

MIOSPORE ANALYSIS OF THE POTTSVILLE COALS  
OF INDIANA

*by*  
G. K. GUENNEL

Indiana Department of Conservation  
GEOLOGICAL SURVEY  
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Guennel

Miospores, Pottsville

1958



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# CONTENTS

3

	Page
Abstract . . . . .	7
Introduction . . . . .	8
Purpose of study . . . . .	8
Acknowledgments . . . . .	8
Procedure . . . . .	9
Correlation of coal beds . . . . .	9
Collecting localities . . . . .	9
General stratigraphy . . . . .	9
Coals in the Mansfield Formation . . . . .	18
Coals in the Brazil Formation . . . . .	21
Lower Block a zone . . . . .	24
Lower Block b zone . . . . .	24
Lower Block c zone . . . . .	27
Upper Block a zone . . . . .	27
Upper Block b zone . . . . .	28
Upper Block c zone . . . . .	29
Minshall Coal . . . . .	31
Coal II . . . . .	32
Coals in the lower part of the Staunton Formation . . . . .	32
Correlation within the Illinois Basin . . . . .	33
Taxonomy . . . . .	37
History of spore classification . . . . .	37
Descriptions of species . . . . .	41
Selected bibliography . . . . .	87
Index of stratigraphic terms and spore names . . . . .	91

# ILLUSTRATIONS

(Plates follow index)

- Plate 1. *Cirratriradites*, *Lycospora*, and *Endosporites*.  
 2. *Endosporites*, *Guthoerlisporites*, *Florinites*,  
 and *Leiotriletes*.  
 3. *Leiotriletes*, *Granulatisporites*, *Converrucosi-*  
*sporites*, *Apiculatisporites*, *Lophotriletes*,  
*Pustulatisporites*, and *Microreticulatisporites*.  
 4. *Punctatisporites*, *Calamospora*, and *Densosporites*.  
 5. *Triquitrites*, *Laevigatosporites*, and *Latosporites*.  
 6. *Reticulatisporites*, *Dictyotriletes*, *Raistrickia*,  
 and *Alatisporites*.

	Page
Text figure 1. Map of southwestern Indiana showing collecting sites - - - - -	10
2. Generalized stratigraphic column of the Pottsville Series in Indiana - - - - -	11
3. Graphs showing percentage relationships of miospore genera in the French Lick, Pinnick, Shoals, and Blue Creek coals - - -	19
4. Graphs showing percentage relationships of miospore genera in some coals of the Mansfield Formation - - - - -	20
5. Graphs showing percentage relationships of miospore genera in the Block coals - - -	25
6. Graphs showing percentage relationships of miospore genera in the Minshall Coal, Coals II and III, and unnamed coals in the lower part of the Staunton Formation - -	33
7. Diagram showing ranges and relative abun- dances of principal miospore genera in lower Pennsylvanian coals of Indiana - - -	34

	Page
Text figure 8. Diagram showing the numerical relationships of species among sets of samples from different coals and between sets of the same coal - - - - -	36
9. <i>Cirratiradites arcuatus</i> sp. nov.; photomicrograph and drawing of holotype - - - -	45
10. <i>Cirratiradites foveatus</i> sp. nov.; photomicrograph and drawing of holotype - - - -	46
11. <i>Endosporites parvus</i> sp. nov.; photomicrograph and drawing of holotype - - - -	51
12. <i>Endosporites circularis</i> sp. nov.; photomicrograph and drawing of holotype - - - -	52
13. <i>Endosporites breviradiatus</i> sp. nov.; photomicrograph and drawing of holotype - -	55
14. <i>Leiotriletes parvus</i> sp. nov.; photomicrograph and drawing of holotype - - - -	57
15. <i>Pustulatisporites crenatus</i> sp. nov.; photomicrograph and drawing of holotype - -	64
16. <i>Calamospora parva</i> sp. nov.; photomicrograph and drawing of holotype - - - -	71
17. <i>Triquitrites bucculentus</i> sp. nov.; photomicrograph and drawing of holotype - - - -	73
18. <i>Reticulatisporites annulatus</i> sp. nov.; photomicrograph and drawing of holotype - -	81
19. <i>Reticulatisporites areolatus</i> sp. nov.; photomicrograph and drawing of holotype - -	83
20. <i>Alatisporites pottsvillensis</i> sp. nov.; photomicrograph and drawing of holotype - -	86

	Page
Table 1. Collecting sites from which samples were obtained for spore analyses - - - - -	12
2. Correlation of stratigraphically related samples - - -	22
3. Species of spores (in percent) in Lower Block a samples - - - - -	24
4. Species of spores (in percent) in Lower Block b samples - - - - -	26
5. Species of spores (in percent) in Lower Block c samples - - - - -	27
6. Species of spores (in percent) in Upper Block a samples - - - - -	28
7. Species of spores (in percent) in Upper Block b samples - - - - -	29
8. Species of spores (in percent) in Upper Block c samples - - - - -	30
9. Species of spores (in percent) in Minshall samples -	31
10. Species of spores (in percent) in Coal II samples - -	32
11. Equation of 13 prominent genera in the Pottsville coals, classified according to the Schopf, Wilson, and Bentall (1944) system, with the Potonie and Kremp (1954) taxa - - - - -	42



# MIOSPORE ANALYSIS OF THE POTTSVILLE COALS OF INDIANA

By G. K. Guennel

## ABSTRACT

Ninety-eight coal samples were collected for this study at 85 localities in 12 Indiana counties. Percentage relationships of miospore genera and relative abundances of species were determined for these samples and can be used successfully in correlating coal beds within the Pottsville Series (Pennsylvanian System).

Two formations, the Mansfield and the Brazil, constitute the Pottsville Series in Indiana. Miospore analysis revealed seven distinct spore assemblages for samples of coals from the Mansfield Formation and indicates the need for further detailed study of these coals. Samples from the Brazil Formation displayed eight distinct assemblages. These spore patterns are useful for dividing the Brazil Formation into eight zones and indicate that the formation may have more coal seams than geologists have previously thought.

The Upper Block Coal (Brazil Formation) from Clay County, Ind., has a pronounced abundance of the genus *Cirratriradites* and thus can be differentiated from the Lower Block Coal (Brazil Formation). Three distinct spore patterns were obtained from coals presumably contemporaneous in deposition with Lower Block Coal. The 3 zones are thought to represent 3 coals in stratigraphic sequence. The lower coal seam, high in *Laevigatosporites*, is called Lower Block a zone; the middle seam, characterized by a dual dominance of *Lycospora* and *Laevigatosporites*, is called Lower Block b zone; and the upper seam, high in *Densosporites*, is called the Lower Block c zone.

Three distinct spore patterns also were obtained from coals presumably contemporaneous in deposition with Upper Block Coal. The 3 zones are thought to represent 3 coals in stratigraphic sequence. The lower coal seam, marked by a pronounced *Cirratriradites* peak, is called Upper Block a zone; the middle seam, dominated by *Laevigatosporites*, *Granulatisporites*, and *Endosporites*, is called Upper Block b zone; and the upper seam, completely dominated by *Laevigatosporites*, is called Upper Block c zone.

A comparison of generic abundance graphs of Indiana and Illinois coals reveals some striking generic hemerae. For example, the spore assemblage of the Pinnick coal (Mansfield Formation) of Indiana is similar to the spore patterns of the Battery Rock and Reynoldsburg Coals (Caseyville Group) of Illinois. *Cirratriradites* hemerae are found in the Tarter and Willis Coals of Illinois and in the Upper Block a zone of Indiana. A pronounced *Endosporites* peak can be seen in the Minshall Coal (Brazil Formation) of Indiana and may be correlative with a similar peak in the Seville, Rock Island, Curlew, and Bald Hill Coals of Illinois.

The classificatory system of Schopf, Wilson, and Bentall was used in this study. The 13 prominent miospore genera of the Pottsville coals, classified according to this system, also are equated with the Potonie and Kremp taxa. The 12 new species described and figured are: *Cirratiradites arcuatus*, *Cirratiradites foveatus*, *Endosporites parvus*, *Endosporites circularis*, *Endosporites breviradiatus*, *Leiotriletes parvus*, *Pustulatisporites crenatus*, *Calamospora parva*, *Triquitrites bucculentus*, *Reticulatisporites annulatus*, *Reticulatisporites areolatus*, and *Alatisporites pottsvillensis*.

## INTRODUCTION

### PURPOSE OF STUDY

The mapping of coal beds, vital to resources studies, depends on accurate identification and correlation of coal seams. Spore analysis of the Pottsville coals of Indiana was undertaken to determine whether differences in spore assemblages are great enough to differentiate coal seams and whether spore patterns, assumed to be characteristic of a given coal, show lateral persistency. A major objective was to express spore relationships statistically so as to find a reliable and efficient method of correlation.

### ACKNOWLEDGMENTS

Appreciation is expressed to Drs. Charles F. Deiss, State Geologist, and Charles E. Wier, Head of the Coal Section, Indiana Geological Survey, for their continued interest in spore research as a stratigraphic tool.

Critical reading of the manuscript and helpful comments by Dr. Robert M. Kosanke of the Illinois Geological Survey are gratefully acknowledged. The author also is indebted to the many mine operators for their cooperation in permitting sampling on their premises.

## PROCEDURE

Details of sampling and preparation of coals were discussed in a previous paper (Guennel, 1952, p. 5-10) and need not be repeated here. Channel samples of coal were collected and prepared by standard methods, macerated in Schulze's reagent, stained, and mounted on glass slides. Except for a few samples which had extremely sparse spore populations, 200 spores were counted and identified for each bench sample collected.

## CORRELATION OF COAL BEDS

## COLLECTING LOCALITIES

Coal samples were obtained at 85 localities. At 11 sites 2 separate coal seams were sampled, and at 1 outcrop 3 coals in vertical sequence were sampled. Most of the coal seams were sampled in layers or benches; this method of sampling provided 112 samples for preparation and study. Table 1 gives the location and description of sites where samples were obtained. The site numbers in table 1 refer to those shown in figure 1. Letters are appended to some site numbers in table 1 to indicate that more than one coal seam was sampled at these sites.

## GENERAL STRATIGRAPHY

The Pennsylvanian System of rocks in Indiana is divided into the Pottsville, Allegheny, and Conemaugh Series. Cumings (1922, p. 408 and 527-528) equated the rocks at the base of the Pennsylvanian System, which rest unconformably on Chester and older rocks and are bounded at the top by the disconformity above Coal II, with the Pottsville rocks of the Appalachian region. According to Cumings, two formations, the Mansfield and the Brazil, constitute the Pottsville Series in Indiana. The contact between the two formations was defined by Cumings as the base of the Lower Block Coal at Brazil. The generalized stratigraphic column (fig. 2) shows the stratigraphy and lithology of the Pottsville rocks in Indiana.



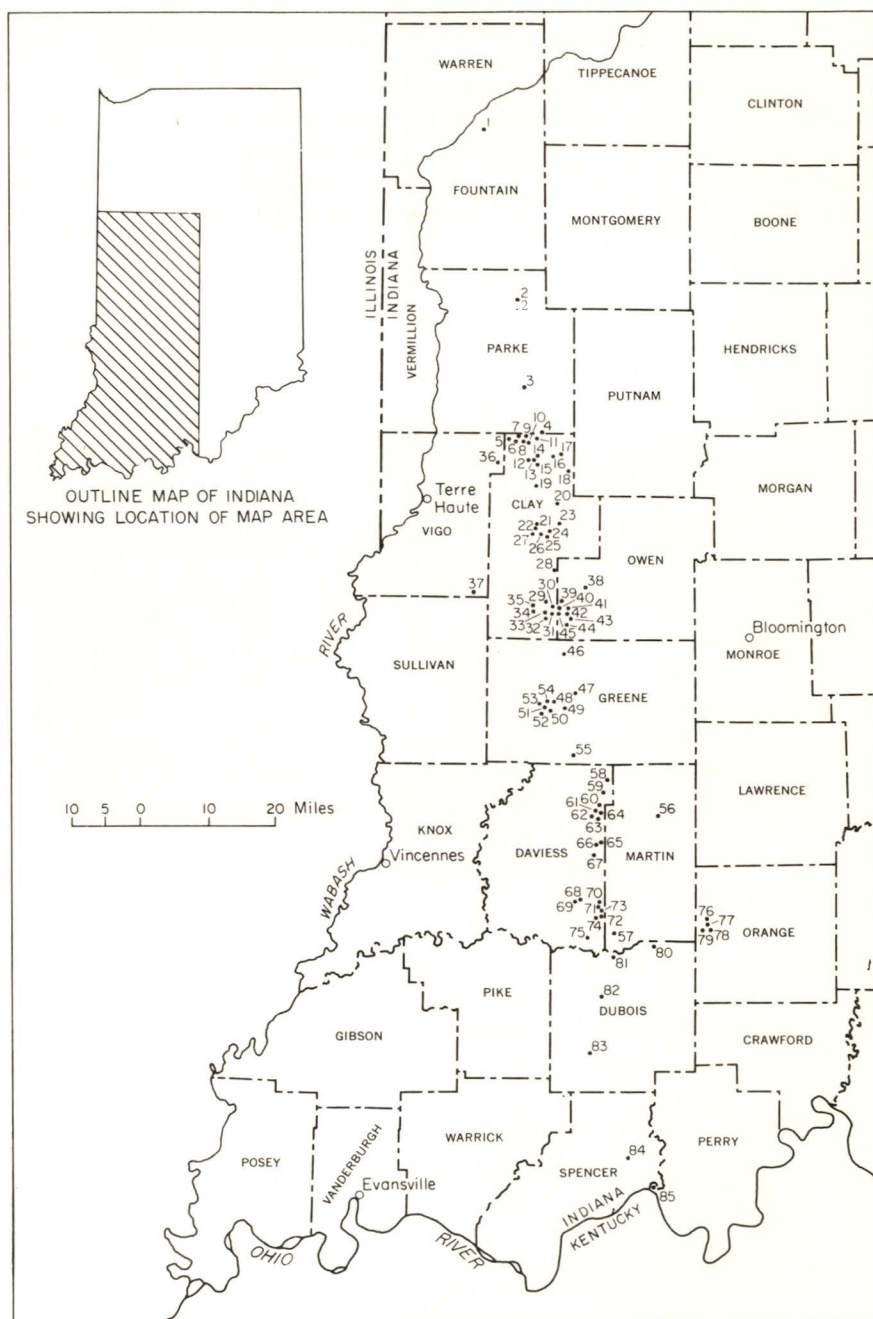


Figure 1. Map of southwestern Indiana showing collecting sites.



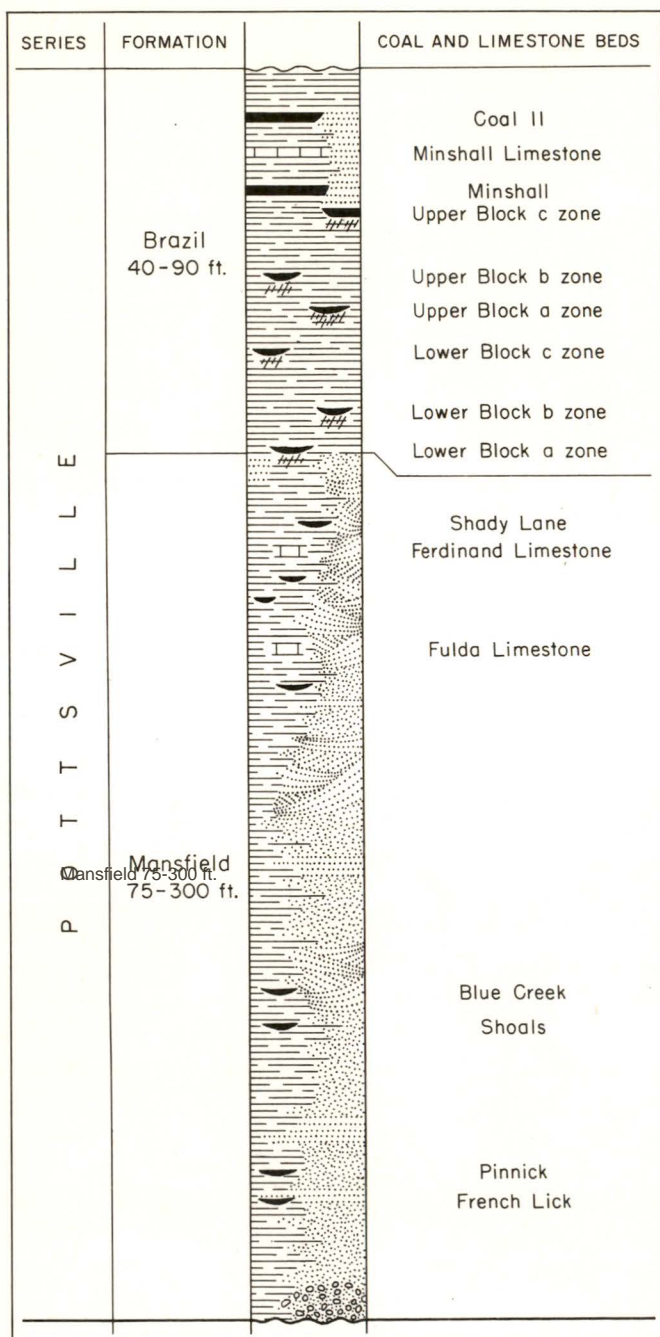


Figure 2. Generalized stratigraphic column  
of the Pottsville Series in Indiana.

Table 1.--Collecting sites from which samples were obtained for spore analyses

Site and sample No.	County	Quarter	Sec.	T.	R.	Coal bed <sup>1</sup>	Collection No.	Description of collecting site	Altitude (feet)
1	Fountain	SW/ SW	19	21N	7W	UBb	Ma-32	Outcrop; north bank of Big Shawnee Creek	ca. 520
2	Parke	SW/ SW	25	17N	7W	Mans.	Ma-4	Outcrop; bed of Wapalo Creek	ca. 575
3	Parke	NE/ NE	35	15N	7W	Min.	II-11	Maple Grove strip mine	ca. 605
4	Parke	SW/ NE	32	14N	6W	LBa	B-31	Turner strip mine	619
5a	Clay	SW/ SW	4	13N	7W	Staun.	II-5	Ader strip mine	577
5b	Clay	SW/ SW	4	13N	7W	Staun.	II-4	Ader strip mine	559
6	Clay	NW/ SW	2	13N	7W	UBc	B-30	Outcrop; stream bank	580
7	Clay	NE/ NW	2	13N	7W	UBc	M-19	G. & F. strip mine	610
8	Clay	NE/ SE	2	13N	7W	UBc	M-24	G. & F. strip mine	640
9	Clay	NW/ NW	1	13N	7W	UBc	M-20	G. & F. strip mine; coal in high wall	625
10	Clay	NW/ SW	1	13N	7W	UBc	B-29	G. & F. strip mine	636
11	Clay	SW/ SE	6	13N	6W	UBc	B-28	G. & F. strip mine	656
12	Clay	SE/ SW	24	13N	7W	UBc	B-53	Turner & Thompson strip mine	600
13	Clay	SE/ SE	24	13N	7W	UBc	B-58	Log Cabin strip mine	593
14a	Clay	NE/ NW	19	13N	6W	UBa	B-59	Quality strip mine	631
14b	Clay	NE/ NW	19	13N	6W	LBa	B-60	Quality strip mine	602
15	Clay	SW/ NW	30	13N	6W	UBc	M-16	Love Bros. strip mine	624
16a	Clay	SE/ NE	21	13N	6W	UBc	M-22	Quality strip mine	671
16b	Clay	SE/ NE	21	13N	6W	UBa	B-54	Quality strip mine	649
17	Clay	NE/ SW	14	13N	6W	Mans.	Ma-10	Outcrop; stream valley 1,500 feet north of road	640

## CORRELATION OF COAL BEDS

18	Clay	SE/ SE	36	13N	6W	Mans.	Ma-25	Outcrop; gully 1,200 feet north of road intersection	ca. 635
19	Clay	NW/ SE	7	12N	6W	Min.	M-23	Outcrop; stream valley at east edge of Big Bend strip mine	ca. 625
20	Clay	SE/ SE	22	12N	6W	UBa	B-64	Outcrop; stream valley west side of road, 1,000 feet north of road intersection	ca. 625
21	Clay	SE/ NE	7	11N	6W	LBa	B-57	Big Bend strip mine	ca. 545
22	Clay	NE/ SE	7	11N	6W	LBc	B-16	Big Bend strip mine	ca. 550
23	Clay	NE/ NW	11	11N	6W	LBb	B-2	Hickory strip mine	650
24a	Clay	NW/ NE	16	11N	6W	UBa	B-10	Log Cabin strip mine	620
24b	Clay	NW/ NE	16	11N	6W	LBb	B-11	Log Cabin strip mine	605
25a	Clay	NW/ SW	16	11N	6W	LBc	B-63	Log Cabin strip mine; upper coal	ca. 615
25b	Clay	NW/ SW	16	11N	6W	LBa	B-61	Log Cabin strip mine; lower coal	ca. 600
26	Clay	SE/ SE	17	11N	6W	UBc	B-17	Big Bend strip mine	ca. 660
27	Clay	Center	18	11N	6W	UBa	B-1	Big Bend strip mine	ca. 525
28	Clay	NW/ SE	10	10N	6W	LBa	B-27	Maumee strip mine	551
29	Clay	SE/ NE	4	9N	6W	LBa	B-3	Commodore strip mine	534
30	Clay	NW/ NE	10	9N	6W	Min.	M-10	Outcrop; stream valley 200 feet south of section line	599
31	Clay	NW/ NW	15	9N	6W	II	M-5	Outcrop 1 1/2 miles west of Coal City	589
32	Clay	NW/ NW	15	9N	6W	II	II-1	Outcrop; creek bed north bank	590
33	Clay	NW/ NW	15	9N	6W	II	II-12	Outcrop; creek bed south bank	585
34	Clay	NW/ NE	7	9N	6W	Min.	M-6	Outcrop; creek bed 1,000 feet north of house	554

See footnote at end of table, p. 17.

Table 1.--Collecting sites from which samples were obtained for spore analyses--Continued

Site and sample No.	County	Quarter	Sec.	T.	R.	Coal bed <sup>1</sup>	Collection No.	Description of collecting site	Altitude (feet)
35	Clay	NE/NE	7	9N	6W	Min.	M-11	Gillespie strip mine	ca. 600
36	Vigo	SW/ NW	29	13N	7W	Staun.	M-12	Outcrop 200 feet northwest of road	541
37a	Vigo	NE/ NW	35	10N	8W	Min.	M-15	Well cutting; drill hole	ca. 449
37b	Vigo	NE/ NW	35	10N	8W	LBb	B-18	Well cutting, drill hole	ca. 399
38	Owen	NW/ NW	28	10N	5W	UBa	B-26	Rohr strip mine	ca. 650
39	Owen	SW/ SW	2	9N	6W	Min.	M-4	Commodore strip mine	606
40	Owen	SW	2	9N	6W	Min.	M-2	Commodore strip mine	ca. 640
41	Owen	SW/ SE	2	9N	6W	LBb	B-9	Outcrop; gully three-fourths mile north of Coal City	596
42	Owen	NE/ NE	11	9N	6W	Min.	B-8	Outcrop; gully	ca. 640
43	Owen	SE/ SE	11	9N	6W	LBb	B-12	Commodore strip mine	569
44	Owen	NW/ NW	13	9N	6W	LBb	B-5	Outcrop; creek bank	565
45	Owen	SE/ SE	11	9N	6W	UBb	B-4	Outcrop; creek bank	580
46	Greene	NE/ SW	12	8N	6W	UBa	B-14	Michael strip mine	553
47	Greene	SE	7	8N	5W	LBb	B-7	Michael strip mine	585
48	Greene	NE/ NW	30	7N	5W	UBa	B-15	Hakilo strip mine	545
49	Greene	NW/ SE	24	7N	6W	LBc	B-13	Hert strip mine	523
50a	Greene	SE/ NW	27	7N	6W	Min.	M-9	Smock strip mine	502
50b	Greene	SE/ NW	27	7N	6W	LBc	B-6	Smock strip mine	483
51	Greene	SE/ SE	21	7N	6W	Min.	M-3	Yake strip mine	517
52	Greene	NW	28	7N	6W	II	II-7	Gillespie strip mine	510



53	Greene	NE/SW	21	7N	6W	II	II-2	Outcrop; railroad cut, west end	545
54	Greene	NW/SE	21	7N	6W	II	II-3	Outcrop; railroad cut, east end	545
55	Greene	NE/SW	30	6N	5W	UBc	II-6	Outcrop; stream bank one-quarter mile east of Newberry	ca. 580
56	Martin	SE/SE	7	4N	3W	Mans.	Ma-2	Slope mine half a mile southwest of Indian Springs	ca. 700
57	Martin	NW	6	1N	4W	LBc	Ma-33	Outcrop east side of Highway 45	511
58a	Daviess	NW/NW	13	5N	5W	UBc	B-32	Outcrop west side of Highway 45	538
58b	Daviess	NW/NW	13	5N	5W	LBb	B-20	Outcrop west side of Highway 45	529
59	Daviess	SE/NE	26	5N	5W	UBc	B-24	Outcrop; strip mine west of Highway 45	557
60	Daviess	NE/NE	2	4N	5W	LBb	B-19	Outcrop; stream bank	549
61a	Daviess	SE/NE	10	4N	5W	Min.	M-14	Outcrop; ravine 100 yards south of road	567
61b	Daviess	SE/NE	10	4N	5W	LBb	B-23	Outcrop; ravine 100 yards south of road	556
61c	Daviess	SE/NE	10	4N	5W	LBa	B-22	Outcrop; ravine 100 yards south of road	542
62	Daviess	SW	10	4N	5W	UBb	B-21	Outcrop; stream bank	531
63	Daviess	NW/SE	10	4N	5W	UBb	III-8	Kelsey slope mine	539
64	Daviess	NE/NE	14	4N	5W	LBa	Ma-9	Outcrop; stream bank	552
65	Daviess	Center	35	4N	5W	UBc	B-47	Outcrop; road cut	ca. 500
66	Daviess	SE/SE	34	4N	5W	UBb	B-45	Outcrop; stream bank	474
67	Daviess	SW/SW	10	3N	5W	UBb	Ma-23	Outcrop; road cut about 2 1/2 miles northwest of Loogootee	ca. 560
68	Daviess	SE/SE	7	2N	5W	UBa	B-38	Shaft mine	ca. 580
69	Daviess	SE/SE	7	2N	5W	LBa	B-39	Outcrop	ca. 573
70	Daviess	NW/NW	14	2N	5W	LBa	B-41	Strip mine; upper coal	520

See footnote at end of table, p. 17.

Table 1.—Collecting sites from which samples were obtained for spore analyses--Continued

Site and sample No.	County	Quarter	Sec.	T.	R.	Coal bed <sup>1</sup>	Collection No.	Description of collecting site	Altitude (feet)
71a	Daviess	SE/ SW	14	2N	5W	UBc	B-65	Loogootee Block strip mine; upper coal	530
71b	Daviess	SE/ SW	14	2N	5W	LBb	B-66	Loogootee Block strip mine; lower coal	510
72	Daviess	NE/ SE	23	2N	5W	LBc	Ma-22	Outcrop; stream cut	510
73	Daviess	SE/ SE	23	2N	5W	UBc	B-46	Landrey test pit	570
74a	Daviess	SW/ NW	26	2N	5W	UBc	B-42	Strip mine about 1 mile northeast of Alfordsville	519
74b	Daviess	SW/ NW	26	2N	5W	LBa	B-43	Strip mine about 1 mile northeast of Alfordsville	509
75	Daviess	SW/ SW	9	1N	5W	Min.	M-18	Outcrop; stream cut	405
76	Orange	SW/ NE	32	2N	2W	Mans.	Ma-35	Outcrop; stream bed	ca. 730
77	Orange	SE/ SE	32	2N	2W	Mans.	Ma-5	Braxton quarry	ca. 750
78	Orange	NW/ NW	4	1N	2W	Mans.	Ma-36	Outcrop; road cut east side of hill	705
79	Orange	NE/ NW	5	1N	2W	Mans.	Ma-6*	Brown Moore quarry	ca. 750
80	Dubois	SW/ SW	18	1N	3W	Mans.	Ma-34	Outcrop; behind barn opposite road T	ca. 660
81	Dubois	SE/ SW	30	1N	4W	Mans.	Ma-15	Outcrop; road cut south side of Highway 56	ca. 470
82	Dubois	Center N 1/2	26	1S	5W	Mans.	Ma-16	Outcrop	ca. 560
83	Dubois	NE/ NE	4	3S	5W	UBb	B-33	Shale pit south of Highway 64	515
84	Spencer	SW	21	5S	4W	LBc	IV-5	Hagedorn strip mine	ca. 460
85a	Perry	NW/ SE	13	6S	4W	LBc	Ma-18	Outcrop northeast side of Highway 66	460
85b	Perry	NW/ SE	13	6S	4W	LBb	Ma-19	Outcrop northeast side of Highway 66	458

— <sup>1</sup> Staun. - Coals in the Staunton Formation

II - Coal II

Min. - Minshall Coal

UBc - Upper Block Coal, zone c

UBb - Upper Block Coal, zone b

UBa - Upper Block Coal, zone a

LBc - Lower Block Coal, zone c

LBb - Lower Block Coal, zone b

LBa - Lower Block Coal, zone a

Mans. - Coals in the Mansfield Formation

In this report discussion of spore assemblages in terms of relative abundances of spore genera is based on the system of classification of Schopf, Wilson, and Bentall (1944). The reader is advised to refer to the generic relation chart (p. 42); it will enable him to split the "sensu lato" genera into the restricted ones established by the system of Potonie and Kremp (1954, 1955, and 1956a and b). Only abundances exceeding 1 percent are shown on the generic percentage graphs (figs. 3-6).

#### COALS IN THE MANSFIELD FORMATION

Logan (1922, p. 623) listed three coals in the Mansfield Formation--namely, the Cannelton, Kirksville, and Shoals coals; he thought the Cannelton and Shoals coals were the same age. Ashley (1899, p. 97-101) listed 2 and 3 coals respectively in his Divisions I and II. Wier and Esarey (1951, pl. 4) showed four lenticular coal beds in the Mansfield. There are undoubtedly more coal seams in the Mansfield Formation than those mentioned above, but only a systematic and detailed study of the stratigraphy, aided by spore analyses of the coal seams, will clarify this vague situation. The fact that the coals in the Mansfield Formation have never been economically important and have not been mined extensively accounts, in part, for the lack of information.

Only 11 samples of coals in the Mansfield Formation were used in this study. Several other samples, collected as Mansfield, have been tentatively correlated with younger coals. On the basis of spore assemblages, the 11 samples seemingly fall into 7 groups.

One sample of badly weathered shaly coal (no. 78, table 1 and fig. 1), called the French Lick coal by Franklin (1939, p. 3), revealed a spore assemblage quite different from that derived from analyses of three samples of a slightly younger coal, the Pinnick coal of Franklin (1939, p. 6). On the other hand, analysis indicated that the three samples of the Pinnick coal (nos. 76, 77, and 79) were strikingly similar in spore content. Figure 3 shows the percentage relationships of miospore genera in the French Lick and Pinnick coals.

A sample (no. 56) of coal from the Indian Springs area, Martin County, seems to be the Shoals coal of Logan (1922, p. 623). This sample displayed a spore assemblage distinct from any other



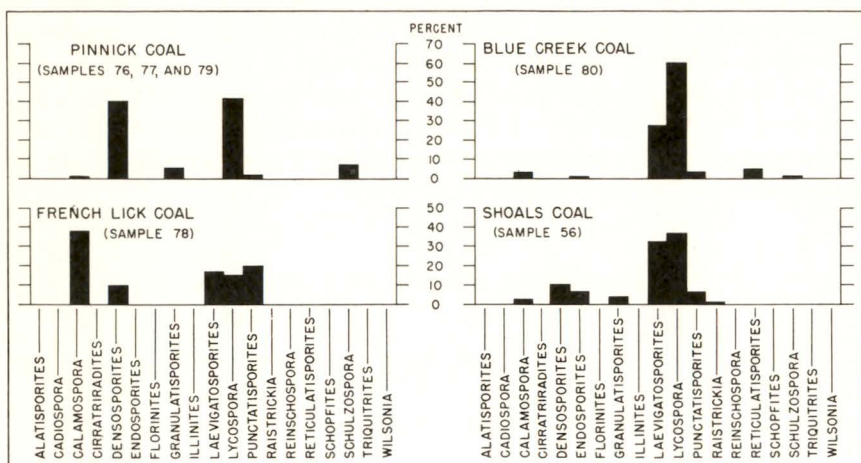


Figure 3. Graphs showing percentage relationships of miospore genera in the French Lick, Pinnick, Shoals, and Blue Creek coals.

found in samples of the Mansfield Formation (fig. 3). An outcrop sample (no. 80) of a coal seam from Dubois County, probably equivalent to the one Jenkins (1956) called the Blue Creek coal, had still another distinct spore assemblage. Figure 3 shows that the spore population of the latter coal (no. 80) is dominated by *Lycospora*, but both *Lycospora* and *Laevigatosporites* dominate the spore population of the Martin County sample (no. 56).

Two other samples from Dubois County (nos. 81 and 82) revealed spore assemblages whose dominant genera, *Laevigatosporites* and *Lycospora*, compared favorably. A comparison of species, however, and the presence of *Densosporites* and a type named *Knoxisporites* by Potonie and Kremp (1954, p. 147) in sample 81 point up differences. The spore assemblage of a sample from Parke County (no. 2) superficially resembles the spore diagrams of both samples 81 and 82, but when species and the less abundant genera of the three samples are compared, a close relationship continues to exist only with sample 82. Sample 2 has 16 species in common with sample 82 and 7 of the 10 most abundant species, but only 11 species are common to both samples 2 and 81. Furthermore, the spore assemblage of sample 81 contains rather con-

spicuous amounts (4.5 and 3.5 percent respectively) of *Densosporites* and *Knoxisporites*, two genera completely missing in samples 2 and 82. Bar graphs of the three samples are shown in figure 4.

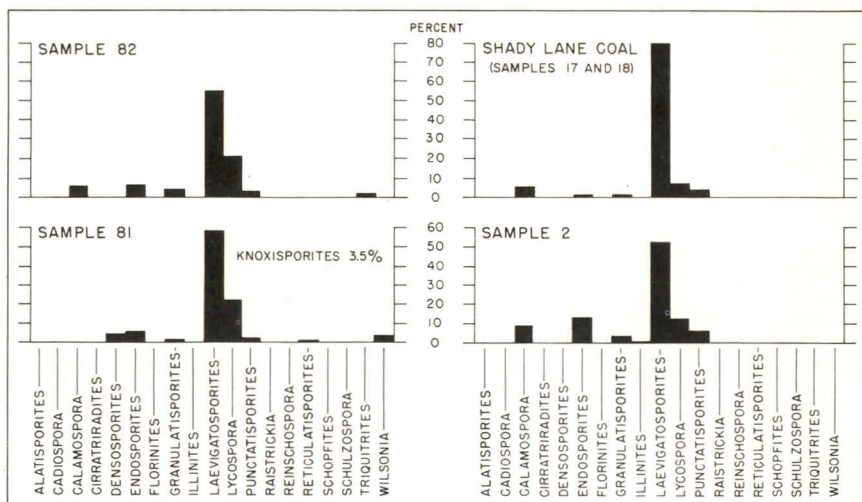


Figure 4. Graphs showing percentage relationships of miospore genera in some coals of the Mansfield Formation.

Two samples from Clay County (nos. 17 and 18) are believed to be from the same coal bed because of a striking similarity in spore patterns. As the composite graph in figure 4 shows, the spore population is completely dominated by *Laevigatosporites*. The name Shady Lane Coal was applied to this coal by Hutchison (in preparation).

The results of spore analysis support the contention that two distinct coal seams, the French Lick and the Pinnick, are present in the lower part of the Mansfield Formation. If the coal from the Indian Springs area is the Shoals coal, and if Logan (1922, p. 623) was correct in correlating it with the Cannelton coal, presumably the "Main Cannelton coal" of Cox (1872, p. 84), then the possibility that the Blue Creek coal and the "Top coal vein" of Cox are correlatives needs to be investigated. No samples of coal associated with the Fulda Limestone are available, but the stra-

tigraphic information pertinent to the coals represented by samples 81, 82, and 2 indicates that they lie above the Fulda Limestone, probably near the Ferdinand Limestone. The exact stratigraphic position of the Shady Lane Coal also is questionable, but this coal probably lies above the Ferdinand Limestone.

These brief remarks point up the need for a study of the coals in the Mansfield Formation. A detailed spore study of coals in the Mansfield Formation is contemplated. This study should help to solve the stratigraphic problems peculiar to this heretofore neglected portion of the Pennsylvanian rocks of Indiana.

#### COALS IN THE BRAZIL FORMATION

Ashley (1899, p. 103) named three coals in the Brazil area: the Lower and Upper Block coals and the rider coal. Logan (1922, p. 624-625) and Cumings (1922, p. 525) listed four coals within the Brazil Formation; namely, Lower Block, Upper Block, Minshall Coal, and Coal II. Wier and Esarey (1951, pl. 4) showed six coals within the Brazil Formation. Spore analyses seem to indicate that a number of relatively small basins may have served as depositories during late Pottsville time and that six distinct coal seams may have been formed during the deposition of the Block coals.

Coal II and Minshall Coal are readily identifiable and differentiable on the basis of spore assemblages, but the numerous samples of Block coal presented such a diversity of spore patterns that, initially, any semblance of uniformity seemed to be coincidence. To bring some semblance of sequence and classification into this maze of spore patterns, those coals definitely related stratigraphically were selected to serve as a framework. (See table 2.) The remaining samples then were fitted into this scheme. Two samples of coals from the Brazil Formation were taken from 10 collecting sites, and 3 coals were exposed at 1 site (no. 61, tables 1 and 2 and fig. 1). First, it was noted that samples 37a, 50a, and 61a (see tables 1 and 2 and fig. 1) had similar spore patterns, which compared favorably with those derived from samples of Minshall Coal. On the other hand, the spore pattern resulting from sample 16a, which was thought to be Minshall Coal, failed to fit the patterns derived from samples of Minshall Coal, but resembled the spore assemblages of samples 58a, 71a, and



Table 2.--Correlation of stratigraphically related samples

Coal	Site No. <sup>1</sup>										
	14	16	24	25	37	50	58	61	71	74	85
Minshall ---	-----	-----	-----	-----	Sample 37a	Sample 50a	-----	Sample 61a	-----	-----	-----
Upper Block c zone ---	-----	Sample 16a	-----	-----	-----	-----	Sample 58a	-----	Sample 71a	Sample 74a	-----
Upper Block a zone ---	Sample 14a	Sample 16b	Sample 24a	-----	-----	-----	-----	-----	-----	-----	-----
Lower Block c zone ---	-----	-----	-----	Sample 25a	-----	Sample 50b	-----	-----	-----	-----	Sample 85a
Lower Block b zone ---	-----	-----	Sample 24b	-----	Sample 37b	-----	Sample 58b	Sample 61b	Sample 71b	-----	Sample 85b
Lower Block a zone ---	Sample 14b	-----	-----	Sample 25b	-----	-----	-----	Sample 61c	-----	Sample 74b	-----

<sup>1</sup> Site numbers refer to locations in table 1 and figure 1.



74a. Samples 16b, 14a, and 24a had similar spore patterns.

The spore pattern of sample 24b proved to be similar to those obtained from samples 37b, 58b, 71b, 85b, and 61b. The spore assemblage of sample 61c compared favorably with the spore assemblages of samples 14b, 25b, and 74b. Sample 25a fitted samples 85a and 50b in spore pattern. Thus five fairly distinct spore patterns evolved for the coals below the Minshall Coal. After comparing the remaining samples of coals from the Brazil Formation with samples of the coals listed in table 2, one group of samples that could not be correlated remained. This group (six samples) whose spore patterns proved to be alike added a sixth distinct spore assemblage to those derived from coals fitting stratigraphically into the rock sequence containing the Block coals.

The diversity of spore assemblages found in the Block coals, initially thought to be only two in number, can be interpreted in various ways. One interpretation is that the change from one spore assemblage to another is coincident with a change in vegetational pattern, the implication being that different plant communities existed within the basin of deposition. A second interpretation is that climax was never attained and that the spore assemblages represent only lower stages of plant succession, feasibly different stages of the same plant succession. The author believes, however, that a number of small basins were formed within the major basin of deposition at different times, and thus six different groups of Block coals were deposited. Because stratigraphic evidence strongly hints that there are at least four separate Block coals, the assumption that the two additional groups represent separate coal beds seems justified. As more samples become available, especially of coals from the Mansfield Formation, the problem of determining whether a number of lenticular beds, that is, small-basin fillings, are contemporaneous or whether the coal vegetations grew at different times will become more acute.

Because six distinct spore assemblages resulted from the analyses, the Block coals have been divided for convenience only into zones in the following manner:

Upper Block Coal	{	Upper Block c zone
		Upper Block b zone
		Upper Block a zone

Lower Block Coal      { Lower Block c zone  
                                  { Lower Block b zone  
                                  { Lower Block a zone

*Lower Block a zone.*--Of the stratigraphically related samples, samples 14b, 25b, 61c, and 74b have spore graphs marked by a dominance of *Laevigatosporites* and a secondary complex of *Punctatisporites*, *Endosporites*, and *Lycospora* (fig. 5). A third group of genera is composed of *Granulatisporites*, *Cirratiradites*, and *Calamospora*. The generic graphs of samples 4, 21, 28, 29, 64, 69, and 70 resemble this pattern. Each of the species in table 3 averaged more than 1 percent and was recorded in more than half of the Lower Block a samples.

Table 3.--Species of spores (in percent) in Lower Block a samples

Species	Percent
<i>Calamospora pallida</i> (Loose) S. W. and B., 1944 .....	1.05
<i>Cirratiradites arcuatus</i> sp. nov. ....	2.87
<i>Endosporites ornatus</i> Wils. and Coe, 1940 .....	1.31
<i>E. pellucidus</i> Wils. and Coe, 1940 .....	2.15
<i>E. rotundus</i> (Ibr.) S. W. and B., 1944 .....	2.35
<i>Granulatisporites deltiformis</i> (Wils. and Coe) S. W. and B., 1944 .....	1.19
<i>Laevigatosporites medius</i> Kos., 1950 .....	26.36
<i>L. minimus</i> (Wils. and Coe) S. W. and B., 1944 .....	3.29
<i>L. ovalis</i> Kos., 1950 .....	28.62
<i>Latosporites globosus</i> (Schem.) Pot. and Kremp, 1956 .....	2.10
<i>L. latus</i> (Kos.) Pot. and Kremp, 1954 .....	3.53
<i>Lycospora parva</i> Kos., 1950 .....	3.64
<i>Punctatisporites provectus</i> Kos., 1950 .....	1.25

*Lower Block b zone.*--One group of the remaining samples stood out by virtue of its relatively high *Lycospora* count, a singular phenomenon among the Block coals. This abundance of *Lycospora* was not uniform, however. In samples 58b, 61b, and 85b *Lycospora* exceeded *Laevigatosporites* in abundance, but in samples 24b and 37b the two genera shared numerical domination. In sample 71b *Laevigatosporites* dominated the assemblage, exceeding *Lycospora* in abundance. Fortunately, sample 24b had been collected in benches or layers; an examination of this sample showed

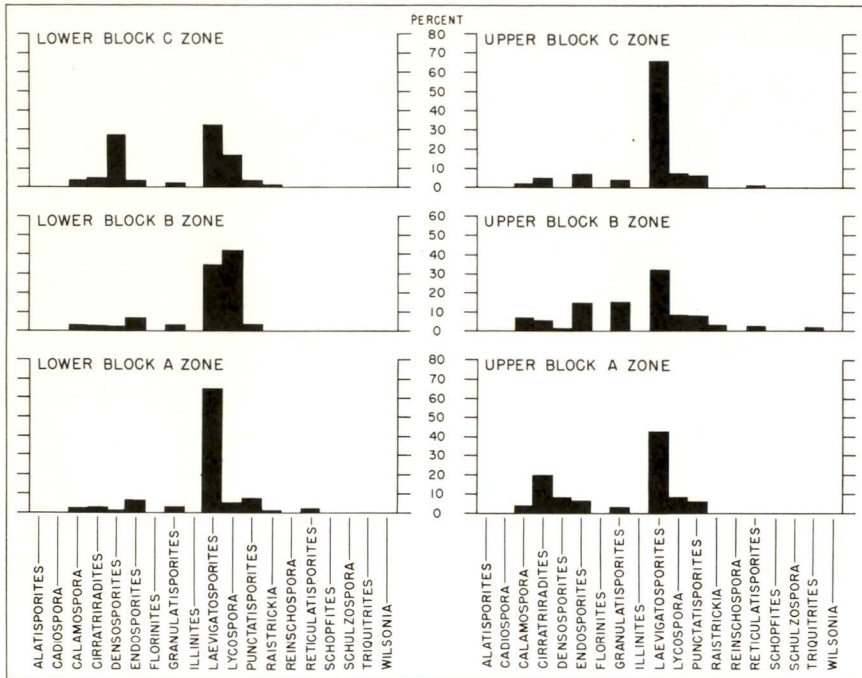


Figure 5. Graphs showing percentage relationships of miospore genera in the Block coals.

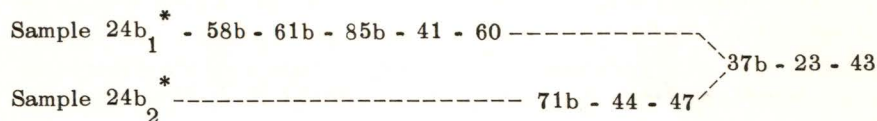
that the upper part was similar to samples 58b, 61b, and 85b. The lower part of sample 24b, on the other hand, resembled sample 71b, which showed *Laevigatosporites* dominating the spore assemblage.

A graph showing a dominance of *Laevigatosporites* and *Lycospora* results from combining the percentages of the benches of sample 24b. The assumption then that samples 24b and 37b represent a fully developed coal seam, whereas sample 71b represents only the lower part and samples 58b, 61b, and 85b the upper part, is inevitable. In other words, coal represented by sample 71b was being deposited at site 71 while coal deposition also was taking place at sites 24 and 37. Deposition ended at site 71 about the time it started at sites 58, 61, and 85. Coal deposition continued, however, at sites 24 and 37.

Two other samples (nos. 23 and 43) revealed spore assemblages having *Laevigatosporites-Lycospora* dominance, and thus



they are assumed to be samples of fully developed Lower Block b coals, whereas samples 44 and 47 represent the same truncated seam as sample 71b. Graphs of samples 41 and 60, showing *Lycospora* as the dominant spore genus, are similar to those for samples 58b, 61b, and 85b and thus seem to represent only the upper part of the Lower Block b zone. A résumé in tabular form shows these relationships more clearly:



The generic picture for the Lower Block b zone is: *Lycospora* and *Laevigatosporites* dominate the spore assemblage (see fig. 5), and *Endosporites*, *Punctatisporites*, and *Granulatisporites* are accessory genera. The species shown in table 4 averaged more than 1 percent and were recorded in 6 or more of the 11 samples.

Table 4.--Species of spores (in percent) in Lower Block b samples

Species	Percent
<i>Calamospora pallida</i> (Loose) S. W. and B., 1944 - - - - -	1.07
<i>Densosporites reynoldsburgensis</i> Kos., 1950 - - - - -	1.76
<i>Endosporites ornatus</i> Wils. and Coe, 1940 - - - - -	1.23
<i>E. pellucidus</i> Wils. and Coe, 1940 - - - - -	1.25
<i>E. rotundus</i> (Ibr.) S. W. and B., 1944 - - - - -	2.25
<i>Laevigatosporites medius</i> Kos., 1950 - - - - -	6.57
<i>L. minimus</i> (Wils. and Coe) S. W. and B., 1944 - - - - -	1.24
<i>L. ovalis</i> Kos., 1950 - - - - -	21.31
<i>Latosporites latus</i> (Kos.) Pot. and Kremp, 1954 - - - - -	1.08
<i>Lycospora granulata</i> Kos., 1950 - - - - -	2.82
<i>L. parva</i> Kos., 1950 - - - - -	16.20
<i>L. pseudoannulata</i> Kos., 1950 - - - - -	1.51
<i>L. punctata</i> Kos., 1950 - - - - -	14.13
<i>L. pusilla</i> (Ibr.) S. W. and B., 1944 - - - - -	7.39

\* Subscript numbers 1 and 2 following sample 24b indicate that this sample was collected in two benches or layers.



*Lower Block c zone.*--A third zone of Lower Block Coal is indicated by samples 25a, 50b, and 85a. The outstanding feature is the high percentage of *Densosporites*, primarily at the expense of *Lycospora*. Samples 49, 22, 72, and 57 also displayed spore assemblages with a high *Densosporites* count. Sample 84, analyzed previously (Guennel, 1952, p. 27, 28), was reexamined and assigned to this group.

The standard graph for samples of the Lower Block c zone is characterized by the dominance of *Densosporites* and either *Laevigatosporites* or *Lycospora*. Accessory genera include *Cirratriradites*, *Endosporites*, *Punctatisporites*, *Granulatisporites*, *Calamospora*, and *Reticulatisporites*. (See fig. 5.) The species common in half or more of the samples studied and averaging more than 1 percent of the spore population are shown in table 5.

Table 5.--Species of spores (in percent) in Lower Block c samples

Species	Percent
<i>Cirratriradites arcuatus</i> sp. nov. ....	4.55
<i>Densosporites lobatus</i> Kos., 1950 ....	15.30
<i>D. reynoldsburgensis</i> Kos., 1950 ....	9.60
<i>Endosporites rotundus</i> (Ibr.) S. W. and B., 1944 ....	1.15
<i>Laevigatosporites medius</i> Kos., 1950 ....	8.75
<i>L. minimus</i> (Wils. and Coe) S. W. and B., 1944 ....	1.10
<i>L. ovalis</i> Kos., 1950 ....	19.40
<i>Latosporites latus</i> (Kos.) Pot. and Kremp, 1954 ....	1.45
<i>Lycospora parva</i> Kos., 1950 ....	6.20
<i>L. punctata</i> Kos., 1950 ....	5.05

*Upper Block a zone.*--Samples 14a, 16b, and 24a of the stratigraphically related group (see table 2) displayed similar spore assemblages. Samples 20, 27, 38, 46, 48, and 68 also showed comparable spore patterns. The characteristic mark of this coal is the high *Cirratriradites* count, although *Laevigatosporites* remains the most abundant genus (fig. 5). Accessory genera are *Lycospora*, *Densosporites*, *Endosporites*, and *Punctatisporites*. Species averaging more than 1 percent and found in 5 or more of

the 8 samples studied are shown in table 6.

Table 6.--*Species of spores (in percent) in Upper Block a samples*

Species	Percent
<i>Cirratriradites arcuatus</i> sp. nov. ....	19.09
<i>Densosporites lobatus</i> Kos., 1950 .....	3.62
<i>Endosporites pellucidus</i> Wils. and Coe, 1940 .....	2.21
<i>E. rotundus</i> (Ibr.) S. W. and B., 1944 .....	2.18
<i>Laevigatosporites medius</i> Kos., 1950 .....	12.28
<i>L. minimus</i> (Wils. and Coe) S. W. and B., 1944 .....	2.24
<i>L. ovalis</i> Kos., 1950 .....	20.65
<i>L. punctatus</i> Kos., 1950 .....	1.31
<i>Latosporites globosus</i> (Schem.) Pot. and Kremp, 1956 .....	4.33
<i>L. latus</i> (Kos.) Pot. and Kremp, 1954 .....	1.31
<i>Lycospora parva</i> Kos., 1950 .....	3.91
<i>L. pusilla</i> (Ibr.) S. W. and B., 1944 .....	1.67
<i>Microreticulatisporites microtuberosus</i> (Loose) Pot. and Kremp, 1955 .....	2.02
<i>Punctatisporites obliquus</i> Kos., 1950 .....	1.22

*Upper Block b zone.*--Another group of samples, believed to approximate the Upper Block Coal in age, lacked distinctly dominant genera. *Laevigatosporites*, although the most abundant genus, is followed rather closely by *Granulatisporites* and *Endosporites* (fig. 5). Seven samples showed this unusual generic assemblage and are therefore believed related. The definite representation of *Cirratriradites* and *Endosporites* indicates that this coal, designated as Upper Block b, may be intermediate in age between the Upper Block (Upper Block a) and the rider (Upper Block c) of the Brazil area. The species shown in table 7 averaged 1 percent or more and were recorded in half or more of the samples.

Table 7.--Species of spores (in percent) in Upper Block b samples

Species	Percent
<i>Calamospora pallida</i> (Loose) S. W. and B., 1944	3.33
<i>Cirratriradites arcuatus</i> sp. nov.	1.33
<i>C. foveatus</i> sp. nov.	3.33
<i>Endosporites formosus</i> Kos., 1950	1.91
<i>E. ornatus</i> Wils. and Coe, 1940	2.41
<i>E. pellucidus</i> Wils. and Coe, 1940	4.75
<i>E. rotundus</i> (Ibr.) S. W. and B., 1944	2.33
<i>Granulatisporites pallidus</i> Kos., 1950	1.25
<i>G. verrucosus</i> (Wils. and Coe) S. W. and B., 1944	2.25
<i>Laevigatosporites medius</i> Kos., 1950	9.00
<i>L. minimus</i> (Wils. and Coe) S. W. and B., 1944	1.58
<i>L. ovalis</i> Kos., 1950	16.83
<i>Latosporites latus</i> (Kos.) Pot. and Kremp, 1954	1.16
<i>Leiotriletes inflatus</i> (Schem.) Pot. and Kremp, 1955	1.08
<i>L. parvus</i> sp. nov.	1.08
<i>Lophotriletes microsaetosus</i> (Loose) Pot. and Kremp, 1955	2.25
<i>Lycospora parva</i> Kos., 1950	6.24
<i>L. punctata</i> Kos., 1950	1.50
<i>Punctatisporites provectus</i> Kos., 1950	1.75

*Upper Block c zone.*--A large group of samples, divisible into three subgroups, presented various problems. One group, because of a relatively high *Cirratriradites* count, was thought to be closely related to the Upper Block a zone. The lack of *Densosporites* and the fact that *Laevigatosporites* was considerably higher in the Upper Block Coal prevented complete agreement with the spore assemblages typical of the Upper Block a zone. Another group of samples was fairly abundant in *Endosporites*, and thus it was assumed that these samples were related to the Minshall Coal. The much higher percentage of *Laevigatosporites* and the sparsity of *Lycospora*, however, were not characteristic Minshall Coal assemblages. A third group of samples had a fairly high representation of both *Cirratriradites* and *Endosporites*. Two of the samples (nos. 11 and 13) had been collected in benches and thus provided an explanation for the representation of both genera.



Analyses of the benches showed that the upper part of the coal was high in *Cirratriradites* and the lower part was high in *Endosporites*. If the relationship of these genera had been reversed, that is, *Cirratriradites* abundant in the lower half and *Endosporites* high in the upper part, a fusion of Upper Block and Minshall Coals might be postulated. The bench analysis, fortunately, prevented such erroneous assumptions. Apparently a recurrent floral development is evident here. *Cirratriradites* showed its maximum development in the Upper Block a zone and also was abundant in the upper part of a younger coal. Samples 10, 16a, 26, and 74a showed this high *Cirratriradites* representation and therefore were correlated with the upper parts of samples 11 and 13, whose lower benches found counterparts in samples 7, 15, 55, 59, and 73. The composite graphs of samples 11 and 13 resemble those of samples 6, 8, 9, 12, 58a, 65, and 71a. This coal seam, first shown by Wier and Esarey (1951, pl. 4), is called Upper Block c for easy reference.

*Laevigatosporites* is the dominant genus for this coal. Low-ranking accessory genera are *Lycospora*, *Endosporites*, *Punctatisporites*, *Cirratriradites*, *Granulatisporites*, *Calamospora*, and *Reticulatisporites* (fig. 5). The species present in half or more of the samples and averaging 1 percent or more in relative abundance are shown in table 8.

Table 8.--Species of spores (in percent) in Upper Block c samples

Species	Percent
<i>Cirratriradites arcuatus</i> sp. nov. ....	4.58
<i>Endosporites pellucidus</i> Wils. and Coe, 1940 ....	2.82
<i>E. rotundus</i> (Ibr.) S. W. and B., 1944 ....	1.55
<i>Granulatisporites deltiiformis</i> (Wils. and Coe) S. W. and B., 1944 ....	1.26
<i>Laevigatosporites medius</i> Kos., 1950 ....	19.86
<i>L. minimus</i> (Wils. and Coe) S. W. and B., 1944 ....	3.66
<i>L. ovalis</i> Kos., 1950 ....	33.94
<i>Latosporites latus</i> (Kos.) Pot. and Kremp, 1954 ....	3.71
<i>Lycospora punctata</i> Kos., 1950 ....	2.75
<i>Microreticulatisporites microtuberosus</i> (Loose) Pot. and Kremp, 1955 ...	1.08



*Minshall Coal*.--Samples 30, 34, 35, 39, 40, 50a, and 51 from Clay, Owen, and Greene Counties served as the basis for the standard generic graph of the Minshall Coal. The outstanding feature of the spore assemblages found in these samples is the unusually high *Endosporites* count. Sample 37a obtained from a well cutting in southeastern Vigo County, also showed the characteristically high percentage of *Endosporites*, as did sample 19. Sample 3, thought to be Coal II when collected, revealed a spore assemblage almost identical with the Minshall generic patterns. The spore diagram of sample 42, collected as an Upper Block sample, also fitted the Minshall pattern, as did two previously stratigraphically unidentified samples (nos. 61a and 75) from Daviess County. Sample 61a was of special significance because it represented the top of three coals from a single exposure (tables 1 and 2 and fig. 1). A composite graph (fig. 6), representing the 13 samples enumerated above, shows the following generic characteristics: *Laevigatosporites* and *Endosporites* are the dominant genera and are followed by *Lycospora*; *Punctatisporites* and *Granulatisporites* are accessory genera. The species shown in table 9 averaged more than 1 percent and were recorded in 7 or more of the Minshall samples.

Table 9.--Species of spores (in percent) in Minshall samples

Species	Percent
<i>Calamospora pallida</i> (Loose) S. W. and B., 1944 .....	1.34
<i>Endosporites formosus</i> Kos., 1950 .....	2.68
<i>E. ornatus</i> Wils. and Coe, 1940 .....	5.28
<i>E. pellucidus</i> Wils. and Coe, 1940 .....	6.30
<i>E. rotundus</i> (Ibr.) S. W. and B., 1944 .....	4.31
<i>Laevigatosporites medius</i> Kos., 1950 .....	7.19
<i>L. minimus</i> (Wils. and Coe) S. W. and B., 1944 .....	1.65
<i>L. ovalis</i> Kos., 1950 .....	25.97
<i>Latosporites latus</i> (Kos.) Pot. and Kremp, 1954 .....	1.98
<i>Lycospora granulata</i> Kos., 1950 .....	1.51
<i>L. parva</i> Kos., 1950 .....	5.03
<i>L. punctata</i> Kos., 1950 .....	4.05
<i>Triquitrites bransonii</i> Wils. and Hoffm., 1956 .....	1.28

*Coal II.*--Samples 32, 33, 53, and 54 displayed similar spore patterns. Sample 52, whose stratigraphic position was unknown, and sample 31, thought to be Minshall Coal, were added to this group because of similarities in spore patterns. A standard Coal II graph (fig. 6), based on generic percentage relationships among six samples, shows the following characteristics: *Laevigatosporites* and *Lycospora* dominate the spore pattern. *Endosporites*, a major constituent in the underlying Minshall Coal, is reduced to accessory status. *Punctatisporites*, *Granulatisporites*, *Triquitrites*, and *Calamospora* form a low-ranking tertiary group. This pattern is distinct from those based on analyses of the Minshall Coal (fig. 6) and Coal III (Guennel, 1952, p. 26). The species averaging more than 1 percent and found in 4 or more Coal II samples are shown in table 10.

Table 10.--Species of spores (in percent) in Coal II samples

Species	Percent
<i>Calamospora pallida</i> (Loose) S. W. and B., 1944 - - - - -	1.30
<i>Converrucosporites sulcatus</i> (Wils. and Kos.) Pot. and Kremp, 1955 - - -	1.33
<i>Endosporites ornatus</i> Wils. and Coe, 1940 - - - - -	1.47
<i>E. pellucidus</i> Wils. and Coe, 1940 - - - - -	5.46
<i>Laevigatosporites medius</i> Kos., 1950 - - - - -	4.33
<i>L. minimus</i> (Wils. and Coe) S. W. and B., 1944 - - - - -	12.19
<i>L. ovalis</i> Kos., 1950 - - - - -	20.33
<i>Latosporites globosus</i> (Schem.) Pot. and Kremp, 1956 - - - - -	3.22
<i>L. latus</i> (Kos.) Pot. and Kremp, 1954 - - - - -	1.27
<i>Lycospora granulata</i> Kos., 1950 - - - - -	1.94
<i>L. parva</i> Kos., 1950 - - - - -	16.97
<i>L. punctata</i> Kos., 1950 - - - - -	12.75
<i>L. pusilla</i> (Ibr.) S. W. and B., 1944 - - - - -	4.50
<i>Triquitrites bransonii</i> Wils. and Hoffm., 1956 - - - - -	1.47

#### COALS IN THE LOWER PART OF THE STAUNTON FORMATION

Two samples were taken from coal seams exposed in the Log Cabin Coal Co. pit 2 miles northeast of Coal Bluff in Clay County. These coal seams probably occupy a stratigraphic position some-

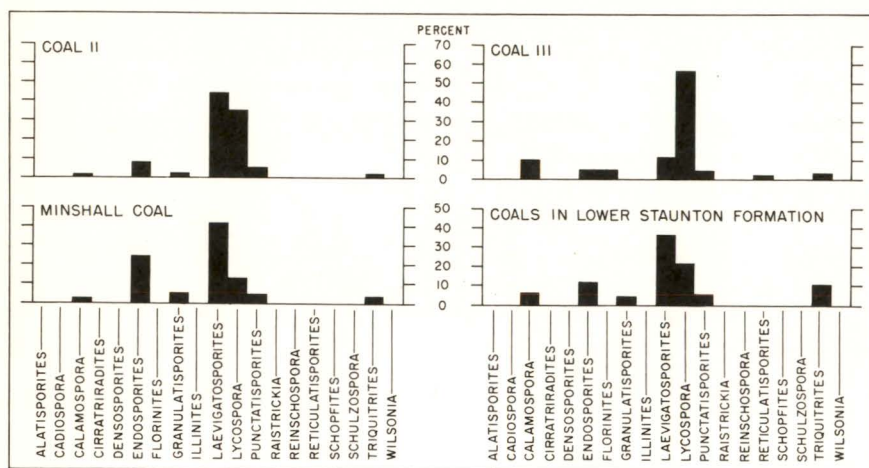


Figure 6. Graphs showing percentage relationships of miospore genera in the Minshall Coal, Coals II and III, and unnamed coals in the lower part of the Staunton Formation.

where in the interval between the Minshall Coal and Coal III, presumably above Coal II and therefore in the Staunton Formation. The upper coal (sample 5a) is about 20 feet above the lower coal (sample 5b). On the basis of generic patterns these two seams are not differentiable. A third sample (no. 36) probably came from the same stratigraphic interval and showed a spore pattern similar to those of samples 5a and 5b. All three samples, in addition to resembling each other in generic assemblage patterns, show similarities with the Coal II spore graphs (fig. 6). *Laevigatosporites* and *Lycospora* are the dominant genera, and *Triquitrites*, *Endosporites*, *Calamospora*, *Punctatisporites*, and *Granulatisporites* are accessory genera. The relatively high *Triquitrites* count may be significant, but until more samples of coals from this stratigraphic interval are available, no correlation can be made.

#### CORRELATION WITHIN THE ILLINOIS BASIN

Although any correlations between Indiana and Illinois coals at this stage of spore research are necessarily conjectural and perhaps



presumptuous, some similarities in the distribution trends of the spore genera found in Indiana and Illinois coals are too obvious to ignore. Comparing the generic abundance graph of Illinois coals (Kosanke, 1947, p. 283)\* to a similar graph representing Indiana coals (fig. 7) results in some striking similarities.

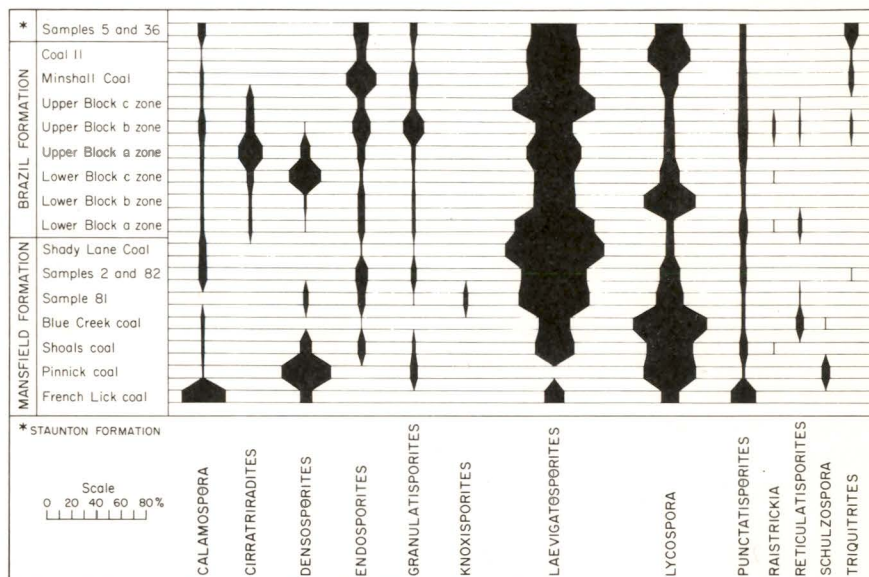


Figure 7. Diagram showing ranges and relative abundances of principal miospore genera in lower Pennsylvanian coals of Indiana.

That *Laevigatosporites* makes its initial appearance in the Reynoldsburg Coal, that *Densosporites* attains its maximum development in the same coal and is a prominent genus in the coal below, the Battery Rock, and that *Schulzospora* has been found only in the latter coal, indicate a close relationship between these coals of the Caseyville Group and the French Lick and Pinnick coals of Indiana (fig. 7).

\*

Additional information, especially percentage data given later (Kosanke, 1950), enabled the writer to construct a more accurate and usable graph.



Another striking feature of the generic histograms is the distinct *Cirratriradites* hemera. Kosanke's graph shows the maximum development of this genus in the Tarter and Willis Coals in Illinois, and in Indiana *Cirratriradites* attains its greatest abundance in the lowest zone of the Upper Block Coal (fig. 7).

It also is noteworthy that *Densosporites* shows an increase in the Tarter-Willis, as it does in the Upper Block a zone, although a more pronounced *Densosporites* increase seems to occur in the coal just below, the Lower Block c zone. The fact that the *Cirratriradites* hemera and *Densosporites* flare were noted in the Tarter and Willis Coals may indicate a relationship between these Illinois seams and the lowest zone of the Upper Block Coal of Indiana.

A gradual, but nevertheless definite, increase in *Endosporites-Florinites* is recorded in the Illinois distribution chart within the Rock Island to Davis and Wiley Coals. A similar thickening of the *Endosporites-Florinites* abundance bar takes place in the interval between the middle zone of the Upper Block Coal and the unnamed coals of the lower part of the Staunton Formation in the Indiana graph; the maximum thickening of this abundance bar is found in the Minshall Coal. The spore graph for Coal II of Indiana seems to fit the Davis-Wiley spore pattern. The *Triquitrites* high mentioned by Kosanke (1950, p. 69) may have its counterpart in the Coal II-Coal III interval, that is, the coals in the lower part of the Staunton Formation (fig. 7).

Coal III, dominated by *Lycospora*, seems to have no equivalent in the Illinois spore graphs, but the graphs for Coal IIIa and the No. 2 (Colchester) Coal of Illinois show a close resemblance.

Correlation by species lists was found to be hazardous when applied either to Indiana coals alone or to coals within the Illinois Basin. Increasing the number of samples extends the vertical distribution of allegedly restricted species and also the number of species within a given coal. This tends to limit the usefulness of index and guide fossils. Although no appreciable increase in species should be noticeable beyond a certain number of samples, not enough samples were available to substantiate this assumption. Apparently more than 18 samples of any given coal seam are needed to reveal this "leveling off."

A species list based on a large number of samples may contain most of the species of a list based on a small number of

samples, even though the larger list has been derived from an entirely different coal. For example, the species list based on 13 samples of Minshall Coal contained 132 species; 26 of these same species were recorded by Schemel (1951, p. 745, 746) among 34 species in the Mystic Coal of Iowa, and 19 of these same species were found by Kosanke (1950, p. 74, 75) among 35 species in the Herrin (No. 6) Coal of Illinois. Because of the number of species that are common to the Minshall, Mystic, and Herrin (No. 6) Coals, one might erroneously conclude that these three coals are of the same age. The Minshall Coal, however, is much older than either the Herrin or the Mystic.

Merely reducing the number of samples in order to attain a comparably low number proved futile also. Several tests showed that a large number of stratigraphically different coals may have as many species in common as the constituent samples of one particular coal bed. Figure 8 shows the numerical relationships of species among four sets of samples. Two randomly selected sets

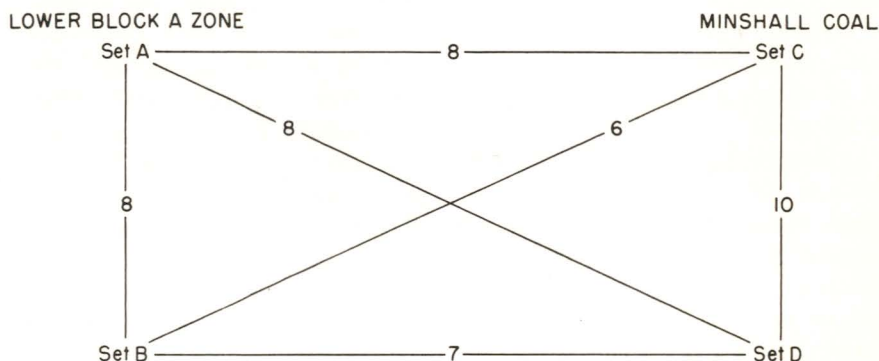


Figure 8. Diagram showing the numerical relationships of species among sets of samples from different coals and between sets of the same coal.

of two samples each of Lower Block Coal contained eight species which were common to both sets, that is, all four samples. Similarly, 2 Minshall sets contained 10 common species. Set A (Lower Block a zone, samples 14b and 25b) and set C (Minshall, samples

40 and 51) had 8 common species, and set B (Lower Block a zone, samples 61c and 21) and set D (Minshall, samples 39 and 34) had 7 species in common. Cross comparisons of sets A and D and sets B and C showed 8 and 6 common species. Six species were common to all four sets of samples. Because species found in different samples of the same coal bed may not differ appreciably in number and kind from those found in different coals, correlation based purely on species lists is highly conjectural.

Differences between sets of samples of Lower Block a zone coal and Minshall Coal become readily apparent, however, when relative abundances of species, expressed by average percentages, are compared. *Laevigatosporites medius* Kos., 1950, *Endosporites ornatus* Wils. and Coe, 1940, and *Endosporites pellucidus* Wils. and Coe, 1940, were found in all four sets of samples (fig. 8). The latter 2 species made up 7.3 and 5.2 percent of the Minshall spores, but in samples of the Lower Block a zone they averaged only 1.31 and 2.15 percent respectively. *Laevigatosporites medius*, on the other hand, was a prominent species (24.72 percent) in the Lower Block a sets but averaged only 3.2 percent in the Minshall sets. Some of the species found in the Minshall Coal only, such as *Lycospora pusilla* (Ibr.) S. W. and B., 1944, *Lycospora punctata* Kos., 1950, and *Triquitrites bransonii* Wils. and Hoffm., 1956, may be of diagnostic value because they represent recognizable parts of the total spore population in samples of Minshall Coal.

If a large number of specimens serves as the source for percentage derivations, and if the relative abundance and vertical range of species are determined, correlation by species may well become the most accurate and effective tool. Merely listing species, without indicating how many samples were analyzed and in what amounts the species are present in the spore assemblages, does not suffice as a basis for correlation.

## TAXONOMY

### HISTORY OF SPORE CLASSIFICATION

Miospores were defined by the author (1952, p. 10) as "all fossil spores and sporelike bodies smaller than 0.20 mm, including homospores, true microspores, small megaspores, pollen grains,



and pre-pollen." By ignoring the biological aspects the controversy of spore affinities and functions is evaded, and consequently spore analysis can be applied unimpededly to stratigraphy. The preparation of coal for spore analysis involves sizing by screening of the macerated coal. The small fraction, which contains the particles that are smaller than  $200\mu$ , is used for statistical spore analysis. The spores and sporelike bodies in this fraction are of unknown origin, and thus the term "microspore," which refers to male spores only, cannot be applied to them.

Various systems of classification of isolated spores have been used, ranging from the use of Roman numerals to the standard system of binary names. Any system, however, will have to be an arbitrary one until the affinities of isolated spores are definitely determined. Knox (1950, p. 308-309), in justifying artificial classification, said: "A natural classification of fossil spores is at present practically impossible, since few of the spores so far described have been found in organic connection with the parent plant. It is thus necessary to formulate an artificial system using the various morphological features which have been found to be of diagnostic value."

Bennie and Kidston (1886, p. 106-115), dealing with macrospores only, placed all spores under two groups, *Triletes* and *Lagenicula*. They also used these terms as generic names. Three divisions, roughly corresponding to families, were established within the group *Triletes*: Division *Laevigati* contained four types or species designated as *Triletes* I to IV; division *Apiculati* contained *Triletes* V to XIII, and division *Zonales* included *Triletes* XIV to XVIII. Two types, *Lagenicula* I and II, were assigned to the *Lagenicula* group.

Zerndt (1930a, p. 312), also working with macrospores only, used diameter as a criterion for differentiation of spores and referred to such types as Spore 0.5 mm or Spore 2.1 mm. Later (1930b, p. 43-55) he followed Bennie and Kidston's system and assigned Latinized binomials to types described for the first time. Under the group *Laevigati* of the genus *Triletes*, for example, Zerndt placed *Triletes* type I Kidston and *T. glabratus* Zerndt. Still later (1937, p. 584) Zerndt indicated subspecific forms by lettered number as well as trinomial designation. An example of this method is Type 11a. *Triletes auritus* var. *grandis*.



Ibrahim (1933, p. 17-48) placed all spores and sporelike bodies under the heading Sporites, which he divided into three groups: Triletes, Aletes, and Monoletes. Each generic name was appended by "-sporites" to indicate that a spore was meant, and thus such generic names as *Reticulati-sporites* and *Alati-sporites* were created. This system followed the universal practice of paleobotanists who use such suffixes as "-strobilus," "-phyllum," "-xylon," or "carpus" to indicate whether a fossil is a cone, leaf, wood fragment, or fructification respectively. All spores bearing a triradiate scar were assigned to the Triletes group, the oval bodies bearing a single linear dehiscence scar were assigned to Monoletes, and those without a scar were assigned to Aletes.

Raistrick (1934) employed perhaps the simplest system of classification. His seven "genera" were designated by letters A to G and the species by numbers. His spores were thus known as B3, E2, G1, etc.

Luber and Waltz (1938) prefixed Ibrahim's group terms with Azono- and Zono-; this classification resulted in the following generic names: *Azonotriletes*, *Zonotriletes*, *Azonaletes*, *Zonaletes*, and *Azonomonoletes*. Their specific names were indicative chiefly of the type of dehiscence mark.

Schopf (1938, p. 23-53) established four sections of the genus *Triletes*; namely, *Aphanozonati*, *Lagenicula*, *Auriculati*, and *Triangulati*. He also added *Cystosporites*, *Monoletes*, *Parasporites*, and *Sporites* as generic entities.

Schopf, Wilson, and Bentall (1944) revised much of the previously published taxonomic material and established a flexible binomial system of nomenclature. New genera could be added easily, and the number of species could be increased as needed.

Potonie and Kremp (1954) elaborated on previous attempts to accommodate all spores and sporelike bodies to a divisional scheme. Three "Oberabteilungen" (Sporonites, Sporites, and Pollenites) serve as major divisions. Spores and other parts of fungi are grouped under Sporonites. Sporites contains all fossil spores possessing tetrad markings and also bodies that do not show haplotypic features but resemble spores in other ways. Pollenites contains all miospores which lack tetrad scars and may or may not have a special germination apparatus. The Sporites and Pollenites are divided into three and four "Abteilungen" respectively; these in turn are subdivided into "Unterabteilungen."

"Reihen" or series form a suprageneric echelon. This system of classification is given below in skeletal form.

- I. Oberabteilung Sporonites (R. Pot.) Ibr., 1933
- II. Oberabteilung Sporites H. Pot., 1893
  - A. Abteilung Triletes (Reinsch) emend. Pot. and Kremp, 1954
    - 1. Unterabteilung Azonotriletes Lub., 1935
      - a. Reihe Laevigati (Bennie and Kidst.) emend. Pot. and Kremp, 1954
      - b. Reihe Apiculati (Bennie and Kidst.) emend. Pot. and Kremp, 1954
      - c. Reihe Murornati Pot. and Kremp, 1954
    - 2. Unterabteilung Lagenotriletes Pot. and Kremp, 1954
  - B. Abteilung Zonales (Bennie and Kidst.) emend. Pot. and Kremp, 1954
    - 1. Unterabteilung Auritotriletes Pot. and Kremp, 1954
      - a. Reihe Auriculati (Schopf) emend. Pot. and Kremp, 1954
    - 2. Unterabteilung Zonotriletes Waltz, 1935
      - a. Reihe Cingulati Pot. and Klaus, 1954
      - b. Reihe Zonati Pot. and Kremp, 1954
  - C. Abteilung Monoletes Ibr., 1933
    - 1. Unterabteilung Azonomonoletes Lub., 1935
    - 2. Unterabteilung Zonomonoletes Pot. and Kremp, 1954
  - D. Abteilung Cystites Pot. and Kremp, 1954
- III. Oberabteilung Pollenites R. Pot., 1931
  - A. Abteilung Saccites Erdtm., 1947
    - 1. Unterabteilung Polysaccites Cooks., 1947
    - 2. Unterabteilung Monosaccites Chit., 1951
    - 3. Unterabteilung Disaccites Cooks., 1947
  - B. Abteilung Napites Erdtm., 1947
    - 1. Unterabteilung Azonaletes Lub., 1935
    - 2. Unterabteilung Zonaletes Lub., 1935
  - C. Abteilung Precolpates Pot. and Kremp, 1954
  - D. Abteilung Monocolpates Ivers. and Tr.-Sm., 1950

## DESCRIPTIONS OF SPECIES

The classificatory system of Schopf, Wilson, and Bentall (1944) was followed during the analytical investigations. The miospore genera mentioned in spore assemblages and correlation patterns need to be equated with the Potonie and Kremp (1954) taxa to enable the reader to compare their distribution patterns with those of other regions. The 13 prominent genera in the coals of the Pottsville Series of Indiana can be assigned to a rather large number of genera of the Potonie and Kremp (1954) system. A group of species assignable to one genus of the classification system of Schopf, Wilson, and Bentall (1944) may be found in a number of different genera of the Potonie and Kremp (1954) classification system. Schopf, Wilson, and Bentall (1944) genera found in Indiana are equated with the Potonie and Kremp taxa in table 11. This does not imply, however, that all Potonie and Kremp (1954) genera are considered valid taxa by the author.

Although most of the spores encountered in this study were readily identified, many spores could not be classified under existing specific headings. Because some of the "unknowns" were fairly abundant and may have correlative value, their descriptions are given below. A number of miospores previously described and assigned by other authors are also discussed. Whenever use of the Potonie and Kremp classificatory system (Potonie and Kremp, 1954, 1955, 1956a) seemed advantageous, the species in question were fitted into that systematic framework.



Table 11.--*Equation of 13 prominent genera in the Pottsville coals, classified according to the Schopf, Wilson, and Bentall (1944) system, with the Potonie and Kremp (1954) taxa*

Schopf, Wilson, and Bentall, 1944	Potonie and Kremp, 1954
<i>Calamospora</i> S. W. and B., 1944	<i>Calamospora</i> S. W. and B., 1944 <i>Punctatasporites</i> Ibr., 1933 <i>Punctatisporites</i> Ibr., 1933
<i>Cirratriradites</i> Wils. and Coe, 1940	<i>Cirratriradites</i> Wils. and Coe, 1940 <i>Densosporites</i> (Berry) Pot. and Kremp, 1954 <i>Endosporites</i> Wils. and Coe, 1940 <i>Lycospora</i> S. W. and B., 1944 <i>Microsporites</i> Dijks., 1946
<i>Densosporites</i> (Berry) S. W. and B., 1944	<i>Anulatisporites</i> (Loose) Pot. and Kremp, 1954 <i>Cristatisporites</i> Pot. and Kremp, 1954 <i>Densosporites</i> (Berry) Pot. and Kremp, 1954
<i>Endosporites</i> Wils. and Coe, 1940	<i>Auroraspora</i> H. S. and M., 1955 <i>Cirratriradites</i> Wils. and Coe, 1940 <i>Endosporites</i> Wils. and Coe, 1940 <i>Florinites</i> S. W. and B., 1944 <i>Guthoerlisporites</i> Bhardw., 1954 <i>Microsporites</i> Dijks., 1946
<i>Florinites</i> S. W. and B., 1944	<i>Endosporites</i> Wils. and Coe, 1940 <i>Florinites</i> S. W. and B., 1944
<i>Granulatisporites</i> (Ibr.) S. W. and B., 1944	<i>Acanthotriletes</i> (Naum.) Pot. and Kremp, 1954 <i>Anapiculatisporites</i> Pot. and Kremp, 1954 <i>Calamospora</i> S. W. and B., 1944 <i>Converrucosisporites</i> Pot. and Kremp, 1954 <i>Cyclogranisporites</i> Pot. and Kremp, 1954 <i>Granulatisporites</i> Ibr., 1933 <i>Leiotriletes</i> (Naum.) Pot. and Kremp, 1954 <i>Lophotriletes</i> (Naum.) Pot. and Kremp, 1954 <i>Lycospora</i> S. W. and B., 1944 <i>Planisporites</i> (Knox) Pot. and Kremp, 1954 <i>Punctatisporites</i> Ibr., 1933



Table 11.--Equation of 13 prominent genera in the Pottsville coals, classified according to the Schopf, Wilson, and Bentall (1944) system, with the Potonie and Kremp (1954) taxa--Continued

Schopf, Wilson, and Bentall, 1944	Potonie and Kremp, 1954
<i>Laevigatosporites</i> (Ibr.) S. W. and B., 1944	<i>Laevigatosporites</i> Ibr., 1933 <i>Latosporites</i> Pot. and Kremp, 1954 <i>Punctatosporites</i> Ibr., 1933 <i>Speciososporites</i> Pot. and Kremp, 1954 <i>Tuberculatosporites</i> Imgr., 1952 <i>Verrucosporites</i> (Knox) Pot. and Kremp, 1954
<i>Lycospora</i> S. W. and B., 1944	<i>Lycospora</i> S. W. and B., 1944
<i>Punctatisporites</i> (Ibr.) S. W. and B., 1944	<i>Apiculatisporites</i> Ibr., 1933 <i>Camptotriletes</i> (Naum.) Pot. and Kremp, 1954 <i>Converrucosisporites</i> Pot. and Kremp, 1954 <i>Cyclogranisporites</i> Pot. and Kremp, 1954 <i>Dictyotriletes</i> (Naum.) Pot. and Kremp, 1954 <i>Leiotriletes</i> (Naum.) Pot. and Kremp, 1954 <i>Lophotriletes</i> (Naum.) Pot. and Kremp, 1954 <i>Microreticulatisporites</i> (Knox) Pot. and Kremp, 1954 <i>Planisporites</i> (Knox) Pot. and Kremp, 1954 <i>Punctatisporites</i> (Ibr.) Pot. and Kremp, 1954 <i>Pustulatisporites</i> Pot. and Kremp, 1954 <i>Verrucosisporites</i> (Ibr.) Pot. and Kremp, 1954
<i>Raistrickia</i> S. W. and B., 1944	<i>Apiculatisporites</i> Ibr., 1933 <i>Raistrickia</i> (S. W. and B.) Pot. and Kremp, 1954
<i>Reticulatisporites</i> (Ibr.) S. W. and B., 1944	<i>Dictyotriletes</i> (Naum.) Pot. and Kremp, 1954 <i>Knoxisporites</i> Pot. and Kremp, 1954 <i>Microreticulatisporites</i> (Knox) Pot. and Kremp, 1954

Table 11.--Equation of 13 prominent genera in the Pottsville coals, classified according to the Schopf, Wilson, and Bentall (1944) system, with the Potonie and Kremp (1954) taxa--Continued

Schopf, Wilson, and Bentall, 1944	Potonie and Kremp, 1954
<i>Reticulatisporites</i> (Ibr.) S. W. and B., 1944--Continued	<i>Reticulatasporites</i> (Ibr.) Pot. and Kremp, 1954 <i>Reticulatisporites</i> (Ibr.) Pot. and Kremp, 1954
<i>Schulzospora</i> Kos., 1950	<i>Schulzospora</i> Kos., 1950
<i>Triquitrites</i> Wils. and Coe, 1940	<i>Ahrensisporites</i> Pot. and Kremp, 1954 <i>Galeatisporites</i> Pot. and Kremp, 1954 <i>Granulatisporites</i> Ibr., 1933 <i>Triquitrites</i> (Wils. and Coe) Pot. and Kremp, 1954

*Cirratriadites arcuatus* sp. nov.

Text figure 9; plate 1, figures 1-4

*Description.*--Spores are radial and trilete and have a round to triangular outline. The equatorial flange or zona is from 4 to 12 $\mu$  wide. The triangular shape is usually due to a widening of the flange opposite the ray termini. The spore diameter, including the flange, measures from 24 to 42 $\mu$  and averages 32.25 $\mu$ . The holotype measures 34 $\mu$ . The spore coat is granulose or unornamented and is 0.5 $\mu$  thick. The trilete rays are usually distinct and may extend into the flange, serving as supporting ribs. Other flange supports are formed by wall thickenings which tend to anastomose and form arches. The suture of the scar is inconspicuous.

*Holotype.*--Sample 24a, slide 2513; Log Cabin Coal Co. strip pit, Upper Block a zone, Clay County, Ind.

*Discussion.*--This spore resembles Kosanke's *Cirratriadites difformis* and *C. rotatus*, but is considerably smaller than either. *C. difformis* ranges from 52 to 68 $\mu$  in size and has a smaller number of flange ribs than *C. arcuatus* sp. nov. *C. rotatus* has a known

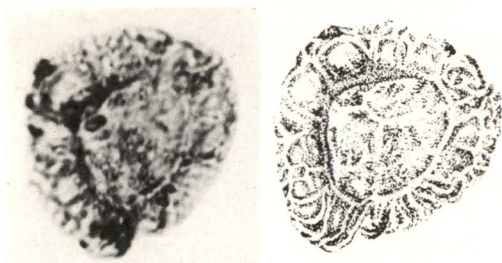


Figure 9.--*Cirratriradites arcuatus* sp. nov.  
photomicrograph and drawing of holotype.

size range of 46 to 58 $\mu$  and features a "coarsely punctate to reticulate" spore coat (Kosanke, 1950, p. 36), whereas *C. arcuatus* is either unornamented or finely granulose. Butterworth and Williams (1954, p. 759) thought that *C. rotatus* and *C. tenuis* (Loose) S. W. and B., 1944, are conspecific, whereas Potonie and Kremp (1956a, p. 125, 126) listed both of Kosanke's species under *Cirratriradites* but assigned *C. tenuis* to *Densosporites* (Potonie and Kremp, 1956a, p. 120). Although the equatorial band of *C. tenuis* may have a thickened, serrated inner layer, its width and membranous nature fit the definition of flange or zona (Potonie and Kremp, 1955, p. 15) rather than cingulum, and therefore these species should remain under *Cirratriradites*.

*Occurrence.*--This spore is very common in the Indiana Block coals and is most abundant in the Upper Block a zone, where it makes up 20 to 40 percent of the total spore count.

*Cirratriradites foveatus* sp. nov.

Text figure 10; plate 1, figures 5 and 6

*Description.*--Spores are radial and trilete and have a round to triangular outline. The equatorial flange or zona is from 7 to 12 $\mu$  wide. The diameter, including flange, measures from 48 to 68 $\mu$ . The holotype measures 56 $\mu$ . The surface of the spore body is unornamented or granulose. The trilete rays extend to the periphery of the body, and their ridges may continue into the flange as supporting ribs. Radial, anastomosing striations may further ornament the flange. The sutures are indistinct. A single pit or



fovea on the distal surface is an important feature of this spore.

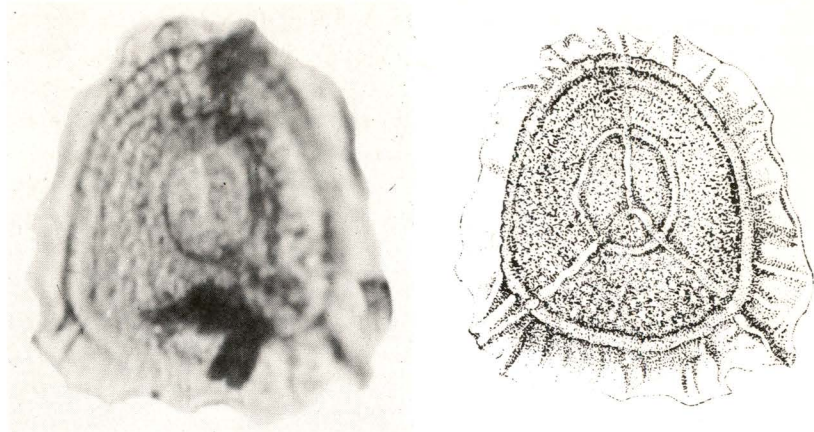


Figure 10.--*Cirratiradites foveatus* sp. nov.; photomicrograph and drawing of holotype.

*Holotype*.--Sample 63, slide 2827; Kelsey slope mine, Upper Block b zone, Daviess County, Ind.

*Discussion*.--The fovea is not unique; it has been pictured in other species of *Cirratiradites* by several authors. It is believed to be a thin area on the distal side, but it may be a depression or actual opening in the spore coat. Potonie and Kremp (1956a, p. 127), in discussing another species, stated that the foveae are formed by a weakening of the exoexine. The fovea in *C. foveatus* seems to be rimmed by a thicker, darker band.

*Occurrence*.--*C. foveatus* sp. nov. is found in the Block coals only. In the Upper Block b zone it makes up more than 3 percent of the spore total.

*Cirratiradites saturni* (Ibr.) S. W. and B., 1944

Plate 1, figure 7

Ibrahim (Potonie, Ibrahim, and Loose, 1932, p. 448) described this species under the generic heading of *Sporonites*. A year later he (Ibrahim, 1933, p. 30) changed the generic name to *Zonalesporites*, made *Z. saturni* synonymous with *Sporonites formosus*, which he had figured and described in 1932 (Potonie, Ibrahim, and



Loose, 1932, p. 447, pl. 14, fig. 10), and emended the description of *Z. saturni* somewhat. He extended the size range to 66u and 108u and described the equatorial zona as being radially folded, having an irregular margin, and being 8 to 12u wide. He described the body reticulations as indistinct and small, 1 to 2u, and stated that the trilete rays are distinct and lined by lamellae which reach the periphery. He further mentioned one to three rings, which are centrally located and measure 10 to 15u. Knox (1950, p. 330) described this feature as a "characteristic central ring around the points of intersection of the rays." Schopf, Wilson, and Bentall (1944, p. 44), with reference to *C. maculatus*, corrected the misconception that the foveal rings are apical; the present author is convinced that the foveae observed on specimens of *Cirratiradites* are distally located.

Potonie and Kremp (1956a, p. 128) placed *Cirratiradites maculatus* Wils. and Coe, 1940, in synonymy with *C. saturni* and designated the latter as genotype. Schopf, Wilson, and Bentall (1944, p. 43) had typified the genus with *C. maculatus*. One discrepancy between the descriptions of *C. saturni* and *C. maculatus* is evident. Ibrahim (1933, p. 30) mentioned a reticulate ornamentation, whereas Wilson and Coe (1940) failed to describe the body surface and gave no indication of a reticulum with their drawing (Wilson and Coe, 1940, pl. 1, fig. 7).

*Occurrence.*--Only a few specimens, whose body surfaces are faintly reticulate, have been found in coals in the upper part of the Brazil Formation.

### *Lycospora pseudoannulata* Kos., 1950

#### Plate 1, figures 14 and 15

Kosanke (1950, p. 45) described the cingulum of this species as a "greatly expanded equatorial ridge appearing to resemble a flange." Hoffmeister, Staplin, and Malloy (1955, p. 383) interpreted the cingulum as a distinct flange and transferred the species to *Cirratiradites* Wils. and Coe, 1940, but Potonie and Kremp (1956a, p. 103) retained it as a member of *Lycospora* (S. W. and B.) Pot. and Kremp, 1954.

*Occurrence.*--This species is encountered throughout the coals in the Pottsville Series and seems to be most abundant in the Lower Block b zone, where it makes up as much as 4.5 percent of the total spore count.

*Lycospora punctata* Kos., 1950

Plate 1, figures 8 and 9

Kosanke (1950, p. 45) described the cingulum as a "slightly expanded equatorial ridge" and stated that this species is similar to *L. pseudoannulata* and is differentiable only on the basis of body ornamentation. Hoffmeister, Staplin, and Malloy (1955, p. 382) placed this species in *Cirratiradites* Wils. and Coe, 1940, as did Wilson and Hoffmeister (1956, p. 15). Potonie and Kremp (1956a, p. 103), on the other hand, kept the species in *Lycospora* but pointed out similarities with *L. pseudoannulata* and *L. pelucida* (Wicher) S. W. and B., 1944. *L. submarginata* (Waltz) Pot. and Kremp, 1956, and *L. loganii* Wils., 1952, also have flangelike cingula and may be synonymous with *L. punctata* Kos., 1950. Waltz (Luber and Waltz, 1938, figs. 33 and 105; pl. A, fig. 12, and pl. B, fig. 31) pictured flanged spores allegedly conspecific with *L. pusilla* (Ibr.) S. W. and B., 1944, which Potonie and Kremp (1956a, p. 101), however, removed from synonymy. Waltz' pictures closely resemble *Lycospora punctata* Kos., 1950.

*Occurrence.*--*Lycospora punctata* Kos., 1950, is found in every coal of the Pottsville Series, attaining its maximum abundance in the Lower Block b and c zones, but showing another abundance peak in the coal sequence from the Upper Block c zone to Coal II.

*Lycospora parva* Kos., 1950

Plate 1, figure 10

Potonie and Kremp (1956, p. 103, 104) stated that *Lycospora pusilla* (Ibr.) S. W. and B., 1944, has the narrowest cingulum of any species listed. Kosanke (1950, p. 44, 45) pointed out the similarity between *L. parva* and *L. pusilla* but mentioned that the former has a narrower flange. The original sketch of Ibrahim

(Potonie, Ibrahim, and Loose, 1932, pl. 15, fig. 20) shows a thick cingulum, but Potonie and Kremp (1956a, pl. 17, fig. 351) show a photograph of Ibrahim's holotype which definitely indicates that the cingulum is narrow. These authors (1956a, p. 103) delimited the size of *L. pusilla* as follows: "Groesse etwa 30(25) - 40 $\mu$ ." Thus the smaller specimens of *L. pusilla* certainly fit the size range of *L. parva*, which Kosanke gave as 25.1 to 32.5 $\mu$ . Until conspecificity is proved by actual comparison of type material, the writer is forced to separate the two species on size alone. Those specimens that measured between 25 and 32 $\mu$  were assigned to *L. parva* and those that fit the 33 to 42 $\mu$  size range were recorded as *L. pusilla*.

*Occurrence.*--Based on the above size separation, *L. parva* Kos., 1950, occurs abundantly throughout the coals of Pottsville age in Indiana.

### *Lycospora pusilla* (Ibr.) S. W. and B., 1944

Plate 1, figures 11 and 12

Potonie and Kremp (1956a, p. 104) listed Upper Westphalian B and Lower Westphalian C as the stratigraphic zones containing *L. pusilla*. These European zones, according to Moore and others (1944), are roughly equivalent to the Tradewater and Carbondale Formations of southern Illinois. *Lycospora pusilla* (33 to 42 $\mu$ ) was recorded in all coals of the Pottsville Series. This extends the distribution record downward to include the Caseyville formation of southern Illinois, which was collated by Moore and others (1944) with Westphalian A and Namurian C.

The distribution discrepancy is even greater for *Lycospora parva*, which Kosanke (1950) restricted to coals of the lower McLeansboro in Illinois. In Indiana, *Lycospora parva*, as defined above, is found in all coals of the Pottsville Series. The writer is reluctant to establish a new species solely on the basis of stratigraphic distribution and, thus forced to rely strictly on morphographic features, is unable to differentiate the Indiana specimens from *L. pusilla* and *L. parva*.

*Occurrence.*--Spores fitting the general description of *L. pusilla* and measuring from 33 to 42 $\mu$  in diameter have been recorded in all coals of the Pottsville Series. Peaks in abundance have been



recorded in the Lower Block b zone and in Coal II.

*Lycospora granulata* Kos., 1950

Plate 1, figure 13

This distinctly granulose form may be conspecific with *Lycospora subtriquetra* (Lub.) Pot. and Kremp, 1956, *Lycospora brevipiculata* (Lub.) Pot. and Kremp, 1956, and *Lycospora torquifer* (Loose) Pot. and Kremp, 1956. Except for its smaller size, *Lycospora rugosa* Schem., 1951, is like *L. granulata* Kos., 1950, and may be merely a smaller form of the latter species.

*Occurrence.*--Although this species has been recorded in all coals of Pottsville age, it never has been a major constituent. It is fairly abundant in the Lower Block a samples and also in the Minshall Coal and Coal II.

*Endosporites parvus* sp. nov.

Text figure 11; plate 1, figures 16 and 17

*Description.*--The spores are radially symmetrical and trilete and vary in shape from triangular to round to oval. The saccus is granulose to finely reticulate on the inside and tends to fold. The spore body is unornamented and measures from 20 to 25 $\mu$  in diameter. The inconspicuous trilete rays extend to the periphery of the spore body. The holotype measures 38 $\mu$ , the body occupying 22 $\mu$  of this overall measurement. The size range of the species is 30 to 45 $\mu$ , and the average size is 38 $\mu$ .

*Holotype.*--Sample 47, slide 1105; Michael strip mine, Lower Block b zone, Greene County, Ind.

*Discussion.*--The smallest *Endosporites* species previously described is *E. minutus* H. S. and M., 1955, which ranges from 40 to 45 $\mu$ , but which has a proportionally larger central body than *E. parvus* sp. nov. Another small species, *E. pellucidus* Wils. and Coe, 1940, has a relatively small spore body, but is larger in overall size than *E. parvus* and has short trilete rays.

*Occurrence.*--This species is found in every coal seam of



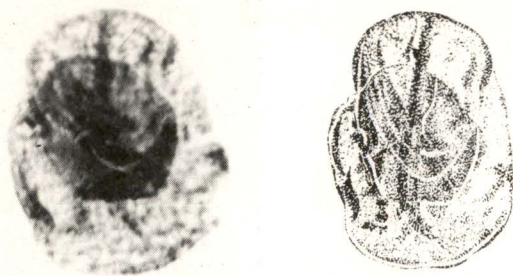


Figure 11.--*Endosporites parvus* sp. nov.;  
photomicrograph and drawing of holotype.

the Pottsville Series except Coal II, but never in abundance. It is most conspicuous in the Upper Block b and c zones and the Minshall Coal.

*Endosporites circularis* sp. nov.

Text figure 12; plate 1, figures 18 and 19

*Description.*--Spores are radial and trilete and are circular to subtriangular in outline. The saccus is finely reticulate on the interior and extends from 4 to 10u beyond the spore body. The tightly fitting saccus seems to be restricted to the equator. If the saccus actually encloses the entire distal part of the spore body, it fits the convex distal area tightly and forms a second distal ring of attachment. Two concentric rings are thus visible. The spore body is unornamented or finely granulose and measures from 32 to 38u in diameter. The overall size range is 36 to 46u, and the average is 40u. The holotype measures 40u. The trilete rays are conspicuous and reach the body periphery. The sutures are lined by lamellae which are 4 to 8u high.

*Holotype.*--Sample 39, slide 952; Commodore strip mine, Minshall Coal, Owen County, Ind.

*Discussion.*--The question whether this form should be placed under *Endosporites* Wils. and Coe, 1940, or should become a third species of *Wilsonia* Kos., 1950, confronted the author. Kosanke

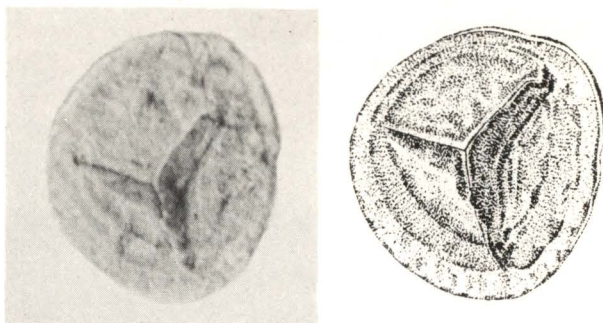


Figure 12.--*Endosporites circularis* sp. nov.;  
photomicrograph and drawing of holotype.

(1950, p. 54) said that "*Wilsonia* is related to *Endosporites* differing in that the body is indistinct" owing to almost complete envelopment of the spore proper by the saccus. Potonie and Kremp (1954, p. 173) contended that this feature is of insufficient magnitude to justify *Wilsonia* as a separate generic entity. The same authors claimed that this allegedly peculiar saccus attachment is also found among forms of *Endosporites*. In view of the contested status of *Wilsonia* and the fact that the Indiana specimens in question are much smaller (36 to 46 $\mu$  compared with 69 to 98 $\mu$  for *Wilsonia*), this species is assigned to *Endosporites* Wils. and Coe, 1940.

*Occurrence.*--This rather striking species has been recorded in samples from the Upper Block b zone through Coal II, but only scattered specimens have been found.

#### *Endosporites pellucidus* Wils. and Coe, 1940

#### Plate 1, figure 20

Potonie and Kremp (1956a, p. 163) hinted at synonymy with *E. rotundus* (Ibr.) S. W. and B., 1944. The overall size of *E. pellucidus* has been given as 47 to 57 $\mu$ ; this is considerably smaller than *E. rotundus* and warrants keeping the two species separated until and unless intermediate sizes are reported.

*Occurrence.*--This species is common in all coals of the

Pottsville Series; it gains a prominent position in the spore assemblage of the Upper Block a zone and retains its through Coal II. Although it is present in samples from the Mansfield Formation, the species is an insignificant constituent of these lower coals.

*Endosporites ornatus* Wils. and Coe, 1940

Plate 2, figure 1

Potonie and Kremp (1956a, p. 163) implied that *E. ornatus* and *E. formosus* Kos., 1950, are practically indistinguishable and that the former species is separable from *E. globiformis* (Ibr.) S. W. and B., 1944, by having a smaller saccus and from *E. zonalis* (Loose) Knox, 1950, by having a larger saccus. *Endosporites globiformis* was listed by Ibrahim (Potonie, Ibrahim, and Loose, 1932, p. 448) as ranging from 131 to 146 $\mu$  in size and was shown to have a definite reticulum marking the inside of the saccus wall. Potonie and Kremp's (1956a, pl. 20, fig. 459) photo of Ibrahim's type specimen also shows this reticulum. Wilson and Coe (1940, p. 184) stated that the size of *E. ornatus* ranges from 91 to 113 $\mu$  and that the "outer wall" (obviously the saccus wall) is granulose. The differences in size and saccus ornamentation seem to be more valid criteria for differentiating the two species than the variable relationship of saccus extension to body radius employed by Potonie and Kremp. The authors (Potonie and Kremp, 1956a, p. 162) also expressed the opinion that two other large species, *E. angulatus* Wils. and Coe, 1940, and *E. vesicatus* Kos., 1950, may be synonymous with *E. globiformis*. *E. vesicatus*, however, has apical papillae as Kosanke's picture (Kosanke, 1950, pl. 7, fig. 8) clearly shows.

*Occurrence.*--*Endosporites ornatus* is found in all coals in the Pottsville Series and is most abundant in the Minshall Coal.

*Endosporites formosus* Kos., 1950

Plate 2, figure 2

As mentioned above, Potonie and Kremp felt that *E. ornatus*



may be conspecific with *E. formosus*. The saccus ornamentation of *E. formosus* was described as coarsely punctate to finely reticulate by Kosanke (1950, p. 37), whereas *E. ornatus*, according to Wilson and Coe (1940, p. 184), has a granulose saccus. According to Potonie and Kremp (1956a, p. 161), *E. formosus* has a strongly developed limbus supporting the saccus.

*Occurrence.*--*E. formosus* is represented in all coals in the Pottsville Series. The species is most abundant in the Minshall Coal.

### *Endosporites rotundus* (Ibr.) S. W. and B., 1944

Plate 2, figure 3

Potonie and Kremp (1956a, p. 163) hinted at synonymy with *E. pellucidus* Wils. and Coe, 1940, and figured and described a form under *E. cf. rotundus* which has a rather tight saccus and is only 52 $\mu$  in diameter as compared with the 63 to 87 $\mu$  range listed for the species by Ibrahim (1933, p. 31). *E. rotundus* (Ibr.) S. W. and B., 1944, also has a wider saccus than *E. cf. rotundus*. The overall size of *E. pellucidus* has been given as 47 to 57 $\mu$ ; this is considerably smaller than *E. rotundus*.

*Occurrence.*--Saccate spores identified as *E. rotundus* are sparsely distributed in the Mansfield Formation. This spore species is common in the Block coals, and it is a conspicuous member of the spore assemblages in the Minshall Coal.

### *Endosporites breviradiatus* sp. nov.

Text figure 13; plate 2, figure 4

*Description.*--Spores are radially symmetrical and trilete and are round, oval, or triangular in outline. The spore body, which shows the same variations in shape, is unornamented to finely granulose. The body measures from 30 to 60 $\mu$  in diameter, and the overall measurements range from 55 to 85 $\mu$ . The trilete rays are well developed and have raised lips, but they are short; they are one-half to two thirds the length of the body radius. The

saccus is infrareticulate and tends to fold. The body is large in relation to the saccus; that is, the body radius is greater than the saccus extension. The holotype measures 70u in overall diameter, and the spore body has a diameter of 45u.

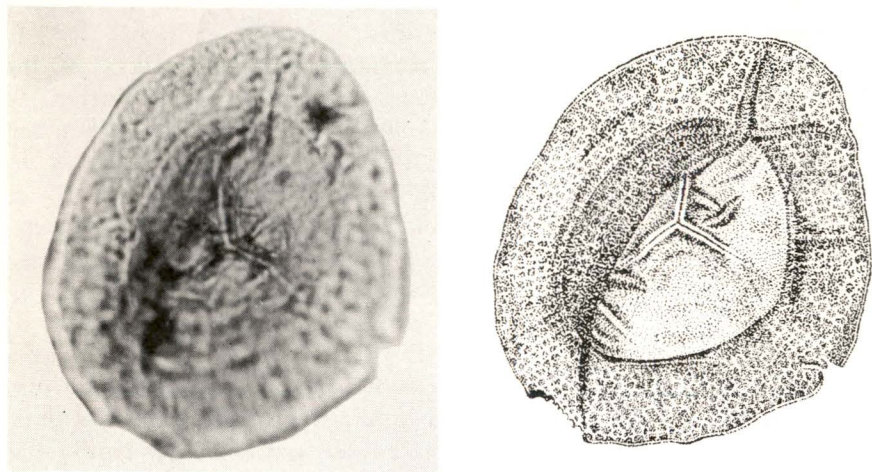


Figure 13.--*Endosporites breviradiatus* sp. nov.;  
photomicrograph and drawing of holotype.

*Holotype*.--Sample 39, slide 952; Commodore strip mine, Minshall Coal, Owen County, Ind.

*Discussion*.--Ibrahim (1933, p. 31) designated measurements that range from 63 to 87u for *E. rotundus*. Many of the saccate spores found in Indiana fit this size range and the other characteristics listed by Ibrahim, such as a punctate surface and the triradiate scar extending to the periphery of the spore body. However, a number of *Endosporites* specimens found in this study that fall into the 60 to 80u size range fail to fit the other characteristics. The relatively small saccus, its distinct reticulum, and the short trilete rays are features that prevent assignment of this spore type to *E. rotundus*.

*Occurrence*.--*E. breviradiatus* sp. nov. parallels *E. rotundus* in distribution. It is found in all coals of the Pottsville Series, but it is rare in the Mansfield Formation. It is never a major constituent.

*Guthoerlisporites magnificus* Bhardw., 1954

## Plate 2, figure 5

This form had been recorded by the author as an unassigned species of *Endosporites* until Bhardwaj (1954, p. 518, 519) established the new genus *Guthoerlisporites*. Whether folding of the body wall, which apparently is the one distinguishing feature of this genus, is a characteristic of sufficient magnitude to warrant the establishment of a new genus is questionable. The claim by Bhardwaj (1954, p. 519) that spores of this genus have shorter tecta than *Endosporites* and lack a limbus seems to be rather nebulous. The present writer doubts whether *Endosporites* has a uniform, separate structure which rims the saccus, but he interprets the "limbus" as a continuous peripheral fold formed by the compression of the saccus. The tecta (rays) of *Endosporites* vary considerably and do not always extend to the bladder so that this alleged feature loses validity. Whether this particular type of spore is assigned to *Endosporites* as just another species or is considered as the type for a distinct genus is a matter of individual preference. The fact remains that specimens which fit the description and figures of Bhardwaj's *Guthoerlisporites magnificus* have been encountered in Indiana.

*Occurrence.*--This spore is found only in the Minshall Coal.

*Florinites antiquus* S. W. and B., 1944

## Plate 2, figure 6

In the original species definition (Schopf, Wilson, and Bentall, p. 58) the size of this pollen grain is given as 55 to 90 by 40 to 75 $\mu$ . Although the drawing of the holotype (Schopf, Wilson, and Bentall, 1944, p. 59) shows a rather coarse infrareticulum, the size range of the lacunae was defined as 1 to 3 $\mu$ ; this range fits that of the specimens pictured in this report as well as others recorded as *F. antiquus* from coals in the Pottsville Series.

*Occurrence.*--*F. antiquus* has not been encountered in the Mansfield samples, and only a few grains have been found in one sample of the Lower Block a zone. The Lower Block b and c zones and Upper Block a zone do not contain this species. Minor



quantities have been recorded in the Upper Block b and c zones, however, and in the Minshall Coal and Coal II.

*Leiotriletes parvus* sp. nov.

Text figure 14; plate 2, figures 7 and 8

*Description.*--Spores are radial and trilete and are triangular in outline. The interradial margins are concave or nearly straight, and the corners are rounded. The spore diameter ranges from 16 to 28 $\mu$  and averages 20 $\mu$ . The trilete scar is distinct and extends more than halfway to the margin. Lips are present. The spore coat is unornamented and is thin. The holotype measures 22 $\mu$ .

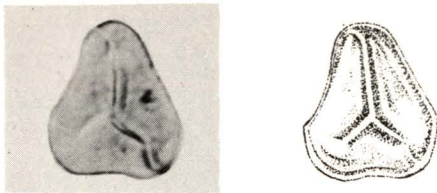


Figure 14.--*Leiotriletes parvus* sp. nov.; photomicrograph and drawing of holotype.

*Holotype.*--Sample 45, slide 851; outcrop, Upper Block b zone, Owen County, Ind.

*Discussion.*--In splitting up the unwieldy genus *Granulatisporites* Ibr., 1933, Potonie and Kremp (1954, p. 120) emended the genus *Leiotriletes* Naum., 1937, to encompass all smooth-coated triangular miospores. Of the concave forms assignable to this genus, only *L. priddyi* (Berry) Pot. and Kremp, 1955, and *L. adnatus* (Kos.) Pot. and Kremp, 1955, come close to the diminutiveness of *L. parvus* sp. nov. *L. adnatus*, in addition to being larger (32 to 39 $\mu$ ), has a rather thick spore coat and granulose contact areas. The description of *L. priddyi* compares favorably with that identifying *L. parvus* sp. nov., but its size was given as "up to 35 $\mu$ " by Berry (1937, p. 156). Because two distinct size groups seem to exist, the writer feels compelled to erect a new species for the smaller, previously unclassified group.

*Occurrence.*--This small levigate spore is found in all coals of the Pottsville Series, but it is never a major constituent.

*Leiotriletes priddyi* (Berry) Pot. and Kremp, 1955

Plate 2, figure 9

The line drawings of Berry (1937, fig. 2) are inadequate, but his description is sufficiently detailed to be quite useful. As implied above, this species may merely represent the larger specimens of one morphologic spore entity.

*Occurrence.*--This species attains a degree of abundance only in the coals of the Mansfield Formation.

*Leiotriletes inflatus* (Schem.) Pot. and Kremp, 1955

Plate 3, figures 1 and 2

The separation of triangular spores on the basis of concavity or convexity of their sides seems to be rather tenuous. Frequently such a spore has one or two sides expanded (convex) and the third side straight or even concave. Partial dessication and shrinkage may well change a convex, bloated form to a concave one, and it is feasible for a concave form to become inflated. The plane of compression also may affect the shaping of the interradian areas and consequently the outline. Some of the forms are obviously structurally concave, convex, or straight sided, especially those having thick, rigid spore coats, such as *L. crassus* (Knox) Pot. and Kremp, 1955, *L. sphaerotriangulatus* (Loose) Pot. and Kremp, 1954, *L. adnatus* (Kos.) Pot. and Kremp, 1955, *L. pellucidus* (Kos.) Pot. and Kremp, 1955, and *L. concavus* (Kos.) Pot. and Kremp, 1955. *L. inflatus* has convex sides and *L. priddyi* concave sides by definition, but the two species may be spores from the same plant, although they cannot be conspecific as long as they are treated as disassociated organ species. *L. inflatus*, treated as an arbitrarily defined spore entity, may be conspecific with the organ species *L. minutus* (Knox) Pot. and Kremp, 1955, and *L. adnatoides* Pot. and Kremp, 1955.

*Occurrence.*--*Leiotriletes inflatus* is found in all coals of

Pottsville age, but not abundantly. It is most prevalent in the Upper Block b and c zones and the Minshall Coal.

*Granulatisporites verrucosus* (Wils. and Coe) S. W. and B., 1944

Plate 3, figure 3

Although the photo shown here is seemingly not identical with the drawing of Wilson and Coe (1940, pl. 1, fig. 10), Wilson and Hoffmeister (1956, pl. 2, fig. 4) showed a photograph of *G. verrucosus* which is identical with the photomicrograph pictured in this report. Wilson, as one of the authors of the species, certainly is a competent judge, and the photomicrograph published by him and Hoffmeister may well be considered as a plesiotype.

*Occurrence.*--Scattered specimens of this species are found throughout the Pottsville, but only in the coal sequence from the Upper Block a zone through the Minshall Coal is the species found with any consistency.

*Granulatisporites deltiformis* (Wils. and Coe) S. W. and B., 1944

Plate 3, figures 4 and 5

Wilson and Coe (1940, p. 185) assigned this species to the genus *Triquitrites*. Schopf, Wilson, and Bentall (1944, p. 32), obviously with Wilson's consent, decided that the species belonged to *Granulatisporites*. Unfortunately they also felt the same way about Ibrahim's *Laevigatisporites deltoides*, and thus two species, quite distinct morphologically but with the same specific epithet, were classified as *Granulatisporites*. *Deltoides* was retained as the epithet of Ibrahim's species, but the epithet of Wilson and Coe's species was altered to *deltiformis*. Knox (1950, p. 315) retained the latter epithet but placed the species under *Planisporites*. Potonie and Kremp (1956a, p. 87) listed the species as *deltiformis* but returned it to *Triquitrites*. Wilson and Hoffmeister (1956, p. 17) kept the species under *Granulatisporites*. Ibrahim initially called his *Laevigatisporites deltoides* *Sporonites deltoides* (Potonie, Ibrahim, and Loose, 1932, p. 448);



the specific epithet *deltooides* was retained by other authors, but they assigned this species to different genera. After Schopf, Wilson, and Bentall (1944, p. 32, 33) had assigned it to *Granulatisporites* and Knox (1950, p. 315) had assigned it to *Planisporites*, Potonie and Kremp (1956a, p. 88, 89) determined that Ibrahim's original type is actually an auriculate form and thus belongs to *Triquitrites*. In view of all this confusion, which the present author feels has finally resolved itself, it seems wise to retain the specific epithet *deltiformis* for the small (26 to 30u) species of Wilson and Coe, although this species belongs to the genus *Granulatisporites*. Ibrahim's *deltooides*, large (65.5 x 77u) and definitely with cushioned corners, seems to be permanently assigned to the genus *Triquitrites*.

Wilson and Coe's (1940, p. 184) original description of *Triquitrites* included the statement: "Wide margin or equatorial flange may be present at angles." This obviously refers to auriculae, valvae, or cushions, that is, thickenings of the coat opposite the ray termini. In diagnosing the species *deltiformis*, these two authors said that it lacks the "equatorial flange," that is, auriculae. The fact that Wilson and Coe (1940, p. 185) spoke of an "exine without ornamentation" may be an oversight or misinterpretation. No spore coat is entirely smooth. Perhaps a finely granulose exine was considered as part of the inherent structural makeup and not as "ornamentation." *G. deltiformis* (Wils. and Coe) apparently was misinterpreted, or Wilson and Hoffmeister (1956, pl. 2, fig. 3) would not have pictured under that name a specimen which is definitely granulose.

*Occurrence.*--*Granulatisporites deltiformis* (Wils. and Coe) S. W. and B., 1944, is found throughout the Pottsville coals, but it is never found as a major assemblage constituent. It is encountered most frequently in the Upper Block b zone.

### *Granulatisporites pallidus* Kos., 1950

#### Plate 3, figure 6

Potonie and Kremp (1955, p. 59) made *Granulatisporites pallidus* synonymous with *Granulatisporites parvus* (Ibr.) S. W. and B., 1944. The descriptions given by these authors are strikingly similar, but the photographs shown by Potonie and Kremp (1955,

pl. 12, figs. 161-171) tend to give a different concept of the appearance of the species than does Kosanke's photo (Kosanke, 1950, pl. 3, fig. 3). The broadly rounded corners and slightly concave sides mentioned by Kosanke as definite features of this miospore seem to be lacking in the specimens photographed by Potonie and Kremp. Open triradiate scars are prevalent features of the latter series of photos and may further serve to distinguish the two spore types.

*Occurrence.*--The species is found in every coal of the Pottsville Series, but it attains numerical prominence only in the Upper Block a and b zones.

*Converrucosisporites sulcatus* (Wils. and Kos.)  
Pot. and Kremp, 1955

Plate 3, figure 7

Potonie and Kremp (1954) segregated a number of verrucose, corrugated, and vaguely reticulate miospores into three genera: *Verrucosisporites*, *Converrucosisporites*, and *Camptotriletes*. Under the Schopf, Wilson, and Bentall (1944) system these roughly ornamented types were grouped with *Punctatisporites* and *Granulatisporites*. To extract these rather distinctively ornamented spores from these two genera was a recognized necessity, but whether the new grouping solves the problem is debatable. Differentiation of verrucose, vaguely reticulate, and corrugated ornamentation is difficult and highly conjectural. The separation of *Verrucosisporites* from *Converrucosisporites* on the basis of spore shape (outline) is also tenuous. A small verrucose-reticulate spore closely resembling the photomicrograph published by Wilson and Hoffmeister (1956, pl. 1, fig. 11) is common in the coals of the Pottsville Series of Indiana and needed to be identified. However, the photograph accompanying the original description of *Punctatisporites sulcatus* (Wilson and Kosanke, 1944, fig. 4) fails to indicate clearly whether the spore coat is verrucose or reticulate; on the other hand, the Wilson and Hoffmeister photograph (Wilson and Hoffmeister, 1956, pl. 1, fig. 11) shows essentially a reticulate pattern, which tends to be verrucose near the periphery. This spore, triangular in outline and verrucose-

reticulate in ornamentation, should be removed from the genus *Punctatisporites*; for expediency's sake it is classified as *Converrucosisporites*, the genus to which Potonie and Kremp (1955, p. 64) assigned this species.

*Occurrence.*--*Converrucosisporites sulcatus* (Wils. and Kos.) Pot. and Kremp, 1955, is found throughout the Pottsville and occurs in greatest quantity from the Upper Block c zone upward.

### *Apiculatisporites pineatus* H. S. and M., 1955

#### Plate 3, figure 8

Potonie and Kremp (1955, p. 76) distinguished *Apiculatisporites* (Ibr.) Pot. and Kremp, 1954, from *Lophotriletes* on the basis of a more rounded shape. Hoffmeister, Staplin, and Malloy (1955, p. 381) described a species, *Apiculatisporites pineatus*, which also has been found in the Pottsville coals of Indiana. The generic definition and the drawing typifying the genus *Cristatisporites* (Potonie and Kremp, 1954, p. 142, and pl. 7, fig. 26) fit the species discussed here rather well; in fact, they resemble this species much more than they do species assigned to the genus by Potonie and Kremp (1955, p. 105, 106). Perhaps the drawing of *Cristatisporites* is not truly representative; if it were, the genus should be assigned to the series Apiculati rather than Murornati.

*Occurrence.*--Only a few specimens of this species are found in Pottsville coals.

### *Lophotriletes gibbosus* (Ibr.) Pot. and Kremp, 1954

#### Plate 3, figure 9

This species also has been assigned to several different genera. Ibrahim (1933, p. 25) called it *Verrucosi-sporites gibbosus*; Lubert (Lubert and Waltz, 1938, p. 7, fig. 91) figured the species under *Azonotriletes*; Schopf, Wilson, and Bentall (1944, p. 33) placed it in *Granulatisporites*; and Knox (1950, p. 317), in splitting *Granulatisporites*, assigned the species to *Verrucoso-sporites*. Potonie and Kremp (1954, p. 129) established the species as



genotype of *Lophotriletes* (Naum.) Pot. and Kremp, 1954. The size and distribution of the conidia are similar in *L. gibbosus* and *L. microsaetosus*. Only overall size seems to separate the two species. Potonie and Kremp (1955, p. 74) gave 40 to 50 $\mu$  as the size range for *L. gibbosus* and 25 to 40 $\mu$  for *L. microsaetosus*. Although the present author failed to find any of the larger specimens (40 to 50 $\mu$ ), he did find two distinct size groups, one ranging from 20 to 30 $\mu$  and the other from 30 to 40 $\mu$ ; thus he assigned the larger specimens pictured to *L. gibbosus* instead of both groups to *L. microsaetosus*.

*Occurrence.*--*L. gibbosus* is only sparsely represented in the coals from Lower Block c through the Minshall.

*Lophotriletes microsaetosus* (Loose) Pot. and Kremp, 1955

Plate 3, figure 10

The nomenclatorial history of this species is also diverse. Loose (Potonie, Ibrahim, and Loose, 1932, p. 450) described this spore under the name *Sporonites microsaetosus*, and Ibrahim (1933, p. 26) placed it in his newly created genus *Setosi-sporites*. Schopf, Wilson, and Bentall (1944, p. 33) shifted it to *Granulatisporites*, and Knox (1950, p. 314) transferred it to her newly established genus *Spinoso-sporites*, only to have it assigned to *Lophotriletes* by Potonie and Kremp (1955, p. 74).

*Occurrence.*--*Lophotriletes microsaetosus* (Loose) Pot. and Kremp, 1955, is sparsely represented in the lower coals; it becomes more common in the Upper Block b zone and is most abundant in the Upper Block c zone. It is fairly abundant through the Minshall Coal and Coal II.

*Pustulatisporites crenatus* sp. nov.

Text figure 15; plate 3, figure 11

*Description.*--Spores are radial and trilete and have round to subtriangular outlines. The diametric measurement ranges from 35 to 52 $\mu$ . The holotype measures 46 $\mu$ . The spore coat is from 1 to 2 $\mu$  thick and smooth in the nonpustulate areas. Small teeth,

pointed to truncated and measuring 1 to  $3u$  at their bases and from 1 to  $4u$  in height, are scattered over most of the proximal surface and all of the distal area. The teeth tend to be reduced in size in the proximity of the trilete rays. The rays are from 12 to  $18u$  long and are lined by lips.

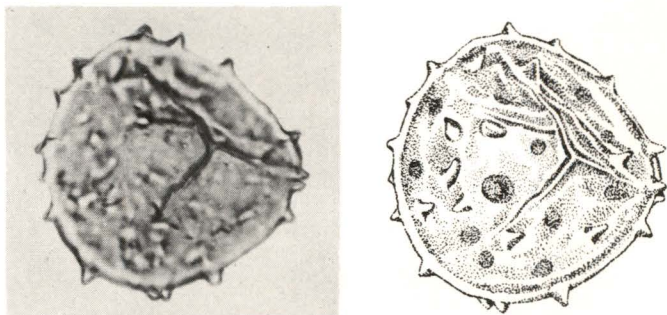


Figure 15.--*Pustulatisporites crenatus* sp. nov.;  
photomicrograph and drawing of holotype.

*Holotype*.--Sample 31, slide 967; outcrop, Coal II, Clay County, Ind.

*Discussion*.--*P. pustulatus* Pot. and Kremp, 1954, has the characteristically scattered coni, but it is much larger than *P. crenatus*, and its coni are less conspicuous. Some of the *Apiculatisporites* species also resemble *P. crenatus*, but most of them are larger and have the apiculae or coni more closely spaced.

*Occurrence*.--This spore type is found in small quantities only in the Upper Block b and c zones and in the Minshall Coal.

#### *Microreticulatisporites nobilis* (Wicher) Knox, 1950

Plate 3, figure 12

Three species which were redescribed by Potonie and Kremp (1955, p. 99-101) are morphologically similar and may be size stages of one species. *M. lacunosus* (Ibr.) Knox, 1950, ranges from 50 to  $70u$ ; *M. fistulosus* (Ibr.) Knox, 1950, from 40 to  $50u$ ; and *M. nobilis* (Wicher) Knox, 1950, from 30 to  $45u$ , according to

Potonie and Kremp (1955, p. 99-101). The reticulations measure from 1 to 3 $\mu$  in *M. nobilis* and 2 $\mu$  in the other two species. Potonie and Kremp (1955, p. 99-101), in counting the minute arcs formed by the muri on the spore margin, listed 70 arcs for *M. lacunosus*, 45 for *M. fistulosus*, and 50 for *M. nobilis*.

Wicher's definition (Wicher, 1934, p. 186) sets this species off from the other two discussed above by a relatively coarse reticulum and rather thick muri.

*Occurrence.*--This relatively small species is found sparsely represented in the coals of the Mansfield Formation and in the Lower Block c and Upper Block c zones.

*Microreticulatisporites microreticulatus* Knox, 1950

Plate 3, figure 13

The description and drawing of Knox (1950, p. 321, and 1948, fig. 42) are very similar to those of Hoffmeister, Staplin, and Malloy (1955, p. 391, pl. 36, fig. 3) which represent *Microreticulatisporites fundatus*.

*Occurrence.*--Though never abundant, the species is found in all coals in the Pottsville Series except the Lower Block c zone.

*Microreticulatisporites reticulopunctatus*

(H. S. and M.) nov. comb.

Plate 3, figures 14 and 15

Hoffmeister, Staplin, and Malloy (1955, p. 394) described a species under *Punctatisporites* which definitely fits the description of *Microreticulatisporites* (Potonie and Kremp, 1955, p. 96). Loose (Potonie, Ibrahim, and Loose, 1932, p. 450, pl. 18, fig. 37) described and figured *Sporonites microreticulatus* which closely resembles *M. reticulopunctatus* (H. S. and M.) nov. comb. and is probably synonymous with it. If so, then Loose's species has priority, but the epithet *microreticulatus* has already been used for a species described by Knox (1950, p. 321) under *Microreti-*



*culatisporites*. The species described by Knox is distinct from the two species under discussion here.

*Occurrence.*--This spore is sparsely represented in the Lower Block a zone, the Upper Block c zone, the Minshall Coal, and Coal II.

*Microreticulatisporites microtuberosus* (Loose)  
Pot. and Kremp, 1955

Plate 3, figures 16 and 17

Loose (Potonie, Ibrahim, and Loose, 1932, p. 450) originally described this miospore as being tuberoso and retained it under the genus *Tuberculatisporites* (Loose, 1934, p. 147) after Ibrahim (1933, p. 23) had placed it there. Schopf, Wilson, and Bentall (1944, p. 31) transferred it to *Punctatisporites*, and Knox (1950, p. 316) placed it in her genus *Planisporites*. Potonie and Kremp (1955, p. 100-101, and pl. 15, figs. 273-277) showed and interpreted this form to be irregularly reticulate; they claimed that the "tubercles" of Loose's description are fused into muri enclosing minute lacunae and thus forming a reticulum.

*Occurrence.*--This rather conspicuous species is found in coals of the Mansfield Formation and in all coals of the Brazil Formation except Coal II. Its greatest abundance is in the Upper Block c zone and the Minshall Coal.

*Punctatisporites provectus* Kos., 1950

Plate 4, figure 1

Ibrahim (1933, p. 21) defined the genus as follows: "Sporen mit Y-Marke, bei denen die Oberfläche des Exospors fein sandig erscheint." Potonie and Kremp (1955, p. 41-42) claimed to follow Ibrahim's intended definition except for restricting the genus to round miospores only. They further claimed that finely punctate to infrareticulate spore coats, which they termed structureless, cannot be used to differentiate genera. Still, the "finely punctate" miospore *P. orbicularis* Kos., 1950, was forced into the genus *Cyclogranisporites* by these authors (Potonie and Kremp, 1955,

p. 61), whereas Ibrahim's genotype, *Punctatisporites punctatus*, was defined by that author as possessing "deutliche Punktierung" and having a weakly rough outline. By choosing the name *Punctatisporites*, Ibrahim (1933, p. 21) seemed to allude to punctate spore coats, and the photomicrograph which Potonie and Kremp (1955, pl. 11, fig. 122) published of Ibrahim's holotype certainly cannot be construed to possess a levigate spore coat. It is the opinion of the present writer that such species as *Punctatisporites orbicularis*, *P. provectus*, and *P. vagus* fit Ibrahim's description of the genus *Punctatisporites* and that these species have been rather carelessly transferred to *Cyclogranisporites*.

*Occurrence.*--*Punctatisporites provectus* has been recorded in all coals in the Pottsville Series, but it is rather sparsely represented from the Lower Block b zone upward. The species is fairly abundant in the Lower Block a zone and in coals of the Mansfield Formation.

#### *Punctatisporites* cf. *mundus* Kos., 1950

##### Plate 4, figure 2

In a written communication Kosanke expressed the opinion that the specimen shown on plate 4, figure 2, is more broadly rounded opposite the rays and that the ornamentation is finer and more sharply defined than the spores he found in the Friendsville Coal of Illinois and that perhaps a new species needs to be defined to accommodate the Indiana spores.

*Occurrence.*--A few scattered specimens are found in all three zones of the Lower Block Coal, but none are found in the older coals or in the Upper Block zones. Only the Minshall Coal contains any appreciable amounts of this miospore.

#### *Punctatisporites punctatus* Ibr., 1933

##### Plate 4, figure 3

This spore was first pictured and described by Ibrahim (Potonie, Ibrahim, and Loose, 1932, p. 448, pl. 15, fig. 18) under

*Sporonites punctatus*. Knox (1950, p. 316) transferred the species to *Planisporites*, but Potonie and Kremp (1954, p. 120) designated it as the genotype of the genus *Punctatisporites*. Hoffmeister, Staplin, and Malloy (1955, pl. 36, fig. 5) figured a species, *P. pseudoelevatus*, which resembles *P. punctatus* considerably and may be synonymous with it.

*Occurrence.*--*P. punctatus* is very sparsely represented in the Pottsville coals of Indiana.

#### *Punctatisporites obliquus* Kos., 1950

##### Plate 4, figure 4

Potonie and Kremp (1955, p. 44) modified Kosanke's description (Kosanke, 1950, p. 16) of the species *Punctatisporites obliquus* somewhat; they extended the size range upward from 46 to 60 $\mu$  and made the exine ornamentation more or less finely infrapunctate and the outline smooth. Kosanke (1950, p. 16) described the ornamentation as minutely punctate and pointed out that it has the appearance of being minutely papillate. Kosanke's photo (Kosanke, 1950, pl. 2, fig. 5) definitely has a granular appearance.

*Occurrence.*--This species is sparsely represented in all the coals examined in this study; only in the Upper Block a zone is it a conspicuous constituent.

#### *Punctatisporites stramineus* (Wils. and Kos.) nov. comb.

##### Plate 4, figures 5-8

Wilson and Kosanke (1944, p. 329) described this species as having a diameter of 30 to 45 $\mu$ , having a smooth 3 $\mu$ -thick wall with compression folds, and having trilete rays which extend about one-half the distance to the equator. Their photo (Wilson and Kosanke, 1944, fig. 1) unfortunately was poorly reproduced. Wilson and Hoffmeister (1956, pl. 1, fig. 5) showed a photo which is identical with a fairly large number of specimens found in the Pottsville. One of the diagnostic features of the genus *Calamo-*



*spora* (Schopf, Wilson, and Bentall, 1944, p. 49) is a thin spore coat; this gives *Calamospora* a membranous appearance. Irregular folding is common because of the thin exine. The species under discussion has a thick exine, as does the species described by Wilson and Kosanke, and the folding is of the regular compression type. This spore certainly fails to display the characteristic membranous appearance of other species of *Calamospora* and is therefore assigned to the genus *Punctatisporites*, whose definition it fits more closely than that of *Calamospora*.

*Occurrence.*--This species is a prominent member of the spore assemblages of most coals in the Pottsville Series. According to available information, its greatest abundance is in the Upper Block c zone and in the Minshall Coal.

*Punctatisporites* cf. *obesus* (Loose) Pot. and Kremp, 1955

Plate 4, figure 9

Several large, smooth, thick-walled spores which resemble *Calamospora flava* Kos., 1950, a species which Potonie and Kremp (1955, p. 42) assigned to *Punctatisporites*, have been recorded in a few samples of the Upper Block b and c zones. Kosanke (written communication), however, feels that the Indiana specimens are less translucent than his *Calamospora flava* and that they fail to show the characteristic folding of the lips. Another spore which closely resembles the Indiana specimens is *Laevigatisporites obesus* Loose (1934, p. 145), a species which was also transferred to *Punctatisporites* by Potonie and Kremp (1955, p. 43, 44). If the redefined genus *Punctatisporites* (Potonie and Kremp, 1954, p. 120) is to be accepted, the discrepancy between the new definition, which stresses a sculptureless exine, and such a distinctly punctate species as *P. punctatus* Ibr., 1933, which was designated as type, must be resolved. The two species under discussion here fail to resemble *P. punctatus*, although *Punctatisporites obesus* allegedly may be infrapunctate (Potonie and Kremp, 1955, p. 43). No infrapunctation is observable in the Indiana specimens. Reluctance to base new species on only a few specimens has been voiced previously in this paper and applies here. Perhaps this problem could be partly solved by group-

ing these very distinctive, large, thick-walled spores under a separate generic heading and then attempting specific differentiation by comparing actual specimens rather than by using pictorial and descriptive material.

*Occurrence.*--This distinctive megasporelike organ is found only in the Upper Block b and c zones.

*Calamospora pallida* (Loose) S. W. and B., 1944

Plate 4, figures 10 and 11

This membranous miospore, because of its granulose coat, was assigned to *Punctatisporites* by Ibrahim (1933, p. 21) after Loose (Potonie, Ibrahim, and Loose, 1932, p. 450) had described it as *Sporonites pallidus*. Schopf, Wilson, and Bentall (1944, p. 52) placed the species with their genus *Calamospora*. The species is strikingly similar to *C. flexilis* Kos., 1950. Potonie and Kremp (1955, p. 47) also alluded to this possible synonymy.

*Occurrence.*--*C. pallida* and *C. flexilis* are common in all coals of Pottsville age in Indiana; they are most abundant in the Minshall Coal and Coal II.

*Calamospora parva* sp. nov.

Text figure 16; plate 4, figure 12

*Description.*--Spores are trilete and radially symmetrical, originally spherical in shape, and round to elliptical in compressed state. Folding due to the membranous nature of the spore coat, which is levigate to infragranulose, is common. The exine may be thicker and darker in the contact areas. The trilete rays are short and measure from 5 to 7 $\mu$ . The longest diametric measurement ranges from 32 to 45 $\mu$  and averages 37 $\mu$ . The holotype is 38 $\mu$  at the longest diameter.

*Holotype.*--Sample 66, slide 4104; outcrop, Upper Block b zone, Daviess County, Ind.

*Discussion.*--This species is typical of the genus *Calamospora*. It is the smallest species described by anyone to date.

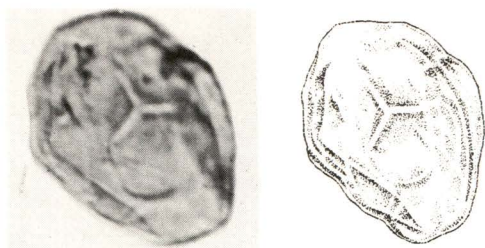


Figure 16.--*Calamospora parva* sp. nov.;  
photomicrograph and drawing of holo-  
type.

*Occurrence.*--Specimens of this small *Calamospora* are found throughout the Pottsville coals, but this species is not a major constituent of the sporal assemblages.

*Densosporites lobatus* Kos., 1950

Plate 4, figures 13 and 14

It is conceivable that the apparent great variability in the cingulum of the species of this genus is brought about by maceration. Experiments to determine whether a solid entire cingulum can be reduced to a multi-layered, fringelike equatorial belt need to be undertaken. Otherwise the literature will become cluttered with a multitude of "species" based on stages of disintegration of the cingulum. There seems to be some evidence that this situation already exists. The crenulate and clefted margins of certain specimens may simply be manifestations of maceration. That the problem is acute is evidenced by the difficulty encountered in differentiating between an equatorial flange (zona) and equatorial rim (cingulum) when the latter is layered and fringed. Not only are species of *Densosporites* involved in this controversy, but the question affects generic definitions as well. (See discussion under *Cirratiradites arcuatus*, p. 44-45.)

Whether the specimen shown on plate 4, figure 13, is actually *Densosporites lobatus*, whether it should be classified as *D. ruhui*, *D. sinuosus*, or *D. lorincatus*, or whether several other specific epithets should be considered as synonyms needs to



be answered in order to straighten out the existing taxonomic muddle.

*Occurrence.*--The species is interpreted in a rather broad sense and may therefore represent several form species. As such it has been recorded in all coals of Pottsville age up through the Minshall Coal. It is a dominant constituent in the French Lick, Pinnick, and Shoals coals of the Mansfield Formation and in the Lower Block c zone of the Brazil Formation.

### *Densosporites reynoldsburgensis* Kos., 1950

Plate 4, figure 15

Potonie and Kremp (1954, p. 159-160) differentiated *Anulatisporites* from *Densosporites* on the basis of structure and sculpture of the cingulum. *Anulatisporites* allegedly has an unsculptured cingulum, but it can show "muschelige Abbrueche," that is, peeling or sloughing off in concentric layers. Kosanke (1950, p. 33) described the cingulum of *D. reynoldsburgensis* as "essentially opaque with a few minor pits or punctations." The photos (Kosanke, 1950, pl. 6, figs. 9-11) show the cingulum to be entire, rather uniformly opaque, and certainly without marginal crenulations or serrations. The few minor pits mentioned by Kosanke do not represent sculpturing or ornamentation. If texture, structure, and sculpture of the cingulum are valid criteria for distinguishing *Densosporites* from *Anulatisporites*, this species, along with several others, justifiably belongs to the latter genus. The validity of *Anulatisporites* as a generic entity, however, is questionable. Loose (1934, p. 151), in a footnote, said that such forms as *Zonalesporites annulatus* and *Z. lorica-tus*, because they possess centrifugal thickenings rather than membranous flanges, should be grouped under *Annulatisporites*. Whether this statement suffices to validate *Anulatisporites* as a genus is debatable.

The description and photographs of *Anulatisporites annulatus* (Loose) Pot. and Kremp, 1954, given by Potonie and Kremp (1956a, p. 112, and pl. 17, figs. 365-372) and those given by Kosanke (1950, p. 33, and pl. 6, figs. 9-11) of *Densosporites reynoldsburgensis* Kos., 1950, are very similar. The two species could

be conspecific.

A fairly large number of spores that differed from *Densosporites reynoldsburgensis* only because of size (measuring only about 30u in diameter) were included in the *D. reynoldsburgensis* count.

*Occurrence.*--The distribution record of *D. reynoldsburgensis* essentially parallels that of *D. lobatus*. This species is an important sporal constituent in the lower coals of the Mansfield Formation and is found infrequently in the Block coal zones and the Minshall Coal, except in the Lower Block c zone, where it is abundant.

*Triquitrites bucculentus* sp. nov.

Text figure 17; plate 5, figures 1 and 2

*Description.*--Spores are radially symmetrical and trilete and have triangular shape. The marginal areas opposite the ray termini are somewhat thickened as are the diagnostic rounded pustulae which deform the spore outline. The exine is levigate. The trilete rays are distinct and extend two-thirds the distance to the margin. The size range is 25 to 40u, and the holotype measures 32u.

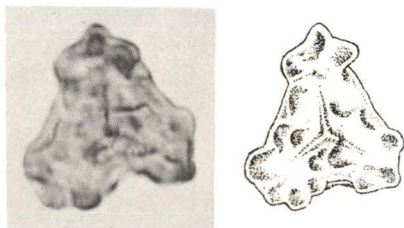


Figure 17.--*Triquitrites bucculentus* sp. nov.; photomicrograph and drawing of holotype.

*Holotype.*--Sample 45, slide 851; outcrop, Upper Block b zone, Owen County, Ind.

*Discussion.*--The valvae of many *Triquitrites* species are indented, lobed, or divided into digitate protuberances. Some

*Triquitrites* species have papillae, and others like *T. bucculentus* sp. nov. and *T. crassus* Kos., 1950, have blisterlike protuberances. The latter species, in addition to being almost twice the size of *T. bucculentus*, has straight or convex sides and smaller protuberances in relation to body size. Wilson and Hoffmeister (1956, pl. 3, fig. 23) pictured a specimen of *Triquitrites* which may represent an exaggerated stage of pustule development. Their specimen does resemble the specimen shown on plate 5, figure 2, however, and may belong to this species.

*Occurrence.*--This species is not found in the Mansfield Formation, but a small number of specimens have been found from the Lower Block a zone through the Minshall Coal.

### *Triquitrites spinosus* Kos., 1943

#### Plate 5, figure 3

Knox (1950, p. 327) expressed the opinion that her species *T. papillosus* may be conspecific with *T. spinosus* Kos., but Potonie and Kremp (1955, p. 82, 83) redescribed Knox's holotype under *Pustulatisporites* and ignored *T. spinosus* entirely. If *Pustulatisporites papillosus* (Knox) Pot. and Kremp, 1955, shows no indication of valval development opposite the rays, the two cannot be conspecific. *T. spinosus* is described as having conspicuous thickenings at the corners (Kosanke, 1943, p. 128).

*Occurrence.*--This species is found only in the Lower Block zones and the Minshall Coal.

### *Triquitrites dividius* Wils. and Hoffm., 1956

#### Plate 5, figure 4

This species is described (Wilson and Hoffmeister, 1956, p. 25, and pl. 3, figs. 10 and 11) and figured as a relatively large (40 to 49 $\mu$ ) triangular spore with rather inconspicuous and flattened valvae. A spore which fits this description was found by the author in some of the Pottsville coal samples.

*Occurrence.*--*T. dividius* is sparsely represented in the Potts-



ville coals of Indiana.

*Triquitrites additus* Wils. and Hoffm., 1956

Plate 5, figure 5

Wilson and Hoffmeister (1956, p. 24) grouped specimens with lobed projections under the specific epithet *additus*. The miospore shown on plate 5, figure 5, is characterized by such lobed projections and is thought to belong to *T. additus*.

*Occurrence.*--This spore is found infrequently in the coals of the Pottsville Series.

*Triquitrites exiguus* Wils. and Kos., 1944

Plate 5, figures 6 and 7

Four species with distinct, bulging cushions or valvae have been described. Potonie and Kremp (1956a, p. 91) pointed out that *T. triturgidus* (Loose) S. W. and B. resembles *T. pulvinatus* Kos. The two may be conspecific. Loose (Potonie, Ibrahim, and Loose, 1932, p. 450) gave measurements of 45.5 to 64.5u for *T. triturgidus*, and Kosanke (1950, p. 39) gave 41.5 to 52.6u as the size range for *T. pulvinatus*. Wilson and Kosanke (1944, p. 332) described a small species (22 to 30u), which has pronounced cushions, as *T. exiguus*, and Wilson and Hoffmeister (1956, p. 24, 25) described a cushioned species, *T. bransonii*, which fills the size gap between *T. pulvinatus* and *T. exiguus*.

*Occurrence.*--*T. exiguus* is not found in the Lower Block b and c zones. In all other coals it is sparsely, but consistently, represented.

*Triquitrites bransonii* Wils. and Hoffm., 1956

Plate 5, figures 8 and 9

The majority of *Triquitrites* spores recorded in this study measured between 30 and 40u, had well-developed valvae, and

displayed distinct rays. *T. protensus* Kos., 1950, because it seemed to have similar characteristics, and because a more suitable species was lacking, served tentatively to accommodate the Indiana specimens. Potonie and Kremp (1956a, p. 97), however, thought that *T. protensus* could be assigned to the genus *Ahrensisporites* Pot. and Kremp, 1954. Kosanke (1950, p. 40) said that "the thickenings of *T. protensus* sp. nov. are distinct from those of all other known species of the genus," and his photograph (Kosanke, 1950, pl. 8, fig. 2) does show one rather sinuous cushion which may be the extension of distally prominent cyrtomes or curved thickenings, which characterize *Ahrensisporites*. Although Wilson and Hoffmeister's (1956, pl. 3, figs. 1-5) photographs indicate considerable diversity in body shape and, perhaps more significantly, in size and shape of the valvae, the size range given can accommodate the group found in the Pottsville of Indiana, and consequently this group of *Triquitrites* spores is now assigned to *T. bransonii*.

The Indiana group certainly fits the forms illustrated by Wilson and Hoffmeister (1956) in figures 3 and 4 on plate 3. Perhaps this group is sufficiently different from the holotype (Wilson and Hoffmeister, 1956, pl. 3, fig. 1) to warrant eventual separation from *T. bransonii*.

*Occurrence.*--This spore type is rather common throughout the Pottsville coals. A definite increase in number is found in the coal sequence from the Upper Block c zone through Coal II.

### *Triquitrites desperatus* Pot. and Kremp, 1955

#### Plate 5, figure 10

A number of triangular specimens were found which were small and almost devoid of valvae and had truncated corners and straight to convex sides. Because none of the specimens show indications of the barbed projections mentioned by Bhardwaj and Kremp (1955, p. 54) in describing *T. truncatus*, these spores are assigned to *T. desperatus* Pot. and Kremp, 1955, whose description they fit rather closely.

*Occurrence.*--The species is not important numerically, but it does show a slight abundance increase in the Upper Block a

and b zones.

### *Triquitrites sculptilis* Balme, 1952

Plate 5, figure 11

Spores which seemed to be reticulate but which had all the other features of *Triquitrites* were found during this study. The reticulate appearance of the spore coat is due to an undulating exine rather than a definite reticulum. This feature is distinctive for *T. sculptilis*, and there is little doubt that the Indiana specimens can be assigned to this species. Ibrahim (1933, p. 37) described under *Reticulati-sporites trigonus* a triangular small spore which has an indistinct reticulum and truncated corners, as the drawing (Ibrahim, 1933, pl. 5, fig. 34) definitely shows. This species, assigned to *Granulati-sporites* by Schopf, Wilson, and Bentall (1944, p. 33) and to *Microreticulati-sporites* by Knox (1950, p. 322), may be conspecific with *T. sculptilis*.

*Occurrence.*--*T. sculptilis* is found sparsely represented only in the Upper Block and younger coals.

### *Laevigatosporites ovalis* Kos., 1950

Plate 5, figures 12-14

Potonie and Kremp (1956a, p. 139, 140) placed *L. ovalis* and *L. vulgaris major* Loose in synonymy with *L. vulgaris* Ibr. Unless open or closed scars and minute differences in the essentially levigate spore coats are used for speciation, size is the only criterion for differentiating these levigate bean-shaped spores. Potonie and Kremp (1956a, p. 140) classified the species of *Laevigatosporites* on that basis and gave the following size ranges:

<i>L. maximus</i> (Loose) Pot. and Kremp, 1956	- - 100 to 130u
<i>L. vulgaris</i> Ibr. . . . .	70 to 100u
<i>L. desmoinensis</i> (Wils. and Coe) S. W. and B., 1944 . . . . .	45 to 70u



<i>L. medius</i> Kos., 1950 - - - - -	35 to 45u
<i>L. minimus</i> (Wils. and Coe) S. W. and B., 1944 -	20 to 35u

Kosanke (1950, p. 28) separated *L. desmoinensis* from *L. vulgaris* on the basis of exine ornamentation, claiming that *L. vulgaris* "has a much coarser spore coat." Wilson and Coe (1940, p. 182) gave the size range of *Phaseolites desmoinensis*, which was assigned to *Laevigatosporites* by Schopf, Wilson, and Bentall (1944, p. 37), as 60 to 75u; Kosanke (1950, p. 29) listed the known size range of *L. ovalis* as 45 to 65u. It is difficult to understand why Potonie and Kremp, in regrouping the *Laevigatosporites* species on the basis of size, made *L. ovalis*, rather than *L. desmoinensis*, synonymous with *L. vulgaris*. In retaining *L. desmoinensis*, Potonie and Kremp (1956a, p. 139) placed *L. vulgaris minor* Loose, 1934, and *L. punctatus* Kos., 1950, into synonymy with it. The latter species definitely does not belong there, because it has a "distinctly punctate" spore coat (Kosanke, 1950, p. 30). This characteristic, in fact, makes this species assignable to *Punctatosporites*.

*Laevigatosporites* specimens found in the Pottsville coals of Indiana can easily be accommodated by four size groups which fit the size ranges of the following species:

<i>L. desmoinensis</i> - - - - -	60 to 75u
<i>L. ovalis</i> - - - - -	45 to 65u
<i>L. medius</i> - - - - -	36 to 43u
<i>L. minimus</i> - - - - -	20 to 35u

**Occurrence.**--*L. ovalis* is one of the miospores found most frequently in the Pottsville coals. It is a major sporal constituent in all coals except some of those in the Mansfield Formation, where it may be missing entirely.

#### *Laevigatosporites medius* Kos., 1950

Plate 5, figures 15 and 16

*L. medius* was retained by Potonie and Kremp (1956a, p. 138) for bilateral levigate miospores ranging from 35 to 45u in size.

*Occurrence.*--*L. medius* and *L. ovalis* have similar distribution in the Pottsville coals of Indiana. They are missing from the same Mansfield samples, and they are similar in abundance in the coals of the Brazil Formation. This similarity indicates that the two species may be spores derived from the same plant.

*Laevigatosporites minimus* (Wils. and Coe) S. W. and B., 1944

Plate 5, figure 17

Smooth-coated monolete spores which measure between 22 and 32 $\mu$  and thus are too small to be assigned to *Laevigatosporites medius* were encountered in this study. Potonie and Kremp (1956a, p. 139) gave the size range of *L. minimus* as 20 to 35 $\mu$ ; this is an upward extension from 29 $\mu$  as originally stated by Wilson and Coe (1940, p. 183). The Indiana specimens therefore can be assigned to *L. minimus* as redefined by Potonie and Kremp.

*Occurrence.*--This minute spore was recorded in only one sample of the Mansfield coals. Throughout the Block coal zones and in the Minshall Coal it is conspicuous but never prominent. In Coal II, however, *L. minimus* averages more than 12 percent of the spore count, and in the Staunton samples it makes up about 5 percent of the spore population.

*Laevigatosporites desmoinensis* (Wils. and Coe)  
S. W. and B., 1944

Plate 5, figure 18

*Laevigatosporites vulgaris minor* Loose, 1934, has a size range of 40 to 70 $\mu$  and is partially conspecific with *L. desmoinensis*, but the smaller spores grouped there by Loose can be assigned to *L. ovalis* Kos., 1950.

*Occurrence.*--This species is absent from the Mansfield Formation, but it is consistently, although sparsely, represented in the coals of the Brazil Formation.

*Latosporites globosus* (Schem.) Pot. and Kremp, 1956

## Plate 5, figure 19

Shape is actually the only criterion differentiating *Laevigatosporites* from *Latosporites* (Potonie and Kremp, 1956a, p. 137-144). Exine sculpturing is given as levigate to infrapunctate for *Laevigatosporites* and levigate to infrareticulate for *Latosporites*. The genus *Punctatosporites*, not to be confused with *Punctatisporites* and *Punctatasporites*, is defined as having a finely granulate exine. Schemel (1951, p. 746) described the spore coat of *Laevigatosporites globosus* as "densely and minutely punctate." Either this feature was ignored by Potonie and Kremp, or the shape characteristic was considered of greater importance.

Numerous small monolete spores that fit the description of Schemel (1951, p. 746 and 747), that is, that measure between 20 and 30 $\mu$ , that are more or less circular in outline, and that have a finely punctate and thick exine, have been found in the Pottsville coals.

*Occurrence.*--This species is found in all the Pottsville coals, but it exceeds the 1 percent average only in the Lower Block a and Upper Block a zones and in Coal II.

*Latosporites latus* (Kos.) Pot. and Kremp, 1954

## Plate 5, figure 20

This broadly oval form was designated as the genotype by Potonie and Kremp (1954, p. 165). These authors differentiated *Latosporites* from *Laevigatosporites* by its broadly oval to nearly round outline when equatorially compressed and by its more concave outline in meridian section that may terminate in an angle distally.

*Occurrence.*--*Latosporites latus* is present in all coals of the Brazil Formation, but it is most abundant in the Upper Block c zone and in the Minshall Coal. This species is not found in some coals of the Mansfield Formation.



*Reticulatisporites annulatus* sp. nov.

Text figure 18; plate 6, figures 1 and 2

*Description.*--Spores are radial and trilete and have round to oval outlines. The size ranges from 55 to 75 $\mu$  and averages 68 $\mu$ . The holotype measures 64 $\mu$ . The distinctly membranous nature of the muri gives the appearance of an equatorial flange. The muri are thin (1 to 2 $\mu$ ) and long (10 to 15 $\mu$ ); the lacunae measure 8 to 16 $\mu$ . Folding of the reticulum is common because of the membranous nature of the muri. The trilete rays, usually obscured by the reticulum, reach almost to the periphery. The spore exine ranges from 1.5 to 3.5 $\mu$  in thickness.

*Holotype.*--Sample 85a, slide 5801; outcrop, Lower Block c zone, Perry County, Ind.

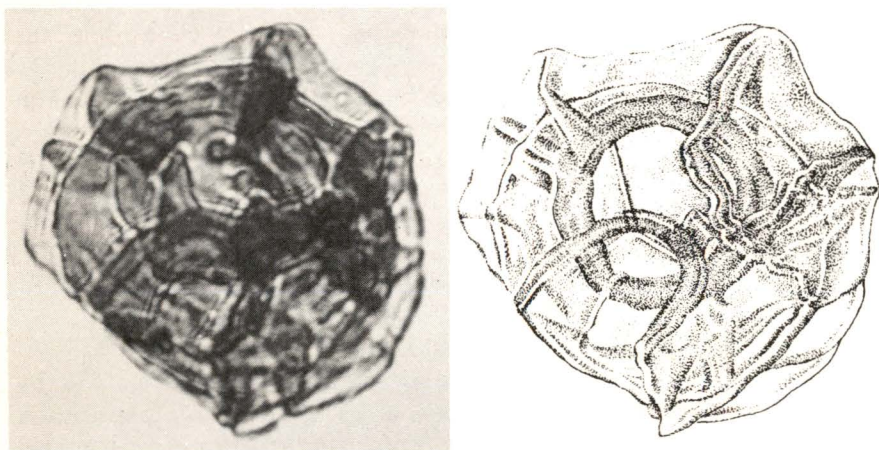


Figure 18.--*Reticulatisporites annulatus* sp. nov.;  
photomicrograph and drawing of holotype.

*Discussion.*--Potonie and Kremp (1954, p. 144) separated *Reticulatisporites* from *Dictyotriletes* on the basis of tall muri; they stated: "Die Lumina des Reticulums sind von hohen Muri begrenzt, so dass die Muri im Umriss der Spore...als senkrecht auf der Exine stehende Zinken erscheinen." When the muri of *Reticulatisporites* are oriented parallel to the slide, they are translucent and appear

membranous. The muri of *Dictyotriletes*, on the other hand, are low ridges, and thus the reticulum of this genus fails to appear membranous. This distinction is not easily made in some spores, especially when the terms used to describe species are relative. Actual measurements defining the muri and lacunae, as Kosanke (1950, p. 26, 27) has done, help to clarify the matter. Potonie and Kremp (1956a, p. 113) stated that *R. muricatus* Kos. is indistinguishable from *R. reticulatus* Ibr.; they discounted the fact that the former has taller muri and thus a more membranous appearance. If such a feature is of sufficient magnitude to differentiate genera, it should be a valid criterion for separating species. *R. reticulatus* Ibr., as Ibrahim's (Potonie, Ibrahim, and Loose, 1932, pl. 14, fig. 3) drawing and Potonie and Kremp's (1955, pl. 16, figs. 310-312) photographs show, has rather low and thick muri. *R. annulatus* sp. nov., because of its tall and thin muri, resembles *R. reticuliformis* Ibr., *R. evolvens* (Waltz) Pot. and Kremp, *R. velatus* (Waltz) Pot. and Kremp, and *R. muricatus* Kos. Because the Indiana specimens fall into a size group much smaller than the 81.9 to 96.6u range given by Kosanke for *R. muricatus*, they are considered a separate species.

*Occurrence.*--This species is found only in the Block and older coals.

### *Reticulatisporites reticulatus* Ibr., 1933

#### Plate 6, figures 3 and 4

As mentioned previously, the drawing and photographs published as representatives of *R. reticulatus* show a rather low mural network and irregularly arranged lacunae. Potonie and Kremp (1955, p. 112) gave the size range as 75 to 90u. Luber (Luber and Waltz, 1938, fig. 99) published a drawing of *Azontriletes reticulatus* (Ibr.) which shows regular hexagonal lacunae bounded by very low muri and which is obviously unlike *R. reticulatus* Ibr.

*Occurrence.*--*R. reticulatus* is found in the Lower Block a and c zones and the three zones of the Upper Block Coal, but it is never abundant.

*Reticulatisporites areolatus* sp. nov.

Text figure 19; plate 6, figure 7

*Description.*--Spores are radial and trilete and are round in outline. The size ranges from 26 to 38 $\mu$  and averages 32 $\mu$ . The holotype measures 32 $\mu$ . The muri delimiting the lacunae of the reticulum are about 1 $\mu$  thick and from 2 to 5 $\mu$  high. The lacunae are from 5 to 8 $\mu$  wide. The trilete rays, usually obscured by the reticulum, extend about two-thirds the distance to the spore margin. The spore exine is about 1 $\mu$  thick.

*Holotype.*--Sample 24a, slide 2509; outcrop, Log Cabin strip mine, Upper Block a zone, Clay County, Ind.

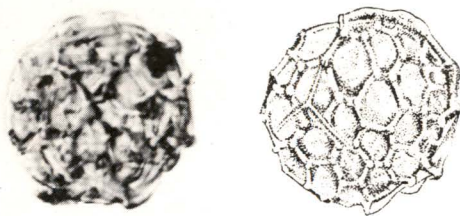


Figure 19.--*Reticulatisporites areolatus* sp. nov.; photomicrograph and drawing of holotype.

*Discussion.*--Although the muri do not extend conspicuously beyond the spore periphery, they nevertheless protrude and are definite uniformly thin muri; consequently, the species belongs to *Reticulatisporites*. Two species described by Knox (1950, p. 321), *Microreticulatisporites spicatus* and *M. spinulosus*, resemble this species. *M. spicatus* is larger and has smaller lacunae and longer muri. Although Knox failed to show membranous connections among the protruding spinose muri, they must be present because the spacing of the spines coincides with the spacing of the lacunar borders. If the spines were projections of low mural ridges, they would protrude at irregular intervals. *M. spinulosus* fits the size range of *R. areolatus* sp. nov. more closely, but the lacunae are smaller and therefore more numerous. *M. reticulocingulum* (Loose) Pot. and Kremp, 1955, also resembles *R. areolatus*. Because of



its relatively great size range and variability in lacunar measurements, as evidenced by the photographs of Potonie and Kremp (1955, pl. 16, figs. 306-308), *M. reticulocingulum* may encompass all species mentioned in this discussion. *Lycospora venusta* (Loose) Pot. and Kremp, 1956, a reticulate species, fits the description and size of *R. reticulocingulum* perfectly, except for allegedly possessing a flange. This flange, as the drawing of Loose (Potonie, Ibrahim, and Loose, 1932, pl. 18, fig. 36) shows, is merely the membranous reticulum extending beyond the body periphery.

*Occurrence.*--Specimens of this species are found in the coals in the Mansfield Formation, in the Lower Block a and Upper Block a and b zones, and in the Minshall Coal.

*Dictyotriletes mediareticulatus* (Ibr.) Pot. and Kremp, 1954

Plate 6, figures 5 and 6

Ibrahim (1933, p. 34) described the species under *Reticulatisporites*; Luber (Luber and Waltz, 1938, fig. 107) figured it under *Azonotriletes*, probably erroneously because his drawing shows more and smaller lacunae; and Potonie and Kremp (1954, p. 144) unintentionally made it the genotype of *Dictyotriletes*. This error was rectified later (Potonie and Kremp, 1955, p. 107), and *D. bireticulatus* was substituted. Although the size range as given by these authors is 50 to 80 $\mu$ , some of the smaller specimens found in Indiana coals have been assigned to this species, and thus the size has been extended downward to about 45 $\mu$ . Whether actually two distinct size groups are contained within this species has not been ascertained, and therefore the writer refrained from establishing another species.

*Occurrence.*--This species is sparsely represented only in the Lower Block c zone, the Upper Block zones, and the Minshall Coal.

*Raistrickia aculeolata* Wils. and Kos., 1944

## Plate 6, figure 8

Wilson and Kosanke (1944, p. 331) gave the size for *R. aculeolata* as 50 to 69 $\mu$ , and Hoffmeister, Staplin, and Malloy (1955, p. 395) described a species, *R. multipertica*, which is very similar, but which is smaller in overall proportions (measuring 40 to 44 $\mu$ ) and has a denser spine arrangement. Although the size of the Indiana specimens fits that given for *R. multipertica*, they are placed with *R. aculeolata* because of the scattered distribution of the spines. Perhaps the size range of *R. aculeolata* needs to be extended downward to about 40 $\mu$ .

*Occurrence.*--Scattered spores of this species are found in the Minshall Coal and in older coals; this species is most abundant in the Upper Block b zone.

*Raistrickia superba* (Ibr.) S. W. and B., 1944

## Plate 6, figure 9

Another species of *Raistrickia*, definitely distinct from the forms assigned to *R. aculeolata* on the basis of size and the shape and arrangement of the baculae, is found in the coals of the Pottsville Series. Potonie and Kremp (1955, p. 88, and pl. 15, figs. 262 and 263) mentioned that the baculae are not all uniformly long, that their tips are truncated, and that some are "kegelfoermig." This adjective, meaning cone shaped, could be construed to infer club shape, such as the shape of a bowling pin. Rather than basing a new species on such a characteristic of the baculae, setae, spinae, or fibrae, as the digitate projections that characterize this genus have been variously called, this writer would assign these miospores to *Raistrickia superba*. If more specimens of this form are found and some stratigraphic significance becomes attached to it, this problem will have to be considered again.

*Occurrence.*--This species is found in all Pottsville coals of Indiana, but it is never a conspicuous sporal element.

*Alatisporites pottsvillensis* sp. nov.

Text figure 20; plate 6, figures 10 and 11

*Description.*--Spores are trilete and radially symmetrical and have three bladders. The sacchi or bladders are attached at the interradian margins of the spore body; they bulge out beyond the spore periphery and meet distally. The bladders are membranous, tend to fold (appearing to be more than three), and are levigate to infragranulose. The spore body is triangular in outline and has straight slightly convex or slightly concave sides and rounded corners. The exine is levigate to finely granulose and rather thick; it measures from 1.5 to 3.5 $\mu$ . The scar may be split open and reaches the periphery of the spore body. The body measurements range from 40 to 49 $\mu$ ; the overall size, including sacchi, is 60 to 75 $\mu$ ; and the holotype measures 61 $\mu$ .

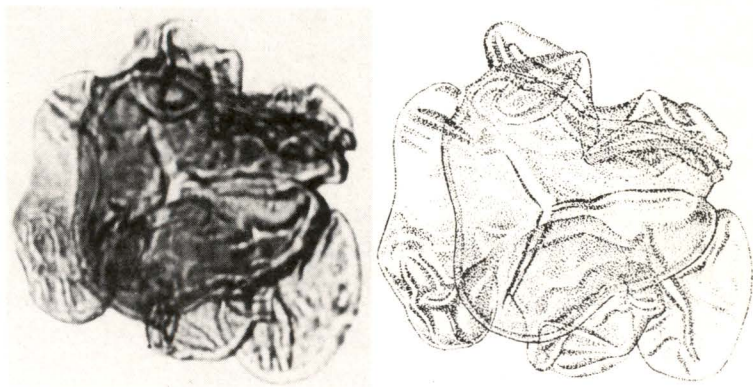


Figure 20.--*Alatisporites pottsvillensis* sp. nov.;  
photomicrograph and drawing of holotype.

*Holotype.*--Sample 31, slide 971; outcrop, Coal II, Clay County, Ind.

*Discussion.*--Only *A. hexalatus* Kos., 1950, approaches this relatively small species in size, but the fact that it is a six-winged species and has a papillate proximal surface makes it readily distinguishable from *A. pottsvillensis* sp. nov.

*Occurrence.*--The species is sparsely represented in the



Pottsville from the Lower Block b zone through Coal II; it has not been found in the Mansfield Formation.

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## INDEX OF STRATIGRAPHIC TERMS AND SPORE NAMES

(Italic numbers indicate descriptions)

Page

## A

<i>Acanthotriletes</i> - - - - -	42
<i>aculeolata</i> , <i>Raistrickia</i> - - - - -	85, pl. 6
<i>additus</i> , <i>Triquitrites</i> - - - - -	75, pl. 5
<i>adnatoides</i> , <i>Leiotriletes</i> - - - - -	58
<i>adnatus</i> , <i>Leiotriletes</i> - - - - -	57, 58
<i>Ahrensispores</i> - - - - -	44, 76
<i>Alatisporites</i> - - - - -	19, 20, 25, 33, 39
<i>hexalatus</i> - - - - -	86
<i>pottsvillensis</i> - - - - -	8, 86, pl. 6
<i>Aletes</i> - - - - -	39
Allegheny Series - - - - -	9
<i>Anapiculatisporites</i> - - - - -	42
<i>angulatus</i> , <i>Endosporites</i> - - - - -	53
<i>annulatus</i> , <i>Reticulatisporites</i> - - - - -	8, 81, pl. 6
<i>annulatus</i> , <i>Zonales-sporites</i> - - - - -	72
<i>antiquus</i> , <i>Florinites</i> - - - - -	56, pl. 2
<i>Anulatisporites</i> - - - - -	42, 72
<i>anulatus</i> - - - - -	72
<i>anulatus</i> , <i>Anulatisporites</i> - - - - -	72
<i>Aphanozonati</i> - - - - -	39
<i>Apiculati</i> - - - - -	38, 40, 62
<i>Apiculatisporites</i> - - - - -	43, 62, 64
<i>pineatus</i> - - - - -	62, pl. 3
<i>arcuatus</i> , <i>Cirratriradites</i> - - - - -	8, 24, 27, 28, 29, 30, 44, 71, pl. 1
<i>areolatus</i> , <i>Reticulatisporites</i> - - - - -	8, 83, pl. 6
<i>Auriculati</i> - - - - -	40
<i>Auriculati</i> - - - - -	39
<i>Auritotriletes</i> - - - - -	40
<i>auritus grandis</i> , <i>Triletes</i> - - - - -	38
<i>Auroraspora</i> - - - - -	42
<i>Azonaletes</i> - - - - -	40
<i>Azonaletes</i> - - - - -	39
<i>Azonomonoletes</i> - - - - -	40
<i>Azonomonoletes</i> - - - - -	39
<i>Azonotriletes</i> - - - - -	40
<i>Azonotriletes</i> - - - - -	39, 62, 84
<i>reticulatus</i> - - - - -	82

## B

Bald Hill Coal - - - - -	7
Battery Rock Coal - - - - -	7, 34

## B--Continued

<i>bireticulatus</i> , <i>Dictyotriletes</i> - - - - -	84
Blue Creek coal - - - - -	11, 19, 20, 34
<i>bransonii</i> , <i>Triquitrites</i> - - - - -	31, 32, 37, 75, pl. 5
Brazil Formation - - - - -	7, 9, 11, 21, 23, 34, 47, 66, 72, 79, 80
<i>breviapiculata</i> , <i>Lycospora</i> - - - - -	50
<i>breviradiatus</i> , <i>Endosporites</i> - - - - -	8, 54, pl. 2
<i>bucculentus</i> , <i>Triquitrites</i> - - - - -	8, 73, pl. 5

## C

<i>Cadiospora</i> - - - - -	19, 20, 25, 33
<i>Calamospora</i> - - - 19, 20, 24, 25, 27, 30, 32, 33, 34, 42, 68, 69, 70, 71	
<i>flava</i> - - - - -	69
<i>flexilis</i> - - - - -	70
<i>pallida</i> - - - - -	24, 26, 29, 31, 32, 70, pl. 4
<i>parva</i> - - - - -	8, 70, pl. 4
<i>Camptotriletes</i> - - - - -	43, 61
Cannelton coal - - - - -	18, 20
Carbondale Formation - - - - -	49
Caseyville formation - - - - -	49
Caseyville Group - - - - -	7, 34
Cingulati - - - - -	40
<i>circularis</i> , <i>Endosporites</i> - - - - -	8, 51, pl. 1
<i>Cirratriradites</i> - - - 7, 19, 20, 24, 25, 27, 28, 29, 30, 33, 34, 35, 42, 45,	
<i>arcuatus</i> - - - - -	8, 24, 27, 28, 29, 30, 44, 71, pl. 1
<i>difformis</i> - - - - -	44
<i>foveatus</i> - - - - -	8, 29, 45, pl. 1
<i>maculatus</i> - - - - -	47
<i>rotatus</i> - - - - -	44, 45
<i>saturni</i> - - - - -	46, pl. 1
<i>tenuis</i> - - - - -	45
Coal II - - - - -	11, 13, 14, 15, 17, 21, 31, 32, 33, 34, 35, 48, 50, 51,
52, 53, 57, 63, 64, 66, 70, 76, 79, 80, 87	
Coal III - - - - -	32, 33, 35
Coal IIIa - - - - -	35
<i>concavus</i> , <i>Leiotriletes</i> - - - - -	58
Conemaugh Series - - - - -	9
<i>Conv verrucosiporites</i> - - - - -	42, 43, 61, 62
<i>sulcatus</i> - - - - -	32, 61, pl. 3
<i>crassus</i> , <i>Leiotriletes</i> - - - - -	58
<i>crassus</i> , <i>Triquitrites</i> - - - - -	74
<i>crenatus</i> , <i>Pustulatisporites</i> - - - - -	8, 63, pl. 3
<i>Cristatisporites</i> - - - - -	42, 62
Curlew Coal - - - - -	7
<i>Cyclogranisporites</i> - - - - -	42, 43, 66, 67
Cystites - - - - -	40



C--Continued

*Cystosporites* - - - - - 39

D

Davis Coal - - - - - 35  
*deltiformis*, *Granulatisporites* - - - - - 24, 30, 59, pl. 3  
*deltoides*, *Laevigatosporites* - - - - - 59  
*deltoides*, *Sporonites* - - - - - 59  
*Densosporites* - - - 7, 19, 20, 25, 27, 29, 33, 34, 35, 42, 45, 71, 72  
    *lobatus* - - - - - 27, 28, 71, 73, pl. 4  
    *loricatus* - - - - - 71  
    *reynoldsburgensis* - - - - - 26, 27, 72, pl. 4  
    *ruhous* - - - - - 71  
    *sinuosus* - - - - - 71  
*desmoinensis*, *Laevigatosporites* - - - - - 77, 78, 79, pl. 5  
*desmoinensis*, *Phaseolites* - - - - - 78  
*desperatus*, *Triquitrites* - - - - - 76, pl. 5  
*Dictyotriletes* - - - - - 43, 81, 82, 84  
    *bireticulatus* - - - - - 84  
    *mediareticulatus* - - - - - 84, pl. 6  
*difformis*, *Cirratrilites* - - - - - 44  
*Disaccites* - - - - - 40  
*dividuus*, *Triquitrites* - - - - - 74, pl. 5

E

*Endosporites* - - - 7, 19, 20, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34,  
    35, 42, 50, 51, 52, 55, 56  
    *angulatus* - - - - - 53  
    *breviradiatus* - - - - - 8, 54, pl. 2  
    *circularis* - - - - - 8, 51, pl. 1  
    *formosus* - - - - - 29, 31, 53, pl. 2  
    *globiformis* - - - - - 53  
    *minutus* - - - - - 50  
    *ornatus* - - - - - 24, 26, 29, 31, 32, 37, 53, 54, pl. 2  
    *parvus* - - - - - 8, 50, pl. 1  
    *pellucidus* - - - - 24, 26, 28, 29, 30, 31, 32, 37, 50, 52, 54, pl. 1  
    *rotundus* - - - - - 24, 26, 27, 28, 29, 30, 31, 52, 54, 55, pl. 2  
    *vesicatus* - - - - - 53  
    *zonalis* - - - - - 53  
*evolvens*, *Reticulatisporites* - - - - - 82  
*exiguus*, *Triquitrites* - - - - - 75, pl. 5

F

Ferdinand Limestone - - - - - 11, 21  
*fistulosus*, *Microreticulatisporites* - - - - - 64, 65  
*flava*, *Calamospora* - - - - - 69  
*flexilis*, *Calamospora* - - - - - 70  
*Florinites* - - - - - 19, 20, 25, 33, 35, 42  
    *antiquus* - - - - - 56, pl. 2

## F--Continued

<i>formosus</i> , <i>Endosporites</i> - - - - -	29, 31, 53, pl. 2
<i>formosus</i> , <i>Sporonites</i> - - - - -	46
<i>foveatus</i> , <i>Cirratiradites</i> - - - - -	8, 29, 45, pl. 1
French Lick coal - - - - -	11, 18, 19, 20, 34, 72
Friendsville Coal - - - - -	67
Fulda Limestone - - - - -	11, 20, 21
<i>fundatus</i> , <i>Microreticulatisporites</i> - - - - -	65

## G

<i>Galeatisporites</i> - - - - -	44
<i>gibbosus</i> , <i>Lophotriletes</i> - - - - -	62, pl. 3
<i>gibbosus</i> , <i>Verrucosi-sporites</i> - - - - -	62
<i>glabratus</i> , <i>Triletes</i> - - - - -	38
<i>globiformis</i> , <i>Endosporites</i> - - - - -	53
<i>globosus</i> , <i>Latosporites</i> - - - - -	24, 28, 32, 80, pl. 5
<i>grandis</i> , <i>Triletes auritus</i> - - - - -	38
<i>granulata</i> , <i>Lycospora</i> - - - - -	26, 31, 32, 50, pl. 1
<i>Granulatisporites</i> - - 7, 19, 20, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34, 42,	44, 57, 59, 60, 61, 62, 63, 77
<i>deltiformis</i> - - - - -	24, 30, 59, pl. 3
<i>pallidus</i> - - - - -	29, 60, pl. 3
<i>parvus</i> - - - - -	60
<i>verrucosus</i> - - - - -	29, 59, pl. 3
<i>Guthoerlisporites</i> - - - - -	42, 56
<i>magnificus</i> - - - - -	56, pl. 2

## H

Herrin (No. 6) Coal - - - - -	36
<i>hexalatus</i> , <i>Alatisporites</i> - - - - -	86

## I

<i>Illinites</i> - - - - -	19, 20, 25, 33
<i>inflatus</i> , <i>Leiotriletes</i> - - - - -	29, 58, pl. 3

## K

Kirksville coal - - - - -	18
<i>Knosisporites</i> - - - - -	19, 20, 34, 43

## L

<i>lacunosus</i> , <i>Microreticulatisporites</i> - - - - -	64, 65
<i>Laevigati</i> - - - - -	38, 40
<i>Laevigatisporites obesus</i> - - - - -	69
<i>Laevigatosporites</i> - - - - 7, 19, 20, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33,	34, 43, 77, 78, 80
<i>deltoides</i> - - - - -	59
<i>desmoinensis</i> - - - - -	77, 78, 79, pl. 5
<i>maximus</i> - - - - -	77
<i>medius</i> - - - - 24, 26, 27, 28, 29, 30, 31, 32, 37, 78, 79, pl. 5	
<i>minus</i> - - - - 24, 26, 27, 28, 29, 30, 31, 32, 78, 79, pl. 5	

## L--Continued

*Laevigatosporites*--Continued

<i>ovalis</i> - - - - -	24, 26, 27, 28, 29, 30, 31, 32, 77, 79, pl. 5
<i>punctatus</i> - - - - -	28, 78
<i>vulgaris</i> - - - - -	77, 78
<i>vulgaris major</i> - - - - -	77
<i>vulgaris minor</i> - - - - -	78, 79
<i>Lagenicula</i> - - - - -	38
<i>Lagenicula</i> - - - - -	39
<i>Lagenotriteles</i> - - - - -	40
<i>Latosporites</i> - - - - -	43, 80
<i>globosus</i> - - - - -	24, 28, 32, 80, pl. 5
<i>latus</i> - - - - -	24, 26, 27, 28, 29, 30, 31, 32, 80, pl. 5
<i>latus</i> , <i>Latosporites</i> - - - - -	24, 26, 27, 28, 29, 30, 31, 32, 80, pl. 5
<i>Leiotriteles</i> - - - - -	42, 43, 57
<i>adnatoides</i> - - - - -	58
<i>adnatus</i> - - - - -	57, 58
<i>concavus</i> - - - - -	58
<i>crassus</i> - - - - -	58
<i>inflatus</i> - - - - -	29, 58, pl. 3
<i>minutus</i> - - - - -	58
<i>parvus</i> - - - - -	8, 29, 57, pl. 2
<i>pellucidus</i> - - - - -	58
<i>priddyi</i> - - - - -	57, 58, pl. 2
<i>sphaerotriangulatus</i> - - - - -	58
<i>lobatus</i> , <i>Densosporites</i> - - - - -	27, 28, 71, 73, pl. 4
<i>loganii</i> , <i>Lycospora</i> - - - - -	48
<i>Lophotriteles</i> - - - - -	42, 43, 62, 63
<i>gibbosus</i> - - - - -	62, pl. 3
<i>microsaetosus</i> - - - - -	29, 63, pl. 3
<i>loricatus</i> , <i>Densosporites</i> - - - - -	71
<i>loricatus</i> , <i>Zonalesporites</i> - - - - -	72
Lower Block a zone - - 7, 11, 12, 13, 15, 16, 17, 22, 24, 25, 34, 36, 37,	50, 56, 66, 67, 74, 80, 82, 84
Lower Block b zone - - 7, 11, 13, 14, 15, 16, 17, 22, 24, 25, 26, 34, 48,	50, 56, 67, 75, 87
Lower Block c zone - - 7, 11, 13, 14, 15, 16, 17, 22, 24, 25, 27, 34, 35,	48, 56, 63, 65, 72, 73, 75, 81, 82, 84
Lower Block Coal - - - - -	7, 9, 21, 24, 36, 67, 73, 74, 79, 82
<i>Lycospora</i> - - - - -	7, 19, 20, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 35,
	42, 43, 47, 48
<i>breviapiculata</i> - - - - -	50
<i>granulata</i> - - - - -	26, 31, 32, 50, pl. 1
<i>loganii</i> - - - - -	48
<i>parva</i> - - - - -	24, 26, 27, 28, 29, 31, 32, 48, 49, pl. 1
<i>pellucida</i> - - - - -	48
<i>pseudoannulata</i> - - - - -	26, 47, 48, pl. 1



## L--Continued

*Lycospora*--Continued

<i>punctata</i> - - - - -	26, 27, 29, 30, 31, 32, 37, 48, pl. 1
<i>pusilla</i> - - - - -	26, 28, 32, 37, 48, 49, pl. 1
<i>rugosa</i> - - - - -	50
<i>submarginata</i> - - - - -	48
<i>subtriquetra</i> - - - - -	50
<i>torquifer</i> - - - - -	50
<i>venusta</i> - - - - -	84

## M

McLeansboro Group - - - - -	49
<i>maculatus</i> , <i>Cirratriradites</i> - - - - -	47
<i>magnificus</i> , <i>Guthoerlisporites</i> - - - - -	56, pl. 2
<i>major</i> , <i>Laevigatosporites vulgaris</i> - - - - -	77
Mansfield Formation - - 7, 9, 11, 12, 13, 15, 16, 17, 18, 20, 21, 23, 34, 53, 54, 55, 56, 58, 65, 66, 67, 72, 73, 74, 78, 79, 80, 84, 87	
<i>maximus</i> , <i>Laevigatosporites</i> - - - - -	77
<i>mediareticulatus</i> , <i>Dictyotriletes</i> - - - - -	84, pl. 6
<i>medius</i> , <i>Laevigatosporites</i> - - - - -	24, 26, 27, 28, 29, 30, 31, 32, 37, 78, 79, pl. 5
<i>Microreticulatisporites</i> - - - - -	43, 65, 66, 77
<i>fistulosus</i> - - - - -	64, 65
<i>fundatus</i> - - - - -	65
<i>lacunosus</i> - - - - -	64, 65
<i>microreticulatus</i> - - - - -	65, pl. 3
<i>microtuberosus</i> - - - - -	28, 30, 66, pl. 3
<i>nobilis</i> - - - - -	64, pl. 3
<i>reticulocingulum</i> - - - - -	83, 84
<i>reticulopunctatus</i> - - - - -	65, pl. 3
<i>spicatus</i> - - - - -	83
<i>spinulosus</i> - - - - -	83
<i>microreticulatus</i> , <i>Microreticulatisporites</i> - - - - -	65, pl. 3
<i>microreticulatus</i> , <i>Sporonites</i> - - - - -	65
<i>microsaetosus</i> , <i>Lophotriletes</i> - - - - -	29, 63, pl. 3
<i>microsaetosus</i> , <i>Sporonites</i> - - - - -	63
<i>Microsporites</i> - - - - -	42
<i>microtuberosus</i> , <i>Microreticulatisporites</i> - - - - -	28, 30, 66, pl. 3
<i>minimus</i> , <i>Laevigatosporites</i> - 24, 26, 27, 28, 29, 30, 31, 32, 78, 79, pl. 5	
<i>minor</i> , <i>Laevigatosporites vulgaris</i> - - - - -	78, 79
Minshall Coal - - 7, 11, 12, 13, 14, 15, 16, 17, 21, 22, 23, 29, 30, 31, 32, 33, 34, 35, 36, 37, 50, 51, 53, 54, 55, 56, 57, 59, 63, 64, 66, 67, 69, 70, 72, 73, 74, 79, 80, 84, 85	
Minshall Limestone Member - - - - -	11
<i>minutus</i> , <i>Endosporites</i> - - - - -	50
<i>minutus</i> , <i>Leiotriletes</i> - - - - -	58
Monocolpates - - - - -	40
Monoletes - - - - -	39

## M--Continued

<i>Monoletes</i> - - - - -	39
<i>Monosaccites</i> - - - - -	40
<i>multipectica, Raistrickia</i> - - - - -	85
<i>mundus, Punctatisporites</i> - - - - -	67, pl. 4
<i>muricatus, Reticulatisporites</i> - - - - -	82
<i>Murornati</i> - - - - -	40, 62
<i>Mystic Coal</i> - - - - -	36

## N

<i>No. 2 (Colchester) Coal</i> - - - - -	35
<i>nobilis, Microreticulatisporites</i> - - - - -	64, pl. 3

## O

<i>obesus, Laevigati-sporites</i> - - - - -	69
<i>obesus, Punctatisporites</i> - - - - -	69, pl. 4
<i>obliquus, Punctatisporites</i> - - - - -	28, 68, pl. 4
<i>orbicularis, Punctatisporites</i> - - - - -	66, 67
<i>ornatus, Endosporites</i> - - - - -	24, 26, 29, 31, 32, 37, 53, 54, pl. 2
<i>ovalis, Laevigatosporites</i> - - - - -	24, 26, 27, 28, 29, 30, 31, 32, 77, 79, pl. 5

## P

<i>pallida, Calamospora</i> - - - - -	24, 26, 29, 31, 32, 70, pl. 4
<i>pallidus, Granulatisporites</i> - - - - -	29, 60, pl. 3
<i>pallidus, Sporonites</i> - - - - -	70
<i>papillosus, Pustulatisporites</i> - - - - -	74
<i>papillosus, Triquitrites</i> - - - - -	74
<i>Parasporites</i> - - - - -	39
<i>parva, Calamospora</i> - - - - -	8, 70, pl. 4
<i>parva, Lycospora</i> - - - - -	24, 26, 27, 28, 29, 31, 32, 48, 49, pl. 1
<i>parvus, Endosporites</i> - - - - -	8, 50, pl. 1
<i>parvus, Granulatisporites</i> - - - - -	60
<i>parvus, Leiotriletes</i> - - - - -	8, 29, 57, pl. 2
<i>pellucida, Lycospora</i> - - - - -	48
<i>pellucidus, Endosporites</i> - - - - -	24, 26, 28, 29, 30, 31, 32, 37, 50, 52, 54, pl. 1
<i>pellucidus, Leiotriletes</i> - - - - -	58
<i>Pennsylvanian System</i> - - - - -	7, 9
<i>Phaseolites desmoinensis</i> - - - - -	78
<i>pineatus, Apiculatisporites</i> - - - - -	62, pl. 3
<i>Pinnick coal</i> - - - - -	7, 11, 18, 19, 20, 34, 72
<i>Planisporites</i> - - - - -	42, 43, 59, 60, 66, 68
<i>Pollenites</i> - - - - -	39, 40
<i>Polysaccites</i> - - - - -	40
<i>Pottsville Series</i> - - - - -	7, 9, 11, 48, 49, 50, 51, 53, 54, 55, 56, 58, 59, 61, 62, 65, 67, 68, 69, 70, 71, 72, 74, 75, 76, 78, 79, 80, 85, 87
<i>pottsvillensis, Alatisporites</i> - - - - -	8, 86, pl. 6
<i>Precolpates</i> - - - - -	40
<i>priddy, Leiotriletes</i> - - - - -	57, 58, pl. 2
<i>protensus, Triquitrites</i> - - - - -	76

## P--Continued

<i>provectus</i> , <i>Punctatisporites</i> - - - - -	24, 29, 66, pl. 4
<i>pseudoannulata</i> , <i>Lycospora</i> - - - - -	26, 47, 48, pl. 1
<i>pseudoelevatus</i> , <i>Punctatisporites</i> - - - - -	68
<i>pulvinatus</i> , <i>Triquitrites</i> - - - - -	75
<i>punctata</i> , <i>Lycospora</i> - - - - -	26, 27, 29, 30, 31, 32, 37, 48, pl. 1
<i>Punctatasporites</i> - - - - -	42, 80
<i>Punctatisporites</i> - 19, 20, 24, 25, 26, 27, 30, 31, 32, 33, 34, 42, 43, 61, 62, 65, 66, 67, 68, 69, 70, 80	
<i>mundus</i> - - - - -	67, pl. 4
<i>obesus</i> - - - - -	69, pl. 4
<i>obliquus</i> - - - - -	28, 68, pl. 4
<i>orbicularis</i> - - - - -	66, 67
<i>provectus</i> - - - - -	24, 29, 66, pl. 4
<i>pseudoelevatus</i> - - - - -	68
<i>punctatus</i> - - - - -	67, 69, pl. 4
<i>stramineus</i> - - - - -	68, pl. 4
<i>sulcatus</i> - - - - -	61
<i>vagus</i> - - - - -	67
<i>Punctatosporites</i> - - - - -	43, 78, 80
<i>punctatus</i> , <i>Laevigatosporites</i> - - - - -	28, 78
<i>punctatus</i> , <i>Punctatisporites</i> - - - - -	67, 69, pl. 4
<i>punctatus</i> , <i>Sporonites</i> - - - - -	68
<i>pusilla</i> , <i>Lycospora</i> - - - - -	26, 28, 32, 37, 48, 49, pl. 1
<i>Pustulatisporites</i> - - - - -	43, 74
<i>crenatus</i> - - - - -	8, 63, pl. 3
<i>papillosus</i> - - - - -	74
<i>pustulatus</i> - - - - -	64
<i>pustulatus</i> , <i>Pustulatisporites</i> - - - - -	64

## R

<i>Raistrickia</i> - - - - -	19, 20, 25, 33, 34, 43, 85
<i>aculeolata</i> - - - - -	85, pl. 6
<i>multipectica</i> - - - - -	85
<i>superba</i> - - - - -	85, pl. 6
<i>Reinschospora</i> - - - - -	19, 20, 25, 33
<i>Reticulatasporites</i> - - - - -	44
<i>Reticulatisporites</i> - 19, 20, 25, 27, 30, 33, 34, 39, 43, 44, 81, 83, 84	
<i>annulatus</i> - - - - -	8, 81, pl. 6
<i>areolatus</i> - - - - -	8, 83, pl. 6
<i>evolvens</i> - - - - -	82
<i>muricatus</i> - - - - -	82
<i>reticulatus</i> - - - - -	82, pl. 6
<i>reticuliformis</i> - - - - -	82
<i>trigonus</i> - - - - -	77
<i>velatus</i> - - - - -	82



## R--Continued

<i>reticulatus</i> , <i>Azonotriteles</i> - - - - -	82
<i>reticulatus</i> , <i>Reticulatisporites</i> - - - - -	82, pl. 6
<i>reticuliformis</i> , <i>Reticulatisporites</i> - - - - -	82
<i>reticulocingulum</i> , <i>Microreticulatisporites</i> - - - - -	83, 84
<i>reticulopunctatus</i> , <i>Microreticulatisporites</i> - - - - -	65, pl. 3
Reynoldsburg Coal - - - - -	7, 34
<i>reynoldsburgensis</i> , <i>Densosporites</i> - - - - -	26, 27, 72, pl. 4
Rock Island Coal - - - - -	7, 35
<i>rotatus</i> , <i>Cirratriletes</i> - - - - -	44, 45
<i>rotundus</i> , <i>Endosporites</i> - - - - -	24, 26, 27, 28, 29, 30, 31, 52, 54, 55, pl. 2
<i>rugosa</i> , <i>Lycospora</i> - - - - -	50
<i>ruhus</i> , <i>Densosporites</i> - - - - -	71

## S

Saccites - - - - -	40
<i>saturni</i> , <i>Cirratriletes</i> - - - - -	46, pl. 1
<i>saturni</i> , <i>Zonales-sporites</i> - - - - -	46, 47
<i>Schopfites</i> - - - - -	19, 20, 25, 33
<i>Schulzospora</i> - - - - -	19, 20, 25, 33, 34, 44
<i>sculptilis</i> , <i>Triquitrites</i> - - - - -	77, pl. 5
<i>Setosi-sporites</i> - - - - -	63
Seville Coal - - - - -	7
Shady Lane Coal - - - - -	11, 20, 21, 34
Shoals coal - - - - -	11, 18, 19, 20, 34, 72
<i>sinuosus</i> , <i>Densosporites</i> - - - - -	71
<i>Speciososporites</i> - - - - -	43
<i>sphaerotriangulatus</i> , <i>Leiotriletes</i> - - - - -	58
<i>spicatus</i> , <i>Microreticulatisporites</i> - - - - -	83
<i>Spinoso-sporites</i> - - - - -	63
<i>spinosus</i> , <i>Triquitrites</i> - - - - -	74, pl. 5
<i>spinulosus</i> , <i>Microreticulatisporites</i> - - - - -	83
Sporites - - - - -	39, 40
<i>Sporites</i> - - - - -	39
Sporonites - - - - -	39, 40
<i>Sporonites</i> - - - - -	46
<i>deltoides</i> - - - - -	59
<i>formosus</i> - - - - -	46
<i>microreticulatus</i> - - - - -	65
<i>microsaetosus</i> - - - - -	63
<i>pallidus</i> - - - - -	70
<i>punctatus</i> - - - - -	68
Staunton Formation - - - - -	12, 14, 17, 32, 33, 34, 35, 79
<i>stramineus</i> , <i>Punctatisporites</i> - - - - -	68, pl. 4
<i>submarginata</i> , <i>Lycospora</i> - - - - -	48
<i>subtriquetra</i> , <i>Lycospora</i> - - - - -	50
<i>sulcatus</i> , <i>Conv verrucosisporites</i> - - - - -	32, 61, pl. 3

	Page
S--Continued	
<i>sulcatus</i> , <i>Punctatisporites</i> - - - - -	61
<i>superba</i> , <i>Raistrickia</i> - - - - -	85, pl. 6
T	
Tarter Coal - - - - -	7, 35
<i>tenuis</i> , <i>Cirratiradites</i> - - - - -	45
<i>torquifer</i> , <i>Lycospora</i> - - - - -	50
Tradewater Formation - - - - -	49
<i>Triangulati</i> - - - - -	39
<i>trigonus</i> , <i>Reticulatisporites</i> - - - - -	77
<i>Triletes</i> - - - - -	38, 39, 40
<i>Triletes</i> - - - - -	38, 39
<i>auritus grandis</i> - - - - -	38
<i>glabratus</i> - - - - -	38
<i>Triquitrites</i> - 19, 20, 25, 32, 33, 34, 35, 44, 59, 60, 73, 74, 75, 76, 77	75, pl. 5
<i>additus</i> - - - - -	75, pl. 5
<i>bransonii</i> - - - - -	31, 32, 37, 75, pl. 5
<i>bucculentus</i> - - - - -	8, 73, pl. 5
<i>crassus</i> - - - - -	74
<i>desperatus</i> - - - - -	76, pl. 5
<i>dividuus</i> - - - - -	74, pl. 5
<i>exiguus</i> - - - - -	75, pl. 5
<i>papillosus</i> - - - - -	74
<i>protensus</i> - - - - -	76
<i>pulvinatus</i> - - - - -	75
<i>sculptilis</i> - - - - -	77, pl. 5
<i>spinosus</i> - - - - -	74, pl. 5
<i>triturgidus</i> - - - - -	75
<i>truncatus</i> - - - - -	76
<i>triturgidus</i> , <i>Triquitrites</i> - - - - -	75
<i>truncatus</i> , <i>Triquitrites</i> - - - - -	76
<i>Tuberculatisporites</i> - - - - -	66
<i>Tuberculatosporites</i> - - - - -	43
U	
Upper Block a zone - 7, 11, 12, 13, 14, 15, 17, 22, 23, 25, 27, 28, 29,	30, 34, 35, 44, 45, 53, 56, 59, 61, 68, 76, 80, 82, 83, 84
Upper Block b zone - 7, 11, 12, 14, 15, 16, 17, 23, 25, 28, 34, 46, 50,	52, 57, 59, 60, 61, 63, 64, 69, 70, 73, 77, 82, 84, 85
Upper Block c zone - 7, 11, 12, 13, 15, 16, 17, 22, 23, 25, 28, 29, 30,	34, 48, 50, 57, 59, 62, 63, 64, 65, 66, 69, 70, 76, 80, 82, 84
Upper Block Coal - - - - -	7, 21, 23, 29, 30, 35, 67, 73, 77, 79, 82
V	
<i>vagus</i> , <i>Punctatisporites</i> - - - - -	67
<i>velatus</i> , <i>Reticulatisporites</i> - - - - -	82
<i>venusta</i> , <i>Lycospora</i> - - - - -	84

## Page

## V--Continued

<i>Verrucosisporites</i> - - - - -	43, 61
<i>gibbosus</i> - - - - -	62
<i>Verrucosporites</i> - - - - -	43, 62
<i>verrucosus</i> , <i>Granulatisporites</i> - - - - -	29, 59, pl. 3
<i>vesicatus</i> , <i>Endosporites</i> - - - - -	53
<i>vulgaris</i> , <i>Laevigatosporites</i> - - - - -	77, 78
<i>vulgaris major</i> , <i>Laevigatosporites</i> - - - - -	77
<i>vulgaris minor</i> , <i>Laevigatosporites</i> - - - - -	78, 79

## W

Wiley Coal - - - - -	35
Willis Coal - - - - -	7, 35
<i>Wilsonia</i> - - - - -	51, 52

## Z

Zonales - - - - -	38, 40
<i>Zonales-sporites</i> - - - - -	46
<i>annulatus</i> - - - - -	72
<i>loricatus</i> - - - - -	72
<i>saturni</i> - - - - -	46, 47
Zonaletes - - - - -	40
<i>Zonaletes</i> - - - - -	39
<i>zonalis</i> , <i>Endosporites</i> - - - - -	53
Zonati - - - - -	40
Zonomonoletes - - - - -	40
Zonotriletes - - - - -	40
<i>Zonotriletes</i> - - - - -	39





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PLATES 1-6

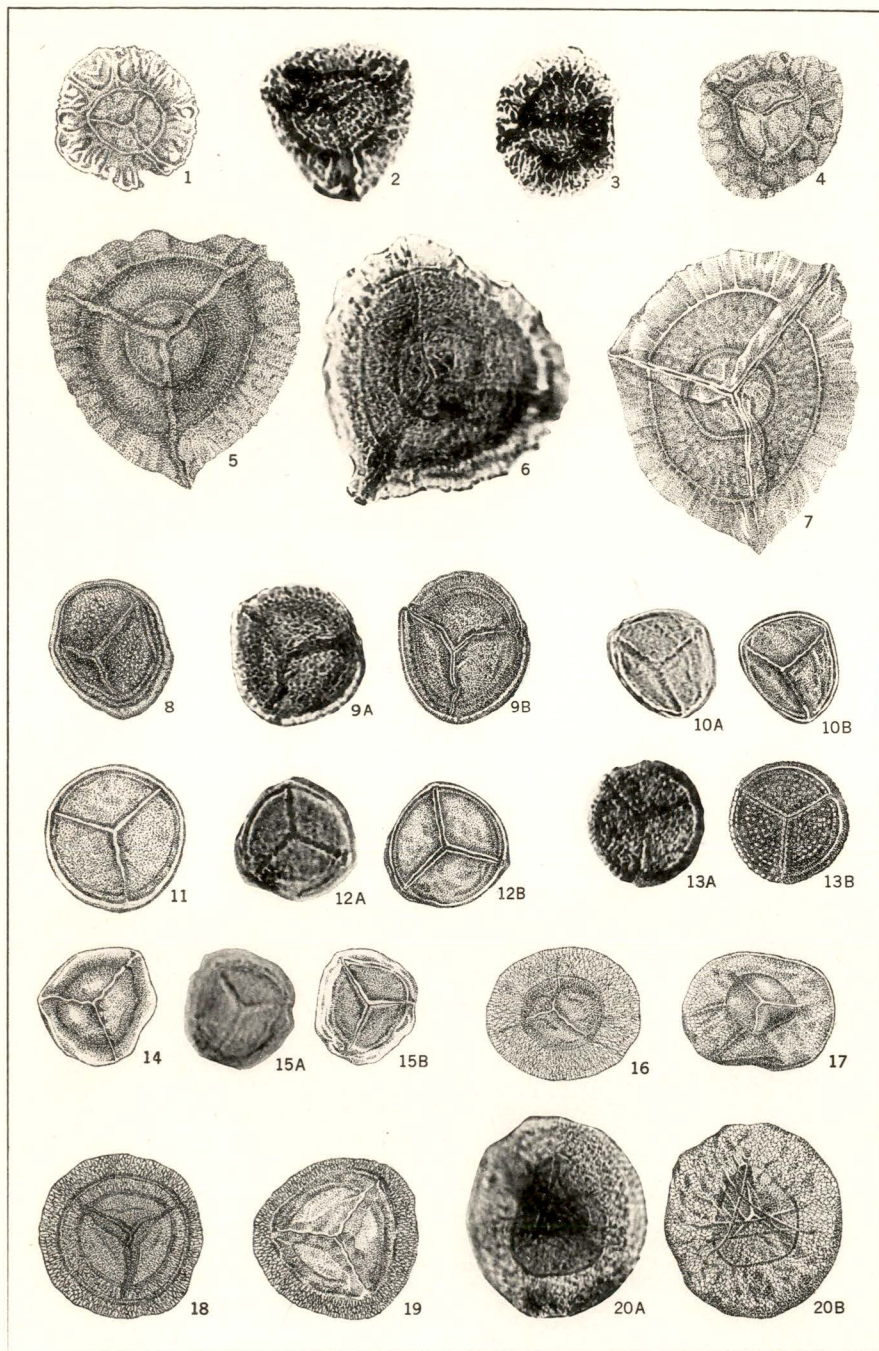
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PLATE 1  
(Magnification is 500X)

- Figures 1-4. *Cirratriradites arcuatus* sp. nov. (p. 44).  
1. (paratype), drawing, slide 2511, sample 24a.  
2. (paratype), photomicrograph, slide 2513, sample 24a.  
3. (paratype), photomicrograph, slide 2511, sample 24a.  
4. (paratype), drawing, slide 2515, sample 24a.
- 5-6. *Cirratriradites foveatus* sp. nov. (p. 45).  
5. (paratype), drawing, slide 3115, sample 59.  
6. (paratype), photomicrograph, slide 2901, sample 61a.
7. *Cirratriradites saturni* (Ibr.) S. W. and B., 1944. (p. 46).  
drawing, slide 2872, sample 62.
- 8-9. *Lycospora punctata* Kos., 1950. (p. 48).  
8. drawing, slide 5801, sample 85a.  
9A. photomicrograph, slide 959, sample 39.  
9B. drawing, slide 959, sample 39.
10. *Lycospora parva* Kos., 1950. (p. 48).  
10A. photomicrograph, slide 975, sample 31.  
10B. drawing, slide 975, sample 31.
- 11-12. *Lycospora pusilla* (Ibr.) S. W. and B., 1944. (p. 49).  
11. drawing, slide 753, sample 39.  
12A. photomicrograph, slide 974, sample 31.  
12B. drawing, slide 974, sample 31.
13. *Lycospora granulata* Kos., 1950. (p. 50).  
13A. photomicrograph, slide 952, sample 39.  
13B. drawing, slide 952, sample 39.
- 14-15. *Lycospora pseudoannulata* Kos., 1950. (p. 47).  
14. drawing, slide 975, sample 31.  
15A. photomicrograph, slide 963, sample 31.  
15B. drawing, slide 963, sample 31.
- 16-17. *Endosporites parvus* sp. nov. (p. 50).  
16. (paratype), drawing, slide 1105, sample 47.  
17. (paratype), drawing, slide 1105, sample 47.
- 18-19. *Endosporites circularis* sp. nov. (p. 51).  
18. (paratype), drawing, slide 974, sample 31.  
19. (paratype), drawing, slide 954, sample 39.
20. *Endosporites pellucidus* Wils. and Coe, 1940. (p. 52).  
20A. photomicrograph, slide 957, sample 39.  
20B. drawing, slide 957, sample 39.

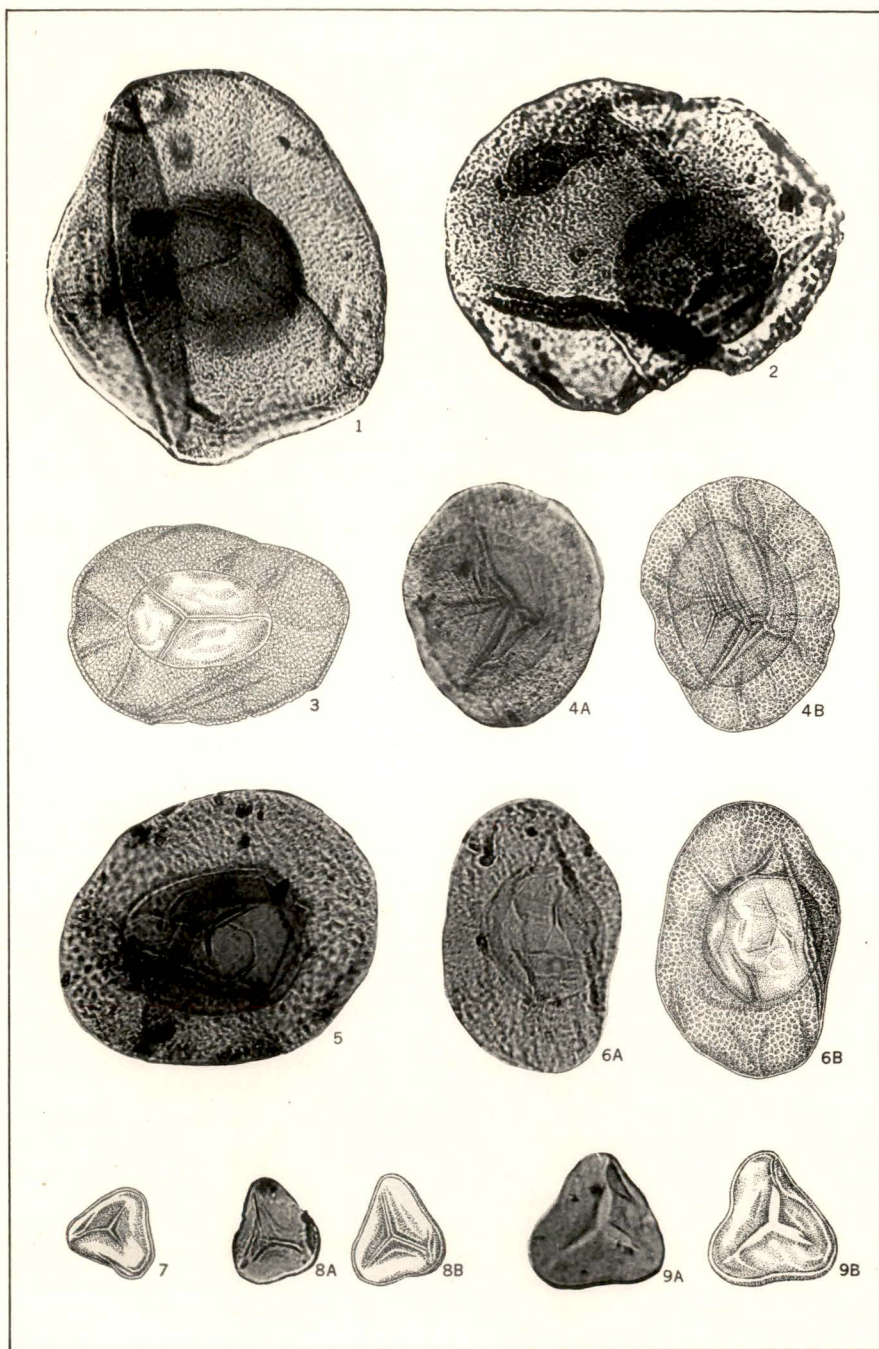




CIRRATRIRADITES, LYCOSPORA, AND ENDOSPORITES.

PLATE 2  
(Magnification is 500X)

- Figures
1. *Endosporites ornatus* Wils. and Coe, 1940. (p. 53).  
photomicrograph, slide 957, sample 39.
  2. *Endosporites formosus* Kos., 1950. (p. 53).  
photomicrograph, slide 952, sample 39.
  3. *Endosporites rotundus* (Ibr.) S. W. and B., 1944. (p. 54).  
drawing, slide 951, sample 39.
  4. *Endosporites breviradiatus* sp. nov. (p. 54).  
4A. (paratype), photomicrograph, slide 952, sample 39.  
4B. (paratype), drawing, slide 952, sample 39.
  5. *Guthoerlisporites magnificus* Bhardw., 1954. (p. 56).  
photomicrograph, slide 956, sample 39.
  6. *Florinites antiquus* S. W. and B., 1944. (p. 56).  
6A. photomicrograph, slide 956, sample 39.  
6B. drawing, slide 956, sample 39.
  - 7-8. *Leiotriletes parvus* sp. nov. (p. 57).  
7. (paratype), drawing, slide 1105, sample 47.  
8A. (paratype), photomicrograph, slide 975, sample 31.  
8B. (paratype), drawing, slide 975, sample 31.
  9. *Leiotriletes priddyi* (Berry) Pot. and Kremp, 1955. (p. 58).  
9A. photomicrograph, slide 971, sample 31.  
9B. drawing, slide 971, sample 31.

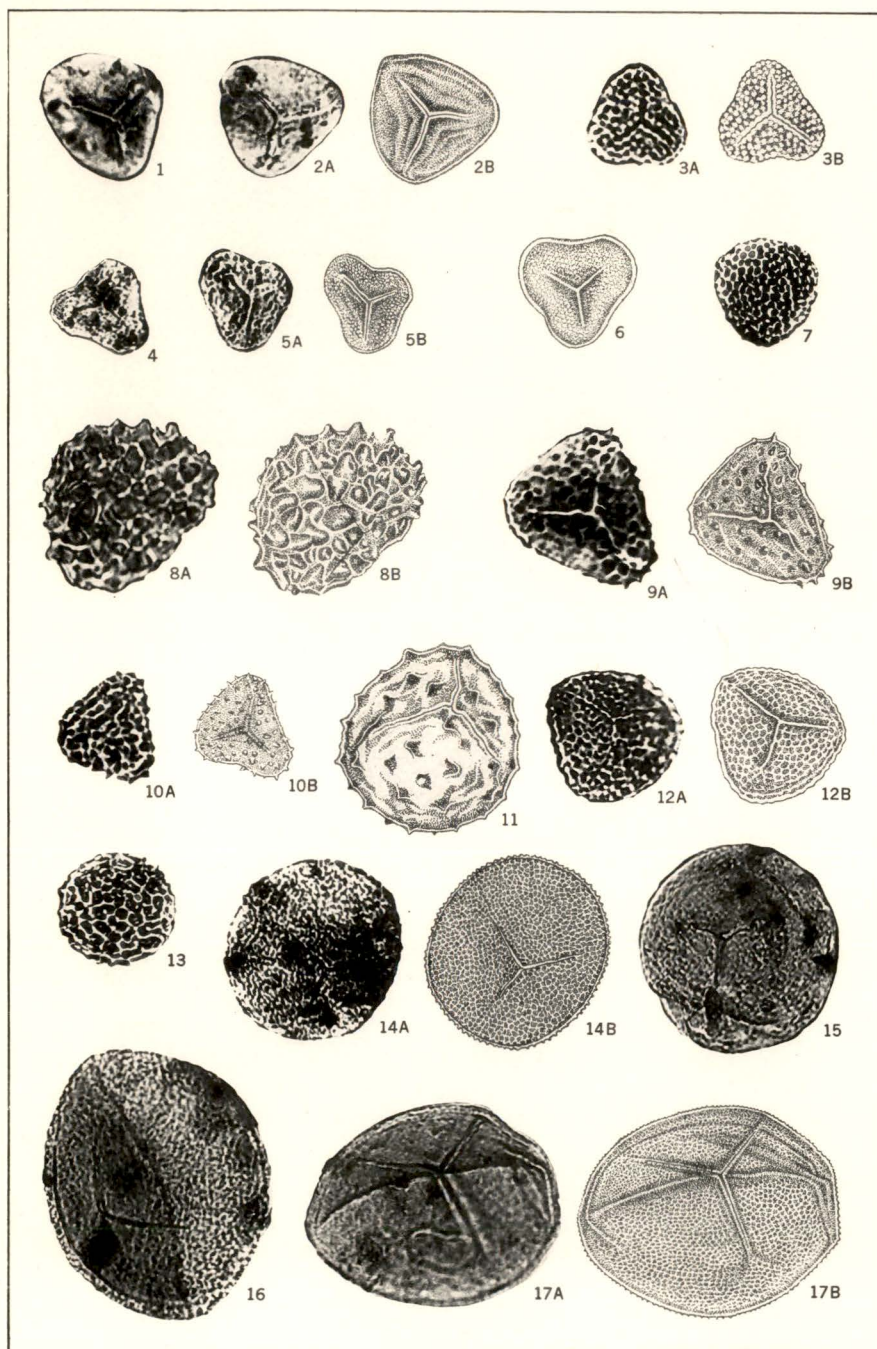


ENDOSPORITES, GUTHOERLISPORITES, FLORINITES, AND LEIOTRILETES.



PLATE 3  
(Magnification is 500X)

- Figures 1-2. *Leiotriletes inflatus* (Schem.) Pot. and Kremp, 1955. (p. 58).  
1. photomicrograph, slide 752, sample 53.  
2A. photomicrograph, slide 1126, sample 42.  
2B. drawing, slide 1126, sample 42.
3. *Granulatisporites verrucosus* (Wils. and Coe) S. W. and B., 1944. (p. 59).  
3A. photomicrograph, slide 967, sample 31.  
3B. drawing, slide 967, sample 31.
- 4-5. *Granulatisporites deltiformis* (Wils. and Coe) S. W. and B., 1944. (p. 59).  
4. photomicrograph, slide 752, sample 53.  
5A. photomicrograph, slide 851, sample 45.  
5B. drawing, slide 851, sample 45.
6. *Granulatisporites pallidus* Kos., 1950. (p. 60).  
drawing, slide 1105, sample 47.
7. *Converrucosisporites sulcatus* (Wils. and Kos.) Pot. and Kremp, 1955. (p. 61).  
photomicrograph, slide 969, sample 31.
8. *Apiculatisporites pineatus* H. S. and M., 1955. (p. 62).  
8A. photomicrograph, slide 969, sample 31.  
8B. drawing, slide 969, sample 31.
9. *Lophotriletes gibbosus* (Ibr.) Pot. and Kremp, 1954. (p. 62).  
9A. photomicrograph, slide 4102, sample 66.  
9B. drawing, slide 4102, sample 66.
10. *Lophotriletes microsaetosus* (Loose) Pot. and Kremp, 1955. (p. 63).  
10A. photomicrograph, slide 852, sample 45.  
10B. drawing, slide 852, sample 45.
11. *Pustulatisporites crenatus* sp. nov. (p. 63).  
(paratype), drawing, slide 966, sample 31.
12. *Microreticulatisporites nobilis* (Wicher) Knox, 1950. (p. 64).  
12A. photomicrograph, slide 3828, sample 55.  
12B. drawing, slide 3828, sample 55.
13. *Microreticulatisporites microreticulatus* Knox, 1950. (p. 65).  
photomicrograph, slide 3114, sample 59.
- 14-15. *Microreticulatisporites reticulopunctatus* (H. S. and M.) nov. comb. (p. 65).  
14A. photomicrograph, slide 890, sample 51.  
14B. drawing, slide 890, sample 51.  
15. photomicrograph, slide 966, sample 31.
- 16-17. *Microreticulatisporites microtuberosus* (Loose) Pot. and Kremp, 1955. (p. 66).  
16. photomicrograph, slide 3116, sample 59.  
17A. photomicrograph, slide 973, sample 31.  
17B. drawing, slide 973, sample 31.

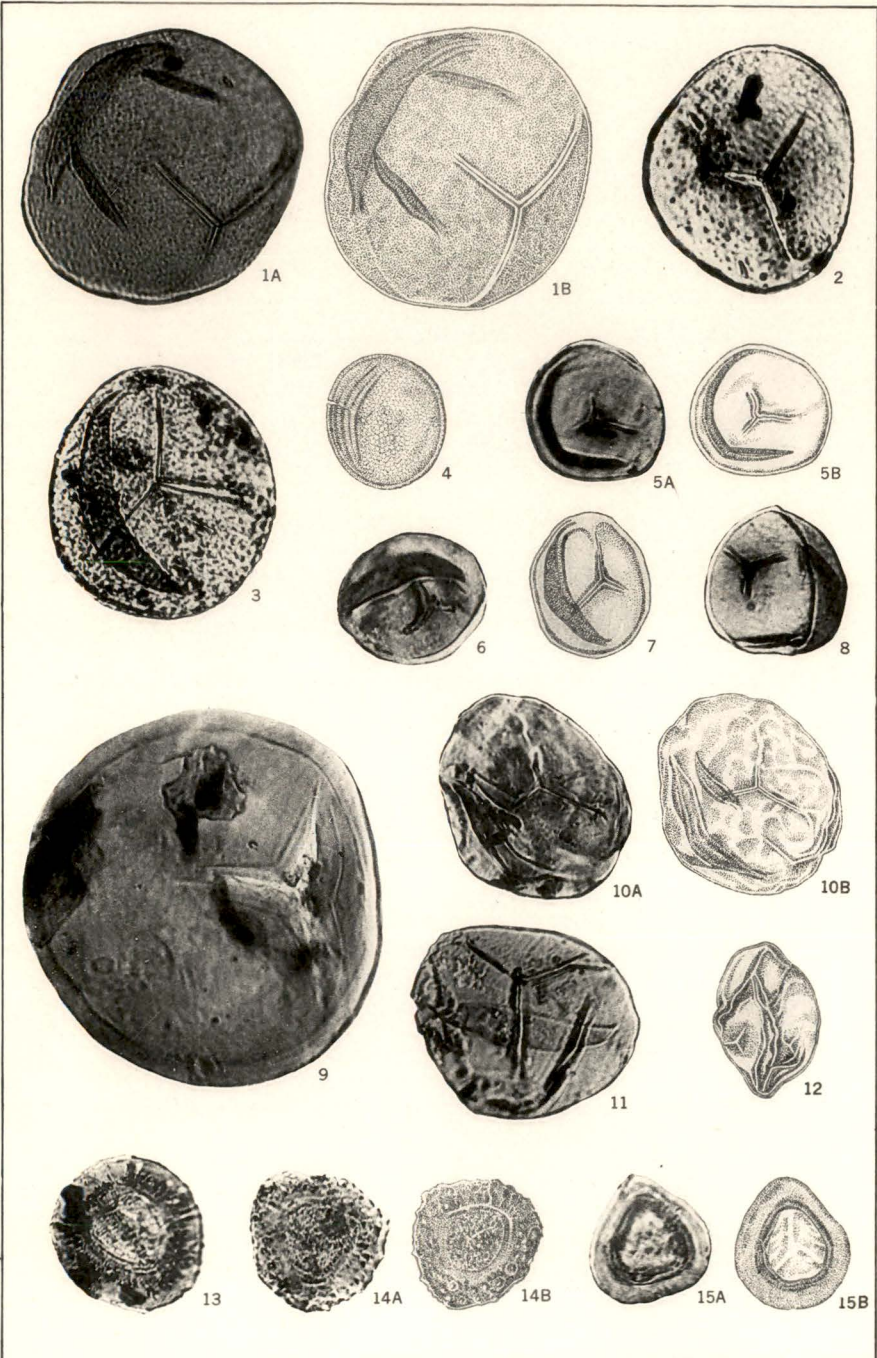


LEIOTRILETES, GRANULATISPORITES, CONVERRUCOSISPORITES,  
APICULATISPORITES, LOPHOTRILETES, PUSTULATISPORITES, AND  
MICRORETICULATISPORITES.

PLATE 4  
(Magnification is 500X)

- Figures
1. *Punctatisporites provectus* Kos., 1950. (p. 66).
    - 1A. photomicrograph, slide 4104, sample 66.
    - 1B. drawing, slide 4104, sample 66.
  2. *Punctatisporites* cf. *mundus* Kos., 1950. (p. 67).
    - photomicrograph, slide 965, sample 31.
  3. *Punctatisporites punctatus* Ibr., 1933. (p. 67).
    - photomicrograph, slide 1977, sample 30.
  4. *Punctatisporites obliquus* Kos., 1950. (p. 68).
    - drawing, slide 2026, sample 29.
  - 5-8. *Punctatisporites stramineus* (Wils. and Kos.) nov. comb. (p. 68).
    - 5A. photomicrograph, slide 952, sample 39.
    - 5B. drawing, slide 952, sample 39.
    6. photomicrograph, slide 954, sample 39.
    7. drawing, slide 3026, sample 32.
    8. photomicrograph, slide 958, sample 39.
  9. *Punctatisporites* cf. *obesus* (Loose) Pot. and Kremp, 1955. (p. 69).
    - photomicrograph, slide 851, sample 45.
  - 10-11. *Calamospora pallida* (Loose) S. W. and B., 1944. (p. 70).
    - 10A. photomicrograph, slide 3564, sample 26.
    - 10B. drawing, slide 3564, sample 26.
    11. photomicrograph, slide 4105, sample 66.
  12. *Calamospora parva* sp. nov. (p. 70).
    - (paratype), drawing, slide 4105, sample 66.
  - 13-14. *Densosporites lobatus* Kos., 1950. (p. 71).
    13. photomicrograph, slide 2520, sample 24a.
    - 14A. photomicrograph, slide 2522, sample 24a.
    - 14B. drawing, slide 2522, sample 24a.
  15. *Densosporites reynoldsburgensis* Kos., 1950. (p. 72).
    - 15A. photomicrograph, slide 377, sample 84.
    - 15B. drawing, slide 377, sample 84.





PUNCTATISPORITES, CALAMOSPORA, AND DENSOSPORITES.

PLATE 5  
(Magnification is 500X)

- Figures 1-2. *Triquitrites bucculentus* sp. nov. (p. 73).  
1. (paratype), drawing, slide 1101, sample 47.  
2. (paratype), photomicrograph, slide 852, sample 45.
3. *Triquitrites spinosus* Kos., 1943. (p. 74).  
3A. photomicrograph, slide 959, sample 39.  
3B. drawing, slide 959, sample 39.
4. *Triquitrites dividuus* Wils. and Hoffm., 1956. (p. 74).  
photomicrograph, slide 3827, sample 55.
5. *Triquitrites additus* Wils. and Hoffm., 1956. (p. 75).  
5A. photomicrograph, slide 851, sample 45.  
5B. drawing, slide 851, sample 45.
- 6-7. *Triquitrites exiguus* Wils. and Kos., 1944. (p. 75).  
6. photomicrograph, slide 3702, sample 5a.  
7A. photomicrograph, slide 965, sample 31.  
7B. drawing, slide 965, sample 31.
- 8-9. *Triquitrites bransonii* Wils. and Hoffm., 1956. (p. 75).  
8. photomicrograph, slide 975, sample 31.  
9A. photomicrograph, slide 965, sample 31.  
9B. drawing, slide 965, sample 31.
10. *Triquitrites desperatus* Pot. and Kremp, 1955. (p. 76).  
10A. photomicrograph, slide 852, sample 45.  
10B. drawing, slide 852, sample 45.
11. *Triquitrites sculptilis* Balme, 1952. (p. 77).  
11A. photomicrograph, slide 852, sample 45.  
11B. drawing, slide 852, sample 45.
- 12-14. *Laevigatosporites ovalis* Kos., 1950. (p. 77).  
12. photomicrograph, slide 969, sample 31.  
13. photomicrograph, slide 4106, sample 66.  
14. photomicrograph, slide 975, sample 31.
- 15-16. *Laevigatosporites medius* Kos., 1950. (p. 78).  
15. photomicrograph, slide 974, sample 31.  
16. photomicrograph, slide 965, sample 31.
17. *Laevigatosporites minimus* (Wils. and Coe) S. W. and B.,  
1944. (p. 79).  
drawing, slide 765, sample 54.
18. *Laevigatosporites desmoinensis* (Wils. and Coe)  
S. W. and B., 1944. (p. 79).  
photomicrograph, slide 956, sample 39.
19. *Latosporites globosus* (Schem.) Pot. and Kremp, 1956. (p. 80).  
drawing, slide 2303, sample 29.
20. *Latosporites latus* (Kos.) Pot. and Kremp, 1954. (p. 80).  
photomicrograph, slide 956, sample 39.



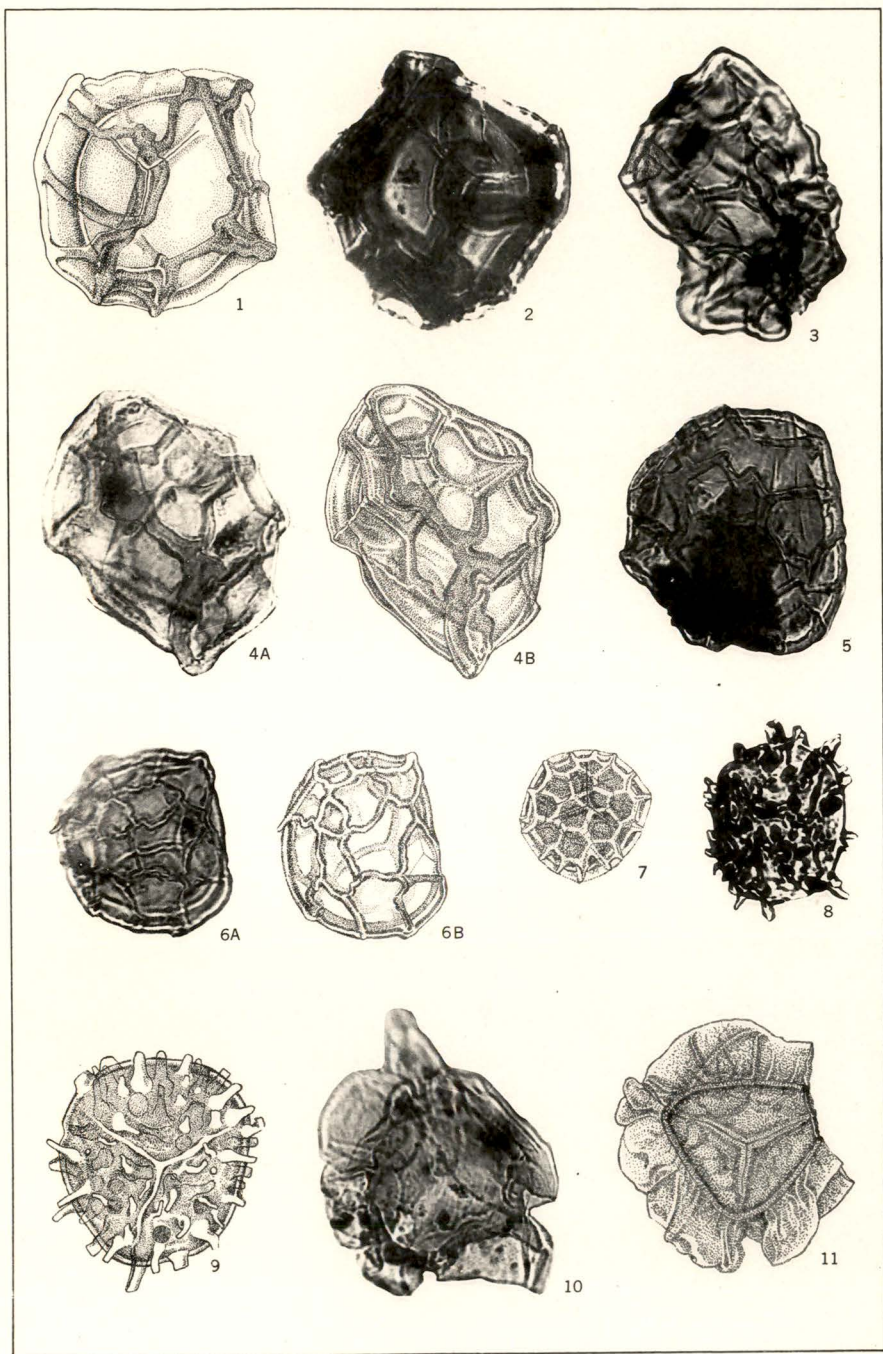


TRIQUITRITES, LAEVIGATOSPORITES, AND LATOSPORITES.



PLATE 6  
(Magnification is 500X)

- Figures 1-2. *Reticulatisporites annulatus* sp. nov. (p. 81).  
1. (paratype), drawing, slide 1105, sample 47.  
2. (paratype), photomicrograph, slide 1105, sample 47.
- 3-4. *Reticulatisporites reticulatus* Ibr., 1933. (p. 82).  
3. photomicrograph, slide 5489, sample 83.  
4A. photomicrograph, slide 3563, sample 26.  
4B. drawing, slide 3563, sample 26.
- 5-6. *Dictyotriletes mediareticulatus* (Ibr.) Pot. and Kremp,  
1954. (p. 84).  
5. photomicrograph, slide 890, sample 51.  
6A. photomicrograph, slide 3972, sample 11.  
6B. drawing, slide 3972, sample 11.
7. *Reticulatisporites areolatus* sp. nov. (p. 83).  
(paratype), drawing, slide 2929, sample 40.
8. *Raistrickia aculeolata* Wils. and Kos., 1944. (p. 85).  
photomicrograph, slide 974, sample 31.
9. *Raistrickia superba* (Ibr.) S. W. and B., 1944. (p. 85).  
drawing, slide 1128, sample 42.
- 10-11. *Alatisporites pottsvillensis* sp. nov. (p. 86).  
10. (paratype), photomicrograph, slide 2503, sample 24a.  
11. (paratype), drawing, slide 3026, sample 32.



RETICULATISPORITES, DICTYOTRILETES, RAISTRICKIA, AND  
ALATISPORITES.







