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PALYNOLOGY OF VERMEJO FORMATION COALS (UPPER CRETACEOUS) IN THE CANON CITY COAL FIELD, FREMONT COUNTY, COLORADO

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

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BY

ROBERT TRAVIS CLARKE

Norman, Oklahoma

1963

PALYNOLOGY OF VERMEJO FORMATION COALS (UPPER CRETACEOUS) IN THE CANON CITY COAL FIELD, FREMONT COUNTY, COLORADO

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DISSERTATION COMMITTEE

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PALYNOLOGY OF VERMEJO FORMATION COALS (UPPER CRETACEOUS) IN THE CANON CITY COAL FIELD, FREMONT COUNTY, COLORADO

CHAPTER I

INTRODUCTION

This palynological investigation of the Vermejo Formation coals (Upper Cretaceous) was undertaken with the following objectives: (1) to identify and describe the microfossils recovered from the coals; (2) to establish botanical affinities for the identified taxa; (3) to determine whether a major floral change occurs between the upper and lower coals; (4) to evaluate ecologically the palynological assemblage for environmental and climatic determinations; and (5) to attempt an age determination of the Vermejo Formation by palynological analysis. In addition, the Vermejo Formation megafossil assemblage, described by Knowlton in 1917, is compared with the palynological assemblage described in this study.

Couper (1953) and Cookson (1953 and 1959) have published papers describing Upper Cretaceous microfossils from Australia and New Zealand. Bolkhovitina (1953) has worked extensively with Upper Cretaceous coals of Russia. European work, which has been mainly concerned with Tertiary coals, also includes Cretaceous studies by Ross (1949), Nilsson (1958), Krutzsch (1959), and Pacltová (1960).

Relatively few palynological publications describing microfossils from uppermost Cretaceous deposits of North America are available for assemblage comparisons. Pierce (1961), Groot and Penny (1960), and Groot, Penny, and Groot (1961) all deal with Coniacian or older Upper Cretaceous deposits. Three publications and one unpublished M. S. thesis, however, are concerned with Santonian or younger Upper Cretaceous deposits of North America. These are Radforth and Rouse (1954), Rouse (1957), Anderson (1960), and Ames (1950) and the palynological assemblages contained therein are compared with the assemblage of the Vermejo Formation coals.

The collected samples and microslides are stored in the Oklahoma Palynological Collection of the Oklahoma Geological Survey, Norman, Oklahoma.

Acknowledgments

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Appreciation is expressed to Dr. C. C. Branson, Director of the School of Geology, Dr. E. A. Frederickson and Dr. C. A. Merritt of the School of Geology, and to Dr. G. J. Goodman, Department of Botany, for serving on the doctoral committee. Thanks are extended to Dr. C. A. Moore for his aid in the field studies.

National Science Foundation Grant No. G-22083 provided funds for chemicals and materials used in the sample preparation.

CHAPTER II

STRATIGRAPHY

Introduction

The Vermejo Formation was named by W. T. Lee in 1913 from the type exposure in Vermejo Park, New Mexico (Wilmarth, 1938). The earliest report of coal bearing strata in this area is given by the 1819 - 1820 Major S. H. Long Expedition to the Rocky Mountains. These coal beds were assigned to the Tertiary by Hayden (1869), Clark (1873), and Lesquereux (1873). Stephenson, in 1874, was the first to assign a Cretaceous age to the Vermejo Formation and this was gradually accepted after 1881 when he referred the coal beds of the Raton Mesa area to the Laramie Formation. The Laramie Formation was also used for the strata of the Canon City Coal Field until 1913. Lee and Knowlton (1917) present a more complete account of early investigations and nomenclatural problems to that date. An Upper Cretaceous age for the Vermejo Formation is now generally agreed upon with few exceptions, for example, Bartram (1937) who assigned the Vermejo Formation to the Lower Tertiary.

Local Stratigraphy

The Canon City Coal Field (three to six miles wide and eleven to twelve miles long) is located to the east of the Wet Mountains and south of Canon City in Fremont County, Colorado. The field is structurally located in an asymmetric synclinal basin with gently dipping beds in the east and steeply dipping beds in the west. The Vermejo Formation is approximately 1,100 feet thick and is unconformably overlain by the Raton Formation of Tertiary age and conformably underlain by the Trinidad Sandstone of Cretaceous age. Only the lower 600 to 700 feet contain coal beds and this is divided by the Rockvale sandstone member into upper and lower coal bearing zones. Hills (1893, p. 322) reports as many as 16 coal beds in the productive zones, but only a few are traceable for any distance in the field. Most of the coal beds, shales, and sandstones are lenticular.

Lee and Knowlton (1917) illustrate a number of sections measured in the Canon City Coal Field which graphically show the lithologic variance within the Vermejo Formation. Because all the major coal beds do not occur in a single section it was necessary to make a generalized, composite section of the Vermejo Formation to show the relative position of these beds. The section was compiled from Washburne (1910, p. 351) and from field work during the summers of 1960 and 1962.

The Trinidad Sandstone is a massive buff colored marine unit about 50 to 100 feet thick that has a constant lithology throughout the coal field. The Raton Formation is most prevalent in the western part of the coal field where it reaches a thickness of close to 500 feet and contains many granite cobbles. To the east, at the Williamsburg section of Lee and Knowlton (1917), the formation is only 20 feet thick and the sediments are mainly coarse sands with a few fine pebbles. These facts indicate the sediment source was near the depositional site and to the west.

	Feet
Unconformity at the base of the Raton Formation	
Sandstone, buff, coarser at the top	250-500
Sandstone, buff, soft, friable Shale, gray, with thin coal beds	125
Brookside coal bed (OPC 833).	
Sandstone, buff, soft, friable Shale, gray, few coal beds	75-165
Chandler coal bed	
Sandstone, buff, thin Shale, gray	30-40
Rockvale sandstone member, buff, massive . .	40-75
Shale, gray, with thin coal beds	20-30
Royal Gorge coal beds (OPC 831).	
Sandstone, buff, soft, friable Shale, gray	60-75
Radiant coal bed	
Shale, gray, with thin coal beds	75-100
Magnet or Ocean Wave coal bed (OPC 830 and OPC 918).	
Sandstone, buff, thin shales and coal beds .	100-120
Nonac coal bed	
Sandstone, buff-brown	30-50
Rockvale or Brewster coal bed (OPC 919).	
Shale, gray	0-4
Trinidad Sandstone	

Relative positions of the Vermejo Formation coal beds

Regional Correlation

One of the keys to correlation of Upper Cretaceous deposits in the Colorado area is the thickness of the Pierre Shale. This unit conformably underlies the Trinidad Sandstone and increases in thickness to the north. In the Raton Mesa Coal Field it is 2,500 feet thick, increases to about 3,300 feet thick in the Canon City area, and to 5,500 feet thick in the Denver Basin (Weimer, 1959, p. 14). The Fox Hills Sandstone of the Denver Basin conformably overlies the Pierre Shale and is the lithologic equivalent of the Trinidad Sandstone. This same relationship applies to the nonmarine Laramie and Vermejo formations. While they are lithologic equivalents, it is probable that they are not time equivalents. Thicker sediments of the Pierre Shale in the Denver Basin suggest deposition continued for a longer time in this area than in the Canon City or Raton Mesa area, and that the sea slowly retreated northward during Upper Cretaceous time.

CHAPTER III

COLLECTIONS

Eleven sections of Vermejo Formation coals were measured and channel samples collected during the summers of 1960 and 1962. All samples taken from the sections were chemically processed and examined for microfossil content. Five of these sections were selected for this study from throughout the coal-bearing zones of the formation. Figure 1 shows the locality and a graphic illustration of the sections studied. Each section was assigned an Oklahoma Palynological Collection number (OPC) and each segment of the channel sample assigned an alphabetic designation, labeled A, B, C, etc. from the base upwards, according to its stratigraphic position.

OPC 833: Wall in strip pit part of underground mine, NE$\frac{1}{4}$ Sec. 24, T. 20 S., R. 70 W., Fremont County, Colorado. This coal bed is equivalent to the Brookside coal bed.

Lithology	Thickness Feet	Thickness Inches
Sandstone, buff, thin shale partings near base	15-20	--
Coal, weathered, poor quality	--	6
Shale, gray, sandy	--	11

Lithology	Thickness Feet	Inches
Coal, upper 40 inches bony	--	84
Kaolinite	--	3
Coal, bituminous, blocky	--	45
Shale, brown, soft, floor of strip pit .	--	2

Sample No.	Lithology	Sample thickness	Position
OPC 833 X	coal	6 inches	143" - 149" above base
OPC 833 W *	shale	11 inches	132" - 143" above base
OPC 833 V	coal	6 inches	126" - 132" above base
OPC 833 U	coal	6 inches	120" - 126" above base
OPC 833 T	coal	6 inches	114" - 120" above base
OPC 833 S	shale	6 inches	108" - 114" above base
OPC 833 R *	coal	6 inches	102" - 108" above base
OPC 833 Q	coal	6 inches	96" - 102" above base
OPC 833 P	coal	6 inches	90" - 96" above base
OPC 833 O	coal	6 inches	84" - 90" above base
OPC 833 N *	coal - shale	6 inches	78" - 84" above base
OPC 833 M *	coal - shale	6 inches	72" - 78" above base
OPC 833 L	coal	6 inches	66" - 72" above base
OPC 833 K	coal	6 inches	60" - 66" above base
OPC 833 J	coal	6 inches	54" - 60" above base
OPC 833 I	coal	6 inches	48" - 54" above base
OPC 920	kaolinite	3 inches	45" - 48" above base
OPC 833 H	coal	3 inches	42" - 45" above base
OPC 833 G	coal	6 inches	36" - 42" above base

Sample No.	Lithology	Sample thickness	Position
OPC 833 F	coal	6 inches	30" - 36" above base
OPC 833 E	coal	6 inches	24" - 30" above base
OPC 833 D	coal	6 inches	18" - 24" above base
OPC 833 C	coal	6 inches	12" - 18" above base
OPC 833 B	coal	6 inches	6" - 12" above base
OPC 833 A	coal	6 inches	0" - 6" above base

Sample OPC 920 was collected inside the entrance to the mine whereas the OPC 833 samples were collected outside the mine on the strip pit cut. The asterisks noted by samples OPC 833 W, R, N, and M indicate that there was a variance within each of these segments and their lithology is shown in greater detail below.

OPC 833 W	shale, gray, soft	6 inches
	shale, black, hard	5 inches
OPC 833 R	coal, shaly, bony	6 inches
OPC 833 N	coal, blocky	$1\frac{1}{2}$ inches
	shale, gray with coal stringers	$4\frac{1}{2}$ inches
OPC 833 M	coal, blocky	1 inch
	shale, gray	2 inches
	coal, bony	3 inches

All other samples designated as "coal" are a good to fair grade bituminous coal.

OPC 831: Wall of strip pit, S½ Sec. 7, T. 20 S., R. 69 W., Fremont County, Colorado. This coal bed is probably equivalent to the Royal Gorge lower coal bed

Lithology	Thickness Feet	Thickness Inches
Shale, gray-brown, sandy	12	--
Coal, bituminous, blocky	--	28
Shale, black, carbonaceous, coaly	--	1½
Shale, brown, floor of strip pit	--	3

Sample No.	Lithology	Sample thickness	Position
OPC 831 O	coal	2 inches	26" - 28" above base
OPC 831 N	coal	2 inches	24" - 26" above base
OPC 831 M	coal	2 inches	22" - 24" above base
OPC 831 L	coal	2 inches	20" - 22" above base
OPC 831 K	coal	2 inches	18" - 20" above base
OPC 831 J	coal	2 inches	16" - 18" above base
OPC 831 I	coal	2 inches	14" - 16" above base
OPC 831 H	coal	2 inches	12" - 14" above base
OPC 831 G	coal	2 inches	10" - 12" above base
OPC 831 F	coal	2 inches	8" - 10" above base
OPC 831 E	coal	2 inches	6" - 8" above base
OPC 831 D	coal	2 inches	4" - 6" above base
OPC 831 C	coal	2 inches	2" - 4" above base
OPC 831 B	coal	2 inches	0" - 2" above base
OPC 831 A	coaly shale	1½ inches	below coal

OPC 830: Wall of strip pit, $S\frac{1}{2}$ Sec. 7, T. 20 S., R. 69 W., Fremont County, Colorado. This coal bed is probably the equivalent of the Ocean Wave or Magnet Mine coal seam.

Lithology	Thickness Feet	Thickness Inches
Shale, gray-brown, iron stained, gypsum stringers	20	--
Shale, gray	3	--
Coal, bituminous, blocky	--	52
Shale, brown, lignitic, floor of strip pit	--	4

Sample No.	Lithology	Sample thickness	Position
OPC 830 L	coal	4 inches	48" - 52" above base
OPC 830 K	coal	4 inches	44" - 48" above base
OPC 830 J	coal	4 inches	40" - 44" above base
OPC 830 I	coal	4 inches	36" - 40" above base
OPC 830 H	coal	4 inches	32" - 36" above base
OPC 830 G	coal	4 inches	28" - 32" above base
OPC 830 F	coal	4 inches	24" - 28" above base
OPC 830 E	coal	4 inches	20" - 24" above base
OPC 830 D	coal	4 inches	16" - 20" above base
OPC 830 C	coal	4 inches	12" - 16" above base
OPC 830 B	coal	4 inches	8" - 12" above base
OPC 830 A	coal	4 inches	4" - 8" above base
OPC 830 AA	coal	4 inches	0" - 4" above base

OPC 918: Wall of abandoned mine entrance, $NE\frac{1}{4}$ Sec. 13, T. 19 S., R. 70 W., Fremont County, Colorado. This coal bed is equivalent to the Ocean Wave or Magnet Mine coal bed.

Lithology	Thickness Feet	Thickness Inches
Covered interval	10	--
Shale, gray-brown	--	10
Coal, bituminous, blocky	--	54
Shale, brown, soft	--	3

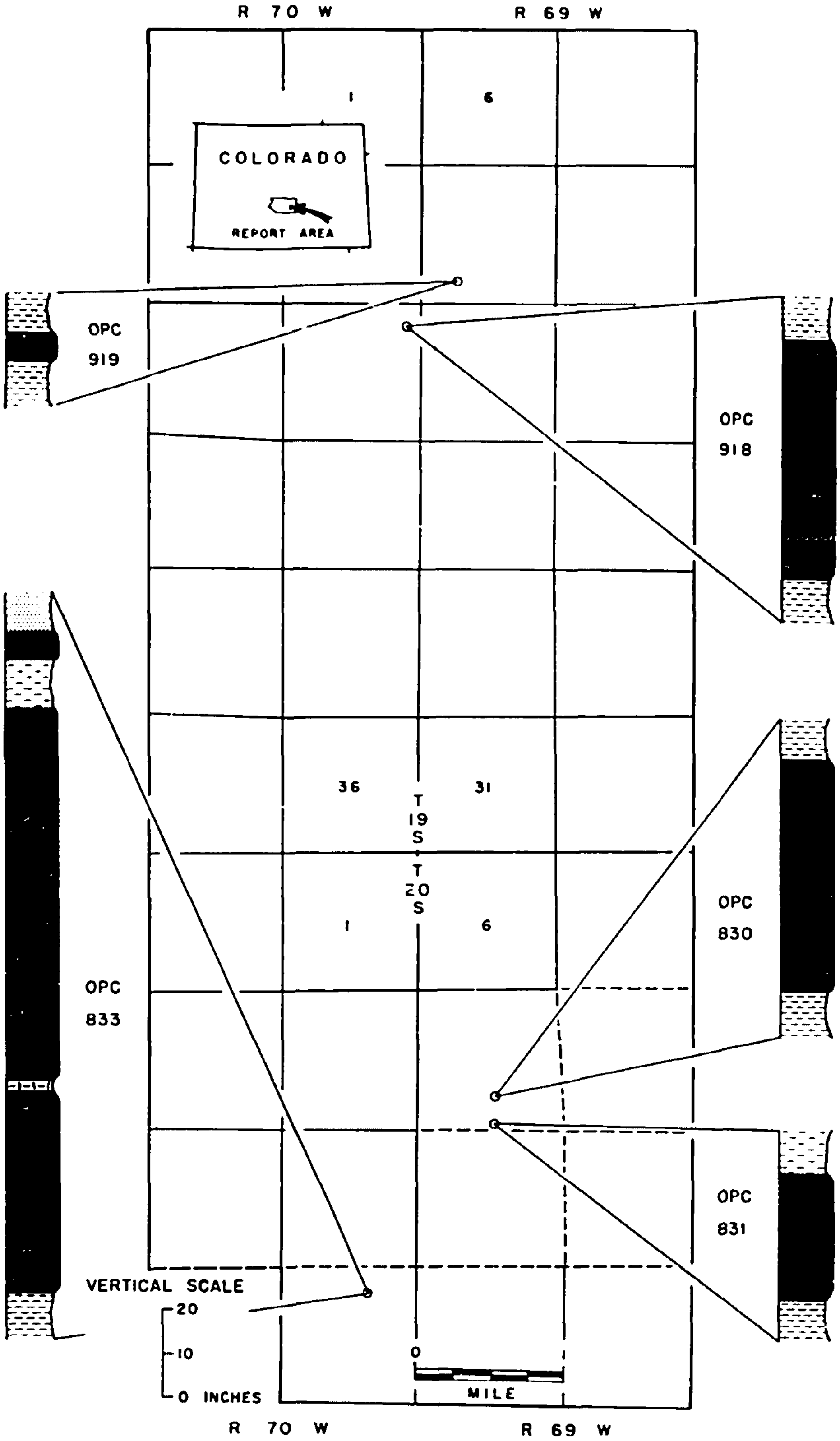
Sample No.	Lithology	Sample thickness	Position
OPC 918 K	shale	10 inches	0" - 10" above top
OPC 918 J	coal	6 inches	48" - 54" above base
OPC 918 I	coal	6 inches	42" - 48" above base
OPC 918 H	coal	6 inches	36" - 42" above base
OPC 918 G	coal	6 inches	30" - 36" above base
OPC 918 F	coal	6 inches	24" - 30" above base
OPC 918 E	coal	6 inches	18" - 24" above base
OPC 918 D	coal	6 inches	12" - 18" above base
OPC 918 C	coal	6 inches	6" - 12" above base
OPC 918 B	coal	6 inches	0" - 6" above base
OPC 918 A	shale	3 inches	below coal

OPC 919: Road cut on Colorado Highway 115, $SW\frac{1}{4}$ Sec. 7, T. 19 S., R. 69 W., Fremont County, Colorado. This coal bed is equivalent to the Rockvale or Brewster coal bed.

Lithology	Thickness Feet	Inches
Shale, gray-brown	10	--
Shale, brown, lignitic	--	18
Coal, weathered, poor quality	--	6
Shale, brown, lignitic, soft	--	2

Sample No.	Lithology	Sample thickness	Position
OPC 919 D	shale	4 inches	0" - 4" above coal
OPC 919 C	coal	3 inches	3" - 6" above base
OPC 919 B	coal	3 inches	0" - 3" above base
OPC 919 A	shale	2 inches	below coal

Section OPC 919 has only six inches of coal in the road cut where it was collected. However, information from a retired miner indicated that this same coal bed thickens to three or four feet 100 yards to the south. Two abandoned mine entrances are both unsafe to enter and samples were collected from the road cut.



LOCATION MAP AND SAMPLED INTERVALS OF THE VERMEJO FORMATION COAL SEAMS, FREMONT COUNTY, COLORADO

FIGURE 1

CHAPTER IV

SAMPLE PREPARATION AND STUDY PROCEDURE

Preparation

Laboratory techniques employed in this research are essentially those outlined by Wilson (1959a). Each sample was crushed into small fragments and thoroughly mixed. A five- to ten-gram sample cut was placed in a polyethylene beaker and covered with 52-percent hydrofluoric acid for 10 to 15 hours. Shales were first treated with hydrochloric acid to remove the carbonates, and then treated with hydrofluoric acid. Residues were washed several times with distilled water to remove excess acid, then mixed with an equal amount (by volume) of powdered potassium chlorate, and covered with concentrated nitric acid. This mixture was permitted to stand for 12 to 15 hours. Residues were again washed several times with distilled water to remove the acid, and treated with a saturated solution of potassium carbonate for five to ten minutes. After washing the residues with distilled water, and centrifuging several times, each preparation was stained with Safranin O. The residue was allowed to stand for a few minutes, then washed and centrifuged until the water was only slightly colored. Most of the residues were then stored in an aqueous solution containing a few drops of acetic acid as a preservative.

Samples from sections OPC 918 and OPC 919 were prepared further because there was a large amount of fine material remaining in the residue. Each residue was placed in a 500 ml beaker, covered with water, and placed for a short time (five to ten seconds at most) in the ultrasonic generator. One to two grams of Calgon were added at this point and the beaker filled by a vigorous stream of water, thoroughly mixing the residue. The residue was allowed to settle for one hour and the top one or two inches decanted off with a U-tube siphon. The beaker was filled with fresh water and the residue again thoroughly mixed. Decanted material was checked for fossil content and discarded if none was present. The above process was repeated several times with decreasing time intervals and slightly increasing the amount of material decanted. The final decantation was made when all the material had settled to the bottom of the beaker in about 30 minutes and the water was clear. The time to complete this extra step was more than justified by the cleaner preparation and the decreased time to make the microslides.

Further sample and microslide preparation used in this study is outlined by Wilson (1959b). One variation in the method was employed because Safranin O is more soluble in the Clearcol mounting media then in water, and a bleeding effect occurs when a stained sample is mixed with Clearcol. To combat this undesirable condition a flat toothpick used to spread the sample in Clearcol was first dipped in a dilute solution of Clorox. This action bleached the background, but did not affect the stained fossils to any degree.

A total of 620 microslides was prepared from the residues and 335 (five from each sample) were used in this study.

Study Procedure

The microslides were studied with the aid of an American Optical Microstar compound binocular microscope, using 10X W. F. oculars, and 10X, 43X, and 97X objectives. Each microslide was examined by systematic traverses. Microfossils selected for photographing were ringed with glass marking ink. Notations marked on specimen slides included sample number, slide number, and ring number; i.e. OPC 831 A-4-7. Selected specimens were photographed with a Leitz Ortholux microscope, using Adox KB-14 film.

Assemblage counts were made after the microfossils had been photographed and identified. All slides prepared from each sample level were employed to insure a random sampling. Relative percents of the various species in each sample were calculated, and histograms were made of the dominant genera.

CHAPTER V

PALEONTOLOGY

The spore and pollen assemblage of the Vermejo Formation coals from Fremont County, Colorado, consist of 64 genera containing 116 species. Five new genera and 71 new species have been described, but are not assigned binomial names. In addition, four spore types and three pollen types were described, but were not given specific rank. Excluded from the above total are seven species of Fungi imperfectae, two species of microforaminifera, and one species of Hystrichosphaeridia.

Fossil preservation was excellent in all but a few samples. The shales above and below the coal from sections OPC 918 and OPC 919 were completely barren, and sample OPC 918 H contained so few fossils that an assemblage determination was not possible. Sample OPC 920 contained only an abundance of plant tissue.

A conservative approach to systematic taxonomy is used in this dissertation. Specimens in the Vermejo Formation coals which are assigned to previously described species are tentatively identified by a cf. designation because specimens from the original preparation were not examined. Most angiospermous pollen, in particular, are classified into purely morphologic genera and are not assigned specific names, i.e. Tricolpites sp. D. Forms definitely related to modern genera are so assigned only when a fossil occurrence has been previously reported for the genus.

The taxonomic arrangement used in the dissertation is essentially the morphologic system of R. Potonié and Kremp (1955 and 1956) elaborated by R. Potonié (1956, 1958, and 1960). A systematic arrangement of dispersed spores and pollen is, of necessity, mainly artificial because phylogenetic affinities are unknown or are insufficiently known.

SPORAE DISPERSAE

Anteturma SPORITES H. Potonié, 1893

FUNGI IMPERFECTAE

FUNGUS SPORE SP. A

Plate 1, figure 1

Spores unicellular, spherical, wall smooth, 2.0 microns thick, pore type germinal aperture, overall diameter, 20.0 to 40.0 microns.

Typical specimen: OPC 830 A-3-4. Overall diameter, 25.0 x 25.0 microns.

Discussion: This species is commonly found in the Vermejo Formation coals.

Figured specimen: OPC 830 A-3-4.

FUNGUS SPORE SP. B

Plate 1, figure 2

Spores one ranked, individuals consist of five to seven cells, individuals sometimes connected, septations bidentate, cell wall smooth, slightly convex, overall dimensions, 18.0 - 25.0 x 45.0 - 55.0 microns.

Discussion: An interesting character concerning this species is the fact the individuals are sometimes connected to one another. Most of the specimens observed, however, were not connected.

This species occurs infrequently throughout the Vermejo Formation coals.

Figured specimen: OPC 833 M-1-5.

FUNGUS SPORE SP. C

Plate 1, figure 3

Spores one ranked, individuals consist of ten to fifteen cells, terminal cells rounded with no apparent aperture, septations bidentate, cell wall smooth, slightly convex, overall dimensions, 18.0 - 25.0 x 90.0 - 125.0 microns.

Typical specimen: OPC 833 M-2-6. Overall dimensions, 21.0 x 102.0 microns.

Discussion: Fungus Spore sp. C differs from Fungus Spore sp. B in the fact that the individuals are in no case connected and possess a greater number of cells. The species occurs rarely in the Vermejo Formation coals.

Figured specimen: OPC 833 M-2-6.

FUNGUS SPORE SP. D

Plate 1, figure 5

Spores one ranked, individuals consist of eight to many cells, septations bidentate, cell wall smooth, sides straight, overall dimensions, 25.0 - 32.0 x 150.0 - 230.0 microns.

Typical specimen: OPC 830 G-1-3. Overall dimensions, 28.1 x 201.5 microns.

Discussion: This species occurred rarely in the palynological assemblage.

Figured specimen: OPC 830 G-1-3.

FUNGUS SPORE SP. E

Plate 1, figure 4

Spores one ranked, individuals consisting of eight or more cells, septations simple, cell wall smooth, invaginated at septations, overall dimensions, 15.0 - 23.0 x 115.0 - 150.0 microns.

Typical specimen: OPC 830 J-4-4. Overall dimensions, 17.0 x 135.0 microns.

Discussion: The species is a sparse constituent of the Vermejo Formation coals palynological assemblage.

Figured specimen: OPC 830 J-4-4.

FUNGUS SPORE SP. F

Plate 1, figure 6

Spores bilocular, elliptical, septation simple, cell wall smooth, overall dimensions, 23.0 - 27.0 x 38.0 - 50.0 microns.

Discussion: This species occurs infrequently in all sections of the Vermejo Formation coals.

Figured specimen: OPC 830 G-4-1.

FUNGUS SPORE SP. G

Plate 1, figure 10

Spores multicellular, individuals one ranked, but occur in "colonies", septations simple, walls between lineages thickened, some lineages grow obliquely to others, overall dimensions, 48.0 to 65.0 microns.

Typical specimen: OPC 833 M-1-11. Overall dimensions, 51.0 x 56.0 microns.

Discussion: Only a few specimens of this fungus spore type were observed in the palynological assemblage.

Figured specimen: OPC 833 M-1-11.

Turma TRILETES Reinsch, 1881 emend. R. Potonié and Kremp, 1954

Subturma Azonotriletes Luber, 1935

Infraturma Laevigati Bennie and Kidston, 1886 emend. R. Potonié, 1956

Genus SPHAGNUMSPORITES Raatz, 1937

Type species: Sphagnumsporites stereoides (R. Potonié and Venitz, 1934) Raatz, 1937

1934 Sporites stereoides R. Potonié and Venitz (p. 11, pl. 1, fig. 4).

1937 Sphagnumsporites stereoides (R. Potonié and Venitz, 1934) Raatz (p. 9, pl. 1, fig. 4).

SPHAGNUMSPORITES cf. S. ANTIQUASPORITES

Wilson and Webster, 1946

Plate 1, figure 8

This species, characterized by the relatively short trilete rays, was first described from the Paleocene Fort Union Formation of Wyoming. S. cf. S. antiquasporites occurs in moderate abundance in the Vermejo Formation coals.

Affinity: Related to the family Sphagnaceae.

Figured specimen: OPC 833 M-5-4.

SPHAGNUMSPORITES cf. S. AUSTRALIS (Cookson, 1947)

R. Potonié, 1956

Plate 1, figure 9

1947 Trilites australis Cookson (p. 136, pl. 15, figs. 58 - 59).

1953 Sphagnites australis (Cookson, 1947) Cookson (p. 463).

1953 Sphagnites australis forma crassa (Cookson, 1947) Cookson (p. 464, pl. 1, figs. 2 - 4).

1956 Sphagnumsporites australis forma crassa (Cookson, 1953) R. Potonié, 1956 (p. 17).

Discussion: The few specimens observed from the Vermejo Formation coals are referable to Cookson's forma crassa of Sphagnites australis. Drozhastchich (1961, p. 14, pl. XLVIII, fig. 7) illustrated an identical form with those found in this study.

Affinity: Related to the family Sphagnaceae.

Figured specimen: OPC 833 F-1-4.

SPHAGNUMSPORITES cf. S. PSILATUS (Ross, 1949) Couper, 1958

Plate 1, figure 7

1949 Trilites psilatus Ross (p. 32, pl. 1, fig. 12).

1958 Sphagnumsporites psilatus (Ross, 1949) Couper (p. 131, pl. 15, figs. 1 - 2).

Discussion: This species was first reported from the Upper Cretaceous (post-Senonian) of Sweden. S. cf. S. psilatus differs from S. cf. S. antiquasporites in the longer trilete rays and in the thicker spore wall. It occurs in moderate abundance throughout the Vermejo Formation coals.

Affinity: Related to the family Sphagnaceae.

Figured specimen: OPC 831 A-3-2.

Genus DELTOIDOSPORA Miner, 1935 emend. R. Potonié, 1956

Type species: Deltoidospora halli Miner, 1935 (p. 618, pl. 24, figs., 7 - 8).

DELTOIDOSPORA cf. D. HALLI Miner, 1935

Plate 1, figure 11

Discussion: Spores of D. cf. D. halli make up an important percentage of the palynological assemblage from the Vermejo Formation coals, and the species occurs in all samples.

Affinity: Probably related to the family Gleicheniaceae. Miner (1935, p. 618) related this spore to the Mesozoic fern genera Gleichenites, Gleicheniopsis, and Laccopteris.

Figured specimen: OPC 833 O-3-4.

DELTOIDOSPORA SP. A

Plate 1, figures 13 - 14

Spores trilete, radial, equatorial contour triangular to rounded triangular, trilete simple, laesurae two-thirds spore radius, exine 2.0 to 3.0 microns thick, slight interradial thickening, overall dimensions, 33.0 to 42.0 microns.

Typical specimen: OPC 833 M-1-9. Overall dimensions, 41.0 x 41.0 x 41.0 microns.

Discussion: Spores of this type are here placed in the genus Deltoidospora rather than in the genus Leiotriletes Naumova, 1937 emend. R. Potonié and Kremp, 1954, as discussed by Bharadwaj and Venkatachala (1961, p. 19-20). Leiotriletes adrienniformis, in Nilsson (1958, p. 31) is almost identical with this described species. D. sp. A possesses a thicker exine and has more rounded apices than does D. cf. D. halli.

Affinity: Possibly related to the family Gleicheniaceae.

Figured specimens: OPC 833 M-1-9 and OPC 831 O-5-1.

Genus CYATHIDITES Couper, 1953

Type species: Cyathidites australis Couper, 1953 (p. 27, pl. 2 figs. 11 - 12).

CYATHIDITES cf. C. MINOR Couper, 1953

Plate 1, figures 17 , 19

Discussion: Couper (1953, p. 27) described this genus as possessing only concave sides, and related the species to Coniopteris hymenophylloides (Brongniart, 1828) Seward, 1900. However, in 1958 (pl. 20, figs., 5 - 7) Couper illustrated spores of this species with straight to slightly convex sides. The spores found in the Vermejo Formation coals palynological assemblage exhibited a gradation between concave, straight, and convex sides, and are here all included in the genus Cyathidites. Most of the specimens observed did, however, possess concave sides. C. cf. C. minor is an important constituent of the palynological assemblage. It occurred in almost all sample segments and attained a maximum abundance in the lower part of section OPC 830.

Affinity: Couper (1958, p. 139) stated that the dispersed spores almost certainly belong to the Mesozoic cyatheaceous or dicksoniaceous ferns.

Figured specimens: OPC 831 A-6-1 and OPC 830 AA-1-7.

Genus MATONISPORITES Couper, 1958

Type species: Matonisporites phlebopteroides Couper, 1958 (p. 140, pl. 20, fig. 15).

MATONISPORITES cf. M. EQUIEXINOUS Couper, 1958

Plate 1, figure 18

Discussion: M. equiexinous was first described from the Jurassic and Lower Cretaceous of Great Britain. It is a rare spore type in the Vermejo Formation coals.

Affinity: Probably related to the fern family Matoniaceae.

Figured Specimen: OPC 830 C-2-6.

Genus GLEICHENIIDITES Ross, 1949 emend.

Delcourt and Sprumont, 1955

Type species: Gleicheniidites senonicus Ross, 1949 emend. Delcourt and Sprumont, 1955

1949 Gleicheniidites senonicus Ross (p. 31, pl. 1, figs. 3 - 4).

1955 Gleicheniidites senonicus Ross, 1949 emend. Delcourt and Sprumont (p. 26).

GLEICHENIIDITES SP. A

Plate 1, figures 12, 16

Spores trilete, radial, outline triangular, trilete simple, reaching or almost reaching the equator, kyrtome distinct, side straight to concave, exine smooth, about 1.0 micron thick, overall diameter, 23.0 to 33.0 microns.

Typical specimen: OPC 918 C-5-7. Overall diameter, 25.0 x 25.5 x 25.5 microns.

Discussion: G. sp. A is one of the more common species in the Vermejo Formation coals and is present in almost all the samples studied.

Affinity: Probably related to the modern fern genus Gleichenia.

Figured specimens: OPC 918 C-5-7 and OPC 833 A-1-5.

GLEICHENIIDITES SP. B

Plate 1, figure 15

Spores radial, trilete, outline rounded triangular, laesurae extend almost to equator, kyrtome concave and connects around apices of laesurae, kyrtome 2.0 to 3.0 microns wide, exine smooth, 1.0 micron thick, overall diameter, 35.0 to 45.0 microns.

Typical specimen: OPC 830 F-1-6. Overall diameter, 38.0 x 38.0 x 40.0 microns.

Discussion: Nilsson (1958, pl. 1, figs. 12 - 13) illustrated a similar spore type, Concavisporites toralis (Leschik, 1955) Nilsson, 1958, from the Upper Triassic Rhaetic of Sweden. Bolkhovitina and Kotova (1963, pl. 1, fig. 12, and pl. 3, fig. 10) relate a morphologically similar form to the genus Phlebopteris, a Mesozoic fern.

The species is a minor spore type in the Vermejo Formation coals .

Affinity: Possibly related to the Mesozoic fern genus

Phlebopteris, considered by Couper (1958, p. 116) to belong to the family Matoniaceae. It is also possible these dispersed spores belong to the family Gleicheniaceae.

Figured specimen: OPC 830 F-1-6.

Genus LYGODIUMSPORITES R. Potonié, Thomson, and Thiergart, 1950 emend. R. Potonié, 1956

Type species: *Lygodiumsporites adriennis* (R. Potonié and Gelletich, 1933) R. Potonié, Thomson, and Thiergart, 1950

1933 *Punctatisporites adriennis* R. Potonié and Gelletich (p. 521, pl. 2, fig. 14).

1950 *Lygodiumsporites adriennis* (R. Potonié and Gelletich, 1933) R. Potonié, Thomson, and Thiergart (p. 45, pl. A, fig. 7, and pl. C, fig. 2).

LYGODIUMSPORITES cf. L. ADRIENNIS (R. Potonié and Gelletich, 1933) R. Potonié, Thomson, and Thiergart, 1950

Plate 2, figure 2

Discussion: Fossil spores ascribed to the genus *Triplanosporites* Pflug, 1953 (see Thomson and Pflug, 1953 and Krutzsch, 1959) are based on folded specimens. Deák (1959) has shown, through experimentation with spores of modern *Lygodium*, that these folds are produced by compaction and are not good criteria of a generic character.

L. cf. *L. adriennis* is one of the major spore types in the palynological assemblage of the Vermejo Formation coals. It is present in all sample levels and is the dominant species in some of the middle levels of sections OPC 918 and OPC 830.

Affinity: Related to the modern genus Lygodium.

Figured specimen: OPC 918 D-3-3.

Genus CALAMOSPORA Schopf, Wilson, and Bentall, 1944

Type species: Calamospora hartungiana Schopf, 1944 in Schopf, Wilson, and Bentall, 1944 (p. 51, fig. 1).

CALAMOSPORA cf. C. MESOZOICA Couper, 1958

Plate 2, figure 1

Discussion: C. mesozoica was first described from the Lower and Middle Jurassic of Great Britain. It is a rare spore type in the present samples.

Affinity: Couper (1958, p. 132) stated that this species is possibly related to the equisetalean Neocalamites nathorsti Erdtman.

Figured specimen: OPC 831 A-1-6.

Genus TODISPORITES Couper, 1958

Type species: Todisporites major Couper, 1958 (p. 134, pl. 16, fig. 6).

TODISPORITES cf. T. MINOR Couper, 1958

Plate 2, figure 6

Discussion: Couper (1958, p. 134 - 135) described two species of Todisporites (T. major and T. minor) from the Jurassic of Great Britain. The main criteria for creating the two species was a bimodal frequency curve plotted from overall size data. A size frequency curve plotted from specimens in the Vermejo Formation coals showed only one species to be present. The size range of these specimens overlap the size range of Couper's two species, but the majority fall within the *T. minor* size range and this specific name is used.

T. cf. *T. minor* occurs infrequently in the lower coals of the Vermejo Formation.

Affinity: Comparable to spores of the modern genus *Todites*, a member of the family Osmundaceae.

Figured specimen: OPC 830 I-2-7.

TODISPORITES cf. TODITES UNDANS (Brongniart) Harris, 1937

Plate 2, figure 3

Discussion: The specimens found in the Vermejo Formation coals are almost identical to the spores described by Couper (1958, p. 108, pl. 16, fig. 3) as *Todites undans*. They are here included under the fossil genus *Todisporites*. It is a rare constituent and occurs in only three levels from different samples.

Affinity: Comparable to spores of the modern genus *Todites*, a member of the family Osmundaceae.

Figured specimen: OPC 833 W-2-1.

Genus LESCHIKISPORIS R. Potonié, 1958

Type species: *Leschikisporis aduncus* (Leschik, 1955) R. Potonié, 1958

1955 *Punctatosporites aduncus* Leschik (p. 27, pl. 3, fig. 17).

1958 *Leschikisporis aduncus* (Leschik, 1955) R. Potonié (p. 18, pl. 1, fig. 9).

This genus was established for laevigate spores with asymmetric trilete marks.

LESCHIKISPORIS cf. L. ADUNCUS (Leschik, 1955) R. Potonié, 1958

Plate 2, figure 4

Discussion: Most of the specimens found in the Vermejo Formation coals are slightly larger than the size range originally noted by Leschik. This difference is considered minor and a new species is not established merely because of this variance.

L. cf. L. aduncus is found rarely from the coals stratigraphically lower than section OPC 833.

Affinity: Leschik (1955, p. 27) stated that the botanical affinity of this species is with the family Polypodiaceae.

Figured specimen: OPC 831 A-3-15.

Infraturma Apiculati Bennie and Kidston, 1886 emend.
R. Potonié, 1956

Genus GRANULATISPORITES Ibrahim, 1933 emend.
R. Potonié and Kremp, 1954

Type species: Granulatisporites granulatus Ibrahim, 1933 (p. 22, pl. 6, fig. 51).

GRANULATISPORITES SP. A

Plate 2 figure 5

Spores trilete, radial, outline rounded triangular, laesurae two-thirds spore radius, exine 1.0 to 1.5 microns thick, finely granular, overall dimensions, 32.0 to 47.0 microns.

Typical specimen: OPC 833 W-3-21. Overall dimensions, 35.7 x 42.1 x 45.9 microns.

Discussion: This species is a minor floral element of the Vermejo Formation coals.

Affinity: Probably filicinean.

Figured specimen: OPC 833 W-3-21.

Genus VERRUCOSISPORITES Ibrahim, 1933 emend.

R. Potonié and Kremp, 1954

Type species: Verrucosisporites verrucosus (Ibrahim, 1932) Ibrahim, 1933

1932 Sporonites verrucosus Ibrahim in Potonié, Ibrahim, and Loose (p. 448, pl. 15, fig. 17)

1933 Verrucosi-sporites verrucosus (Ibrahim, 1932) Ibrahim (p. 25, pl. 2, fig. 17).

VERRUCOSISPORITES cf. V. ASYMMETRICUS (Cookson and Dettmann, 1958) Pocock, 1962

Plate 2, figure 7

1958 Apiculatisporites asymmetricus Cookson and Dettmann (p. 100, pl. 14, fig. 11).

1962 Verrucosisporites asymmetricus (Cookson and Dettmann, 1958) Pocock (p. 56, pl. 8, figs. 124-126).

Discussion: V. asymmetricus was first described from the Lower Cretaceous of Australia and the specimens found here compare favorably with the original description. The species was observed in all sections except OPC 831, but is only a minor constituent of the coals.

Affinity: Filicinean.

Figured specimen: OPC 918 B-2-2.

VERRUCOSISPORITES SP. A

Plate 2, figure 9

Spores trilete, radial, outline spherical, laesurae one-half to two-thirds the spore radius, exine verrucate, verrucae closely spaced, 0.5 micron high, 1.0 to 3.0 microns wide, gives an impression of a negative reticulum, overall diameter, 56.0 to 70.0 microns.

Typical specimen: OPC 918 E-2-5. Overall diameter, 66.3 x 66.3 microns.

Discussion: This species is a minor floral element in the Vermejo Formation coals.

Affinity: Probably related to the family Osmundaceae.

Figured specimen: OPC 918 E-2-5.

VERRUCOSISPORITES SP. B

Plate 2, figure 8

Spores trilete, radial, outline sub-spherical, laesurae about one-half spore radius, exine verrucate, verrucae irregular, closely spaced, 2.0 to 3.0 microns high, 2.0 to 7.0 microns wide, verrucae in some cases connected, overall diameter, 48.0 to 56.0 microns.

Discussion: This species differs from V. sp. A in the largerand sometimes connected verrucae and in the smaller size. Only a few specimens were observed in the assemblage.

Affinity: Unknown.

Figured specimen: OPC 833 L-2-8.

GENUS E

Spores trilete, radial, outline circular to subcircular, distal face laevigate, proximal face ornamented with widely spaced verrucae, trilete laesurae bifurcated near equator forming three "proximal segments", ornamentation restricted to "segments", overall diameter, 40.0 to 50.0 microns.

GENUS E SP. A

Plate 2, figures 10 - 11

Spores trilete, radial, outline circular to subcircular, distal face laevigate, proximal face ornamented with widely spaced (2.0 to 4.0 microns) verrucae, verrucae 1.0 to 1.5 microns wide, about 0.5 micron high, laesurae thin, bifurcated near equator forming three "proximal segments" (see Plate 2, figure 11), ornamentation restricted to "segments", bifurcated laesurae about 15.0 microns wide at equator, overall diameter, 40.0 to 50.0 microns.

Typical specimen: OPC 830 I-2-3. Overall diameter, 42.0 x 45.0 microns.

Discussion: This species occurs rarely throughout the Vermejo Formation coals.

Affinity: Unknown.

Figured specimen: OPC 830 I-2-3.

GENUS C

Spores trilete, radial, outline triangular to subtriangular, laesurae extend to overlap of distal ornamentation upon proximal surface, proximal face laevigate, distal surface baculate, ornamentation extends proximally and equatorially covers about one-third proximal surface, gives illusion of a thickened equatorial cingulum, overall dimensions, 39.0 tp 55.0 microns.

GENUS C SP. A

Plate 2, figures 12 - 13

Spores trilete, radial, outline triangular to subtriangular, laesurae extend to overlap of distal ornamentation upon proximal surface, proximal face laevigate, distal surface baculate, baculae 2.0 to 3.0 microns wide, 2.0 to 3.0 microns high, spaced 3.0 to 5.0 microns apart, ornamentation extends proximally and equatorially covers about one-third the proximal face giving a false impression of a thickened equatorial cingulum, overall dimensions, 39.0 to 55.0 microns.

Typical specimen: OPC 918 D-1-8. Overall dimensions, 46.0 x 46.0 x 46.0 microns.

Discussion: Spores of this type are sufficiently diagnostic and different from other previously described genera to warrant a new generic recognition. Genus C sp. A occurs in moderate abundance in all samples except OPC 831.

Affinity: Probably filicinean.

Figured specimens: OPC 918 D-1-8 and OPC 918 C-2-30.

Genus APICULATISPORITES Ibrahim, 1933 emend.

R. Potonié and Kremp, 1954

Type species: Apiculatisporites aculeatus Ibrahim, 1933 (p. 23, pl. 6, fig. 57).

R. Potonié and Kremp (1956b, p. 94) designated this species as the type for the genus Apiculatisporis R. Potonié and Kremp, 1956. This transfer is not recognized because Apiculatisporites is a valid name and has priority over the genus later established by R. Potonié and Kremp. The genus Apiculatisporis should be placed in synonomy with Ibrahim's genus Apiculatisporites.

APICULATISPORITES cf. A. SPINIGER Leschik, 1955

Plate 3, figure 3

Discussion: This species was first described from the Upper Triassic (Middle Keuper) of Switzerland. It is a rare spore type in the Vermejo Formation coals and did not occur in the assemblage counts.

Affinity: Leschik (1955, p. 18) related dispersed spores of this type to the modern genus Danaea, a member of the family Marattiales.

Figured specimen: OPC 833 W-2-14.

Genus OSMUNDACIDITES Couper, 1953

Type species: Osmundacidites wellmanii Couper, 1953 (p. 20, pl. 1, fig. 5).

OSMUNDACIDITES cf. O. WELLMANII Couper, 1953

Plate 3, figure 1

Discussion: Spores of O. cf. O. wellmanii found in the Vermejo Formation coals are generally in the lower end of the size range noted by Couper (1953, p. 20) for this species. Their overall size more closely approximates the size range for the specimens assigned to this species by Pocock (1962, p. 35).

O. cf. O. wellmanii is present in all sections, but comprises only about one to three percent of the palynological assemblage from any one level.

Affinity: Related to the family Osmundaceae.

Figured specimen: OPC 833 W-5-17.

OSMUNDACIDITES SP. A

Plate 3, figure 2

Spores trilete, radial, outline circualr, laesurae about one-half spore radius, exine 2.0 to 2.5 microns thick, finely granular, overall diameter, 62.0 to 76.0 microns.

Typical specimen: OPC 831 B-5-2. Overall diameter, 71.6 x 74.0 microns.

Discussion: O. sp. A is consistantly larger than O. cf. O. wellmanii and, primarily, possesses a granular exine. It is found sparsely in the Vermejo Formation coals.

Affinity: Probably osmundaceous.

Figured specimen: OPC 831 B-5-2.

Genus ACANTHOTRILETES Naumova, 1937 emend.

R. Potonié and Kremp, 1954

Type species: Acanthotriletes ciliatus (Knox, 1950) R. Potonié and Kremp, 1955

1950 Spinoso-sporites ciliatus Knox (p.312, pl. 17, fig. 206).

1955 Acanthotriletes ciliatus (Knox, 1950) R. Potonié and Kremp (p. 133, pl. 20, fig. 3).

Krutzsch (1959, p. 132) established the genus Echinatisporis to include small trilete spores with spines. Krutzsch's genus is considered invalid because the name Acanthotriletes has priority, and is used in this study.

ACANTHOTRILETES cf. A. VARISPINOSUS Pocock, 1962

Plate 3, figures 5 - 6

Discussion: A. varispinosus was first described from the Lower Cretaceous of western Canada. The specimens observed in the Vermejo Formation coals are identical with those originally described.

This species is rare and is primarily found in the middle and upper segments of sections OPC 918 and OPC 833.

Affinity: Pocock (1962, p. 36) stated that they probably are spores from a Cretaceous species of selaginellous affinity.

Figured specimens: OPC 918 F-3-10 and OPC 918 F-2-4.

Genus PILOSISPORITES Delcourt and Sprumont, 1955

Type species: Pilosisporites trichopapillosus (Thiergart, 1949) Delcourt and Sprumont, 1955

1949 Sporites trichopapillosus Thiergart (p. 22, pls. 4/5, fig. 18).

1955 Pilosisporites trichopapillosus (Thiergart, 1949) Delcourt and Sprumont (p. 35, pl. 3, fig. 3).

PILOSISPORITES SP.

Plate 3, figure 4

Spore trilete, radial, outline subtriangular, laesurae about two-thirds spore radius, ornamentation of thin spines, 1.0 to 3.0 microns high, 1.0 to 2.0 microns wide at base, spines present on outer wall (perine ?), exine appears to have pulled away from perine (?), overall dimensions, 51.0 x 51.0 x 51.0 microns.

Discussion: Only one specimen of this spore type was found in the Vermejo Formation coals.

Affinity: Possibly filicinean.

Figured specimen: OPC 833 H-4-1.

Infraturma Murornati R. Potonié and Kremp, 1954

Genus LYCOPODIACIDITES Couper, 1953 emend.

R. Potonié, 1956

Type species: Lycopodiacidites bullerensis Couper, 1953 (p. 26, pl. 1, fig. 9).

LYCOPODIACIDITES cf. L. KUEPPERI Klaus, 1960

Plate 3, figure 11

Discussion: Spores observed in the Vermejo Formation coals are similar to those of the species described by Klaus (1960, p. 135) from the Alpine Triassic of Europe. It is a minor floral element in the palynological assemblage.

Affinity: Lycopodiaceous.

Figured specimen: OPC 830 J-4-1.

LYCOPODIACIDITES SP. A

Plate 3, figure 10

Spores trilete, radial, subspherical, laesurae two-thirds spore radius, proximal face laevigate, distal face covered with closely spaced irregular rugae, overall diameter, 24.0 to 41.0 microns.

Typical specimen: OPC 830 J-2-1. Overall diameter, 28.0 x 30.0 microns.

Discussion: _L_. sp. A is common throughout the Vermejo Formation coals. It attains a maximum abundance in the middle and upper levels of sections OPC 830 and OPC 833.

Affinity: Unknown lycopodiaceous affinity.

Figured specimen: OPC 830 J-2-1.

Genus LYCOPODIUMSPORITES Thiergart, 1938

Type species: _Lycopodiumsporites_ _agathoecus_ (R. Potonié, 1934) Thiergart, 1938

1934b _Sporites_ _agathoecus_ R. Potonié (p. 43, pl. 1, fig. 25).

1938 _Lycopodiumsporites_ _agathoecus_ (R. Potonié, 1934) Thiergart (p. 293, pl. 22, figs. 9 - 10).

LYCOPODIUMSPORITES cf. L AUSTROCLAVITIDITES (Cookson, 1953) Pocock, 1962

Plate 3, figure 9

1953 Lycopodium austroclavitidites Cookson (p. 469, pl. 2, fig. 35).

1958 Lycopodiumsporites clavatoides Couper (p. 132, pl. 15, figs. 10 - 13).

1959 Lycopodium reticulumsporites Rouse (p. 309, pl. 2, figs. 1 - 3).

1962 Lycopodiumsporites austroclavitidites (Cookson, 1953) Pocock (p. 33, pl. 1, figs. 5 - 6).

Discussion: This species was first described from pre-Tertiary clays of South Australia. L. cf. L. austroclavitidites is a sparse element in the Vermejo Formation coals palynological assemblage and is found mainly in sections OPC 830 and OPC 833.

Affinity: Probably related to the "Clavatoide type" of the modern genus Lycopodium.

Figured specimen: OPC 833 M-3-7.

LYCOPODIUMSPORITES SP. A

Plate 3, figure 7

Spores trilete, radial, outline subtriangular, laesurae extend almost to periphery, proximal face laevigate, distal face reticulate, lumina rounded, 2.0 to 4.0 microns wide, muri 1.0 to 2.0 microns wide, raised about 1.0 micron, overall dimensions, 49.0 to 56.0 microns.

Typical specimen: OPC 831 A-4-7. Overall dimensions, 55.0 x 55.0 x 55.0 microns.

Discussion: A number of specimens of this species were observed in the Vermejo Formation coals, primarily in level A, section OPC 831. The species is not abundant in any sample.

Affinity: Lycopodiaceous.

Figured specimen: OPC 831 A-4-7.

LYCOPODIUMSPORITES SP. B

Plate 3, figures 12 - 13

Spores trilete, radial, outline subspherical, trilete indistinct, laesurae extend more than one-half spore radius, proximal face laevigate, distal face covered with raised incomplete reticulum, extends proximally and covers about one-half the proximal face, lumina 3.0 to 6.0 microns wide when enclosed, muri 1.0 to 2.0 microns wide, 1.0 to 2.0 microns high, overall diameter, 40.0 to 46.0 microns.

Discussion: This spore type occurred rarely in the middle of section OPC 833. No typical specimen was here designated.

Affinity: Lycopodiaceous, possibly related to the modern genus Lycopodium.

Figured specimen: OPC 833 L-2-9.

LYCOPODIUMSPORITES SP. C

Plate 3, figure 8

Spore trilete, radial, outline subtriangular, laesurae extend to margin, proximal face laevigate, distal face reticulate, lumina 6.0 to 11.0 microns wide, muri slightly raised, thin membraneous sheath covers distal face and extends for 2.0 to 4.0 microns beyond periphery, overall dimensions, 48.5 x 48.5 x 48.5 microns.

Discussion: A single specimen of this species was found in the Vermejo Formation coals.

Affinity: Probably related to the modern genus Lycopodium.

Figured specimen: OPC 831 A-1-12.

LYCOPODIUMSPORITES ? SP.

Plate 4, figure 2

Spores trilete, radial, outline subtriangular, laesurae extend to edge of thim membraneous "rim", proximal face laevigate, distal face reticulate, lumina 4.0 to 9.0 microns wide, equatorial "rim" 5.0 to 10.0 microns wide, overall dimensions, 51.0 to 63.0 microns.

Discussion: From the few specimens observed in the middle of section OPC 833 it was not possible to determine whether the "rim" is a true equatorial rim or whether it extends over the distal face of the spore.

Affinity: Unknown lycopodiaceous affinity ?

Figured specimen: OPC 833 I-4-1.

Genus CICATRICOSISPORITES R. Potonié and Gelletich, 1933

Type species: Cicatricosisporites dorogensis R. Potonié and Gelletich, 1933 (p. 522, pl. 1, figs. 1 - 5).

1951 Mohrioisporites dorogensis R. Potonié (p. 114, pl. 20, fig. 14).

1953 *Mohrioisporites australiensis* Cookson (p. 470, pl. 2, figs. 31 - 34).

1956 *Cicatricosporites australiensis* (Cookson, 1953) R. Potonié (p. 48).

CICATRICOSISPORITES cf. C. DOROGENSIS R. Potonié and Gelletich, 1933

Plate 4, figure 4

Discussion: *C.* cf. *C. dorogensis* is a minor spore type in the Vermejo Formation coals. It is found in all sections except OPC 919, but is not abundant in any sample.

Chandler (1955, p. 304) described the spores found in a fertile pinnule of *Anemia colwellensis* from the Tertiary of England. These spores compare closely with those here assigned to *C.* cf. *C. dorogensis*.

Affinity: Schizaeacean, probably related to the modern genus *Anemia*.

Figured specimen: OPC 831 A-4-2.

GENUS B

Spores trilete, radial, outline triangular to rounded triangular, laesurae deeply grooved, extend to equator, exine covered with irregular branched ridges separated by linear branched furrows, furrows do not extend to trilete mark, overall dimensions, 40.0 to 50.0 microns.

GENUS B SP. A

Plate 4, figures 1 - 3

Spores trilete, radial, outline triangular to rounded triangular, laesurae deeply grooved, extend to equator, exine covered with irregular branched ridges, 3.0 to 4.0 microns wide, 3.0 to 4.0 microns high, ridges separated by linear branched furrows 1.0 micron wide, furrows do not extend to trilete mark, overall dimensions, 40.0 to 50.0 microns.

Typical specimen: OPC 833 L-4-2. Overall dimensions, 45.0 x 45.0 x 45.0 microns.

Discussion: This genus is restricted mainly to section OPC 833, but does occur infrequently in other samples.

Affinity: Schizaeacean, possibly related to the modern genus Anemia.

Figured specimens: OPC 833 L-4-2 and OPC 830 E-1-1.

Turma ZONALES Bennie and Kidston, 1886 emend. R. Potonié, 1956

Subturma Auritotriletes R. Potonié and Kremp, 1954

Infraturma Appendiciferi R. Potonié, 1956

Genus APPENDICISPORITES Weyland and Krieger, 1953

Type species: Appendicisporites tricuspidatus Weyland and Krieger, 1953 (p. 12, pl. 3, fig. 18).

Weyland and Krieger (1953) and Weyland and Greifeld (1953) described the species and both descriptions were published in the same volume of Palaeontographica (vol. 95). Weyland and Krieger's description occurs first in the publication and this is then accepted as the original designation of the type species.

APPENDICISPORITES cf. A. TRICORNITATUS Weyland and Greifeld, 1953

Plate 4, figure 5

Discussion: This species was first described from the Lower Senonian of Germany. It is a rare spore type in the Vermejo Formation coals and does not occur in the assemblage counts.

Affinity: Schizaeacean, possibly related to the modern genus Anemia.

Figured specimen: OPC 833 M-5-6.

APPENDICISPORITES SP. A

Plate 4, figures 7 - 9

Spores trilete, radial, equatorial contour rounded triangular, laesurae about two-thirds spore radius, proximal face laevigate, distal face sculptured with series of ridges, usually three or four, each possessing apical projections 6.0 to 10.0 microns long, ridges approximately parallel equatorial contour, decreasing in outline from the equatorial contour inward on the distal face, ridges 1.0 to 3.0 microns wide, 1.0 to 2.0 microns high, inter-ridge area 7.5 to 15.0 microns wide in plan view, overall dimensions, 63.0 to 80.o microns.

Typical specimen: OPC 918 D-1-4. Overall dimensions, 74.0 x 76.0 x 76.0 microns.

Discussion: This species is larger than A. cf. A. tricornitatus and possesses a peculiar "layered" effect with the apical projections from each ridge. Plate 4, figure 7 illustrates a side view of a specimen showing the raised ridges and a group of the apical projections. Plate 4, figure 9 is a slightly oblique plan view of the distal surface, illustrating the ridges and apical projections.

A. sp. A is a minor constituent of the Vermejo Formation coals' palynological assemblage.

Affinity: Schizaeacean, possibly related to the modern genus *Anemia*.

Figured specimens: OPC 918 D-1-4, OPC 830 G-3-3, and OPC 831 J-2-1.

SPORE TYPE C

Plate 4, figure 11

Spores trilete, radial, proximal face laevigate, distal face sculptured with broad ridges, 4.0 to 6.0 microns wide, 2.0 to 4.0 microns high, separated by furrows 1.0 micron wide, ridges blunt, possess apical projections 4.0 to 5.0 microns wide, 4.0 to 9.0 microns long, overall dimensions, 76.0 to 94.0 microns.

Discussion: Only a few complete speciemns of this spore type were found, but numerous fragments were observed in the coals.

Affinity: Possibly schizaeacean.

Figured specimen: OPC 830 D-1-3.

Subturma Zonotriletes Waltz, 1935

Infraturma Cingulati R. Potonié and Klaus, 1954

Genus CINGULATISPORITES Thomson in Thomson and Pflug, 1953 emend. R. Potonié, 1956

Type species: *Cingulatisporites levispeciosus* Pflug in Thomson and Pflug, 1953 (p. 58, pl. 1, fig. 16).

CINGULATISPORITES cf. C. LEVISPECIOSUS Pflug

in Thomson and Pflug, 1953

Plate 4, figure 6

Discussion: This species was first described from the (?) Danian to Paleocene of Germany. It is sparsely found throughout the Vermejo Formation coals, but is not abundant.

Affinity: Probably related to the family Selaginellaceae.

Figured specimen: OPC 833 L-2-2.

CINGULATISPORITES cf. C. PSEUDOALVEOLATUS Couper, 1958

Plate 5, figure 1

Discussion: C. pseudoalveolatus was first described from the Middle Jurassic of Great Britain. The specimens assigned to this species are almost identical with those described by Couper (1958, p. 147, pl. 25, figs. 5 - 6). It is found primarily in section OPC 918, but is also present in other samples.

Affinity: Unknown.

Figured specimen: OPC 833 L-4-3.

CINGULATISPORITES SP. A

Plate 4, figure 10

Spores trilete, radial, outline subtriangular, trilete mark usually indistinct, wavy, laesurae extend to inner margin of cingulum, cingulum 2.0 to 3.0 microns wide, exine smooth, three small pores (?) 3.0 to 4.0 microns wide centrally located on distal face, normally located beneath trilete rays, overall dimensions, 25.0 to 35.0 microns.

Typical specimen: OPC 918 D-1-3. Overall dimensions, 27.0 x 31.0 x 31.0 microns.

Discussion: Krasnova (1961, p. 35, pl. 7, figs. 5 - 6) illustrated a number of specimens assigned to Selaginella velata (Weyland and Krieger, 1953) Krasnova, 1961 which are morphologically to the specimens found in the Vermejo Formation coals.

Affinity: Probably related to the family Selaginellaceae.

Figured specimen: OPC 918 D-1-3.

CINGULATISPORITES SP. B

Plate 5, figure 2

Spores trilete, radial, outline subtriangular, laesurae extend one-half spore radius, proximal face laevigate, distal face incompletely reticulate, equatorial cingulum hyaline, thins at spore apices, cingulum up to 4.5 microns wide in interradial areas, overall dimensions, 33.0 to 41.0 microns.

Typical specimen: OPC 833 N-4-4. Overall dimensions, 35.7 x 38.3 x 38.3 microns.

Discussion: The thinning of the cingulum at the spore apices is similar to that of the genus Camarozonosporites. However, this feature appears to be a thin cingulum on C. sp. B rather than an equatorial, irregular rim as exhibited by Camarozonosporites.

Affinity: Unknown.

Figured specimen: OPC 833 N-4-4.

CINGULATISPORITES SP. C

Plate 4, figure 12

Spores trilete, radial, outline rounded triangular, laesurae extend to cingulum, trilete bordered by thickened ridge, 1.0 to 2.0 microns wide, cingulum 4.0 to 6.0 microns wide, irregular in outline, distal face exhibits faint incomplete reticulation, overall dimensions, 42.0 to 49.0 microns.

Discussion: Reissinger (1950, pl. 12, fig. 37) illustrated a form related to Selaginella cuspidata Link, and almost identical with the species here described.

Affinity: Probably related to the family Selaginellaceae.

Figured specimen: OPC 833 R-2-1.

SPORE TYPE A

Plate 5, figure 3

Spores trilete, radial, outline rounded triangular, laesurae extend two-thirds spore radius, commissure raised, proximal face laevigate to finely granular, distal face laevigate with rounded crater-like pits scattered over surface, extend just over equator onto proximal face, pits 2.0 to 3.0 microns wide, 1.0 to 2.0 microns deep, spore wall 5.0 to 7.0 microns thick, overall dimensions, 58.0 to 65.0 microns.

Discussion: This spore type could not be included in any previous generic description and too few specimens were observed to attempt a generic description in this study.

Affinity: May possibly be related to the modern genus Phylloglossum (see Erdtman, 1957, p. 87).

Figured specimen: OPC 833 Q-2-4.

Genus CAMAROZONOSPORITES R. Potonié, 1956 emend. Klaus, 1960

Type species: Camarozonosporites cretaceus (Weyland and Krieger, 1953) R. Potonié, 1956

1953 Rotaspora cretacea Weyland and Krieger (p. 12, pl. 3, fig. 27).

1956 Camarozonosporites cretaceus (Weyland and Krieger, 1953) R. Potonié (p. 65, pl. 9, fig. 85).

R. Potonié (1956, p. 65) stated this generic name was first used by Pant (1954, p. 51), but the name was not validly published until 1956. Camarozonosporites is used for the inclusion of spore types similar to Lycopodiacidites, but which exhibit a thinning of the exine at the spore apices.

CAMAROZONOSPORITES cf. C. RUDIS (Leschik, 1955) Klaus, 1960

Plate 5, figure 8

1955 Verrucosisporites rudis Leschik (p. 15, pl. 1, fig. 15).

1960 Camarozonosporites rudis (Leschik, 1955) Klaus (p. 136, pl. 29, figs. 12, 14).

Discussion: Leschik (1955, p. 15) originally described the species from the Upper Triassic (Middle Keuper) of Switzerland. The specimens observed in the Vermejo Formation coals are slightly larger than the noted size range for the emended species (Klaus, 1960, p. 136), but this difference is not considered sufficient for the establishment of a new species.

C. cf. C. rudis occurs infrequently in the palynological assemblage.

Affinity: Probably related to spores of the family Lycopodiaceae.

Figured specimen: OPC 833 V-2-7.

CAMAROZONOSPORITES SP. A

Plate 5, figures 5 - 6

Spores trilete, radial, outline subspherical, trilete rays deeply grooved into proximal face, laesurae extend to equatorial flange, proximal face laevigate, distal face broadly reticulate, true interradial flange or rim, 7.5 to 10.0 microns wide, separates proximal face from distal face, but does not parallel equator, flange bends proximally toward ray extensions in side view (see Plate 5, figure 6), overall dimensions, 79.0 to 93.0 microns.

Typical specimen: OPC 918 C-4-8. Overall dimensions, 82.0 x 82.0 x 84.0 microns.

Discussion: This spore type differs from C. cf. C. rudis in its broad reticulate distal ornamentation, the width and orientation of the equatorial flange, and in its larger size. It is present in minor abundance from all sections studied.

Affinity: Unknown.

Figured specimens: OPC 918 C-4-8 and OPC 830 J-3-2.

Turma MONOLETES Ibrahim, 1933

Subturma Azonomonoletes Luber, 1935

Infraturma Laevigatomonoleti Dybova and Jachowicz, 1957

Genus LAEVIGATOSPORITES Ibrahim, 1933 emend.

Schopf, Wilson, and Bentall, 1944

Type species: Laevigatosporites vulgaris (Ibrahim, 1932) Ibrahim, 1933

1932 Sporonites vulgaris Ibrahim in R. Potonie, Ibrahim, and Loose (p. 448, pl. 15, fig. 16).

1933 Laevigatosporites vulgaris (Ibrahim, 1932) Ibrahim (p. 39 - 40, pl. 2, fig. 16, pl. 5, figs. 37, 39).

LAEVIGATOSPORITES cf. L. OVATUS Wilson and Webster, 1946

Plate 5, figure 7

Discussion: L. ovatus was first described from the Fort Union coal (Paleocene) of Montana. It is one of the more abundant species and occurs throughout the Vermejo Formation coals.

Affinity: Filicinean, probably related to the family Polypodiaceae.

Figured specimen: OPC 830 D-1-6.

LAEVIGATOSPORITES SP. A

Plate 5, figure 11

Spores monolete, bilateral, kidney or bean shaped, exine 3.0 to 5.5 microns thick, laevigate or finely punctate, overall dimensions, 40.0 to 45.0 x 58.0 to 64.0 microns.

Typical specimen: OPC 833 M-2-2. Overall dimensions, 43.0 x 63.8 microns.

Discussion: L. sp. A is a minor spore type in the palynological assemblage of the Vermejo Formation coals.

Affinity: Probably polypodiacean.

Figured specimen: OPC 833 M-2-2.

LAEVIGATOSPORITES SP. B

Plate 5, figures 10, 12

Spores monolete, bilateral, outline oval to subspherical, monolete one-half to two-thirds length of spore, exine laevigate, 1.0 to 2.5 microns thick, overall dimensions, 45.0 to 61.0 x 58.0 to 77.0 microns.

Typical specimen: OPC 830 AA-2-2. Overall dimensions, 53.6 x 58.7 microns.

Discussion: Specimens assigned to this species are about twice as large as _L._ cf. _L._ _ovatus_, and do not possess a thickened spore wall as exhibited by _L._ sp. A. It is a common spore type and abundantly occurs in all sections of the Vermejo Formation coals.

Affinity: Polypodiacean.

Figured specimens: OPC 830 AA-2-2 and OPC 830 B-2-4.

Infraturma Sculptatomonoleti Dybova and Jachowitz, 1957
(equal to Infraturma Ornati R. Potonie, 1956)

Genus MARATTISPORITES Couper, 1958

Type species: _Marattisporites_ _scabratus_ Couper, 1958 (p. 133, pl. 15, fig. 20).

MARATTISPORITES cf. M. SCABRATUS Couper, 1958

Plate 5, figure 4

Discussion: The specimens observed in the Vermejo Formation coals are essentially identical with the type species described by Couper. The species is found in only a few sample levels, but totals 6.0 percent of the palynological assemblage in level A, section OPC 830.

Affinity: Couper (1958, p. 134) stated that the dispersed spores match perfectly the spores of the Mesozoic fern _Marattiopsis_.

Figured specimen: OPC 830 A-5-1.

Genus POLYPODIISPORITES R. Potonié, 1934

Type species: _Polypodiisporites favus_ (R. Potonié, 1931) R. Potonié, 1934

1931d _Polypodii(?)-sporites favus_ R. Potonié (p.556).

1934b _Polypodiisporites favus_ (R. Potonié, 1931) R. Potonié (p. 38, pl.1, figs. 19 - 20).

POLYPODIISPORITES cf. P. FAVUS (R. Potonié, 1931) R. Potonié, 1934

Plate 5, figure 9

Discussion: Most of the specimens observed in the Vermejo Formation coals are smaller than the stated size range, but otherwise fit the description, even to the negative reticulate appearance of the exine.

The species is one of the common forms and is present in all segments. It is most abundant in the upper part of each different section.

Affinity: Probably polypodiacean.

Figured specimen: OPC 831 0-5-5.

Genus EXTRAPUNCTATOSPORIS Krutzsch, 1959

Type species: _Extrapunctatosporis_ _extrapunctoides_ Krutzsch, 1959 (p. 199, pl. 40, fig. 439).

EXTRAPUNCTATOSPORIS cf. E. INTRAINAEQUALIS Krutzsch, 1959

Plate 6, figures 10 - 11

Spores monolete, bilateral, monolete over one-half spore length, exine finely granular, overall dimensions, 35.0 to 38.0 x 76.0 to 79.0 microns.

Discussion: Krutzsch (1959, p. 201) illustrated a diagram of the species of _Extrapunctatosporis_ and, in particular, pointed out that the exine surface of _E_. _intrainaequalis_ is finely granular. The specimens observed here also exhibit this character.

Only two specimens of this spore type were observed in the Vermejo Formation coals.

Affinity: Possibly related to the modern genus _Tmesipteris_ in the family Psilotaceae (see Harris, 1955, pl. 1, figs. 18 - 19).

Figured specimens: OPC 831 0-4-2 and OPC 918 C-2-20.

Genus SCHIZAEA Smith, 1793

Type species: _Schizaea_ _dichotoma_ (Linnaeus, 1753) Smith ?, 1793 Academy Turin, Mémoires, vol. 5, p. 419.

SCHIZAEA cf. S. RETICULATA Cookson, 1957

Plate 6, figure 5

Discussion: The species was first described from the Paleocene of South Australia. Specimens occurring in the Vermejo Formation coals are essentially identical with her description, even though it was based on a single specimen. Only a few specimens of *S*. cf. *S*. *reticulata* were found in the Vermejo Formation coals.

Affinity: Cookson (1957, p. 43) stated that *S*. *reticulata* is possibly a more primitive type of *S. pusilla* Pursh, 1814.

Figured specimen: OPC 918 C-5-6.

SCHIZAEA SP. A

Plate 6, figures 1, 2, 4

Spores monolete, bilateral, monolete one-half to two-thirds spore length, perine 1.5 to 2.5 microns thick, microreticulate or tectate (?), exine microreticulate, lumina 1.0 micron wide, overall dimensions, 59.0 to 75.0 x 84.0 to 104.0 microns.

Typical specimen: OPC 833 V-5-1. Overall dimensions, 59.0 x 89.0 microns.

Discussion: Cookson (1957) described a number of species of Schizaea from Tertiary coals of Australia and Papua. Some of these species are similar in character (*S*. *fromensis*, *S*. *albertonensis*, and *S*. *punctata*) and specimens from the Vermejo Formation coals could be placed in each of these species. However, they appear to be identical in light of the fact that specimens are here found with the perine intact (Plate 6, fig. 1), with the perine partially eroded (Plate 6, figure 4), and with the perine completely lost (Plate 6, figure 2). It is apparent that the spores found here are of a single species rather than of two or three species. The spores described here are undoubtedly similar to those described by Cookson, but it was thought best not to place them in one of her species.

Krutzsch (1959, p. 211) assigned spores of this type to the genus Microfoveolatosporis Krutzsch, 1959.

S. sp. A is found scattered throughout the Vermejo Formation coal samples, but nowhere in any concentration.

Affinity: A member of the family Schizaeaceae.

Figured specimens: OPC 830 I-3-3, OPC 833 J-2-4, and OPC 833 V-5-1.

Genus VERRUCATOSPORITES Pflug, 1952 ex Thomson and Pflug, 1953 emend. R. Potonié, 1956

Type species: Verrucatosporites alienus (R. Potonié, 1931) Thomson and Pflug, 1953

1931d Sporonites alienus R. Potonié (p. 556, fig. 1).

1953 Verrucatosporites alienus (R. Potonié, 1931) Thomson and Pflug (p. 59, pl. 3, fig. 47).

Pflug (1952) first used the name Verrucosisporites, but he did not describe the genus or assign a type species. According to the International Code of Botanical Nomenclature, Article 36, the genus is not validly published in Pflug's study because he did not describe the genus. Thomson and Pflug in 1953 subsequently made the generic description and assigned the type species, but made no reference to

Pflug (1952). Apparently Thomson and Pflug's manuscript was sent to the publisher before Pflug's manuscript, but their study was not published until after Pflug's study. Because the effective date of publication establishes priority it seemed advisable to cite Pflug (1952) as the author of the proposed, but not validly published, name Verrucatosporites and cite Thomson and Pflug (1953) as the subsequent authors who ascribe the generic name to Pflug (see Recommendation 46A, International Code of Botanical Nomenclature).

VERRUCATOSPORITES cf. V. ALIENUS (R. Potonié, 1931)

Thomson and Pflug, 1953

Plate 6, figures 8 - 9

Discussion: Spores of this type closely resemble the description of *V. alienus* in Thomson and Pflug (1953). It is a minor element of the palynological assemblage.

Affinity: Polypodiacean.

Figured specimens: OPC 833 F-1-2 and OPC 831 G-5-1.

SPORE TYPE B

Plate 6, figure 7

Spores monolete, bilateral, monolete about one-half spore length, exine coarsely reticulate, lumina 4.0 to 7.0 microns wide, muri 2.0 to 3.0 microns wide, raised 1.0 to 2.0 microns, overall dimensions, 53.0 x 70.0 microns.

Discussion: A single specimen of this spore type was observed in the Vermejo Formation coals and a more precise generic assignment could not be made.

Affinity: Unknown.

Figured specimen: OPC 918 F-5-4.

SPORE TYPE E

Plate 6, figure 6

Spore monolete, bilateral, monolete extends almost length of spore, exine granular and reticulate, lumina 2.0 to 4.0 microns wide, reticulations absent in monolete area, overall dimensions, 43.4 x 61.2 microns.

Discussion: A single specimen of this spore type was observed in the Vermejo Formation coals.

Affinity: Unknown.

Figured specimen: OPC 918 F-2-14.

GENUS A

Spores monolete, bilateral, monolete extends almost length of spore, thickened raised ridge parallels monolete mark, exine foveolate, foveola oval to rounded, widely spaces, some foveola arranged parallel to spore outline, overall dimensions, 35.0 to 41.0 x 53.0 to 61.0 microns.

GENUS A SP. A

Plate 6, figure 3

Spores monolete, bilateral, monolete extends almost length of spore, thickened ridge 1.0 to 2.0 microns wide parallels monolete mark, exine foveolate, foveola oval to rounded, 2.0 to 4.0 microns wide, 1.0 to 2.0 microns deep, spaced 5.0 to 7.0 microns apart, some foveola arranged parallel to spore outline, overall dimensions 35.0 to

41.0 x 53.0 to 61.0 microns.

Typical specimen: OPC 918 E-3-6. Overall dimensions, 39.0 x 55.0 microns.

Discussion: This species could not be placed in any previously described genus and is here described as new. It was found in minor percents from section OPC 918.

Affinity: Unknown.

Figured specimen: OPC 918 E-3-6.

Anteturma POLLENITES R. Potonié, 1931

Turma EUPOLLENITES Klaus, 1960

Subturma Operculati Venkatachala and Goczan, (manuscript)

Genus CLASSOPOLLIS Pflug, 1953 emend.
Pocock and Jansonius, 1961

Type species: Classopollis classoides Pflug, 1953 emend. Pocock and Jansonius, 1961

1953 Classopollis classoides Pflug (p. 91, pl. 16, figs. 29 - 30).

1961 Classopollis classoides Pflug, 1953 emend. Pocock and Jansonius (p. 443 - 444, pl. 1, figs. 1 - 9).

CLASSOPOLLIS cf. C. CLASSOIDES Pflug, 1953 emend.
Pocock and Jansonius, 1961
Plate 7, figures 5 - 6

Discussion: The few specimens found in the Vermejo Formation coals are almost identical with the type species description as emended by Pocock and Jansonius (1961).

Affinity: Probably related to the Mesozoic conifer family Cheirolepidaceae.

Figured specimens: OPC 831 C-3-1 and OPC 830 L-2-1.

Turma SACCITES Erdtman, 1947

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

Infraturma Triletesacciti Leschik, 1955

GENUS D

Symmetry radial, outline circular, central body oval, distinct, surface laevigate, usually possesses indistinct trilete mark, commissures raised when present, bladder or exosporium (?) finely reticulate to finely granular, completely encloses central body, mode of bladder attachment unknown, central body 35.0 to 53.0 microns, overall diameter, 54.0 to 86.0 microns.

GENUS D SP. A

Plate 7, figures 1 - 2

Description identical to that of genus.

Typical specimen: OPC 833 T-2-6. Central body, 45.0 x 47.0 microns, overall diameter, 60.0 x 67.0 microns.

Discussion: This species is almost totally restricted in distribution to level T, section OPC 833, where it comprises 7.0 percent of the palynological assemblage.

The genus here described may be related to Perinopollenites elatoides Couper, 1958. Pocock (1962, p. 60) reported the same species from the Jurassic-Cretaceous boundary of western Canada, and stated that a weak trilete mark may be present.

Affinity: Unknown.

Figured specimens: OPC 833 T-1-2 and OPC 833 T-2-6.

Subturma Disaccites Cookson, 1947

Infraturma Disaccitrileti Leschik, 1955

Genus VITREISPORITES Leschik, 1955

Type species: Vitreisporites signatus Leschik, 1955 (p. 53, pl. 8, fig. 10).

VITREISPORITES cf. V. PALLIDUS (Reissinger, 1938) Nilsson, 1958

Plate 7, figures 3 - 4

1938 Pityosporites pallidus Reissinger (p. 14).

1950 Pityopollenites pallidus (Reissinger, 1938) Reissinger, (p. 109, pl. 15, figs. 1 - 5).

1958 Caytonipollenites pallidus (Reissinger, 1938) Couper (p. 150, pl. 26, figs. 7 - 8).

1958 Vitreisporites pallidus (Reissinger, 1938) Nilsson (p. 77 - 78, pl. 7, figs. 12 - 14).

Discussion: Pollen of this type found in the Vermejo Formation coals is identical with V. pallidus shown in Nilsson (1958). It is rarely found in section OPC 830, and not in other levels.

Affinity: Caytonialean.

Figured specimens: OPC 830 F-5-2 and OPC 830 K-1-1.

Infraturma Pinosacciti Erdtman, 1945 emend. R. Potonié, 1956

Genus PINUSPOLLENITES Raatz, 1937

Type species: Pinuspollenites labdacus (R. Potonié, 1931)
Raatz, 1937

1931c Pollenites labdacus R. Potonié (p. 5, fig. 32).

1937 Pinuspollenites labdacus (R. Potonié, 1931)
Raatz (p. 16).

A relatively few number of bisaccate pollen grains were found in the palynological assemblage of the Vermejo Formation coals. The majority of the specimens are divided into two genera, Pinuspollenites and Piceaepollenites, primarily on the basis of bladder attachment. In side view specimens of Piceaepollenites exhibit an almost straight angle of attachment between the bladder and the central body (Plate 7, figure 13) whereas the attachment of the bladder in Pinuspollenites is of a more angular nature (Plate 7, figure 8). The bladders of Piceaepollenites appear to merge with the central body and those of Pinuspollenites are distinct from the central body. This latter character was used to identify forms oriented in a position other than side view.

PINUSPOLLENITES SP. A

Plate 7, figures 8 - 9

Pollen grains bisaccate, central body granular, oval in plan view, bladders reticulate, attachment distal, forming definite angle with central body when observed in side view, bladders esch cover one-fourth to one-third distal part of central body in plan view, bladders 45.0 to 55.0 microns wide, depth 25.0 to 35.0 microns, overall dimensions, 48.0 to 55.0 x 67.0 to 82.0 microns.

Typical specimen: OPC 833 Q-2-1. Overall dimensions, 51.0 x 71.0 microns.

Discussion: P. sp. A is the most abundant bisaccate pollen in the Vermejo Formation coals, but in no level does it comprise more than 2.0 percent of the total assemblage.

Affinity: Related to the family Pinaceae.

Figured specimens: OPC 833 N-3-9 and OPC 833 Q-2-1.

Infraturma Abietosacciti Erdtman, 1945 emend. R. Potonié, 1958

Genus ABIESPOLLENITES Thiergart in Raatz, 1937

Type species: Abiespollenites absolutus Thiergart in Raatz, 1937 (p. 16, pl. 1, fig. 11, illustration apparently mislabeled as A. verus, see fig. 9).

ABIESPOLLENITES SP. A

Plate 7, figure 10

Pollen grain bisaccate, central body covered with a distal cap, 3.5 microns thick, granular, faint longitudinal furrow on cap, bladders finely reticulate, bladders about 70.0 microns wide, 30.0 microns deep, overall dimensions, height, 68.0 microns, width, 75.0 microns.

Discussion: A single specimen of this species was observed in the Vermejo Formation coals.

Affinity: Related to the family Pinaceae.

Figured specimen: OPC 833 S-5-10.

Genus PICEAEPOLLENITES R. Potonié, 1931

Type species: Piceaepollenites alatus R. Potonié, 1931b (p. 28, pl. 2).

PICEAEPOLLENITES SP. A

Plate 7, figures 13 - 14

Pollen grains bisaccate, central body finely granular, oval in plan view, about 50.0 to 56.0 microns, bladder attachment distal, forms straight angle with central body when observed in side view, in plan view bladders each cover one-third to one-half distal side of central body, bladders finely reticulate, bladders 50.0 to 55.0 microns wide, depth 25.0 to 30.0 microns, overall dimensions, 51.0 to 56.0 x 72.0 to 78.0 microns.

Typical specimen: OPC 918 B-5-8. Overall dimensions, 51.0 x 76.5 microns.

Discussion: This pollen type is similar to the type species of Piceaepollenites. It is not an abundant species in the Vermejo Formation coals.

Affinity: Related to the family Pinaceae.

Figured specimens: OPC 918 B-5-8 and OPC 918 B-4-1.

Infraturma Podocarpoiditi R. Potonié, Thomson, and Thiergart, 1950

Genus PODOCARPIDITES Cookson, 1947 emend. R. Potonié, 1958

Type species: Podocarpidites ellipticus Cookson, 1947 (p. 131, pl. 13, fig. 6).

PODOCARPIDITES SP.

Plate 7, figure 7

Pollen bisaccate, central body circular, proximal cap 3.0 to 5.0 microns thick, granulose, marginal rim around proximal cap, sacci attached to distal side of central body, sacci finely reticulate, 33.0 to 39.0 microns wide, 20.0 to 26.0 microns long, overall dimensions, 33.0 to 38.0 x 49.0 to 53.0 microns.

Discussion: Only three specimens of this pollen type were observed in the Vermejo Formation coals.

Affinity: Probably podocarpacean.

Figured specimen: OPC 833 F-4-6.

Turma ALETES Ibrahim, 1933

Subturma Azonaletes Luber, 1935 emend. R. Potonié and Kremp, 1954

Infraturma Psilonapiti Erdtman, 1947

Genus INAPERTUROPOLLENITES Pflug, 1952 ex Thomson and Pflug, 1953 emend. R. Potonie, 1958

Type species: Inaperturopollenites dubius (R. Potonié and Venitz, 1934) Thomson and Pflug, 1953

1934 Pollenites magnus dubius R. Potonié and Venitz (p. 17, pl. 2, fig. 21).

1953 Inaperturopollenites dubius (R. Potonié and Venitz, 1934) Thomson and Pflug (p. 65, pl. 4, fig. 89, pl. 5, figs. 1 - 3).

The problem of validity and priority for the generic name Inaperturopollenites is similar to that for the genus Verrucatosporites, described on p. 59 - 60 of the present study.

Inaperturate pollen with essentially laevigate or finely granular exine is placed in the genus Inaperturopollenites whereas inaperturate pollen with a definite granular exine is placed in the genus Araucariacites.

INAPERTUROPOLLENITES cf. I. PATELLAEFORMIS Weyland and Greifeld, 1953

Plate 8, figure 5

Discussion: This species was first described from the Lower Senonian of Germany. It is of minor importance in the palynological assemblage of the Vermejo Formation coals.

Affinity: Unknown.

Figured specimen: OPC 830 D-4-2.

INAPERTUROPOLLENITES SP. A

Plate 8, figures 3 - 4

Pollen grains inaperturate, oval, usually develop a split (see Plate 8, figure 4), exine finely granular, overall dimensions, 23.0 to 35.0 microns.

Typical specimen: OPC 830 F-1-4. Overall dimensions, 28.0 x 30.6 microns.

Discussion: Pollen grains here attributed to I. sp. A occur both with and without the exine exhibiting a split. Split inaperturate pollen grains have usually been assigned to a form genus of Taxodium whereas grains with identical ornamentation but not split have been assigned to the genus Inaperturopollenites. It is obvious these two types are identical and should both be placed in one genus. Inaperturopollenites is chosen because the grains are originally inaperturate and the split is a secondary character.

I. sp. A is a common member of the palynological assemblage from the Vermejo Formation coals.

Affinity: Related to the family Taxodiaceae.

Figured specimens: OPC 830 F-1-4 and OPC 831 A-2-1.

INAPERTUROPOLLENITES SP. B

Plate 8, figure 8

Pollen grains inaperturate, oval, exine laevigate, frequently folded, overall dimensions, 18.0 to 38.0 microns.

Typical specimen: OPC 831 B-1-3. Overall dimensions, 25.5 x 35.5 microns.

Discussion: I. sp. B is most abundant in section OPC 833, but occurs regularly in the lower coal sections.

Affinity: Unknown.

Figured specimen: OPC 831 B-1-3.

POLLEN TYPE A

Plate 8, figures 6 - 7

Pollen grains inaperturate (?), outline subcircular, exine laevigate to finely granular with a coarse reticulation covering the surface, lumina 7.0 to 10.0 microns wide, muri surrounding each lumina separate, thus each muri is double walled (see Plate 8, figure 6), outline usually invaginated where muri are present, overall diameter, 34.0 to 48.0 microns.

Discussion: Too few specimens, three, of this pollen type were observed to make a more definite designation.

Affinity: Unknown. If the muri actually separate individual pollen grains in a polyad, then this form might be related to the modern genus Acacia (see Cookson, 1954).

Figured specimen: OPC 833 W-5-15.

Infraturma Granulonapiti Cookson, 1947

Genus ARAUCARIACITES Cookson, 1947 ex Couper, 1953

Type species: (subsequent designation) Araucariacites australis Cookson, 1947 (p. 130, pl. 13, fig. 3).

Cookson and Duigan (1951), in a work on Australian Tertiary Araucariaceae described some pollen typed obtained from fructifications of Araucaria and Agathis. It was stated that the pollen of Agathis is generally smaller then the pollen of Araucaria and it is the smaller form that is found in the Vermejo Formation coals.

ARAUCARIACITES SP. A

Plate 8, figures 9 - 10

Pollen grains inaperturate, spherical, exine granular, 1.0 to 1.5 microns thick, overall diameter, 25.0 to 34.0 microns.

Typical specimen: OPC 918 F-1-3. Overall diameter, 27.0 x 27.0 microns.

Discussion: A. sp. A attains a moderate abundance in the Vermejo Formation coals and is present in all sections.

Affinity: Araucariacean, probably related to the modern genus Agathis.

Figured specimens: OPC 918 F-1-3 and OPC 831 G-2-1.

Infraturma Spinonapiti Erdtman, 1947

POLLEN TYPE B

Plate 8, figure 11

Pollen inaperturate (?), outline spherical, exine covered with short spines, 2.0 to 3.0 microns long, spaced 2.0 to 3.0 microns apart, overall diameter excluding spines, 34.0 to 46.0 microns.

Discussion: This pollen type occurred as a rare element in the Vermejo Formation coals. It is here designated as Pollen Type B because the majority of specimens observed were fragmentary and too few complete specimens were found to make a more definite assignment.

Affinity: Unknown.

Figured specimen: OPC 918 E-1-21.

POLLEN TYPE C

Plate 8, figures 12 - 13

Pollen inaperturate (?), outline irregular, oval to elongate, exine laevigate with numerous spines projecting from surface, spines

4.0 to 6.0 microns long, spaced 2.0 to 6.0 microns apart, overall dimensions excluding spines, 28.0 to 31.0 x 43.0 to 49.0 microns.

Discussion: Sporites echinosporus R. Potonié, 1934b (pl. 1, fig. 33) appears similar to the pollen type here described. No mention of a trilete mark is made in the original description and yet R. Potonié (1956, p. 33) placed this species in the trilete genus Anemiidites Ross, 1949. This transfer is not accepted because a trilete mark was observed in neither the original illustration by R. Potonie nor in the specimens here observed. This form probably belongs in the Turma Pollenites rather than in the Turma Sporites. Van der Hammen (1954, table 2) illustrated a morphologically similar form, Monocolpites ruedae, from the Maestrichtian of Colombia.

Too few specimens of this pollen type were observed to warrant a more precise assignment.

Affinity: Unknown.

Figured specimens: OPC 833 A-2-5 and OPC 833 A-2-3.

Turma PLICATES, PLICATA of Naumova, 1937 emend. R. Potonié, 1960

Subturma Praecolpates R. Potonié and Kremp, 1954

Genus EUCOMMIIDITES Erdtman, 1948 emend. Couper, 1958

Type species: Eucommiidites troedsonii Erdtman, 1948 (p. 267-268, text figs. 5 - 10 and 13 - 15).

This genus, originally described by Erdtman (1948) as a tricolpate pollen grain, was subsequently emended by Couper (1958) who interpreted the morphology as being monosulcate. Hughes (1961) also emended the genus and he interpreted the morphology as being zoni-sulcate.

EUCOMMIIDITES cf. E. MINOR Groot and Penny, 1961

Plate 8, figure 16

Discussion: This species is smaller than the size range for the type species, E. troedsonii, but favorably compares with the size range of E. minor. However, the tricolpate interpretation of the pollen grain by Groot and Penny (1961) is not accepted in this study. A monosulcate or zonisulcate interpretation seems more practical.

E. cf. E. minor occurred rarely in the palynological assemblage of the Vermejo Formation coals.

Affinity: Probably gymnospermous.

Figured specimen: OPC 831 F-3-4.

Subturma Polyplicates Erdtman, 1952

Genus EPHEDRIPITES Bolchovitina, 1953

Type species: Ephedripites mediolobatus Bolchovitina, 1953 (p. 60, pl. 9, fig. 15).

EPHEDRIPITES SP. A

Plate 7, figures 11 - 12

Pollen polyplicate, ellipsoidal, five or six ridges alternating with furrows extend to polar region, polar thickenings 5.0 to 7.0 microns wide, 2.0 to 3.0 microns thick, ridges distinct from polar thickenings, exine laevigate, 1.0 micron thick, overall dimensions, 21.0 to 24.0 x 41.0 to 44.0 microns.

Discussion: Ephedripites corrugatus Wilson, 1962, described from the Flowerpot Formation (Permian) of Oklahoma, is morphologically similar to the forms observed in the Vermejo Formation coals. It is obvious, however, that they are not related to the same species.

Only two specimens of this species were found in the Vermejo Formation coals, both from level C, section OPC 833.

Affinity: Gnetalean.

Figured specimens: OPC C-1-3 and OPC 833 C-1-4.

Genus EPHEDRA (Tournefort, 1737) Linnaeus, 1753

Type species: Ephedra distachys Linnaeus, 1753, Species Plantarum, vol. 2, p. 1040

EPHEDRA cf. E. NOTENSIS Cookson, 1956

Plate 8, figures 1 - 2

Discussion: This species is placed in the genus Ephedra rather than in the genus Ephedripites because the forms here observed are undoubtedly related to the modern genus. E. cf. E. notensis occurs mainly in the lower part of the Vermejo Formation coals sections and is especially abundant in level A, section OPC 831.

Affinity: Related to the modern genus Ephedra.

Figured specimens: OPC 831 A-3-8 and OPC 831 A-1-3.

Subturma Monocolpates Iverson and Troels-Smith, 1950

Infraturma Intortes, Intorta of Naumova, 1937 emend. R. Potonié, 1958

Genus CYCADOPITES Wodehouse, 1933 ex Wilson and Webster, 1946

Type species: Cycadopites follicularis Wilson and Webster, 1946 (p. 274, pl. 1, fig. 7).

CYCADOPITES ? SP.

Plate 8, figure 19

Pollen monosulcate, ellipsoidal, sulcus long, extends length of grain, 1.0 to 3.0 microns wide, exine finely granular, overall dimensions: 18.0 to 22.0 x 26.0 to 32.0 microns.

Discussion: Only a few specimens of this species were observed from the palynological assemblage. Although the forms were finely granular they appeared to have a close affinity with the genus Cycadopites.

Affinity: Cycadaceae.

Figured specimen: OPC 830 AA-1-6.

Infraturma Retectines Maljavkina, 1949 emend R. Potonié, 1958

Genus MONOSULCITES Cookson, 1947 ex Couper, 1953

Type species: (subsequent designation) Monosulcites minimus Cookson, 1947 (p. 135, pl. 15, figs. 47 - 50).

MONOSULCITES cf. M. MINIMUS Cookson, 1947

Plate 8, figure 15

Discussion: This species is a rare element in the Vermejo Formation coals.

Affinity: Ginkgoalean, probably related to the genus Ginkgo.

Figured specimen: OPC 831 A-1-18.

MONOSULCITES cf. M. CARPENTIERI Delcourt and Sprumont, 1955

Plate 8, figure 14

Discussion: This species occurred rarely in the palynological assemblage of the Vermejo Formation coals.

Affinity: Bennettitalean, according to Couper (1958, p. 158).

Figured specimen: OPC 833 0-2-7.

Genus LILIACIDITES Couper, 1953

Type species: <u>Liliacidites</u> <u>kaitangataensis</u> Couper, 1953 (p. 56, pl. 7, fig. 97).

LILIACIDITES cf. L. KAITANGATAENSIS Couper, 1953

Plate 8, figure 17

Discussion: The few specimens found in the Vermejo Formation coals are slightly smaller than the size range noted for the species by Couper (1953, p. 56), but do not vary sufficiently to warrant establishment of a new species.

Affinity: Liliaceous.

Figured specimen: OPC 831 A-2-18.

LILIACIDITES cf. L. INTERMEDIUS Couper, 1953

Plate 8, figure 18

Discussion: Although the specimens observed in the Vermejo Formation coals are slightly smaller than the original size range noted for the species, they are still referable to <u>L.</u> <u>intermedius</u>. This species is present in all sections but the uppermost, OPC 833.

Affinity: Liliaceous.

Figured specimen: OPC 831 A-2-23.

Infraturma Monoptyches Naumova, 1937 emend. R. Potonié, 1958

Genus SABALPOLLENITES Thiergart, 1938

Type species: Sabalpollenites convexus Thiergart, 1938 (p. 308, pl. 24, fig. 15).

SABALPOLLENITES SP. A

Plate 9, figures 1 - 2

Pollen monocolpate, bilateral, ovoid, colpus extends almost entire length of grain, exine granular, or faintly negative reticulate, overall dimensions, 24.0 to 34.0 x 26.0 to 44.0 microns.

Typical specimen: OPC 918 B-5-7. Overall dimensions, 32.0 x 40.0 microns.

Discussion: S. sp. A occurs regularly throughout the Vermejo Formation coals.

Affinity: Related to the modern palm genus Sabal.

Figured specimens: OPC 918 B-5-7 and OPC 918 B-5-1.

SABALPOLLENITES SP. B

Plate 8, figure 20

Pollen grains monocolpate, bilateral, ovoid, colpus broad, extends almost entire length of grain, exine finely granular giving impression of negative reticulum, overall dimensions, 24.0 to 27.0 x 30.0 to 32.0 microns.

Typical specimen: OPC 830 A-4-12. Overall dimensions, 25.5 x 30.6 microns.

Discussion: This species differs from S. sp. A primarily in the broad colpus and the rounded colpus apices. Rectosulcites Anderson, 1960 is morphologically similar to the species here described except for the granular exine.

In the assemblage counts S. sp. A and S. sp. B were grouped for convenience and because they appear to have a similar botanical affinity.

Affinity: Related to the modern palm genus Sabal.

Figured specimen: OPC 830 A-4-12.

Subturma Triptyches, Triptycha of Naumova, 1937 emend.
R. Potonié, 1960

Genus TRICOLPITES Cookson, 1947 ex Couper, 1953

Type species: (Subsequent designation) Tricolpites reticulatus Cookson, 1947 (p. 134, pl. 15, fig. 45).

The form genus Tricolpites was established for tricolpate angiospermous pollen grains of uncertain affinity.

TRICOLPITES cf. T. RETICULATUS Cookson, 1947

Plate 9, figures 3 - 4

Pollen grains tricolpate, prolate, colpi extend to poles, exine about 1.0 micron thick, reticulate, lumina generally 1.0 micron wide, overall dimensions, 18.0 to 21.0 x 23.0 28.0 microns.

Typical specimen: OPC 833 B-1-2. Overall dimensions, polar view, 23.0 x 23.0 microns.

Discussion: This species is a major floral element and occurs throughout the Vermejo Formation coals. It is most abundant in the transitional lithologic samples, i.e. coal underlying shale.

Affinity: Probably related to the modern angiosperm family Salicaceae.

Figured specimens: OPC 833 B-1-2 and OPC 831 H-1-3.

TRICOLPITES SP. A

Plate 9, figures 7 - 8

Pollen grains tricolpate, prolate, colpi extend to poles, exine 1.0 micron thick, finely granular, giving impression of negative reticulation, overall dimensions, 19.0 to 23.0 x 26.0 to 30.0 microns.

Typical specimen: OPC 830 E-5-3. Overall dimensions, 22.0 x 28.0 microns.

Discussion: This species is one of the more abundant palynological elements in the Vermejo Formation coals. It occurs in all levels from all sections and attains a maximum abundance of 28.0 percent in the lower part of section OPC 831.

Affinity: Unknown angiospermous pollen.

Figured specimens: OPC 830 E-5-3 and OPC 831 A-2-16.

TRICOLPITES SP. B

Plate 9, figure 17

Pollen grains tricolpate, prolate, colpi extend almost to poles, exine laevigate, 1.5 to 2.0 microns thick, overall dimensions, 18.0 to 22.0 x 29.0 to 35.0 microns.

Typical specimen: OPC 833 V-1-8. Overall dimensions, 18.0 x 29.0 microns.

Discussion: Tricolpites sp. B is one of the abundant pollen types in the Vermejo Formation coals. The thicker exine and larger size distinguish this species from Tricolpites sp. C.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 833 V-1-8.

TRICOLPITES SP. C

Plate 9, figures 5 - 6

Pollen grains tricolpate, spherical to prolate, colpi extend almost to poles, exine laevigate or finely granular, overall dimensions, 15.0 to 20.0 microns.

Typical specimen: OPC 830 J-2-5. Overall dimensions, 18.0 x 18.0 microns.

Discussion: This species occurs in moderate numbers in the Vermejo Formation coals' palynological assemblage.

Affinity: Unknown angiospermous pollen.

Figured specimens: OPC 830 J-2-5 and OPC 833 Q-1-1.

TRICOLPITES SP. D

Plate 9, figures 13 - 14

Pollen grains tricolpate, prolate, colpi broad, 3.0 microns wide at equator, colpi united at one pole, exine finely reticulate, overall dimensions, 25.0 to 30.0 microns.

Typical specimen: OPC 833 N-2-15. Overall dimensions, 27.0 x 28.0 microns.

Discussion: Tricolpites sp. D possesses an unusual morphological character in the fact that the colpi are united at only a single pole. This feature is illustrated on Plate 9, figures 13 - 14 which show the two poles of a single specimen.

This species occurs rarely in section OPC 833, where it is mainly restricted to level N.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 833 N-2-15.

TRICOLPITES SP. E

Plate 9, figures 19 - 20

Pollen grains tricolpate, spherical, colpi short, 8.0 to 10.0 microns long, lips thickened, exine 2.0 to 2.5 microns thick, laevigate to finely granular, overall dimensions, 33.0 to 36.0 microns.

Typical specimen: OPC 833 U-3-3. Overall dimensions, 35.0 x 35.0 microns.

Discussion: This species is a minor constituent of the Vermejo Formation coals and was not found stratigraphically higher than the lower few levels of section OPC 833.

Affinity: Unknown angiospermous pollen.

Figured specimens: OPC 833 U-3-3 and OPC 833 U-2-3.

TRICOLPITES SP. F

Plate 9, figures 11 - 12

Pollen grains tricolpate, spherical, colpi extend almost to poles, exine baculate, overall dimensions, 16.0 to 19.0 microns.

Typical specimen: OPC 833 X-3-13. Overall dimensions, 17.0 x 17.0 microns.

Discussion: Tricolpites sp. F occurs primarily in the upper sections, OPC 831 and OPC 833, of the Vermejo Formation coals where it is generally restricted to the transitional lithologic samples, i.e. coal overlying shale.

Affinity: Unknown angiospermous pollen.

Figured specimens: OPC 833 X-3-13 and OPC 833 X-5-1.

TRICOLPITES SP. G

Plate 9, figures 9 - 10

Pollen grains tricolpate, prolate, colpi extend almost to poles, exine laevigate except at poles, polar regions reticulate, lumina about 1.0 micron wide, overall dimensions, 14.0 to 18.0 x 20.0 to 24.0 microns.

Typical specimen: OPC 918 C-2-28. Overall dimensions, 17.0 x 22.0 microns.

Discussion: The diagnostic feature of this species is the reticulate polar area, see Plate 9, figure 10. The species was observed as a rare floral element from all sections except the uppermost.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 918 C-2-28.

TRICOLPITES SP. H

Plate 9, figure 16

Pollen grains tricolpate, prolate, colpi extend to poles, colpi lips thickened, exine reticulate, lumina 0.5 to 1.5 microns wide, lumina larger in equatorial, intercolpae area, muri 1.0 to 1.5 microns wide, overall dimensions, 35.0 to 44.0 microns, in polar view.

Discussion: Only a few specimens of this pollen grain were observed in the Vermejo Formation coals.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 918 F-1-10.

TRICOLPITES SP. I

Plate 9, figure 18

Pollen grains tricolpate, trilobate in polar view, colpi extend to poles, lips thickened, exine reticulate, lumina 1.0 to 2.0 microns wide, muri slightly raised, overall dimensions, 35.0 to 41.0 microns.

Discussion: Only a few specimens of this form were found in the Vermejo Formation coals.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 918 E-1-3.

TRICOLPITES SP. J

Plate 10, figures 1 - 2

Pollen grains tricolpate (tricolporate ?), outline trilobate in polar view, colpi extend almost to poles, exine finely reticulate in polar and inter colpi areas, laevigate adjacent to colpi, overall dimensions, 20.0 to 29.0 microns.

Typical specimen: OPC 830 F-3-1. Overall dimensions, 26.0 x 26.0 microns.

Discussion: A few specimens of this species exhibit indistinct circular pores equatorially in the colpi area. However, the number of specimens was too small to definitely relate the species to a tricolporate form genus.

This pollen type is a major constituent of the palynological assemblage of the Vermejo Formation coals.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 830 F-3-1.

TRICOLPITES SP. K

Plate 10, figure 3

Pollen grains tricolpate (tricolporate ?), outline concave triangular in polar view, colpi short, exine laevigate, overall dimensions, 19.0 to 26.0 microns.

Typical specimen: OPC 830 K-2-1. Overall dimensions, 20.4 x 23.0 microns.

Discussion: Only a faint impression of pores in the colpi area was observed. Because the majority of specimens were oriented in polar view it was not possible to investigate this possibility more fully. The species is a rare element in the palynological assemblage.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 830 K-2-1.

Genus DICORYPHE Thouars, 1804

Type species: Dicoryphe stipulacea St. Hilaire, 1805, Expos. Fam., vol. 2, p. 348.

DICORYPHE ? SP.

Plate 10, figures 4 - 5

Pollen tricolpate (?), spherical to subspherical, colpi indistinct, reticulum covering pollen surface, raised and in some cases tending to pull free from main pollen body, lumina 4.5 to 11.0 microns wide, muri 1.0 to 2.0 microns wide, 2.0 to 5.0 microns high, overall diameter, 30.0 to 55.0 microns.

Typical specimen: OPC 918 C-3-4. Overall diameter, 34.0 x 34.0 microns.

Discussion: Specimens found in the Vermejo Formation coals resemble _D. scotia_ Simpson, 1961, but the tricolpate structure was observed on only a few specimens. It may possibly be hidden on other specimens by the reticulation.

Dicoryphe ? sp. is a rare element in the palynological assemblage of the Vermejo Formation coals.

Affinity: Simpson (1961, p. 459) stated that the genus is a member of the family Hamamelidaceae and is endemic to Madagascar.

Figured specimens: OPC 918 C-3-4 and OPC 919 B-2-3.

Genus AQUILAPOLLENITES Rouse, 1957

Type species: _Aquilapollenites quadrilobus_ Rouse, 1957 (p. 370).

AQUILAPOLLENITES cf. A. NOVACOLPITES Funkhouser, 1961

Plate 10, figure 6

Discussion: This species was described from the Mesa Verde Formation (Campanian) of Wyoming. The specimen which best shows the characteristic furrow between the protrusions, on and parallel to the equator, possesses only two equatorial protrusions extending from the main axis instead of the usual three. This variation is considered minor and the specimen is related to the species described by Funkhouser. Only three specimens of this species were found in the Vermejo Formation coals.

Affinity: Funkhouser (1961, p. 193) stated that the closest modern counterparts are with the family Santalaceae.

Figured specimen: OPC G-3-2.

AQUILAPOLLENITES cf. A. POLARIS Funkhouser, 1961

Plate 10, figures 7 - 8

Discussion: A. polaris was described from the Lance Formation (Maestrichtian) of Wyoming. Pollen attributed to the species from the Vermejo Formation coals is identical with the species described by Funkhouser in all but one aspect. The colpus on each equatorial protrusion is apparently continuous through the tip of the protrusion and makes the species tricolpate rather than tridemicolpate (see Plate 10, figure 7).

Affinity: Possibly related to the family Santalaceae.

Subturma Ptychotriporines, Ptychotriporina of Naumova, 1937

Infraturma Prolati Erdtman, 1943

Genus TRICOLPOROPOLLENITES Pflug, 1952 ex Thomson and Pflug, 1953

Type species: Tricolporopollenites dolium (R. Potonié, 1931) Thomson and Pflug, 1953

1931b Pollenites dolium R. Potonié (p. 25, pl. 1).

1953 Tricolporopollenites dolium (R. Potonié, 1931) Thomson and Pflug (p. 98, pl. 12, figs. 114 - 117).

R. Potonié (1960, p. 101) placed this genus in synonomy with Rhoipites Wodehouse, 1933. This transfer leaves no valid form genus for tricolporate pollen of unknown angiospermous affinity and hence the transfer is not recognized in the present study.

The problem of validity and priority for the generic name Tricolporopollenites is similar to that for the genus Verrucatosporites, described on p. 59 - 60 of the present study.

TRICOLPOROPOLLENITES SP. A

Plate 10, figures 12 - 13

Pollen grains tricolporate, prolate, thickened lips on either side of colpi, colpi extend almost to poles, pores equatorial, exine microreticulate, overall dimensions, 36.0 to 42.0 x 46.0 to 54.0 microns.

Typical specimen: OPC 833 W-2-17. Overall dimensions, 38.0 x 47.0 microns.

Discussion: This species occurs abundantly in all sections of the Vermejo Formation coals.

Affinity: Possibly related to the modern genus Rhus, a member of the family Anacardiaceae.

Figured specimens: OPC 833 W-2-17 and OPC 918 B-2-7.

TRICOLPOROPOLLENITES SP. B

Plate 10, figure 11

Pollen grains tricolporate, outline triangular, sides slightly convex, colpi extend to poles, pores equatorial, pores indistinct, exine finely granular, overall dimensions, 24.0 to 31.0 microns.

Typical specimen: OPC 831 A-2-36. Overall dimensions, 28.0 x 28.0 microns.

Discussion: This species is restricted in abundance to the lower part of section OPC 831, but does occur sparsely in OPC 830 and OPC 918.

Affinity: *T.* sp. B is probably related to the modern family Rhamnaceae.

Figured specimen: OPC 831 A-2-36.

TRICOLPOROPOLLENITES SP. C

Plate 10, figures 9 - 10

Pollen grains tricolporate, outline triangular, sides slightly convex, colpi extend to poles, pores equatorial, indistinct, exine finely and irregularly reticulate, lumina 1.0 micron wide, overall dimensions, 25.0 to 30.0 microns.

Typical specimen: OPC 833 N-5-7. Overall dimensions, 28.0 x 28.0 microns.

Discussion: This species differs morphologically from *T.* sp. B in the reticulate exine (see Plate 10, figure 10). It is restricted to the uppermost coal (OPC 833) of the Vermejo Formation where it occurs sparsely.

Affinity: Possibly related to the modern family Rhamnaceae.

Figured specimen: OPC 833 N-5-7.

TRICOLPOROPOLLENITES SP. D

Plate 10, figure 15

Pollen grains tricolporate, prolate, exine laevigate to finely granular, 1.0 micron thick, colpi narrow, 10.0 to 13.0 microns long, pores oval, 2.0 to 3.0 microns high, 3.0 to 4.5 microns wide, overall dimensions, 19.0 to 23.0 x 26.0 to 29.0 microns.

Discussion: Only a few specimens of this species were found in the Vermejo Formation coals.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 833 M-3-9.

Infraturma Oblati Erdtman, 1943

Genus CUPANIEIDITES Cookson and Pike, 1954

Type species: Cupanieidites orthoteichus Cookson and Pike, 1954 (p. 213, pl. 2, fig. 75).

CUPANIEIDITES cf. C. MAJOR Cookson and Pike, 1954

Plate 11, figure 1

Discussion: This species was first described from the Eocene of Australia. The only difference between the original described species and the present specimens is the slightly larger polar islands observed in the latter. It is rarely found in section OPC 833 and does not occur in any other section.

Affinity: Cookson and Pike (1954, p. 213) stated that the fossil pollen closely approaches pollen grains of Cupaniopsis, a rain forest tree of eastern Australia.

Figured specimen: OPC 833 U-1-5.

CUPANIEIDITES SP. A

Plate 11, figure 2

Pollen grains tricolporate, outline triangular, colpi united at poles, pores equatorial, deeply sunken, exine finely granular, overall dimensions, 15.0 to 21.0 microns.

Typical specimen: OPC 833 W-2-3. Overall dimensions, 18.5 x 20.4 microns.

Discussion: This species differs from _C._ cf. _C._ _major_ in the lack of polar islands and in its smaller size. It is present only at the top of the uppermost coal, OPC 833.

Affinity: Possibly related to the modern genus _Cupaniopsis_.

Figured specimen: OPC 833 W-2-3.

Turma POROSES, POROSA of Naumova, 1937 emend. R. Potonié, 1960

Subturma Monoporines, Monoporina of Naumova, 1937

Genus MONOPOROPOLLENITES Meyer, 1956 emend.

R. Potonié, 1960

Type species: _Monoporopollenites_ _gramineoides_ Meyer, 1956 (p. 111, pl. 4, fig. 29).

MONOPOROPOLLENITES cf. M. GRAMINEOIDES Meyer, 1956

Plate 10, figure 16

Discussion: The specimens in the Vermejo Formation coals conform to the emended description of the genus by R. Potonié (1960, p. 110). Pacltová (1960, p. 136) recorded the species from the

Senonian of Czechoslovakia. *M.* cf. *M. gramineoides* was evident in the assemblage counts only from sections OPC 830 and OPC 918.

Affinity: Possibly related to the modern grass family Gramineae.

Figured specimen: OPC 918 E-1-11.

Subturma Triporines, Triporina of Naumova, 1937 emend.
R. Potonié, 1960

Genus TRIVESTIBULOPOLLENITES Pflug, 1952 ex
Thomson and Pflug, 1953

Type species: *Trivestibulopollenites betuloides* Pflug in Thomson and Pflug, 1953 (p. 85, pl. 9, fig. 34).

The problem of validity and priority for the generic name *Trivestibulopollenites* is similar to that for the genus *Verrucatosporites*, described on p. 59 - 60 of the present study.

TRIVESTIBULOPOLLENITES ? SP.

Plate 11, figure 3

Pollen grain triporate, outline triangular, interporal equatorial thickening 3.0 to 4.0 microns thick, pores enclosed within an oval vestibulum 2.0 to 5.0 microns wide, pores circular, diameter about 1.0 micron, overall dimensions, 25.0 x 25.0 microns.

Discussion: A single specimen of this pollen type was observed, but it was considered sufficiently diagnostic for inclusion within the genus *Trivestibulopollenites*.

Affinity: Betulacean ?

Figured specimen: OPC 833 N-5-1.

Genus TRIPOROPOLLENITES Pflug, 1952 ex

Thomson and Pflug, 1953

Type species: _Triporopollenites_ _coryloides_ Pflug in Thomson and Pflug, 1953 (p. 84, pl. 9, fig. 20).

The problem of validity and priority for the generic name _Triporopollenites_ is similar to that for the genus _Verrucatosporites_, described on p. 59 - 60 of the present study.

TRIPOROPOLLENITES SP. A

Plate 10, figures 14 , 17

Pollen grains triporate, outline rounded triangular, exine laevigate or finely granular, pore areas thickened, overall diameter, 24.0 to 35.0 microns.

Typical specimen: OPC 833 U-3-1. Overall diameter, 33.0 x 33.0 microns.

Discussion: Triporate pollen assigned to this species exhibit both the _Betula_ or _Myrica_ type of pore pattern as illustrated by Wodehouse (1935, p. 363, fig. 99). The difference between the two types was not here considered sufficient for establishing two species.

_T_. sp. A is found abundantly in all sample levels and accounts for 75.0 percent of the total palynological assemblage from certain levels.

Affinity: Betulacean or possibly myricacean.

Figured specimens: OPC 833 U-3-1 and OPC 918 D-4-5.

TRIPOROPOLLENITES SP. B

Plate 11, figures 5 - 6

Pollen grains triporate, outline triangular to rounded triangular, exine laevigate, 0.5 to 1.0 micron thick, pore areas thickened, overall diameter, 25.0 to 35.0 microns.

Typical specimen: OPC 830 C-1-4. Overall diameter, 33.0 x 33.0 microns.

Discussion: T. sp. B differs from T. sp. A in the triangular outline and more distinct poral thickenings. The species was observed as a minor constituent in the Vermejo Formation coals.

Affinity: Betulacean, possibly related to the modern genus Betula.

Figured specimens: OPC 833 W-5-1 and OPC 830 C-1-4.

TRIPOROPOLLENITES SP. C

Plate 11, figure 4

Pollen grains triporate, outline triangular, sides slightly convex, exine laevigate, 2.0 microns thick, pore areas greatly thickened, overall diameter, 26.0 to 33.0 microns.

Discussion: This species differs from T. sp. B in the thicker exine and thicker pore structure. Only a few specimens of this pollen type were observed in the Vermejo Formation coals.

Affinity: Unknown, possibly related to the Betulaceae.

Figured specimen: OPC 830 B-4-2.

TRIPOROPOLLENITES SP. D

Plate 11, figure 7

Pollen grains triporate, outline circular, pores invaginated in outline, exine laevigate to finely granular, overall diameter, 12.0 to 16.0 microns.

Typical specimen: OPC 831 A-2-11. Overall diameter, 13.0 x 14.0 microns.

Discussion: This species occurs regularly in section OPC 833 and is also present in the lower part of section OPC 831.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 831 A-2-11.

TRIPOROPOLLENITES SP. E

Plate 11, figure 8

Pollen grain triporate, outline circular, exine granular, 1.5 to 2.5 microns thick, pores equatorial, circular, about 4.0 microns wide, rim bordering pores 1.0 to 1.5 microns thick, laevigate, overall diameter, 27.0 x 31.0 microns.

Discussion: A single specimen of this pollen type was found in the Vermejo Formation coals.

Affinity: Unknown angiospermous pollen.

Figured specimen: OPC 833 U-3-4.

Genus TILIAEPOLLENITES R. Potonié, 1931 ex R. Potonié and Venitz, 1934

Type species: <u>Tiliaepollenites</u> <u>instructus</u> R. Potonié, 1931 ex R. Potonié and Venitz, 1934

1931d Tiliaepollenites instructus R. Potonié (p. 556)

1934 Tiliaepollenites instructus R. Potonié, 1931 ex Potonié and Venitz (p. 37, pl. 4, fig. 109).

TILIAEPOLLENITES ? SP.

Plate 11, figure 12

Pollen grains triporate, outline rounded triangular to oblate, exine laevigate, pores 2.0 to 3.0 microns wide, deeply sunken, overall diameter, 24.0 to 32.0 microns.

Discussion: T. ? sp. rarely occurs in the palynological assemblage of the Vermejo Formation coals.

Affinity: Possibly related to the family Tiliaceae ?

Figured specimen: OPC 830 I-2-4.

Genus PROTEACIDITES Cookson, 1950

Type species: Proteacidites adenanthoides Cookson, 1950 (p. 172, pl. 2, fig. 21).

PROTEACIDITES SP. A

Plate 11, figures 10 - 11

Pollen grains triporate, outline triangular, sides straight or slightly convex, pores equatorial, exine of pore areas strongly thickened, pores vary from circular (Plate 11, figure 10) to notch-like (Plate 11, figure 11), exine irregularly reticulate, generally coarser reticulations along equatorial interporal area, lumina 1.0 to 3.5 microns wide, muri less than 1.0 micron wide or high, overall diameter, 30.0 to 39.0 microns.

Typical specimen: OPC 833 N-1-12. Overall diameter, 33.2 x 33.2 microns.

Discussion: This species is one of the more common palynological elements in the Vermejo Formation coals. It occurs more frequently in the upper coals, OPC 833 and OPC 831, than in the lower coals, OPC 830, OPC 918, and OPC 919. P. thalmanii Anderson, 1960 described from the Kirtland Shale and Lewis Shale (Upper Cretaceous) of New Mexico, is morphologically similar to the species described in this study.

Affinity: Related to the family Proteaceae.

Figured specimens: OPC 833 N-1-12 and OPC 833 N-2-12.

PROTEACIDITES SP. B

Plate 11, figure 14

Pollen grains triporate, outline triangular, sides straight or slightly convex, pores circular, equatorial, exine of pore areas weakly thickened, exine finely and uniformly reticulate, lumina less than 1.0 micron. overall diameter, 23.0 to 26.0 microns.

Typical specimen: OPC 833 O-1-12. Overall diameter, 24.0 x 25.5 microns.

Discussion: P. sp. B occurs as a rare floral element in the Vermejo Formation coals.

Affinity: Probably related to the family Proteaceae.

Figured specimen: OPC 833 O-1-12.

PROTEACIDITES SP. C

Plate 11, figure 15

Pollen grains triporate, outline triangular, sides straight, slightly concave, or slightly convex, pores circular, equatorial, exine of pore areas weakly thickened, irregularly reticulate, 1.0 to 1.5 microns wide in equatorial area between pores, less than 0.5 micron wide in polar and poral areas, overall diameter, 28.0 to 34.0 microns.

Typical specimen: OPC 831 H-1-1. Overall diameter, 29.0 x 30.6 microns.

Discussion: This species is rarely found in the upper coals, OPC 833 and OPC 831, of the Vermejo Formation.

Affinity: Probably related to the family Proteaccae.

Figured specimen: OPC 831 H-1-1.

Genus CARYAPOLLENITES Raatz, 1937

Type species: Caryapollenites simplex (R. Potonié, 1931) Raatz, 1937

1931c Pollenites simplex R. Potonié (p. 3, fig. 4).

1937 Caryapollenites simplex (R. Potonié, 1931) Raatz (p. 19, pl. 1, fig. 6).

CARYAPOLLENITES SP. A

Plate 11, figure 9

Pollen grains triporate, outline circular, exine 2.0 microns thick, laevigate, pores located at equator on one hemisphere, pores 4.0 microns wide, overall diameter, 50.0 to 55.0 microns.

Discussion: Only a few specimens of this species were observed in the Vermejo Formation coals.

Affinity: Juglandaceae, related to the modern genus Carya.

Figured specimen: OPC 831 B-5-1.

Genus PISTILLIPOLLENITES Rouse, 1962

Type species: Pistillipollenites mcgregorii Rouse, 1962 (p. 206, pl. 1, figs. 8 - 12).

The original description of Pistillipollenites stated that these pollen grains are triporate or tricolpate (?), but the openings are generally obscured by the club- or pistil-shaped elements of ornamentation (Rouse, 1962, p. 206). No openings of this nature were observed on the specimens here described and it is not believed that the ornamentation obscures these openings, if they are indeed present. The affinity of the genus is stated by Rouse to be with the genus Rusbyanthus, but it appears to possess three definite colpi and may possibly be tricolporate (Erdtman, 1952, p. 185). The specimens observed in the Vermejo Formation coals are believed to belong to the fossil genus Pistillipollenites, but are not related to the modern genus Rusbyanthus.

PISTILLIPOLLENITES SP. A

Plate 11, figures 16 - 17

Pollen grains non-aperturate (?), outline subcircular, exine surface granular with irregularly spaced globular warts, 2.0 to 3.0 microns high, 2.0 to 3.0 microns wide, overall diameter, 27.0 to 30.0 microns.

Typical specimen: OPC 918 F-3-8. Overall diameter, 28.0 x 28.0 microns.

Discussion: This species differs from P. mcgregorii in the granular surface and in the lack of any distinguishable aperture. It is a rare species in the Vermejo Formation coals and is found mainly in section OPC 830.

Affinity: Unknown.

Figured specimens: OPC 918 F-3-8 and OPC 830 F-4-5.

PISTILLIPOLLENITES ? SP.

Plate 11, figures 18 - 19

Pollen grains non-aperturate (?), outline subcircular, exine covered with globular warts, spaced 2.0 to 3.0 microns apart, warts 1.0 to 1.5 microns high, 1.0 to 1.5 microns wide, overall diameter, 23.0 to 28.0 microns.

Typical specimen: OPC 831 A-1-2. Overall diameter, 25.5 x 25.5 microns.

Discussion: This species differs from P. sp. A in the more numerous and closely spaced globular warts, and in the lack of a granular exine. It is mainly found in the lower part of section OPC 831 and the upper part of section OPC 830.

Affinity: Unknown.

Figured specimen: OPC 831 A-1-2.

Subturma Polyporines, Polyporina of Naumova, 1937 emend. R. Potonié, 1960

Infraturma Stephanoporiti, Stephanoporites of van der Hammen, 1954

Genus PTEROCARYAPOLLENITES Raatz, 1937

Type species: Pterocaryapollenites stellatus (R. Potonié, 1931) Raatz, 1937

1931b Pollenites stellatus R. Potonié (p. 28, pl. 2).

1937 Pterocaryapollenites stellatus (R. Potonié, 1931) Raatz (p. 18, pl. 1, fig. 8).

R. Potonie (1960, p. 132) cites Thiergart (1937 Separatum) as the author of this genus. Apparently R. Potonié was using a pre-print of Thiergart's paper, which was validly published in 1938, as the reference. In terms of priority a pre-print is not here considered as a valid publication.

PTEROCARYAPOLLENITES SP. A

Plate 11, figure 13

Pollen grains polyporate, outline pentagonal, five porate, circualr pores located at corners, exine i.0 to 1.5 microns thick, laevigate or finely granular, overall diameter, 25.0 to 33.0 microns.

Discussion: Only a few specimens of this species were observed in the Vermejo Formation coals.

Affinity: Juglandaceae, related to the modern genus Pterocarya.

Figured specimen: CPC 833 P-4-1.

Genus PACHYSANDRA Micheaux, 1803

Type species: Pachysandra procumbens Micheaux, 1803, Flora Boreale Am., vol. 2, p. 177, pl. 45.

PACHYSANDRA cf. P. PROCUMBENTIFORMIS Samoilovich, 1961

Plate 12, figures 1 - 2

Discussion: This fossil species, described by Samoilovich (1961, p. 199, pl. 64, fig. 1a - 1d), is analogous to the modern species

P. procumbens Micheaux, 1803. Plate 12, figure 2 illustrates the ornamentation surrounding each forae of this polyforate pollen grain.

P. cf. *P. procumbentiformis* occurs infrequently in sections OPC 918, OPC 820, and OPC 833.

Affinity: The genus is a member of the family Buxaceae.

Figured specimen: OPC 833 N-4-10.

INCERTAE SEDIS

Genus OVOIDITES R. Potonié, 1951

Type species: *Ovoidites ligneolus* (R. Potonié, 1931) R. Potonié, 1951

1931b *Pollenites ? ligneolus* R. Potonié (p. 28, pl. 2).

1951 *Ovoidites ligneolus* (R. Potonié, 1931) R. Potonié (pl. 21, fig. 185).

OVOIDITES ? SP.

Plate 12, figure 8

Pollen grains syncolpate (?), bilateral, exine finely granular, overall dimensions, 33.0 to 36.0 x 74.0 to 89.0 microns.

Discussion: This pollen type (?) is a rare element in the Vermejo Formation coals.

Affinity: Unknown.

Figured specimen: OPC 918 D-3-6.

Genus SCHIZOSPORIS Cookson and Dettmann, 1959

Type species: *Schizosporis reticulatus* Cookson and Dettmann, 1959 (p. 213 - 214, pl. 1, figs. 1 - 4).

SCHIZOSPORIS cf. S. COOKSONI Pocock, 1962

Plate 12, figure 5

Discussion: S. cf. S. cooksoni is a rare species in the Vermejo Formation coals. It occurs in only three levels, each from a different section.

Affinity: Unknown.

Figured specimen: OPC 833 U-1-7.

SCHIZOSPORIS cf. S. PARVUS Cookson and Dettmann, 1959

Plate 12, figure 4

Discussion: The specimens observed in the Vermejo Formation coals are almost identical with the species described from the Albian and Cenomanian (?) of South Australia by Cookson and Dettmann (1959). Size of the present specimens is slightly larger than that noted for S. parvus, but the two are without a doubt the same species.

The species is restricted to the lower part of section OPC 918, primarily in level C.

Affinity: Unknown.

Figured specimen: OPC 918 C-4-12.

INCERTAE SEDIS SP. A

Plate 12, figure 3

Body subspherical to oval, surface covered with numerous flattened, basally connected membraneous projections, 10.0 to 20.0 microns long, projections pointed or toothed at apex, overall dimensions, 57.0 to 100.0 microns.

Discussion: Only two specimens of this form were found in the Vermejo Formation coals. Specimens similar to the ones observed here have been reported from the Upper Cretaceous Lance, Lewis, and Laramie formations, and the Paleocene Fort Union Formation (oral communication, L. R. Wilson).

Affinity: Unknown.

Figured specimen: OPC 918 B-3-4.

INCERTAE SEDIS SP. B

Plate 12, figures 11 - 13

Body oval to spherical, surface punctate, wall or shell layered, ornamented layer 2.0 to 3.0 microns thick, "inner wall" 8.0 to 12.0 microns thick, apparently encloses an oval central void, generally two or more grooves encircle body, grooves 10.0 to 15.0 microns deep, extend through "inner wall", ornamented layer extends to base of grooves, overall dimensions, 50.0 to 70.0 x 60.0 to 90.0 microns.

Discussion: This fossil Incertae sedis was observed primarily from level A, section OPC 831 in the Vermejo Formation coals.

Affinity: Unknown, possibly an animal ?

Figured specimen: OPC 831 A-3-14.

Order HYSTRICHOSPHAERIDIA

Family Hystrichosphaeridae Deflandre, 1937

Genus BALTISPHAERIDIUM Eisenack, 1958

Type species: Baltisphaeridium longispinosum (Eisenack, 1931) Eisenack, 1958

1931 Ovum hispidium longispinosum Eisenack (p. 110, pl. 5, figs. 6 - 17).

1938 Hystrichosphaeridium longispinosum (Eisenack, 1931) Eisenack (p. 12 - 14, pl. 1, figs. 1 - 9).

1958 Baltisphaeridium longispinosum (Eisenack, 1931) Eisenack (p. 398).

BALTISPHAERIDIUM SP. A

Plate 12, figures 9 - 10

Body spherical, laevigate (?), spinose, spines smooth, conical, 7.0 to 14.0 microns long, closely spaced, spines apparently solid, overall diameter excluding spines, 24.0 to 32.0 microns.

Discussion: The few specimens of this marine organism observed in the Vermejo Formation coals were mainly restricted to levels A and S of section OPC 833.

Figured specimens: OPC 833 A-2-4 and OPC 833 S-3-12.

PHYLUM PROTOZOA

"MICROFORAMINIFERA"

MICROFORAMINIFERA SP. A

Plate 12, figure 6

Microforaminifera planispiral, chambers lobate, sutures distinct, umbilicus open (?), overall dimensions, 28.0 x 33.0 microns.

Discussion: A single specimen of this form was found in the Vermejo Formation coals. It occurred in a level composed of coal and shale.

Figured specimen: OPC 833 M-1-1.

MICROFORAMINIFERA SP. B

Plate 12, figure 7

Microforaminifera uniserial to biserial (?), chamber walls thin, chambers join in angular manner, sutures distinct, overall dimensions, 34.0 x 82.0 microns.

Discussion: This form is tentatively placed under the heading Microforaminifera because it does not possess the common uniserial or biserial mode of chamber arrangement. A single specimen was observed from the Vermejo Formation coals.

Figured specimen: OPC 830 J-1-1.

LIST OF SPECIES OCCURRING IN THE VERMEJO FORMATION COALS

SPORAE DISPERSAE

I. FUNGI IMPERFECTAE

1. Fungus Spore sp. A
2. Fungus Spore sp. B
3. Fungus Spore sp. C
4. Fungus Spore sp. D
5. Fungus Spore sp. E
6. Fungus Spore sp. F
7. Fungus Spore sp. G

II. BRYOPHYTA

8. Sphagnumsporites cf. S. antiquasporites
9. Sphagnumsporites cf. S. australis
10. Sphagnumsporites cf. S. psilatus
11. Cingulatisporites cf. C. levispeciosus

III. PTERIDOPHYTA

12. Deltoidospora cf. D. halli
13. Deltoidospora sp. A
14. Cyathidites cf. C. minor
15. Matonisporites cf. M. equiexinous
16. Gleicheniidites sp. A
17. Gleicheniidites sp. B
18. Lygodiumsporites cf. L. adriennis
19. Calamospora cf. C. mesozoica
20. Todisporites cf. T. minor
21. Todisporites cf. Todites undans
22. Leschikisporis cf. L. aduncus
23. Granulatisporites sp. A
24. Verrucosisporites cf. V. asymmetricus
25. Verrucosisporites sp. A
26. Verrucosisporites sp. B
27. Genus E sp. A
28. Genus C sp. A
29. Apiculatisporites cf. A. spiniger
30. Osmundacidites cf. O. wellmanii
31. Osmundacidites sp. A

32. *Acanthotriletes* cf. *A. varispinosus*
33. *Pilosisporites* sp.
34. *Lycopodiacidites* cf. *L. kuepperi*
35. *Lycopodiacidites* sp. A
36. *Lycopodiumsporites* cf. *L. austroclavitidites*
37. *Lycopodiumsporites* sp. A
38. *Lycopodiumsporites* sp. B
39. *Lycopodiumsporites* sp. C
40. *Lycopodiumsporites* ? sp.
41. *Cicatricosisporites* cf. *C. dorogensis*
42. Genus B sp. A
43. *Appendicisporites* cf. *A. tricornitatus*
44. *Appendicisporites* sp. A
45. Spore Type C
46. *Cingulatisporites* cf. *C. pseudoalveolatus*
47. *Cingulatisporites* sp. A
48. *Cingulatisporites* sp. B
49. *Cingulatisporites* sp. C
50. Spore Type A
51. *Camarozonosporites* cf. *C. rudis*
52. *Camarozonosporites* sp. A
53. *Laevigatosporites* cf. *L. ovatus*
54. *Laevigatosporites* sp. A
55. *Laevigatosporites* sp. B
56. *Marattisporites* cf. *M. scabratus*
57. *Polypodiisporites* cf. *P. favus*
58. *Extrapunctatosporis* cf. *E. intrainaequalis*
59. *Schizaea* cf. *S. reticulata*
60. *Schizaea* sp. A
61. *Verrucatosporites* cf. *V. alienus*
62. Genus A sp. A
63. Spore Type B
64. Spore type D

IV. GYMNOSPERMAE

65. *Classopollis* cf. *C. classoides*
66. Genus D sp. A
67. *Vitreisporites* cf. *V. pallidus*
68. *Pinuspollenites* sp. A
69. *Abiespollenites* sp. A
70. *Piceaepollenites* sp. A
71. *Podocarpidites* sp.
72. *Inaperturopollenites* cf. *I. patellaeformis*
73. *Inaperturopollenites* sp. A
74. *Inaperturopollenites* sp. B
75. Pollen Type A
76. *Araucariacidites* sp. A
77. Pollen Type B
78. Pollen Type C

79. Eucommiidites cf. E. minor
80. Ephedra cf. E. notensis
81. Ephedripites sp. A

V. ANGIOSPERMAE

a. Dicotyledonae

82. Tricolpites cf. T. reticulatus
83. Tricolpites sp. A
84. Tricolpites sp. B
85. Tricolpites sp. C
86. Tricolpites sp. D
87. Tricolpites sp. E
88. Tricolpites sp. F
89. Tricolpites sp. G
90. Tricolpites sp. H
91. Tricolpites sp. I
92. Tricolpites sp. J
93. Tricolpites sp. K
94. Dicoryphe ? sp.
95. Aquilapollenites cf. A. novacolpites
96. Aquilapollenites cf. A. polaris
97. Tricolporopollenites sp. A
98. Tricolporopollenites sp. B
99. Tricolporopollenites sp. C
100. Tricolporopollenites sp. D
101. Cupanieidites cf. C. major
102. Cupanieidites sp. A
103. Monoporopollenites cf. M. gramineoides
104. Trivestibulopollenites ? sp.
105. Triporopollenites sp. A
106. Triporopollenites sp. B
107. Triporopollenites sp. C
108. Triporopollenites sp. D
109. Triporopollenites sp. E
110. Tiliaepollenites ? sp.
111. Proteacidites sp. A
112. Proteacidites sp. B
113. Proteacidites sp. C
114. Caryapollenites sp. A
115. Pistillipollenites sp. A
116. Pistillipollenites ? sp.
117. Pterocaryapollenites sp. A
118. Pachysandra cf. P. procumbentiformis

b. Monocotyledonae

119. Cycadopites ? sp.
120. Monosulcites cf. M. minimus
121. Monosulcites cf. M. carpentieri

122. Liliacidites cf. L. kaitangataensis
123. Liliacidites cf. L. intermedius
124. Sabalpollenites sp. A
125. Sabalpollenites sp. B

VI. INCERTAE SEDIS

126. Ovoidites ? sp.
127. Schizosporis cf. S. cooksoni
128. Schizosporis cf. S. parvus
129. Incertae sedis sp. A
130. Incertae sedis sp. B

HYSTRICHOSPHAERIDIA

131. Baltisphaeridium sp. A

"MICROFORAMINIFERA"

132. Microforaminifera sp. A
133. Microforaminifera sp. B

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This list has been arranged phylogenetically and its arrangement varies from the morphologic system of R. Potonie used in the descriptive palynology section of this study.

CHAPTER VI

DISCUSSION

Palynological Associations

Relative palynomorph abundances in the Vermejo Formation coals are illustrated in two ways. The first is by a master assemblage chart (Table 1) showing the number of species occurring in the assemblage counts and their relative abundance in each sample, and the second is by a table (Table 2) illustrating generic distribution in the lower, middle, and upper portions of each section. Histograms also have been used to illustrate the relative abundances and vertical floral changes of the thirteen dominant genera occurring in the Vermejo Formation coals. The thirteen dominant genera are *Sphagnumsporites*, *Deltoidospora*, *Gleicheniidites*, *Cyathidites*, *Lygodiumsporites*, *Laevigatosporites*, *Polypodiisporites*, *Inaperturopollenites*, *Sabalpollenites*, *Tricolpites*, *Tricolporopollenites*, *Triporopollenites*, and *Proteacidites*. Conclusions obtained from the histogram study are discussed under Paleoecological Considerations.

The following list is a phylogenetic grouping of genera observed in the Vermejo Formation coals. Groups 1 through 5 are Fungi Imperfectae, Bryophyta, Psilopsida, Lycopsida, and Sphenopsida; groups 6 through 12 are Filicales; group 13 is composed of spores of uncertain affinity; groups 14 through 16 are Gymnospermae; group 17 is composed of monocotyledon Angiospermae; groups 18 through 20 are composed of dicotyledon Angiospermae; and the remaining groups are non-aperturate, pollen of uncertain affinity, Incertae sedis, and "Microforaminifera".

1. Fungi Imperfectae

2. Bryophyta
    Sphagnumsporites
    Cingulatisporites (in part)

3. Psilopsida
    Extrapunctatosporis (?)

4. Lycopsida
    Acanthotriletes
    Lycopodiacidites
    Lycopodiumsporites
    Cingulatisporites (in part)
    Camarozonosporites

5. Sphenopsida
    Calamospora

6. Marattiales
    Marattisporites

7. Osmundaceae
    Osmundacidites
    Todisporites

8. Gleicheniaceae
    Deltoidospora
    Gleicheniidites

9. Cyatheaceae
    Cyathidites

10. Schizaeaceae
    Lygodiumsporites
    Cicatricosisporites
    Genus B
    Appendicisporites
    Schizaea
    Spore Type C

11. Polypodiaceae
    Leschikisporis
    Laevigatosporites
    Polypodiisporites
    Verrucatosporites

12. Undifferentiated filicinean spores
    Apiculatisporites
    Granulatisporites
    Matonisporites

Verrucosisporites
Pilosisporites
Genus C
Spore Type A

13. Spores of uncertain affinity
    Genus A
    Genus E
    Spore Type B
    Spore Type D

14. Cycadales and Ginkgoales
    Cycadopites ?
    Monosulcites

15. Coniferales
    Pinuspollenites
    Abiespollenites
    Piceaepollenites
    Podocarpidites
    Inaperturopollenites (in part)
    Araucariacidites
    Vitreisporites (?)

16. Gnetales
    Ephedra
    Ephedripites

17. Monocolpate and Monoporate
    Liliacidites
    Sabalpollenites
    Monoporopollenites

18. Tricolpate and Polycolpate
    Dicoryphe ?
    Tricolpites
    Aquilapollenites

19. Tricolporate
    Tricolporopollenites
    Cupanieidites

20. Triporate and Polyporate
    Trivestibulopollenites ?
    Triporopollenites
    Tiliaepollenites ?
    Proteacidites
    Caryapollenites
    Pistillipollenites
    Pterocaryapollenites
    Pachysandra

21. Non-aperturate
    Inaperturopollenites (in part)

22. Pollen of uncertain affinity
    Classopollis
    Eucommiidites
    Genus D
    Pollen Type A
    Pollen Type B
    Pollen Type C

23. Incertae sedis
    Ovoidites ?
    Schizosporis
    Incertae sedis
    Baltisphaeridium

24. "Microforaminifera"

- - - - - - - - - -

Comparisons With Other Upper Cretaceous Palynological Assemblages

Literature concerning the palynology of Upper Cretaceous deposits is sparse in comparison with that of the Carboniferous or Tertiary. Six publications exist which include taxonomic descriptions and illustrations of North American Upper Cretaceous palynology. Three palynological publications and one unpublished study dealing with Santonian or younger strata from North America describe assemblages which are compared with the palynological assemblage of the Vermejo Formation coals.

1. Ames (1950) in an unpublished Masters Thesis from the University of Massachusetts reported on a study of the Como coal from South Park, Colorado. His collection area is approximately 70 to 80 miles northwest of the present collection locality. The samples were collected from a mine dump of uncertain stratigraphic position, but the

assemblage described by Ames is identical with the assemblage from the Vermejo Formation coals.

2. Radforth and Rouse (1954) described plant microfossils from coal beds in the Brazeau Formation of western Alberta. Essentially all of the spore and pollen types described by them have been observed in the Vermejo Formation coals. Taxa common to both formations include Sphagnum, Mohria-type, Polypodium-sporites, Lycopodium, Laevigatosporites, Podocarpus, Pinus, Cycadopites, Betula, Carya, Aquilapollenites, and a number of undescribed forms. Names listed above, except Aquilapollenites, correspond to the classification scheme of Radforth and Rouse.

3. Rouse (1957), in a paper primarily designed to introduce a new taxonomic nomenclatural approach, described the spore and pollen flora of the Comox Formation (Campanian) and Oldman Formation (Santonian) from western Canada. The assemblage,obtained from several coal beds and a roof shale in the formations, is similar in many respects to the palynological assemblage of the Vermejo Formation coals. Although Rouse's generic and specific identifications and the present identifications do not in all cases agree, there are few forms in the two formations which can not be morphologically related.

4. Anderson (1960) described an uppermost Cretaceous (Maestrichtian) and Tertiary flora from New Mexico. The Cretaceous Kirtland Shale most closely approaches the age of the Vermejo Formation on the basis of similarity in their palynological assemblages and in previous age determination, the Vermejo Formation by Lee and Knowlton (1917) and the Kirtland Shale by Knowlton (1916) and Reeside (1924),

see Anderson (p. 4).

The Kirtland Shale samples were collected from a carbonaceous zone within a micaceous mudstone whereas the samples collected for this study are coal. Anderson (p.5) makes the following general statement concerning the Kirtland Shale palynological assemblage: "Polypodiaceous spores and Lycopodium spores are very common, but spores are subordinate to pollen in variety and number". The same statement id true for the palynological assemblage of the Vermejo Formation coals except that a greater variety of filicinean spores was observed. Proteacidites, the dominant dicotyledon of the Kirtland Shale is of lesser importance in the Vermejo Formation coals but, nevertheless, it is one of the more abundant genera.

Because the sediments at both localities are interpreted as being deposited in restricted swampy areas, it would appear that depositional conditions were nearly similar. However, environmental conditions were sufficiently different to create coal in one area and only a carbonaceous zone within a mudstone in the other. This difference would affect ecological conditions and cause a variance in the two palynological assemblages.

Relative abundance data for the spore and pollen assemblages are not presented in all the above studies and it is not possible to determine which are the dominant species. However, because a large percentage of genera and species are common to all assemblages it is possible to postulate that similar climatic or environmental conditions existed at each of the above localities.

Comparison of the Palynological Assemblage from the Vermejo Formation Coals with the Vermejo Formation Plant Megafossils

Knowlton, in Lee and Knowlton (1917) reported a flora of 108 species, representing 51 genera and 26 families, from the Vermejo Formation in the Raton Mesa region and in the Canon City Coal Field. This paleobotanic study and identification was made mainly from fossil wood and leaf impressions collected from the shales and sandstones of the formation. Of the 51 plant megafossil genera, 29 were found in the Canon City Coal Field. The following list of 29 genera includes the family or larger group identification to which Knowlton assigned each genus.

GENUS	FAMILY or LARGER GROUP
Halymenites	Algae
Acrostichum	Polypodiaceae
Polystichum	Polypodiaceae
Pteris	Polypodiaceae
Asplenium	Polypodiaceae
Stenopteris	Polypodiaceae
Osmunda	Osmundaceae
Gleichenia	Gleicheniaceae
Anemia	Schizaeaceae
Sequoia	Pinaceae
Cupressinoxylon	Pinaceae
Sabal	Palmae
Canna	Cannaceae
Juglans	Juglandaceae
Myrica	Myricaceae
Salix	Salicaceae
Quercus	Fagaceae
Dryophyllum	Fagaceae
Ficus	Moraceae
Laurus	Lauraceae
Platanus	Platanaceae
Amelanchier	Rosaceae
Phaseolites	Papilionaceae
Celastrus	Celastraceae
Rhamnus	Rhamnaceae

GENUS	FAMILY or LARGER GROUP
Pterospermites	Sterculiaceae
Viburnum	Caprifoliaceae
Palaeoster	Incertae sedis
Phyllites	Incertae sedis

Five of the 29 genera listed are definitely common to the palynological assemblage of the Vermejo Formation coals.

1. Osmunda is represented by spores of the genus Osmundacidites.

2. Gleichenia is represented by the fossil spore genus Gleicheniidites.

3. Anemia, a member of the family Schizaeaceae, is represented by the fossil genus Cicatricosisporites.

4. Sabal is represented by the fossil palm genus Sabalpollenites.

5. Salix is represented by pollen of Tricolpites cf. T. reticulatus.

In addition to the listed forms, a few other plant megafossils are possibly related botanically to plant microfossils from the Vermejo Formation coals. However, this relationship is questionable because many of the palynological fossils are assigned to form genera. The following three megafossil genera come under this category.

1. Myrica - Triporopollenites sp. A in part is possibly related to the family Myricaceae.

2. Ficus - Abundantly found as a megafossil, this genus may be represented in the palynological assemblage by Triporopollenites sp. D

3. Rhamnus - Tricolporopollenites sp. B and T. sp. C may be related to the family Rhamnaceae.

Plant megafossils found in the Raton Mesa region, but not found in the Canon City Coal Field are represented in the palynological assemblage by:

1. Taxodium, represented by Inaperturopollenites sp. A.

2. Brachyphyllum. Classopollis-type pollen has been related in part to this genus by Pocock and Jansonius (1961, p. 448).

Although a few taxa are common to both assemblages, by far the majority of forms are dissimilar. The difference can best be accounted for by two facts: 1) differences in opportunity for preservation, transportation, and resistance to corrosion; and 2) the megafossils were collected from the shales and sandstones of the Vermejo Formation whereas the described microfossils were restricted to coal beds occurring within the formation. This latter difference is probably the main cause for the variance in the two floral assemblages. The megafossil assemblage appears to indicate a more upland vegetation than the palynological assemblage and the ecological conditions of the former was probably warm and moist, although not to the extent of a coal swamp environment. This statement is based in part on the greater abundance of filicinean spores found in the palynological assemblage in comparison with the megafossil assemblage.

Paleoecological Considerations

It is possible to postulate paleoecological conditions at the time the Vermejo Formation coals were deposited from an ecological study of modern groups to which the microfossils are related. The ecology of major groups represented in the palynological assemblage is discussed below.

Bryophyta are represented in the coals by Sphagnumsporites, and are indicative of acidic swamp conditions.

Most of the filicinean spores encountered in the coals are related to the following four families.

1. Gleicheniaceae - The family is composed primarily of terrestrial ferns inhabiting drier regions in the tropics and subtropics of the south temperate regions.

2. Cyatheaceae - Considered to be true tree ferns, this family is restricted in distribution to tropical mountain forests.

3. Schizaeaceae - Although the majority of species assigned to this family are tropical, Schizaea and Lygodium extend as far north as New England and southern Canada.

4. Polypodiaceae - Genera assigned to this largest of the fern families have diverse habits. Because of the tropical or subtropical nature of the above fern families it possibly can be assumed here that the palynological representatives of this family are also tropical or subtropical in habit.

Taxodium is well represented in the palynological assemblage by Inaperturopollenites sp. A and the modern species live today in warm temperate, shallow water, swamp environments.

Cycadopites is related to the gymnosperm family Cycadaceae which are woody trees or shrubs confined to tropical or subtropical regions of the world.

Monosulcites pollen, in part, is morphologically similar to pollen of the modern genus *Ginkgo* (or *Ginkyo*, see Lawrence, 1951, p. 358). The genus attained world wide distribution during Mesozoic and Tertiary time, but is today found native only in warm temperate regions of western China.

Bisaccate gymnosperm pollen related to the Coniferales is not abundant in the palynological assemblage, which indicates that the parent trees were probably located in a more upland environment, distant from the swamp, and that their dispersed pollen was transported a long distance.

Ephedra and *Ephedripites*, members of the gymnosperm order Gnetales occur in minor abundance and are indicative of warm temperate to tropic arid climate.

The Palmae, represented in the palynological assemblage by *Sabalpollenites*, are tropical and subtropical woody plants indicative of frost-free climatic conditions.

Dicotyledoneous angiosperms are found in a variety of habitats from arctic to tropic regions. The abundance of *Tricolpites* sp. A and *Triporopollenites* sp. A indicates that their parent plants were probably living in the swamp, whereas the parent plants of *Proteacidites* sp. A and *Tricolpites* cf. *T. reticulatus*, whose pollen occurs less frequently, were probably located away from the swamp proper.

The few Hystrichosphaeridia which occur in a shale from level S, section OPC 833 indicate a shallow-water marine environment for this lithologic unit.

Histogram studies of the thirteen dominant genera occurring in five sampled coals from the Vermejo Formation show no major floral change between the lowest and highest coal in the formation. A major floral change was not expected because the Vermejo Formation was probably deposited in a relatively short period of time in comparison with the time necessary for evolutionary development. A stable climate for this area is indicated by the similar palynological assemblage from the upper to the lower coals of the formation.

The few shale units within the coals can be accounted for by two criteria. The swamps were only slightly elevated above sea level or an upland inlet to the swamp deposited fine sediment at a rate prohibitive to coal formation. The former condition is considered to be wide spread and would account for marine microfossils in the shales, whereas the latter probably would be only of local extent and contain no marine microfossils.

The depositional environment of the Vermejo Formation coals appears to be that of a low lying swamp with occasional encroachments by the sea. Palynological fossils deposited in the coals suggest a tropical to subtropical climate for central Colorado during Vermejo Formation time.

Summary and Conclusions

A total of 123 species of spores and pollen is reported from the Vermejo Formation coals in the Canon City Coal Field, Fremont County, Colorado. In addition to the above, four spore types, three pollen types, one species of Hystrichosphaeridia, and two species of microforaminifera are identified.

Angiosperm pollen is the dominant floral element, but a large percentage of fern spores were apparently local to the coal swamp.

No major floral change is discernable between the lowest and highest coal in the formation. There are vertical variations in species percents and species occurrence, which however, cannot be interpreted as a major floral change. The lack of a major floral change within the Vermejo Formation is expected because no abrupt lithologic change occurs. The alternating shales, sandstones, and coals within the formation are considered to be minor deviations in a relatively constant environment.

The palynological assemblage of the coals is indicative of a tropic to subtropic climate. The tropic and subtropic genera were probably from plants local and adjacent to the coal swamp and at least some of the warm temperate genera were from upland plants.

The following conclusions are drawn from this palynological investigation of the Vermejo Formation coals.

1. The palynological assemblage includes taxa found in both Cretaceous and Tertiary sediments. However, a latest Cretaceous or, at the youngest, a transitional Cretaceous-Tertiary age is indicated by the overall floral aspect.

2. The overwhelming abundance of pollen and spores and absence of marine organisms in all but two levels indicates continental origin for the coals.

3. No major floral change was observed between the lowest and highest coals in the formation, however, minor variations in floral composition do occur.

4. Depositional environment of the coal was a continental near-shore, semi-restricted swamp. Occasional encroachments by the sea halted swamp deposition in certain areas and thin shales were deposited, which in turn, were sometimes again covered by the swamp upon retreat of the sea.

5. The climate in central Colorado during deposition of the Vermejo Formation coals was probably tropical or subtropical, and definitely more mesic than at the present time.

TABLE 2 - STRATIGRAPHIC DISTRIBUTION OF GENERA

GENUS	OPC 919		OPC 918			OPC 830			OPC 831			OPC 833		
	L	U	L	M	U	L	M	U	L	M	U	L	M	U
Fungi Imperfectae	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sphagnumsporites			x	x	x	x	x	x	x	x	x	x	x	x
Deltoidospora	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cyathidites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Matonisporites						x				x				x
Gleicheniidites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lygodiumsporites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Calamospora									x					
Todisporites		x	x	x	x	x	x	x	x	x	x	x	x	x
Leschikisporis									x					
Granulatisporites			x		x	x	x	x	x	x	x	x	x	x
Verrucosisporites	x		x	x	x		x	x	x		x	x	x	x
Genus E			x			x	x	x	x			x	x	
Genus C	x	x	x	x	x	x	x	x			x		x	x
Apiculatisporites														x
Osmundacidites		x	x	x	x	x	x	x	x	x	x	x	x	x
Acanthotriletes				x				x					x	x
Pilosisporites												x		
Lycopodiacidites			x	x	x	x	x	x	x	x	x	x	x	x
Lycopodiumsporites		x	x			x		x	x	x			x	x
Cicatricosisporites			x				x		x			x	x	x
Genus B							x						x	x
Appendicisporites			x	x	x	x	x	x	x	x	x	x	x	x

TABLE 2 - STRATIGRAPHIC DISTRIBUTION OF GENERA														
GENUS	OPC 919		OPC 918			OPC 830			OPC 831			OPC 833		
	L	U	L	M	U	L	M	U	L	M	U	L	M	U
Cingulatisporites			x	x	x		x	x	x	x	x	x	x	x
Camarozonosporites	x	x	x	x	x	x	x	x			x	x	x	x
Laevigatosporites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Marattisporites						x			x	x				
Polypodiisporites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Extrapunctatosporis			x								x			
Schizaea		x	x	x	x	x	x	x	x		x	x	x	x
Verrucatosporites				x					x	x				x
Genus A			x	x	x		x							
Classopollis								x	x					
Genus D													x	x
Vitreisporites							x	x						
Pinuspollenites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Abiespollenites														x
Piceaepollenites			x					x			x			
Podocarpidites		x										x		
Inaperturopollenites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Araucariacidites	x		x	x	x	x	x	x	x	x	x	x	x	x
Eucommiidites													x	
Ephedra			x						x			x		
Ephedripites												x		
Cycadopites ?						x								
Monosulcites				x			x	x				x	x	x

TABLE 2 - STRATIGRAPHIC DISTRIBUTION OF GENERA														
GENUS	OPC 919		OPC 918			OPC 830			OPC 831			OPC 833		
	L	U	L	M	U	L	M	U	L	M	U	L	M	U
Liliacidites	x			x		x	x	x	x	x				x
Sabalpollenites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tricolpites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Dicoryphe ?	x		x	x	x					x	x		x	x
Aquilapollenites									x			x		x
Tricolporopollenites	x		x	x	x	x	x		x	x	x	x	x	x
Cupanieidites												x	x	x
Monoporopollenites				x		x								
Trivestibulopollenites													x	
Triporopollenites	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tiliaepollenites ?								x					x	
Proteacidites	x		x	x		x	x	x	x	x	x	x	x	x
Caryapollenites									x					
Pistillipollenites								x	x	x		x	x	x
Pterocaryapollenites													x	x
Pachysandra				x		x	x					x	x	x
Ovoidites ?			x		x				x					
Schizosporis			x			x								x
Incertae sedis A			x									x		
Incertae sedis B									x					
Baltisphaeridium												x		x
Microforaminifera								x					x	

BIBLIOGRAPHY

Ames, H. T., 1951, Plant microfossils in a Colorado Cretaceous coal: unpublished Master's Thesis, University of Massachusetts.

Anderson, R. Y., 1960, Cretaceous-Tertiary palynology, eastern side of the San Juan Basin, New Mexico: New Mexico Bureau of Mines, Memoir 6, 58 p.

Barnett, H., 1955, Illustrated genera of imperfect fungi: The Burgess Publishing Company, Minneapolis, 218 p.

Bartram, J. G., 1937, Upper Cretaceous of Rocky Mountain area: American Association of Petroleum Geologists, Bulletin, vol. 21, p. 899 - 913.

Bharadwaj, D. C., and Venkatachala, B. S., 1961, Spore assemblage out of a Lower Carboniferous shale from Spitzbergen: The Palaeobotanist, vol. 10, nos. 1 and 2, p. 18 - 47.

Bolkhovitina, N. A., 1953, Sporovo-pyl'tsevaya kharakteristika melovykh otlozheniy tsentral'nykh oblastey SSSR: Akad. Nauk SSSR, Inst. Geol. Nauk, Trudy, Vypusk 145 (Geol. Seriya, no. 61), 184 p. 16 pl., 10 figs.

Bolkhovitina, N. A., and Kotova, I. G., 1963, Sporovo-pyl'tsevaya kompleksy uglenosnoy tolshchi Suyfunskogo basseyna na Dal'nem Vostoke: Akademii Nauk SSSR, Izvestiya, Seriya Geologicheskaya, no. 1, Yanvar', p. 77 - 92.

Chandler, M. E. J., 1955, The Schizaeaceae of the south of England in Early Tertiary times: British Museum (Natural History) Geology Bulletin, vol. 2, no. 7, p. 291 - 314, pls. 32 - 38, 2 text figs.

Cookson, I. C., 1947, Plant microfossils from the lignites of the Kerguelen Archipelago: British-Australian-New Zealand Antarctic Research Expedition 1929 - 1931, Science Reports-Series A, vol. 2, part 8, p. 127 - 142, 5 pls.

Cookson, I. C., 1950, Fossil pollen grains of proteaceous type from Tertiary deposits in Australia: Australian Journal of Scientific Research, vol. 3, no. 2, p. 166 - 177.

Cookson, I. C., 1953, Difference in microspore composition of some samples from a bore at Comaum, S. Australia: Australian Journal of Botany, vol. 1, no. 3, p. 462 - 473, 2 pls.

Cookson, I. C., 1954, The Cainozoic occurrence of Acacia in Australia: Australian Journal of Botany, vol. 2, no. 1, p. 52 - 59.

Cookson, I. C., 1956, On some Australian Tertiary spores and pollen grains that extend the geological and geographical distribution of living genera: Royal Society of Victoria, Melbourne, Proceedings, vol. 69, p. 41 - 53.

Cookson, I. C., 1959, On Schizosporis, a new form genus from Australian Cretaceous deposits: Micropaleontology, vol. 5, no. 2, p. 213 - 216, 1 pl.

Cookson, I. C.,and Dettmann, M. E., 1958, Some trilete spores from Upper Mesozoic deposits in the eastern Australian region: Royal Society of Victoria, Melbourne, Proceedings, vol. 70, part 2, p. 95 - 128.

Cookson, I. C.,and Duigan, S. L., 1951, Tertiary Araucariaceae from south-eastern Australia, with notes on living species: Australian Journal of Scientific Research, vol. 4, no. 4, p. 415 - 449.

Cookson, I. C.,and Pike, K. M., 1954, Some dicotyledonous pollen types from Cainozoic deposits in the Australian region: Australian Journal of Botany, vol. 2, no. 2, p. 197 - 219.

Couper, R. A., 1953, Upper Mesozoic and Cainozoic spores and pollen grains from New Zealand: New Zealand Geological Survey, Paleontological Bulletin 22, 77 p., 9 pls., 3 figs.

Couper, R. A., 1956, Evidence of a possible gymnospermous origin for Tricolpites troedssonii Erdtman: New Phytologist, a British botanical journal, vol. 55, p. 280 - 285, 1 pl.

Couper, R. A., 1958, British Mesozoic microspores and pollen grains: Palaeontographica, Part B, vol. 103, p. 75 - 179, 17 pls., 11 figs., 12 tables.

Deák, M. H., 1959, Observations concernant le changement de forme des spores triletes: Revue de Micropaléontologie, vol. 2, no. 1, p. 28 - 30.

Delcourt, A. F.,and Sprumont, G., 1955, Les spores et graines de pollen du Wealdien du Hinaut: Société Belge de Géologie de Paléontologie et d'Hydrologie, Brussels, Mémoires, new series 4, no. 5, 73 p., 4 pls., 15 text figs.

Dev, Sukh, 1959, The fossil flora of the Jabalpur Series-3, spores and pollen grains: The Palaeobotanist, vol. 8, nos. 1 and 2, p. 43 - 56.

Dorf, Erling, 1942, Upper Cretaceous floras of the Rocky Mountain region: Carnegie Institute of Washington, Publication 508, 168 p.

Drozhastchich, N. B., 1961, in Pyl'tsa i spory zapadnoy Sibiri yura-paleotsen: VNIGRI, Trudy, new series, Vypusk, 177 p. 13 - 19.

Eisenack, Alfred, 1931, Neue Mikrofossilien des baltischen Silurs. I.: Paläeontologische Zeitschrift, vol. 13, p. 74 - 118, 5 text figs., 5 pls.

Eisenack, Alfred, 1938, Hystrichosphaerideen und verwandte Formen im baltischen Silur: Zeitschrift für Geschiebeforschung, vol. 14, p. 1 - 30, 4 pls.

Eisenack, Alfred, 1958, Mikroplankton aus dem norddeutschen Apt nebst einigen Bemerkungen über fossile Dinoflagellaten: Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie, Abhandlungen, Part B, vol. 106, p. 383 - 422.

Erdtman, G., 1943, An introduction to pollen analysis: The Chronica Botanica Company, Waltham, Massachusetts, 239 p.

Erdtman, G., 1948, Did dicotyledonous plants exist in Jurassic time?: Geologiska Foreningen i Stockholm, Forhandlingar, vol. 70, p. 265 - 271, 1 fig.

Erdtman, G., 1952, Pollen morphology and plant taxonomy, angiosperms: The Chronica Botanica Company, Waltham, Massachusetts, 539 p.

Erdtman, G., 1957, Pollen and spore morphology, plant taxonomy, gymnosperms, Pteridophyta, Bryophyta: The Ronald Press Company, New York, 151 p.

Funkhouser, J. W., 1961, Pollen of the genus Aquilapollenites: Micropaleontology, vol. 7, no. 2, p. 193 - 198, 2 pls.

Groot, J. J., and Penny, J. S., 1960, Plant microfossils and age of non-marine Cretaceous sediments of Maryland and Delaware: Micropaleontology, vol. 6, no. 2, p. 225 - 236, 2 pls., 1 fig., 3 tables.

Groot, J. J., Penny, J. S., and Groot, C., 1961, Plant microfossils and age of the Raritan, Tuscaloosa, and Magothy formations of the eastern United States: Palaeontographica, Part B, vol. 108, p. 121 - 140, 3 pls., i fig., 2 tables.

Hammen, Th. van der, 1954, El desarrollo de la flora colombiana en los periodos geologicos: Bogotá, Boletín Geológico, vol. 2, no. 1, p. 49 - 106, 21 pls., 7 figs.

Harris, W. F., 1955, A manual of the spores of New Zealand Pteridophyta: New Zealand Department of Scientific and Industrial Research, Wellington, Bulletin 116, 186 p.

Hills, R. C., 1893, Coal fields of Colorado: U. S. Geological Survey Mineral Resources, 1892, p. 319 - 362.

Hughes, N. F., 1961, Further interpretation of Eucommiidites Erdtman, 1948: Palaeontology, vol. 4, part 2, p. 292 - 299, 2 pls., 1 fig.

Ibrahim, A. C., 1933, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Dissertation, Konrad Triltsch, Wurzburg, 49 p., 8 pls., 1 fig.

Jansonius, J., 1962, Palynology of Permian and Triassic sediments, Peace River Area, western Canada: Palaeontographica, Part B, vol. 110, p. 35 - 98.

Klaus, W., 1960, Sporen der karnischen Stufe der ostalpinen Trias: Austria, Geologischen Bundesanstalt, Jahrbuch, vol. 5, p. 107 - 184, 11 pls., 14 figs.

Knowlton, F. H., 1914, Cretaceous-Tertiary boundary in the Rocky Mountain Region: Amer. Assoc. Petroleum Geologists, Bulletin, vol. 25, p. 325 - 340.

Knowlton, F. H., 1922, The Laramie flora of the Denver Basin - with a review of the Laramie problem: U. S. Geol. Survey, Professional Paper 130, 169 p.

Knox, E. M., 1950, The spores of Lycopodium, Phylloglossum, Selaginella, and Isoetes: Botanical Society Edinburgh, Transactions, vol. 35, p. 209 - 357.

Krasnova, L. N., 1961, Selaginellaceae: in Pyl'tsa i spory zapadnoy Sibiri yura-paleotsen: VNIGRI, Trudy, new series, Vypusk 177, p. 19 - 44.

Kremp, G., 1949, Pollenanalytische Untersuchung des miozänen Braunkohlenlagers von Konin an der Warthe: Palaeontographica, Part B, vol. 90, p. 53 - 93, 7 pls.

Krutzsch, W., 1959, Mikropalaontologische (sporenpaläeontologische) Untersuchungen im der Braunkohle des Geiseltales: Geologie, Zeitschrift für das Gesamtgebiet der geologie und mineralogie sowie der angewandten geophysik, Beihefte, vols. 21 - 22, 425 p., 49 pls., 38 figs., 12 tables.

Landis, E. R., 1959, Coal resources of Colorado: U. S. Geol. Survey, Bulletin 1072c, p. 131 - 232.

Lanjouw, J. [chm.], 1956, International code of botanical nomenclature: Internat. Bot. Cong., 8th, Paris 1954, 338 p.

Lantz, J., 1958, Étude des spores et pollens d' un Echantillon Purbeckien de L'ile D'oleron: Revue de Micropaléontologie, vol. 1, no. 1, p. 33 - 37.

Lawrence, G. H. M., 1951, Taxonomy of vascular plants: The Macmillan Company, New York, 823 p.

Lee, W. T., 1913, Recent discovery of dinosaurs in the Tertiary: Amer. Jour. Science, vol. 185, p. 531 - 534.

Lee, W. T., and Knowlton, F. H., 1917, Geology and paleontology of the Raton Mesa and other regions in Colorado and New Mexico: U. S. Geol. Survey, Professional Paper 101, 450 p.

Leschik, G., 1955, Die Keuperflora von Neuwelt bei Basel, II. Die Iso-und Mikrosporen: Schweizerische Palaontologische Gesellschaft, Zurich, Abhandlungen, vol. 72, 70 p., 10 pls., 1 text fig.

Mann, J. C., 1958, Geology of the Chandler Syncline, Fremont County, Colorado: Kansas Geological Society, Guidebook 22nd Field Conference, p. 153 - 163.

Meyer, B. L., 1956, Mikrofloristische Untersuchungen an jungtertiären Braunkohlen im östlichen Bayern: Geologica Bavarica, vol. 25, p. 100 - 128, 5 pls.

Miner, E. L., 1935, Paleobotanical examinations of Cretaceous and Tertiary coals: American Midland Naturalist, vol. 16, no. 4, p. 585 - 625, 7 pls., 6 figs., 1 table.

Nilsson, Tage, 1958, Über das Vorkommen eines mesozoischen Sapropelgesteins in Schonen: Institutes of Mineralogy, Paleontology, and Quaternary Geology, University of Lund, Sweden, Publication no. 53, 111 p.

Pacltová, Blanca, 1960, Plant Microfossils (mainly Sporomorphae) from the lignite deposits near Mydlovary in the České Budějovice Basin (South Bohemia): Czechoslovakia, Ústřední Ústav, Geologický, Rozpravy, Sborník, Prague, vol. 25, p. 109 - 176.

Pflug, H. D., 1952, Palynologie und Stratigraphie der eozanen Braunkohlen von Helmstedt: Paläontologische Zeitschrift, vol. 26, p. 112 - 137, 3 pls.

Pflug, H. D., 1953, Zur Entstehung und Entwicklung des angiospermiden Pollens in der Erdgeschichte: Palaeontographica, Part B, vol. 95, p. 60 - 171, 11 pls.

Pierce, R. L., 1961, Lower Upper Cretaceous plant microfossils from Minnesota: Minnesota Geological Survey, Bulletin 42, 86 p., 3 pls., 1 fig., 3 tables.

Pocock, S. A. J., 1962, Microfloral analysis and age determination of strata at the Jurassic-Cretaceous Boundary in the Western Canada Plains: Palaeontographica, Part B, vol. 111, p. 1 - 95.

Pocock, S. A. J., and Jansonius, J., 1961, The pollen genus Classopollis Pflug, 1953: Micropaleontology, vol. 7, no. 4, p. 430 - 449, 1 pl., 6 text figs.

Potonié, Robert, 1931a, Zur Mikroscopie der Braunkohlen. I: Zeitschrift Braunkohle, vol. 30, p. 325 - 333, 2 pls.

Potonié, Robert, 1931b, Pollenformen der miocänen Braunkohle. II: Gesellschaft Naturforschender Freunde, Berlin, Sitzungsberichte, nos. 1 - 3, p. 24 - 28, 1 pl.

Potonié, Robert, 1931c, Pollenformen aus tertiären Braunkohlen. III: K. Preussische Geologische Landesanstalt und Bergakademie, Berlin, Jahrbuch, vol. 52, p. 1 - 7, 34 text figs.

Potonié, Robert, 1931d, Zur Mikroscopie der Braunkohlen. IV: Zeitschrift Braunkohle, vol. 30, p. 554 - 556.

Potonié, Robert, 1934a, Zur Morphologie der fossilen Pollen und Sporen: K. Preussische Geologische Landesanstalt und Bergakademie, Institute für Paläobotanik und Petrographie der Brennsteine, Berlin, Arbeiten, vol. 4, p. 5 - 24.

Potonié, Robert, 1934b, Zur Mikrobotanik des eozänen Humodils des Geiseltals: K. Preussische Geologische Landesanstalt und Bergakademie, Institut für Paläobotanik und Petrographie der Brennsteine, Berlin, Arbeiten, vol. 4, p. 25 - 125.

Potonié, Robert, 1951, Revision stratigraphisch wichtiger Sporomorphen des mitteleuropäischen Tertiärs: Palaeontographica, Part B, vol. 91, p. 131 - 151, 2 pls., 1 table.

Potonié, Robert, 1956, Synopsis der Gattungen der Sporae dispersae, Teil I: Amt für Bodenforschung, Geologischen Jahrbuch, Hannover, Beihefte, no. 23, 103 p., 11 pls.

Potonié, Robert, 1958, Synopsis der Gattungen der Sporae dispersae, Teil II: Amt für Bodenforschung, Geologischen Jahrbuch, Hannover, Beihefte, no. 31, 114 p. 11 pls.

Potonié, Robert, 1960, Synopsis der Gattungen der Sporae dispersae, Teil III: Amt für Bodenforschung, Geologischen Jahrbuch, Hannover, Beihefte, no. 39, 189 p., 9 pls.

Potonié, Robert, and Gelletich, J., 1933, Über Pteridophyten-Sporen einer eozänen Braunkohle aus Dorog in Ungarn: Gesellschaft Naturforschender Freunde, Berlin, Sitzungsberichte, vol. 33, p. 517 - 528, 2 pls.

Potonié, Robert, Ibrahim, A. C., and Loose, F., 1932, Sporenformen aus dem Flözen Aegir un Bismark des Ruhrgebietes: Neues Jahrbuch fur Mineralogie, Geologie, und Palaontologie, Beilage, Part B, vol. 67, p. 438 - 454, 7 pls., 1 fig.

Potonié, Robert, and Kremp, Gerhart, 1954, Die Gattungen der paläozoischen Landesanstalten, Bundesrepublik, Geologisches Jahrbuch, vol. 69, p. 11 - 195, 17 pls., 5 text figs.

Potonié, Robert, and Kremp, Gerhart, 1955, Die Sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte, Teil I: Palaeontographica, Part B, vol. 98, p. 1 - 136, 16 pls., 37 figs.

Potonié, Robert, and Kremp, Gerhart, 1956, Die Sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte, Teil II: Palaeontographica, Part B, vol. 99, p. 85 - 191, 6 pls., 51 figs.

Potonié, Robert, Thomson, P. W., and Thiergart, F., 1950, Zur Nomenklatur und Klassifikation der neogenen Sporomorphae (Pollen und Sporen): Geologischen Landesantalten, Bundesrepublik, Geologisches Jahrbuch, vol. 65, p. 35 - 70, 3 pls., 1 fig.

Potonié, Robert, and Venitz, A., 1934, Zur Mikrobotanik des miocänen Humodils der niederrheinischen Bucht: K. Preussische Geologische Landesanstalt und Bergakademie, Institut für Paläobotanik und Petrographie der Brennsteine, Berlin, Arbeiten, vol. 5, p. 1 - 54, 4 pls.

Raatz, G. V., 1937, Mikrobotanisch-stratigraphische Untersuchung der Braunkohle des Muskauer Bogens: Preussischen Geologischen Landesanstalt, Abhandlungen, neue Folge, vol. 183, p. 1 - 48, 1 pl., 5 figs.

Radforth, N. W., and Rouse, G. E., 1954, The classification of recently discovered Cretaceous plant microfossils of potential importance to the stratigraphy of western Canadian coals: Canadian Journal of Botany, vol. 32, p. 187 - 201.

Reissinger, Adolf, 1938, Die "Pollenanalyse" ausgedehnt auf alle Sedimentgesteine der geologischen Vergangenheit: Palaeontographica, Part B, vol. 84, p. 1 - 49.

Reissinger, Adolf, 1950, Die "Pollenanalyse"ausgedehnt auf alle Sedimentgesteine der geologischen Vergangenheit: Palaeontogarphica, Part B, vol. 90, p. 99 - 126.

Ross, N. E., 1949, On a Cretaceous pollen and spore-bearing clay deposit of Scandia: Geological Institution of the University of Upsala, Bulletin, vol. 34, p. 25 - 43, 3 pls., 4 figs.

Rouse, G. E., 1957, The application of a new nomenclatural approach to Upper Cretaceous plant microfossils from western Canada: Canadian Journal of Botany, vol. 35, p. 349 - 375.

Rouse, G. E., 1959, Plant microfossils from Kootenay coal-measures strata of British Columbia: Micropaleontology, vol. 5, no. 3, p. 303 - 324, 2 pls.

Rouse, G. E., 1962, Plant microfossils from the Burrard Formation of western British Columbia: Micropaleontology, vol. 8, no. 2, p. 187 - 218, pls. 1 - 5.

Samoilovich, S. R., 1961, Buxaceae; in Pyl'tsa i spory zapadnoy Sibiri yura-paleotsen: VNIGRI, Trudy, new series, Vypusk 177, p. 199.

Schopf, J. M., Wilson, L. R., and Bentall, R., 1944, An annotated synopsis of Paleozoic fossil spores and the definition of generic groups: Illinois State Geological Survey Report of Investigations, no. 91, p. 1 - 72, 3 pls., 5 figs.

Simpson, J. B., 1961, The Tertiary pollen-flora of Mull and Ardnamurchan: Royal Society Edinburgh, Transactions, vol. 64, no. 16, p. 421 - 468.

Thiergart, F., 1938, Die Pollenflora der Niederlausitzer Braunkohle, besonders im Profil der Grube Marga bei Senftenberg: Preussischen Geologischen Landesanstalt, Jahrbuch, vol. 58, p. 282 - 351, p pls.

Thiergart, F., 1949, Der stratigraphische Wert mesozoischer Pollen und Sporen: Palaeontogriphica, Part B, vol. 89, p. 1 - 34, 5 pls., 1 text fig.

Thomson, P. W., and Pflug, H. D., 1953, Pollen und Sporen des mitteleuropäischen Tertiärs: Palaeontographica, Part B, vol. 94, p. 1 - 137, 15 pls., 20 figs.

Weimer, R. J., 1959, Upper Cretaceous stratigraphy, Colorado: Rocky Mountain Association of Geology, 11th Field Conference, p. 9 - 16.

Weyland, H., and Greifeld, G., 1953, Über strukturbietende Blätter und pflanzliche Mikrofossilien aus dem untersenonen Toner der Gegend von Quedlingburg: Palaeontographica, Part B, vol. 95, p. 30 - 52, 8 pls., 4 figs.

Weyland, H., and Krieger, W., 1953, Die Sporen und Pollen der Aachener Kreide und ihre Bedeutung für die Charakterisierung des mittleren Senons: Palaeontographica, Part B, vol. 95, p. 6 - 29, 5 pls.

Wilmarth, M. G., 1938, Lexicon of geologic names of the United States: U. S. Geol. Survey, Bulletin 896.

Wilson, L. R., 1959a, A method for determining a useful microfossil assemblage for correlation: Oklahoma Geological Survey, Oklahoma Geology Notes, vol. 19, no. 4, p. 91 - 93, 1 fig.

Wilson, L. R., 1959b, A water-miscible mountant for palynology: Oklahoma Geological Survey, Oklahoma Geology Notes, vol. 19, no. 5, p. 110 - 111.

Wilson, L. R., 1962, Permian plant microfossils from the Flowerpot Formation, Greer County, Oklahoma, Oklahoma Geological Survey Circular 49, 50 p. 3 pls.

Wilson, L. R., and Webster, R. M., 1946, Plant microfossils from a Fort Union coal of Montana: American Journal of Botany, vol. 33, no. 4, p. 271 - 278, 2 pls.

Wodehouse, R. P., 1933, Tertiary pollen- II, The oil shales of the Eocene Green River Formation: Torrey Botanical Club, Bulletin, vol. 60, p. 470 - 524, 54 figs., 1 table.

Wodehouse, R. P., 1935, Pollen grains - their structure, identification and significance in science and medicine: Reprinted 1959 Hafner Publishing Company, New York, 574 p.

APPENDIX

PLATE I

Figure

1. Fungus Spore sp. A
25.0 x 25.0 microns; OPC 830 A-3-4.

2. Fungus Spore sp. B
20.5 x 107.1 microns; OPC 833 M-1-5.

3. Fungus Spore sp. C
21.0 x 102.0 microns; OPC 833 M-2-6.

4. Fungus Spore sp. E
17.0 x 135.0 microns; OPC 830 J-4-4.

5. Fungus Spore sp. D
28.1 x 201.5 microns; OPC 830 G-1-3.

6. Fungus Spore sp. F
25.5 x 41.0 microns; OPC 830 G-4-1.

7. <u>Sphagnumsporites</u> cf. <u>S.</u> <u>psilatus</u> (Ross, 1949) Couper, 1958
20.5 x 20.5 x 22.7 microns; OPC 831 A-3-2.

8. <u>Sphagnumsporites</u> cf. <u>S.</u> <u>antiquasporites</u> Wilson and Webster, 1946 33.0 x 33.0 microns; OPC 833 M-5-4.

9. <u>Sphagnumsporites</u> cf. <u>S.</u> <u>australis</u> (Cookson, 1947) R. Potonié, 1956 37.0 x 37.0 microns; OPC 833 F-1-4.

10. Fungus Spore sp. G
51.0 x 56.0 microns; OPC 833 M-1-11.

11. <u>Deltoidospora</u> cf. <u>D.</u> <u>halli</u> Miner, 1935
29.0 x 29.0 microns; OPC 833 O-3-4.

12, 16 <u>Gleicheniidites</u> sp. A
- 12. 24.0 x 24.0 microns; OPC 833 A-1-5.
- 16. 25.0 x 25.5 microns; OPC 918 C-5-7.

13, 14 <u>Deltoidospora</u> sp. A
- 13. 40.0 x 41.0 microns; OPC 833 M-1-9.
- 14. 38.0 x 41.0 microns; OPC 831 O-5-1.

15. <u>Gleicheniidites</u> sp. B
38.0 x 40.0 microns; OPC 830 F-1-6.

PLATE I - continued

Figure

17, 19 *Cyathidites* cf. *C. minor* Couper, 1953
17. 39.0 x 43.0 microns; OPC 830 AA-1-7.
19. 28.0 x 29.0 microns; OPC 831 A-6-1.

18. *Matonisporites* cf. *M. equiexinous* Couper, 1958
54.0 x 56.0 microns; OPC 830 C-2-6.

PLATE 1

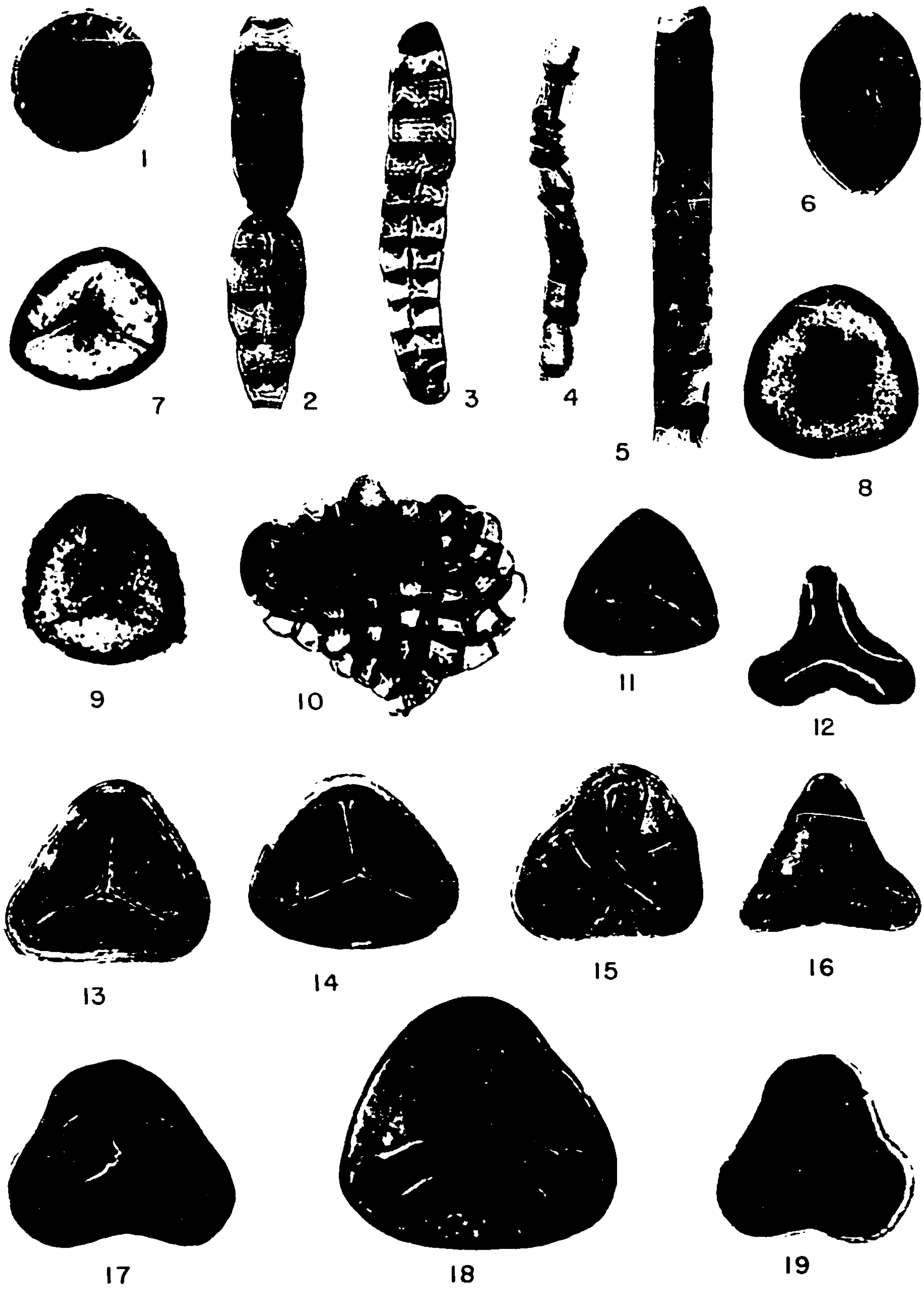


PLATE 2

Figure

1. Calamospora cf. C. mesozoica Couper, 1958
48.5 x 48.5 microns; OPC 831 A-1-6.

2. Lygodiumsporites cf. L. adriennis (Potonié and Gelletich, 1933) R. Potonié, Thomson, and Thiergart, 1950
64.0 x 66.0 x 67.0 microns; OPC 918 D-3-3.

3. Todisporites cf. Todites undans (Brongniart) Harris, 1937
43.4 x 45.9 microns; OPC 833 W-2-1.

4. Leschikisporis cf. L. aduncus (Leschik, 1955) R. Potonié, 1958 58.0 x 58.0 microns; OPC 831 A-3-15.

5. Granulatisporites sp. A
35.7 x 42.1 x 45.5 microns; OPC 833 W-3-21.

6. Todisporites cf. T. minor Couper, 1958
40.0 x 46.0 microns; OPC 830 I-2-7.

7. Verrucosisporites cf. V. asymmetricus (Cookson and Dettmann, 1958) Pocock, 1962 48.5 x 53.5 x 53.5 microns; OPC 918 B-2-2.

8. Verrucosisporites sp. B
48.5 x 56.0 microns; OPC 833 L-2-8.

9. Verrucosisporites sp. A
66.3 x 66.3 microns; OPC 918 E-2-5.

10, 11. Genus E sp. A
- 10. 42.0 x 45.0 microns; OPC 830 I-2-3.
- 11. enlargement of above specimen.

12, 13. Genus C sp. A
- 12. 46.0 x 46.0 x 46.0 microns; OPC 918 D-1-8.
- 13. 52.0 x 52.0 x 52.0 microns; OPC 918 C-2-30.

PLATE 2

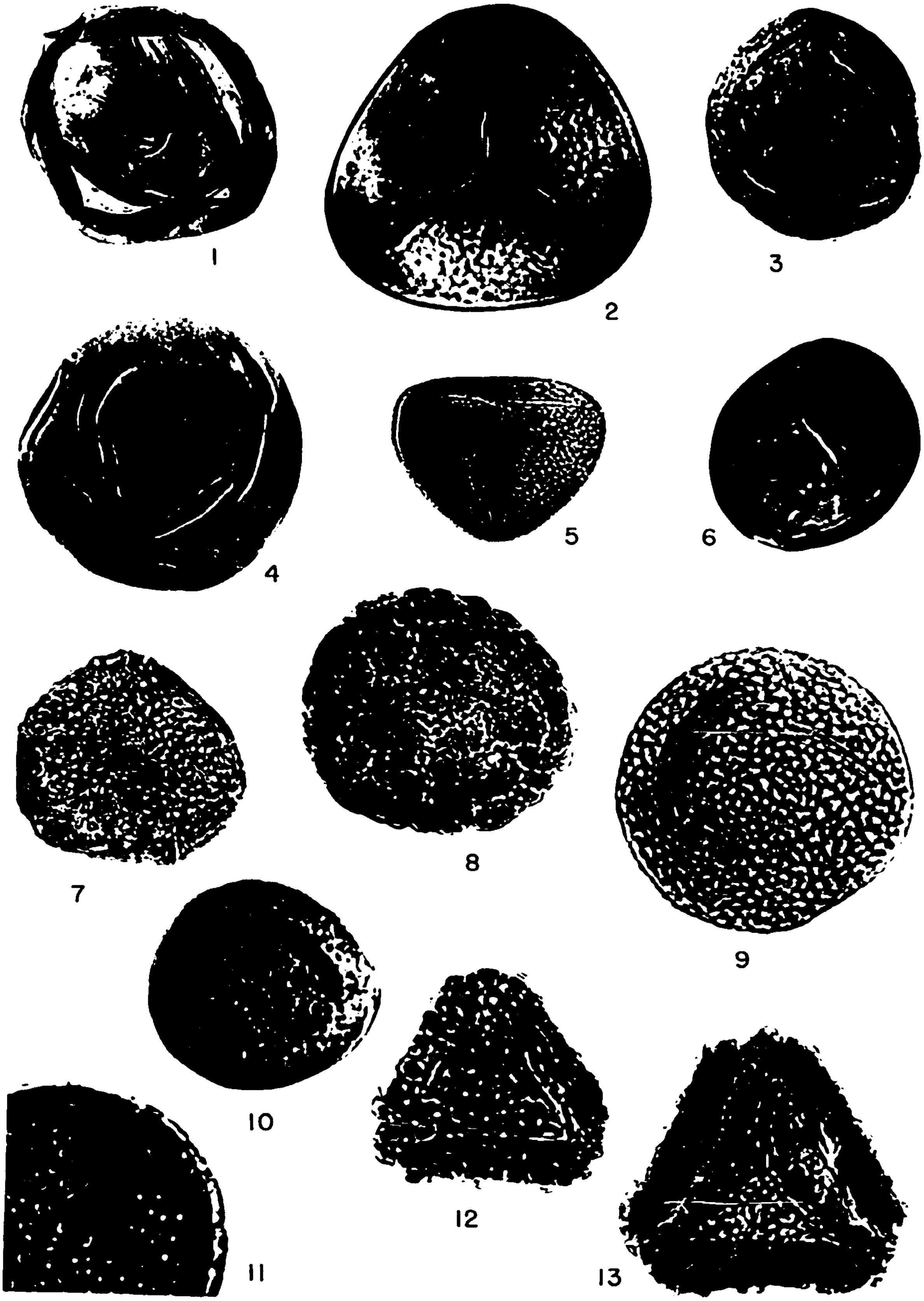


PLATE 3

Figure

1. _Osmundacidites_ cf. _O. wellmanii_ Couper, 1953
41.0 x 41.0 microns; OPC 833 W-5-17.

2. _Osmundacidites_ sp. A
71.5 x 74.0 microns; OPC 831 B-5-2.

3. _Apiculatisporites_ cf. _A. spiniger_ Leschik, 1955
43.0 x 43.0 microns; 833 W-2-14.

4. _Pilosisporites_ sp.
51.0 x 51.0 x 51.0 microns; OPC 833 H-4-1.

5, 6. _Acanthotriletes_ cf. _A. varispinosus_ Pocock, 1962
5. 27.2 x 37.0 microns; OPC 918 F-2-4.
6. 28.3 x 28.3 microns; OPC 918 F-3-10.

7. _Lycopodiumsporites_ sp. A
55.0 x 55.0 x 55.0 microns; OPC 831 A-4-7.

8. _Lycopodiumsporites_ sp. C
48.5 x 48.5 x 48.5 microns; OPC 831 A-1-12.

9. _Lycopodiumsporites_ cf. _L. austroclavitidites_ (Cookson, 1953) Pocock, 1962 45.9 x 51.0 microns; OPC 833 M-3-7.

10. _Lycopodiacidites_ sp. A
28.0 x 30.0 microns; OPC 830 J-2-1.

11. _Lycopodiacidites_ cf. _L. kuepperi_ Klaus, 1960
61.0 x 64.0 microns; OPC 830 J-4-1.

12, 13. _Lycopodiumsporites_ sp. B
12. 41.0 x 43.0 microns, proximal view; OPC 833 L-2-9.
13. 41.0 x 43.0 microns, distal view; OPC 833 L-2-9.

PLATE 3

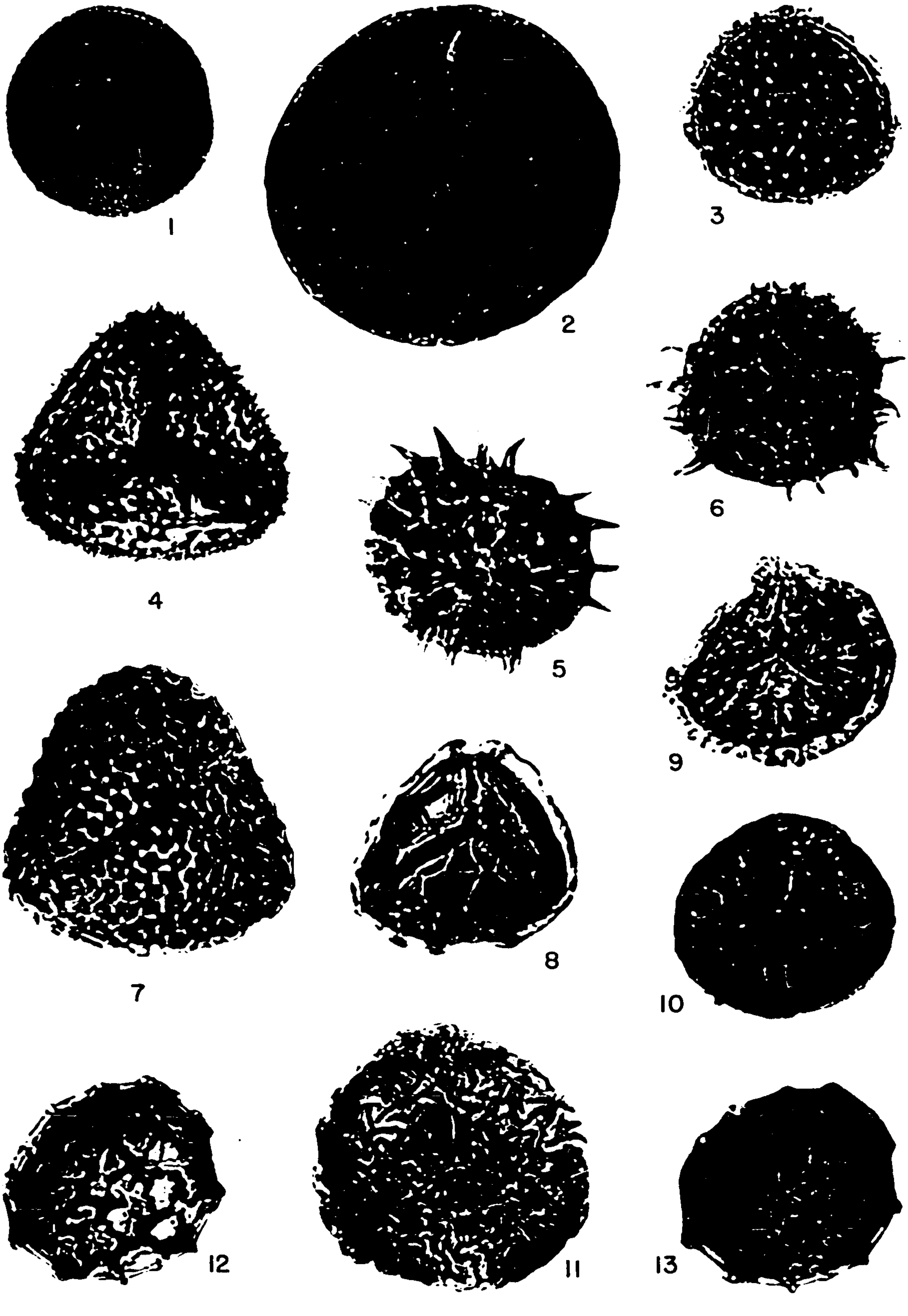


PLATE 4

Figure

1, 3. *Genus B sp. A*

1. 45.0 x 45.0 x 45.0 microns; OPC 830 E-1-1.
3. 46.0 x 46.0 x 49.0 microns; OPC 833 C-4-2.

2. *Lycopodiumsporites* ? sp.
56.0 x 60.0 x 60.0 microns; OPC 833 I-4-1.

4. *Cicatricosisporites* cf. *C. dorogensis* R. Potonié and Gelletich, 1933 53.5 x 56.1 x 56.1 microns; OPC 831 A-4-2.

5. *Appendicisporites* cf. *A. tricornitatus* Weyland and Greifeld, 1953 36.0 x 40.0 x 41.0 microns; OPC 833 M-5-6.

6. *Cingulatisporites* cf. *C. levispeciosus* Pflug in Thomson and Pflug, 1953 43.4 x 46.0 x 46.0 microns; OPC 833 L-2-1.

7 - 9. *Appendicisporites* sp. A

7. 59.0 x 64.0 microns; OPC 830 G-3-3.
8. 74.0 x 76.0 microns; OPC 918 D-1-4.
9. 64.0 x 74.0 microns; OPC 831 J-2-1.

10. *Cingulatisporites* sp. A
27.0 x 31.0 x 31.0 microns; OPC 918 D-1-3.

11. Spore Type C
63.3 x 81.6 microns; OPC 830 D-1-3.

12. *Cingulatisporites* sp. C
43.3 x 45.9 x 45.9 microns; OPC 833 R-2-1.

PLATE 4

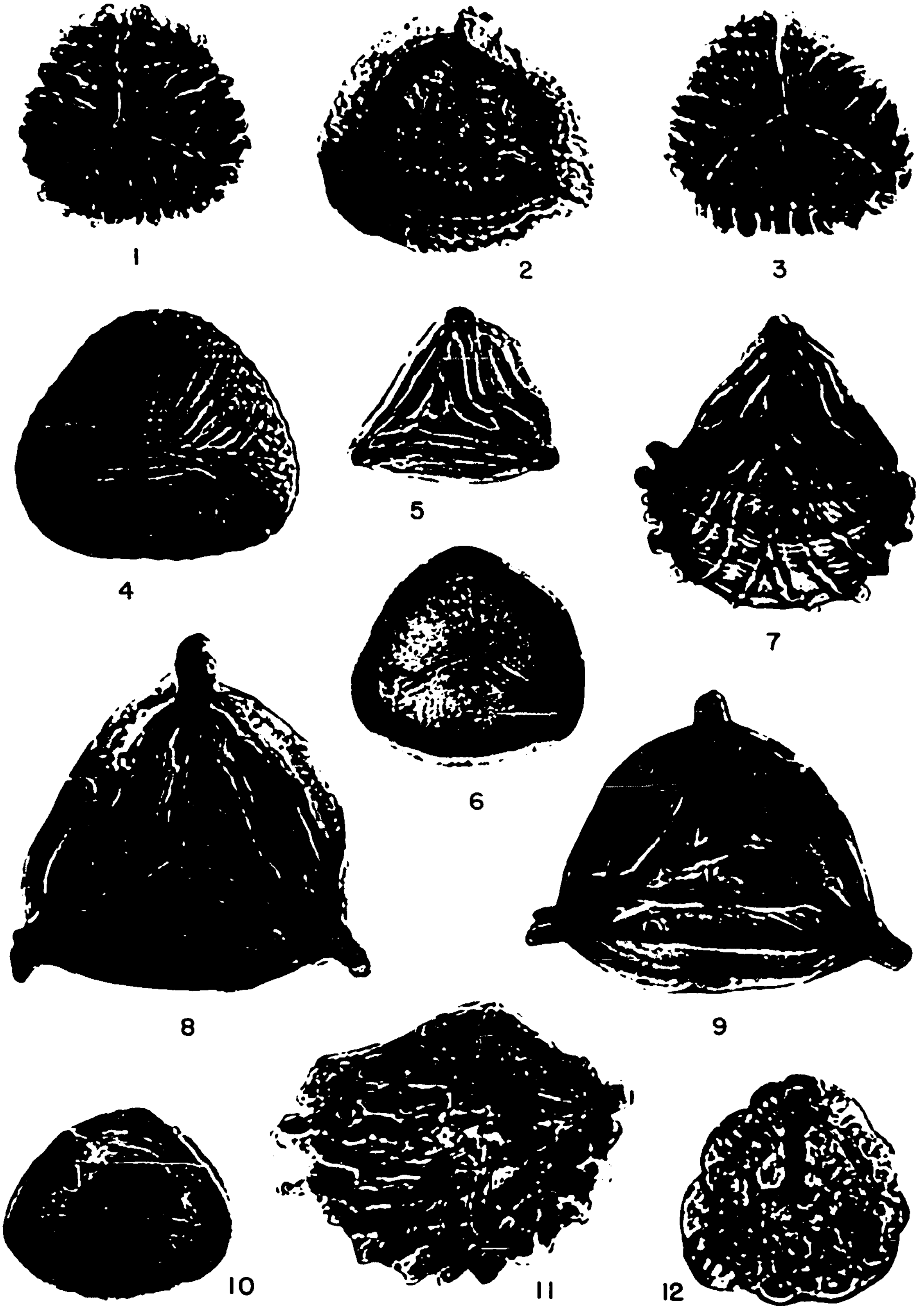


PLATE 5

Figure

1. *Cingulatisporites* cf. *C. pseudoalveolatus* Couper, 1958
46.0 x 46.0 x 51.0 microns; OPC 833 L-4-3.

2. *Cingulatisporites* sp. B
35.7 x 35.7 x 38.3 microns; OPC 833 N-4-4.

3. Spore Type A
58.0 x 63.0 x 63.0 microns; OPC 833 Q-2-4.

4. *Marattisporites* cf. *M. scabratus* Couper, 1958
18.0 x 26.0 microns; OPC 830 A-5-1.

5, 6. *Camarozonosporites* sp. A
5. 82.0 x 82.0 x 84.0 microns; OPC 918 C-4-8.
6. 66.0 x 81.0 microns; OPC 830 J-3-2.

7. *Laevigatosporites* cf. *L. ovatus* Wilson and Webster, 1946
28.1 x 38.3 microns; OPC 830 D-1-6.

8. *Camarozonosporites* cf. *C. rudis* (Leschik, 1955) Klaus, 1960
61.0 x 67.0 x 69.0 microns; OPC 833 V-2-7.

9. *Polypodiisporites* cf. *P. favus* (R. Potonié, 1931) R. Potonié, 1934 41.0 x 55.0 microns; OPC 831 O-5-5.

10, 12. *Laevigatosporites* sp. B
10. 53.6 x 58.7 microns; OPC 830 AA-2-2.
12. 45.9 x 58.7 microns; OPC 830 B-2-4.

11. *Laevigatosporites* sp. A
43.0 x 63.8 microns; OPC 833 M-2-2.

PLATE 5

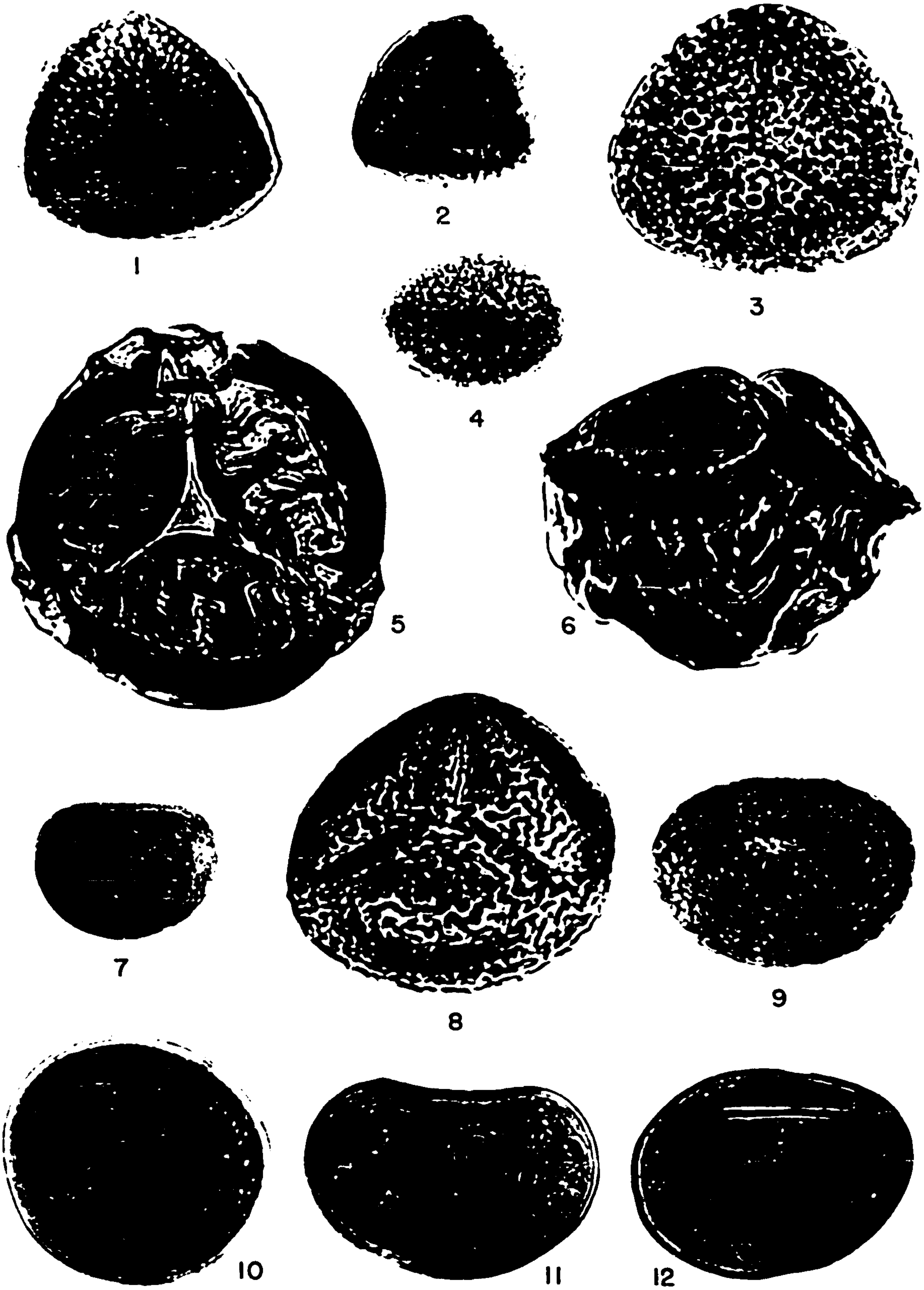


PLATE 6

Figure

1, 2, 4. Schizaea sp. A
- 1. 74.0 x 94.0 microns; OPC 833 J-2-4.
- 2. 69.0 x 94.0 microns; OPC 830 I-3-3.
- 4. 59.0 x 89.0 microns; OPC 833 V-5-1.

3. Genus A sp. A
39.0 x 55.0 microns; OPC 918 E-3-6.

5. Schizaea cf. S. reticulata Cookson, 1957
56.0 x 66.0 microns; OPC 918 C-5-6.

6. Spore Type D
43.4 x 61.2 microns; OPC 918 F-2-14.

7. Spore Type B
53.0 x 70.0 microns; OPC 918 F-5-4.

8, 9. Verrucatosporites cf. V. alienus (R. Potonié, 1931) Thomson and Pflug, 1953
- 8. 48.5 x 69.0 microns; OPC 831 G-5-1.
- 9. 39.0 x 54.0 microns; OPC 833 F-1-2.

10, 11. Extrapunctatosporis cf. E. intrainaequalis Krutzsch, 1959
- 10. 35.0 x 76.5 microns; OPC 918 C-2-20.
- 11. 38.0 x 79.0 microns; OPC 831 O-4-2.

PLATE 6

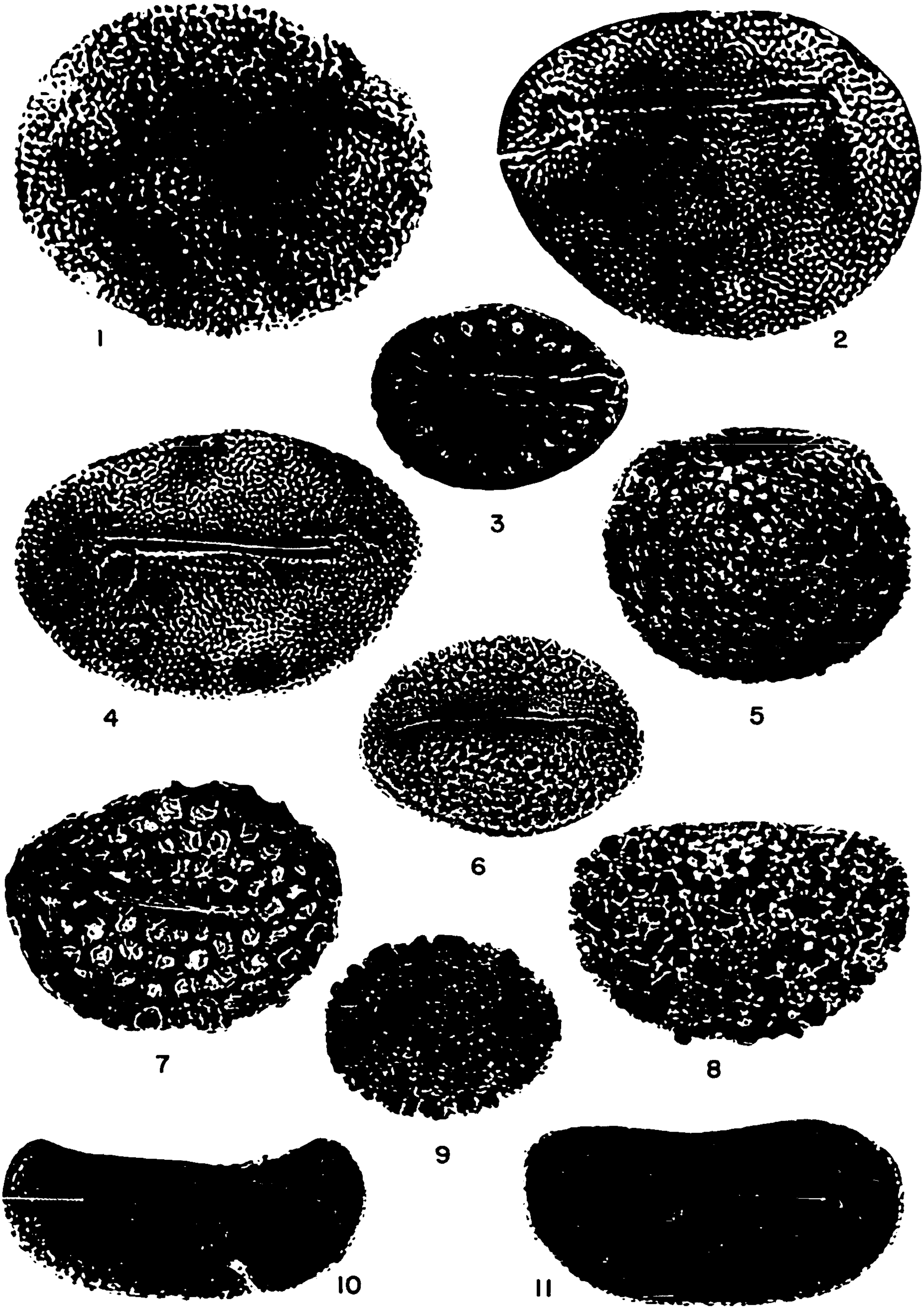


PLATE 7

Figure	
1, 2.	Genus D sp. A 1. 51.0 x 68.9 microns; OPC 833 T-1-2. 2. 64.0 x 64.0 microns; OPC 833 T-2-6.
3, 4.	Vitreisporites cf. V. pallidus (Reissinger, 1938) Nilsson, 1958 3. 23.0 x 30.0 microns; OPC 830 K-1-1. 4. 23.0 x 36.0 microns; OPC 830 F-5-2.
5, 6.	Classopollis cf. C. classoides Pflug, 1953 emend. Pocock and Jansonius, 1961 5. 25.5 x 30.6 microns; OPC 831 C-3-1. 6. 20.4 x 20.4 microns; OPC 830 L-2-1.
7.	Podocarpidites ? sp. 36.2 x 48.5 microns; OPC 833 F-4-6.
8, 9.	Pinuspollenites sp. A 8. 53.6 x 76.5 microns; OPC 833 Q-2-1. 9. 50.0 x 60.0 microns; OPC 833 N-3-9.
10.	Abiespollenites sp. A 68.0 x 75.0 microns; OPC 833 S-5-10.
11, 12.	Ephedripites sp. A 11. 18.3 x 43.4 microns; OPC 833 C-1-3. 12. 23.0 x 40.8 microns; OPC 833 C-1-4.
13, 14	Piceaepollenites sp. A 13. 51.0 x 76.5 microns; OPC 918 B-5-8. 14. 54.0 x 76.0 microns; OPC 918 B-4-1.

PLATE 7

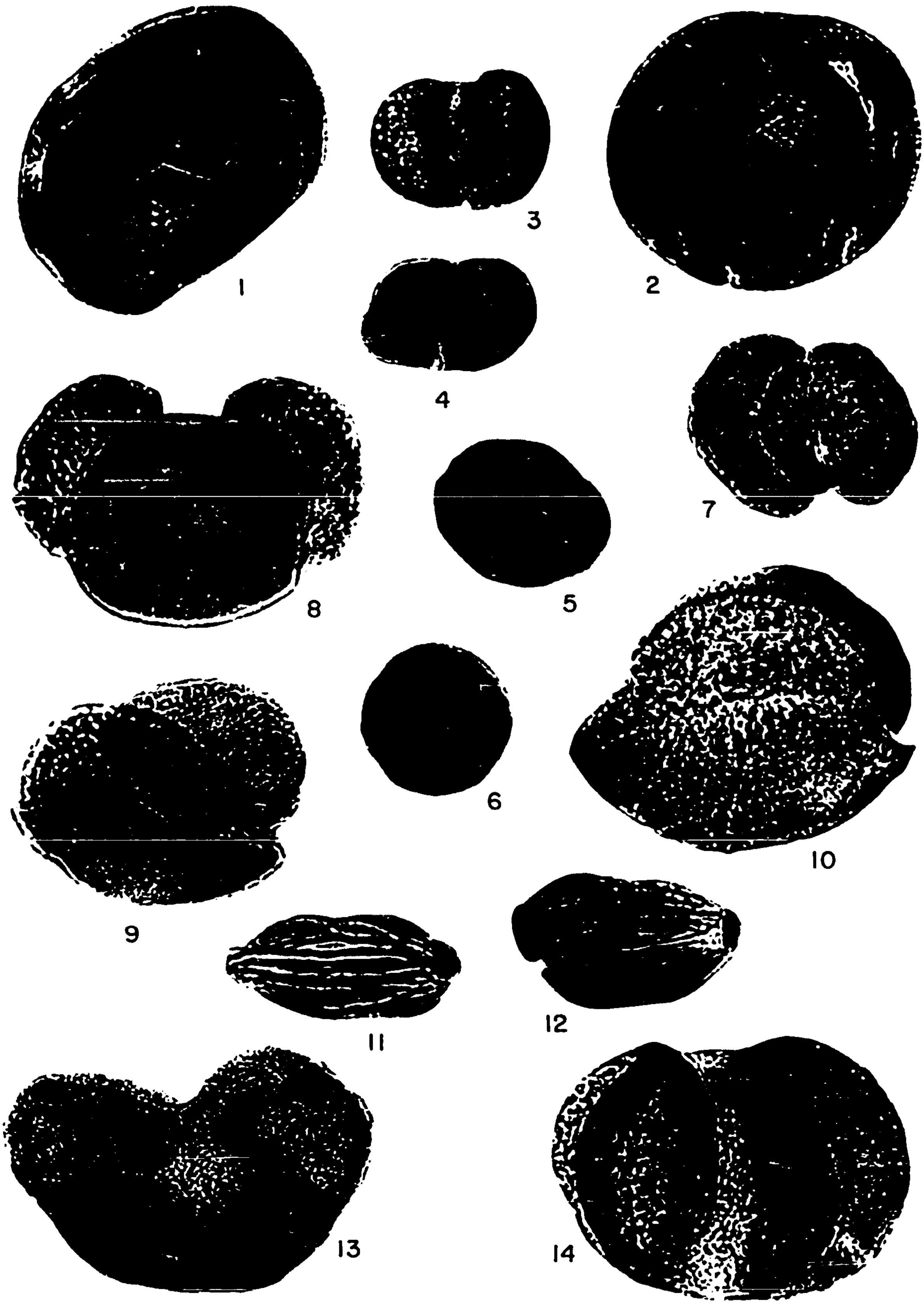


PLATE 8

Figure

1, 2. Ephedra cf. E. notensis Cookson, 1956
1. 24.0 x 38.0 microns; OPC 831 A-1-3.
2. 22.0 x 37.0 microns; OPC 831 A-3-8.

3, 4. Inaperturopollenites sp. A
3. 28.0 x 30.6 microns; OPC 830 F-1-4.
4. 23.0 x 25.0 microsn; OPC 831 A-2-1.

5. Inaperturopollenites cf. I. patellaeformis Weyland and Greifeld, 1953 51.0 x 53.0 microns; OPC 830 D-4-2.

6, 7. Pollen Type A
6. 36.0 x 43.0 microns, focus on muri; OPC 833 W-5-15.
7. 36.0 x 43.0 microns; OPC 833 W-5-15.

8. Inaperturopollenites sp. B
25.5 x 35.5 microns; OPC 831 B-1-3.

9, 10. Araucariacites sp A
9. 27.0 x 27.0 microns; OPC 918 F-1-3.
10. 23.0 x 25.5 microns; OPC 831 G-2-1.

11. Pollen Type B
43.4 x 44.5 microns; OPC 918 E-1-21.

12, 13. Pollen Type C
12. 30.6 x 43.4 microns; OPC 833 A-2-3.
13. 28.1 x 51.0 microns; OPC 833 A-2-5.

14. Monosulcites cf. M. carpentieri Delcourt and Sprumont, 1955
30.6 x 81.6 microns; OPC 833 O-2-7.

15. Monosulcites cf. M. minimus Cookson, 1947
18.5 x 43.4 microns; OPC 831 A-1-18.

16. Eucommiidites cf. E. minor Groot and Penny, 1960
25.5 x 29.4 microns; OPC 831 F-3-4.

17. Liliacidites cf. L. kaitangataensis Couper, 1953
28.1 x 51.0 microns; OPC 831 A-2-18.

18. Liliacidites cf. L. intermedius Couper, 1953
30.6 x 33.0 microns; OPC 831 A-2-23.

19. Cycadopites ? sp.
20.0 x 32.0 microns; OPC 830 AA-1-6.

20. Sabalpollenites sp. B
25.5 x 31.6 microns; OPC 830 A-4-12.

PLATE 8

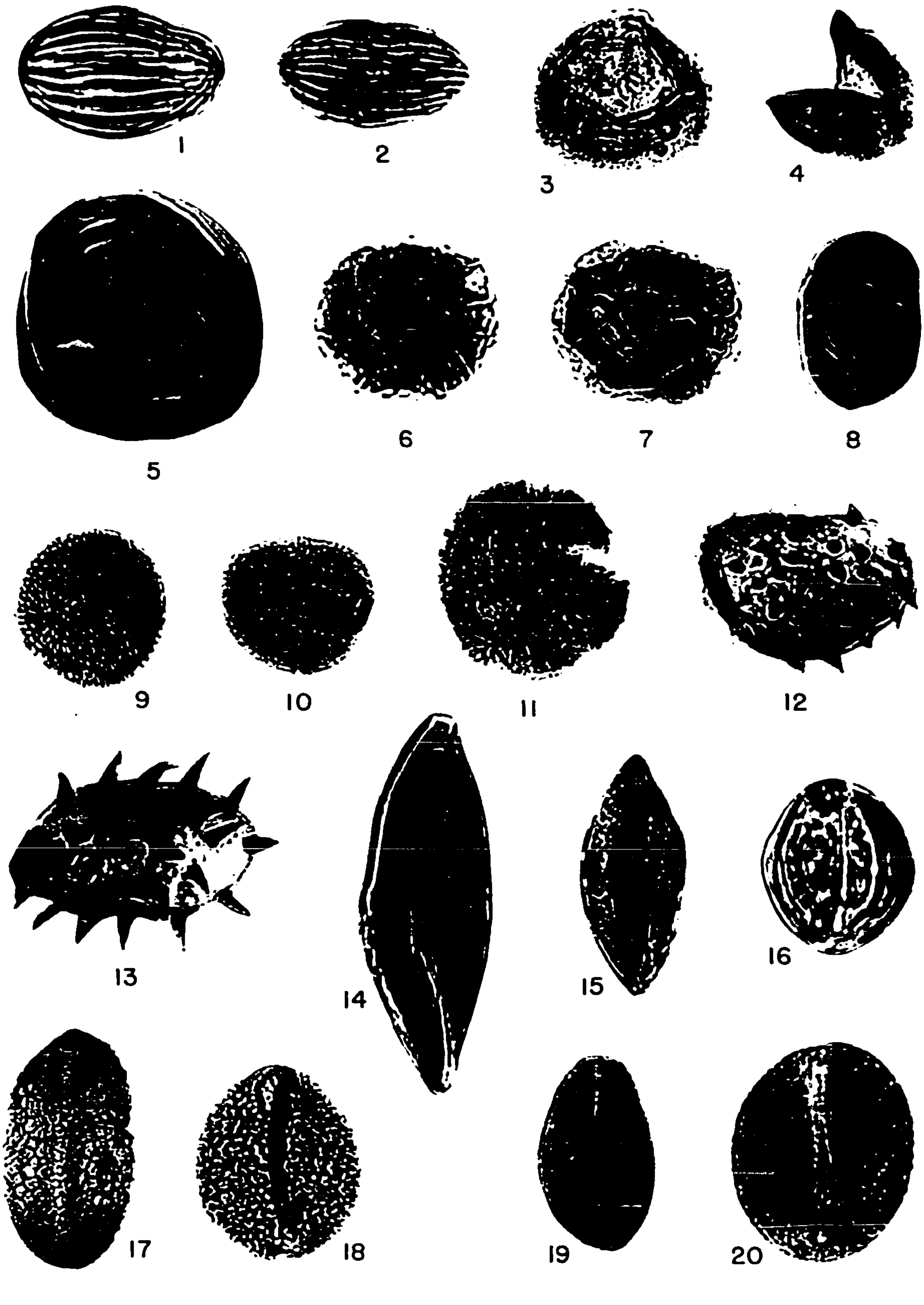


PLATE 9

Figure

1, 2. <u>Sabalpollenites</u> sp. A
1. 32.0 x 40.0 microns; OPC 918 B-5-7.
2. 24.0 x 28.0 microns; OPC 918 B-5-1.

3, 4. <u>Tricolpites</u> cf. <u>T. reticulatus</u> Cookson, 1947
3. 20.4 x 25.5 microns; OPC 831 H-1-3.
4. 23.0 x 23.0 microns; OPC 833 B-1-2.

5, 6. <u>Tricolpites</u> sp. C
5. 18.0 x 18.0 microns; OPC 830 J-2-5.
6. 16.0 x 17.0 microns; OPC 833 Q-1-1.

7, 8. <u>Tricolpites</u> sp. A
7. 21.5 x 23.0 microns; OPC 831 A-2-16.
8. 22.0 x 28.0 microns; OPC 830 E-5-3.

9, 10. <u>Tricolpites</u> sp. G
9. 17.0 x 28.0 microns; OPC 918 C-2-28.
10. same specimen, focus on pole.

11, 12. <u>Tricolpites</u> sp. F
11. 17.9 x 17.9 microns; OPC 833 X-5-1.
12. 17.0 x 17.0 microns; OPC 833 X-3-13.

13 - 15. <u>Tricolpites</u> sp. D
15. 27.0 x 28.0 microns; OPC 833 N-2-15.
13. same specimen, focus on one pole.
14. same specimen, focus on other pole.

16. <u>Tricolpites</u> sp. H
43.4 x 43.4 microns; OPC 918 F-1-10.

17. <u>Tricolpites</u> sp. B
17.9 x 28.2 microns; OPC 833 V-1-8.

18. <u>Tricolpites</u> sp. I
35.7 x 40.8 microns; OPC 918 E-1-3.

19, 20. <u>Tricolpites</u> sp. E
19. 35.0 x 35.0 microns; OPC 833 U-3-3.
20. 34.0 x 34.0 microns; OPC 833 U-2-3.

PLATE 9

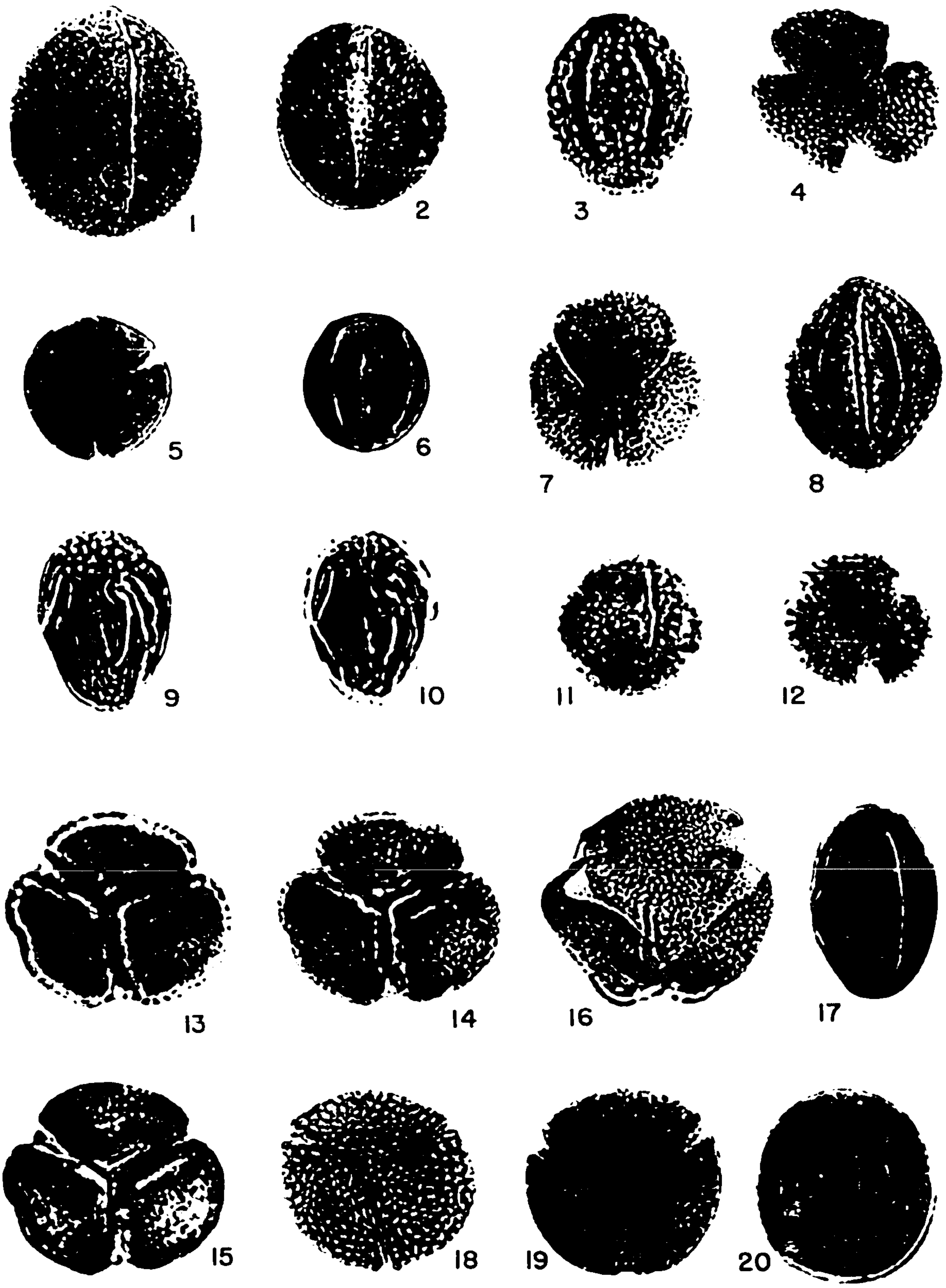


PLATE 10

Figure

1, 2 Tricolpites sp. J
1. 26.0 x 26.0 microns; OPC 830 F-3-1.
2. same specimen, focus on pole.

3. Tricolpites sp. K
20.4 x 23.0 microns; OPC 830 K-2-1.

4, 5. Dicoryphe ? sp.
4. 34.0 x 34.0 microns; OPC 918 C-3-4.
5. 52.0 x 55.0 microns; OPC 919 B-2-3.

6. Aquilapollenites cf. A. novacolpites Funkhouser, 1961
51.0 x 58.8 microns; OPC 833 G-3-2.

7, 8. Aquilapollenites cf. A. polaris Funkhouser, 1961
7. 51.0 x 53.1 microns; OPC 833 F-4-7.
8. 38.3 x 48.5 microns; OPC 833 S-5-1.

9, 10. Tricolporopollenites sp. C
9. 28.0 x 28.0 microns; OPC 833 N-5-7.
10. same specimen, focus on pole.

11. Tricolporopollenites sp. B
28.0 x 28.0 microns; OPC 831 A-2-36.

12, 13. Tricolporopollenites sp. A
12. 48.5 x 51.0 microns; OPC 918 B-2-7.
13. 38.0 x 47.0 microns; OPC 833 W-2-17.

14, 17. Triporopollenites sp. A
14. 34.0 x 35.0 microns; OPC 918 D-4-5.
17. 33.0 x 33.0 microns; OPC 833 U-3-1.

15. Tricolporopollenites sp. D
21.0 x 27.0 microns; OPC 833 M-3-9.

16. Monoporopollenites cf. M. gramineoides Meyer, 1956
19.0 x 22.0 microns; OPC 918 E-1-11.

PLATE 10

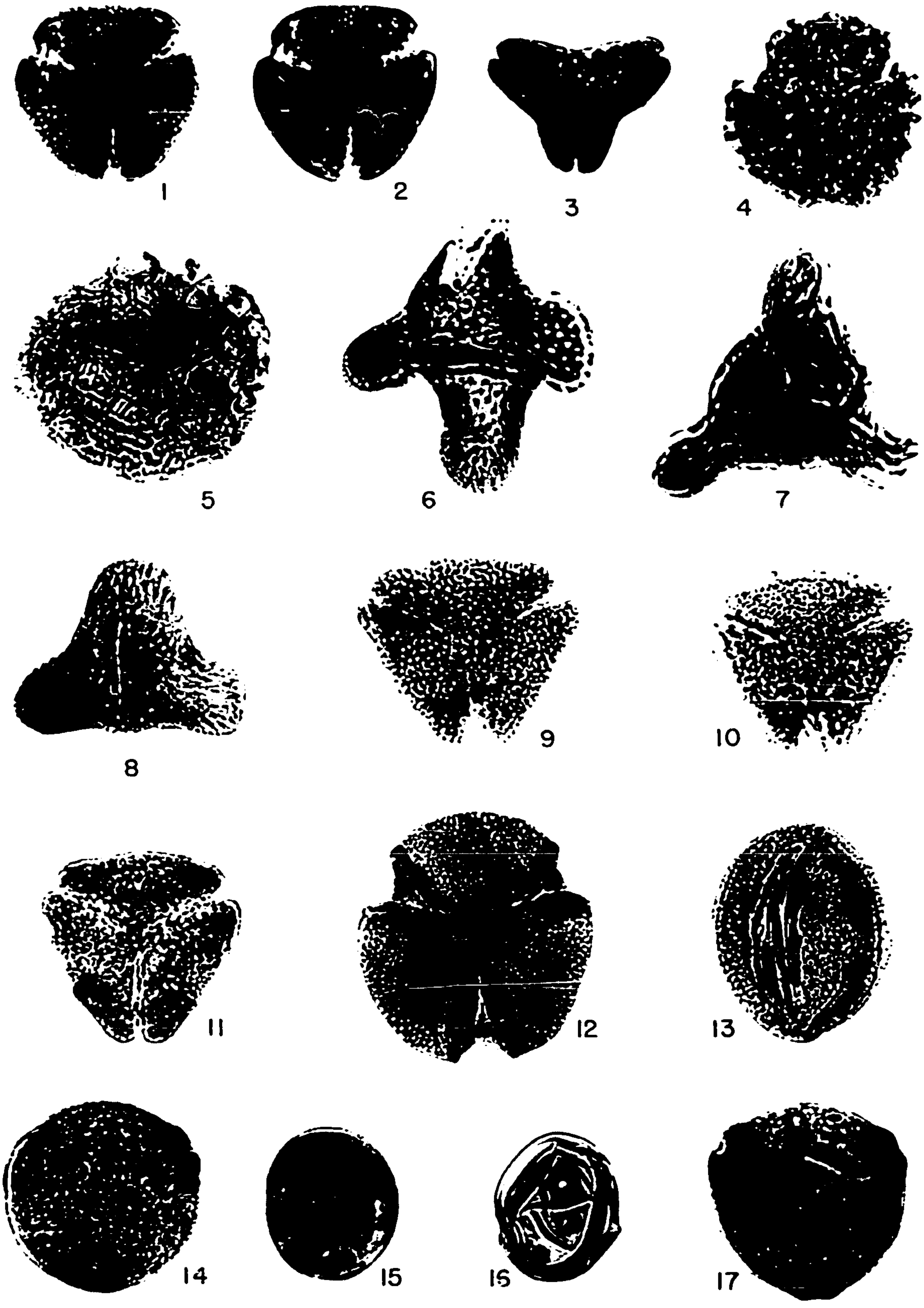


PLATE 11

Figure

1. Cupanieidites cf. C. major Cookson and Pike, 1954
25.5 x 28.0 microns; OPC 833 U-1-5.

2. Cupanieidites sp. A
18.5 x 20.4 microns; OPC 833 W-2-3.

3. Trivestibulopollenites ? sp.
25.0 x 26.0 microns; OPC N-5-1.

4. Triporopollenites sp. C
28.1 x 29.8 microns; OPC 830 B-4-2.

5, 6. Triporopollenites sp. B
5. 28.0 x 30.5 microns; OPC 833 W-5-1.
6. 29.0 x 29.0 microns; OPC 830 C-1-4.

7. Triporopollenites sp. D
13.0 x 14.0 microns; OPC 831 A-2-11.

8. Triporopollenites sp. E
27.0 x 31.0 microns; OPC 833 U-3-4.

9. Caryapollenites sp. A
53.6 x 53.6 microns; OPC 831 B-5-1.

10, 11. Proteacidites sp. A
10. 33.2 x 33.2 microns; OPC 833 N-1-12.
11. 34.0 x 34.0 microns; OPC 833 N-2-12.

12. Tiliaepollenites ? sp.
27.0 x 29.0 microns; OPC 830 I-2-4.

13. Pterocaryapollenites sp. A
25.0 x 25.0 microns; OPC 833 P-4-1.

14. Proteacidites sp. B
24.0 x 25.5 microns; OPC 833 O-1-12.

15. Proteacidites sp. C
29.0 x 30.6 microns; OPC 831 H-1-1.

16, 17. Pistillipollenites sp. A
16. 28.0 x 28.0 microns; OPC 918 F-3-8.
17. 35.7 x 40.8 microns, tetrad; OPC 830 F-4-5.

18, 19. Pistillipollenites ? sp.
18. 25.5 x 25.5 microns; OPC 831 A-1-2.
19. 25.5 x 25.5 microns; OPC 831 A-1-2.

PLATE II

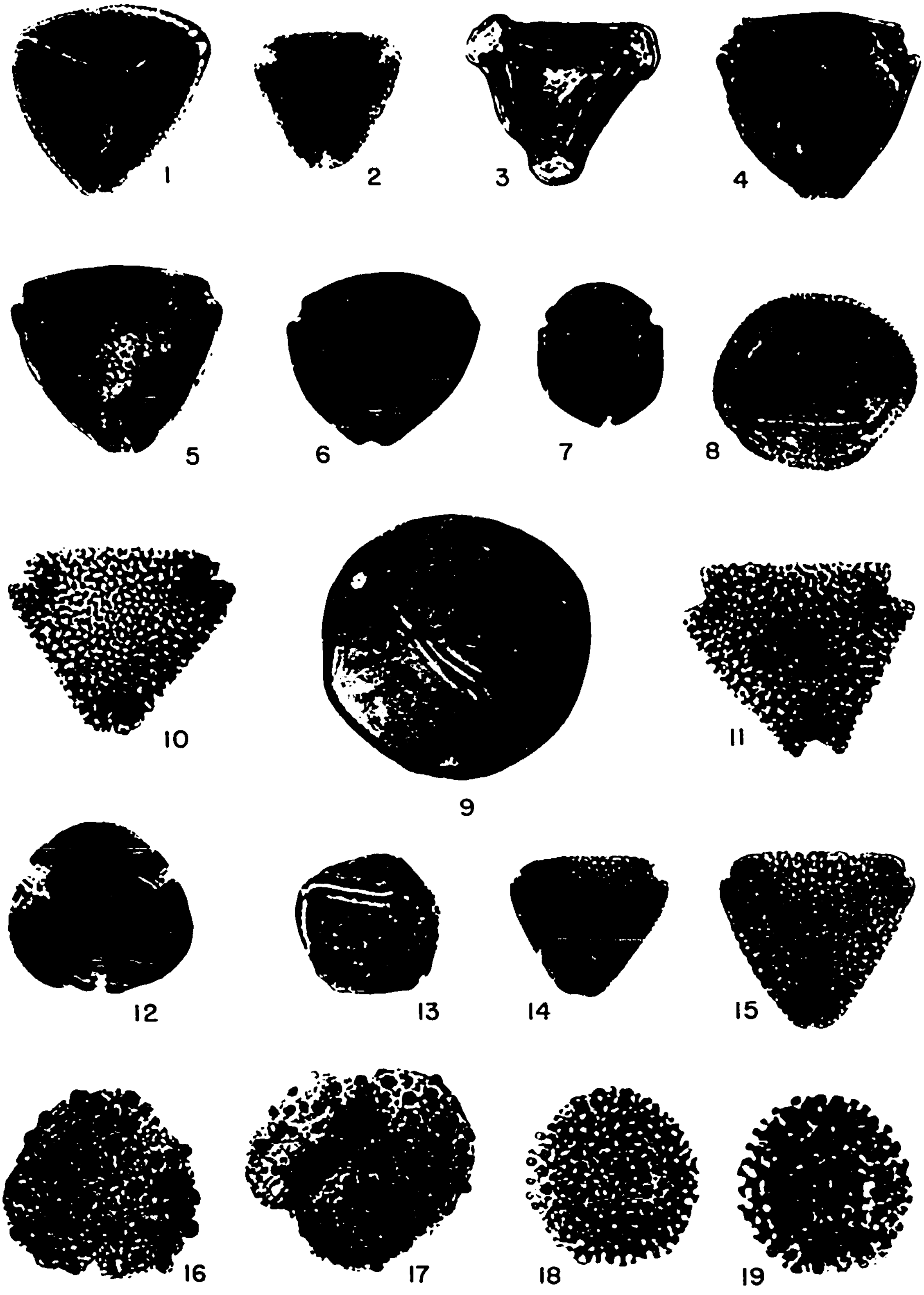


PLATE 12

Figure

1, 2. Pachysandra cf. P. procumbentiformis Samoilovich, 1961
1. 35.5 x 40.8 microns; OPC 833 N-4-10.
2. same specimen, enlargement of forae ornamentation.

3. Incertae sedis sp. A
88.0 x 100.0 microns; OPC 918 B-3-4.

4. Schizosporis cf. S. parvus Cookson and Dettmann, 1959
56.0 x 115.0 microns; OPC 918 C-4-12.

5. Schizosporis cf. S. cooksoni Pocock, 1962
30.6 x 35.7 microns; OPC 833 U-1-7.

6. Microforaminifera sp. A
28.0 x 33.0 microns; OPC 833 M-1-1.

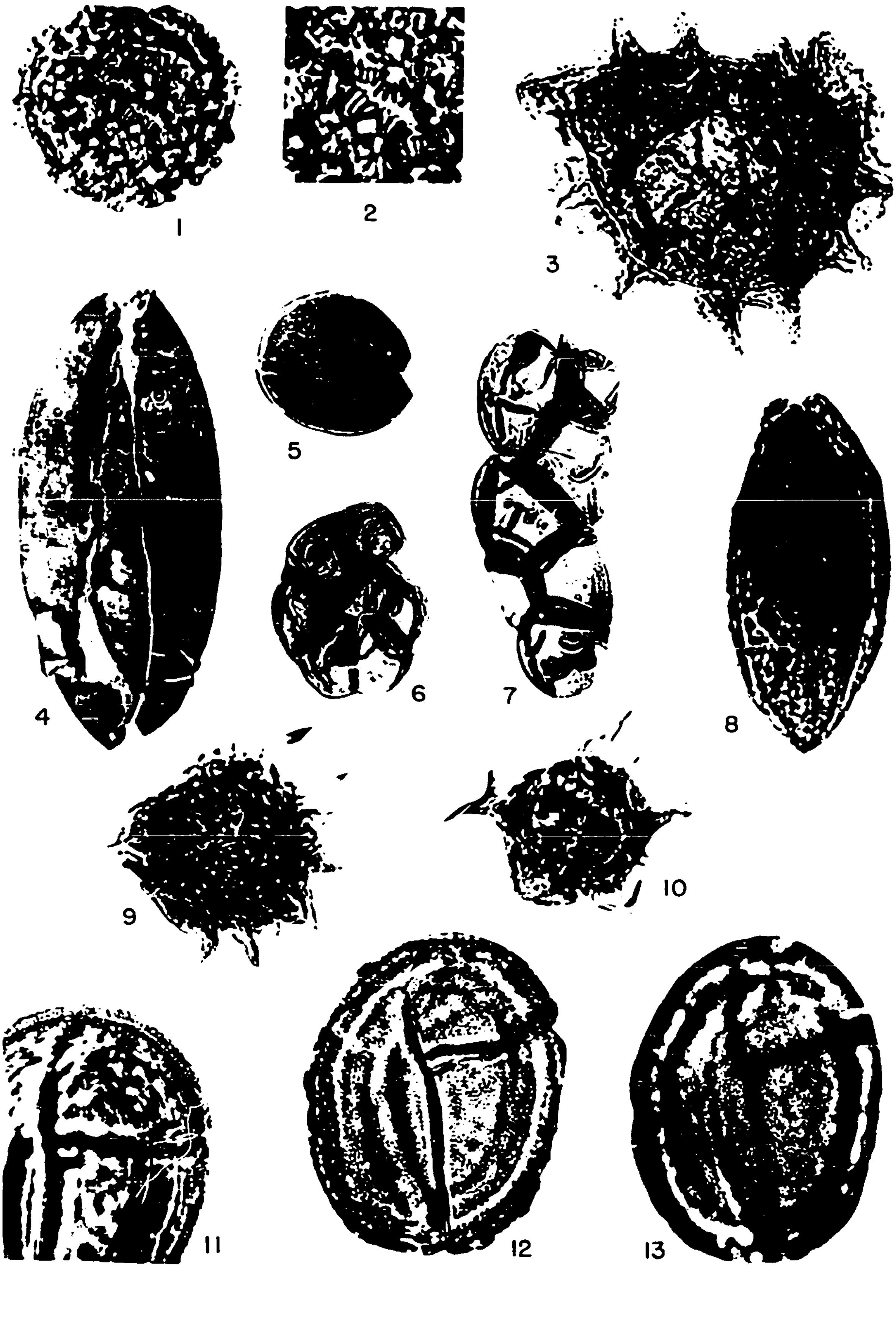
7. Microforaminifera sp. B
34.0 x 82.0 microns; OPC 830 J-1-1.

8. Ovoidites ? sp.
33.0 x 74.0 microns; OPC 918 D-3-6.

9, 10. Baltisphaeridium sp. A
9. 43.4 x 43.4 microns; OPC 833 A-2-4.
10. 40.8 x 51.0 microns; OPC 833 S-3-12.

11 - 13. Incertae sedis sp. B
11. OPC 831 A-3-14, enlargement of wall structure.
12. 66.0 x 85.0 microns; OPC 831 A-3-14,
focus on periphery.
13. same specimen, focus of outer wall.

PLATE 12



PALYNOMORPHS	OPC 919 B	OPC 919 C	OPC 918 (B–J)	OPC 830 (AA, A–L)	OPC 831 (A–O)	OPC 833 (A–X)
SPORES						
TRILETE						
Sphagnumsporites cf S. antiquasporites			[illegible]	[illegible]	[illegible]	[illegible]
S. cf S. psilatus			[illegible]	[illegible]	[illegible]	[illegible]
Deltoidospora cf D. hallii	20	25	[illegible]	[illegible]	[illegible]	[illegible]
D. sp A	05		[illegible]	[illegible]	[illegible]	[illegible]
Cyathidites cf C. minor	15	45	[illegible]	[illegible]	[illegible]	[illegible]
Gleicheniidites sp A	65	30	[illegible]	[illegible]	[illegible]	[illegible]
G. sp B			[illegible]	[illegible]	[illegible]	[illegible]
Lycopodiumsporites cf L. adriennis	75	55	[illegible]	[illegible]	[illegible]	[illegible]
Calamospora cf C. mesozoica			[illegible]	[illegible]	[illegible]	[illegible]
Toroisporites cf T. minor		05	[illegible]	[illegible]	[illegible]	[illegible]
T. cf Todites ungans			[illegible]	[illegible]	[illegible]	[illegible]
Leschikisporis cf L. aduncus			[illegible]	[illegible]	[illegible]	[illegible]
Granulatisporites sp A			[illegible]	[illegible]	[illegible]	[illegible]
Verrucosisporites cf V. asymmetricus			[illegible]	[illegible]	[illegible]	[illegible]
V. sp A	05		[illegible]	[illegible]	[illegible]	[illegible]
V. sp B			[illegible]	[illegible]	[illegible]	[illegible]
Genus E sp A			[illegible]	[illegible]	[illegible]	[illegible]
Genus C sp A	05	25	[illegible]	[illegible]	[illegible]	[illegible]
Osmundacidites cf O. wellmanii		05	[illegible]	[illegible]	[illegible]	[illegible]
O. sp A			[illegible]	[illegible]	[illegible]	[illegible]
Acanthotriletes cf A. varispinosus			[illegible]	[illegible]	[illegible]	[illegible]
Lycopodiacidites cf L. kuepperi		05	[illegible]	[illegible]	[illegible]	[illegible]
L. sp A			[illegible]	[illegible]	[illegible]	[illegible]
Lycopodiumsporites sp A			[illegible]	[illegible]	[illegible]	[illegible]
L. sp B			[illegible]	[illegible]	[illegible]	[illegible]
L. cf L. austroclavatidites		05	[illegible]	[illegible]	[illegible]	[illegible]
L. ? sp			[illegible]	[illegible]	[illegible]	[illegible]
Cicatricosisporites cf C. dorogensis			[illegible]	[illegible]	[illegible]	[illegible]
Genus B sp A			[illegible]	[illegible]	[illegible]	[illegible]
Appendicisporites sp A			[illegible]	[illegible]	[illegible]	[illegible]
Cingulatisporites cf C. levispeciosus			[illegible]	[illegible]	[illegible]	[illegible]
C. cf C. pseudoalveolatus			[illegible]	[illegible]	[illegible]	[illegible]
C. sp A			[illegible]	[illegible]	[illegible]	[illegible]
C. sp B			[illegible]	[illegible]	[illegible]	[illegible]
Camarozonosporites cf C. rudis	05		[illegible]	[illegible]	[illegible]	[illegible]
C. sp A	10	20	[illegible]	[illegible]	[illegible]	[illegible]
MONOLETE						
Laevigatosporites cf L. ovatus	35		[illegible]	[illegible]	[illegible]	[illegible]
L. sp A			[illegible]	[illegible]	[illegible]	[illegible]
L. sp B	65	25	[illegible]	[illegible]	[illegible]	[illegible]
Marattisporites cf M. scabratus			[illegible]	[illegible]	[illegible]	[illegible]
Polypodiisporites cf P. favus	60	50	[illegible]	[illegible]	[illegible]	[illegible]
Schizaea sp A		20	[illegible]	[illegible]	[illegible]	[illegible]
Verrucatosporites cf V. alienus			[illegible]	[illegible]	[illegible]	[illegible]
Genus A sp A			[illegible]	[illegible]	[illegible]	[illegible]
POLLEN						
GYMNOSPERM						
ALETE						
Inaperturopollenites sp A			[illegible]	[illegible]	[illegible]	[illegible]
I. sp B			[illegible]	[illegible]	[illegible]	[illegible]
I. cf I. patellaeformis	10	10	[illegible]	[illegible]	[illegible]	[illegible]
Araucariacites sp A	05		[illegible]	[illegible]	[illegible]	[illegible]
Pollen type B			[illegible]	[illegible]	[illegible]	[illegible]
SACCATE						
Genus D sp A			[illegible]	[illegible]	[illegible]	[illegible]
Vitreisporites cf V. pallidus			[illegible]	[illegible]	[illegible]	[illegible]
Pinuspollenites sp A	20	15	[illegible]	[illegible]	[illegible]	[illegible]
Piceaepollenites sp A			[illegible]	[illegible]	[illegible]	[illegible]
Podocarpidites sp			[illegible]	[illegible]	[illegible]	[illegible]
MONOSULCATE						
Monosulcites cf M. minimus			[illegible]	[illegible]	[illegible]	[illegible]
M. cf M. carpentieri			[illegible]	[illegible]	[illegible]	[illegible]
PLICATE						
Eucommiidites cf E. minor			[illegible]	[illegible]	[illegible]	[illegible]
Ephedripites sp			[illegible]	[illegible]	[illegible]	[illegible]
Ephedra cf E. notensis			[illegible]	[illegible]	[illegible]	[illegible]
OPERCULATE						
Classopollis cf C. classoides			[illegible]	[illegible]	[illegible]	[illegible]
ANGIOSPERM						
MONOCOLPATE						
Liliacidites cf L. intermedius	30		[illegible]	[illegible]	[illegible]	[illegible]
L. cf L. kaitangataensis			[illegible]	[illegible]	[illegible]	[illegible]
Sabalpollenites sp A and sp B	40	40	[illegible]	[illegible]	[illegible]	[illegible]
TRICOLPATE						
Tricolpites cf T. reticulatus		05	[illegible]	[illegible]	[illegible]	[illegible]
T. sp A	40	15	[illegible]	[illegible]	[illegible]	[illegible]
T. sp B	15		[illegible]	[illegible]	[illegible]	[illegible]
T. sp C			[illegible]	[illegible]	[illegible]	[illegible]
T. sp D			[illegible]	[illegible]	[illegible]	[illegible]
T. sp E			[illegible]	[illegible]	[illegible]	[illegible]
T. sp F			[illegible]	[illegible]	[illegible]	[illegible]
T. sp G	05		[illegible]	[illegible]	[illegible]	[illegible]
T. sp H			[illegible]	[illegible]	[illegible]	[illegible]
T. sp J	35	05	[illegible]	[illegible]	[illegible]	[illegible]
T. sp K			[illegible]	[illegible]	[illegible]	[illegible]
Dicoryphe ? sp	15		[illegible]	[illegible]	[illegible]	[illegible]
Aquilapollenites cf A. polaris			[illegible]	[illegible]	[illegible]	[illegible]
TRICOLPORATE						
Tricolporopollenites sp A	65		[illegible]	[illegible]	[illegible]	[illegible]
T. sp B			[illegible]	[illegible]	[illegible]	[illegible]
T. sp C			[illegible]	[illegible]	[illegible]	[illegible]
T. sp D			[illegible]	[illegible]	[illegible]	[illegible]
Cupanieidites cf C. major			[illegible]	[illegible]	[illegible]	[illegible]
C. sp A			[illegible]	[illegible]	[illegible]	[illegible]
PORATE						
Monoporopollenites cf M. gramineoides			[illegible]	[illegible]	[illegible]	[illegible]
Triporopollenites sp A	275	370	[illegible]	[illegible]	[illegible]	[illegible]
T. sp B			[illegible]	[illegible]	[illegible]	[illegible]
T. sp D			[illegible]	[illegible]	[illegible]	[illegible]
Tiliaepollenites ? sp			[illegible]	[illegible]	[illegible]	[illegible]
Proteacidites sp A	10		[illegible]	[illegible]	[illegible]	[illegible]
P. sp C			[illegible]	[illegible]	[illegible]	[illegible]
Pistillipollenites sp A			[illegible]	[illegible]	[illegible]	[illegible]
P. ? sp			[illegible]	[illegible]	[illegible]	[illegible]
Pachysandra cf P. procumbentiformis			[illegible]	[illegible]	[illegible]	[illegible]
INCERTAE SEDIS						
Ovoidites ? sp			[illegible]	[illegible]	[illegible]	[illegible]
Schizosporis cf S. parvus			[illegible]	[illegible]	[illegible]	[illegible]
Incertae sedis sp B			[illegible]	[illegible]	[illegible]	[illegible]
Baltisphaeridium sp A			[illegible]	[illegible]	[illegible]	[illegible]

Sample OPC 918 A barren

T = Trace, species present in sample but not in assemblage counts

TABLE I. RELATIVE PERCENTS OF PALYNOLOGICAL FOSSILS IN THE VERMEJO FORMATION COALS, FREMONT COUNTY, COLORADO

GENERA		1	2	3	4	5	6	7	8	9	10	11	12	13
OPC 833	UPPER	2.3	0.7	7.4	0.9	2.8	8.2	5.2	8.1	1.4	21.7	1.8	26.9	3.3
	MIDDLE	2.9	1.3	9.3	0.8	2.0	5.8	1.9	4.0	1.9	12.1	1.0	43.5	3.3
	LOWER	1.6	1.7	14.9	1.2	2.7	7.9	5.4	4.6	2.7	19.8	1.0	28.1	2.3

GENERA		1	2	3	4	5	6	7	8	9	10	11	12	13
OPC 831	UPPER	3.7	3.6	12.6	1.9	4.5	6.6	8.8	3.2	4.1	16.6	0.3	14.2	0.5
	MIDDLE	0.3	1.0	1.8	1.9	5.1	14.8	2.4	1.8	3.2	45.3	2.3	3.7	5.1
	LOWER	1.1	0.9	0.1	4.7	6.4	8.8	1.3	7.8	4.5	22.0	10.0	11.7	5.9

GENERA		1	2	3	4	5	6	7	8	9	10	11	12	13
OPC 830	UPPER	6.5	2.0	12.0	1.8	5.4	6.2	15.3	3.6	1.6	5.9	0	25.9	0.8
	MIDDLE	5.1	1.3	7.6	1.9	8.5	15.1	4.9	10.2	2.9	14.6	0.9	16.8	0.8
	LOWER	1.0	1.0	0.9	6.3	3.4	23.3	6.3	4.6	3.5	29.2	2.0	5.8	2.9

GENERA		1	2	3	4	5	6	7	8	9	10	11	12	13
OPC 918	UPPER	0	2.0	6.5	4.5	6.3	5.0	6.3	3.5	0.8	3.5	0.8	43.3	0
	MIDDLE	0.5	2.0	2.7	0.8	8.1	7.9	3.3	2.9	3.4	12.1	5.7	35.8	1.5
	LOWER	0.7	2.5	4.5	2.8	14.0	15.0	3.2	4.2	6.2	9.3	3.3	19.3	3.3

GENERA		1	2	3	4	5	6	7	8	9	10	11	12	13
OPC 919	UPPER	0	2.5	3.0	6.0	15.5	12.5	5.0	1.0	4.0	2.5	0.5	37.5	0
	LOWER	0	2.5	6.5	1.5	7.5	20.0	6.0	1.0	4.0	6.5	6.5	27.5	1.0

LIST OF GENERA

1. SPHAGNUMSPORITES
2. DELTOIDOSPORA
3. GLEICHENIIDITES
4. CYATHIDITES
5. LYGODIUMSPORITES
6. LAEVIGATOSPORITES
7. POLYPODIISPORITES
8. INAPERTUROPOLLENITES
9. SABALPOLLENITES
10. TRICOLPITES
11. TRICOLPOROPOLLENITES
12. TRIPOROPOLLENITES
13. PROTEACIDITES

FIGURE 2. HISTOGRAMS OF THE 13 DOMINANT GENERA IN THE VERMEJO FORMATION COALS, FREMONT COUNTY, COLORADO