

**BUREAU OF ECONOMIC GEOLOGY**  
**The University of Texas at Austin**  
**Austin, Texas**

**Peter T. Flawn, Director**

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**Report of Investigations — No. 64**

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**Palynology of the Eddleman Coal**  
**(Pennsylvanian)**  
**of North-Central Texas**

**By**

**J. FRED STONE**



**December 1969**

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# Palynology of the Eddleman Coal (Pennsylvanian) of North-Central Texas

J. Fred Stone<sup>1</sup>

## ABSTRACT

The Eddleman Coal (Thrifty Formation, Cisco Group) in Young County, Texas, yielded a spore and pollen flora which was classified into 37 genera and 65 species. Ten species are regarded as new and are assigned to existing genera. A single new species is described and placed within a new genus. New taxa are named and described in accordance with the rules of the International Code of Botanical Nomenclature (1961). On the basis of the contained palynomorphs, the Eddleman Coal at the type locality is divisible into a lower and upper portion with the upper portion being distinguished by an increased abundance of the monosaccate genus *Florinites*. The chi-square test is used as a means of comparing samples

from different localities. No statistically significant correlations are attainable between the samples tested.

The flora substantiates the Virgilian age of the Eddleman Coal. The flora has 11 genera and 20 species in common with the microflora of the McLeansboro Group (Illinois Basin) as described by Kosanke (1950) and 22 genera and 18 species in common with the McLeansboro microflora as described by Peppers (1964). The Upper McLeansboro Group is in part Virgilian in age. The species *Columinisporites pepperi* Stone, sp. nov., *Crassispora plicata*, *Calamospora pusilla*, and *Latipulvinites kosankii* have been reported only from the Upper McLeansboro, and they are present in the Eddleman Coal.

## INTRODUCTION

No previously published accounts of palynological investigations of rocks of the Virgilian Series (uppermost Pennsylvanian) of north-central Texas are known. Jizba (1962) described bisaccate pollen grains from Virgilian rocks of Kansas. Kosanke (1950) and Peppers (1964) have described spores from formations of the McLeansboro Group in the Illinois Basin. The uppermost McLeansboro has been correlated with the Virgilian Series (Ko-

sanke, Simon, Wanless and Willman, 1960).

For contributions to this study, appreciation is expressed to Professor Edward Heuer, Department of Geology, Texas Christian University, to Mr. Robert L. Tabbert, Atlantic Richfield Company, and to Dr. R. M. Kosanke, United States Geological Survey. Dr. Russell Faulkner, Department of Biology, and Dr. Daniel Jarvis, Department of Geology, Texas Christian University, also contributed helpful suggestions.

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## STRATIGRAPHY

The Thrifty Formation is approximately 126 feet thick and is composed of the following members, in order from oldest to youngest: Avis Sandstone, unnamed shale, Ivan Limestone, unnamed shale, Blach Ranch Limestone, unnamed shale, and Breckenridge Limestone. The shale member between the Ivan Limestone and the Blach Ranch Limestone was sampled for this study. From the descriptions of various measured sections by Brown (1962), the upper few feet of this interval is a gray shale varying locally to light brown and olive green in color. It is calcareous and silty with abundant carbonaceous laminae and occasional ferruginous bands. At all outcrops of this shale interval observed, one or more thin coal beds were present at positions varying from a few inches to a few feet beneath the base of the lower limestone bed of the Blach Ranch Limestone. The coal bed or interbedded coal and shale just below the Blach Ranch Limestone is here designated the Eddleman Coal because of the proximity of productive localities to Lake Eddleman. The type locality for the Eddleman Coal is Locality 9 of this paper (figs. 1 and 3). The name Eddleman Coal is considered to be of an informal status in accordance with Article 8 of the Code of Stratigraphic Nomenclature (Amer. Comm. on Stratigraphic Nomenclature, 1961). Individual coal beds are usually thin but vary in thickness from 2 to 3 inches up to 17 inches. The coal is

impure, being very shaly, and where it reaches its greatest thickness it contains several platy shale partings. At the type locality (Locality 9, fig. 3) the coal attains a thickness of 17 inches. The thinness and lack of resistance to weathering of the Eddleman Coal preclude its being a rock unit which is mappable or even traceable between exposures; however, it is thought either to be a persistent and continuous coal bed or, and more likely, a rock unit of alternating shale and coal with the coal beds overlapping each other regionally in a "shingled" fashion. The presence of two thin coal beds at Locality 4 (fig. 2) suggests the latter possibility. The Eddleman Coal was sampled in Young and Stephens counties at Localities 4-9, 11, 14 where it occurs beneath the Blach Ranch Limestone. Farther north in Jack County the Blach Ranch Limestone is not present, but its rock-stratigraphic position is marked by a zone of abundant fossils (Brown, 1962). The Eddleman Coal is present beneath the fossil zone and samples were collected at Localities 1-3 in Jack County. Work by Terriere (1960) south of the Callahan Divide indicates that the Speck Mountain Limestone occupies the rock-stratigraphic position of the Blach Ranch Limestone. The coal bed beneath the Speck Mountain Limestone is considered to be the Eddleman Coal, and it was sampled at Localities 22-26 in Brown County (Stone, 1966).

## SAMPLE LOCALITIES

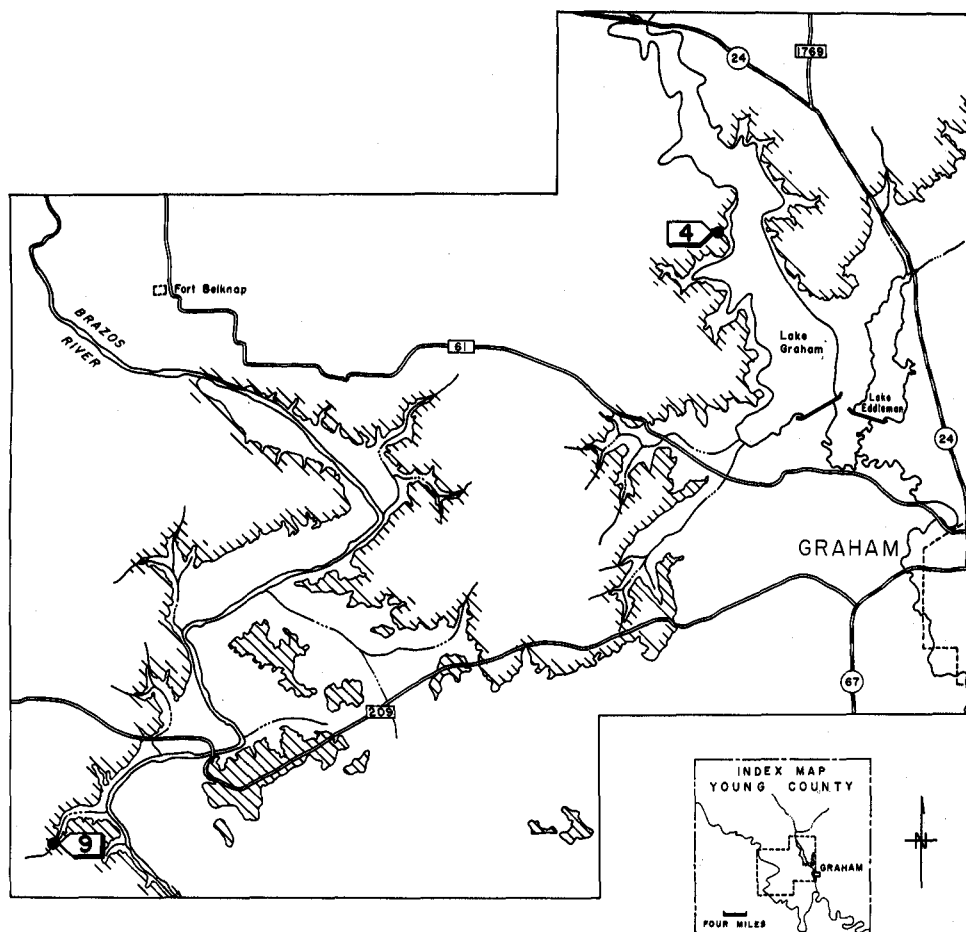
Samples were collected from shale, clay, and coal exposures at 26 localities in Brown, Eastland, Stephens, Palo Pinto, Young, and Jack counties, Texas. A total of 65 samples was processed for this study. Of this total, 14 samples from Localities 4 and 9 yielded a palynomorph assemblage which was amenable to identification. The samples from these two localities provide the basis for this study. The remainder of the samples have been considered previously (Stone, 1966).

Locality 4, from which samples 4A and 4B were taken, is situated in Young County, Texas (fig. 1). It is at the head of a gully along a dirt road about 0.4 mile south of a dead-end county road on the west side of Lake Graham only a few feet from the water's edge. Locality 4 is Meas-

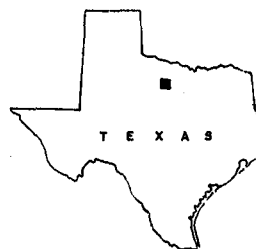
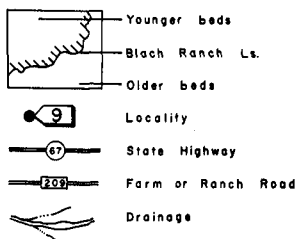
ured Section 11a of Brown (1962). The beds exposed at this outcrop and the intervals represented by samples 4A and 4B are shown in figure 4 (in pocket).

Locality 9, from which samples 9A-9K and composite sample 9L were taken, is also situated in Young County, Texas (fig. 1). The exposure is on the east bank of a small creek about 20 yards east of a county road approximately 0.1 mile south of a gentle curve in the county road. The locality is 1.5 miles south of Farm Road 209. The county road extends south from Farm Road 209 at a point 1.6 miles west of the bridge over the Brazos River west of Graham. Locality 9 is Measured Section 6 of Brown (1962). The beds exposed at this outcrop and the intervals represented by samples 9A-9K are illustrated in figure 3.





### LEGEND



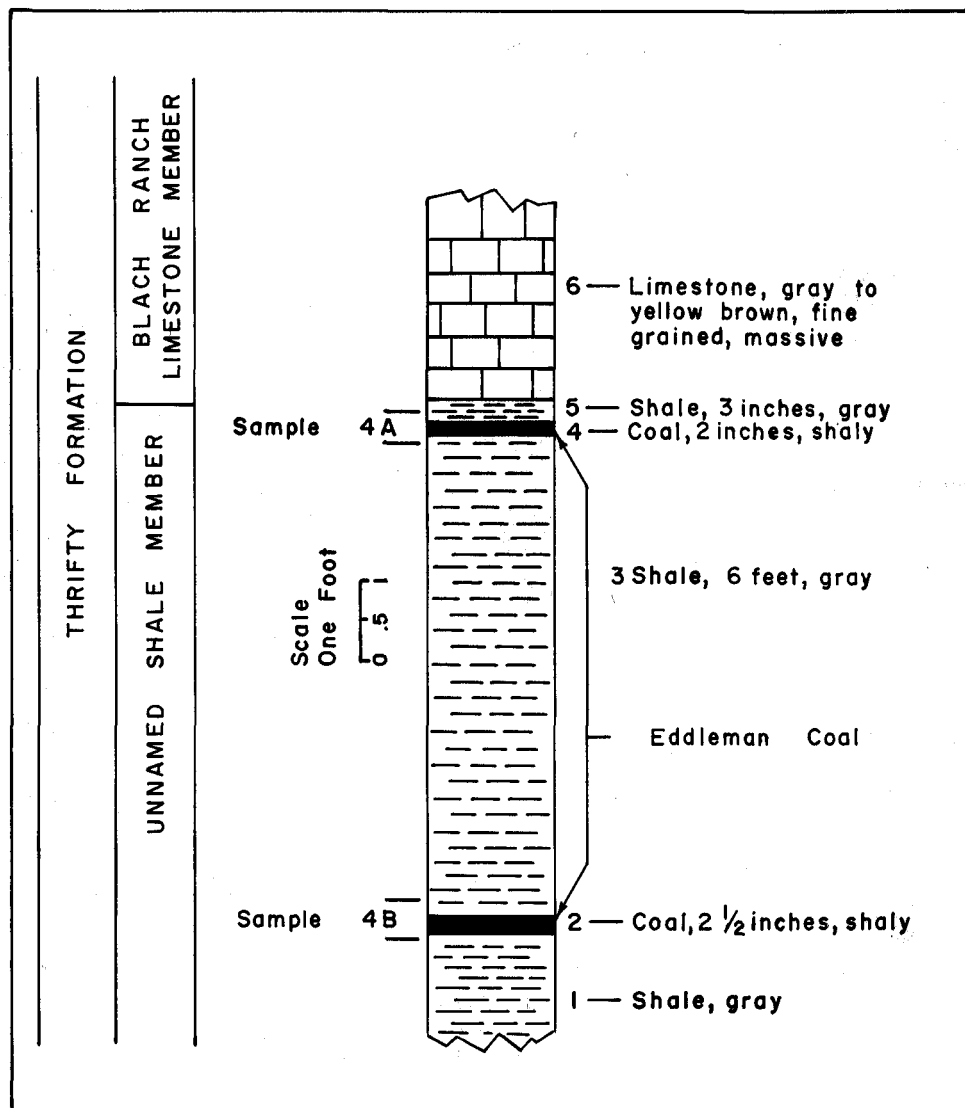


FIG. 2. Geologic section, Locality 4, Lake Graham, Young County, Texas. (In part after Brown, 1962.)

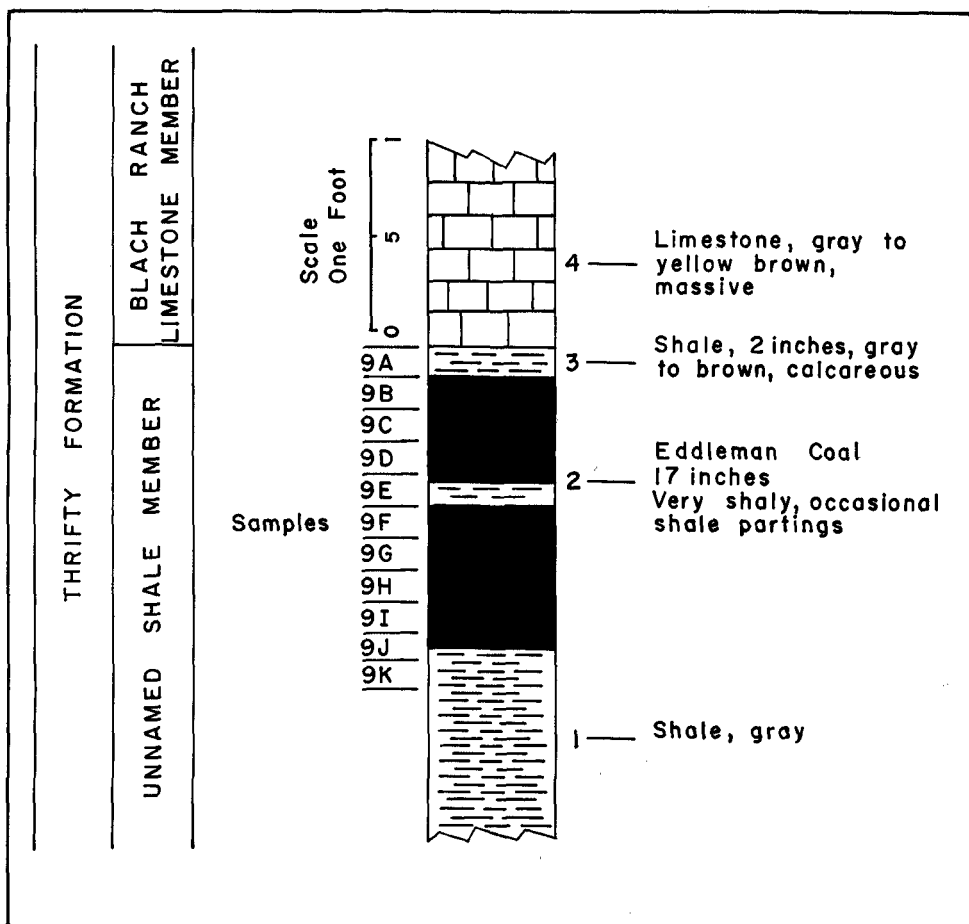


FIG. 3. Geologic section, Locality 9, Young County, Texas.

## PROCESSING TECHNIQUES

The following procedures were used in the laboratory processing of samples:

1. Demineralization
  - a. Hydrochloric acid
  - b. Hydrofluoric acid
2. Oxidation—Schulze solution
3. Wash—acetone solution
4. Initial heavy liquid flotation
5. Oxidation—potassium hydroxide solution
6. Second heavy liquid flotation
7. Differential centrifugation
8. Stain—Safranine 0
9. Microscope slide preparation

**Variations in the general processing technique** were necessary for some individual samples. The processing techniques discussed by Kosanke (1950) and by Norem (1956) were most useful as a guide in establishing a technique.

Maceration and partial oxidation of the plant material was accomplished using a Schulze solution which consisted of a saturated solution of potassium chlorate in

concentrated (70%) nitric acid. The reaction was allowed to continue for approximately 15 minutes. The initial heavy liquid separation was accomplished using crystalline zinc bromide dissolved in 10% HCl, giving a solution with a specific gravity of 1.925. After thorough mixing, the sample was centrifuged for 20 minutes at 2000 r.p.m. Further oxidation was effected with a 5% potassium hydroxide solution. The specific gravity of the second heavy liquid was 1.800. Some samples were screened to 177 microns. Clearcol and Diaphane were used as mounting media. The slides were examined using a Leitz Labolux microscope, and photographs were taken with a Zeiss photomicroscope.

The Geology Department of Texas Christian University, Fort Worth, Texas, is the depository for the microscope slides.

## STATISTICAL CONSIDERATIONS

The optimum number of specimens to be counted per slide was found to be 375 (Wilson, 1959). The relative abundance of each species in each sample was calculated (table 1).

The information provided in table 1 has been summarized by calculating the relative abundance of each genus and plotting the relative abundance of the dominant genera on a bar graph for each sample. The genera indicated as dominant occur as 5% or more of at least one sample (fig. 4, in pocket).

A visual comparison of the bar graphs in figure 4, to note the samples which most closely match each other, could be used as

a basis for correlation between Localities 4 and 9. A statistical test may be employed to indicate more precisely the degree of similarity between Sample 4A or 4B and each of the Samples 9A through 9K. The chi-square test is a direct test of significance that is suitable for cases in which the observations can be classified into discrete categories and treated as frequencies. Since the observations involve categories (species or genera) for which frequencies (number of individuals) are noted, the chi-square test is applicable to palynological correlations. The utility of the chi-square test has been previously noted by Gray and Guennel (1961).

TABLE 1. Percentages of palynomorphs.

	9A	9B	9C	9D	9E	9F	Samples 9G	9H	9I	9J	9K	4A	4B
<i>Laevigatosporites desmoinensis</i>	2.91	5.11	4.87	1.69	4.00	2.61	1.14	4.84	10.81	11.06	7.63	4.11	1.43
<i>L. ovalis</i>	0.00	2.36	5.38	0.00	2.28	2.18	0.00	2.18	5.82	11.29	11.84	6.03	2.86
<i>L. globosus</i>	0.00	2.75	1.54	1.69	1.71	3.27	1.42	2.18	2.64	0.24	1.84	0.00	1.43
<i>L. minimus</i>	0.97	1.57	16.67	10.17	0.00	9.15	9.38	5.81	3.17	2.59	5.79	1.10	4.28
<i>L. minutus</i>	6.80	16.11	23.08	8.19	0.57	17.21	8.24	10.41	12.70	6.12	8.95	20.55	7.14
<i>Columinisporites pepperi</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monoletes ovatus</i>	0.00	0.00	0.00	0.00	1.71	0.00	0.28	0.24	0.00	0.00	0.00	0.00	0.00
<i>M. ellipsoides</i>	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.53	0.27	0.00
<i>Calamospora microrugosus</i>	0.00	0.78	2.31	0.00	1.14	0.44	0.57	1.21	1.32	5.41	3.42	1.37	0.00
<i>C. saarina</i>	4.85	4.12	1.54	10.17	5.71	6.54	6.25	7.51	15.34	7.06	14.74	3.56	4.28
<i>C. pedata</i>	0.00	0.59	0.51	0.00	0.00	0.65	0.00	0.73	0.00	0.70	1.32	0.54	0.00
<i>C. pusilla</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58	0.00	0.00
<i>Punctatisporites</i> cf. <i>P. provectus</i>	14.56	6.68	3.59	11.58	10.28	18.30	31.25	19.61	12.43	8.00	5.00	32.88	12.86
<i>P. sp. 1</i>	2.91	0.78	0.00	1.13	5.71	1.09	3.41	2.42	3.70	0.47	2.10	3.01	0.00
<i>P. orbicularis</i>	3.88	1.38	0.26	0.56	0.00	0.22	0.00	0.24	0.26	0.00	1.05	3.29	4.28
<i>Cyclogranisporites obliquus</i>	0.97	0.78	0.51	1.69	0.57	1.96	1.42	5.33	3.44	4.94	2.89	0.82	2.86
<i>Punctatisporites minutus</i>	15.53	11.79	14.10	26.84	8.00	18.08	17.90	17.92	12.43	15.06	6.84	6.58	22.86
<i>P. sp. 2</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	1.05	0.00	0.00
<i>P. sp. 3</i>	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.26	0.00	0.00
<i>Apiculatisporis aculeatus</i>	1.94	1.38	1.54	4.80	7.43	1.52	5.40	1.45	4.50	2.12	3.95	0.00	0.00
<i>Granulatisporites granularis</i>	4.85	6.68	2.56	1.13	0.57	3.05	2.27	3.15	1.59	0.47	6.05	1.37	0.00
<i>G. microsaetosus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>G. irregularis</i>	0.00	0.59	0.51	0.00	0.57	1.96	0.00	0.00	0.00	0.70	0.00	0.82	2.86
<i>G. punctatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	1.41	0.79	0.54	0.00
<i>Leiotriletes</i> sp.	1.94	0.00	0.51	0.85	0.00	0.44	0.28	0.24	0.00	0.24	0.26	0.00	8.57
<i>L. tripartitus</i>	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Latipulvinites</i> cf. <i>L. kosankii</i>	0.97	2.16	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.82	0.00
<i>Reticulatisporites</i> sp.	1.94	0.00	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.00	1.05	0.27	0.00
<i>R. velatus</i> ?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00
<i>Microreticulatisporites rotundus</i>	0.00	0.20	0.00	0.00	0.00	0.22	0.85	0.00	1.32	0.70	1.32	0.00	0.00
<i>Converrucosisporites sulcatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	1.92	0.00
<i>Convolutispora ampla</i>	1.94	1.77	0.77	1.13	0.00	1.09	1.70	3.39	2.12	0.24	2.10	0.82	1.43
<i>Crassispora plicata</i>	4.85	0.00	0.00	0.00	0.00	0.65	1.42	1.21	0.00	0.00	0.26	0.27	0.00

<i>Cadospora magna</i>	1.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.10	0.00	0.00
<i>C. fragilis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65	1.32	0.00	0.00
<i>Raistrickia aculeata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>R. crinita</i>	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>R. crocea</i>	0.00	0.00	0.00	0.28	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.27	0.00
<i>R. irregularis</i>	0.00	0.00	0.51	0.85	1.14	0.87	0.00	0.97	0.00	2.12	1.05	1.92	0.00
<i>R. prisca</i>	0.00	0.00	0.00	0.00	0.57	0.44	0.28	0.00	0.00	0.00	0.00	0.00	0.00
<i>R. annulatus</i>	0.00	0.00	0.26	0.00	0.00	0.22	0.00	0.24	0.00	0.00	0.00	0.00	0.00
<i>Savitrisorites triangulus</i>	2.91	0.00	0.26	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00
<i>Triquitrites crassus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Verrucosisorites</i> sp.	0.00	1.18	0.26	0.28	1.14	0.87	0.00	0.00	0.00	0.00	0.00	0.27	2.86
<i>Densosporites</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Duplicatotriletes heueri</i>	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trilete spore	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Vestispora profunda</i>	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Endosporites ornatus</i>	0.00	0.00	0.00	0.56	0.00	0.22	0.28	0.00	0.00	0.00	0.00	0.00	0.00
<i>E. rotundus</i>	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Potoeisorites tabbertii</i>	0.00	0.00	0.00	0.00	0.00	0.22	0.85	2.18	0.00	0.00	0.00	0.00	0.00
<i>Florinites antiquus</i>	6.80	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00
<i>F. cf. F. parvus</i>	2.91	7.07	9.74	11.86	34.86	0.22	0.00	0.00	0.00	0.00	0.26	6.00	4.28
<i>F. clarkei</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00
<i>F. pellucidus</i>	10.68	15.32	5.90	2.26	10.28	0.00	0.28	1.21	0.26	0.70	0.00	2.74	15.71
Monosaccate grain 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monosaccate grain 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Complexisorites polymorphus</i>	0.00	0.00	0.26	0.00	0.00	0.65	0.00	0.24	1.06	0.70	0.53	0.00	0.00
Bisaccate grain 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bisaccate grain 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bisaccate grain 3	1.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Vesicaspora schaubergeri</i>	0.97	2.55	2.31	1.69	0.57	4.79	5.11	4.36	4.23	15.53	1.84	1.37	0.00
Bisaccate grain 4	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rhizomaspota</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fungal hypha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	99.96	99.99	100.01	99.96	99.95	100.01	99.98	99.99	100.20	99.99	99.97	99.97	99.99%

The chi-square values obtained for the combinations of each of the samples from Locality 4 with each of the samples from Locality 9 are presented in table 2.

TABLE 2. *Calculated values of chi-square.*

Samples Tested	X <sup>2</sup>
4A-9A	59.66
4A-9B	118.52
4A-9C	99.84
4A-9D	49.91
4A-9E	171.58
4A-9F	25.85
4A-9G	30.42
4A-9H	19.71
4A-9I	43.48
4A-9J	80.83
4A-9K	101.29
4B-9A	6.60
4B-9B	20.12
4B-9C	47.75
4B-9D	32.54
4B-9E	29.24
4B-9F	94.32
4B-9G	69.61
4B-9H	64.74
4B-9I	75.16
4B-9J	91.06
4B-9K	103.68

A table of critical values of chi-square provides a means of deciding the probability of a null hypothesis of the two samples coming from the same population being correct.

It will be observed from table 2 that the correlation, Sample 4B-Sample 9A, produced a value of chi-square of 6.60. Table 3 indicates that the probability is between 0.20 and 0.30 that such a value of chi-square will occur if the null hypothesis is correct. If the commonly used 0.05 level of significance is chosen as an acceptance level, the probability should be 0.95 or greater. The null hypothesis must be rejected and the two samples assumed not to have come from the same population. The remaining values of chi-square are larger than 6.60 and the null hypothesis must also be rejected for each pair of samples tested on the basis of the chi-square test. It cannot be stated with any acceptable degree of statistical certainty that a correlation exists between any of the samples from the two localities.

TABLE 3. *Selected critical values of chi-square for 5 degrees of freedom (McCollough and Van Atta, 1963).*

P	X <sup>2</sup>
.99	0.55
.98	0.75
.95	1.14
.90	1.61
.80	2.34
.70	3.00
.50	4.35
.30	6.06
.20	7.29

## DISCUSSION AND CONCLUSIONS

### COMPOSITION OF THE FLORA

The microfossil flora of the Eddleman Coal exists in an excellent state of preservation. The flora is both abundant and diverse, consisting of 65 species. Only 3 genera and 8 species of monolete spores are present, but the monolete genus *Laevigatosporites*, represented by 5 species, is one of the most abundant genera of the flora. The flora is dominated by trilete spores. Twenty trilete genera with 39 species are present. The trilete genera *Calamospora*, *Punctatisporites*, *Apiculatisporis*, *Gramulatisporites*, and *Leiotriletes* are the most abundant, with *Punctatisporites* represented by 6 species and being the most abundant genus of the entire flora. Other notable trilete genera are *Crassispota*, *Cadiospora*, and *Raistrickia*. Six genera and 10 species of monosaccate grains are present. *Florinites* is the most abundant genus, but *Endosporites* and *Potonieisporites* are also important monosaccate genera. Bisaccate grains are present as 7 species possibly representing 7 genera. *Vesicaspora* is the only abundant bisaccate genus, but *Complexisporites* is also important. A single species presumed to be a fungus is also present.

### VERTICAL VARIATION IN THE FLORA AT LOCALITY 9

Considerable variation in the flora exists within the Eddleman Coal at Locality 9 (fig. 5, in pocket). Because many of the short-ranged species are very rare, especially those which occur in a single sample, their presence or absence may be only a matter of sampling variability. Also, the presence or absence of species must in part be related to differential preservation associated with changes in lithology. The state of preservation of the palynomorphs in the coal was much better than in the shales, and the possibility exists of many species not being preserved in the shale. The entire coal is impure and shaly with oc-

casional shale partings on the order of  $\frac{1}{4}$  inch in thickness. All of Sample 9K and approximately one-half of Sample 9J are shale which forms an underclay for the coal (fig. 3). Sample 9E represents a large shale parting, and the sample is almost entirely shale. Sample 9A is shale which constitutes a roof shale for the coal. The floral "breaks" defined on ranges of species coincide with the change in lithology. The floral changes, at least in part, however, are a result of environmental changes evidenced by the change in lithology, and the changes are not thought to represent a floral succession.

In terms of the ranges of species a change is observed at the base of the section between Samples 9K and 9J. At this level, 3 species disappear and 9 species appear for the first time. Another change is noted in the interval of Samples 9G and 9F, with 7 species disappearing and 6 species appearing.

Changes occur throughout the upper half of the coal with the top of the section being marked by the disappearance of 16 species and the appearance of 1 species at the level of Sample 9A.

A more effective way of characterizing the variations in the flora is to use the changes in the relative abundance of the dominant genera (fig. 4). Zoning within the coal that is based on the relative abundance of the dominant genera will be less influenced by sampling variability; however, the change may still be related to changes in lithology and differential preservation. The 9 dominant genera are present in almost every sample, and each of the dominant genera constitutes 5% of at least one sample. The majority of the palynomorphs seen were members of the genera *Laevigatosporites* and *Punctatisporites*. These two genera dominate each sample, one or the other being the most abundant genus throughout the samples with the exception of Sample 9E. *Calamospora* is an important constituent of the



coal, and it is most abundant in the four lowermost samples from Locality 9. The most striking change is the sudden increase in abundance of the monosaccate genus *Florinites* in Sample 9E. *Florinites* increases from a relative abundance of less than 2% in the lower 6 samples to 45% in Sample 9E, where it is the most abundant genus. The abundance "burst" of *Florinites* occurs in a shale parting and provides a means of dividing the coal into upper and lower portions. *Florinites* continues to be abundant, constituting about 10% of the four upper samples.

Samples 9K through 9F, from the lower portion of the coal, are characterized by the dominant abundance of *Laevigatosporites* and *Punctatisporites*. *Calamospora* is most abundant in the lower portion. The rarity of monosaccate grains is considered diagnostic. *Vesicaspora* occurs, perhaps anomalously, as 15% of Sample 9J.

The upper portion of the coal is characterized by the abundance of the monosaccate genus *Florinites*; however, *Laevigatosporites* and *Punctatisporites* continue as the most abundant genera. The abundance of *Calamospora* is decreased; whereas, *Granulatisporites* is increased slightly.

Hypotheses which may be invoked to account for floral changes within a coal bed include (1) a true floral succession with the dominant genera changing within the plant community as the plants themselves modify their environment and (2) a floral migration in response to changes in the environment, such as a marine transgression. Because the total stratigraphic interval of the Eddleman Coal is so thin, little plant evolution is thought to have occurred.

Monoletes and trilete spores are thought to have been supplied for the most part by plants indigenous to coal swamps (Gibson, 1961), and in the Eddleman Coal little change is in evidence with these groups, ruling out floral succession. At Locality 9

an encroaching marine environment presumably forced the migration of the plants which supplied the monoletes and trilete spores. As the swamp flora was displaced, the relative abundance of the wind-transported monosaccate and bisaccate grains increased at the expense of the monoletes and trilete spores. The shaly parting of Sample 9E perhaps represents a temporary inundation. The abundance of monosaccate grains in the upper portion of the coal probably reflects a continued trend toward more marine conditions culminating in the Blach Ranch Limestone.

#### COMPARISON OF COALS AT LOCALITIES 4 AND 9

A possible contemporaneity exists between the plant populations producing the microfloras of Sample 4B of Locality 4 (fig. 2) and the uppermost sample at Locality 9 (fig. 3). Sample 4B contains 20% *Florinites* which corresponds to the monosaccate abundance diagnostic of the upper part of the coal at Locality 9. It is to be noted that the genera *Apiculatisporis* and *Vesicaspora* are absent from Sample 4B and that they are important constituents of Sample 9A. Although it is not statistically significant, the smallest chi-square value was obtained for the test comparing Sample 4B and Sample 9A, indicating a greater probability that Samples 4B and 9A came from the same population than for any of the other comparisons. If the lower coal at Locality 4 is a lateral continuation of the upper part of the coal and shale at Locality 9, then the upper coal at Locality 4 might be interpreted as indicative of "shingling" of the Eddleman Coal interval. This in turn would suggest that the site of coal deposition was displaced eastward in time by marine transgression. A study of comparable Pennsylvanian coals by Upshaw and Hedlund (1967) led them to conclude that the "coals were probably deposited in separate minor coal swamps, related in time, but localized and different in details of deposition."

# AGE OF THE EDDLEMAN COAL

The stratigraphic position of the Eddleman Coal indicates an age of Virgilian (latest Pennsylvanian). The flora is characteristically Pennsylvanian with the presence and abundance of *Laevigatosporites*, *Calamospora*, *Punctatisporites*, *Granulatisporites*, *Raistrickia*, *Endosporites*, and *Florinites*. The absence of *Lycospora*, *Reinschospora*, and common species of *Reticulatisporites* is notable. The flora of the Eddleman Coal has 11 genera and 20 species in common with the floras of the McLeansboro Group as described by Kosanke (1950) and 22 genera and 18 species in common as described by Peppers (1964). The Upper McLeansboro Group is in part Virgilian in age. The species *Columinisporites pepperi*, *Crassispota plicata*, *Calamospora pusilla*, and *Latipulvinites kosankii* have only been reported to date from the Upper McLeansboro, and

they are present in the Eddleman Coal. The microflora substantiates the Virgilian age of the Eddleman Coal.

The Eddleman Coal has 14 genera but only 9 species in common with the older (Missourian) Coffeyville Formation microflora as described by Upshaw and Hedlund (1967). In terms of species in common a greater taxonomic similarity is noted with the Virgilian coals of the Illinois Basin than with geographically closer but older Oklahoma coals. The presence of palynomorphs which are more representative of the Permian attest to the Late Pennsylvanian age. *Rhizomaspora*, *Vesicaspora schaubergeri*, and *Complexisporites polymorphus* became more abundant in the Permian (Wilson, 1962, and Jizba, 1962). Notable in this respect are the striate Bisaccate Grains 1, 2, and 3, because striate bisaccate pollen grains are more abundant in the Permian (Shaffer, 1964).

## DESCRIPTION OF PALYNOMORPHS

Several systems of classification of fossil palynomorphs have been proposed. The problems of palynomorph nomenclature and the proposed systems of classification have been reviewed by Bhardwaj (1955a) and Dettmann (1963). Binomial designations are in use for all formally named species, and the rules of priority and typification found in the International Code of Botanical Nomenclature (1961) are followed by palynologists. Inasmuch as the majority of fossil spore and pollen grains are found dispersed in the rock record and not in association with plant megafossils, the plant affinities of these microfossils are not known and their phylogenetic classification is precluded. The existing classification systems are artificial morphologic ones and include those of Bennie and Kidston (1886), Ibrahim (1933), Raistrick (1934), Naumova (1939), Erdtman (1947), Potonié (1956, 1958, 1960), and Pierce (1961). Because no one of the systems has attained widespread usage, none is followed in this paper. The species described herein are assigned to morphologic genera, much after the fashion of Kosanke (1950) and Peppers (1964), but no suprageneric taxa are used. Rather the genera have been grouped for convenience into the following large morphologic categories which are not strictly defined: Monolete Spores, Trilete Spores, Mono-saccate Grains, Bisaccate Grains, and Fungi. Within each morphologic category the genera are arranged in an order which reflects in a general way increasing morphologic complexity. In each species description the morphology of the species is considered in sequence as follows: (1) shape and symmetry; (2) nature of the germinal aperture including the type of aperture, its size, the nature of the lips if present, and the nature of the commissure; (3) nature of the exine including its thickness, ornamentation, and the presence of special structures such as sacci, perines,

auriculae, and contact faces; and (4) size range. A standardized morphological terminology is used in the species descriptions. A glossary has been prepared which presents the morphological terminology of this paper. The terminology is patterned mainly after Kosanke (1950) with some definitions adapted from Kremp (1965).

The treatment of the distribution of each species is not necessarily exhaustive and is limited to reported occurrences in Pennsylvanian strata of the conterminous United States. Some of the information concerning the occurrence of species is after Urban (1962). The distribution of each species within the Eddleman Coal at Localities 4 and 9 is shown in figure 5 (in pocket).

### MONOLETE SPORES

**Genus LAEVIGATOSPORITES (Ibrahim) Schopf, Wilson, and Bentall, 1944**

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

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

Pl. I, figs. 1 and 2

1940 *Phaseolites desmoinensis* Wilson and Coe, p. 183, fig. 4.

1944 *Laevigatosporites desmoinensis* (Wilson and Coe) Schopf, Wilson, and Bentall, p. 37.

**Discussion.**—Specimens slightly larger than the size range, 60 to 75 microns, given in the original species description are here included in *L. desmoinensis*. Spores which are assignable to *Laevigatosporites* form a size continuum at least from 20 to 100 microns, and species based on size are purely arbitrary.

**Occurrence.**—Wilson and Coe (1940) indicated that *L. desmoinensis* is the most universal and abundant microfossil in the coals of the Desmoinesian Series of Iowa. It was reported by Schemel (1951) from the Mystic Coal of Iowa. Kosanke (1950) reported the species in Illinois as ranging

from the middle part of the McCormick Group to near the top of the McLeansboro Group. Peppers (1964) reported the occurrence of the species in the Trivoli Cyclothem and the Henshaw Formation of the McLeansboro Group in the Illinois Basin. It was reported by Guennel (1958) from the Pottsville coals of Indiana. In Oklahoma it has been found occurring in the following coals: McAlester (Morgan, 1955), Croweburg (Wilson and Hoffmeister, 1956), Weir-Pittsburg (Higgins, 1960), Rowe (Davis, 1961), Secor (R. T. Clarke, 1961), and Iron Post (Gibson, 1961).

**LAEVIGATOSPORITES OVALIS**  
Kosanke, 1950

Pl. I, fig. 3

1950 *Leavigatosporites ovalis* Kosanke, p. 29.

*Discussion.*—According to Kosanke (1950), *L. ovalis* is distinct from *L. desmoinensis* in having definite lips and in being shorter and wider.

*Occurrence.*—Kosanke (1950) gave the range of *L. ovalis* as the upper part of the McCormick Group through the upper part of the McLeansboro Group of Illinois. Peppers (1964) reported the species from the Trivoli Cyclothem, Fithian Cyclothem, and the Henshaw Formation of the McLeansboro Group in the Illinois Basin. Schemel (1951) reported it from the Mystic Coal in Iowa. Guennel (1958) reported it from the Pottsville coals of Indiana. In Oklahoma, it was reported from the following coals: Stigler and McAlester (Morgan, 1955), Croweburg (Wilson and Hoffmeister, 1956), Weir-Pittsburg (Higgins, 1960), Rowe (Davis, 1961), Secor (R. T. Clarke, 1961), Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961).

**LAEVIGATOSPORITES GLOBOSUS**  
Schemel, 1951

Pl. I, fig. 4

1951 *Laevigatosporites globosus* Schemel, p. 746, fig. 2.

*Discussion.*—Schemel (1951) compared this species with *L. punctatus* Kosanke, 1950, stating that *L. punctatus* is more

coarsely and sharply punctate, characteristically larger, and more broadly oval than *L. globosus*.

*Occurrence.*—Schemel (1951) originally reported this species from the Mystic and Marshall Coals of Appanoose and Madison counties of Iowa. Guennel (1958) reported it from the Pottsville Coals of Indiana. Wilson and Hoffmeister (1956) recorded *L. globosus* from the Croweburg Coal of Oklahoma.

**LAEVIGATOSPORITES MINIMUS (Wilson and Coe)**  
Schopf, Wilson, and Bental, 1944

Pl. I, fig. 5

1940 *Phaseolites minimus* Wilson and Coe, p. 183, pl. I, fig. 5.

1944 *Laevigatosporites minimus* (Wilson and Coe) Schopf, Wilson, and Bental, p. 37.

*Discussion.*—The original size range for this species was 21 to 29 microns (Wilson and Coe, 1940). Potonié and Kremp (1956) extended the size range to 20 to 35 microns as was recorded and recognized by Guennel (1958).

*Occurrence.*—The first report of *L. minimus* was from the Desmoinesian Series of Iowa by Wilson and Coe (1940). Schemel (1951) reported it from the Mystic Coal of Iowa. Kosanke (1943) reported it from the Pittsburgh and Pomeroy Coals of Ohio and from the upper part of the McCormick Group through the McLeansboro Group of Illinois (Kosanke, 1950). Guennel (1958) reported it from the Pottsville Coals of Indiana. In Oklahoma the species has been reported from the Croweburg Coal (Wilson and Hoffmeister, 1956), Weir-Pittsburg Coal (Higgins, 1960), Rowe Coal (Davis, 1961), and Tebo Coal (Ruffin, 1961).

**LAEVIGATOSPORITES MINUTUS (Ibrahim)**  
Schopf, Wilson, and Bental, 1944

Pl. I, fig. 6

1933 *Punctatosporites minutus* Ibrahim, p. 40, pl. 5, fig. 33.

1944 *Laevigatosporites minutus* (Ibrahim) Schopf, Wilson, and Bental, p. 37.

*Discussion.*—A size range of 16 to 25 microns for the long dimension is observed

from measurements given by Ibrahim (1933) in the original species description. Kosanke (1950) indicated a size range of "slightly under 20 microns to 30 microns" for *L. minutus*. A size range of 16 to 30 microns is adopted in this study.

**Occurrence.**—Kosanke (1950) reported *L. minutus* from the Tradewater, Carbondale, and McLeansboro Groups of Illinois. Peppers (1964) found *L. minutus* in the Trivoli Cyclothem, Fithian Cyclothem, and the Henshaw Formation of the Illinois Basin.

**Genus COLUMINISPORITES Peppers, 1964**

Genotype: *Columinisporites ovalis* Peppers, 1964.

**COLUMINISPORITES PEPPERI Stone, sp. nov.**

Pl. I, figs. 7 and 8

**Diagnosis.**—Specimens of *Columinisporites* in the size range 60 to 78 microns in the longest dimension.

**Description.**—The spores are bean-shaped to oval with bilateral symmetry. The germinal aperture is monoete, 25 microns long, and usually obscure with the commissure closed or slightly open. The exine is 2 microns thick and covered with a coarse reticulum, composed of anastomosing ridges, in which the muri are 1.5 to 2 microns wide and raised about 2 microns. The lumina of the reticulum are about 12 microns across and polygonal in outline. The muri roughly parallel the long dimension of the spore. Closely spaced striations occur within the lumina. They are small, less than 1 micron, and transverse to the reticulum. The observed size range was 60 to 70 microns in the long dimension and 40 to 45 microns in the small dimension.

**Holotype.**—Plate I, figure 8.

**Paratype.**—Plate I, figure 7.

**Discussion.**—These spores from the Edleman Coal are believed to be conspecific with the spore designated "*Columinisporites* sp. 1" but not named by Peppers (1964). A structure that is believed to be

definitely a monoete mark is present near the margin of one spore (Pl. I, fig. 8). The nature of the germinal aperture was not apparent on other individuals. The specific name commemorates R. A. Peppers' discovery of the species.

**Occurrence.**—This species has only been reported previously from the Trivoli Cyclothem (Modesto Formation, McLeansboro Group) of the Illinois Basin by Peppers (1964).

**Genus MONOLETES (Ibrahim) Schopf, Wilson, and Bental, 1944**

Genotype: *Monoletes ovatus* Schopf, 1935.

**MONOLETES OVATUS Schopf, 1935**

Pl. I, fig. 9

1935 *Monoletes ovatus* Schopf, p. 176.

**Discussion.**—The presence of two large folds on the distal surface distinguishes *M. ovatus* from *M. ellipsoides*.

**Occurrence.**—*M. ovatus* was reported from the Herrin (No. 6) Coal of the Carbondale Formation of Illinois by Schopf (1938). Peppers (1964) reported it from the Trivoli Cyclothem, Fithian Cyclothem, and Henshaw Formation of the McLeansboro Group of the Illinois Basin.

**MONOLETES ELLIPSOIDES (Ibrahim) Schopf, 1938**

Pl. I, fig. 12

1932 *Sporonites ellipsoides* Ibrahim, p. 449, pl. 17, fig. 29.

1933 *Laevigatosporites ellipsoides* (Ibrahim) Ibrahim, p. 40, pl. 4, fig. 29.

1934 *Punctatosporites ellipsoides* (Ibrahim) Loose, pp. 158-159, pl. 7, fig. 35.

1934 *Sporites ellipsoides* (Ibrahim) Wicher, p. 185.

1938 *Monoletes ellipsoides* (Ibrahim) Schopf, p. 45, pl. 1, fig. 14; pl. 6; figs. 5 and 6.

**Discussion.**—The absence of large folds on the distal surface distinguishes *M. ellipsoides* from *M. ovatus*.

**Occurrence.**—*M. ellipsoides* was reported from the Herrin (No. 6) Coal of the Carbondale Formation of Illinois by Schopf (1938).

TRILETE SPORES

Genus *CALAMOSPORA*

Schopf, Wilson, and Bental, 1944

Genotype: *Calamospora hartungiana* Schopf, 1944, in Schopf, Wilson, and Bental.

*CALAMOSPORA MICRORUGOSUS* (Ibrahim)

Schopf, Wilson, and Bental, 1944

Pl. I, fig. 10

1932 *Sporonites microrugosus* Ibrahim, p. 447, pl. 14, fig. 9.

1933 *Laevigatosporites microrugosus* (Ibrahim) Ibrahim, p. 18, pl. 1, fig. 9.

1944 *Calamospora microrugosus* (Ibrahim) Schopf, Wilson, and Bental, p. 52.

*Occurrence*.—Kosanke (1950) reported *C. microrugosus* from the Tradewater Group of Illinois. Schemel (1950) reported the species from the post-Madison, pre-Belden coal of Daggett County, Utah. The species has been recorded from the following Oklahoma coals: Rowe (Davis, 1961), Secor (R. T. Clarke, 1961), and Mineral (Urban, 1962).

*CALAMOSPORA SAARINA* Bhardwaj, 1957a

Pl. I, fig. 11

1957a *Calamospora saarina* Bhardwaj, p. 81, pl. 22, figs. 13–15.

*Discussion*.—*C. membrana* differs in having longer rays and in having a thicker exine near the trilete mark, becoming more membranous beyond it. *C. pallida* and *C. flexilis* do not have darkened contact faces and have a thicker spore coat (Bhardwaj, 1957a). The specimens from the Eddleman Coal lower the size range from 50 to 65 microns to 45 to 65 microns.

*Occurrence*.—Urban (1962) reported this species from the Mineral Coal of Oklahoma.

*CALAMOSPORA PEDATA* Kosanke, 1950

Pl. I, fig. 13

1950 *Calamospora pedata* Kosanke, p. 42.

*Occurrence*.—Kosanke (1950) reported this species from the Tradewater and McLeansboro Groups of Illinois. Peppers (1964) reported it from the Trivoli Cyclothem in Macoupin County, Illinois.

*CALAMOSPORA PUSILLA* Peppers, 1964

Pl. I, fig. 14

1964 *Calamospora pusilla* Peppers, p. 15.

*Discussion*.—The lower extent of the size range has been decreased 3 microns to 20 microns. The specimens from the Eddleman Coal differ from Peppers' (1964) description in that no "rugose" ornamentation was observed under oil immersion at  $\times 1000$  magnification. The over-all appearance of the small folds, which is here described as contorted, could be considered rugose.

*Occurrence*.—Peppers (1964) reported this species from the Trivoli Cyclothem in Franklin County, Illinois.

Genus *PUNCTATISPORITES* (Ibrahim)

Schopf, Wilson, and Bental, 1944

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

*PUNCTATISPORITES* cf. *P. PROVECTUS*

Kosanke, 1950

Pl. I, fig. 15

1950 *Punctatisporites provectus* Kosanke, p. 17.

*Discussion*.—The size range of *P. provectus* given by Kosanke (1950) is 72 to 83 microns. The specimens from the Eddleman Coal are a few microns smaller and do not have well-developed lips, but they compare favorably in other characteristics.

*Occurrence*.—Kosanke (1950) reported this species from the Caseyville Group of Illinois. Guennel (1958) reported *P. provectus* from the Pottsville coals of Indiana.

*PUNCTATISPORITES* sp. 1

Pl. II, figs. 1 and 2

*Description*.—The spores are round with radial symmetry. The germinal aperture is trilete with rays about 23 microns in length, being approximately two-thirds the length of the radius. No lips are present and the commissure is distinct and slightly open. The exine is 1 micron thick and entirely covered with evenly spaced granules about 2 to 3 microns in diameter. The

granulose ornaments are closely spaced (2 to 3 microns) but not touching. The observed size range was from 55 to 80 microns.

**PUNCTATISPORITES ORBICULARIS Kosanke, 1950**

Pl. II, fig. 3

1950 *Punctatisporites orbicularis* Kosanke, p. 16

*Occurrence.*—Kosanke (1950) reported this species from the McLeansboro Group of Illinois. Peppers (1964) found *P. orbicularis* to be an abundant spore of the Trivoli Cyclothem, Fithian Cyclothem, and Henshaw Formation of the Illinois Basin. It has been reported from the Croweburg Coal (Wilson and Hoffmeister, 1956) and the Rowe Coal (Davis, 1961) in Oklahoma.

**PUNCTATISPORITES MINUTUS Kosanke, 1950**

Pl. II, fig. 5

1950 *Punctatisporites minutus* Kosanke, p. 15.

*Discussion.*—The specimens from the Eddleman Coal are a few microns smaller than the 27.3 to 32.5 micron size range reported by Kosanke (1950). The specimens from the Eddleman Coal do not agree with *P. minutus* as emended by Peppers (1964), but they do agree with *P. minutus* Kosanke, 1950, as described originally.

*Occurrence.*—Kosanke (1950) reported this species from the McLeansboro Group of Illinois. Peppers (1964) reported *P. minutus* as an abundant spore from the McLeansboro Group of the Illinois Basin.

**PUNCTATISPORITES sp. 2**

Pl. II, fig. 6

*Description.*—The shape of the spores is triapsidate or roundly triangular, and the symmetry is radial. The germinal aperture is trilete with rays 25 microns in length. The rays extend almost all the way to the spore margin. Lips are present, but they are indistinct as a result of folding of the exine adjacent to the rays. The commissure is indistinct. The exine is about 1.5 microns in thickness. The ornamentation is verrucate; the verrucae are 2 to 3

microns wide at the base, 1 to 2 microns wide at the apex, and about 3 microns in length. The observed size range was 60 to 70 microns.

**PUNCTATISPORITES sp. 3**

Pl. II, fig. 7

*Description.*—The spores are round with radial symmetry. The germinal aperture is trilete with rays about 29 microns in length, being about one-third the spore diameter. The lips are about 2 microns in width and tend to be obscured by the ornamentation. The commissure is distinct and slightly open. The exine is about 3 microns thick with thick and rugged-appearing vermiculate ornamentation. The ridges are 5 microns wide, 2 to 4 microns high, and 20 to 30 microns long. The openings between the ridges are from 2 to 5 microns wide. The observed size range was from 95 to 100 microns.

*Discussion.*—The specimens from the Eddleman Coal closely resemble *P. grandivermiculatus* Peppers, 1964, but differ from it in being smaller and in having a prominent and distinct trilete mark.

**Genus CYCLOGRANISPORITES  
Potonié and Kremp, 1954**

Genotype: *Cyclogranisporites leopoldi* (Kremp)  
Potonié and Kremp, 1954

**CYCLOGRANISPORITES OBLIQUUS (Kosanke)  
Upshaw and Hedlund, 1967**

Pl. II, fig. 4

1950 *Punctatisporites obliquus* Kosanke, p. 16,  
pl. 2, fig. 5.

1967 *Cyclogranisporites obliquus* (Kosanke)  
Upshaw and Hedlund, p. 150, pl. II, fig. 5.

*Discussion.*—The original size range was 31 to 46 microns (Kosanke, 1950). Measured specimens from the Eddleman Coal ranged in size from 21 to 31 microns.

*Occurrence.*—Kosanke (1950) reported this species from the Tradewater, Carbon-dale, and McLeansboro Groups of Illinois. *P. obliquus* was reported from the McLeansboro Group of the Illinois Basin by Peppers (1964). Schemel (1951) reported it from the Mystic and Marshall Coals of

Iowa. Wilson and Hoffmeister (1956) reported it from the Croweburg Coal of Oklahoma. Guennel (1958) reported it from the Pottsville coals of Indiana.

Genus *APICULATISPORIS* (Ibrahim)  
Potonié and Kremp, 1956

Genotype: *Apiculatisporis* (*Apiculatisporites*)  
*aculeatus* (Ibrahim, 1933).

*APICULATISPORIS ACULEATUS* (Ibrahim)  
Potonié and Kremp, 1956

Pl. II, figs. 8 and 9

1933 *Apiculatisporites aculeatus* Ibrahim, p. 78,  
pl. 14, fig. 235.

1956 *Apiculatisporis aculeatus* (Ibrahim)  
Potonié and Kremp, p. 76.

*Discussion.*—Two individuals with less dense spine coats are included in this species. They are thought to represent only morphological variation within the species. The upper limit of the size range (55 to 75 microns) has been extended from 60 microns to 75 microns.

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

Genotype: *Granulatisporites granularis* Ibrahim,  
1933.

*GRANULATISPORITES GRANULARIS* Kosanke, 1950

Pl. II, figs. 10, 11

1950 *Granulatisporites granularis* Kosanke, p. 22.

*Discussion.*—Specimens of *G. granularis* usually occur compressed in a good proximal-distal orientation, but some individuals may be compressed in an oblique or equatorial orientation (Pl. II, fig. 11).

*Occurrence.*—Kosanke (1950) reported this species from the Carbondale and McLeansboro Groups of Illinois. Peppers (1964) reported it from the Trivoli Cyclothem of Illinois. Morgan (1955) reported *G. granularis* from the McAlester Coal of Oklahoma, and Wilson and Hoffmeister (1956) reported it from the Croweburg Coal of Oklahoma.

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

Pl. II, fig. 12

1932 *Sporonites microsaetosus* Loose, p. 450, pl.  
18, fig. 40.

1933 *Setosporites microsaetosus* (Loose) Ibrahim, p. 26

1944 *Granulatisporites microsaetosus* (Loose),  
Schopf, Wilson, and Bentall, p. 33.

*Discussion.*—A single specimen assignable to this species was observed from the Eddleman Coal. The proposed new transfers, *Spinospores microsaetosus* (Loose) of Knox (1950) and *Lophotriletes microsaetosus* (Loose) of Potonié and Kremp (1955), are not recognized.

*Occurrence.*—Schemel (1950) reported this species from the post-Madison, pre-Belden coal of Daggett County, Utah. Guennel (1958) reported it (designated *Lophotriletes microsaetosus* (Loose) of Potonié and Kremp, 1955) from the Pottsville coals of Indiana.

*GRANULATISPORITES IRREGULARIS* Stone, sp. nov.

Pl. II, figs. 13 and 14

*Diagnosis.*—The spores are distinguished by the seemingly sporadic occurrence of granules on the exine.

*Description.*—The spores are triangular in shape with rounded apices and slightly concave sides. Radial symmetry is present. The germinal aperture is trilete with rays 11 microns in length. Lips are absent. The commissure is distinct and slightly open. The exine is about 2 microns thick with granulose ornamentation. The granules are erratically situated about the exine. The granules vary from 1 to 3 microns in diameter and from 1 to 2 microns in height. Some of the granules are elongate and ridge-like and others project beyond the margin of the spore. Slightly thickened contact faces are present between the rays of the trilete mark. The observed size range was 25 to 37 microns.

*Holotype.*—Plate II, figure 13.

*Discussion.*—On some specimens the granules are concentrated at the apices of the triangular-shaped spores. If such an arrangement could be considered a thickening of the apices, the species could be placed in the genus *Triquitrites*, in which case, it would compare favorably with *T. sp. 2* of Peppers (1964, p. 40). The specific name refers to the irregularly spaced granules.



**GRANULATISPORITES PUNCTATUS** Stone, sp. nov.

Pl. II, figs. 15 and 16

*Diagnosis.*—The spores are 40 to 50 microns in the longest dimension and punctate with contact faces.

*Description.*—The spores are triangular with rounded apices and concave sides. Radial symmetry is exhibited by the spores. The germinal aperture is trilete with rays 20 microns in length. Lips are absent. The commissure is distinct and closed. The exine is 1 micron thick and punctate. The punctae are about 0.5 micron in size and closely spaced over the entire exine. Small folds occur around the spore margin. Hardly distinguishable contact faces are present. The observed size range was 40 to 50 microns.

*Holotype.*—Plate II, figure 15.

*Discussion.*—Specimens of *G. punctatus* usually occur compressed in good proximal-distal orientation, but some individuals may be compressed in an oblique or equatorial orientation (Pl. II, fig. 16). This species is thought to be conspecific with *G. sp. B* of Schemel (1950). The specific name refers to the punctate ornamentation.

*Occurrence.*—The specimen designated *G. sp. B* by Schemel (1950) was reported from the post-Madison, pre-Belden coal of Daggett County, Utah.

**Genus LEIOTRILETES** (Naumova)  
Potonié and Kremp, 1955

Genotype: *Leiotriletes sphaerotriangulus* (Loose, 1932).

**LEIOTRILETES** sp.

Pl. II, fig. 17

*Description.*—The spores are triangular in shape with rounded apices and concave sides. Radial symmetry is exhibited. The trilete germinal aperture has rays about 10 microns in length. The lips are 2 to 3 microns wide and slightly raised. The commissure is distinct and closed. The exine is 1 micron thick and levigate. Small folds may be present. The observed size range was 30 to 35 microns in the longest dimension.

**LEIOTRILETES TRIPARTITUS** Stone, sp. nov.

Pl. II, fig. 18

*Diagnosis.*—The spores are distinguished by a dark band which parallels each side of the trilete rays.

*Description.*—The spores are triangular with convex sides and slightly rounded apices. The symmetry is radial. The germinal aperture is trilete with rays 20 microns in length. The rays extend to within 5 microns of the spore margin. The lips are thin and slightly raised. The commissure is distinct and closed. The exine is 1 micron thick and levigate. A darkened band 4 to 5 microns wide parallels each side of the trilete rays about two-thirds of their length toward the spore margin. The bands are slightly thickened but not noticeably raised above the surrounding exine. The observed size range was 37 to 47 microns.

*Holotype.*—Plate II, figure 18.

*Discussion.*—The bands observed in this species are not noticeably raised above the surrounding exine as in *Latipulvinites kosankii* Peppers. The bands are not thought to represent contact faces since they do not become wider in the interray areas. The specific name refers to the three areas of the bands.

**Genus LATIPULVINITES** Peppers, 1964

Genotype: *Latipulvinites kosankii* Peppers, 1964.

**LATIPULVINITES** cf. *L. KOSANKII* Peppers, 1964

Pl. II, figs. 19 and 20

1964 *Latipulvinites kosankii* Peppers, p. 26.

*Discussion.*—The specimens from the Eddleman Coal ranged in size from 46 to 65 microns, whereas the specimens described by Peppers (1964) were 38.9 to 48.6 microns in size. Peppers (1964) gave the following discussion:

*L. kosankii* appears somewhat similar to *Ahrensisporites minutus* Alpern, 1958, but the latter is smaller (25 microns). *L. kosankii* is also similar to the specimen illustrated as *A. cf. A. angulatus* (Kosanke) Potonié and Kremp, 1956. *L. kosankii* strongly resembles a spore designated by Neves (1958, pl. 2, fig. 6) as spore type "C," except that the latter is more nearly circular in outline and is larger (63 microns).

*Occurrence*.—Peppers (1964) reported this species from the Trivoli Cyclothem, Fithian Cyclothem, and Henshaw Formation of the Illinois Basin.

**Genus RETICULATISPORITES (Ibrahim)**  
Schopf, Wilson, and Bentall, 1944

Genotype: *Reticulatisporites reticulatus* (Ibrahim) Ibrahim, 1933.

**RETICULATISPORITES** sp.

Pl. II, figs. 21 and 22

*Description*.—The spores are round with radial symmetry. The germinal aperture is trilete with rays 23 microns in length. Lips are absent. The commissure is distinct and closed. The trilete mark is obscured by the ornamentation. The exine is 2 microns thick and covered with a loose reticulum composed of a system of irregularly anastomosing muri. The muri are 1 micron wide and 1 to 5 microns high. The muri extend beyond the spore margin, giving the appearance of a perine. The lumina are 10 to 20 microns in width. The observed size range was 61 to 74 microns.

**RETICULATISPORITES VELATUS ? Loose, 1934**

Pl. II, figs. 23 and 24

1934 *Reticulatisporites velatus* Loose, p. 155, pl. 7, fig. 10.

*Discussion*.—The identification of these spores as *R. velatus* is considered questionable because of the limited description (Loose, 1934) available for comparison.

**Genus MICRORETICULATISPORITES (Knox)**  
Polonié and Kremp, 1954

Genotype: *Microreticulatisporites lacunosus* (Ibrahim) Knox, 1950.

**MICRORETICULATISPORITES ROTUNDUS**  
Stone, sp. nov.

Pl. II, figs. 25 and 26

*Diagnosis*.—Microreticulate spores in the size range 35 to 45 microns.

*Description*.—The spores are round and have radial symmetry. The trilete mark of the germinal aperture is always obscured by the muri, but the rays are about 15 microns in length. Lips were not observed,

and the commissure is indistinct and closed or open. The exine is approximately 1 micron thick. The ornamentation is reticulate. The muri are 1 micron wide and 1 micron high. The lumina are variously sized from 2 to 5 microns in width and irregularly shaped. Occasionally minor folding is present. The observed size range was 35 to 45 microns in the longest dimension.

*Holotype*.—Plate II, figure 26.

*Discussion*.—This species compares favorably with *M. microtuberosus* (Loose) of Potonié and Kremp (1955), but it is several microns smaller in size. The specific name refers to the circular outline.

**Genus CONVERRUCOSISPORITES**  
Potonié and Kremp, 1954

Genotype: *Converrucosisporites triquetrus* (Ibrahim, 1933).

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

Pl. III, figs. 1 and 2

1944 *Punctatisporites sulcatus* Wilson and Kosanke, p. 331, fig. 4.

1955 *Converrucosisporites sulcatus* (Wilson and Kosanke) Potonié and Kremp, p. 64.

*Discussion*.—The size range is here extended from 30 to 40 microns (Wilson and Kosanke, 1944) to 30 to 50 microns.

*Occurrence*.—*C. sulcatus* was described by Wilson and Kosanke (1944) from the Desmoinesian Series of Iowa. Kosanke (1950) reported it from the Tradewater and McLeansboro Groups of Illinois. Peppers (1964) reported the species from the Trivoli Cyclothem, Fithian Cyclothem, and the Henshaw Formation of the Illinois Basin. Schemel (1951) recorded it from the Mystic Coal of Iowa. Guennel (1958) reported it from the Pottsville coals of Indiana. The species has been recorded from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Weir-Pittsburg (Higgins, 1960), Secor (R. T. Clarke, 1961), Iron Post (Gibson, 1961), Tebo (Ruffin, 1961), and Mineral (Urban, 1962).

**Genus CONVOLUTISPORA Hoffmeister,  
Staplin, and Malloy, 1955**

Genotype: *Convolutispora florida* Hoffmeister, Staplin, and Malloy, 1955.

**CONVOLUTISPORA AMPLA  
Hoffmeister, Staplin, and Malloy, 1955**

Pl. III, figs. 3 and 4

1955 *Convolutispora ampla* Hoffmeister, Staplin, and Malloy, p. 384.

**Discussion.**—The specimens from the Eddleman Coal reduce the known smallest size from 40 to 35 microns.

**Occurrence.**—*C. ampla* was reported from the Hardinsburg Formation (Mississippian) of Illinois and Kentucky by Hoffmeister, Staplin, and Malloy (1955). As far as is known, *C. ampla* has not been reported previously from Pennsylvanian rocks, although other species of this genus have been reported (Peppers, 1964).

**Genus CRASSISPORA Bhardwaj, 1957b**

Genotype: *Crassispora ovalis* Bhardwaj, 1957b

**CRASSISPORA PLICATA Peppers, 1964**

Pl. III, figs. 5 and 6

1964 *Crassispora plicata* Peppers, p. 17.

**Discussion.**—The size range was originally observed to be 48.6 to 74.9 microns (Peppers, 1964). It is here extended to 37 to 86 microns. Peppers (1964) reported that the proximal surface is minutely punctate and free from "con." Compressed specimens from the Eddleman Coal did not permit a differentiation of the ornamentation of the proximal and distal surface, the entire spore surface appearing granulose.

**Occurrence.**—Peppers (1964) reported this species from the Trivoli Cyclothem, Fithian Cyclothem, and Henshaw Formation of the Illinois Basin.

**Genus CADIOSPORA Kossanke, 1950**

Genotype: *Cadiospora magna* Kossanke, 1950.

**CADIOSPORA MAGNA Kossanke, 1950**

Pl. III, fig. 7

1950 *Cadiospora magna* Kossanke, p. 50.

**Discussion.**—Some spores of this species from the Eddleman Coal are smaller (90

to 110 microns) than the original size range (100 to 117.6 microns) given by Kossanke (1950).

**Occurrence.**—Kossanke (1950) reported this species from the LaSalle Coal of the McLeansboro Group of northern Illinois. Peppers (1964) reported it from the McLeansboro Group of the Illinois Basin.

**CADIOSPORA FRAGILIS Stone, sp. nov.**

Pl. III, fig. 8

**Diagnosis.**—Spores with an exine 3 to 4 microns thick.

**Description.**—The spores are round with radial symmetry. The germinal aperture is trilete with rays 30 microns in length. Distinct lips, 2 microns in thickness, are raised and curled or wavy in appearance. The commissure is indistinct and closed. The exine is 3 microns thick and punctate. Arcuate ridges are a prominent feature of the spore. The rays of the trilete mark extend to the arcuate ridges. The observed size range was 80 to 105 microns.

**Holotype.**—Plate III, figure 8.

**Discussion.**—The species is placed in the genus *Cadiospora* because of its comparable size, distinct lips, and prominent arcuate ridges. The specific name refers to the fragile appearance of the thin and transparent exine.

**Genus RAISTRICKIA  
Schopf, Wilson, and Bental, 1944**

Genotype: *Raistrickia grovensis* Schopf, 1944, in Schopf, Wilson, and Bental.

**RAISTRICKIA ACULEATA Kossanke, 1950**

Pl. III, fig. 9

1950 *Raistrickia aculeata* Kossanke, p. 46.

**Discussion.**—Only a single individual of this species was observed from the Eddleman Coal.

**Occurrence.**—Kossanke (1950) reported this species in the McLeansboro Group of Illinois. Peppers (1964) reported it from the Henshaw Formation of Kentucky. Urban (1962) reported *R. aculeata* from the Mineral Coal of Oklahoma and Kansas.

**RAISTRICKIA CRINITA Kosanke, 1950**

Pl. III, fig. 10

1950 *Raistrickia crinita* Kosanke, p. 46.

*Discussion.*—The original size range of 54 to 67 microns as given by Kosanke (1950) is here extended to include individuals up to 79 microns in size.

*Occurrence.*—Kosanke (1950) reported the species from the Tradewater, Carbondale, and McLeansboro Groups of Illinois. Peppers (1964) reported it from the Fithian Cyclothem and the Henshaw Formation of the Illinois Basin. The species has been recorded from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Iron Post (Gibson, 1961), and Tebo (Ruffin, 1961). Urban (1962) reported a single questionable specimen from the Mineral Coal in Kansas.

**RAISTRICKIA CROCEA Kosanke, 1950**

Pl. III, figs. 11 and 12

1950 *Raistrickia crocea* Kosanke, p. 47.

*Occurrence.*—Kosanke (1950) described *R. crocea* from the Carbondale Group of Illinois. The species has been reported from the following Oklahoma coals: Croweburg (Wilson and Hoffmeister, 1956), Iron Post (Gibson, 1961), Tebo (Ruffin, 1961), and Mineral (Urban, 1962).

**RAISTRICKIA IRREGULARIS Kosanke, 1950**

Pl. III, figs. 13 and 14

1950 *Raistrickia irregularis* Kosanke, p. 47.

*Occurrence.*—Kosanke (1950) reported this species from the Tradewater and Carbondale Groups of Illinois. Peppers (1964) reported it from the Trivoli Cyclothem in Macoupin County, Illinois. *R. irregularis* has been reported from Oklahoma in the Secor Coal (R. T. Clarke, 1961) and in the Mineral Coal (Urban, 1962).

**RAISTRICKIA PRISCA Kosanke, 1950**

Pl. III, fig. 15

1950 *Raistrickia prisca* Kosanke, p. 48.

*Discussion.*—*R. prisca* is closely related

to *R. grovensis* Schopf. It differs from *R. grovensis* by the presence of thickened contact faces, elevated lips, and by being somewhat larger in size (Kosanke, 1950).

*Occurrence.*—Kosanke (1950) reported the species from the Caseyville and Tradewater Groups of Illinois. Wilson and Hoffmeister (1956) reported it from the Croweburg Coal of Oklahoma.

**RAISTRICKIA ANNULATUS Stone, sp. nov.**

Pl. III, fig. 16

*Diagnosis.*—Spores distinguished by a sparse coat of long spines which have alternate light and dark bands.

*Description.*—The spores are round with radial symmetry. The germinal aperture was obscured on all specimens observed of this species; however, it is assumed to be trilete. The exine is 1 micron thick. The spore is covered by a sparse coat of long slightly tapering blunt-tipped spines. The spines are 10 to 15 microns in length, 4 to 5 microns in width at the base, and 2 to 4 microns in width at the apex. The spines have alternating light and dark bands from base to apex. The dark bands are about 1 micron in width and appear to be thickened and raised, giving the outline of the spine a wavy appearance from base to apex. Thirty-one spines were counted beyond the margin of one spore. The observed size range was from 75 to 80 microns in the longest dimension, exclusive of the spines.

*Holotype.*—Plate III, figure 16.

*Discussion.*—*R. annulatus* closely resembles *R. aculeata* and *R. crinita* but is distinct from them in that the spines of *R. annulatus* are longer, fewer in number, less closely spaced, and have alternate light and dark bands around them. Five specimens of this species were observed in the Eddleman Coal. The specific name refers to the banding around the spines.

**Genus SAVITRISPORITES Bhardwaj, 1955b**

Genotype: *Savitrisorites triangulus* Bhardwaj, 1955b.

**SAVITRISPORITES TRIANGULUS Bhardwaj, 1955b**

Pl. IV, figs. 1-3

1955b *Savitrissporites triangulus* Bhardwaj, p. 128.

*Discussion.*—*S. triangulus* is distinct from *S. majus* Bhardwaj in having straight interangles rather than convex interangles and in having rays of equal length rather than one longer ray and two shorter rays. The upper limit of the size range of *S. triangulus* is here extended from 65 to 85 microns. The term "spines" is preferred to the term "coni" to designate the type of ornamentation observed on this species.

*Occurrence.*—*Savitrissporites* has been reported from the Secor Coal of Oklahoma by R. T. Clarke (1961) and from the Trivoli Cyclothem of the McLeansboro Group of the Illinois Basin by Peppers (1964).

**Genus TRIQUITRITES Wilson and Coe, 1940**Genotype: *Triquitrites arcuatus* Wilson and Coe, 1940.**TRIQUITRITES CRASSUS Kosanke, 1950**

Pl. VI, figs. 4 and 5

1950 *Triquitrites crassus* Kosanke, p. 38.

*Discussion.*—One specimen has been assigned to this species which has only two auriculae present. The exine of the angle is intact and is not thickened nor does it bear projections (Pl. IV, fig. 5).

*Occurrence.*—Kosanke (1950) reported *T. crassus* from the Tradewater, Carbon-dale, and McLeansboro Groups of Illinois. The species has been reported from the Croweburg Coal of Oklahoma by Wilson and Hoffmeister (1956).

**Genus VERRUCOSISPORITES (Ibrahim) Potonié and Kremp, 1955**Genotype: *Verrucosisporites verrucosus* (Ibrahim, 1932).**VERRUCOSISPORITES sp.**

Pl. IV, figs. 6-8

*Description.*—The shape of the compressed spore is round to oval. The symmetry is radial. The trilete germinal aper-

ture has rays which vary in length from 29 to 36 microns. Lips are not apparent, but the germinal aperture is obscured by the ornamentation. The commissure is distinct and open about 2 microns. One of the rays of some spores was observed to have split open and doubled its apparent length (Pl. IV, fig. 7). The exine is about 2 microns thick and covered with a dense coat of irregularly shaped verrucae. The verrucae are 2 to 5 microns in diameter and about 2 microns long. The observed size range was from 75 to 135 microns in the longest dimension.

**Genus DENSOSPORITES (Berry) Schopf, Wilson, and Bantall, 1944**Genotype: *Densosporites convensis* (Berry, 1937).**DENSOSPORITES sp.**

Pl. IV, fig. 9

*Explanation.*—The spore is triapsidate and radial. The germinal aperture is trilete with rays approximately 20 microns long. Lips were not observed and the commissure was indistinct and closed. The exine is thick and possesses a dark and massive cingulum that is 10 microns wide. The ornamentation of the cingulum is strongly granulose while the remaining spore surface is more lightly granulose. The size observed was 45 microns. Only a single spore assignable to *Densosporites* was encountered from the Eddleman Coal.

**Genus DUPLICATOTRILETES Stone, gen. nov.**Genotype: *Duplicatotriletes heueri* Stone, sp. nov.

*Description.*—The small spores are triapsidate in shape and asymmetrical but tend toward radial symmetry. The germinal aperture is trilete and the rays extend to the equator. Thick raised lips are present and the commissure is distinct. An aperture is present which resembles a second trilete mark. This second mark lies across one ray of the primary trilete mark with one of its rays in one interray of the primary trilete mark and the other two rays in an adjacent interray of the primary trilete mark. No lips are present on the second mark.

**DUPLICATOTRILETES HEUERI** Stone, sp. nov.

Pl. IV, fig. 10

*Description.*—The spores are triapside and asymmetrical but tend toward radial symmetry. The germinal aperture is trilete with rays 12 microns in length extending to the spore equator. The lips are 1.5 microns wide and raised. The commissure is distinct and closed. An aperture is present which resembles a second trilete mark. The second mark lies across one ray of the primary trilete mark with one of its rays in one interray of the primary trilete mark and the other two rays in an adjacent interray of the primary trilete mark. The rays of the second mark are 6 to 7 microns in length. Lips are absent from the second mark, and its commissure is distinct and closed. The exine is 1 to 2 microns thick and appears levigate, but it is seen to be minutely punctate with an oil immersion objective at  $\times 1000$  magnification. The size range is 15 to 20 microns in the longest dimension.

*Holotype.*—Plate IV, figure 10.

*Discussion.*—Four individuals of this species, all having two distinct apertures (?), were observed from the Eddleman Coal.

**TRILETE SPORE**

Pl. IV, fig. 11

*Explanation.*—Spore, trilete, triapside, baculate, rays extend to margin, 50 microns. A single specimen of this morphological type was found from the Eddleman Coal. An identification and species description were not attempted on the basis of a single individual.

**MONOSACCATE GRAINS**

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

Genotype: *Vestispora profunda* Wilson and Hoffmeister, 1956.

**VESTISPORA PROFUNDA**  
**Wilson and Hoffmeister, 1956**

Pl. IV, fig. 12

1956 *Vestispora profunda* Wilson and Hoffmeister, p. 27, pl. 2, figs. 16–19.

*Discussion.*—Three poorly preserved specimens of *V. profunda* were observed from the Eddleman Coal.

*Occurrence.*—This species was reported by Wilson and Hoffmeister (1956) from the Croweburg Coal of Oklahoma. It has also been reported from the Secor Coal (R. T. Clarke, 1961), Iron Post Coal (Gibson, 1961), Tebo Coal (Ruffin, 1961), and Mineral Coal (Urban, 1962), all of Oklahoma.

**Genus ENDOSPORITES Wilson and Coe, 1940**

Genotype: *Endosporites ornatus* Wilson and Coe, 1940.

**ENDOSPORITES ORNATUS Wilson and Coe, 1940**

Pl. IV, figs. 13 and 14

1940 *Endosporites ornatus* Wilson and Coe, p. 184, pl. 1, fig. 2.

*Discussion.*—The size range reported by Wilson and Coe (1940) was 91 to 113 microns for the longest dimension and 47 to 54 microns for the central body. The size range is here extended to 90 to 120 microns over-all and 42 to 68 microns for the central body.

*Occurrence.*—Wilson and Coe (1940) reported the species from the Des Moines Series of Iowa. Kosanke (1950) reported it from the Tradewater, Carbondale, and McLeansboro Groups of Illinois. Wilson and Hoffmeister (1956) reported *E. ornatus* from the Croweburg Coal of Oklahoma. Guennel (1958) reported it from the Pottsville coals of Indiana.

**ENDOSPORITES ROTUNDUS (Ibrahim)**  
**Schopf, Wilson, and Bental, 1944**

Pl. IV, fig. 15

1933 *Zonalessporites rotundus* Ibrahim, p. 31, pl. 8, fig. 73.

1944 *Endosporites rotundus* (Ibrahim) Schopf, Wilson, and Bental, p. 46.

*Discussion.*—Only 2 specimens assignable to *E. rotundus* were found from the Eddleman Coal.

*Occurrence.*—Guennel (1958) reported *E. rotundus* from the Pottsville coals of Indiana.

**Genus POTONIEISPORITES Bhardwaj, 1954**

Genotype: *Potonieisporites novicus* Bhardwaj, 1954.

**POTONIEISPORITES TABBERTII Stone, sp. nov.**

Pl. V, figs. 1–3

*Diagnosis.*—Grains in the size range 110 to 160 microns in the long dimension, with a central body ranging from 60 to 95 microns.

*Description.*—The shape of the grains is oval to round. The central body is round. The grains are bilaterally symmetrical. The aperture consists of a linear slit or sulcus that is located in the center of the central body and parallels the long dimension of the grain. The length of the sulcus is about 60 microns, and it extends almost to the margin of the central body. The grains are monosaccate, and the saccus extends 10 to 30 microns beyond the central body. The saccus is less than 1 micron in thickness while the exine of the central body is 1 to 2 microns thick. The saccus is more transparent than the central body. The outer ornamentation of the saccus is punctate. The punctae are less than 0.5 micron in diameter. The inner ornamentation of the saccus is reticulate. The lumina are 2 to 3 microns in diameter while the muri are 1 to 2 microns in width. Two large centrally located folds extending almost the entire length of the central body normal to the sulcus are common. Folding of the central body is common around its margin. The observed size range was 110 to 160 microns in the long dimension for the over-all measurement and 60 to 95 microns in the long dimension for the central body.

*Holotype.*—Plate V, figure 1.

*Paratype.*—Plate V, figure 3.

*Discussion.*—This species resembles *P. elegans* (Wilson and Kosanke) Wilson and Venkatachala, 1964, but is smaller.

*Occurrence.*—*Potonieisporites* has been reported from the Henshaw Formation of the Illinois Basin by Peppers (1964).

**Genus FLORINITES Schopf, Wilson, and Bantall, 1944**

Genotype: *Florinites antiquus* Schopf, 1944, in Schopf, Wilson, and Bantall.

**FLORINITES ANTIQUUS Schopf, 1944**

Pl. V, fig. 4

1944 *Florinites antiquus* Schopf, in Schopf, Wilson, and Bantall, p. 58.

*Occurrence.*—Schopf, Wilson, and Bantall (1944) reported this species from the Tradewater Group of Illinois. Kosanke (1950) reported it from the Caseyville, Tradewater, Carbondale, and McLeansboro Groups of Illinois. Peppers (1964) reported it from the Trivoli Cyclothem, Fithian Cyclothem, and Henshaw Formation of the Illinois Basin. Morgan (1955) reported it from the McAlester Coal of Oklahoma, and also Wilson and Hoffmeister (1956) reported it from the Croweburg Coal of Oklahoma. Guennel (1958) reported *F. antiquus* from the Pottsville coals of Indiana.

**FLORINITES cf. F. PARVUS  
Wilson and Hoffmeister, 1956**

Pl. V, fig. 5

1956 *Florinites parvus* Wilson and Hoffmeister, p. 16.

*Discussion.*—Wilson and Hoffmeister (1956) gave the size range of *F. parvus* as 50 to 58 microns and indicated this smaller size as a distinction between *F. parvus* and *F. antiquus*. The specimens from the Eddleman Coal compare favorably with *F. parvus* except for the fact that they form a size continuum from 45 to 85 microns. The specimens here designated *F. cf. F. parvus* are observed to have a smaller central body to over-all size ratio than the ratio for *F. antiquus*.

*Occurrence.*—Wilson and Hoffmeister (1956) reported this species from the Croweburg Coal of Oklahoma.

**FLORINITES CLARKEI Stone, sp. nov.**

Pl. V, figs. 6–8

*Diagnosis.*—Monosaccate grains 110 to 125 microns in the over-all longest dimen-

sion and 65 to 80 microns in the diameter of the central body.

*Description.*—The shape of the grains is broadly oval while the central body is round to slightly oval. Bilateral symmetry is exhibited. The germinal aperture is absent or represented by an indefinite trilete pattern. The grains are monosaccate, and the saccus extends 20 to 30 microns beyond the central body. The saccus is 1 micron thick, punctate (punctae less than 0.5 micron in diameter) externally, and reticulate internally. The lumina are 1 to 5 microns in diameter, and the muri are 1 to 2 microns wide. The exine of the central body is 2 to 3 microns thick. A system of coarse reticulate cracks, 5 to 10 microns wide, is present on the central body. Large folds are common around the margin of the central body. The size range of the long dimension is 110 to 125 microns, and the central body ranges 65 to 80 microns in diameter.

*Holotype.*—Plate V, figure 7.

*Paratype.*—Plate V, figure 8.

*Discussion.*—This species with a size range of 110 to 125 microns is intermediate in size between *F. antiquus* (55 to 90 microns) and *F. similis* Kosanke, 1950 (124 to 142 microns). This species is thought to be conspecific with Monosaccate Grain 2 of Peppers (1964, p. 43, pl. 7, fig. 15).

**FLORINITES PELLUCIDUS (Wilson and Coe)  
Wilson, 1958**

Pl. V, figs. 9 and 10

1940 *Endosporites pellucidus* Wilson and Coe, p. 184, pl. 1, fig. 13.

1958 *Florinites pellucidus* (Wilson and Coe) Wilson, p. 101, pl. 1, fig. 3.

**MONOSACCATE GRAIN 1**

Pl. VI, fig. 1

*Explanation.*—Grain, monosaccate, round, trilete, reticulate, over-all 88 microns, central body 40 microns. A single specimen of this morphological type was found from the Eddleman Coal. Identifica-

tion and species description were not attempted on the basis of a single individual.

**MONOSACCATE GRAIN 2**

Pl. VI, fig. 2

*Explanation.*—Grain, monosaccate, oval, central body round, germinal aperture not visible, reticulate, over all 115 microns, central body 49 microns. A single specimen of this morphological type was found from the Eddleman Coal. Identification and species description were not attempted on the basis of a single individual.

**BISACCATE GRAINS**

**Genus COMPLEXISPORITES Jizba, 1962**

Genotype: *Complexisporites polymorphus* Jizba, 1962.

**COMPLEXISPORITES POLYMORPHUS Jizba, 1962**

Pl. VI, figs. 3 and 4

1962 *Complexisporites polymorphus* Jizba, p. 879.

*Discussion.*—“*Complexisporites polymorphus* is distinguished by the circular groove with diameter less than that of the body, the crescent shape of the sacchi with maximum saccus width along the distal line of attachment, and by the types of fissure arrays. *Kosankeisporites elegans* (Kosanke, 1950) Bhardwaj, 1955 resembles complexly fissured specimens of *C. polymorphus* but lacks a circular groove and has a more ellipsoidal body and larger, more closely spaced sacchi. *Leuckisporites virkkiae* (Klaus, 1953) Potonié and Klaus, 1954 resembles *C. polymorphus* specimens which have only a single median fissure except for the circular groove” (Jizba, 1962).

*C. polymorphus* closely resembles *Protohaploxypinus chaloneri* Clarke, except for the fact that R. F. A. Clarke (1965) described *P. chaloneri* as having 10 to 12 striae (“taeniae”) and *C. polymorphus* has only 4 to 6 striae.

*Distribution.*—Jizba (1962) reported



the occurrence of *C. polymorphus* as Late Pennsylvanian (Virgil), Early Permian (Wolfcamp), and Middle Permian (Leonard) in the U. S. midcontinent area. Shaffer (1964) reported *Complexisporites* species from Permian (Leonardian) evaporites of Kansas.

#### BISACCATE GRAIN 1

Pl. VI, fig. 5

*Explanation.*—Grain, bisaccate, central body round but not distinct due to the overlap of the sacci, about 12 striae extend the length of the grain and are present on the central body and the sacci, sacci reticulate, over-all 80 microns, central body about 40 microns. A single specimen of this morphological type was found from the Eddleman Coal. Identification and species description were not attempted on the basis of a single individual.

#### BISACCATE GRAIN 2

Pl. VI, fig. 6

*Explanation.*—Grain, bisaccate, oval, central body round, 4 large striae parallel the long dimension of the grain on the central body and sacci, 3 folds on the central body parallel the short axis of the grain, sacci reticulate, over-all 75 microns, central body 42 microns. A single specimen of this morphological type was found from the Eddleman Coal. Identification and species description were not attempted on the basis of a single individual.

#### BISACCATE GRAIN 3

Pl. VI, fig. 7

*Explanation.*—Grain, bisaccate, central body round, sacci finely reticulate, 2 grooves in the central body parallel the short dimension of the grain, minor folding in the sacci and central body, over-all 98 microns, central body 58 microns. A single specimen of this morphological type was found from the Eddleman Coal. Identification and species description were not attempted on the basis of a single indi-

vidual; however, the grain resembles *Striatosaccites tractiferinus* (Samoilovitch) emend. Jizba, 1962.

#### Genus VESICASPORA (Schemel) Wilson and Venkatachala, 1963

Genotype: *Vesicaspora wilsonii* Schemel, 1951.

#### VESICASPORA SCHAUBERGERI (Klaus) Jizba, 1962

Pl. VI, figs. 8 and 9

- 1953 *Disaccites schaubergeri* Klaus, p. 54.  
1954 *Pityosporites schaubergeri* Potonié and Klaus, pp. 536–539.  
1956 *Falcisporites granulatus* Leschik, p. 136.  
1957 *Pityosporites granulatus* (Leschik) Grebe, pp. 63–64.  
1962 *Vesicaspora schaubergeri* (Klaus) Jizba, p. 883.

*Discussion.*—According to Jizba (1962), *V. wilsonii* Schemel has a smaller (relative to over-all size) and more elliptical body than *V. schaubergeri*.

*Occurrence.*—This species has been reported from the Lower Middle Permian of the U. S. midcontinent by Jizba (1962) and has no previous occurrence from the Pennsylvanian to the author's knowledge.

#### BISACCATE GRAIN 4

Pl. VI, fig. 10

*Explanation.*—Grain, bisaccate, oval, central body oval, sacci reticulate, over-all 65 microns. A single specimen of this morphological type was found from the Eddleman Coal. Identification and species description were not attempted on the basis of a single individual; however, the grain resembles *Alisporites plicatus* Jizba, 1962.

#### Genus RHIZOMASPORA Wilson, 1962

Genotype: *Rhizomaspora radiata* Wilson, 1962.

#### RHIZOMASPORA sp.

Pl. VI, fig. 11

*Description.*—The grain is oval with bilateral symmetry and bisaccate. The sacci are crescent-shaped and the central body is round. The sacci are infrareticulae. The central body is ornamented by several centrally radiating ridges. An obscure sulcus

is present. The over-all length is 78 microns, and the central body is 37 microns in diameter.

*Discussion.*—A single specimen assignable to *Rhizomaspora* was found in the Eddleman Coal. It closely resembles *R. radiata* Wilson except for an over-all length which is smaller than the 140 to 170 microns size range for *R. radiata* given by Wilson (1962). A new species was not erected on the basis of a single specimen.

*Occurrence.*—Three species of *Rhizomaspora* were described from the Permian Flowerpot Formation of Oklahoma by Wil-

son (1962). Peppers (1964) reported a grain which he designated *Rhizomaspora* cf. *R. radiata* Wilson, from the Fithian Cyclothem (Pennsylvanian) of Illinois. Peppers' grain is 93.7 microns in length.

## FUNGI

### FUNGAL HYPHA

Pl. VI, figs. 12 and 13

*Explanation.*—The form is thought to represent a fungal hypha. Identification and description were not attempted for these specimens.

## GLOSSARY

- Apical papilla** (pl., **ae**)—roundish protuberance of the exine at the apex of the interarray area of a trilete spore.
- Arcuate ridges**—curved raised areas of the exine at the outer (most equatorial) portion of the contact faces.
- Auriculae**—the thickened apices of a triangular-shaped spore.
- Baculate**—a type of ornamentation consisting of rods, with the height greater than the largest diameter.
- Cingulum**—a ring-like thickening of the equatorial region of a spore.
- Commissure**—the line of dehiscence of a germinal aperture.
- Contact faces**—the areas adjacent to the germinal aperture which were touching other spores of the tetrad. May be thickened and dark.
- Conus** (pl., **i**)—here equated with echina, an exine element, short and pointed with a broad base. Length equal to or less than width at base.
- Distal**—away from the surface of attachment in the tetrad.
- Exine**—the outer resistant layer of pollen and spores.
- Gemma** (pl., **ae**)—a knob-like element of which the lower part is constricted.
- Granulate**—a design formed by more or less isodiametric elements, in more or less random arrangement, greater than 0.5 micron in size. “Granulose” is considered synonymous.
- Levigate**—a smooth spore surface. “Psilate” is considered synonymous.
- Lip**—elongate raised area immediately adjacent to either side of the commissure.
- Lumen** (pl., **lumina**)—the opening in the network of a reticulum.
- Monolete**—possessing a single straight tetrad scar.
- Mums** (pl., **i**)—a wall or low ridge separating the lumina of a reticulum.
- Perine**—an extra-exinous layer of spores and pollen.
- Puncta** (pl., **ae**)—a small element of the exine, less than 0.5 micron, which is more or less isodiametric.
- Proximal**—toward the surface of attachment in the tetrad.
- Ray**—one of the three extensions forming the trilete mark.
- Reticulum**—a network of anastomosing ridges (muri) enclosing small spaces (lumina).
- Rugose**—a design consisting of irregular elongate ridges which are not parallel. “Rugulate” is considered synonymous.
- Saccus** (pl. **i**)—an air bladder.
- Setose**—a type of ornamentation consisting of bristles. “Echinate” is considered synonymous.
- Spine**—a sharp-pointed projection which tapers gradually, length greater than width.
- Stria** (pl., **ae**)—a groove, may be between the ridges of a rugose design.
- Sulcus**—a single furrow.
- Triapsidate**—a triangular shape with convex sides.
- Trilete**—possessing a triradiate tetrad scar.
- Umbo**—a boss or elevated area.
- Vermiculate**—possessing grooves with the appearance of worm tracks.
- Verruca** (pl., **ae**)—a wart-like projection in which the lower part is not constricted, size greater than 0.5 micron, may be asymmetrical.

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# Plates I–VI

The explanations for Plates I—VI include coordinates which designate the position of illustrated specimens on the numbered slides. Known positions on each slide to be used in re-occupying the coordinates are given in table 4.

TABLE 4. *Zeiss photomicroscope coordinates of a known position on the microscope slides prepared for this study.*

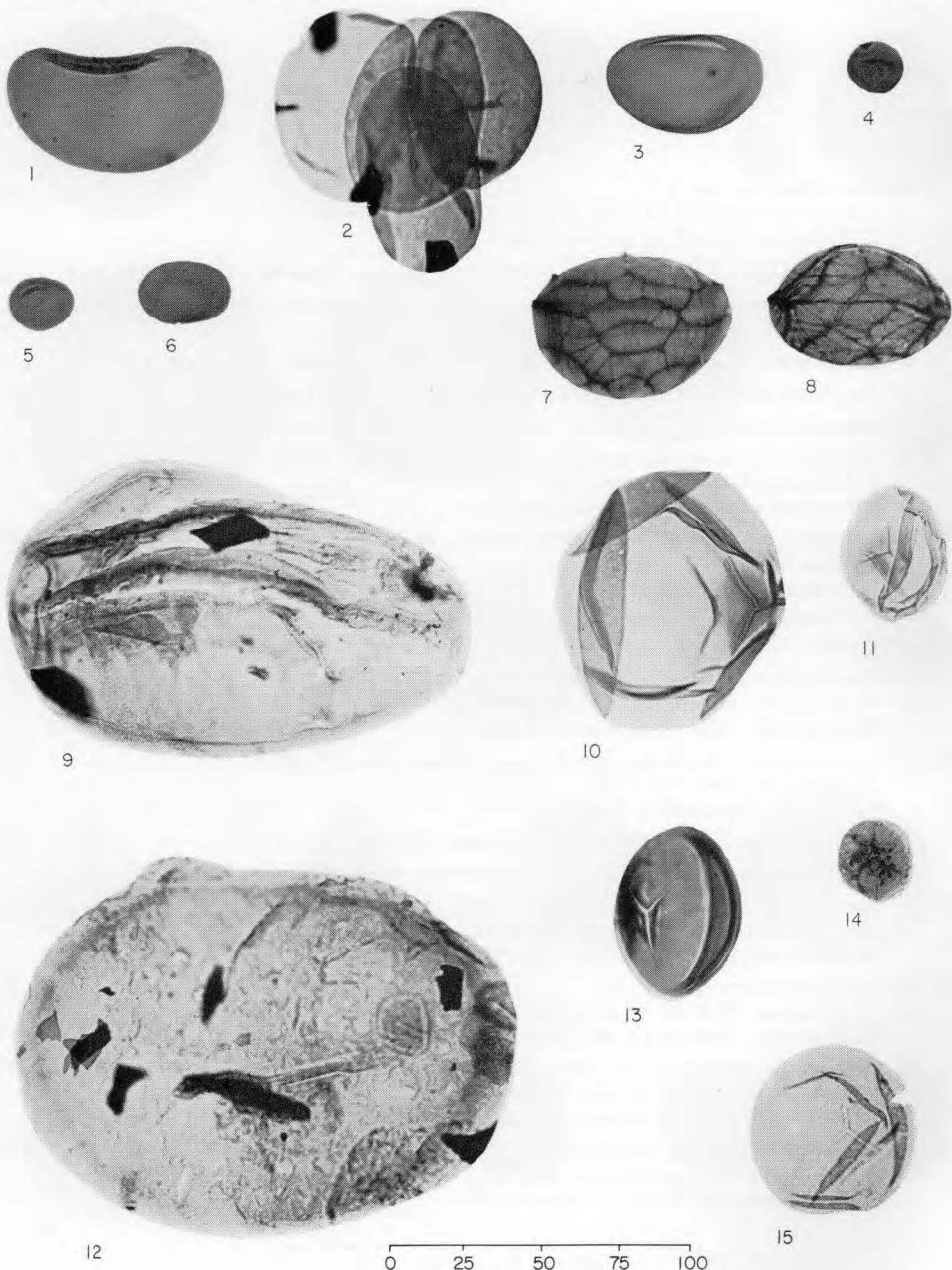
Slide Number	Lower Left Corner of Coverglass
9A AI	51.0–107.5
9B AI	54.0–108.0
9C AI	53.7–107.6
9C AIII	50.8–107.6
9D AI	52.3–107.7
9E AI	53.9–107.7
9F AI	51.0–108.3
9G AI	51.7–108.2
9H AI	53.8–107.4
9I AI	53.8–108.1
9J AI	52.4–108.1
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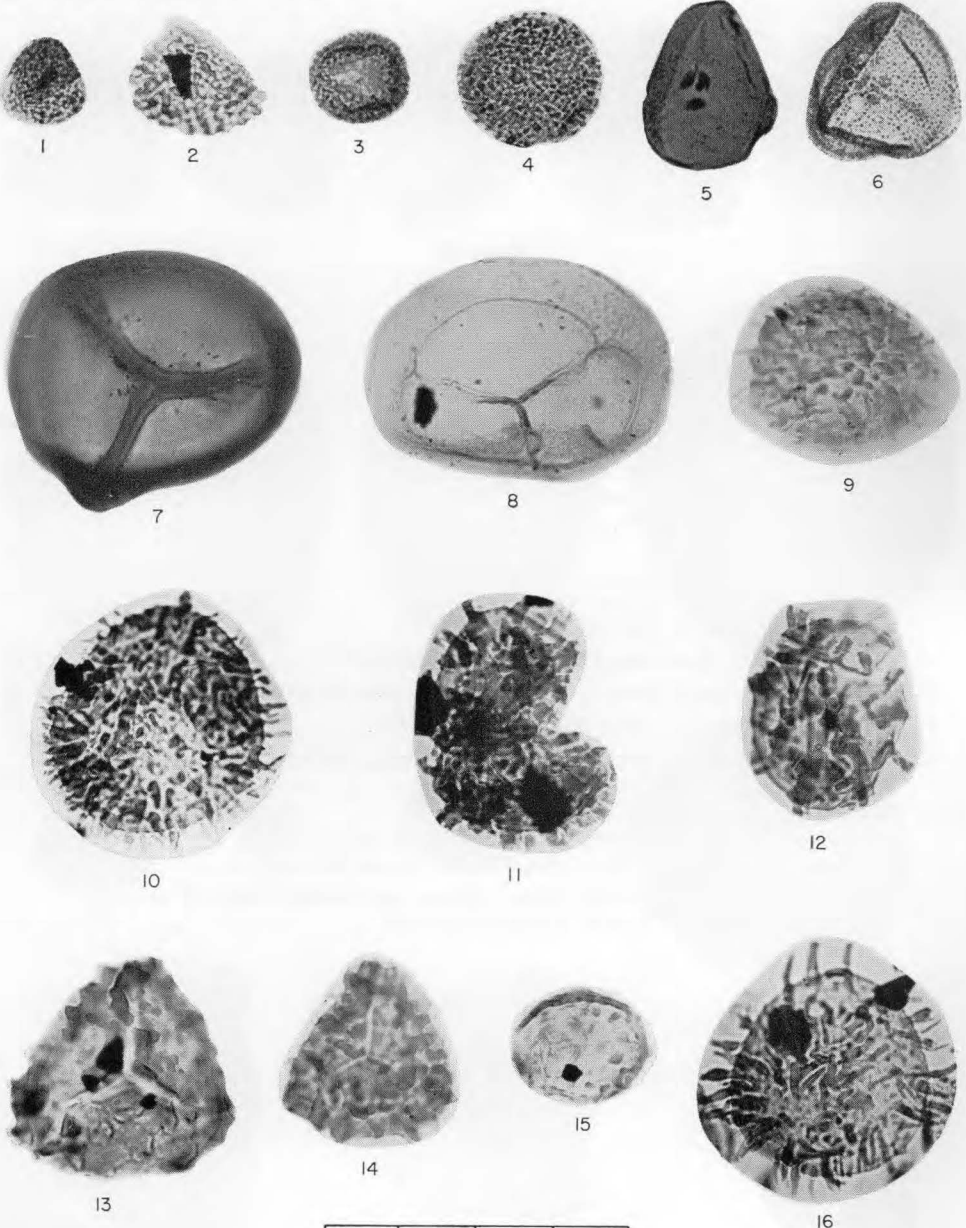


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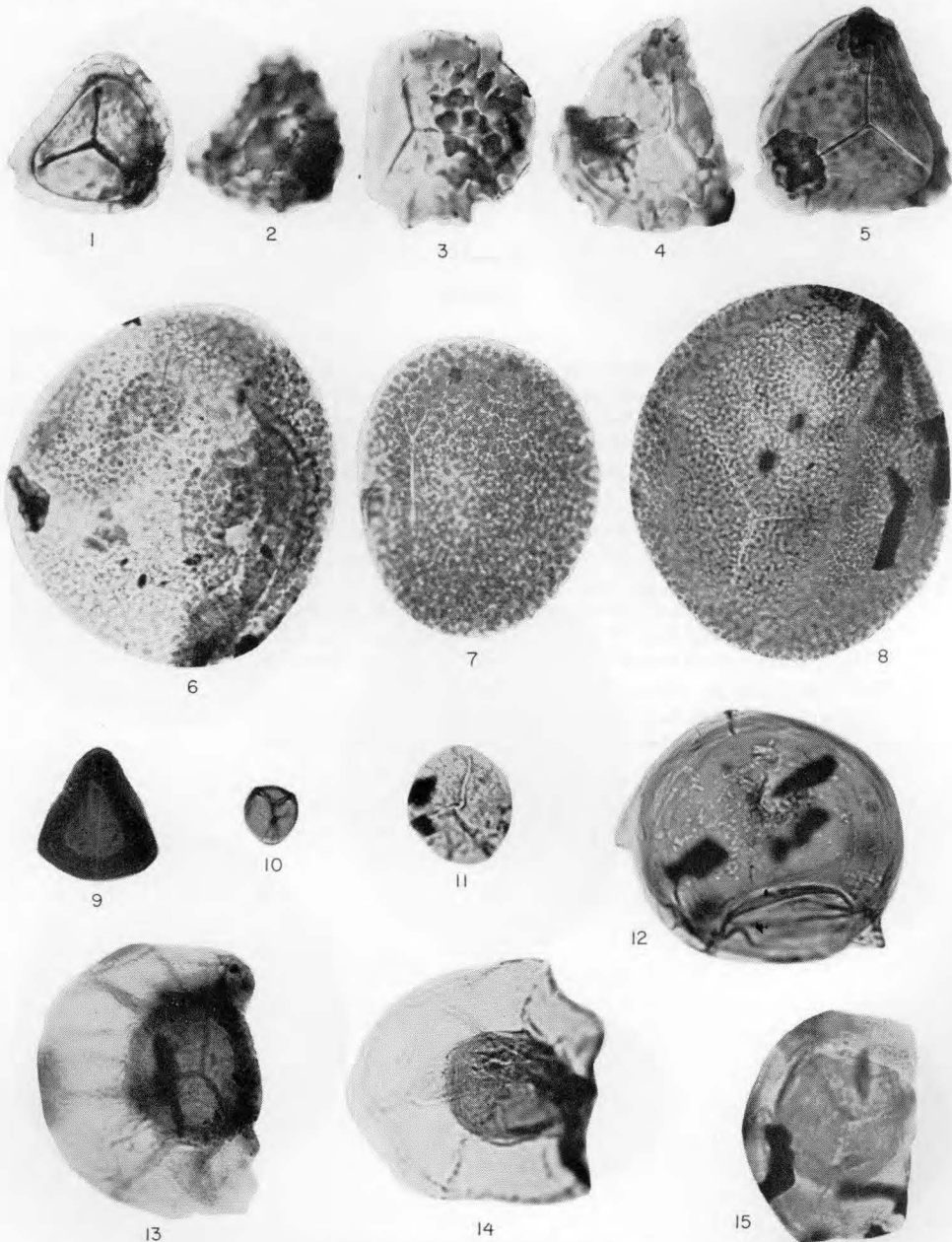


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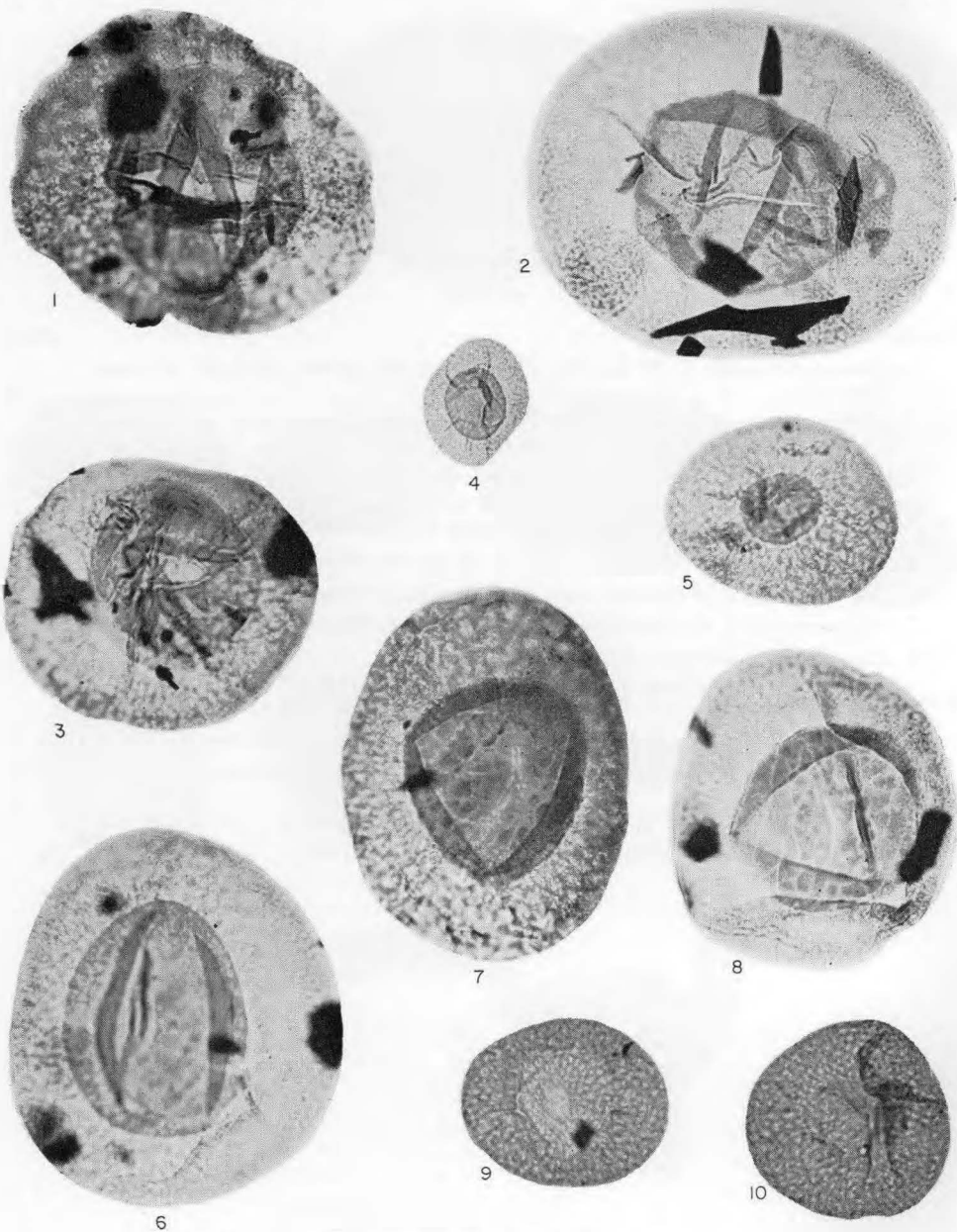
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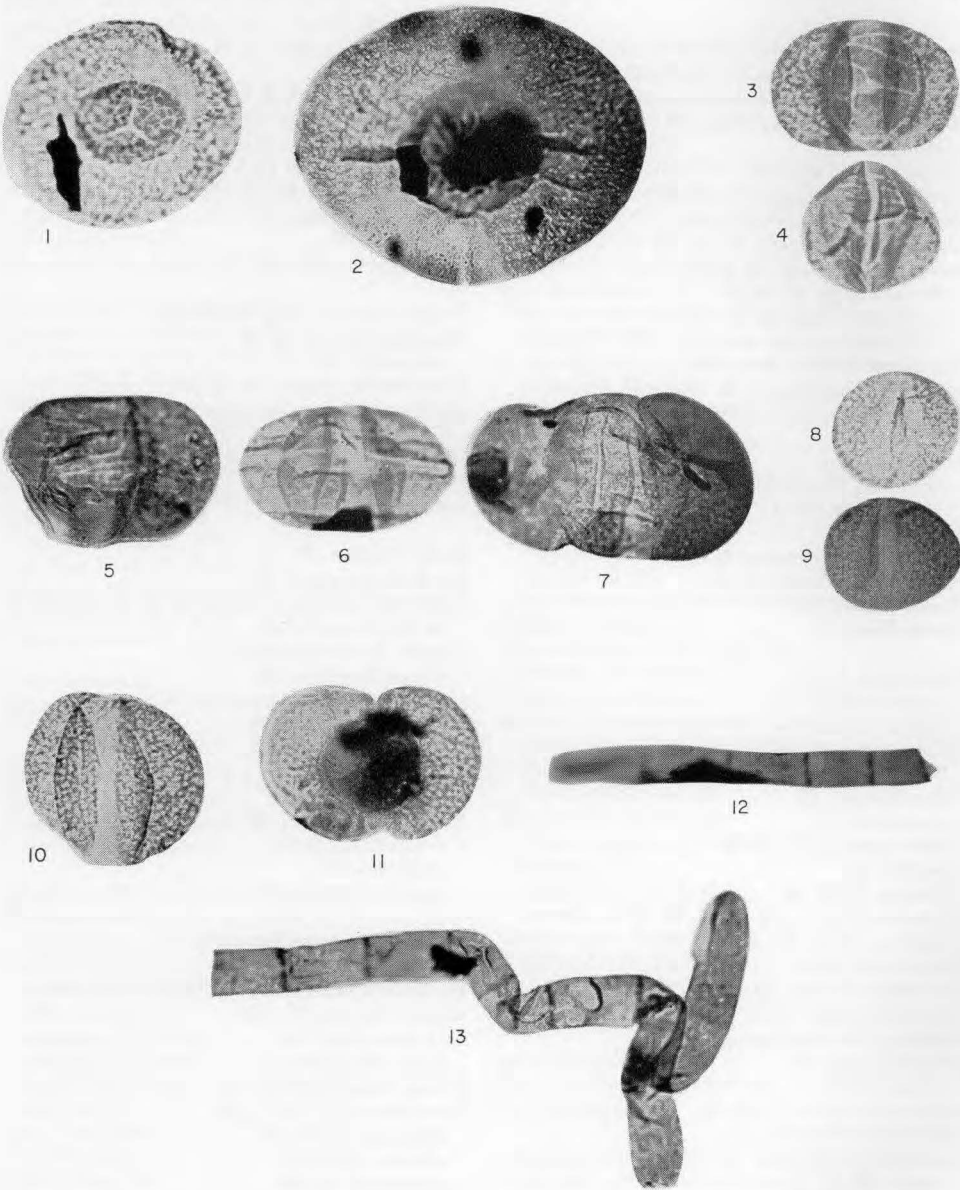
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