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PERMIAN PLANT MICROFOSSILS FROM THE FLOWERPOT FORMATION

GREER COUNTY, OKLAHOMA

by

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PERMIAN PLANT MICROFOSSILS FROM THE FLOWERPOT FORMATION, GREER COUNTY, OKLAHOMA*

L. R. Wilson

ABSTRACT

The partial palynological assemblage described includes 27 species of spores and pollen grains assigned to 23 genera. Nine genera and 22 species are new. The Flowerpot Shale deposit in which the fossils occur accumulated as a marine near-shore sediment. The environment is indicated by the presence of scolecodont and hystrichosphaerid fossils. Relative percentages of the more abundant genera of spores and pollen are as follows: *Lueckisporites* 68.1 percent, *Strotersporites* 15.9 percent, *Vittatina* 2.5 percent, *Potonieisporites* 1.9 percent, and *Alisporites* 1.4 percent. These genera are interpreted as having been derived from a semi-arid upland flora. A minor element of spores, consisting of *Calamospora, Laevigatosporites,* and possibly other genera, is interpreted as representing a more mesic lowland flora. The closest floristic correlation appears to be with the Zechstein (Upper Permian) flora of Germany.

INTRODUCTION

In recent years numerous Permian deposits in Russia, Germany, India, and Australia have yielded rich floras of fossil spores and pollen. The Permian deposits of the United States have been neglected by the plant micropaleontologists, but recent investigations have demonstrated that the American Permian deposits also contain much the same palynological flora as is found elsewhere.

* Report of one study conducted under National Science Foundation Grant G6589.

The Flowerpot assemblage has proved to be an abundant and varied flora and the present study includes but a portion of the species observed. Description of the other species will have to await the completion of studies now in progress.

The first samples of Permian shales containing the fossils described here were collected by W. E. Ham of the Oklahoma Geological Survey on April 10, 1958, from the Flowerpot Shale and given to the writer for study. Several shale samples from various levels in the section were included in the collection and, although they all contain fossil spores and pollen, a twelve-inch-thick shale from the Flowerpot Formation, 30 feet below its top, was chosen for intensive study. Subsequently additional samples were collected by Dr. Ham and the writer and the fossils from these and from the first samples constitute the material of this report. The deposit is on the north side of Salt Fork of the Red River (NE¼ SE¼ SE¼ sec. 2, T. 4 N., R. 23 W.) approximately five miles southwest of Mangum, Greer County, Oklahoma (fig. 1).

The writer wishes to express his appreciation to W. E. Ham for supplying the initial samples of the Flowerpot Shale and for aid in subsequent field work. C. C. Branson and Alex. Nicholson have aided materially by their personal interest in the project and in reading the manuscript.

GEOLOGY

The Flowerpot Shale is an important Permian formation in the El Reno Group of the Guadalupean Series (table 1). It was named by Cragin (1896) for shales in Flowerpot Mound, southwest of Medicine Lodge, Kansas. The Flowerpot Formation has an areal distribution from south-central Kansas, southwestward through Oklahoma into northern Texas. Near its type locality in Kansas it is 173 to 190 feet thick (Norton, 1939). In Blaine County, Oklahoma, its thickness is 430 feet (Fay, 1958). In Greer County. Edwards (1958) measured a 239-foot section 4 miles northwest of Mangum.

TABLE 1. STRATIGRAPHIC CHART OF THE PERMIAN PERIOD

American Standard Section		Western Oklahoma		Central Oklahoma		North-Central Oklahoma		U. S. S. R. Perm Basin	Pakistan Salt Range	
Ochoan Series			Elk City Ss. Doxey Shale Cloud Chief Fm.		Quartermaster Formation		Cloud Chief Ss. Day Creek Dol.	? Tatarian Stage	Upper Permian Series	Upper Productus Limestone - - - ? - - -
Guadalupean Series	Capitan Ls.	Whitehorse Gr.	Rush Springs Sandstone Marlow Formation	Whitehorse Gr.	Rush Springs Sandstone Marlow Formation	Whitehorse Gr.	Rush Springs Sandstone Marlow Formation			Middle Productus Limestone
	Word Fm.	El Reno Group	Dog Creek Sh Blaine Formation *- - - - - - - - - - Flowerpot Shale	El Reno Group	Chickasha Formation Duncan Ss.	El Reno Group	Dog Creek Sh Blaine Formation Flowerpot Shale CedarHills Ss	Kazanian Stage - - ? - - ? - - Ufimian Stage		
Leonardian Series			Hennessey Shale Garber Ss. Wellington Formation		Hennessey Shale Garber-Wellington Formation		Hennessey Shale Garber Ss. Wellington Formation	Kungurian Stage - - - - - - - - Artinskian Stage	Lower Permian Series	Lower Productus Limestone
Wolfcampian Series								Sakmarian Stage		Talchir Tillite - - - ? - - -

*Pollen-bearing shale of this report

(modified from Dunbar and others, 1960)

At the locality where the fossil spores and pollen were collected, the following section was measured by W. E. Ham, L. R. Wilson, and R. F. Hansen, Jr.

Formation	Description	Feet
Blaine Formation (lower part)	*Cedartop Gypsum Member*	
	Gypsum, grayish-white, medium-grained	9.7
	Jester Dolomite	
	Dolomite, laminated, light brownish-gray, fine-crystalline	0.5
	Shale, bluish-gray, slightly silty, blocky	1.7
	Shale, reddish-brown, blocky; cut by thin stringers of satin spar	16.0
	Haystack Gypsum Member	
	Gypsum, white, fine-grained	4.9
	Shale, greenish-gray at top and reddish-brown below	1.3
	Gypsum, white, fine- to medium-grained	11.2
Flowerpot Formation	Shale, greenish medium-gray, well-stratified	0.5
	Shale, greenish-gray; upper part interstratified with thin layers of dolomite; grades into dolomite along outcrop	1.6
	Shale, bluish-gray; conchoidal fracture	1.7
	Shale, reddish-brown, blocky; contains veins of selenite	5.4
	Shale, pale greenish-gray; conchoidal fracture	2.0
	Shale, reddish-brown; conchoidal fracture	1.5
	Gypsum, pinkish-gray, compact, fine-crystalline	0.2
	Shale, pale greenish-gray, gypsiferous	1.2
	Shale, predominantly reddish-brown	9.9
	Shale, pale greenish-gray	0.8
	Siltstone, shaly, gypsiferous; ledge-former	0.9
	Shale, bluish-gray; conchoidal fracture	1.7
	Dolomite, laminated, gray, fine-crystalline	1.7
	Shale, medium-gray, fissile	0.1
	Dolomite, gray, laminated; contains casts of hopper-shaped halite crystals	0.1
	Dolomite and gray shale, thinly interbedded	0.5
	Shale, medium-gray, fissile	0.3
	Dolomite, silty, light greenish-gray, laminated	0.7
	Shale, olive-gray, fissile. *Source bed of spores and pollen in this paper*	0.7
	Shale, pale bluish-green, blocky	1.0
	Shale, reddish-brown; mottled with green spots at top	1.0
	Siltstone, reddish-brown; slightly gypsiferous; prominent ledge-former	1.0
	Siltstone, reddish-brown; green at base	1.0
	Shale, blocky; conchoidal fracture; interbedded red and green layers	10.0

Section below covered by alluvium at level of Salt Fork.

In the measured section described above, the source bed of the spores and pollen is an olive-gray fissile shale which ranges from seven to twelve inches in thickness along the cliff. It weathers to a brownish gray and retains its stratified appearance, as shown in figure 2.

The Flowerpot Shale is a marine deposit as indicated by its lithology and by the presence of the marine or brackish-water hystrichosphaerid and scolecodont microfossils. No other invertebrate fossils have been collected from this formation. The great quantity of spores and pollen in the shale indicates that the ancient land mass was not far distant.

PREPARATION AND STUDY TECHNIQUE

The sample-digestion techniques employed in preparing the Flowerpot Shale samples were those commonly practiced by palynologists. Each sample was boiled in 52-percent hydrofluoric acid for five minutes, centrifuged, and washed with distilled water. It was then treated with hot, concentrated nitric acid and potassium chlorate until all reaction ceased. At this point the sample was placed in a glass beaker and lowered into the aqueous bath of an ultrasonic generator for several minutes. After this treatment the sample was washed repeatedly with distilled water and made slightly basic with ammonium hydroxide. The fossils are yellow to brown; consequently staining was unnecessary. Microscopic slides were made from a concentrated fossil preparation using both glycerine-jelly and Clearcol mounting media (Wilson, 1959b). The density of fossils on some slides is such that the numbers range from 10,000 to 20,000 specimens. One hundred and fifty microslide preparations were examined. The fossils have been studied with the Zeiss Photomicroscope, using 12.5x oculars and Neofluar 40/0.75, Neofluar 100/1.30 Oel, Ph 2 Neofluar 25/0.60, and Ph 3 Neofluar 100/1.30 Oel objectives. The photographs from which the illustrations of this publication were prepared were taken with the Leitz Ortholux microscope, using a 10x objective and 4 mm Apo A. 0.95 40:1 objective. Kodachrome A film was used to make the photomicrograph transparencies for the plates. Color photography often shows details of wall structure better than black and white photography; but, with the employment of several relatively new fine-grained films and the careful use of filters, equally satisfactory results can be attained.

DESCRIPTIVE PALYNOLOGY

The specimens described in this report are in the Oklahoma Palynological Collection maintained by the Oklahoma Geological Survey in Norman, Oklahoma.

The arrangement of the taxa follows the Sporae dispersae system proposed by Potonié and Kremp (1955, 1956). The taxa designations, anteturma, turma, subturma, and infraturma are used to indicate morphological relationships. These terms in the Sporae dispersae do not have the phylogenetic inference of a natural classification.

The abundance of the fossils is indicated in the text for each species by the number of specimens seen, by the percentage of 2,000 counted specimens, or by the following scale, which roughly indicates the number on each microscope slide.

Rare	0 - 2 individuals
Uncommon	3 - 5
Common	6 - 9
Abundant	10 - many

The preparation area on these slides is about 5.25 square centimeters and the average number of fossils on a slide is approximately 2,000. Nearly 70 percent of these fossils belong to the genus *Lueckisporites.*

Anteturma SPORITES H. Potonié 1893

Turma TRILETES (Reinsch 1881) emend. Potonié and Kremp 1954

Subturma Azonotriletes Luber 1935

Infraturma Laevigati (Bennie and Kidston 1886) emend. Potonié and Kremp 1954

Calamospora Schopf, Wilson, and Bentall 1944

GENOTYPE: *Calamospora hartungiana* Schopf 1944, *in* Schopf, Wilson, and Bentall (p. 51-52, fig. 1).

Calamospora cf. *C. breviradiata* Kosanke 1950

Plate I, figure 6

Specimens of *Calamospora* are well preserved but uncommon in the studied samples of Flowerpot Shale. At least two species are present, but only *C. breviradiata* is identified. This species has been reported by Kosanke (1950) as ranging from the upper part of the Tradewater Series to the La Salle coal bed in the upper portion of the McLeansboro Series in the Illinois Pennsylvanian System. In Oklahoma, Wilson and Hoffmeister (1956) have reported it from the Croweburg coal, which is approximately in the middle part of the Des Moines Supergroup of the Pennsylvanian System.

The stratigraphic range of *C. breviradiata,* from early in the Pennsylvanian to Middle Permian time, may be considered as being too long a life span for a plant species. For a natural species this might be true, but *C. breviradiata* and most other fossil spores and pollen grains are form species, defined on observable taxonomic characters, and consequently do not necessarily represent natural species. Most of the *Calamospora* spores observed in the Flowerpot Shale fit the definition of *C. breviradiata* so closely that it seems best to refer them to that species rather than to erect another.

Ilustration: Specimen OPC 1-1-19-1.

Calamospora sp.

Spores slightly smaller than previous species, 55 to 59 microns in diameter; spore wall laevigate, 1.5 microns thick, compression folds mostly peripheral; trilete rays 23 microns long, approximately twice as long as *C. breviradiata,* commissure weakly developed, straight, not marginate; proximal polar area not thickened as in *C. breviradiata.*

Five specimens were observed, none is illustrated.

Infraturma Muronati Potonié and Kremp 1954

Tririctus gen. nov.

GENOTYPE: *Tririctus reticulatus* sp. nov.

Spores trilete; subtriangular, oblate; known diameter 50 to 58 microns; commissure indistinct, extends to equator; lips ridge-like, opaque, broader than high, widest in polar area; membranous crest present over lips and attached on outer edges, generally split medianly to inner edge of equator wall, translucent; wall 1.5 to 3 microns thick on sides, 5 to 7 microns thick at angles; proximal surface reticulate, lumen diameter 1 to 4 microns; greatest near lips, murae 0.5 to 1 micron wide; distal surface coarsely granular, grana 0.5 to 1 micron in diameter.

Generic name is given in reference to the tripartite splitting of the membranous crest above the commissure lips.

Tririctus reticulatus sp. nov.

Plate I, figure 5

Diagnosis is same as for genus. Lips of commissure 3 to 10 microns wide, 21 to 30 microns long, approximately 3 microns high.

Holotype: Specimen OPC 1-2-3. Diameter 51 x 55 microns; lips 3 to 9.8 microns wide, 23 to 27 microns long; wall 1.5 to 2 microns thick on sides, 5 to 6 microns thick at angles.

Tririctus reticulatus is an uncommon spore in the studied Flowerpot Shale section. Affinity of the species is tentatively placed with the Selaginellaceae because of the trilete crest and similarity to some modern *Selaginella* species. The size would suggest that it is a microspore if that affinity is correct.

Turma ZONALES (Bennie and Kidston 1886 of Ibrahim 1933) emend. Potonié 1956

Subturma Zonotriletes (Waltz 1938) emend. Potonié and Klaus 1954

Infraturma Cingulati Potonié and Klaus 1954

Anguisporites Potonié and Klaus 1954

GENOTYPE: *Anguisporites anguinus* Potonié and Klaus 1954 (pl. 10, fig. 4).

Anguisporites intonsus sp. nov.

Plate I, figure 3

Spores radial, trilete; discoidal, diameter 48 to 55 microns; cingulum 2 to 4 microns wide; trilete rays 20 to 23 microns long, wavy, extend to cingulum, lips prominent, forming a sinuous ridge, 2 to 3 microns wide; ornamentation appears densely granular under low magnification, but, with high magnification, it is seen to be minutely vermiculate.

Holotype: Specimen OPC 1-2-4. Diameter 49.5 x 52.9 microns; cingulum 2.3 to 3.5 microns wide; rays 20 to 21 microns long.

This species is uncommon but more abundant than *Anguisporites contortus*. *A. intonsus* resembles the genotype but its ornamentation, like that of *A. contortus,* is vermiculate.

The specific name is in reference to the roughened nature of the exine.

Anguisporites contortus sp. nov.

Plate I, figure 4

Spores radial, trilete; discoidal, diameter 50 to 57 microns; cingulum 3 to 5 microns wide; trilete rays 20.7 to 23 microns long, wavy, extend to cingulum, lips prominent, forming sinuous ridges, 2 to 3 microns wide; wall thickenings low, wavy, and covered with minute vermiculate ornamentation.

Holotype: Specimen OPC 1-3-9. Diameter 55.2 microns; cingulum 3.5 to 4.6 microns wide; rays 20.7 to 23 microns long.

Rare in the examined portion of the Flowerpot Shale. It is distinguished from *Anguisporites anguinus,* the genotype, and from *A. intonsus* by the conspicuous contorted ornamentation that is the basis for the specific name.

Turma MONOLETES Ibrahim 1933
Subturma Azonomonoletes Luber 1935
Infraturma Psilamonoleti v. d. Hammen 1955

Lunulasporites gen. nov.

GENOTYPE: *Lunulasporites vulgaris* sp. nov.

Spores bilateral; monolete; proximal and distal views oval, side view crescentic; proximal surface concave, distal convex; known size range, length 40 to 60 microns, width 35 to 50 microns; suture straight, simple, restricted to concave proximal surface; wall translucent to transparent, 3.5 to 4 microns thick, laevigate, minutely granulate, or punctate.

Generic name refers to the crescent shape of the spore in side view.

The crescent shape of this spore makes it easily distinguished from *Laevigatosporites* with which it appears to be most closely related. The proximal surface is deeply concave in some specimens, and the equator appears as a slightly thickened rim. There is a superficial resemblance of *Lunulasporites* to *Aratrisporites* (Leschik 1955) emend. Klaus 1960, but the latter contains a central body.

Lunulasporites vulgaris sp. nov.
Plate I, figure 8

General diagnosis same as generic; specific dimensions: length 44 to 60 microns, width 35 to 50 microns; suture length 30 to 39 microns; wall laevigate, but may be minutely granular or punctate depending upon severity of the sample preparation.

Holotype: Specimen OPC 1-9-4. Length 55.2 microns, width 43.7 microns.

Although *Lunulasporites vulgaris* is an uncommon fossil in the Flowerpot Shale, it occurs also in the overlying Blaine Formation. Its distinctiveness should make it a useful Permian stratigraphic marker.

Laevigatosporites (Ibrahim 1933) emend.
Schopf, Wilson, and Bentall 1944

GENOTYPE: *Laevigatosporites vulgaris* (Ibrahim) Ibrahim 1933

Laevigatosporites ovalis ? Kosanke 1950

One species of *Laevigatosporites* has been observed in the

Flowerpot Shale, but it is too rare to make certain an identification with *L. ovalis*. The dimensions of the specimens have a slightly narrower range (50 to 55 microns long by 37 to 40 microns wide) than those given by Kosanke for *L. ovalis* (45 to 65 microns long); otherwise the spores are alike.

Typical specimen: OPC 1-2-10a. Not illustrated.

Anteturma POLLENITES R. Potonie 1931

Turma SACCITES Erdtman 1947

Subturma Monosaccites (Chitaley 1951) Potonié and Kremp 1954

Infraturma Triletesacciti Leschik 1955

Nuskoisporites Potonié and Klaus 1954

GENOTYPE: *Nuskoisporites dulhuntyi* Potonié and Klaus 1954

Nuskoisporites crenulatus sp. nov.

Plate I, figures 1, 2

Spores radial; trilete; monosaccate; oblately flattened, circular to slightly triangular in equatorial view; total diameter 90 to 100 microns; central body diameter 35 to 58 microns, wall 2 microns thick; saccus width 20 to 35 microns, overlap on central body 9 to 14 microns, contact edge deeply crenulate, teeth in many specimens paired and separated from adjacent pairs by shallow furrows; trilete simple, generally obscure, one-third diameter of central body; saccus finely reticulate; central body granular to reticulate.

Specimens of *Nuskoisporites crenulatus* are uncommon and many are distorted. The species is smaller than *N. dulhuntyi*, and the contact edge of the saccus and central body is deeply crenulate, which character is referred to by the specific name. Differs from *N. radiatus* Hennelly by the presence of a crenulate edge on the central body and by the smaller average size of this structure.

Holotype: Specimen OPC 1-1-3a. (pl. I, fig. 1). Total diameter 96.6 x 98.9 microns; central body 50.6 x 57.5 microns; overlap on central body 11.5 to 13.8 microns.

Infraturma Aletesacciti Leschik 1955

Potonieisporites Bhardwaj 1954

GENOTYPE: *Potonieisporites novicus* Bhardwaj 1954 (p. 520-521, fig. 10).

Potonieisporites simplex sp. nov.

Plate III, figures 1-3

Pollen round to oval; monolete; monosaccate, oblately flattened, subcircular to oval in equatorial view; total diameter 85 to 125 microns; central body subcircular to oval, diameter 55 to 72 microns, wall 2 to 3 microns thick, translucent; saccus attached at equator of central body, contact edge entire, width of saccus 20 to 32 microns, wall 1.5 to 2 microns thick, translucent; ornamentation of saccus and central body finely reticulate under oil immersion and phase optics; suture simple, length 28 to 64 microns, varies with maturity of spore.

Holotype: Specimen OPC 1-1-7 (pl. III, fig. 2). Dimensions, total length 122.1 microns, width 86.6 microns; central body length 70.9 microns, width 59.1 microns; specimen slightly distorted.

Specimens abundant and appear to be in several stages of maturity. Some fully expanded specimens may be immature because in these the germinal structure is weakly developed and obscure except under oil immersion optics. Such a specimen is illustrated by figure 1 on plate III. Most specimens possess taper-pointed folds across the central body. The orientation of the folds appears to be related to the maturity and development of the central body, as shown in figure 2 of plate III and by the torn specimen in figure 3 of the same plate. *Potonieisporites simplex* appears to be normally smaller than *P. novicus,* the genotype, and the lips of the commissura are not thickened. The ornamentation of the central body is finely reticulate rather than laevigate as suggested by Bhardwaj's drawing of *P. novicus.*

Hoffmeisterites gen. nov.

GENOTYPE: *Hoffmeisterites microdens* sp. nov.

Pollen monosaccate; bilateral; equatorial outline oval, oblately flattened; saccus approximately ¼ longer than wide, attached proximately at equator of tube cell and distally near the sulcus, saccus wider at long ends of grain than at sides, wall approximately 1 micron thick, surface rough, infrareticulate, coarser near attachment edge; tube cell oval in outline, sulcus indistinct, distal wall approximately 1 micron thick, proximal wall approximately 2.5 microns thick, punctate or reticulate, contact with saccus accentuated by a narrow wall thickening, compression folds and longitudinal medial fracture commonly present on proximal surface of tube cell.

The name *Hoffmeisterites* is given to this genus in honor of Dr. W. S. Hoffmeister who has contributed greatly to the development of palynology in the petroleum industry.

Hoffmeisterites slightly resembles *Sahnites* (Pant 1954) Pant 1955 and *Vestigisporites* Balmé and Hennelly 1955 but both of these are bisaccate, except in the latter which may be, in some specimens, monosaccate. The distal attachment of the saccus in *Hoffmeisterites* is below the equator, adjacent to the sulcus whereas the sacci of the other genera are attached in the equatorial region. Compression folds on the proximal surface of the tube cell of *Hoffmeisterites* are characteristic of the genus. These folds normally form a polygonal configuration on the proximal side which nearly outlines the area of the sulcus on the distal side. The folds may obscure the contact of the saccus and sulcus area when the grain is viewed on the proximal side. The longitudinal fracture commonly present in the proximal surface of the tube cell is irregular and appears to be related to compression rather than to a functional feature. Balmé and Hennelly (1955, p. 95) report "a short transverse slit or fold which recalls a monolete tetrad scar" in *Vestigisporites* but it is unlike that of *Hoffmeisterites*.

Hoffmeisterites microdens sp. nov.

Plate III, figure 4

General morphology same as generic description. Total length of grains 130 to 140 microns, width 80 to 92 microns; tube cell length 75 to 81 microns, width 65 to 72 microns, proximal margin of tube cell 1.5 to 2 microns wide, somewhat crenulate around ends and irregular on sides, exine punctate or minutely reticulate.

The specific name refers to the partial microcrenulate margin of the tube cell on its proximal side.

Holotype: Specimen OPC 1-1-15. Dimensions: total length 136.8 microns, width 86.4 microns; tube cell 79 microns long, 67.2 microns wide.

Species is uncommon.

Zonalasporites Ibrahim 1933

GENOTYPE: *Zonalasporites ulughbeki* Ibrahim 1933 (pl. 14, fig. 11; photograph in Potonié and Kremp 1956, II, pl. 18, fig. 410, not from original preparation).

Zonalasporites punctatus sp. nov.

Plate I, figure 9

Radial; alete; spherical to subspherical; diameter 50 to 54 microns; outer wall translucent, crowded convolute folds, 8 to 10 microns high, 1 to 6 microns wide, uniformly punctate, punctae about

1 micron in diameter; inner wall or body obscured by convolutae, slightly less translucent.

The specific name refers to the punctate nature of the convolute folds.

Holotype: Specimen OPC 1-3-5. Diameter 53.1 microns, convolute folds 8 to 10 microns high, 1 to 6 microns wide.

This fossil is rare in the Flowerpot Shale. The genotype was described from the Grenze Westphalian B/C of Germany but no fossils of the genus have been reported from the Pennsylvanian rocks of North America. It is possible that this particular Flowerpot Shale fossil is a conifer with a pollen grain similar to that of *Tsuga* although the convolute outer wall structure of the latter appears more finely constructed. The placement of the fossil in *Zonalasporites* is based upon its convolute non-aperturate structure, but when better understood may more appropriately be recognized as a distinct generic taxon or it may possibly be assigned to *Tsugaepollenites* Potonié and Venitz 1934.

Subturma Disaccites Cookson 1947

Infraturma Striatiti Pant 1954

Lueckisporites (Potonié and Klaus 1954) emend. Potonié 1958

1954 Potonié and Klaus, p. 531, pl. 10, fig. 3.

1958 Potonié, p. 50, pl. 6, figs. 54, 55.

GENOTYPE: *Lueckisporites virkkiae* Potonié and Klaus 1954.

Lueckisporites virkkiae Potonié and Klaus 1954

Plate II, figure 8

The Flowerpot Shale specimens resemble *Lueckisporites virkkiae* of Potonié and Klaus but are slightly larger. The length of the European specimens is given as 35 to 90 microns; specimens from the Flowerpot Shale are 49 to 118 microns long and average 67 microns. The extreme length may be the result of distortion and probably is not significant. Other average measurements for the Flowerpot Shale *Lueckisporites* are as follows: tube cell length 43 microns, width 40 microns; saccus length 12 microns, width 61 microns. The two sections of the proximal surface possess punctae that are about one micron in diameter and are spaced approximately that distance apart. Under phase-contrast oil immersion, the punctae appear to extend vertically through most of the irregularly undulating cap. The sacci are mostly laevigate on the exterior with bright-field oil-immersion optics, but under phase-contrast oil-immersion optics possess scattered punctae. Internally the saccus walls are rough but without a regular pattern.

Illustration: Specimen OPC 1-3-2.

L. virkkiae is the most abundant fossil in the Flowerpot Shale. In a count of 2,000 fossils it was represented by 1,362 specimens, or 68.10 percent of the assemblage. Similar high percentages have been reported by Grebe (1957) from the Zechstein of Germany, where the species constitutes as much as 90 percent of the assemblages.

Strotersporites gen. nov.

GENOTYPE: *Strotersporites communis* sp. nov. (pl. II, fig. 1).

Pollen bilateral; bisaccate; nearly oval in proximal and distal views, oblate; tube cell 0.6 to 0.9 longer than the sacci; tube cell ovoid, proximal side with 10 to 14 long-axial ribs, separated by striae, some tapering to a point before reaching equator, others dentate at termini, irregularly pitted, a more pronounced stria or a rupture is apparent between the medial ribs of many specimens; equator without rim; distal wall thinner than proximal wall, laevigate or granular; sulcus obscure; sacci reniform flattened, 0.7 to 0.9 wider than tube cell, slightly directed distally, proximal attachment at equator, distal overlap slightly more than one-third of the tube cell, infrareticulate, radial lineation.

The name *Strotersporites* is in reference to a resemblance of the ribs to crossbeams on the proximal tube-cell surface.

The tube cell of *Strotersporites* is slightly longer than the sacci but the sacci are wider than the tube cell, and in the latter respect the genus differs from *Striatites* Pant 1955. *Strotersporites* resembles *Striatopodocarpites (al. Taeniaesporites) antiquus* (Leschik 1956) Potonié 1958, but in the illustration the latter appears to have a marginal thickening on or near the tube-cell equator. *Lueckisporites richteri* Klaus 1955 probably should be assigned to *Strotersporites* for the relative sizes of the sacci and tube cell appear to be equivalent to *Strotersporites*.

Criteria followed here for separating genera of bisaccate pollen grains are: the relative shape and size of the tube cell and sacci, the manner of insertion of the sacci on the tube cell, the structure of the tube cell, and the type of proximal and distal ornamentation.

Strotersporites communis sp. nov.
Plate II, figures 1-3

Pollen bilateral, bisaccate; oval in proximal and distal views; total length 120 to 185 microns; sacci reniform, wider than tube cell, tilted distally, slightly flattened, length 48 to 70 microns, width 80 to 90 microns, infrareticulate; tube cell ovoid, length 65 to 80 microns, width 68 to 80 microns, height 65 to 80 microns, proximal surface ornamented with 10 to 14 flat ridges, some tapered to a point, 3 to 14 microns wide, often bidentate at termini, finely pitted; distal surface without ridges, thinner wall minutely granular, sulcus obscure.

The specific name is in reference to the common occurrence of the fossil in the Flowerpot Shale.

Holotype: Specimen OPC 1-6-1. Dimensions: total length 157.6 microns, tube cell length 72.8 microns, width 74.8 microns; sacci length 65 microns, width 82.7 microns.

This species is abundant and variable; most specimens are oriented in equatorial view, indicating the flattened nature of the sacci. *Strotersporites communis* superficially resembles *Protodiploxypinus giganteus* Samoilovich 1953 but the latter has a tube cell that is essentially the same width as the sacci. In Samoilovich's illustrations (pl. IV, fig. 3 and pl. V, fig. 1) the proximal ridges of *P. giganteus* appear to be mostly continuous across the entire surface, whereas those of *S. communis* in many cases taper to a point near the equator. The ridge termini of *P. giganteus* are without the dentate margins present in *S. communis.*

Further studies of this highly variable Flowerpot Shale species may show that more than one species of *Strotersporites* is present in the assemblage.

Rhizomaspora gen. nov.

GENOTYPE: *Rhizomaspora radiata* sp. nov. (pl. II, fig. 7).

Pollen bilateral; bisaccate; oblate; tube cell circular or slightly oval in proximal or distal view, approximately two-thirds the size of one saccus, wall thick, 2.5 to 3 microns, proximal surface ornamented with radiating or diverging ribs which are smooth or minutely pitted; distal wall thinner, sulcus narrow, often obscure; sacci reniform, proximal attachment on equator, distal attachment deeply inserted upon tube cell, unattached parts often adjacent or overlapping on free edges, infrareticulate, slightly radial lineation from saccus attachment.

The name *Rhizomaspora* refers to the root-like mass of ribs radiating from the proximal polar area of the tube cell.

This genus resembles *Platysaccus* in proximal or distal profile, but the latter lacks the radiating root-like ornamentation on the proximal surface of the tube cell. Balmé and Hennelly (1955, pl. I, figs. 6-10) illustrated a pollen form as *Lueckisporites fusus* which would not belong in *Lueckisporites* as emended but in *Rhizomaspora.*

Present known size range 80 to 170 microns long, 50 to 120 microns wide.

Rhizomaspora radiata sp. nov.
Plate II, figure 7

General morphology as described for the genus; 140 to 170 microns long, 108 to 120 microns wide; tube cell circular to slightly oval, 80 to 85 microns long, 61 to 68 microns wide, proximal wall thick, darker color than sacci, surface in polar area with crowded subparallel ribs which irregularly radiate toward equator, variable width and structure; sacci broadly reniform, touching or overlapping on free edges, 70 to 82 microns long, 108 to 120 microns wide, wall 1.5 to 2 microns thick, irregular, infrareticulate, slightly oriented radially from tube cell.

Specific name refers to the radiating nature of the proximal surface ornamentation.

Holotype: Specimen OPC 1-11-7. Total dimensions, 157.6 by 118.2 microns, tube cell 84.7 by 63.4 microns, sacci 78.8 by 118.2 microns.

Rhizomaspora radiata is the most common of the three species described here and constitutes about one percent of the fossil assemblage.

Rhizomaspora divaricata sp. nov.
Plate II, figure 6

Pollen, 76 to 95 microns long, 57 to 64 microns wide, with comparatively large, 35 to 46 by 57 to 64 microns, oblately flattened reniform sacci, attachment on distal side not adjacent and edges normally not touching or overlapping each other, thin walled, wall 1.5 microns thick, infrareticulate; tube cell circular in proximal or distal view, diameter 20 to 34 microns, proximal surface heavily ribbed, subparallel in polar area, radiating irregularly toward equatorial contact, minutely pitted; distal surface thinner, sulcus obscure.

The specific name is given in reference to the wing-like spread of the sacci.

Holotype: Specimen OPC 1-2-16. Dimensions, 89 by 59 microns, tube cell 29 by 29 microns, sacci 39 by 59 microns.

Specimens of *Rhizomaspora divaricata* are uncommon. The species is distinctive when encountered in the assemblage and, except for its thick, ornamented proximal tube-cell surface, it might easily be mistaken for *Platysaccus papilionis*.

Rhizomaspora lemniscata sp. nov.

Plate II, figure 5

Pollen 118 to 140 microns long, 70 to 90 microns wide; sacci reniform, 51 to 64 microns long, 70 to 90 microns wide, infrareticulate, lineated radially; tube cell 42 to 59 microns, slightly oval in proximal or distal view, proximal surface subparallel ribbed in polar area, diverging and tapered toward sacci, some extending completely across proximal surface, 4 to 5 microns wide, irregularly pitted.

The specific name refers to the ribbon-like ornamentation on part of the proximal surface of the tube cell.

Holotype: Specimen OPC 1-12-1. Dimensions, 126.5 by 82.5 microns, tube cell 48.3 by 52.9 microns, sacci 59.8 by 82.8 microns.

Rhizomaspora lemniscata is common in the Flowerpot Shale assemblage and is readily distinguished from the other species of *Rhizomaspora* by the more regular and less radiating ribs of the proximal surface.

Fastigatisporites Leschik 1956

GENOTYPE: *Fastigatisporites cruciatus* Leschik 1956 (p. 135, pl. 22, fig. 5).

Fastigatisporites physema sp. nov.

Plate II, figure 4

Total dimensions, 126 to 162 microns long, 78 to 104 microns high in side view; tube cell subspherical, 75 to 91 microns long by 70 to 84 microns high (polar axis), transverse width across equator not determinable because of normal orientation of grains on slide; wall of proximal surface thicker than that of distal, ornamented with ridges circumscribed by narrow furrows originating at sacci roots, extending across proximal surface diverging toward equator, forming crisscross pattern of striae and interrupted ridges, width of ridges 7 to 10 microns, irregularly pitted; distal surface granular; sulcus lineation not apparent; sacci bulbous, few folded, 65 to 74 microns diameter, steeply inclined distally, proximal attachment on equator, each saccus encompassing nearly one-half of equator, free portions of sacci overlapping each other, distal attachment obscure but inserted over approximately one-third of the area of tube cell, wall 2 to 2.5 microns thick, coarsely infrareticulate, surface rough on many specimens.

Specific name refers to the bubble-like shape of the sacci.

Holotype: Specimen OPC 1-10-8. Dimensions, total length 133.9 microns, width 98.5 microns, tube cell 84.7 by 72.89 microns, sacci 70.9 by 65 microns.

The sacci of *Fastigatisporites physema* appear to be considerably more bulbous, the crisscross ridges of the tube cell wider and less numerous than illustrated for the genotype. The dimensions of *F. physema* are almost twice those of *F. cruciatus*.

The new species is a common member of the assemblage.

Mucrosaccus gen. nov.

GENOTYPE: *Mucrosaccus alatus* sp. nov. (pl. II, fig. 10).

Pollen bilateral; bisaccate; tube cell circular oblate, proximal surface with 4 to 6 concentrically arranged crests that are aligned with the long axis of the grain, crests undulate, minute linear pitted, thickness of tube-cell wall obscured by crests; sulcus indefinite, narrowly confined between deeply inserted sacci, thin walled, about 1.5 microns thick; sacci wider than tube cell, subtriangular in proximal-distal view, oblate and tapering to point in side view, slightly oriented distally, proximal insertion on tube cell equator, distal insertion irregular, extends nearly to center of tube cell, outer edges often adjacent; wall about 1 micron thick, infrareticulation weakly developed, outer surface smooth to rough. Presently known size range: total length 84 to 98 microns, width 58 to 65 microns.

The name *Mucrosaccus* is in reference to the pointed nature of the sacci.

Mucrosaccus alatus sp. nov.

Plate II, figure 10

Description as for the genus; total dimensions, length 84 to 98 microns, width 58 to 65 microns; tube-cell length 42 to 52 microns, width 40 to 48 microns; height of tube-cell crests 4 to 8 microns; saccus length 42 to 49 microns, width 58 to 65 microns.

The specific name is given in reference to the wing-like appearance of the sacci.

Holotype: Specimen OPC 1-2-8. Total dimensions, 63.2 by 93.6 microns; tube cell length 46.8 microns, width 42.3 microns; saccus length 46.8 microns, width 60.9 microns.

Mucrosaccus alatus is a rare element in the materials studied. Not more than one dozen specimens have been seen, but because the species is markedly distinct, it may be a valuable stratigraphic fossil. Several specimens appear to have a single distal compression fold on each saccus, extending from its pointed outer edge to the place of insertion on the tube cell. This is shown on the holotype illustration. In the center of the tube-cell cap of many specimens there is a short, crescent-shaped crack, or cleft, that parallels the crests and that in few cases extends beyond the center third of the tube cell's linear diameter.

The morphological affinity of *Mucrosaccus* appears to be closest to *Rhizomaspora* and the genus may be related to the Podocarpaceae.

Hamiapollenites gen. nov.

GENOTYPE: *Hamiapollenites saccatus* sp. nov. (pl. III, fig. 7).

Pollen bilateral; bisaccate; tube cell circular in equatorial view, slightly oblate, wall 2 to 3 microns thick; proximal surface with 8 to 12 ribs oriented in long axial direction, slightly tapered toward ends, one or two may taper to point near center of proximal face, 5 to 8 microns wide near center, 2 to 3 microns high, smooth or minutely punctate under oil-immersion optics; distal surface with 6 to 10 ribs oriented at right angles to the proximal, slightly tapered at ends, 5 to 8 microns wide near center of distal face, smooth or minutely punctate under oil immersion; germinal apparatus and distal sulcus in many cases obscure; sacci slightly reniform and flattened, not as wide as tube cell, extended in same plane as equator or slightly oriented distally, attachment restricted to proximity of equator, not overlapping onto the tube cell, wall irregularly ornamented on outside, translucent and internal structure obscure. Known size range: total length 47 to 75 microns, width 30 to 48 microns.

This spore genus was named in honor of Dr. William E. Ham, who discovered the Flowerpot Shale section used in this study and who has contributed much to the understanding of the Permian geology of Oklahoma.

Hamiapollenites saccatus sp. nov.

Plate III, figure 7

Description as for genus; total dimensions, length 47 to 75 microns, width 30 to 48 microns; tube-cell length 31 to 47 microns, width 30 to 36 microns; sacci 8 to 24 microns long, 25 to 30 microns wide.

Holotype: Specimen OPC 1-3-12 (OGS F 1-3-12). Total dimensions, 43.7 by 71.3 microns, tube cell 34.5 by 43.7 microns, sacci 18.4 by 27.6 microns.

Hamiapollenites saccatus is an uncommon fossil in the Flowerpot Shale, and most of the specimens are distorted.

Another species of *Hamiapollenites* has been observed in greater abundance by the writer in the Red Cave formation of Texas, and Schaffer (1961, pl. 4, figs. 1-3) has illustrated a still different species from the Wellington Formation of Kansas (table 1). Both of these formations are somewhat older than the Flowerpot Shale. Hart (1960, pl. 1, figs. 3, 4) illustrated two fossils that belong to this genus from the Lower Permian of Tanganyika.

When *H. saccatus* was first studied in 1958 (Wilson, 1959a) it was thought to be related to the Gnetales because of the ribbed nature of the proximal and distal faces and apparent relationship with *Vittatina* which was assigned by Samoilovich to the Welwitschiaceae type of pollen. Subsequent observations tend to cast doubt on the gnetalean affinity because the germinal structure of *Hamiapollenites* and the probable, though obscure, germinal structure of *Vittatina* are associated with the distal side of the grain and are oriented transversely instead of parallel to the long axis. If the direction of the germinal aperture is an indicator of phylogenetic affinity, *Hamiapollenites* and *Vittatina* are more closely allied to the Coniferales than to the Gnetales.

Vittatina (Luber 1940) ex Samoilovich 1953, emended Wilson

GENOTYPE: *Vittatina subsaccata* Samoilovich, 1953 (p. 44 pl. IX, fig. 4a), here designated.

Pollen bilateral; roundly fusiform when inflated; normally slightly flattened in plane of equator; equator oriented with long dimension of grain; proximal surface with 7 to 18 raised, rounded to flat ribs, parallel to equator, converging at ends, some dichotomously divided or tapered; distal surface with 3 (?) to 10 ribs appears oriented at right angles to equator, not completely converging, some divided or tapered; equator rim-like, similar to proximal surface ribs; terminae of long axis entire and often slightly depressed, sometimes oriented toward proximal surface; germinal structure on distal side appears to be between central ribs, obscure; ornamentation of ribs ranges from smooth to minutely punctate, granular, verrucose, or reticulate.

Compressed specimens may possess folds across the widest part of the grain and one or more folds at the tapered ends. Others appear to have the ends protruding asymmetrically, simulating small sacci; but similar forms observed in Oklahoma cannot be considered as having true sacci. Samoilovich (1953, p. 44) used a term that may be translated "incipient air sacks?" for the structures at the linear ends of the grains of *Vittatina subsaccata*. The illustration of the holotype (Samoilovich, 1953, pl. IX, fig. 4a) does not show structures that can be unequivocally termed sacci. Because of the great variability in pollen grains of the *Vittatina* type, it is proposed that the genus be restricted to those forms without sacci.

In this study the genus is transferred to the infraturma Striatiti because the germinal structure is oriented similar to other species assigned there. It may later prove desirable to establish a separate infraturma for forms like *Vittatina.*

Vittatina lata sp. nov.
Plate III, figure 11

Pollen bilateral; broadly oval in equatorial view, many specimens slightly flattened in plane of equator; length 50 to 70 microns, width 40 to 52 microns; proximal surface with 6 to 10 longitudinal ribs, converging at ends, few terminating near center of face, flat, 6 to 11.5 microns wide, 2 to 3 microns high near center of proximal face, punctate under oil immersion, punctae approximately 0.5 micron in diameter; distal surface with 9 to 10 transverse ribs converging, broad, flat, 6 to 10 microns wide, 2 to 3 microns high, occasionally tapering to point near center of distal face, punctate under oil immersion, punctae approximately 0.5 micron in diameter; compressed specimens may have folds near ends of long axis; germinal slit, apparent in some specimens, located centrally and appears as a simple cleft extending transversely across distal face.

The specific name refers to the broad, flat appearance of most specimens.

Holotype: Specimen OPC 1-2-15a. Dimensions, 55 microns long, 43.3 microns wide.

Vittatina lata is an abundant species and is readily distinguished from *V. costabilis* by the wider and fewer ribs, and by the general absence of bifurcated proximal ribs.

Vittatina costabilis sp. nov.
Plate III, figure 12

Pollen bilateral; broadly oval in equatorial view, slightly flattened in plane of equator; length 40 to 66 microns, width 30 to 52 microns; proximal surface with 12 to 20 longitudinal ribs, converging or tapering toward ends, some terminating near center of proximal face, round-topped, 2 to 4 microns wide, 2 to 3 microns high; convergence point of proximal surface ribs in many cases slightly depressed, punctate under oil immersion, punctae about 1 micron in diameter; distal surface with 3 to 7 transverse ribs, except for the central rib, most are obscure, 5 to 8 microns wide, 2 to 3 microns high, tapering toward equatorial rim, darker color than others, punctate under oil immersion, punctae about 0.5 micron in diameter; compression folds may occur near convergence area of proximal ribs.

The specific name is given with reference to the rib-like ornamentation of the exine.

Holotype: Specimen OPC 1-3-4. Dimensions, 64.5 microns long, 50.6 microns wide.

Vittatina costabilis is a common species but not as abundant as *V. lata.*

Vittatina sp.
Plate III, figure 10

Pollen bilateral; fusiform in side view, presumably oval in equatorial view; length 62.0 microns, width 28.3 microns; proximal side slightly larger than distal side, 12 or more longitudinal ribs converging at ends, some terminating with tapered points near center of face, raised and rounded tops in cross section 3 to 5 microns wide, 2 to 3 microns high in polar area, surface appears finely punctate under bright-field oil immersion, under phase-contrast oil immersion the walls are distinctly infrategillate-baculate; equator a somewhat sigmoidal rib similar in structure to proximal ribs, straight on proximal side, irregular on distal: distal surface with 8 or 9 ribs which are oriented perpendicular to equator, center rib widest, 13.8 microns wide, 2 to 3 microns high, all raised, tops rounded, ends tapered at contract with equator, wall structure as on proximal ribs.

Specimen: OPC 1-2-7 (F 1-2-7).

A single specimen of this type was observed and, although it is distinctive, it is not given a name. In an earlier note and illustration (Wilson, 1959a, pl. 1, fig. 11), this specimen was referred to *Ephedripites* Bolchovitina and compared with modern *Ephedra.* The transverse orientation of the distal ribs and the probable transverse direction of a germinal structure would tend to remove it from ephedran affinity and relate it more closely with *Hamiapollenites* and probably with the Coniferales. Other species of *Vittatina* occur in the Flowerpot Shale and will be described in another study.

Infraturma Pinosacciti (Erdtman 1947) emend. Potonié 1958

Alisporites (Daugherty 1941) emend. Potonié and Kremp 1956

GENOTYPE: *Alisporites opii* Daugherty 1941 (p. 98, pl. 34, fig. 2).

Pollen bisaccate, bilateral; equatorial outline oval; oblately flattened; tube cell and sacci essentially the same width; germinal furrow distal, not distinct; tube cell oval to nearly circular, wider than long, wall uniformly thick, approximately 2 microns, translucent, one-third to one-half free of overlapping sacci; ornamentation minute; sacci reniform, not inclined, approximately equal in size to the tube cell and overlapping on it by approximately one-half of their length, contact with tube cell distinct, compressed specimens commonly possess folds in overlapping area; infrareticulate ornamentation; dimensions: 100 to 200 microns long, 60 to 80 microns wide; tube cell 50 to 75 microns long, 60 to 65 microns wide.

Fossil bisaccate pollen are among the most difficult grains to differentiate satisfactorily into genera and species. This is especially true with those species found in Late Paleozoic and Early Mesozoic rocks. During that time the group appears to have evolved and differentiated along several lines. Early palynologists tended to lump many of these types into a few genera but more recently they have attempted greater differentiation. A resolution of these problems will require exhaustive studies. In the case of *Alisporites,* it is clear from the several illustrations published by Daugherty (1941) that his concept of the genus *Alisporites* was exceedingly inclusive. His definition could conceivably include most of the described saccate conifer pollen. The emendation was made to restrict the genus to those bisaccate fossil pollen without differential inclination of the sacci, with unthickened proximal tube-cell wall, and with a tube cell deeply inserted into the sacci. The holotype illustration of *A. opii* (Daugherty, 1941, fig. 2) shows these characters. Specimens in the Flowerpot Shale, which structurally resemble the illustrated type, indicate that these characters are constant and are worthy of recognition. Other specimens cited and illustrated by Daugherty (1941) as species of *Alisporites* should be assigned elsewhere, but that is not undertaken in this study.

Although *Alisporites* was described from Upper Triassic rocks of Arizona, pollen of this genus and other genera are abundant in the Flowerpot Shale, suggesting that during the Permian and Triassic Periods these floras had several spore and pollen elements in common and that the paleoecologic conditions were probably quite similar.

Alisporites aequus sp. nov.

Plate III, figures 5, 6

Pollen bilateral; bisaccate; equatorial outline oval; 98 to 154 microns long, 60 to 78 microns wide; tube cell oval to nearly circular in proximal or distal view, 50 to 62 microns long, 60 to 75 microns wide, 2 microns thick, flattened in polar axial dimension, sulcus 1 micron in diameter, obscure, approximately one-third of tube cell free of sacci; cap punctate forming wavy reticulate pattern; sacci reniform, not inclined, 30 to 50 microns long, 60 to 75 microns wide, about 1 micron thick, same width as tube cell, and overlapping the tube cell by approximately one-half length of the sacci; compression folds present in overlap area of many specimens, infrareticulate.

The specific name is in reference to the symmetry possessed by the fossil grains.

Holotype: Specimen OPC 1-1-6 (pl. III, fig. 5). Dimensions, total length 104 microns, width 65 microns, tube-cell length 59.1 microns, width 65 microns.

Alisporites aequus is common in the section studied. It differs from the genotype in having a proportionally greater distance between the sacci on the equator.

Infraturma Podocarpoiditi Potonié, Thomson, and Thiergart 1950

Platysaccus (Naumova 1937) ex Potonié and Klaus 1954

GENOTYPE: *Platysaccus papilionis* Potonié and Klaus, 1954 (p. 540-541, pl. 10, fig. 12).

Platysaccus papilionis Potonié and Klaus 1954

Two specimens have been observed in the Flowerpot Shale that compare closely with the description of *P. papilionis* Potonié and Klaus 1954.

The dimensions of these specimens are 98.5 by 39.4 microns (OPC 1-8-9), and 128 by 90.6 microns (OPC 1-8-8). Not illustrated.

Subturma Polysaccites Cookson 1947

Trochosporites gen. nov.

GENOTYPE: *Trochosporites reniformis* sp. nov. (pl. II, fig. 9).

Pollen trisaccate; tube cell oblate, circular to subangular in proximal or distal views, uniform membranous marginal zone on equator 2 to 6 microns wide; proximal side of tube cell thicker than distal, coarsely punctate, edge slightly crenulate appearing as a continuous ring central to marginal zone; distal side smooth, overlapped by sacci, each one-fourth of tube-cell diameter, no germinal apparatus visible; sacci separate or slightly overlapping, reniform, inserted at equator and part of distal surface of tube cell, horizontally disposed, subexineous reticulation present, outer surface nearly smooth.

The name *Trochosporites* is in reference to the wheel-like radial character of the pollen.

Trochosporites is closely related to *Crustaesporites,* but differs by the presence of a distinct marginal zone on the equator and by the absence of parallel ridges across the proximal surface of the tube cell. The shape of the *Trochosporites* tube cell is more nearly circular and the thickened edge of the proximal surface wall forms a nearly uniform ring rather than sickle- or crescent-shaped thickenings across the base of the sacci. In the description of *C. globosus,* Leschik (1956, p. 130) stated that one of the three sacci is free and the other two are joined at their bases by an 8-micron-wide border.

Trochosporites is an uncommon element in the Flowerpot Shale.

The botanical affinity of *Trochosporites* is uncertain, but the genus may belong to the Podocarpaceae if the somewhat similar morphology of the pollen is a valid criterion.

Trochosporites reniformis sp. nov.

Plate II, figure 9

Description as for the genus; total dimensions 45 to 84 microns; tube cell 30 to 49 microns; length of sacci 21 to 29 microns, width 38 to 51 microns; marginal zone on equator 2 to 6 microns wide, finely striated radially.

The specific name is in reference to the kidney-shaped sacci.

Holotype: Specimen OPC 1-1-19-2. Total dimensions: 52.2 by 69 microns; tube cell 34.5 by 36.8 microns; marginal zone 5.7 microns wide; sacci length 23 to 27.5 microns, width 39 to 49.2 microns. The holotype has an irregular rupture on the proximal surface of the tube cell. This feature does not occur on other specimens examined.

Crustaesporites Leschik 1956

GENOTYPE: *Crustaesporites globosus* Leschik 1956 (p. 130, pl. 21, fig. 2).

Crustaesporites globosus ? Leschik 1956

Only four specimens that can be assigned to *Crustaesporites* have been observed in the Flowerpot Shale and, except for the fact that the sacci are separate, these specimens might be designated as *C. globosus* Leschik.

Typical specimen: OPC 1-3-8. Not illustrated.

Turma ALETES Ibrahim 1933
Subturma Azonoletes (Luber 1935) Potonié and Kremp 1954
Clavatasporites gen. nov.

GENOTYPE: *Clavatasporites irregularis* sp. nov. (pl. I, fig. 7).

Spores radial; alete; subspherical, most specimens distorted; wall about 2 microns thick, densely clavate to baculate, presently known size range 54 to 90 microns.

The name *Clavatasporites* is in reference to the clavate type of ornamentation and absence of a visible germinal structure.

Clavatasporites irregularis sp. nov.
Plate I, figure 7

Morphological description same as for the genus; dimensions 54 to 90 microns, shape extremely irregular, wall ornament clavate or baculate, 4 to 6 microns long, 3 to 4 microns in diameter.

The specific name refers to the wide range of shapes in which the fossil is found.

Holotype: Specimen OPC 1-1-8. Dimensions, 84.7 by 65 microns.

Clavatasporites irregularis is an uncommon fossil in the studied section of the Flowerpot Shale and consequently its morphology is not well understood. The distorted shapes in which the specimens are found and the irregularly ruptured walls suggest that the spore does not possess a definite germinal structure. No natural affinity is known.

Turma PLICATES (=PLICATA Naumova 1937, 1939) emend. Potonié 1960
Subturma Praecolpates Potonié and Kremp 1954
Schopfipollenites Potonié and Kremp 1954

GENOTYPE: *Schopfipollenties ellipsoides* (Ibrahim) Potonié and Kremp 1954 (p. 180).

1932 *Sporonites ellipsoides* Ibrahim *in* Potonié, Ibrahim, and Loose, p. 449, pl. 17, fig. 29.

1933 *Laevigato-sporites ellipsoides* Ibrahim, p. 40, pl. 4, fig. 29.

1934 *Punctato-sporites ellipsoides* (Ibrahim) Loose, p. 158, pl. 7, fig. 35.

1934 *Sporites ellipsoides* (Ibrahim) Wicher, p. 185 (non 1934 [*Calamiti?*] *Sporites laevigatus* [Ibrahim] Wicher, p. 172).

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

1946 *Monoletes ellipsoides* (Ibrahim) Dijkstra, p. 62.

Schopfipollenites signatus sp. nov.
Plate I, figure 10

Bilateral; oval in outline; length 150 to 220 microns, width 95 to 150 microns; monolete suture, simple, approximately two-thirds length of body, somewhat sigmoid in direction, two distal folds distinct, nearly parallel except at ends; equatorial border 5 to 10 microns at ends, 15 to 18 microns on sides; ornamentation coarsely punctate, punctae diameter about 1.5 microns.

The specific name is in reference to the sigmoid shape of the suture.

Holotype: Specimen OPC 1-1-9. Dimensions, length 206.8 microns, width 137.8 microns.

Schopfipollenites signatus is an uncommon fossil in the section studied. The use of an ultrasonic generator in disaggregating the clay samples apparently is one reason for the scarcity of *Schopfipollenites* on the slides. Many fragments of this fossil are found in some slide preparations. The species *S. signatus* differs from *S. ellipsoides* in its much smaller size and in the marked punctate ornamentation.

Turma POLYPLICATES Erdtman 1952
Ephedripites Bolchovitina 1953
GENOTYPE: *Ephedripites mediolobatus* Bolchovitina 1953
(p. 60, pl. 9, fig. 15; pl. 11, fig. 120).

Ephedripites corrugatus sp. nov.
Plate III, figure 9

Pollen bilateral, fusiform, polycolpate?, one germinal furrow generally distinct, extends to polar region, generally open, five ridges commonly visible in one surface view, pointed at terminae and distinct from polar thickening, 2 to 3 microns wide; wall 1.5 to 2 microns thick, laevigate or minutely punctate under oil-immersion phase optics; length 34 to 52 microns, equatorial diameter 25 to 37 microns.

Specific name refers to the wrinkled nature of the exine.

Holotype: Specimen OPC 1-3-7. Dimensions, length 49.2 microns, equatorial diameter 27.5 microns.

In a preliminary study of the gnetalean fossils of the Flowerpot Shale (Wilson, 1959a) this species was tentatively referred to *Welwitschia* because of an apparent single colpus. There is some doubt as to there being but a single colpus and for that reason it is assigned to *Ephedripites*. This genus is considered a better place of assignment than *Gnetaceaepollenites* for the specimens do not show striations in the furrows. Measurements of the holotype were retaken with the Zeiss Photomicroscope and are approximately 1 micron larger than those given in the paper cited above.

Pollen grains of this and other undescribed species are common in the Flowerpot Shale. They present a major study before a complete understanding is possible. One of the undescribed species is shown in figure 8 on plate III. This specimen has been lost; consequently its description is not included.

DISCUSSION

The fossil spore and pollen assemblage of the studied section of the Flowerpot Shale consists of 27 reported species and of nearly as many more species that require further study. Most of this flora consists of saccate pollen forms and they also comprise the greatest number of individual grains. The most abundant of these belong to the species *Lueckisporites virkkiae* Potonié and Klaus.

To determine the relative abundance of the species, an assemblage count of two thousand specimens was made. This showed the following percentages for the various genera:

Lueckisporites — — —	68.10	*Fastigatisporites* — —	0.30
Strotersporites — —	15.91	*Rhizomaspora* — — —	0.23
Vittatina — — — —	2.52	*Nuskoisporites* — —	0.14
Potonieisporites — —	1.93	*Trochosporites* — — —	0.12
Alisporites — — — —	1.47	*Lunulasporites* — —	0.11
Calamospora — — —	0.75	*Clavatasporites* — —	0.10
Ephedripites — — —	0.36	*Platysaccus* — — — —	0.01

Unidentified — — — — 7.97

In the assemblage count, only sixteen of the 27 recognized species were observed. This may be explained by the great abundance of *Lueckisporites* which masks all others in the relative percentage study. It should be emphasized that there is no way of determining the exact vegetational cover of an area by the number of pollen grains in sediments, for different plants produce different amounts of spores or pollen, and these are not uniformly dispersed or preserved. However, from the great relative abundance of *Lueckisporites,* it would seem reasonable to assume that its parent plant species was an important member of the Flowerpot Shale flora and also that this plant must have grown not far from the place of sediment deposition. *Lueckisporites, Strotersporites, Alisporites, Fastigatisporites, Rhizomaspora, Platysaccus, Mucrosaccus, Trocho-*

sporites, Crustaesporites, and *Hamiapollenites* all possess sacci like or similar to those of many of the modern conifer pollen species, and therefore it can be assumed that the Flowerpot flora contained an important if not dominant conifer element. The sediments in the Flowerpot Formation suggest by their red color and their selenite and salt content that they were deposited under warm arid or semi-arid conditions. The abundance of conifer pollen could suggest a semi-arid climate similar to that in which many conifers grow today in the southwestern part of the United States and in northern Mexico. These conifers form essentially upland forests and are well adapted to a warm dry climate. Also in the Flowerpot flora are several species of ephedran-like pollen which, if related to the genus *Ephedra,* strongly suggest a semi-arid climate because modern species are xerophytes of tropical and temperate zones.

The spore and pollen assemblage also suggests that another ecological element was present in the Flowerpot flora. The spores of the genera *Calamospora, Laevigatosporites,* and possibly *Lunulasporites* indicate the existence of a lowland mesic to hydrophilous community, possibly equivalent to modern strand or coastal-swamp types. The first two genera are common associates in the coal-swamp floras of the Pennsylvanian Period and the last, which is morphologically similar to *Laevigatosporites,* also may have originated in a similar ecology. Saccate pollen are transported largely by wind to places of deposition, but water and gravity may have been more important to the transport of the spores interpreted as originating from swamp-land vegetation.

The place of deposition of the Flowerpot spores and pollen was a shallow-marine environment where clays accumulated. This is indicated by the presence of hystrichosphaerid and scolecodont fossils in the shale. Hystrichosphaerids of the type that have been observed (Wilson, 1960) are known only from marine and brackish waters. Scolecodonts are jaws of polychaetous worms which are mainly shallow-water mud-burrowing animals.

A postulated paleoecology of the Flowerpot Shale deposit includes: (1) a shallow coastal marine or brackish-water environment containing a restricted marine fauna, (2) an adjacent narrow zone of coastal swamp or an inlet containing swamp vegetation, and (3) a low upland or plain with a varied forest of conifers and other semi-arid to arid plants, all characteristic of a warm temperate or subtropic climate.

A comparison of the Flowerpot Shale flora with other Permian palynological assemblages shows that an almost world-wide similarity exists. The preponderance of saccate pollen and the decline of Pennsylvanian spore types are recognizable in all described floras. Concerning the distribution of plant megafossils, David White (1942, p. 1050) stated, "The data in hand show a remarkably wide geographic distribution of early Permian types, including genera and species, suggestive of the extraordinary distribution of the 'Coal Measures' (Pennsylvanian) and older Mesozoic floras. The migration of some of the Permian types is surpassed perhaps only in the 'Lower Coal Measures' [Mississippian] and Jurassic." Whether the spores and pollen have an age-distribution pattern similar to that of the megaflora cannot yet be determined, but the Permian palynological floras are remarkably similar in saccate genera.

The rise to importance of the saccate pollen genera, particularly of the bisaccate forms, appears to have occurred suddenly with the advent of Permian time. This may be more apparent than real because palynological studies of Pennsylvanian rocks have been more concerned with coal-swamp floras recorded in the coals than with the floras which lived on higher ground, the remains of which are preserved in the intervening shales. Palynological studies of Permian rocks in contrast are largely investigations of shale, and such sediments contain a greater proportion of wind-borne pollen. The evolution of saccate pollen began in Early Pennsylvanian time or earlier as shown by the fossil genera *Florinites, Illinites,* and others. Typically Permian-Triassic genera *Alisporites* and *Platysaccus* are now known to occur in the uppermost Tebo coal levels and in the overlying shale. These belong to the Cabaniss Group, Desmoinesian Series of the Pennsylvanian Period. The discovery was made recently by James Ruffin at the Oklahoma Geological Survey palynology laboratory. The presence of striate-monosaccate pollen in the upper levels of the Mineral coal (also Cabaniss Group) was discovered by James Urban. These occurrences indicate that certain ancient conifer pollen genera evolved in pre-Permian time. The evolution of the conifer pollen saccus appears to have been associated with aridity in the Upper Pennsylvanian, Permian, and Triassic climates and, with other conifer xerophytic structures, has persisted to the present mainly in xeric and physiologically dry environments. The sacci of conifer pollen also may be xerophytic structures. If climatic control has tempered the rise of the conifers and other distinctive Permian elements, their wide distribution is not unexpected, for the Permian was a time of aridity and extreme temperature changes that has left its mark on all parts of the world where these rocks are present. The concept that aridity with high or low temperatures, or that glaciation and extremely low temperatures prevailed over the entire earth at various times during the Permian-Triassic periods is undoubtedly incorrect. Mesic floras also existed in parts of the globe during these times and the presence of their fossil remains proves their past existence. However, severe climates must have influenced the direction of evolution and the development of ecological segregates among the conifers and ephedrans may have occurred at that time.

Until the Flowerpot Shale flora is more fully studied, a detailed analysis of this and other published floras will not be attempted. The Permian palynological flora which appears to be most like the Flowerpot flora is that of the Zechstein of Europe described by Grebe (1957). In this Upper Permian flora are reported the genera *Nuskoisporites, Crustaesporites, Anguisporites, Lueckisporites, Platysaccus,* and *Strotersporites* (*Lueckisporites richteri*). *Lueckisporites virkkiae* is the dominant species, comprising approximately 85 percent of the pollen and spore assemblage. In the Flowerpot assemblage it constitutes slightly more than 68 percent.

SELECTED BIBLIOGRAPHY

BALMÉ, B. E., and HENNELLY, J. P. F., 1955, Bisaccate sporomorphs from Australian Permian coals: Australian Jour. Botany, vol. 3, no. 1, p. 89-98, pls. 1-6.

................1956, Monolete, monocolpate, and alete sporomorphs from Australian Permian sediments: Australian Jour. Botany, vol. 4, no. 1, 54-67, pls. 1-3.

................1956, Trilete sporomorphs from Australian Permian sediments: Australian Jour. Botany, vol. 4, no. 3, p. 240-260, pls. 1-10, figs. 1-2.

BHARDWAJ, D. C., 1954, Einige neue Sporengattungen des Saarkarbons: Neues Jahrbuch Geologie Paläontologie, Monatshefte, vol. 11, p. 512-525, 12 figs.

................1955a, The spore genera from the Upper Carboniferous coals of the Saar and their value in stratigraphic studies: Palaeobotanist, Lucknow, vol. 4, p. 119-149, 2 pls., 3 tables.

................1955b, An approach to the problem of taxonomy and classification in the study of Sporae dispersae: Palaeobotanist, Lucknow, vol. 4, p. 3-9.

BHARDWAJ, D. C., and VENKATACHALA, B. S., 1957, Microfloristic evidence on the boundary between the Carboniferous and Permian systems in Pfalz (W. Germany): Palaeobotanist, Lucknow, vol. 6, p. 1-11, 2 pls., 5 tables.

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 pls., 10 figs.

CASE, E. C., 1918, Permo-Carboniferous conditions versus Permo-Carboniferous time: Jour. Geology, vol. 24, p. 500-504, 1 fig.

COOKSON, Isabel C., 1947, Plant microfossils from the lignites of Kerguelen Archipelago: Adelaide, British-Australian-New Zealand Antarctic Research Expedition, 1929-31, Sci. Repts., ser. A, vol. 2, pt. 8, p. 127-142, pls. 13-17.

CRAGIN, F. W., 1896, The Permian System in Kansas: Colorado College Studies, vol. 6, p. 1-48.

DARRAH, W. C., 1935, Permian elements in the fossil flora of the Appalachian Province. I. *Taeniopteris*: Harvard Univ. Bot. Museum, Leaflets, vol. 3, p. 137-148.

DAUGHERTY, L. H., 1941, The Upper Triassic flora of Arizona: Carnegie Inst. Washington, Pub. 526, 108 p., 34 pls.

DORF, E., 1955, Plants and the geologic time scale, *in* The crust of the Earth: Geol. Soc. America, Spec. Paper 62, p. 575-592.

................1957. The Earth's changing climates: Weatherwise, vol. 10, p. 54-59, 2 figs.

DULHUNTY, J. A., 1946, Principal microspore-types in the Permian coals of New South Wales: Linnean Soc. New South Wales, Proc., vol. 70, pts. 3-4, 1 pl., 3 figs.

DUNBAR, C. O., 1941, Permian faunas. A study in facies: Geol. Soc. America, Bull. ,vol. 52, p. 313-332, 8 figs.

DUNBAR, C. O., et al., 1960, Correlation of the Permian formations of

North America: Geol. Soc. America, Bull., vol. 71, p. 1763-1806, 1 pl., 2 figs.

EDWARDS, J. D., 1958, Areal geology of the northwest Mangum area: Okla. University, M. S. thesis (unpublished) 96 p.

ELIAS, M. K., 1936, Late Paleozoic plants of the Midcontinent region as indicators of time and of environment: Internat. Geol. Congress, 16th, Washington 1933, Rept., p. 691-700, 1 fig.

ERDTMAN, G., 1947, Suggestions for the classification of fossil and recent pollen grains and spores: Svensk Botanisk Tidskrift, vol. 41, no. 1, p. 104-114.

EVANS, Noel, 1931, Stratigraphy of Permian beds of northwestern Oklahoma: Amer. Assoc. Petroleum Geologists, Bull., vol. 15, p. 405-439.

FAY, R. O., 1958, Permian stratigraphy of Blaine County, Oklahoma—a preliminary report: Okla. Acad. Science, Proc., vol. 38, p. 82-86, 1 fig.

FLORIN, Rudolph, 1936, On the structure of the pollen-grains in the Cordaitales: Svensk Botanisk Tidskrift, vol. 30, p. 624-651, 3 pls.

................1936, On the structure of the pollen-grains in the Cordaitales: Svensk Botanisk Tidskrift, vol. 31, p. 305-338, 3 pls.

................1950, Upper Carboniferous and Lower Permian conifers: Bot. Review, vol. 16, p. 258-282.

................1951, Evolution in *Cordaites* and conifers: Acta Horti Bergiani, vol. 15, p. 285-388, 70 figs., 1 pl.

GORDON, C. H., GIRTY, G. H., and WHITE, David, 1911, The Wichita formation of northern Texas: Jour. Geology, vol. 19, p. 110-134.

GREBE, Hilde, 1957 (1958), Zur Mikroflora des niederrheinischen Zechsteins: Germany, Geol. Landesanstalt, Geol. Jahrbuch, vol. 73, p. 51-74, 3 pls., 2 figs.

HAMMEN, Th. van der, 1955, Principios para la Nomenclatura Palinologica Sistemica: Colombia, Instituto Geologico Nacional, Boletin Geologico, vol. 2, no. 2, 21 p., Bogotá.

HART, G. F., 1960, Microfloral investigation of the Lower Coal Measures (K2); Ketewaka-Mchuchuma coalfield, Tanganyika: Tanganyika Geol. Survey, Bull. 30, 18 p., 4 figs.

IBRAHIM, A. C., 1933, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Würzburg, Konrad Triltsch, 47 p.

KLAUS, Wilhelm, 1953, Mikrosporen-Stratigraphie der ostalpinen Salzberge: Austria, Geol. Bundesanstalt, Verhandlungen, vol. 3, p. 161-175.

................1953 (1955), Über die Sporendiagnose des deutschen Zechsteinsalzes und des alpinen Salzgebirges: Deutsch. Geol. Gesellschaft, Zeitschrift, Hannover, vol. 105, p. 776-788, 2 pls.

................1960, Sporen der karnischen Stufe der ostalpinen Trias: Austria, Geol. Bundesanstalt, Jahrbuch, Sonderband 5, p. 107-183, pls. 28-38.

KOSANKE, R. M., 1950, Pennsylvanian spores of Illinois and their use in correlation: Illinois State Geol. Survey, Bull. 74, 128 p., 16 pls., 7 figs.

KRISHNAN, M. S., 1954, History of the Gondwana era in relation to the distribution and development of flora: Birbal Sahni Inst. Palaeobotany, Sir Albert Charles Seward Mem. Lecture 14, p. 3-15, 2 figs.

LESCHIK, Georg, 1955 (1956), Die Keuperflora von Neuewelt bei Basel, II. Die Iso- und Mikrosporen: Schweizerischen Paläontologischen Abhandlungen, vol. 27, no. 2, 70 p., 10 pls.

.................1956, Sporen aus dem Salzton des Zechsteins von Neuhof (bei Fulda): Palaeontographica, series B, vol. 100, sections 4-6, p. 122-142, pls. 20-22.

.................1959, Sporen aus den "Karru-Sandstein" von Norronaub (Südwest-Afrika): Senckenbergiana Lethaea, vol. 40, p. 51-95, 5 pls.

LUBER, A. A., 1938, Spores and pollen of coaly Permian sediments from USSR: (Russian with English summary) problemy Sovetskoi Geologii, vol. 8, no. 2, p. 152-160.

LUBER, A. A., and WALTZ, I. E., 1938, Classification and stratigraphic value of spores of some Carboniferous coal deposits in the USSR: Centr. Geol. Prospecting Inst., Trans. 105, p. 1-46, 10 pls.

MEHTA, K. R., 1944, Microfossils from a carbonaceous shale from the Pali Beds of the south Rewa Gondwana basin: India, Natl. Acad. Science, Proc., vol. 14, pts. 4-5, p. 125-141, 1 pl., 5 text-figs.

MOORE, R. C., ELIAS, M. K., and NEWELL, N. D. 1936, A "Permian" flora from the Pennsylvanian rocks of Kansas: Jour. Geology, vol. 44, p. 1-31, 12 figs.

NAUMOVA, S. N., 1937, Spores and pollen of the coals of the USSR: Internat. Geol. Congress, 17th, Moscow 1937, Rept., vol. 1, p. 353-364.

NORTON, G. H., 1939, Permian red beds of Kansas: Amer. Assoc. Petroleum Geologists, Bull., vol. 23, p. 1751-1819, 24 figs.

PANT, D. D., 1955, On two new disaccate spores from the Bacchus Marsh Tillite, Victoria (Australia): Annals Magazine Nat. History, ser. 12, vol. 8, p. 757-765, 1 pl., 1 fig.

POTONIÉ, Robert, 1956, Synopsis der Gattungen der Sporae dispersae. Teil I. Sporites: Amt für Bodenforschung, Beihefte Geologischen Jahrbuch, Hannover, vol. 23, p. 1-103, 11pls.

.................1958, Synopsis der Gattungen der Sporae dispersae. Teil II. Sporites (Nachträge), Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates: Amt für Bodenforschung, Beihefte Geologischen Jahrbuch, Hannover, vol. 31, 114 p., 11 pls.

.................1960, Synopsis der Gattungen der Sporae dispersae. Teil III. Nachträge Sporites, Fortsetzung Pollenites mit Generalregister zu Teil I-III: Amt für Bodenforschung, Beihefte Geologischen Jahrbuch, Hannover, vol. 39, 189 p., 9 pls.

POTONIÉ, Robert and KLAUS, W., 1954, Einige Sporengattungen des alpinen Salzgebirges: Germany, Geol. Landesanstalt, Geologischen Jahrbuch, vol. 68, p. 517-546, 10 pls., 11 figs.

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

................1956, Die Sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte, Teil II: Palaeontographica, vol. 99, series B, p. 85-191, pls. 17-22, figs. 38-88.

RODE, K. P., 1953, The Gondwana formations of India and the nature of Gondwanaland: Rajputana Univ., Mem. 2, p. 1-12, 1 table.

SAMOILOVICH, S.R.,1953, Pollen and spores from the Permian deposits of the Cherdyn' and Aktyubinsk areas, Cis-Urals, *translation by* Elias, M. K., 1961: Okla. Geol. Survey, Circ. 56. (*from* Paleobotanicheskii sbornik: Vsesoiuznyi nauchno-issledovatel'skii geologo-razvedochnyi institut, Leningrad, Trudy, new series, no. 75, p. 5-57, pls. 1-17, in Russian).

SCHAFFER, B. L., 1961 Microfloral successions in Permian evaporites: Univ. Missouri, M. S. thesis (unpublished).

SCHAEFFER, K. M. M., 1960, Late Paleozoic bisaccate pollen from the Midcontinent area: Univ. Illinois, Doctoral thesis (unpublished).

SCHUCHERT, Charles, 1932, Permian floral provinces and their interrelations: Amer. Jour. Science, vol. 224, p. 405-413.

SCOTT, G. L., and HAM, W. E. 1957, Geology and gypsum resources of the Carter area, Oklahoma: Okla. Geol. Survey, Circ. 42, 64 p., 8 pls., 5 figs.

STEEVES, M. W. and BARGHOORN, E. S., 1959, The pollen of Ephedra: Harvard Univ., Arnold Arboretum, Jour., vol. 40, p. 221-259.

STONELEY, H. M. M., 1958, The Upper Permian flora of England: Brit. Museum (Nat. History), Bull., Geology, vol. 3, no. 9.

SURANGE, K. R., SRIVASTAVA, P. N., and SINGH, Prem, 1953, Microfossil analysis of some Lower Gondwana coal seams of West Bokaro, Bihar: India, Natl. Institute Science, Bull., no. 2, p. 111-127, figs. 1-65.

TCHIGOURIAEVA, A. A., 1949, Structure du pollen des Gnetales: Akademia Nauk SSSR, Doklady, vol. 65, no. 4, p. 555-557. French translation by S. Ketchian *in* Grana Palynologica 1954, new series, vol. 1, no. 1, p. 95-98.

VIRKKI, C., 1945, Spores from the Lower Gondwanas of India and Australia, with an introductory note by B. Sahni: India, Natl. Acad. Science, Proc., vol. 15, pls. 4-5, p. 93-176, pls. 1-15, 81 figs.

WHITE, David, 1892, Fossil plants from the Wichita or Permian beds of Texas: Geol. Soc. America, Bull., vol. 3, p. 217-218.

................1903, Summary of fossil plants recorded from the Upper Carboniferous and Permian formations of Kansas: U. S. Geol. Survey, Bull. 211, p. 85-117.

..................1924, Permian of western America from the paleobotanical standpoint: Pan-Pacific Sci. Congress, Australia 1923, Proc., vol. 2, p. 1050-1077.

WILSON, L. R., 1959a, Geological history of the Gnetales: Okla. Geol. Survey, Okla. Geology Notes, vol. 19, p. 35-40, 1 pl.

..................1959b, A water-miscible mountant for palynology: Okla. Geol. Survey, Okla. Geology Notes, vol. 19, p. 110-111.

..................1960, A Permian hystrichosphaerid from Oklahoma: Okla. Geol. Survey, Okla. Geology Notes, vol. 20, p. 170, 1 fig.

WILSON, L. R. and HOFFMEISTER, W. S., 1956, Plant microfossils of the Croweburg coal: Okla. Geol. Survey, Circ. 32, 57 p., 5 pls.

Plate I

Nuskoisporites, Anquisporites, Tririctus, Calamospora, Clavatasporites, Lunulasporites, Zonalasporites, and *Schopfipollenites*

Plate I

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Fig. 1.	*Nuskoisporites crenulatus* sp. nov., holotype. OPC 1-1-3 Dimensions: 98.9x96.6 microns; central body 50.6x57.5 microns	14
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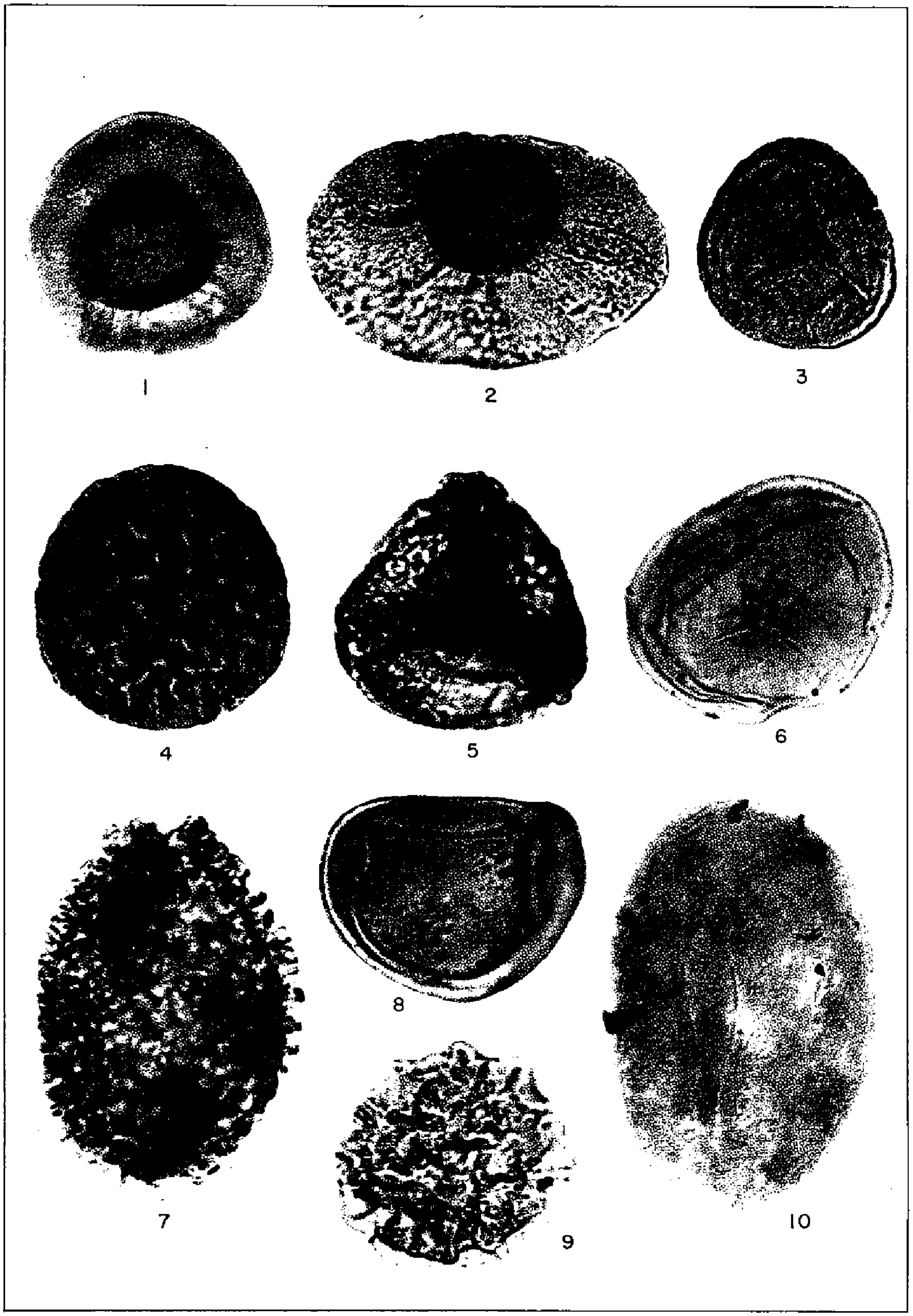
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Plate II

Strotersporites, *Fastigatisporites*, *Rhizomaspora*, *Lueckisporites*, *Trochosporites*, and *Mucrosaccus*

Plate II

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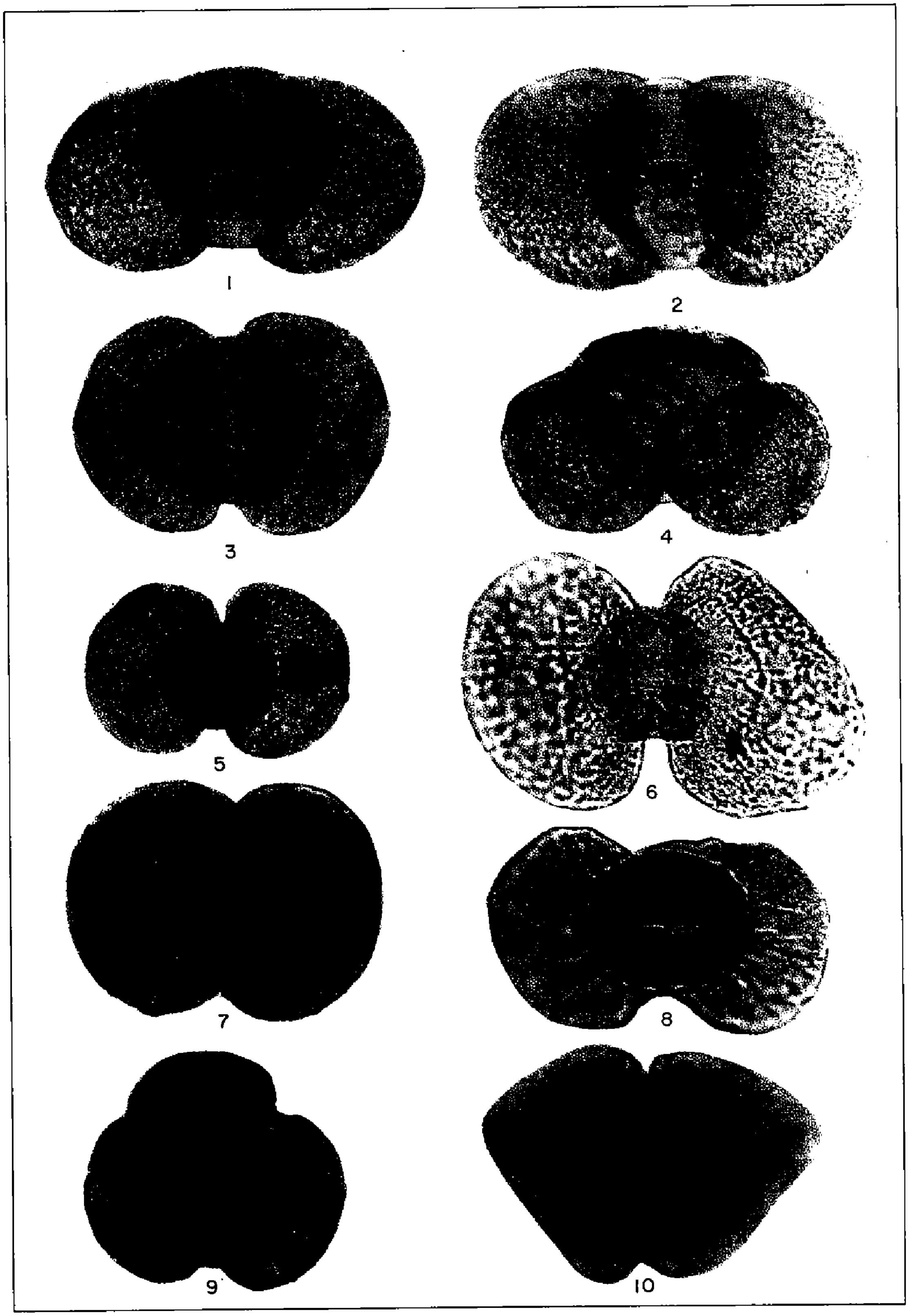
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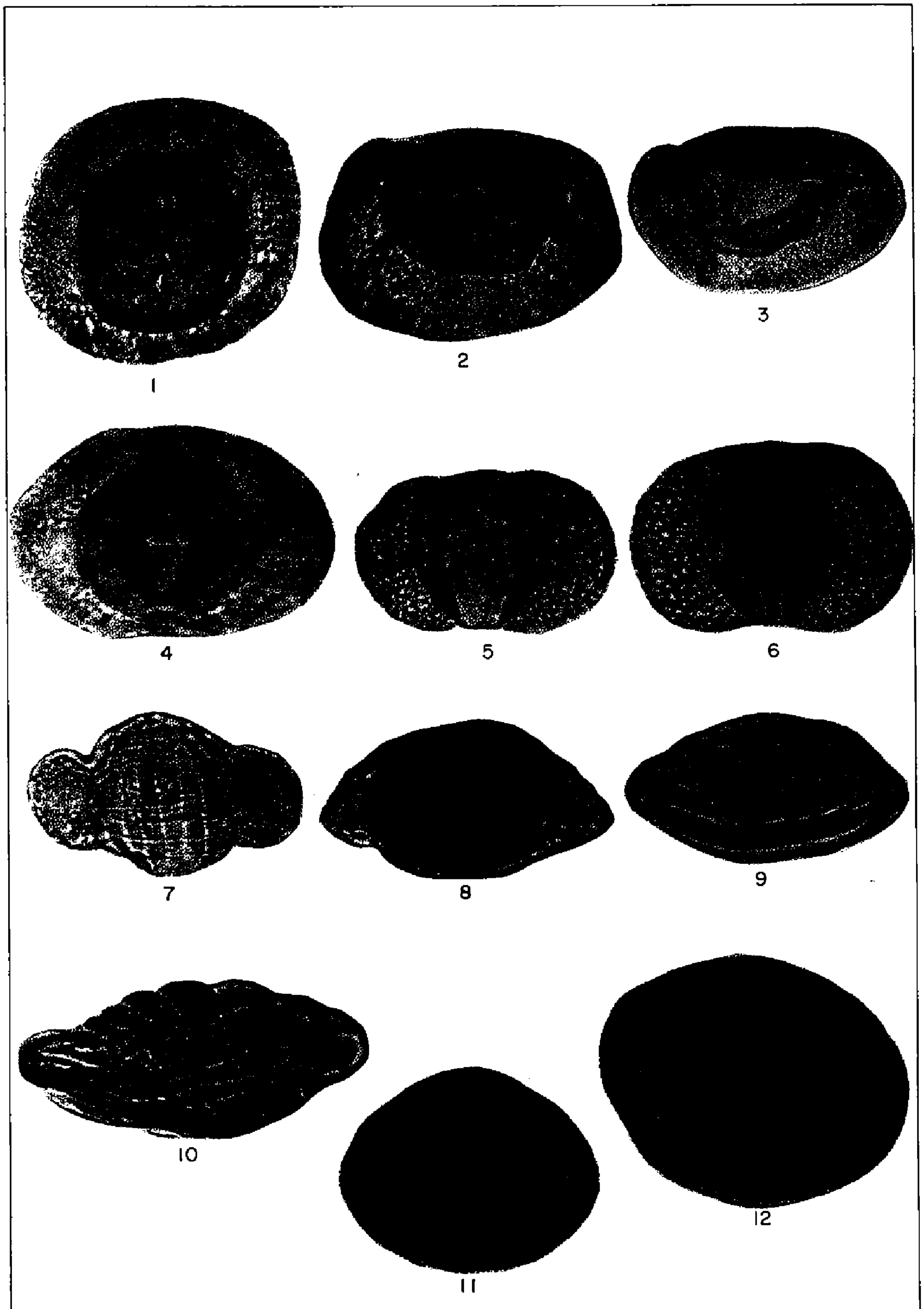
Plate III

Potonieisporites, *Hoffmeisterites*, *Alisporites*, *Hamiapollenites*, *Ephedripites*, and *Vittatina*

Plate III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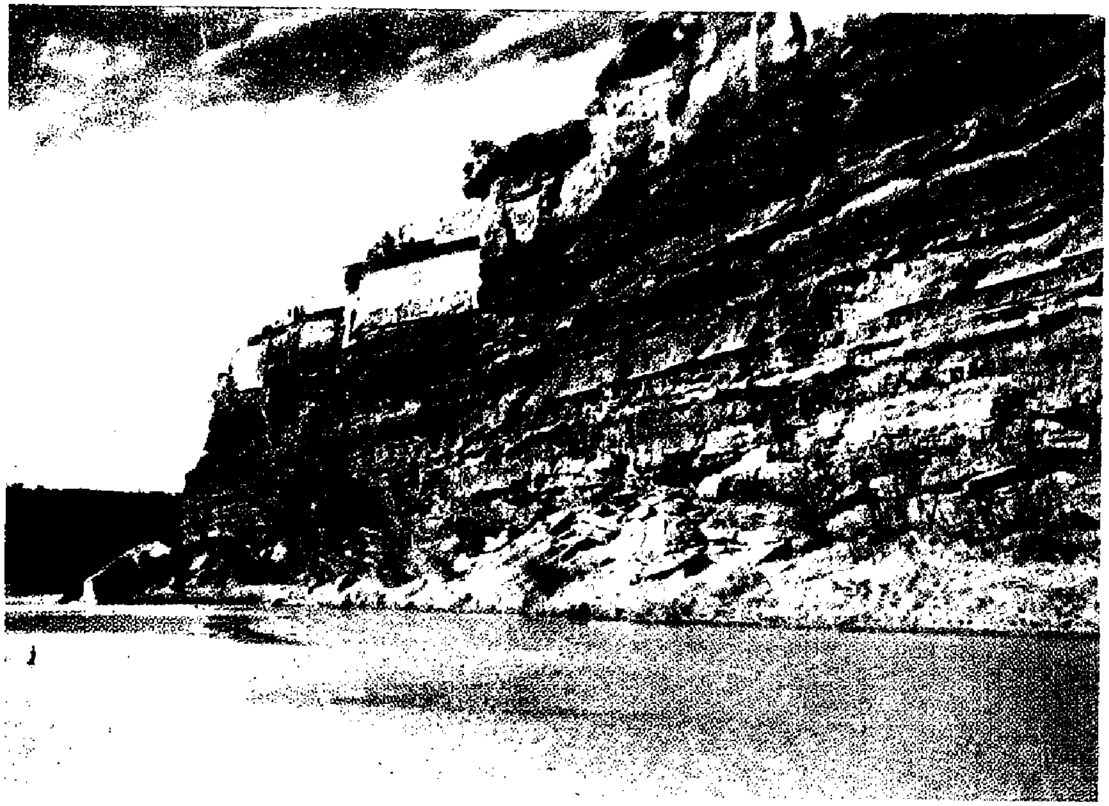

Fig. 1. Cliff on Salt Fork of Red River, 5 miles southwest of Mangum, Greer County, Oklahoma. Showing the upper part of the Flowerpot shale exposed below the massive white gypsum. The Blaine formation overlies the Flowerpot shale.

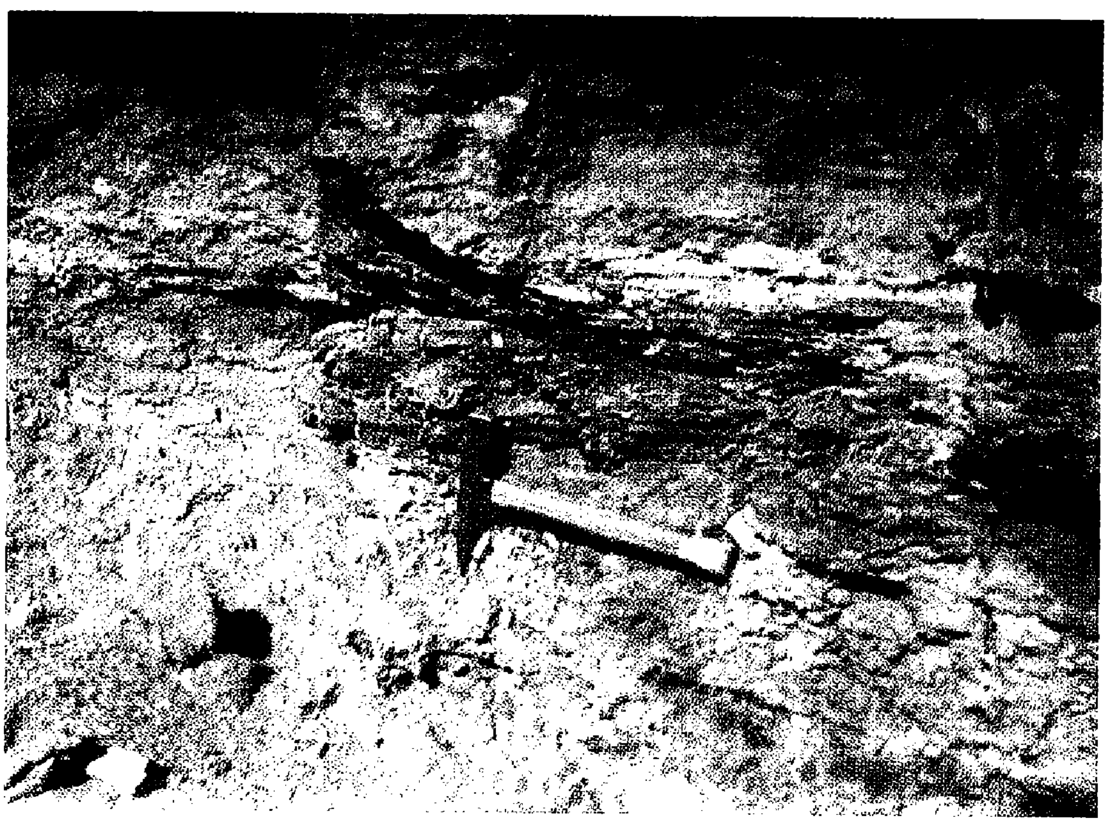

Fig. 2. Detail of shale bed from which the fossil spores and pollens reported here were recovered. It is the eight-inch bed of brownish-gray laminated shale 30 feet below the top of the formation.