

IOWA GEOLOGICAL SURVEY

IOWA CITY, IOWA

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TECHNICAL PAPER No. 6

**AN INTRODUCTION TO THE STRATIGRAPHIC PALYNOLOGY
OF THE CHEROKEE GROUP (PENNSYLVANIAN) COALS OF IOWA**

by

ROBERT L. RAVN

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ABSTRACT

The Cherokee Group of southern Iowa consists of a complex sequence of sediments including numerous coals. Lateral relationships of the coal seams are unclear on the basis of lithologic evidence alone. Preliminary palynological studies suggested the need for detailed examination of vertical variability of miospore populations within selected coal seams as a supplement to routine channel sample analyses for biostratigraphic correlation. A thick coal of uncertain stratigraphic relations, designated CP-19-4, was sampled to test the utility of detailed miospore profile evaluation.

CP-19-4 yielded a diverse, well-preserved miospore population with marked vertical variation, appearing to relate closely to gross petrologic variability of coal lithotypes. Three major miospore associations were distinguished, dividing the seam into nearly equal sub-units;—a lower interval, dominated by gymnospermous prepollen and pollen grains, designated the *Florinites* interval; a middle interval, characterized by an abundance of lycopsid-related spores, designated the *Densosporites-Crassispora* interval; and an upper interval, dominated by the arborescent lycopsid spore *Lycospora granulata*, designated the *Lycospora* interval. The overall miospore assemblage is equivalent in age to that of the Pope Creek Coal of the Illinois Basin.

A paleoecologic reconstruction of the coal swamp depositional history is suggested on the basis of the miospore profile. The distribution of specific miospores within the seam indicates a series of depositional events,

evidence of which may be traceable laterally and useful for correlation. A comparison with coals obtained from other cores illustrates the utility of the approach in complex stratigraphic sections.

Formal taxonomic information is provided for 171 miospore species; eight new genera, 13 new species and 4 new combinations are proposed. Additionally, diagnoses of 3 species are formally emended, and 1 new name is proposed to replace a previous name found to be a junior homonym under provisions of the International Code of Botanical Nomenclature (1978). New taxonomic names proposed in this report are: *Leiotriletes guennelii* nom. nov. emend., *Calamospora nebulosa* sp. nov., *Adeliosporites multiplicatus* gen. et sp. nov., *Lophotriletes confertus* sp. nov., *Cuneiosporites rigidus* gen. et sp. nov., *Tetanisporites granulatus* gen. et sp. nov., *Apiculatisporis saetiger* (Peppers) comb. nov., *Crassispora annulata* sp. nov., *Cirratriradites reticulatus* sp. nov., *Thysanites densus* gen. et sp. nov., *Vestispora luminata* sp. nov., *Diaphanospora parvigracila* (Peppers) comb. nov., *Potonieisporites solidus* sp. nov., *Wilsonites circularis* (Guennel) comb. nov., *Pseudoillinites diversiformis* (Kosanke) gen. nov. et comb. nov. emend., *Peppersites ellipticus* gen. et sp. nov., *Wapellites variabilis* gen. et sp. nov., and *Phillipsites tenuis* gen. et sp. nov. *Reinschospora triangularis* (Kosanke, 1950) is emended.

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concerning patterns of floral succession as revealed by the palynology of Oklahoma coals, and to Dr. Gene Mapes of the Department of the Department of Botany, Ohio University, for bringing to the writer's attention the plant-group affinities of a number of newly discovered fructifications containing miospores from Midcontinent Pennsylvanian shales.

Drs. Baker and Avcin, Mr. Donald Koch, Assistant State Geologist, and Mr. Charles Huelsbeck, Iowa Geological Survey Librarian, critically reviewed the manuscript.

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INTRODUCTION

The Cherokee Group (Des Moines Series, Pennsylvanian System) of southern Iowa consists of interbedded marine and non-marine sediments that include numerous coals (fig. 1). Complex facies relationships characterize the strata, and exposures are sparse due to a thick Pleistocene cover over much of the region. These factors historically have prevented detailed stratigraphic correlation, particularly in the lower portion of the sequence (fig. 2). The recent renewal of economic interest in Iowa coal has fostered a need for more precise knowledge of the stratigraphy of Cherokee coals and of their lateral continuity as minable units.

Accordingly, in 1973, the Iowa Geological Survey

began a systematic coal resource project including a coring program, concentrating initially in the southeasternmost portion of the coal-bearing region where strippable deposits were thought to exist. Samples secured through coring have been subjected to various forms of stratigraphic analysis, including the study of conodonts, ostracodes and fusulinid foraminifera from marine strata, and palynomorphs from coals and non-marine shales. Coal palynology has proven particularly effective in correlation. This report is the first of a series addressing the palynology of Iowa coals, and is derived in large part from a Master's thesis at the Department of Geology, University of Iowa (Ravn, 1977a). Portions of the report have been presented previously at scientific meetings (Ravn, 1977b, 1977c).

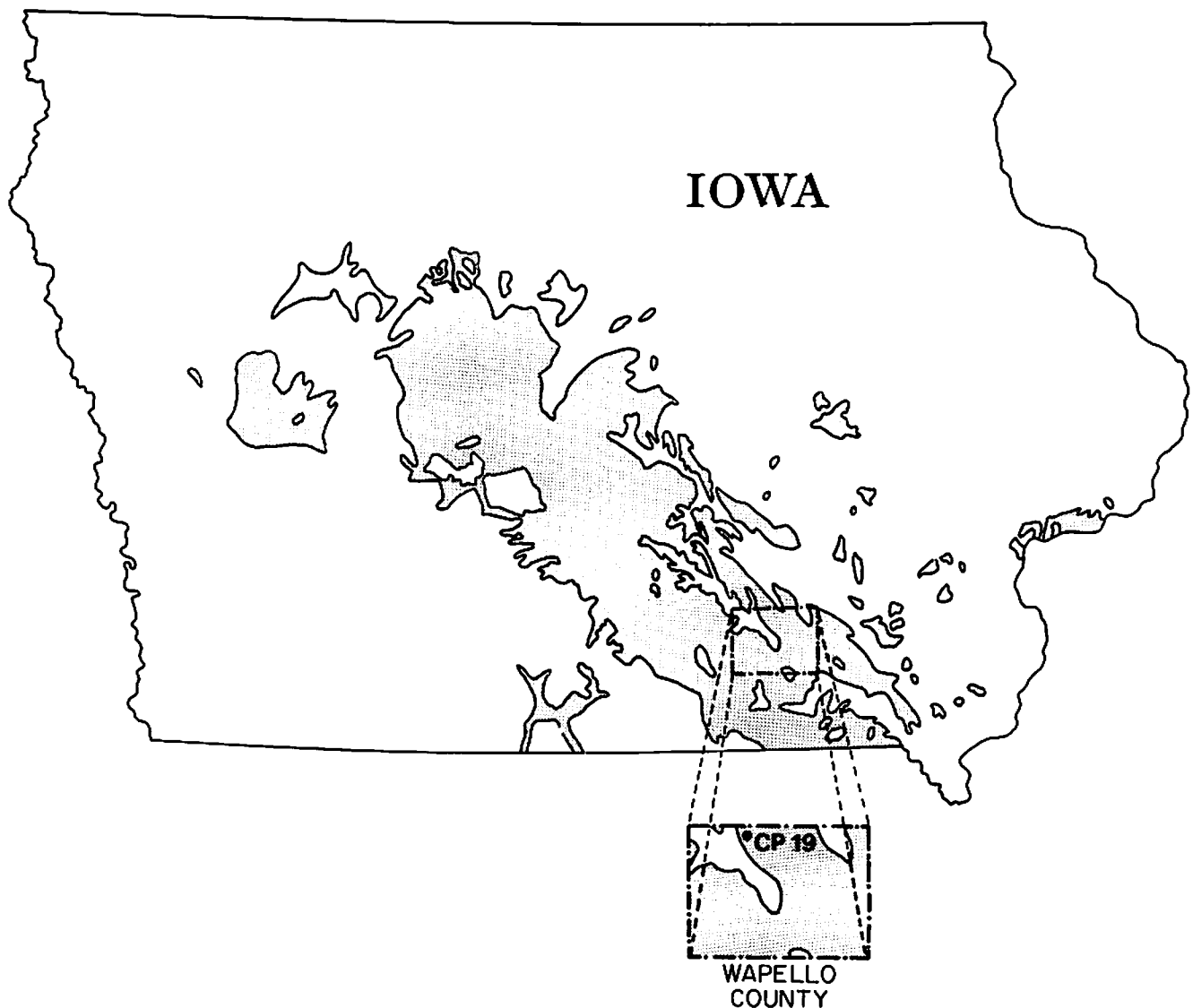


Figure 1. Sub-Pleistocene exposure of the Cherokee Group and beds believed of equivalent age in Iowa, (shaded) with the locality of Iowa Geological Survey corehole CP-19.

PREVIOUS WORK

Stratigraphy—The stratigraphy of the Pennsylvanian System in Iowa was first outlined by White and St. John (1870). They, and other early workers (e.g., Bain, 1894; Hinds, 1909), noted the complex nature of the stratigraphy, particularly as related to the coal beds. The correlation problem was most acute in the lower portion of the Iowa Pennsylvanian section, the Cherokee Group (fig. 2). The present coring program has helped compensate for the paucity of surface exposure of the Cherokee, but also has confirmed the observations of the early workers concerning its complexity.

The Cherokee Group has been divided informally into Upper and Lower units on the basis of the relative persistence of traceable lithologic horizons (Landis and Van Eck, 1965). The stratigraphy of the Upper Cherokee is somewhat better known; its major rock units have been identified and correlated with equivalent units in Illinois (Weller, Wanless, Cline and Stookey, 1942). The level of understanding of the Lower Cherokee was summarized by Landis and Van Eck (1965, p. 37): "The stratigraphy of the Lower Cherokee in Iowa is virtually unknown, both because stratigraphic relations are very complex and because data are insufficient in several critical areas . . . the lateral relations of coal beds of minable thickness are doubtful or unknown in many areas." The table of estimated coal reserves (Landis and Van Eck, 1965, p. 95-141) emphasizes the lack of stratigraphic control. Included in the reserves of most counties are uncorrelated coal beds or beds of questionable relationship; in many instances these beds are of commercial thickness and are estimated to contain significant reserves.

Palynology—Prior to the current project, palynological investigation of Iowa coals was limited to a number of short papers concerned principally with taxonomy (Wilson and Brokaw, 1937; Wilson and Coe, 1940; Wilson, 1943, 1958, 1960; Wilson and Kosanke, 1944; Schemel, 1951). An abstract (Hornbacker and Habib, 1962) discussed the palynology of the Bevier and Wheeler coals of Iowa, Kansas and Missouri, though the data remain unpublished. The most extensive study of Carboniferous palynology in Iowa previous to the current project is that of Urban (1971) who described an Upper Mississippian miospore assemblage from eastern Iowa. A number of paleobotanical papers concerned with reproductive structures and miospore affinities of Pennsylvanian plants have described material collected in Iowa (Hoskins and Cross, 1943; Mamay, 1950 and 1954a; Baxter, 1955 and 1963; Murdy and Andrews, 1957; Baxter and Leisman, 1967; Eggert and Kryder, 1969; Millay and Taylor, 1974 and 1976; Courvoisier and Phillips, 1975; Baxendale and Baxter, 1977). In summary, the stratigraphic distribution of miospores in Iowa coals is virtually unknown, and the basic taxonomy of the miospore population has not been documented thoroughly. (The term *miospore* as defined by Guennel, 1952, refers to spores and pollen smaller than 200 microns in maximum dimension; it is a purely descriptive term having no implications concerning precise biological function, and can include isospores, microspores, small megaspores and pollen grains.)

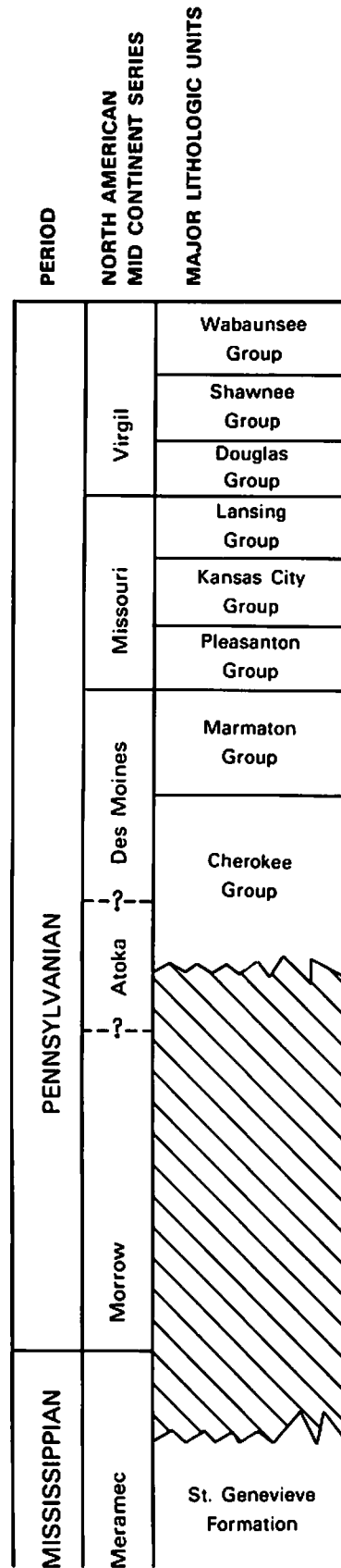


Figure 2. Generalized stratigraphic nomenclature in the Upper Mississippian and Pennsylvanian Systems south-central Iowa (strata equivalent to the shaded area are not known to be present in south-central Iowa).

A considerable body of literature exists concerning miospores of Pennsylvanian or Carboniferous age from coal-bearing strata elsewhere. It is beyond the scope of this report to summarize the literature in any detail, although many works are referenced in the Taxonomy section of the paper. Of special importance to this study were the extensive reports on the palynology of the Illinois Basin coals by Kosanke (1950) and Peppers (1964 and 1970), and the detailed stratigraphic study of miospores from the British Coal Measures by Smith and Butterworth (1967), whose biostratigraphic framework has proven useful in assessing the age of other Iowa coals not considered in this report (Ravn and Fitzgerald, 1978).

SCOPE AND PURPOSE

Palynological correlation of coal seams elsewhere has been accomplished largely through analysis of channel samples representative of the entire thickness of each given seam. This technique has the advantage of simplicity and speed of evaluation, and has been proved an effective stratigraphic method in areas where coal seams and associated strata are widespread and persistent (e.g., Peppers, 1970). In such areas lateral variation in miospore populations of seams tends not to be great, usually allowing clear differentiation of individual coals on the basis of total miospore population counts. The complexity of the Cherokee section in Iowa, coupled with the lack of previous palynological data from the coals, created uncertainty about the reliability of simple channel sample correlation here. Preliminary work with cores has confirmed the need, at least in certain areas, for a more sophisticated approach toward miospore biostratigraphy.

As a result, it was considered necessary to investigate the potential usefulness of the vertical miospore succession within seams as a stratigraphic tool. Knowledge of the progression of plant successions through the depositional history of the coal swamp, as recorded in the miospore profile, also was considered to have potential value in understanding other coal characteristics, such as geochemistry, which are under examination. An appropriate coal seam of uncertain stratigraphic relationship therefore was chosen to be sampled at closely spaced intervals, to determine the character of its miospore profile.

The coal was recovered from core CP-19, located in the NW $\frac{1}{4}$, NE $\frac{1}{4}$, NE $\frac{1}{4}$, Section 18, T. 73N, R. 14W, Wapello County, Iowa. The seam is designated lithologic unit 4 in the core log (Iowa Geological Survey Core Log, CP-19), and is 180 cm (5 ft. 7 in.) thick; it immediately overlies a 10 cm (4 in.) thick coaly shale (unit 5), which was sampled for miospores as part of the coal seam. Hereafter in this report the entire interval sampled (units 4 and 5) is referred to as CP-19-4, unless specified otherwise.

As indicated in fig. 3, a cross-section illustrating its position relative to coals recovered in nearby cores, stratigraphic relations of CP-19-4 are far from obvious. In addition, CP-19-4 is both thick enough and shallow enough to be of economic interest, and several old mining operations near the site of the corehole probably extracted coal from this seam (M. J. Avcin, personal communication, 1977).

The seam proved to contain an exceptionally diverse and well-preserved miospore assemblage which served to document for the first time a major portion of the miospore population encountered in the Cherokee Group coals of Iowa. The formal taxonomic description of this miospore assemblage is a principal purpose of this report and is designed to provide a base from which further palynological correlation can proceed. The character and interpretation of the miospore profile, and its utility in correlation, form the second major purpose of the study.

METHOD

The coal was recovered in eleven segments of varying length, due to fracturing at natural points of weakness in the seam during coring; coaly shale CP-19-5 constituted a twelfth segment, and each segment was assigned a numerical designation denoting its relative position within the core (fig. 4). The segments were split into units 1 to 2 cm (0.4 to 0.8 in.) thick (it was difficult to be more precise due to natural breaks in the core). These units were assigned alphabetic designations within their respective segments (see Appendix II).

Samples from 86 of the units were macerated for miospores, employing variations of standard Schulze solution techniques (Schulze solution, KOH, HF) described by Peppers (1970); detailed preparation procedures are given in Appendix I. Throughout most of the seam alternate sections were selected for maceration, but in portions of special interest, such as the top and bottom and around certain petrologic changes in the seam, several adjacent sections were processed and examined. A minimum of four microscope slides from each sample processed were prepared, with residues mounted either in Canada Balsam, Piccolyte Resin or Permout Cement (see discussion of mounting media in Appendix I). After a review of statistical considerations (Barkley, 1934; Tomlinson, 1957; Dimpleby, 1957; Mosimann, 1965) a miospore population sample size of 250 miospores was selected for counting under a high-power dry objective. Following the basic count, four slides of each sample were scanned under low-power to determine the presence of rare species not observed during the population count. Additional slides of samples found to contain miospores of undescribed or undetermined types were examined when appropriate. Data from these examinations are included in Appendix II. Sample residues and slides are repositied at the Department of Geology, University of Iowa, Iowa City, IA 52242.

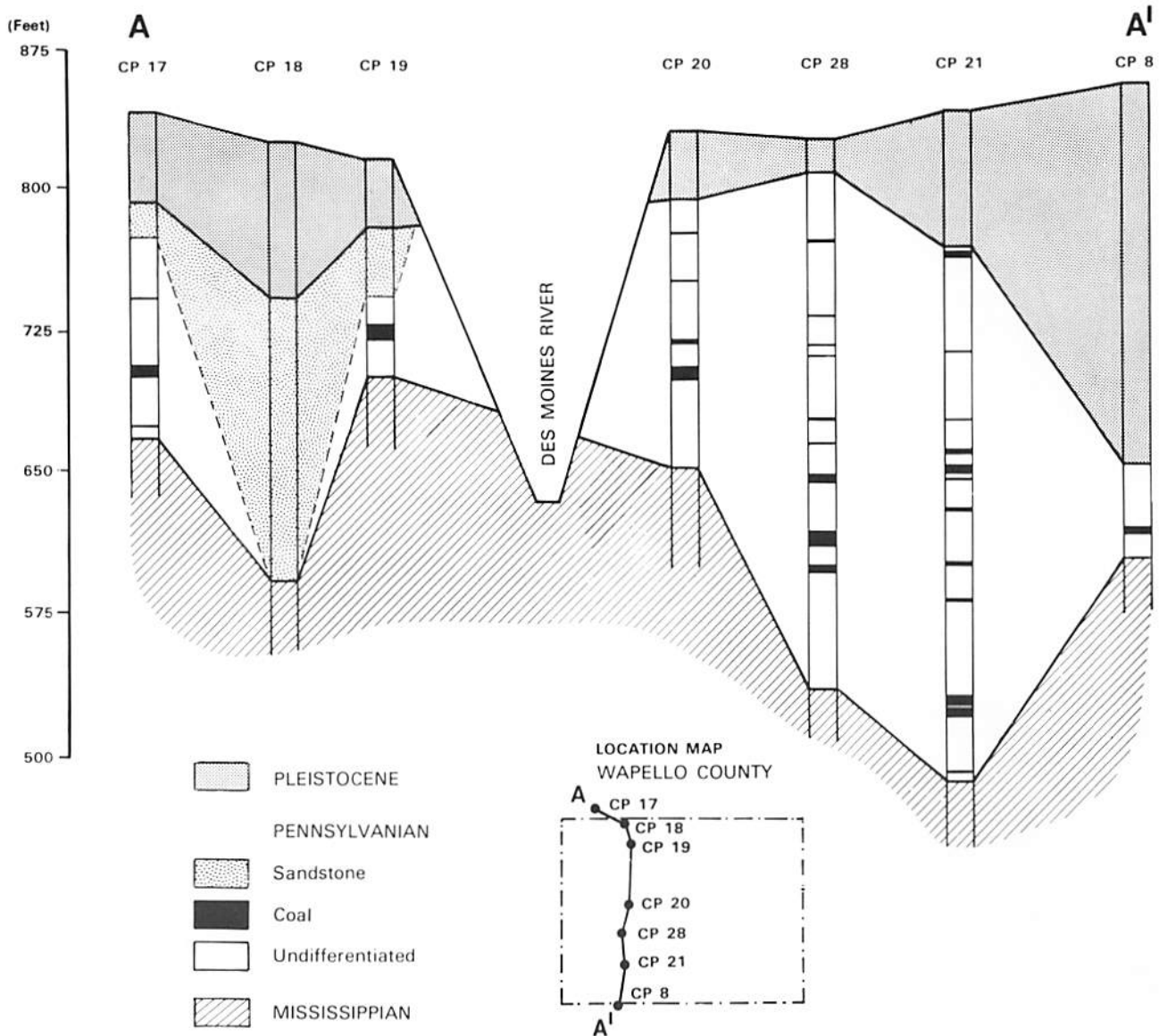


Figure 3. Uncorrelated cross-section through the Cherokee Group of Wapello County, illustrating present elevational relationships of coal seams encountered in a typical group of Iowa Geological Survey coreholes including CP-19.

PALYNOLOGY OF CP-19-4

The following miospore species observed in the study of CP-19-4 are provided with formal systematics:

Leiotriletes guennelii nom. nov. emend.
Leiotriletes levis (Kosanke) Potonié and Kremp 1955
Leiotriletes priddyi (Berry) Potonié and Kremp 1955
Leiotriletes sphaerotriangulus (Loose) Potonié and Kremp 1955

Leiotriletes turgidus Marshall and Smith 1964
Punctatisporites aerarius Butterworth and Williams 1958
Punctatisporites cf. *curviradiatus* Staplin 1960
Punctatisporites edgarensis Peppers 1970
Punctatisporites cf. *edgarensis* Peppers 1970
Punctatisporites kankakeensis Peppers 1970
Punctatisporites minutus (Kosanke) Peppers 1964
Punctatisporites nitidus Hoffmeister, Staplin and Malloy 1955

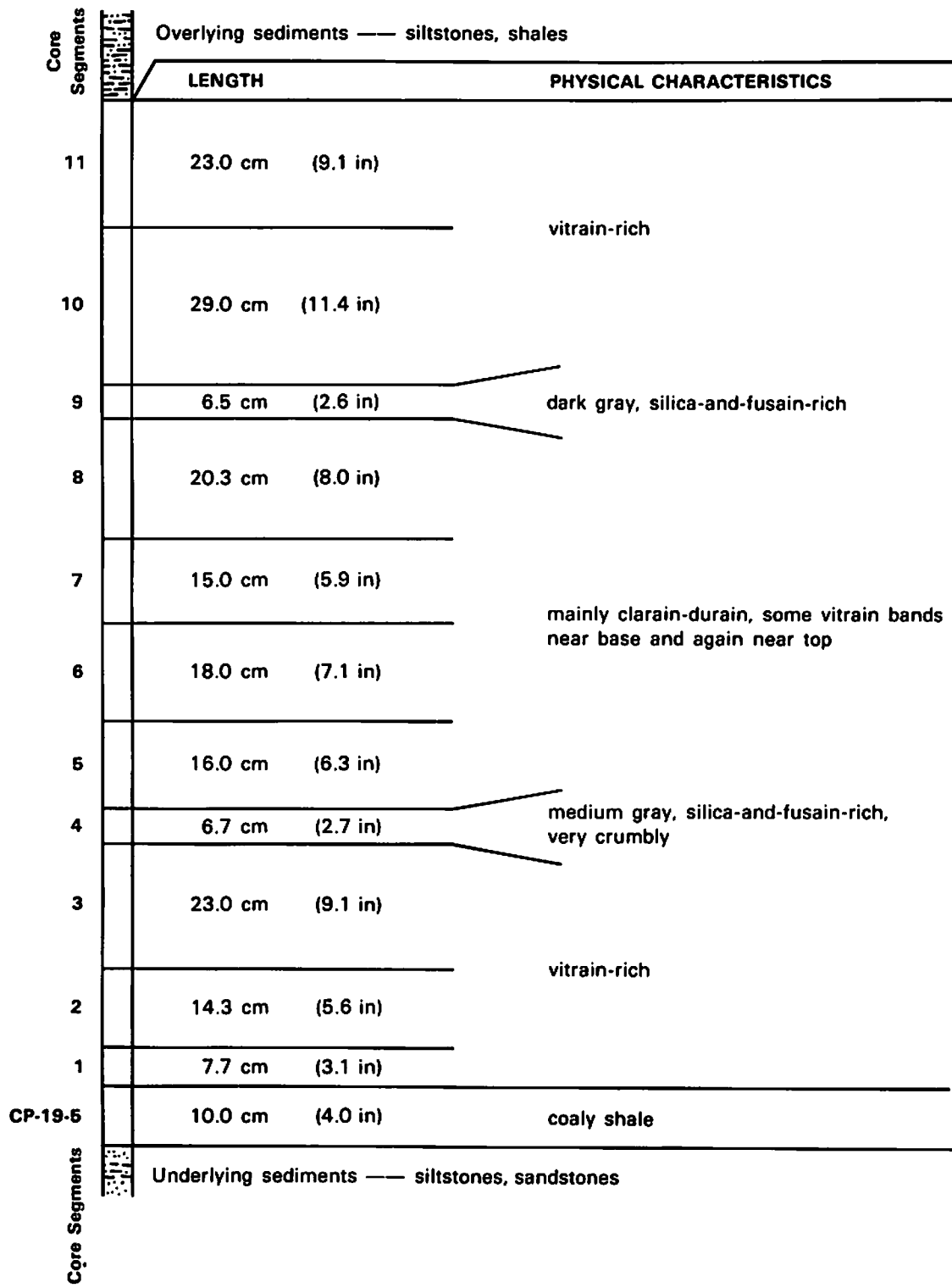


Figure 4. Measurements and general physical description of segments of coal seam CP-19-4 and adjacent sediments.

- Punctatisporites cf. nudus* Artüz 1957
Punctatisporites obliquus Kosanke 1950
Calamospora breviradiata Kosanke 1950
Calamospora hartungiana Schopf, in Schopf, Wilson and Bental 1944
Calamospora liquida Kosanke 1950
Calamospora cf. mutabilis (Loose) Schopf, Wilson and Bental 1944
Calamospora nebulosa sp. nov.
Calamospora cf. pedata Kosanke 1950
Calamospora straminea Wilson and Kosanke 1944
Elaterites triferens Wilson 1943
Adelisporites multiplicatus gen. et sp. nov.
Verrucosporites donarii Potonié and Kremp 1955
Verrucosporites microtuberosus (Loose) Smith and Butterworth 1967
Verrucosporites sifati (Ibrahim) Smith and Butterworth 1967
Verrucosporites verrucosus (Ibrahim) Ibrahim 1933
Kewaneesporites patulus (Peppers) Peppers 1970
Cyclogranisporites aureus (Loose) Potonié and Kremp 1955
Cyclogranisporites cf. leopoldi (Kremp) Potonié and Kremp 1955
Cyclogranisporites microgranus Bharadwaj 1957
Cyclogranisporites minutus Bharadwaj 1957
Cyclogranisporites orbicularis (Kosanke) Potonié and Kremp 1955
Cyclogranisporites parvus Bharadwaj 1957
Granulatisporites adnatoides (Potonié and Kremp) Smith and Butterworth 1967
Granulatisporites granularis Kosanke 1950
Granulatisporites granulatus Ibrahim 1933
Granulatisporites microgranifer Ibrahim 1933
Granulatisporites parvus (Ibrahim) Potonié and Kremp 1955
Lophotriletes commissuralis (Kosanke) Potonié and Kremp 1955
Lophotriletes confertus sp. nov.
Lophotriletes copiosus Peppers 1970
Lophotriletes gibbosus (Ibrahim) Potonié and Kremp 1955
Lophotriletes granoornatus Artüz 1957
Lophotriletes ibrahimii (Peppers) Pi-Radondy and Doubinger 1968
Lophotriletes microsaeetus (Loose) Potonié and Kremp 1955
Lophotriletes mosaicus Potonié and Kremp 1955
Lophotriletes rarispinosus Peppers 1970
Lophotriletes cf. tuberifer (Imgrund) Potonié and Kremp 1955
Waltzispora sagittata Playford 1962
Anapiculatisporites spinosus (Kosanke) Potonié and Kremp 1955
Anaplanisporites bacchatus (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967
Apiculatisporis abditus (Loose) Potonié and Kremp 1955
Apiculatisporis aculeatus (Ibrahim) Smith and Butterworth 1967
Apiculatisporis irregularis (Kosanke) Potonié and Kremp 1955
Apiculatisporis latigranifer (Loose) Potonié and Kremp 1955
Apiculatisporis saetiger (Peppers) Peppers and Ravn comb. nov.
Apiculatisporis variocorneus Sullivan 1964
Apiculatasporites spinulistratus (Loose) Ibrahim 1933
Acanthotriletes aculeolatus (Kosanke) Potonié and Kremp 1955
Acanthotriletes echinatus (Knox) Potonié and Kremp 1955
Acanthotriletes cf. falcatus (Knox) Potonié and Kremp 1955
Acanthotriletes triquetrus Smith and Butterworth 1967
Raistrickia crocea Kosanke 1950
Raistrickia lacerata Peppers 1970
Raistrickia lowellensis Peppers 1970
Raistrickia cf. macra Bharadwaj 1957
Raistrickia pilosa Kosanke 1950
Raistrickia protensa Kosanke 1950
Spackmanites facierugosus (Loose) Habib 1966
Convolutispora cerina sp. nov.
Microreticulatisporites harrisonii Peppers 1970
Microreticulatisporites nobilis (Wicher) Knox 1950
Dictyotriletes bireticulatus (Ibrahim) Potonié and Kremp 1954
Dictyotriletes castanaeformis (Horst) Sullivan 1964
Dictyotriletes densoreticulatus Potonié and Kremp 1955
Dictyotriletes distortus Peppers 1970
Dictyotriletes reticulocingulum (Loose) Smith and Butterworth 1967
Camptotriletes bucculentus (Loose) Potonié and Kremp 1955
Camptotriletes cf. corrugatus (Ibrahim) Potonié and Kremp 1955
Latipulvinites kosankii Peppers 1964
Ahrensia guerickei (Horst) Potonié and Kremp 1954
Stellisporites inflatus Alpern 1958
Tantillus triquetrus Felix and Burbridge 1967
Triquitrites additus Wilson and Hoffmeister 1956
Triquitrites bransonii Wilson and Hoffmeister 1956
Triquitrites crassus Kosanke 1950
Triquitrites exiguus Wilson and Kosanke 1944
Triquitrites minutus Alpern 1958
Triquitrites protensus Kosanke 1950
Triquitrites sculptilis (Balme) Smith and Butterworth 1967
Triquitrites subspinosus Peppers 1970
Indospora boleta Peppers 1970
Zosterosporites triangularis Kosanke 1973
Simozonotriletes intortus (Waltz) Potonié and Kremp 1954
Knoxisporites stephanephorus Love 1960
Knoxisporites triradiatus Hoffmeister, Staplin and Malloy 1955
Reticulatisporites reticulatus (Ibrahim) Ibrahim 1933
Reinschospora speciosa (Loose) Schopf, Wilson and Bental 1944

- Reinschospora triangularis* (Kosanke) emend.
Cuneisporites rigidus gen. et sp. nov.
Tetanisporites granulatus gen. et sp. nov.
Savitrissporites nux (Butterworth and Williams) Smith and Butterworth 1967
Grumosporites (?) *rufus* (Butterworth and Williams) Smith and Butterworth 1967
Cristatisporites indignabundus (Loose) Staplin and Jansonius 1964
Radiizonates cf. *difformis* (Kosanke) Staplin and Jansonius 1964
Cingulizonates loricatus (Loose) Butterworth and Smith, in Butterworth et al., 1964
Crassispora annulata sp. nov.
Crassispora kosankei (Potonié and Kremp) Smith and Butterworth 1967
Cappasporites distortus Urban 1966
Densosporites anulatus (Loose) Smith and Butterworth 1967
Densosporites irregularis Hacquebard and Bars 1957
Densosporites sphaerotriangularis Kosanke 1950
Densosporites spinifer Hoffmeister, Staplin and Malloy 1955
Densosporites triangularis Kosanke 1950
Lycospora granulata Kosanke 1950
Lycospora micropapillata (Wilson and Coe) Schopf, Wilson and Bentall 1944
Lycospora pellucida (Wicher) Schopf, Wilson and Bentall 1944
Lycospora rotunda Bharadwaj 1957
Lycospora cf. *L. torquifer* (Loose) Potonié and Kremp 1956
Cirratriradites annuliformis Kosanke and Brokaw, in Kosanke, 1950
Cirratriradites maculatus Wilson and Coe 1940
Cirratriradites reticulatus sp. nov.
Cirratriradites saturni (Ibrahim) Schopf, Wilson and Bentall 1944
Endosporites globiformis (Ibrahim) Schopf, Wilson and Bentall 1944
Endosporites staplinii Gupta and Boozer 1969
Endosporites zonalis (Loose) Knox 1950
Alatisporites hoffmeisterii Morgan 1955
Alatisporites pustulatus (Ibrahim) Ibrahim 1933
Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson and Bentall 1944
Laevigatosporites cf. *dunkardensis* Clendening 1970
Laevigatosporites globosus Schemel 1951
Laevigatosporites medius Kosanke 1950
Laevigatosporites minutus (Ibrahim) Schopf, Wilson and Bentall 1944
Laevigatosporites ovalis Kosanke 1950
Laevigatosporites striatus Alpern 1959
Laevigatosporites vulgaris (Ibrahim) Ibrahim 1933
Laevigatosporites cf. *vulgaris* (Ibrahim) Ibrahim 1933
Thymospora cf. *pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963
Torisporea securis Balme 1952
Tuberculatosporites robustus (Kosanke) Peppers 1970
Vestispora fenestrata (Kosanke and Brokaw) Spode, in Smith and Butterworth, 1967
Vestispora laevigata Wilson and Venkatachala 1963
Vestispora luminata sp. nov.
Vestispora pseudoreticulata Spode, in Smith and Butterworth, 1967
Vestispora cf. *reticulata* (Laveine) Loboziak 1971
Aumancisporites striatus Alpern 1958
Thysanites densus gen. et sp. nov.
Colatisporites decorus (Bharadwaj and Venkatachala) Williams, in Neves et al., 1973
Hymenospora multirugosa Peppers 1970
Diaphanospora parvigracila (Peppers) comb. nov.
Florinites mediapudens (Loose) Potonié and Kremp 1956
Florinites millotti Butterworth and Williams 1954
Florinites occultus Habib 1966
Florinites visendus (Ibrahim) Schopf, Wilson and Bentall 1944
Florinites cf. *volans* (Loose) Potonié and Kremp 1956
Potonieisporites elegans (Wilson and Kosanke) Habib 1966
Potonieisporites solidus sp. nov.
Costatacycylus crenatus (Felix and Burbridge) Urban 1971
Wilsonites circularis (Guennel) Peppers and Ravn comb. nov.
Wilsonites delicatus (Kosanke) Kosanke 1959
Wilsonites vesicatus (Kosanke) Kosanke 1959
Pityosporites westphalensis Williams 1955
Platysaccus saarensis (Bharadwaj) Jizba 1962
Peppersites ellipticus gen. et sp. nov.
Illinites unicus (Kosanke) Helby 1966
Pseudoillinites diversiformis (Kosanke) gen. nov. et comb. nov.
Phillipsites tenuis gen. et sp. nov.
Wapellites variabilis gen. et sp. nov.
Schopfpollenites ellipsoides (Ibrahim) Potonié and Kremp 1954
Trihyphaecites triangulatus Peppers 1970

In addition, a number of miospores were encountered in CP-19-4 which could be assigned to genera but not with confidence to any described species. Several of these are illustrated and provided with informal description; although they were not observed in numbers sufficient to delimit morphologic variation adequately for formal new species diagnoses, they may be useful for future biostratigraphic comparison of CP-19-4 and other coals.

MIOSPORE DISTRIBUTION IN CP-19-4

Physical Profile—Distinct petrologic differences exist in the physical characteristics of the twelve segments of CP-19-4, and a brief discussion of the gross petrology of the seam is in order.

The lengths of the segments are illustrated in figure 4. The lowermost segment (lithologic unit CP-19-5) is a dark gray to black, tough, non-fissile shale with occasional stringers of bright vitrain, possibly representing individual plant remains such as cordaite

leaves. Segments 1, 2 and 3 of the coal seam proper are rather uniform in appearance, consisting of alternating bands of vitrain ("bright coal") and clarain (petrologic terms as defined by Stopes, 1919, and Stach, 1968) usually in bands 5 mm (0.2 in.) or less thick. Segment 4 is a friable gray coal whose basic petrologic character is difficult to determine; during maceration, it was found to contain appreciably more fusain and silicate material than the surrounding segments. Segments 5 through 8 are characterized by a dominance of tough, dense durain ("dull coal"); vitrain bands are virtually absent except in the lower portion of segment 5 and in the upper part of segment 8. Segment 9 resembles segment 4, but is not as friable. The upper two segments, 10 and 11, contain abundant vitrain bands exceeding in number and thickness those observed in the basal portion of the seam.

CP-19-4 occupies the interval 27.9 to 29.8 meters (91'8" to 97'7") below the ground surface in the core (the core was logged using feet-and-inch measurements which will be retained here for descriptive clarity; the log is unpublished, but along with other coal coring project logs, is on open file at the Iowa Geological Survey in Iowa City). The seam is immediately overlain by 2.7 meters (9 feet) of dark gray, pyritic, shaley siltstone to silty shale which is interlaminated with minor, occasionally calcareous, light gray, bioturbated siltstone. The upper coal contact is gradational over about 0.5 cm (1/4 inch). The base grades into a medium dark gray clayey, sandy siltstone which grades downward into a light gray massive sandstone; the sandstone grades into an interbedded sandstone-siltstone sequence with a total thickness from the base of the seam to the next major lithologic change of about 4 meters (13 feet). The relative influences of marine and non-marine conditions on the sediments above and below the coal seam are not obvious, and therefore it is not possible to define from the sedimentology whether the sequence containing coal CP-19-4 resulted from a transgression or regression of marine waters, or from some non-marine succession of events. This ambiguity of sediment origin is common to coal-bearing sequences in the Lower Cherokee, and contributes strongly to the difficulties of lithostratigraphic correlation noted earlier.

Miospore Profile—Three major miospore associations which are related closely to the petrologic categories of the seam have been recognized. For purposes of discussion, these associations have been designated after their characteristic miospore genera: The *Florinities* interval, the *Densosporites-Crassispora* interval, and the *Lycospora* interval. It is to be stressed that these designations apply only to the miospore distribution of CP-19-4, and are not considered a model for miospore paleoecology of other Iowa coals: insufficient data exist at present to permit such generalizations about miospore distributions in coals of the Cherokee Group.

The *Florinities* interval: The lower third of the seam (CP-19-5, segments 1-3 of CP-19-4) contains a high percentage of gymnosperm-related miospores, dominated by *Florinities mediapudens* (fig. 5). Lesser percentages of *Florinities millotti*, *Pityosporites westphalensis*, *Wilsonites* spp., *Potoniaisporites elegans* and other

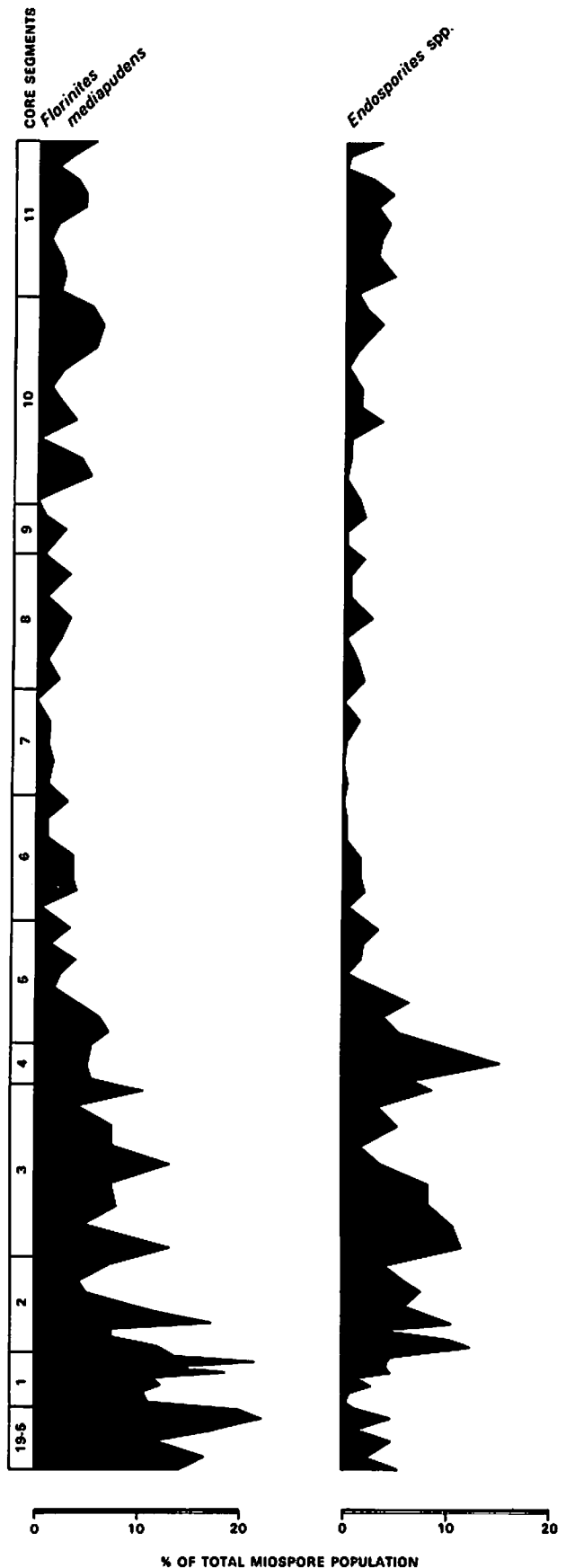


Figure 5. Miospore profiles of *Florinities mediapudens* and *Endosporites* spp. within CP-19-4.

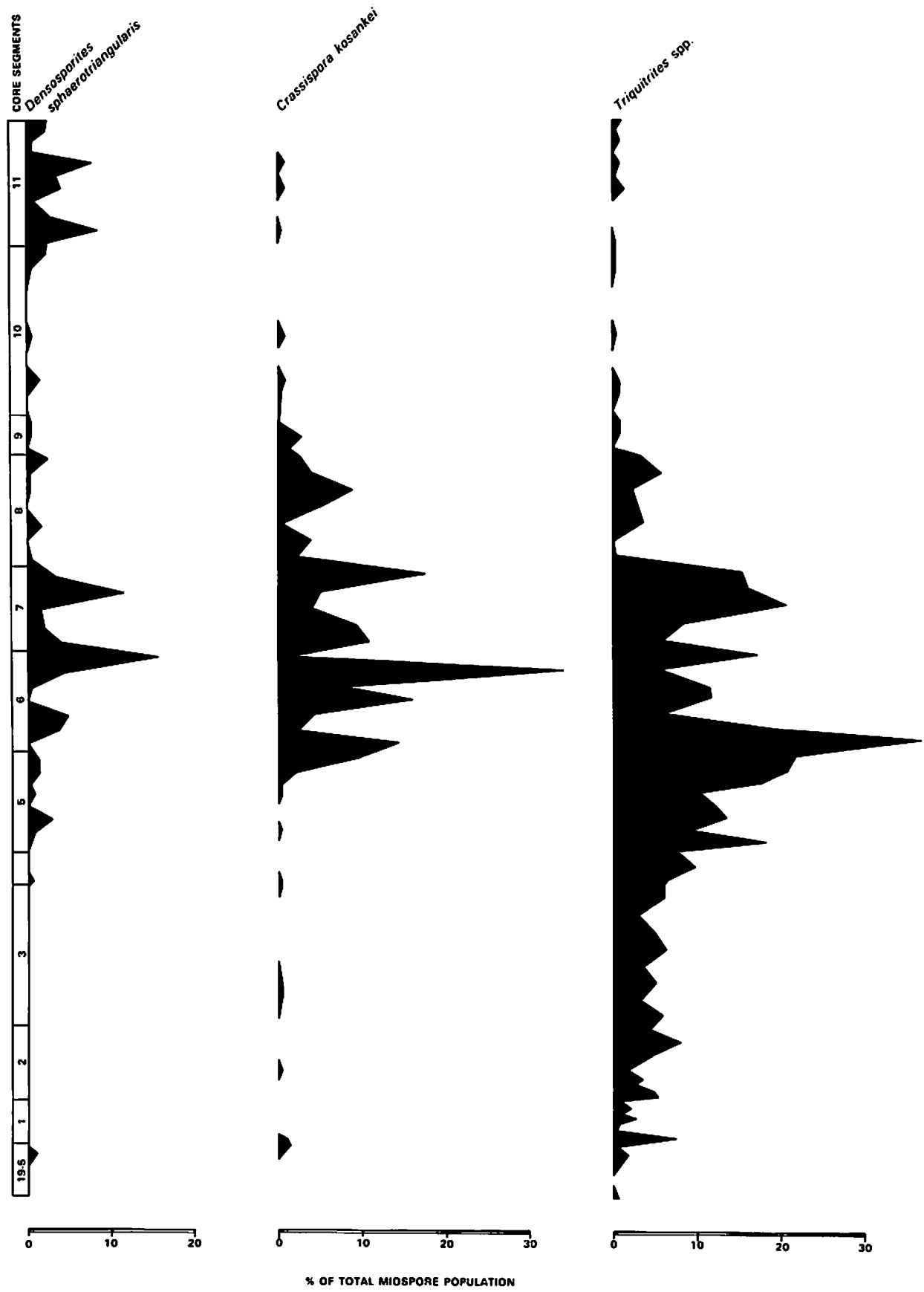


Figure 6. Miospore profiles of *Densosporites sphaerotriangularis*, *Crassispora kosankei* and *Triquirites* spp. within CP-19-4.



Figure 7. Miospore profiles of *Lycospora granulata* and *Lycospora pellucida* within CP-19-4.

gymnospermous saccate taxa occur. *Lycospora pellucida*, *Endosporites globiformis*, *Punctatisporites minutus* and *Laevigatosporites globosus* are characteristic species having plant-group affinities other than gymnospermous. Other frequently observed species include *Laevigatosporites minutus*, *Laevigatosporites ovalis*, *Cappasporites distortus*, *Calamospora brevibradiata*, *Vestispora laevigata* and *Cyclogranisporites aureus*.

Certain horizons display a high diversity of miospore species; many rarer species, such as *Reinschospora triangularis* and *Dictyotriletes reticulocingulum* are contained almost exclusively in such horizons. In summary, the *Florinites* interval is characterized by an abundance of gymnospermous miospores, a high diversity of taxa, and restricted vertical distribution of several taxa not observed elsewhere in the seam.

The *Densosporites-Crassispora* interval: The middle portion of the seam (segments 4-9) is marked by a sharp reduction in the number and diversity of gymnospermous miospores, and by the appearance in high percentages of *Densosporites sphaerotriangularis* and *Crassispora kosankei* (fig. 6). Various species of *Triquitrites*, *Cyclogranisporites minutus*, and fern-related miospores of the genus *Granulatisporites* also increase. The abundance of *Lycospora pellucida* varies widely throughout the interval. The species increases in abundance to over 30% of the miospore population in segment 4, declines to 2-10% through segments 5 and 6, and increases sharply in segment 7, reaching peaks of over 50% in segments 8 and 9. *Cyclogranisporites aureus*, *Calamospora brevibradiata*, *Punctatisporites minutus*, *Laevigatosporites minutus*, *Laevigatosporites ovalis*, *Cappasporites distortus*, *Vestispora laevigata* and *Endosporites globiformis* remain relatively common throughout the interval.

In general, fern-related taxa are more important in the miospore population of the *Densosporites-Crassispora* interval than they are in the *Florinites* interval, and gymnosperm-related taxa, conversely, are much less important. A few species (e.g., *Vestispora luminata*, *Dictyotriletes distortus*) are confined to the interval, but the presence of vertically-restricted taxa is not as characteristic of the *Densosporites-Crassispora* interval as it is of the *Florinites* interval. Diversity of species in the *Densosporites-Crassispora* interval is somewhat less than that in the *Florinites* interval.

The *Lycospora* interval—The upper third of the seam (segments 10 and 11) is characterized by the dominance of *Lycospora granulata*, which consistently constitutes 50% or more of the miospore population (fig. 7). The change in the most abundant species of *Lycospora* from *L. pellucida* in the lower two intervals to *L. granulata* in the uppermost interval is abrupt, occurring at the base of segment 10. *Crassispora kosankei* becomes uncommon above segment 8, and is observed only occasionally in the *Lycospora* interval. *Densosporites sphaerotriangularis* is also seldom observed from the top of segment 8 to the top of segment 10, where it again appears in abundance ranging up to nearly 10%. *Florinites mediapudens* is virtually the only gymnosperm-related taxon seen in the *Lycospora* interval; it increases slightly in abundance over the numbers encountered in the *Densosporites-*

Crassispora interval.

The *Lycospora* interval is characterized also by a reduction in the diversity of the miospore population. *Triquitrites* spp. virtually disappear, as do a number of fern-related taxa important in the *Densosporites-Crassispora* interval (e.g., *Cyclogranisporites minutus*, *Granulatisporites adnatoides*, *Lophotriletes* spp., *Acanthotriletes triquetrus*).

The total miospore profile, categorized by major plant-group affinities, is shown in fig. 8. It reveals that changes in the floras throughout peat deposition tend to be reflected most strongly by various lycopsid-related miospores, whereas certain other plant groups, particularly sphenopsids, appear to have remained constant throughout the existence of the coal swamp. In addition to the sphenopsid-related miospores (*Calamospora* spp., larger *Laevigatosporites* spp., *Vestispora* spp.), the more uniform components of the miospore flora include *Cappasporites distortus* and a group of miospores believed related to marattialean ferns (smaller *Laevigatosporites* spp., *Punctatisporites minutus*, *Torispora securis*).

PALEOECOLOGICAL INTERPRETATION OF MIOSPORE PROFILES

A primary interest of this study is the evaluation of the floral paleoecology of the coal swamp as recorded in its miospore profile. The progression of peat deposition through changing environmental conditions may have had an influence on certain physico-chemical features of the coal, such as its sulfur content; stratigraphic relations of coal seams may also be clarified through comparison of the miospore profiles of seams to their overall population frequencies. These points will be discussed in more detail shortly.

In order to interpret the paleoecology of the seam from its miospore profile, several questions must be answered: How much is known of the paleobotanical affinities of dispersed miospores in the Pennsylvanian? How accurately does the dispersed miospore population record the actual local plant community? How reliable are analogies between modern environments and the plant fossil record of the Pennsylvanian? What were the paleoecological preferences of the various Pennsylvanian plant groups?

Many major miospore genera have been associated directly with major plant groups through paleobotanical studies; as related to the miospore population of CP-19-4, these affinities are discussed in the Taxonomy. Genera with known plant affiliations include nearly all of those quantitatively important in CP-19-4. It must be noted, however, that miospore genera are based on morphological characteristics, and do not imply phylogenetic affinity of the various species assigned to them. Some genera (e.g., *Punctatisporites*, *Laevigatosporites*, *Cyclogranisporites*), are known to contain species of varied phylogenetic affinities; others (e.g., *Granulatisporites*) probably do as well. Nonetheless, many important genera (e.g., *Calamospora*, *Lycospora*) have been correlated repeatedly with

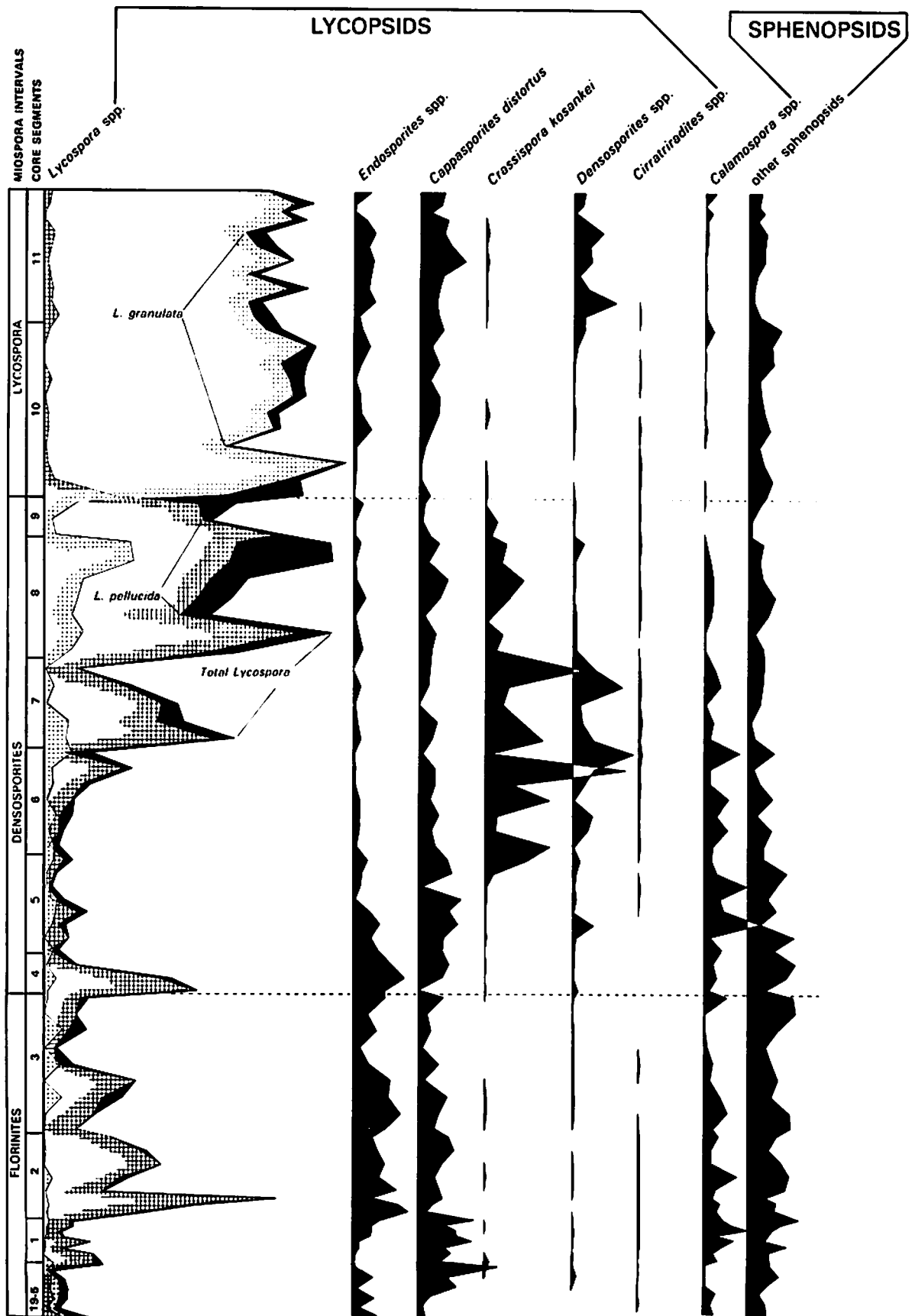
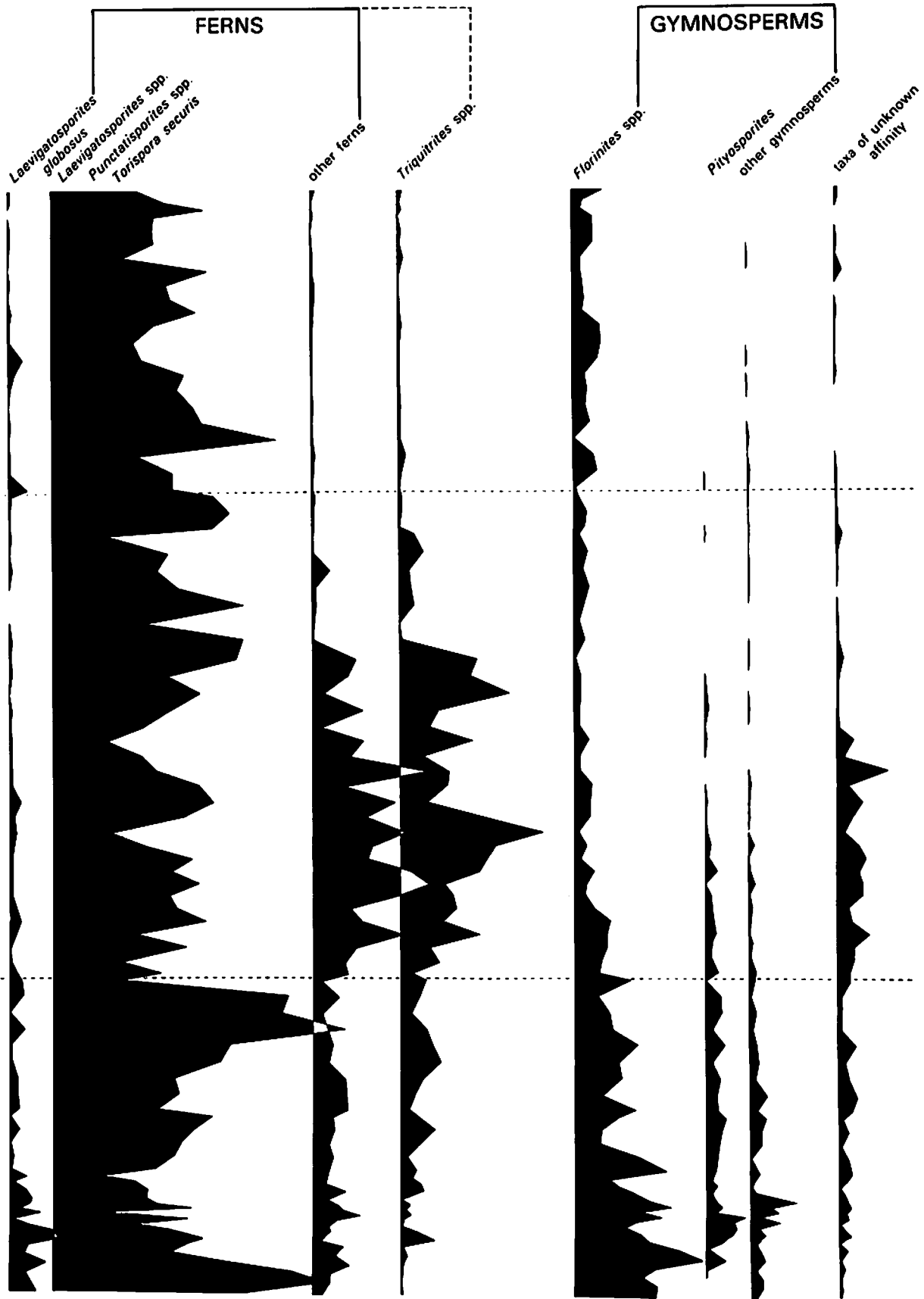


Figure 8. Total miospore profile of CP-19-4, with taxa keyed to major plant groups according to known paleobotanical affinities.



particular plant groups, and others (e.g., *Vestispora*) display morphologies so distinctive that it is likely the form genus reflects a phylogenetically related group of species.

Certain gross miospore morphologies appear to be characteristic of major plant groups, although interpretations based on simple physical characteristics must be approached with caution. Many round to sphaerotriangular trilete spores with conspicuous cinguli or similar equatorial structures (e.g., *Lycospora*, *Densosporites*, *Cirratriletes*) are known to be of lycopsid origin. Small deltoid trilete spores of various ornamentation (e.g., *Leiotriletes*, *Lophotriletes*) have been associated consistently with ferns, suggesting that a similar genus such as *Anapiculatisporites*, which has never been reported *in situ*, is probably fern-related also.

The parent plants of many genera presently remain unknown, although future paleobotanical study seems certain to resolve some of these mysteries. Some distinctive spores (e.g., *Cadiospora*, *Reinschospora*) have not been isolated from fructifications; others (e.g., *Alatisporites*) have been observed *in situ*, but the affinities of the fructifications are uncertain (Courvoisier and Phillips, 1975).

Study of modern pollen suggests proceeding with caution in interpreting the paleoecological significance of miospore form species and form genera. The taxonomic level to which one can distinguish pollen from modern plants varies widely from group to group. Pollen of the various major species of walnuts (*Juglans*) ordinarily can be differentiated; pollen of the major species of elms (*Ulmus*) cannot. Both genera contain species that grow in a variety of environmental conditions. Pollen of grasses (Gramineae) ordinarily cannot be differentiated below the family level. Miospores of some Pennsylvanian form taxa seem likely to have been produced by phylogenetically unrelated plants with a variety of paleoenvironmental preferences.

Preservation—Modern pollen grains are affected differentially by physical and chemical decomposition of organic detritus (Sangster and Dale, 1961), and ancient miospores probably suffered in a similar manner. Examples exist in modern pollen studies where certain grains, for instance *Populus*, are not preserved, or are destroyed during sample preparation (Erdtman, 1969). This phenomenon may occur with pre-Quaternary samples as well. Some taxa with thinner exines are normally found in torn or folded condition, while thicker or more compact miospores are usually better preserved. Unidentifiable fragments of exine found in most samples are more likely to be pieces of diaphanous genera such as *Calamospora* or *Cappasporites* than they are to be from *Densosporites* or *Triquitrites*. Large saccata taxa such as *Endosporites* and *Florinites* often can be identified at least to the generic level from partial specimens; a consistent criterion must be applied for identification of individual specimens in such cases.

Spore preservation in CP-19-4 generally was excellent. Minor corrosion of grains was noted in the upper third of the seam, though it was not severe enough to prevent identification of well-oriented specimens.

Coals of the North American Midcontinent commonly exhibit poorer preservation in upper portions of seams than in lower portions (L. R. Wilson, personal communication, 1977), perhaps due to slight oxidation related to sediments overlying the coal seam. The exine degradation in CP-19-4 is not believed to result in significant selective loss of taxa, though this possibility must not be discounted. The presence throughout the seam of miospores such as *Cappasporites distortus*, which has a thin and easily broken exine, argues against major preservational bias between different horizons of CP-19-4.

Miospore rain—The relationship of the miospore population to the contemporaneous flora at any given time is difficult to assess. The tool of the Quaternary palynologist, comparison of the pollen rain to the extant plant population of a particular environment, is not available for study of Paleozoic deposits. Even in Quaternary studies, projection of a local or regional plant community from a pollen record is difficult and often speculative (Moore and Webb, 1978). It is necessary, therefore, to deal with numbers of various miospores as relative amounts, and to take into consideration the possibility that abundant spore producers in the Pennsylvanian may bias a given miospore population disproportionately to their actual presence in the coal swamp.

An assumption central to interpretation of paleoecology on the basis of dispersed spores is that the spore population is derived dominantly from the contemporaneous flora of the local environment, i.e., as sediment, the spores are autochthonous. By analogy with studies of modern pollen rain, it seems probable that the quantitative influence of miospores from sources other than local or near-local is minor, especially if the Carboniferous peat swamp was a forest (Janssen, 1966). Exceptions may exist, however. The organic sediments of most coals are believed to be autochthonous, although examples of allochthonous or semi-allochthonous coals are known (Hacquebard and Donaldson, 1969). Modern peat-forming environments thought to be similar to Carboniferous coal-forming environments usually do not display great amounts of transport of pollen by moving water, although some has been postulated (Habib and Groth, 1967). In instances of large-scale transport, miospores are subject to oxidation and tend to be poorly preserved. Other indications of sediment transport (e.g., significant amounts of fusain are often present (Hacquebard and Donaldson, 1969).

Aerial transport of miospores into the peat swamp from adjacent areas is another potential source of difficulty in paleoecological interpretation. Observations of modern forests indicate that pollen from distant sources does not contribute greatly to the total pollen rain (Faegri and Iversen, 1975), though individual grains can be transported great distances (Maher, 1969); some rare grains in Paleozoic sediments may have been transported in this manner. The situation in environments of more open vegetation, such as open moors and marshes, is less clear. Pollen rain from an adjacent forest can be significant, but the pollen production of modern marshes and grassy environments also can exceed that of forests

(Faegri and Iversen, 1975), tending to dilute allochthonous pollen contribution.

Few studies have been done comparing microfossils with macrofossils in Carboniferous coals. Those that exist (e.g., Phillips, Peppers, Avcin and Laughnan, 1974) indicate a good correlation between the miospore content and the macrofossil content of many coals. Similar results have been obtained in comparisons of Quaternary palynology and macrofossil study of autochthonous sediments (Watts and Winter, 1966; Baker, 1976; Van Zant, 1976). Studies of extant flora and pollen production (e.g., Davis and Webb, 1975) suggest that the relationship of pollen rain to flora generally is close, and the quantitative effect of pollen grains foreign to the flora is minimal. In the absence of other evidence or anomalies, the miospore population of most coals is believed to reflect accurately the contemporaneous local flora. A thorough discussion of the transport problem in deposition of pollen and spores may be found in Tschudy (1969).

Modern environmental analogs—Determination of modern analogs to Carboniferous coal swamps has been a matter of controversy and debate for many years. Our limited knowledge of plant group affinities of miospores and of the paleoenvironmental tolerances of ancient plants restricts direct comparisons of Carboniferous miospore successions with palynological profiles of recent peat swamps. Without postulating an exact environmental analog, it is possible through study of modern swamps to suggest the potential lateral and vertical variation in miospore populations and petrographic character of coals in areas as complex stratigraphically as the Lower Cherokee Group of Iowa.

Cohen (1974) described and illustrated spatial variation in peat-forming environments and corresponding plant communities within the Okefenokee Swamp in Georgia. The swamp complex consists basically of shrub-and-tree swamps, unforested marshes or "prairies" with standing water and floating vegetation, sand islands, and open-water lakes. Cohen related these variations to pre-swamp topography, and noted that they had changed little in basic extent and character through the history of the swamp. He also observed a basal zone of charcoal and abundant siliceous sponge spicules, and suggested that it indicated a period of peat oxidation before the peat now present began to accumulate. A phenomenon similar to this could produce high-silica, fusain-rich layers in Carboniferous coals, such as segment 4 of CP-19-4.

Comparison of a pollen diagram with a petrologic study of peat from the Whitewater Bay area near Cape Sable, southern Florida (Cohen and Spackman, 1972) revealed a strong correlation between palynological and petrological characteristics. Similar observations were made by A. H. V. Smith, (1957, 1962) and other workers on Carboniferous coal seams. In contrast to the Okefenokee Swamp study (Cohen, 1974), Cohen and Spackman (1972) noted that both the petrology and the palynology of the southern Florida swamp peat recorded a number of environmental alterations through time, including a major shift from fresh-water peats near the

base to salt-water peats above.

Spackman, Riegel and Dolsen (1969) described lateral relations of various peat-forming environments in the same region. They noted that a few inches difference in elevation relative to the water table often resulted in considerable differences in vegetation and organic sedimentation. Variations in the spore-pollen content of surface samples in the Whitewater Bay area were observed previously by Spackman, Scholl and Taft (1964), who distinguished associations of certain plants with marine (*Rhizophora*, *Avicennia*), brackish (*Conocarpus*, *Polypodium*, *Taxodium*, *Typha*, Cyperaceae, Compositae) and fresh-water (*Ovoidites*, *Pinus*, *Nymphaea*, *Sagittaria*, *Cephalanthus*, Chenopodiaceae) environments. Spackman, Cohen, Given and Casagrande (1974) observed correlative petrographic variations in the peat at several localities in the Whitewater Bay area. Palynological analyses were not performed on all localities, but, if the observations of Cohen and Spackman (1972) apply, similar correlative variations in the spore-pollen content of the peats reflecting changing environments might be expected. A form of "event stratigraphy" recorded by changes in the palynological content of the peat might allow correlation between localities even when total pollen populations vary widely at separate localities due to local environmental factors.

CARBONIFEROUS MIOSPORE SUCCESSIONS

The most extensive previous investigations of miospore successions in Carboniferous coal seams are those of A. H. V. Smith (1957, 1962) on the Coal Measures of Great Britain. Smith (1957) presented a depositional model for the British coal swamps based on correlation of coal petrography with miospore assemblages. As the coals he studied span the stratigraphic horizon represented by CP-19-4 and contain many of the same miospore taxa, a comparison of Smith's (1957) model and the miospore succession of CP-19-4 is in order.

Smith (1957) described a series of miospore "phases" which tended to occur in a particular order in the British coal seams. These he labeled "Lycospore", "Transition", "Densospore" and "Incursion". The Lycospore and Densospore Phases were named after their respective dominant miospore genera. The Transition Phase was, as its name implies, transitional in miospore content and, presumably, in paleoenvironment between the Lycospore and Densospore Phases. The Incursion Phase was believed to be a record of a period of inundation of the swamp by fresh water. Smith (1957) observed that the Lycospore Phase always occurs at the base of British coal seams, and that the Lycospore and Densospore Phases never occur vertically adjacent to one another; the Transition Phase always intervenes. The Incursion Phase is an irregular component which might be found anywhere within a seam. The Lycospore-Transition-Densospore-Transition-Lycospore sequence might be repeated any number of times, with two or more Lycospore or Densospore Phases repeated around a Transition, and with Incursion Phases randomly present.

Petrographically, the Lycospore Phase is associated with "bright coal" (vitrain) and the Densospore Phase with "dull coal" (vitrain-durain); these associations were recognized by earlier workers (e.g., Knox, 1942) in less formal ways, and are consistent with the gross petrographic character of the various intervals of CP-19-4 (see figure 3). It is tempting to equate Smith's (1957) Lycospore Phase with both the *Florinites* and *Lycospora* intervals of CP-19-4, his Densospore Phase with the *Densosporites-Crassispora* interval, and his Transition Phase with the two silica-fusain rich units (segments 4 and 9); an IncurSION Phase might be considered perhaps as the cause of the vertically-restricted occurrences of rare taxa in the *Florinites* interval. However, although similarities exist in the distributions of some major taxa (e.g., *Densosporites sphaerotriangularis*), between Smith's (1962) model and CP-19-4, there are many important differences: *Crassispora kosankei* is an important component of the *Densosporites-Crassispora* interval of CP-19-4, but Smith (1962) considered it characteristic of his IncurSION Phase; *Lycospora granulata* dominates the *Lycospora* interval of CP-19-4, but is a Transition Phase species in the British coals. Certain species (e.g., *Dictyotriletes bireticulatus*, *Verrucosisorites* spp., *Apiculatisporis additus*) are much more abundant in the British coals than in CP-19-4; others significant to CP-19-4 (e.g., *Cappasporites distortus*, *Triquitrites* spp., *Potonieisporites elegans*) are not mentioned in Smith's (1962) report. Gymnosperm-related miospores are much more abundant in the miospore population of CP-19-4 and other Iowa coals than they appear to be in the British coals. Smith (1962) also stressed the importance of making paleoecological interpretations on the basis of species level taxonomy. The various species of the genus *Densosporites*, for example, do not occur in association with the same miospore phase in the British coals. A similar observation may be made for the two major species of *Lycospora* in CP-19-4 (fig. 7). A number of investigations of the paleoecology of coal seams have relied on the abundances of both these genera as taxonomic units with no note of species profiles.

Several other miospore successions have been studied by various workers in different geographical regions (Habib and Groth, 1967; Habib, 1968; Hacquebard and Donaldson, 1969; Koval'chuk and Uziyuk, 1973; Wilson, 1976). A variety of miospore succession patterns has been revealed. The likelihood emerges that coal swamps in local paleogeographical regions had different floral and sedimentological successions, influenced by a variety of tectonic, climatic and seral factors. The swamps may have originated and been terminated by a number of different mechanisms, and no single model will serve to explain all or even most of the paleoecological successions.

Our knowledge of the actual paleoecology of Carboniferous plants is extremely limited. Evidence regarding paleoenvironmental conditions of ancient floral communities is largely drawn through inference and is equivocal. Analogies drawn between fossil and recent plants based on apparent similarity of structures or presumed habitat must be approached with caution (Scott, 1977).

Disagreement exists over the paleoenvironmental relationships of the major plant groups reflected in the miospore successions. Neves (1958) suggested that the cordaites, represented by the distribution of *Florinites*, were marine-margin plants; Chaloner (1958c), employing the same data, argued that the cordaites were upland plants. Later, Chaloner (1968) suggested climatic control as a possible factor in cordaite distribution, as well. A similarity of root structure led Cridland (1964) to postulate a potential similarity of ecology between certain cordaites and modern mangroves. Other cordaite species appear to have had more upland habitats (Cridland and Morris, 1963). The rise of the gymnosperm-dominated floras of the Upper Pennsylvanian and Permian has been connected to the probable upland habitat of many earlier Pennsylvanian gymnosperms (Frederiksen, 1972).

As another example, Smith (1968) attributed the development of his Densospore Phase to the seral buildup of peat above the water surface, allowing plants favoring drier conditions to colonize the swamp. In contrast, Habib and Groth (1967) believed the upward increase in abundance of *Densosporites* in the Lower Kittanning Coal to indicate a change from a fresh- to a brackish-water environment as marine waters encroached upon the swamp during transgression. Their argument was based on comparison of the miospore distribution in their coal to palynological successions observed in the peat of the Whitewater Bay area (Spackman, Dolsen and Riegel, 1966), and suggests a mangrove-like role for the *Densosporites*-lycopods.

Owing primarily to lack of data, these and other similar interpretational problems remain unresolved. Detailed discussions of the major environmental controls on coal-swamp development may be found in Smith (1962) and Chaloner and Muir (1968).

INTERPRETATION OF CP-19-4

Palynology and Paleoecology

Based on the gross physical properties of the seam and on inferences drawn from other Carboniferous coals and modern peat swamps, the following working hypothesis is proposed to account for the miospore succession in CP-19-4:

Stage 1—Peat developed initially in an environment conducive to rapid variation in plant communities and/or occasional influx of miospores from an environment outside the immediate locality. Certain horizons in the lower portion of the seam contain miospores rare to absent elsewhere (e.g., level 1Z, which contains *Dictyotriletes reticulocingulum*, *Reinschospora triangularis*, and *Alatisporites pustulatus*). The predominance of *Florinites mediapudens*, *Pityosporites westphalensis*, *Potonieisporites elegans* and other gymnosperm-related taxa, plus *Endosporites globiformis*, indicates that the local flora was dominated by cordaites and *Endosporites*-producing lycopods. This flora is similar to that found in shales immediately beneath the Lower Kittanning Coal by Habib and Groth (1967). Various tree ferns (represented by *Punctatisporites minutus*, *Laevigatosporites globosus* and other species) and lepidodendrons (*Lycospora pellucida*) were also

prominent. Abundant fusain fragments in the lowermost samples suggest the possibility of a period or periods of peat destruction during the early stage of swamp development; a similar phenomenon has been noted in certain modern peat swamps (Cohen, 1974).

Two major possibilities, or a combination of the two, could account for the high diversity and rapid changes in minor elements of the miospore population during peat deposition: (1) Fluctuations in water level may have caused rapid changes in the local plant community; (2) An occasional environmental event, such as a storm or flood, may have contributed a brief pulse of allochthonous miospores from regions outside the peat swamp, and mixed them with miospores from the local flora. The first case resembles the situation observed by Spackman, Riegel and Dolsen (1969) in the Whitewater Bay area of southern Florida, where considerable differences in flora from one locality to another are controlled by relatively small differences in elevation with respect to the water table.

Stage 2—A concentration of fusain and a high silica content (possibly a residual concentrate) suggest a period of drier conditions which resulted in partial peat destruction and/or a reduced rate of peat accumulation during the time represented by segment 4 of CP-19-4. Significant changes in both major and minor elements of the miospore population support the likelihood of a major environmental change, although it is not possible from the miospore population alone to determine the exact character of the alteration of environment.

Stage 3—A period of more open marsh conditions is suggested by the abundance of *Densosporites sphaerotriangularis* (herbaceous lycopod), *Cyclogranisporites minutus*, *Lophotriletes* spp., *Granulatisporites* spp., (small ferns) and *Triquirites* (probable small ferns) in segments 5 through 8. Herbaceous plants appear to be more strongly represented in the miospore population of the *Densosporites* interval than they are in other portions of the seam. Miospores known to have affinities with arborescent plants are still present, however, particularly the lycopod represented by *Crassispora kosankei* (*Sigillaria*: Courvoisier and Phillips, 1975). Perhaps these latter plants were more suited to open growth than were lepidodendrons (*Lycospora*), which appear to have been closed-forest plants; *Lycospora* is poorly represented in the miospore population until segments 7 and 8, when *L. pellucida* becomes the dominant miospore species. *Densosporites sphaerotriangularis* and the small fern-related miospores conversely decrease in abundance in segments 7 and 8. These changes are relatively gradual, and appear to record the encroachment of a more forested swamp into the open marsh.

Several hypotheses have been proposed to account for horizons that show abundant *Densosporites* in other coals, ranging from a lowering of the water table in the swamp (Smith, 1962, 1968) to increased salinity during a marine transgression (Habib and Groth, 1967). Again, from the miospore succession alone, it is not possible to determine which of these hypotheses is more applicable, or if other paleoecological factors were involved. Correlation of palynology with other lines of inquiry, such as petrography and geochemistry, might be of

assistance in interpreting the depositional environments of such palynologically distinct horizons within coal seams.

Stage 4—A second period of partial peat destruction and/or slowed accumulation similar to that of Stage 2 is recorded in segment 9 of CP-19-4. The change in composition of the miospore assemblage in this instance is very abrupt, occurring at the top of segment 9. The sudden shift in dominant species of *Lycospora* from *L. pellucida* to *L. granulata* has been discussed previously in the Description of CP-19-4. The abruptness of this and other changes noted in the miospore population at this horizon indicates a period of peat destruction or non-accumulation during which the character of the local flora changed.

Stage 5—The final major stage of peat deposition appears to have taken place in a relatively stable forested swamp. *Lepidodendrons* (*Lycospora granulata*) dominated the flora, and the diversity of plants was reduced. Few changes in the miospore succession are recorded in segments 10 and 11 of CP-19-4. *Densosporites sphaerotriangularis* does become abundant again in segment 11, possibly indicating development of more widespread areas of herbaceous vegetation within the forest, although the other herbaceous plant miospores common to Stage 3 do not return in abundance. *Cordaites* (*Florinites mediapudens*) and *Endosporites*-producing lycopods were moderately abundant, and sphenopsids (*Calamospora*, *Laevigatosporites* spp.) were somewhat reduced in number.

STRATIGRAPHIC POSITION OF CP-19-4

The miospore population of CP-19-4 indicates an age equivalent to the Pope Creek Coal of Illinois (Peppers, personal communication, 1977), the uppermost coal of the Abbott Formation, which is conventionally correlated to the uppermost Atoka Series of the Midcontinent (Willman et al., 1975). Stratigraphic relationships between Atoka and the overlying Des Moines Series are poorly known, but the miospore biostratigraphy of CP-19-4 and other coals from Iowa Geological Survey core holes suggest an older age for the lower portion of the Pennsylvanian section in southeast and south-central Iowa than was thought previously.

A number of relatively rare miospore species were observed in CP-19-4 which appear to be at or near the upper limit of their range in comparison to the Illinois Basin, and to other coals in Iowa. These taxa include *Endosporites staplinii*, *Dictyotriletes bireticulatus*, *Radiizonates* cf. *difformis*, *Densosporites anulatus* and *Cristatisporites indignabundus*. Certain species, e.g., *Densosporites irregularis* and *Waltzisporea sagittata* were observed in CP-19-4 above their previously reported stratigraphic ranges; it is possible that these taxa were redeposited from older sediments, although the source of such sediments is problematical. It seems more likely that these spores represent rare local plants in or adjacent to the coal swamp. Similar circumstances certainly existed for rare species observed well below their previously reported ranges, e.g., *Platysaccus saarensis* and *Aumancisporites striatus*. As the palynology of coals from the stratigraphic horizon represented by CP-19-4 has not been described extensively from the Midcontinent,

seemingly anomalous occurrences such as these are not surprising.

Several other taxa appear to have narrow ranges of occurrences in Iowa, confined to one or two coals in the lower portions of other cores; these include *Zosterosporites triangularis*, *Peppersites ellipticus*, *Wapellites variabilis*, *Pseudoillinites diversiformis*, *Adeliosporites multiplicatus*, *Cuneisporites rigidus*, and *Tetanisporites granulatus*. Ordinarily, the absence of certain miospores from the population would be regarded as negative evidence of dubious value, but as the miospore population of CP-19-4 was examined much more exhaustively than are most samples (22,000 spores counted plus scanning of several hundred slides for rare taxa), the absence of taxa known to become prominent in coals only slightly higher in the section is also considered diagnostic. Conspicuous by their absence were such species as *Vesicaspora wilsonii* Schemel 1951, *Microreticulatisporites sulcatus* (Wilson and Kosanke) Smith and Butterworth 1967, *Schopfites dimorphus* Kosanke 1950, *S. colchesterensis* Kosanke 1950, *Cadiospora magna* Kosanke 1950, *Mooreisporites inusitatus* (Kosanke) Neves 1961, *Murospora kosankei* Somers 1952, and *Thymospora pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963; a species somewhat similar to the latter was observed (Plate 16, figs. 2-4), but was very rare. Species mentioned above are not described and illustrated in this report, but will be in a forthcoming study dealing with stratigraphic range of miospores in the Cherokee Group coals, (Iowa Geological Survey Technical Paper 7, in preparation).

Finally, the overall population frequencies of abundant taxa such as *Lycospora granulata*, *L. pellucida*, *Cappasporites distortus*, *Punctatisporites minutus*, *Laevigatosporites globosus*, *L. ovalis*, *Endosporites globiformis* and *Florinites mediapudens* (as noted in diagrams and data table) are typical of the lower Des Moines-upper Atoka interval in the Illinois Basin (Peppers, personal communication, 1977).

The miospore assemblage described above is present in equivalent coals from other Iowa Geological Survey cores, and is easily distinguished from those found in horizons both above and below. It appears to be one of the more persistent and laterally continuous in the Iowa section studies so far and is frequently of potential economic thickness, although other factors such as thickness of overburden and sulfur content will affect minability. The coal provides one of the best defined biostratigraphic horizons for subsurface correlation of the lower Cherokee.

On the basis of its palynology, CP-19-4 correlates with the coals indicated in fig. 9, the same diagrammatic

cross-section of cores shown in fig. 3, with proposed correlations added. CP-19-4 represents the lower of two persistent seams that occur in a close relationship in many of the cores studied in the course of the drilling project. One or the other of these seams occasionally is absent (as in CP-17), perhaps because of a channel cut-out or some other post- or syndepositional factor; the absence of the upper seam in CP-19 appears to result from post-depositional erosion. The palynological character of these two seams is similar, and when only one is present, distinction of the stratigraphic relationship is difficult on the basis of the total miospore population.

CONCLUSION

A series of events is reflected in the miospore profile of CP-19-4. This palynological record of depositional events may differ from that of another coal seam, even though total miospore populations averaged over the total thickness of each seam (i.e., channel-sampled) may be similar. The miospore profile of a seam may relate additionally to a larger progression of depositional environments as might be expected during phases of marine transgression or regression common to the Pennsylvanian of the North American Midcontinent. These phases of deposition, in turn, may exert significant control over physico-chemical characteristics of coal seams, such as their sulfur and trace-element contents. Such potential relationships between the palynology of coals and other characteristics remain virtually unexamined.

Sampling intervals as fine as those employed in the analysis of CP-19-4 probably are not necessary in order to determine only the major characteristics of miospore profiles of coal seams. Following the initial research on CP-19-4, procedures were established at the Iowa Geological Survey Coal Division whereby coal cores are routinely split into benches ranging from 4 to 12 cm. (1.6 to 4.7 inches) in thickness. These benches are crushed individually and portions are removed and combined to create a composite sample for each seam, which is then processed for palynology. After evaluation of the composite (essentially a channel) sample, bench samples may be processed and examined as appropriate for resolution of specific problems. Data from these examinations are on open file at the Iowa Geological Survey, and are being employed for stratigraphic correlation within the Cherokee Group. Reports on correlations within specific study areas are in preparation and will be published as the project proceeds.

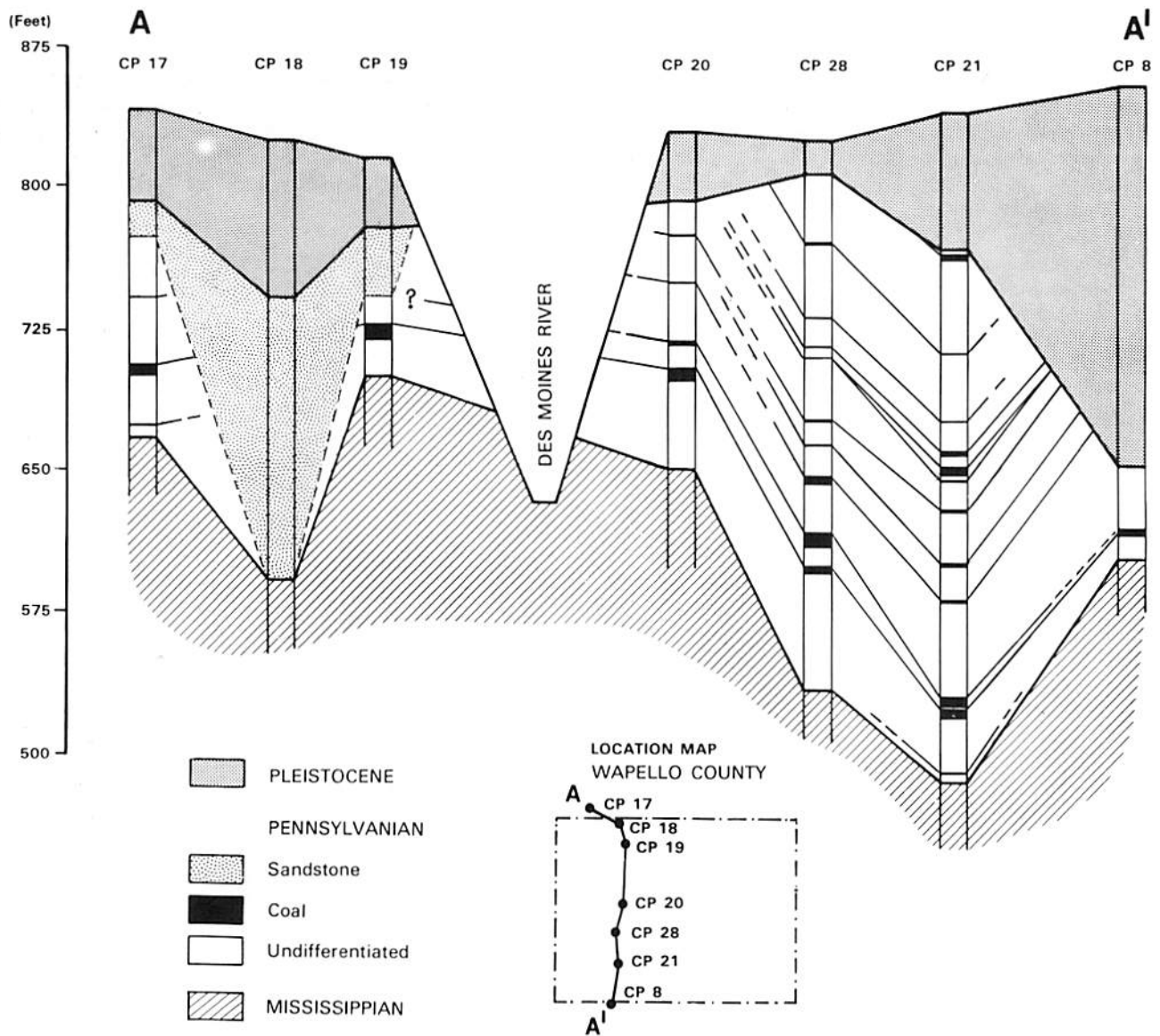


Figure 9. Correlated cross-section from figure 3, with seam correlations based on palynological data.

TAXONOMY

Generic classification follows the system of Potonié and Kremp (1954, 1955, 1956), except for those genera described subsequently by others.

No formal taxonomic classification of miospores is attempted above the generic level, although for convenience of comparison with other literature, the organization of taxa generally follows that of Smith and Butterworth (1967) and Peppers (1970). The author agrees with the objections expressed by Schopf (1969) to form taxonomy above the level of the genus; thorough discussions of the intricacies of miospore systematics and nomenclature may be found in Smith and Butterworth (1967) and Schopf (1969).

Comparison of palynological studies is not always easy due to differences in reporting techniques employed by various investigators (Turnau, 1978). This is particularly vexing in comparison of the occurrence of less abundant species. Some investigators have chosen to disregard rare miospores in making stratigraphic or paleoecological interpretations of miospore assemblages, although the experience of Quaternary palynologists suggests that proper evaluation of palynological samples must include consideration of scarce taxa as well as abundant ones (Moore and Webb, 1978). As this report and its companion paper (Ravn, IGS Technical Paper 7, in preparation) are intended as basic reference reports, both are designed to be as comprehensive in description of the Iowa Pennsylvanian miospore assemblages as is reasonably possible. A major concern of the studies has been to assess the relative utility of the various miospore taxa for stratigraphic purposes in Iowa; notes concerning the stratigraphic usefulness (or lack thereof) of each miospore species described will be given in Technical Paper 7.

Only those species observed in CP-19-4 are noted in this report. Other miospore species important to correlation of Iowa coals which occur at different stratigraphic horizons will be described in future publications. In a few instances, specimens from coals other than CP-19-4 have been illustrated for comparison, or because they demonstrated more clearly the diagnostic characteristics of proposed new taxa.

As floral paleoecology of the coal swamp is a principal concern of this paper, notes are made of the known paleobotanical affinities of the various miospore genera. It is stressed that, as miospore species are morphologically defined, the particular known affinity or affinities of the miospore genus may not apply to all species assigned to that genus.

All new genera and species are provided with formal diagnoses. Synonymies and discussions of individual taxonomic problems are given when appropriate. Terms applied to indicate relative abundance are modified and expanded from Smith and Butterworth (1967) as follows:

Rare	Specimens encountered only on final scanning of slides
Infrequent	Less than 0.5% of the miospore population of the sample

Frequent	0.5–2.0%
Common	2.0–5.0%
Very common	5.0–10.0%
Abundant	10.0–25.0%
Dominant	Greater than 25.0%

The general distribution of each miospore species within CP-19-4 also is noted. Those species indicated simply as "Rare" without subsequent modifying comment were considered to be too few in number to assess the characteristics of distribution meaningfully. Specific information on the occurrence and abundance of all miospore species in seam CP-19-4 may be found in Appendix II.

Genus *LEIOTRILETES* (Naumova) Potonié and Kremp 1954

Type species—*L. sphaerotriangulus* (Loose) Potonié and Kremp 1955.

Discussion—Genus *Leiotriletes* encompasses trilete, deltoid miospores having laevigate external surfaces, though they may on occasion bear fine infrasculpture. The Mesozoic genera *Deltoidospora* Miner 1935 and *Cyathidites* Couper 1953 are very similar, but the name *Leiotriletes* is in general use for miospores of this type from the Paleozoic.

Affinity—Filicales (Remy and Remy, 1957; Potonié 1962); coenopterids (Good, 1979).

Leiotriletes guennelii nom. nov. emend.
(Plate 1, fig. 1)

1958 *Leiotriletes parvus* Guennel, p. 57, text-fig. 14, pl. 2, fig. 7, 8.

non 1953 *Leiotriletes parvus* Naumova, p. 44, pl. 5, fig. 10.
non 1958 *Leiotriletes parvus* Nilsson, p. 30, pl. 1, fig. 1.

Diagnosis—(emended from Guennel, 1958, p. 57) Miospores radial, trilete, triangular in equatorial outline, usually in good proximal-distal orientation. Interradial margins straight to slightly concave, angles rounded. Laesurae straight, extend $\frac{1}{2}$ to $\frac{3}{4}$ to margin. Lips present, thin, sometimes indistinct. Exine laevigate both externally and internally, relatively thin, seldom folded.

Size—(from Guennel, 1958, p. 57) 16–28 microns maximum diameter.

Discussion—*L. parvus* Guennel 1958 appears to be a junior homonym of the Mesozoic *L. parvus* Nilsson 1958 (Nilsson is one of the few Mesozoic palynologists to employ the generic name *Leiotriletes*), necessitating the adoption of a new name for the species. *L. parvus* Naumova 1953 is also a homonym, but Naumova's names were not erected in accordance with provisions of the International Code of Botanical Nomenclature and are generally considered invalid among Western workers, although many (e.g., genus *Leiotriletes*) have been validated through emendation by later investigators.

Loboziak (1971) considered *L. parvus* Guennel 1958 to be synonymous with *L. subadnatoides* Bharadwaj 1957, but the latter species is described as "intra-punctate" (Bharadwaj, 1957a), whereas specimens observed in CP-19-4 display no internal ornamentation, even under a high-power oil immersion

objective. The emendation of Guennel's (1958) description of *L. parvus* is made to clarify and emphasize the absence of ornamentation of *L. guennelii*. The small size distinguishes *L. guennelii* from the larger *L. priddyi* (Berry) Potonié and Kremp 1955.

Derivation—The specific name is proposed in recognition of G. K. Guennel, who originally described the species.

Occurrence—Rare.

Leiotriletes levis (Kosanke) Potonié and Kremp 1955
(Plate 1, figs. 4, 8)

- 1950 *Granulati-sporites levis* Kosanke, p. 21, pl. 3, fig. 5.
1955 *Leiotriletes levis* (Kosanke) Potonié and Kremp, p. 38.
1966 *Ahrensiporites vagus* Habib, p. 640, pl. 106, fig. 5.

Discussion—*L. levis* differs from the type species, *L. sphaerotriangulus* (Plate 1, fig. 3), in the possession of conspicuous thickened areas around the trilete mark.

Occurrence—Rare, lower portion of the *Florinites* interval.

Leiotriletes priddyi (Berry) Potonié and Kremp 1955
(Plate 1, fig. 2)

- 1937 *Zonales-sporites priddyi* Berry, p. 156, text-fig. 2.
1944 *Granulati-sporites* (?) *priddyi* (Berry) Schopf, Wilson and Bentall, p. 33.
1950 *Plani-sporites priddyi* (Berry) Knox, p. 316, pl. 17, fig. 220.
1955 *Leiotriletes priddyi* (Berry) Potonié and Kremp, p. 38.

Discussion—As noted by Smith and Butterworth (1967), the original description and illustration of this species are inadequate for proper comparison. Nonetheless, the general size range and dimensions given by Berry (1937) and modified through usage of later workers cover forms of *Leiotriletes* not assignable to other described species. In practice, during study of CP-19-4 and other Iowa coals, forms ranging in maximum diameter from 28 to 36 microns, and having straight to convex interradial margins are assigned to *L. priddyi*.

Occurrence—Rare, observed most often in the *Florinites* interval.

Leiotriletes sphaerotriangulus (Loose) Potonié and Kremp 1955
(Plate 1, fig. 3)

- 1932 *Sporonites sphaerotriangulus* Loose in Potonié Ibrahim and Loose, p. 451, pl. 18, fig. 45.
1933 *Laevigati-sporites sphaerotriangulus* (Loose) Ibrahim, p. 20.
1944 *Punctati-sporites sphaerotriangulatus* (Loose) Schopf, Wilson and Bentall, p. 31.
1950 *Plani-sporites sphaerotriangulatus* (Loose) Knox, p. 316, pl. 17, fig. 214.
1954 *Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, p. 120.
1955 *Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, p. 41, pl. 11, figs. 107-109.
1965a *Deltoidisporites sphaerotriangulus* (Loose) Laveine, p. 131, pl. 10, fig. 6.

Discussion—In practice in this report, unornamented forms of *Leiotriletes* having straight or convex interradial sides and a maximum diameter of 36-50 microns are assigned to *L. sphaerotriangulus*. The combination *L.*

sphaerotriangulus was proposed by Potonié and Kremp in 1954, but not properly validated until their 1955 publication (Kremp and Ames, 1959).

Occurrence—Rare, *Florinites* interval.

Leiotriletes turgidus Marshall and Smith 1964
(Plate 1, fig. 7)

- 1964 *Leiotriletes turgidus* Marshall and Smith, p. 658, pl. 99, figs. 1-3.

Occurrence—Rare, coaly shale CP-19-5.

Leiotriletes sp. 1
(Plate 1, fig. 5)

Description—Radial, trilete, triangular in equatorial outline with distinctly concave interradial margins. Exine laevigate, moderately thin (1.5-2 microns). Laesurae straight, $\frac{2}{3}$ to $\frac{3}{4}$ of spore radius, angles rounded. Darkened contact area surrounds trilete mark. Size of illustrated specimen 32.5 microns maximum diameter.

Discussion—*L.* sp. 1 resembles *L. priddyi* in size, but differs in possession of concave interradial margins.

Occurrence—Rare.

Leiotriletes sp. 2
(Plate 1, fig. 6)

- 1970 *Leiotriletes* sp. 1, Peppers, p. 82, pl. 1, fig. 10.

Description—Radial, trilete, triangular in equatorial outline, with straight to slightly concave interradial margins. Exine faintly infrapunctate (?), thin (1.0-1.5 microns), with occasional crescentic folds adjacent to equator near angles. Laesurae straight $\frac{2}{3}$ of spore radius, faint contact area may be present. Size of illustrated specimen 31.9 microns maximum diameter.

Discussion—This miospore appears to be identical to *L.* sp. 1 of Peppers (1970).

Occurrence—Rare.

Leiotriletes sp. 3
(Plate 1, fig. 9)

Description—Radial, trilete, triangular in equatorial outline, inter-radial margins slightly convex. Exine laevigate, possibly infragranulose, thick (about 3 microns) and dark, appearing in compression as a faint equatorial "zona". Laesurae straight, $\frac{1}{2}$ of spore radius. Size of illustrated specimen 55.5 microns maximum diameter.

Discussion—*L.* sp. 3 is uncommonly large for the genus.

Occurrence—Rare.

Genus PUNCTATISPORITES (Ibrahim)
Potonié and Kremp 1954

Type species—*P. punctatus* (Ibrahim) Ibrahim 1933.

Affinity—*Punctatisporites* is a broadly defined, generalized form genus encompassing spores of many different plants of fern affinities (Mamay, 1950, 1957; Remy and Remy, 1955a; Abbott, 1961; Pfefferkorn, Peppers and Phillips, 1971; Courvoisier and Phillips, 1975). Miospores conforming to the species *P. kankakeensis* Peppers 1970 recently have been isolated

from a pteridosperm fructification (Stidd, 1978). Long (1977a) also illustrated spores possibly corresponding to *Punctatisporites* from a pteridosperm.

Punctatisporites aerarius Butterworth
and Williams 1958
(Plate 2, figs. 4, 5)

1958 *Punctatisporites aerarius* Butterworth and Williams, p. 360, pl. I, figs. 10, 11.

Occurrence—Rare, but widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals.

Punctatisporites cf. *curviradiatus* Staplin 1960
(Plate 1, figs. 13-15)

1960 *Punctatisporites curviradiatus* Staplin, p. 7, pl. 1, figs. 17, 20.

1965 *Punctatisporites curviradiatus* Staplin 1960; Omara and Schultz, p. 52, pl. 24, fig. 5.

Discussion—Miospores assigned to *P.* cf. *curviradiatus* resemble the type description of Staplin (1960), except for being more oval in outline and having the appearance of a narrow zona. Miller (1966) described similar spores with granulose surface, erecting the genus *Circlettisporites* on the basis of the off-polar compression and what he interpreted to be a peculiar sort of zona. Wilson and Venkatachala (1967) determined that the "zona" was merely the appearance of the relatively thick exine in compression, invalidated *Circlettisporites*, and assigned the species erected by Miller (*C. dawsonensis*) to *Leschikisporis* Potonič 1958; they also assigned another species with an asymmetrical trilete mark, *Punctatisporites obliquus* Kosanke 1950, to *Leschikisporis*. Staplin (1960) noted the similarity of *P. curviradiatus* to species of *Leschikisporis*, but stated that *P. curviradiatus* did not possess the single shortened trilete ray characteristic of *Leschikisporis*; nonetheless, his illustrated specimens appear to possess a shortened ray similar to that observed in *P. curviradiatus*.

Peppers (1970) considered the asymmetrical laesurae to be of insufficient importance to warrant assignment to a new genus and retained *P. curviradiatus* and *P. obliquus* under *Punctatisporites*. Peppers' practice is followed in this report. Specimens of *P.* cf. *curviradiatus* observed in CP-19-4 and other Iowa coals closely resemble the specimen illustrated by Omara and Schultz (1965) from the Lower Carboniferous of North Africa. *P. resolutus* Playford 1971, from the Lower Carboniferous of Australia, is similar in general aspects to *P.* cf. *curviradiatus*, but is larger and has a finely granulose infrasculpture.

Occurrence—Rare, but widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals.

Punctatisporites edgarensis Peppers 1970
(Plate 2, fig. 7)

1970 *Punctatisporites edgarensis* Peppers, p. 82-83, pl. 1, figs. 16, 17.

Occurrence—Rare, observed only in coaly shale CP-19-5.

Punctatisporites cf. *edgarensis* Peppers 1970
(Plate 2, fig. 8)

Discussion—*P.* cf. *edgarensis* differs from the type in possessing conspicuous, well-defined vermiform to convolute ridges on the distal surface. The occurrence of *P.* cf. *edgarensis* in CP-19-4 and other Iowa coals does not always coincide with that of *P. edgarensis*, but frequently the two forms are found together. They appear to be morphologically distinct; it is not clear whether *P.* cf. *edgarensis* should be regarded as a separate species or merely as a variant of the type.

Occurrence—Rare, lower levels of the *Florinites* interval.

Punctatisporites kankakeensis Peppers 1970
(Plate 2, fig. 2)

1970 *Punctatisporites kankakeensis* Peppers, p. 83-84, text-fig. 12, pl. 2, figs. 2, 3.

Occurrence—Rare.

Punctatisporites minutus (Kosanke)
Peppers 1964
(Plate 1, figs. 10, 11)

1950 *Punctatisporites minutus* Kosanke, p. 15, pl. 16, fig. 3.

1964 *Punctatisporites minutus* (Kosanke) Peppers, p. 31, pl. 4, fig. 7.

non 1967 *Punctatisporites minutus* Kosanke 1950, Smith and Butterworth, p. 126, pl. 1, figs. 15, 16.

Discussion—In this report, assignment of miospores to *P. minutus* adheres to the emendation of Peppers (1964). The spores described and illustrated by Smith and Butterworth (1967) as *P. minutus* Kosanke 1950 do not appear to be the same species.

Occurrence—*P. minutus* is abundant throughout CP-19-4, occasionally a dominant species at certain horizons in the *Florinites* interval.

Punctatisporites nitidus Hoffmeister,
Staplin and Malloy 1955
(Plate 1, fig. 12)

1955 *Punctatisporites nitidus* Hoffmeister, Staplin and Malloy, p. 393-394, pl. 36, fig. 4.

Occurrence—Rare.

Punctatisporites cf. *nudus* Artüz 1957
(Plate 2, fig. 1)

1957 *Punctatisporites nudus* Artüz, p. 241, pl. 1, fig. 4.

1970 *Punctatisporites* sp. 1 Peppers, p. 84, pl. 2, fig. 8.

Discussion—*P.* cf. *nudus* closely resembles the type description of Artüz (1957), but, as the miospore is spherical, laevigate, and has a thick exine, it resembles a number of other described species as well. The assignment of miospores to this species is made, therefore, with reservation. It appears to be identical to *P.* sp. 1 of Peppers (1970).

Occurrence—Rare.

Punctatisporites obliquus Kosanke 1950
(Plate 15, fig. 7)

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

1967 *Leschikisporis obliquus* (Kosanke) Wilson and Venkatachala, p. 364.

Discussion—As noted by Peppers (1970), distinction of *P. obliquus* from *Laevigatosporites globosus* Schemel

1951 is difficult in practice. Peppers employed a size boundary of 30 microns maximum dimension to distinguish the species, *P. obliquus* being the larger. Forms displaying the vestigial third ray were comparatively rare in CP-19-4, whereas monolet forms larger than 30 microns occurred more commonly; orientation of individual grains frequently obscures the laesura such that the possible presence of a third ray is uncertain. The reliability and usefulness of distinguishing the two species for statistical purposes in CP-19-4 was considered questionable; the population figure given for *L. globosus* in the data includes *P. obliquus*. A specimen assignable to *P. obliquus* is displayed on plate 15 adjacent to specimens of *L. globosus* for visual comparison.

Occurrence—See *Laevigatosporites globosus* Schemel 1951.

Punctatisporites sp. 1
(Plate 2, fig. 3)

Description—Miospore radial, trilete, circular in equatorial outline. Laesurae simple, straight, length about $\frac{2}{3}$ of spore radius. Exine finely punctate, moderately thick, appearing in compression as a zona approximately 3 microns wide. Size of illustrated specimen 43.3 microns maximum diameter.

Discussion—*P.* sp. 1 bears resemblances to a number of species of *Punctatisporites*, but is not assignable with certainty to any.

Occurrence—Rare.

Genus PHYLLOTHECOTRILETES Lubert 1955

Type species—*P. nigritellus* (Lubert) Lubert 1955.
Affinity—Unknown.

Phyllothecotriletes sp. 1
(Plate 2, fig. 6)

Description—Miospore radial, trilete, circular in equatorial outline. Laesurae straight, with distinct lips, less than $\frac{1}{2}$ of spore radius. Exine thick (3 or more microns), finely punctate, with round to elongate pits 1-3 microns in maximum dimension and about 1 micron deep, scattered irregularly over the entire surface. Slightly darkened contact area in region of trilete mark on proximal surface. Size of illustrated specimen 102.2 microns maximum diameter.

Discussion—*Phyllothecotriletes* sp. 1 is considerably larger than other described species of *Phyllothecotriletes*.

Occurrence—Rare.

Genus CALAMOSPORA Schopf, Wilson and Bentall 1944

Type species—*C. hartungiana* Schopf in Schopf, Wilson and Bentall 1944.

Affinity—Various sphenopsids (Arnold, 1944; Delevoryas, 1955; Kosanke, 1955; Remy, 1955; Walton, 1957; D. L. Smith, 1962; Baxter, 1963; Hibbert and Eggert, 1965; Abbott, 1968; Thomas, 1969; Courvoisier and Phillips, 1975; Good and Taylor, 1975; Good, 1976). The studies of Good and Taylor (1975) and Good (1976)

have suggested strongly that the morphologic speciation of *Calamospora* is unreliable for stratigraphic utility. Few palynologists in recent years have considered species *Calamospora* as having much stratigraphic significance, and the discussions of the various species in this report indicate the taxonomic difficulties within the genus. Millay (1979) isolated spores from a species of the marattialean fern *Scolecopteris* which, if found in dispersed spore residues, probably would be assigned to *Calamospora*.

Calamospora breviradiata Kosanke 1950
(Plate 3, fig. 2)

- 1950 *Calamospora breviradiata* Kosanke, p. 41, pl. 9, fig. 4.
1957a *Calamospora minuta* Bharadwaj, p. 80, pl. 22, figs. 8, 9.
non 1950 *Calamospora minutus* Knox, p. 332, pl. 19, fig. 301.
1957a *Calamospora saariana* Bharadwaj, p. 81, pl. 22, figs. 13-15.
1965a *Calamisporites breviradiatus* (Kosanke) Laveine, p. 131.
1966 *Calamisporites minutus* (Bharadwaj) Coquel, p. 17, pl. 1, fig. 15.

Discussion—A maximum size boundary of 70 microns is employed in this study to differentiate *C. breviradiata* from the larger *C. hartungiana*; most specimens of *C. breviradiata* were smaller than 65 microns maximum diameter, whereas most specimens of *C. hartungiana* were larger than 75 microns, indicating a bimodal size distribution for the two forms. The darkened contact area common to both species is less pronounced in *C. hartungiana* than in *C. breviradiata*. At the lower end of the size range quoted by Smith and Butterworth (1967, p. 131-132) for *C. cf. breviradiata* of 42 microns, no similar natural break occurs, at least in the coal examined for this report. The smaller but otherwise morphologically identical *C. minuta* Bharadwaj 1957 is therefore considered conspecific with *C. breviradiata*. *C. saariana* Bharadwaj 1957 appears indistinguishable from *C. breviradiata*.

Occurrence—*C. breviradiata* is the most abundant species of *Calamospora* observed in CP-19-4. It is frequent to common throughout the seam, with greatest abundance in the *Florinites* interval and lower levels of the *Densosporites-Crassispora* interval.

Calamospora hartungiana Schopf in Schopf,
Wilson and Bentall, 1944
(Plate 3, fig. 5)

- 1944 *Calamospora hartungiana* Schopf, in Schopf, Wilson and Bentall, p. 51-52, text-fig. 1.
1965a *Calamisporites hartungianus* (Schopf) Laveine, p. 131.
1966 *Calamospora elliptica* Habib, p. 632-633, pl. 104, figs. 9, 10.

Occurrence—Rare, but widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals.

Calamospora liquida Kosanke 1950
(Plate 3, fig. 3)

- 1950 *Calamospora liquida* Kosanke, p. 41-42, pl. 9, fig. 1.
1965a *Calamisporites liquidus* (Kosanke) Laveine, p. 131, pl. 10, fig. 9.

Occurrence—Rare.

Calamospora cf. mutabilis (Loose) Schopf,
Wilson and Bentall 1944
(Plate 3, fig. 4)

- 1932 *Calamiti*?-*Sporonites mutabilis* Loose in Potonié Ibrahim and Loose, p. 451, pl. 19, figs. 50a-c.
1934 *Calamiti*?-*Sporites mutabilis* Loose, p. 145.
1944 *Calamospora mutabilis* (Loose) Schopf, Wilson and Bentall, p. 52.
1965a *Calamisporites mutabilis* (Loose) Laveine, p. 131, pl. 10, fig. 7.

Discussion—*C. mutabilis* is somewhat larger than *C. hartungiana* and is described and illustrated as possessing longer laesurae and no darkened contact area. Spores designated in this report as *C. cf. mutabilis* possess rather short laesurae and are somewhat thicker and less folded than are specimens referred to *C. mutabilis* by other authors (e.g., Peppers, 1970, pl. 2, fig. 12). In this study, specimens larger than 75 microns in maximum dimension displaying no darkened contact area were assigned to *C. cf. mutabilis*.

Occurrence—Rare.

Calamospora nebulosa sp. nov.
(Plate 3, figs. 8-12)

Diagnosis—Miospores radial, trilete, circular in equatorial outline, normally in good proximal-distal orientation. Laesurae straight, with distinct lips, $\frac{1}{3}$ to $\frac{1}{2}$ of spore radius. Distal hemisphere possesses an irregular thickened region around pole, commonly superimposed through compression upon trilete mark, giving the appearance of a proximal contact area. Crescentic compression folds along equator common, but polar regions seldom folded. Exine moderately thick for the genus, 2-2.5 microns.

Size—(11 specimens) 63-94 microns maximum diameter.

Discussion—*C. nebulosa* is similar to *C. hartungiana* in size, but differs in the possession of a distal thickening and the absence of a proximal contact area. The generally good proximal-distal orientation in compression is unusual for the genus and suggests either that the spore originally was subspherical or possibly that the distal thickening exercised a degree of control over the depositional orientation prior to burial and compression. No other species of *Calamospora* is known to possess a distal thickening. The distal thickening may represent a remnant of an attachment structure for elaters (see Discussion of *Elaterites* Wilson 1943).

Derivation—The specific nomen refers to the cloudy (*nebulosa*) appearance of the distal thickening.

Occurrence—Rare, observed most often in the *Densosporites-Crassispora* interval.

Holotype—Plate 3, fig. 9, slide 6Z4 coordinates 139-35, 85.2 microns maximum diameter.

Paratype—Plate 3, fig. 8, slide 6Z2 coordinates 125-45, 72.4 microns.

Paratype—Plate 3, fig. 10, slide 6Z1 coordinates 123.5-54.5, 94.1 microns.

Paratype—Plate 3, fig. 11, slide 1B4 coordinates 121.5-49.5, 83.8 microns.

Paratype—Plate 3, fig. 12, slide 6Z4 coordinates 130-32.5, 87.0 microns.

Calamospora cf. pedata Kosanke 1950
(Plate 3, figs. 6, 7)

- 1950 *Calamospora pedata* Kosanke, p. 42, pl. 9, fig. 3.
1965a *Calamisporites pedatus* (Kosanke) Laveine, p. 131, pl. 10, fig. 8

Discussion—Miospores designated *C. cf. pedata* resemble the type description of Kosanke (1950) in general aspect and particularly in the characteristic single fold, but differ in possessing raised laesurae with distinct lips. A faint contact area is often present in *C. cf. pedata* as well, and the laesurae are somewhat shorter than are those of the type.

Occurrence—Rare, observed primarily in the *Densosporites-Crassispora* interval.

Calamospora straminea Wilson and Kosanke 1944
(Plate 3, fig. 1)

- 1944 *Calamospora straminea* Wilson and Kosanke, p. 329, fig. 1.
1958 *Punctatisporites stramineus* (Wilson and Kosanke) Guennel, p. 68, pl. 4, figs. 5-8.

Occurrence—Rare.

Genus ELATERITES Wilson 1943

Type species—*E. triferens* Wilson 1943.

Affinity—Spores of genus *Elaterites* were first described from an Iowa coal ball (Wilson, 1943), where they were found associated with Calamarian fructifications. Similar reports of *Elaterites* from Calamitean cones were made from Kansas (Wilson, 1963a) and again from the original Iowa locality (Baxter and Leisman, 1967). More recently, elater-bearing spores have been described from a variety of Pennsylvanian sphenopsid fructifications (Good and Taylor, 1974, 1975; Good, 1975, 1976). Good and Taylor (1975) reviewed previous reports of perisporate or elater-bearing spores suggestive of *Elaterites* and suggested that the dispersed spore genera *Calamospora*, *Elaterites* and *Vestispora* (Wilson and Hoffmeister) Wilson and Venkatachala 1963 may represent ontogenetic stages of phylogenetically similar spores. The similarity of *Elaterites* and certain species of *Vestispora* with striate exoexines (e.g., *V. costata* (Balme) Spode in Smith and Butterworth, 1967; *V. lucida* (Butterworth and Williams) Potonié 1960; *V. colchesterensis* Peppers 1970) tends to support their view. Non-striate species of *Vestispora* (e.g. *V. fenestrata* (Kosanke and Brokaw) Spode in Smith and Butterworth, 1967; *V. luminata* sp. nov.) are more difficult to relate to *Elaterites*. As many of the form species of *Vestispora* have distinct stratigraphic ranges (Smith and Butterworth, 1967; Clayton *et al.*, 1977), evaluation of potential phylogenetic and/or ontogenetic relationships between *Calamospora*, *Elaterites* and *Vestispora* is by no means simple.

Elaterites triferens Wilson 1943
(Plate 4, fig. 1)

- 1943 *Elaterites triferens* Wilson, p. 518, figs. 1-6.

Discussion—*E. triferens* has been reported only once previously from macerated coal residues (Peppers, 1970).

Specimens observed in CP-19-4 invariably displayed corroded and torn perisporia, suggesting that the elaters and perispores did not withstand conditions of preservation or preparation techniques well. In the absence of the perispore, the main spore body of *E. triferens* would be assigned to *Calamospora*. It is therefore possible that these spores originally were much more abundant in the spore population than presently recognized. Similar observations were made by Good and Taylor (1975). *Occurrence*—Rare.

Genus ADELISPORITES gen. nov.

Type species—*A. multiplicatus* sp. nov.

Diagnosis—Miospores radial, trilete, usually in good proximal-distal orientation. Laesurae raised, sinuous, commonly associated with folds near the margin, tending to support proximal face of grain upon compression, resulting in folds at the margin and on the distal surface, commonly resulting in a more or less hexagonal equatorial outline.

Derivation—The generic nomen refers to the inconspicuous appearance of the spore (*adelos*: hidden, secret), as it sometimes may be mistaken for a folded fragment of exine, especially at low magnifications.

Affinity—Unknown.

Adelisporites multiplicatus sp. nov.
(Plate 4, figs. 2-6)

Diagnosis—Miospores conforming to the characteristics of the genus. Central region often dark, obscuring laesurae. Exine 1.5-2 microns thick, laevigate. Laesurae often appear as a trilete-shaped fold 2-4 microns, wide; no commissure has been observed.

Size—(23 specimens) 21-34 microns maximum diameter.

Discussion—The rather irregular morphology of this spore may cause it to pass unrecognized in some samples. It may resemble folded small specimens of *Calamospora*, but it differs in the pseudohexagonal outline. Though not known to be abundant, its occurrence is frequent enough in Iowa coals to have potential stratigraphic utility.

Derivation—The specific nomen refers to the much-folded (*multiplicatus*) appearance of the spore.

Occurrence—Rare, but widely distributed in CP-19-4, especially in the *Florinites* interval.

Holotype—Plate 4, fig. 2, slide 1C2 coordinates 136.5-60, 26.8 maximum diameter.

Paratype—Plate 4, fig. 3, CP-19-5 slide B-2 coordinates 137-65, 29.1 microns.

Paratype—Plate 4, fig. 4, CP-19-5 slide Z-7 coordinates 128-51, 23.9 microns.

Paratype—Plate 4, fig. 5, slide 1C3 coordinates 137.5-45.5, 26.2 microns.

Paratype—Plate 4, fig. 6, slide 5H2 coordinates 120-52.5, 23.4 microns.

Genus VERRUCOSISPORITES (Ibrahim) Smith
and Butterworth 1967

Type species—*V. verrucosus* (Ibrahim) Ibrahim 1933.

Affinity—Miospores assignable to *Verrucosisporites* have been correlated with a variety of fern fructifications

(Remy and Remy, 1955a, 1957; Murdy and Andrews, 1957; Phillips and Rosso, 1970; Courvoisier and Phillips, 1975; Mapes, 1978; Millay, 1979).

Verrucosisporites donarii Potonié and
Kremp 1955
(Plate 4, fig. 7)

1955 *Verrucosisporites donarii* Potonié and Kremp, p. 67, pl. 13, fig. 193.

Occurrence—Rare, but widely distributed throughout CP-19-4.

Verrucosisporites microtuberosus (Loose) Smith
and Butterworth 1967
(Plate 4, fig. 9)

1932 *Sporonites microtuberosus* Loose in Potonié Ibrahim and Loose, p. 450, pl. 18, fig. 33.

1934 *Tuberculati-sporites microtuberosus* Loose, p. 147.

1944 *Punctati-sporites microtuberosus* (Loose) Schopf, Wilson and Bentall, p. 31.

1950 *Plani-sporites microtuberosus* (Loose) Knox, p. 316, pl. 17, fig. 211.

1955 *Microreticulatisporites microtuberosus* (Loose) Potonié and Kremp, p. 100, pl. 15, figs. 273-277.

1955 *Microreticulatisporites verus* Potonié and Kremp, p. 102-103, pl. 15, fig. 286.

1959 *Cyclogranisporites pergranulus* Alpern, p. 142, pl. 2, fig. 55, pl. 3, figs. 56-58.

1964 *Verrucosisporites verus* (Potonié and Kremp) Smith *et al.*, p. 1075, pl. 3, fig. 8.

1967 *Verrucosisporites microtuberosus* (Loose) Smith and Butterworth, p. 149, pl. 5, figs. 9-11.

Occurrence—Rare.

Verrucosisporites sifati (Ibrahim) Smith
and Butterworth 1967
(Plate 4, fig. 10)

1933 *Reticulati-sporites sifati* Ibrahim, p. 35, pl. 8, fig. 67.

1955 *Microreticulatisporites sifati* (Ibrahim) Potonié and Kremp, p. 102, pl. 15, figs. 282-285.

1967 *Verrucosisporites sifati* (Ibrahim) Smith and Butterworth, p. 152, pl. 6, fig. 1.

Occurrence—Rare.

Verrucosisporites verrucosus (Ibrahim) Ibrahim 1933
(Plate 4, fig. 8)

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

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

1938 *Azonotriletes verrucosus* (Ibrahim) Luber in Luber and Waltz, pl. 7, fig. 95.

1944 *Punctati-sporites verrucosus* (Ibrahim) Schopf, Wilson and Bentall, p. 32.

1950 *Verrucoso-sporites verrucosus* (Ibrahim) Knox, p. 319, pl. 17, fig. 230.

Occurrence—Rare, widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals of CP-19-4.

Genus KEWANEESPORITES Peppers 1970

Type species—*K. reticuloides* (Kosanke) Peppers 1970.

Affinity—Unknown.

Kewanesporites patulus (Peppers) Peppers 1970
(Plate 4, figs. 11-14)

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

1970 *Kewanesporites patulus* (Peppers) Peppers p. 95.

Discussion—Specimens observed in CP-19-4 did not possess the membrane noted by Peppers (1970). In his generic description, however, Peppers (1970, p. 94) stated that the membrane frequently is absent, due either to preservation or preparational difficulties. Specimens of *K. patulus* clearly displaying a membrane have been observed in other Iowa coals. *Trilites decoratus* Gupta 1970 has a similar ornament, but is smaller.

Occurrence—Rare.

Genus CYCLOGRANISPORITES Potonić and Kremp
1954

Type species—*C. leopoldi* (Kremp) Potonić and Kremp 1955.

Affinity—Various ferns and lyginopterid pteridosperms. Spores of *Cyclogranisporites* were listed as of pteropsid affinity by Potonić (1962). Andrews and Mamay (1948) recovered a spore possibly corresponding to the genus from a fern sporangium. Spores resembling *C. minutus* Bharadwaj 1957 have been isolated from a fern fructification of the Mazon Creek flora of Illinois (Pfefferkorn, Peppers and Phillips, 1971), and spores resembling *C. micaceus* Imgrund 1960 have been described from a Midcontinent fern fructification (Mapes and Schabillion, 1979). Apparent prepollen or pollen grains corresponding morphologically to *Cyclogranisporites* have been described from lyginopterid pteridosperm fructifications (Millay and Taylor, 1976, 1977; Millay, Eggert and Dennis, 1978). Hagemann (1966) recovered spores resembling smaller species of *Cyclogranisporites* from a lycopod fructification, but some of his illustrated specimens appear to possess a faint cingulum, a feature not characteristic of *Cyclogranisporites*.

Cyclogranisporites aureus (Loose) Potonić and Kremp
1955

(Plate 5, fig. 8)

1934 *Reticulatisporites aureus* Loose, p. 155, pl. 7, fig. 24.

1944 *Punctatisporites aureus* (Loose) Schopf, Wilson and Bentall, p. 30.

1950 *Planisporites aureus* (Loose) Knox, p. 315.

1955 *Cyclogranisporites aureus* (Loose) Potonić and Kremp, p. 61, pl. 13, figs. 184-186.

Occurrence—Rare to infrequent, widely distributed throughout the *Florinites* and *Densosporites-Crassispora* intervals; virtually absent from the *Lycospora* interval.

Cyclogranisporites cf. *leopoldi* (Kremp) Potonić
and Kremp 1955
(Plate 5, fig. 2)

1952 *Granulatisporites leopoldi* Kremp, p. 348, pl. 156, figs. 15, 16.

1954 *Cyclogranisporites leopoldi* (Kremp) Potonić and Kremp, p. 126, pl. 20, fig. 103.

1955 *Cyclogranisporites leopoldi* (Kremp) Potonić and Kremp, p. 62, pl. 13, figs. 174-178.

Discussion—The grana of specimens designated *C. cf. leopoldi* are larger and more conspicuous than those of specimens illustrated by Potonić and Kremp (1955). Although the combination *C. leopoldi* was first proposed by Potonić and Kremp in 1954, Kremp and Ames (1959) considered the name to be inadequately validated until Potonić and Kremp's (1955) publication.

Cyclogranisporites microgranus Bharadwaj 1957
(Plate 5, fig. 6)

1957a *Cyclogranisporites microgranus* Bharadwaj, p. 84, pl. 22, figs. 29-32.

Occurrence—Rare.

Cyclogranisporites minutus Bharadwaj 1957
(Plate 5, fig. 1)

1957a *Cyclogranisporites minutus* Bharadwaj, p. 83, pl. 22, figs. 22-23.

Discussion—*C. minutus* is distinguished from the similar-sized *C. leopoldi* by possession of finer, more closely spaced grana.

Occurrence—Rare to frequent in the *Florinites* interval, generally frequent in the *Densosporites-Crassispora* interval, virtually absent from the *Lycospora* interval.

Cyclogranisporites orbicularis (Kosanke)
Potonić and Kremp 1955
(Plate 5, fig. 5)

1950 *Punctatisporites orbicularis* Kosanke, p. 16, pl. 2, fig. 9.

1955 *Cyclogranisporites orbicularis* (Kosanke) Potonić and Kremp, p. 60.

Occurrence—Rare.

Cyclogranisporites parvus Bharadwaj 1957
(Plate 5, figs. 3, 4)

1957a *Cyclogranisporites parvus* Bharadwaj, p. 85, pl. 23, figs. 7, 8.

Discussion—*C. parvus* is similar in character of ornament to *C. minutus*, but is commonly somewhat larger and possesses a more or less symmetrical trilete mark with a pronounced darkened contact area.

Occurrence—Rare, but widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals.

Cyclogranisporites sp. 1
(Plate 5, fig. 7)

Description—Miospore radial, trilete, apparently spherical in original shape. Laesurae about ½ of spore radius, may be asymmetrical, with distinct lips. Exine relatively thin, evenly ornamented with low grana, approximately 1 micron in height, often elliptical in outline, long axis as much as 2 microns, densely packed with bases not quite touching. Crescentic compression folds commonly arranged along equator. Size of illustrated specimen 53.0 microns maximum diameter.

Discussion—The relatively large oval or elliptical grana approach the size and shape of verrucae, making this spore appear transitional between *Cyclogranisporites* and *Verrucosporites*. The character

of the compression folding resembles that of *C. provectus* (Kosanke) Potonié and Kremp 1955, but the granulose sculpture of the latter species is much finer.

Occurrence—Rare, *Densosporites*-*Crassispora* interval.

Genus GRANULATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species—*G. granulatus* Ibrahim 1933.

Affinity—Spores assignable to *Granulatisporites* have been isolated from Paleozoic and Mesozoic fern fossils (Mamay, 1950; Harris, 1961; Grauvogel-Stamm and Doubinger, 1975; Good, 1979). One species, *G. frustulentus* (Balme and Hassell) Playford 1971, described from the Australian Lower Carboniferous, is considered a "lycosporoid" element of the spore flora (Kemp *et al.*, 1977), and is likely to have lycosid affinity; this species has not been reported from North American or European coals. Millay, Eggert and Dennis (1978) have suggested that certain Lyginopterid pteridosperm prepollen or pollen grains with a trilete suture and a roundly triangular outline might be assigned to *Granulatisporites* if found dispersed.

Granulatisporites adnatoides (Potonié and Kremp)
Smith and Butterworth 1967
(Plate 5, figs. 13, 14)

- 1955 *Leiotriletes adnatoides* Potonié and Kremp, p. 38, pl. 11, figs. 112-115.
1960 *Granulatisporites parvigranulatus* Staplin, p. 15, pl. 3, figs. 8, 9.
1964 *Granulatisporites tenuis* Peppers, p. 20, pl. 12, figs. 11, 12.
1965a *Deltoidisporites adnatoides* (Potonié and Kremp) Laveine, p. 131.
1967 *Granulatisporites adnatoides* (Potonié and Kremp) Smith and Butterworth, p. 139, pl. 3, figs. 12-14.

Discussion—This species appears essentially laevigate at lower magnifications, and was interpreted as having a fine granulose infrasculpture by Potonié and Kremp (1955). Smith and Butterworth (1967) noted that examination at higher power under oil immersion revealed the outer surface of the spore to be granulose. The similar species *L. adnatus* (Kosanke) Potonié and Kremp 1955 is described as finely granulose in the region of the trilete mark; distinction of the two species is very difficult in practice, and they should perhaps be regarded as conspecific. Nearly all forms encountered in CP-19-4 possess grana visible at the margin, and they are therefore assigned to *G. adnatoides*. Other finely granulose species of similar size include *G. granularis* Kosanke 1950, *G. microgranifer* Ibrahim 1933 and *G. piroformis* Loose 1934; all these, however, appear distinctly granulose even at lower magnifications.

Occurrence—Rare to occasionally frequent in the *Densosporites*-*Crassispora* interval, rarely observed elsewhere in CP-19-4.

Granulatisporites granularis Kosanke 1950
(Plate 5, figs. 11, 12)

- 1950 *Granulatisporites granularis* Kosanke, p. 22, pl. 3, fig. 2.

Occurrence—Rare, observed most frequently in the *Florinites* interval.

Granulatisporites granulatus Ibrahim 1933
(Plate 5, figs. 15, 16)

- 1933 *Granulatisporites granulatus* Ibrahim, p. 22, pl. 6, fig. 51.
1950 *Planisporites granulatus* (Ibrahim) Knox, p. 315, pl. 17, fig. 217.
1957a *Granitriletes granifer* Dybová and Jachowicz, p. 125-127, pl. 31, fig. 3.

Occurrence—Rare.

Granulatisporites microgranifer Ibrahim 1933
(Plate 5, figs. 9, 10)

- 1933 *Granulatisporites microgranifer* Ibrahim, p. 22, pl. 5, fig. 32.
1938 *Azonotriletes microgranifer* (Ibrahim) Luber in Luber and Waltz, pl. 7, fig. 92.
1956 *Lophotriletes microgranifer* (Ibrahim) Ishchenko, p. 38, pl. 5, figs. 70-71.
1957a *Granitriletes microgranifer* (Ibrahim) Dybová and Jachowicz, p. 127-128, pl. 31, fig. 4.

Occurrence—Rare.

Granulatisporites parvus
(Ibrahim) Potonié and Kremp 1955
(Plate 5, figs. 17-19)

- 1932 *Sporonites parvus* Ibrahim in Potonié Ibrahim and Loose, pl. 15, fig. 21.
1933 *Punctatisporites parvus* Ibrahim, pl. 2, fig. 21.
1934 *Reticulatisporites parvus* (Ibrahim) Loose, p. 154, pl. 7, fig. 18.
1944 *Granulatisporites parvus* (Ibrahim) Schopf, Wilson and Bentall, p. 33.
1950 *Microreticulatisporites parvus* (Ibrahim) Knox, p. 321, pl. 18, fig. 247.
1955 *Granulatisporites parvus* (Ibrahim) Potonié and Kremp, p. 59, pl. 12, figs. 161-171.
1957b *Granitriletes parvus* (Ibrahim) Dybová and Jachowicz, p. 181, pl. 2, fig. 17.

Discussion—Potonié and Kremp (1955) considered *G. pallidus* Kosanke 1950 to be synonymous with *G. parvus*. Both species are recognized by Peppers (1970). His illustrations and comparisons of the illustrations and descriptions of Kosanke (1950) and Potonié and Kremp (1955) suggest that *G. pallidus* is more distinctly and densely granulose than is *G. parvus*. Miospores assignable to *G. pallidus* have been observed in other Iowa coals, but not in CP-19-4. The two species are herein considered distinct.

Occurrence—Rare, but widely distributed in the *Florinites* and *Densosporites*-*Crassispora* intervals; virtually absent from the *Lycospora* interval.

Genus LOPHOTRILETES (Naumova) Potonié and Kremp 1954

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

Affinity—Miospores assignable to *Lophotriletes* have been isolated from fern sporangia (Remy and Remy, 1957; Taylor and Eggert, 1969; Good, 1979).

Lophotriletes commissuralis (Kosanke) Potonié and Kremp 1955
(Plate 5, fig. 22)

- 1950 *Granulatisporites commissuralis* Kosanke, p. 20, pl. 3, fig. 1.
 1955 *Lophotriletes commissuralis* (Kosanke) Potonié and Kremp, p. 73, pl. 14, figs. 222, 223.
 non 1960 *Lophotriletes commissuralis* (Kosanke) Potonié and Kremp 1955; Imgrund, p. 164, pl. 15, figs. 66-68.
 1965a *Lophisporites commissuralis* (Kosanke) Laveine, p. 133.

Occurrence—Rare, widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals.

Lophotriletes confertus sp. nov.
 (Plate 6, figs. 9-13)

Diagnosis—Miospores radial, trilete, triangular in equatorial outline, usually in good proximal-distal orientation; interrarial margins straight to convex. Laesurae reaching approximately $\frac{3}{4}$ of spore radius, often somewhat obscured by ornamentation of exine, with slight, indistinct lips. Exine thick and dark, ornamented on both hemispheres with coarse coni having fused bases. Coni 2-5 microns in height, equal or broader at bases, reduced near or arranged concentrically along trilete mark; 18-25 coni are usually visible at margin. Fusing of bases may make coni appear elongate or irregular in outline.

Size—(16 specimens) 38-51 microns maximum diameter.

Discussion—This species is assigned to *Lophotriletes* due to the distinctly conate appearance of the ornament at the margin. The fusing of elements at their bases gives *L. confertus* a somewhat different appearance than most other species of the genus. It most closely resembles *L. insignitus* (Ibrahim) Potonié and Kremp 1955, in which the coni are of similar size and number, but are separated at their bases, and *L. ibrahimii* (Peppers) Pi-Radondy and Doubinger 1968, which has concave interrarial margins and only occasional fusing of bases of elements.

Derivation—The specific nomen refers to the crowded (*confertus*) nature of the ornament.

Occurrence—Rare, observed primarily in the *Florinites* interval.

Holotype—Plate 6, fig. 9, slide 2J2 coordinates 127.5-41, 43.3 microns maximum diameter.

Paratype—Plate 6, fig. 10, slide 1D5 coordinates 121.5-60.

Paratype—Plate 6, fig. 11, slide 2J6 coordinates 128-29, 50.2 microns.

Paratype—Plate 6, fig. 12, slide 2F2 coordinates 132-55, 47.9 microns.

Paratype—Plate 6, fig. 13, slide 1Y1 coordinates 122-36, 48.5 microns.

Lophotriletes copiosus Peppers 1970
 (Plate 6, figs. 6, 7)

- 1970 *Lophotriletes copiosus* Peppers, p. 97, pl. 5, figs. 25, 26.

Occurrence—Rare, *Florinites* interval.

Lophotriletes gibbosus (Ibrahim) Potonié and Kremp 1955
 (Plate 6, fig. 5)

- 1933 *Verrucosi-sporites gibbosus* Ibrahim, p. 25, pl. 6, fig. 49.
 1938 *Azonotriletes gibbosus* (Ibrahim) Luber in Luber and Waltz, pl. 7, fig. 91.
 1944 *Granulatisporites gibbosus* (Ibrahim) Schopf, Wilson and Bentall, p. 33.
 1950 *Verrucosi-sporites gibbosus* (Ibrahim) Knox, p. 317, pl. 17, fig. 232.
 1954 *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp, p. 129.
 1955 *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp, p. 74, pl. 14, figs. 220, 221.
 non 1958 *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp Guennel, p. 62, pl. 3, fig. 3.
 1965a *Lophisporites gibbosus* (Ibrahim) Laveine, p. 133.

Discussion—As for several of the species designated as type species of Potonié and Kremp's (1954) new genera, the specific name was not validated until 1955 (Kremp and Ames, 1959).

Occurrence—Rare.

Lophotriletes granoornatus Artüz 1957
 (Plate 5, figs. 24, 25)

- 1957 *Lophotriletes granoornatus* Artüz, p. 244, pl. 2, fig. 13.

Discussion—Assignment of miospores to *L. granoornatus* follows the practice of Peppers (1970), who noted that the photograph and drawing of the type specimen of Artüz (1957) are dissimilar. Specimens illustrated on plate 5 of this report closely resemble those illustrated by Peppers (1970, pl. 5, figs. 18, 23). Artüz characterized the ornament as consisting of grana; if this is correct, the species probably should be reassigned to *Granulatisporites*, but the type material should be re-examined before any such emendation is made.

Occurrence—Rare.

Lophotriletes ibrahimii (Peppers) Pi-Radondy and Doubinger 1968
 (Plate 5, fig. 26)

- 1964 *Granulatisporites ibrahimi* Peppers, p. 20, pl. 2, figs. 9, 10.
 1968 *Lophotriletes ibrahimi* (Peppers) Pi-Radondy and Doubinger, p. 412-414, pl. 1, fig. 2.

Discussion—Traverse, Ames and Spackman (1973) altered the spelling of the specific nomen from *ibrahimi* to *ibrahimii* as an orthographic correction.

Occurrence—Rare.

Lophotriletes microsaetosus (Loose) Potonié and Kremp 1955
 (Plate 5, fig. 23)

- 1932 *Sporonites microsaetosus* Loose in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 40.
 1933 *Setosi-sporites microsaetosus* (Loose) Ibrahim, p. 26.
 1934 *Setosisporites microsaetosus* (Loose) Loose, p. 148.
 1944 *Granulatisporites microsaetosus* (Loose) Schopf, Wilson and Bentall, p. 33.
 1950 *Spinoso-sporites microsaetosus* (Loose) Knox, p. 314, pl. 17, fig. 203.
 1955 *Lophotriletes microsaetosus* (Loose) Potonié and Kremp, p. 74, pl. 14, figs. 229-230.
 1958 *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp 1954; Guennel, p. 62, pl. 3, fig. 3.
 non 1955 *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp, p. 74, pl. 14, figs. 220, 221.
 1960 *Lophotriletes commissuralis* (Kosanke) Potonié and

Kremp 1955; Imgrund, p. 164, pl. 15, figs. 66-68.
non 1955 *Lophotriletes commissuralis* (Kosanke) Potonić and Kremp, p. 73, pl. 14, figs. 222, 223.
1965a *Lophisporites microsaelosus* (Loose) Laveine, p. 133.

Discussion—*Acanthotriletes aculeolatus* (Kosanke) Potonić and Kremp 1955 is similar to *L. microsaelosus*; the former species is slightly larger and more distinctly spinose. Forms intermediate to the two species were observed occasionally in CP-19-4, and distinction was sometimes difficult. It is possible that the two species are end-members of a continuum, but a formal study of the morphologic variation of a large number of specimens would be necessary to resolve the matter.

Occurrence—Rare, *Florinites* and *Densosporites-Crassispora* intervals.

Lophotriletes mosaicus Potonić and Kremp 1955
(Plate 6, fig. 4)

1955 *Lophotriletes mosaicus* Potonić and Kremp, p. 75, pl. 14, figs. 227, 228.
1965a *Lophisporites mosaicus* (Potonić and Kremp) Laveine, p. 133.

Occurrence—Rare.

Lophotriletes rarispinosus Peppers 1970
(Plate 5, figs. 20, 21)

1970 *Lophotriletes rarispinosus* Peppers, p. 96, text-fig. 17, pl. 5, figs. 20-22.

Occurrence—Rare, lower portion of the *Florinites* interval.

Lophotriletes cf. tuberifer (Imgrund) Potonić and Kremp 1955
(Plate 6, figs. 1-3)

1955 *Lophotriletes tuberifer* (Imgrund) Potonić and Kremp, p. 73.
1960 *Lophotriletes tuberifer* (Imgrund) Potonić and Kremp 1955; Imgrund p. 163, pl. 14, fig. 42.

Discussion—This species was first described by Imgrund (1952) in his thesis, which has not been available to this writer. Specimens designated *L. cf. tuberifer* in this report display similar ornamentation to the holotype illustrated by Imgrund (1960), but were usually smaller than the quoted size range (44-70 microns).

Occurrence—Rare.

Lophotriletes sp. 1
(Plate 6, fig. 8)

Description—Miospore radial, trilete, triangular in equatorial outline, convex interradial margins. Laesurae straight, approximately $\frac{3}{4}$ of spore radius, somewhat obscured by ornament of exine. Ornament consists of coarse, irregular, sometimes blunt coni, packed closely together, sometimes fused at bases. Coni 2-4 microns in height, 3-6 microns in basal width, polygonal in basal outline; about 20 coni project from margin. Size of illustrated specimen 38.4 microns maximum diameter.

Discussion—*L.* sp. 1 resembles *L. mosaicus*, but the coni are less regular in size and shape.

Occurrence—Rare.

Lophotriletes sp. 2
(Plate 6, figs. 14, 15)

Description—Miospore radial, trilete, triangular in equatorial outline, straight interradial margins, broadly rounded angles. Laesurae approximately $\frac{2}{3}$ of spore radius, straight, with indistinct lips. Ornament of rounded coni 1-3 microns in height and basal width, regularly distributed on both hemispheres, reduced in size near trilete mark on proximal surface. Space between coni about equal to basal width of coni. About 30 coni project from margin. Size of illustrated specimen 34.8 microns maximum diameter.

Discussion—*L.* sp. 2 is a distinctive, easily recognized form which does not strongly resemble previously described species of the genus.

Occurrence—Rare.

Genus WALTZISPORA Staplin 1960

Type species—*W. lobophora* (Waltz) Staplin 1960.
Affinity—Unknown.

Waltzispora sagittata Playford 1962
(Plate 6, fig. 16)

non 1955 *Granulatisporites politus* Hoffmeister, Staplin and Malloy, p. 389, pl. 36, fig. 13.
1960 *Leiotriletes politus* (Hoffmeister, Staplin and Malloy) Love, pl. 1, fig. 1.
1962 *Waltzispora sagittata* Playford, p. 582-583, text-fig. 5c, pl. 79, fig. 12.

Discussion—The occurrence of *W. sagittata* at the stratigraphic horizon represented by the miospore assemblage of CP-19-4 is unusual, as the genus has been reported previously only from Mississippian and lower Pennsylvanian strata. Only two specimens were observed, and the possibility of reworking from older deposits must be considered; other species of *Waltzispora* (e. g., *W. prisca* (Kosanke) Sullivan 1964 and *W. polita* (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967 occur in appreciable numbers in Iowa coals not greatly older than CP-19-4.

There is no physical evidence of reworking in CP-19-4.

Occurrence—Rare.

Genus ANAPICULATISPORITES (Potonić and Kremp) Smith and Butterworth 1967

Type species—*A. isselburgensis* Potonić and Kremp 1954.

Affinity—Unknown.

Anapiculatisporites spinosus (Kosanke) Potonić and Kremp 1955
(Plate 6, figs. 17, 18)

1950 *Granulatisporites spinosus* Kosanke, p. 22, pl. 3, fig. 7.
1955 *Anapiculatisporites spinosus* (Kosanke) Potonić and Kremp, p. 82, pl. 14, figs. 253-255.
non 1967 *Granulatisporites spinosus* Kosanke 1950; Felix and Burbridge, p. 364, pl. 54, fig. 10.

Occurrence—Rare, but widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals.

Genus ANAPLANISPORITES Jansonius 1962
Type species—*A. telephorus* Klaus 1960.
Affinity—Unknown.

Anaplanisporites baccatus (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967
(Plate 6, figs. 19, 20)

- 1955 *Punctatisporites? baccatus* Hoffmeister, Staplin and Malloy, p. 392, pl. 36, fig. 2.
1958 *Apiculatisporis baccatus* (Hoffmeister, Staplin and Malloy) Butterworth and Williams, p. 363, pl. 1, fig. 25.
1967 *Anaplanisporites baccatus* (Hoffmeister, Staplin and Malloy) Smith and Butterworth, p. 166, pl. 7, figs. 1-5.

Occurrence—Rare.

Genus APICULATISPORIS Potonié and Kremp 1956

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

Discussion—The generic name was altered from *Apiculatisporites* without emendation by Potonié and Kremp (1956), when the former name was found to be a junior homonym of the megaspore genus *Apiculati-sporites* Bennie and Kidston 1886.

Affinity—Unknown.

Apiculatisporis abditus (Loose)
Potonié and Kremp 1955
(Plate 7, fig. 8)

- 1932 *Sporonites abditus* Loose in Potonié, Ibrahim and Loose, p. 451, pl. 19, fig. 53.
1934 *Verrucosi-sporites abditus* Loose, p. 154.
1944 *?Raistrickia abditus* (Loose) Schopf, Wilson and Bentall, p. 55.
1950 *Verrucoso-sporites abditus* (Loose) Knox, p. 317.
1955 *Apiculatisporites abditus* (Loose) Potonié and Kremp, p. 78, pl. 14, figs. 237-239.
1962 *Apiculatisporis abditus* (Loose) Pierart, tabl. 2.

Occurrence—Rare, but widely distributed in CP-19-4.

Apiculatisporis aculeatus (Ibrahim) Smith and Butterworth 1967
(Plate 7, figs. 1-3)

- 1933 *Apiculati-sporites aculeatus* Ibrahim, p. 23, pl. 6, fig. 57.
1944 *Punctati-sporites aculeatus* (Ibrahim) Schopf, Wilson and Bentall, p. 30.
1950 *Spinoso-sporites aculeatus* (Ibrahim) Knox, p. 313.
1955 *Apiculatisporites aculeatus* (Ibrahim) Potonié and Kremp, p. 78, pl. 14, figs. 235, 236, 241.
1956 *Apiculatisporis aculeatus* (Ibrahim) Potonié and Kremp, p. 94.
1967 *Apiculatisporis aculeatus* (Ibrahim) Smith and Butterworth, p. 170, pl. 7, figs. 12, 13.

Discussion—Smith and Butterworth (1967) described *A. aculeatus* as having a round to roundly triangular equatorial outline. Miospores assigned to this species observed in CP-19-4 invariably displayed sphaerotriangular outlines. The ornament of *A. aculeatus* is similar to that of *Lophotriletes pseudaculeatus* Potonié and Kremp 1955, but the latter species is more distinctly triangular.

Occurrence—Rare, observed primarily in the

Florinites and *Densosporites-Crassispora* intervals.

Apiculatisporis irregularis (Kosanke) Potonié and Kremp 1955
(Plate 8, fig. 7)

- 1950 *Raistrickia irregularis* Kosanke, p. 47-48, pl. 11, fig. 5.
1955 *Apiculatisporites irregularis* (Kosanke) Potonié and Kremp, p. 77.
1956 *Apiculatisporis irregularis* (Kosanke) Potonié and Kremp, p. 94.
non 1967 *Apiculatisporis irregularis* (Alpern) Smith and Butterworth, p. 171-172, pl. 7, figs. 18-19.
non 1967 *Apiculatisporis irregularis* Ybert, Nahuys and Alpern, p. 1609-1610, pl. 1, figs. 22-24.

Discussion—As noted by Peppers (1970), *Apiculatisporis* (*Raistrickia*) *irregularis* resembles *A. abditus*, the two species differing chiefly in the relative length of spines on the distal hemisphere. *A. irregularis* is distinguished by possessing spines that are clearly longer than they are broad; the spines of *A. abditus* are shorter and may appear to fuse at their bases.

Occurrence—Rare.

Apiculatisporis latigranifer (Loose)
Potonié and Kremp 1955
(Plate 7, fig. 6)

- 1932 *Sporonites latigranifer* Loose in Potonié, Ibrahim and Loose, p. 452, pl. 19, fig. 54.
1934 *Granulati-sporites latigranifer* Loose, p. 147.
1944 *Punctati-sporites latigranifer* (Loose) Schopf, Wilson and Bentall, p. 31.
1950 *Spinoso-sporites latigranifer* (Loose) Knox, p. 314.
1955 *Apiculatisporites latigranifer* (Loose) Potonié and Kremp, p. 79, pl. 14, figs. 244, 245.
1960 *Apiculatisporis latigranifer* (Loose) Imgrund, p. 164-165, pl. 14, figs. 43-45.

Occurrence—Rare.

Apiculatisporis saetiger (Peppers) Peppers and Ravn comb. nov.
(Plate 7, figs. 4, 5)

- 1964 *Punctatisporites saetiger* Peppers, p. 30, pl. 4, figs. 1, 2.

Discussion—This species is reassigned to *Apiculatisporis* on the basis of the spinose sculpture. The suture is trilete, although one ray typically is shortened and sometimes virtually absent. The reassignment is made with some uncertainty. *A. saetiger* usually is oval in shape and may appear monolet, simulating species of the genera *Laevigatosporites* Ibrahim 1933 and *Punctatosporites* Ibrahim 1933. The sculpture of specimens observed in CP-19-4 was fine and closely-spaced, though it has been observed to vary considerably in other coals.

Occurrence—Rare.

Apiculatisporis variocorneus Sullivan 1964
(Plate 7, fig. 7)

- 1964 *Apiculatisporis variocorneus* Sullivan, p. 363-364, pl. 58, figs. 4-8.

Occurrence—Rare, observed only in CP-19-5.

Apiculatisporis sp. 1
(Plate 7, fig. 9)

Description—Miospore radial, trilete, circular in equatorial outline. Laesurae $\frac{3}{4}$ of spore radius with pronounced lips 2-3 microns in width. Sculpture consists of loosely arranged small spinae 2 microns or less in height and basal width. Exine rather thin, folding frequent. Size of illustrated specimen 45.6 microns maximum diameter.

Discussion—The pronounced lips and thin exine distinguish *A. sp.* 1 from other species of similar size.

Occurrence—Rare.

Genus APICULATASPORITES (Ibrahim) Smith and Butterworth 1967

Type species—*A. spinulistratus* (Loose) Ibrahim 1933.

Discussion—As emended by Smith and Butterworth (1967), genus *Apiculatasporites* accommodates spores with a finer grade of conate ornament than those assigned to *Apiculatisporis*. The ornament of the type species, *A. spinulistratus*, is cited as about 1-2.5 microns in height, which is similar to that of some species of *Apiculatisporis*, e.g., *A. latigranifer*. The distinction between the two genera is questionable, and it may be desirable upon examination of the original material to transfer *A. spinulistratus* to *Apiculatisporis*; such a reassignment would serve to eliminate the unfortunate confusion between the similar generic names.

Affinity—?Filicales (Potonié, 1962).

Apiculatasporites spinulistratus (Loose) Ibrahim 1933
(Plate 7, figs. 10, 11)

- 1932 *Sporonites spinulistratus* Loose in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 47.
1933 *Apiculata-sporites spinulistratus* (Loose) Ibrahim, p. 37.
1934 *Apiculati-sporites spinulistratus* Loose, p. 153.
1934 *Apiculati-sporites globosus* Loose, p. 152, pl. 7, fig. 14.
1944 *Punctati-sporites spinulistratus* (Loose) Schopf, Wilson and Bentall, p. 31.
1950 *Spinoso-sporites spinulistratus* (Loose) Knox, p. 314.
1955 *Planisporites spinulistratus* (Loose) Potonié and Kremp, p. 71, pl. 14, figs. 214-219.

Occurrence—Rare.

Genus ACANTHOTRILETES (Naumova) Potonié and Kremp 1954

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

Affinity—Spores assignable to *Acanthotriletes* have been recovered from fern fructifications (Remy and Remy, 1957; Good, 1979).

Acanthotriletes aculeolatus (Kosanke) Potonié and Kremp 1955
(Plate 7, fig. 14)

- 1950 *Granulatisporites aculeolatus* Kosanke, p. 22, pl. 3, fig. 8.
1955 *Acanthotriletes aculeolatus* (Kosanke) Potonié and Kremp, p. 84.

Occurrence—Rare.

Acanthotriletes echinatus (Knox) Potonié and Kremp 1955
(Plate 7, fig. 12)

1950 *Spinoso-sporites echinatus* Knox, p. 313, pl. 17, fig. 208.

1955 *Acanthotriletes echinatus* (Knox) Potonié and Kremp, p. 84.

non 1955 *Acanthotriletes echinatus* Hoffmeister, Staplin and Malloy, p. 379, pl. 38, figs. 1, 2.

Occurrence—Rare, but widely distributed in the *Florinites* interval; rare elsewhere in CP-19-4.

Acanthotriletes cf. falcatus (Knox) Potonié and Kremp 1955
(Plate 7, fig. 15)

1950 *Spinoso-sporites falcatus* Knox, p. 313, pl. 17, fig. 205.

1955 *Acanthotriletes falcatus* (Knox) Potonié and Kremp, p. 84.

Discussion—The ornament of *A. cf. falcatus* is more widely distributed than that of the specimens illustrated by Smith and Butterworth (1967).

Occurrence—Rare.

Acanthotriletes triquetrus Smith and Butterworth 1967
(Plate 7, fig. 13)

1967 *Acanthotriletes triquetrus* Smith and Butterworth, p. 179, pl. 8, figs. 13, 14.

1967 *Granulatisporites spinosus* Kosanke 1950; Felix and Burbridge, p. 364, pl. 54, fig. 10.

non 1950 *Granulatisporites (Anapiculatisporites) spinosus* Kosanke, p. 22, pl. 3, fig. 7.

Occurrence—Rare to infrequent in the *Florinites* and *Densosporites-Crassispora* intervals; virtually absent from the *Lycospora* interval.

Genus RAISTRICKIA (Schopf, Wilson and Bentall) Potonié and Kremp 1954

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

Affinity—Filices (Radforth, 1938, 1939; Mamay, 1950; Remy and Remy, 1955a; Phillips and Andrews, 1965; Grauvogel-Stamm and Doubinger, 1975).

Raistrickia crocea Kosanke 1950
(Plate 8, fig. 5)

1950 *Raistrickia crocea* Kosanke, p. 47, pl. 11, fig. 6

Discussion—*R. crocea* closely resembles *R. saetosa* (Loose) Schopf, Wilson and Bentall 1944, and the two species are considered synonymous by Smith and Butterworth (1967). The bacula of specimens observed in CP-19-4 appear longer and somewhat thinner than those illustrated by Smith and Butterworth, and more like those of *R. crocea* as illustrated by Kosanke (1950).

Occurrence—*R. crocea* is the most commonly observed species of the genus in CP-19-4; in numbers it is usually rare, but is found in most samples in the *Florinites* and *Densosporites-Crassispora* intervals.

Raistrickia lacerata Peppers 1970
(Plate 8, fig. 3)

1970 *Raistrickia lacerata* Peppers, p. 104, pl. 7, figs. 12, 13.

Occurrence—Rare.

Raistrickia lowellensis Peppers 1970
(Plate 8, figs. 4, 6)

1970 *Raistrickia lowellensis* Peppers, p. 105, pl. 8, figs. 3, 4.

Occurrence—Rare.

Raistrickia cf. *macra* Bharadwaj 1957
(Plate 8, fig. 8)

1957a *Raistrickia macra* Bharadwaj, p. 89, pl. 23, fig. 23.

Discussion—*R.* cf. *macra* differs from the type description of Bharadwaj (1957a) in displaying only a very indistinct negative reticulum.

Occurrence—Rare.

Raistrickia pilosa Kosanke 1950
(Plate 8, fig. 2)

1950 *Raistrickia pilosa* Kosanke, p. 48, pl. 11, fig. 4.

Occurrence—Rare.

Raistrickia protensa Kosanke 1950
(Plate 8, fig. 1)

1950 *Raistrickia protensa* Kosanke, p. 46, pl. 11, figs. 1-3.

Occurrence—Rare.

Genus SPACKMANITES Habib 1966

Type species—*S. ellipticus* Habib 1966.

Affinity—Unknown.

Spackmanites facierugosus (Loose)
Habib 1966
(Plate 8, figs. 9-11)

?1934 *Reticulati-sporites facierugosus* Loose, p. 155, pl. 7, fig. 26.

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

1966 *Spackmanites facierugosus* (Loose) Habib, p. 638, pl. 105, fig. 19.

1967 unidentified 16239; Barss, pl. 23, fig. 4.

1967 unidentified 16398; Barss, pl. 29, fig. 19.

non 1967 ?*Verrucosporites facierugosus* (Loose) Butterworth and Williams 1954; Barss, pl. 8, fig. 7.

1970 *Spackmanites* cf. *facierugosus* (Loose) Habib; Peppers, p. 109, pl. 8, figs. 17-20.

non 1979 *Verrucosporites facierugosus* (Loose) Butterworth and Williams 1954; Etensohn and Peppers, pl. 1, fig. 11.

Discussion—A question exists concerning the synonymy of this species as given by Habib (1966). It is uncertain that the specimen illustrated in a line-drawing by Loose (1934) is actually the same taxon as that designated by Habib (1966). Habib provided no formal diagnosis for *S. facierugosus* beyond that of the genus itself; Peppers (1970) did provide a detailed description and noted the difficulty of interpreting Loose's (1934) illustration. A species that appears to be distinctly different from *S. facierugosus* has been illustrated as ?*Verrucosporites facierugosus* (Loose) Butterworth and Williams 1954 by Barss (1967, pl. 8, fig. 7) and as *Verrucosporites* (sic?) *facierugosus* (Loose) Butterworth and Williams 1954 by Etensohn and Peppers (1979, pl. 1, fig. 11). Barss (1967) also illustrated specimens regarded as unassigned which appear to correspond to *S. facierugosus* (pl. 23, fig. 4, pl. 29, fig. 19) and clearly differ from his illustrated specimen of ?*V. facierugosus*.

S. facierugosus as illustrated by Habib (1966) and described (as *S.* cf. *facierugosus* by Peppers, 1970) is a

distinctive, easily recognized and stratigraphically useful species despite its muddled synonymy. Distinction between *S. facierugosus* and the type species, *S. ellipticus* Habib 1966, is questionable. A complete range of variation between the two forms was observed in the study of CP-19-4; the majority of specimens closely resembled those illustrated by Peppers (1970, pl. 8, figs. 17-20) and therefore are designated *S. facierugosus* in this report. If synonymy exists between *S. facierugosus* and *S. ellipticus*, it might be preferable to employ the latter name and to reject synonymy with *Reticulati-sporites facierugosus* Loose 1934. *Verrucosporites pseudobaculatus* Laveine 1965 is similar to *S. facierugosus* and may be synonymous.

Occurrence—Rare to infrequent in the *Florinites* and *Densosporites-Crassispora* intervals; virtually absent from the *Lycospora* interval.

Genus CONVOLUTISPORIA Hoffmeister, Staplin and Malloy 1955

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

Affinity—Smith and Butterworth (1967) suggested that spores from a fern fructification (*Senftenbergia*) described by Radforth (1938) were assignable to *Convolutispora*; Potonié (1962) assigned the same spores to genus *Camptotriletes* (Naumova) Potonié and Kremp 1954. Jennings and Eggert (1977) also reported spores corresponding to *Convolutispora in situ* from *Senftenbergia*. Cridland (1966) illustrated spores from a fern sporangium which closely resemble certain larger species of *Convolutispora*.

Convolutispora cerina sp. nov.
(Plate 8, figs. 12-15)

1964 *Convolutispora* sp. 2 Peppers, p. 17, pl. 1, fig. 17.

Diagnosis—Miospores radial, trilete, circular to subcircular in equatorial outline, usually in good proximal-distal orientation. Laesurae straight, $\frac{2}{3}$ to more than $\frac{3}{4}$ of spore radius. Exine rather thick, approximately 3 microns, often appearing as a zona in compression. Proximal surface laevigate, distal surface ornamented by low, irregular, flat convolute ridges, width 3-6 microns, height 1-2 microns. Slight indentation of spore margin related to distal sculpture is sometimes visible at the angles.

Size—(10 specimens) 36-50 microns maximum diameter.

Discussion—Although it is not considered a diagnostic feature, specimens of *C. cerina* observed in CP-19-4 did not accept staining as readily as most other miospores, and were conspicuous by their waxy yellowish appearance. The spore designated *Convolutispora* sp. 2 by Peppers (1964) appears virtually identical. *C. laminosa* Neves 1961 and *C. superficialis* Felix and Burbridge 1967 resemble *C. cerina*, but both the former species are larger and bear less distinct ornamentation than *C. cerina*.

Derivation—The specific nomen refers to the waxy yellow (*cerina*) appearance of the spore in stained preparations.

Occurrence—Rare.

Holotype—Plate 8, fig. 12, slide 3M6 coordinates 130-71.5, 44.5 microns maximum diameter.

Paratype—Plate 8, fig. 13, slide 3M6 coordinates 134-31.5, 43.9 microns.

Paratype—Plate 8, fig. 14, slide 1Y1 coordinates 122.5-36, 46.2 microns.

Paratype—Plate 8, fig. 15, slide 1Y1 coordinates 126.5-35, 45.6 microns.

Convolutispora? sp. 1
(Plate 9, fig. 1)

Description—Miospore circular in outline, exine thick and dark, bearing a uniform, vaguely convolute sculpture. No suture has been observed. Size of illustrated specimen 34.2 microns maximum diameter.

Discussion—Due to the irregularity of the sculpture and the apparent absence of any laesurae, the assignment of this species to *Convolutispora* is tentative. It resembles *C. sp. 1* of Peppers (1970, p. 108, pl. 8, fig. 15), but the latter shows a definite trilete mark.

Occurrence—Rare.

Genus MICRORETICULATISPORITES (Knox)
Potonić and Kremp 1954

Type species—*M. lacunosus* (Ibrahim) Knox 1950.

Affinity—?Filicales. Potonić (1962) considered spores from an Iowa fern fructification described by Mamay (1950) to be assignable to *Microreticulatisporites*.

Microreticulatisporites harrisonii Peppers 1970
(Plate 9, fig. 10)

1970 *Microreticulatisporites harrisonii* Peppers, p. 110, pl. 9, fig. 1.

Occurrence—Rare.

Microreticulatisporites nobilis (Wicher) Knox 1950
(Plate 9, figs. 11, 12)

1934 *Sporites nobilis* Wicher, p. 186, pl. 8, fig. 30.

1944 *Punctati-sporites nobilis* (Wicher) Schopf, Wilson and Bentall, p. 31.

1950 *Microreticulatisporites nobilis* (Wicher) Knox, p. 321, pl. 18, fig. 242.

Occurrence—Rare to infrequent, widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals, rare in the *Lycospora* interval.

Microreticulatisporites sp. 1
(Plate 9, fig. 15)

Description—Miospore radial, trilete, triangular in equatorial outline, interrational margins slightly convex, angles moderately rounded. Laesurae straight, $\frac{1}{4}$ of spore radius. Exine thick and dark, uniformly and coarsely microreticulate. Lacunae generally circular, about 2 microns wide, separated by rounded muri 4-6 microns wide. Muri appear sometimes as verrucate ridges, especially at margin. Size of illustrated specimen 41.0 microns maximum diameter.

Discussion—The ornament of *M. sp. 1* resembles that of *M. sulcatus* (Wilson and Kosanke) Smith and Butterworth 1967, but is coarser. *M. sp. 1* could be assigned possibly to genus *Converrucosisporites* Potonić and Kremp 1954.

Occurrence—Rare.

Genus DICTYOTRILETES (Naumova) Smith
and Butterworth 1967

Type species—*D. bireticulatus* (Ibrahim) Smith and Butterworth 1967.

Affinity—Unknown; listed as questionably filicinean by Potonić and Kremp (1954). Spores with a reticulate ornament assignable possibly to *Dictyotriletes* or to *Reticulatisporites* (Ibrahim) Neves 1964 were recovered by Mamay (1954b) from a fructification, but Smith and Butterworth (1967) stated that the taxonomic affinity of the plant fossil was uncertain. Millay (1979) isolated monolete reticulate spores from a species of the marattialean fern *Scolecopteris* which resemble the species *D. castaneaeformis*. These spores appear to be variants of the genus *Thymospora* Wilson and Venkatachala 1963 (see Discussion of *D. castaneaeformis*).

Dictyotriletes bireticulatus (Ibrahim) Smith
and Butterworth 1967
(Plate 9, fig. 6)

1932 *Sporonites bireticulatus* Ibrahim in Potonić, Ibrahim and Loose, p. 447, pl. 14, fig. 1.

1933 *Reticulatisporites bireticulatus* Ibrahim, p. 35, pl. 1, fig. 1.

1934 *Reticulata-sporites bireticulatus* Ibrahim; Loose, pl. 7, fig. 28.

1950 *Reticulatisporites mediareticulatus* Ibrahim; Knox, p. 323, pl. 18, fig. 253.

1952 *Reticulatisporites mediareticulatus* Ibrahim; Balme, p. 176, text-fig. 1c.

1952 *Reticulatisporites* cf. *mediareticulatus* Ibrahim; Balme and Butterworth, pl. 48, figs. 4a, 4b.

1954 *Dictyotriletes bireticulatus* (Ibrahim) Potonić and Kremp, p. 108.

1954 *Reticulatisporites* cf. *mediareticulatus* Ibrahim; Butterworth and Millott, p. 21, fig. 8b.

1956 *Reticulatisporites mediareticulatus* Ibrahim; Butterworth and Millott, text-fig. 3(8).

1964 *Dictyisporites bireticulatus* (Ibrahim) Levet-Carette, p. 271, pl. 10, fig. 17.

1967 *Dictyotriletes bireticulatus* (Ibrahim) Smith and Butterworth, p. 194-195, pl. 11, figs. 14-15.

Occurrence—Rare; observed in the *Florinites* and *Lycospora* intervals, not encountered in the *Densosporites-Crassispora* interval.

Dictyotriletes castaneaeformis (Horst) Sullivan 1964
(Plate 9, figs. 2-4)

1943 *Aletes castaneaeformis* Horst, p. 124, fig. 82.

1955 *Reticulatisporites castaneaeformis* (Horst) Potonić and Kremp, p. 169.

1964 *Dictyotriletes castaneaeformis* (Horst) Sullivan, p. 367.

Discussion—The assignment of this species to *Dictyotriletes* was made on the basis of ornament, and the nature of the suture is in doubt. Smith and Butterworth (1967) described *D. castaneaeformis* as apparently alete, and considered it synonymous with *D. clatriformis* (Artüz) Sullivan 1964. *D. clatriformis* is indistinctly trilete, whereas *D. castaneaeformis* is generally oval in shape, and some specimens (e.g., pl. 9, fig. 3) display what appears to be a monolete laesura. It is possible that this form species accommodates spores of various unknown plant affinities, but no reliable basis seems to

exist for subdivision into separate species.

Occurrence—Rare.

Dictyotriletes densoreticulatus Potonié and Kremp
1955
(Plate 9, fig. 7)

1955 *Dictyotriletes densoreticulatus* Potonié and Kremp, p. 109, pl. 16, fig. 313.

Occurrence—Rare.

Dictyotriletes distortus Peppers 1970
(Plate 9, fig. 9)

1970 *Dictyotriletes distortus* Peppers, p. 112, pl. 9, figs. 9-11.

Occurrence—Rare, *Densosporites-Crassispora* interval.

Dictyotriletes reticulocingulum (Loose) Smith
and Butterworth 1967
(Plate 9, figs. 5, 8)

1932 *Sporonites reticulocingulum* Loose in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 41.

1934 *Reticulati-sporites reticulocingulum* Loose, p. 156.

1944 ?*Punctati-sporites reticulocingulum* (Loose) Schopf, Wilson and Bentall, p. 31.

1950 *Microreticulatisporites reticulocingulum* (Loose) Knox, p. 321.

1967 *Dictyotriletes reticulocingulum* (Loose) Smith and Butterworth, p. 198, pl. 11, figs. 27-29.

Discussion—Smith and Butterworth (1967) noted a great deal of variation in the relative coarseness of the reticulate ornament of specimens they assigned to this species. Specimens observed in CP-19-4 and other Iowa coals tend to display a consistent fine reticulum with little variation between proximal and distal surfaces, resembling the specimen illustrated on plate 11, fig. 27 of Smith and Butterworth (1967). Peppers (1970) made a similar observation concerning specimens encountered in Illinois Basin coals. As the holotype (Smith and Butterworth, 1967) appears to be rather finely reticulate, the assignment of specimens in CP-19-4 to *D. reticulocingulum* is appropriate.

Occurrence—Infrequent in a narrow horizon of the lower *Florinites* interval, rarely observed elsewhere.

Genus **CAMPTOTRILETES** (Naumova) Potonié
and Kremp 1954

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

Affinity—Filices; Mamay (1950) isolated spores assignable to *Camptotriletes* from fern fructifications.

Camptotriletes bucculentus (Loose) Potonié
and Kremp 1955
(Plate 9, fig. 13)

1934 *Verrucosi-sporites bucculentus* Loose, p. 154, pl. 7, fig. 15.

1944 *Punctati-sporites bucculentus* (Loose) Schopf, Wilson and Bentall, p. 30.

1950 *Verrucoso-sporites bucculentus* (Loose) Knox, p. 317.

1955 *Camptotriletes bucculentus* (Loose) Potonié and Kremp p. 104, pl. 16, figs. 287, 288.

Occurrence—Rare.

Camptotriletes cf. *corrugatus* (Ibrahim) Potonié
and Kremp 1954
(Plate 9, fig. 14)

1933 *Reticulati-sporites corrugatus* Ibrahim, p. 35, pl. 5, fig. 41.

1944 *Punctati-sporites corrugatus* (Ibrahim) Schopf, Wilson and Bentall, p. 30.

1954 *Camptotriletes corrugatus* (Ibrahim) Potonié and Kremp, p. 104, pl. 16, figs. 289, 290.

Discussion—The semi-reticulate ornament of spores designated *C. cf. corrugatus* appears somewhat coarser than that of the type illustrations in Potonié and Kremp (1954, pl. 16, figs. 289, 290).

Occurrence—Rare.

Genus **LATIPULVINITES** Peppers 1964

Type species—*L. kosankii* Peppers 1964.

Affinity—Unknown.

Latipulvinites kosankii Peppers 1964
(Plate 9, fig. 16)

1964 *Latipulvinites kosankii* Peppers, p. 26, pl. 3, figs. 13, 14.

Discussion—*L. kosankii* bears a superficial resemblance to species of the genus *Ahrensia* Potonié and Kremp 1954, but the triradiate ridges of *L. kosankii* are located on the proximal surface, as opposed to the kyrtomes of *Ahrensia*, which are located on the distal surface. *Concavisporites lunzensis* (Klaus) Chaloner 1969, from the Triassic of Austria, closely resembles *L. kosankii*.

Occurrence—Rare.

Genus **AHRENSISPORITES** Potonié and Kremp
1954

Type species—*A. guerickei* (Horst) Potonié and Kremp 1954.

Affinity—Unknown.

Ahrensia guerickei (Horst) Potonié
and Kremp 1954
(Plate 9, fig. 17)

1943 *Triletes guerickei* Horst, pl. 7, figs. 58, 59, 61-64.

1954 *Ahrensia guerickei* Potonié and Kremp, p. 155.

Occurrence—Rare.

Genus **STELLISPORITES** Alpern 1958

Type species—*S. inflatus* Alpern 1958.

Affinity—Unknown.

Stellisporites inflatus Alpern 1958
(Plate 10, fig. 1)

1958 *Stellisporites inflatus* Alpern, p. 78, pl. 1, fig. 14.

Occurrence—Rare.

Genus **TANTILLUS** Felix and Burbridge 1967

Type species—*T. triquetrus* Felix and Burbridge 1967.

Affinity—Unknown.

Tantillus triquetrus Felix and Burbridge 1967
(Plate 10, figs. 2-8)

1967 *Tantillus triquetrus* Felix and Burbridge, p. 383-384, pl. 65, figs. 4, 5.

Discussion—The ornamentation of *T. triquetrus* is described by Felix and Burbridge (1967) as laevigate to minutely granulose. Forms observed in Iowa coals range from laevigate (plate 10, fig. 2) to distinctly granulose (plate 10, figs. 3, 4) to minutely spinose (plate 10, figs. 7, 8). This variability or ornament suggests that further speciation of the genus may be useful, but too few specimens have been observed during the present study to establish reliable categories for morphologic types.

Occurrence—Rare, but widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals.

Genus TRIQUITRITES (Wilson and Coe)
Potonié and Kremp 1954

Type species—*T. arcuatus* Wilson and Coe 1940.

Affinity—Schopf, Wilson and Bentall (1944) suggested a filicinean affinity for this genus, but no miospores corresponding to *Triquitrites* appear to have been described from fructifications of known affinity. Moore (1946) illustrated spores resembling *Triquitrites* from a reproductive structure of unknown paleobotanical relationship.

Triquitrites additus Wilson and Hoffmeister 1956
(Plate 10, figs. 11, 15)

1956 *Triquitrites additus* Wilson and Hoffmeister, p. 24, pl. 3, figs. 6-9.

Occurrence—Rare to infrequent in the *Densosporites-Crassispora* interval, virtually absent elsewhere in CP-19-4.

Triquitrites bransonii Wilson and Hoffmeister 1956
(Plate 10, figs. 13, 14)

1956 *Triquitrites bransonii* Wilson and Hoffmeister, p. 24-25, pl. 3, figs. 1-5.

Discussion—*T. bransonii*, *T. protensus* Kosanke 1950 and *T. pulvinatus* Kosanke 1950 are very similar, and distinctions between them often are made with some hesitancy. Among specimens observed in CP-19-4, a range of variation existed between forms assignable to *T. bransonii* and *T. protensus*. Both species are provided systematic treatment and illustrated in this report, but they are considered together in the data (see Appendix II).

Occurrence—Infrequent to occasionally frequent in the *Densosporites-Crassispora* interval, rarely observed elsewhere.

Triquitrites crassus Kosanke 1950
(Plate 10, fig. 18)

1950 *Triquitrites crassus* Kosanke, p. 38, pl. 8, fig. 6.

Occurrence—Rare, lower levels of the *Florinites* interval.

Triquitrites exiguus Wilson and Kosanke 1944
(Plate 10, fig. 10)

1944 *Triquitrites exiguus* Wilson and Kosanke, p. 332, fig. 2.

Discussion—*T. exiguus* resembles *T. protensus* but is smaller. In practice, specimens smaller than 30 microns in maximum diameter are assigned to *T. exiguus*; forms 30 microns or larger are assigned to *T. protensus*.

Occurrence—Rare to infrequent in the *Densosporites-Crassispora* interval, rare in the *Florinites* interval, and virtually absent from the *Lycospora* interval.

Triquitrites minutus Alpern 1958
(Plate 10, fig. 9)

1958 *Triquitrites minutus* Alpern, p. 77, pl. 1, figs. 9, 10.

Discussion—*T. minutus* is similar to *T. exiguus* in size, but displays only rudimentary, inconspicuous thickenings at the angles.

Occurrence—Rare, observed primarily in the *Florinites* interval.

Triquitrites protensus Kosanke 1950
(Plate 10, fig. 12)

1950 *Triquitrites protensus* Kosanke, p. 40, pl. 8, fig. 2.

Occurrence—See *T. bransonii*.

Triquitrites sculptilis (Balme) Smith and Butterworth 1967

1952 *Triquitrites sculptilis* Balme, p. 181, text-fig. 1g.

1957b *Triquitrites coesfeldens* Bharadwaj, p. 123, pl. 25, figs. 66, 67.

1958 *Triquitrites bucculentus* Guennel, p. 73, pl. 5, figs. 1, 2.

1965a *Triquisporites sculptilis* (Balme) Laveine, p. 134, pl. 10, fig. 42.

1967 *Triquitrites sculptilis* (Balme) Smith and Butterworth, p. 204, pl. 12, figs. 10-15.

Discussion—Gupta (1970) proposed synonymy of *T. sculptilis* Balme 1952 with *T. trigonus* (Ibrahim) Gupta 1969, but his synonymy did not take into account the emendation of *T. sculptilis* by Smith and Butterworth (1967). The relationship of *T. sculptilis* as illustrated both by Balme (1952) and Smith and Butterworth (1967) with the description and illustration of *Reticulatisporites trigonus* Ibrahim 1933 is unclear, and it is considered advisable to retain *T. sculptilis* as a valid name.

Occurrence—Infrequent to frequent in the *Densosporites-Crassispora* interval, rare in the *Florinites* interval, virtually absent from the *Lycospora* interval.

Triquitrites subspinus Peppers 1970
(Plate 10, fig. 17)

1970 *Triquitrites subspinus* Peppers, p. 118, pl. 11, figs. 8, 9.

Occurrence—Rare.

Genus INDOSPORA Bharadwaj 1960

Type species—*I. clara* Bharadwaj 1960.

Affinity—Unknown.

Indospora boleta Peppers 1970
(Plate 11, fig. 2)

1970 *Indospora boletus* Peppers, p. 118, pi. 11, figs. 12, 13.

Discussion—Specimens of *I. boleta* observed in CP-19-4 were slightly smaller than those noted by Peppers (1970), but the character of the ornamentation corresponds closely to the type description. The spelling of the specific nomen is altered from *boletus* to *boleta* to bring it into orthographic agreement with the generic nomen.

Occurrence—Rare.

Genus ZOSTEROSPORITES Kosanke 1973

Type species—*Z. triangularis* Kosanke 1973.

Affinity—Unknown.

Zosterosporites triangularis Kosanke 1973
(Plate 10, figs. 19, 20)

1973 *Zosterosporites triangularis* Kosanke, p. 11, text-fig. 5, pl. 1, figs. 1-6.

Discussion—The spore figured by Alpern (1959) as indeterminate no. 368 appears to be *Z. triangularis*. *Ahrensia* *aspersus* Gupta 1969 resembles *Z. triangularis*, but is somewhat larger and possesses distinct kyrtomes instead of a beltlike thickening near the equator. *Z. triangularis* appears to have a relatively restricted stratigraphic range in the lower Cherokee coals of Iowa and is particularly characteristic of the seam represented by CP-19-4.

Occurrence—Rare, observed primarily in the *Florinites* interval.

Genus SIMOZONOTRILETES (Naumova) Potonić and Kremp 1954

Type species—*S. intortus* (Waltz) Potonić and Kremp 1954.

Affinity—Unknown.

Simozonotriletes intortus (Waltz) Potonić and Kremp 1954
(Plate 12, fig. 6)

1938 *Zonotriletes intortus* Waltz in Luber and Waltz, pl. 2, fig. 24.

1954 *Simozonotriletes intortus* (Waltz) Potonić and Kremp, p. 159.

1957a *Simozonotriletes priscus* Dybová and Jachowicz, p. 152, pl. 41, figs. 1, 2.

1962 *Murospora intorta* (Waltz) Playford, p. 609, pl. 86, figs. 12, 13.

Occurrence—Rare.

Genus KNOXISPORITES (Potonić and Kremp) Neves and Playford 1961

Type species—*K. hageni* Potonić and Kremp 1954.

Affinity—Unknown.

Knoxisporites stephanephorus Love 1960
(Plate 10, fig. 22)

1960 *Knoxisporites stephanephorus* Love, p. 118, text-fig. 8, pl. II, figs. 1, 2.

Discussion—*K. stephanephorus* is very similar to, and possibly synonymous with *K. rotatus* Hoffmeister, Staplin and Malloy 1955 and *K. glomus* Shwartsman in Inosova, Krusina and Shwartsman, 1976. The three species were described originally from widely separated

stratigraphic horizons, and similar forms have been noted from the Upper Mississippian to the Lower Permian (Bless, Loboziak and Streel, 1977). *K. ruhlandi* Doubinger and Rauscher 1966 displays a distal ornament similar to that of *K. stephanephorus*, but the equatorial outline of the former species is sphaerotriangular rather than circular.

Occurrence—Rare.

Knoxisporites triradiatus Hoffmeister, Staplin and Malloy 1955
(Plate 10, fig. 23)

1955 *Knoxisporites triradiatus* Hoffmeister, Staplin and Malloy, p. 391, pl. 37, figs. 11-12.

Occurrence—Rare.

Genus RETICULATISPORITES (Ibrahim) Neves 1964(a)

Type species—*R. reticulatus* (Ibrahim) Ibrahim 1933.

Affinity—Sphenopsid (Andrews and Agashe, 1963).

Reticulatisporites reticulatus (Ibrahim) Ibrahim 1933
(Plate 10, fig. 21)

1932 *Sporonites reticulatus* Ibrahim in Potonić, Ibrahim and Loose, p. 447, pl. 14, fig. 3.

1933 *Reticulatisporites reticulatus* (Ibrahim) Ibrahim, p. 33, pl. 1, fig. 3.

1938 *Azonotriletes reticulatus* (Ibrahim) Luber in Luber and Waltz, pl. 7, fig. 99.

Occurrence—Rare.

Genus REINSCHOSPORA Schopf, Wilson and Bentall 1944

Type species—*R. speciosa* (Loose) Schopf, Wilson and Bentall 1944.

Affinity—Unknown.

Reinschospora speciosa (Loose) Schopf, Wilson and Bentall 1944
(Plate 11, fig. 1)

1934 *Alati-sporites speciosus* Loose, p. 151, pl. 7, fig. 1.

1944 *Reinschospora bellitas* Bentall in Schopf, Wilson and Bentall, p. 53, fig. 2.

1944 *Reinschospora speciosa* (Loose) Schopf, Wilson and Bentall, p. 53.

Discussion—*R. magnifica* Kosanke 1950 is similar and may be synonymous. *R. punctata* Kosanke 1950 is distinguished from *R. speciosa* by possession of a distinctly punctate ornament; Urban (1971) observed that the corona is an equatorial extension of an exoexine separation over the entire spore body and noted a punctate ornament of the exoexine in some specimens ascribed to *R. speciosa*.

Occurrence—Rare.

Reinschospora triangularis (Kosanke) emend.
(Plate 11, figs. 3-6)

1950 *Reinschospora triangularis* Kosanke, p. 43, pl. 9, figs. 6, 7.

1957 *Reinschospora fimbriata* Artüz, p. 255, pl. 7, fig. 50.

1965a *Reinschisporites triangularis* (Kosanke) Lavcine, p. 134, pl. 10, fig. 40.

Diagnosis (emended from description of Kosanke, 1950, p. 43)—Miospores radial, trilete, triangular in outline exclusive of corona. Margin between radii slightly convex, corners opposite radii pointed, rarely folded. Spore coat laevigate, may appear slightly granulose (?infrasculpture) under oil immersion objective. Equatorial portion of spore ornamented with a corona of bifurcating spines often with rounded or bulbous tips. Spines near angles extend 5 to 6 microns beyond spore wall; spines midway between angles approximately twice as long. All spines appear to originate well within the spore wall. A quasi-trilete fringe of similar but smaller spines occurs opposite the laesurae on the distal surface. Outline of spore including corona is subspherical. Spores may bear subtriangular groups of minute papillae or grana, 6-20 in number, on the proximal surface near the angles; papillae about 1 micron in width and height. Distal surface occasionally ornamented with coarse cone-shaped spines, ranging from scattered individuals to a moderately crowded spinose sculpture covering most of the distal surface. Spines 2-4 microns in width and height, both dimensions approximately equal on any given spine. Trilete rays, lips and commissure distinct, extending nearly to angles.

Size—Kosanke's (1950) size range of 66-79 microns maximum diameter is extended downward to include spores as small as 50 microns in maximum diameter.

Discussion—During the study of CP-19-4 and other Iowa coals, the writer observed spores bearing groups of papillae or grana near the angles and coarse cone-shaped distal spines, but in other respects corresponding to *R. triangularis* Kosanke 1950. After study of Kosanke's holotype, it was considered more appropriate to emend the diagnosis to include such forms rather than to erect a new species. The newly-included characteristics may be present in the Iowa material due to preservational fortuity. The distal spines, in particular, appear to exist in a complete range of variation from none (plate 11, fig. 2), similar to the holotype (Kosanke, 1950), to many (plate 11, fig. 3).

Occurrence—Rare. Observed only in a narrow horizon in the *Florinites* interval.

Genus CUNEISPORITES gen. nov.

Type species—*C. rigidus* sp. nov.

Diagnosis—Miospores radial, trilete, strongly triangular to wedge-shaped in proximal-distal orientation. Sides straight to slightly convex, angles narrowly rounded. Exine thick and dark, thicker at equator and angles, reinforcing triangular shape upon compression. Often slightly elongated in one direction, producing bilaterally symmetrical wedge-shaped outline. Compression folds parallel to equator, especially on distal surface, give the impression of a zona. Trilete rays straight, extending nearly to equator.

Discussion—The relatively uniform equatorial thickening of the exine, which is not a flange or separate zonal structure from the main spore body, serves to distinguish *Cuneisporites* from other strongly triangular genera. It most closely resembles *Zosterosporites*, but the

latter genus possess a beltlike equatorial thickening much more distinct than the thickening of *Cuneisporites*.

Derivation—The generic nomen refers to the wedge-shaped (*cuneus*) aspect of the miospore in polar compression.

Affinity—Unknown.

Cuneisporites rigidus sp. nov.
(Plate 11, figs. 7-9)

Diagnosis—Miospores conforming to the characteristics of the genus. Normally in good proximal-distal orientation. Both proximal and distal surfaces evenly ornamented with closely spaced fine grana less than 1 micron in breadth and height, scarcely visible at margin. Laesurae bearing narrow but distinct lips. Thickness of exine at equator between rays about 3 microns, may be slightly thicker at angles. Compression folds often produce appearance of a triangular zona congruent to the equator. Spores commonly dark, making features difficult to discern.

Size—(12 specimens) 40-50 microns maximum diameter.

Discussion—*C. rigidus* resembles *Stenozonotriletes infirmus* Naumova 1953 (p. 74, pl. 11, fig. 4). The genus *Stenozonotriletes* has been emended (Hacquebard, 1957; Potonić, 1958) to apply only to spores with a distinct cingulum; Smith and Butterworth (1967) noted that care must be taken to distinguish a true cingulum from the marginal rim of thick-walled spores in compression, a feature displayed by *Cuneisporites*. *C. rigidus* also resembles *Gravisporites densus* Habib 1966, but the latter displays conspicuous thickening along the trilete rays. The status of the genus *Gravisporites* Bharadwaj 1954 is in question; Smith and Butterworth (1967) considered it synonymous with *Cadiospora* Kosanke 1950, and neither *C. rigidus* nor Habib's (1966) species correspond properly to *Cadiospora*.

Derivation—The specific nomen of *C. rigidus* is derived from the apparent rigidity of the spore margin and angles, resulting in the strong triangularity of the spore upon compression.

Occurrence—Rare.

Holotype—Plate 11, fig. 8, slide 2H2 coordinates 128-55.5, 47.3 microns maximum diameter.

Paratype—Plate 11, fig. 7, shale CP-10-49 slide B-9 coordinates 127-69.5, 45.6 microns.

Paratype—Plate 11, fig. 9, slide 2H3 coordinates 125-40, 41.0 microns.

Genus TETANISPORITES gen. nov.

Type species—*T. granulatus* sp. nov.

Diagnosis—Miospores radial, trilete, subtriangular in equatorial outline. Laesurae straight, extending to angles, commissure narrow, bordered by a raised, thickened area of uniform width which serves to reinforce the proximal surface of the spore during compression, producing compression folds or wrinkles on the distal surface transverse to the laesurae midway between the pole and the angles. Compression folds occasionally

absent, but usually one or more of the angles bears such a transverse fold; folds often give the spore a semi-hexagonal outline.

Discussion—The characteristic thickened region bordering the laesurae is similar to that observed in *Cadiospora*, but the latter genus possesses faint *curvaturae* (Smith and Butterworth, 1967) and a circular outline.

Derivation—The generic nomen refers to the stiffened (*tetanus*) thick border along the laesurae which produces the characteristic folding on compression.

Affinity—Unknown.

Tetanisporites granulatus sp. nov.
(Plate 11, figs. 10-12)

Diagnosis—Miospores conforming to the characteristics of the genus. Both proximal and distal surfaces evenly ornamented with closely spaced fine grana about 1 micron in breadth and height, producing a serrated margin. Ridge along laesurae up to 8 microns in width and 2 microns in height. Usually in good proximal-distal orientation. Exine thick (3 microns or greater) and dark, often rendering observation of morphologic features difficult.

Size—(23 specimens) 36-51 microns maximum diameter.

Discussion—Although *T. granulatus* is the sole species of the genus described at present, miospores with an essentially laevigate exine having characteristics typical of *Tetanisporites* have been observed in certain Iowa coals (not in CP-19-4).

Derivation—The specific nomen refers to the granulose ornament.

Occurrence—Rare.

Holotype—Plate 11, fig. 11, slide 1C1 coordinates 132-60.5, 50.7 microns maximum diameter.

Paratype—Plate 11, fig. 10, slide 6V3 coordinates 134.5-51, 45.6 microns.

Paratype—Plate 11, fig. 12, coal CP-10-7 slide 12 coordinates 119-58, 49.6 microns.

Genus SAVITRISPORITES Bharadwaj 1955

Type species—*S. triangularis* Bharadwaj 1955.

Affinity—Filicales. Spores corresponding to *Savitrisporites* were recovered from a fern fructification by Radforth (1939).

Savitrisporites nux (Butterworth and Williams)
Smith and Butterworth 1967
(Plate 12, fig. 2)

- 1958 *Callisporites nux* Butterworth and Williams, p. 377, pl. 3 figs. 24-25.
1964 *Savitrisporites nux* (Butterworth and Williams) Sullivan, p. 373, pl. 60, figs. 1-5.
1964 *Convverrucosporites idili* Ibrahim-Okay and Artüz, p. 272-273, text-fig. 1, pl. 1, fig. 4.
1967 *Savitrisporites nux* (Butterworth and Williams) Smith and Butterworth, p. 223-225, pl. 15, figs. 1-3.

Occurrence—Rare.

Savitrisporites sp. 1
(Plate 12, fig. 3)

Description—Miospores radial, trilete, broadly sphaerotriangular in equatorial outline. Often obliquely compressed, suggesting that the original shape was somewhat hemispherical. Ornament of low, irregular ridges or broad, partly fused verrucae as large as 5 microns in width at base. Ridges on proximal surface indistinctly aligned parallel to laesurae; laesurae reaching nearly to equator. One rather conspicuous ridge usually runs along equator on proximal surface, appearing as a reduced cingulum. Exine relatively thick. Size of illustrated specimen 54.7 microns maximum diameter.

Discussion—The alignment of ornament congruent to the laesurae on the proximal surface is typical of the genus, but the ornament is less conspicuous than in other species. The equatorial outline of *S. sp. 1* is more rounded than most other species.

Occurrence—Rare.

Genus GRUMOSISPORITES Smith and Butterworth 1967

Type species—*G. verrucosus* (Butterworth and Williams) Smith and Butterworth 1967.

Affinity—Unknown.

Grumosisorites (?) *rufus* (Butterworth and Williams)
Smith and Butterworth 1967
(Plate 12, fig. 1)

- 1958 *Verrucosisorites rufus* Butterworth and Williams, p. 363, pl. 1, figs. 44, 45.
1967 *Grumosisorites rufus* (Butterworth and Williams) Smith and Butterworth, p. 231, pl. 17, figs. 1-7.
1970 *Grumosisorites* cf. *rufus* (Butterworth and Williams) Smith and Butterworth 1967; Peppers, p. 119, pl. 11, fig. 15.

Discussion—The exine separation characterizing genus *Grumosisorites* is very indistinctly developed in *G. rufus*. Specimens observed in CP-19-4 did not reveal exine separation clearly, and therefore assigned questionably to the genus, even though other characters such as size, shape and ornament correspond to *G. rufus*.

Occurrence—Rare.

Genus CRISTATISPORITES (Potonié and Kremp)
Butterworth, Jansonius, Smith and Staplin 1964

Type species—*C. indignabundus* (Loose) Staplin and Jansonius 1964.

Affinity—Lycopsid (Chaloner, 1962).

Cristatisporites indignabundus (Loose) Staplin
and Jansonius 1964
(Plate 12, figs. 4, 5)

- 1932 *Sporonites indignabundus* Loose in Potonié, Ibrahim and Loose, p. 451, pl. 19, fig. 51.
1934 *Apiculati-sporites indignabundus* Loose, p. 153.
1944 *Densosporites indignabundus* (Loose) Schopf, Wilson and Bentall, p. 40.
1954 *Cristatisporites indignabundus* (Loose) Potonié and Kremp, p. 142.
1964 *Cristatisporites indignabundus* (Loose) Staplin and Jansonius, p. 108-109, text-fig. 2c, pl. 19, figs. 7-9, 12, 14, 20.
1965b *Densosporites indignabundus* (Loose) Laveine, p. 133.

Discussion—*C. indignabundus* is highly variable in ornamentation. An inconveniently large number of species of *Cristatisporites* have been erected, many distinguished by subtle, narrowly circumscribed morphologic features that paleobotanical studies (e.g., Leisman, 1970) indicate may be individual variations of phylogenetically identical spores. Specimens observed in CP-19-4 correspond closely to the descriptions and illustrations of *C. indignabundus* reported by previous workers.

Occurrence—Rare.

Genus RADIIZONATES Staplin and Jansonius 1964

Type species—*R. aligerens* (Knox) Staplin and Jansonius 1964.

Affinity—Lycopsid (Courvoisier and Phillips, 1975).

Radiizonates cf. *difformis* (Kosanke) Staplin and Jansonius 1964
(Plate 12, figs. 7, 8)

- 1950 *Cirratrividites difformis* Kosanke, p. 35, pl. 7, fig. 3.
1957a *Cingulizonates asteroides* Dybová and Jachowicz, p. 173-174, pl. 54, figs. 1-4.
1957a *Cingulizonates karczeuskii* Dybová and Jachowicz, p. 175-176, pl. 56, figs. 1-4.
1964 *Radiizonates difformis* (Kosanke) Staplin and Jansonius, p. 106.

Discussion—Spores designated *R. cf. difformis* differ from the type description in being somewhat smaller, and occasionally displaying less distinct ribbing in the flange.

Occurrence—Rare.

Genus CINGULIZONATES (Dybová and Jachowicz)

Butterworth, Jansonius, Smith and Staplin 1964

Type species—*C. bialatus* (Waltz) Smith and Butterworth 1967.

Affinity—Lycopsid (Chaloner, 1958a).

Cingulizonates loricatus (Loose) Butterworth and Smith in Butterworth *et al.*, 1964
(Plate 13, fig. 13)

- 1932 *Sporonites loricatus* Loose in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 42.
1934 *Zonales-sporites loricatus* Loose, p. 151.
1964a *Densisporites loricatus* (Loose) Agrali, p. 13.
1964 *Cingulizonates loricatus* (Loose) Butterworth and Smith, in Butterworth *et al.*, p. 1053, pl. 2, fig. 4.

Discussion—Smith and Butterworth (1967) noted the essential similarity between *C. loricatus* and *C. bialatus*. In British coals, the two species have distinct stratigraphic ranges. The genus does not appear to have been reported previously from Midcontinent North American coals, and the specimens encountered in CP-19-4 are assigned to *C. loricatus* due to its occurrence in equivalent Westphalian strata in Britain (Smith and Butterworth, 1967; Clayton *et al.*, 1977). *C. loricatus* has also been observed in abundance in Lower Pennsylvanian coals of eastern Iowa.

Occurrence—Rare.

Genus CRASSISPORA (Bharadwaj) Sullivan 1964

Type species—*C. kosankei* (Potonié and Kremp) Smith and Butterworth 1967.

Affinity—Miospores of genus *Crassispora* have been isolated from reproductive cones of the lycopsid family Sigillariaceae (Rettschlag and Remy, 1954; Courvoisier and Phillips, 1975). Spores resembling *Crassispora* also have been recovered from the sphenopsid cone *Calamostachys* (Abbott, 1968).

Crassispora annulata sp. nov.
(Plate 12, figs. 11-15)

1964 *Crassispora plicata* Peppers (in part), p. 17, pl. 2, fig. 2.

non 1964 *Crassispora plicata* Peppers (in part), p. 17, pl. 1, fig. 18.

1964 *Crassispora kosankei* (Potonié and Kremp) Bharadwaj; Sullivan, pl. 60, fig. 14.

Diagnosis—Miospores radial, trilete, roundly triangular in equatorial outline, normally in good proximal-distal orientation. Laesurae faint, difficult to observe, extend nearly to angles. Spores display a distinct separation of the intexine, resulting in a uniform ring-like sub-equatorial structure or "annulus". The separation of exine layers appears to be confined to the equatorial region of the spore, as the intexine is not folded and the zone of separation around the equator is relatively uniform in width on any individual specimen. The width of the zone of exine separation varies from 3 to 8 microns between specimens. Exine thin, 2 microns or less, and crescentic compression folds commonly cross the polar areas of the spore, obscuring the laesurae; margin usually not folded. Faint apical papillae are present. External sculpture varies from finely to coarsely granulose, and is confined to the distal hemisphere and equatorial margin.

Size—(30 specimens) 36-55 microns maximum diameter.

Discussion—*C. plicata* Peppers 1964 as described is now considered synonymous with *C. kosankei* by Peppers (personal communication 1976). Examination of the type specimens of *C. plicata*, however, revealed that the second paratype (Peppers, 1964, pl. 2, fig. 2) corresponds to *C. annulata* sp. nov. Sullivan (1964, pl. 60, fig. 14) illustrated a similar specimen, and considered it a variant of *C. kosankei*. *C. annulata* sp. nov. is erected therefore with some hesitancy: the decision to create a new species is based on the absence of forms intermediate between *C. annulata* and *C. kosankei* in CP-19-4, and observations on other Iowa coals that suggest the possibility of distinct stratigraphic ranges for the two forms. As the holotype of *C. plicata* does correspond to *C. kosankei*, it is considered advisable in the interest of clarity to propose the new name *C. annulata*, based on characteristics other than those cited by Peppers (1964) in his description of *C. plicata*, rather than to attempt to emend the diagnosis of *C. plicata* and conserve the name. An emendation would create a confusing and potentially ambiguous circumstance concerning types.

C. annulata differs from *C. kosankei* in displaying distinct exine separation; *C. kosankei* has an equatorial

crassitude not present in *C. annulata*, and the character of compression folds in the two species also tends to differ, with folds most often arranged around the equator of *C. kosankei*, but most often transecting polar regions of *C. annulata*. *C. annulata* is also consistently somewhat smaller than *C. kosankei*, although the size ranges of the species overlap.

Derivation—The specific nomen refers to the annular structure formed by the internal membrane.

Occurrence—Rare to infrequent, observed principally in segments 6 and 7 of the *Densosporites-Crassispora* interval.

Holotype—Plate 12, fig. 11, slide 6V3 coordinates 131.5-48.5, 49.6 microns maximum diameter.

Paratype—Plate 12, fig. 12, slide 6R6 coordinates 128-63, 50.1 microns.

Paratype—Plate 12, fig. 13, slide 7M3 coordinates 128-53.5, 42.8 microns.

Paratype—Plate 12, fig. 14, slide 7D2 coordinates 133-56, 38.8 microns.

Paratype—Plate 12, fig. 15, slide 6H4 coordinates 123-41.5, 46.7 microns.

Crassispora kosankei (Potonié and Kremp)
Smith and Butterworth 1967
(Plate 12, figs. 9, 10)

1955 *Planisporites kosankei* Potonié and Kremp, p. 71, pl. 13, figs. 208-213.

1957a *Planisporites ovalis* Bharadwaj, p. 86, pl. 23, figs. 9, 10.

1957b *Crassispora ovalis* Bharadwaj, p. 126, pl. 25, figs. 73-76.

1957b *Crassispora kosankei* (Potonié and Kremp) Bharadwaj, p. 127.

1957 *Apiculatisporites apiculatus* (Ibrahim) Dybová and Jachowicz (*non sensu* Ibrahim) p. 87, pl. 15, figs. 1-4.

1964 *Crassispora plicata* Peppers (in part), p. 17, pl. 1, fig. 18, pl. 2, fig. 1.

non 1964 *Crassispora plicata* Peppers (in part), p. 17, pl. 2, fig. 2.

1967 *Crassispora kosankei* (Potonié and Kremp) Smith and Butterworth, p. 234, pl. 19, figs. 2-4.

Discussion—See Discussion of *C. annulata* sp. nov.

Occurrence—Characteristic species of the *Densosporites-Crassispora* interval, where it is often abundant and occasionally dominant; rare in the *Florinites* and *Lycospora* intervals.

Genus CAPPASPORITES Urban 1966

Type species—*C. distortus* Urban 1966.

Affinity—Miospores of genus *Cappasporites* have been isolated from the lycopod cone *Achlamydocarpon* (Courvoisier and Phillips, 1975; Leisman and Phillips, 1979).

Cappasporites distortus Urban 1966
(Plate 13, figs. 1, 2)

1966 *Cappasporites distortus* Urban, p. 114, pl. 1, figs. 1-14.

1966 *Granisporites medius* Dybová and Jachowicz 1957; Habib, p. 634, pl. 105, figs. 2, 3, 5.

1970 *Crassispora plicata?* Peppers 1964; Peppers, pl. 11, fig. 19.

Discussion—*Apiculatisporis irregularis* (Alpern) Smith and Butterworth 1967 displays an ornament similar to that of *C. distortus*, but the grana are arranged

in loose groups or patches and appear to occur on both distal and proximal surfaces; grana of *C. distortus* are more random in distribution and are confined to the distal surface. *A. irregularis* (Alpern) Smith and Butterworth 1967 is a junior homonym of *A. irregularis* (Kosanke) Potonié and Kremp 1955.

Occurrence—Common to occasionally abundant throughout CP-19-4, although somewhat reduced in numbers in the *Densosporites-Crassispora* interval.

Genus DENSOSPORITES (Berry) Butterworth,
Jansonius, Smith and Staplin 1964

Type species—*D. covensis* Berry 1937.

Affinity—Miospores assignable to *Densosporites* have been described from minute lycopod cones, probably related to herbaceous plants (Chaloner, 1958a; Bharadwaj, 1958; Leisman, 1970).

Densosporites anulatus (Loose) Smith
and Butterworth 1967
(Plate 13, figs. 3-5)

1932 *Sporonites anulatus* Loose in Potonié, Ibrahim and Loose, p. 451, pl. 18, fig. 44.

1934 *Zonales-sporites (Anulatis-sporites) anulatus* Loose, p. 151.

1944 *Densosporites annulatus* (Loose) Schopf, Wilson and Bentall, p. 40.

1950 *Denso-sporites reynoldsburgensis* Kosanke, p. 33, pl. 6, figs. 9-11.

1956 *Anulatisporites anulatus* (Loose) Potonié and Kremp, p. 112, pl. 17, figs. 365-372.

1967 *Densosporites anulatus* (Loose) Smith and Butterworth, p. 239, pl. 19, figs. 5, 6.

Occurrence—Rare.

Densosporites irregularis Hacquebard and Barss 1957
(Plate 13, fig. 9)

1957 *Denso-sporites irregularis* Hacquebard and Barss, p. 31, pl. 4, figs. 11-14.

Discussion—*D. cavus* Urban 1971 (p. 118, pl. 26, figs. 10-12, pl. 27, figs. 1-5) displays similar "excavations" around the cingulum, but has small conic on the distal surface, and is smaller than *D. irregularis*.

Occurrence—Rare.

Densosporites sphaerotriangularis Kosanke 1950
(Plate 13, figs. 7, 8)

1950 *Densosporites sphaerotriangularis* Kosanke, p. 33-34, pl. 6, fig. 7.

1964 *Densosporites sphaerotriangularis* (Kosanke) Levet-Carette, p. 273.

Occurrence—Characteristic of the *Densosporites-Crassispora* interval, where it ranges from common to dominant. Rare in the *Florinites* interval and lower levels of the *Lycospora* interval, but becomes frequent to common in the uppermost levels of the seam.

Densosporites spinifer Hoffmeister, Staplin and Malloy
1955
(Plate 13, figs. 10-12)

1955 *Densosporites spinifer* Hoffmeister, Staplin and Malloy, p. 386-387, pl. 36, figs. 16, 17.

Discussion—*D. spinifer* was first described from the Mississippian and is given a range of Viséan to Namurian (Upper Mississippian equivalent) by Smith and Butterworth (1967) in Britain. Miospores assigned to this species in CP-19-4 correspond closely to the description of Hoffmeister, Staplin and Malloy (1955).

Occurrence—Rare, *Densosporites-Crassispora* interval.

Densosporites triangularis Kosanke 1950
(Plate 13, fig. 6)

- 1950 *Densosporites triangularis* Kosanke, p. 34, pl. 7, fig. 1.
1958 *Densosporites spongiosus* Butterworth and Williams, p. 380, pl. 3, figs. 40, 41.
1966 *Densosporites oblatum* Habib, p. 641-642, pl. 106, figs. 12, 14.

Occurrence—Rare, *Florinites* interval.

Genus LYCOSPORA (Schopf, Wilson and Bentall)
Potoničand Kremp 1954

Type species—*L. micropapillata* (Wilson and Coe) Schopf, Wilson and Bentall 1944.

Discussion—A great many species of *Lycospora* have been described, and paleobotanical studies of spores from reproductive structures have indicated that many are superfluous (Balbach, 1966). In an attempt to bring order to the genus, Somers (1971) revised *Lycospora*, synonymizing many species into a few broadly defined form categories. This revision has been employed variously by subsequent authors, and the utility of certain synonymies has been questioned (e.g. Coquel, 1973). The revision is not followed in this report.

Affinity—Miospores of genus *Lycospora* have been correlated by numerous investigators with the reproductive structures of arborescent lepidodendrids (Andrews and Pannell, 1942; Chaloner, 1953a; Felix, 1954; Sen, 1958; Leisman and Spohn, 1962; Abbott, 1963; Balbach, 1966, 1967; Leisman and Rivers, 1971; Courvoisier and Phillips, 1975). Spores conforming to *L. granulata* Kosanke 1950 are related to the organ genus *Lepidocarpon* (Phillips, 1979).

Lycospora granulata Kosanke 1950
(Plate 13, fig. 15)

- 1950 *Lycospora granulata* Kosanke, p. 45, pl. 10, figs. 4, 6.
1957a *Lycospora denticulata* Bharadwaj, p. 103, pl. 27, fig. 9.
1957a *Lycospora triangulata* Bharadwaj, p. 103, pl. 27, figs. 13, 14.
1964b *Lycosisporites granulatus* (Kosanke) Agrali, p. 14.
non 1967 *Lycospora? granulata* Kosanke 1950; Smith and Butterworth, p. 247, pl. 20, figs. 1-3.

Discussion—Miospores assignable to *L. granulata* under Kosanke's (1950) description exhibit variable coarseness and density of granulose ornament, a characteristic noted by other workers (e.g., Smith and Butterworth, 1967).

Occurrence—*L. granulata* is infrequent to frequent through the *Florinites* and *Densosporites-Crassispora* intervals, but becomes the dominant miospore species above segment 9, marking the base of the *Lycospora*

interval. *L. granulata* consistently constitutes 50% or more of the miospore population in segments 10 and 11.

Lycospora micropapillata (Wilson and Coe) Schopf,
Wilson and Bentall 1944
(Plate 13, fig. 14)

- 1940 *Cirratriradites micropapillatus* Wilson and Coe, p. 184, fig. 6.
1944 *Lycospora micropapillata* (Wilson and Coe) Schopf, Wilson and Bentall, p. 54.

Discussion—The original diagnosis of this species is inadequate and was not emended by Schopf, Wilson and Bentall (1944) when reassigned as the type species of *Lycospora*. Wilson (1958, pl. 1, fig. 6) noted that the original size measurements of the species were in error and provided the first photographic illustration of it. Specimens observed in CP-19-4 are therefore assigned with some hesitancy to *L. micropapillata* primarily on the basis of comparison with Wilson's (1958) illustration.

Occurrence—Rare to infrequent in the *Lycospora* interval, rare in the *Florinites* and *Densosporites-Crassispora* intervals.

Lycospora pellucida (Wicher) Schopf, Wilson
and Bentall 1944
(Plate 13, fig. 16)

- 1934 *Sporites pellucidus* Wicher, p. 186, pl. 8, fig. 29.
1944 *Lycospora pellucidus* (Wicher) Schopf, Wilson and Bentall, p. 54.
1950 *Lycospora punctata* Kosanke, p. 45, pl. 10, fig. 7.
1950 *Lycospora pseudoannulata* Kosanke, p. 45, pl. 10, fig. 3.
1955 *Cirratriradites uber* Hoffmeister, Staplin and Malloy, p. 383, pl. 36, fig. 24.
1957a *Lycospora microgranulata* Bharadwaj, p. 104, pl. 27, fig. 18.
1957 *Lycospora tenuireticulata* Artüz, p. 250, pl. 5, fig. 32.
1957 *Lycospora uzunmehmedi* Artüz, p. 250, pl. 5, fig. 33.
1960 *Lycospora uber* (Hoffmeister, Staplin and Malloy) Staplin, p. 20, pl. 4, figs. 13, 17, 18, 20.
1964 *Lycosisporites pellucidus* (Wicher) Levet-Carette, p. 272, pl. 10, fig. 24.

Discussion—The likelihood of synonymy of *L. punctata* and *L. pseudoannulata* with *L. pellucida* has been suggested by previous workers (Smith and Pierart, in Pierart *et al.*, 1964; Smith and Butterworth, 1967; Peppers, 1970). *L. uber*, *L. microgranulata* and *L. uzunmehmedi* are also considered synonymous with *L. pellucida* in this report. Somers (1971) considered *L. pellucida* to be synonymous with *L. pusilla* (Ibrahim) Schopf, Wilson and Bentall 1944, but this view is not followed here.

Occurrence—Common to occasionally dominant through the *Florinites* interval, infrequent to common in the lower portion of the *Densosporites-Crassispora* interval, rising to dominance with a peak of abundance of more than 50% in the upper portion of the interval; rare to infrequent throughout the *Lycospora* interval.

Lycospora rotunda Bharadwaj 1957
(Plate 13, figs. 19, 20)

- 1957a *Lycospora rotunda* Bharadwaj, p. 103, pl. 27, figs. 10-12.

- 1957 *Lycospora nitida* Artüz, p. 250, pl. 5, fig. 34.
1957 *Lycospora paulula* Artüz, p. 250, pl. 5, fig. 35.

Occurrence—Rare.

Lycospora cf. *L. torquifer* (Loose) Potonié
and Kremp 1956

- ?1932 *Sporonites torquifer* Loose in Potonié, Ibrahim and
Loose, p. 450, pl. 18, fig. 43.
?1934 *Reticulati-sporites torquifer* Loose, p. 154.
1956 *Lycospora torquifer* (Loose) Potonié and Kremp, p. 104,
pl. 17, fig. 355-359.

Discussion—Pierart (1964) excluded *L. torquifer* from the genus *Lycospora* after an examination of photographs of the holotype indicated that it did not possess a cingulum. Potonié and Kremp (1956), in reassigning the species to *Lycospora*, illustrated four additional specimens which are definitely cingulate. Specimens observed in CP-19-4 closely resemble these specimens and have a granulose ornament intermediate in coarseness between *L. granulata* and *L. rotunda*. Peppers (1970) recognized similar spores as *L. cf. torquifer*.

Occurrence—Rare.

Genus CIRRATRIRADITES Wilson and Coe 1940

Type species—*C. maculatus* Wilson and Coe 1940.

Affinity—Miospores of genus *Cirratriradites* have been isolated from the herbaceous lycopod cone *Selaginellites* (Chaloner, 1954; Hoskins and Abbott, 1956; Schlanker and Leisman, 1961).

Cirratriradites annuliformis Kosanke
and Brokaw, in Kosanke 1950
(Plate 14, fig. 2)

- 1950 *Cirratriradites annuliformis* Kosanke and Brokaw; in
Kosanke, p. 35, pl. 7, fig. 6.

Occurrence—Rare.

Cirratriradites maculatus Wilson and Coe 1940
(Plate 14, fig. 1)

- 1940 *Cirratriradites maculatus* Wilson and Coe, p. 183, pl. 1,
fig. 7.

Discussion—Wilson and Coe (1940) erected *C. maculatus* as the type species of the genus but provided a *camera lucida* drawing and little formal description. Potonié and Kremp (1956) considered *C. maculatus* synonymous with *C. saturni* (Ibrahim) Schopf, Wilson and Bentall 1944, which was described initially in 1932 and had priority. Wilson (1966) re-examined both the type material of *C. maculatus* and Potonié's specimens of *C. saturni*, and re-established *C. maculatus* as a valid taxon. Both species occur in CP-19-4 and are readily distinguishable on the basis of Wilson's (1966) description and photographic illustrations.

Despite the several publications discussing the status of *C. maculatus*, no satisfactory diagnosis appears to exist. It is therefore considered advisable to construct one in this report. The following diagnosis is based on the original discussion of Wilson and Coe (1940), Wilson's (1966) discussion, and observations of specimens in CP-19-4; it does not alter the major characteristics of the species and does not constitute an emendation.

Diagnosis—Miospores radial, trilete, roundly triangular in equatorial outline; usually in good proximal-distal orientation. Equatorial flange without rods or conspicuous striations, finely serrate at margin. Width of flange about 15 microns, fairly uniform around equator of spore. Triradiate ridges sinuose, crossing flange to margin at angles. Single distal fovea present, sometimes constricted so as to give appearance of two or more. Main body of spore finely punctate or granulose (?infrasculpture), exine rather thick, sometimes nearly opaque.

Occurrence—Rare, but widely distributed throughout CP-19-4.

Cirratriradites reticulatus sp. nov.
(Plate 14, figs. 4-6)

Diagnosis—Miospores radial, trilete, sphaerotriangular to nearly circular in equatorial outline, usually in good proximal-distal orientation. Finely serrate equatorial flange, very thin, diaphanous and nearly transparent in outer region, slightly thicker near conjunction with spore body; fine radial striations occur in thicker portion of flange. Flange 5-10 microns wide, slightly wider at angles. Laesurae raised, narrow and slightly sinuose, reaching to angles, often indistinct, obscured by distal ornament. Proximal surface nearly laevigate to finely punctate (?infrasculpture), exine thin; distal surface of spore body covered with well-developed reticulum of irregularly polygonal lumina. Muri 1-2 microns wide, about 1 micron in height, tending to merge near edge of spore body. Over most of the distal surface, lumina are relatively equal in size, 2-8 microns in maximum dimension. Spore body seldom folded, but flange often possesses minor folds.

Size—(10 specimens) 42-54 microns maximum diameter including flange.

Discussion—No distal fovea has been observed. *C. reticulatus* is distinguished from other species of the genus by its strongly developed distal reticulum. *C. saturni* has a finer, less conspicuous reticulate sculpture, but is usually larger, has a more substantial flange, and normally bears a distal fovea.

Derivation—The specific nomen refers to the reticulate distal ornament.

Occurrence—Rare, observed only in coaly shale unit, CP-19-5.

Holotype—Plate 14, fig. 4, CP-19-5 slide Y-4 coordinates 124.5-33, 52.4 microns maximum diameter including flange.

Paratype—Plate 14, fig. 5, CP-19-5 slide A-3 coordinates 128-61, 49.6 microns.

Paratype—Plate 14, fig. 6, CP-19-5 slide X-5 coordinates 137.5-34.5, 51.3 microns.

Cirratriradites saturni (Ibrahim) Schopf,
Wilson and Bentall 1944
(Plate 14, fig. 3)

- 1932 *Sporonites saturni* Ibrahim in Potonié, Ibrahim and
Loose, p. 448, pl. 15, fig. 14.
1933 *Zonales-sporites saturni* Ibrahim, p. 30, pl. 2, fig. 14.
1938 *Zonotriletes saturni* (Ibrahim) Lubner in Lubner and Waltz,
p. 8, fig. 102.

1944 *Cirratiradites saturni* (Ibrahim) Schopf, Wilson and Bentall, p. 44.

1965a *Cirratrisporites saturni* (Ibrahim) Laveine, p. 134.

Discussion—Wilson (1966) indicated that *C. saturni* differs from *C. maculatus* in possession of a reticulate sculpture on the spore body and radial striations in the flange.

Occurrence—Rare.

Genus ENDOSPORITES Wilson and Coe 1940

Type species—*E. ornatus* Wilson and Coe 1940.

Discussion—As noted by Smith and Butterworth (1967), the generic diagnosis of Wilson and Coe (1940) has become inadequate for separation of pseudosaccate spore genera, and is in need of emendation based on study of type materials. Although not noted by Wilson and Coe (1940), most subsequent studies have considered possession of a limbus to be a generic character for *Endosporites*, distinguishing it from such genera as *Florinites* Schopf in Schopf, Wilson and Bentall 1944 and *Wilsonites* (Kosanke) Kosanke 1959.

Affinity—Spores of genus *Endosporites* have been described as microspores from the cone of a heterosporous arborescent lycopod (Chaloner, 1953b, 1958b; Brack and Taylor, 1972). Recent study of the cone genus (*Polysporia*), however, suggests an herbaceous rather than an arborescent habit (DiMichele, Mahaffy and Phillips, in press).

Endosporites globiformis (Ibrahim) Schopf,
Wilson and Bentall 1944
(Plate 14, fig. 7)

1932 *Sporonites globiformis* Ibrahim in Potonić, Ibrahim and Loose, p. 447, pl. 14, fig. 5.

1933 *Zonales-sporites globiformis* Ibrahim, p. 28, pl. 1, fig. 5.

1938 *Zonotriletes globiformis* (Ibrahim) Luber in Luber and Waltz, pl. 8, fig. 103, pl. B, fig. 30.

1944 *Endosporites globiformis* (Ibrahim) Schopf, Wilson and Bentall, p. 45.

1965a *Endopollenites globiformis* (Ibrahim) Laveine, p. 136.

Discussion—Distinction between *E. globiformis* and *E. zonalis* (Loose) Knox 1950 is made on the basis of the ratio of body radius to pseudosaccus radius; *E. globiformis* has a body radius smaller than the width of the pseudosaccus, where *E. zonalis* has a body radius greater than that of the pseudosaccus. *E. zonalis* commonly, though not always, also display a faint zonal structure around the margin of the spore body, which may reflect some exine separation. Smith and Butterworth (1967) noted the existence of several similar and possibly synonymous species, including *E. ornatus*, the type species, which is described as having a body-to-pseudosaccus ratio intermediate between *E. globiformis* and *E. zonalis*.

Occurrence—Common to abundant in the *Florinites* interval, infrequent or rare in the *Densosporites-Crassispora* interval, frequent to common in the *Lycospora* interval. The overall frequency curve of *E. globiformis* is similar to that of *Florinites mediapudens* (Loose) Potonić and Kremp 1956, suggesting a possible paleoecologic similarity in the two saccate species. Smith

and Butterworth (1967) observed a similar distributional relationship.

Endosporites staplinii Gupta
and Boozer 1969
(Plate 14, figs. 9-11)

1960 *Endosporites? parvus* Staplin, p. 33, pl. 7, figs. 8, 12.

non 1958 *Endosporites parvus* Guennel, p. 50-51, test-fig. 11, pl. 1, figs. 16, 17.

1969 *Endosporites staplinii* Gupta and Boozer, p. 78.

1976 *Endosporites cf. micromanifestus* Hacquebard 1957; Tillement, Peniguel and Guillemin, p. 438, pl. 1, fig. 27.

Discussion—The spelling of the specific name is altered from *staplini* to *staplinii* as an orthographic correction without emendation.

E. egemeni (Agrali) Loboziak 1971 resembles *E. staplinii*, but the inadequacy of the original description of *E. egemeni* (Agrali, 1964b), which was not expanded in Loboziak's (1971) reassignment, makes comparison difficult and suggests that *E. egemeni* would best be regarded as a *nomen nudum*. *E. egemeni* is given a size range slightly larger than that of *E. staplinii* (24-35 microns: Staplin, 1960), and the former was described from strata younger than that characterized by reported occurrences of *E. staplinii*. Neither Agrali (1964b) nor Loboziak (1971) suggested synonymy of *E. egemeni* with *E. parvus* Staplin 1960.

Occurrence—Rare, observed primarily in the *Florinites* interval.

Endosporites zonalis (Loose) Knox 1950
(Plate 14, fig. 8)

1934 *Zonales-sporites zonalis* Loose, p. 148, pl. 7, fig. 5.

1944 *Cirratiradites zonalis* (Loose) Schopf, Wilson and Bentall, p. 44.

1950 *Endosporites zonalis* (Loose) Knox, p. 332.

1965a *Endopollenites zonalis* (Loose) Laveine, p. 136.

Occurrence—Rare to infrequent throughout CP-19-4; less abundant than *E. globiformis*.

Genus ALATISPORITES (Ibrahim) Smith
and Butterworth 1967

Type species—*A. pustulatus* (Ibrahim) Ibrahim 1933.

Affinity—Unknown. Spores of *Alatisporites* have been isolated from a fructification of uncertain paleobotanical relationship (Courvoisier and Phillips, 1975).

Alatisporites hoffmeisterii Morgan 1955
(Plate 15, figs. 1, 2)

1955 *Alatisporites hoffmeisterii* Morgan, p. 37-38, pl. 2, figs. 1-8.

Occurrence—Rare, observed most often in the *Florinites* interval.

Alatisporites pustulatus (Ibrahim) Ibrahim 1933
(Plate 14, figs. 12, 13)

1932 *Sporonites pustulatus* Ibrahim in Potonić, Ibrahim and Loose, p. 448, pl. 14, fig. 12.

1933 *Alati-sporites pustulatus* (Ibrahim) Ibrahim, p. 32, pl. 1, fig. 12.

1965 *Alatipollenites pustulatus* (Ibrahim) Laveine, p. 136.

Discussion—*A. trialatus* Kosanke 1950 is similar to *A. pustulatus*, but the latter species is ornamented on the proximal surface of the spore body by small, sinuose folds of the pseudosaccus, while the former is relatively smooth.

Occurrence—Rare, except for a narrow horizon in the *Florinites* interval where it is frequent.

Genus LAEVIGATOSPORITES Ibrahim 1933

Type species—*L. vulgaris* (Ibrahim) Ibrahim 1933.

Discussion—Several other genera of small monolete spores have been erected, notably *Punctatosporites* Ibrahim 1933, *Latosporites* Potonié and Kremp 1954 and *Speciososporites* Potonié and Kremp 1954, which are distinguished from *Laevigatosporites* on the basis of characters which may be subject to considerable variation or which may be difficult to determine with consistency. Small monolete spores observed in CP-19-4 having little or no exine ornament were assigned entirely to *Laevigatosporites*, although certain of the other genera could have been employed in individual instances. These alternative assignments are noted where appropriate in the individual species synonymies.

Affinity—*Laevigatosporites* is a highly generalized form taxon containing miospores of both sphenopsid and fern affinities. Species larger than about 35 microns in length have been isolated only from sphenopsid fructifications (Reed, 1938; Andrews and Mamay, 1951; Leisman and Graves, 1964). In CP-19-4, species larger than 35 microns include *L. medius*, *L. ovalis*, *L. desmoinensis*, *L. striatus*, *L. cf. dunkardensis*, *L. vulgaris* and *L. cf. vulgaris*. Smaller monolete spores assignable to *Laevigatosporites* have been isolated from both ferns (Mamay, 1950; Ewart, 1961) and sphenopsids (Baxter, 1950; Andrews and Mamay, 1951). The smaller species in CP-19-4 include *L. globosus* and *L. minutus*; they are considered to have marattialean fern affinities, although a degree of uncertainty exists.

Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson and Bentall 1944 (Plate 15, fig. 11)

1940 *Phaseolites desmoinensis* Wilson and Coe, p. 182, pl. 1, fig. 4.

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

Discussion—In this report, distinction between *L. medius*, *L. ovalis*, *L. desmoinensis* and *L. vulgaris* is made arbitrarily on the basis of length. The size range of *L. desmoinensis* was cited originally as 60-75 microns (Wilson and Coe, 1940), and is employed for *L. desmoinensis* here. Smith and Butterworth (1967) considered *L. desmoinensis* to be synonymous with *L. vulgaris*. In CP-19-4, however, a bimodal size distribution of larger forms of *Laevigatosporites* was observed. Few specimens occurred with lengths of 70-80 microns, and a 75-micron boundary was employed for separation of the smaller *L. desmoinensis* from the larger *L. vulgaris*. *L. vulgaris* is commonly thinner than *L. desmoinensis* and often possesses minor compression folds near the ends of the laesura; *L. desmoinensis* rarely displays folds.

Occurrence—Rare to infrequent throughout CP-19-4.

Laevigatosporites cf. dunkardensis Clendening 1970 (Plate 15, fig. 14)

1969 *Laevigatosporites plicatus* Clendening, p. 263, pl. 3, figs. 1-7.

non 1968 *Laevigatosporites plicatus* Kar, p. 120-121, pl. 1, figs. 28, 29.

1970 *Laevigatosporites dunkardensis* Clendening, p. 788.

Discussion—*L. dunkardensis* overlaps the size ranges of *L. desmoinensis* and *L. vulgaris* but is distinguished from these latter species by its extremely thin, much-folded *Calamospora*-like exine. Specimens observed in CP-19-4, designated *L. cf. dunkardensis*, displayed a more distinct, raised laesura than specimens of *L. dunkardensis* described by Clendening (1969).

Occurrence—Rare, observed primarily in lower levels of the *Florinites* interval.

Laevigatosporites globosus Schemel 1951 (Plate 15, figs. 4-6)

1951 *Laevigatosporites globosus* Schemel, p. 746-747, fig. 2.

1956 *Latosporites globosus* (Schemel) Potonié and Kremp, p. 140.

Discussion—Spores assigned to *L. globosus* in CP-19-4 displayed ornamentation ranging from punctate to laevigate to granulose, as illustrated in plate 15, figs. 4-6. See also Discussion of *Punctatisporites obliquus*.

Occurrence—Common in lower levels of *Florinites* interval, rare to infrequent above segment 1.

Laevigatosporites medius Kosanke 1950 (Plate 15, figs. 8, 9)

1934 *Laevigatosporites minor* Loose (in part), p. 158, pl. 7, fig. 12.

1950 *Laevigatosporites medius* Kosanke, p. 29, pl. 16, fig. 2.

Discussion—*L. medius* is considered here to have a length ranging from 32-45 microns.

Occurrence—Rare, but widely distributed throughout CP-19-4.

Laevigatosporites minutus (Ibrahim) Schopf, Wilson and Bentall 1944 (Plate 15, fig. 3)

1933 *Punctato-sporites minutus* Ibrahim, p. 40, pl. 5, fig. 33.

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

Discussion—Forms smaller than 32 microns in length are assigned here to *L. minutus*. The relations of this species with *L. minimus* (Wilson and Coe) Schopf, Wilson and Bentall 1944 and *L. perminutus* Alpern 1959 are unclear. The exine of *L. minutus* commonly appears infrapunctate.

Occurrence—Common to abundant throughout CP-19-4.

Laevigatosporites ovalis Kosanke 1950 (Plate 15, fig. 10)

1934 *Laevigatosporites minor* Loose (in part), p. 158, pl. 7, fig. 12.

1950 *Laevigatosporites ovalis* Kosanke, p. 29-30, pl. 5, fig. 7.

Discussion—*L. ovalis* is considered to have a length ranging from 45-60 microns. Most specimens were somewhat wider in relation to their length than were specimens of *L. desmoinensis*.

Occurrence—Common to abundant in the *Florinites* and *Densosporites-Crassispora* intervals, frequent to common in the *Lycospora* interval.

Laevigatosporites striatus Alpern 1959
(Plate 15, figs. 12, 13)

1959 *Laevigatosporites striatus* Alpern, p. 153, pl. 11, figs. 267, 268.

Discussion—The arcuate striations of *L. striatus* appear to result from compression of a group of spores against one another, followed by separation of individual spores, possibly during maceration. Several masses of these spores were observed in CP-19-4. In the absence of striations, the spores would correspond to *L. ovalis*. Both *L. ovalis* and *L. striatus* did not accept safranin stain readily, suggesting similarity in exine characteristics. Despite these implications of potential synonymy of *L. striatus* with *L. ovalis*, it is possible that the deposition of spores of *L. striatus* in masses may be due to their production by a plant phylogenetically distinct from that which produced *L. ovalis* spores. The distribution of *L. striatus* in CP-19-4 does not mimic that of *L. ovalis*, and study of other Iowa coals indicates that differences exist in the stratigraphic ranges of the two species (Ravn, I.G.S. Technical Paper 7, in preparation). *L. striatus* is therefore maintained as a valid form species.

Occurrence—Rare, but widely distributed in the upper *Florinites* interval and throughout the *Densosporites-Crassispora* interval; seldom observed elsewhere in CP-19-4.

Laevigatosporites vulgaris (Ibrahim) Ibrahim 1933
(Plate 15, fig. 15)

1932 *Sporonites vulgaris* Ibrahim in Potonié, Ibrahim and Loose, p. 448, pl. 15, fig. 16.

1933 *Laevigato-sporites vulgaris* (Ibrahim) Ibrahim, p. 39, pl. 2, fig. 16.

Discussion—In practice, forms of *Laevigatosporites* ranging from 75 to 100 microns in length, having a laesura of $\frac{2}{3}$ to more than $\frac{3}{4}$ of the spore length, and displaying a relatively thin, but not diaphanous and heavily folded exine, are assigned to *L. vulgaris*. Specimens larger than 100 microns in length are assigned to *L. maximus* (Loose) Potonié and Kremp 1956; no specimens fitting this description were encountered in CP-19-4, although the species has been observed in other Iowa coals. *L. dunkardensis* can be of similar size to *L. vulgaris*, but the former species has an extremely thin exine, which is almost always heavily folded. A miospore designated *L. cf. vulgaris* is described following.

Occurrence—Rare.

Laevigatosporites cf. vulgaris (Ibrahim) Ibrahim 1933
(Plate 15, fig. 16)

Description—Similar to *L. vulgaris* in length, but with a considerably thicker exine and more oval shape. Laesura normally about $\frac{1}{2}$ of spore length.

Occurrence—Rare.

Genus THYMOSPORA Wilson and Venkatachala
1963(a)

Type species—*T. thiessenii* (Kosanke) Wilson and Venkatachala 1963.

Affinity—Marattiales (Millay, 1979).

Thymospora cf. pseudothiessenii (Kosanke) Wilson
and Venkatachala 1963
(Plate 16, figs. 2-4)

1950 *Laevigatosporites pseudothiessenii* Kosanke, p. 30, pl. 5, fig. 10.

1956 *Verrucosporites pseudothiessenii* (Kosanke) Potonié and Kremp, p. 144.

1963a *Thymospora pseudothiessenii* (Kosanke) Wilson and Venkatachala, p. 125, pl. I, figs. 1-11, pl. II, figs. 1-12.

Discussion—Miospores designated *T. cf. pseudothiessenii* display a greater variety of ornament than normal for *T. pseudothiessenii*.

Occurrence—Rare, *Florinites* interval.

Genus TORISPORA (Balme) Doubinger and Horst
1961

Type species—*T. securis* Balme 1952.

Affinity—Investigations of *Torispora* have established that it represents the outermost cells of a sporangial mass in which the inner cells correspond to certain species of *Laevigatosporites* and *Thymospora* (Horst, 1957; Guennel and Neavel, 1961; Artüz, 1962). Spores corresponding to *Torispora* have been isolated from fern fructifications, along with smaller forms of *Laevigatosporites* (Laveine, 1969, 1970). Stach (1975) suggested a pteridospermous affinity, but this has not been substantiated and seems unlikely.

Torispora securis Balme 1952
(Plate 16, fig. 1)

1952 *Torispora securis* Balme, p. 183, text-fig. 3a-3d.

1957a *Torispora recta* Dybová and Jachowicz, p. 197, pl. 66, figs. 1-4.

1957a *Torispora undulata* Dybová and Jachowicz, p. 197, pl. 67, figs. 1-4.

1957a *Torispora speciosa* Dybová and Jachowicz, p. 198, pl. 68, figs. 1-4.

Discussion—Alpern (1958, 1959) and Alpern, Doubinger and Horst (1965) have erected a number of species of *Torispora* differentiated by ornamentation. Smith and Butterworth (1967) suggested relationships between the species of *Torispora* and various other monolet species of similar ornamentation. Specimens observed in CP-19-4 were uniformly of fine granulose ornamentation, and all were assigned to *T. securis*; *Laevigatosporites globosus* displays similar ornament.

Occurrence—Rare to infrequent throughout CP-19-4.

Genus TUBERCULATOSPORITES Imgrund 1960

Type species—*T. anicystoides* Imgrund 1960.

Affinity—Unknown.

Tuberculatosporites robustus (Kosanke) Peppers 1970
(Plate 16, figs. 5, 6)

- 1950 *Laevigatosporites robustus* Kosanke, p. 30, pl. 5, fig. 9.
 1966 *Tuberculatosporites spinoplicatus* Habib, p. 644, pl. 107, figs. 1-3.
 1970 *Tuberculatosporites robustus* (Kosanke) Peppers, p. 127, pl. 13, figs. 1, 2.

Occurrence—Rare, *Florinites* interval.

Genus VESTISPORIA (Wilson and Hoffmeister)
 Wilson and Venkatachala 1963(b)

Type species—*V. profunda* Wilson and Hoffmeister 1956.

Affinity—Mamay (1954a) described spores assignable to *Vestisporia* from Iowa sphenopsid cone. Similar spores have been isolated from a variety of sphenopsid-related fructifications (Levittan and Barghorn, 1948; W. Remy, 1955; R. Remy, 1959; Brush and Barghoorn, 1964). See also Discussion of genus *Elaterites*.

Vestisporia fenestrata (Kosanke and Brokaw)
 Spode, in Smith and Butterworth, 1967
 (Plate 17, figs. 2, 3)

- 1950 *Punctatisporites fenestratus* Kosanke and Brokaw, in Kosanke, 1950, p. 15, pl. 2, fig. 10.
 1954 *Microreticulatisporites fenestratus* (Kosanke and Brokaw) Butterworth and Williams, p. 755, pl. 17, figs. 1-3, text-fig. 1, fig. 2.
 1955 *Foveolatisporites fenestratus* (Kosanke and Brokaw) Bharadwaj, p. 126, pl. 1, fig. 4.
 1963b *Vestisporia fenestrata* (Kosanke and Brokaw) Wilson and Venkatachala, p. 99, pl. 1, figs. 13, 14.
 1965b *Vestisporites fenestratus* (Kosanke and Brokaw) Laveine, p. 2556, pl. 1, figs. 9, 24.
 1967 *Vestisporia fenestrata* (Kosanke and Brokaw) Spode, in Smith and Butterworth, p. 296, pl. 25, figs. 3-6.

Discussion—*V. velensis* (Bharadwaj) Wilson and Venkatachala 1963 is similar to *V. fenestrata* and possibly synonymous.

Occurrence—Rare.

Vestisporia laevigata Wilson and Venkatachala 1963
 (Plate 16, figs. 7-9)

- 1963b *Vestisporia laevigata* Wilson and Venkatachala, p. 98, pl. 1, figs. 8-11.
 1965b *Vestisporites laevigatus* (Wilson and Venkatachala) Laveine, p. 2556, pl. 1, fig. 10.

Occurrence—Rare to infrequent throughout CP-19-4.

Vestisporia luminata sp. nov.
 (Plate 17, figs. 4-10)

Diagnosis—Miospores radial, trilete, spherical, bearing operculate exoexine with strongly developed reticulum. Muri about 3 microns in width, 2-3 microns in height, lumina 3-6 microns in diameter, oval to polygonal in outline. Lumina of operculum tend to be somewhat more round in outline. Inner body thin; both body and trilete rays very difficult to observe in most specimens owing to density of exoexine ornament.

Size—(21 specimens) 78-111 microns maximum diameter.

Discussion—*V. luminata* most closely resembles *V. fenestrata*, differing from the latter in the greater size and commonly polygonal outline of the lumina. *V. pseudoreticulata* Spode (in Smith and Butterworth,

1967) possesses a secondary reticulum which, in the most distinct specimens, may have a similar aspect to the reticulum of *V. luminata*, but *V. pseudoreticulata* also displays a coarse primary reticulum not seen in *V. luminata*. A spore described by Ibrahim (1933) as *Reticulata-sporites spongiosus* bears some resemblance to *V. luminata*, but it is unclear from the description and illustration whether this spore could be assigned to *Vestisporia*.

Derivation—The specific nomen refers to the distinctive lumina.

Occurrence—Rare, observed most often in the *Densosporites-Crassisporea* interval.

Holotype—Plate 17, fig. 4, slide 5Z6 coordinates 123-51.5, 96.6 microns maximum diameter.

Paratype—Plate 17, fig. 6, slide 6Z6 coordinates 128-50, 93.7 microns.

Paratype—Plate 17, fig. 7, slide 6H2 coordinates 131.5-43.5, 88.0 microns.

Paratype—Plate 17, fig. 8, slide 6V1 coordinates 125-49, 92.3 microns.

Paratype—Plate 17, fig. 9, slide 6Z5 coordinates 125-58.5, 102.2 microns.

Paratype—Plate 17, fig. 10, slide 6H3 coordinates 118.5-56, 99.4 microns.

Vestisporia pseudoreticulata Spode in
 Smith and Butterworth, 1967
 (Plate 16, figs. 10, 11)

- 1964b *Vestisporia pseudoreticulata* Spode, in Neves, p. 1233, pl. 3, figs. 1, 2.
 1965b *Vestisporites pseudoreticulatus* (Spode) Laveine, p. 2556, pl. 1, figs. 6, 18.
 1967 *Vestisporia pseudoreticulata* Spode, in Smith and Butterworth, p. 298-299, pl. 25, figs. 13, 14.

Discussion—The name *V. pseudoreticulata* Spode was first cited by Neves (1964b), who provided illustrations but no taxonomic information. The name appears to have been validated by subsequent description in Smith and Butterworth (1967).

Occurrence—Rare, *Florinites* interval.

Vestisporia cf. *reticulata*
 (Laveine) Loboziak 1971
 (Plate 16, fig. 12)

1965b *Vestisporites reticulatus* Laveine, p. 2558, pl. 1, fig. 21.

1971 *Vestisporia reticulata* (Laveine) Loboziak, p. 81, pl. 12, fig. 8.

Discussion—*V. reticulata* is distinguished from other species of the genus by its rather uniform reticulum of elongate lumina and strongly developed curved muri. The species does not display a secondary reticulum and the ornament is more regular than that of *V. irregularis*. Specimens observed in CP-19-4 are designated *V. cf. reticulata* because they appear to have a somewhat finer reticulum than that of the holotype.

Occurrence—Rare, *Florinites* interval.

Vestisporia sp. 1
 (Plate 17, fig. 1)

Description—Miospore radial, trilete, originally spherical, with operculate exoexine. Ornament of

relatively indistinct round indentations or shallow lumina 2-4 microns wide, most strongly developed along margin of operculum. Large areas of exoexine may be essentially laevigate and grade into areas of indentation. Size of illustrated specimen 72.4 microns maximum diameter.

Discussion—The indistinctness and irregular distribution of indentations distinguishes *V. sp. 1* from other species. Some specimens bear extremely shallow indentations and suggest that this miospore may be a variant of *V. laevigata*. Erection of a new species is considered inappropriate in view of the uncertainty about variation within existing species.

Occurrence—Rare, observed most often in the *Densosporites-Crassispora* interval.

Genus AUMANCISPORITES Alpern 1958

Type species—*A. striatus* Alpern 1958.

Affinity—Unknown.

Aumancisporites striatus Alpern 1958
(Plate 18, figs. 1-3)

1958 *Aumancisporites striatus* Alpern, p. 84-86, pl. 2, figs. 53-54.

Occurrence—Rare, lower levels of the *Florinites* interval.

Genus THYSANITES gen. nov.

Type species—*T. densus* sp. nov.

Diagnosis—Miospores radial, trilete, with a distinct central body and a thin equatorial flange which is often crenulate and expanded at the angles. Flange much narrower than width of spore body, attached near or along the equator. Outline of spore body and outline of flange both sphaerotriangular. Laesurae straight, raised, about ½ of radius of spore body.

Discussion—Genus *Thysanites* superficially resembles the genera *Diaphanospora* (Balme and Hassell) Evans 1970 and *Hymenospora* Neves 1961, but these latter genera display perisporia which enclose the spore body rather than an equatorially attached flange.

Derivation—The generic nomen refers to the fringe-like (*thysanus*) appearance of the flange.

Affinity—Unknown.

Thysanites densus sp. nov.
(Plate 18, figs. 4-9)

Diagnosis—Miospores conforming to the characteristics of the genus. Nearly always in good proximal-distal orientation. Spore body very thick and dark, tending to obscure laesurae. Flange width along interrational side ranges from about one-fourth to less than one-eighth the diameter of the spore body. Flange usually widened, often folded at angles, very finely granulose or punctate.

Size—(13 specimens) 24-36 microns maximum diameter of central body, 36-50 microns maximum diameter including flange.

Derivation—The specific nomen refers to the thick (*densus*) exine of the spore body.

Occurrence—Rare, observed most often in lower levels of the *Florinites* interval.

Holotype—Plate 18, fig. 6, side 1X5 coordinates 119-60, 30.2 microns maximum diameter of spore body exclusive of flange.

Paratype—Plate 18, figs. 4, 5, slide 1C1 coordinates 132-45, 31.4 microns.

Paratype—Plate 18, fig. 7, slide 1Z5 coordinates 122-64, 34.2 microns.

Paratype—Plate 18, figs. 8, 9, slide 6Z6 coordinates 124-61, 30.2 microns.

Genus COLATISPORITES Williams in Neves *et al.*, 1973

Type species—*C. decorus* (Bharadwaj and Venkatachala) Williams in Neves *et al.*, 1973.

Affinity—Unknown.

Colatisporites decorus (Bharadwaj and Venkatachala) Williams in Neves *et al.*, 1973
(Plate 1, figs. 16-18)

1961 *Tholisporites decorus* Bharadwaj and Venkatachala, p. 39, pl. 10, figs. 142-146.

1973 *Colatisporites decorus* (Bharadwaj and Venkatachala) Williams, in Neves *et al.*, p. 41, pl. 2, figs. 11-13, pl. 4, fig. 19.

Occurrence—Rare, observed most often in the *Florinites* interval.

Genus HYMENOSPORA Neves 1961

Type species—*H. palliolata* Neves 1961.

Discussion—A number of similar perisporate genera have been described, many from the Mesozoic; the genera *Hymenospora* and *Diaphanospora* Balme and Hassell 1962 were described from rocks of Paleozoic age, and the originally Mesozoic genus *Perotrilites* (Erdtman) ex Couper 1953 also has been employed in some Paleozoic studies (e.g., Hughes and Playford, 1961; Varma, 1969; Peppers, 1970). Peppers (1970) discussed the essential morphologic similarity among these genera. Evans (1970) re-evaluated the type material of various species of several perisporate genera, and emended the diagnoses of *Perotrilites* and *Diaphanospora*, restricting the former to zonate rather than perisporate miospores. The relationship of *Hymenospora* to the other genera was not discussed by Evans (1970); his emendation of *Diaphanospora* stressed the tenuous nature of the perispore, which appears to contrast with that of *Hymenospora*, in which the perispore often is thick enough to obscure details of the central body. *Hymenospora* also differs in manner of attachment of perispore to central body (Neves, 1961). These distinctions appear to function adequately to separate species observed in the study of Iowa coal microfloras, although intermediate forms may occur in other areas or at other stratigraphic intervals. The taxonomy of cavate spores in general remains difficult and in need of further study.

Affinity—Unknown.

Hymenospora multirugosa Peppers 1970
(Plate 18, fig. 10)

1970 *Hymenospora multirugosa* Peppers, p. 129, pl. 13, figs. 8, 9.

Occurrence—Rare.

Genus DIAPHANOSPORA (Balme and Hassell)
Evans 1970

Type species—*D. riciniata* (Balme and Hassell) Evans 1970.

Affinity—Unknown. Good (1976) suggested a calamitean affinity for at least some perisporate miospores of genus *Perotrilites*, which, as originally defined, would correspond to *Diaphanospora*. A review of specimens observed in this study and reported in previous work, however, demonstrates a lack of morphologic similarity between the most common types of Paleozoic calamitean spores (*Calamospora*) and the central bodies of species of *Diaphanospora*. Perisporate spores may have developed in a number of plant groups.

Diaphanospora parvigracila (Peppers) comb. nov.
(Plate 18, fig. 11)

1970 *Perotrilites* (sic) *parvigracilus* Peppers, p. 128, pl. 13, figs. 5-7.

Discussion—Evans' (1970) emendation of genus *Perotrilites* excluded truly perisporate species, requiring reassignment of *P. parvigracilus* to another genus. *Diaphanospora* is described as having a thin perispore, which is characteristic also of this species. The name *Hymenospora parvigracilis* has been employed by Gupta (1977), apparently in reference to the same species; no validly published taxonomic reassignment appears to exist for this combination, although several papers in press were cited by Gupta (1977) as containing his formal taxonomic information.

Occurrence—Rare.

Diaphanospora sp. 1
(Plate 18, fig. 12)

Description—Miospore radial, trilete, sphaerotriangular in equatorial outline. Spore body covered by a profusely wrinkled, moderately thin perispore which extends up to 8 microns from the margin of the spore body at irregularly distributed points; elsewhere the perispore appears to fit closely about the spore body. Laesurae distinct, extending about $\frac{3}{4}$ of the distance to the spore body margin. Spore body relatively thick, details difficult to discern because of the perispore covering. Size of illustrated specimen 58.2 microns, maximum diameter of spore body exclusive of perispore.

Discussion—*D.* sp. 1 differs from *D. parvigracila* in displaying a sphaerotriangular outline of the spore body and radially symmetrical laesurae. The perispore of *D.* sp. 1 is somewhat thicker and more profusely wrinkled than that of *D. parvigracila*, and *D.* sp. 1 is larger than *D. parvigracila*.

Occurrence—Rare.

Genus FLORINITES Schopf in Schopf, Wilson
and Bentall 1944

Type species—*F. mediapudens* (Loose) Potonié and Kremp 1956.

Affinity—Cycadofilicales, Cordaitales, Coniferales (Potonié, 1962). The presence of a distinctly infrareticulate saccus or sacci is considered an indication of gymnospermous pollen or prepollen. Pollen grains corresponding to *Florinites* have been described from cordaite (Delevoryas, 1953; Wilson, 1960; Brush and Barghoorn, 1962; Potonié, 1969; Millay and Taylor, 1974, 1976) and pteridosperm (Long, 1977b) fructifications.

Florinites mediapudens (Loose) Potonié
and Kremp 1956
(Plate 19, figs. 1, 2)

- 1934 *Reticulata-sporites mediapudens* Loose, p. 158, pl. 7, fig. 8.
1940 *Endosporites pellucidus* Wilson and Coe, p. 184, pl. 1, fig. 3.
1944 *Florinites antiquus* Schopf in Schopf, Wilson and Bentall, p. 58-59, fig. 4.
1956 *Florinites mediapudens* (Loose) Potonié and Kremp, p. 169, pl. 21, figs. 468-471.
1957a *Florinites circularis* Bharadwaj, p. 116, pl. 30, fig. 17, 18.
1957a *Endosporites mediapudens* (Loose) Dybová and Jachowicz, p. 207, pl. 71, fig. 4.
1958 *Florinites pellucidus* (Wilson and Coe) Wilson, p. 99, pl. 1, fig. 3.
1965a *Florinipollenites mediapudens* (Loose) Laveine, p. 135.
1966 *Florinipollenites pellucidus* (Wilson and Coe) Coquel, p. 21.

Discussion—Employment of the name *F. mediapudens* in this report follows the practice of Smith and Butterworth (1967), who suggested the synonymy of *F. pellucidus*; *F. antiquus* was previously considered a junior synonym of *F. pellucidus* by Wilson (1963b). Miospores resembling those designated *F. cf. florini* Imgrund 1960 in Smith and Butterworth (1967) were also observed in CP-19-4 and are included in *F. mediapudens* in this report. Several other species, including *F. parvus* Wilson and Hoffmeister 1956, *F. ovalis* Bharadwaj 1957 and *F. junior* Potonié and Kremp 1956, are similar to *F. mediapudens*. Forms resembling these species were observed occasionally in CP-19-4, but distinction between them and specimens of *F. mediapudens* could not be made with certainty, and all such specimens are included in *F. mediapudens*. It is likely that these morphologically generalized pollen grains represent a number of gymnospermous plants of varied phylogenetic relationships. Correlation of palynological and paleobotanical data for coals of a stratigraphic horizon similar to that of CP-19-4 suggests that cordaites were the dominant *Florinites*-producing plants in the coal swamps (Phillips, Peppers, Avcin and Laughnan, 1975).

Occurrence—*F. mediapudens* is the most abundant gymnosperm-related miospore in CP-19-4. It occurs in virtually every level of the seam, is common to abundant throughout the *Florinites* interval, infrequent to frequent in the *Densosporites-Crassispora* interval, and frequent to common through the *Lycospora* interval.

Florinites millotti Butterworth and
Williams 1954
(Plate 19, fig. 3)

- 1954 *Florinites millotti* Butterworth and Williams, p. 760,
text-fig. 1, 8, pl. 18, figs. 7, 8.
1966 *Florinipollenites millotti* (Butterworth and Williams)
Coquel, p. 21, pl. 2, fig. 14, 15.

Occurrence—Frequent to common throughout the
Florinites interval, rare to infrequent through the rest of
the seam.

Florinites occultus Habib 1966
(Plate 19, fig. 4)

- 1966 *Florinites occultus* Habib, p. 649, pl. 108, figs. 4, 5a,
5b.

Occurrence—Rare, *Florinites* interval.

Florinites visendus (Ibrahim) Schopf,
Wilson and Bentall 1944
(Plate 20, fig. 1)

- 1933a *Reticulata-sporites visendus* Ibrahim, p. 39, pl. 8, fig.
66.
1944 *Florinites* (?) *visendus* (Ibrahim) Schopf, Wilson and
Bentall, p. 60.
1966 *Florinipollenites visendus* (Ibrahim) Coquel, p. 28, pl. 2,
fig. 16.

Occurrence—Rare.

Florinites cf. *volans* (Loose) Potonić
and Kremp 1956
(Plate 19, figs. 5, 6)

- 1932 *Sporonites volans* Loose in Potonić, Ibrahim and Loose,
p. 451, pl. 18, fig. 6.
1933 *Reticulati-sporites volans* (Loose) Ibrahim, p. 36.
1934 *Zonales-sporites volans* (Loose) Loose, p. 149.
1944 *Endosporites volans* (Loose) Schopf, Wilson and Bentall,
p. 46.
1956 *Florinites volans* (Loose) Potonić and Kremp, p. 170, pl.
21, fig. 462.
1966 *Guthörlipollenites volans* (Loose) Coquel, p. 21, pl. 2, fig.
21.
1971 *Guthörlisporites volans* (Loose) Loboziak, p. 87, pl. 13,
fig. 11.

Discussion—Miospores designated *F. cf. volans*
resemble closely certain species ascribed to the genus
Guthoerlisporites Bharadwaj 1954. *Guthoerlisporites*
theoretically is distinguished from *Florinites* by
possession of a central body free from the saccus on the
proximal surface. Observations by Peppers (1970) cast
doubt on this interpretation, which is in any event
difficult to apply in practice. Nygreen and Bourn (1967)
have described complete morphological transitions in a
late Pennsylvanian shale among miospores assignable to
Potonieisporites Bharadwaj 1954 and three other genera,
including *Guthoerlisporites*. Most species assigned to
Guthoerlisporites are circular in outline, rather than
elliptical, which is common for species of *Florinites*.
Specimens observed in CP-19-4 tended to be circular, but
were not exclusively so; the central body is more distinct
than that of *Wilsonites* (Kosanke) Kosanke 1959, and the
size range is somewhat smaller than that of *F. volans*
proper. The assignment of *F. cf. volans* is made primarily
as a matter of convenience, as no existing designation
appears to be entirely satisfactory.

Occurrence—Rare to infrequent, *Florinites* interval.

Genus *POTONIEISPORITES* Bharadwaj 1954

Type species—*P. novicus* Bharadwaj 1954.

Affinity—Morphologically gymnospermous, but not
specifically known.

Potonieisporites elegans (Wilson and Kosanke)
Habib 1966
(Plate 20, fig. 9)

- 1944 *Florinites elegans* Wilson and Kosanke, p. 330, fig. 3.
1964 *Potonieisporites elegans* (Wilson and Kosanke) Wilson
and Venkatachala, p. 67, 68, figs. 1, 2.
1966 *Potonieisporites elegans* (Wilson and Kosanke) Habib, p.
648-649, pl. 108, fig. 3.

Occurrence—Rare, observed most often in the
Florinites interval.

Potonieisporites solidus sp. nov.
(Plate 19, figs. 7-9)

Diagnosis—Monosaccate pollen grains with a large,
thick elliptical central body free from the saccus on the
proximal surface. Straight monolete suture on proximal
surface of central body less than $\frac{1}{4}$ the length of the
central body; laesura surrounded by a slightly thickened
area which is difficult to observe on most specimens
owing to the overall thickness of the central body. Central
body granulose to punctate, seldom folded. Bladder
attachment overlaps about $\frac{1}{4}$ the diameter of the central
body on the proximal surface, and is not usually
crenulate; nature of bladder attachment, if any, on the
distal surface is unclear. Central body occupies $\frac{1}{2}$ to more
than $\frac{2}{3}$ of the length of the saccus and more than $\frac{3}{4}$ of the
width of the saccus. Saccus coarsely infrareticulate, often
slightly constricted medially, which may be a feature of
miospore compression.

Size—(10 specimens) 99-127 microns maximum
dimension.

Discussion—This species is assigned to
Potonieisporites on the basis of the apparent attachment
of the saccus to the proximal surface of the central body,
and the monolete suture. It differs from other species of
the genus by possession of the large, thick and normally
unfolded central body and by the shortness and unflexed
nature of the suture.

Derivation—The specific nomen refers to the thick
(*solidus*) nature of the central body.

Occurrence—Rare, lower levels of the *Florinites*
interval.

Holotype—Plate 19, fig. 7, slide 1Z3 coordinates
121-64, 120.7 microns, maximum dimension.

Paratype—Plate 19, fig. 8, CP-19-5 slide Z-7
coordinates 127-39, 120.7 microns.

Paratype—Plate 19, fig. 9, slide 1Y5 coordinates
132-38.5, 105.1 microns.

Genus *COSTATASCYCLUS* (Felix and Burbridge)
Urban 1971

Type species—*C. crenatus* (Felix and Burbridge)
Urban 1971.

Affinity—Morphologically gymnospermous, but not
specifically known.

Costatascyclus crenatus (Felix and Burbridge)
Urban 1971
(Plate 20, fig. 2)

- 1967 *Costatascyclus crenatus* Felix and Burbridge, p. 411, pl. 64, fig. 6.
1971 *Costatascyclus crenatus* (Felix and Burbridge) Urban, p. 114-115, pl. 25, figs. 4-9.

Occurrence—Rare, *Florinites* interval.

Genus WILSONITES (Kosanke) Kosanke 1959

Type species—*W. vesicatus* (Kosanke) Kosanke 1959.

Affinity—Morphologically gymnospermous, but not specifically known.

Wilsonites circularis (Guennel)
Peppers and Ravn comb. nov.
(Plate 20, fig. 3)

- 1958 *Endosporites circularis* Guennel, p. 51, text-fig. 12, plate 1, figs. 18, 19.

Discussion—Guennel (1958) assigned this species to *Endosporites* due to some uncertainties which existed at the time concerning the status of *Wilsonia* (*Wilsonites*). The transfer to *Wilsonites* is made without descriptive emendation.

Occurrence—Rare, *Florinites* interval.

Wilsonites delicatus (Kosanke) Kosanke 1959
(Plate 20, fig. 5)

- 1950 *Wilsonia delicata* Kosanke, p. 54-55, pl. 14, fig. 4.
1959 *Wilsonites delicatus* (Kosanke) Kosanke, p. 700.
1966 *Guthoertisporites delicatus* (Kosanke) Habib, p. 646, pl. 107, fig. 9.

Occurrence—Rare to infrequent, *Florinites* interval.

Wilsonites vesicatus (Kosanke) Kosanke 1959
(Plate 20, fig. 4)

- 1950 *Wilsonia vesicatus* Kosanke, p. 54, pl. 14, figs. 1-3.
1957b *Guthoertisporites velensis* Bharadwaj, p. 130, pl. 26, fig. 120.
1959 *Wilsonites vesicatus* (Kosanke) Kosanke, p. 700.

Occurrence—Rare to infrequent, *Florinites* interval, rare in the *Densosporites-Crassispora* and *Lycospora* intervals.

Genus PITYOSPORITES (Seward) Manum 1960

Type species—*P. antarcticus* Seward 1914.

Affinity—Potonié (1962) suggested an affinity with pteridosperms but disagreement with this view has been expressed (Manum, 1960). Certain species (e.g., *P. westphalensis* Williams 1955) display a striking similarity to many modern coniferous pollen grains.

Pityosporites westphalensis Williams 1955
(Plate 20, fig. 8)

- 1955 *Pityosporites westphalensis* Williams, p. 467, text-figs. 1, 2, pl. 6, figs. 1-6.

Occurrence—Rare to infrequent in the *Florinites* and *Densosporites-Crassispora* intervals, virtually absent from the *Lycospora* interval.

Genus PLATYSACCUS (Naumova) Potonié
and Klaus 1954

Type species—*P. papilionis* Potonié and Klaus 1954.

Affinity—Morphologically gymnospermous, but not specifically known.

Platysaccus saarensis (Bharadwaj) Jizba 1962
(Plate 20, figs. 6, 7)

- 1957a *Alisporites saarensis* Bharadwaj, p. 117-118, pl. 31, figs. 14, 15.
1962 *Platysaccus saarensis* (Bharadwaj) Jizba, p. 885, pl. 124, figs. 59-61.

Occurrence—Rare, but widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals.

Genus ILLINITES (Kosanke) Helby 1966

Type species—*I. unicus* (Kosanke) Helby 1966.

Discussion—Helby (1966) regarded *Kosankeisporites elegans* (Kosanke) Bharadwaj 1955 and *Complexisporites polymorphus* Jizba 1962 as synonymous with *Illinites unicus* Kosanke 1950. Although not specifically designated so by Helby, this synonymy appears to constitute a *de facto* emendation of both the genus *Illinites* and the species *I. unicus*, and is designated as such in this report. The formal synonymy is listed in full under the species *I. unicus*.

Affinity—Pteridosperm (Remy, 1954).

Illinites unicus (Kosanke) Helby 1966
(Plate 21, fig. 5)

- 1950 *Illinites unicus* Kosanke, p. 51-52, pl. 1, figs. 3, 4.
1950 *Illinites elegans* Kosanke, p. 52, pl. 1, figs. 1, 2.
1955 *Kosankeisporites elegans* (Kosanke) Bharadwaj, p. 137, pl. 2, figs. 16-17.
1970 *Kosankeisporites elegans* (Kosanke) Peppers, p. 133-134, text-fig. 29, pl. 14, figs. 6-8.
1962 *Complexisporites polymorphus* Jizba, p. 869, pl. 121, figs. 1-14.
1966 *Illinites unicus* (Kosanke) Helby, p. 680-681, pl. 8, figs. 9-18, pl. 9, fig. 1, ?figs. 3, 4.

Discussion—Helby's (1966) observations concerning the variability of ornamentation of the central body of *I. unicus* are supported by the variable nature of the morphology of these miospores in CP-19-4 and other Iowa coals.

Occurrence—Rare.

Genus PSEUDOILLINITES gen. nov.

Type species—*P. diversiformis* (Kosanke) comb. nov. emend.

Diagnosis—Bilateral, monosaccate, monolete prepollen or pollen grains. Central body normally extending nearly the full width of the saccus, resulting in the appearance of a bisaccate grain. Central body characterized by two strongly developed crescentic compression folds at right angles to the long axis of the saccus, usually producing a more or less hexagonal outline for the central body. Proximal surface of central body free from saccus. Saccus oval, width approximately $\frac{2}{3}$ of length; extensions of saccus from central body in long dimension approximately $\frac{1}{2}$ the width of the central

body. Saccus coarsely infrareticulate, reticulations becoming somewhat finer near juncture with central body.

Discussion—Genus *Pseudoillinites* is proposed to accommodate monosaccate prepollen or pollen grains in which the central body is so expanded as to approach bisecting the saccus into separate laterally attached sacci. The type species originally was assigned to genus *Florinites*, but the relationship of the central body to the saccus, both in general appearance and manner of attachment, is not typical of *Florinites*. The pseudobisaccate appearance of the genus also serves to differentiate it from *Potonieisporites*, in which the characteristics of body attachment to saccus are similar.

Derivation—The generic nomen refers to the similarity of general appearance of the genus to the bisaccate genus *Illinites*.

Affinity—Morphologically gymnospermous, but not specifically known.

Pseudoillinites diversiformis (Kosanke)
comb. nov. emend.
(Plate 21, figs. 9-11)

1950 *Florinites diversiformis* Kosanke, p. 49, pl. 12, fig. 5.
non 1976 *Florinites* cf. *diversiformis* Kosanke 1950; Tillement,
Peniguel and Guillemain, p. 439, pl. 1, fig. 29.

Diagnosis—Miospores conforming to the characteristics of the genus. Central body thick and dark, laevigate or nearly so. Laesura about ½ the width of central body, terminations commonly obscured by compression folds.

Discussion—Occasional specimens of *P. diversiformis* develop fortuitous folding of the central body in addition to the two well-developed lateral compression folds. In such specimens, the central body is less regularly hexagonal in outline and may not bisect the saccus as completely as that of normal specimens. This latter condition appears to be true of the holotype (Kosanke, 1950, pl. 12, fig. 5). Study of both the holotype and material from the holotype maceration indicates that most specimens display the characteristics described in the generic and specific diagnoses of this report and that the holotype is an unusual specimen.

Occurrence—Rare to occasionally infrequent, *Florinites* interval.

Genus PEPPERSITES gen. nov.

Type species—*P. ellipticus* sp. nov.

Diagnosis—Bilateral, monosaccate, monoete prepollen or pollen grains. Central body oval to elliptical in outline, proximal surface free from saccus. Saccus relatively small in relation to central body, appressed to central body in short dimension, slightly expanded in long dimension, finely infrareticulate. Saccus attached to central body near equator on proximal surface; nature of attachment to distal surface uncertain.

Discussion—Genus *Peppersites* is distinguished from other monosaccate genera by the relatively large size of the central body in relation to the saccus. The genus superficially resembles *Schulzospora* Kosanke 1950, but

the latter genus is clearly trilete and bears a granulose saccus.

Derivation—The generic nomen is proposed in honor of Dr. Russel A. Peppers of the Illinois Geological Survey.

Affinity—Morphologically gymnospermous, but not specifically known.

Peppersites ellipticus sp. nov.
(Plate 21, figs. 1-4)

Diagnosis—Miospores conforming to the characteristics of the genus. Central body thick and dark, laevigate to faintly punctate or granulose. Laesura approximately ½ the length of the central body, with slightly thickened lips; laesura sometimes obscured by thickness of central body. Central body seldom folded. Maximum extension of saccus from central body in long dimension normally less than ¼ the maximum dimension of the central body. Saccus very finely infrareticulate, often displaying slightly crenulated margin.

Size—(10 specimens) 51-74 microns maximum dimension.

Derivation—The specific nomen refers to the elliptical outline of the central body.

Occurrence—Rare, *Florinites* interval.

Holotype—Plate 21, fig. 1, slide 1Z3 coordinates 121-53.5, 51.3 microns maximum dimension including saccus.

Paratype—Plate 21, fig. 2, slide 1C4 coordinates 130.5-62, 61.0 microns.

Paratype—Plate 21, fig. 3, slide 1Y3 coordinates 127.5-35, 65.6 microns.

Paratype—Plate 21, fig. 4, slide 1Y4 coordinates 119-72.5, 53.6 microns.

Genus WAPELLITES gen. nov.

Type species—*W. variabilis* sp. nov.

Diagnosis—Bilateral, monosaccate prepollen or pollen grains with an apparently alete, dark, elliptical to nearly circular central body. Saccus infrareticulate, constricted medially, greatly expanded in long dimension of grain. Extent of constriction of saccus ranges from specimens which are clearly monosaccate to those in which the saccus is so appressed to the central body in the short dimension as to give the grain the appearance of being bisaccate. Central body appears to be attached to the saccus both proximally and distally; radiating crenulations of the saccus extending approximately ½ the radius of the central body occur on the proximal(?) surface, but are not always visible due to characteristics of the central body.

Discussion—Genus *Wapellites* most closely resembles genus *Costatascyclus* in overall characteristics, particularly in the nature of the attachment of the central body to the saccus and the radiating crenulations of the saccus in the region of the central body. In the latter genus, however, the saccus is not so conspicuously constricted around the central body, and folds of the saccus occur on the face of the central body (Urban, 1971). *Costatascyclus* is monoete, whereas *Wapellites* appears to be alete; minor marks have been observed on

the central bodies of some specimens which resemble faint trilete laesurae, but these may be fortuitous wrinkles or folds. Genus *Rhizomaspora* Wilson 1962 resembles *Wapellites* in general appearance, but is definitely bisaccate.

Derivation—The generic nomen is derived from Wapello County, Iowa, the site of the Iowa Geological Survey core hole CP-19.

Affinity—Morphologically gymnospermous, but not specifically known.

Wapellites variabilis sp. nov.
(Plate 22, figs. 1-3)

Diagnosis—Miospores corresponding to the characteristics of the genus. Central body laevigate, very thick and dark, with thickness of the exine (4 or more microns) giving the appearance of a "zona" in compression. Longitudinal expansions of the saccus semi-circular in outline; maximum width of saccus $\frac{1}{2}$ to $\frac{3}{4}$ maximum diameter of the central body. Internal reticulations of saccus grade from very fine near the central body to moderately coarse away from it.

Size—(10 specimens) 72-99 microns maximum dimension.

Derivation—The specific nomen refers to the variability in the appearance of the saccus from clearly monosaccate to pseudo-bisaccate.

Occurrence—Rare, lower levels of the *Florinites* interval.

Holotype—Plate 22, fig. 1, slide 1Z3 coordinates 125.5-47, 98.0 microns maximum dimension including saccus.

Paratype—Plate 22, fig. 2, slide 1Z3 coordinates 131-38, 92.7 microns.

Paratype—Plate 22, fig. 3, slide 1Z3 coordinates 119-42, 95.5 microns.

Genus PHILLIPSITES gen. nov.

Type species—*P. tenuis* sp. nov.

Diagnosis—Bilateral, bisaccate prepollen or pollen grains. Central body elongate, more or less rectangular in outline, with sacca attached at either end of central body in long dimension; sacca sometimes slightly inclined toward distal(?) surface of central body. Line of attachment between sacca and central body relatively straight; little or no constriction of outline of grain occurs at the points of attachment of sacca to central body. Sacca relatively small in relation to central body, width of sacca about $\frac{1}{2}$ the length of the central body. Sacca display internal reticulation of variable coarseness. Central body laevigate to faintly punctate or granulose, thickest near sacca, thinning toward middle, but without clearly developed sulcus. Overall outline of grain including sacca elliptical.

Discussion—Genus *Phillipsites* differs from other bisaccate genera in having a large central body thinning toward the middle, and relatively small sacca attached in an unstricted manner. It is most similar to *Pityosporites*, but the latter has relatively larger sacca constricted at the points of attachment, and displays a well-developed distal sulcus.

Derivation—The generic nomen is proposed in honor of Dr. Tom L. Phillips of the Department of Botany, University of Illinois.

Affinity—Morphologically gymnospermous, but not specifically known.

Phillipsites tenuis sp. nov.
(Plate 21, figs. 6-8)

Diagnosis—Miospores conforming to the characteristics of the genus. Central body very thin toward middle, often torn open or highly folded. Lines of attachment of sacca to central body appear thickened; sacca do not overlap central body on compression.

Size—(21 specimens) 92-139 microns maximum dimension.

Derivation—The specific nomen refers to the thin (*tenuis*) nature of the central body.

Occurrence—Rare, but widely distributed throughout the *Florinites* interval.

Holotype—Plate 21, fig. 6, slide 1Z6 coordinates 127-43.5, 115.0 microns maximum dimension including sacca.

Paratype—Plate 21, fig. 7, slide 1D3 coordinates 122-71.5, 87.5 microns.

Paratype—Plate 21, fig. 8, slide 1X4 coordinates 123.5-46.5, 99.4 microns.

Saccate grain no. 1
(Plate 21, fig. 12)

Description—Miospore radial, trilete, with a closely appressed, crenulated saccus. Outline of spore body circular, laesurae short, relatively indistinct. Saccus punctate or possibly very finely infrareticulate appears to be attached to spore body on both proximal and distal surface. Saccus extends irregularly from equator of spore body to a maximum distance of 8 microns. Size of illustrated specimen 57.0 microns, spore body exclusive of saccus.

Discussion—Saccate grain no. 1 resembles certain specimens of perispore-bearing genera, such as *Diaphanospora*, but the outer "membrane" appears more like a true saccus than a perispore.

Occurrence—Rare.

Genus SCHOPFIPOLLENITES Potonić and Kremp 1954

Type species—*S. ellipsoides* (Ibrahim) Potonić and Kremp 1954.

Discussion—Pollen grains corresponding to *Schopfipollenites* were first described under the name *Monoletes* by Ibrahim (1933). Potonić (1960) considered the name *Monoletes* to be invalid, and most subsequent investigators (e.g., Smith and Butterworth, 1967) have recognized *Schopfipollenites* as the proper generic name. Nevertheless, the name *Monoletes* continues to be employed, particularly in an informal sense.

Affinity—Pollen grains corresponding to *Schopfipollenites* have been correlated with a variety of Medullosan pteridosperm fructifications (Florin, 1937; Schopf, 1938; Delevoryas, 1964; Eggert and Kryder, 1969; Leisman and Peters, 1970; Taylor, 1971; Stidd,

Leisman and Phillips, 1977; Millay, Eggert and Dennis, 1978).

Schopfipollenites ellipsoides (Ibrahim)
Potonić and Kremp 1954
(Plate 22, figs. 6, 7)

- 1932 *Sporonites ellipsoides* Ibrahim in Potonić, 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.
1938 *Monoletes ellipsoides* (Ibrahim) Schopf, p. 45, pl. 1, fig. 14 and pl. 6, figs. 5, 6.
1954 *Schopfipollenites ellipsoides* (Ibrahim) Potonić and Kremp, p.180.

Discussion—Winslow (1959) suggested the possible synonymy of *Monoletes ovatus* Schopf 1938.

Occurrence—Not assessed quantitatively, as few specimens of these large pollen grains pass through the 250-micron screen employed in the preparation process. *Schopfipollenites* spp. have been reported abundantly throughout the Pennsylvanian coals of the North American Midcontinent (Phillips, Peppers, Avcin and Laughnan, 1975).

Schopfipollenites sp. 1
(Plate 22, figs. 8-10)

Description—Bilateral, monolete pollen grains corresponding in general aspect to *S. ellipsoides*, but displaying a conspicuous, regularly wrinkled surface. Size of illustrated specimen 242.9 microns maximum dimension.

Discussion—As pointed out by Winslow (1959) and Smith and Butterworth (1967), distinction of species of *Schopfipollenites* on a morphologic basis is often problematical. It is therefore possible that *S. sp. 1* may represent a variant of *S. ellipsoides*.

Occurrence—Rarely observed in CP-19-4, but subject to the same quantitative bias as *S. ellipsoides*.

Genus TRIHYPHAECITES Peppers 1970

Type species—*T. triangulatus* Peppers 1970.
Affinity—Fungal? (Peppers, 1970).

Trihyphaecites triangulatus Peppers 1970
(Plate 22, figs. 4, 5)

1970 *Trihyphaecites triangulatus* Peppers, p. 135, pl. 14, figs. 13-16.

Occurrence—Rare, but widely distributed in the *Florinites* and *Densosporites-Crassispora* intervals.

APPENDIX I

PREPARATION TECHNIQUES

Chemical preparation and slide mounting techniques described here are presently in use by the Iowa Geological Survey Coal Division, and were adapted from those in use at the Illinois Geological Survey, (Peppers, 1970). Thorough discussions of various preparation techniques and theoretical considerations may be found in Brown (1960), Gray (1965) and Andersen (1965).

The following chemical preparation schedule was followed in the preparation of samples from CP-19-4:

1. Approximately 5-gm samples, crushed with mortar and pestle until the largest fragments are of medium sand size.

2. Maceration for two days in Schulze solution (1 part saturated solution potassium chlorate, 2 parts concentrated nitric acid).

3. 3 water washes (centrifuging and decanting supernatant liquid).

4. 10-15 minute treatment with 10% solution of potassium hydroxide, followed by sufficient water washes to clarify supernatant liquid, removing humic acids.

5. 24-hour treatment with cold 48% hydrofluoric acid, followed by 4 water washes.

6. Sieve with fine jet of water through 250-micron screen.

7. Centrifuge for 45 seconds, to settle out palynomorphs and leave ultra-fine debris in suspension.

8. 50% ethanol-50% water wash, followed by 2 washes in 95% ethanol. (Peppers [1970] recommended further treatment with absolute ethanol, but this was found not to be necessary.)

9. Staining with 5-10 ml concentrated ethanol solution of either basic fuchsin or safranin O stains. The major purpose of stains is to enhance visibility of fine detail, and for photography. Both fuchsin and safranin are adequate, but safranin was found to be superior to fuchsin, and has since become the standard stain used in palynological preparations at the Iowa Geological Survey.

10. 50% ethanol-50% xylene wash, followed by one straight xylene wash. Samples are now ready for slide preparation.

SLIDE MOUNTING MEDIA AND TECHNIQUES

It is normally desirable to employ uniform techniques and media in slide preparation, to facilitate comparison of samples. This is particularly important in regard to measuring the sizes of miospores, as some mounting media (e.g., glycerine jelly) are known to cause appreciable swelling of spore exines (Smith and Butterworth, 1967). At the outset of this project, however, several mounting techniques were tried as experiments, although those media known to cause changes in spore sizes were not tried. Three co-soluble resins were employed: Piccolyte, Permout, and Canada Balsam. All three have similar refractive indices and are

soluble in xylene. Piccolyte and Permount have a higher percent volatile base than does Canada Balsam, and shrinkage of these mountants under the slide cover glasses was an occasional problem. Another experiment allowing a smear of piccolyte to dry on a slide, and affixing a cover glass later with another medium was tried, and produced fairly good results, although spores sometimes tended to aggregate during drying of the smear.

The most satisfactory medium was determined to be Canada Balsam, and it is presently the standard palynological mountant used in Iowa Geological Survey palynological preparations. Slides are prepared by placing a drop of Canada Balsam on the microscope slide, securing a portion of sample with a teasing needle and mixing with the Canada Balsam to a desirable concentration. A cover slip is placed on the mixture, and gentle, but firm pressure is applied with a soft-pointed applicator (preferably wooden) to spread the mixture to the edges of the cover glass. Slides are placed in a low-temperature oven (105-110°F) for 4-10 days.

Many other workers have employed water-miscible mountants with success, but these have not been used at the Iowa Geological Survey, as their preparations appear

to be at least as complex as the use of resin media (Wilson, 1959). Andersen (1965) criticized the use of Canada Balsam because of its high refractive index, but this objection is overcome by staining of samples.

Due to employment of three separate media for slides in this study, a check was made on the relative sizes of representative abundant spore taxa in each of the mountants. No significant difference in spore sizes was found, probably due to the chemical similarity and co-solubility of the resins.

Following slide-making, samples were prepared for storage by returning to an ethanol base by washing twice with 95% ethanol, rinsing with a spray-jet of ethanol into a storage vial, centrifuging and decanting the supernatant ethanol, and adding sufficient glycerine to equal twice the residue volume. The ethanol remaining in the residue mixes with the glycerine, and serves to retard potential bacterial or algal growth while the sample is in storage. Should additional slides be needed later, the glycerine can be removed by washing with ethanol, and the normal mounting procedure may be followed, including staining (re-staining is necessary due to the removal of stain by previous ethanol washes during storage).

APPENDIX II

DATA

Data presented here are the result of population counts of miospores at 86 levels within seam CP-19-4. 250 identifiable miospores were counted at each level. Numbers for each taxon listed indicate the number of individual specimens of each taxon identified during the

population count. Taxa encountered during scanning of slides following completion of the population count are represented by "X". Percentages of occurrence of individual taxa are calculated readily by multiplying the data figure by .4. See also Method.

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PLATES

Figures are magnified 750X except as noted otherwise. Specimens are from coal CP-19-4 except as noted. Many specimens, particularly those with fine sculpture patterns, were photographed using Nomarski interference-contrast illumination, which produces the effect of a scanning light and greatly enhances resolution of surface detail. Occasionally two views of a given specimen are illustrated, one with normal transmitted light, one with Nomarski illumination; in such instances the Nomarski view is designated by (N). Dimensions of specimens in microns refer to the maximum diameter unless specified otherwise. Coordinates refer to the mechanical stage of the Leitz Wetzlar microscope, serial number 826091, at the University of Iowa Department of Geology.

PLATE 1

FIGURE

1. *Leiotriletes guennelii* nom. nov; slide DB1Y coordinates 121-62.5, 23.9 microns.
2. *Leiotriletes priddyi* (Berry) Potonié and Kremp 1955; slide 1C4 coordinates 136-43, 33.1 microns.
3. *Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp 1955; slide 1C4 coordinates 127-36, 42.8 microns.
4. *Leiotriletes levis* (Kosanke) Potonié and Kremp 1955; slide 1Y5 coordinates 118.5-44, 32.5 microns.
5. *Leiotriletes*, sp. 1; slide 1Y3 coordinates 132.5-70, 32.5 microns.
6. *Leiotriletes* sp. 2; slide 6T1 coordinates 127-49, 31.9 microns.
7. *Leiotriletes turgidus* Marshall and Smith 1964; CP-19-5 slide A-4 coordinates 129-35, 54.2 microns.
8. *Leiotriletes levis* (Kosanke) Potonié and Kremp 1955; slide 1X6 coordinates 125.5-59, 41.8 microns.
9. *Leiotriletes* sp. 3; slide 1Y6 coordinates 121-69, 55.5 microns.
10. *Punctatisporites minutus* (Kosanke) Peppers 1964; slide 1W1 coordinates 119-71.5, 28.5 microns.
11. *Punctatisporites minutus* (Kosanke) Peppers 1964; slide 2J3 coordinates 125-43.5, 34.2 microns.
12. *Punctatisporites nitidus* Hoffmeister, Staplin and Malloy 1955; slide 3A2 coordinates 135.5-55, 35.3 microns.
13. *Punctatisporites* cf. *curviradiatus* Staplin 1960; slide 5F4 coordinates 134-44, 37.1 microns.
14. *Punctatisporites* cf. *curviradiatus* Staplin 1960; slide 1C1 coordinates 138.5-45, 41.6 microns.
15. *Punctatisporites* cf. *curviradiatus* Staplin 1960; slide 1C4 coordinates 136-37.5, 58.1 microns.
16. *Colatisporites decorus* (Bharadwaj and Venkatachala) Williams in Neves et al., 1973; slide 1C2 coordinates 122-48, 52.4 microns.
17. *Colatisporites decorus* (Bharadwaj and Venkatachala) Williams in Neves et al., 1973; slide 1C2 coordinates 119.5-47.5, 47.3 microns.
18. *Colatisporites decorus* (Bharadwaj and Venkatachala) Williams in Neves et al., 1973; slide 1X2 coordinates 129-49, 54.7 microns.

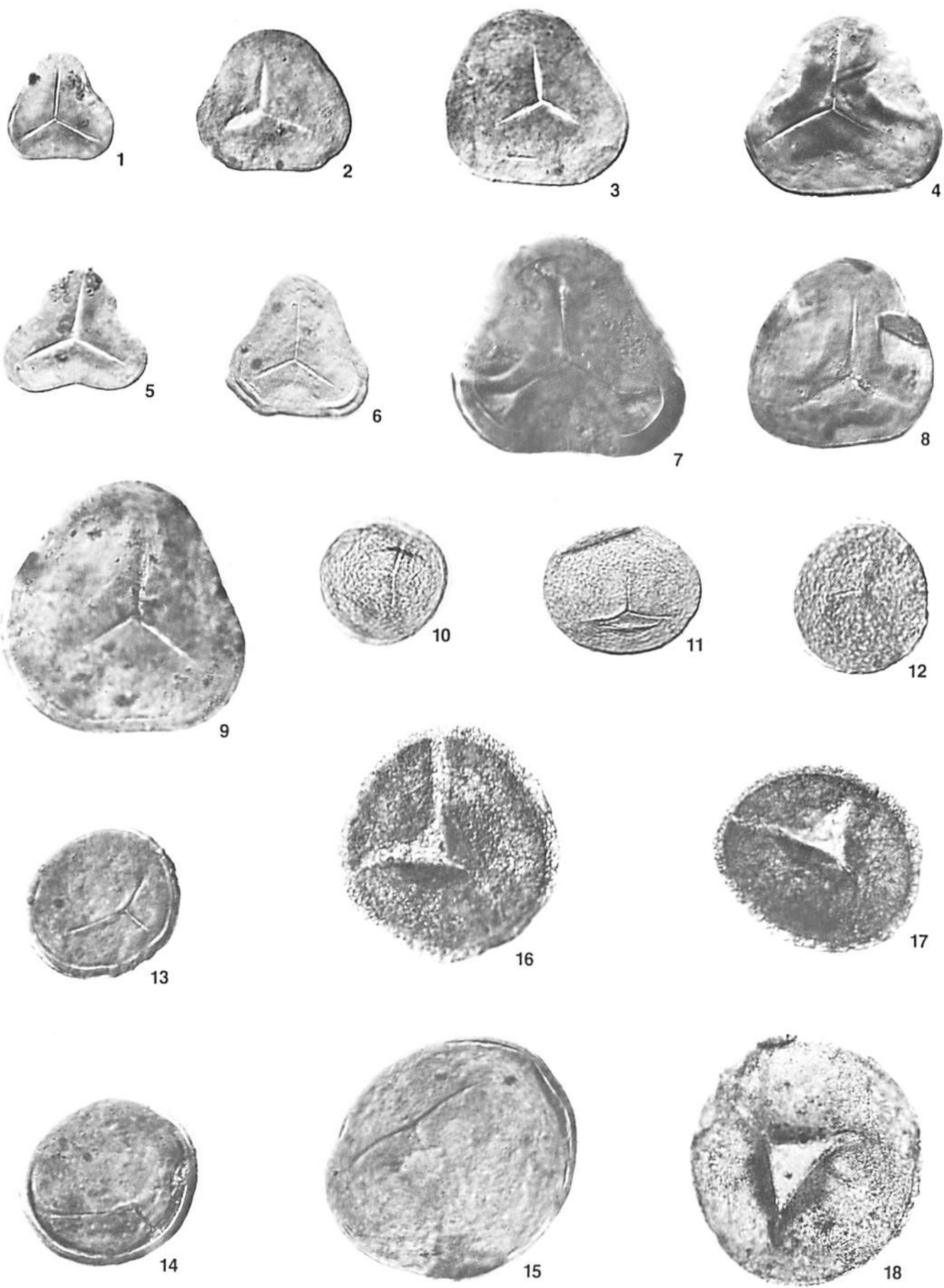


PLATE 2

FIGURE

1. *Punctatisporites* cf. *nudus* Artüz 1957; slide 1W2 coordinates 123-59, 51.3 microns.
2. *Punctatisporites kankakeensis* Peppers 1970; slide 5A9 coordinates 120-66, 68.7 microns.
3. *Punctatisporites* sp. 1; slide 7B3 coordinates 125-60, 43.3 microns.
4. *Punctatisporites aerarius* Butterworth and Williams 1958; slide 6H2 coordinates 136-53.5, 61.0 microns.
4. *Punctatisporites aerarius* Butterworth and Williams 1958; slide 6Z6 coordinates 132-37.5, 75.2 microns.
6. *Phyllothecotriletes* sp. 1; slide 5A3 coordinates 133-32.5, 102.2 microns (300X).
7. *Punctatisporites edgarensis* Peppers 1970; CP-19-5 slide A-3 coordinates 127.5-59.5, 109.3 microns (300X).
8. *Punctatisporites* cf. *edgarensis* Peppers 1970; slide 1X6 coordinates 126-38, 132.1 microns (300X).

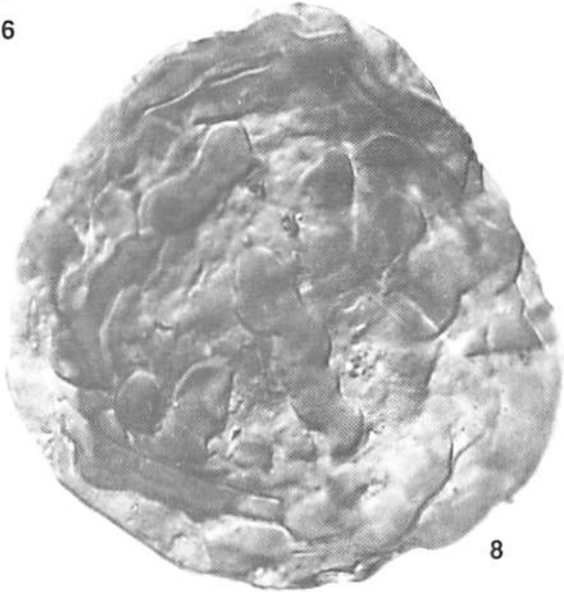
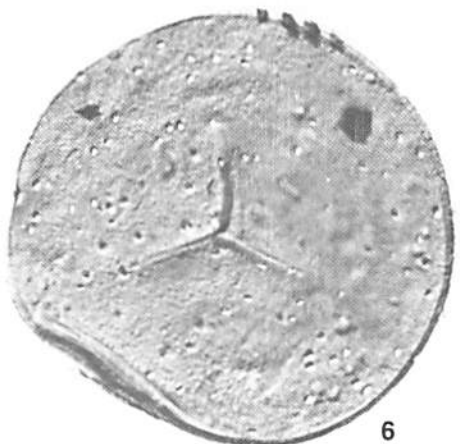
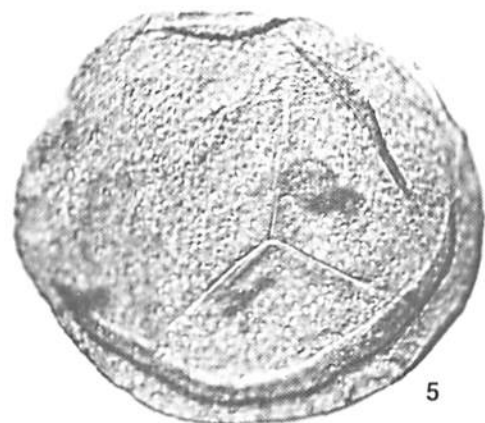
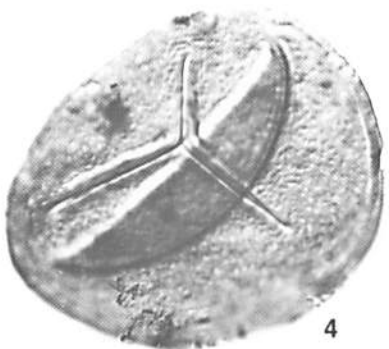


PLATE 3

FIGURE

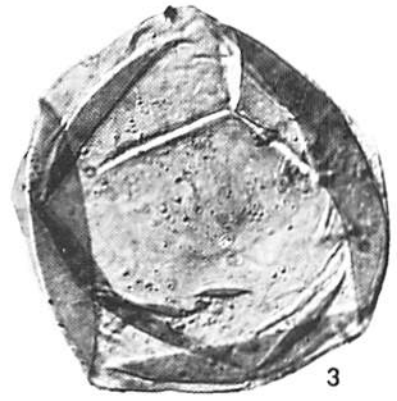
1. *Calamospora straminea* Wilson and Kosanke 1944; slide 1W2 coordinates 120.5-65, 35.9 microns.
2. *Calamospora breviradiata* Kosanke 1950; slide 1Z3 coordinates 121-49, 50.7 microns.
3. *Calamospora liquida* Kosanke 1950; slide 1C4 coordinates 124-56.5, 61.6 microns.
4. *Calamospora* cf. *mutabilis* (Loose) Schopf, Wilson and Bentall 1944; slide 5A6 coordinates 118.5-63, 110.8 microns (300X).
5. *Calamospora hartungiana* Schopf in Schopf, Wilson and Bentall 1944; slide 1C2 coordinates 123.5-39, 76.7 microns (300X).
6. *Calamospora* cf. *pedata* Kosanke 1950; slide 6Z1 coordinates 128.5-49.5, 61.0 microns.
7. *Calamospora* cf. *pedata* Kosanke 1950; slide 6Z2 coordinates 133-56.6, 92.3 microns (300X).
8. *Calamospora nebulosa* sp. nov.; paratype, slide 6Z2 coordinates 125-45, 72.4 microns (300X).
9. *Calamospora nebulosa* sp. nov.; holotype, slide 6Z4 coordinates 139-35, 85.2 microns (300X).
10. *Calamospora nebulosa* sp. nov.; paratype, slide 6Z1 coordinates 123.5-54.5, 94.1 microns (300X).
11. *Calamospora nebulosa* sp. nov.; paratype, slide 1B4 coordinates 121.5-49.5, 83.8 microns (300X).
12. *Calamospora nebulosa* sp. nov.; paratype, slide 6Z4 coordinates 130-32.5, 87.0 microns (300X).



1



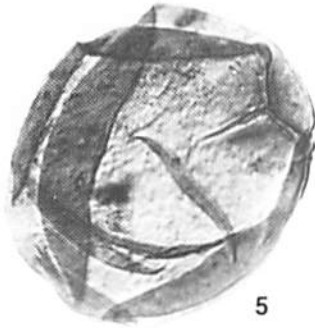
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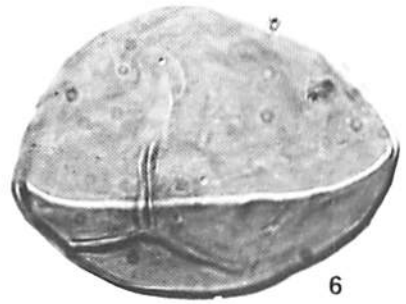
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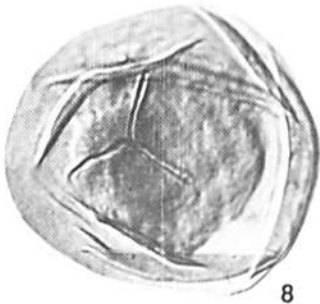
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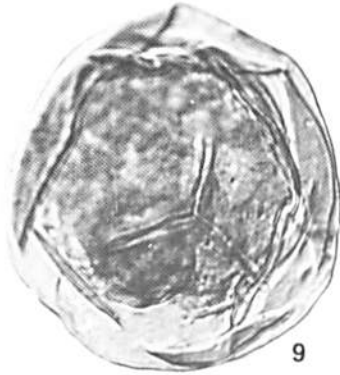
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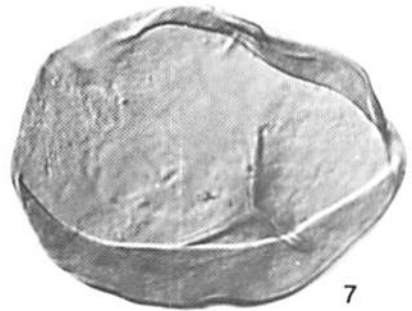
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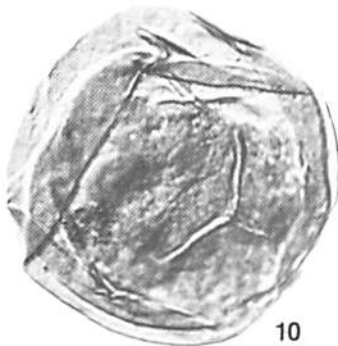
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12

PLATE 4

FIGURE

1. *Elaterites triferens* Wilson 1943; slide DB1Y coordinates 124-52, 62.7 microns, spore body excluding perispore.
2. *Adelisorites multiplicatus* sp. nov.; holotype, slide 1C2 coordinates 136.5-60, 26.8 microns.
3. *Adelisorites multiplicatus* sp. nov.; paratype, CP-19-5 slide B-2 coordinates 137-65, 29.1 microns.
4. *Adelisorites multiplicatus* sp. nov.; paratype, CP-19-5 slide Z-7 coordinates 128-51, 23.9 microns.
5. *Adelisorites multiplicatus* sp. nov.; paratype, slide 1C3 coordinates 137.5-45.5, 26.2 microns.
6. *Adelisorites multiplicatus* sp. nov.; paratype, slide 5H2 coordinates 120-52.5, 23.4 microns.
7. *Verrucosisorites donarii* Potonić and Kremp 1955; slide 1C2 coordinates 128-53.5, 41.6 microns.
8. *Verrucosisorites verrucosus* (Ibrahim) Ibrahim 1933; slide DB1Y coordinates 129-57.5, 72.5 microns.
9. *Verrucosisorites microtuberosus* (Loose) Smith and Butterworth 1967; slide 1C4 coordinates 129-46.5, 90.0 microns (300X).
10. *Verrucosisorites sifati* (Ibrahim) Smith and Butterworth 1967; slide 7M1 coordinates 123-38.5, 110.8 microns (300X).
11. *Kewaneesporites patulus* (Peppers) Peppers 1970; slide 5J4 coordinates 130-36, 45.0 microns.
12. same as fig. 11 (N).
13. *Kewaneesporites patulus* (Peppers) Peppers 1970; slide 5A2 coordinates 130-69, 46.7 microns.
14. same as fig. 13 (N).

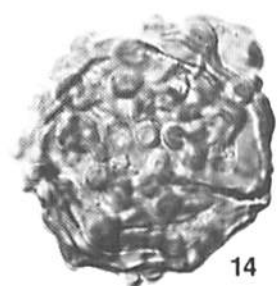
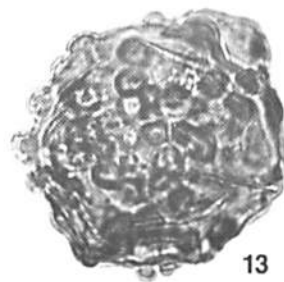
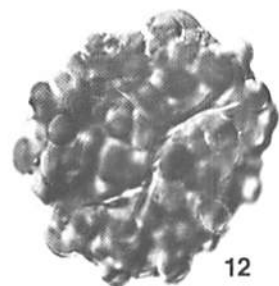
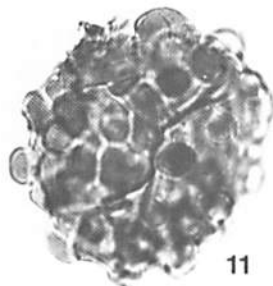
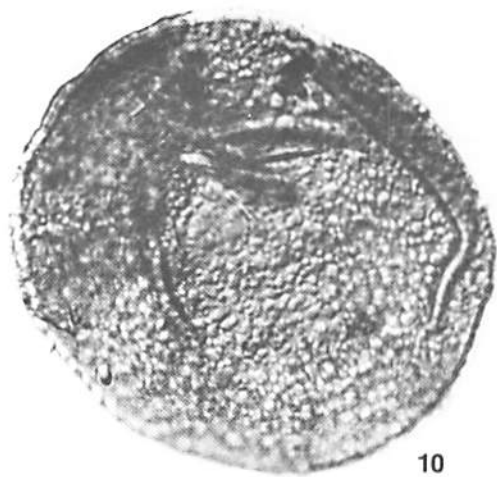
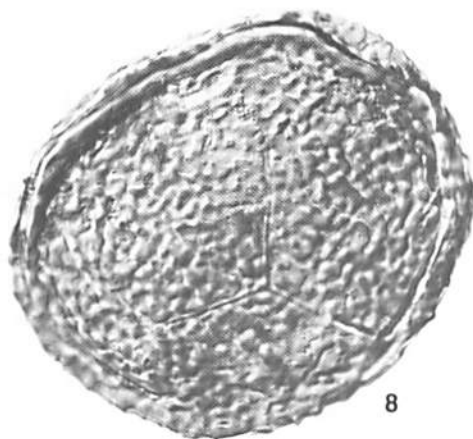
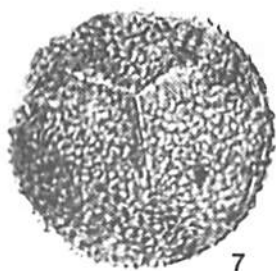
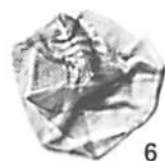
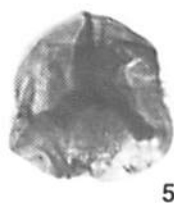
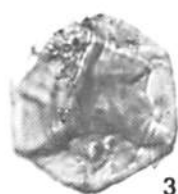
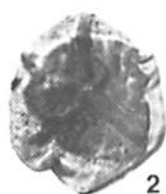
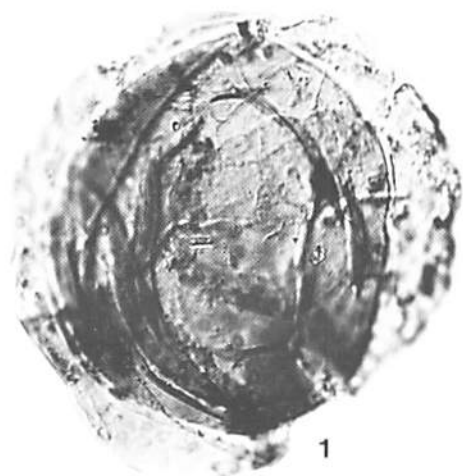


PLATE 5

FIGURE

1. *Cyclogranisporites minutus* Bharadwaj 1957; slide 1X2 coordinates 128-41.5, 28.5 microns.
2. *Cyclogranisporites* cf. *leopoldi* (Kremp) Potonié and Kremp 1955; slide 1Y4 coordinates 139-70, 33.1 microns.
3. *Cyclogranisporites parvus* Bharadwaj 1957; slide 1Y6 coordinates 125-50, 31.4 microns.
4. *Cyclogranisporites parvus* Bharadwaj 1957; slide 6Z1 coordinates 133.5-55 41.0 microns.
5. *Cyclogranisporites orbicularis* (Kosanke) Potonié and Kremp 1955; slide 1B8 coordinates 132.49, 39.3 microns.
6. *Cyclogranisporites microgranus* Bharadwaj 1957; slide 1Y3 coordinates 124-40.5, 45.0 microns.
7. *Cyclogranisporites* sp. 1; slide 6Z4 coordinates 132-57, 53.0 microns.
8. *Cyclogranisporites aureus* (Loose) Potonié and Kremp 1955; slide 5Z2 coordinates 130-65.5, 80.9 microns (300X).
9. *Granulatisporites microgranifer* Ibrahim 1933; slide 1Z6 coordinates 133.5-39.5, 21.7 microns.
10. *Granulatisporites microgranifer* Ibrahim 1933; slide 1C4 coordinates 122.5-57, 22.8 microns.
11. *Granulatisporites granularis* Kosanke 1950; slide 1Z6 coordinates 129.5-47, 25.1 microns.
12. *Granulatisporites granularis* Kosanke 1950; slide 1C4 coordinates 138-43.5, 25.7 microns.
13. *Granulatisporites adnatoides* (Potonié and Kremp) Smith and Butterworth 1967; slide 4Y4 coordinates 120-66, 30.2 microns.
14. *Granulatisporites adnatoides* (Potonié and Kremp) Smith and Butterworth 1967; slide 6Z6 coordinates 132-59, 28.5 microns.
15. *Granulatisporites granulatus* Ibrahim 1933; slide 1X6 coordinates 130.5-66, 21.6 microns.
16. *Granulatisporites granulatus* Ibrahim 1933; slide 1C6 coordinates 119.5-71.5, 28.5 microns.
17. *Granulatisporites parvus* (Ibrahim) Potonié and Kremp 1955; slide 1Z3 coordinates 124-51.5, 36.5 microns.
18. *Granulatisporites parvus* (Ibrahim) Potonié and Kremp 1955; slide 1X6 coordinates 126-62, 31.9 microns.
19. *Granulatisporites parvus* (Ibrahim) Potonié and Kremp 1955; slide DB1Y coordinates 125-63.5, 29.6 microns.
20. *Lophotriletes rarispinosus* Peppers 1970; slide 1C4 coordinates 127-43, 22.8 microns.
21. *Lophotriletes rarispinosus* Peppers 1970; slide 1C1 coordinates 139-57, 26.2 microns.
22. *Lophotriletes commissuralis* (Kosanke) Potonié and Kremp 1955; slide 1C6 coordinates 124.5-63, 28.5 microns.
23. *Lophotriletes microsaetosus* (Loose) Potonié and Kremp 1955; slide DB1Y coordinates 126-61.5, 28.5 microns exclusive of ornament.
24. *Lophotriletes granoornatus* Artüz 1957; slide 1C4 coordinates 129.5-42, 30.8 microns.
25. *Lophotriletes granoornatus* Artüz 1957; slide 1C2 coordinates 129-57, 31.9 microns.
26. *Lophotriletes ibrahimii* (Peppers) Pi-Radondy and Doubinger 1968; slide 2F3 coordinates 136-42, 39.9 microns.

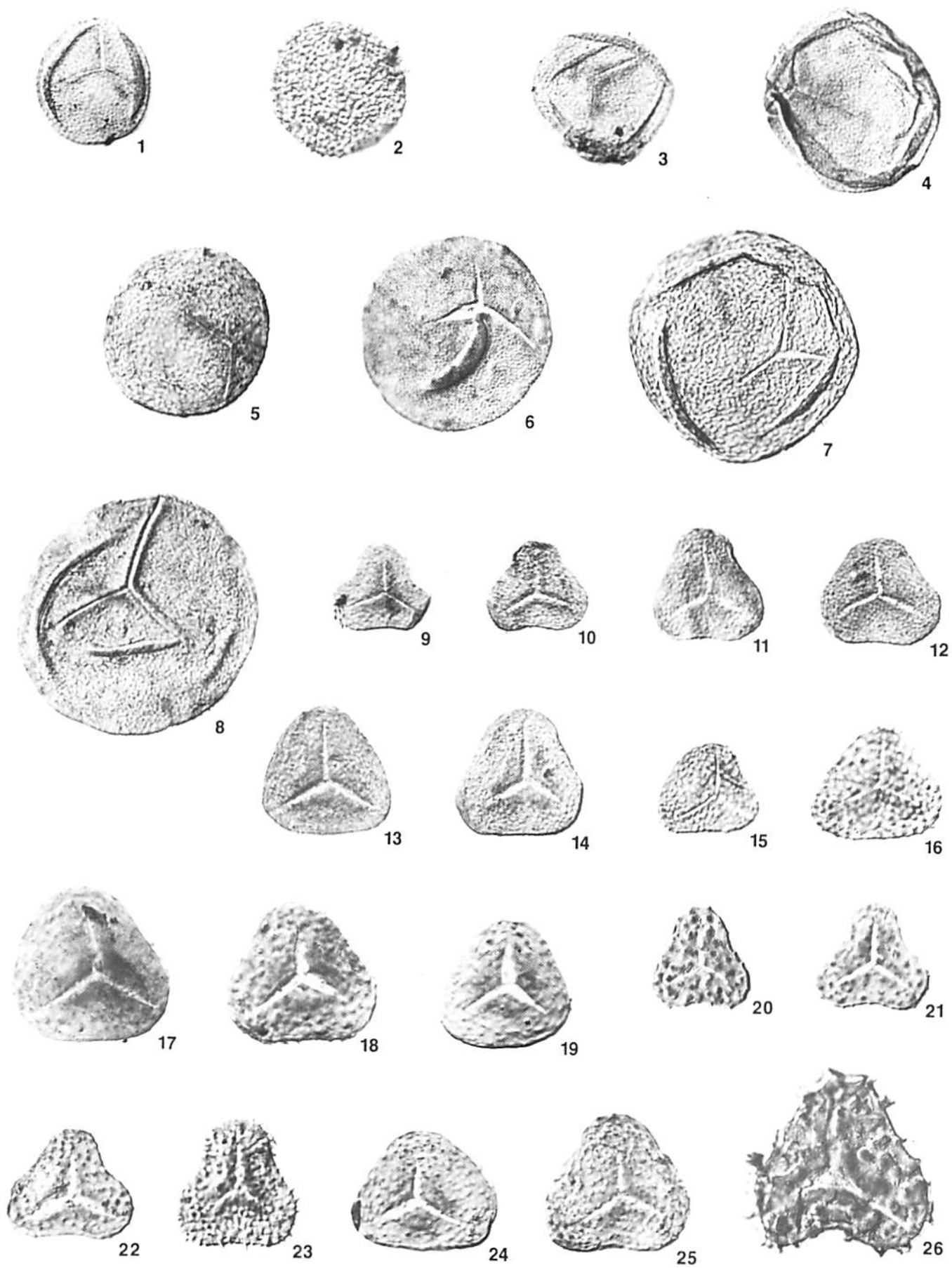
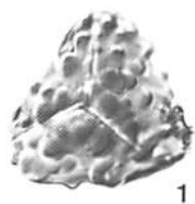


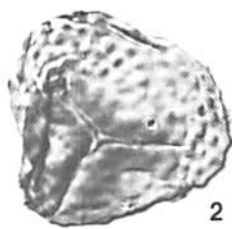
PLATE 6

FIGURE

1. *Lophotriletes cf. tuberifer* (Imgrund) Potonié and Kremp 1955; slide 1Z1 coordinates 118.5-49.5, 31.4 microns.
2. *Lophotriletes cf. tuberifer* (Imgrund) Potonié and Kremp 1955; slide 1Y3 coordinates 124-39.5, 37.1 microns.
3. *Lophotriletes cf. tuberifer* (Imgrund) Potonié and Kremp 1955; slide 1X5 coordinates 123-41, 44.5 microns.
4. *Lophotriletes mosaicus* Potonié and Kremp 1955; slide 1Z3 coordinates 137-38, 31.9 microns.
5. *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp 1955; slide 1D6 coordinates 137-40, 43.9 microns.
6. *Lophotriletes copiosus* Peppers 1970; slide 1C6 coordinates 121-46, 36.5 microns.
7. *Lophotriletes copiosus* Peppers 1970; slide 1C1 coordinates 138.5-45, 39.9 microns.
8. *Lophotriletes* sp. 1; slide 6T1 coordinates 122.5-64.5, 38.4 microns.
9. *Lophotriletes confertus* sp. nov.; holotype, slide 2J2 coordinates 127.5-41, 43.3 microns.
10. *Lophotriletes confertus* sp. nov.; paratype, slide 1D5 coordinates 121.5-60, 41.7 microns.
11. *Lophotriletes confertus* sp. nov.; paratype, slide 2J6 coordinates 128-29, 50.2 microns.
12. *Lophotriletes confertus* sp. nov.; paratype, slide 2F2 coordinates 132-55, 47.9 microns.
13. *Lophotriletes confertus* sp. nov.; paratype, slide 1Y1 coordinates 122-36, 48.5 microns.
14. *Lophotriletes* sp. 2; slide 6Z2 coordinates 124-36.5, 34.8 microns.
15. same as fig. 14 (N).
16. *Waltzispora sagittata* Playford 1962; slide 4A6 coordinates 125-38.5, 30.2 microns.
17. *Anapiculatisporites spinosus* (Kosanke) Potonié and Kremp 1955; slide 1W2 coordinates 129-72.5, 24.5 microns.
18. *Anapiculatisporites spinosus* (Kosanke) Potonié and Kremp 1955; slide 1Y2 coordinates 127-54.5, 22.8 microns.
19. *Anaplanisporites baccatus* (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967; slide 5A2 coordinates 133-61.5, 26.2 microns.
20. *Anaplanisporites baccatus* (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967; slide 1Y4 coordinates 123.5-60, 26.2 microns.



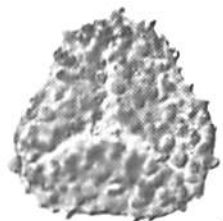
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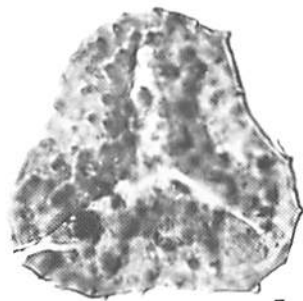
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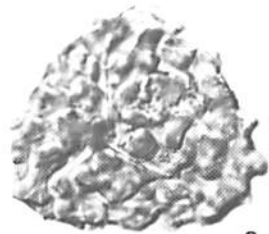
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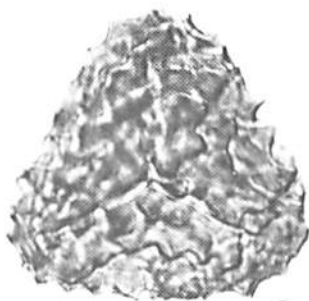
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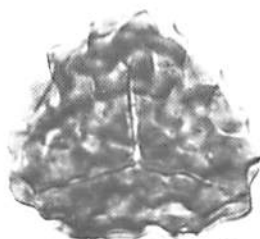
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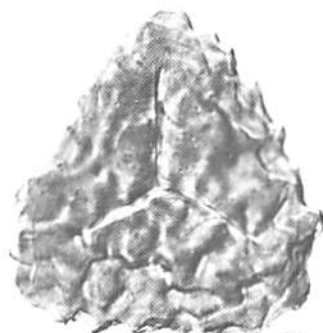
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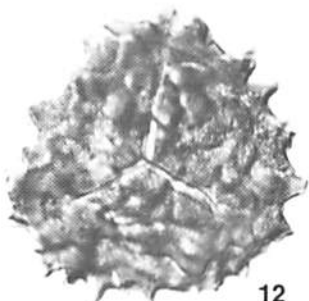
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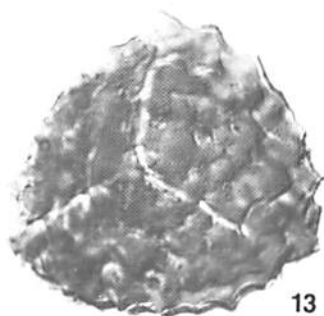
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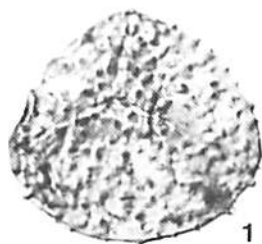


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PLATE 7

FIGURE

1. *Apiculatisporis aculeatus* (Ibrahim) Smith and Butterworth 1967; slide 1W1 coordinates 122-72, 37.1 microns.
2. *Apiculatisporis aculeatus* (Ibrahim) Smith and Butterworth 1967; slide 5Z1 coordinates 135-63, 33.1 microns.
3. *Apiculatisporis aculeatus* (Ibrahim) Smith and Butterworth 1967; slide 2J3 coordinates 120-40, 44.5 microns.
4. *Apiculatisporis saetiger* (Peppers) Peppers and Ravn comb. nov.; slide 5A7 coordinates 119-50.5, 20.5 microns.
5. *Apiculatisporis saetiger* (Peppers) Peppers and Ravn comb. nov.; slide DB1Z coordinates 122.5-56, 22.8 microns.
6. *Apiculatisporis latigranifer* (Loose) Potonié and Kremp 1955; slide 1Y6 coordinates 123-38, 68.4 microns (300X).
7. *Apiculatisporis variocorneus* Sullivan 1964; CP-19-5 slide Z-7 coordinates 127.5-44, 68.2 microns exclusive of ornament (300X).
8. *Apiculatisporis abditus* (Loose) Potonié and Kremp 1956; slide 3A4 coordinates 132.5-31, 68.4 microns.
9. *Apiculatisporis* sp. 1; slide 1X1 coordinates 127-40, 45.6 microns.
10. *Apiculatasporites spinulistratus* (Loose) Ibrahim 1933; slide 6V4 coordinates 122-61.5, 48.5 microns.
11. *Apiculatasporites spinulistratus* (Loose) Ibrahim 1933; slide 7R3 coordinates 131-42, 62.7 microns.
12. *Acanthotriletes echinatus* (Knox) Potonié and Kremp 1955; slide 1Z2 coordinates 139-69.5, 25.7 microns.
13. *Acanthotriletes triquetrus* Smith and Butterworth 1967; slide 3M6 coordinates 122-57.5, 24.5 microns exclusive of ornament.
14. *Acanthotriletes aculeolatus* (Kosanke) Potonié and Kremp 1955; slide 1C4 coordinates 126.5-67, 33.1 microns.
15. *Acanthotriletes* cf. *falcatus* (Knox) Potonié and Kremp 1955; slide 2H4 coordinates 124-30.5, 45.6 microns exclusive of ornament.



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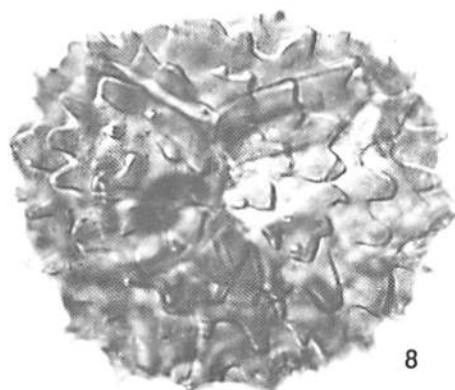
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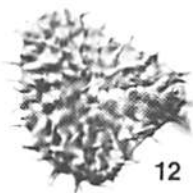
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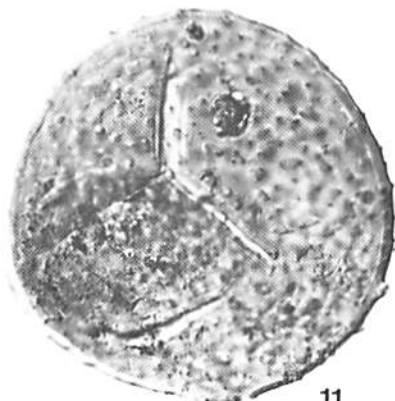
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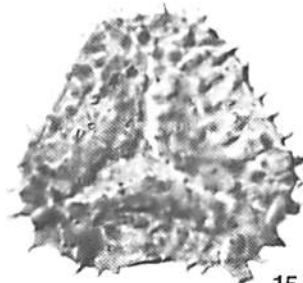
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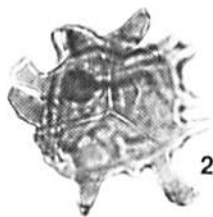
PLATE 8

FIGURE

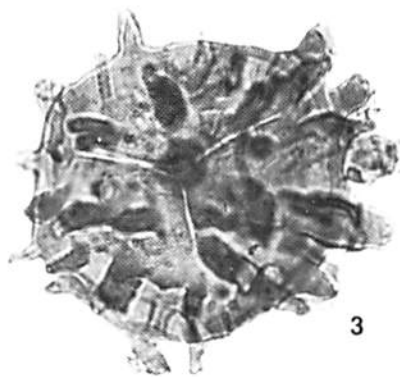
1. *Raistrickia protensa* Kosanke 1950; slide 2J3 coordinates 136.5-50, 46.2 microns, exclusive of ornament.
2. *Raistrickia pilosa* Kosanke 1950; slide 4M2 coordinates 133-47, 24.5 microns exclusive of ornament.
3. *Raistrickia lacerata* Peppers 1970; slide 5C3 coordinates 131-39.5, 55.4 microns exclusive of ornament.
4. *Raistrickia lowellensis* Peppers 1970; slide 6Z1 coordinates 134.5-56.5, 39.9 microns exclusive of ornament.
5. *Raistrickia crocea* Kosanke 1950; slide 5A4 coordinates 134.5-61.5, 61.6 microns exclusive of ornament.
6. *Raistrickia lowellensis* Peppers 1970; slide 6Z4 coordinates 130-32.5, 55.9 microns exclusive of ornament.
7. *Apiculatisporis irregularis* (Kosanke) Potonié and Kremp 1955; slide 3A4 coordinates 125.5-44.5, 57.0 microns exclusive of ornament.
8. *Raistrickia* cf. *macra* Bharadwaj 1957; slide 6R5 coordinates 133-58.5, 52.4 microns.
9. *Spackmanites facierugosus* (Loose) Habib 1966; slide 5A2 coordinates 125-59.5, 29.6 microns.
10. same as fig. 9 (N).
11. *Spackmanites facierugosus* (Loose) Habib 1966; slide 3Z5 coordinates 132.5-64, 46.7 microns.
12. *Convolutispora cerina* sp. nov.; holotype, slide 3M6 coordinates 130-71.5, 44.5 microns.
13. *Convolutispora cerina* sp. nov.; paratype, slide 3M6 coordinates 134-31.5, 43.9 microns.
14. *Convolutispora cerina* sp. nov.; paratype, slide 1Y1 coordinates 122.5-36, 46.2 microns.
15. *Convolutispora cerina* sp. nov.; paratype, slide 1Y1 coordinates 126.5-35, 45.6 microns.



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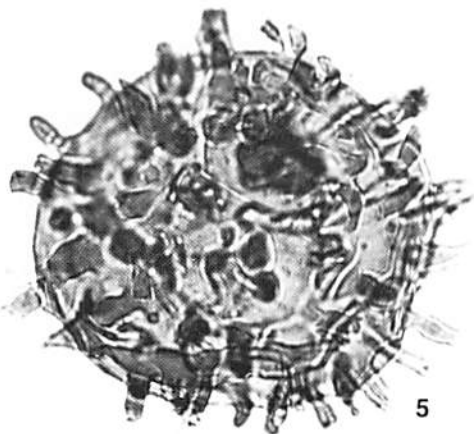
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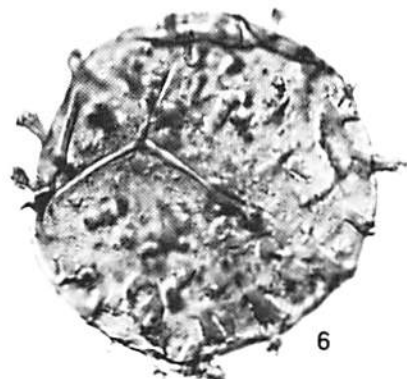
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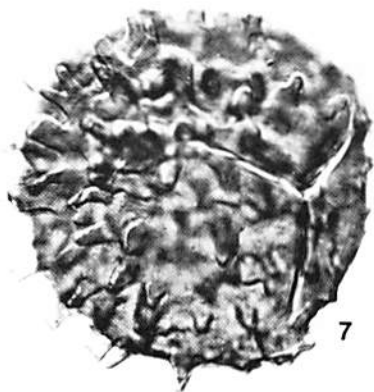
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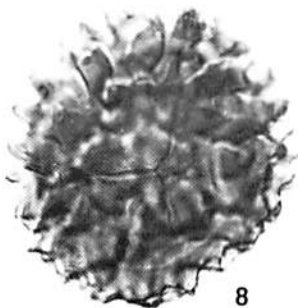
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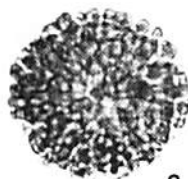
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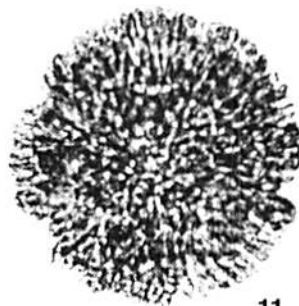
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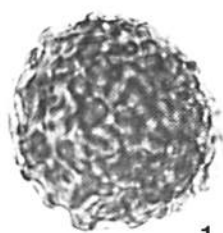


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PLATE 9

FIGURE

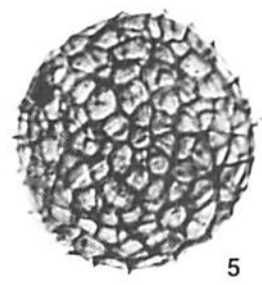
1. *Convolutispora*(?) sp. 1; slide 5A7 coordinates 122-54.5, 34.2 mrons.
2. *Dictyotriletes castaneaeformis* (Horst) Sullivan 1964; slide 2J5 coordinates 129-43, 26.2 microns.
3. *Dictyotriletes castaneaeformis* (Horst) Sullivan 1964; slide 5A3 coordinates 123-50, 26.2 microns.
4. *Dictyotriletes castaneaeformis* (Horst) Sullivan 1964; slide DB1Z coordinates 125-60.5, 31.4 microns.
5. *Dictyotriletes reticulocingulum* (Loose) Smith and Butterworth 1967; slide 1Z1 coordinates 120-48, 41.6 microns.
6. *Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp 1954; slide 1Y1 coordinates 139.5-50.5, 53.6 microns.
7. *Dictyotriletes densoreticulatus* Potonié and Kremp 1955; slide 1Z5 coordinates 118.5-40, 61.0 microns.
8. *Dictyotriletes reticulocingulum* (Loose) Smith and Butterworth 1967; slide 6H4 coordinates 127-44.5, 43.9 microns.
9. *Dictyotriletes distortus* Peppers 1970; slide 6F5 coordinates 138.5-49, 38.2 microns.
10. *Microreticulatisporites harrisonii* Peppers 1970; slide 1C4 coordinates 121-51.5, 32.5 microns.
11. *Microreticulatisporites nobilis* (Wicher) Knox 1950; slide 6V4 coordinates 119.5-52.5, 34.2 microns.
12. *Microreticulatisporites nobilis* (Wicher) Knox 1950; CP-19-5 slide Y-4 coordinates 131-38, 40.6 microns.
13. *Camptotriletes bucculentus* (Loose) Potonié and Kremp 1955; slide 5A9 coordinates 126.5-55, 40.6 microns.
14. *Camptotriletes* cf. *corrugatus* (Ibrahim) Potonié and Kremp 1955; slide 1Z6 coordinates 120-51, 54.2 microns.
15. *Microreticulatisporites* sp. 1; slide 1D6 coordinates 122-44, 41.0 microns.
16. *Latipulvinites kosankii* Peppers 1964; slide 1Y5 coordinates 119.5-71, 34.8 microns.
17. *Ahrensispores guerickei* (Horst) Potonié and Kremp 1954; slide 5Z1 coordinates 133.5-45, 37.1 microns exclusive of kytomes.



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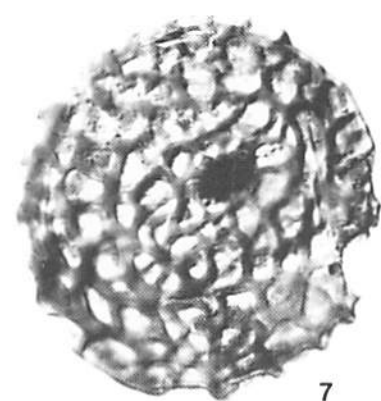
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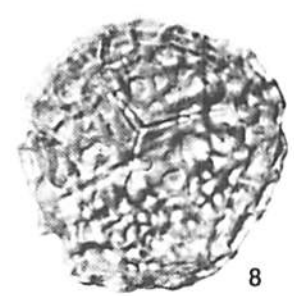
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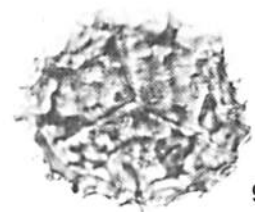
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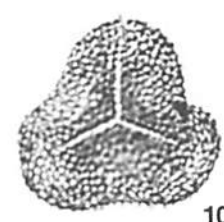
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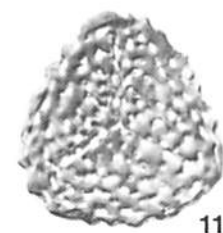
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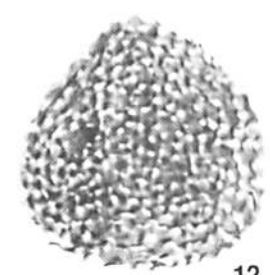
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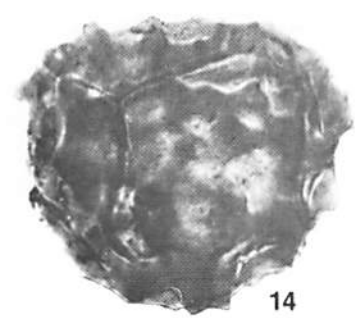
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PLATE 10

FIGURE

1. *Stellisporites inflatus* Alpern 1958; slide 5A7 coordinates 122.5-63.5, 26.2 microns.
2. *Tantillus triquetrus* Felix and Burbridge 1967; slide 6Z1 coordinates 131-64, 19.9 microns.
3. *Tantillus triquetrus* Felix and Burbridge 1967; CP-43-44 slide 4 coordinates 122-48.5, 21.7 microns.
4. *Tantillus triquetrus* Felix and Burbridge 1967; CP-27-7 slide 1 coordinates 130-45, 25.7 microns.
5. *Tantillus triquetrus* Felix and Burbridge 1967; slide DB1Z coordinates 137.5-56.5, 16.0 microns.
6. *Tantillus triquetrus* Felix and Burbridge 1967; slide 1Z6 coordinates 129-50.5, 19.4 microns.
7. *Tantillus triquetrus* Felix and Burbridge 1967; slide 5A1 coordinates 127-61.5, 22.6 microns.
8. same as fig. 7 (N).
9. *Triquitrites minutus* Alpern 1958; slide 2F2 coordinates 125.5-62, 25.1 microns.
10. *Triquitrites exiguus* Wilson and Kosanke 1944; slide 3A2 coordinates 121-56.5, 25.7 microns.
11. *Triquitrites additus* Wilson and Hoffmeister 1956; slide 5Z3 coordinates 139-41, 31.9 microns.
12. *Triquitrites protensus* Kosanke 1950; slide 6Z6 coordinates 130-46, 34.2 microns.
13. *Triquitrites bransonii* Wilson and Hoffmeister 1956; slide 6Z2 coordinates 125-48, 34.2 microns.
14. *Triquitrites bransonii* Wilson and Hoffmeister 1956; slide 7R4 coordinates 132-40, 36.9 microns.
15. *Triquitrites additus* Wilson and Hoffmeister 1956; slide 5A3 coordinates 124-60, 35.3 microns.
16. *Triquitrites sculptilis* (Balme) Smith and Butterworth 1967; slide 6Z4 coordinates 136-54, 34.8 microns.
17. *Triquitrites subspinosus* Peppers 1970; slide 3Z6 coordinates 126-60, 39.9 microns.
18. *Triquitrites crassus* Kosanke 1950; CP-19-5 slide A-4 coordinates 126.5-33, 45.6 microns.
19. *Zosterosporites triangularis* Kosanke 1973; slide 1X1 coordinates 127-59.5, 31.4 microns.
20. *Zosterosporites triangularis* Kosanke 1973; slide 1W2 coordinates 137-51.5, 27.9 microns.
21. *Reticulatisporites reticulatus* (Ibrahim) Ibrahim 1933; slide 6Z1 coordinates 126-56, 75.4 microns (300X).
22. *Knoxisporites stephanephorus* Love 1960; slide 6R2 coordinates 133-42, 41.6 microns.
23. *Knoxisporites triradiatus* Hoffmeister, Staplin and Molloy 1955; slide 5A1 coordinates 127-66.5, 63.9 microns.

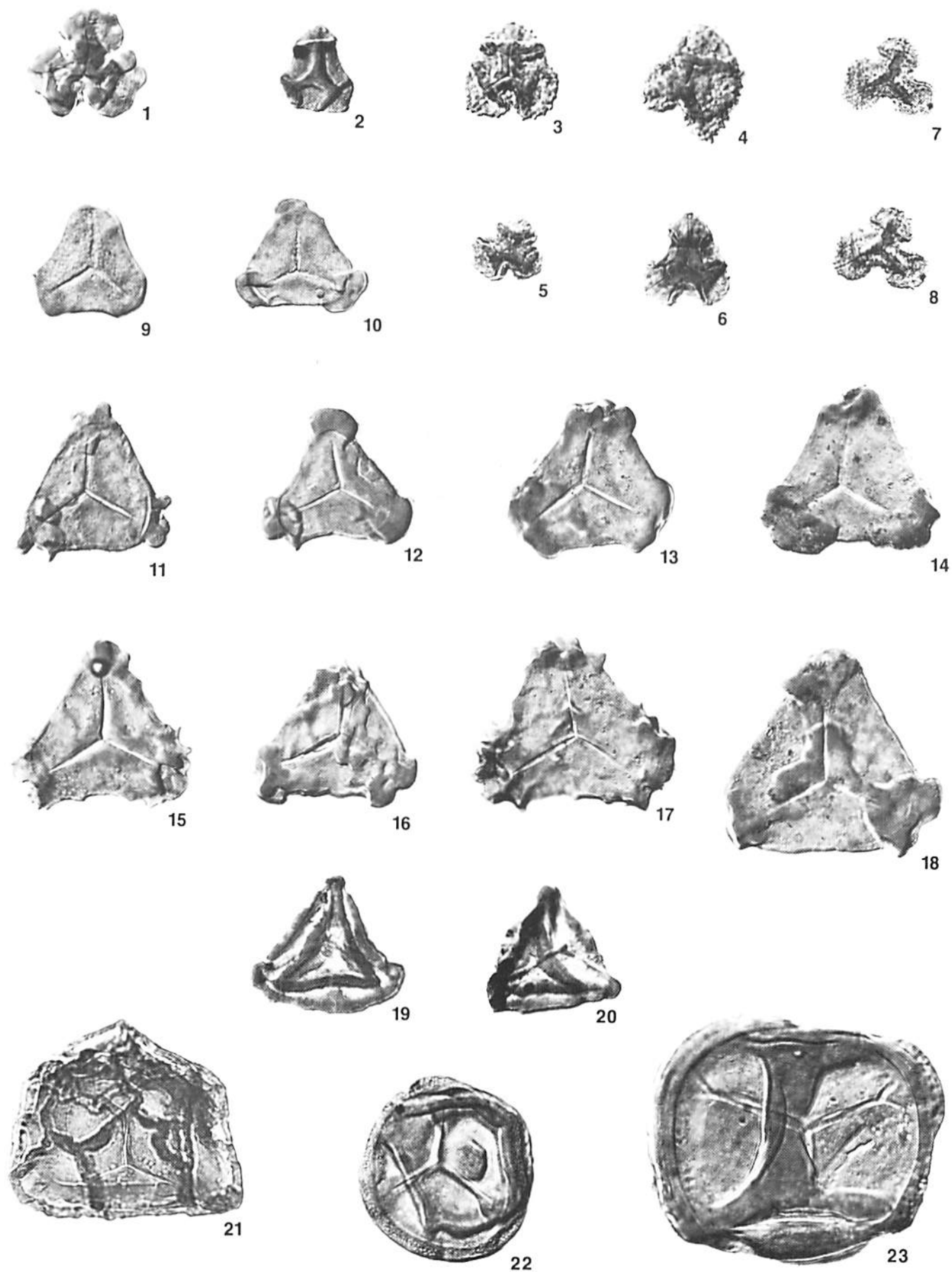


PLATE 11

FIGURE

1. *Reinschospora speciosa* (Loose) Schopf, Wilson and Bentall 1944; slide 5A3 coordinates 132-38, 51.1 microns exclusive of ornament.
2. *Indospora boleta* Peppers 1970; slide 6T2 coordinates 129-59, 22.2 microns exclusive of ornament.
3. *Reinschospora triangularis* (Kosanke) emend.; slide 1Z3 coordinates 134.5-61, 57.0 microns exclusive of ornament.
4. *Reinschospora triangularis* (Kosanke) emend.; slide 1Z2 coordinates 127.5-49, 55.6 microns exclusive of ornament.
5. *Reinschospora triangularis* (Kosanke) emend.; slide 1Z12 coordinates 133-60, 55.3 microns exclusive of ornament.
6. *Reinschospora triangularis* (Kosanke) emend.; slide DB1Z coordinates 132-70, 59.9 microns exclusive of ornament.
7. *Cuneisporites rigidus* sp. nov.; paratype, CP-10-49 slide B-9 coordinates 127-69.5, 45.6 microns.
8. *Cuneisporites rigidus* sp. nov.; holotype, slide 2H2 coordinates 128-55.5 47.3 microns.
9. *Cuneisporites rigidus* sp. nov.; paratype, slide 2H3 coordinates 125-40, 41.0 microns.
10. *Tetanisporites granulatus* sp. nov.; paratype, slide 6V3 coordinates 134.5-51, 45.6 microns.
11. *Tetanisporites granulatus* sp. nov.; holotype, slide 1C1 coordinates 132-60.5, 50.7 microns.
12. *Tetanisporites granulatus* sp. nov.; paratype, CP-10-7 slide 12 coordinates 119-58, 49.6 microns.

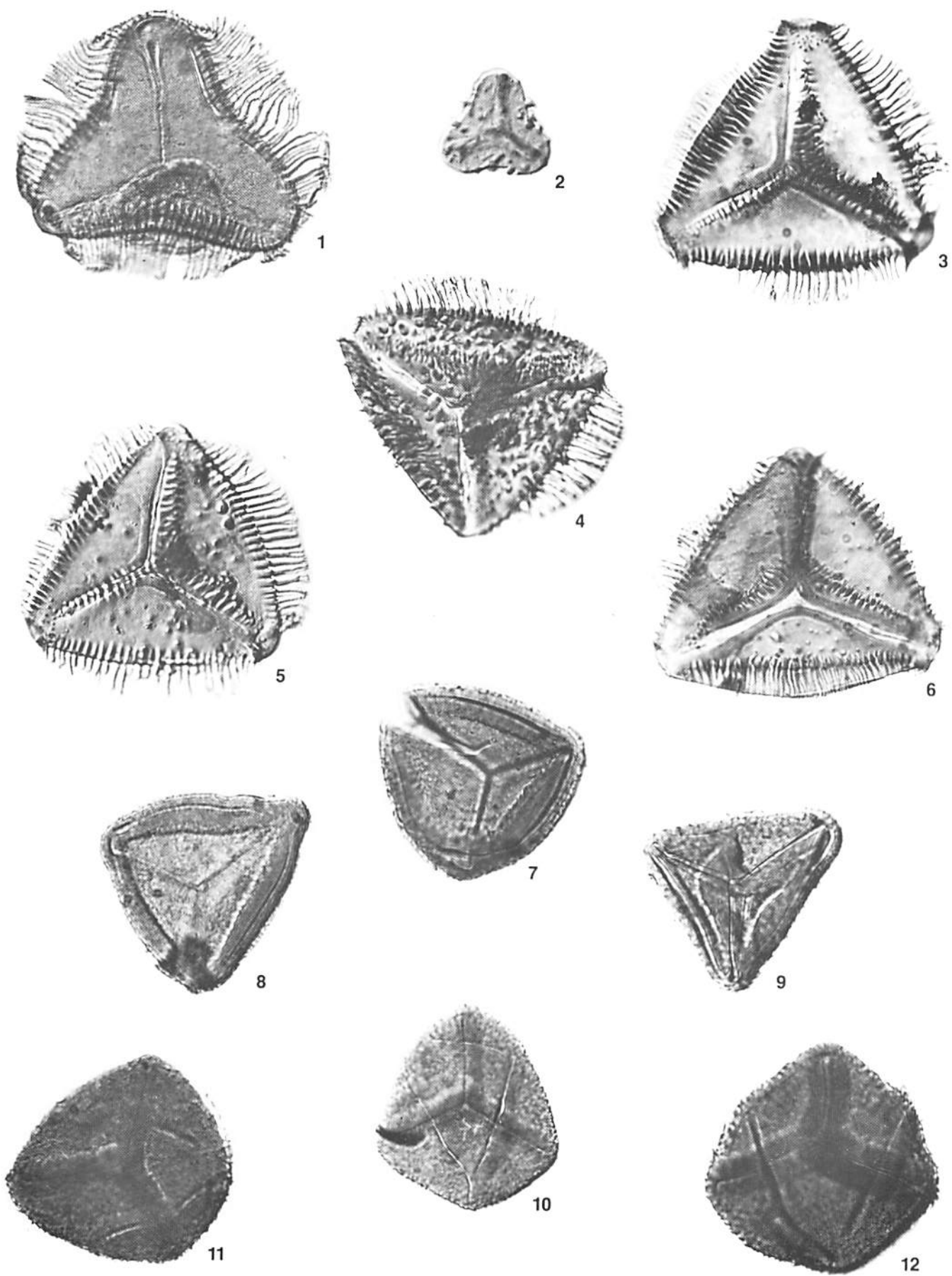


PLATE 12

FIGURE

1. *Grumosporites* (?) *rufus* (Butterworth and Williams) Smith and Butterworth 1967; slide 6R6 coordinates 137-30, 51.3 microns.
2. *Savitrisporites nux* (Butterworth and Williams) Smith and Butterworth 1967; slide 4A3 coordinates 125-36, 47.7 microns.
3. *Savitrisporites* sp. 1; slide 6R2 coordinates 119.5-65, 54.7 microns.
4. *Cristatisporites indignabundus* (Loose) Staplin and Jansonius 1964; slide 5A6 coordinates 130-52, 48.6 microns.
5. same as fig. 4 (N).
6. *Simozotriletes intortus* (Waltz) Potonić and Kremp 1954; slide 3A5 coordinates 140-63.5, 62.7 microns.
7. *Radiizonates* cf. *difformis* (Kosanke) Staplin and Jansonius 1964; slide 1W2 coordinates 133-52, 35.3 microns.
8. *Radiizonates* cf. *difformis* (Kosanke) Staplin and Jansonius 1964; slide 4A5 coordinates 120-22.5, 48.5 microns.
9. *Crassispora kosankei* (Potonić and Kremp) Smith and Butterworth 1967; slide 6V2 coordinates 124-55, 48.5 microns.
10. *Crassispora kosankei* (Potonić and Kremp) Smith and Butterworth 1967; slide 6Z1 coordinates 136-38.5, 54.2 microns.
11. *Crassispora annulata* sp. nov.; holotype, slide 6V3 coordinates 131.5-48.5, 49.6 microns.
12. *Crassispora annulata* sp. nov.; paratype, slide 6R6 coordinates 128-63, 50.1 microns.
13. *Crassispora annulata* sp. nov.; paratype, slide 7M3 coordinates 128-53.5, 42.8 microns.
14. *Crassispora annulata* sp. nov.; paratype, slide 7D2 coordinates 133-56, 38.8 microns.
15. *Crassispora annulata* sp. nov.; paratype, slide 6H4 coordinates 123-41.5, 46.7 microns.

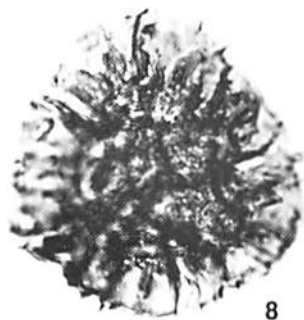
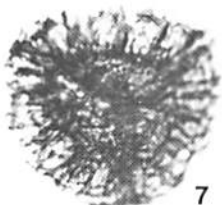
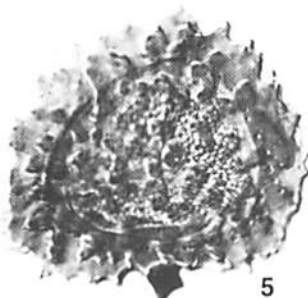
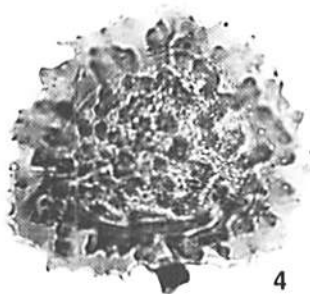
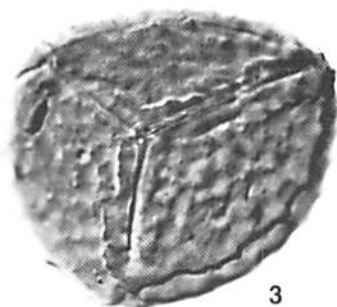
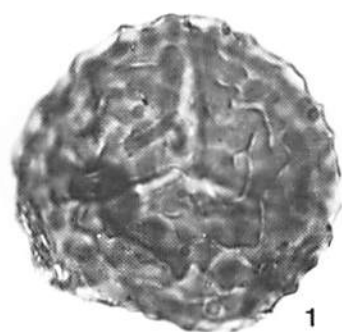


PLATE 13

FIGURE

1. *Cappasporites distortus* Urban 1966; slide 1B8 coordinates 138-62, 53.0 microns.
2. *Cappasporites distortus* Urban 1966; slide 5A4 coordinates 134-63, 55.9 microns.
3. *Densosporites anulatus* (Loose) Smith and Butterworth 1967; slide 2A2 coordinates 122-47.5, 27.4 microns.
4. *Densosporites anulatus* (Loose) Smithland Butterworth 1967; slide 3U5 coordinates 121-52.5, 27.9 microns.
5. *Densosporites anulatus* (Loose) smith and Butterworth 1967; slide 11Z6 coordinates 124-49, 38.2 microns.
6. *Densosporites triangularis* Kosanke 1950; slide 1X2 coordinates 126.5-57.5, 48.5 microns.
7. *Densosporites sphaerotriangularis* Kosanke 1950; slide 6Z1 coordinates 125.5-57, 39.3 microns.
8. *Densosporites sphaerotriangularis* Kosanke 1950; slide 6Z6 coordinates 132-49.5, 40.5 microns.
9. *Densosporites irregularis* Hacquebard and Barss 1957; slide 3Z2 coordinates 130.5-65.6, 49.6 microns.
10. *Densosporites spinifer* Hoffmeister, Staplin and Malloy 1955; slide 6Z4 coordinates 130-33, 35.9 microns exclusive of spines.
11. *Densosporites spinifer* Hoffmeister, Staplin and Molloy 1955; slide 6Z6 coordinates 136-48, 33.6 microns exclusive of spines.
12. *Densosporites spinifer* Hoffmeister, Staplin and Molloy 1955; slide 6V4 coordinates 128.5-54, 33.6 microns exclusive of spines.
13. *Cingulizonates loricatus* (Loose) Butterworth and Smith in Butterworth *et al.*, 1964; slide 6T3 coordinates 120.5-50, 37.6 microns.
14. *Lycospora micropapillata* (Wilson and Coe) Schopf, Wilson and Bentall 1944; slide 10H4 coordinates 139.5-53.5, 23.9 microns.
15. *Lycospora granulata* Kosanke 1950; slide 1Z4 coordinates 123.5-70, 29.6 microns.
16. *Lycospora pellucida* (Wicher) Schopf, Wilson and Bentall 1944; slide 2H6 coordinates 121.5-64, 36.5 microns.
17. *Lycospora* cf. *L. torquifer* (Loose) Potonié and Kremp 1956; slide 1Y1 coordinates 122.5-68, 34.8 microns.
18. *Lycospora* cf. *L. torquifer* (Loose) Potonié and Kremp 1956; slide DB1Z coordinates 136-62, 31.9 microns.
19. *Lycospora rotunda* Bharadwaj 1957; slide 11Z6 coordinates 124-49.5, 35.9 microns.
20. *Lycospora rotunda* Bharadwaj 1957; CP-19-5 slide A-6 coordinates 122-63.5, 37.1 microns.

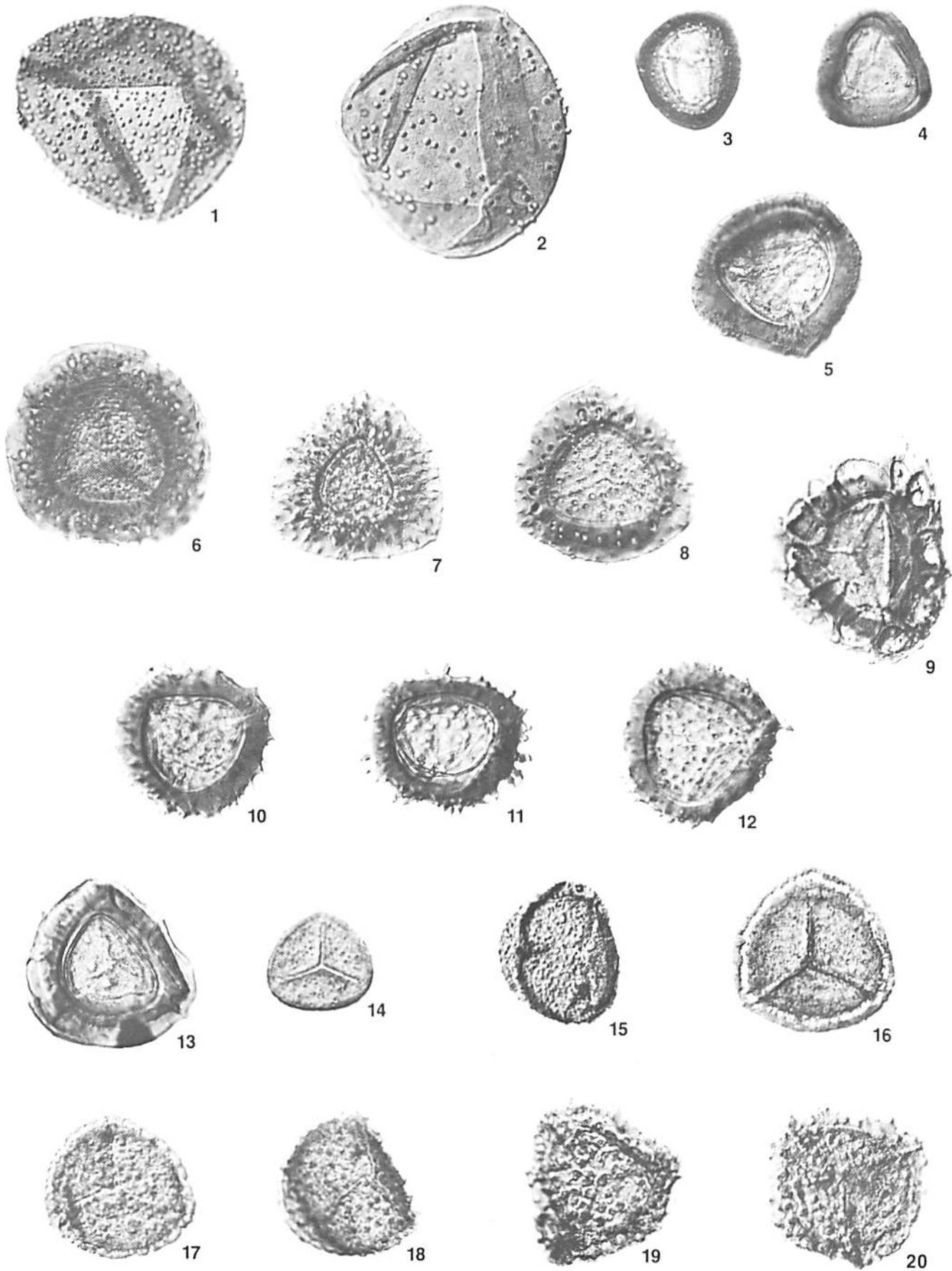


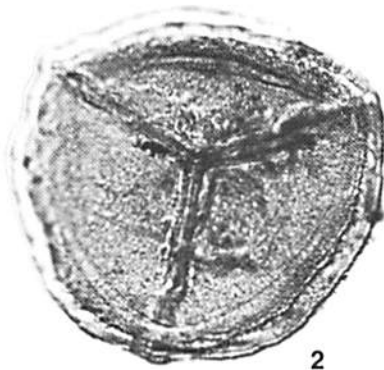
PLATE 14

FIGURE

1. *Cirratiradites maculatus* Wilson and Coe 1940; slide 1Z1 coordinates 122-58.5, 75.3 microns (300X).
2. *Cirratiradites annuliformis* Kosanke 1950; slide 6H2 coordinates 130-73, 59.3 microns.
3. *Cirratiradites saturni* (Ibrahim) Schopf, Wilson and Bentall 1944; slide 4M4 coordinates 120-47.5, 65.3 microns (300X).
4. *Cirratiradites reticulatus* sp. nov.; holotype, CP-19-5 slide Y-4 coordinates 124.5-33, 52.4 microns.
5. *Cirratiradites reticulatus* sp. nov.; paratype, CP-19-5 slide A-3 coordinates 128-61, 49.6 microns.
6. *Cirratiradites reticulatus* sp. nov.; paratype, CP-19-5 slide X-5 coordinates 137-5.34.5, 51.3 microns.
7. *Endosporites globiformis* (Ibrahim) Schopf, Wilson and Bentall 1944; slide 1Z2 coordinates 121-43.5, 92.9 microns (300X).
8. *Endosporites zonalis* (Loose) Knox 1950; slide 1Z4 coordinates 131-48, 85.2 microns (300X).
9. *Endosporites staplinii* Gupta and Boozer 1969; slide 2H6 coordinates 119-33, 33.1 microns.
10. *Endosporites staplinii* Gupta and Boozer 1969; slide 3A1 coordinates 129-62, 31.4 microns.
11. *Endosporites staplinii* Gupta and Boozer 1969; FITZ II slide 23 coordinates 126-57.5, 35.3 microns.
12. *Alatisporites pustulatus* (Ibrahim) Ibrahim 1933; slide 3A2 coordinates 121-58, 90.0 microns (300X).
13. *Alatisporites pustulatus* (Ibrahim) Ibrahim 1933; slide 1Z4 coordinates 122-51, 86.8 microns (300X).



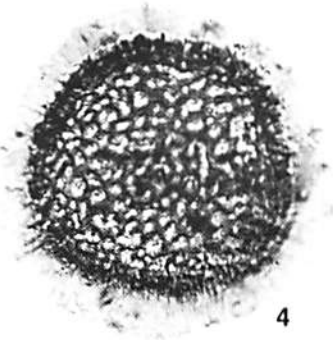
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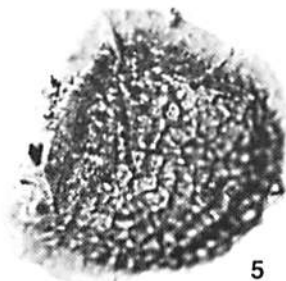
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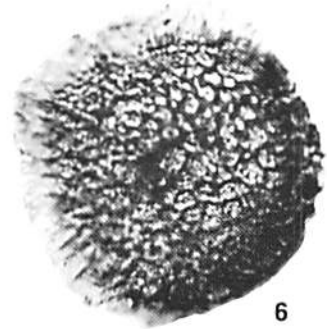
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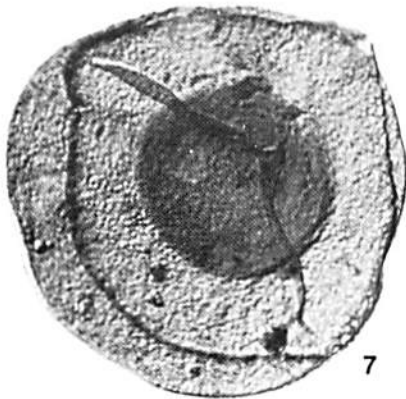
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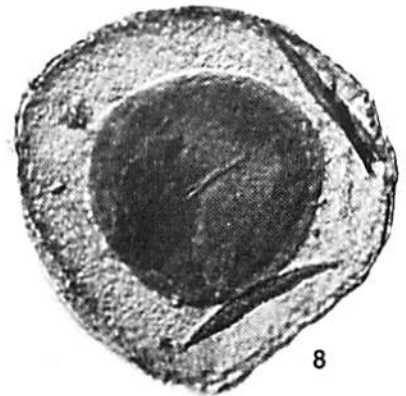
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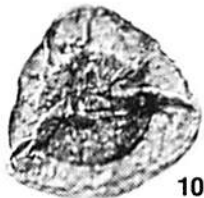
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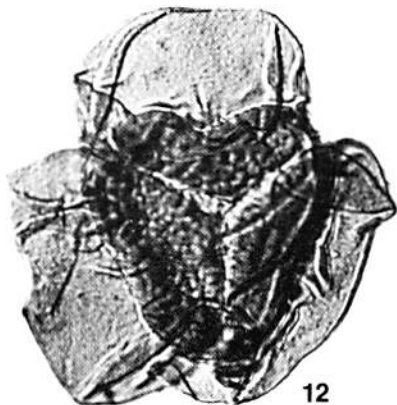
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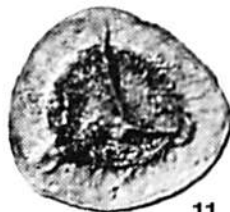
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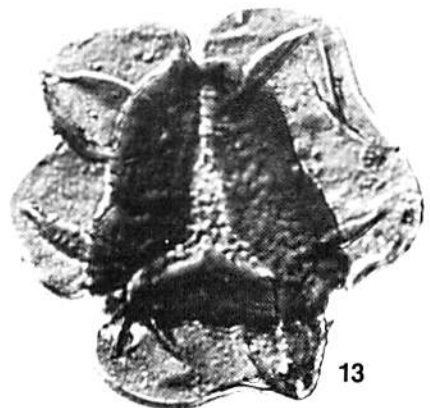
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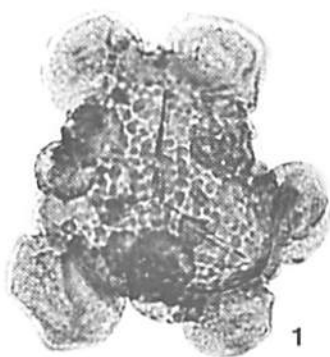


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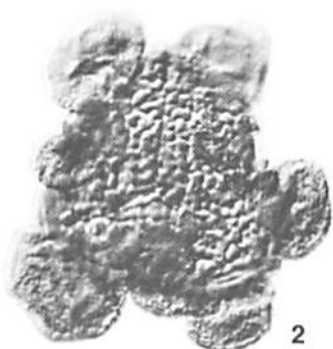
PLATE 15

FIGURE

1. *Alatisporites hoffmeisterii* Morgan 1955; slide 1Y4 coordinates 126.5-46, 55.4 microns exclusive of bladders (300X).
2. same as fig. 1 (N).
3. *Laevigatosporites minutus* (Ibrahim) Schopf, Wilson and Bentall 1944; slide 3Z6 coordinates 122-49, 20.4 microns.
4. *Laevigatosporites globosus* Schemel 1951; slide 6H1 coordinates 123-53.5, 27.9 microns.
5. *Laevigatosporites globosus* Schemel 1951; slide 1Z2 coordinates 125.5-42.5, 30.2 microns.
6. *Laevigatosporites globosus* Schemel 1951; slide DB1Z coordinates 126.5-60.5, 31.4 microns.
7. *Punctatisporites obliquus* Kosanke 1950; slide 1C1 coordinates 119.5-65.5, 33.1 microns.
8. *Laevigatosporites medius* Kosanke 1950; slide 1Z6 coordinates 132-45, 33.1 microns.
9. *Laevigatosporites medius* Kosanke 1950; slide 1X1 coordinates 123.5-53.5, 35.9 microns.
10. *Laevigatosporites ovalis* Kosanke 1950; slide 6R6 coordinates 120-65.5, 47.3 microns.
11. *Laevigatosporites desmoinensis* (Wilson and Coe) Schopf, Wilson and Bentall 1944; slide 1Z1 coordinates 130-74, 63.3 microns.
12. *Laevigatosporites striatus* Alpern 1959; slide 5A4 coordinates 135-46, 56.4 microns.
13. *Laevigatosporites striatus* Alpern 1959; slide 5A2 coordinates 130.5-64, 51.9 microns.
14. *Laevigatosporites* cf. *dunkardensis* Clendening 1970; slide 1C6 coordinates 119-49, 78.0 microns (300X).
15. *Laevigatosporites vulgaris* (Ibrahim) Ibrahim 1933; slide 6Z3 coordinates 130.5-32.5, 84.4 microns.
16. *Laevigatosporites* cf. *vulgaris* (Ibrahim) Ibrahim 1933; slide 2H2 coordinates 129-46.5, 90.9 microns (300X).



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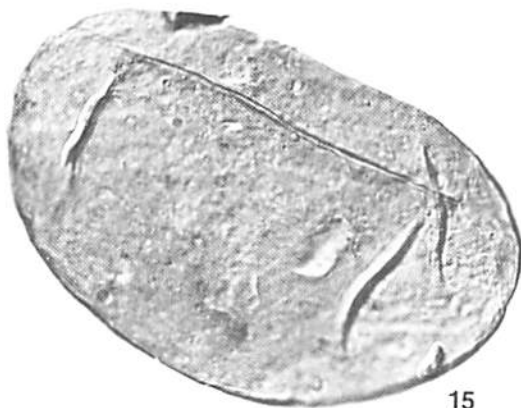
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PLATE 16

FIGURE

1. *Torispora securis* Balme 1952; slide 6Z6 coordinates 125-56.5, 34.2 microns.
2. *Thymospora* cf. *pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963; CP-19-5 slide B-1 coordinates 134-46, 23.9 microns.
3. *Thymospora* cf. *pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963; slide 1X4 coordinates 121-45, 27.9 microns.
4. *Thymospora* cf. *pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963; slide 1Y4 coordinates 122-64, 22.8 microns.
5. *Tuberculatosporites robustus* (Kosanke) Peppers 1970; slide 1C1 coordinates 124-62, 73.8 microns (300X).
6. *Tuberculatosporites robustus* (Kosanke) Peppers 1970; slide 1C6 coordinates 137-55, 105.1 microns (300X).
7. *Vestispora laevigata* Wilson and Venkatachala 1963; slide 3Z6 coordinates 130.5-39, 78.1 microns (300X).
8. *Vestispora laevigata* Wilson and Venkatachala 1963; slide 1W1 coordinates 125.5-60, 63.8 microns.
9. *Vestispora laevigata* Wilson and Venkatachala 1963; slide DB1Z coordinates 134-58, 68.0 microns.
10. *Vestispora pseudoreticulata* Spode in Smith and Butterworth, 1967; slide 1C1 coordinates 124-66, 73.8 microns.
11. *Vestispora pseudoreticulata* Spode in Smith and Butterworth, 1967; slide 1D4 coordinates 123.5-63.5, 65.3 microns.
12. *Vestispora* cf. *reticulata* (Laveine) Loboziak 1971; slide 1X1 coordinates 127-39.5, 83.8 microns.

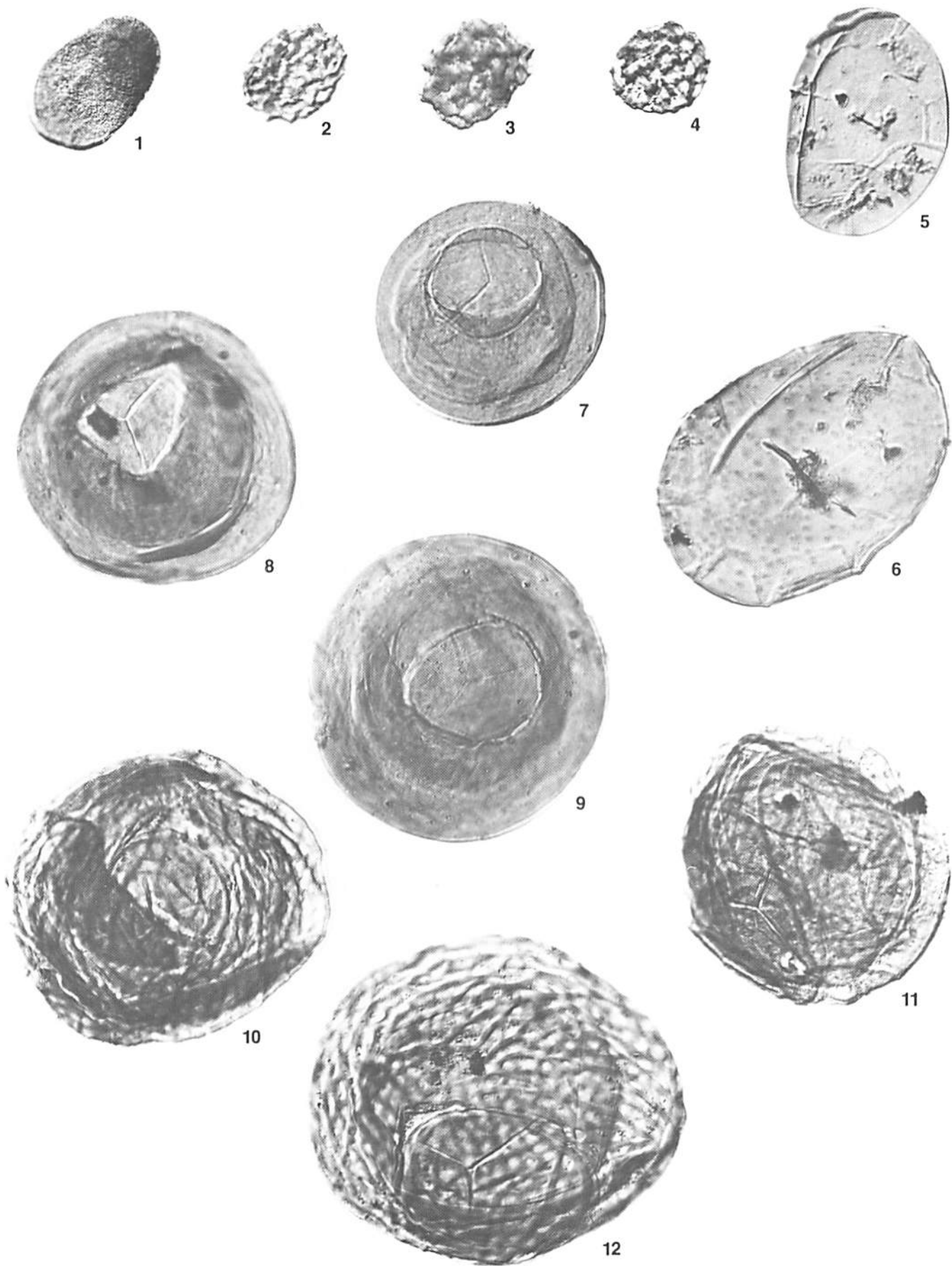


PLATE 17

FIGURE

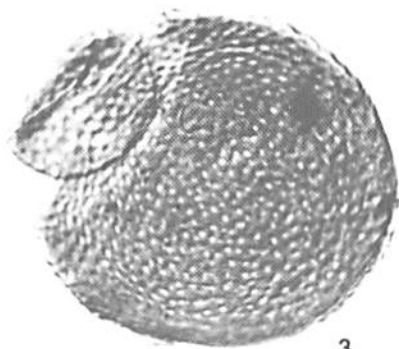
1. *Vestispora* sp. 1; slide 5A6 coordinates 132-32, 72.4 microns (300X).
2. *Vestispora fenestrata* (Kosanke and Brokaw) Spode in Smith and Butterworth 1967; slide 6Z1 coordinates 133.5-55.5, 62.1 microns.
3. *Vestispora fenestrata* (Kosanke and Brokaw) Spode in Smith and Butterworth 1967; CP-23-2 slide 4 coordinates 119-66, 96.6 microns (300X).
4. *Vestispora luminata* sp. nov.; holotype, slide 5Z6 coordinates 123-51.5, 96.6 microns (300X).
5. *Vestispora luminata* sp. nov.; detached operculum, slide 6Z2 coordinates 133.5-46.5, 43.9 microns.
6. *Vestispora luminata* sp. nov.; paratype, slide 6Z6 coordinates 128-50, 93.7 microns (300X).
7. *Vestispora luminata* sp. nov.; paratype, slide 6H2 coordinates 131.5-43.5, 88.0 microns (300X).
8. *Vestispora luminata* sp. nov.; paratype, slide 6V1 coordinates 125-49, 92.3 microns (300X).
9. *Vestispora luminata* sp. nov.; paratype, slide 6Z5 coordinates 125-58.5, 102.2 microns (300X).
10. *Vestispora luminata* sp. nov.; paratype, slide 6H3 coordinates 118.5-56, 99.4 microns (300X).



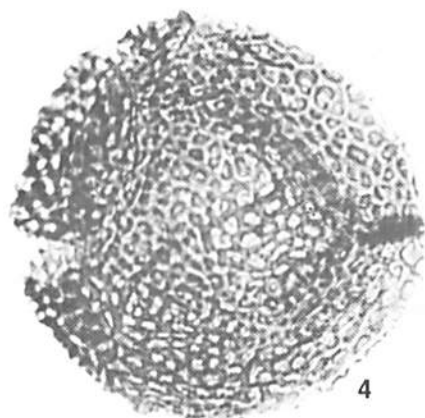
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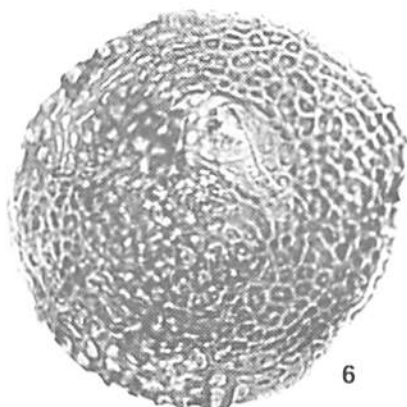
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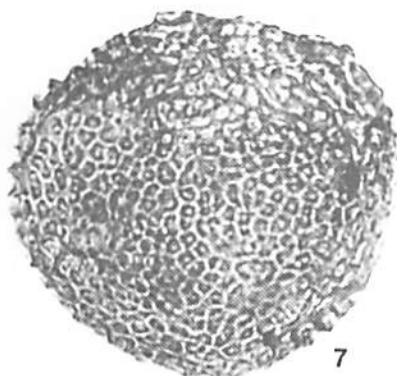
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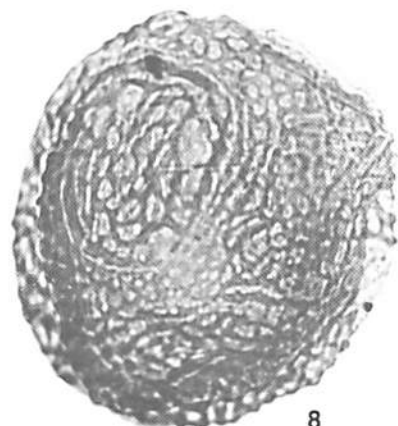
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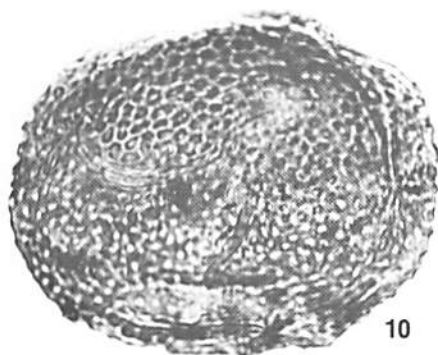
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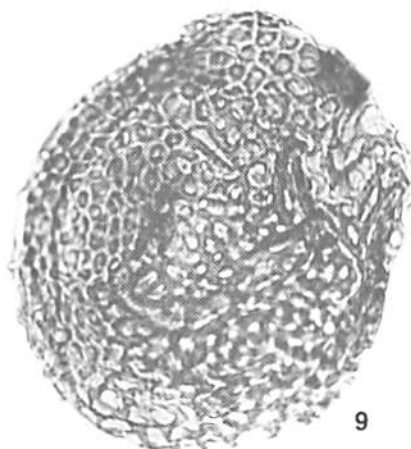
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PLATE 18

FIGURE

1. *Aumancisporites striatus* Alpern 1958; slide 1C6 coordinates 139-64, 54.2 microns.
2. *Aumancisporites striatus* Alpern 1958; slide 1C2 coordinates 134-61, 62.7 microns.
3. *Aumancisporites striatus* Alpern 1958; slide 1Y4 coordinates 133-66, 43.9 microns.
4. *Thysanites densus* sp. nov.; paratype, slide 1C1 coordinates 132-45, 31.4 microns, spore body exclusive of flange.
5. same as fig. 4 (N).
6. *Thysanites densus* sp. nov.; holotype, slide 1X5 coordinates 119.5-60, 30.2 microns, spore body exclusive of flange.
7. *Thysanites densus* sp. nov.; paratype, slide 1Z5 coordinates 122-64, 34.2 microns, spore body exclusive of flange.
8. *Thysanites densus* sp. nov.; paratype, slide 6Z6 coordinates 124-61, 30.2 microns, spore body exclusive of flange.
9. same as fig. 8 (N).
10. *Hymenospora multirugosa* Peppers 1970; slide 1C2 coordinates 128.5-56, 45.6 microns.
11. *Diaphanospora parvigracila* (Peppers) comb. nov.; slide 6R6 coordinates 135-36.5, 39.9 microns, spore body exclusive of perispore.
12. *Diaphanospora* sp. 1; slide 7M1 coordinates 121.5-51, 58.2 microns, spore body exclusive of perispore.



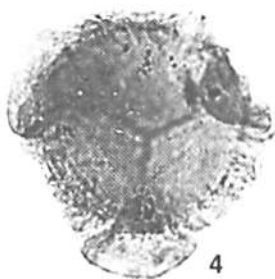
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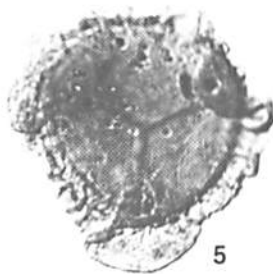
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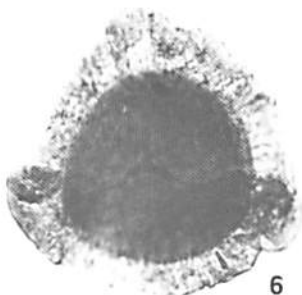
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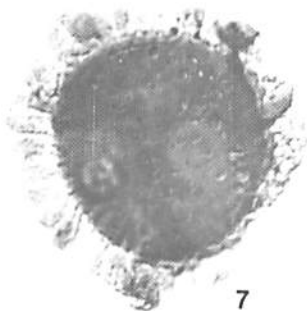
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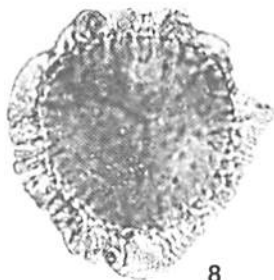
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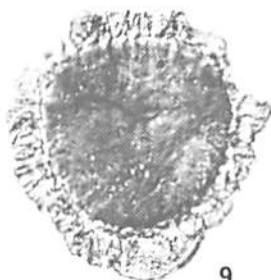
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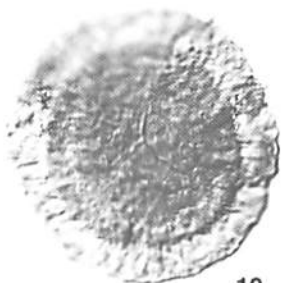
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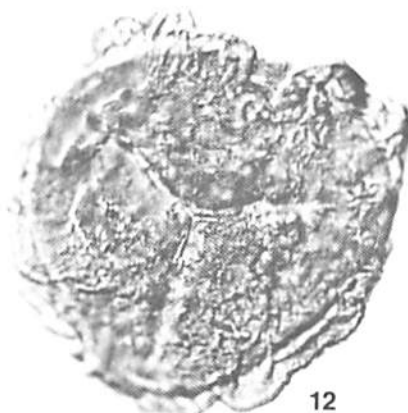
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PLATE 19

FIGURE

1. *Florinites mediapudens* (Loose) Potonić and Kremp 1956; slide 1Z2 coordinates 128-46, 75.3 microns (300X).
2. *Florinites mediapudens* (Loose) Potonić and Kremp 1956; slide 3A2 coordinates 134-44, 79.5 microns (300X).
3. *Florinites millotti* Butterworth and Williams 1954; slide 1C2 coordinates 129-57, 42.2 microns.
4. *Florinites occultus* Habib 1966; slide 1Z6 coordinates 134-58, 67.6 microns.
5. *Florinites* cf. *volans* (Loose) Potonić and Kremp 1956; slide 1D3 coordinates 131-61, 75.3 microns (300X).
6. *Florinites* cf. *volans* (Loose) Potonić and Kremp 1956; CP-19-5 slide B-2 coordinates 131-67.5, 73.8 microns (300X).
7. *Potonieisporites solidus* sp. nov.; holotype, slide 1Z3 coordinates 121-64, 120.7 microns (300X).
8. *Potonieisporites solidus* sp. nov.; paratype, CP-19-5 slide Z-7 coordinates 127-39, 120.7 microns (300X).
9. *Potonieisporites solidus* sp. nov.; paratype, slide 1Y5 coordinates 132-38.5, 105.1 microns (300X).

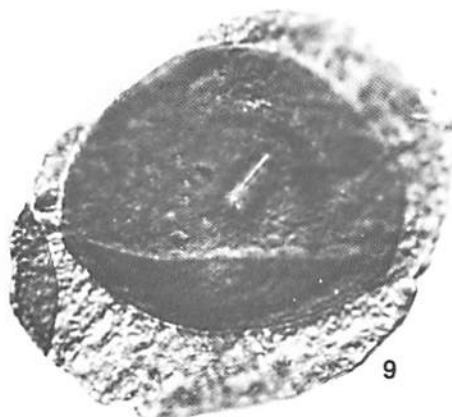
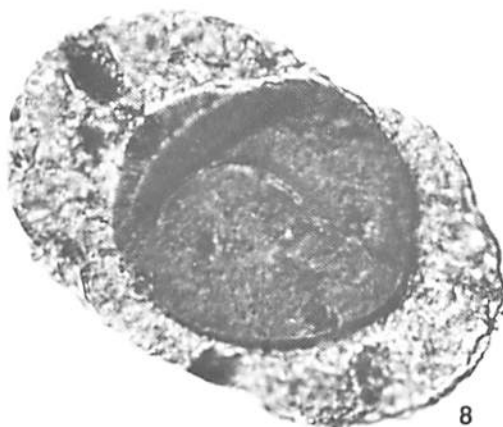
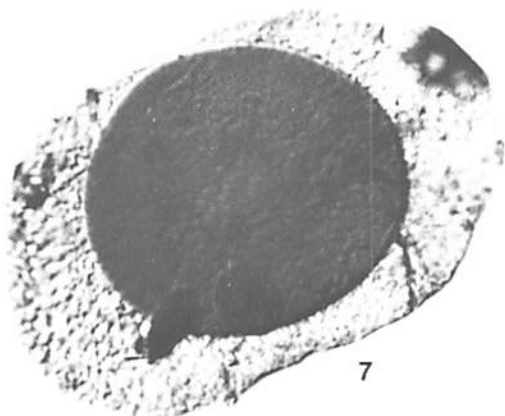
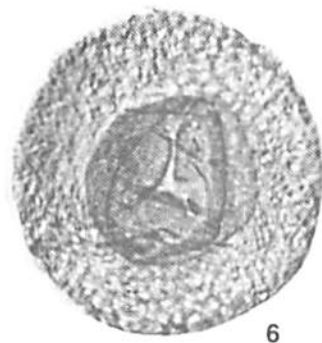
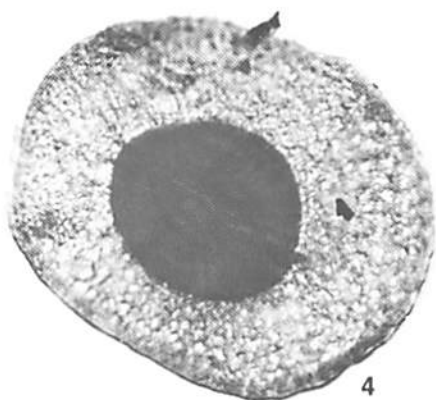
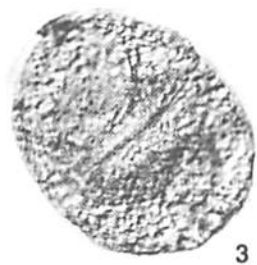


PLATE 20

FIGURE

1. *Florinites visendus* (Ibrahim) Schopf, Wilson and Bentall 1944; slide 5A6 coordinates 127.5-46.5, 147.7 microns (300X).
2. *Costatascyclus crenatus* (Felix and Burbridge) Urban 1971; slide 1W2 coordinates 125-38, 153.3 microns (300X).
3. *Wilsonites circularis* (Guennel) Peppers and Ravn comb. nov.; slide 1Y6 coordinates 134-43.5, 45.6 microns.
4. *Wilsonites vesicatus* (Kosanke) Kosanke 1959; slide 1X2 coordinates 119-55, 70.1 microns.
5. *Wilsonites delicatus* (Kosanke) Kosanke 1959; slide 1Z4 coordinates 123-54.5, 86.6 microns (300X).
6. *Platysaccus saarensis* (Bharadwaj) Jizba 1962; slide 3R1 coordinates 134-49, 47.3 microns.
7. *Platysaccus saarensis* (Bharadwaj) Jizba 1962; slide 3Z5 coordinates 134-50, 45.6 microns.
8. *Pityosporites westphalensis* Williams 1955; slide 2L1 coordinates 133-47.5, 52.4 microns.
9. *Potonieisporites elegans* (Wilson and Kosanke) Habib 1966; slide 1C4 coordinates 133-64, 153.3 microns (300X).

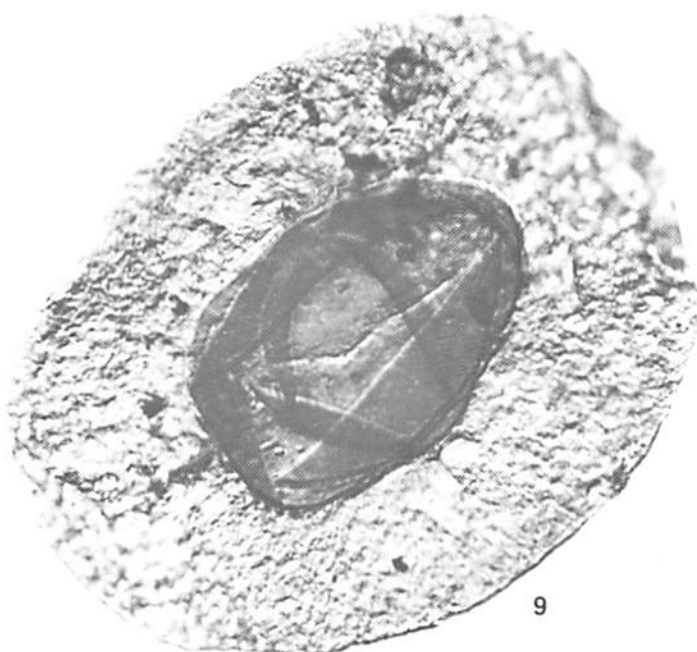
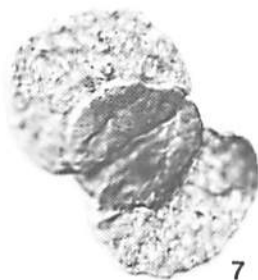
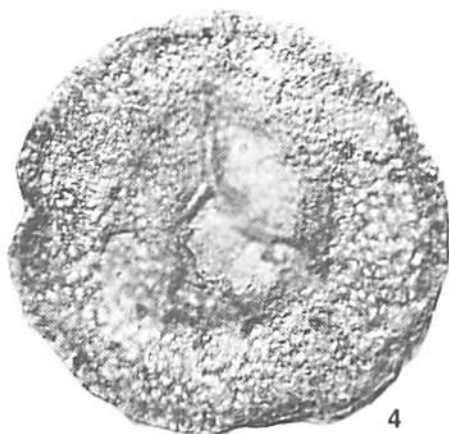
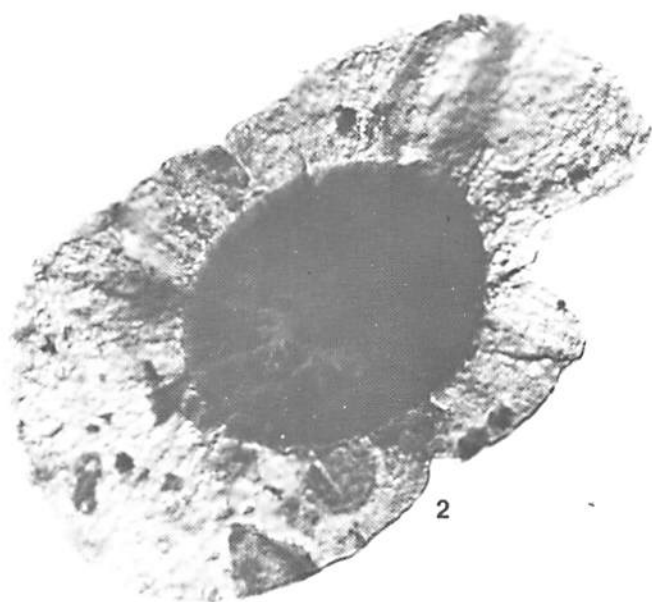


PLATE 21

FIGURE

1. *Peppersites ellipticus* sp. nov.; holotype, slide 1Z3 coordinates 121-53.5, 51.3 microns.
2. *Peppersites ellipticus* sp. nov.; paratype, slide 1C4 coordinates 130.5-62, 61.0 microns.
3. *Peppersites ellipticus* sp. nov.; paratype, slide 1Y3 coordinates 127.5-35, 65.6 microns.
4. *Peppersites ellipticus* sp. nov.; paratype, slide 1Y4 coordinates 119-72.5, 53.6 microns.
5. *Illinites unicus* (Kosanke) Helby 1966; slide 7Y1 coordinates 127.5-41.5, 47.7 microns.
6. *Phillipsites tenuis* sp. nov.; holotype, slide 1Z6 coordinates 127-43.5, 115.0 microns (300X).
7. *Phillipsites tenuis* sp. nov.; paratype, slide 1D3 coordinates 122-71.5, 87.5 microns (300X).
8. *Phillipsites tenuis* sp. nov.; paratype, slide 1X4 coordinates 123.5-46.5, 99.4 microns (300X).
9. *Pseudoillinites diversiformis* (Kosanke) comb. nov.; slide 1Z4 coordinates 124-61, 102.3 microns (300X).
10. *Pseudoillinites diversiformis* (Kosanke) comb. nov.; slide 1Z2 coordinates 134-45, 109.3 microns (300X).
11. *Pseudoillinites diversiformis* (Kosanke) comb. nov.; slide 1Y5 coordinates 125-39, 100.8 microns (300X).
12. Saccate grain no. 1; slide 2H6 coordinates 124-60, 57.0 microns, spore body exclusive of saccus.



PLATE 22

FIGURE

1. *Wapellites variabilis* sp. nov.; holotype, slide 1Z3 coordinates 125.5-47, 98.0 microns (300X).
2. *Wapellites variabilis* sp. nov.; paratype, slide 1Z3 coordinates 131-38, 92.7 microns (300X).
3. *Wapellites variabilis* sp. nov.; paratype, slide 1Z3 coordinates 119-42, 95.5 microns (300X).
4. *Trihyphaecites triangulatus* Peppers 1970; slide 1Z1 coordinates 134-63, 31.9 microns maximum dimension of central body.
5. *Trihyphaecites triangulatus* Peppers 1970; slide 1Y3 coordinates 122.5-39.5, 34.2 microns maximum dimension of central body.
6. *Schopfpollenites ellipsoides* (Ibrahim) Potonić and Kremp 1954; slide 1Y11 coordinates 119-63.5, 308.1 microns (180X).
7. same as fig. 6 (N).
8. *Schopfpollenites* sp. 1; slide 8Z1 coordinates 127-55.5, 242.9 microns (240X).
9. same as fig. 8 (N).
10. detail, fig. 9 (750X).

