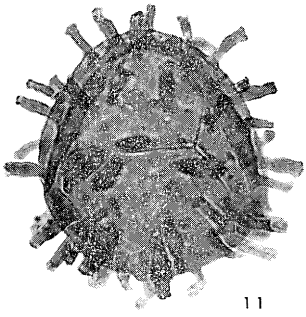
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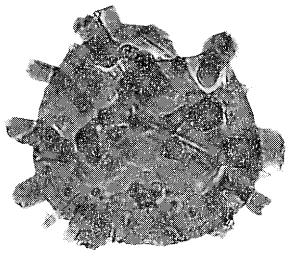
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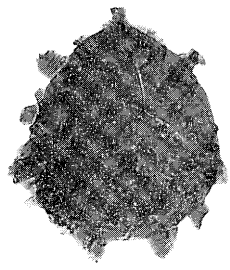
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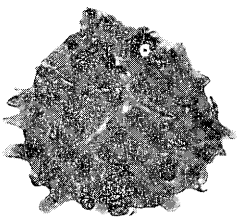
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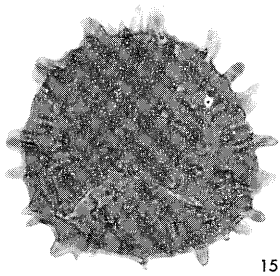
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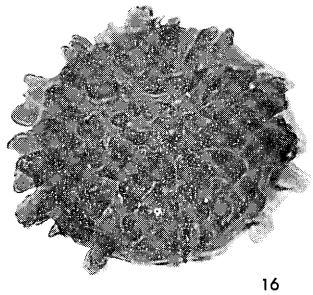
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PEPPERS — PENNSYLVANIAN SPORES

PLATE 8

(Magnification 500× unless otherwise stated)

FIGURE

1. *Raistrickia dispar* sp. nov., holotype; Lowell Coal, maceration 1190, slide 6; 53.0 by 49.4μ; p. 105.

2. *Raistrickia dispar* sp. nov., paratype; Colchester (No. 2) Coal, maceration 1402-A, slide 15; 58.5 by 52.3μ; p. 105.

3. *Raistrickia lowellensis* sp. nov., holotype; Lowell Coal, maceration 1384-N, slide 11; 46.5 by 43.9μ; p. 105.

4. *Raistrickia lowellensis* sp. nov., paratype; Colchester (No. 2) Coal, maceration 1386-A, slide 4; 48.8 by 42.3μ; p. 105.

5. *Raistrickia subcrinita* sp. nov., holotype; Summum (No. 4) Coal, maceration 1405-B, slide 12; 48.8 by 47.5μ; p. 106.

6. *Raistrickia subcrinita* sp. nov., paratype; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 16; 46.2 by 42.3μ; p. 106.

7. *Raistrickia pilosa* Kosanke, 1950; Danville (No. 7) Coal, maceration 1418-A, slide 17; 31.5 by 30.9μ; p. 106.

8. *Raistrickia pontiacensis* sp. nov., holotype; Lowell Coal, maceration 1387-D, slide 9; 56.2 by 51.7μ; p. 106.

9. *Raistrickia superba* (Ibrahim) Schopf, Wilson, and Bentall, 1944; Colchester (No. 2) Coal, maceration 723-C, slide 5; 55.3 by 52.3μ; p. 107.

10. *Raistrickia* sp. 1; Colchester (No. 2) Coal, maceration 1402-B, slide 10; 52.0 by 43.2μ; p. 107.

11. *Raistrickia* sp. 2; Danville (No. 7) Coal, maceration 1418-A, slide 16; 59.2 by 52.0μ; p. 107.

12. *Raistrickia* (?) sp. 3; Lowell Coal, maceration 1404-O, slide 7; 76.1 by 71.5μ; p. 107.

13. *Convolutispora* cf. *florida* Hoffmeister, Staplin, and Malloy, 1955; Colchester (No. 2) Coal, maceration 1413-A, slide 19; 48.1 by 45.8μ; p. 108.

14. *Convolutispora fromensis* Balme and Hassell, 1962; Colchester (No. 2) Coal, maceration 1246, slide 13; 48.8 by 48.8μ; p. 108.

15. *Convolutispora* sp. 1; Murphysboro Coal, maceration 1160 (RR), slide 20; 37.4 by 35.2μ; p. 108.

16. *Convolutispora* sp. 2; Colchester (No. 2) Coal, maceration 1386-A, slide 16; 51.7 by 45.5μ; p. 108.

17. *Spackmanites* cf. *facierugosus* (Loose) Habib, 1966; Herrin (No. 6) Coal, maceration 878, slide 1; 36.1 by 35.7μ; p. 109.

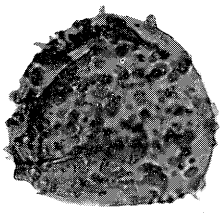
18. *Spackmanites* cf. *facierugosus* (Loose) Habib, 1966; Summum (No. 4) Coal, maceration 1133-B2 (RR), slide 1; endexine 35.8 by 31.9μ; p. 109.

19. *Spackmanites* cf. *facierugosus* (Loose) Habib, 1966; Colchester (No. 2) Coal, maceration 1402-C, slide 5; 53.0 by 49.7μ; p. 109.

20. *Spackmanites* cf. *facierugosus* (Loose) Habib, 1966; portion of same specimen shown in figure 19; magnification 1000×; p. 109.

21. *Maculatasporites punctatus* sp. nov., holotype; Springfield (No. 5) Coal, maceration 1408-B, slide 3; 40.0 by 40.0μ; p. 110.

22. *Maculatasporites punctatus* sp. nov., paratype; Colchester (No. 2) Coal, maceration 1246, slide 12; 42.3 by 39.3μ; p. 110.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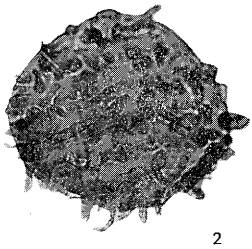
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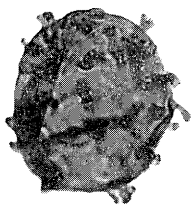
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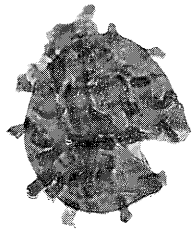
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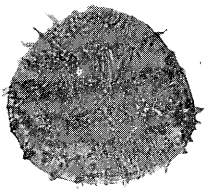
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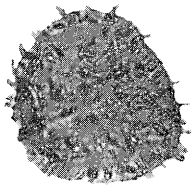
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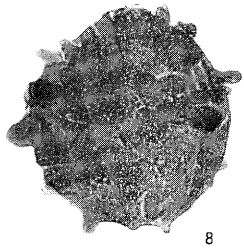
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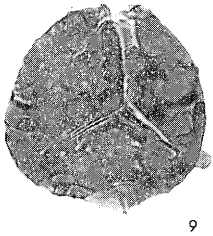
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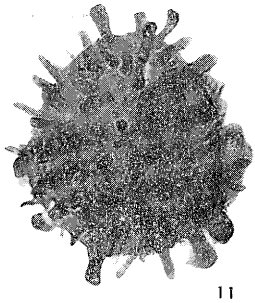
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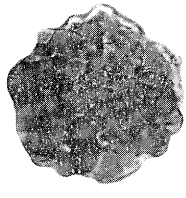
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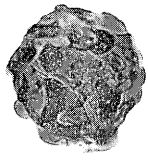
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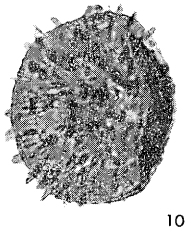
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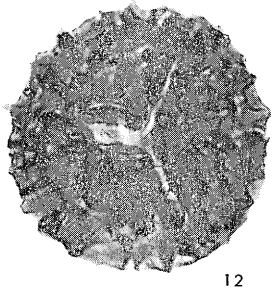
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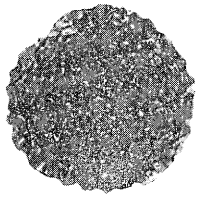
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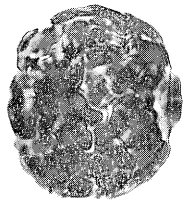
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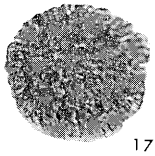
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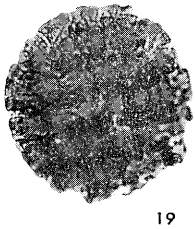
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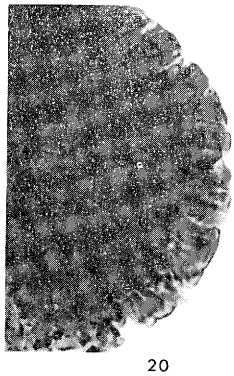
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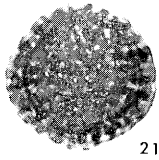
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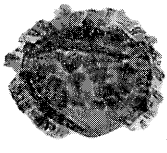
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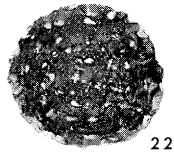
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PEPPERS — PENNSYLVANIAN SPORES

PLATE 9

(Magnification 500× unless otherwise stated)

FIGURE

1. *Microreticulatisporites harrisonii* sp. nov., holotype; Murphysboro Coal, maceration 1160 (RR), slide 16; 33.8 by 30.9μ; magnification 1000×; p. 110.

2. *Microreticulatisporites hortonensis* Playford, 1963; Summum (No. 4) Coal, maceration 1249-A, slide 20; 48.4 by 37.4μ; p. 111.

3. *Microreticulatisporites* cf. *lunatus* (Knox) Knox, 1950; Springfield (No. 5) Coal, maceration 722-B, slide 8; 39.7 by 39.3μ; p. 111.

4. *Microreticulatisporites sulcatus* (Wilson and Kosanke) Smith and Butterworth, 1967; Herrin (No. 6) Coal, maceration 924-B, slide 5; 54.6 by 52.0μ; p. 111.

5. *Microreticulatisporites nobilis* (Wicher) Knox, 1950; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 8; 34.1 by 33.2μ; p. 111.

6. *Dictyotriletes danvillensis* sp. nov., holotype; Danville (No. 7) Coal, maceration 1404-HH, slide 14; 55.3 by 54.3μ; p. 111.

7. *Dictyotriletes danvillensis* sp. nov., paratype; Danville (No. 7) Coal, maceration 876 (RR), slide 16; 52.7 by 48.1μ; p. 111.

8. *Dictyotriletes densoreticulatus* Potonié and Kremp, 1955; Summum (No. 4) Coal, maceration 1249-A, slide 1; 58.5 by 58.5μ; p. 112.

9. *Dictyotriletes distortus* sp. nov., holotype; Colchester (No. 2) Coal, maceration 1386-B, slide 19; 36.1 by 34.1μ; p. 112.

10. *Dictyotriletes distortus* sp. nov., paratype; Summum (No. 4) Coal, maceration 1405-B, slide 12; 32.5 by 30.9μ; p. 112.

11. *Dictyotriletes distortus* sp. nov., portion of holotype shown in figure 9; magnification 1000×; p. 112.

12. *Dictyotriletes* cf. *falsus* Potonié and Kremp, 1955; Summum (No. 4) Coal, maceration 1249-A, slide 9; 52.0 by 45.5μ; p. 112.

13. *Dictyotriletes* cf. *reticulocingulum* (Loose) Smith and Butterworth, 1967; Summum (No. 4) Coal, maceration 1405-C, slide 9; 46.2 by 37.4μ; p. 112.

14. *Reticulatisporites lacunosus* Kosanke, 1950; Lowell Coal, maceration 1404-Q, slide 25; 94.3 by 79.3μ; p. 113.

15. *Reticulatisporites reticulatus* (Ibrahim) Ibrahim, 1933; uncorrelated coal between Cardiff and Summum (No. 4) (?) Coals, maceration 954-B, slide 11; 94.3 by 80.6μ; p. 113.

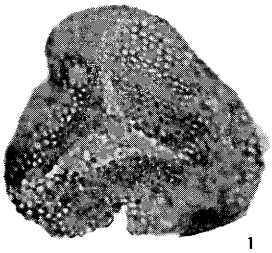
16. *Reticulatisporites pseudomuricatus* sp. nov., holotype; Lowell Coal, maceration 1404-R, slide 4; 61.4 by 57.9μ, including muri; p. 113.

17. *Reticulatisporites pseudomuricatus* sp. nov., paratype; Lowell Coal, maceration 1404-Q, slide 22; 61.8 by 61.8μ; including muri; p. 113.

18. *Reticulatisporites* sp. 1; Summum (No. 4) Coal, maceration 1405-A, slide 20; 52.0 by 45.8μ, including muri; p. 113.

19. *Reticulatisporites* sp. 2; Cardiff Coal, maceration 1133-C1 (RR), slide 4; 50.4 by 47.1μ; p. 113.

20. *Camptotriletes bucculentus* (Loose) Potonié and Kremp, 1955; Colchester (No. 2) Coal, maceration 1402-C, slide 5; 48.8 by 46.5μ; p. 114.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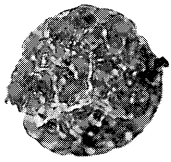
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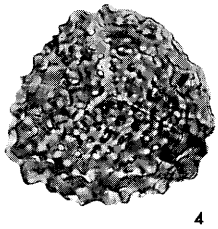
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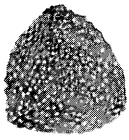
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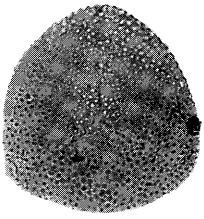
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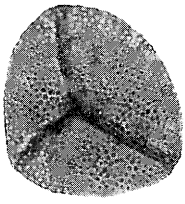
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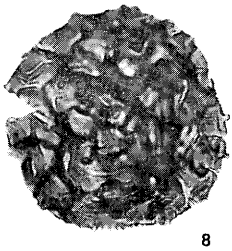
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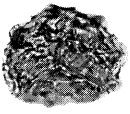
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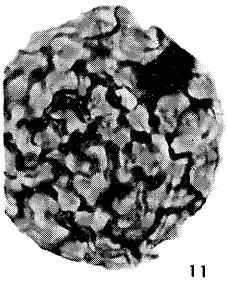
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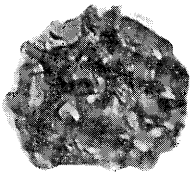
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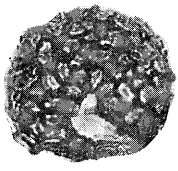
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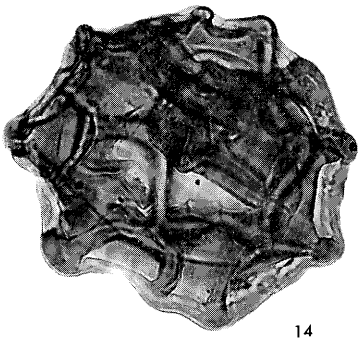
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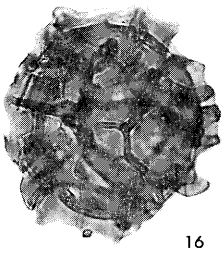
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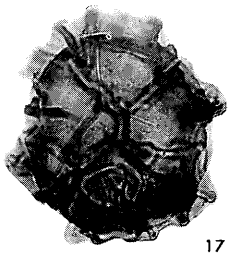
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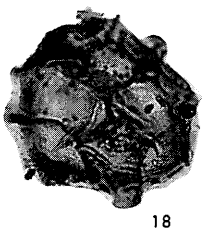
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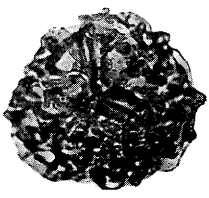
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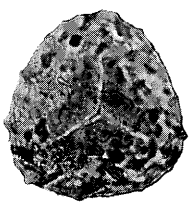
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PEPPERS — PENNSYLVANIAN SPORES

PLATE 10

(Magnification 500× unless otherwise stated)

FIGURE

1. *Camptotriletes triangularis* sp. nov., holotype; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 28; 45.5 by 39.7μ; p. 114.

2. *Camptotriletes triangularis* sp. nov., paratype; Summum (No. 4) Coal, maceration 1234-F, slide 19; 35.8 by 34.1μ; p. 114.

3. *Knoxisporites rotatus* Hoffmeister, Staplin, and Malloy, 1955; Colchester (No. 2) Coal, maceration 1384-I, slide 15; 48.8 by 48.1μ; p. 114.

4. *Vestispora colchesterensis* sp. nov., holotype; Colchester (No. 2) Coal, maceration 1387-B, slide 5; 95.2 by 91.0μ; p. 115.

5. *Vestispora colchesterensis* sp. nov., paratype; Colchester (No. 2) Coal, maceration 1246, slide 20; 75.4 by 71.5μ; p. 115.

6. *Vestispora laevigata* Wilson and Venkatachala, 1963b; Colchester (No. 2) Coal, maceration 982-C1, slide 17; 83.9 by 75.1μ; p. 115.

7. *Vestispora profunda* Wilson and Hoffmeister, 1956; Herrin (No. 6) Coal, maceration 1404-BB, slide 7; 68.3 by 63.4μ; p. 115.

8. *Vestispora* cf. *pseudoreticulata* Spode (*in* Smith and Butterworth, 1967); Colchester (No. 2) Coal, maceration 1246, slide 12; 89.7 by 65.0μ; p. 115.

9. *Vestispora wanlessii* sp. nov., holotype; Murphysboro Coal, maceration 1160 (RR), slide 20; 88.7 by 83.9μ; p. 115.

10. *Vestispora wanlessii* sp. nov., paratype; Murphysboro Coal, maceration 1160 (RR), slide 17; 85.5 by 78.0μ; p. 115.

11. *Triquitrites additus* Wilson and Hoffmeister, 1956; Colchester (No. 2) Coal, maceration 1034-B (RR), slide 20; 43.9 by 42.3μ; p. 116.

12. *Triquitrites* cf. *additus* Wilson and Hoffmeister, 1956; Lowell Coal, maceration 1402-G, slide 14; 36.7 by 36.1μ; p. 116.

13. *Triquitrites desperatus* Potonié and Kremp, 1956; Colchester (No. 2) Coal, maceration 954-Ea, slide 5; 26.3 by 26.0μ; p. 116.

14. *Triquitrites minutus* Alpern, 1958; Summum (No. 4) (?) Coal, maceration 954-Ab, slide 10; 26.0 by 23.7μ; p. 116.

15. *Triquitrites pulvinatus* Kosanke, 1950; Lowell Coal, maceration 1404-P, slide 18; 34.5 by 31.9μ; p. 116.

16. *Triquitrites dividuus* Wilson and Hoffmeister, 1956; Danville (No. 7) Coal, maceration 1384-S, slide 13; 41.6 by 40.0μ; p. 116.

17. *Triquitrites exiguus* Wilson and Kosanke, 1944; Colchester (No. 2) Coal, maceration 1401-D, slide 14; 29.3 by 25.0μ; p. 116.

18. *Triquitrites protensus* Kosanke, 1950; Summum (No. 4) Coal, maceration 1249-B, slide 12; 30.2 by 29.6μ; p. 116.

19. *Triquitrites truncatus* Bhardwaj and Kremp, 1955; Summum (No. 4) Coal, maceration 1405-A, slide 19; 32.8 by 29.9μ; p. 117.

20. *Triquitrites bransonii* Wilson and Hoffmeister, 1956; Lowell Coal, maceration 1279-E, slide 7; 31.2 by 27.0μ; p. 117.


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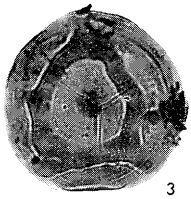
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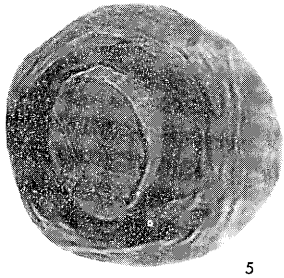
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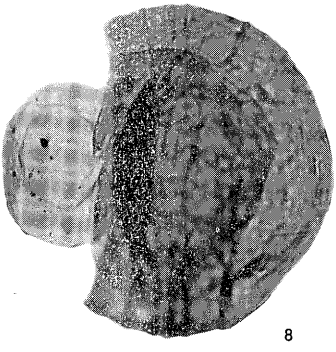
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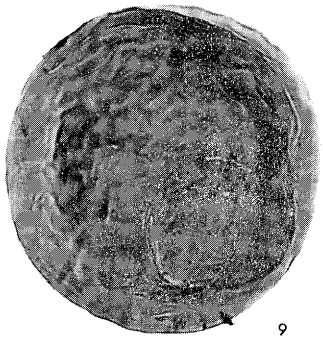
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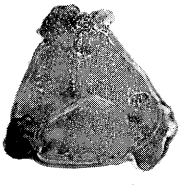
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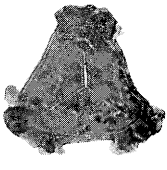
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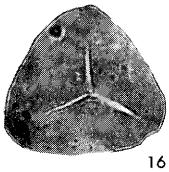
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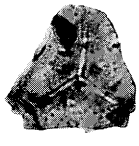
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PEPPERS — PENNSYLVANIAN SPORES

PLATE 11

(Magnification 500× unless otherwise stated)

FIGURE

1. *Triquitrites* cf. *arculatus* (Wilson and Coe) Schopf, Wilson, and Bentall, 1944; Lowell Coal, maceration 1190, slide 5; 32.5 by 30.9μ; p. 117.
2. *Triquitrites sculptilis* Balme, 1952; Lowell Coal, maceration 1413-B, slide 16; 35.8 by 35.8μ; p. 117.
3. *Triquitrites sculptilis* Balme, 1952; Lowell Coal, maceration 1404-Q, slide 15; 33.2 by 31.5μ; p. 117.
4. *Triquitrites* cf. *sculptilis* Balme, 1952; Herrin (No. 6) Coal, maceration 1398, slide 5; 37.4 by 32.5μ; p. 117.
5. *Triquitrites* cf. *sculptilis* Balme, 1952; Cardiff Coal, maceration 1133-C1 (RR), slide 9; 26.7 by 23.4μ; p. 117.
6. *Triquitrites crassus* Kosanke, 1950; Colchester (No. 2) Coal, maceration 1034-B (RR), slide 21; 49.7 by 48.8μ; p. 117.
7. *Triquitrites trigonappendix* (Loose) Schopf, Wilson, and Bentall, 1944; Colchester (No. 2) Coal, maceration 1386-A, slide 11; 45.5 by 42.3μ; p. 118.
8. *Triquitrites subspinosus* sp. nov., holotype; Summum (No. 4) Coal, maceration 1405-B, slide 19; 34.8 by 32.5μ; p. 118.
9. *Triquitrites subspinosus* sp. nov., paratype; Lowell Coal, maceration 1190, slide 5; 36.4 by 34.8μ; p. 118.
10. *Triquitrites* sp. 1; Summum (No. 4) Coal, maceration 1405-B, slide 7; 52.0 by 48.8μ; p. 118.
11. *Mooreisporites inusitatus* (Kosanke) Neves, 1961; Colchester (No. 2) Coal, maceration 1246, slide 19; 64.0 by 58.5μ; p. 118.
12. *Indospora boletus* sp. nov., holotype; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 46; 26.0 by 26.0μ; magnification 1000×; p. 118.
13. *Indospora boletus* sp. nov., paratype; Colchester (No. 2) Coal, maceration 1133-D (RR), slide 11; 30.9 by 29.3μ; p. 118.
14. *Ahrensisporites guerickei* Horst, 1955; Murphysboro Coal, maceration 1160 (RR), slide 4; 41.0 by 39.7μ; p. 119.
15. *Grumosisporites* cf. *rufus* (Butterworth and Williams) Smith and Butterworth, 1967; Colchester (No. 2) Coal, maceration 1413-A, slide 14; 43.6 by 42.3μ; p. 119.
16. *Crassispora plicata* Peppers, 1964; Colchester (No. 2) Coal, maceration 1246, slide 12; 57.9 by 56.9μ; p. 120.
17. *Crassispora plicata* Peppers, 1964; Colchester (No. 2) Coal, maceration 1246, slide 5; focus on distal surface; magnification 1000×; p. 120.
18. *Crassispora plicata* Peppers, 1964; same specimen shown in figure 17; focus on proximal surface; p. 120.
19. *Crassispora plicata* ? Peppers, 1964; Colchester (No. 2) Coal, maceration 1246, slide 16; 63.4 by 56.6μ; p. 120.
20. *Lycospora paulula* Artuz, 1957; Lowell Coal, maceration 1402-G, slide 20; 35.8 by 27.6μ; p. 121.
21. *Lycospora subjuga* Bhardwaj, 1957b; Springfield (No. 5) Coal, maceration 722-C, slide 15; 25.4 by 23.7μ; p. 121.
22. *Lycospora torquifer* (Loose) Potonié and Kremp, 1956; Abingdon (?) Coal, maceration 1404-J, slide 11; 32.5 by 29.6μ; p. 121.
23. *Cadiospora fithiana* Peppers, 1964; Springfield (No. 5) Coal, maceration 1408-A, slide 14; 81.3 by 78.0μ; p. 121.


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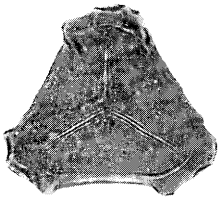
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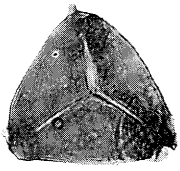
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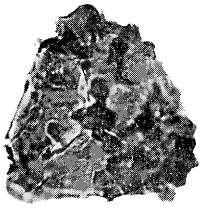
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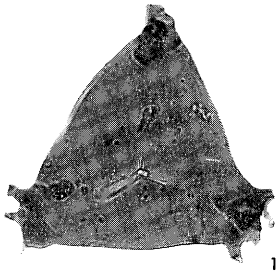
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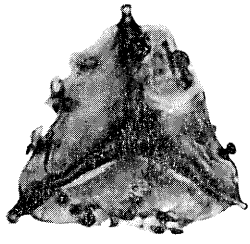
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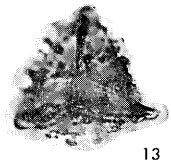
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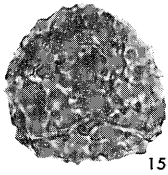
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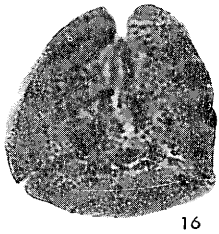
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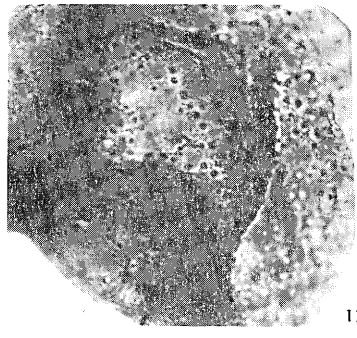
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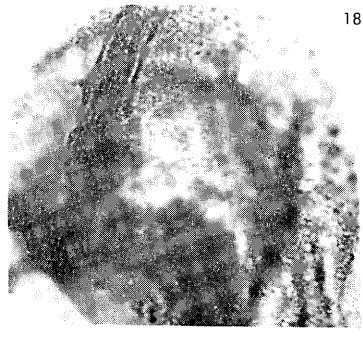
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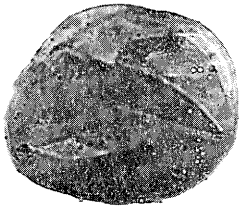
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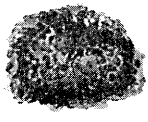
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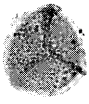
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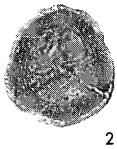
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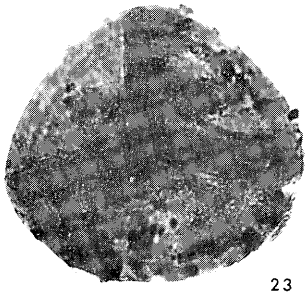
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PEPPERS — PENNSYLVANIAN SPORES

PLATE 12

(Magnification 500× unless otherwise stated)

FIGURE

1. *Cadiospora magna* Kosanke, 1950; Colchester (No. 2) Coal, maceration 1404-L, slide 11; 93.9 by 91.0μ; p. 121.

2. *Murospora kosankei* Somers, 1952; Lowell Coal, maceration 1402-F, slide 1; 28.3 by 24.7μ; p. 121.

3. *Murospora kosankei* Somers, 1952; Herrin (No. 6) Coal, maceration 1404-CC, slide 19; 41.6 by 29.6μ; p. 121.

4. *Densosporites triangularis* Kosanke, 1950; Colchester (No. 2) Coal, maceration 723-A, slide 11; 55.3 by 52.0μ; p. 121.

5. *Densosporites triangularis* Kosanke, 1950; Cardiff (?) Coal, maceration 1034-A, slide 5; 61.8 by 44.5μ; p. 121.

6. *Densosporites* cf. *lobatus* Kosanke, 1950; Colchester (No. 2) Coal, maceration 1246, slide 21; 44.5 by 42.1μ; p. 122.

7. *Cristatisporites alpernii* Staplin and Jansonius, 1964; Colchester (No. 2) Coal, maceration 1143-C (RR), slide 10; 52.7 by 51.4μ; p. 122.

8. *Vallatisporites* sp. 1; Colchester (No. 2) Coal, maceration 1246, slide 16; 55.3 by 50.1μ; p. 122.

9. *Cirratriradites annuliformis* Kosanke and Brokaw, *in* Kosanke, 1950; Lowell Coal, maceration 1404-Q, slide 19; 75.4 by 62.1μ; p. 122.

10. *Cirratriradites tenuis* sp. nov., holotype; Danville (No. 7) Coal, maceration 876 (RR), slide 14; 96.2 by 83.2μ; p. 122.

11. *Cirratriradites tenuis* sp. nov., paratype; Danville (No. 7) Coal, maceration 876 (RR), slide 3; 77.4 by 68.3μ; p. 122.

12. *Reinschospora magnifica* Kosanke, 1950; Danville (No. 7) Coal, maceration 1404-HH, slide 11; 56.6 by 54.3μ; p. 123.

13. *Reinschospora* cf. *magnifica* Kosanke, 1950; Danville (No. 7) Coal, maceration 1404-HH, slide 14; 39.0 by 34.8μ; p. 123.

14. *Reinschospora triangularis* Kosanke, 1950; Colchester (No. 2) Coal, maceration 1246, slide 8; 58.8 by 53.6μ, not including setae; p. 123.

15. *Balteosporites minutus* sp. nov., paratype; Danville (No. 7) Coal, maceration 1404-HH, slide 9; 29.3 by 25.7μ; p. 124.

16. *Balteosporites minutus* sp. nov., holotype; Danville (No. 7) Coal, maceration 1404-HH, slide 11; 32.5 by 29.3μ; magnification 1000×; p. 124.

17. *Savitrisporites asperatus* Sullivan, 1964; Colchester (No. 2) Coal, maceration 1402-C, slide 19; 39.0 by 39.0μ; p. 125.

18. *Savitrisporites majus* Bhardwaj, 1957a; Lowell Coal, maceration 1402-F, slide 13; 45.5 by 39.0μ; p. 125.

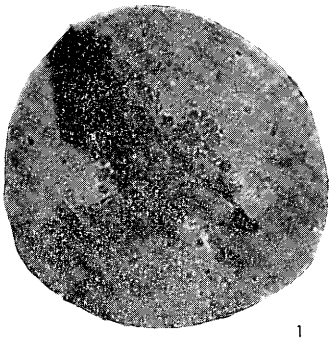
19. *Savitrisporites* ? sp. 1; Lowell Coal, maceration 1404-O, slide 5; 45.5 by 43.9μ; p. 125.

20. *Laevigatosporites globosus* Schemel, 1951; Lowell Coal, maceration 1404-Q, slide 14; 21.8 by 18.9μ; p. 125.

21. *Laevigatosporites medius* Kosanke, 1950; Lowell Coal, maceration 1190, slide 4; 38.0 by 19.5μ; p. 127.

22. *Laevigatosporites punctatus* Kosanke, 1950; DeKoven Coal, maceration 1381-D, slide 18; 33.5 by 25.4μ; p. 127.

23. *Laevigatosporites vulgaris* (Ibrahim) Ibrahim, 1933; Lowell Coal, maceration 1190, slide 16; 89.7 by 47.8μ; p. 127.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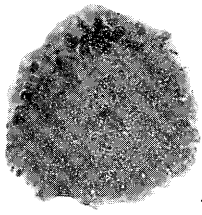
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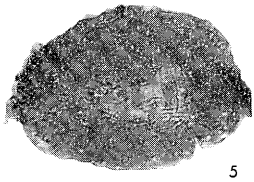
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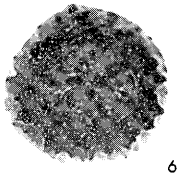
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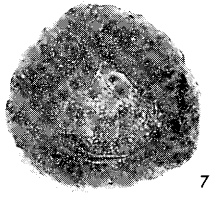
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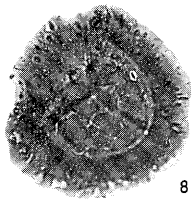
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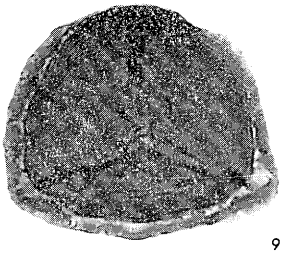
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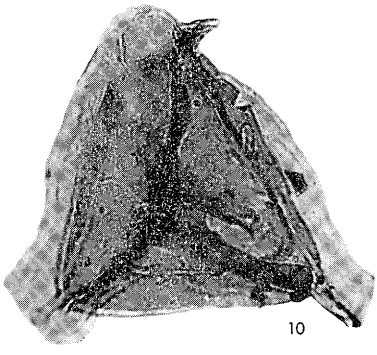
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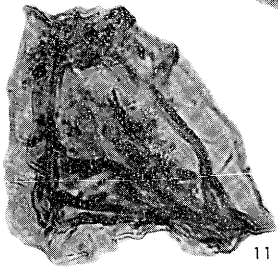
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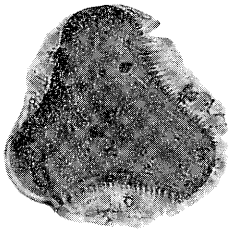
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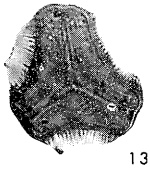
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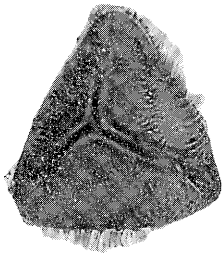
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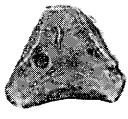
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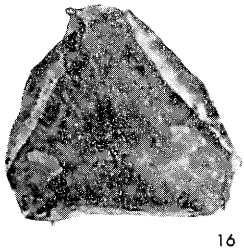
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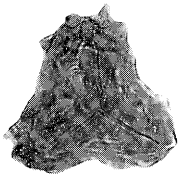
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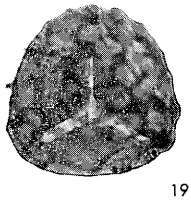
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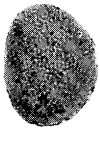
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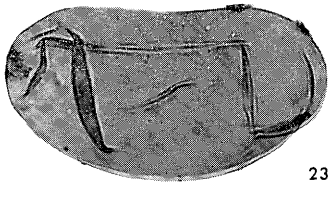
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PEPPERS — PENNSYLVANIAN SPORES

PLATE 13

(Magnification 500× unless otherwise stated)

FIGURE

1. *Tuberculatosporites robustus* (Kosanke) comb. nov., holotype; New Haven Coal, maceration 574, slide 8; 101.8 by 73.5μ; p. 127.

2. *Tuberculatosporites robustus* (Kosanke) comb. nov.; Colchester (No. 2) Coal, maceration 1230-C, slide 15; 123.5 by 81.3μ; p. 127.

3. *Columinisporites ovalis* Peppers, 1964; Murphysboro Coal, maceration 1160 (RR), slide 2; 52.0 by 29.3μ; p. 128.

4. *Wilsonites delicatus* (Kosanke) Kosanke, 1959; Danville (No. 7) Coal, maceration 1384-S, slide 11; 88.7 by 85.5μ; p. 128.

5. *Perotriletes parvigracilus* sp. nov., holotype; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 37; 45.8 by 40.6μ; p. 128.

6. *Perotriletes parvigracilus* sp. nov., paratype; Lowell Coal, maceration 1404-Q, slide 22; 47.5 by 40.0μ; focus on proximal surface; p. 128.

7. *Perotriletes parvigracilus* sp. nov., paratype; same specimen shown in figure 8; focus on distal surface; p. 128.

8. *Hymenospora multirugosa* sp. nov., holotype; Danville (No. 7) Coal, maceration 1384-U, slide 12; 39.0 by 35.1μ; p. 129.

9. *Hymenospora multirugosa* sp. nov., paratype; Cardiff Coal, maceration 1133-C1 (RR), slide 18; 39.0 by 35.8μ; p. 129.

10. *Hymenospora paucirugosa* sp. nov., holotype; Colchester (No. 2) Coal, maceration 954-Ee, slide 18; 65.0 by 62.1μ; p. 130.

11. *Hymenospora paucirugosa* sp. nov., paratype; Cardiff Coal, maceration 954-Dd, slide 7; 74.1 by 62.1μ; p. 130.

12. *Hymenospora paucirugosa* sp. nov., paratype; Lowell Coal, maceration 1404-R, slide 18; 78.7 by 71.7μ; p. 130.

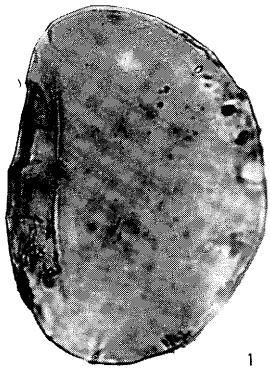
13. *Hymenospora paucirugosa* sp. nov., paratype; Summum (No. 4) Coal, maceration 1249-B, slide 11; 68.3 by 65.3μ; p. 130.

14. *Endosporites globiformis* (Ibrahim) Schopf, Wilson, and Bentall, 1944; Springfield (No. 5) Coal, maceration 1408-A, slide 9; 87.8 by 73.0μ; p. 130.

15. *Endosporites plicatus* Kosanke, 1950; Lowell Coal, maceration 1404-Q, slide 23; 78.0 by 61.1μ; p. 131.

16. *Paleospora fragila* Habib, 1966; Houchin Creek Coal (IVa) (Indiana), maceration 1509-J, slide 18; 107.9 by 81.3μ; p. 131.

17. *Florinites antiquus* Schopf (*in* Schopf, Wilson, and Bentall, 1944); Colchester (No. 2) Coal, maceration 1386-A, slide 18; 67.0 by 52.0μ; p. 131.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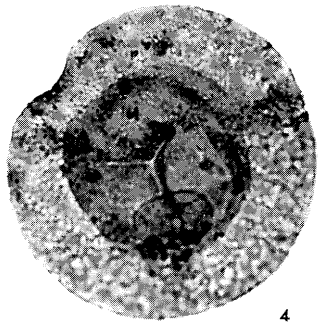
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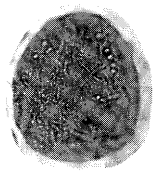
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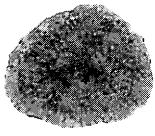
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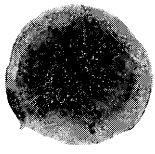
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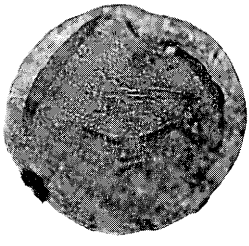
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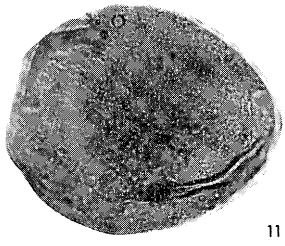
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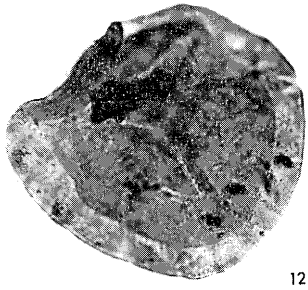
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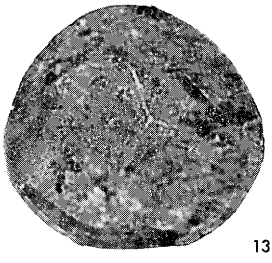
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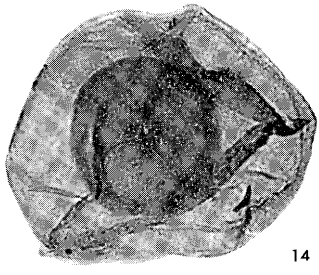
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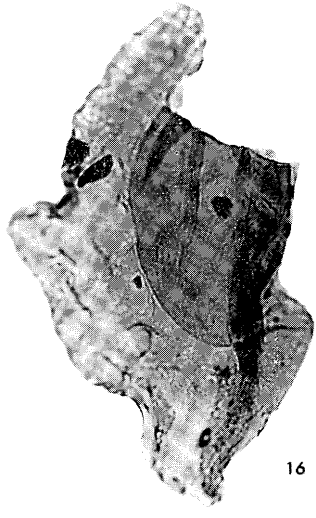
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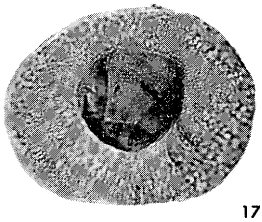
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15

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PLATE 14

(Magnification 500× unless otherwise stated)

FIGURE

1. *Florinites grandis* Kalibova, 1964; uncorrelated coal between Cardiff and Summum (No. 4) (?) Coals, maceration 954-B, slide 18; 129.0 by 117.0μ; p. 131.

2. *Florinites similis* Kosanke, 1950; Cardiff Coal, maceration 954-Dd, slide 10; 119.3 by 95.2μ; p. 131.

3. *Florinites similis* Kosanke, 1950; Cardiff Coal, maceration 954-Dd, slide 15; 113.1 by 103.7μ; p. 131.

4. *Florinites millotti* Butterworth and Williams, 1954; Lowell Coal, maceration 1404-P, slide 12; 48.4 by 35.4μ; p. 132.

5. *Vesicaspora wilsonii* (Schemel) Wilson and Venkatachala, 1963d; Houchin Creek Coal (IVa) (Indiana), maceration 1509-J, slide 24; 42.9 by 34.8μ; p. 132.

6. *Kosankeisporites elegans* (Kosanke) emend., holotype; McCleary's Bluff Coal, maceration 490-A, slide 5; 63.0 by 51.4μ; magnification 1000×; p. 133.

7. *Kosankeisporites elegans* (Kosanke) emend.; New Haven Coal, maceration 574, slide 40; 62.8 by 45.5μ; p. 133.

8. *Kosankeisporites elegans* (Kosanke) emend.; same specimen shown in figure 7, to show distinct trilete mark; p. 133.

9. *Complexisporites chalonerii* Habib, 1966; Danville (No. 7) Coal, maceration 1384-R, slide 13; 65.0 by 43.2μ; p. 134.

10. *Alatisporites trialatus* Kosanke, 1950; Lowell Coal, maceration 1404-Q, slide 4; 85.5 by 81.3μ, including sacs; p. 135.

11. *Alatisporites hexalatus* Kosanke, 1950; Colchester (No. 2) Coal, maceration 1230-CC, slide 14; 82.9 by 78μ, including sacs; p. 135.

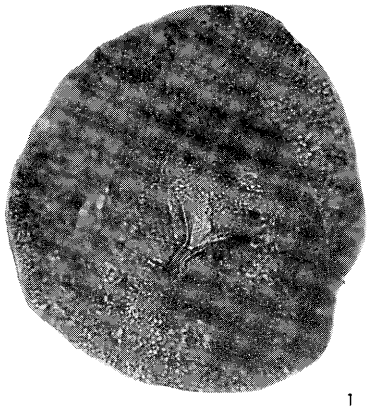
12. *Alatisporites punctatus* Kosanke, 1950; Springfield (No. 5) Coal, maceration 1392, slide 11; 51.4 by 48.8μ; p. 135.

13. *Trihyphaecites triangulatus* sp. nov., holotype; uncorrelated coal bands between Colchester (No. 2) and Cardiff Coals, maceration 1133-E, slide 8; maximum diameter of triangular body, 38.4μ; p. 135.

14. *Trihyphaecites triangulatus* sp. nov., paratype; Springfield (No. 5) Coal, maceration 630, slide 25; maximum diameter of triangular body, 35.8μ; p. 135.

15. *Trihyphaecites triangulatus* sp. nov., paratype; Springfield (No. 5) Coal, maceration 1392, slide 8; maximum diameter of largest triangular body, 42.3μ; p. 135.

16. *Trihyphaecites triangulatus* sp. nov., paratype; Abingdon (?) Coal, maceration 1404-I, slide 4; maximum diameter of triangular body, 38.4μ; p. 135.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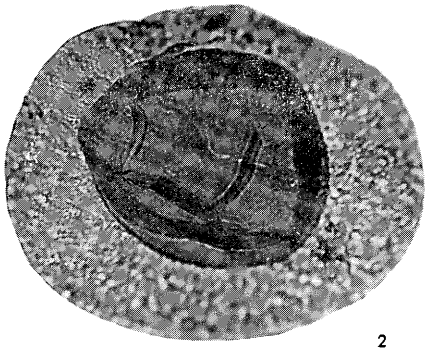
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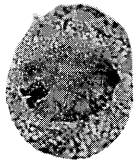
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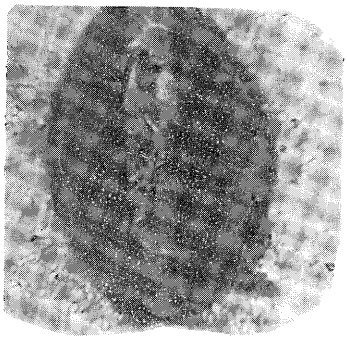
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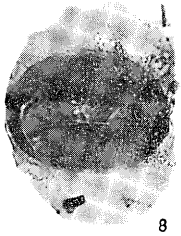
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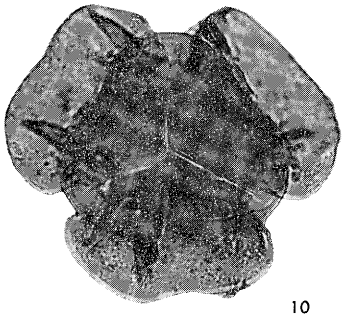
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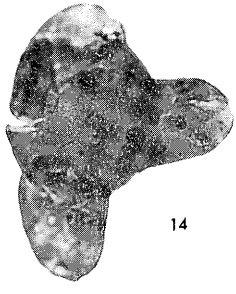
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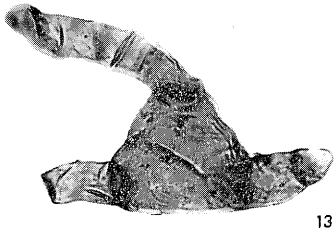
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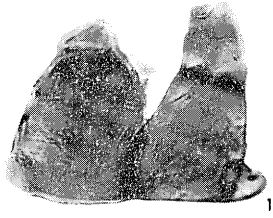
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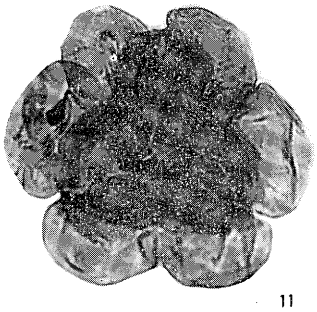
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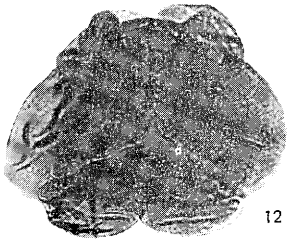
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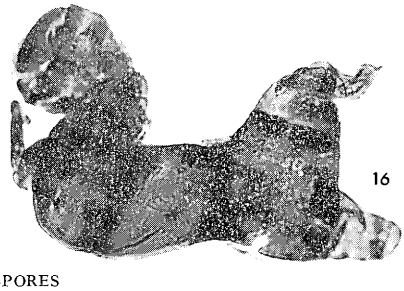
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173 p., 14 pls., 29 figs., 1 table, January 1970