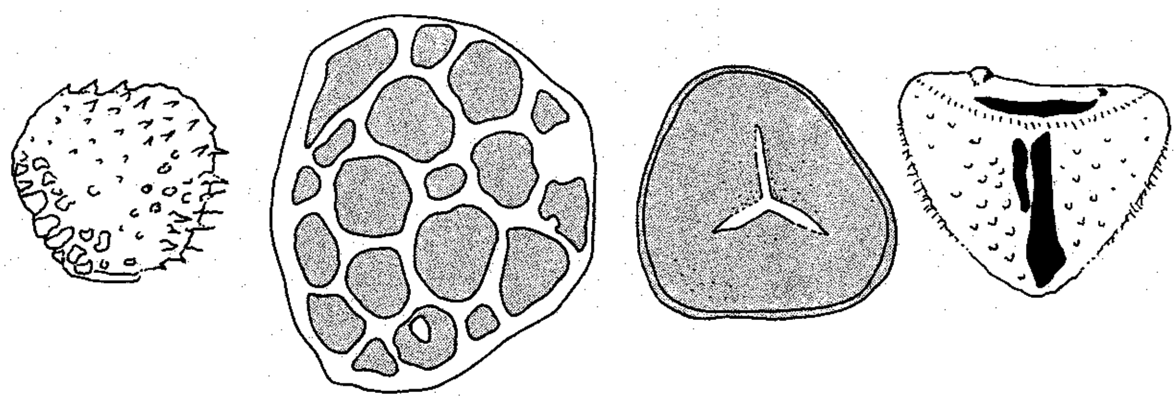
PALYNOSTRATIGRAPHY OF THE LOWER AND MIDDLE PENNSYLVANIAN COALS OF IOWA

Technical Paper No. 7

Robert L. Ravn



Donald L. Koch
State Geologist and Director

IOWA GEOLOGICAL SURVEY
123 North Capitol Street
Iowa City, Iowa 52242
319-338-1173

PALYNOSTRATIGRAPHY OF THE LOWER AND MIDDLE PENNSYLVANIAN COALS OF IOWA

ROBERT L. RAVN

IOWA GEOLOGICAL SURVEY TECHNICAL PAPER NO. 7

1986

ABSTRACT

The Pennsylvanian System in Iowa includes strata ranging from Morrowan to Virgilian in age. Based primarily on core studies, the palynology of coals has formed the basis for refinement of stratigraphic correlations through the dominantly non-marine Lower and Middle Pennsylvanian sequence, and has permitted formational subdivision of the complex Cherokee Group. The palynological characteristics of the major coals and coal-bearing units are described in detail. The sequence of miospore appearances and extinctions permits close correlation of Iowa coals to coals of the Illinois Basin. In addition, the miospore stratigraphy of Iowa coals corresponds strongly to published zonations for the Upper Carboniferous coal-bearing strata of western Europe and the Soviet Union.

In recognition of serious problems that exist in the application of standard Midcontinent Pennsylvanian chronostratigraphic nomenclature to the Iowa section, practical means for distinction of Morrowan, Atokan and Desmoinesian strata are proposed to facilitate regional correlations. The extinction of *Schulzospora rara* is used to mark the top of the Morrowan Series, and the extinction of *Dictyotriletes bireticulatus* is considered to indicate the top of the Atokan.

314 species assigned to 111 genera are documented and illustrated, and their observed occurrences in the Iowa section are summarized. Three new genera, *Anacanthotriletes*, *Anafoveosporites* and *Dictyomonolites* are proposed: the diagnoses of five genera, *Apiculatasporites* Ibrahim 1933, *Reticulitriletes* Mädler 1964, *Sinuspores* Artüz 1957, *Dictyotriletes* Naumova ex Potonié and Kremp 1954 and *Spackmanites* Habib 1966 are emended to reflect new interpretations of their morphology. Thirteen new species are described, and thirteen other new names are proposed to correct or avoid homonymies. Several other genera are reviewed and new combinations proposed.

TABLE OF CONTENTS

TEXT-FIGURES AND TABLE

INTRODUCTION

SCOPE AND PURPOSE

The Pennsylvanian System in Iowa consists of diverse non-marine and marine sediments now known to record most of Pennsylvanian time, from early (Morrowan Series) to late (Virgilian Series). Significant coal resources occur in various parts of the section, concentrated particularly in the Cherokee Group (text-figure 1). In 1980, the Iowa Geological Survey concluded a comprehensive program designed to examine in detail numerous aspects of the major coal-bearing strata in the state, including subsurface stratigraphy, which historically has been very poorly understood. Uncertainty about stratigraphic relationships and lateral continuity of coal seams of minable thickness and quality has long been a major limiting factor in the assessment and development of Iowa's coal.

A principal means of correlation of subsurface coal seams during the IGS project was analysis of the plant microfossils preserved in the coals. Palynostratigraphic identification of coal seams has been successfully employed in other areas (esp. Illinois and Oklahoma). and techniques similar to those documented in previous literature were used on the Iowa material. This paper details the results of the palynostratigraphic study of Iowa coals performed from 1975 to 1980. Certain portions of the project, especially discussions of the theory and methods of palynostratigraphic interpretation as applied to Iowa coals were published previously as Iowa Geological Survey Technical Paper 6 (Ravn, 1979).

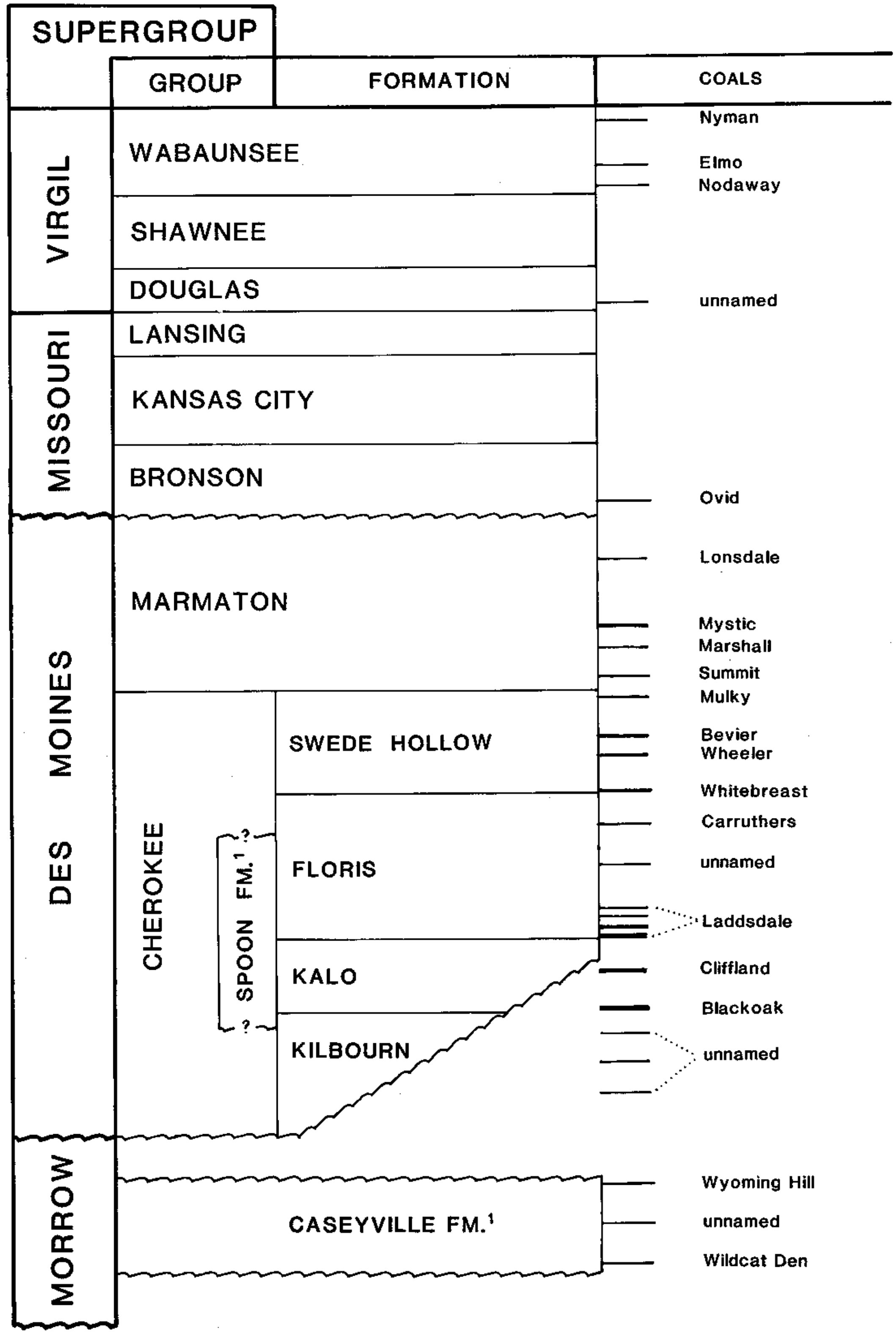
Another result of the IGS coal resources program was the revision of Pennsylvanian stratigraphic nomenclature in Iowa (Ravn et al., 1984; see also text-figure 1). In some parts of the stratigraphic column, the revised nomenclature departs considerably from that generally in use prior to 1974 (e.g., Landis and Van Eck, 1965). Of particular importance for this report is the new formational subdivision of the Cherokee Group. A detailed discussion of problems and ambiguities of stratigraphic nomenclature and terminology as it applies to the Iowa Pennsylvanian is given in Appendix II of this paper.

ACKNOWLEDGMENTS

Many persons have provided assistance during the course of this project. Special gratitude is extended to Dr. Richard G. Baker, Department of Geology. University of Iowa, who as a faculty advisor to a chronically disorganized and bewildered graduate student, provided sensitive and enthusiastic counsel without which the present report could not have materialized. Dr. Baker was also most generous in permitting use of laboratory facilities under his direction. I wish to thank Dr. Russel A. Peppers, Illinois State Geological Survey, whose examinations of Iowa coal samples in the early stages of this project provided the initial information necessary for development of the stratigraphic interpretations presented in this report, and whose hospitality and technical assistance is most gratefully acknowledged. I also wish to thank Dr. Tom L. Phillips, Department of Botany, University of Illinois, who has provided invaluable paleobotanical expertise regarding paleoecology and miospore affinities, and whose continuing interest in the project has been most gratifying. Dr. H. Richard Lane, Amoco Production Company Research, Tulsa, Oklahoma, kindly provided a pre-publication copy of a paper on Midcontinent stratigraphy. Dr. Gar W. Rothwell of Ohio University and Dr. Alfred Traverse of Pennsylvania State University contributed useful information on paleobotanical research.

The manuscript has been reviewed with great patience and care by Drs. Baker, Peppers and Traverse, and Iowa Geological Survey staff including Raymond Anderson, Chief of Stratigraphy and Economic Geology Division, Mary Howes, Dr. Brian Witzke and Paul Van Dorpe. Dr. Matthew J. Avcin, former Chief of the Coal Division, IGS, directed the overall coring project and provided impetus for the palynostratigraphic study, as well as providing material and technical assistance. Donald L. Koch, Iowa State Geologist and Chief of IGS, also reviewed the manuscript at various stages of its development, and has provided the backing necessary for its publication, for which I am very grateful.

Laboratory preparation of samples was performed with the assistance of Mary Howes, Barbara Stewart, Darcy Swade, Calvin Cumerlato, Blane Nansel and Minh Nguyen. Certain of the text-figures were drafted by Patricia Lohmann of IGS. Many of the scanning electron photomicrographs were taken by William Dorsey, Amoco Production Company. New Orleans, Louisiana. Dr. Emily Vokes of the Department of Geology, Tulane University, New Orleans, provided darkroom facilities which permitted completion of the necessary photography. Manuscript typing at various stages of the project was done by



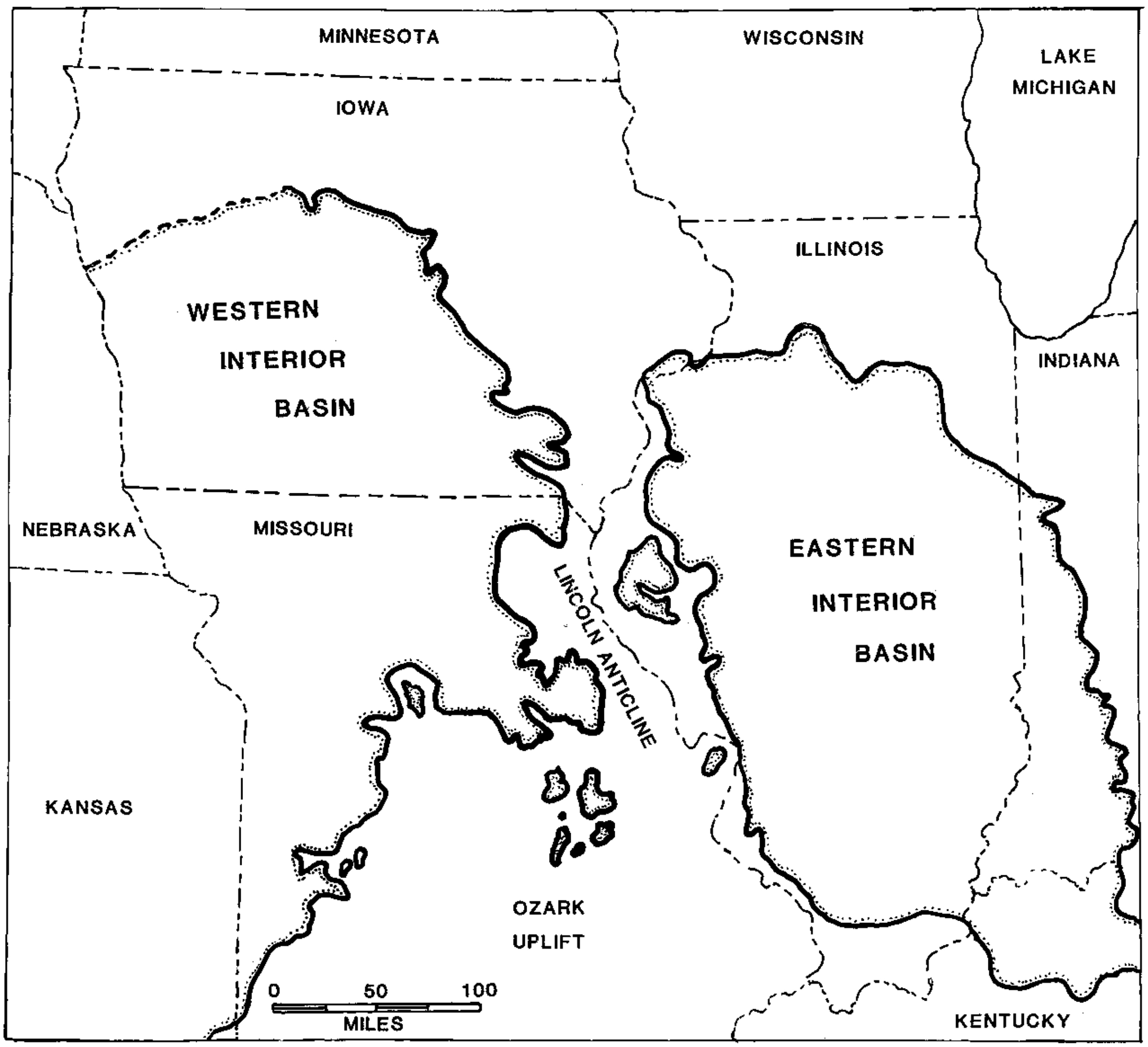
Text-figure 1. Generalized stratigraphic nomenclature for the Pennsylvanian System in Iowa (From Ravn et al., 1984). [1]Indicates units present only in the Eastern Interior (Illinois) Basin area of Scott and Muscatine Counties.

Laurie Comstock, IGS. I also wish to acknowledge the assistance and encouragement of my wife, Janet L. Gregory, in proofreading, gathering of reference materials and general encouragement throughout the long development of this paper.

A special debt of gratitude is owed to my friend and colleague, John W. Swade, of the Department of Geology, University of Iowa, who aided immeasurably in the development of the stratigraphic interpretations presented here through his work on Cherokee and Marmaton Group lithostratigraphy and conodont biostratigraphy. John Swade died of cancer at the age of 31 on March 9, 1983.

GEOLOGIC SETTING

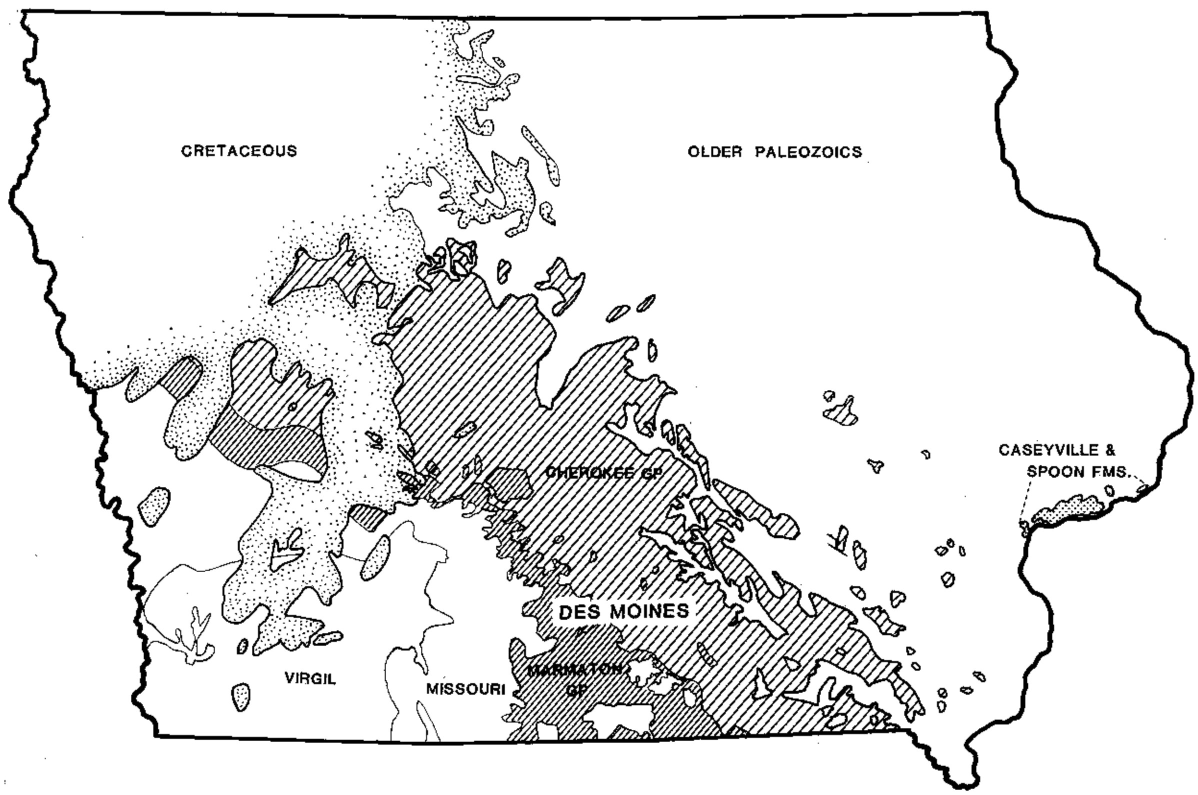
Pennsylvanian sediments in Iowa were deposited in two major structural basins (text-figure 2). Of these, the Western Interior (or, in Iowa, Forest City) Basin occupies about the southwestern third of the



Text-figure 2. Major structural basins of the Upper Paleozoic, Midcontinent North America (after Fitzgerald, 1977).

state. Pennsylvanian beds of the Eastern Interior (or Illinois) Basin exist today only as remnant erosional outliers near the Mississippi River Valley. In that area, some strata are assigned to the Caseyville Formation (Morrowan Series) and are older than any Pennsylvanian strata yet encountered in the Western Interior Basin of Iowa (Ravn and Fitzgerald, 1982). Although of small geographical extent, they represent an important episode in the Pennsylvanian stratigraphic record of the state. Sandstones assigned to the Spoon Formation (Desmoinesian Series) also are known from near the Mississippi River in Scott and Muscatine Counties (Fitzgerald, 1977).

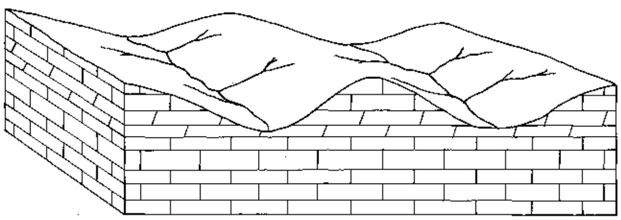
In the Western Interior Basin, Pennsylvanian strata unconformably overlie Mississippian carbonates and dip gently to the south and west toward Kansas, where the Pennsylvanian System ultimately is overlain by conformable Permian strata. In Iowa, erosional beveling has exposed successively older strata toward the north and east (text-figure 3). The main updip Pennsylvanian pre-Pleistocene subcrop limit (excluding numerous small outliers) occurs roughly along a line from north central Iowa toward the southeast corner of the state. To the northwest and along the elevated drainage divide of the Mississippi and Missouri River systems, Pennsylvanian strata are overlain by Cretaceous siliciclastic sediments of the Dakota Formation.



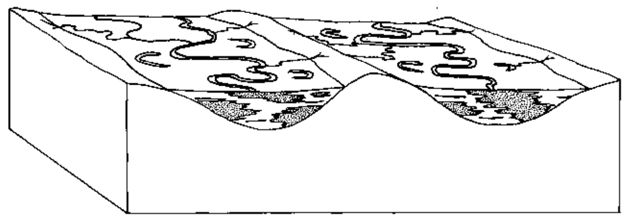
Text-figure 3. Generalized pre-Pleistocene subcrop map of Iowa (after Hershey, 1969).

Pennsylvanian strata of the Western Interior Basin record deposition possibly as old as uppermost Morrowan Series through the Upper Pennsyvlanian Virgilian Series (see Appendix II for discussion of chronostratigraphic terminology). As much as 1600-1700 feet of Pennsylvanian sediment are known to be present in the subsurface of southwestern Iowa (Lemish and Palmquist, 1980): approximately one-half of this thickness is represented by the Cherokee Group (text-figure 1). The Cherokee Group contains the bulk of the economically minable coal in Iowa and forms the focus of this report.

In general terms, the history of Pennsylvanian deposition in Iowa was a slow progression from dominantly non-marine deposition in the early Pennsylvanian to mainly marine deposition by late Pennsylvanian time. The land surface in late Mississippian time was exposed and eroded (text-figure 4), and, as most of the rock was carbonate, karst development occurred. By the onset of Pennsylvanian deposition, a surface of considerable relief and irregularity existed (probably measurable in hundreds of feet across the region). Stream gradients lowered, erosion ceased in the valleys, and terrigenous clastics began to be deposited (text-figure 5); this event apparently occurred in very early Pennsylvanian time in easternmost Iowa, but did not take place until slightly later in central and south-central Iowa. In eastern Iowa, these beds overlie Devonian carbonates and, as mentioned, they are considered an extension of the Caseyville Formation of Illinois.



Text-figure 4. Schematic representation of the pre-Pennsylvanian erosional surface.

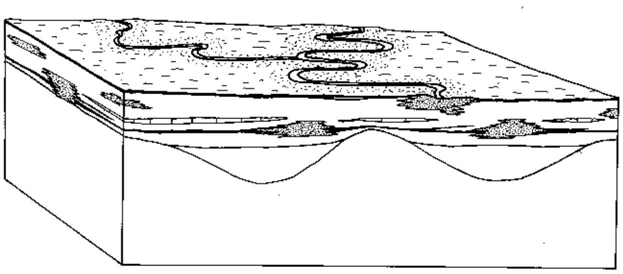


Text-figure 5. Schematic representation of deposition of the Kilbourn Formation.

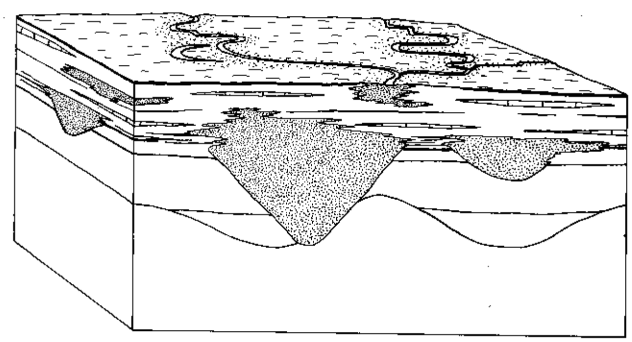
In the Western Interior Basin, the infilling of topographic lows on the Mississippian surface by fluvial processes was slow and sporadic, resulting in a laterally discontinuous package of sandstones (including some thick channel- or valley-fill sands), shales and thin coals that are not widely traceable as stratigraphically identifiable units. The strata representing this period of sedimentation have been designated the Kilbourn Formation (Ravn et al., 1984).

Eventually, the deposition of sediment in the valleys of the Mississippian surface levelled the topographic relief. This levelling is signalled by the first major episode of coal formation in the Pennsylvanian of Iowa, the widely traceable and economically significant Blackoak Coal. The Blackoak peat swamp probably formed in response to a further lowering of stream gradients due to a rise in sea level to the south and west. Peat accumulated over a wide area of low-lying, level ground. The Blackoak Coal marks the base of the Kalo Formation, which also includes a second major widespread coal, the Cliffland. The Kalo is dominated by shales and siltstones, with sandstones being considerably less abundant than in the Kilbourn Formation, indicating a lack of coarse sediment influx and probably a sluggish, low-energy drainage system (text-figure 6).

Above the Kalo Formation lies the Floris Formation, whose base is marked by a laterally complex coal sequence known as the Laddsdale Coal Member (text-figure 7). These coals are closely related and appear to represent a single major coal-forming event made complex by intervals of clastic sediment which periodically inundated the swamps in various areas. Minor tectonic movements also may have contributed to the lateral irregularity of sedimentation by providing localized areas of uplift, erosion and redeposition.



Text-figure 6. Schematic representation of deposition of the Kalo Formation.



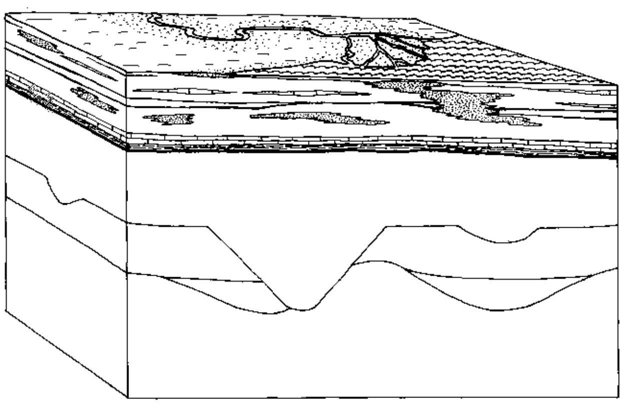
Text-figure 7. Schematic representation of deposition of the Floris Formation.

Thick valley-fill sandstones are present in the Floris, including the well-known sandstones surrounding the Red Rock Reservoir in Marion County and the thick sandstones overlying the type section of the Kalo in Webster County (described in detail by Burggraf et al., 1981). In places (e.g., IGS core CP-18; see text-figure 10), these sandstones were deposited in valleys cut all the way to the Mississippian carbonates, apparently having removed pre-existing Kilbourn and Kalo strata.

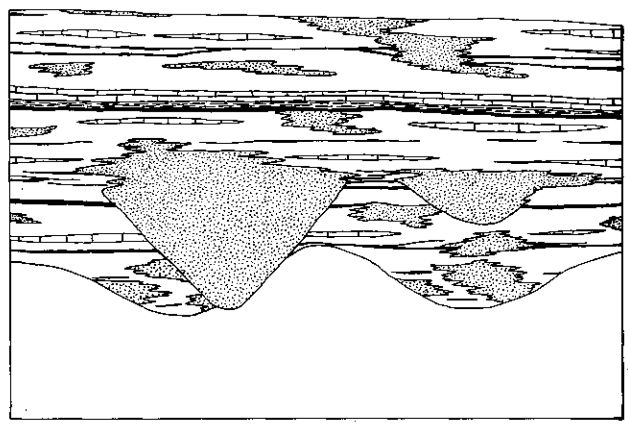
At least two more thin but distinct coal beds occur in the upper part of the Floris Formation, an unnamed bed and the newly-designated Carruthers Coal (formerly known as the Wiley in Iowa; Ravn et al., 1984). Unlike the coals of the Laddsdale Member, these two beds show considerable persistence and can be traced individually through a number of the IGS coal division cores. This increasing regularity of widespread coal beds, coupled with a greater proportion of associated marine sediments appears to presage the increased marine influence upon sedimentation in the uppermost Cherokee Group.

The upper Cherokee Swede Hollow Formation records the first strong influence of Pennsylvanian cyclothemic marine transgressions into Iowa (the Ardmore Cyclothem; Van Dorpe, 1980a). The base of the formation is placed at the widely recognized Whitebreast Coal, which overlain by the equally persistent Oakley Shale and Ardmore Limestone (text-figure 8). The rest of the Swede Hollow also shows evidence of cyclothemic deposition, although the strata are not as uniform as in the Whitebreast-Ardmore interval.

The result of this sequence of depositional events (text-figure 9), is a sedimentary package of great variability, both vertically and laterally, that, as known only from sparse outcrops and mines, presented extreme difficulty for stratigraphic interpretation. Unravelling the sequence of sedimentary events required biostratigraphic identification of coals in subsurface obtained through coring (see Methods of Investigation).



Text-figure 8. Schematic representation of deposition of the Swede Hollow Formation.



Text-figure 9. Schematic representation of Cherokee Group sediments in cross-section.

Post-Cherokee deposition in the Pennsylvanian of Iowa was characterized by much greater persistence of lithologically identifiable units, and therefore presents less difficulty to the stratigrapher. Marine carbonates and shales become volumetrically more important and of more regular occurrence in the sedimentary record; non-marine sediments, particularly coals, become both less frequent and less important. Only the well-developed Mystic Coal is of economic importance in the Marmaton Group in Iowa. This increased influence of marine deposition continued throughout the remainder of the Iowa Pennsylvanian. Although several coal beds are known from the Virgil Supergroup (see Appendix II) in southwestern Iowa, the uppermost coal examined during this project was the Ovid Coal, a thin but persistent bed within the Pleasanton Formation of the Bronson Group (Missouri Supergroup).

PREVIOUS WORK

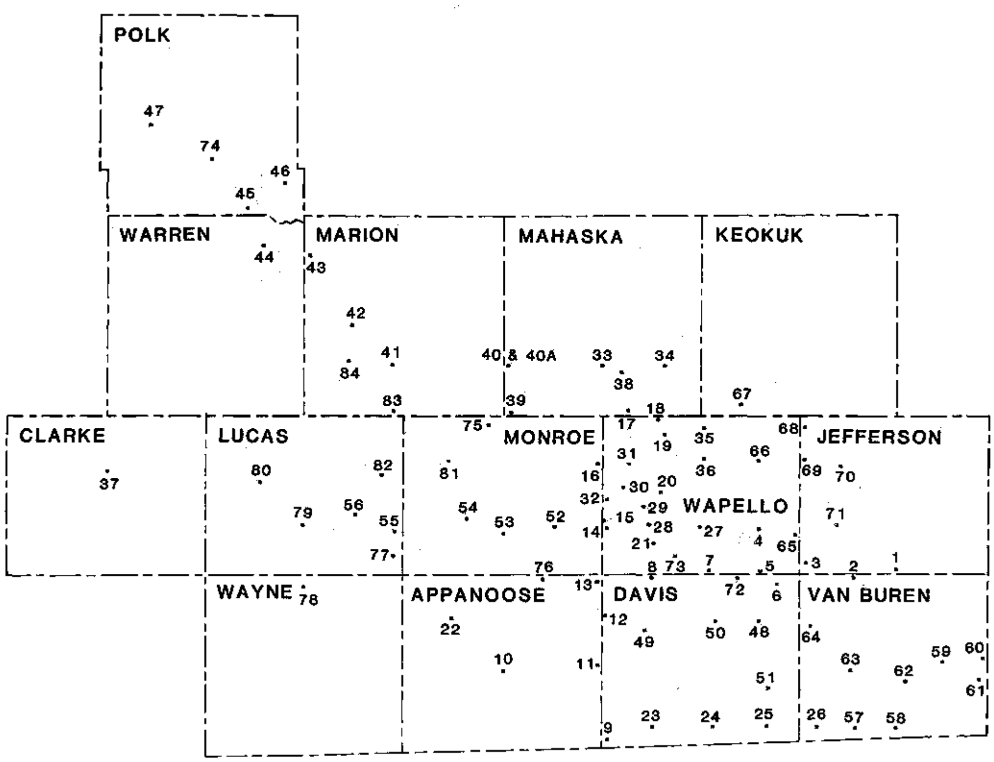
The published literature relating to the geology of Iowa coal deposits is voluminous, and a thorough bibliography on the subject is now available from the Iowa Geological Survey (Van Dorpe, 1980b). Much of the early work (e.g., White and St. John, 1870; Bain, 1894; Hines, 1909; Lugn, 1926; Stookey, 1935) remains a valuable source of information. D. G. Stookey produced a large volume of useful work on the Pennsylvanian of Iowa that was never published; much of this work exists in manuscript form and has now been collected at the Iowa Geological Survey in Iowa City. More recent summaries of Pennsylvanian coal-bearing strata in Iowa include the useful overview of Landis and Van Eck (1965), and reports of Lemish and Palmquist (1980) and Lemish and others (1981) that provide data and interpretation for geographic areas not specifically covered by the IGS coring program.

Previous palynological study of the Pennsylvanian in Iowa was summarized by Ravn (1979). That report discussed in detail the collection and preparation techniques involved in the palynological examination of Iowa coals during this project, and also described the miospore paleoecology of a single coal bed from IGS core CP-19 in Wapello County (now identified as Blackoak). Since the publication of that paper, two unpublished master's theses on the palynology of coals from other IGS cores have been completed. DeDecker (1980) examined composite samples from three cores (CP-9, CP-10 and CP-21 in Davis, Appanoose and Wapello Counties, respectively) and discussed possible correlations among them as well as possible correlations to coals in the Illinois Basin. Egner (1981) examined detailed bench samples from all coals in core CP-41 in Marion County, one of the longer cores taken during the project, and described in detail the potential of using intra-seam vertical miospore population profiles as a correlation tool. (Further comments on the relative utility of bench and composite coal samples can be found under Methods of Investigation in this report.) Additionally, Ravn and Fitzgerald (1982) described and documented the miospore assemblages in the Morrowan Caseyville Formation coals from eastern Iowa.

Other studies of the IGS cores relating to Pennsylvanian stratigraphy and depositional environments are those of O'Brien (1977), Van Dorpe (1980a), Swade (1982), Gregory (1982) and Howes (1983).

METHODS OF INVESTIGATION

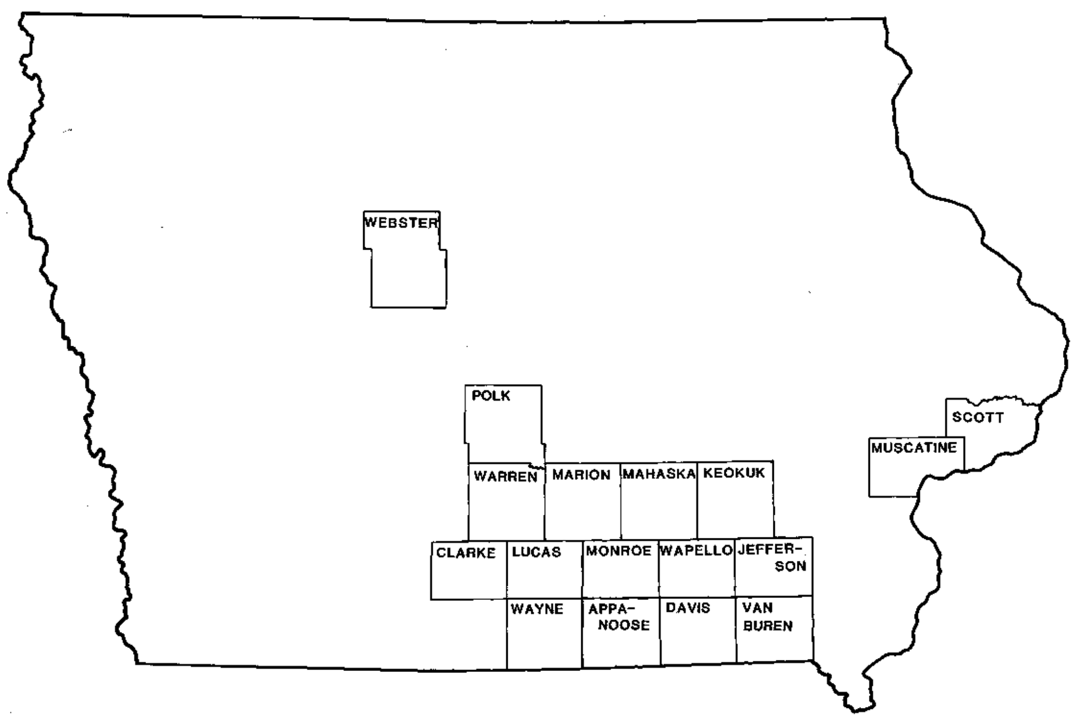
The major emphasis of this project was to examine coals obtained from subsurface by the Iowa Geological Survey Coal Division in an extensive coring program (text-figure 10). Cores were taken at 84



Text-figure 10. Locations of Iowa Geological Survey Coal Division cores.

locations in a 14-county area of central and southeast Iowa from 1974 to 1979. These were supplemented by outcrop and mine samples collected from Webster, Scott and Muscatine Counties (text-figure 11), as well as several localities within the 14-county coring area. Detailed lithologic descriptions of all the cores were prepared and are available at a nominal charge from the Iowa Geological Survey, 123 North Capitol Street, Iowa City, Iowa 52242.

Coals examined ranged in thickness from a fraction of an inch to more than six feet. In most cases, coals greater than three inches in thickness were sampled in intervals ('benches') to permit potential examination of vertical changes in the miospore assemblage through the bed. A detailed discussion of the potential value of such sampling in determining coal-swamp paleoecology and stratigraphically useful miospore profiles was given in Technical Paper 6 (Ravn, 1979). Vertical variation in the miospore content of coal beds records the variation in original peat-swamp floral ecology through time (see esp. the work of A. H. V. Smith, 1957, 1962, 1964a, 1964b, 1968). Although a great deal of uncertainty exists concerning the specific paleoecologic variables affecting particular plant groups in the Carboniferous (e.g., Neves, 1958; Chaloner, 1958a; Frederiksen, 1972; Brunner, 1978), empirical observation has shown that, in many areas, these changes in miospore content through a given coal can be traced laterally, providing a potentially powerful tool for fine correlation of coals in a particular basin (e.g., Meyers, 1966; Gibson and Clarke, 1968).



Text-figure 11. Study area.

Unfortunately, such studies require detailed quantitative analyses of many samples of each individual coal bed. This is a time-consuming procedure which has seldom been undertaken, and for which few truly adequate suites of samples exist anywhere; the Iowa Geological Survey's benched core samples represent such a collection, and future studies of these samples should provide much valuable insight into the paleoecology of Pennsylvanian coal swamps.

To establish an initial biostratigraphic framework for the Iowa coal-bearing section, this investigating concentrated on examination of composite samples from each seam, representative of the entire coal. Use of such composite samples (analogous to 'channel' samples made by cutting a pie-shaped wedge of sample from the entire length of any particular lithology in core) is the standard method of examining coals for palynology. It has the obvious disadvantage of eliminating any consideration of vertical miospore population profiles, but is a necessity for initial reconnaissance of a large area where many individual coal beds must be examined. In this study, composite samples were made by combining small portions of each benched sample throughout individual coals. Both the benched and composite raw coal samples are retained at the Iowa Geological Survey for potential future study. To date, few of the benched samples have been examined; Technical Paper 6 (Ravn, 1979) concentrated on thinly benched samples of a single coal (Blackoak) in core CP-19, and, as mentioned, Egner (1981) analyzed somewhat thicker benched samples from all coals in CP-41.

Standard maceration techniques involving the use of Schulze's solution, KOH and HF were used in processing the coals for palynomorphs (see Ravn, 1979). Detailed descriptions of palynological processing techniques for coals and other sediments can be found in Brown (1960), Andersen (1965), Gray (1965), Barss and Williams (1973) and Doher (1980). Smith and Butterworth (1967) also provided a thorough discussion of the potential variables in chemical maceration and mounting media that may affect palynological recovery. Sample residues from this study, stored in glycerin and ethanol, as well as finished palynological slides, are housed in the paleontology repository of the Department of Geology, University of Iowa, Iowa City, Iowa 52242. They are available for further examination; appropriate arrangements may be made by contacting the curator of the repository.

Sample examination consisted of a 250-miospore population count of each sample, plus scanning of several slides for the presence of rare taxa. The 250-count miospore sum was chosen as the minimum practical figure for statistical validity and ease of percentage calculations. Mosimann(1965) provided formulas for calculation of confidence intervals to determine the validity of such population counts. Maher (1972) constructed nomograms for easy graphic application of Mosimann's formulas, and Moore and Webb (1978) discussed their application in detail. Many more statistical techniques of varying levels of complexity and sophistication are available for the testing of palynological data (e.g., Christopher and Hart, 1971; Clapham, 1972; Christopher, 1978, 1981), and it is possible to inundate the utility of one's data and observations in such analyses. For ease of application, however, Mosimann's formulas are recommended for routine use in population-count studies.

PALYNOLOGICAL INTERPRETATIONS

DESCRIPTION

Caseyville Formation Coals

Coals of the Caseyville Formation, presently known in Iowa only from Scott and Muscatine Counties (text-figure 3), have been the subject of a detailed palynological study by Ravn and Fitgerald (1982). Three coals are known to be present in the Caseyville, in ascending order, the Wildcat Den, an unnamed thin coal, and the Wyoming Hill. These collectively contain a diverse miospore assemblage with many forms not observed or observed only rarely in younger Cherokee Group coals to the west.

Lycopsid-related forms quantitatively dominate the Caseyville assemblage, including various species of the genera *Lycospora, Densosporites, Cristatisporites, Radiizonates, Crassispora,* and *Granasporites.* Species encountered exclusively in the Caseyville coals included *Microreticulatisporites hortonensis, Reticulitriletes clatriformis, Reticulitriletes insculptus, Savitrisporites asperatus, Savitrisporites robustus, Vestispora lucida, Lycospora noctuina, Lycospora orbicula, Densosporites variabilis, Vallatisporites* sp. cf. *V. foveolatus, Radiizonates striatus, Cristatisporites connexus, Gulisporites torpidus, Pustulatisporites papillosus, Gorgonispora* sp. cf. *G. minima, Bellispores nitidus, Knoxisporites seniradiatus, Trinidulus diamphidios, Spelaeotriletes triangulus, Rugospora radiata, Laevigatosporites contactus, Schulzospora elongata,* and *Schulzospora rara.* Certain other species, conspicuously including *Densosporites irregularis, Cristatisporites indignabundus, Spencerisporites radiatus, Retispora staplinii, Sinuspores sinuatus,* and *Grumosisporites varioreticulatus,* are much more abundant in the Caseyville coals than they are in Cherokee Group coals.

Kilbourn Formation Coals

The Kilbourn Formation is the basal unit of the Cherokee Group. It records mainly the infilling of erosional topographic irregularities on the Mississippian carbonate surface. Coals of the Kilbourn are thin and localized, and few can be traced laterally for any significant distance; none have been named formally. That these coals are younger than those of the Caseyville Formation is demonstrated by the consistent absence of the characteristic Caseyville miospores noted previously.

Although the distinctive Caseyville assemblage was not seen in any coals from the IGS cores in the 14-county area to the west, a similar assemblage was recovered from shale samples near the base of the Pennsylvanian in core CP-6 (see text-figure 10). This shale yielded a rich, well-preserved miospore assemblage that included several species characteristic of the Caseyville assemblage, but not found in Kilbourn Formation coals. These species included *Verrucosisporites morulatus*, *Microreticulatisporites concavus*, *Densosporites aculeatus*, *Cordylosporites papillatus*, *Tricidarisporites arcuatus* and *Anafoveosporites avcinii*. Species considered in this report to be key indicators of Morrowan strata, *Schulzospora rara*, *Schulzospora elongata*, *Radiizonates striatus* and *Trinidulus diamphidios*, were not present, but several important species not present in the Caseyville appear for the first time in the CP-6 shale. These include *Vestispora pseudoreticulata*, *Endosporites globiformis*, *Radiizonates difformis* and *Alatisporites pustulatus*.

The section sampled in CP-6 may represent a localized early Pennsylvanian deposit in a low area on the underlying Mississippian surface. In age, it is intermediate to the Caseyville coals and Kilbourn Formation coals sampled in other cores, and is considered here to be lower Atokan. This interpretation suggests that very little of the lower Pennsylvanian stratigraphic record is missing from Iowa. Sampling of basal Pennsylvanian shales from other cores may reveal deposits of similar age, but as this project concentrated on coals, systematic shale sampling was not undertaken. The possibility also exists that coals of this age, bearing palynomorphs similar to those in the CP-6 shale or even the Caseyville coals, may be present in the deep subsurface west of the study area.

The overall miospore content of the Kilbourn coals sampled from IGS cores is highly variable, probably due to their localized nature and the influence of local paleoenvironmental factors on the peat swamp plant community. Several species of lycopsid-related 'densospores' (i.e., spores with thick cingula; see Systematic Paleontology) often are abundant, including *Densosporites annulatus*, *Radiizonates difformis* and *Cristatisporites indignabundus*. *Lycospora* spp. dominate many, but not all, of the Kilbourn coals sampled; of the two quantitatively most important species, *L. pellucida* usually is more abundant than *L. granulata*. The lycopsid-related *Granasporites medius* was observed to dominate a few samples. Saccate miospores of gymnospermous affinities, especially *Florinites* spp., increase considerably from their rather sparse representation in the Caseyville coals. Three important and distinctive genera make their first appearance in Kilbourn Formation sediments. *Alatisporites* and *Vestispora* were observed in the CP-6 shale, and *Triquitrites sculptilis* occurs in Kilbourn coals as the earliest representative of the genus in the Pennsylvanian of Iowa. The distinctive species *Cyclogranisporites aureus* also appears first in Kilbourn Formation coals.

In general, the variability of the miospore content within coals of the Kilbourn Formation makes it difficult to generalize in a meaningful way about an overall Kilbourn assemblage. Many of the samples examined from IGS cores contained low-diversity miospore populations having few, if any, diagnostic species; additionally, miospores in many samples were poorly preserved. Identification of these coals sometimes was made on the basis of their position underlying the much more obvious and easily identifiable Blackoak Coal of the Kalo Formation.

Kalo Formation Coals

Two major coals occur in the Kalo Formation, the Blackoak and the Cliffland. Both of these are known to be split by local clastic deposits into two or more individual coal beds (e.g., cores CP-10, CP-37, CP-42, CP-44, CP-58, CP-78). As yet, the geographic control on the distribution of these 'split' seams is poorly understood, but the evidence from core CP-37 in Clarke County (see text-figure 10) suggests a generalized thickening of the Kalo interval toward the southwest (Gregory, 1982).

The Blackoak is the oldest widely traceable coal in Iowa. Its deposition marks a significant change in the gross paleoenvironment of peat formation from that of the localized Kilbourn coals. In keeping with this significantly different widespread swamp, the miospore assemblage differs dramatically from those of older coals.

The Blackoak Coal contains the first appearance of the distinctive miospore *Torispora securis*. This marattialean-related monolete spore occurs in abundances exceeding 5% in many Blackoak samples, and the total marattialean fern-related taxa (including *Laevigatosporites globosus* and *Punctatisporites minutus*) sometimes constitutes more than 50% of the miospore population. In contrast to the marattialean taxa, lycopsid-related spores are reduced in abundance; *Lycospora* spp. seldom exceed 25% of the population and often are present as less than 5%. These changes in miospore dominance record a sharp change in swamp paleoecology, which is reflected further in the less abundant elements of the miospore flora, as well.

Triquitrites tribullatus also appears for the first time in the Blackoak Coal, often in considerable abundance. *Laevigatosporites minor* and other larger *Laevigatosporites* spp., with the exception of the huge *Laevigatosporites maximus*, are much more abundant in the Blackoak than they are in older coals. Various *Vestispora* spp. and the distinctive *Microreticulatisporites nobilis* become common in the Blackoak. Other species appearing for the first time in Iowa coals include *Cyclogranisporites leopoldii*, *Lophotriletes ibrahimii*, *Verrucosisporites donarii*, *Reticulatisporites reticulatus*, *Anacanthotriletes paucispinosus*, *Anapiculatisporites vegrandis*, *Spinosporites exiguus*, *Punctatosporites rotundus*, *Dictyomonolites swadei*, *Alatisporites hoffmeisterii* and *Pityosporites westphalensis*.

Several stratigraphically important species occur regularly for the last time in the Blackoak Coal. Most notable among these is *Dictyotriletes bireticulatus*, which is relatively rare, but was observed in most Blackoak samples. The extinction of this miospore has been regarded as a significant correlation marker both in North America and in Europe (see <u>Palynostratigraphic Interpretation: Comparisons</u>). Other species appearing at the top of their range in Iowa in the Blackoak Coal include *Savitrisporites nux*, *Knoxisporites triradiatus*, *Cristatisporites indignabundus*, *Radiizonates difformis*, *Densosporites annulatus*, *Densosporites irregularis* (rarely) and *Retispora staplinii*. Overall, the Blackoak assemblage is probably the most diverse in the Iowa section, rivalled only by the Wildcat Den Coal of the Caseyville Formation.

The miospore assemblage of the Cliffland Coal resembles that of the Blackoak in major constituents and abundances, but is lacking certain key species (those listed as becoming extinct in the Blackoak), and is therefore correspondingly lower in diversity of the miospore population. *Lycospora* spp. often are even less common than in the Blackoak, usually constituting only a few percent of the population. Monolete and relatively unornamented round trilete forms related to marattialean ferns dominate the assemblages of many samples; conspicuous among these are *Punctatisporites glaber*, *Cyclogranisporites obliquus*, *Laevigatosporites minor* and *Laevigatosporites desmoinesensis*. Gymnospermous pollen or prepollen (esp. *Florinites mediapudens*) also is usually abundant. The distinctive trilete zonate form *Murospora kosankei* makes its first appearance in the Cliffland, and *Dictyomonolites swadei*, an infrequent component of Blackoak assemblages, is found more regularly in the Cliffland. Alete baculate spores of the genus *Spackmanites* reach their maximum abundance in the Cliffland Coal. These characteristics, however, were not observed uniformly in all Cliffland samples; where key forms are absent, palynological distinction between the Blackoak and Cliffland Coals can be difficult.

Floris Formation Coals

The base of the Floris Formation is defined as the Laddsdale Coal Member, sometimes a single bed, usually more than one, ranging in core to as many as five in a closely-spaced complex. Palynological correlation of individual beds from core to core proved impossible except in a few adjacent cores. This entire group of coals appears to represent a single important coal-forming episode during Cherokee Group deposition.

Palynologically, the Laddsdale complex is marked by the earliest regular occurrences of *Microreticulatisporites sulcatus* and *Mooreisporites inusitatus*. The distinctive alete spore *Maculatasporites asperatus* was most commonly encountered in Laddsdale coals, as were *Lycospora rotunda*, *Reticulatisporites reticulatus* and *Alatisporites trialatus*. *Verrucosisporites verrucosus*, *Verrucosisporites sifatii*, *Lophotriletes ibrahimii*, *Pilosisporites williamsii*, *Convolutispora florida*, *Vestispora clara*, *Cuneisporites rigidus*, *Zosterosporites triangularis*, *Quasillinites diversiformis* and *Peppersites ellipticus* were observed for the final time in the Laddsdale complex.

The character of the major constituents of the Laddsdale miospore assemblage usually resembles that of the Blackoak and Cliffland, with *Lycospora* spp. tending to be subordinate in numbers to small marattialean monolete and trilete spores. Exceptions to this pattern were observed in a few samples, however. The overall assemblage in the Laddsdale coals remains diverse, especially in comparison to younger coals in the section.

Above the Laddsdale Coal Member, a thin but relatively persistent coal bed occurs in many of the IGS cores. It usually contained a poorly-preserved, impoverished miospore assemblage, and sometimes was virtually barren. This coal is unnamed, and would be of little interest palynologically, except that it contains the earliest regular occurrence of *Thymospora pseudothiessenii* (rare and sporadic occurrences of this species were noted in slightly older coals). The appearance of this species represents a significant horizon for interregional correlation. This unnamed Floris Formation coal also marks the last regularly observed occurrence of *Torispora securis*. Where the assemblage is preserved adequately to assess in a quantitative fashion, *Lycospora granulata* tends to be the dominant species, although *Densosporites sphaerotriangularis* and *D. triangularis* often are abundant.

The uppermost coal of the Floris Formation is the Carruthers. In IGS cores, the Carruthers yielded a low-diversity assemblage having virtually no biostratigraphically diagnostic species. *Lycospora granulata* and the two species of *Densosporites* mentioned above are usually the most abundant constituents, along with *Granasporites medius* in some samples.

Swede Hollow Formation Coals

As discussed briefly under Geologic Setting, strata of the Swede Hollow Formation are more persistent laterally and more easily traceable than are those of older portions of the Cherokee Group (Ravn et al., 1984). As such, correlation of the coals in the Swede Hollow depended more heavily on lithologic observations than on palynologic characteristics. As the miospore populations of Swede Hollow coals tend to be less diverse than those of older coals, palynostratigraphic distinctions in the Swede Hollow coals are less clear.

The basal coal of the Swede Hollow Formation is the Whitebreast, which is recognized easily on both lithologic and palynologic evidence. The important miospore species *Schopfites dimorphus*, *Raistrickia subcrinita* and *Triquitrites spinosus* appear regularly for the first time in the Whitebreast (one problematical occurrence of *S. dimorphus* was observed in an outcrop sample considered to be a probable bed of the Laddsdale complex). The Whitebreast also marks the last appearance of *Densosporites* spp. in the Iowa section, as a regular and quantitatively important part of the miospore assemblage. The Whitebreast Coal is a bed of great lateral uniformity, associated with the overlying Ardmore Limestone in the oldest easily recognizable cyclothemic unit in the Pennsylvanian of Iowa (Van Dorpe, 1980a). In accordance with this lithologic uniformity, the miospore assemblage also tends to be very uniform from one sample to another, being of moderate diversity and dominated by *Lycospora granulata*, which normally represents slightly more than 50% of the miospore population.

Two closely related coal beds occur in the middle part of the Swede Hollow Formation, the Wheeler and the Bevier. These two beds appear to coalesce into a single unit toward the north and east, separating in a wedge relationship toward the south and west. Palynological distinction between them is difficult, further suggesting a close depositional relationship. *Cadiospora magna* and *Raistrickia crinita* appear for the first time in the Wheeler. Some Wheeler samples contained exceptionally high percentages of *Lycospora granulata*, constituting more than 75% of the miospore population. Samples of the Bevier generally contained about 50% *Lycospora granulata.*

The uppermost Swede Hollow coal is the Mulky. Few samples of the Mulky were studied, in part because it is not always present in the section, and also because many of the IGS cores contain only older strata. No significant diagnostic taxa appeared in the samples studied, although the irregularly striate bisaccate pollen grain *Illinites unicus* was observed more commonly in the Mulky than in older coals, and *Lycospora pellucida* increased in abundance to a level near that of *L. granulata*, each constituting 20-30% of the miospore population.

Post-Cherokee Coals

As the emphasis of the IGS coring project centered on coals of the Cherokee Group, few cores penetrated younger strata. Samples from three younger coals, the Summit and Mystic of the Marmaton Group and the Ovid Coal of the Missouri Supergroup were examined. *Thymospora pseudothiessenii*, *Triquitrites spinosus* and *Cadiospora magna*, all of which occur in relatively low percentages in most Cherokee Group coal samples studied, increased in abundance in the Summit and Mystic Coals. *Lycospora granulata*, however, continues to be the dominant miospore species in both these coals.

The basal Missourian Ovid Coal was present in only one core (CP-37 in Clarke County), but several samples of this coal were collected from outcrops in Iowa and northern Missouri in conjunction with a Ph.D. dissertation project on the Hertha Formation of the Bronson Group (Ravn, 1981a). The Ovid is of interest in Iowa principally as a useful stratigraphic marker bed. As the lowest Missourian coal, it records the virtual disappearance of *Lycospora* spp. from the Midcontinent at the end of Desmoinesian time (noted by numerous investigators in other areas, including Phillips and others, 1974). *Calamospora* spp., *Laevigatosporites* spp., and *Endosporites globiformis* tend to dominate the Ovid miospore assemblage, with *Cadiospora magna*, *Schopfites dimorphus* and *Triquitrites spinosus* being relatively common. *Thymospora pseudothiessenii* is rare in the Ovid samples examined, and other *Thymospora* spp., which become abundant in later Missourian and Virgilian coals elsewhere in North America (e.g., Clendening, 1975) were not observed.

COMPARISONS

The palynological succession observed in the Iowa coals compares favorably with successions described elsewhere in North America and Europe (e.g., Smith and Butterworth, 1967; Peppers, 1970; 1979; 1984; Loboziak, 1974; Clayton et al., 1977; Owens, Loboziak and Teteriuk, 1978). The following palynostratigraphic 'events' (listed in ascending stratigraphic order) observed in Iowa appear to have the greatest significance for long-distance ocrrelation, based on evaluation of Iowa data and other reports:

1. Extinction of *Schulzospora* spp.

2. Appearance of *Endosporites globiformis*.

3. Extinction of *Sinuspores* (*Punctatisporites*) *sinuatus* (approx. = extinction of *Grumosisporites varioreticulatus*).

4. Appearance of *Torispora securis*.

5. Extinction of *Dictyotriletes bireticulatus* (approx. = extinctions of *Densosporites annulatus* and *Retispora staplinii*).

6. Appearance of *Microreticulatisporites sulcatus*.

7. Appearance of *Thymospora* spp.

8. Appearance of *Schopfites dimorphus* (approx. = appearance of *Cadiospora magna*).

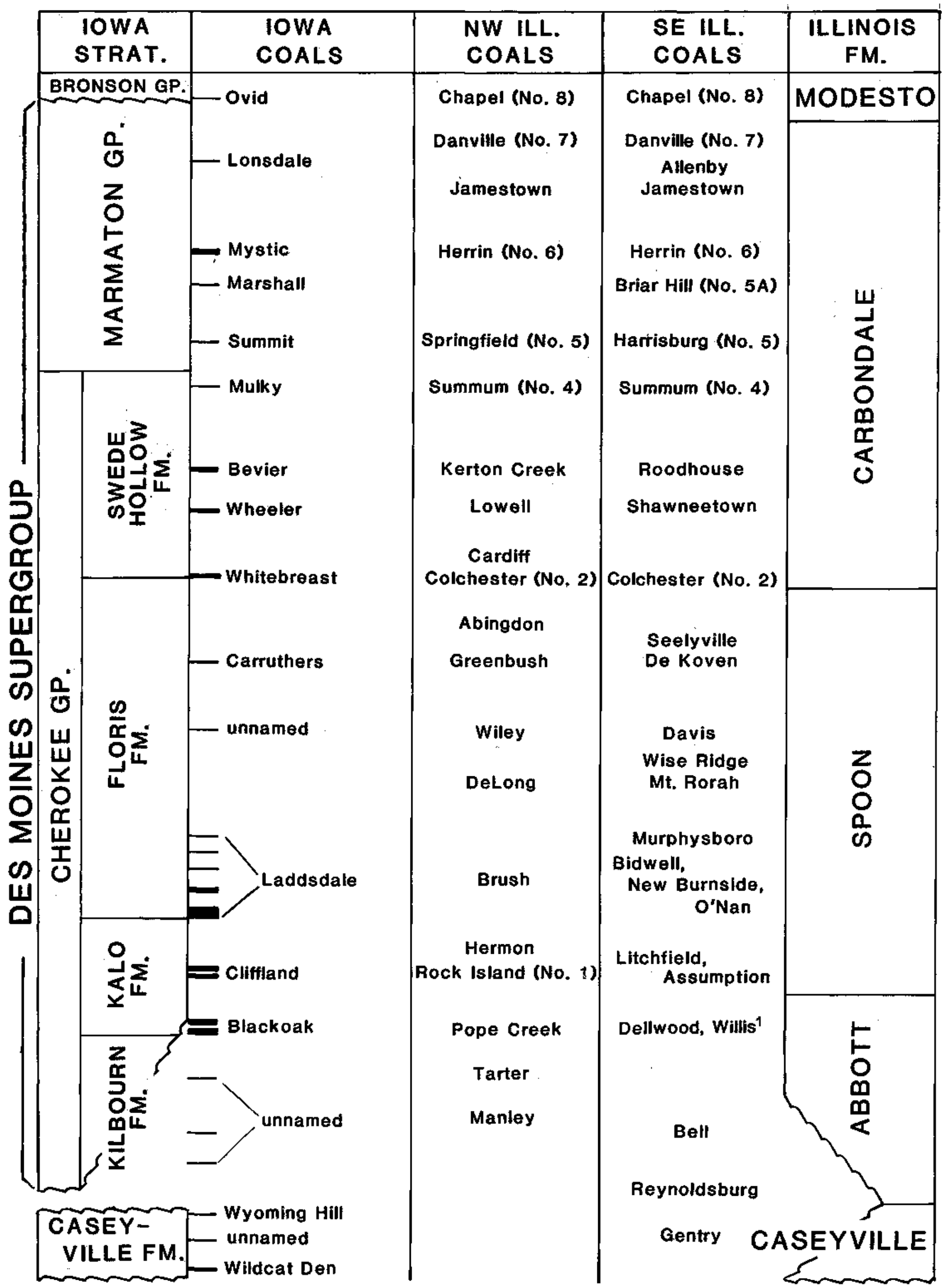
Although other extinctions and appearances also are useful for comparison, these seem to be the most widely and uniformly recognized across much of North America and Europe. The correspondance between this sequence as observed in Iowa and as reported in other studies is strong. Probably the most easily made comparison is between the Iowa section and the coals of the Illinois Basin, which have been the subject of much palynostratigraphic study (e.g., Schopf, 1938; Kosanke, 1950; Peppers, 1964, 1970, 1979, 1984). Proposed correlations of coals in Iowa and Illinois are shown on text-figure 12.

The lithostratigraphic equivalence of the Whitebreast Coal with the Colchester (No.2) Coal in Illinois, and the equivalence of the Mystic with the Herrin (No. 6) Coal in Illinois are well established (Weller et al., 1942; Lemish et al., 1981). Palynostratigraphic data from this study and the report of Peppers (1970) are fully consistent with these lithostratigraphic interpretatiions. Correlations below the Colchester-Whitebreast Coals, however, are much less clear from purely lithostratigraphic evidence, and must therefore be based on biostratigraphic interpretations. Peppers' (1970) thorough study did not include much of the section below the Colchester, but a later paper (Peppers, 1984) did include the ranges of several key taxa throughout the Pennsylvanian of Illinois.

In a shorter, more generalized study, however, Peppers (1979) included several observations on the coals of the Illinois Basin which have considerable significance for correlation with the Iowa section. In a generalized range chart, Peppers (1979) recorded a pair of important palynologic events that also were observed in Iowa. *Torispora* increases in abundance suddenly in the Willis Coal in Illinois, coupled with a dramatic decrease in the abundance of *Lycospora* spp. These two events also coincide in the Blackoak Coal in Iowa.

The position of the Willis Coal in the Illinois stratigraphic column apparently is somewhat questionable. Kosanke and others (1960) and Hopkins and Simon (1975) correlated the Willis (a southern Illinois coal name) to the Tarter Coal (of northern and western Illinois). Peppers and Popp (1979), however, correlated the Willis to the stratigraphically higher Pope Creek Coal, apparently on the basis of recent palynological study by Peppers. (The Illinois coal correlations shown on text-figure 12 are amended to show this change in interpretation.)

Probable correlation of the Blackoak to the Pope Creek and Willis Coals is suggested further by Peppers' (1979) observation that the extinction of the miospore genus *Radiizonates* occurs below the Spoon Formation in Illinois (i.e., the Pope Creek Coal and below). The species *R. difformis* extends to, but not above the Blackoak Coal in Iowa. Peppers (1979, p. 11) noted also that 'thick-walled fern-like spores rapidly increased in abundance in the upper part of the Abbott Formation,' represented by the Pope Creek and Willis Coals; the Blackoak miospore assemblage records a sharp increase in the abundance



Text-figure 12. Proposed correlations of Iowa coals to coals of the Illinois Basin (as described by Hopkins and Simon, 1975; [1]indicates an amended correlation in Illinois by Peppers and Popp, 1979).

of such spores, represented by species such as *Laevigatosporites globosus*, *Cyclogranisporites obliquus* and *Punctatisporites glaber.* Similarly, the marattialean-related *Punctatisporites minutus* increases near the top of the Abbott Formation in Illinois and in the Blackoak Coal in Iowa.

Correlation of the Blackoak to the Pope Creek-Willis Coals suggests correlation of the overlying Cliffland Coal to the Rock Island (No. 1) Coal in Illinois. Peppers (1979, p. 12) indicated that the maximum abundance of *Torispora* extended from the Willis Coal to 'a coal just above the Rock Island Coal.' In Iowa, *Torispora securis* is found most abundantly in the Blackoak and Cliffland Coals, with somewhat reduced abundance in the Laddsdale Coals, above which it essentially disappears.

Correlation of the Blackoak to the Pope Creek and of the Cliffland to the Rock Island indicates the general biostratigraphic equivalence of Floris Formation coals in Iowa (the Laddsdale complex, an unnamed bed and the Carruthers Coal) to the major part of the Spoon Formation in Illinois, including the Brush, Delong, Wiley and Greenbush Coals. The Floris Formation in Iowa contains a laterally complex sequence of sediments, and precise coal-to-coal correlations between Iowa and Illinois in this interval probably are not possible. One significant biostratigraphic correlation may be made, however, at the horizon of the regular appearance of *Thymospora pseudothiessenii*, which occurs in the unnamed Floris Formation coal in Iowa and apparently in the Wiley Coal in Illinois (Peppers, 1970). Kosanke (1950), in his original description of this species (as *Laevigatosporites pseudothiessenii*), placed its lower limit of occurrence in the slightly younger DeKoven Coal. (The name Wiley formerly was applied to what is now designated as the Carruthers Coal in Iowa; Ravn and others [1984] have recommended discontinuing the use of the name Wiley for the Iowa coal because the palynostratigraphic evidence indicates that the Illinois Wiley is not equivalent to the Carruthers.)

Coal-to-coal correlation between Iowa and Illinois also is not possible below the Blackoak-Pope Creek horizon, due to the local nature of the coals in the Kilbourn and Caseyville Formations in Iowa. However, the abundance of *Densosporites annulatus* in Kilbourn Coals equates closely to the reported peak of abundance of the species in the 'lower part of the Atokan' in Illinois (Hopkins and Simon, 1975, p. 181; by their columnar section on p. 165, this would equate approximately to the Manley and Reynoldsburg Coals). The miospore assemblages of the Caseyville Formation coals in both states are unquestionably similar, especially in the presence of the key species *Schulzospora rara* and *Radiizonates striatus* (Hopkins and Simon, p. 178).

This correlation of the Iowa coal sequence to the Illinois coal sequence permits consideration of the assignment of chronostratigraphic series units to the Iowa section, necessary for further comparison to Pennsylvanian and Upper Carboniferous stratigraphy in other regions. A complex theoretical problem exists concerning the meaning of lithostratigraphic and chronostratigraphic subdivisions and their relationships, especially as historically applied to the North American Midcontinent Pennsylvanian. For reasons of simple practicality and in the interest of comparative stratigraphy, I have chosen to correlate the chronostratigraphic series used in the Illinois Basin (Hopkins and Simon, 1975) directly to the Iowa section. The resultant application of the Atokan Series designation to part of the Iowa section conflicts with some historical usage. Reasons for adopting this approach concern the complexity of lithostratigraphy vs. chronostratigraphy and are discussed in detail in Appendix II.

Given the Iowa-Illinois correlations constructed in text-figure 12, application of the chronostratigraphic series designations in the sense employed in the Illinois Basin is relatively simple. Hopkins and Simon (1975) placed the lower boundary of the Desmoinesian Series at the lithostratig-raphic boundary between the Abbott and Spoon Formations (i.e., between the Pope Creek and Rock Island Coals). Therefore, in Iowa, this chronostratigraphic boundary should fall in the middle of the Kalo Formation, between the Blackoak and Cliffland Coals. (Peppers, 1979, placed the Atokan-Desmoinesian boundary slightly higher, above the Rock Island Coal, but cited no reasons for doing so. For purposes of biostratigraphic recognition in Iowa, the interpretation of Hopkins and Simon, 1975, is more useful.) The Morrowan-Atokan boundary in Illinois is placed between the Caseyville and Abbott Formations, which conveniently corresponds to the interval between the Caseyville and Kilbourn Formations in Iowa.

As discussed in Appendix II, the use of chronostratigraphic terms is meaningless unless firm biostratigraphic grounds for their recognition are defined. Two widely recognized extinctions occur in the Iowa section at the positions of the series boundaries as extended from the Illinois Basin. These are the extinction of *Schulzospora rara*, which is used here as defining the Morrowan-Atokan boundary, and the extinction of *Dictyotriletes bireticulatus*, which is used to define the Atokan-Desmoinesian boundary. (In Illinois, *D. bireticulatus* is known to extend above the Rock Island Coal, somewhat higher than it is seen in Iowa; Peppers, personal communication, 1986).

Although a great deal of study has been devoted to Pennsylvanian palynology elsewhere in North America, few syntheses of the ranges of miospore species in areas other than Iowa and Illinois have been published. L. R. Wilson at the University of Oklahoma has published a large number of papers on individual coals in Oklahoma, and has also supervised many theses and dissertations which, unfortunately, remain for the most part unpublished. Comparison of the Iowa succession to these, as far as is possible, suggests some differences in miospore ranges between Iowa and Oklahoma, and possibly some significant differences in the character of miospore assemblages between the two areas due to paleoenvironmental factors. A good lithostratigraphic correlation can be made between the Croweburg Coal (= Henryetta Coal) of Oklahoma and the Colchester (No. 2) Coal of Illinois (Wilson and Hoffmeister, 1956; Meyers, 1966). Therefore, the Croweburg appears to correlate directly to the Whitebreast Coal in Iowa (Van Dorpe, 1980a).

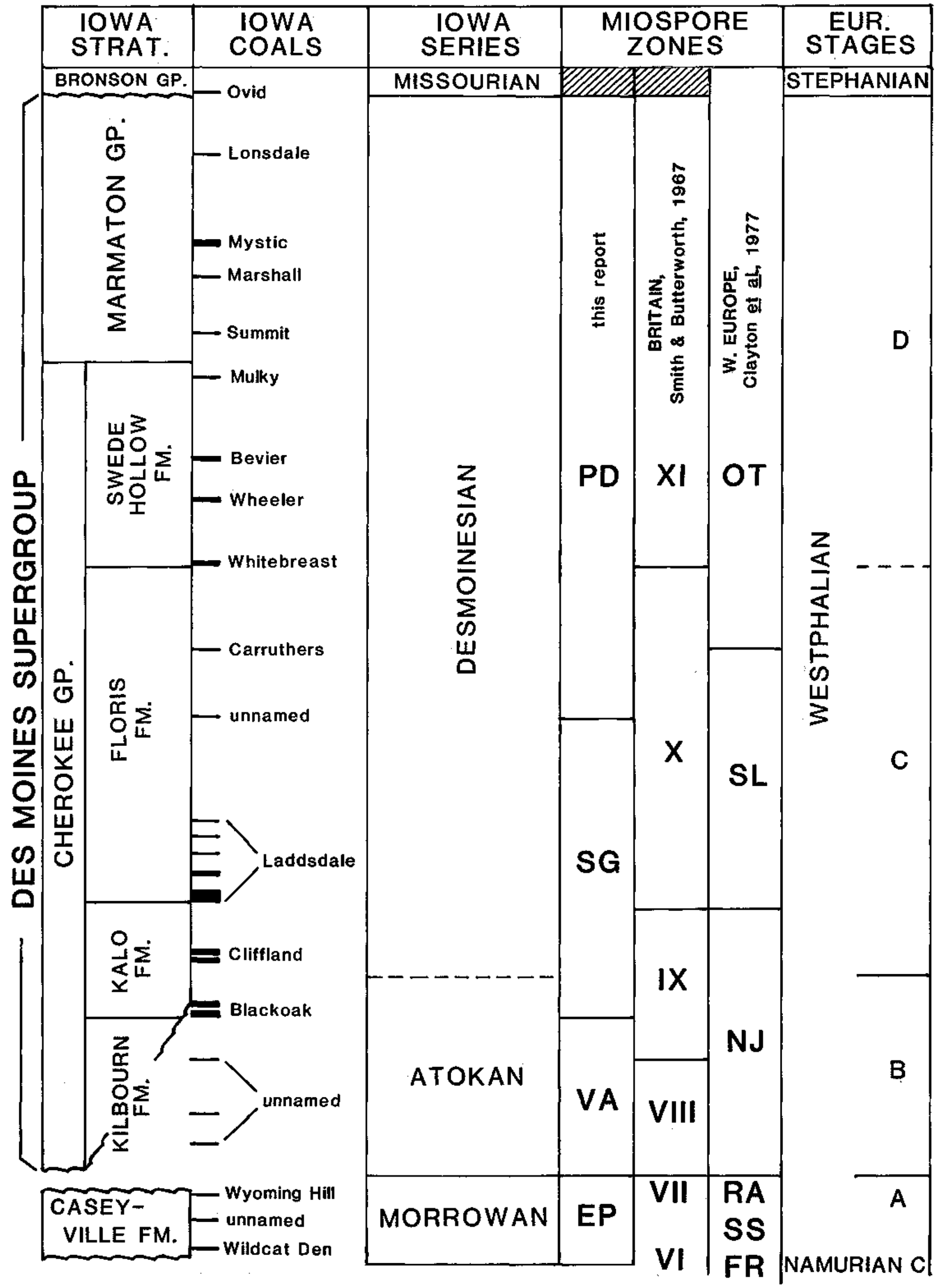
Wilson (1976) summarized data from a number of theses and dissertations on Oklahoma coals; although these data are summarized only at the level of miospore genera, certain useful comparisons to the Iowa section can be made. the principal zone of occurrence of *Alatisporites* in Oklahoma is from the Rowe Coal upward through the Mineral Coal. In Iowa, *Alatisporites* spp. were observed mainly between the Blackoak and Whitebreast Coals. Wilson reported *Leschikisporis* spp. (= *Cyclogranisporites obliquus*, *Punctatisporites glaber* and possibly *Laevigatosporites globosus*) as appearing in abundance in the Lower McAlester Coal; in Iowa the equivalent taxa appear, in abundance, in the Blackoak Coal. In the Oklahoma section, *Vestispora* spp. appear at a slightly lower level, in the Upper Hartshorne Coal; in Iowa *Vestispora* spp. (with the exception of the species *V. lucida*) appear in the Kilbourn Formation, just below the Blackoak Coal. In the absence of species-level identification from the Oklahoma Coals, however, few other comparisons to the Iowa section can be made. Re-evaluation of the numerous theses and unpublished reports on Oklahoma coals would be most valuable in establishing correlations across the Western Interior Basin.

Gupta (1977) published a highly generalized miospore range chart for the Pennsylvanian and Lower Permian of north-central Texas. The Strawn Stage, considered equivalent to the Desmoinesian Series, is subdivided into upper and lower units. *Thymospora pseudothiessenii* and *Vesicaspora wilsonii* are shown as appearing in the upper Strawn, which could correspond generally to their appearance in the upper part of the Cherokee Group in Iowa. Many of the other miospore ranges illustrated by Gupta, however, conflict with those observed in Iowa, and as no taxa are illustrated, detailed comparison of identifications is not possible.

Ravn (1981b) proposed a sequence of four major miospore zones through the Lower and Middle Pennsylvanian of Iowa in order to facilitate comparison with published zonations for the European Upper Carboniferous. The succession observed in Iowa (text-figure 13) compares closely to that reported in several European studies (e.g., Smith and Butterworth, 1967; Loboziak, 1974; van Wijhe and Bless, 1974; Clayton et al., 1977; Owens et al., 1978). Following the practice of Clayton and others (1977), the zones are given two-letter designations referring to the specific names of two characteristic taxa. The lowermost of these zones is redefined here and given a new designation from, based on subsequent study.

The oldest zone in the Iowa section is the RS zone (nominal species *Schulzospora rara-Radiizonates striatus*), which encompasses the Caseyville Formation coals; this zone was designated the EP zone by Ravn (1981b), but one of the original nominal species (*Cordylosporites papillatus*) has subsequently been observed in strata younger than those of the Caseyville Formation, and it is considered desirable to redefine the zone to recognize the extinction of *Schulzospora rara*, which is also used to define the Morrowan-Atokan boundary. The VA zone (*Grumosisporites varioreticulatus-Densosporites annulatus*) includes the coals of the Kilbourn Formation. The SG zone (*Torispora securis-Laevigatosporites globosus*) includes those coals which tend to be dominated by small monolete and trilete marattialean-related miospores: Blackoak, Cliffland and Laddsdale. Two subzones can be recognized within the SG zone in some cores, a lower SGb subzone (*Dictyotriletes bireticulatus*) confined in Iowa to the Blackoak Coal, in which the named species is present, and an upper SGk subzone (*Murospora kosankei*) that includes the Cliffland and Laddsdale Coals. The fourth major miospore zone is the PD zone (*Thymospora pseudothiessenii-Schopfites dimorphus*), which includes all other coals examined except the Ovid. This zone also can be divided into subzones, a lower PDt subzone (*Densosporites triangularis*) that includes the coals (unnamed Floris Formation coal, Carruthers and Whitebreast) in which both *Thymospora pseudothiessenii* and *Densosporites* spp. were observed, and an upper PDs subzone (*Triquitrites spinosus*), in which the nominal species is present and *Densosporites* spp. are not. Details on other species characteristic of the coals of these zones may be found under Palynostratigraphy: Description.

The zonal subdivision is designed to erect relatively narrow but distinct biostratigraphic units that can be used for comparison to stratigraphically equivalent sections in other regions (esp. Europe). Text-figure 13 illustrates the comparison of Iowa miospore zones to the European zones of Clayton and others



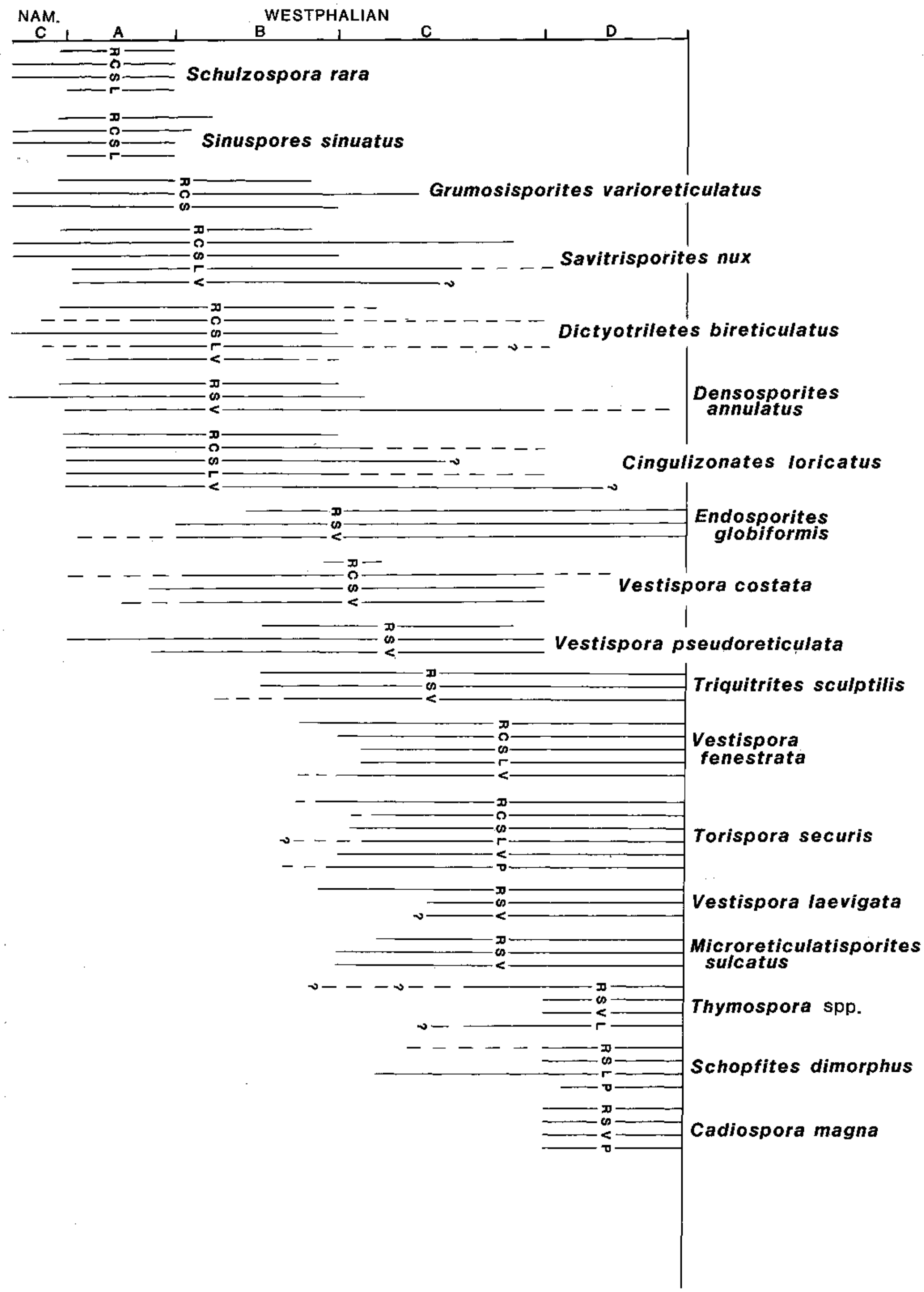
Text-figure 13. Comparison of Iowa coal stratigraphy and miospore zonation to two major European zonations and to European stage nomenclature.

(1977); also compared are the North American Midcontinent Series and standard European Stages. These comparisons are made possible by the striking similarity in the sequence of miospore appearances and extinctions in the Iowa section and Europe.

The ranges of a number of key miospore taxa observed in this study and as reported from Illinois by Peppers (1970, 1979, 1984) and from western Europe by Smith and Butterworth (1967), van Wijhe and Bless (1974), Loboziak (1974) and Clayton and others (1977) are shown on text-figure 14. The similarities in bases and tops of ranges between the two continents are obvious. A few exceptions can be seen, the most notable of which is *Densosporites annulatus*, which does not occur above the Westphalian B equivalent in Iowa, but ranges considerably higher in the section in Europe; for reasons that remain enigmatic, *Densosporites* spp. in general continue to be present much higher in the European Carboniferous than they do in North America (Butterworth, 1966). The overall similarity of the ranges of the species shown on text-figure 13, however, suggests that they are reliable stratigraphic indicators that can be applied over a very wide area during the Lower and Middle Pennsylvanian. They demonstrate that the Iowa coal sequence examined during this project spans essentially the entirety of the European Westphalian Stage.

CONCLUSION

A great deal of research remains to be done on the subjects of miospore paleoecology of coal swamps, regional and interregional paleogeographic variability in miospore distributions and in basic palynostratigraphy in the Carboniferous. This report is intended as a reconnaissance of the stratigraphic distribution of miospores in the Pennsylvanian coals of Iowa. It was designed to provide a basic palynostratigraphic framework to aid in working out the stratigraphy of this difficult part of the Iowa geologic column. Future study of coals and other sediments, especially in areas westward of the main study area, undoubtedly will result in alterations and refinements of the stratigraphy presented here. If this report can serve as a starting point for further examination of the coal-bearing strata in Iowa, it will have served its intended purpose.



Text-figure 14. Comparison of selected miospore ranges observed in Iowa to those reported from other areas. R = this report; C = Clayton et al., 1977, western Europe; S = Smith and Butterworth, 1967, Britain; L = Loboziak, 1974, western Europe; V = van Wijhe and Bless, 1974, western Europe; P = Peppers, 1970, 1979, Illinois Basin.

SYSTEMATIC PALEONTOLOGY

ORGANIZATION

Systematic organization of miospore form genera has long been a problem for palynologists working with pre-Quaternary material. Approaches toward data organization for Paleozoic material have ranged from simple alphabetization of generic names to construction of elaborate, informal (but formal-appearing), hierarchical, supergeneric classification systems, based on morphology. Alphabetization superficially simplifies data presentation for the reader, but it obscures real and potential generic relationships and is unstable, with the order of presentation changing with each new generic transfer. The supergeneric morphologic systems, especially favored by European workers (e.g., Smith and Butterworth, 1967; Loboziak, 1971), strive toward stability of presentation in order to facilitate comparison among reports. Many American palynologists (e.g., Schopf, 1969; Urban, 1971) have expressed objections to these schemes, criticizing especially the implication of potential biologic relationships among miospore genera that either are unknown or are demonstrably false, and the proliferation of terminology (turma, infraturma, subturma, anteturma, suprasubturma, etc.). Some authors (e.g., Peppers, 1970, Ravn, 1979) have attempted to follow the general organization of the commonly used supergeneric schemes without invoking the terminology, but this approach has the unsatisfactory result of appearing to be random.

Some palynologists studying Mesozoic material have divided their approaches among artificial morphologic systems (e.g., Hedlund, 1966; Norris, 1969; Playford, 1971a; Norvick and Burger, 1975; Wingate, 1980), alphabetic listing (Agasie, 1969; Srivastava, 1977), and abandonment of the Linnéan system altogether (e.g., Hughes and Moody-Stuart, 1967, 1969; Hughes and Croxton, 1973). Many, however (especially those investigating the Cretaceous, e.g., Brenner, 1963; C. Singh, 1964, 1971; Habib, 1970; Romans, 1975), have chosen to incorporate known or suspected paleobotanical relationships of miospores into their classifications.

Until recently, firm knowledge of the paleobotanical relationships of miospores has been too sparse to permit the use of such a system in Paleozoic studies. Recent advances, however, allow assignment of most major Carboniferous miospore genera at least to major plant groups. Accordingly, a supergeneric classification system incorporating known paleobotanical relationships is employed here. The system classifies miospore genera into twelve basic categories, using both paleobotanical affinities and major morphological characteristics:

1. Trilete filicineans, marattialeans and lyginopterids.
2. Trilete sphenopsids.
3. Trilete lycopsids.
4. Trilete of unknown affinities.
5. Monolete marattialeans, sphenopsids and lyginopterids.
6. Monolete of unknown affinities.
7. Alete of unknown affinities.
8. Polyplicate probable gymnosperms.
9. Monosaccate gymnosperms.
10. Bisaccate gymnosperms.
11. Medullosan pteridosperms.
12. Fungi.

No desire exists to formalize this broad categorization into a systematic Latinized nomenclatural edifice. It is designed simply to allow for a more natural organization of miospore taxa, recognizing as presently possible the known paleobotanical affinities of the miospores. As constructed it is applicable only to the miospore population examined in this study (Lower to basal Upper Pennsylvanian), although with minor modification and perhaps the addition of other basic categories it could be adapted to other parts of the Paleozoic column. Recent summaries of the known paleobotanical affinities of Devonian spores (Allen, 1980; Gensel, 1980) suggest, for instance, that sufficient knowledge now exists to permit gross paleobotanical classification of dispersed Devonian miospore populations. Future paleobotanical study is certain to refine any such categorization.

An alphabetic index to genera is provided at the end of the report (Appendix I). Descriptive terminology used is in accordance with glossaries provided by Kremp (1965), Smith and Butterworth (1967) and Grebe (1971). The stratigraphic occurrences of each unequivocally identified species encountered during the study is briefly summarized. Terms used to describe relative abundance of individual miospore taxa are as follows:

Extremely rare
: Specimens encountered too sporadically to allow any confident assessment of their occurrence.

Rare
: Specimens encountered in many samples, but usually observed during final scanning of slides rather than during the 250-miospore count.

Frequent
: 0.5-2.0% of the miospore population (i.e., encountered during the population count but in statistically insignificant numbers).

Common
: 2.0-5.0% of the miospore population.

Abundant
: 5.0-25.0% of the miospore population.

Dominant
: Greater than 25.0% of the miospore population.

For reasons of practicality, this usage differs slightly from that applied in Technical Paper 6 (Ravn, 1979).

TRILETE FILICINEANS, MARATTIALEANS AND LYGINOPTERIDS

Many Carboniferous plants of diverse affinities produced trilete spores and prepollen grains assignable to numerous miospore genera. As the precise paleobotanical affinities of most of these cannot be deduced reliably from their morphology alone, they are considered here as a broad category. The order of presentation progresses from the less ornamented to the more complexly ornamented forms, to facilitate comparison with the most commonly used supergeneric morphological classification systems.

Genus *DELTOIDOSPORA* Miner 1935

Type species -- *D. hallii* Miner 1935.

Remarks -- McGregor (1973), Srivastava (1977) and others have demonstrated conclusively the priority of *Deltoidospora* over *Leiotriletes* and other generic names that have been applied to triangular laevigate trilete spores. The use of *Deltoidospora* in this report departs from the practice of preliminary reports on the Pennsylvanian of Iowa (Ravn, 1979; Egner, 1981; Ravn and Fitzgerald, 1982), as well as that of most other literature on Carboniferous palynology. An astonishing number of species of these morphologically simple spores have been described under *Leiotriletes* in strata ranging from the Devonian (e.g., Allen, 1965) to the Upper Tertiary (e.g., Mohr, 1984). Treatment of *Leiotriletes* as a junior synonym of *Deltoidospora* necessitates reassignment of these species, although many are so generalized in morphology or so poorly described and illustrated that nothing would be gained by such an exercise. Several Upper Paleozoic species of *Leiotriletes* that have been described and illustrated adequately are transferred to *Deltoidospora* in the Systematics that follow.

Paleobotanical affinities -- In the Carboniferous, spores of this kind have been correlated with various filicineans (Remy and Remy, 1957; Eggert and Delevoryas, 1967; Rothwell, 1976, 1978; Good, 1979; questionably Chaphekar and Alvin, 1972; Good, 1981; Holmes, 1981).

Deltoidospora gracilis (Imgrund) n. comb.

(Plate 1, figure 1)

1952 *Laevigatisporites gracilis* Imgrund, p. 20 (Invalid; unpublished thesis).
1960 *Leiotriletes gracilis* Imgrund, p. 153, pl. 13, figs. 8, 9.
1964 *Granulatisporites* sp. 2 Peppers, p. 21, pl. 2, fig. 17.
non 1965 *Leiotriletes gracilis* Menéndez, p. 49, pl. 1, figs. 3-5.

Remarks -- *D. gracilis* differs from *D. subadnatoides* (Bhardwaj) n. comb. in being thinner and often possessing compression folds. Peppers (1970, pl. 1, figs. 7, 8; *D. subadnatoides* as *Leiotriletes parvus* Guennel 1958) provided comparative illustrations of these species.

Occurrence -- Rare, observed in a shale sample from the basal Kilbourn Formation in core CP-6, the Blackoak, Cliffland, Laddsdale and Bevier Coals.

Deltoidospora levis (Kosanke) n. comb.

(Plate 1, figure 5)

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

Remarks -- Eggert and Delevoryas (1967) recovered spores assignable to *D. levis* from fructifications of the filicinean genus *Sermaya*.

Occurrence -- Rare, observed in most coals from the Blackoak upward throughout the section.

Deltoidospora ornata (Ishchenko) Braman and Hills 1977

(Plate 1, figures 6, 7)

1956 *Leiotriletes ornatus* Ishchenko, p. 22, pl. 2, figs. 18-21.
1977 *Deltoidospora ornata* (Ishchenko) Braman and Hills, p. 598, pl. 1, fig. 12.

Remarks -- Small, morphologically generalized spores referable to *D. ornata* have been reported widely from the Lower Carboniferous throughout the world (e.g., Playford, 1962, 1978; Sullivan, 1964a; Doubinger and Rauscher, 1966; Felix and Burbridge, 1967; Hibbert and Lacey, 1969; Braman and Hills, 1977). Spores of this kind appear to be less common in the Upper Carboniferous, and they were observed only rarely in the lower portion of the Iowa Pennsylvanian. *D. ornata* resembles *D. pseudolevis* (Peppers) n. comb. but is thicker and has a more convex amb.

Occurrence -- Rare, observed in the Wildcat Den and Wyoming Hill Coals, the Kilbourn Formation and the Blackoak Coal.

Deltoidospora priddyi (Berry) McGregor 1973

(Plate 1, figure 3)

1937 *Zonales-sporites priddyi* Berry, p. 156, 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.
1973 *Deltoidospora priddyi* (Berry) McGregor, p. 16, pl. 1, figs. 6, 7.

Remarks -- Circumscription of *D. priddyi* in this report follows the criterion of 28-36 μm maximum diameter as described by Ravn (1979).

Occurrence -- Rare, observed in most coals throughout the section.

Deltoidospora smithii n. name

(Plate 1, figures 10-13)

1965 *Leiotriletes turgidus* Marshall and Smith, p. 658, pl. 99, figs. 1-3 (non *Leiotriletes turgidus* Kara-Murza).
1971 *Leiotriletes labrum* Urban, p. 129, pl. 33, figs. 4-6.

Remarks -- As indicated by the synonymy, *Leiotriletes turgidus* Marshall and Smith 1965 is a junior homonym. The new name *D. smithii* is proposed in recognition that a transfer under the name *L. labrum* Urban 1971 would create a homonymy with *Deltoidospora labra* Guennel 1963. The new name honors Dr. A. H. V. Smith, who originally described the species. Comparisons of specimens reported by Ravn (1979) under the name *L. turgidus* and by Ravn and Fitzgerald (1982) under the name *L. labrum* reveals no significant distinctions; comparison of the type descriptions and illustrations (Marshall and Smith, 1965; Urban, 1971) likewise indicates synonymy. SEM examination of specimens of *D. smithii* reveals that the surface is minutely (sub-optically) punctate.

Occurrence -- Rare, observed in the Wildcat Den Coal, the Kilbourn Formation, the Blackoak and Laddsdale Coals.

Deltoidospora sphaerotriangula (Loose) n. comb.

(Plate 1, figure 4)

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* (*sic*) (Loose) Schopf, Wilson and Bentall, p. 31.
1950 *Plani-sporites sphaerotriangulatus* (*sic*) (Loose) Knox, p. 316, pl. 17, fig. 214.
1954 *Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, p. 120.
1965a *Deltoidisporites sphaerotriangulus* (Loose) Laveine, p. 131, pl. 10, fig. 6.

Remarks -- *D. sphaerotriangula* is distinguished from *D. priddyi* by being larger than 36 μm in maximum diameter (Ravn, 1979).

Occurrence -- Rare, observed in the Kilbourn Formation, the Blackoak and Laddsdale Coals and the unnamed coal of the Floris Formation.

Deltoidospora subadnatoides (Bhardwaj) n. comb.

(Plate 1, figure 2)

1952 *Laevigatisporites sporadicus* Imgrund, p. 22, figs. 20, 60-62 (Invalid; unpublished thesis).
1955 *Leiotriletes sporadicus* (Imgrund) Potonié and Kremp, p. 38 (Invalid; type not figured).
1957a *Leiotriletes subadnatoides* Bhardwaj, p. 80, pl. 22, figs. 5-7.
1958 *Leiotriletes parvus* Guennel, p. 57, pl. 2, figs. 7, 8; text-fig. 14.
non 1953 *Leiotriletes parvus* Naumova, p. 44, pl. 5, fig. 10.
non 1958 *Leiotriletes parvus* Nilsson, p. 30, pl. 1, fig. 1.
? 1964 *Leiotriletes magnificus* H. P. Singh, p. 241, pl. 44, figs. 3, 4.
1979 *Leiotriletes guennelii* Ravn, p. 20, pl. 1, fig. 1.

Remarks -- Ravn (1979) erected the new name *L. guennelii* to replace the junior homonym *L. parvus* Guennel 1958, as indicated by the synonymy above. At that time *L. guennelii* was considered distinct from *L. subadnatoides* Bhardwaj on the basis of the latter species being described as 'intrapunctate.' I no longer believe this distinction to be valid and propose the transfer to *Deltoidospora* under the senior legitimate specific epithet.

Occurrence -- Rare, observed in a shale sample from the basal Kilbourn in core CP-6, the Blackoak, Laddsdale and Whitebreast Coals.

Deltoidospora subintorta (Waltz) Braman and Hills 1977
var. *rotundata* Waltz

(Plate 1, figure 8)

1941 *Azonotriletes subintortus* Waltz var. *rotundatus* Waltz, in Luber and Waltz, p. 13-14, pl. 2, fig. 15b.
1952 *Leiotriletes subintortus* (Waltz) Ishchenko var. *rotundatus* Waltz, p. 11, pl. 1, fig. 7.
1971 *Leiotriletes subintortus* (Waltz) Ishchenko 1952; Urban, p. 128, pl. 32, figs. 7-9.
1977 *Deltoidospora subintorta* (Waltz) Braman and Hills var. *rotundata* Waltz, p. 598, pl. 1, fig. 13.
1982 *Leiotriletes subintortus* (Waltz) Ishchenko 1952; Ravn and Fitzgerald, p. 113, pl. 1, figs. 4, 5.

Occurrence -- Rare, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation and in the Kilbourn Formation.

The following species are transferred here to *Deltoidospora*:

Deltoidospora angulata (Urban) n. comb.:
1971 *Leiotriletes angulatus* Urban, p. 128, pl. 33, figs. 1-3.

Deltoidospora atshanensis (Singh) n. comb.:
1964 *Leiotriletes atshanensis* H. P. Singh, p. 241, pl. 44, figs. 1, 2.

Deltoidospora badamensis (Venkatachala and Kar) n. comb.:
1965 *Lacinitriletes badamensis* Venkatachala and Kar, p. 339, pl. 1, figs. 8-15; non pl. 1, fig. 7.
1975 *Leiotriletes badamensis* (Venkatachala and Kar) Foster, p. 125, pl. 1, figs. 20, 21.

Deltoidospora blairatholensis (Foster) n. comb.:
1975 *Leiotriletes blairatholensis* Foster, p. 126, pl. 1, figs. 1-3.

Deltoidospora convexa (Kosanke) n. comb.:
1950 *Granulati-sporites convexus* Kosanke, p. 20, pl. 3, fig. 6.
1950 *Plani-sporites deltoides* (auct. non Ibrahim) Knox, p. 315, pl. 17, fig. 216.
1955 *Leiotriletes convexus* (Kosanke) Potonié and Kremp, p. 39, pl. 11, fig. 110.
non 1953 *Leiotriletes convexus* Bolkhovitina, p. 25, pl. 2, fig. 17.

Deltoidospora pseudolevis (Peppers) n. comb.:
1970 *Leiotriletes pseudolevis* Peppers, p. 80, pl. 1, figs. 3, 4.

Deltoidospora pyramidata (Sullivan) n. comb.:
1964a *Leiotriletes pyramidatus* Sullivan, p. 357, pl. 57, figs. 2, 3.

Deltoidospora tumida (Butterworth and Williams) n. comb.:
1958 *Leiotriletes tumidus* Butterworth and Williams, p. 128, pl. 32, figs. 10-12.

The following new name is proposed to avoid a problem of homonymy:

Deltoidospora sullivanii n. name:
1964a *Leiotriletes plicatus* Sullivan, p. 356, pl. 57, figs. 4-6.
non 1969 *Leiotriletes plicatus* Maheshwari and Bose, p. 11, pl. 1, figs. 10, 11; text-fig. 3.

Erection of this new name is necessary to avoid homonymy with *Deltoidospora plicata* Singh 1977, a species from the Tertiary of Assam, India. The new name honors Dr. Herbert G. Sullivan of Amoco Production Company, Calgary, Alberta, Canada, who originally described the species.

Genus *PUNCTATISPORITES* Ibrahim emend. Potonié and Kremp 1954

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

Paleobotanical affinities -- Various filicineans and marattialeans (Mamay, 1950, 1957; Remy and Remy, 1955a; Abbott, 1961; Laveine, 1969; Pfefferkorn, Peppers and Phillips, 1971; Chaphekar and Alvin, 1972; Courvoisier and Phillips, 1975; Rothwell, 1976; Setlik et al., 1979a; Millay, 1982; Millay and Taylor, 1984). Stidd (1978) recovered primitive trilete prepollen grains corresponding to *P. kankakeensis* Peppers 1970 from the pteridosperm *Potoniea*; Long (1977a) also illustrated pteridospermous prepollen grains possibly assignable to *Punctatisporites*.

Punctatisporites aerarius Butterworth and Williams 1958

(Plate 2, figure 16)

1958 *Punctatisporites aerarius* Butterworth and Williams, p. 360, pl. 1, figs. 10, 11.

Occurrence -- Rare, observed in the Blackoak, Cliffland and Laddsdale Coals.

Punctatisporites edgarensis Peppers 1970

(Plate 2, figure 19)

1970 *Punctatisporites edgarensis* Peppers, p. 82-83, pl. 1, figs. 16, 17.
1979 *Punctatisporites* cf. *edgarensis* Peppers 1970; Ravn, p. 22, pl. 2, fig. 7.

Remarks -- *P. edgarensis* resembles *Sinuspores sinuatus* Artüz emend. in general size and thickness, but the latter displays conspicuous thickened folds that characteristically form a curvaturate ridge. *P. obesus* (Loose) Potonié and Kremp 1955 and several other species are similar to *P. edgarensis* in size and thickness, but have no discernible ornamentation. Some specimens of *P. edgarensis* display coarsely convolute ridges developed strongly enough to suggest that they might better be placed in the genus *Convolutispora*, but most are less distinctly ornamented. Ravn (1979) distinguished two forms, one of which (designated *P.* cf. *edgarensis*) was more strongly ornamented. Examination of many samples subsequent to the completion of that report has led to the conclusion that these are only morphologic variants of the species, and further distinction is unwarranted.

Occurrence -- Rare, observed in the Blackoak, Laddsdale and Carruthers Coals.

Punctatisporites flavus (Kosanke) Potonié and Kremp 1955

(Plate 2, figure 15)

1950 *Calamospora flava* Kosanke, p. 41, pl. 9, fig. 2.
1955 *Punctatisporites flavus* (Kosanke) Potonié and Kremp, p. 42.

Occurrence -- Rare, observed from the Wildcat Den Coal through the Whitebreast Coal.

Punctatisporites glaber (Naumova) Playford 1962

(Plate 1, figures 18, 19)

1938 *Azonotriletes glaber* (Naumova) Waltz, in Luber and Waltz, p. 8, pl. 1, fig. 2, pl. A, fig. 3.
1952 *Leiotriletes glaber* (Waltz) Ishchenko, p. 13-14, pl. 2, figs. 15, 16.
1955 *Calamospora glabra* (Naumova) Potonié and Kremp, p. 47.
1955 *Punctatisporites? callosus* Hoffmeister, Staplin and Malloy, p. 392, pl. 39, fig. 7.
non 1957 *Punctatisporites callosus* Artüz, p. 242, pl. 1, fig. 5.
1956 *Leiotriletes glaber* Naumova; Ishchenko, p. 18-19, pl. 1, figs. 7, 8.
1957 *Punctatisporites planus* Hacquebard, p. 308, pl. 1, fig. 12.
1960 *Punctatisporites curviradiatus* Staplin, p. 7, pl. 1, figs. 17, 20.
1979 *Punctatisporites* cf. *curviradiatus* Staplin 1960; Ravn, p. 22, pl. 1, figs. 13-15.

Remarks -- Playford (1962) discussed the difficulties of speciation among spores with this general morphology. Numerous other synonyms undoubtedly exist, and the stratigraphic utility of these forms is limited, although their occurrence in the Pennsylvanian of Iowa appears to be near the top of their reported range. Playford (1962) considered *P. nitidus* Hoffmeister, Staplin and Malloy 1955 to be synonymous with *P. glaber* but Smith and Butterworth (1967) disagreed.

Occurrence -- Rare to frequent, observed in most coals from the Wyoming Hill through the unnamed coal of the Floris Formation; most common in the Blackoak, Cliffland and Laddsdale Coals.

Punctatisporites sp. cf. *P. incomptus* Felix and Burbridge 1967

(Plate 1, figure 14)

cf. 1967 *Punctatisporites incomptus* Felix and Burbridge, p. 357, pl. 53, fig. 12.
1982 *Punctatisporites* cf. *incomptus* Felix and Burbridge 1967; Ravn and Fitzgerald, p. 113, pl. 1, fig. 10.

Remarks -- *P.* sp. cf. *P. incomptus* resembles the species described by Felix and Burbridge (1967), but is smaller and has slightly less pronounced folds along the trilete rays.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Punctatisporites irrasus Hacquebard 1957

(Plate 1, figures 15, 16)

1957 *Punctatisporites irrasus* Hacquebard, p. 308, pl. 1, figs. 7, 8.

Remarks -- This species closely resembles *P. fissus* Hoffmeister, Staplin and Malloy 1955 (non *P. fissus* Leschik 1956) in size and overall appearance, especially of the trilete laesura, which is usually seen gaping open in a manner similar to that of the specimens illustrated here. *P. fissus* is described as 'distinctly granular' (Hoffmeister, Staplin and Malloy, 1955, p. 393); the surface of *P. irrasus* is 'finely infragranulose (peppery)' (Hacquebard, 1957, p. 308). Synonymy is possible, but determination of such requires a close examination of the types of both species.

Occurrence -- Rare, observed in the Wildcat Den and Wyoming Hill Coals and in the Kilbourn Formation.

Punctatisporites kankakeensis Peppers 1970

(Plate 2, figures 20, 21)

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

Occurrence -- Rare, observed in the Blackoak and Bevier Coals.

Punctatisporites minutus Kosanke emend. Peppers 1964

(Plate 1, figure 9)

1950 *Punctati-sporites minutus* Kosanke, p. 15-16, pl. 16, fig. 3.
1964 *Punctatisporites minutus* Kosanke emend. Peppers, p. 31, pl. 4, fig. 7.
non 1967 *Punctatisporites minutus* auct. non Kosanke 1950; Smith and Butterworth, p. 126, pl. 1, figs. 15, 16.

Occurrence -- Frequent to sometimes dominant throughout the section. Usually most abundant in the Blackoak and Cliffland Coals. Tends to be less abundant than the distinctly monolete and elongate *Punctatosporites minutus* Ibrahim 1933 in coals younger than the Laddsdale complex.

Punctatisporites sp. cf. *P. nudus* Artüz 1957

(Plate 1, fig. 17)

cf. 1957 *Punctatisporites nudus* Artüz, p. 241, pl. 1, fig. 4.
1970 *Punctatisporites* sp. 1 Peppers, p. 84, pl. 2, fig. 8.
1979 *Punctatisporites* cf. *nudus* Artüz 1957; Ravn, p. 22, pl. 2, fig. 1.

Remarks -- Spores designated here as *P.* sp. cf. *P. nudus* closely resemble the spores described by Artüz (1957), but they are of such a generalized morphology that they may correspond to other described species as well. They are generally larger than 40 µm in maximum diameter and have trilete rays 1/2 to 2/3 of the radius of the spore. The exine of these spores is thinner than that of *P. glaber* and the rays are symmetrical.

Occurrence -- Rare, observed in the Wildcat Den Coal, a shale from the basal Kilbourn Formation in core CP-6, the Blackoak, Cliffland and Laddsdale Coals.

Punctatisporites obesus (Loose) Potonié and Kremp 1955

(Plate 2, figures 17, 18)

1932 *Sporonites obesus* Loose, in Potonié, Ibrahim and Loose, p. 451, pl. 19, fig. 39.
1934 *Laevigatisporites obesus* (Loose) Loose, p. 145.
1944 *?Calamospora obesus* (Loose) Schopf, Wilson and Bentall, p. 52.
1955 *Punctatisporites obesus* (Loose) Potonié and Kremp, p. 43, pl. 11, fig. 124.
1964 *Punctatisporites potoniei* Venkatachala and Bharadwaj, p. 164, pl. 1, fig. 6.

Remarks -- Smith and Butterworth (1967) cited a size range for this species of 94-125 µm. Specimens as small as 68 µm in maximum diameter occur in Iowa coals (e.g., pl. 2, fig. 17). As a continuous gradation exists from these small forms into spores exceeding 120 µm, I consider all to be *P. obesus*. As *P. potoniei* was distinguished originally on the basis of its smaller size, I regard it as synonymous.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Wheeler.

Genus *GRANULATISPORITES* Ibrahim emend. Potonié and Kremp 1954.

Type species -- *G. granulatus* Ibrahim 1933.

Remarks -- Distinction of species within *Granulatisporites* is difficult, as many appear to intergrade within miospore populations. The stratigraphic utility of many *Granulatisporites* species therefore is limited. Forms documented in this report are presented mainly to illustrate the range of morphologic variability within this complex genus in the Pennsylvanian of Iowa.

Paleobotanical affinities -- Various filicineans (Mamay, 1950; Harris, 1961; Grauvogel-Stamm and Doubinger, 1975; Scott, 1978; Good, 1979). Millay, Eggert and Dennis (1978) suggested that certain primitive prepollen grains associated with Lyginopterids might be assignable to *Granulatisporites*. An important Lower Carboniferous species from the southern hemisphere, *G. frustulentus* (Balme and Hassell) Playford 1971, has been termed a 'lycosporoid' element in the miospore flora (Kemp et al., 1977); morphologically, it resembles the lycopsid-related genus *Lycospora* more closely than it does the triangular, azonate spores typical of *Granulatisporites*. Turnau (1978) proposed a new genus, *Prolycospora*, to accommodate *G. frustulentus* and several similar species.

Granulatisporites adnatus Kosanke 1950

(Plate 2, figures 1, 2)

1950 *Granulati-sporites adnatus* Kosanke, p. 20, pl. 3, fig. 10.
1955 *Leiotriletes adnatoides* Potonié and Kremp, p. 38, pl. 11, figs. 112-115.
? 1955 *Leiotriletes adnatus* (Kosanke) Potonié and Kremp, p. 39, pl. 11, fig. 111.

1960 *Granulatisporites parvigranulatus* Staplin, p. 15, pl. 3, figs. 8, 9.
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.

Remarks -- Smith and Butterworth (1967), Ravn (1979) and Ravn and Fitzgerald (1982) have discussed the close similarity between *G. adnatus* and *G. adnatoides.* Further study indicates that the variability of sculpture within this complex of forms is entirely transitional between the two species. No useful stratigraphic purpose is achieved by maintenance of the subtle morphologic distinction between them, and I therefore consider them synonymous. The possibility exists of further synonymies with other described species.

Occurrence -- Rare to common, observed in all coals from the Wildcat Den to the unnamed coal of the Floris Formation.

Granulatisporites granularis Kosanke 1950

(Plate 2, figures 3, 4)

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

Remarks -- Potonié and Kremp (1955) considered *G. granularis* to be synonymous with *G. piroformis* Loose 1934. Their illustrated specimens (Potonié and Kremp, 1955, pl. 12, figs. 152-156), which include the holotype (fig. 152), appear to be ornamented more coarsely than does the type specimen of *G. granularis.* The generalized morphology and distinct, finely granulose ornament of *G. granularis* also are characteristic of several other species, however, suggesting the likelihood of further synonymy.

Occurrence -- Rare to occasionally frequent, observed in most coals from the Wildcat Den through the Whitebreast.

Granulatisporites granulatus Ibrahim 1933

(Plate 2, figure 9)

1933 *Granulati-sporites granulatus* Ibrahim, p. 22, pl. 6, fig. 51.
1950 *Plani-sporites granulatus* (Ibrahim) Knox, p. 315, pl. 17, fig. 217.
1957a *Granitriletes granifer* Dybová and Jachowicz, pl. 125-127, pl. 31, fig. 3.
1958 *Acanthotriletes granulatus* (Ibrahim) Ishchenko, p. 47, pl. 3, fig. 41.
non 1969 *Acanthotriletes granulatus* Gupta, p. 164, pl. 31, fig. 44.

Occurrence -- Rare, observed in most coals from the Wildcat Den to the Wheeler.

Granulatisporites microgranifer Ibrahim 1933

(Plate 2, figures 5, 6)

1933 *Granulatisporites microgranifer* Ibrahim, p. 22, pl. 5, fig. 32.
1938 *Azonotriletes microgranifer* (Ibrahim) Luber, in Luber and Waltz, pl. 7, fig. 92.
1950 *Plani-sporites microgranifer* (Ibrahim) Knox, p. 315, pl. 17, fig. 218.
1956 *Lophotriletes microgranifer* (Ibrahim) Ishchenko, p. 38, pl. 5, figs. 70, 71.
1957a *Granitriletes microgranifer* (Ibrahim) Dybová and Jachowicz, p. 127, pl. 31, fig. 4.

Remarks -- *G. microgranifer* has a finer, more closely spaced granulose sculpture than does the similar-sized *G. minutus* Potonié and Kremp 1955. Potonié and Kremp (1955) cited a size range of 25?-40 μm for *G. microgranifer* but Smith and Butterworth (1967) cited a range of 18-28 μm. Specimens observed in Iowa coals agree closely with the size of those described by Smith and Butterworth.

Occurrence -- Rare to frequent, observed in coals from the Kilbourn Formation through the Whitebreast.

Granulatisporites minutus Potonié and Kremp 1955

(Plate 2, figures 11, 12)

1955 *Granulatisporites minutus* Potonié and Kremp, p. 59, pl. 12, figs. 147, 148.

Occurrence -- Rare, but observed in nearly all coals throughout the section.

Granulatisporites pallidus Kosanke 1950

(Plate 2, figure 10)

1950 *Granulati-sporites pallidus* Kosanke, p. 21, pl. 3, fig. 3.

Remarks -- Potonié and Kremp (1955) considered *G. pallidus* to be synonymous with *G. parvus* (Ibrahim) Potonié and Kremp 1955, but observations of Guennel (1958) and Peppers (1970) indicate that the two species are distinct. *G. pallidus* is concavely triangular with relatively fine, closely spaced grana; *G. parvus* normally is convexly triangular with coarse, more widely spaced grana and a darkened zone adjacent to the trilete mark.

Occurrence -- Rare, but observed in most coals throughout the section.

Granulatisporites parvus (Ibrahim) Schopf, Wilson and Bentall 1944

(Plate 2, figure 14)

1932 *Sporonites parvus* Ibrahim, in Potonié, Ibrahim and Loose, p. 448, pl. 16, fig. 21.
1933 *Punctati-sporites parvus* (Ibrahim) Ibrahim, pl. 2, fig. 21.
non 1977 *Punctatisporites parvus* Anderson, p. 67(9.3), pl. 65, figs. 1-7.
1934 *Reticulati-sporites parvus* (Ibrahim) Loose, p. 154, pl. 7, fig. 18.
1944 *Granulati-sporites parvus* (Ibrahim) Schopf, Wilson and Bentall, p. 33.
1950 *Microreticulati-sporites 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.

Occurrence -- Rare, observed in the Wildcat Den, Cliffland, Blackoak and Laddsdale Coals.

Granulatisporites sp. cf. *G. piroformis* Loose 1934

(Plate 2, figures 7, 8, 13)

cf. 1934 *Granulati-sporites piroformis* Loose, p. 147, pl. 7, fig. 19.
cf. 1938 *Azonotriletes piroformis* (Loose) Luber, in Luber and Waltz, pl. 5, fig. 65.
cf. 1950 *Plani-sporites piroformis* (Loose) Knox, p. 316, pl. 17, fig. 219.
cf. 1952 *Acanthotriletes piriformis* (*sic*) (Loose) Ishchenko, pl. 5, fig. 53.
1967 *Granulatisporites* cf. *piroformis* Loose 1934; Smith and Butterworth, p. 141-142, pl. 4, figs. 1-3.
1982 *Granulatisporites* cf. *piroformis* Loose 1934; Ravn and Fitzgerald, p. 117, pl. 2, figs. 10, 11.

Remarks -- Smith and Butterworth (1967) illustrated specimens designated *G.* cf. *piroformis* that correspond closely to those observed in Iowa coals. They described the sculpture of their specimens as 'closely packed, rounded grana (with) bases touching' (Smith and Butterworth, 1967, p. 141), but their illustrations show specimens with what appear to be rather widely spaced grana. The principal difference between the type description of *G. piroformis* (see Potonié and Kremp, 1955) and specimens observed in Iowa coals is that the latter are smaller, ranging from 20-28 μm in maximum diameter. See also Remarks under *G. granularis*.

Occurrence -- Rare to abundant, Wildcat Den Coal; rare to frequent in unnamed coals of the Caseyville Formation and the Wyoming Hill Coal; rare in the Kilbourn Formation.

Granulatisporites verrucosus (Wilson and Coe) Schopf, Wilson and Bentall 1944

(Plate 3, figures 1, 2)

1940 *Triquitrites verrucosus* Wilson and Coe, p. 185, fig. 10.
1944 *Granulati-sporites verrucosus* (Wilson and Coe) Schopf, Wilson and Bentall, p. 33.
1950 *Plani-sporites verrucosus* (Wilson and Coe) Knox, p. 316, pl. 17, fig. 221.
non 1958 *Triquitrites verrucosus* Alpern, p. 77, pl. 1, fig. 6.

Remarks -- Schopf, Wilson and Bentall (1944) reassigned this species to *Granulatisporites* under their broad generic definition, which included spores with a deltoid amb and wide variation in ornament. The narrower definition of *Granulatisporites* by Potonié and Kremp (1954), followed by most subsequent workers, restricted the genus to spores with granulose sculpture. Despite the specific epithet *verrucosus* and the statement of Wilson and Coe (1940) describing the sculptural elements as papillae, the ornament is best characterized as large, loosely-spaced grana. The assignment to *Granulatisporites* as presently defined therefore appears appropriate. The ornament of *G. verrucosus*, however, is coarser than that of other species of the genus.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Whitebreast.

Genus *CYCLOGRANISPORITES* Potonié and Kremp 1954

Type species -- *C. leopoldii* (Kremp) Potonié and Kremp 1954.

Paleobotanical affinities -- Various filicineans, marattialeans and lyginopterids (Andrews and Mamay, 1948; Laveine, 1969; Skog et al., 1969; Pfefferkorn, Peppers and Phillips, 1971; Thomas and Crampton, 1971; Galtier and Grambast, 1972; Courvoisier and Phillips, 1975; Millay and Taylor, 1976, 1982, 1984; Millay, Eggert and Dennis, 1978; Mapes and Schabilion, 1979; Taylor and Millay, 1981; Stubblefield et al., 1982; Scott, Galtier and Clayton, 1985; Stidd, Rischbieter and Phillips, 1985). Various ontogenetic and phylogenetic relationships also may exist among finely granulose or granulose-punctate spores individually assignable to or intermediate among the genera *Cyclogranisporites*, *Punctatisporites*, *Punctatosporites* and *Laevigatosporites*. Jennings (1976) demonstrated *in situ* variation of prepollen grains from ovoid-monolete to spherical-trilete forms in certain lyginopterid pollen organs; Millay (1979a) suggested that one of the genera (*Telangium*) cited by Jennings as a lyginopterid fructification is instead of marattialean affinity. Thus, spores (or prepollen) assignable to the form-genus *Cyclogranisporites* appear to have been produced by a large complex of plants of diverse affinities. The species of *Cyclogranisporites* reported *in situ* from a lycopod cone by Hagemann (1966a) has been transferred to *Lycospora* (*L. orbicula*) by Smith and Butterworth (1967) because of the presence of a narrow cingulum.

Cyclogranisporites aureus (Loose) Potonié and Kremp 1955

(Plate 3, figures 11, 12)

1934 *Reticulati-sporites aureus* Loose, p. 155, pl. 7, fig. 24.
1944 *Punctati-sporites aureus* (Loose) Schopf, Wilson and Bentall, p. 30.
1950 *Plani-sporites aureus* (Loose) Knox, p. 315, pl. 17, fig. 209.
1955 *Cyclogranisporites aureus* (Loose) Potonié and Kremp, p. 61, pl. 13, figs. 184-186.
1964 *Cyclogranisporites fuscus* Venkatachala and Bharadwaj, p. 169, pl. 5, figs. 50-52.

Occurrence -- Rare to frequent, the Kilbourn Formation to the Mulky Coal.

Cyclogranisporites lasius (Waltz) Playford 1962

(Plate 3, figures 15, 16)

1938 *Azonotriletes lasius* Waltz, in Luber and Waltz, p. 9, pl. 1, fig. 4, pl. A, fig. 4.
1953 *Trachytriletes lasius* (Waltz) Naumova, pl. 5, fig. 20.
1955 *Filicitriletes lasius* (Waltz) Luber, p. 55, pl. 2, fig. 50.
1962 *Cyclogranisporites lasius* (Waltz) Playford, p. 585, pl. 79, figs. 19, 20.

Remarks -- *C. lasius* resembles smaller specimens of *C. aureus* but lacks the thickenings along the trilete rays characteristic of the latter species.

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale from the basal Kilbourn Formation in core CP-6.

Cyclogranisporites leopoldii (Kremp) Potonié and Kremp 1954

(Plate 3, figures 9, 10)

1952 *Granulatisporites leopoldi* Kremp, p. 348, pl. 15b, figs. 15, 16.
1952 *Granulatisporites aspersus* Imgrund, p. 24, figs. 35-38 (Invalid; unpublished thesis).
1954 *Cyclogranisporites leopoldi* (Kremp) Potonié and Kremp, p. 126, pl. 20, fig. 103.
1955 *Cyclogranisporites aspersus* (Imgrund) Potonié and Kremp, p. 60 (*Nomen nudum*; no description or illustration).

Occurrence -- Rare, observed in the Blackoak, Cliffland, Laddsdale and Summit Coals.

Cyclogranisporites microgranus Bhardwaj 1957

(Plate 3, figures 17, 18)

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

Occurrence -- Rare, observed in most coals from the Blackoak through the Wheeler.

Cyclogranisporites minutus Bhardwaj 1957 emend.

(Plate 3, figures 3, 4)

1957a *Cyclogranisporites minutus* Bhardwaj, p. 83, pl. 22, figs. 22, 23.
1957a *Cyclogranisporites parvus* Bhardwaj, p. 83, pl. 23, figs. 7, 8.
non 1977 *Cyclogranisporites parvus* (Lakhanpal, Sah and Dube) Anderson, p. 74 (9.3), pl. 72, figs. 1-9.
1960 *Cyclogranisporites* cf. *minutus* Bhardwaj 1957: Staplin, p. 9, pl. 1, fig. 28.
1964a *Cyclogranisporites* cf. *minutus* Bhardwaj 1957; Sullivan, p. 360, pl. 57, figs. 17, 18.
1967 *Cyclogranisporites* cf. *minutus* Bhardwaj 1957: Smith and Butterworth, p. 143, pl. 4, figs. 4-7.

Emended diagnosis (modified after Bhardwaj, 1957a, and Smith and Butterworth, 1967) -- Trilete miospores, amb circular, trilete rays straight, simple, extending two-thirds to three-fourths of radius, often asymmetrical in arrangement and length. Larger specimens tend to display poorly-defined darkenings along the rays. Exine thin, often heavily folded. Ornament of uniform minute grana 0.5-1.0 μm in diameter, separated from one another by spaces equal to or slightly greater than their diameter, on both proximal and distal surfaces. 50 to 100 grana project from margin.

Size (100 specimens from the Iowa Pennsylvanian) -- 26-44 μm, maximum diameter.

Remarks -- Although recognized as a distinct species by Ravn (1979), *C. parvus* is regarded here as synonymous with *C. minutus.* Examination of additional material has demonstrated that both forms intergrade indistinguishably in miospore populations throughout the Iowa section.

Occurrence -- Rare to common, observed in most coals throughout the section; tends to be most abundant in the Caseyville Formation, Blackoak and Cliffland Coals.

Cyclogranisporites obliquus (Kosanke) Upshaw and Hedlund 1967

(Plate 3, figures 6-8)

1950 *Punctati-sporites obliquus* Kosanke, p. 16, pl. 2, fig. 5.
non 1964 *Punctatosporites obliquus* (auct. non Kosanke) Venkatachala and Bhardwaj, p. 184, pl. 1, fig. 194.

1967 *Cyclogranisporites obliquus* (Kosanke) Upshaw and Hedlund, p. 150, pl. 2, fig. 5.
1967 *Leschikisporis obliquus* (Kosanke) Wilson and Venkatachala, p. 364.

Remarks -- In Technical Paper 6, Ravn (1979) discussed this species under the name *Punctatisporites obliquus*. Upshaw and Hedlund (1967) transferred the species to *Cyclogranisporites* because of its finely granulose ornament. In Iowa coals, ornamentation of miospores having the general morphology of *C. obliquus* varies from granulose to nearly laevigate. As discussed by Ravn (1979), a complete intergradation of morphology appears to exist between larger asymmetrically trilete forms assigned to *C. obliquus* and smaller monolete forms assigned more appropriately either to *Laevigatosporites globosus* Schemel 1951 or to *Punctatosporites granifer* Potonié and Kremp emend. Alpern and Doubinger 1973. Habib (1966) and Peppers (1970) noted a similar intergradation of forms. Certain Iowa coal samples displayed a preponderance of one form or the other, and several contained abundant numbers of miospores corresponding closely to the description and illustration of Upshaw and Hedlund (1967), whose reassignment of the species seems appropriate.

Courvoisier and Phillips (1975) documented *in situ* variation from the trilete to the monolete condition among spores of this kind. The genus *Leschikisporis* Potonié 1958, erected to accommodate asymmetrically trilete miospores, appears to be of little value in light of such paleobotanical study, and its distinction from *Punctatisporites* and *Cyclogranisporites* is not maintained in this report. See also discussions by Peppers (1970) for *Punctatisporites obliquus* and *Laevigatosporites globosus*.

Occurrence -- Even though certain samples were found to contain smaller or larger forms selectively, no reliable stratigraphic pattern to these variations in occurrence was seen. The local variations in abundance of one kind over another may reflect unknown paleoenvironmental factors or ontogenetic relationships among the spores. As in Technical Paper 6, the overall occurrence information for this complex of miospores is summarized under *Laevigatosporites globosus*.

Cyclogranisporites orbicularis (Kosanke) Potonié and Kremp 1955

(Plate 3, figure 5)

1950 *Punctati-sporites orbicularis* Kosanke, p. 16, pl. 2, fig. 9.
1955 *Cyclogranisporites orbicularis* (Kosanke) Potonié and Kremp, p. 60.

Remarks -- As suggested by Peppers (1970), the symmetrically trilete forms assignable to *C.* (*Punctatisporites*) *orbicularis* may intergrade with the *C. obliquus* complex discussed previously. In the Iowa coals, *C. orbicularis* forms were comparatively rare, and were considered separately.

Occurrence -- Rare, observed in the Blackoak, Cliffland, Laddsdale and Wheeler Coals.

Cyclogranisporites peppersii n. name

(Plate 3, figures 13, 14)

1970 *Cyclogranisporites breviradiatus* Peppers, p. 88-89, pl. 4, figs. 1-3.
non 1959 *Cyclogranisporites breviradiata* de Jersey, p. 5(1960), pl. 1, fig. 18.

Remarks -- Erection of a new name is necessary in light of the homonymy cited above. The specific epithet is in honor of Dr. R. A. Peppers of the Illinois State Geological Survey, who originally described the species.

Occurrence -- Rare, observed only in the Wheeler Coal. Peppers (1970) reported this distinctive species in Illinois Basin coals from the Colchester (No. 2) Coal upward; the Colchester is considered stratigraphically equivalent to the Whitebreast Coal in Iowa (see text-figure 12), which lies immediately below the Wheeler. Therefore the oldest appearance of *C. peppersii* may represent a useful horizon for correlation in Iowa and Illinois.

Cyclogranisporites staplinii (Peppers) Peppers 1970

(Plate 21, figure 22)

1964 *Punctatisporites staplini* Peppers, p. 35, pl. 5, figs. 5, 6.
1970 *Cyclogranisporites staplini* (Peppers) Peppers, p. 89, pl. 4, fig. 5.

Remarks -- Peppers (1970) noted that the rather coarse ornamentation of this species resembles that of certain species assigned to *Cyclobaculisporites* Bhardwaj 1955, a genus made invalid by transfer of its type species to *Verrucosisporites*. Smith (1971) reported that the genus had been revalidated through designation of a new type species, but no provision for such revalidation of a genus exists under rules of the ICBN. *Cyclogranisporites* appropriately accommodates *C. staplinii*, and possibly several other of the species assigned by various authors to *Cyclobaculisporites*.

Occurrence -- Rare, but observed in most coals from the Blackoak to the Mystic.

Cyclogranisporites sp. 1

(Plate 3, figure 19)

1970 *Cyclogranisporites* sp. 1 Peppers, p. 89, pl. 4, fig. 6.

Remarks -- Only two specimens of this distinctive miospore were observed during this study. These appear to be identical to the species designated *C.* sp. 1 by Peppers (1970).

Occurrence -- Extremely rare, observed only in the Wheeler Coal. Peppers (1970) observed *C.* sp. 1 only in the Colchester (No. 2) Coal in Illinois, a unit stratigraphically equivalent to the Whitebreast, which underlies the Wheeler.

Genus *VERRUCOSISPORITES* Ibrahim emend. Smith and Butterworth 1967

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

Paleobotanical affinities -- Various filicineans and marattialeans (Remy and Remy, 1955a, 1957; Murdy and Andrews, 1957; Phillips and Rosso, 1970; Courvoisier and Phillips, 1975; Mapes and Schabilion, 1979; Millay, 1979b; Millay and Taylor, 1982). Stidd, Rischbieter and Phillips (1985) have documented prepollen grains assignable to *Verrucosisporites* from the fructification of a lyginopterid pteridosperm.

Verrucosisporites donarii Potonié and Kremp 1955

(Plate 4, figures 18, 19)

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

Occurrence -- Rare, but observed regularly in coals from the Blackoak through the Whitebreast.

Verrucosisporites microtuberosus (Loose) Smith and Butterworth 1967

(Plate 4, figure 13)

1932 *Sporonites microtuberosus* Loose, in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 33.
1934 *Tuberculati-sporites microtuberosus* (Loose) 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. 86.
1957a *Tuberculatisporites regularis* Dybová and Jachowicz, p. 114, pl. 26, figs. 1-4.
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. 4, figs. 9-11.

Remarks -- Loboziak (1971) and Ravn (1979) considered *Cyclogranisporites pergranulus* Alpern 1958 to be synonymous with *V. microtuberosus*. Alpern's species was transferred to *Verrucosisporites* by Venkatachala and Bharadwaj (1964) and subsequently emended by Smith and Alpern (in Smith, 1971). Comparison of the descriptions and illustrations in Smith (1971) indicate that the verrucae of *V. microtuberosus* are more closely spaced than that of *V. pergranulus*; the latter species also is characterized as being oval in outline. These distinctions are subtle and are not recognized easily on many specimens, but Smith (1971) examined the type material of both species and considered them distinct.

Occurrence -- Rare, but observed regularly from the Kilbourn Formation to the Whitebreast Coal.

Verrucosisporites morulatus (Knox) Potonié and Kremp emend. Smith and Butterworth 1967

(Plate 4, figures 11, 12, 20)

1948 Type 20K Knox, text-fig. 23.
1950 *Verrucoso-sporites morulatus* Knox, p. 318, pl. 17, fig. 235.
1955 *Verrucosisporites morulatus* (Knox) Potonié and Kremp, p. 65.
1967 *Verrucosisporites morulatus* (Knox) Potonié and Kremp emend. Smith and Butterworth, p. 152, pl. 5, figs. 15, 16.
1968 *Spackmanites rotundus* Habib, p. 202, pl. 2, figs. 2, 3.

Occurrence -- Rare to common, observed only in the Wildcat Den and Wyoming Hill Coals and in a shale sample from the base of the Kilbourn Formation in core CP-6.

Verrucosisporites sp. cf. *V. nitidus* Playford 1964

(Plate 4, figure 10)

cf. 1953 *Lophotriletes grumosus* Naumova, p. 57, pl. 7, figs. 14, 15.
non 1952 *Lophotriletes grumosus* (Ibrahim) Ishchenko.
cf. 1956 *Lophotriletes* aff. *grumosus* (Naumova) Ishchenko, p. 40, pl. 7, fig. 74.
1962 *Convolutispora stigmoidea* Bharadwaj and Venkatachala, p. 21, pl. 1, figs. 3-7.
cf. 1964b *Verrucosisporites grumosus* (Naumova) Sullivan, p. 1252, pl. 1, figs. 9-15.
non 1933 *Verrucosi-sporites grumosus* Ibrahim, p. 25, pl. 8, fig. 68.
cf. 1964 *Verrucosisporites nitidus* Playford, p. 13, pl. 3, figs. 3-6.

Remarks -- Only a single specimen was observed during this study; it is smaller than spores normally assigned to the species, but otherwise is similar.

Occurrence -- Extremely rare, observed only in the Wildcat Den Coal.

Verrucosisporites sifatii (Ibrahim) Smith and Butterworth 1967

(Plate 4, figures 16, 17)

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.
1957a *Tuberculatisporites permagnus* Dybová and Jachowicz, p. 113, pl. 25, figs. 1-4.

Occurrence -- Rare, observed in the Blackoak, Cliffland and Laddsdale Coals.

Verrucosisporites verrucosus (Ibrahim) Ibrahim 1933

(Plate 4, figures 14, 15)

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.
1933 *Verrucosi-sporites microverrucosus* Ibrahim, p. 25, pl. 7, fig. 60.

1938 *Azonotriletes verrucosus* (Ibrahim) Luber, in Luber and Waltz, pl. 7, fig. 95.
1944 *Punctati-sporites verrucosus* (Ibrahim) Schopf, Wilson and Bentall, p. 32.
1944 *Punctati-sporites microverrucosus* (Ibrahim) Schopf, Wilson and Bentall, p. 31.
1950 *Verrucoso-sporites verrucosus* (Ibrahim) Knox, p. 319, pl. 17, fig. 230.
1950 *Verrucoso-sporites microverrucosus* (Ibrahim) Knox, p. 318, ?pl. 17, fig. 228.
1957a *Tuberculatisporites gigantonodatus* Dybová and Jachowicz, p. 116, pl. 27, figs. 1-4.

Occurrence -- Rare to frequent, observed regularly in coals from the Wildcat Den through the Laddsdale.

The following new names are proposed to correct problems of homonymy:

Verrucosisporites henshawensis n. name:
1964 *Punctatisporites rudis* Peppers, p. 34, pl. 5, figs. 3, 4.
1971 *Verrucosisporites rudis* (Peppers) Smith, p. 74, pl. 20, figs. 1-3.
non 1956 *Verrucosisporites rudis* Leschik, p. 15, pl. 1, fig. 15.

Derivation -- The specific epithet is chosen after the type stratigraphic unit, the Henshaw Formation (Upper Pennsylvanian) of western Kentucky (Peppers, 1964).

Verrucosisporites kaiserii n. name:
1971 *Verrucosisporites densus* Kaiser, p. 132, pl. 34, pl. 34, figs. 3-5.
non 1970 *Verrucosisporites densus* (Bolkhovitina) Pocock, p. 46, pl. 9, fig. 2.
non 1977 *Verrucosisporites densus* Bharadwaj and Tiwari, p. 33, pl. 3, figs. 33-35.

Derivation -- After H. Kaiser, who originally described the species.

Genus *LOPHOTRILETES* Naumova emend. Potonié and Kremp 1954

Type species -- *L. gibbosus* (Ibrahim) Potonié and Kremp 1955.

Paleobotanical affinities -- Filicinean (Remy and Remy, 1957; Taylor and Eggert, 1969; Good, 1979; Millay and Taylor, 1982).

Lophotriletes commissuralis (Kosanke) Potonié and Kremp 1955

(Plate 4, figures 1, 2)

1950 *Granulati-sporites 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* auct. non (Kosanke) Potonié and Kremp 1955; Imgrund, p. 164, pl. 15, figs. 66-68.
1965a *Lophisporites commissuralis* (Kosanke) Laveine, p. 133.

Occurrence -- Rare to frequent, observed in most coals from the Wildcat Den to the Bevier.

Lophotriletes copiosus Peppers 1970

(Plate 5, figure 1)

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

Occurrence -- Rare, observed in the Blackoak, Cliffland and Laddsdale Coals.

Lophotriletes gibbosus (Ibrahim) Potonié and Kremp 1955

(Plate 5, figure 8)

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 *Granulati-sporites gibbosus* (Ibrahim) Schopf, Wilson and Bentall, p. 33.
1950 *Verrucoso-sporites gibbosus* (Ibrahim) Knox, p. 317, pl. 17, fig. 232.
1952 *Acanthotriletes gibbosus* (Ibrahim) Ishchenko, pl. 5, fig. 48.
1954 *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp, p. 129 (Invalid; basionym not stated).
1955 *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp, p. 74, pl. 14, figs. 220, 221.
non 1958 *Lophotriletes gibbosus* auct. non (Ibrahim) Potonie and Kremp; Guennel, p. 62, pl. 3, fig. 3.
1965a *Lophisporites gibbosus* (Ibrahim) Laveine, p. 133.

Occurrence -- Rare, observed in most coals from the Kilbourn Formation through the Bevier.

Lophotriletes? granoornatus Artüz 1957

(Plate 4, figure 9)

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

Remarks -- Ravn (1979) discussed the possibility that this species might be placed equally well in *Granulatisporites*; see also the discussion by Peppers (1970).

Occurrence -- Rare, observed only in the Blackoak and Laddsdale Coals.

Lophotriletes ibrahimii (Peppers) Pi-Radondy and Doubinger 1968

(Plate 5, figures 11-13)

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

Occurrence -- Rare to frequent, observed regularly in the Blackoak, Cliffland and Laddsdale Coals; tends to be most abundant in the Cliffland.

Lophotriletes microsaetosus (Loose) Potonié and Kremp 1955

(Plate 4, figures 5, 6)

1932 *Sporonites microsaetosus* Loose, in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 46.
1933 *Setosi-sporites microsaetosus* (Loose) Ibrahim, p. 26.
1934 *Setosisporites microsaetosus* (Loose) Loose, p. 148.
1944 *Granulati-sporites 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* auct. non (Ibrahim) Potonié and Kremp; Guennel, p. 62, pl. 3, fig. 3.
1960 *Lophotriletes commissuralis* auct. non (Kosanke) Potonié and Kremp; Imgrund, p. 164, pl. 15, figs. 66-68.
1965a *Lophisporites microsaetosus* (Loose) Laveine, p. 133.

Remarks -- This species may intergrade morphologically with *Pilosisporites aculeolatus* (Kosanke) n. comb.

Occurrence -- Rare to frequent, observed in most coals from the Wildcat Den to the Mulky.

Lophotriletes mosaicus Potonié and Kremp 1955

(Plate 4, figures 7, 8)

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

Remarks -- *L. cursus* Upshaw and Creath 1965 resembles *L. mosaicus* but is larger.

Occurrence -- Rare, observed in the Wildcat Den Coal, the Kilbourn Formation, the Blackoak and Cliffland Coals.

Lophotriletes pseudaculeatus Potonié and Kremp 1955

(Plate 5, figures 2, 3)

1955 *Lophotriletes pseudaculeatus* Potonié and Kremp, p. 75, pl. 14, figs. 20-22.
1965a *Lophisporites pseudaculeatus* (Potonié and Kremp) Laveine, p. 133.

Occurrence -- Rare, observed in the Kilbourn Formation, the Blackoak, Cliffland, Laddsdale and Bevier Coals.

Lophotriletes rarispinosus Peppers 1970

(Plate 4, figures 3, 4)

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

Occurrence -- Rare, observed in the Blackoak, Laddsdale, Whitebreast and Wheeler Coals.

Lophotriletes sp. cf. *L. tuberifer* (Imgrund) Potonié and Kremp, in Imgrund, 1960

(Plate 5, figures 4, 5)

cf. 1952 *Tuberculatisporites tuberifer* Imgrund, p. 31, fig. 64 (Invalid; unpublished thesis).
cf. 1955 *Lophotriletes tuberifer* (Imgrund) Potonié and Kremp, p. 73 (Invalid; type not figured).
cf. 1960 *Lophotriletes tuberifer* (Imgrund) Potonié and Kremp, in Imgrund, p. 163, pl. 14, fig. 42.

Remarks -- As noted by Ravn (1979), the specimens observed in Iowa were smaller than the size range for the species as reported by Imgrund (1960). By publishing a description and an illustration of the holotype, Imgrund (1960) validated the species.

Occurrence -- Rare, observed only in the Kilbourn Formation and the Blackoak Coal.

The following new name is proposed to correct a problem of homonymy:

Lophotriletes hardinsburgensis n. name:
1955 *Granulati-sporites tuberculatus* Hoffmeister, Staplin and Malloy, p. 389, pl. 36, fig. 12.
1964a *Lophotriletes tuberculatus* (Hoffmeister, Staplin and Malloy) Sullivan, p. 361.
non 1953 *Lophotriletes tuberculatus* Bolkhovitina, p. 32, pl. 3, fig. 5.
non 1956 *Lophotriletes tuberculatus* (Waltz) Ishchenko, p. 40, pl. 6, figs. 75, 76.

Derivation -- The new specific epithet is derived from the type stratigraphic unit, the Hardinsburg Formation (Upper Mississippian) of western Kentucky (Hoffmeister, Staplin and Malloy, 1955).

Genus *APICULATASPORITES* Ibrahim emend.

1933 *Apiculati-sporites* Ibrahim, p. 23 (in part).
1933 *Apiculata-sporites* Ibrahim, p. 37.
1954 *Apiculatisporites* Ibrahim emend. Potonié and Kremp, p. 130 (*non sensu* Bennie and Kidston, 1886).
1956b *Apiculatisporis* Potonié and Kremp, p. 94.
1966 *Apiculatasporites* Ibrahim emend. Visscher, p. 328.
1967 *Apiculatasporites* Ibrahim emend. Smith and Butterworth, p. 176.

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

Emended diagnosis -- Azonate trilete miospores; originally more or less spherical, amb circular or nearly so. Ornamented on both proximal and distal surfaces with discrete apiculate elements that may be coni or small spines, and may be of differing kinds on the same specimen. Sculptural elements not so large as to appreciably alter the overall spore outline. Sculptural elements may be reduced or absent from areas immediately adjacent to the trilete mark, but are not sharply restricted from the proximal surface.

Comparison -- *Apiculatasporites* as herein emended is distinguished from *Echinatisporis* Krutzsch 1959 by having conate ornament, at least in part, and by having smaller sculptural elements that do not appreciably alter the spore outline.

Remarks -- *Apiculatasporites* Ibrahim emend. is proposed here as the senior appropriate genus to encompass azonate trilete, more or less spherical miospores bearing apiculate sculpture of relatively uniform distribution over both proximal and distal surfaces. As noted, this emendation places in synonymy the widely-used *Apiculatisporis* Potonié and Kremp 1956. The taxonomic history of of these two genera is complex and confusing, and their distinction seems ultimately to rest on little more than inter-pretational and orthographic errors.

Ibrahim (1933) instituted two genera of regrettably similar spelling, *Apiculata-sporites* and *Apiculati-sporites* respectively, for the concepts of alete and trilete spores having apiculate sculpture. The only species assigned to the presumed alete genus, *Apiculata-sporites* and therefore its type species by monotypy, was *A. spinulistratus* (Loose) Ibrahim n. comb. Ibrahim made this transfer despite the fact that Loose (in Potonié, Ibrahim and Loose, 1932) described the species as trilete. Ibrahim (1933) stated that he was unable to detect the trilete mark described by Loose. This interpretation and the monotypic assignment to *Apiculata-sporites* proved unfortunate, as the holotype (reillustrated by Potonié and Kremp, 1955, pl. 14, fig. 214) clearly is trilete. The source of much of the taxonomic difficulty stems from this interpretational error.

In his originally trilete genus, *Apiculati-sporites* Ibrahim (1933) included both megaspores and miospores. A megaspore (designated *Triletes* VI by Bennie and Kidston, 1886) was selected as the type species. Potonié and Kremp (1954) maintained that the megaspores in *Apiculati-sporites* should be transferred to the senior genus *Tuberculatisporites*, thus removing the type species of the former genus and rendering it invalid. They proposed that *Apiculatisporites* be reserved for miospores, and designated a 'neotype' species, *A. aculeatus* Ibrahim 1933.

This procedure is contrary to the rules of the ICBN; the transfer of the type species of *Apiculatisporites* to *Tuberculatisporites* renders the former genus a junior synonym of the latter. Subsequently, Potonié and Kremp (1956b) recognized this procedural error, and they proposed a new genus, *Apiculatisporis* to encompass miospores formerly included in *Apiculatisporites*. They transferred *A. aculeatus* (Ibrahim) and designated it as the type species. Since then, *Apiculatisporis* has been used widely as a repository for spherical azonate trilete miospores with apiculate sculpture.

Following Ibrahim's (1933) transfer of *Sporonites spinulistratus* Loose 1932 to *Apiculata-sporites*, Loose (1934) evidently disagreed with Ibrahim's interpretation of the species as alete, and reassigned it to the trilete genus *Apiculati-sporites*. Citing only Loose's (1934) transfer, Potonié and Kremp (1955) reassigned the species again, to *Planisporites* Knox emend. Potonié and Kremp 1954. Although apparently inadvertent, this procedure had the effect of invalidating *Apiculatasporites* through transfer of its type species. The transfer, however, was from a senior to a junior genus, which again is contrary to the rules of the ICBN. Potonié (1958) recognized the invalidation of *Apiculatasporites* but apparently did not recognize the systematic error. Later, Potonié (1960) reversed this view, and decided that *Apiculatasporites* and *Planisporites* should be regarded as distinct genera, the former reserved for spores with a circular amb, the latter for those with a triangular amb. *Apiculatasporites* was distinguished from *Apiculatisporis* by virtue of the latter having somewhat larger sculptural elements, although this criterion was not explicitly specified.

Visscher (1966) emended the diagnosis of *Apiculatasporites* but did not compare it to *Apiculatisporis*. Smith and Butterworth (1967) independently emended *Apiculatasporites* for the explicit purpose of distinguishing it more clearly from *Apiculatisporis*. In their emendation, *Apiculatasporites* was reserved for spores with small sculptural elements ('not much greater than that of grana'; Smith and Butterworth, 1967, p. 176), and *Apiculatisporis* for spores with larger sculptural elements. In general, the assignment of new species to *Apiculatasporites* in preference to *Apiculatisporis* (e.g., Playford, 1964; Gupta, 1969; Peppers and Damberger, 1969; Butterworth and Mahdi, 1982) has followed this somewhat ambiguous and subjective distinction. Many exceptions exist, however. The assignment of apparently alete miospores to *Apiculatasporites* by Leschik (1956) and Nilsson (1958) is improper; many of these species have since been reassigned.

Smith and Butterworth (1967, p. 176) described the size of the sculptural elements of *Apiculatasporites spinulistratus* as 'generally about 1 μ but may reach about 2.5 μ.' The sculpture of *Apiculatisporis aculeatus* was described as 'about 2.5 μ in height.' (Smith and Butterworth, 1967, p. 170). Several other species assigned to *Apiculatisporis* (e.g., *A. latigranifer*) have an ornament of cones or spines of similar size. The simple size of the sculptural elements therefore does not constitute a consistent or reliable criterion for generic distinction. Many species display wide variation in the size of the sculptural elements even on individual specimens.

The difference between cones and spines has been regarded as of generic significance by many authors, with *Apiculatisporis* reserved for spores with conate ornament. This, too, is a highly variable characteristic, however, and many species display both cones and spines (as well as other kinds of projections) within individual specimens. The distinction between cones and spines is usually defined by the height vs. the basal width of an individual element. The height of cones is greater than the basal width, but not more than twice the basal width, whereas spines have a height exceeding twice the basal width (Smith and Butterworth, 1967). With smaller sculptural elements, however, this determination can be exceedingly difficult, and in many cases the height of the sculptural elements is so close to twice the basal width that the distinction becomes meaningless.

In my view, this subjective distinction in size and the arbitrary distinction in the height-width ratio of the sculptural elements is not sufficient for generic differentiation among this complex of miospores. Clearly, Ibrahim (1933) intended, however erroneously, to distinguish *Apiculata-sporites* from *Apiculati-sporites* based on the presence or absence of a trilete mark among spores having similar kinds of sculpture. The determination of the trilete nature of the type species of the supposedly alete genus renders *Apiculata-sporites* and *Apiculati-sporites* as proposed by Ibrahim, synonymous. The selection of *A. aculeatus* by Potonié and Kremp (1956b) as the type species of *Apiculatisporis* did not establish a morphotype on which to base a genus recognizably distinct from *Apiculatasporites* as typified by *A. spinulistratus*. Subsequent emendations seem designed mainly to rescue a nebulous generic differentiation based ultimately on an erroneous morphologic interpretation. I see no reason to perpetuate this distinction, and I regard the two genera as synonymous. *Apiculatasporites* has clear priority, and I proposed that *Apiculatisporis* be suppressed.

Paleobotanical affinity -- Miospores assignable to *Apiculatasporites* as emended here have been recovered from the fructifications of zygopterid ferns (Pfefferkorn, Peppers and Phillips, 1971; Galtier and Scott, 1979; Scott, Galtier and Clayton, 1985).

Apiculatasporites aculeatus (Ibrahim) n. comb.

(Plate 5, figures 6, 7)

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.
1956a *Apiculatisporis aculeatus* (Ibrahim) Potonié and Kremp, p. 94.

Occurrence -- Rare, observed only in the Kilbourn Formation and the Blackoak Coal.

Apiculatasporites latigranifer (Loose) n. comb.

(Plate 6, figure 7)

1932 *Sporonites latigranifer* Loose, in Potonié, Ibrahim and Loose, p. 452, pl. 19, fig. 54.
1934 *Granulati-sporites latigranifer* (Loose) Loose, p. 147.
1944 *Punctati-sporites latigranifer* (Loose) Schopf, Wilson and Bentall, p. 31.
1950 *Spinoso-sporites latigranifer* (Loose) Knox, p. 314, pl. 17, fig. 200.
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, observed in the Wildcat Den Coal, a shale sample from the basal Kilbourn Formation in core CP-6, and the Blackoak Coal.

Apiculatasporites saetiger (Peppers) n. comb.

(Plate 5, figure 16)

1964 *Punctatisporites saetiger* Peppers, p. 30, pl. 4, figs. 1, 2.
1979 *Apiculatisporis saetiger* (Peppers) Peppers and Ravn, in Ravn, p. 30, pl. 7, figs. 4, 5.

Remarks -- This small, ovoid, asymmetrically trilete species may be a morphologic variant of spinose monolete spores similar to *Spinosporites exiguus* Upshaw and Hedlund 1967, related in a manner similar to the intergradations of morphology noted for the *Cyclogranisporites obliquus-Laevigatosporites globosus* complex discussed previously.

Occurrence -- Rare, observed in coals from the Kilbourn Formation through the Wheeler.

Apiculatasporites setulosus (Kosanke) n. comb.

(Plate 6, figure 6)

1950 *Punctati-sporites setulosus* Kosanke, p. 15, pl. 2, fig. 1.
1955 *Apiculatisporites setulosus* (Kosanke) Potonié and Kremp, p. 77.
1962 *Apiculatisporis setulosus* (Kosanke) Piérart, tabl. 2.

Occurrence -- Rare, but observed in most coals throughout the section.

Apiculatasporites spinososaetosus (Loose) n. comb.

(Plate 5, figure 18)

1932 *Sporonites spinososaetosus* Loose, in Potonié, Ibrahim and Loose, p. 452, pl. 19, fig. 55.
1933 *Apiculati-sporites spinososaetosus* (Loose) Ibrahim, p. 24.
1944 *Raistrickia spinososaetosus* (Loose) Schopf, Wilson and Bentall, p. 56.
1955 *Apiculatisporites spinosaetosus* (*sic*) (Loose) Loose 1934; Potonié and Kremp, p. 80, pl. 14, figs. 22, 23.
1962 *Apiculatisporis spinosaetosus* (*sic*) (Loose) Piérart, tabl. 2.
1967 *Apiculatisporis spinososaetosus* (Loose) emend. Smith and Butterworth, p. 173, pl. 7, figs. 22, 23.

Occurrence -- Rare, observed in most coals from the Kilbourn Formation through the Wheeler.

Apiculatasporites spinulistratus (Loose) Ibrahim 1933

(Plate 5, figures 14, 15)

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) Loose, p. 153.
1934 *Apiculati-sporites globosus* Loose, p. 152, pl. 7, fig. 14.
non 1956 *Apiculatisporites globosus* Leschik, p. 18, pl. 2, fig. 8.
1944 *Punctati-sporites spinulistratus* (Loose) Schopf, Wilson and Bentall, p. 31.
1944 *Punctati-sporites globosus* (Loose) Schopf, Wilson and Bentall, p. 31.
1950 *Spinoso-sporites spinulistratus* (Loose) Knox, p. 314, pl. 17, fig. 202.
1950 *Spinoso-sporites globosus* (Loose) Knox, p. 313, pl. 17, fig. 199.
1955 *Planisporites spinulistratus* (Loose) Potonié and Kremp, p. 71, pl. 14, figs. 214-219.

Occurrence -- Rare, observed in a shale sample from the basal Kilbourn Formation in core CP-6, the Blackoak and Laddsdale Coals.

Apiculatasporites valvatus n. sp.

(Plate 6, figures 10-12)

Diagnosis -- Miospores radial, trilete, amb sphaerotriangular. Exine moderately thick (c. 2-2.5 μm), ornamented on both proximal and distal surfaces with widely spaced coni 1-3 μm in height and basal width. 30-45 coni project from equatorial margin. Space between individual coni usually greater than basal widths of coni. Trilete rays straight, usually gaping open, sometimes appearing to bifurcate at the ends, extending 1/2 to 2/3 of radius. A conspicuous zone of infrasculptural punctae occurs in a slightly thickened region adjacent to the laesura. These punctae may appear as more or less circular pits, or as a row of elongate furrows oriented perpendicular to the trilete rays. The zone of punctae usually extends nearly to the ends of the rays, and the thickened region extends to the angles, giving the spores a vaguely valvate appearance.

Size -- (10 specimens) 41-67 μm maximum diameter excluding ornament.

Remarks -- *A. valvatus* differs from other species of the genus in displaying faint valvae and in possessing the conspicuous punctate region adjacent to the laesura. The assignment of this species to *Apiculatasporites* is made with reservation, and based primarily on the nature of the sculpture. The broadly sphaerotriangular amb and the presence of vague valvae are unusual for the genus.

Derivation -- The specific epithet refers to the characteristic valvae.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Type exposure of the Swede Hollow Formation (see Ravn et al., 1984, p. 34), Lucas County, Iowa: Bevier Coal, Desmoinesian Series.

Occurrence -- Rare, observed only in the Bevier Coal.

Apiculatasporites variocorneus (Sullivan) n. comb.

(Plate 6, figures 8, 9)

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

Occurrence -- Rare, observed from the Wildcat Den Coal through the Blackoak Coal.

Apiculatasporites variusetosus (Peppers) n. comb.

(Plate 5, figure 17)

1964 *Punctatisporites variusetosus* Peppers, p. 34, pl. 5, figs. 1, 2.

Occurrence -- Rare, observed only in the Cliffland Coal.

Apiculatasporites sp. 1

(Plate 5, figure 19)

Description -- Miospore radial, trilete, amb broadly sphaerotriangular. Exine moderately thick, evenly ornamented on both proximal and distal surfaces with small, widely spaced sharp spines, except in the immediate region of the laesura, where the exine is essentially laevigate. Spines 3-4 μm in height, tapering to a basal width of 2-3 μm. Space between individual spines greater than basal width of spines. Trilete rays straight, simple, 2/3 of radius.

Size of illustrated specimen -- 53.0 μm maximum diameter excluding ornament.

Remarks -- The extremely sharp spines serve to distinguish *A.* sp. 1 from other described species. Too few specimens were observed to permit assessment of morphologic variability and no new species is formally erected.

Occurrence -- Rare, observed only in an unnamed coal of the Kilbourn Formation.

The following species conform to *Apiculatasporites* Ibrahim emend. and are transferred:

Apiculatasporites grandis (Hoffmeister, Staplin and Malloy) n. comb.:
1955 *Punctati-sporites grandis* Hoffmeister, Staplin and Malloy, p. 393, pl. 36, fig. 7.

Apiculatasporites iucundus (Venkatachala and Bharadwaj) n. comb.:
1964 *Apiculatisporis iucundus* Venkatachala and Bhardwaj, p. 172, pl. 6, fig. 67.

Apiculatasporites lentus (Playford) n. comb:
1982 *Apiculatisporis lentus* Playford, in Playford, Rigby and Archibald, p. 10, pl. 7, figs. 9-13.

Apiculatasporites microconus (Richardson) n. comb.:
1965 *Apiculatisporis microconus* Richardson, p. 566, pl. 89, fig. 3.
1966 *Cyclogranisporites* sp., McGregor and Owens, pl. 5, fig. 5.

Apiculatasporites microechinatus (Owens) n. comb.:
1971 *Apiculatisporis microechinatus* Owens, p. 14, pl. 2, figs. 4, 6, 7.

Apiculatasporites ovalis (Nilsson) n. comb.:
1958 *Acanthotriletes ovalis* Nilsson, p. 40, pl. 2, figs. 8, 9.
1963 *Planisporites ovalis* (Nilsson) Danzé-Corsin and Laveine, p. 74, pl. 5, figs. 37, 38a.
non 1957a *Planisporites ovalis* Bhardwaj, p. 86, pl. 23, figs. 9, 10.
1964 *Osmundacidites ovalis* (Nilsson) Reinhardt, p. 49, pl. 1, figs. 12, 13.
1965 *Apiculatisporis ovalis* (Nilsson) Norris, p. 245, figs. 2b, 18, 22, 23.
1966 *Baculatisporites microechinus* Schulz, p. 130, pl. 1, figs. 3-5.

Apiculatasporites punctaornatus (Artüz) n. comb.:
1957 *Apiculatisporites punctaornatus* Artüz, p. 245, pl. 3, fig. 15.

Apiculatasporites spinosus (Loose) n. comb.:
1934 *Apiculati-sporites spinosus* Loose, p. 153, pl. 7, fig. 20.
1944 *Punctati-sporites spinosus* (Loose) Schopf, Wilson and Bentall, p. 31.
1950 *Spinoso-sporites spinosus* (Loose) Knox, p. 314, pl. 7, fig. 201.
1963 *Apiculatisporis spinosus* (Loose) Love and Neves, p. 65.
1967 *Apiculatisporis spinosus* (Loose) Gupta, p. 162, pl. 31, fig. 37.

Apiculatasporites subspinosus (Artüz) n. comb.:
1957 *Apiculatisporites subspinosus* Artüz, p. 245, pl. 3, fig. 16.

The following new names are proposed to avoid or correct problems of homonymy:

Apiculatasporites leschikii n. name.:
1956 *Apiculatisporites globosus* Leschik, p. 18, pl. 2, fig. 8.
non 1934 *Apiculati-sporites globosus* Loose, p. 157, pl. 7, fig. 14.
1958 *Bracteolinasporites clavatus* Nilsson, p. 48, pl. 3, fig. 1.
1964a *Cyclotriletes globosus* (Leschik) Mädler, p. 39.
1965 *Apiculatisporis globosus* (Leschik) Playford and Dettmann, p. 137, pl. 13, figs. 16-18.

Derivation -- After G. Leschik, who originally described the species.

Apiculatasporites paraguayensis n. name:
1967 *Apiculatisporites grandis* Menéndez and Pöthe de Baldis, p. 163, pl. 2, fig. J.

Derivation -- After the country of origin. This name is proposed to avoid homonymy with *A. grandis* (Hoffmeister, Staplin and Malloy) n. comb.

Genus *PILOSISPORITES* Delcourt and Sprumont emend. Döring 1965

Type species -- *P. trichopapillosus* (Thiergart) Delcourt and Sprumont 1955.

Remarks -- I consider *Pilosisporites* to be an appropriate generic repository for many triangular species heretofore assigned to *Acanthotriletes*. As discussed in the Remarks under the genus *Echinatisporis*, *Acanthotriletes* is typified in such a manner as to render it inappropriate for miospores. A common conception of *Pilosisporites* (e.g., Sullivan and Marshall, 1966) is that the spinose ornament is concentrated at the apices. This distribution of ornament, however, is not defined as a generic characteristic (Delcourt and Sprumont, 1955; Döring, 1965), nor is it characteristic of the type species, which has an evenly distributed spinose ornament. Reassignment of most triangular *Acanthotriletes* species to *Pilosisporites* is therefore appropriate.

Paleobotanical affinities -- In the Paleozoic, at least, filicinean: Remy and Remy (1957) and Good (1979, 1981) have recovered spores corresponding morphologically to *Pilosisporites* from filicinean fructifications. Baxter (1971) suggested a lycopsid affinity for triangular spores he regarded as assignable to *Acanthotriletes* but the specimens he illustrated appear to have spines restricted to the distal surface and are more properly assignable to *Anacanthotriletes* n. gen., described later in this report.

Pilosisporites aculeolatus (Kosanke) n. comb.

(Plate 7, figure 5)

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

Remarks -- *P. aculeolatus* resembles *Lophotriletes microsaetosus* but has longer, more prominent spines. The two species may intergrade.

Occurrence -- Rare, observed in the Kilbourn Formation, the Blackoak, Laddsdale and Whitebreast Coals.

Pilosisporites dimorphus (Habib) n. comb.

(Plate 7, figures 8, 9)

1966 *Acanthotriletes dimorphus* Habib, p. 637, pl. 105, figs. 10, 11.

Occurrence -- Rare, observed in the Kilbourn Formation, the Cliffland, Laddsdale and Mulky Coals.

Pilosisporites sp. cf. *P. falcatus* (Knox) n. comb.

(Plate 7, figure 10)

cf. 1948 Type 18K Knox, p. 157, fig. 15.
cf. 1950 *Spinoso-sporites falcatus* Knox, p. 313, pl. 17, fig. 205.
cf. 1955 *Acanthotriletes falcatus* (Knox) Potonié and Kremp, p. 84.
1979 *Acanthotriletes* cf. *falcatus* (Knox) Potonié and Kremp 1955; Ravn, p. 31, pl. 7, fig. 15.

Remarks -- As noted by Ravn (1979), the ornamental elements of the species illustrated here are more widely distributed than are those of *A. falcatus* as illustrated in previous literature (e.g., Smith and Butterworth, 1967).

Occurrence -- Extremely rare, observed only in the Blackoak coal.

Pilosisporites triquetrus (Smith and Butterworth) n. comb.

(Plate 7, figures 6, 7)

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

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

Occurrence -- Rare to frequent, observed in most coals from the Kilbourn Formation through the Mystic.

Pilosisporites williamsii n. sp.

(Plate 7, figures 1-3)

1967 *Acanthotriletes echinatus* (Knox) Potonié and Kremp 1955; Smith and Butterworth, p. 178, pl. 8, fig. 10 only.
1979 *Acanthotriletes echinatus* (Knox) Potonié and Kremp 1955; Ravn, p. 31, pl. 7, fig. 12.
1982 *Acanthotriletes* cf. *echinatus* (Knox) Potonié and Kremp 1955; Ravn and Fitzgerald, p. 124-125, pl. 4, figs. 10, 11.

Diagnosis -- Miospores radial, azonate, trilete, amb triangular to subtriangular. Trilete rays straight, simple, in some specimens open, extending 2/3 to 3/4 of radius. Uniformly ornamented on both proximal and distal surfaces with sharp spines 3-5 μm long, 1-2 μm wide at their bases; bases of spines do not touch, and spines generally are separated from one another by spaces wider than the bases of the spines themselves. Interradial sides straight to slightly convex, rarely one or two sides of a given specimen may be slightly concave. Specimens usually preserved in off-polar compressions, suggesting a strongly pyramidal original shape.

Size -- (20 specimens) 22.1-28.5 μm maximum diameter excluding ornament.

Comparison -- *P. williamsii* resembles *P. triquetrus* in size, but the latter species differs in having consistently concave interradial sides, a less pyramidal shape, resulting in common polar compressions, and in having somewhat less robust spines.

Remarks -- This species is proposed to accommodate triangular spores assigned by Smith and Butterworth (1967) to *Acanthotriletes echinatus* (Knox) Potonié and Kremp 1955. Knox (1950) illustrated a circular specimen in erecting the species, but neither she nor Potonié and Kremp (1955) selected a type. Smith and Butterworth (1967, p. 178, pl. 8, fig. 9) designated a circular specimen as a neotype, thus validating the species. They also embraced oval and triangular specimens in the species. I believe this conception of the species to be unjustified and prefer to restrict the species to circular forms as represented by the neotype and by the illustration of Knox (1950). To accommodate the triangular spore represented by the specimen illustrated on plate 8, figure 10 of Smith and Butterworth (1967) and those illustrated in this report, erection of a new species is necessary.

Derivation -- The specific epithet is in honor of Dr. John E. Williams of British Petroleum Company, in recognition of his work on Carboniferous miospores of Britain and elsewhere.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-19 unit 4, Wapello County, Iowa (see Ravn, 1979); Blackoak Coal, Kalo Formation, uppermost Atokan Series.

Occurrence -- Rare to frequent, observed in the Wildcat Den Coal, the Kilbourn Formation, the Blackoak, Cliffland and Laddsdale Coals.

The following species conform to *Pilosisporites* and are therefore transferred:

Pilosisporites bellus (Bose and Kar) n. comb.:
1966 *Acanthotriletes bellus* Bose and Kar, p. 72, pl. 19, figs. 7, 8.

Pilosisporites bradiensis (Playford) n. comb.:
1965 *Acanthotriletes bradiensis* Playford, p. 182-183, pl. 7, figs. 8-11.

Pilosisporites castanea (Butterworth and Williams) n. comb.:
1958 *Acanthotriletes castanea* Butterworth and Williams, p. 365-366, pl. 1, fig. 35.

Pilosisporites concavus (Pi-Radondy and Doubinger) n. comb.:
1968 *Apiculatisporis concavus* Pi-Radondy and Doubinger, p. 414, pl. 3, fig. 5.

Pilosisporites filiformis (Balme and Hennelly) n. comb.:
1956 *Apiculatisporites filiformis* Balme and Hennelly, p. 247, pl. 2, figs. 22, 23.
1965 *Apiculatisporis filiformis* (Balme and Hennelly) Pant and Srivastava, p. 472, pl. 1, fig. 1.
1965 *Acanthotriletes filiformis* (Balme and Hennelly) Tiwari, p. 173, pl. 1, figs. 19, 20.

Pilosisporites golenvauxii (Kar and Bose) n. comb.:
1967 *Acanthotriletes golenvauxii* Kar and Bose, p. 20, pl. 1, fig. 24; pl. 2, figs. 6, 7.

Pilosisporites hastatus (Sullivan and Marshall) n. comb.:
1966 *Acanthotriletes hastatus* Sullivan and Marshall, p. 267, pl. 1, figs. 7-9.

Pilosisporites intonsus (Playford) n. comb.:
1971b *Acanthotriletes intonsus* Playford, p. 19, pl. 5, figs. 1-8.

Pilosisporites microspinosus (Ibrahim) n. comb.:
1933 *Apiculati-sporites microspinosus* Ibrahim, p. 24, pl. 6, fig. 52.
1950 *Spinoso-sporites microspinosus* (Ibrahim) Knox, p. 314, pl. 17, fig. 204.
1955 *Acanthotriletes microspinosus* (Ibrahim) Potonié and Kremp, p. 84, pl. 14, fig. 258.

Pilosisporites splendidus (Neves) n. comb.:
1961 *Acanthotriletes splendidus* Neves, p. 253, pl. 30, fig. 5.

Pilosisporites superbus (Foster) n. comb.:
1979 *Acanthotriletes superbus* Foster, p. 34, pl. 5, figs. 20-25.

Pilosisporites tereteangulatus (Balme and Hennelly) n. comb.:
1956 *Acanthotriletes tereteangulatus* Balme and Hennelly, p. 247-248, pl. 2, figs. 27-29.
1964 *Lophotriletes sparsus* H. P. Singh, p. 247, pl. 44, fig. 23.

Pilosisporites varius (Nilsson) n. comb.:
1958 *Acanthotriletes varius* Nilsson, p. 42, pl. 2, fig. 10.
1963 *Anemiidisporites echinatus* (auct. non Ross) Danzé-Corsin and Laveine, p. 76, pl. 6, figs. 5-7b.
1964b *Anemiidites spinosus* Mädler, p. 180, pl. 2, fig. 11.
1964 *Anemiidites* sp., Reinhardt, p. 50, pl. 2, fig. 11.
1970 *Pilosisporites brevipapillosus* auct. non Couper 1958; Pocock, p. 49, pl. 8, figs. 8, 9.
1973 *Anemiidites echinatus* auct. non Ross 1949; Orbell, pl. 3, fig. 4.
1977 *Acanthotriletes varius* Nilsson emend. Schuurman, p. 186, pl. 4, figs. 1-3.

Genus *RAISTRICKIA* Schopf, Wilson and Bentall emend. Potonié and Kremp 1954

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

Remarks -- Speciation within *Raistrickia* probably has been excessively narrow. Many described species are so rare and variable in morphology as to be essentially useless for biostratigraphic purposes. In contrast, the morphologic conception of the genus itself has been used in a very broad sense by many authors to include species ornamented with serrate setae or bacula, clavae and relatively sharp spines. The type species, *R. grovensis* is ornamented with low, broad bacula that have flat or serrate apices and may coalesce at their bases. Certain species having nearly spinose sculptural elements (e.g., *R. crinita*, *R. subcrinita*) might be considered possibly assignable to *Echinatisporis*.

Paleobotanical affinities -- Filicinean (Radforth, 1938, 1939; Mamay, 1950; Remy and Remy, 1955a; Phillips and Andrews, 1965; Grauvogel-Stamm and Doubinger, 1975; Mickle, 1980).

Raistrickia? abdita (Loose) Schopf, Wilson and Bentall 1944

(Plate 6, figures 1-3)

1932 *Sporonites abditus* Loose, in Potonié, Ibrahim and Loose, p. 451, pl. 19, fig. 53.
1934 *Verrucosi-sporites abditus* (Loose) 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) Piérart, tabl. 2.

Remarks -- The questionable assignment to *Raistrickia* accommodates this species more appropriately than any other, in light of the revision of *Apiculatasporites* proposed previously in this report. The sculpture of *R.? abditus* consists dominantly of blunt, commonly truncated cones that are usually fused at their bases and are essentially restricted to the distal and equatorial portions of the surface. In my view, *Apiculatasporites* (=*Apiculatisporis*) should be restricted to species having discrete, sharply pointed coni or small spines that are not usually fused and are distributed relatively evenly over both distal and proximal surfaces. The robust, truncated cones of this species resemble the short, partly fused bacula of the type species of *Raistrickia* (*R. grovensis*).

Occurrence -- Rare, but observed regularly in most coals throughout the section.

Raistrickia breveminens Peppers 1970

(Plate 8, figures 1-3)

1970 *Raistrickia breveminens* Peppers, p. 102, pl. 7, figs. 3, 4; text-fig. 23A.

Remarks -- *R. breveminens* resembles *R. fulva* Artüz 1957, but differs in having more crowded bacula with more prominently lacerated terminations.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Whitebreast; most regularly observed in the Caseyville and Kilbourn Formation coals.

Raistrickia sp. cf. *R. clavata* Hacquebard emend. Playford 1964

(Plate 7, figure 14)

cf. 1957 *Raistrickia clavata* Hacquebard, p. 310, pl. 1, fig. 25.
cf. 1957 *Raistrickia pistillata* Hacquebard, p. 310-311, pl. 2, fig. 2.
cf. 1964 *Raistrickia clavata* Hacquebard emend. Playford, p. 24-25, pl. 6, figs. 5-10.
1970 *Raistrickia* cf. *clavata* Hacquebard emend. Playford 1964; Peppers, p. 104, pl. 7, fig. 7.

Remarks -- Peppers (1970) attached the reservation to his assignment of this species in Illinois because of the original observations of *R. clavata* in much older (Mississippian) strata; a similar designation is applied here. Morphologically, this spore is virtually identical to the type description and illustrations of Hacquebard (1957) and Playford (1964). The specimens observed in Iowa occur at a stratigraphic horizon very close to that noted by Peppers (1970) in Illinois.

Occurrence -- Extremely rare, observed only in the Wheeler Coal.

Raistrickia crinita Kosanke 1950

(Plate 7, figures 17-19)

1950 *Raistrickia crinita* Kosanke, p. 46, pl. 11, fig. 7.

Occurrence -- Rare, but observed regularly from the Wheeler Coal upward throughout the section.

Raistrickia irregularis Kosanke 1950

(Plate 6, figures 4, 5)

1950 *Raistrickia irregularis* Kosanke, p. 47-48, pl. 11, fig. 5.

1955 *Apiculatisporites irregularis* (Kosanke) Potonié and Kremp, p. 77.
non 1967 *Apiculatisporis irregularis* (Alpern) Smith and Butterworth, p. 171-172, pl. 7, figs. 18, 19.
non 1971 *Apiculatisporis irregularis* Ybert, Nahuys and Alpern, p. 1609-1610, pl. 1, figs. 22-24.

Remarks -- This species may intergrade morphologically with *R.? abdita.*

Occurrence -- Rare, observed in the Blackoak, Cliffland, Laddsdale and Bevier Coals. The existence of specimens intermediate to *R.? abdita* makes firm assessment of occurrence difficult.

Raistrickia lacerata Peppers 1970

(Plate 8, figures 7, 8)

1970 *Raistrickia lacerata* Peppers, p. 104, pl. 7, figs. 12, 13; text-fig. 23C.

Occurrence -- Rare, observed in the Wildcat Den and Blackoak Coals.

Raistrickia lowellensis Peppers 1970

(Plate 8, figures 5, 6)

1970 *Raistrickia lowellensis* Peppers, p. 105, pl. 8, figs. 3, 4; text-fig. 23E.

Occurrence -- Rare, observed in the Kilbourn Formation, the Blackoak, Cliffland, Laddsdale and Wheeler Coals.

Raistrickia sp. cf. *R. macra* Bhardwaj 1957

(Plate 7, figure 12)

cf. 1957a *Raistrickia macra* Bhardwaj, p. 89, pl. 23, fig. 23.
1979 *Raistrickia* cf. *macra* Bhardwaj 1957; Ravn, p. 32, pl. 8, fig. 8.

Remarks -- Specimens observed in Iowa samples tend to be smaller than the size range reported by Bhardwaj (1957a), but correspond in other morphologic details.

Occurrence -- Extremely rare, observed only in the Blackoak Coal.

Raistrickia pilosa Kosanke 1950

(Plate 7, figure 11)

1950 *Raistrickia pilosa* Kosanke, p. 48, pl. 11, fig. 4.
non 1976 *Spinozonotriletes pilosa* (auct. non Kosanke) Kaiser, p. 127-128, pl. 11, fig. 12.

Occurrence -- Rare, observed in the Kilbourn Formation, the Blackoak and Bevier Coals.

Raistrickia protensa Kosanke 1950

(Plate 8, figure 4)

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

Occurrence -- Rare, observed only in the Blackoak Coal.

Raistrickia saetosa (Loose) Schopf, Wilson and Bentall 1944

(Plate 8, figure 9)

1932 *Sporonites saetosus* Loose, in Potonié, Ibrahim and Loose, p. 452, pl. 19, fig. 56.
1933 *Setosi-sporites saetosus* (Loose) Ibrahim, p. 26.
1944 *Raistrickia saetosus* (Loose) Schopf, Wilson and Bentall, p. 56.
1950 *Raistrickia crocea* Kosanke, p. 47, pl. 11, fig. 6.

Occurrence -- Rare, but observed regularly in most coals throughout the section.

Raistrickia subcrinita Peppers 1970

(Plate 7, figures 15, 16)

1970 *Raistrickia subcrinita* Peppers, p. 108, pl. 8, figs. 5, 6; text-fig. 23F.

Occurrence -- Rare, but observed regularly from the Whitebreast Coal upward throughout the section.

Raistrickia superba (Ibrahim) Schopf, Wilson and Bentall 1944

(Plate 7, figure 13)

1933 *Setosi-sporites superbus* Ibrahim, p. 27, pl. 5, fig. 42.
1944 *Raistrickia superbus* (Ibrahim) Schopf, Wilson and Bentall, p. 56.
1965a *Raistrickisporites superbus* (Ibrahim) Laveine, p. 133.

Occurrence -- Rare, observed in the Kilbourn Formation, and in the Blackoak and Cliffland Coals.

Raistrickia sp. 1

(Plate 8, figure 12)

Description -- Miospore radial, trilete, amb roundly triangular. Rays straight, simple, approximately 2/3 of radius. Exine profusely ornamented by cone-shaped setae up to 10 μm in height; basal width of individual setae less than height, but setae tend to fuse with one another at their bases. Setae blunt or rounded at apices. Setae are distributed relatively evenly over the distal surface and equatorial region, but are reduced in size on the proximal surface and are absent from the region of the laesura; approximately 30 setae project at the margin. Exine apart from setae laevigate, relatively thick and dark.

Size of illustrated specimen -- 66.7 μm maximum diameter excluding ornament.

Remarks -- *R.* sp. 1 displays ornament similar to that of *R. irregularis* but the latter species (see pl. 6, fig. 5), as its name implies, usually has more variation in the size and distribution of sculptural elements. Although *R.* sp. 1 may represent an unusually robust variant of *R. irregularis* or some other described species of the genus, its striking morphology does not correspond closely with any other species. Too few specimens were observed to resolve the range of morphology adequately for the formal erection of a new species.

Occurrence -- Extremely rare, observed only in a coal of the Laddsdale complex.

The following new name is proposed to correct a problem of homonymy:

Raistrickia iowana n. name:
1971 *Raistrickia densa* Urban, p. 139, pl. 39, figs. 3-8.
non 1965 *Raistrickia densa* Menéndez, p. 57, pl. 7, figs. 4, 5.

Derivation -- The new specific epithet recognizes the state of Iowa, from which this species was first described (Urban, 1971).

Genus *CONVOLUTISPORA* Hoffmeister, Staplin and Malloy 1955

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

Paleobotanical affinities -- Filicinean (Radforth, 1938; Cridland, 1966; Jennings and Eggert, 1977).

Convolutispora cerina Ravn 1979

(Plate 8, figures 10, 11)

1964 *Convolutispora* sp. 2 Peppers, p. 17, pl. 1, fig. 17.
1979 *Convolutispora cerina* Ravn, p. 32-33, pl. 8, figs. 12-15.

Occurrence -- Rare, observed in the Blackoak and Cliffland Coals.

Convolutispora florida Hoffmeister, Staplin and Malloy 1955

(Plate 9, figures 1-6)

1955 *Convolutispora florida* Hoffmeister, Staplin and Malloy, p. 384, pl. 38, figs. 5, 6.
1965a *Convolutisporites floridus* (Hoffmeister, Staplin and Malloy) Laveine, p. 132.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Cliffland; one questionable occurrence in a coal of the Laddsdale complex.

Convolutispora fromensis Balme and Hassell 1962

(Plate 9, figure 7)

1962 *Convolutispora fromensis* Balme and Hassell, p. 8, pl. 1, figs. 14-16.

Remarks -- Although the species originally was described from the Upper Devonian of Australia (Balme and Hassell, 1962), spores corresponding to *C. fromensis* have been reported from the Lower Carboniferous of Australia (Playford, 1971b, 1976, 1978, 1982; Playford and Satterthwait, 1985) and the Middle Pennsylvanian of Illinois (Peppers, 1970). *C. ampla* Hoffmeister, Staplin and Malloy 1955 has similarly fine ornament, but is much larger.

Occurrence -- Rare, observed in the Wildcat Den, Wyoming Hill and Blackoak Coals.

Convolutispora mellita Hoffmeister, Staplin and Malloy 1955

(Plate 9, figures 16-18)

1955 *Convolutispora mellita* Hoffmeister, Staplin and Malloy, p. 384-385, pl. 38, fig. 10.
1965a *Convolutisporites mellitus* (Hoffmeister, Staplin and Malloy) Laveine, p. 132, pl. 10, fig. 18.

Occurrence -- Rare, observed in the Wildcat Den Coal, the Kilbourn Formation, the Blackoak and Cliffland Coals.

Convolutispora papillosa (Ibrahim) n. comb.

(Plate 9, figs. 14, 15)

1933 *Verrucosi-sporites papillosus* Ibrahim, p. 25, pl. 5, fig. 44.
1944 *Punctati-sporites papillosus* (Ibrahim) Schopf, Wilson and Bentall, p. 31.
1950 *Verrucoso-sporites papillosus* (Ibrahim) Knox, p. 318, pl. 17, fig. 229.
non 1967 *Grumosisporites papillosus* (auct. non Ibrahim) Smith and Butterworth, p. 230, pl. 16, figs. 9-13.
1967 *Convolutispora lepida* Felix and Burbridge, p. 372, pl. 57, fig. 4.

Remarks -- Smith (1971) suggested the transfer of this species from *Verrucosisporites* to *Convolutispora* but did not formally effect it. Ravn and Fitzgerald (1982) recorded the species under the name *C. lepida* Felix and Burbridge.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Convolutispora sp. cf. *C. varicosa* Butterworth and Williams 1958

(Plate 9, figure 9)

cf. 1958 *Convolutispora varicosa* Butterworth and Williams, p. 372, pl. 2, figs. 22, 23.

Remarks -- *C.* sp. cf. *C. varicosa* possesses ornament similar to that of the species as described by Butterworth and Williams (1958), but is smaller.

Occurrence -- Extremely rare, observed only in the Wheeler Coal.

Convolutispora sp. 1

(Plate 9, figure 19)

Description -- Miospore radial, trilete, originally spherical. Rays straight, approximately 3/4 of radius, partly obscured by ornamentation of distal surface. Ornament of low, flat, partly convolute ridges evenly distributed over nearly the entire surface, reduced near the trilete mark. Ridges 1-1.5 µm high, 1-4 µm wide; individual elements variable in size and shape from relatively long branching or anastomosing ridges to small round verrucae or large grana 2 µm or less in diameter. Space between sculptural elements too narrow to accommodate additional elements of equal size. Exine 4-5 µm thick, visible as a 'rim' at the margin.

Size of illustrated specimen -- 58.7 µm maximum diameter.

Remarks -- *C.* sp. 1 displays sculptural characteristics intermediate to *Convolutispora* and certain species of *Verrucosisporites*. Spores of similar size in the latter genus (e.g. *V. verrucosus*) commonly are much thinner and often folded. The sculptural elements of *C.* sp. 1 are less those of other similar-sized species of *Convolutispora* (e.g., *C. mellita*).

Occurrence -- Extremely rare, observed only in the Blackoak Coal.

Genus *MICRORETICULATISPORITES* Knox emend. Potonié and Kremp 1954

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

Remarks -- Smith and Butterworth (1967) have lamented the choice of *M. lacunosus* as the type species, made by Potonié and Kremp (1954), as its ornamen-tation is not clearly microreticulate. In fact, although the line-drawing of Knox (1950, pl. 18, fig. 240) shows a microreticulate spore, the ornamentation of the specimen illustrated photographically by Potonié and Kremp (1955) might better be described as microfoveolate. As Knox's drawing is too generalized to serve as an accurate representation of the species, the illustration of Potonié and Kremp must be regarded as more properly representing the genotype. Given such a typification, *Microreticulatisporites* is in partial conflict with both *Foveotriletes* van der Hammen ex Potonié 1956 (non Pierce, 1961) and *Foveosporites* Balme 1957, genera erected to accommodate microfoveolate trilete spores.

Paleobotanical affinity -- Filicinean (Mamay, 1950; Setlik et al., 1979b).

Microreticulatisporites concavus Butterworth and Williams 1958

(Plate 9, figure 7)

1958 *Microreticulatisporites concavus* Butterworth and Williams, p. 367, pl. 1, figs. 55, 56.

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale sample from the basal Kilbourn Formation in core CP-6.

Microreticulatisporites futilis (Felix and Burbridge) n. comb.

(Plate 26, figures, 1, 2)

1967 *Foveosporites futilis* Felix and Burbridge, p. 377, pl. 57, fig. 13.
1979 *Microreticulatisporites nobilis* auct. non (Wicher) Knox 1950; Ravn, in part, pl. 9, fig. 12.

Remarks -- *M. futilis* resembles *M. nobilis* but possesses a finer grade of ornament and a somewhat less smooth outline at the margin. These morphotypes may intergrade to some degree, but *M. futilis* has been reported previously (Felix and Burbridge, 1967; Ravn and Fitzgerald, 1982) only from strata older than the base of the stratigraphic range cited for *M. nobilis* (e.g., Smith and Butterworth, 1967; van Wijhe and Bless, 1974; Clayton et al., 1977). Therefore, the relatively subtle morphologic distinction between *M. futilis* and *M. nobilis* may be of stratigraphic utility, and is maintained here. A specimen illustrated as *M. nobilis* by Ravn (1979, pl. 9, fig. 12) is more properly assignable to *M. futilis*; it is reillustrated in this report (pl. 26, fig. 2). The species is fully assignable to *Microreticulatisporites* as typified by *M. lacunosus* and is transferred without descriptive emendation. For diagnosis, see Felix and Burbridge (1967).

Occurrence -- Rare, observed in the Wildcat Den and Blackoak Coals.

Microreticulatisporites harrisonii Peppers 1970

(Plate 9, figures 11-13)

1970 *Microreticulatisporites harrisonii* Peppers, p. 110-111, pl. 9, fig. 1.

Remarks -- *M. harrisonii* resembles *M. concavus* but the latter species has 'domed' muri that give the type specimens (Butterworth and Williams, 1958, pl. 1, figs. 55, 56) a roughened outline. The margin of *M. harrisonii* is relatively smooth and the interradial sides commonly are more or less straight. Specimens observed in Iowa coals often were somewhat larger than the size range cited by Peppers (1970) of 28.3-33.8 μm.

Occurrence -- Rare, observed in the Wildcat Den and Wyoming Hill Coals, the Kilbourn Formation and the Blackoak Coal.

Microreticulatisporites hortonensis Playford 1964

(Plate 9, figure 8)

1957 *Microreticulatisporites* sp. A Hacquebard, p. 311, pl. 2, fig. 6.
1964 *Microreticulatisporites hortonensis* Playford, p. 28, pl. 8, figs. 3, 4.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Microreticulatisporites lacunosus (Ibrahim) Knox 1950

(Plate 10, figure 4)

1933 *Reticulati-sporites lacunosus* Ibrahim, p. 36, pl. 6, fig. 50.
non 1950 *Reticulati-sporites lacunosus* Kosanke, p. 26, pl. 5, fig. 5.
1944 *Punctati-sporites lacunosus* (Ibrahim) Schopf, Wilson and Bentall, p. 31.
1950 *Microreticulati-sporites lacunosus* (Ibrahim) Knox, p. 320, pl. 18, fig. 240.

Remarks -- *M. lacunosus* resembles *M. nobilis* (Wicher) Knox 1950, but is considerably larger and has a finer grade of ornamentation. See also Remarks under the genus.

Occurrence -- Extremely rare, observed only in the Blackoak Coal.

Microreticulatisporites nobilis (Wicher) Knox 1950

(Plate 10, figures 1-3)

1934 *Sporites nobilis* Wicher, p. 186, pl. 8, fig. 30.
1944 *Punctati-sporites nobilis* (Wicher) Schopf, Wilson and Bentall, p. 31.
1950 *Microreticulati-sporites nobilis* (Wicher) Knox, p. 321, pl. 18, fig. 242.

Remarks -- *M. nobilis* is similar to *M. fistulosus* (Ibrahim) Knox 1950, the latter being slightly larger. A minority of the specimens observed in Iowa coals fell into the size range cited for *M. fistulosus* by Potonié and Kremp (1955) of 40-50 μm, but otherwise displayed morphologies indistinguishable from those of the smaller specimens. I have considered all to be assignable to *M. nobilis.* If the two species are synonymous, *M. fistulosus* would have priority.

Occurrence -- Rare to occasionally frequent, observed in most coals from the Blackoak through the Wheeler.

Microreticulatisporites sulcatus (Wilson and Kosanke)
Smith and Butterworth 1967

(Plate 10, figures 5-9)

1944 *Punctati-sporites sulcatus* Wilson and Kosanke, p. 311, pl. 1, fig. 4.
1955 *Converrucosisporites sulcatus* (Wilson and Kosanke) Potonié and Kremp, p. 64.
1967 *Microreticulatisporites sulcatus* (Wilson and Kosanke) Smith and Butterworth, p. 193-194, pl. 11, figs. 9, 10.
1969 *Trilites sulcatus* (Wilson and Kosanke) Gupta, p. 160, pl. 31, fig. 29.

Occurrence -- Rare, but observed regularly from the Laddsdale through Summit Coals; questionable occurrences noted in the Blackoak and Cliffland Coals.

Microreticulatisporites sp. 1

(Plate 10, figure 12)

Description -- Miospore radial, trilete, amb roundly triangular. Rays straight, longer than 3/4 of radius, accompanied by low thickened area approximately 3 μm wide on either side. Exine evenly ornamented on both proximal and distal surfaces with small round pits 1 μm or less in diameter, separated from one another by muri 1-3 μm wide. Exine relatively dark, 2 μm thick.

Size of illustrated specimen -- 22.8 μm maximum diameter.

Remarks -- *M.* sp. 1 is smaller than most other described species of the genus, and its sculpture of small pits separated by wider muri does not closely resemble the ornament of other species. The sculpture approaches that characteristic of *Foveosporites* Balme 1957, but does not display any incipient elongation of the pits into 'channels' or vermiculae.

Occurrence -- Extremely rare, observed only in an unnamed coal of the Kilbourn Formation.

Genus *RETICULITRILETES* Mädler 1964 emend.

1954 *Dictyotriletes* Naumova ex Potonié and Kremp, in part, p. 107.
1964a *Reticulitriletes* Mädler, p. 76.
1965 *Palaeospongisporis* Schulz, p. 266.

Type species -- *R. globosus* Mädler 1964.

Emended diagnosis -- Miospores radial, trilete, azonate, originally spherical or nearly so. Trilete rays simple, straight. Both proximal and distal surfaces ornamented with a comprehensive reticulate sculpture consisting of muri of approximately equal height and width, enclosing more or less polygonal lumina of greater width than the muri. Reticulum may be imperfect and may be reduced or absent from areas in the immediate vicinicy of the trilete mark.

Comparison -- Most of the spores reassigned here to *Reticulitriletes* have been assigned previously to *Dictyotriletes. Dictyotriletes* is emended later in this report to restrict it to species having reticulate sculpture confined to the distal surface, in keeping with its type species. *D. bireticulatus* (Ibrahim) Potonié and Kremp emend. Smith and Butterworth 1967. Corbulispora Bharadwaj and Venkatachala 1962 differs from *Reticulitriletes* by having a conspicuously labrate trilete mark, although Hibbert and Lacey (1969) have questioned the significance of the feature for generic differentiation. *Reticulatisporites* as used in this report accommodates coarsely reticulate spores with muri much higher than they are wide. *Palaeospongisporis* Schulz 1965 is indistinguishable from *Reticulitriletes* emend. and is regarded as synonymous.

Remarks -- The emendation of *Dictyotriletes* mentioned above necessitates transfer of miospores having a comprehensive reticulate sculpture on both proximal and distal surfaces to a more appropriate genus. I consider *Reticulitriletes* to be the senior acceptable repository for such species. The reasons for the recognition of *Reticulitriletes* as distinct from *Dictyotriletes* are discussed in the Remarks under *Dictyotriletes.*

Palaeobotanical affinity -- Filicinean. Hamer and Rothwell (1983) and Scott, Galtier and Clayton (1985) have illustrated spores considered to be representative of *Dictyotriletes* recovered from filicinean fructifications. In both cases, the reticulate ornament appears to be comprehensive on both proximal and distal surfaces, and therefore the spores are more properly assignable to *Reticulitriletes.* Mamay (1954b) recovered similar spores from a fructification of uncertain affinity. The genus as emended here encompasses potentially a large number of species, and may ultimately be found to contain spores of diverse origins.

Reticulitriletes clatriformis (Artüz) n. comb.

(Plate 25, figures 15, 16)

1957 *Reticulatisporites clatriformis* Artüz, p. 248, pl. 4, fig. 25.
1964a *Dictyotriletes* cf. *clatriformis* (Artüz) Sullivan, p. 367, pl. 58, fig. 20, pl. 59, figs. 1, 2.

Remarks -- Smith and Butterworth (1967) regarded this species as a probable synonym of *Dictyotriletes castaneaeformis* (Horst) Sullivan 1964. Artüz (1957) described *R. clatriformis* as trilete, although the specimen she illustrated appears to be preserved in an off-polar compression and shows no clear trilete mark. A trilete mark is visible on the specimen illustrated in this report, but it is partly obscured by ornament. The nature of the laesura of *D. clatriformis* is in doubt; see Remarks under *Dictyomonolites swadei* n. gen. n. sp. later in this report.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Reticulitriletes densoreticulatus (Potonié and Kremp) n. comb.

(Plate 24, figure 16)

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

Occurrence -- Rare, observed only in the Blackoak Coal.

Reticulitriletes distortus (Peppers) n. comb.

(Plate 25, figure 14)

1970 *Dictyotriletes distortus* Peppers, p. 112, pl. 9, figs. 9-11; text-fig. 24.

Occurrence -- Rare, observed in the Kilbourn Formation and the Blackoak Coal.

Reticulitriletes falsus (Potonié and Kremp) n. comb.

(Plate 25, figures 10-12)

1955 *Dictyotriletes falsus* Potonié and Kremp, p. 109, pl. 16, figs. 303, 304.
1965a *Dictyisporites falsus* (Potonié and Kremp) Laveine, p. 133, pl. 10, fig. 27.

Occurrence -- Rare, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation, the Kilbourn Formation, and the Laddsdale Coals.

Reticulitriletes mediareticulatus (Ibrahim) n. comb.

(Plate 25, figures 5, 6)

1933 *Reticulati-sporites mediareticulatus* Ibrahim, p. 34, pl. 7, fig. 62.
1938 *Azonotriletes mediareticulatus* (Ibrahim) Luber and Waltz, pl. 8, fig. 107.
1955 *Dictyotriletes mediareticulatus* (Ibrahim) Potonié and Kremp, p. 110, pl. 16, figs. 314, 315.
1967 *Dictyotriletes mediareticulatus* (Ibrahim) Potonié and Kremp emend. Smith and Butterworth, p. 197, pl. 11, figs. 22-24.

Occurrence -- Rare, observed in the Wildcat Den Coal, a shale sample from the basal Kilbourn Formation in core CP-6 and the Blackoak Coal.

Reticulitriletes reticulocingulum (Loose) n. comb.

(Plate 25, figures 7-9)

1932 *Sporonites reticulocingulum* Loose, in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 41.
1934 *Reticulati-sporites reticulocingulum* (Loose) Loose, p. 156.
1944 *?Punctati-sporites reticulocingulum* (Loose) Schopf, Wilson and Bentall, p. 31.
1950 *Microreticulati-sporites reticulocingulum* (Loose) Knox, p. 321.
1967 *Dictyotriletes reticulocingulum* (Loose) Smith and Butterworth, p. 198, pl. 11, figs. 27-29.
1967 *Dictyisporites reticulocingulum* (Loose) Corsin, Coquel and Loboziak, p. 174.
1970 *Dictyotriletes* cf. *reticulocingulum* (Loose) Smith and Butterworth 1967; Peppers, p. 112, pl. 9, fig. 13.

Remarks -- The specimens illustrated by Smith and Butterworth (1967) show a wide range in the coarseness of the reticulum. Peppers (1970) assigned his specimens provisionally to *D. reticulocingulum* because he saw only finely reticulate forms; Ravn (1979) likewise noted only finely reticulate specimens. Subsequent examination of samples from other Iowa coals, however, revealed a range in the relative coarseness of the reticulum similar to that observed by Smith and Butterworth (1967); plate 25, figures 7 and 8 illustrate, respectively, coarsely and finely reticulate forms.

Occurrence -- Rare, observed in the Kilbourn Formation, Blackoak and Cliffland Coals and the unnamed coal of the Floris Formation.

The following species are transferred to *Reticulitriletes* Mädler emend.:

Reticulitriletes cuniculosus (Playford and Satterthwait) n. comb.:
1985 *Dictyotriletes cuniculosus* Playford and Satterthwait, p. 139, pl. 3, figs. 7-9.

Reticulitriletes europaeus (Schulz) n. comb.:
1965 *Palaeospongisporis europaeus* Schulz, p. 266, pl. 20, figs. 11, 12.

Reticulitriletes equigranulatus (Neville) n. comb.:
1968 *Dictyotriletes equigranulatus* Neville, p. 438-439, pl. 1, figs. 5, 6.

Reticulitriletes fundatus (Hoffmeister, Staplin and Malloy) n. comb.:
1955 *Microreticulatisporites fundatus* Hoffmeister, Staplin and Malloy, p. 391, pl. 36, fig. 33.

Reticulitriletes membranireticulatus (Bertelsen) n. comb.:
1972 *Dictyotriletes membranireticulatus* Bertelsen, p. 47. pl. 13, figs. 1-4.

Reticulitrilites proprius (Playford) n. comb.:
1977 *Dictyotriletes* sp., Playford, p. 79. pl. 12, figs. 1, 2.
1978 *Dictyotriletes proprius* Playford. p. 127, pl. 7, figs. 13-19.

Genus *CAMPTOTRILETES* Naumova ex Potonié and Kremp 1954

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

Paleobotanical affinity -- Filicinean (Mamay, 1950; Pfefferkorn, Peppers and Phillips, 1971).

Camptotriletes bucculentus (Loose) Potonié and Kremp 1955

(Plate 10, figures 14, 15)

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, pl. 17, fig. 224.
1955 *Camptotriletes bucculentus* (Loose) Potonié and Kremp, p. 104, pl. 16, figs. 287, 288.

Occurrence -- Rare, observed in the Wildcat Den, the Kilbourn Formation, the Blackoak and Cliffland Coals.

Camptotriletes certus Venkatachala and Bharadwaj 1964

(Plate 10, figure 13)

1964 *Camptotriletes certus* Venkatachala and Bharadwaj, p. 176, pl. 9, figs. 106-108.
1979 *Camptotriletes* cf. *corrugatus* (Ibrahim) Potonié and Kremp 1954; Ravn, p. 34, pl. 9, fig. 14.

Remarks -- Comparison of the description and illustration of *C. certus* by Venkatachala and Bharadwaj (1964) indicates that the spore illustrated as *C.* cf. *corrugatus* by Ravn (1979) is identical; the specimen is reillustrated in this report.

Occurrence -- Rare, observed only in the Blackoak Coal.

Camptotriletes confertus (Ravn) n. comb.

(Plate 5, figures 9, 10)

1979 *Lophotriletes confertus* Ravn, p. 28, pl. 6, figs. 9-13.

Remarks -- Ravn (1979) expressed reservations about the original assignment of this species to *Lophotriletes.* The sculpture of irregular, coalescent ridges bearing sparse, low coni is more characteristic of *Camptotriletes*, to which the species is transferred here without descriptive emendation.

Occurrence -- Rare. observed only in the Blackoak Coal.

Camptotriletes sp. cf. *C. superbus* Neves 1961

(Plate 10, figure 16)

cf. 1961 *Camptotriletes superbus* Neves, p. 257-258, pl. 31, fig. 8.

Remarks -- Specimens noted in Iowa coals display a finer grade of ornamentation and are slightly smaller than the species as described by Neves (1961).

Occurrence -- Rare, observed only in the Blackoak Coal.

Camptotriletes triangularis Peppers 1970

(Plate 10, figures 10, 11)

1970 *Camptotriletes triangularis* Peppers, p. 114, pl. 10, figs. 1, 2; text-fig. 25.

Occurrence -- Rare, observed in the Wildcat Den Coal, a shale sample from the basal Kilbourn Formation in core CP-6, the Blackoak, Laddsdale and Wheeler Coals.

Genus *SAVITRISPORITES* Bhardwaj 1955

Type species -- *S. triangulus* Bhardwaj 1955.

Paleobotanical affinity -- Filicinean (Radforth, 1939).

Savitrisporites asperatus Sullivan 1964

(Plate 11, figures 2-5)

1964a *Savitrisporites asperatus* Sullivan, p. 374, pl. 60, figs. 6-8.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Savitrisporites concavus Marshall and Smith 1965

(Plate 11, figure 1)

1965 *Savitrisporites concavus* Marshall and Smith, p. 661, pl. 99, figs. 9-12.
1971 *Callisporites concavus* (Marshall and Smith) Loboziak, p. 55, pl. 7, figs. 27, 28.

Occurrence -- Rare, observed in the Wildcat Den Coal and the Kilbourn Formation.

Savitrisporites majus Bhardwaj 1957

(Plate 11, figures 6-9)

1957a *Savitrisporites majus* Bhardwaj, p. 97, pl. 26, figs. 6, 7.
1958 *Dictyotriletes camptotus* Alpern, p. 77, pl. 1, figs. 3, 4.
1964 *Savitrisporites camptotus* (Alpern) Venkatachala and Bharadwaj, p. 179, pl. 10, figs. 135-137.

Remarks -- *S. majus* differs from *S. nux* (Butterworth and Williams) Sullivan emend. Smith and Butterworth 1967 in possessing a well-developed reticulate sculpture on the distal surface. *S. majus* also is not commonly found in good proximal-distal orientation, but usually occurs in some form of oblique compression, suggesting an originally pyramidal shape.

Occurrence -- Rare, observed in a shale sample from the basal Kilbourn Formation in core CP-6, the Blackoak and Cliffland Coals.

Savitrisporites nux (Butterworth and Williams) Sullivan emend. Smith and Butterworth 1967

(Plate 11, figures 10-13)

1958 *Callisporites nux* Butterworth and Williams, p. 377, pl. 3, figs. 24, 25.

1964a *Savitrisporites nux* (Butterworth and Williams) Sullivan, p. 373, pl. 60, figs. 1-5.
1964 *Converrucosisporites idili* Ibrahim-Okay and Artüz, p. 272, pl. 1, fig. 4; text-fig. 1.
1967 *Savitrisporites nux* (Butterworth and Williams) Sullivan emend. Smith and Butterworth, p. 223, pl. 15, figs. 1-3.

Occurrence -- Rare to frequent, observed in the Wildcat Den and Wyoming Hill Coals, the Kilbourn Formation and in the Blackoak Coal.

Savitrisporites robustus Ravn and Fitzgerald 1982

(Plate 11, figs. 14, 15)

1982 *Savitrisporites robustus* Ravn and Fitzgerald, p. 136, pl. 8, figs. 4-7.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Savitrisporites sp. 1

(Plate 12, figures 1-3)

1979 *Savitrisporites* sp. 1 Ravn, p. 38, pl. 12, fig. 3.

Remarks -- For description, see Ravn (1979).

Occurrence -- Rare, observed in the Blackoak and Cliffland Coals.

The following species is transferred to *Savitrisporites*:

Savitrisporites bergouniouxii (Pi-Radondy and Doubinger) n. comb.:
1968 *Callisporites bergouniouxii* Pi-Radondy and Doubinger, p. 418, pl. 2, fig. 5.

Genus *KNOXISPORITES* Potonié and Kremp emend. Neves and Playford 1961

Type species -- *K. hageni* Potonié and Kremp 1954.

Paleobotanical affinity -- Filicinean; Scott, Galtier and Clayton (1985) recovered spores corresponding to *K. literatus* (Waltz) Playford 1963 from a filicinean fructification. As miospores exhibiting considerable diversity of morphology are assigned to this genus, the possibility of other paleobotanical origins may exist for other *Knoxisporites* species.

Knoxisporites dissidius Neves 1961

(Plate 29, figure 7)

1961 *Knoxisporites dissidius* Neves, p. 266, pl. 33, figs. 4, 6; text-fig. 4.

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale sample from the basal Kilbourn Formation in core CP-6.

Knoxisporites seniradiatus Neves 1961

(Plate 29, figures 8, 9)

1961 *Knoxisporites seniradiatus* Neves, p. 267-268, pl. 33, fig. 5.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Knoxisporites stephanephorus Love 1960

(Plate 29, figs. 12-15)

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

Remarks -- Several other species of *Knoxisporites* display patterns of distal ornamentation similar to that of *K. stephanephorus* these include *K. rotatus* Hoffmeister, Staplin and Malloy 1955, *K. ruhlandi* Doubinger and Rauscher 1966, and *K. glomus* Shwartsman (in Inosova et al., 1976). Ravn (1979) discussed these similarities.

Occurrence -- Rare, but observed in most coals from the Wildcat Den through the Bevier.

Knoxisporites triradiatus Hoffmeister, Staplin and Malloy 1955

(Plate 29, figures 16-18)

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

Occurrence -- Rare, observed in the Wildcat Den Coal, the Kilbourn Formation and the Blackoak Coal.

TRILETE SPHENOPSIDS

Genus *CALAMOSPORA* Schopf, Wilson and Bentall 1944

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

Remarks -- As noted by Ravn (1979) speciation within *Calamospora* is of questionable utility for stratigraphic purposes. Many individual specimens are preserved in such a manner as to be impossible to assign to described species, and transitional forms are common. The species presented and illustrated in this report represent the range of morphologic variation observed in the Iowa coals under consideration. Notes regarding the stratigraphic occurrences of individual forms must be considered in light of the foregoing comments and those presented by Ravn (1979).

Paleobotanical affinities -- Numerous and varied sphenopsids (Arnold, 1944; Delevoryas, 1955; Kosanke, 1955; Remy, 1955; Walton, 1957; D. L. Smith, 1962; Baxter, 1963; Chaphekar, 1963; Hibbert and Eggert, 1965; Abbott, 1968; Thomas, 1969; Courvoisier and Phillips, 1975; Good and Taylor, 1975; Good, 1976; Gastaldo, 1981). Millay (1979b) recovered spores from a marattialean fructification that probably would be assigned to *Calamospora* if observed in a dispersed miospore residue. Pfefferkorn, Peppers and Phillips (1971) recovered spores questionably assignable to *Calamospora* from a fern fructification (*Myriotheca arnoldii*) whose exact systematic position is uncertain. Leary (1980) recovered spores corresponding to *C. liquida* Kosanke 1950 from the Noeggerathialean *Lacoea*; earlier workers (e.g., Boureau, 1964) have generally considered the Noeggerathiales to be sphenopsids, but Beck (1976) and Leary and Pfefferkorn (1977) have suggested a progymnospermous affinity for this problematical plant group.

Calamospora breviradiata Kosanke 1950

(Plate 13, figure 1)

1950 *Calamospora breviradiata* Kosanke, p. 41, pl. 9, fig. 4.
1957a *Calamospora minuta* Bhardwaj, p. 80, pl. 22, fig. 8.
non 1950 *Calamospora minutus* Knox, p. 332, pl. 19, fig. 301.
1957a *Calamospora membrana* Bhardwaj, p. 81, pl. 22, fig. 11.
1957a *Calamospora saariana* Bhardwaj, p. 81, pl. 22, figs. 13-15.
1965a *Calamisporites breviradiatus* (Kosanke) Laveine, p. 131.
1966 *Calamisporites minutus* (Bhardwaj) Coquel, p. 17, pl. 1, fig. 15.

Occurrence -- Frequent to occasionally abundant, observed throughout the section.

Calamospora flexilis Kosanke 1950

(Plate 12, figures 9-11)

1950 *Calamospora flexilis* Kosanke, p. 41, pl. 9, fig. 5.

Remarks -- *C. flexilis* is distinguished from species of similar size (e.g., *C. liquida*) by the development of folds along the trilete rays. Observations of specimens in Iowa coals suggest that this feature is relatively consistent, and therefore that *C. flexilis* may be more reliably recognized than most other *Calamospora* species

Occurrence -- Rare, observed in the Kilbourn Formation, the Blackoak, Cliffland and Bevier Coals.

Calamospora hartungiana Schopf, in Schopf, Wilson and Bentall, 1944

(Plate 13, figure 12)

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 observed regularly in most coals throughout the section.

Calamospora liquida Kosanke 1950

(Plate 12, figure 6)

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

Occurrence -- Rare, observed from the Wildcat Den through the Cliffland Coal, also in the Bevier Coal.

Calamospora mutabilis (Loose) Schopf, Wilson and Bentall 1944

(Plate 12, figure 12)

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

Occurrence -- Rare, but observed in most coals from the Wildcat Den through the Wheeler.

Calamospora nebulosa Ravn 1979

(Plate 12, figures 7, 8)

1979 *Calamospora nebulosa* Ravn, p. 24, pl. 3, figs. 8-12.
1982 *Calamospora hartungiana* auct. non Schopf, in Schopf, Wilson and Bentall 1944; Ravn and Fitzgerald, pl. 1, fig. 18.

Occurrence -- Rare, observed in the Wildcat Den, Blackoak and Cliffland Coals.

Calamospora parva Guennel 1958

(Plate 12, figure 5)

1958 *Calamospora parva* Guennel, p. 70-71, pl. 4, fig. 12; text-fig. 16.
1958 *Calamospora macer* Williams, in Butterworth and Williams, pl. 1, figs. 21, 22 (*Nomen nudum*; no description).
1965a *Calamisporites macer* (Williams) Laveine, p. 131 (*Nomen nudum*).

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale sample from the basal Kilbourn Formation in core CP-6.

Calamospora pedata Kosanke 1950

(Plate 13, figures 8, 9)

1950 *Calamospora pedata* Kosanke, p. 42, pl. 9, fig. 3.
1965a *Calamisporites pedatus* (Kosanke) Laveine, p. 131, pl. 10, fig. 8.
1979 *Calamospora* cf. *pedata* Kosanke 1950; Ravn, p. 24, pl. 3, figs. 6, 7.

Occurrence -- Rare, observed in most coals from the Kilbourn Formation through the Mystic.

Calamospora straminea Wilson and Kosanke 1944

(Plate 12, figure 4)

1944 *Calamospora straminea* Wilson and Kosanke, p. 329, pl. 1, fig. 1.
1958 *Punctatisporites stramineus* (Wilson and Kosanke) Guennel, p. 68-69, pl. 4, figs. 5-8.

Remarks -- *C. straminea* is similar in size to *C. parva* but is conspicuously thicker.

Occurrence -- Rare, observed in most coals from the Blackoak upward throughout the section.

Genus *ELATERITES* Wilson 1943

Type species -- *E. triferens* Wilson 1943.

Paleobotanical affinities -- Various Calamitales and Sphenophyllales (Wilson, 1943, 1963; Baxter and Leisman, 1967; Good and Taylor, 1974, 1975; Good, 1975, 1976; Kurmann and Taylor, 1984). The various demonstrated and potential ontogenetic relationships among spores of the genera *Elaterites*, *Calamospora* and *Vestispora* have been discussed in detail by Good and Taylor (1975), Good (1976) and Ravn (1983).

Elaterites triferens Wilson 1943

(Plate 14, figure 10)

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

Occurrence -- Rare, observed in an unnamed coal of the Kilbourn Formation and the Blackoak Coal. As Peppers (1970) and Ravn (1979) have noted, however, *Elaterites* is almost certainly inadequately represented in dispersed miospore residues because of the rarity of preservation of the fragile elaters. When the elaters are not present, spores of this kind are referred to the widespread and abundant genus *Calamospora*. The paleobotanical work of Good and Taylor (1974, 1975) and Good (1975, 1976) suggests that many, if not most *Calamospora* species originally bore elaters.

Genus *RETICULATISPORITES* Ibrahim emend. Potonié and Kremp 1954

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

Remarks -- Neves (1964a) interpreted *Reticulatisporites* to be cingulate and emended the genus accordingly. Several subsequent authors (e.g., Potonié, 1966; Playford and Helby, 1968; Playford, 1971b; Urban, 1971) have disagreed with this interpretation, suggesting that the 'cingulum' is nothing more than an equatorial expression of the muri of the reticulum. In the Potonié and Kremp conception of the genus, it is characterized by having a coarse reticulum and muri much higher than they are wide. These criteria are rather subjective, and certain species may be arguably assignable to other reticulate genera (e.g., *Dictyotriletes*) as well as to *Reticulatisporites*. The type species, *R. reticulatus*, has muri confined to the distal surface and equator, and restriction of the genus to species with similar distribution of the reticulum may be desirable. Given these interpretational difficulties, I have chosen in this report to follow the practice of Peppers (1970) and treat *Reticulatisporites* as being the appropriate generic repository for trilete spores having a coarse reticulum and muri considerably higher than they are wide.

Paleobotanical affinity -- Sphenopsid (Andrews and Agashe, 1963); I know of no other reports of spores *in situ* that clearly correspond to *Reticulatisporites*. As the conception of the genus followed here is broad, the possibility exists that species assignable to it may also have been produced by plants other than sphenopsids.

Reticulatisporites sp. cf. *R. magnidictyus* Playford and Helby 1968

(Plate 14, figure 6)

cf. 1968 *Reticulatisporites magnidictyus* Playford and Helby, p. 110-111, pl. 10, figs. 7-10.
1982 *Reticulatisporites* cf. *magnidictyus* Playford and Helby 1968; Ravn and Fitzgerald, p. 134, pl. 7, fig. 11.

Remarks -- The muri of the specimens observed in Iowa do not project as far at the spore margin as do those of the specimens described and illustrated by Playford and Helby (1968), but in other respects, the Iowa specimens are similar to the types.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Reticulatisporites muricatus Kosanke 1950

(Plate 14, figures 3, 4)

1950 *Reticulati-sporites muricatus* Kosanke, p. 27, pl. 4, fig. 7.
1967 *Dictyotriletes muricatus* (Kosanke) Smith and Butterworth, p. 197-198, pl. 11, figs. 25, 26.

Remarks -- Smith and Butterworth (1967) reassigned this species to *Dictyotriletes* because of the absence of a cingulum, under the emendation of *Reticulatisporites* by Neves (1964a). Peppers (1970) questioned the reassignment, preferring to distinguish the two genera on the basis of the height of the muri. See the Remarks under the genus.

Occurrence -- Rare, observed in the Wildcat Den, the Kilbourn Formation and the Laddsdale Coals.

Reticulatisporites polygonalis (Ibrahim) Loose emend. Smith and Butterworth 1967

(Plate 13, figures 10, 11)

1932 *Sporonites polygonalis* Ibrahim, in Potonié, Ibrahim and Loose, p. 447, pl. 14, fig. 8.
1933 *Laevigati-sporites polygonalis* (Ibrahim) Ibrahim, p. 19, pl. 1, fig. 8.
1934 *Reticulati-sporites polygonalis* (Ibrahim) Loose, p. 155, pl. 7, fig. 16.
1955 *Knoxisporites polygonalis* (Ibrahim) Potonié and and Kremp, p. 117, pl. 16, fig. 318; text-fig. 33.
1964a *Reticulatisporites polygonalis* (Ibrahim) Loose emend. Neves, p. 1066.
1967 *Reticulatisporites polygonalis* (Ibrahim) Loose emend. Smith and Butterworth, p. 221-222,

pl. 14, fig. 13.

Remarks -- *R. polygonalis* differs from *R. carnosus* (Knox) Neves 1964 by having more distinct muri on the distal surface. The illustrations of these two species in Smith and Butterworth (1967, pl. 14, figs. 11-13) demonstrate their essential similarity, and the stratigraphic ranges cited are more or less continuous (Namurian A-Lower Westphalian A for *R. carnosus*; Westphalian A-Lower Westphalian C for *R. polygonalis*), suggesting potential synonymy.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Cliffland.

Reticulatisporites reticulatus (Ibrahim) Ibrahim 1933

(Plate 13, figures 4-7)

1932 *Sporonites reticulatus* Ibrahim, in Potonié, Ibrahim and Loose, p. 447, pl. 14, fig. 3.
1933 *Reticulati-sporites reticulatus* (Ibrahim) Ibrahim, p. 33, pl. 1, fig. 3.
1938 *Azonotriletes reticulatus* (Ibrahim) Luber, in Luber and Waltz, pl. 7, fig. 99.
1950 *Reticulati-sporites lacunosus* Kosanke, p. 26, pl. 5, fig. 5.
non 1933 *Reticulati-sporites lacunosus* Ibrahim, p. 36, pl. 6, fig. 50.

Occurrence -- Rare, observed from the Blackoak to the Carruthers Coal.

Genus *VESTISPORA* Wilson and Hoffmeister emend. Wilson and Venkatachala 1963

Type species -- *V. profunda* Wilson and Hoffmeister 1956.

Remarks -- Jansonius and Hills (1976a) suggested that *Vestispora* is a junior synonym of *Periplecotriletes* Naumova ex Ishchenko 1952. The lectotype species, *P. crassus* Ishchenko (designated by Jansonius and Hills, 1976a) appears to be operculate and has a costate-reticulate ornament similar to that of *V. costata* or possibly *V. pseudoreticulata.* If these two genera are synonymous, *Vestispora* species would have to be transferred to *Periplecotriletes* and the diagnosis of the latter would need to be emended to accommodate the variety of ornamentation known to exist among spores having the morphology of *Vestispora.* Examination of the type material would be most helpful in establishing both generic and specific synonymies.

Paleobotanical affinities -- Sphenophyllales, questionably Noeggerathiales (Levittan and Barghoorn, 1948; Mamay, 1954a; W. Remy, 1955; R. Remy, 1959; Brush and Barghoorn, 1964; Taylor, 1986). Suggestions by Good (1975) of a calamitalean affinity for spores of this kind are based on an interpretation of the ontogeny of spores assignable to the genera *Elaterites* and *Calamospora* with which I disagree (Ravn, 1983).

Vestispora clara (Venkatachala and Bharadwaj) n. comb.

(Plate 15, figures 5, 6)

1964 *Foveolatisporites clarus* Venkatachala and Bharadwaj, p. 175, pl. 8, figs. 94-96.
1979 *Vestispora luminata* Ravn, p. 46, pl. 17, figs. 4-10.

Remark -- Examination of the type illustrations and descriptions of *Foveolatisporites clarus* and *Vestispora luminata* indicate clearly that no significant differences exist between the species. Accordingly, they are placed in synonymy, and transferred under the senior name to *Vestispora.*

Occurrence -- Rare, observed in Blackoak, Cliffland and Laddsdale Coals.

Vestispora costata (Balme) Bhardwaj emend. Spode, in Smith and Butterworth, 1967

(Plate 14, figures 1, 2)

1952 *Endosporites costatus* Balme, p. 178, text-fig. 1f.
1952 *Reticulatisporites tortuosus* Balme, in part, text-fig. 1d.
1957b *Vestispora costata* (Balme) Bhardwaj, p. 118, pl. 24, figs. 36-40.
1957a *Cancellatisporites cancellatus* Dybová and Jachowicz, p. 111, pl. 24, figs. 1-4.
1958 *Glomospora costata* (Balme) Butterworth and Williams, p. 385.
1963a *Vestispora cancellata* (Dybová and Jachowicz) Wilson and Venkatachala, p. 99.
1965b *Vestisporites costatus* (Balme) Laveine, p. 2556, pl. 1, fig. 11.
1965b *Vestisporites cancellatus* (Dybová and Jachowicz) Laveine, p. 2556, pl. 1, fig. 14.
1967 *Vestispora costata* (Balme) Spode, in Smith and Butterworth, p. 295-296, pl. 25, figs. 1, 2.
1967 *Vestispora tortuosa* (Balme) Spode, in Smith and Butterworth, p. 299-300, pl. 26, figs. 1, 2.

Remarks -- Distinctions made by Spode (in Smith and Butterworth, 1967) between the species *V. costata* and *V. tortuosa* are very minor and do not serve adequately to permit assignment of specimens to one or the other. As the stratigraphic ranges cited by Smith and Butterworth (1967) are nearly identical, continued recognition of these species as distinct from one another is not justified.

Detached opercula relating to this species have been described under the names *Reticulatasporites facetus* (Ibrahim) Potonié and Kremp 1955 and *Reticulatasporites taciturnus* (Ibrahim) Potonié and Kremp 1955, a practice no longer followed (Smith and Butterworth, 1967).

Occurrence -- Rare, observed in the Kilbourn Formation and the Cliffland Coal.

Vestispora fenestrata (Kosanke and Brokaw) Wilson and Venkatachala
emend. Spode, in Smith and Butterworth, 1967

(Plate 15, figures 1-3)

1950 *Punctati-sporites fenestratus* Kosanke and Brokaw, in Kosanke, p. 15, pl. 2, fig. 10.
1954 *Microreticulatisporites fenestratus* (Kosanke and Brokaw) Butterworth and Williams, p. 755, pl. 17, figs. 1-3; text-figs. 1, 2.
1955 *Foveolatisporites fenestratus* (Kosanke and Brokaw) Bhardwaj, p. 126, pl. 1, fig. 4.
1963a *Vestispora fenestrata* (Kosanke and Brokaw) Wilson and Venkatachala, p. 99, pl. 1, figs. 13, 14.
1964 *Foveolatisporites insignis* Venkatachala and Bharadwaj, p. 175, pl. 8, figs. 100-101.
1965b *Vestisporites fenestratus* (Kosanke and Brokaw) Laveine, p. 2556, pl. 1, figs. 9, 24.
1967 *Vestispora fenestrata* (Kosanke and Brokaw) Wilson and Venkatachala emend. Spode, in Smith and Butterworth, p. 296, pl. 25, figs. 3-6.

Remarks -- Detached opercula relating to this species have been described under the name *Punctatisporites quaesitus* and various subsequent recombinations; this practice is no longer followed (Smith and Butterworth, 1967).

Occurrence -- Rare to occasionally frequent, observed in nearly all coals from the Kilbourn Formation through the Mystic.

Vestispora foveata (Kosanke) Wilson and Venkatachala 1963

(Plate 15, figures 9-12)

1950 *Punctati-sporites foveatus* Kosanke, p. 17, pl. 1, fig. 6.
1955 *Microreticulatisporites foveatus* (Kosanke) Potonié and Kremp, p. 98.
1956 *Foveolatisporites foveatus* (Kosanke) Bhardwaj, p. 119.
1963a *Vestispora foveata* (Kosanke) Wilson and Venkatachala, p. 99.

Occurrence -- Rare, observed in the Blackoak, Cliffland, Laddsdale and Whitebreast Coals.

Vestispora irregularis (Kosanke) Wilson and Venkatachala 1963

(Plate 15, figure 7)

1950 *Reticulati-sporites irregularis* Kosanke, p. 26, pl. 5, fig. 1.

1955 *Microreticulatisporites irregularis* (Kosanke) Potonié and Kremp, p. 98.
non 1957 *Microreticulatisporites irregularis* Rouse. p. 357, pl. 1, figs. 23, 24.
1957b *Novisporites irregularis* (Kosanke) Bhardwaj, p. 120.
1963a *Vestispora irregularis* (Kosanke) Wilson and Venkatachala, p. 99.
1965b *Vestisporites irregularis* (Kosanke) Laveine, p. 2556, pl. 1, fig. 6.

Occurrence -- Rare, observed only in the Cliffland Coal.

Vestispora laevigata Wilson and Venkatachala 1963

(Plate 14, figures 5, 7)

1963a *Vestispora 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 frequent, observed in nearly all coals from the Kilbourn Formation through the Mystic; *V. laevigata* is the most abundant species of the genus in Iowa coals.

Vestispora lucida (Butterworth and Williams) Potonié 1960

(Plate 14, figures 9, 11)

1958 *Glomospora lucida* Butterworth and Williams, p. 384, pl. 4, figs. 4-6.
1960 *Vestispora lucida* (Butterworth and Williams) Potonié, p. 52.
1965b *Vestisporites lucidus* (Butterworth and Williams) Laveine, p. 2556, pl. 4, fig. 4.

Occurrence -- Rare, observed only in the Wildcat Den Coal; no other species of *Vestispora* was encountered in this oldest portion of the Iowa Pennsylvanian.

Vestispora profunda Wilson and Hoffmeister 1956

(Plate 14, figure 8)

1956 *Vestispora profunda* Wilson and Hoffmeister, p. 27, pl. 2, figs. 16-19; text-fig. 1.

Occurrence -- Rare, observed in the Blackoak and Cliffland Coals.

Vestispora pseudoreticulata Spode, in Smith and Butterworth, 1967

(Plate 15, figure 8)

1964b *Vestispora pseudoreticulata* Spode, in Neves, p. 1233, pl. 3, figs. 1, 2 (*Nomen nudum*; no description or typification).
1965b *Vestisporites pseudoreticulatus* (Spode) Laveine, p. 2556, pl. 1, figs. 6, 18 (*Nomen nudum*).
1967 *Vestispora pseudoreticulata* Spode, in Smith and Butterworth, p. 298-299, pl. 25, figs. 13, 14.

Occurrence -- Rare, observed in the Kilbourn Formation, the Blackoak and Cliffland Coals, the unnamed coal of the Floris Formation and the Wheeler Coal.

Vestispora sp. cf. *V. reticulata* (Laveine) Loboziak 1971

(Plate 16, figures 15, 16)

cf. 1965b *Vestisporites reticulatus* Laveine, p. 2558, pl. 1, fig. 21.
cf. 1971 *Vestispora reticulata* (Laveine) Loboziak, p. 81, pl. 12, fig. 8.
1979 *Vestispora* cf. *reticulata* (Laveine) Loboziak 1971; Ravn, p. 46, pl. 16, fig. 12.

Remarks -- The specimens designated here as *V.* sp. cf. *V. reticulata* resemble *V. wanlessii*, but have narrower, more sharply bounded muri and a more complete reticulum. These forms may represent variants of a single species, but too few were observed to permit an assessment of their morphologic variability.

Occurrence -- Extremely rare, observed only in the Blackoak Coal.

Vestispora wanlessii Peppers 1970

(Plate 16, figure 17)

1970 *Vestispora wanlessii* Peppers, p. 115-116, pl. 10, figs. 9, 10.

Occurrence -- Rare, observed only in the Blackoak Coal.

TRILETE LYCOPSIDS

Genus *ANACANTHOTRILETES* n. gen.

Type species -- *A. spinosus* (Kosanke) n. comb.

Diagnosis -- Trilete miospores, azonate, amb triangular; distal surface ornamented with conate to spinate projections; proximal surface and equatorial area free of projections, laevigate or nearly so.

Remarks -- *Anacanthotriletes* is proposed to accommodate certain equatorially triangular species previously assigned to *Anapiculatisporites* Potonié and Kremp emend. Smith and Butterworth 1967 plus the new species *A. paucispinosus*. Because of certain ambiguities concerning the type species of *Anapiculatisporites* and the wide variety of forms that have been assigned to that genus, the establishment of a new genus for species having the morphology described in the diagnosis above is considered desirable. See Remarks under *Anapiculatisporites*.

Comparison -- *Anacanthotriletes* differs from *Pilosisporites* and *Didecitriletes* Venkatachala and Kar 1965 in having the apiculate sculpture confined to the distal surface. *Anapiculatisporites* as interpreted and emended in this report is reserved for forms having circular or subcircular ambs and in which the sculptural elements may project at the equator.

Derivation -- The name *Anacanthotriletes* is intended to signify the similarity of sculptural elements to those of various species historically assigned to *Acanthotriletes* and the restriction of the distribution of these sculptural elements to the distal surface.

Paleobotanical affinity -- Lycopsid. Baxter (1971) observed small, triangular, spinose trilete spores *in situ* in a fructification of an herbaceous lycopod, and suggested that they were assignable to the dispersed spore genera *Granulatisporites* or *Acanthotriletes*. His illustrations demonstrate clearly, however, that the spinose ornament is confined to the distal surface of the spores and that they are very similar if not identical to *A. spinosus* (Kosanke) n. comb., which is probably the most abundant species assignable to *Anacanthotriletes*. The morphology of these spores is unlike that known from any other lycopod fructification in the Carboniferous and in fact more closely resembles spores commonly associated with filicinean ferns, illustrating the hazards of interpreting paleobotanical affinities of miospore taxa solely on the basis of morphology.

Anacanthotriletes paucispinosus n. sp.

(Plate 16, figures 9-14)

Diagnosis -- Miospores corresponding to the characteristics of the genus. Amb strongly triangular, with more or less straight sides and narrowly rounded corners; usually in good proximal-distal orientation, but occasionally in oblique compression, suggesting an originally pyramidal shape. Trilete rays straight, 3/4 or more of radius, with narrow, faint lips, often open or accompanied by compression folds. Exine thin, spores usually pale, even in stained preparations. Proximal surface and equatorial area laevigate, distal surface ornamented with 3-25 irregularly distributed coarse coni or short spines, 1-4 μm long, 1-3 μm broad at their bases, usually sharply pointed but sometimes blunt or rounded; spines on some specimens reduced to little more than large grana.

Size -- (25 specimens) 19-28 μm maximum diameter.

Remarks -- *A. paucispinosus* differs from all other described species of the genus in the low number and coarseness of the sculptural elements. It is approximately the same size as *A. spinosus* but the latter usually has 70-100 fine spines. The two species occur together in some Iowa coals, but they do not appear to intergrade morphologically and they are readily distinguishable from one another.

Derivation -- The specific epithet is derived from the few (*pauci-*) spines characterizing the distal ornament.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-10 unit 49, Appanoose County, Iowa (See Gregory, 1982, p. 140); Blackoak Coal, Kalo Formation, uppermost Atokan Series.

Occurrence -- Rare to occasionally frequent, observed only in the Blackoak and Cliffland Coals.

Anacanthotriletes spinosus (Kosanke) n. comb.

(Plate 16, figures 4-8)

1950 *Granulati-sporites spinosus* Kosanke, p. 22, pl. 3, fig. 7.
1952 *Apiculatisporites asperatus* Imgrund, p. 41, fig. 95 (Invalid; unpublished thesis).
1955 *Acanthotriletes asperatus* (Imgrund) Potonié and Kremp, p. 84 (Invalid; no description or illustration).
1955 *Anapiculatisporites spinosus* (Kosanke) Potonié and Kremp, p. 82, pl. 14, figs. 253-255.
1958 *Anapiculatisporites hispidus* Butterworth and Williams, p. 364, pl. 1, figs. 30, 31.
1960 *Acanthotriletes spinosus* (Kosanke) Imgrund, p. 166, pl. 14, fig. 58.
non 1967 *Granulatisporites spinosus* auct. non Kosanke 1950; Felix and Burbridge, p. 364, pl. 54, fig. 10.

Remarks -- Some specimens observed in Iowa coals more closely resemble specimens illustrated as *Anapiculatisporites minor* Butterworth and Williams emend. Smith and Butterworth (1967, pl. 6, figs. 21-24). These are slightly smaller than typical *A. spinosus*, bear fewer spines and are more often found in good proximal-distal orientation than is normal for specimens of *A. spinosus*. Smith and Butterworth (1967) emended the original diagnosis of *A. minor* to accommodate such specimens observed in the Westphalian of Britain, thereby extending the stratigraphic range of *A. minor* to the Upper Westphalian C. The range of *A. spinosus* cited by Smith and Butterworth is Westphalian D only. Very little difference is apparent between their illustrations of *A. minor* and those of *A. spinosus* (Smith and Butterworth, 1967, pl. 6, figs. 19, 10). The stratigraphic ranges of *A. minor* and *A. spinosus* given by Smith and Butterworth appear to represent an unbroken continuum from Viséan to Westphalian D, with the smaller, less spinose forms found in older strata and the larger, more spinose forms in younger strata. Conspecificity of these two species may therefore exist within a morphologically transitional series of spores. Pending determination of possible synonymy, *A. minor* is transferred below to *Anacanthotriletes*.

Occurrence -- Rare to common, observed in nearly all coals throughout the section.

The following species correspond morphologically to *Anacanthotriletes* n. gen. and are transferred:

Anacanthotriletes concinnus (Playford) n. comb.:
1962 *Anapiculatisporites concinnus* Playford, p. 587-588, pl. 80, figs. 9-12.

Anacanthotriletes minor (Butterworth and Williams) n. comb.:
1958 *Anapiculatisporites minor* Butterworth and Williams, p. 365, pl. 1, figs. 32-34.
1967 *Anapiculatisporites minor* Butterworth and Williams emend. Smith and Butterworth, p. 161, pl. 6, figs. 21-24.

Genus *GRANASPORITES* Alpern emend. Ravn, Butterworth, Peppers and Phillips, in press

1959 *Granasporites* Alpern, p. 139.
1966 *Cappasporites* Urban, p. 112.
1983 *Cappasporites* Urban emend. Chadwick, p. 205.

Type species -- *G. medius* (Dybová and Jachowicz) Ravn, Butterworth, Peppers and Phillips (in press).

Remarks -- As indicated by the synonymy above, Ravn and others (in press) have recently placed the genus *Cappasporites* in synonymy with *Granasporites*. The originally designated type species of both genera (*G. irregularis* Alpern and *C. distortus* Urban) are also considered synonymous with *Granisporites medius* Dybová and Jachowicz 1957, as represented by its holotype. Numerous previous authors (e. g., Courvoisier and Phillips, 1975; Peppers, 1979, 1984; Ravn, 1979; Ravn and Fitzgerald, 1982; Chadwick, 1983) have reported this species in North America under the name *Cappasporites distortus*.

Paleobotanical affinity -- Spores corresponding to *G. medius* have been correlated with the lycopsid fructification *Achlamydocarpon varius* (Courvoisier and Phillips, 1975; Leisman and Phillips, 1979; Phillips, 1979). This fructification and its associated megaspore, *Cystosporites varius* (Wicher) Dijkstra 1946, are known to be associated with certain arborescent lycopods of the genus *Lepidodendron*.

Granasporites medius (Dybová and Jachowicz) Ravn, Butterworth, Peppers and Phillips (in press)

(Plate 17, figures 1-8)

1957a *Granisporites medius* Dybová and Jachowicz (in part), p. 77, pl. 10, figs. 1(holotype), 2.
1959 *Granasporites irregularis* Alpern, p. 139, pl. 1, figs. 7-9.
1966 *Cappasporites distortus* Urban, p. 114, pl. 1, figs. 1-14.
1966a *Granasporites* cf. *irregularis* Alpern 1959; Hagemann, p. 819, pl. 9, figs. 1, 2.
1966 *Granasporites irregularis* Alpern 1959; Möller, p. 877, pl. 6, fig. 7.
1966 *Granisporites medius* Dybová and Jachowicz 1957; Habib, p. 634, pl. 105, figs. 2, 3, 5.
1967 *Apiculatisporis irregularis* (Alpern) Smith and Butterworth, p. 171-172, pl. 7, figs. 18, 19.
non 1955 *Apiculatisporites irregularis* (Kosanke) Potonié and Kremp, p. 77.
non 1971 *Apiculatisporis irregularis* Ybert, Nahuys and Alpern, p. 1609-1610, pl. 1, figs. 22-24.
1970 *Crassispora plicata* (?) Peppers 1964; Peppers, pl. 11, fig. 19.
1973 *Apiculatisporis irregularis* (Alpern) Smith and Butterworth 1967; Châteauneuf, pl. 2, fig. 6.
1983 *Cappasporites distortus* Urban emend. Chadwick, p. 205, pl. 1, figs. 1-10; text-fig. 1.
in press *Granasporites medius* (Dybová and Jachowicz) Ravn, Butterworth, Peppers and Phillips.

Occurrence -- Common to abundant, occasionally dominant, observed throughout the section. The presence of *G. medius* in Morrowan Caseyville Formation coals and in the Morrowan of Kentucky (as *C. distortus*; Ettensohn and Peppers, 1979) represent the oldest reported occurrences. The range of the associated megaspore, *Cystosporites varius*, was cited in North America as the Pennsylvanian by Braman and Hills (1980), but reported to range into the Lower Carboniferous in Europe.

Genus *CRASSISPORA* Bhardwaj emend. Sullivan 1964

Type species -- *C. kosankei* (Potonié and Kremp) Bhardwaj emend. Smith and Butterworth 1967

Paleobotanical affinity -- Sigillariaceae (Schopf, 1941; Rettschlag and Remy, 1954; Courvoisier and Phillips, 1975). Abbott (1968) illustrated spores bearing a resemblance to *Crassispora* that were isolated from a sphenopsid cone (*Calamostachys*; this resemblance probably is superficial.

Crassispora annulata Ravn 1979

(Plate 16, figures 21, 22)

1964 *Crassispora plicata* Peppers, in part, pl. 2, fig. 2 only.

1964a *Crassispora kosankei* (Potonié and Kremp) Bhardwaj 1957; Sullivan, in part, pl. 60, fig. 14 only.
1979 *Crassispora annulata* Ravn, p. 39, pl. 12, figs. 11-15.

Remarks -- The possibility exists that *C. annulata* represents some variant or ontogenetic form of *C. kosankei*. Spores of this kind were observed, however, only in a narrow interval of the Iowa section, and thus they appear to have some stratigraphic utility.

Occurrence -- Rare, observed only in the Kilbourn Formation and the Blackoak Coal.

Crassispora kosankei (Potonié and Kremp) Bhardwaj emend.
Smith and Butterworth 1967

(Plate 16, figures 18-20)

1955 *Planisporites kosankei* Potonié and Kremp, p. 71, pl. 13, figs. 208-213.
1957a *Planisporites ovalis* Bhardwaj, p. 86, pl. 23, figs. 9, 10
non 1963 *Planisporites ovalis* (Nilsson) Danzé-Corsin and Laveine, p. 74, pl. 5, figs. 37, 38a.
1957b *Crassispora ovalis* (Bhardwaj) Bhardwaj, p. 126, pl. 25, figs. 73-76.
1957b *Crassispora kosankei* (Potonié and Kremp) Bhardwaj, p. 127.
1957a *Apiculatisporites apiculatus* (auct. non Ibrahim) Dybová and Jachowicz, p. 87, pl. 15, figs. 1-4.
1964 *Crassispora plicata* Peppers, in part, p. 17, pl. 1, fig. 18, pl. 2, fig. 1; non pl. 2, fig. 2.
1967 *Crassispora kosankei* (Potonié and Kremp) Bhardwaj emend. Smith and Butterworth, p. 234, pl. 19, figs. 2-4.

Remarks -- Specimens of *C. kosankei* observed in the older coals in Iowa (e.g., Wildcat Den and Wyoming Hill) tend to be larger than those in the younger coals, and display more strongly developed equatorial crassitude (see pl. 16, fig. 20). This morphologic variation may reflect a developmental trend leading from the larger Lower Carboniferous species *C. maculosa* (Knox) Sullivan 1964. Smith and Butterworth (1967) cited a range for *C. maculosa* in Britain of Viséan to Namurian, and a range for *C. kosankei* of Namurian and younger, suggesting the possibility of a developmental lineage.

Occurrence -- Rare to occasionally abundant, observed in virtually all coals throughout the Iowa section.

Genus *DENSOSPORITES* Berry emend. Butterworth, Jansonius,
Smith and Staplin 1964

Type species -- *D. covensis* Berry 1937.

Paleobotanical affinity -- Lycopods, probably of small, herbaceous habit (Chaloner, 1958a; Bhardwaj, 1958; Leisman, 1970; Remy and Remy, 1975). The report of Remy and Remy (1975) of spores corresponding to *D. sphaerotriangularis* Kosanke 1950 from a newly-described species of the cone genus *Sporangiostrobus* is of interest due to its stratigraphic position in the Stephanian of Spain. *Densosporites* species, including *D. sphaerotriangularis* show a marked decline to virtual disappearance in post-Desmoinesian (= post-Westphalian) strata in North America.

Densosporites aculeatus Playford 1963

(Plate 17, figures 10, 11)

1963 *Densosporites aculeatus* Playford, p. 631, pl. 88, figs. 16, 17; text-fig. 10e.

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale sample from the basal Kilbourn Formation in core CP-6.

Densosporites annulatus (Loose) Schopf, Wilson and Bentall 1944

(Plate 17, figure 9)

1932 *Sporonites anulatus* Loose, in Potonié, Ibrahim and Loose, p. 451, pl. 18, fig. 44.
1934 *Zonales-sporites (Anulati-sporites) annulatus* (Loose) Loose, p. 151.
1944 *Denso-sporites annulatus* (Loose) Schopf, Wilson and Bentall, p. 40.
1950 *Denso-sporites reynoldsburgensis* Kosanke, p. 33, pl. 6, figs. 9-11.
1956a *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.

Remarks -- Smith and Butterworth (1967) proposed *D. anulatus* as a new combination, despite the fact that Schopf, Wilson and Bentall (1944) previously proposed the same combination. The spelling of the specific epithet is questionable. The initial spelling was later altered by its original author (Loose, 1934), as an orthographic correction (Peppers, personal communication, 1986), followed here. Potonié and Kremp (1955), who noted both spellings, chose to maintain the original, and most subsequent authors have done likewise.

Occurrence -- Rare to occasionally dominant, observed in coals from the Wildcat Den through the Blackoak; tends to be most abundant in the Kilbourn Formation.

Densosporites irregularis Hacquebard and Barss 1957

(Plate 17, figures 13-15)

1957 *Densosporites irregularis* Hacquebard and Barss, p. 31, pl. 4, figs. 11-14.
non 1965 *Densosporites irregularis* Menéndez, p. 68, pl. 5, figs. 6, 7.

Remarks -- *D. cavus* Urban 1971 is similar to *D. irregularis* in having 'excavations' around the cingulum, but is described as smaller, with small scattered coni on the distal surface.

Occurrence -- Common to abundant, Wildcat Den and Wyoming Hill Coals; rare in the Kilbourn Formation and the Blackoak Coal.

Densosporites sphaerotriangularis Kosanke 1950

(Plate 18, figures 15-17)

1950 *Denso-sporites sphaerotriangularis* Kosanke, p. 33-34, pl. 6, fig. 7.
1964 *Densisporites sphaerotriangularis* (Kosanke) Levet-Carette, p. 273, non pl. 10, fig. 25.

Occurrence -- Frequent to abundant, observed from the Wildcat Den through Whitebreast Coals.

Densosporites spinifer Hoffmeister, Staplin and Malloy 1955

(Plate 18, figures 18, 19)

1955 *Denso-sporites spinifer* Hoffmeister, Staplin and Malloy, p. 386, pl. 36, figs. 16, 17.
1962 *Cristatisporites spinifer* (Hoffmeister, Staplin and Malloy) Bharadwaj and Venkatachala, p. 34, pl. 6, figs. 106-108.

Occurrence -- Rare, observed in the Kilbourn Formation and the Blackoak Coal.

Densosporites triangularis Kosanke 1950

(Plate 18, figures 20-23)

1950 *Denso-sporites triangularis* Kosanke, p. 34, pl. 7, fig. 1.
1958 *Densosporites spongeosus* Butterworth and Williams, p. 380, pl. 3, figs. 40, 41.

1966 *Densosporites oblatus* Habib, p. 641-642, pl. 106, figs. 12, 14.

Occurrence -- Rare to occasionally abundant, observed from the Wildcat Den to Whitebreast Coals.

Densosporites variabilis (Waltz) Potonié and Kremp 1956

(Plate 17, figure 12)

1938 *Zonotriletes variabilis* Waltz, in Luber and Waltz, p. 20-21, pl. 4, figs. 44-46, pl. A, fig. 16.
1956a *Densosporites variabilis* (Waltz) Potonié and Kremp, p. 116.
1956 *Trematozonotriletes variabilis* (Waltz) Ishchenko var. *foveolatus* Waltz; Ishchenko, p. 102-103, pl. 22, fig. 248.
1957 *Trematozonotriletes variabilis* (Waltz) Naumova; Byvscheva, p. 1010.
1957a *Anulatisporites bacatus* Dybová and Jachowicz, p. 157, pl. 43, figs. 1-4; text-fig. 1.

Remarks -- Playford (1963) considered the spores designated *D. variabilis* by Butterworth and Williams (1958) to be incorrectly assigned.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Genus *LYCOSPORA* Schopf, Wilson and Bentall emend. Potonié and Kremp 1954

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

Remarks -- Somers (1971, 1972) reviewed the genus *Lycospora* and synonymized the many described species into a few broadly redefined categories. I consider certain of these synonymies, particularly the proposed inclusion of *L. micropapillata*, *L. granulata* Kosanke 1950 and *L. pellucida* (Wicher) Schopf, Wilson and Bentall 1944 with *L. pusilla* (Ibrahim) Schopf, Wilson and Bentall emend. Somers 1972, to be too broad; they do not agree with morphologic distinctions that can be made reliably among spores of this genus as observed in Iowa coals. Coquel (1973) reached a similar conclusion on the basis of detailed morphological studies using the scanning electron microscope. The revisions of Somers (1971, 1972) therefore are not followed in this report. Paleobotanical studies (e.g., Felix, 1954; Balbach, 1966), however, indicate that morphologic speciation within *Lycospora* by palynologists has been excessive; the proposed synonymies of Somers (1972) are useful as guides to potential similarities among species.

Turnau (1978) erected the genus *Prolycospora* to accommodate spores similar to *Lycospora* but having a very narrow cingulum. She transferred to *Prolycospora* several *Lycospora* species as well as the Lower Carboniferous miospore *Granulatisporites frustulentus* (Balme and Hassell) Playford 1971, an important species from the southern hemisphere. The desirability of transferring the latter from *Granulatisporites* is clear, but the distinction of *Prolycospora* from *Lycospora* as understood either in the sense of Potonié and Kremp (1954) or of Somers (1971, 1972) is subtle and of questionable utility. *G. frustulentus* encompasses miospores having a wide variation in morphology (see Playford, 1971b, 1976, 1978; Kemp et al., 1977); many specimens are distinctly *Lycospora*-like in appearance. This species possibly could be reassigned to *Lycospora*.

Paleobotanical affinities -- Various arborescent lycopsids (Andrews and Pannell, 1942; Chaloner, 1953a; Felix, 1954; Sen, 1958; Leisman and Spohn, 1962; Abbott, 1963; Hagemann, 1966a; 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 18, figures 12-14)

1950 *Lycospora granulata* Kosanke, p. 45, pl. 10, figs. 4, 6.
1957a *Lycospora denticulata* Bhardwaj, p. 103, pl. 27, fig. 9.
1957a *Lycospora triangulata* Bhardwaj, 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.

Occurrence -- This is the most abundant miospore species throughout most of the Iowa section. It is generally dominant and often constitutes more than 50% of the miospore population of coals from the Carruthers through the Mystic. Although still abundant, its numbers are reduced in older coals, especially in the Blackoak, Cliffland and Laddsdale Coals, where *Lycospora* overall is less abundant. In coals of the Kilbourn and Caseyville Formations, *L. granulata* tends to be quantitatively secondary to the species *L. pellucida.* Although only a few samples of the basal Missourian Ovid Coal were examined in this study, observations tend to confirm those of Phillips and others (1974) of the virtual disappearance of *Lycospora* species at the Desmoinesian-Missourian boundary.

Lycospora micropapillata (Wilson and Coe) Schopf, Wilson and Bentall 1944

(Plate 18, figures 1, 2)

1940 *Cirratriradites micropapillatus* Wilson and Coe, p. 184, pl. 1. fig. 6.
1944 *Lycospora micropapillata* (Wilson and Coe) Schopf, Wilson and Bentall, p. 54.

Remarks -- Felix (1954) recovered spores corresponding to *L. micropapillata* from the tips of a species of *Lepidostrobus* which also contained larger spores comparable to *L. pellucida.* He suggested that the smaller spores were abortive.

Occurrence -- Rare to occasionally frequent, observed in most coals from the Wildcat Den through the Mystic.

Lycospora noctuina Butterworth and Williams 1958

(Plate 18, figures 10, 11)

1958 *Lycospora noctuina* Butterworth and Williams, p. 376, pl. 3, figs. 14, 15.

Remarks -- The distal verrucae characteristic of *L. noctuina* are not as distinctly developed in specimens observed in Iowa coals as they are in specimens reported mainly from the Lower Carboniferous by other investigators (e.g., Smith and Butterworth, 1967). The occurrence of these forms in the lowermost portion of the Iowa Pennsylvanian is among the youngest reported for the species (Smith and Butterworth, 1967, reported them as extending to the Westphalian A, and Peppers, 1984, also reported the species in the Caseyville Formation in Illinois); this morphologic variation suggests the possibility of a progressive reduction in the size of the verrucae through time.

Occurrence -- Rare to occasionally frequent, observed only in the Wildcat Den Coal.

Lycospora orbicula (Potonié and Kremp) Smith and Butterworth 1967

(Plate 18, figures 3, 4)

1955 *Cyclogranisporites orbiculus* Potonié and Kremp, p. 63, pl. 13, figs. 179-183.
1967 *Lycospora orbicula* (Potonié and Kremp) Smith and Butterworth, p. 249-250, pl. 20, figs. 16-19.

Occurrence -- Rare to frequent, observed in the Wildcat Den and Wyoming Hill Coals.

Lycospora pellucida (Wicher) Schopf, Wilson and Bentall 1944

(Plate 18, figures 7-9)

1934 *Sporites pellucidus* Wicher, p. 186, pl. 8, fig. 29.
1944 *Lycospora pellucidus* (Wicher) Schopf, Wilson and Bentall, p. 54.
1950 *Lycospora pseudoannulata* Kosanke, p. 45, pl. 10, fig. 3.
1950 *Lycospora punctata* Kosanke, p. 45, pl. 10, fig. 7.
1955 *Cirratriradites pseudoannulatus* (Kosanke) Hoffmeister, Staplin and Malloy, p. 383, pl. 36, fig. 25.

1955 *Cirratriradites punctatus* (Kosanke) Hoffmeister, Staplin and Malloy, p. 382.
1955 *Cirratriradites uber* Hoffmeister, Staplin and Malloy, p. 383, pl. 36, fig. 24.
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* (Kosanke) Levet-Carette, p. 272, pl. 10, fig. 24.

Remarks -- See Remarks under the genus; see also the discussion and synonymy of Somers (1972).

Occurrence -- Common to dominant, Caseyville Formation and Kilbourn Formation coals; rare to abundant in coals from the Blackoak through the Mystic.

Lycospora rotunda Bhardwaj 1957

(Plate 18, figures 5, 6)

1956a *Lycospora torquifer* (auct. non Loose) Potonié and Kremp, p. 104, pl. 17, figs. 356-359.
1957a *Lycospora rotunda* Bhardwaj, p. 103, pl. 27, figs. 10-12.
1957 *Lycospora nitida* Artüz, p. 250, pl. 5, fig. 34.
non 1955 *Lycospora nitida* (Horst) Potonié and Kremp, p. 181, pl. 24, fig. 81.
1957 *Lycospora paulula* Artüz, p. 250, pl. 5, fig. 35.
1967 *Lycospora? granulata* auct. non Kosanke 1950; Smith and Butterworth, p. 247, pl. 20, figs. 1-3.

Remarks -- *L. subtriquetra* (Luber) Potonié and Kremp 1955 is similar and may be synonymous (see also Somers, 1972); if so, *L. subtriquetra* would be the senior name.

Occurrence -- Rare to occasionally frequent, observed in most coals from the Wildcat Den through the Bevier; tends to be most frequent in the Laddsdale Coals.

?Lycospora tripapillata n. sp.

(Plate 19, figures 1-5)

Diagnosis -- Miospores radial, trilete, amb roundly triangular, nearly always in good proximal-distal orientation. Trilete rays faint, in some specimens imperceptible, more often slightly raised, narrow, seldom open; rays extend nearly to equator. Low, commonly indistinct apical papillae present, 2-5 μm in diameter, little more than 1 μm high. Cingulum extremely narrow, approximately 1 μm wide, often indistinct or appearing incomplete. Exine relatively thick, laevigate to faintly punctate or granulose, seldom folded.

Size -- (25 specimens) 22-32 μm maximum diameter.

Remarks -- Assignment of this species to *Lycospora* is made with reservation because of the indistinctness of the morphologic features. The apical papillae are characteristic of many lycopod spores, however, and the cingulum, although narrow and poorly developed, is characteristic of *Lycospora*. Peppers (1986, personal communication) has suggested the possibility that these may be disattached endexines of other *Lycospora* species.

Derivation -- The specific epithet refers to the three apical papillae.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-10 unit 49, Appanoose County, Iowa (See Gregory, 1982, p. 140); Blackoak Coal, Kalo Formation, uppermost Atokan Series.

Occurrence -- Rare, observed in the Wildcat Den, Blackoak and Laddsdale Coals.

?Lycospora sp. 1

(Plate 19, figures 6, 7)

Description -- Miospores radial, trilete, amb sphaerotriangular. Trilete rays straight, distinct, extending to angles, accompanied by narrow folds. Exine of proximal surface thin, laevigate to faintly punctate (?infrasculpture). Distal surface ornamented by a distinct but irregular reticulum extending to the cingulum; muri 1-2 μm wide, approximately 1 μm high, enclosing irregularly polygonal lumina 2-7 μm in maximum width. Along distal surface of cingulum, muri grade into a series of radiating ribs that project at the margin, giving the cingulum an irregular, scalloped outline. Cingulum thin, tapering slightly from inner to outer margin.

Size of illustrated specimens -- 33.6 μm and 48.3 μm in maximum diameter.

Remarks -- These spores are assigned questionably to *Lycospora* on the basis of general morphologic resemblance to other species assigned to the genus. They display features characteristic of several lycopsid-related genera. Although the overall appearance is similar to *Lycospora*, the tapering structure of the cingulum more closely resembles certain *Cirratriradites* species The reticulate distal sculpture is similar to that of *C. reticulatus* Ravn 1979, but is less distinct, and the flange of *C. reticulatus* is much thinner and unornamented. The scalloped margin and radial ornamentation of the flange of *?Lycospora* sp. 1 resembles features characteristic of certain species of *Cristatisporites* but the latter genus does not contain forms with reticulate ornamentation. The genus *Retispora* Staplin 1960 accommodates cavate forms with reticulate distal ornamentation, but specimens of *?L.* sp. 1 display no cavation. Too few specimens were observed to allow adequate assessment of morphologic variability, and no new species is erected.

Occurrence -- Extremely rare, observed only in the Kilbourn Formation and the Laddsdale Coals.

Genus *CIRRATRIRADITES* Wilson and Coe 1940

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

Paleobotanical affinities -- The herbaceous lycopod cone genus *Selaginellites* (Lundblad, 1950; Chaloner, 1954; Hoskins and Abbott, 1956; Schlanker and Leisman, 1961).

Cirratriradites annuliformis Kosanke and Brokaw, in Kosanke, 1950

(Plate 19, figure 18)

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

Occurrence -- Rare, observed in coals from the Kilbourn Formation through the Summit.

Cirratriradites maculatus Wilson and Coe 1940

(Plate 19, figures 19, 20)

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

Remarks -- Although some investigators (e.g., Potonié and Kremp, 1956a) have considered *C. maculatus* to be a junior synonym of *C. saturnii* (Ibrahim) Schopf, Wilson and Bentall 1944, Wilson (1966) re-evaluated the type material of both species and regarded them as distinct. The main body of *C. maculatus* is thicker and finely punctate or granulose (possibly infrasculpture; Ravn, 1979). In constrast, the main body of *C. saturnii* is thinner and finely reticulate.

Occurrence -- Rare, observed in most coals from the Kilbourn Formation upward throughout the Iowa section.

Cirratriradites reticulatus Ravn 1979

(Plate 19, figure 17)

1979 *Cirratriradites reticulatus* Ravn, p. 42, pl. 14, figs. 4-6.

Remarks -- *C. foveolatus* Venkatachala and Salujha 1971 is similar to *C. reticulatus*, but is considerably larger and has distal fovea, which have not been observed on specimens of *C. foveolatus*.

Occurrence -- Rare, observed only in the Blackoak Coal.

Cirratriradites saturnii (Ibrahim) Schopf, Wilson and Bentall 1944

(Plate 20, figures 1-4)

1932 *Sporonites saturni* Ibrahim, in Potonié, Ibrahim and Loose, p. 448, pl. 15, fig. 14.
1933 *Zonales-sporites saturni* (Ibrahim) Ibrahim, p. 30, pl. 2, fig. 14.
1938 *Zonotriletes saturni* (Ibrahim) Luber, in Luber and Waltz, p. 8, fig. 102.
1944 *Cirratriradites saturni* (Ibrahim) Schopf, Wilson and Bentall, p. 44.
1965a *Cirratrisporites saturni* (Ibrahim) Laveine, p. 134.

Remarks -- *C. annulatus* Kosanke and Brokaw (in Kosanke, 1950) is closely similar to *C. saturnii* in most respects. Smith and Butterworth (1967) distinguished *C. annulatus* from *C. saturnii* on the basis of the possession of multiple distal fovea by the former. The number of fovea, however, appears to be a variable feature in several species of *Cirratriradites* and may not be a reliable characteristic for inter-specific differentiation.

Occurrence -- Rare, observed in coals from the Kilbourn Formation through the Whitebreast.

Cirratriradites sp. 1

(Plate 20, figures 5-7)

1982 *Cirratriradites saturni* (Ibrahim) Schopf, Wilson and Bentall, 1944; Ravn and Fitzgerald, p. 139, pl. 9, fig. 28.

Description -- Miospores radial, trilete, amb sphaerotriangular. Trilete rays distinct, raised, uniform, extending to equator at angles. Cingulum broad, relatively thin, radially striate, with a distinct concentric medial 'keel.' Distal surface of main body ornamented by a single circular to irregular fovea and very fine spinose sculpture.

Size -- (25 specimens) 72-104 μm maximum diameter.

Remarks -- Ravn and Fitzgerald (1982) regarded specimens of this kind to represent a variant of *C. saturnii* but subsequent examination with the SEM has revealed the ornamentation of the distal surface to be finely spinose rather than reticulate. This difference in sculpture plus the presence of the distinctive medial 'keel' in the cingulum suggests that *C.* sp. 1 represents a distinct species. Taxonomy within the genus is somewhat confused at present, however, and I do not consider erection of a new species at this time to be appropriate without further study and comparison.

Occurrence -- Rare to frequent, observed in Caseyville Formation coals and a shale sample from the basal Kilbourn Formation in core CP-6.

The following new name is proposed to correct a problem of homonymy:

Cirratriradites fragilis n. name:
1970 *Cirratriradites tenuis* Peppers, p. 122, pl. 12, figs. 10, 11.
non 1944 *Cirratriradites tenuis* (Loose) Schopf, Wilson and Bentall, p. 44.

Derivation -- The new specific epithet is chosen to recognize the fragile nature of the exine as evidenced by the type illustrations of Peppers (1970).

Genus *CRISTATISPORITES* Potonié and Kremp emend. Butterworth, Jansonius, Smith and Staplin 1964

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

Paleobotanical affinity -- Lycopsid (Chaloner, 1962).

Cristatisporites connexus Potonié and Kremp 1955

(Plate 19, figures 10, 11)

1955 *Cristatisporites connexus* Potonié and Kremp, p. 160, pl. 16, figs. 291-293.

Occurrence -- Rare, observed only in the unnamed coal of the Caseyville Formation.

Cristatisporites indignabundus (Loose) Potonié and Kremp emend. Staplin and Jansonius 1964

(Plate 19, figures 12-16)

1932 *Sporonites indignabundus* Loose, in Potonié, Ibrahim and Loose, p. 451, pl. 19, fig. 51.
1934 *Apiculati-sporites indignabundus* (Loose) 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) Potonié and Kremp emend. Staplin and Jansonius, p. 108-109, pl. 19, figs. 7-9, 12, 14, 20; text-fig. 2c.
1965a *Densisporites indignabundus* (Loose) Laveine, p. 133.

Remarks -- As demonstrated by the illustrated specimens, spores assignable to *C. indignabundus* vary considerably in ornamentation. In Iowa, the highly spinose forms were observed only in the Caseyville Formation coals.

Occurrence -- Rare to occasionally abundant, observed from the Wildcat Den through Blackoak Coals; most common in Caseyville coals.

Genus *CINGULIZONATES* Dybová and Jachowicz emend. Butterworth, Jansonius, Smith and Staplin 1964

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

Paleobotanical affinity -- Lycopsid (Chaloner, 1958b).

Cingulizonates loricatus (Loose) Butterworth and Smith, in Butterworth et al., 1964

(Plate 19, figures 8, 9)

1932 *Sporonites loricatus* Loose, in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 42.
1934 *Zonales-sporites loricatus* (Loose) Loose, p. 151.
1944 *Densosporites loricatus* (Loose) Schopf, Wilson and Bentall, p. 40.
1964a *Densisporites loricatus* (Loose) Agrali, p. 13.
1964 *Cingulizonates loricatus* (Loose) Butterworth and Smith, in Butterworth et al., p. 1053, pl. 2, fig. 4.

Remarks -- See discussion by Ravn (1979) concerning the similarity between *C. loricatus* and *C. bialatus*.

Occurrence -- Rare to frequent, observed in Caseyville Formation coals; extremely rare occurrence noted in the Blackoak Coal.

Genus *RADIIZONATES* Staplin and Jansonius 1964

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

Paleobotanical affinity -- Lycopsid (Courvoisier and Phillips, 1975).

Radiizonates difformis (Kosanke) Staplin and Jansonius 1964

(Plate 17, figure 16)

1950 *Cirratriradites difformis* Kosanke, p. 35, pl. 7, fig. 3.
1957a *Cingulizonates asteroides* Dybová and Jachowicz, p. 173-174, pl. 54, figs. 1-4.
1957a *Cingulizonates karczewskii* Dybová and Jachowicz, p. 175-176, pl. 56, figs. 1-4.
1964 *Radiizonates difformis* (Kosanke) Staplin and Jansonius, p. 106.
1964 *Radiizonates karczewskii* (Dybová and Jachowicz) Staplin and Jansonius, p. 106.
1979 *Radiizonates* cf. *difformis* (Kosanke) Staplin and Jansonius 1964; Ravn, p. 39, pl. 12, figs. 7, 8.

Occurrence -- Rare to occasionally frequent, observed only in the Kilbourn Formation and the Blackoak Coal.

Radiizonates striatus (Knox) Staplin and Jansonius 1964

(Plate 17, figures 17, 18)

1950 *Cirratriradites striatus* Knox, p. 330, pl. 19, fig. 289.
1957 *Densosporites marginata* Artüz, p. 252, pl. 6, fig. 42.
non 1958 *Densosporites striatus* (auct. non Knox) Butterworth and Williams, p. 380, pl. 3, fig. 36.
1964 *Radiizonates striatus* (Knox) Staplin and Jansonius, p. 106.

Occurrence -- Rare to common, observed in Caseyville Formation Coals.

Genus *SPENCERISPORITES* Chaloner 1951

Type species -- *S. radiatus* (Ibrahim) Felix and Parks 1959.

Paleobotanical affinity -- The lycopsid fructification *Spencerites* (Chaloner, 1951; Leisman, 1962).

Spencerisporites radiatus (Ibrahim) Felix and Parks 1959

(Plate 21, figure 8)

1932 *Sporonites radiatus* Ibrahim, in Potonié, Ibrahim and Loose, p. 449, pl. 16, fig. 25.
1933 *Zonales-sporites radiatus* (Ibrahim) Ibrahim, p. 28, pl. 3, fig. 25.
1934 *Triletes karczewskii* Zerndt, p. 27, pl. 31, fig. 3.
1943 *Triletes (Zonales) radiatus* (Ibrahim) Horst, pl. 2, fig. 15, pl. 3, figs. 16a, b.
1944 *Triletes radiatus* (Ibrahim) Schopf, Wilson and Bentall, p. 24.
1944 *Endosporites? karczewskii* (Zerndt) Schopf, Wilson and Bentall, p. 45.
1946 *Microsporites karczewskii* (Zerndt) Dijsktra and van Vierssen-Trip, p. 64, pl. 4, fig. 40.
1951 *Spencerisporites karczewskii* (Zerndt) Chaloner, p. 862, text-figs. 1, 2, 6, 7.
1955 *Endosporites (?) radiatus* (Ibrahim) Dijkstra, p. 342, pl. 45, fig. 54.
1956a *Microsporites radiatus* (Ibrahim) Dijkstra; Potonié and Kremp, p. 157, pl. 20, figs. 449, 450.
1959 *Spencerisporites radiatus* (Ibrahim) Chaloner; Felix and Parks, p. 362, pl. 1, figs. 1-4, pl. 2, figs. 1-4.

Remarks -- Burbridge and Felix (1976) reviewed morphologic characteristics and stratigraphic occurrences of the species *S. radiatus* and *S. gracilis* and suggested the possibility of morphologic intergradation between them.

Occurrence -- Difficult to assess, as these large spores may be selectively eliminated from samples through the normal screening process. Specimens were observed in the unnamed coal of the Caseyville Formation and the Wyoming Hill Coal. Both J. W. Swade and J. L. Gregory (personal communications, 1980, 1982) recovered specimens of *Spencerisporites* in residues of conodont preparations taken from various parts of the Iowa Geological Survey cores on which this study is based.

Genus *ENDOSPORITES* Wilson and Coe 1940

Type species -- *E. globiformis* (Ibrahim) Schopf, Wilson and Bentall 1944 (= *E. ornatus* Wilson and Coe 1940).

Paleobotanical affinity -- Heterosporous herbaceous lycopods (DiMichele, Mahaffy and Phillips, 1979). Previous investigators regarded the parent plant as probably arborescent, based on the large size of the cone (Chaloner, 1953b, 1958; Brack and Taylor, 1972).

Endosporites globiformis (Ibrahim) Schopf, Wilson and Bentall 1944

(Plate 20, figures 10, 11)

1932 *Sporonites globiformis* Ibrahim, in Potonié, Ibrahim and Loose, p. 447, pl. 14, fig. 5.
1933 *Zonales-sporites globiformis* (Ibrahim) Ibrahim, p. 28, pl. 1, fig. 5.
1938 *Zonotriletes globiformis* (Ibrahim) Luber, in Luber and Waltz, pl. 8, fig. 103, pl. B, fig. 30.
1940 *Endosporites ornatus* Wilson and Coe, p. 184, pl. 1, fig. 2.
1944 *Endosporites globiformis* (Ibrahim) Schopf, Wilson and Bentall, p. 45.
1965a *Endopollenites globiformis* (Ibrahim) Laveine, p. 136.
1965a *Endopollenites ornatus* (Wilson and Coe) Laveine, p. 136.

Occurrence -- Frequent to abundant, observed from the Kilbourn Formation upward throughout the Iowa section.

Endosporites plicatus Kosanke 1950

(Plate 21, fig. 1)

1950 *Endosporites plicatus* Kosanke, p. 37, pl. 7, fig. 7.
1966 *Endosporites grandicorpus* Habib, p. 647, pl. 107, figs. 11, 12.

Remarks -- Smith and Butterworth (1967) considered *E. plicatus* to be synonymous with *E. zonalis* (Loose) Knox 1950. In Iowa coals two distinct forms have been observed. *E. plicatus* is characterized by possession of prominent apical papillae and a thinner central body than that of *E. zonalis*.

Occurrence -- Rare, observed in most coals from the Blackoak through the Mulky.

Endosporites zonalis (Loose) Knox 1950

(Plate 20, figures 8, 9)

1934 *Zonales-sporites zonalis* Loose, p. 148, pl. 7, fig. 5.
1944 *Cirratriradites zonalis* (Loose) Schopf, Wilson and Bentall, p. 44.
1950 *Endosporites zonalis* (Loose) Knox, p. 332, pl. 19, fig. 295.
1965a *Endopollenites zonalis* (Loose) Laveine, p. 136.

Remarks -- The distinction between *E. zonalis* and *E. globiformis* is conventiently regarded as the ratio of central body radius to pseudosaccus radius (greater than 50% for *E. zonalis*, less than 50% for *E. globiformis*). Arbitrary measurements of this kind are less than satisfactory as bases for speciation among miospores. The character of the pseudosaccus appears to differ in the two species as represented in the Iowa material; in *E. globiformis* the pseudosaccus appears to be infragranulose, whereas in *E. zonalis* it appears to be infrapunctate. These features, however, are discerned only with difficulty, as the grade of ornamentation is very fine and lies near the limits of resolution for optical microscopy. Detailed SEM and TEM study may resolve the pseudosaccus morphologies more clearly.

Occurrence -- Rare to occasionally frequent, observed in most coals from the Wildcat Den through the Laddsdale.

TRILETE OF UNKNOWN AFFINITIES

Miospores grouped in this category are assigned to those genera which, in most cases, have not been reported *in situ* from the Carboniferous. In a few cases, *in situ* reports do exist, but the affinity of the parent fructification is unknown. Morphologic similarity of some genera to other genera of known affinities is suggestive of possible relationships, but it is not considered clear evidence of such in this study. The genera are arranged in general order of increasing morphologic complexity.

Genus *ADELISPORITES* Ravn 1979

Type species -- *A. multiplicatus* Ravn 1979.

Adelisporites multiplicatus Ravn 1979

(Plate 21, figures 2-7)

1979 *Adelisporites multiplicatus* Ravn, p. 25, pl. 4, figs. 2-6.

Remarks -- These may be aborted spores related to some other genus. Nevertheless, their distribution in Iowa coals suggests that they may be useful for stratigraphic interpretation. Butterworth and Mahdi (1982) recently have reported the species from the Namurian of England.

Occurrence -- Rare, observed in Wildcat Den Coal, the Kilbourn Formation, the Blackoak, Cliffland and Wheeler Coals.

Genus *GULISPORITES* Imgrund 1960

Type species -- *G. cochlearis* Imgrund 1960.

Gulisporites torpidus Playford 1964

(Plate 22, figure 2)

1964 *Gulisporites torpidus* Playford, p. 8, pl. 1, figs. 13, 14.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Genus *LATIPULVINITES* Peppers 1964

Type species -- *L. kosankei* Peppers 1964.

Latipulvinites kosankii Peppers 1964

(Plate 22, figure 1)

1964 *Latipulvinites kosankii* Peppers, p. 26, pl. 3, figs. 13, 14; text-fig. 6.

Occurrence -- Rare, observed only in the Blackoak Coal.

Genus *PLANISPORITES* Knox emend. Potonié 1960

Type species -- *P. granifer* (Ibrahim) Knox 1950.

Planisporites granifer (Ibrahim) Knox 1950

(Plate 22, figure 14)

1933 *Granulati-sporites granifer* Ibrahim, p. 22, pl. 8, fig. 72.
1944 *Punctati-sporites granifer* (Ibrahim) Schopf, Wilson and Bentall, p. 31.
1950 *Plani-sporites granifer* (Ibrahim) Knox, p. 315, pl. 17, fig. 210.

Occurrence -- Rare, observed in the Blackoak, Cliffland, Laddsdale and Whitebreast Coals.

Genus *CUNEISPORITES* Ravn 1979

non *Cuneisporites* Zhang 1980.

Type species -- *C. rigidus* Ravn 1979.

Cuneisporites rigidus Ravn 1979

(Plate 22, figures 3-5)

1979 *Cuneisporites rigidus* Ravn, p. 37, pl. 11, figs. 7-9.

Occurrence -- Rare, observed in the Blackoak, Cliffland and Laddsdale Coals.

Genus *TETANISPORITES* Ravn 1979

Type species -- *T. granulatus* Ravn 1979.

Tetanisporites granulatus Ravn 1979

(Plate 22, figures 6-8)

1979 *Tetanisporites granulatus* Ravn, p. 38, pl. 11, figs. 10-12.

Occurrence -- Rare, observed in the Blackoak and Cliffland Coals.

Genus *CADIOSPORA* Kosanke 1950

Type species -- *C. magna* Kosanke 1950.

Cadiospora magna Kosanke 1950

(Plate 22, figures 15, 16)

1950 *Cadiospora magna* Kosanke, p. 50, pl. 16, fig. 1.
1954 *Cadiospora sphaera* Butterworth and Williams, p. 761, pl. 19, figs. 1, 2; text-fig. 2.
1954 *Gravisporites sphaerus* (Butterworth and Williams) Bhardwaj, p. 514, text-fig. 21.
1967 *Cadiosisporites magnus* (Kosanke) Agrali and Akyol, p. 13.

Occurrence -- Rare, observed regularly in most coals from the Wheeler upward throughout the section; one occurrence observed in a coal questionably considered to be a seam of the Laddsdale complex.

Genus *SINUSPORES* Artüz emend.

1957 *Sinuspores* Artüz, p. 254.

Type species -- *S. sinuatus* Artüz emend.

Emended diagnosis -- Miospores trilete, amb circular. Exine laevigate or nearly so. A broad, rounded subequatorial thickening of the exine connects the ends of the rays to form curvaturae.

Comparison -- The broad, rounded curvaturate thickening forms the major distinctive characteristic of this genus and serves to distinguish it from *Punctatisporites*, a genus generally reserved to accommodate unornamented spherical trilete miospores. *Retusotriletes* Naumova emend. Streel 1974 is reserved for spores having much thinner, ridge-like or keel-like curvaturae.

Remarks -- The decision to emend and reinstate *Sinuspores* as the appropriate generic assignment for *S.* (*Punctatisporites*) *sinuatus* Artüz results from examination of large numbers of specimens both optically and with the SEM. These examinations led to disagreement with the morphologic interpretation of the species by Neves (1961), who transferred it to *Punctatisporites*. Details of the morphologic interpretation are discussed under the species as follows.

Sinuspores sinuatus Artüz emend.

(Plate 23, figures 9-12)

1957 *Sinuspores sinuatus* Artüz, p. 254, pl. 7, fig. 48.
1958 *Punctatisporites densoarcuatus* Neves, p. 6, pl. 2, fig. 7.
1958 *Punctatisporites coronatus* Butterworth and Williams, p. 360, pl. 1, fig. 12.
1961 *Punctatisporites sinuatus* (Artüz) Neves, p. 252.

Emended diagnosis -- Miospores conforming to the characteristics of the genus. Trilete rays straight, distinct, 2/3 to 3/4 of radius, often open. Exine thick (5 µm or more), commonly with low, irregular folds which may be arranged adjacent to the curvaturate thickening.

Size -- 75-130 µm maximum diameter (cited by Smith and Butterworth, 1967; specimens observed in Iowa coals fell within this size range).

Remarks -- Butterworth and Williams (1958) and Neves (1958) independently described spores corresponding to *S. sinuatus* as species of *Punctatisporites*. Neves (1961) recognized the synonymy, and transferred *S. sinuatus* to *Punctatisporites*, interpreting the subequatorial thickening of the exine to be a variable, non-haptotypic feature not of generic significance. This interpretation is emphasized by Smith and Butterworth (1967, p. 130), who described the exine as 'usually highly folded. Characteristically the folds are broad and situated around the periphery of the spore but they sometimes follow the laesurae, when they give the appearance of broad lips.'

I disagree with this interpretation. Examination of many excellent specimens of *S. sinuatus* in Iowa material and study of the numerous published descriptions and illustrations of the species (e.g., Butterworth and Williams, 1958; Neves, 1958; Smith and Butterworth, 1967; Loboziak and Dil, 1973; Bless and Streel, 1976; Coquel, 1976; Kosanke, 1976; Clayton et al., 1977; Ettensohn and Peppers, 1979) indicate clearly that the subequatorial thickening is a consistent feature associated with the ends of the trilete rays in a manner analogous to curvaturae (see esp. pl. 23, fig. 12). Except for its indentation adjacent to the ends of the rays, the thickening resembles the equatorial cingulum of certain species of the genera *Cincturasporites* Hacquebard and Barss emend. Bharadwaj and Venkatachala 1962 and *Orbisporis* Bharadwaj and Venkatachala 1962 (good illustrations of several species of these genera may be found in Felix and Burbridge, 1967, and Butterworth and Spinner, 1967). Curvaturate thickenings are not characteristic of *Punctatisporites*; in my view the presence of such a thickening in this species mandates resurrection of *Sinuspores* in emended form.

Occurrence -- Rare, observed in coals of the Caseyville and Kilbourn Formations.

Genus *WALTZISPORA* Staplin 1960

Type species -- *W. lobophora* (Waltz) Staplin 1960.

Waltzispora polita (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967

(Plate 21, figure 9)

1955 *Granulati-sporites politus* Hoffmeister, Staplin and Malloy, p. 389, pl. 36, fig. 13.
non 1960 *Leiotriletes politus* (auct. non Hoffmeister, Staplin and Malloy) Love, p. 111, pl. 1, fig. 1.
1967 *Waltzispora polita* (Hoffmeister, Staplin and Malloy) Smith and Butterworth, p. 159-160, pl. 6, fig. 14.

Occurrence -- Rare, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation and a shale sample from the basal Kilbourn Formation in core CP-6.

Waltzispora prisca (Kosanke) Sullivan 1964

(Plate 21, figures 11-13)

1950 *Triquitrites priscus* Kosanke, p. 39, pl. 8, fig. 4.
1964a *Waltzispora prisca* (Kosanke) Sullivan, p. 362, pl. 57, fig. 24.

Occurrence -- Rare, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation, and the Kilbourn Formation; one occurrence observed in a coal of the Laddsdale complex.

Waltzispora sagittata Playford 1962

(Plate 21, figure 10)

1960 *Leiotriletes politus* (auct. non Hoffmeister, Staplin and Malloy) Love, p. 111, pl. 1, fig. 1.
1962 *Waltzispora sagittata* Playford, p. 582-583, pl. 79, fig. 12; text-fig. 5c.

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale sample from the basal Kilbourn Formation in core CP-6; one occurrence observed in the Blackoak Coal.

Genus *CONVERRUCOSISPORITES* Potonié and Kremp 1954

Type species -- *C. triquetrus* (Ibrahim) Potonié and Kremp 1954.

Remarks -- Gupta (1969) considered *Converrucosisporites* to be a junior synonym of *Trilites* Cookson ex Couper 1953. Skarby (1974), however, regarded *Trilites* as a junior synonym of *Cibotiidites* Ross 1949, which is valvate (see also discussion by Srivastava, 1977). *Converrucosisporites* is not valvate, and cannot be considered synonymous with *Cibotiidites*. As the systematic position of *Trilites* is somewhat ambiguous, *Converrucosisporites* is retained here as the appropriate genus for spores of this kind.

Converrucosisporites armatus (Dybová and Jachowicz) Smith and Butterworth 1967

(Plate 21, figures 14-16)

1957a *Converrucitriletes armatus* Dybová and Jachowicz, p. 128, pl. 32, fig. 1.
1967 *Converrucosisporites armatus* (Dybová and Jachowicz) Smith and Butterworth, p. 146-147, pl. 4, figs. 19-21.
1969 *Trilites armatus* (Dybová and Jachowicz) Gupta. p. 160, pl. 31, fig. 30.

Occurrence -- Rare, observed in the Kilbourn Formation and the Blackoak and Bevier Coals.

Converrucosisporites vermiformis n. sp.

(Plate 21, figures 17-20)

Diagnosis -- Miospores radial, trilete, amb triangular; usually in good proximal-distal orientation. Interradial sides slightly convex to markedly concave, may vary on individual specimens. Trilete rays simple, straight, 1/2 to nearly 3/4 of radius. Exine moderately thick and dark, densely ornamented on both proximal and distal surfaces with simple, branched or occasionally vermiform verrucae 2-4 μm wide, 1-2 μm high; verrucae flat-topped to sharply and irregularly pointed, giving a rough outline to the margin. Spaces between verrucae narrower than the verrucae themselves, 1-2 μm wide, appearing as a network of channels or an irregular negative reticulum.

Size -- (20 specimens) 36-48 μm maximum diameter.

Remarks -- *C. vermiformis* is distinguished from other species of the genus by the irregularity and densely crowded nature of the sculptural elements.

Derivation -- The specific epithet is derived from the occasional development of vermiform sculptural elements.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-10 unit 49, Appanoose County, Iowa (see Gregory, 1982, p. 140); Blackoak Coal, Kalo Formation, uppermost Atokan Series.

Occurrence -- Rare, observed only in the Blackoak Coal.

Converrucosisporites sp. 1

(Plate 21, figure 21)

1982 *Converrucosisporites* sp. 1 Ravn and Fitzgerald, p. 118, pl. 2, fig. 21.

Description -- Miospore radial, trilete, amb triangular, with straight interradial sides and rounded angles. Trilete rays straight, reaching nearly to angles. Exine ornamented on both proximal and distal surfaces with rounded, in places coalescent verrucae 2-3 μm wide, 1-2 μm high. Distribution of verrucae on distal surface more or less random, but on proximal surface the verrucae show a marked tendency to align congruent to the rays, becoming more densely packed and forming a thickened area 5-8 μm wide along the rays. Over most of the exine surface, the verrucae are separated by distances greater than the widths of the verrucae themselves, but in the area adjacent to the rays, the separation is less. Exine moderately thick, approximately 2-2.5 μm at the equator.

Size of illustrated specimen -- 45.6 μm maximum diameter.

Comparison -- *C.* sp. 1 closely resembles *Triquitrites exceptus* Potonié and Kremp 1956 in size and ornamentation, but the latter species has conspicuously thickened (valvate) angles.

Occurrence -- Extremely rare, observed only in the Wildcat Den Coal.

Genus *SCHOPFITES* Kosanke 1950

Type species -- *S. dimorphus* Kosanke 1950.

Paleobotanical affinity -- Unknown. Good (1976) suggested a calamitean affinity based on a spore observed *in situ* in a fructification bearing spores corresponding to *Calamospora* and *Elaterites*. This interpretation was based on the appearance of irregular pits on the distal surface of the spore which were believed to result from the diagenetic growth of pyrite crystals (see Neves and Sullivan, 1964). Good's suggestion that dispersed *Schopfites* species might be diagenetically damaged spores otherwise similar to *Calamospora* is highly improbable. The ornament of *Schopfites* clearly consists of distal verrucae rather than pits and is a definite morphologic feature of the genus as opposed to a feature derived from secondary alteration of the exine (Ravn, 1983).

Schopfites carbondalensis Peppers 1970

(Plate 24, figure 10)

1970 *Schopfites carbondalensis* Peppers, p. 91-92, pl. 5, figs. 3, 4; text-fig. 14.

Occurrence -- Rare, observed only in a coal questionably considered to be the Carruthers.

Schopfites dimorphus Kosanke 1950

(Plate 24, figures 11-15)

1950 *Schopfites dimorphus* Kosanke, p. 52, pl. 13, figs. 1-3.
1950 *Schopfites colchesterensis* Kosanke, p. 53, pl. 13, fig. 4.

Remarks -- In his descriptions of the two species synonymized above, Kosanke (1950) cited a size range for *S. dimorphus* of 78-115 μm and distinguished *S. colchesterensis* as being smaller. He reported measurements, however, only for the holotype of *S. colchesterensis*, (78.1 x 90.3 μm) which fall within the range given for *S. dimorphus* Differences in the described ornament of the two species are minor, and reported stratigraphic ranges (Peppers, 1970) are virtually identical. Smith and Butterworth (1967) questioned the validity of the distinction between these two species. As neither reliable morphologic basis nor stratigraphic purpose seems to exist for their continued differentiation, they are regarded here as synonymous, and assigned to *S. dimorphus* to conserve the genotype. Specimens as small as 45 μm in maximum diameter were observed in Iowa coal samples examined during this study.

Occurrence -- Rare, but observed regularly from the Whitebreast Coal upward throughout the section. One anomalous occurrence was observed in a coal considered to be part of the Laddsdale complex.

Genus *PUSTULATISPORITES* Potonié and Kremp 1954

Type species -- *P. pustulatus* Potonié and Kremp 1954.

Pustulatisporites crenatus Guennel 1958

(Plate 22, figures 10, 11)

1958 *Pustulatisporites crenatus* Guennel, p. 63, pl. 3, fig. 11; text-fig. 15.

Occurrence -- Rare, observed in the Wildcat Den Coal, unnamed coals of the the Kilbourn Formation, the Laddsdale and Whitebreast Coals.

Pustulatisporites papillosus (Knox) Potonié and Kremp 1955

(Plate 22, figure 13)

1948 Type 16K Knox, text-fig. 13.
1950 *Triquitrites papillosus* Knox, p. 327, pl. 17, fig. 234.
1955 *Pustulatisporites papillosus* (Knox) Potonié and Kremp, p. 82.

Remarks -- Knox (1950) suggested possible synonymy with *Triquitrites spinosus* Kosanke 1943, but the latter species has conspicuous valvae characteristic of *Triquitrites* and a much less regular development of spinose sculptural elements.

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale sample from the basal Kilbourn Formation in core CP-6.

Pustulatisporites pustulatus Potonié and Kremp 1954

(Plate 22, figure 9)

1954 *Pustulatisporites pustulatus* Potonié and Kremp, p. 134, pl. 20, fig. 93.

Occurrence -- Rare, observed in the Kilbourn Formation and the Laddsdale Coals.

Pustulatisporites verrucifer (Kosanke) n. comb.

(Plate 22, figure 12)

1950 *Punctati-sporites verrucifer* Kosanke, p. 17, pl. 2, fig. 6.
1955 *Apiculatisporites verrucifer* (Kosanke) Potonié and Kremp, p. 77.

Remarks -- The ornament of scattered, rounded, wartlike projections is characteristic of *Pustulatisporites.* Kosanke's (1950) holotype is has a roundly triangular amb, whereas most other species assigned to *Pustulatisporites* are more distinctly triangular. For this reason, the species is transferred with reservation.

Occurrence -- Rare, observed only in the Laddsdale Coals.

Pustulatisporites sp. 1

(Plate 23, figure 1)

1982 *Pustulatisporites* sp. 1 Ravn and Fitzgerald, p. 123, pl. 3, fig. 21.

Description -- Miospore radial, trilete, amb triangular. Interradial sides markedly concave, angles broadly rounded. Trilete rays straight, greater than 3/4 of radius, accompanied by a conspicuous thickened region approximately 5 µm wide. Exine ornamented with scattered low, broad wart-like projections 2-5 µm wide at their bases, 1-2 µm high. Projections vary in size and are distributed irregularly; distances between individual projections generally greater than basal widths of projections. Exine apart from the thickened zone adjacent to the rays is relatively thin and pale.

Size of illustrated specimen -- 37.1 µm maximum diameter.

Remarks -- The amb of this species resembles that of certain *Waltzispora* species (e.g., *W. prisca*) but the ornament is characteristic of *Pustulatisporites.*

Occurrence -- Extremely rare, observed only in the Wildcat Den Coal.

Genus *ANAPICULATISPORITES* Potonié and Kremp 1954

Type species -- *A. isselburgensis* Potonié and Kremp 1954.

Remarks -- The circumscription of this genus is problematical because of an unfortunate choice of a genotype by Potonié and Kremp 1954. The holotype of *A. isselburgensis* is preserved in lateral aspect, and does not allow firm assessment of the outline of the species in a polar view. Many species have been assigned to the genus, including spores with both circular and triangular ambs, and a wide variation in the character and distribution of ornamental elements. The illustration of the holotype of *A. isselburgensis* (Potonié and Kremp, 1955, pl. 14, fig. 252) suggests to me that it has a semicircular amb with low, conate to spinose projections that do extend to the equator. I prefer, therefore, to restrict the genus to similar forms, and to exclude from it forms such as *A. spinosus* (Kosanke) Potonié and Kremp 1955, which are strongly triangular and display ornamentation restricted to the distal surface and not extending to the equator in the interradial regions. Miospores of this latter kind have been placed in the new genus *Anacanthotriletes* earlier in this report.

The use of *Anapiculatisporites* here follows the practice of Playford (1971b), who also applied it to roundly triangular miospores with ornament projecting at the equator. The emendation of Smith and Butterworth (1967) is rejected. As noted by Smith and Butterworth, however, inclusion of forms in which the sculptural elements project at the equator in the interradial regions places *Anapiculatisporites* in some degree of conflict with *Procoronaspora*, and *Anaplanisporites* Jansonius 1962. Both Playford (1971b) and Morbey (1975) have expressed the view that *Anaplanisporites* is improperly typified and thus invalid; in this report, it is regarded as a junior synonym of *Anapiculatisporites*. Distinctions among all these genera are not established satisfactorily, and the use of *Anapiculatisporites* in this report is made with reservation.

Anapiculatisporites baccatus (Hoffmeister, Staplin and Malloy)
n. comb.

(Plate 23, figures 2, 3)

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, observed in the Wildcat Den, Blackoak and Laddsdale Coals.

Anapiculatisporites sp. cf. *A. globulus* (Butterworth and Williams)
n. comb.

(Plate 23, figure 5)

cf. 1958 *Apiculatisporis globulus* Butterworth and Williams, p. 363, pl. 1, figs. 26, 27.
cf. 1967 *Anaplanisporites globulus* (Butterworth and Williams) Smith and Butterworth, p. 167, pl. 7, figs. 26, 27.
1979 *Lophotriletes* sp. 2 Ravn, p. 29, pl. 6, figs. 14, 15.

Remarks -- *Lophotriletes* sp. 2 of Ravn (1979) originally was described as having ornament on both distal and proximal surfaces. Re-examination of the illustrated specimens indicated that the ornament of rounded large grana or warts is confined to the distal surface and equatorial areas. The illustrated specimens resemble *A. globulus* as illustrated by Butterworth and Williams (1958) and Smith and Butterworth (1967) except for having a more triangular amb.

Size of illustrated specimen -- 34.8 μm maximum diameter.

Occurrence -- Extremely rare, observed only in the Blackoak Coal.

Anapiculatisporites protuberatus (Hagemann) n. comb. emend.

(Plate 23, figure 4)

1966b *Pustulatisporites protuberata* Hagemann, p. 824, pl. 9, figs. 4, 5.
1982 *Pustulatisporites protuberatus* Hagemann 1966; Ravn and Fitzgerald, p. 122-123, pl. 3, fig. 18.

Emended diagnosis -- Miospores radial, trilete, amb circular. Trilete rays straight, simple, approximately 1/2 of radius, sometimes faint and indistinct. Proximal surface laevigate to faintly granulose or punctate (?infra-sculpture). distal surface and equator ornamented with scattered sharp-pointed coni 2-3 μm in height, approximately 2 μm in basal width.

Size -- 25-35 μm (Hagemann. 1966b).

Remarks -- The nature and distribution of the ornament of this species indicates that *Anapiculatisporites* is a more appropriate generic assignment than is *Pustulatisporites.*

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Anapiculatisporites vegrandis (Upshaw and Creath) n. comb.

(Plate 16, figures 1-3)

1965 *Pustulatisporites vegrandis* Upshaw and Creath, p. 438, pl. 1, figs. 16, 17.

Remarks -- Upshaw and Creath (1965) made no mention of the distribution of sculptural elements in *P. vegrandis,* although from their illustrations the ornament appears to be confined to the distal surface and equatorial areas. *A. grundensis* Peppers 1970 is similar and may be synonymous.

Occurrence -- Rare, observed in the Blackoak and Cliffland Coals.

Genus *PILEATISPORITES* Peppers 1970

Type species -- *P. aequus* Peppers 1970.

Pileatisporites bakerii Ravn and Fitzgerald 1982

(Plate 24, figures 6-8)

1982 *Pileatisporites bakerii* Ravn and Fitzgerald, p. 124, pl. 4, figs. 3-6.

Occurrence -- Rare, observed in the Wildcat Den Coal and the Kilbourn Formation.

Genus *NEORAISTRICKIA* Potonié 1956

Type species -- *N. truncata* (Cookson) Potonié 1956.

Remarks -- Schulz (1967) considered *Neoraistrickia* to be a junior synonym of *Cepulina* Maljavkina 1949. Similarity certainly exists between these genera, but Maljavkina's genus is too poorly illustrated to demonstrate conclusively a synonymy with *Neoraistrickia.*

Neoraistrickia muscatinensis Ravn and Fitzgerald 1982

(Plate 23, figures 6-8)

1982 *Neoraistrickia muscatinensis* Ravn and Fitzgerald, p. 126, pl. 4, figs. 16-20.

Occurrence -- Rare, observed in the Wildcat Den Coal and an unnamed coal of the Kilbourn Formation.

The following species is transferred to *Neoraistrickia*:

Neoraistrickia baculata (Neves) n. comb.:
1961 *Acanthotriletes baculatus* Neves, p. 254, pl. 31, fig. 1.

Remarks -- For reasons discussed earlier in this report, the genus *Acanthotriletes* is considered improper for miospores. The sculptural elements of this species are distinctly baculate, and render it appropriately assignable to *Neoraistrickia*.

Genus *ECHINATISPORIS* Krutzsch 1959

Type species -- *E. longechinus* Krutzsch 1959.

Remarks -- *Echinatisporis* is used here as the appropriate generic repository for azonate trilete spores having a circular amb and more or less uniformly distributed spinose ornament. As such, it is intended to replace the concept embodied by *Acanthotriletes* as improperly typified by the species *A. ciliatus* (Knox) Potonié and Kremp 1954.

The genus *Acanthotriletes* has been widely used in studies of both Paleozoic and Mesozoic palynological material to accommodate trilete spores having spinose ornament. Despite this wide application, the genus is beset with severe nomenclatural ambiguity as a result of questionable typification. The name *Acanthotriletes* was first used as a *Nomen nudum* by Naumova (1939) for the concept of azonotrilete spinose spores, with no species assigned. Potonié and Kremp (1954) sought to validate the genus by selecting as a type species *Spinososporites ciliatus* Knox 1950. From an accompanying diagrammatic representation (Potonié and Kremp, 1955, p. 83, text-fig. 18), they clearly intended *Acanthotriletes* to accommodate spores with a triangular amb, in a fashion parallel to that of such genera as *Lophotriletes*, *Granulatisporites* and *Converrucosisporites*. Paradoxically, however, they selected as a genotype a species (*A. ciliatus*) that has a circular amb. As a consequence, subsequent authors following the generic system of Potonié and Kremp have assigned to *Acanthotriletes* both triangular and circular forms, a practice contrary to the custom of generic differentiation employed for most trilete spores with other kinds of ornament.

The situation is complicated further by disagreement over typification. Jansonius and Hills (1976c) regarded *Acanthotriletes primigenius* Naumova 1949 as being the valid type species by monotypy, as the 1939 generic diagnosis was not cited and therefore the genus can be regarded as new, validly corresponding to the 1949 species description. They further stated that *A. primigenius* is a Lower Paleozoic acritarch rather than a trilete miospore.

Because of these ambiguities in typification and generic circumscription, *Acanthotriletes* does not serve as an adequately delimited generic repository for most of the species historically assigned to it. In this report, these species are reassigned to two other genera. Forms with a circular amb are assigned to *Echinatisporis*, following the practice of Srivastava (1977) for Mesozoic spores. Forms with a triangular amb are assigned to *Pilosisporites* and are discussed under that genus.

Paleobotanical affinities -- Mesozoic and Cenozoic species assigned to *Echinatisporis* are often compared with spores of extant *Selaginella* species (e.g., Krutzsch, 1963). To my knowledge, however, no examples of spores assignable to this genus have been recovered *in situ* from Paleozoic plant fossils. The paleobotanical affinities of these species must therefore be regarded as unknown.

Echinatisporis knoxiae n. name.

(Plate 7, figure 4)

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.
1967 *Acanthotriletes echinatus* (Knox) Potonié and Kremp 1955 ex Smith and Butterworth, p. 178, pl. 8, fig. 9 only.

Remarks -- This new name is proposed to avoid homonymy with *E. echinatus* (Hoffmeister, Staplin and Malloy) n. comb. The two combinations of *Acanthotriletes echinatus* cited in the synonymy above appear to have been proposed simultaneously, both published in May, 1955. *A. echinatus* (Knox) Potonié and Kremp, however, was not validated until the selection of a neotype by Smith and Butterworth (1967), and therefore is the junior name.

Smith and Butterworth (1967) included both circular and triangular forms in *A. echinatus*, although the illustration of Knox (1950) and the specimen they chose as a neotype are both circular. I disagree with the inclusion of circular and triangular forms within this species; no gradation between such forms was seen in the Iowa material examined in this study. Specimens corresponding to the second specimen illustrated by Smith and Butterworth (1967, pl. 8, fig. 10) are assigned in this report to *Pilosisporites williamsii* n. sp., and *E. knoxiae* is reserved here strictly for circular forms corresponding to the neotype.

Occurrence -- Rare, observed in the Blackoak, Cliffland and Laddsdale Coals.

The following species correspond to *Echinatisporis* and are transferred:

Echinatisporis acritarchus (Neville) n. comb.:
1973 *Acanthotriletes acritarchus* Neville, in Neves et al., p. 30, pl. 1, figs. 3, 4; pl. 3, fig. 3.

Echinatisporis echinatus (Hoffmeister, Staplin and Malloy) n. comb.:
1955 *Acanthotriletes echinatus* Hoffmeister, Staplin and Malloy, p. 379, pl. 38, figs. 1, 2.
non 1955 *Acanthotriletes echinatus* (Knox) Potonié and Kremp, p. 84.

Echinatisporis novicus (Gupta) n. comb.:
1970 *Acanthotriletes novicus* Gupta, p. 78, pl. 1, fig. 6.

Echinatisporis pineatus (Hoffmeister, Staplin and Malloy) n. comb.:
1955 *Apiculati-sporites pineatus* Hoffmeister, Staplin and Malloy, p. 381, pl. 38, fig. 3.

Echinatisporis productus (Peppers) n. comb.:
1964 *Punctatisporites productus* Peppers, p. 31, pl. 4, figs. 5, 6.
1969 *Acanthotriletes productus* (Peppers) Gupta, p. 164.

Echinatisporis socraticus (Neves and Ioannides) n. comb.:
1974 *Acanthotriletes socraticus* Neves and Ioannides, p. 75, pl. 5, figs. 14, 16.

The following new name is proposed to correct a problem of homonymy:

Echinatisporis anadarkoensis n. name:
1961 *Acanthotriletes uncinatus* Felix and Burbridge, p. 492, pl. 1, figs. 9, 10.
non 1956 *Acanthotriletes uncinatus* Balme and Hennelly, p. 249, pl. 3, figs. 35, 36.
non 1956 *Acanthotriletes uncinatus* Ishchenko, p. 30-31, pl. 4, fig. 46.

Remarks -- The new name proposed here is necessary in recognition that *A. uncinatus* Felix and Burbridge 1961 is a junior homonym. The specific epithet recognizes the type locality, the Anadarko Basin of Oklahoma and Texas (Felix and Burbridge, 1961).

Genus *PROCORONASPORA* Butterworth and Williams emend. Smith and Butterworth 1967

Type species -- *P. ambigua* Butterworth and Williams 1958.

Remarks -- Morphological relationships among the genera *Procoronaspora*, *Anapiculatisporites*, *Anaplanisporites*, and *Tricidarisporites* Sullivan and Marshall 1966 are unclear and various assignments of individual species to these genera have been made by different investigators. In particular, a question exists concerning the appropriateness of generic assignment of the perhaps aptly named type species of *Procoronaspora*, which poses a validity problem for the genus itself. Playford (1971b) discussed these matters in detail and suggested that *Tricidarisporites* might serve to accommodate spores now assigned to *Procoronaspora* should the latter genus become invalid. Pending resolution of these questions, the following new species is assigned to *Procoronaspora*, as it most closely resembles several other species assigned to that genus.

Procoronaspora stellata n. sp.

(Plate 24, figures 1-5)

1982 *Procoronaspora* sp. 1 Ravn and Fitzgerald, p. 124, pl. 3, fig. 16.

Diagnosis -- Miospores radial, trilete, amb convexly triangular, usually in good proximal-distal orientation. Trilete rays straight, 1/2 to 2/3 of radius, usually faint and difficult to observe because of distal ornamentation. Proximal surface laevigate or nearly so; distal surface ornamented with evenly spaced sharp spines that extend to and project at the equator. Spines vary in length from less than 2 to approximately 5 μm; basal width of spines usually about 1/2 the height. Bases of spines do not touch, and the distance between individual spines is usually about equal to their basal widths. Longest spines occur along or near the interradial margins; spines reduced or absent near the angles, and reduced in size in the region of the distal pole, where 6-8 spines appear to fuse into a radially symmetrical, low star-shaped projection. 20-30 spines project along equator.

Size -- (10 specimens) 22-32 μm maximum diameter excluding ornament.

Comparison -- *P. stellata* differs from other described species of the genus in the possession of the distal projection formed by the fusing of the spines. *P. williamsii* Staplin 1960 is of similar size and has a similar density of ornament, but lacks the distal projection. *P. serrata* (Playford) Smith and Butterworth 1967 also is similar in general appearance to *P. stellata* but the sculptural elements are more crowded and it also lacks the distal projection. The genus *Procoronaspora* in general has been reported mainly from Lower Carboniferous strata; the appearance of *P. stellata* in the Pennsylvanian of Iowa may represent the youngest reported occurrence of spores assignable to the genus.

Derivation -- The specific epithet refers to the star-shaped (stellate) distal projection.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-10 unit 49, Appanoose County, Iowa (see Gregory, 1982, p. 140): Blackoak Coal, Kalo Formation, uppermost Atokan Series.

Occurrence -- Rare, observed in the Wildcat Den and Blackoak Coals.

Genus *TRICIDARISPORITES* Sullivan and Marshall 1966

Type species -- *T. balteolus* Sullivan and Marshall 1966.

Remarks -- See Remarks under *Procoronaspora.*

Tricidarisporites arcuatus Neville, in Neves et al., 1973

(Plate 24, figure 9)

1966 *Tricidarisporites fasciculatus* (auct. non Love) Sullivan and Marshall, p. 268, pl. 1, fig. 16.
? 1967 *Procoronaspora fasciculata* auct. non Love 1960; Smith and Butterworth, p. 164, pl. 6, fig. 31.
1971 *Tricidarisporites fasciculatus* (auct. non Love) Sullivan and Marshall 1966; Marshall and Williams, pl. 1, fig. 6.
1971 *Procoronaspora fasciculata* auct. non Love 1960; Urban, p. 136-137, pl. 37, figs. 9-11.
1973 *Tricidarisporites arcuatus* Neville, in Neves et al., p. 32, pl. 1, figs. 7, 8.
1982 *Tricidarisporites fasciculatus* (auct. non Love) Sullivan and Marshall 1966; Ravn and Fitzgerald, p. 123, pl. 3, fig. 17.

Remarks -- As indicated by the synonymy above, several reports of *Tricidarisporites fasciculatus* actually are more appropriately assignable to *T. arcuatus.* I wish to thank Dr. John E. Williams of British Petroleum Company for bringing this problem to my attention.

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale sample from the basal Kilbourn Formation in core CP-6.

Genus *DICTYOTRILETES* Naumova ex Potonié and Kremp emend.

Type species -- *D. bireticulatus* (Ibrahim) Potonié and Kremp emend. Smith and Butterworth 1967.

Emended diagnosis -- Miospores azonate, radial, trilete, amb roundly triangular to nearly circular. Distal surface ornamented by a distinct reticulum; proximal surface laevigate or nearly so. Muri extend to equator, where a continuous murus forms the boundary between the proximal and distal surfaces. Muri relatively low, height not more than twice the basal width.

Remarks -- *Dictyotriletes* is emended here to specify the restriction of the reticulum to the distal surface. Smith and Butterworth (1967) suggested the possibility of such an emendation, but did not formally propose it. Potonié and Kremp (1954, 1955) regarded the distribution of sculpture as a character of generic significance for most other trilete miospore genera, but did not make such a distinction in the case of *Dictyotriletes*. In their selection of *D. bireticulatus* as a type species, however, they chose a form in which the reticulum clearly is confined to the distal surface.

Indirect paleobotanical evidence suggests that the distribution of ornamentation on trilete spores may be significant as a potential indicator of plant affinity. In the Carboniferous, most spores of known affinity that display sharp differentiation between the ornamentation of the proximal and distal surfaces are allied to the lycopsids; most spores having relatively uniform distribution of ornament over both proximal and distal surfaces are allied either to ferns or sphenopsids. A possibly related observation concerns the occurrence in dispersed miospore residues of spores united in tetrads. Lycopsid-related taxa (e. g., *Lycospora*, *Densosporites*, *Endosporites*, *Crassispora*, *Granasporites*) are commonly seen in tetrads, but the occurrence of fern- and sphenopsid- related forms in united tetrads is rare. *Dictyotriletes bireticulatus* has sharply differentiated sculpture on the proximal and distal surfaces, and is seen frequently in tetrads, suggesting the possibility of lycopsid affinity, although spores corresponding to *D. bireticulatus* have not, as yet, been found *in situ*. In overall appearance, *D. bireticulatus* bears a strong resemblance to certain modern and fossil *Lycopodium* spores.

Given these observations, I consider desirable the restriction of the genus *Dictyotriletes* to forms having distally reticulate sculpture. Many species having a comprehensive reticulate sculpture, formerly assigned to *Dictyotriletes* are transferred in this report to *Reticulitriletes* Mädler emend. See also Remarks under the genus *Reticulatisporites*.

Comparison -- As emended here, *Dictyotriletes* is differentiated from *Reticulitriletes* by the restriction of the reticulum to the distal surface. *Reticulatisporites* has higher muri that, in the type species, thicken along the top to give the appearance at the equator of a bizonate 'cingulum'; this distinction is not entirely satisfactory for firm generic assignment of certain species. *Retitriletes* van der Hammen ex Pierce emend. Döring et al., in Krutzsch, (1963) is similar to *Dictyotriletes*, but the distribution of the reticulate sculpture on the type species (*R. globosus* Pierce 1961) is poorly known; in many *Retitriletes* species the muri extend to some degree onto the proximal surface.

Paleobotanical affinity -- As mentioned above, spores corresponding to *Dictyotriletes* as emended here have not been recovered *in situ* and the paleobotanical affinity must therefore be regarded as unknown.

Dictyotriletes bireticulatus (Ibrahim) Potonié and Kremp emend.
Smith and Butterworth 1967

(Plate 25, figures 1-4)

1932 *Sporonites bireticulatus* Ibrahim, in Potonié, Ibrahim and Loose, p. 447, pl. 14, fig. 1.
1933 *Reticulati-sporites bireticulatus* (Ibrahim) Ibrahim, p. 35, pl. 1, fig. 1.
1934 *Reticulata-sporites bireticulatus* (Ibrahim) Loose, pl. 7, fig. 28.
1950 *Reticulatisporites mediareticulatus* auct. non Ibrahim; Knox, p. 323, pl. 18, fig. 253.
1952 *Reticulatisporites mediareticulatus* auct. non Ibrahim; Balme, p. 176, text-fig. 1c.
1952 *Reticulatisporites* cf. *mediareticulatus* auct. non Ibrahim; Balme and Butterworth, pl. 48, figs. 4a, b.
1954 *Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp, p. 108.
1954 *Reticulati-sporites* cf. *mediareticulatus* auct. non Ibrahim; Butterworth and Millott, p. 21, fig. 8b.
1956 *Reticulatisporites mediareticulatus* auct. non Ibrahim; Butterworth and Millott, text-fig. 3(8).
1964 *Dictyisporites bireticulatus* (Ibrahim) Levet-Carette, p. 271, pl. 10, fig. 17.
1967 *Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp emend. Smith and Butterworth,

p. 194-195, pl. 11, figs. 14, 15.

Occurrence -- Rare to occasionally frequent, observed regularly in coals from the Wildcat Den through the Blackoak; one occurrence noted in a coal questionably considered to lie in the Floris Formation. The extinction of *D. bireticulatus* is widely recognized as a reliable biostratigraphic horizon both in North America and in Europe; its final regular appearance in the Blackoak Coal of Iowa is proposed here to mark the top of the Atokan Series.

Genus *CORBULISPORA* Bharadwaj and Venkatachala 1961

Type species -- *C. cancellata* (Waltz) Bharadwaj and Venkatachala 1961 (= *C. retiformis* Bharadwaj and Venkatachala 1961).

Remarks -- *Corbulispora* differs from *Reticulitriletes* Mädler emend. in displaying conspicuous thickenings along the trilete rays. Hibbert and Lacey (1969) disagreed with this generic distinction.

Corbulispora? sp. cf. *C. subalveolaris* (Luber) Sullivan 1964

(Plate 25, figures 17-19)

cf. 1938 *Azonotriletes subalveolaris* Luber, in Luber and Waltz, pl. 5, fig. 72.
cf. 1955 *Dictyotriletes subalveolaris* (Luber) Potonié and Kremp, p. 108.
cf. 1964b *Corbulispora subalveolaris* (Luber) Sullivan, p. 1253, pl. 1, figs. 16-20.

Remarks -- Specimens cited as *C.?* sp. cf. *C. subalveolaris* are assigned questionably to the genus because the characteristic thickening along the trilete rays was not observed. In other respects, especially the imperfect character of the muri, they resemble *C. subalveolaris* as illustrated by Sullivan (1964a, b).

Occurrence -- Extremely rare, observed only in the Blackoak Coal.

Genus *CORDYLOSPORITES* Playford and Satterthwait 1985

Type species -- *C. sepositus* Playford and Satterthwait 1985.

Cordylosporites papillatus (Naumova) Playford and Satterthwait 1985

(Plate 13, figures 2, 3)

1938 *Aptera papillata* Naumova, p. 27, pl. 3, fig. 2.
1962 *Reticulatisporites peltatus* Playford, p. 599-600, pl. 84, figs. 1-4.
1963 *Dictyotriletes papillatus* (Naumova) Byvscheva, p. 39, pl. 2, figs. 3-5.
1971b *Reticulatisporites papillatus* (Naumova) Playford, p. 31, pl. 10, figs. 11, 12.
1985 *Cordylosporites papillatus* (Naumova) Playford and Satterthwait, p. 145, pl. 6, figs. 8-10.

Remarks -- Turnau (1978) considered *Raistrickia boleta* Staplin 1960 and *Raistrickia condylosa* Higgs 1975 to be synonymous with *Cordylosporites papillatus*. The spores illustrated by Staplin (1960, pl. 2, figs. 25, 27) are described as 'nearly always corroded' and appear to be so, making comparison with *C. papillatus* uncertain at best. Comparison of the type description and illustrations of *R. condylosa* (Higgs, 1975, p. 396, pl. 2, figs. 15, 16) with other published reports, under various name combinations, of *C. papillatus* (e. g., Playford, 1962; Felix and Burbridge, 1967; Urban, 1971; Braman and Hills, 1977; Ettensohn and Peppers, 1979) does not support synonymy. Playford and Satterthwait (1985) transferred *R. boleta* to *Cordylosporites* as a species distinct from *C. papillatus*. *R. condylosa* conforms to the concept of *Cordylosporites* in having a reticulum with blunt, bulbous projections at the junctions of the muri; it is transferred below.

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale sample from the basal Kilbourn Formation in core CP-6.

Cordylosporites condylosus (Higgs) n. comb.:
1975 *Raistrickia condylosa* Higgs, p. 396, pl. 2, figs. 15, 16.
1978 *Dictyotriletes papillatus* auct. non (Naumova) Byvscheva 1963; Turnau, in part, pl. 2, fig. 4.

Genus *FOVEOSPORITES* Balme 1957

Type species -- *F. canalis* Balme 1957.

Foveosporites insculptus Playford 1962

(Plate 26, figure 3)

1962 *Foveosporites insculptus* Playford, p. 601, pl. 85, figs. 3-5.

Remarks -- *F. insculptus* originally was described (Playford, 1962) and has been reported subsequently from Lower Carboniferous strata (e. g., Turnau, 1978). Its occurrence in the Pennsylvanian of Iowa therefore is somewhat anomalous, but the morphology of specimens from Iowa appears to correspond closely to Playford's description and illustrations.

Occurrence -- Rare, observed only in the Cliffland Coal.

Genus *ANAFOVEOSPORITES* n. gen.

Type species -- *A. avcinii* (Ravn and Fitzgerald) n. comb.

Diagnosis -- Miospores trilete, azonate, amb roundly triangular. Proximal surface laevigate to finely granulose, trilete rays extend nearly to equator. Distal surface foveolate; foveolate ornament may extend to, but not beyond, equator.

Comparison -- *Anafoveosporites* is proposed to accommodate trilete miospores in which the foveolate sculpture is confined to the distal surface, leaving the proximal surface essentially unornamented. The sharp distinction of sculpture between proximal and distal surfaces distinguishes *Anafoveosporites* from *Foveosporites* Balme 1957, in which the foveolate sculpture occurs on both the proximal and distal surfaces. Distinction of these two genera on the basis of this difference in distribution of sculpture follows similar practices among spores having other kinds of sculpture. Known paleobotanical affinities of many kinds of trilete spores indicate that those having sharp differentiation of ornament between proximal and distal surfaces tend to be related to lycopsids, whereas those having more or less uniform sculpture over both proximal and distal surfaces tend to be related to ferns. I therefore consider the proximal/distal distribution of sculpture to be significant and a valid characteristic for generic differentiation.

Derivation -- The generic name recognizes the sculptural similarity to *Foveosporites* combined with the prefix *Ana-* which has been applied similarly to other generic names (e.g., *Anapiculatisporites*, *Anaplanisporites*) to denote the confinement of the sculptural elements to the distal surface.

Anafoveosporites avcinii (Ravn and Fitzgerald) n. comb.

(Plate 26, figs. 4-8)

1982 *Foveosporites avcinii* Ravn and Fitzgerald, p. 130, pl. 6, figs. 1-6.

Occurrence -- Rare, observed in the Wildcat Den Coal and a shale sample from the basal Kilbourn Formation in core CP-6.

The following species conforms to the characteristics of *Anafoveosporites* n. gen. and is transferred without emendation:

Anafoveosporites danvillensis (Peppers) n. comb.:
1970 *Dictyotriletes danvillensis* Peppers. p. 111. pl. 9. figs. 6, 7.

Genus *SECARISPORITES* Neves 1961

Type species -- *S. lobatus* Neves 1961.

Secarisporites remotus Neves 1961

(Plate 25, figure 20)

1961 *Secarisporites remotus* Neves, p. 262, pl. 32. figs. 8, 9.

Occurrence -- Rare, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation and the Kilbourn Formation.

Genus *TRILOBATES* Somers 1952

1952 *Trilobates* Somers, p. 22.
1958 *Stellisporites* Alpern, p. 78.

Type species -- *T. bellii* Somers 1952.

Trilobates bellii Somers 1952

(Plate 28, fig. 1)

1952 *Trilobates bellii* Somers, p. 22, fig. 14.
1958 *Stellisporites inflatus* Alpern, p. 78, pl. 1. fig. 14.

Occurrence -- Rare, observed only in the Blackoak Coal.

Genus *TANTILLUS* Felix and Burbridge 1967

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

Remarks -- *Tantillus* is described by Felix and Burbridge (1967) as having a distal thickening that characteristically forms 'shoulders' near the apices. *Trivolites* Peppers 1964 is similar in appearance, but Peppers (1964) described the thickening characteristic of that genus as proximal, forming an 'area contagionis.' The Mesozoic genera *Cibotiumspora* Chang 1965 and *Obtusisporis* (Krutzsch) Pocock 1970, to which many species have been assigned, also are similar in appearance, having prominent folds or thickenings forming apical 'shoulders.'

Tantillus triquetrus Felix and Burbridge 1967

(Plate 28, figures 2-4)

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

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Laddsdale.

Genus *INDOSPORA* Bharadwaj 1960

Type species -- *I. clara* Bharadwaj 1960.

Indospora boleta Peppers 1970

(Plate 27, figure 3)

1970 *Indospora boletus* Peppers, p. 118, pl. 11, figs. 12, 13; text-fig. 26A.

Occurrence -- Rare, observed only in the Blackoak Coal.

Genus *TRIQUITRITES* Wilson and Coe emend. Potonié and Kremp 1954

Type species -- *T. arculatus* Wilson and Coe 1940.

Remarks -- Speciation within *Triquitrites* often is based on minor subtle characteristics that appear to intergrade within populations. As a result, the stratigraphic utility of certain described species is limited, at best. Some, however (e.g., *T. sculptilis*, *T. spinosus*) are more clearly circumscribed and appear to have value for biostratigraphic interpretation.

Paleobotanical affinity -- Many authors have cited *Triquitrites* as having questionably filicinean affinities, based on speculations of Schopf, Wilson and Bentall (1944). Moore (1946) illustrated ontogenetic development of spores *in situ* that appear to be assignable to *Triquitrites*, but the paleobotanical affinity of the fructification from which the spores were obtained is unknown. The suggestion by Rothwell (1976) that spores recovered from a newly-described pteropsid fructification (*Norwoodia*) may be assignable to *Triquitrites* is questionable.

Triquitrites additus Wilson and Hoffmeister 1956

(Plate 27, figures 1, 2)

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

Occurrence -- Rare to occasionally frequent, observed in virtually all coals from the Blackoak upward throughout the section.

Triquitrites crassus Kosanke 1950

(Plate 26, figures 21, 22)

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

Occurrence -- Rare, observed in the Blackoak, Cliffland and Laddsdale Coals.

Triquitrites minutus Alpern 1958

(Plate 26, figure 9)

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

Occurrence -- Rare, observed in coals from the Blackoak through the Whitebreast.

Triquitrites sculptilis Balme emend. Smith and Butterworth 1967

(Plate 26, figures 13-18)

1952 *Triquitrites sculptilis* Balme, p. 181, text-fig. 1g.
1957b *Triquitrites coesfeldens* Bhardwaj, 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 emend. Smith and Butterworth, p. 204, pl. 12, figs. 10-15.

Remarks -- As noted by Ravn (1979), the proposed synonymy of *T. sculptilis* with *T. trigonus* (Ibrahim) Gupta 1969 (in Gupta, 1970) is considered questionable. Specimens of *T. sculptilis* observed in older Iowa coals tend to be larger and more regularly reticulate than those seen in younger coals.

Occurrence -- Rare to occasionally frequent, observed in virtually all coals from the Kilbourn Formation through the Bevier.

Triquitrites spinosus Kosanke 1943

(Plate 26, figure 20)

1943 *Triquitrites spinosus* Kosanke, p. 128, pl. 3, figs. 2, 2a, 2b.
1966 *Triquitrites magnificus* Habib, p. 639, pl. 106, fig. 3.

Occurrence -- Rare to occasionally frequent, observed regularly in coals from the Whitebreast upward throughout the section.

Triquitrites subspinosus Peppers 1970

(Plate 26, figure 19)

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

Occurrence -- Rare, observed in Blackoak, Cliffland, Laddsdale, Whitebreast and Wheeler Coals.

Triquitrites tribullatus (Ibrahim) Schopf, Wilson and Bentall 1944

(Plate 26, figures 10-12)

1932 *Sporonites tribullatus* Ibrahim, in Potonié, Ibrahim and Loose, p. 448, pl. 15, fig. 13.
1933 *Laevigati-sporites tribullatus* (Ibrahim) Ibrahim, p. 20, pl. 2, fig. 13.
1934 *Valvisi-sporites tribullatus* (Ibrahim) Loose, p. 152, pl. 7, fig. 21.
1938 *Azonotriletes tribullatus* (Ibrahim) Luber, in Luber and Waltz, pl. 7, fig. 88.
1944 *Triquitrites tribullatus* (Ibrahim) Schopf, Wilson and Bentall, p. 47.
1944 *Triquitrites exiguus* Wilson and Kosanke, p. 332, pl. 1, fig. 2.
1950 *Triquitrites protensus* Kosanke, p. 40, pl. 8, fig. 2.
1956 *Triquitrites bransonii* Wilson and Hoffmeister, p. 24-25, pl. 3, figs. 1-5.
1957a *Triquitrites ornatus* Dybová and Jachowicz, p. 137, pl. 34, fig. 2, figs. 1-4.
1965a *Triquisporites tribullatus* (Ibrahim) Laveine, p. 134.

Remarks -- Although several of the species cited in the synonymy above were recognized as distinct by Ravn (1979), subsequent study has indicated that complete morphological gradations exist among this complex of forms in the Iowa section. Distinctions among these species are minor, and do not recognize degrees of morphologic variation commonly present. As all were found to have the same stratigraphic range, no useful purpose is served by their continuing distinction. The discussion of Smith and Butterworth (1967, p. 202-203) concerning *T. bransonii* serves to illustrate the difficulties of taxonomic subdivision within this group. Several other described species may also be synonymous. *T. triturgidus* (Loose) Potonié and Kremp 1956 (probably a senior synonym of *T. pulvinatus* Kosanke 1950) is similar, but has more widely expanded auriculae. Loboziak (1971) considered *T. pannus* (Imgrund) Imgrund 1960 as synonymous, but it is much larger than the other species regarded as synonymous here. *T. tribullatus* appears to be the senior valid name for miospores of this kind.

Occurrence -- Rare to common, observed from the Blackoak Coal upward throughout the section.

Genus *MOOREISPORITES* Neves 1958

Type species -- *M. fustis* Neves 1958.

Mooreisporites inusitatus (Kosanke) Neves 1958

(Plate 27, figures 12, 13)

1950 *Triquitrites inusitatus* Kosanke, p. 39, pl. 8, fig. 7.
1958 *Mooreisporites inusitatus* (Kosanke) Neves, p. 8.

Occurrence -- Rare, observed in nearly all coals from the Laddsdale through the Mystic; one occurrence observed in a coal questionably correlated to the Cliffland.

Genus *AHRENSISPORITES* Potonié and Kremp 1954

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

Ahrensisporites exertus Peppers 1964

(Plate 27, figures 4, 5)

1964 *Ahrensisporites exertus* Peppers, p. 13, pl. 1, figs. 1, 2.
1979 *Ahrensisporites guerickei* auct. non (Horst) Potonié and Kremp 1954; Ravn, p. 34, pl. 9, fig. 17.

Remarks -- The specimen illustrated as *A. guerickei* by Ravn (1979) has a prominent boss at the distal pole and is more appropriately assignable to *A. exertus*; it is reillustrated in this report. As seen on the illustrations in this report (pl. 27, figs. 6, 7), *A. guerickei* may possess a small projection at the distal pole, but it is not as prominent as the distal boss characterizing *A. exertus*.

Occurrence -- Rare, observed in the Blackoak, Cliffland and Laddsdale Coals.

Ahrensisporites guerickei (Horst) Potonié and Kremp ex Horst 1955

(Plate 27, figures 6, 7)

1943 *Triletes guerickei* Horst, pl. 7, figs. 58, 59, 61-64 (Invalid; unpublished thesis).
1954 *Ahrensisporites guerickei* (Horst) Potonié and Kremp, p. 155 (Invalid; holotype not figured).
1955 *Ahrensisporites guerickei* (Horst) Potonié and Kremp ex Horst, p. 178, pl. 23, figs. 58, 59, 61-64.

Remarks -- As indicated by the synonymy, *A. guerickei* was not validated until the publication of Horst (1955) in which the holotype was figured.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Blackoak.

Ahrensisporites ornatus (Neves) n. status

(Plate 27, figures 8-10)

1961 *Ahrensisporites guerickei* var. *ornatus* Neves, p. 263, pl. 32, fig. 11.

Remarks -- *Ahrensisporites guerickei* var. *ornatus* Neves 1961 differs from *A. guerickei* proper by possessing irregular projections on the distal surface, by having less uniform development of the kyrtomes, and by being slightly larger. Neves (1961) also noted that the ranges of stratigraphic occurrence for *A. guerickei* and *A. guerickei* var. *ornatus* differed, with the former being found in younger strata than the latter. A similar distinction in the ranges of occurrence is noted in Iowa. As the two forms do not appear to intergrade morphologically to any significant extent, the variety *ornatus* is considered here to constitute a distinct species, and is raised to specific status.

Occurrence -- Rare, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation and the Kilbourn Formation.

Ahrensisporites sinanii (Artüz) n. comb.

(Plate 27, figure 11)

1957 *Triquitrites sinani* Artüz, p. 248, pl. 4, fig. 27.

Remarks -- Sullivan and Neves (1964) suggested assignment of *T. sinani* Artüz to *Ahrensisporites* but did not formally validate the recombination. Transfer is made here without descriptive emendation. Sullivan and Neves observed a morphological transition between spores of this kind and others which could be assigned more properly to *Triquitrites* in assemblages from near the Namurian-Westphalian boundary in Europe (roughly equivalent to the Morrowan Series in Midcontinent North America). Clayton and others (1977) made similar observations in spore populations characterizing the basal Westphalian. The occurrence of this species in Iowa is in slightly younger strata, and no such morphological transition between genera was observed. As noted, however, the species in Iowa is very rare. The spelling of the specific epithet is corrected for orthography.

Occurrence -- Extremely rare, observed only in the Kilbourn Formation.

Genus *TRINIDULUS* Felix and Paden 1964

Type species -- *T. diamphidios* Felix and Paden 1964.

Trinidulus diamphidios Felix and Paden 1964

(Plate 28, figures 5, 6)

1964 *Trinidulus diamphidios* Felix and Paden, p. 330-332, text-figs. 1-7.

Remarks -- This peculiar and distinctive miospore, interpreted by Felix and Paden (1964) as a partly aborted tetrad in which the three aborts remain attached to the viable spore, is an exceptionally reliable indicator of Morrowan age strata, at least in North America (Felix and Paden, 1964; Kosanke, 1977; Gillespie et al., 1978; Ravn and Fitzgerald, 1982). The spore identified as *Trinidulus* sp. by Neville (1968) from the Upper Viséan of Britain appears to be identical, and Williams (1971) reported *T. diamphidios* from the Westphalian A of Britain. The specimen illustrated as *T. diamphidios* by Clayton and others (1977, pl. 16, fig. 18) is misidentified. Kaiser (1976) reported *T. diamphidios* from the Permian of China, but the assemblage in which it occurs contains several other miospore species usually associated with the Lower Pennsylvanian or equivalent strata, and the occurrence may be partly of reworked material.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Genus *REINSCHOSPORA* Schopf, Wilson and Bentall 1944

Type species -- *R. speciosa* (Loose) Schopf, Wilson and Bentall 1944 (= *R. bellitas* Bentall, in Schopf, Wilson and Bentall, 1944).

Reinschospora speciosa (Loose) Schopf, Wilson and Bentall 1944

(Plate 28, figures 7-9)

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

non 1938 *Zonotriletes speciosus* (Loose) Waltz, in Luber and Waltz, pl. 4, fig. 48,pl. 5, fig. 9.
1944 *Reinschospora speciosa* (Loose) Schopf, Wilson and Bentall, p. 53.
1944 *Reinschospora bellitas* Bentall, in Schopf, Wilson and Bentall, p. 53, fig. 2.
non 1958 *Diatomozonotriletes speciosus* (Loose) Ishchenko, p. 96-97, pl. 13, figs. 165-167.

Remarks -- *R. magnifica* Kosanke 1950 is similar and may be synonymous.

Occurrence -- Rare, observed in coals from the Caseyville Formation through the Laddsdale.

Reinschospora triangularis Kosanke emend. Ravn 1979

(Plate 28, figures 13-15)

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) Laveine, p. 134, pl. 10, fig. 40.
1979 *Reinschospora triangularis* Kosanke emend. Ravn, p. 36, pl. 11, figs. 3-6.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Whitebreast.

Genus *MUROSPORA* Somers 1952

Type species -- *M. kosankei* Somers 1952.

Remarks -- The relationship of *Murospora* to *Simozonotriletes* Naumova ex Potonié and Kremp 1954 is unclear. Hacquebard and Barss (1957) and Playford (1962) considered the two to be synonymous, *Murospora* having priority. Sullivan (1958) and Smith and Butterworth (1967) did not accept this synonymy. Distinction between the two genera in this report follows the practice of Smith and Butterworth.

Murospora kosankei Somers 1952

(Plate 28, figures 10, 11)

1952 *Murospora kosankei* Somers, p. 21, fig. 13a.
1958 *Westphalensisporites irregularis* Alpern, p. 78, pl. 1, figs. 15-17.

Occurrence -- Rare, observed in the Cliffland and Laddsdale Coals and the unnamed coal of the Floris Formation.

Genus *SIMOZONOTRILETES* Naumova ex Potonié and Kremp 1954

Type species -- *S. intortus* (Waltz) Potonié and Kremp 1954.

Remarks -- See Remarks under *Murospora.*

Simozonotriletes intortus (Waltz) Potonié and Kremp 1954

(Plate 27, figures 14-16)

1938 *Zonotriletes intortus* Waltz, in Luber and Waltz, pl. 2, fig. 24.
1943 *Triletes (Zonales) polititorsus* Horst, text-figs. 52-54 (Invalid: unpublished thesis).
1954 *Simozonotriletes intortus* (Waltz) Potonié 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, observed in the Wildcat Den Coal, the Kilbourn Formation and the Blackoak Coal.

Genus *STENOZONOTRILETES* Naumova ex Potonié 1958

Type species -- *S. conformis* Naumova 1953.

Remarks -- *Stenozonotriletes* is distinguished from other similar-appearing genera by having a narrow cingulum that is essentially of uniform width and is not cuneiform (wedge-shaped) in cross-section. This distinction often is difficult to make in practice, and some species now assigned to the genus might better conform to other cingulate genera once their morphologies become better known. In particular, it can be difficult to distinguish a cingulum like that of *Stenozonotriletes* from the marginal 'rim' often seen in non-cingulate thick-walled spores under compression (e.g., *Punctatisporites kankakeensis* or *Deltoidospora sub-intorta* var. *rotundata* elsewhere in this report). Smith and Butterworth (1967) provided a thorough discussion of this genus.

Stenozonotriletes occultus n. sp.

(Plate 29, figures 1-6)

Diagnosis -- Miospores radial, trilete, amb irregularly rounded-triangular, usually in good proximal-distal orientation. Trilete rays straight, with well-developed lips that sometimes thicken toward the proximal pole, but often are obscured by the thickness of the exine; rays extend to, or nearly to, the inner margin of the cingulum. Cingulum 4-7 μm wide, uniform in width on any individual specimen; contact between cingulum and central portion of spore marked by a prominent uniform band 2-3 μm wide that appears to be internal, lining the equatorial portion of the spore cavity. Exine thick and very dark, externally laevigate to faintly punctate; groups of large, scattered punctae occur on the internal proximal surface of the spore cavity, occasionally arranged congruent to the trilete rays, but they may be difficult to discern because of the exine thickness.

Size -- (25 specimens) 42-59 μm maximum diameter.

Comparison -- *S. occultus* differs from other previously described species in its irregularly sphaerotriangular outline and its thickness.

Remarks -- The thick exine renders interpretation of the morphology of this species difficult. The rare specimen preserved in an oblique compression (e.g., pl. 29, fig. 6) confirms the interpretation that the marginal rim is a true cingulum, and not merely the impression of the thick marginal exine in compression. In some specimens the larger 'punctae' on the internal surface of the central spore cavity resemble the patterns of exine degradation reported by Elsik (1966) to be biogenic (e.g., pl. 29, fig. 3).

Derivation -- The specific epithet is derived from the thick, dark (*occultus*) exine.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-65 unit 3, Wapello County, Iowa; unnamed coal, Floris Formation, lower Desmoinesian Series.

Occurrence -- Observed only in one coal sample from core CP-65, in which it was abundant. This coal is considered to be an unnamed coal within the Floris Formation.

Stenozonotriletes sp. 1

(Plate 29, figures 10, 11)

1982 *Stenozonotriletes* sp. 1 Ravn and Fitzgerald, p. 132, pl. 7, figs. 1, 2.

Description -- Miospore radial, trilete, amb sphaerotriangular. Trilete rays straight, accompanied by slight thickenings of the exine, extending to the inner margin of the cingulum. External surface finely and evenly granulose except in the region of the thickening along the rays, where it is essentially laevigate; circular region around proximal pole is diffusely infrapunctate. Cingulum 6-7 μm wide, uniform in width and thickness around spore body. Exine relatively thick and dark.

Size of illustrated specimen -- 57.0 μm maximum diameter.

Comparison -- *S.* sp. 1 resembles several other *Stenozonotriletes* species described in previous literature, but differs from all in sculptural characteristics.

Occurrence -- Extremely rare, observed only in the Wildcat Den Coal.

Genus *ZOSTEROSPORITES* Kosanke 1973

Type species -- *Z. triangularis* Kosanke 1973.

Zosterosporites triangularis Kosanke 1973

(Plate 30, figures 1-3)

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

Occurrence -- Rare, observed sporadically from the Wildcat Den through the Laddsdale Coals.

Genus *BELLISPORES* Artüz emend. Sullivan 1964

Type species -- *B. nitidus* (Horst) Sullivan 1964.

Bellispores nitidus (Horst) Sullivan 1964

(Plate 28, figure 12)

1943 *Triletes nitidus* Horst, pl. 8, fig. 81 (Invalid; unpublished thesis).
1955 *Lycospora nitida* (Horst) Potonié and Kremp, in Horst, p. 181, pl. 24, fig. 81.
non 1957 *Lycospora nitida* Artüz, p. 250, pl. 5, fig. 34.
1957 *Bellispores bellus* Artüz, p. 255, pl. 7, fig. 49.
1957 *Simozonotriletes trilinearus* Artüz, p. 251, pl. 5, fig. 36.
1964a *Bellispores nitidus* (Horst) Sullivan, p. 375.
1965 *Bellisporites nitidus* (Horst) Agrali, in Agrali et al., p. 174.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Genus *GORGONISPORA* Urban 1971

Type species -- *G. convoluta* (Butterworth and Spinner) Playford 1976 (= *G. magna* [Felix and Burbridge] Urban 1971).

Gorgonispora sp. cf. *G. minima* (Felix and Burbridge) n. comb.

(Plate 30, figure 6)

cf. 1967 *Cincturasporites minimus* Felix and Burbridge, p. 398-399, pl. 61, fig. 3.
1982 *Cincturasporites* cf. *minimus* Felix and Burbridge 1967; Ravn and Fitzgerald, p. 135, pl. 7, fig. 15.

Remarks -- *G.* cf. *G. minima* resembles the species described by Felix and Burbridge (1967) in overall morphology. but is considerably smaller.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Genus *VALLATISPORITES* Hacquebard 1957

Type species -- *V. vallatus* Hacquebard 1957.

Paleobotanical affinity -- Not known from direct *in situ* evidence, but the general morphology is much like that of lycopsid-related taxa such as *Densosporites* and *Cristatisporites*.

Vallatisporites sp. cf. *V. foveolatus* (Hughes and Playford) Sullivan 1964

(Plate 30, figure 5)

cf. 1961 *Tholisporites foveolatus* Hughes and Playford, p. 38, pl. 4, figs. 1-7.
cf. 1964a *Vallatisporites foveolatus* (Hughes and Playford) Sullivan, p. 371.

Remarks -- *V.* sp. cf. *V. foveolatus* resembles the species described by Hughes and Playford (1961) in size and in the general relationships of widths of cingulum and central body, but the cingulum is less strongly ornamented than is characteristic of *V. foveolatus*.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Genus *GRUMOSISPORITES* Smith and Butterworth 1967

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

Grumosisporites rufus (Butterworth and Williams) Smith and Butterworth 1967

(Plate 30, figure 10)

1958 *Verrucosisporites rufus* Butterworth and Williams, p. 363, pl. 1, figs. 44, 45.
1967 *Grumosisporites rufus* (Butterworth and Williams) Smith and Butterworth, p. 231, pl. 17, figs. 1-7.
1970 *Grumosisporites* cf. *rufus* (Butterworth and Williams) Smith and Butterworth 1967; Peppers, p. 119, pl. 11, fig. 15.
1979 *Grumosisporites* (?) *rufus* (Butterworth and Williams) Smith and Butterworth 1967; Ravn, p. 38, pl. 12, fig. 1.

Occurrence -- Rare, observed in the Blackoak and Cliffland Coals and the unnamed coal of the Floris Formation.

Grumosisporites varioreticulatus (Neves) Smith and Butterworth 1967

(Plate 30, figures 7-9)

1958 *Dictyotriletes varioreticulatus* Neves, p. 8, pl. 2, figs. 1a, b.
1964 *Verrucosisporites microverrucosus* auct. non Ibrahim 1933; Ibrahim-Okay and Artüz, p. 274, pl. 1, fig. 7.
1967 *Grumosisporites varioreticulatus* (Neves) Smith and Butterworth, p. 232, pl. 17, figs. 8-10.
1967 *Grumosisporites papillosus* (auct. non Ibrahim) Smith and Butterworth, p. 230, pl. 16, figs. 9-13.

Remarks -- As Smith has noted, *G. papillosus* (Ibrahim) Smith and Butterworth 1967 does not correspond to *Verrucosi-sporites papillosus* Ibrahim 1933; the latter has been transferred to *Convolutispora* elsewhere in this paper. Smith and Butterworth distinguished *G. varioreticulatus* from *G. papillosus* on the basis of external ornament. This distinction, however, is very minor and is not obvious from the illustrated specimens of Smith and Butterworth. Forms corresponding to both 'species' occur in the Iowa material examined, and they appear to intergrade. Accordingly, they are considered synonymous here.

Occurrence -- Rare, observed in the Wildcat Den and Wyoming Hill Coals and the unnamed coal of the Kilbourn Formation.

Genus *RETISPORA* Staplin 1960

Type species -- *R. florida* Staplin 1960

Paleobotanical affinity -- Unknown, but the genus is similar morphologically to certain other genera known to be related to lycopsids.

Retispora staplinii (Gupta and Boozer) Ravn and Fitzgerald 1982

(Plate 31, figures 8-12)

1960 *Endosporites? parvus* Staplin, p. 33, pl. 7, figs. 8, 12.
non 1958 *Endosporites parvus* Guennel, p. 50-51, pl. 1, figs. 16, 17; text-fig. 11.
non 1965 *Endosporites parvus* Menéndez, p. 70, pl. 6, fig. 8.
1969 *Endosporites staplini* Gupta and Boozer, p. 78.
1976 *Endosporites* cf. *micromanifestus* Hacquebard 1957; Tillement, Peniguel and Guillemin, p. 438, pl. 1, fig. 27.
1979 *Endosporites staplinii* Gupta and Boozer 1969; Ravn, p. 43, pl. 14, figs. 9-11.
1982 *Retispora staplinii* (Gupta and Boozer) Ravn and Fitzgerald, p. 143, pl. 10, figs. 1-8.

Occurrence -- Frequent to abundant in the Wildcat Den Coal and the unnamed coal of the Caseyville Formation; rare to occasionally frequent in the Kilbourn Formation; rare in the Blackoak Coal.

Genus *SPELAEOTRILETES* Neves and Owens 1966

Type species -- *S. triangulus* Neves and Owens 1966.

Paleobotanical affinity -- Unknown, but the morphology of the genus closely resembles that of *Endosporites*, which is known to be of lycopsid affinity.

Spelaeotriletes triangulus Neves and Owens 1966

(Plate 30, figure 4)

1966 *Spelaeotriletes triangulus* Neves and Owens, p. 345, pl. 1, figs. 1-3.
1966 *Spelaeotriletes arenaceus* Neves and Owens, p. 345-346, pl. 2, figs. 1-3.

Remarks -- Spinner and Clayton (1973) proposed synonymy of the two species named originally by Neves and Owens (1966), on the basis of their observation that an unbroken intergradation of morphology existed between spores assignable to the two species in material from the Viséan of Scotland.

Occurrence -- Extremely rare, observed only in the Wildcat Den Coal and in a shale sample from the basal Kilbourn Formation in core CP-6.

Genus *ALATISPORITES* Ibrahim emend. Smith and Butterworth 1967

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

Paleobotanical affinity -- Courvoisier and Phillips (1975) recovered spores corresponding to *A. trialatus* Kosanke 1950 from a fructification of unknown affinity. Speculations on the affinity of *Alatisporites* by previous investigators have included both filicinean and gymnospermous origin, the latter based primarily on the vesiculate morphology of the genus. Vesiculate spores, however, are now known to be produced by a wide variety of plants, and such a morphology alone cannot be considered to indicate a gymnospermous affinity. The overall morphology of spores assigned to this genus suggests that a gymnospermous affinity is unlikely.

Alatisporites hexalatus Kosanke 1950

(Plate 31, figure 7)

1950 *Alati-sporites hexalatus* Kosanke, p. 23-24, pl. 4, fig. 5.

Remarks -- Distinction between *A. hexalatus* and *A. trialatus* is made solely on the basis of the number of pseudosacci. Observations of Peppers (1970) as well as those made during the course of this study suggest that the development of pseudosacci in spores of this kind is variable, and doubling of a pseudosaccus frequently occurs by means of constriction in the middle. Partial constriction of pseudosacci is common, and this variation may be due to preservation in some instances. The possibility of synonymy between these two species is therefore considerable. As a result, occurrence data (Table I) is given as *A. trialatus/A. hexalatus*; see note under *A. trialatus*.

Alatisporites hoffmeisterii Morgan 1955

(Plate 31, figures 5, 6)

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

Occurrence -- Rare, observed in the Blackoak, Cliffland and Laddsdale Coals and the unnamed coal of the Floris Formation.

Alatisporites pustulatus (Ibrahim) Ibrahim 1933

(Plate 31, figures 3, 4)

1932 *Sporonites pustulatus* Ibrahim, in Potonié, Ibrahim and Loose, p. 448, pl. 14, fig. 12.
1933 *Alati-sporites pustulatus* (Ibrahim) Ibrahim, p. 32, pl. 1, fig. 12.
1965a *Alatipollenites pustulatus* (Ibrahim) Laveine, p. 136.

Remarks -- *A. pustulatus* differs from *A. trialatus* in having a rugulate-verrucate central body.

Occurrence -- Rare, observed in the Kilbourn Formation, the Blackoak and Cliffland Coals.

Alatisporites trialatus Kosanke 1950

(Plate 31, figures 1, 2)

1950 *Alati-sporites trialatus* Kosanke, p. 25, pl. 4, fig. 3.

Remarks -- In addition to the potential synonymy of *A. hexalatus* discussed previously, *A. inflatus* Kosanke 1950 and *A. varius* Kosanke 1950 also differ from *A. trialatus* only in minor characteristics that may represent individual variation within what should more properly be considered a single species.

Occurrence -- (Includes that for *A. hexalatus*) Rare to occasionally frequent, observed in all coals from the Cliffland through the Whitebreast.

Genus *KEWANEESPORITES* Peppers 1970

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

Paleobotanical affinity -- Unknown; Taylor (1972) recovered spores corresponding to *Kewaneesporites* from the fructification *Cyanotheca*, but the affinity of this fossil is uncertain.

Kewaneesporites appressus n. sp.

(Plate 30, figures 11-16)

1979 *Kewaneesporites patulus* auct. non (Peppers) Peppers 1970; Ravn, p. 26, pl. 4, figs. 11-14.

Diagnosis -- Miospores radial, trilete, amb sphaerotriangular, margin altered by sculptural elements, commonly in good proximal-distal orientation. Both proximal and distal surfaces ornamented with coarse, rounded, irregular, sometimes fused verrucae 2-8 μm wide, 2-5 μm high. Verrucae usually loosely arranged, exine exposed between verrucae usually narrower than the verrucae themselves, although verrucae may be reduced in size and number in the region of the trilete mark. 12-25 verrucae project at the margin. Entire spore surface covered by a transparent membrane that may project 1-3 μm above the verrucae at their apices and appears to fuse to the exine at their bases; in some specimens the membrane either is absent or is present only as a layer entirely fused to the rest of the exine and thus is not visible. Trilete rays straight, 1/2 to more than 2/3 of radius, sometimes obscured by ornament and membrane. Exine, not including membrane, thick and dark.

Size -- (25 specimens) 39-50 μm maximum diameter.

Comparison -- *K. appressus* differs from the other two described species of the genus (*K. reticuloides* and *K. patulus*) in the nature and distribution of thke sculptural elements and the associated membrane. *K. reticuloides* displays generally a greater number of smaller, unfused projections. *K. patulus* also usually has more and finer projections, of which many are clavate and which usually are not fused to one another. The general appearance of the ornamentation of *K. appressus* is less regular than that of the other species; the latter also are reported from Illinois Basin strata younger than those in which *K. appressus* was observed in Iowa.

Remarks -- The nature of the membrane covering the exine is unclear. It is separated from the main spore body only over the verrucae in most cases, and thus does not resemble the common 'perispore' observed in many other genera (e.g., *Diaphanospora* Balme and Hassell emend. Evans 1970). The membrane offen has the appearance of a transparent outer 'coating' of the verrucae. As in the other species of the genus, the membrane may be missing (or totally fused) on individual specimens, in which case they would be appropriately assignable to *Verrucosisporites*. The specimens designated *K. patulus* by Ravn (1979) are more properly assigned to *K. appressus* and are noted as such in the synonymy.

Derivation -- The specific epithet is derived from the closely appressed appearance of the membrane.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-17 unit 13, Mahaska County, Iowa; unnamed coal, Kilbourn Formation, Atokan Series.

Occurrence -- Rare, observed in the Kilbourn Formation, the Blackoak, Cliffland and Laddsdale Coals.

Genus *DIAPHANOSPORA* Balme and Hassell emend. Evans 1970

1962 *Diaphanospora* Balme and Hassell, p. 20.
1966a *Palliolatisporites* Hagemann, p. 826.
1970 *Diaphanospora* Balme and Hassell emend. Evans, p. 68.

Type species -- *D. riciniata* Balme and Hassell emend. Evans 1970.

Remarks -- *Diaphanospora* is regarded here as the appropriate generic repository for trilete spores having a circular or nearly circular amb and a thin, diaphanous, unmodified or unornamented perine distinctly separated from the main spore body over most of its surface. As such, *Diaphanospora* is intended to replace in part the generic concept embodied by *Perotrilites* Erdtman ex Couper 1953, prior to the emendation of Evans (1970). Evans reexamined the type material of both *Perotrilites* and *Diaphanospora*, and determined that the type species of *Perotrilites* (*P. granulatus* Couper 1953) was actually zonate rather than perinate.

A wide variety of species, most of them bearing obvious perines or perispores of one kind or another, have been assigned to *Perotrilites*, only some of which can be accommodated in *Diaphanospora*. Additionally, several other genera have been erected for perinate spores of similar general morphology, which are difficult to distinguish with confidence from *Diaphanospora*. *Velamisporites* Bharadwaj and Venkatachala 1962 and *Ricaspora* Bharadwaj and Salujha 1964 each have a granulose perine. *Rugospora*

Neves and Owens 1966 was defined originally as having an endoexine bearing 'characteristic micro-verrucose ornament and a persistent series of folds or plications which give the spores an irregular, corrugated appearance' (Neves and Owens, 1966, p. 350). By the emendation of Turnau(1978), which eliminated the reference to ornamentation of the exoexine, *Rugospora* becomes similar to *Diaphanospora* in concept. In this report, I regard *Rugospora* as being distinct from *Diaphanospora* in having a thinner main spore body and a thicker perine (=exoexine) with more prominent folds that appear to be part of the morphologic organization of the spore rather than random effects of compression. *Hymenospora* also has a thicker perine than *Diaphanospora*, and the perine is attached to the central body over a greater part of its proximal (and possibly distal) surface by means of incised grooves or folds. *Palliolatisporites* is indistinguishable from *Diaphanospora* and is considered synonymous.

The type species of *Diaphanospora* (*D. ricinata*) is described as having a central body with a narrow equatorial thickening, but the illustrations of this are not entirely convincing; neither Balme and Hassell (1962) nor Evans (1970) regarded this characteristic as of generic significance, and in both these papers other species not having such thickenings were assigned to *Diaphanospora*. By the original definition of Balme and Hassell, the ornamentation of the main spore body may be smooth, scabrate or granulose. Guennel (1963) assigned to *Diaphanospora* species having a considerable variation in the structure and organization of the 'perispore'. In order to clarify some taxonomic problems with species improperly assigned to *Perotrilites* or other genera, I have chosen to include within *Diaphanospora* spores having other kinds of small sculptural elements on the central body; in the future, it may be useful to separate genera on the basis of such ornamentation, but at present the confusion and overlapping among the various perisporate genera render further taxonomic splitting undesirable.

Paleobotanical affinities -- Not specifically known. The presence of generalized perisporial coverings is known in trilete spores from the earliest Devonian (Richardson and Ioannides, 1973) to the present, and modern representatives include spores of many kinds of ferns and lycopsids (e.g., Murillo and Bless, 1974); I know of no reports of such spores *in situ* from Carboniferous strata. Suggestions by Good and Taylor (1975) that the presence of a perisporial layer might signal some paleobotanical relationship to *Elaterites*-bearing sphenopsids are considered unlikely. In addition to the difficulties of interpreting paleobotanical relationships for spores of this kind, much taxonomic confusion also exists among the many (and overlapping) perisporate genera. Ravn (1983) discussed these issues in detail.

Diaphanospora parvigracila (Peppers) Ravn 1979

(Plate 32, figures 4, 5)

1970 *Perotriletes* (*sic*) *parvigracilus* Peppers, p. 128, pl. 13, figs. 5-7.
1979 *Diaphanospora parvigracila* (Peppers) Ravn, p. 48, pl. 18, fig. 11.

Remarks -- *D. graysonii* (Varma) n. comb. resembles *D. parvigracila* in size and general characteristics, but it is described as having a rounded equatorial outline and sinuous trilete mark without lips; *D. graysonii* also appears to display greater variability in the relative thickness of the perispore and main spore body. *D. tecta* (Habib) n. comb. also is similar, but is described as symmetrically trilete, whereas the trilete rays of *D. parvigracila* are distinctly asymmetrical in arrangement and length.

Occurrence -- Rare, but observed in most coals from the Wildcat Den through the unnamed coal of the Floris Formation.

Diaphanospora sp. 1

(Plate 32, figures 12, 13)

1982 *Diaphanospora* sp. 1 Ravn and Fitzgerald, p. 146, pl. 10, figs. 20, 21.

Description -- Miospore radial, trilete, amb convexly triangular. Trilete rays straight, extending to spore margin at angles, with prominent lips approximately 3 μm wide. Central body enclosed by thin, transparent, sparsely folded perispore that extends 2 μm or less from the central body along the interradial margins and is closely appressed to the central body over much of the spore surface. A prominent granulose or infragranulose area surrounding the proximal pole appears to be the region of attachment of the perispore. Distal surface of central body laevigate.

Size of illustrated specimen -- 45.1 μm maximum diameter including perispore.

Occurrence -- Extremely rare, observed only in the Wildcat Den Coal.

The following species conform to the generic concept of *Diaphanospora* as emended by Evans (1970), and are transferred:

Diaphanospora graysonii (Varma) n. comb.:
1969 *Perotrilites graysonii* Varma, p. 310, pl. 2, figs. 4, 5.

Diaphanospora minor (Owens) n. comb.:
1971 *Perotrilites minor* Owens, p. 66, pl. 20, figs. 8-10.
non 1973 *Perotrilites minor* (Madler) Antonescu and Taugourdeau-Lantz, p. 7, pl. 6, figs. 63-68, 71, 74.

Diaphanospora plissata (Hagemann) n. comb.:
1966a *Palliolatisporites plissata* Hagemann, p. 826, pl. 10, figs. 18, 19.

Diaphanospora tecta (Habib) n. comb.:
1968 *Proprisporites tectus* Habib, p. 202, pl. 2, figs. 8-10.

The following new name is proposed to correct a problem of homonymy:

Diaphanospora higgsii n. name:
1975 *Perotrilites caperatus* Higgs, p. 401, pl. 7, figs. 10, 12, 13.
non 1970 *Perotrilites caperatus* Kemp, p. 111, pl. 21, fig. 12, pl. 22, figs. 1, 2.

Remarks -- *D. higgsii* possesses an ornament of small rugulae and spines on the distal surface of the main spore body; for that reason the assignment to *Diaphanospora* is considered provisional. The specific epithet is in honor of Dr. Kenneth Higgs, who originally described the species. *Perotrilites caperatus* Kemp 1970 is a problematical species from the Albian of England; it clearly does not belong in *Perotrilites* as emended by Evans (1970), but its proper generic assignment is uncertain.

Genus *HYMENOSPORA* Neves 1961

Type species -- *H. palliolata* Neves 1961.

Hymenospora sp. cf. *H. caperata* Felix and Burbridge 1967

(Plate 32, figures 9-11)

cf. 1967 *Hymenospora caperata* Felix and Burbridge, p. 405-406, pl. 62, fig. 12.
1971 *Hymenospora* cf. *H. caperata* Felix and Burbridge 1967; Urban, p. 125, pl. 30, figs. 8, 9.
1971b *Hymenospora* cf. *H. caperata* Felix and Burbridge 1967; Playford, p. 51, pl. 17, figs. 9-15.
1982 *Hymenospora* cf. *caperata* Felix and Burbridge 1967; Ravn and Fitzgerald, p. 146, pl. 10, figs. 23-25.

Remarks -- Urban (1971) and Playford (1971b) reported spores displaying slight morphologic differences from the species described by Felix and Burbridge (1967), and which closely resemble the spores observed in this study. Playford (1971b) also suggested the possible synonymy of *Cirratriradites granulatipunctatus* Hoffmeister, Staplin and Malloy 1955. *C. granulatipunctatus* appears to be more appropriately assignable to *Hymenospora* but its similarity to other species is not obvious from the type illustration (Hoffmeister, Staplin and Malloy, 1955, pl. 37, fig. 2). *H.* sp. cf. *H. caperata* is distinguished from *H. multirugosa* Peppers 1970 by its ornamentation of coarse, irregular corrugations along the perispore margin; *H. multirugosa* displays a much finer rugose ornament.

Occurrence -- Rare, observed in the Wildcat Den Coal and an unnamed coal of the Kilbourn Formation.

Hymenospora multirugosa Peppers 1970

(Plate 32, figures 1-3)

1970 *Hymenospora multirugosa* Peppers, p. 129, pl. 13, figs. 8, 9.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the unnamed coal of the Floris Formation.

Hymenospora paucirugosa Peppers 1970

(Plate 32, figure 17)

1970 *Hymenospora paucirugosa* Peppers, p. 130, pl. 13, figs. 10-13.

Occurrence -- Rare, observed only in a coal of the Laddsdale complex.

Genus *RUGOSPORA* Neves and Owens emend. Turnau 1978

Type species -- *R. corporata* Neves and Owens 1966.

Remarks -- The emendation of this genus by Turnau (1978) removed reference to a 'microverrucose' ornament (Neves and Owens, 1966). *Rugospora* differs from *Diaphanospora* in having a 'perispore' or 'exoexine' folded into more or less regular rugulae. As previously discussed in the Remarks under *Diaphanospora*, distinction among the various perisporate trilete genera is not entirely clear.

Rugospora gracilirugosa n. sp.

(Plate 32, figures 6-8)

1982 *Rugospora* cf. *minuta* Neves and Ioannides 1974; Ravn and Fitzgerald, p. 147, pl. 11, fig. 1.

Diagnosis -- Miospore radial, trilete, amb circular to broadly rounded triangular. Usually in good proximal-distal orientation. Trilete rays straight, simple, extending 2/3 to 3/4 of radius, often obscured by folds of the perine. Intexine of medium thickness, rarely folded, covered by a closely appressed thin perine which is comprehensively folded into narrow, closely spaced rugulations. Perine appears to be attached to intexine over much of both proximal and distal surfaces; separation of perine from intexine at equator is minor, usually 1-3 μm. Rugulate folds of perine show slight tendency toward radial arrangement near the equator, but are for the most part randomly oriented.

Size -- (12 specimens) 35.7-47.3 μm.

Comparison -- *R. gracilirugosa* is similar to *R. minuta* Neves and Ioannides (1974) in size, but it possesses a finer and less distinct rugulate folding of the perispore.

Remarks -- This species is assigned to *Rugospora* on the basis of the rugose folding of the perine. Because of the apparent close attachment of the perine to the intexine over much of its surface, assignment to *Hymenospora* might be equally appropriate. See Remarks under *Diaphanospora* concerning the difficulties of taxonomic assignment to various perisporate genera.

Derivation -- The specific epithet refers to the relative fineness (*gracilis*) of the rugose folding of the perine.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-17 unit 13, Mahaska County, Iowa; unnamed coal, Kilbourn Formation, Atokan Series.

Occurrence -- Rare, observed in the Wildcat Den Coal and the Kilbourn Formation.

Rugospora radiata Ravn and Fitzgerald 1982

(Plate 32, figures 14-16)

1982 *Rugospora radiata* Ravn and Fitzgerald, p. 147, pl. 11, figs. 3-8.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

The following species correspond morphologically to *Rugospora* and are transferred:

Rugospora cymatila (Allen) n. comb.:
1965 *Rhabdosporites cymatilus* Allen, p. 738-739, pl. 104, figs. 5-8.

Rugospora ruginosa (Playford) n. comb.:
1978 *Grumosisporites ruginosus* Playford, p. 135, pl. 9, figs. 14-20.

Remarks -- Playford (1978) suggested a possible assignment of this species to *Rugospora*, but chose to assign it to *Grumosisporites* because of the diagnosis of Neves and Owens (1966) that specified a microverrucose ornamentation of the exoexine; the emendation of Turnau (1978) removes this objection. Playford (1978) also noted that Neves and Owens indicated that the central body was attached to the exoexine 'only in the region of the trilete mark.' In most perinate spores the nature of attachment of the central body to any outer perine is often difficult to determine, and I do not regard its nature in spores of this kind sufficiently well-determined to use as a generic character. Assignment of this species to *Grumosisporites* is inappropriate, as this genus is characterized by a much thicker outer exine layer bearing various kinds of sculptural elements, and a thinner, usually folded inner body.

Genus *THYSANITES* Ravn 1979

Type species -- *T. densus* Ravn 1979.

Thysanites densus Ravn 1979

(Plate 32, figures 18-20)

1979 *Thysanites densus* Ravn, p. 47, pl. 18, figs. 4-9.

Occurrence -- Rare, observed only in the Blackoak Coal.

MONOLETE MARATTIALEANS, SPHENOPSIDS AND LYGINOPTERIDS

Each of the three major plant groups listed above is known to produce monolete spores or prepollen. Modern psilophytes also produce such spores, although psilophytes are not known from the Carboniferous fossil record. Devonian psilophytes, in contrast, appear to have produced exclusively trilete spores (Allen, 1980; Gensel, 1980). Most monolete spores display simple, generalized morphologies from which determination of the specific paleobotanical affinity is usually not possible.

Genus *LAEVIGATOSPORITES* Ibrahim 1933

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

Remarks -- Similarly to the trilete genus *Calamospora* a large number of species have been ascribed to *Laevigatosporites*, distinguished usually on the basis of arbitrary measurements of one kind or another. Alpern and Doubinger extensively reviewed the taxonomy of Carboniferous monolete spores and broadly synonymized the species of *Laevigatosporites* into three broad species, based on size. In my view, this redefinition of species is too broad, and does not permit separation of this unwieldy genus into useful categories. Additionally, certain other genera were considered synonymous with *Laevigatosporites* (e.g., *Renisporites* Winslow 1959) which have demonstrably different morphologic characteristics. The revision of Alpern and Doubinger therefore is not followed in this report. The major species of *Laevigatosporites* are distinguished on both morphologic and size criteria by Ravn (1979); those criteria will be mentioned briefly as appropriate under the species.

Paleobotanical affinities -- Sphenopsids (Reed, 1938; Baxter, 1950; Andrews and Mamay, 1951; Remy, 1960, 1961; Remy and Remy, 1961; Doubinger, 1961; Leisman and Graves, 1964; Barthel, 1967) and marattialeans (Mamay, 1950; Ewart, 1961; Taylor, 1967; Pfefferkorn, Peppers and Phillips, 1971; Millay and Taylor, 1984). Additionally, Thomas and Crampton (1971) recovered small specimens of *Laevigatosporites* from a fructification of the fern *Zeilleria*, which they regarded as a coenopterid progenitor of the Marattiaceae. Ravn (1979) suggested that the large (greater than 35 μm in length) forms of this genus had been isolated only from sphenopsids, but Taylor's (1967) study indicates that spores as large as 60 μm in length also occur in marattialeans; see also the discussion under the genus *Leioaletes* Staplin 1960.

Laevigatosporites contactus Ravn and Fitzgerald 1982

(Plate 33, figures 17, 18)

1982 *Laevigatosporites contactus* Ravn and Fitzgerald, p. 148, pl. 11, figs. 14, 15, 18, 19.

Remarks -- *L. contactus* is distinguished from other species of similar size by possession of a distinct, *Calamospora*-like contact area along the laesura.

Occurrence -- Rare to frequent, Caseyville Formation coals.

Laevigatosporites desmoinesensis (Wilson and Coe) Schopf, Wilson and Bentall 1944

(Plate 33, figure 10)

1940 *Phaseolites desmoinesensis* Wilson and Coe, p. 182, pl. 1, fig. 4.
1944 *Laevigatosporites desmoinesensis* (Wilson and Coe) Schopf, Wilson and Bentall, p. 37.

Remarks -- As distinguished by Ravn (1979), this species encompasses spores that possess no morphological modification adjacent to the laesura (in contrast to *L. contactus*) and are 60-75 μm in length.

Occurrence -- Rare to occasionally frequent from the Blackoak Coal through the Bevier; rare in the Wildcat Den Coal and in a shale sample from the basal Kilbourn Formation in core CP-6.

Laevigatosporites globosus Schemel 1951

(Plate 33, figure 6)

1951 *Laevigato-sporites globosus* Schemel, p. 748, text-fig. 2.
1956a *Latosporites globosus* (Schemel) Potonié and Kremp, p. 140.

Remarks -- This species may intergrade morphologically with certain slightly larger asymmetrically trilete species (e.g., *Cyclogranisporites obliquus*) and also has a probable paleobotanical relationship with *Torispora securis* Balme emend. Alpern, Doubinger and Horst 1965. See Remarks under those species.

Occurrence -- Common to occasionally abundant in the Blackoak, Cliffland and Laddsdale Coals; rare to common upward throughout the rest of the section.

Laevigatosporites maximus Loose emend. Potonié and Kremp 1956

(Plate 33, figures 21, 22)

1934 *Laevigato-sporites maximus* Loose, p. 58, pl. 7, fig. 11.
1956a *Laevigatosporites maximus* Loose emend. Potonié and Kremp, p. 138, pl. 19, figs. 420, 421.

Remarks -- *L. maximus* accommodates spores greater than 100 μm in length.

Occurrence -- Rare, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation, the Kilbourn Formation and the Cliffland Coal.

Laevigatosporites medius Kosanke 1950

(Plate 33, figures 7, 8)

1950 *Laevigato-sporites medius* Kosanke, p. 29, pl. 16, fig. 12.

Remarks -- *L. medius* accommodates spores 32-45 μm in length.

Occurrence -- Rare, but observed in most coals throughout the section.

Laevigatosporites minor Loose 1934

(Plate 33, figures 9, 11)

1934 *Laevigato-sporites vulgaris minor* Loose, p. 158, pl. 7, fig. 12.
1950 *Laevigato-sporites ovalis* Kosanke, p. 29-30, pl. 5, fig. 7.
1957a *Laevigatosporites minor* (Loose) Potonié and Kremp; Bhardwaj, p. 109, pl. 29, figs. 8, 9.

Remarks -- *L. minor* as used here accommodates spores 45-60 μm in length; Ravn (1979) used the same specific concept under the name *L. ovalis.*

Occurrence -- Frequent to abundant in the Blackoak, Cliffland and Laddsdale Coals; rare to occasionally common in younger coals studied; observed rarely in the Kilbourn Formation.

Laevigatosporites minor f. *striatus* (Alpern) n. status

(Plate 33, figures 15, 16)

1959 *Laevigatosporites striatus* Alpern, p. 153, pl. 11, figs. 267, 268.
non 1977 *Laevigatosporites striatus* (Salujha) Anderson, p. 90(9.3), pl. 80, figs. 14, 15, pl. 81, figs. 1-32.

Remarks -- As noted by Ravn (1979), the 'striations' of this form are caused by compression of masses of the spores, rather than being true exinal structures. Clayton (1972) documented similar compression features in trilete spores assignable to *Punctatisporites.* In the absence of these compression features, spores assigned to *L. striatus* would correspond for the most part to *L. minor* in the sense applied in this report. The observed stratigraphic occurrence of spores of this kind, however, is more limited than that of *L. minor* suggesting the possibility of some stratigraphic utility for *L. striatus.* Retention as a separate form-species, however, is not considered desirable. For that reason, the species is retained here as a distinct form within *L. minor.* The suggested transfer of this species to *Striatosporites* by Alpern and Doubinger (1973) is rejected.

Occurrence -- Rare, observed in most coals from the Blackoak through the Wheeler.

Laevigatosporites vulgaris (Ibrahim) Ibrahim 1933

(Plate 33, figure 19)

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.
1979 *Laevigatosporites* cf. *dunkardensis* auct. non Clendening 1970; Ravn, p. 44, pl. 15, fig. 11.

Remarks -- *L. vulgaris* accommodates spores 75-100 μm in length; see also Remarks under *L.* sp. cf. *L. vulgaris*. Reexamination of the spores designated *L.* cf. *dunkardensis* Clendening 1970 by Ravn (1979) indicates that these are probably thin-walled variants of spores properly assignable to *L. vulgaris.*

Occurrence -- Rare, observed in most coals from the Blackoak upward throughout the section.

Laevigatosporites sp. cf. *L. vulgaris* (Ibrahim) Ibrahim 1933

(Plate 33, figure 20)

Remarks -- Spores designated *L.* sp. cf. *L. vulgaris* fall within the size range used here for *L. vulgaris* but are thicker, more oval in shape and have a relatively short laesura (about 1/2 the spore length).

Occurrence -- Rare, observed only in the Blackoak and Laddsdale Coals.

Genus *LEIOALETES* Staplin 1960

Type species -- *L. aliquandostriatus* Staplin 1960.

Remarks -- Although described as alete, both the type species noted following display a faint, quasi-sutural groove that may represent an incipient or vestigial laesura.

Paleobotanical affinity -- Taylor (1967) isolated spores from a fructification of the fern *Radstockia kidstonii* Taylor that closely resemble *L. circularis* Ravn and Fitzgerald 1982. Taylor referred the spores to *Laevigatosporites*, but noted that no haptotypic features (i.e., a laesura) were observed. The illustrated specimen (Taylor, 1967, pl. 7, fig. 5) does appear to have a faint groove, however, and in both its size and overall shape it is similar to *L. circularis.* C. Singh (1964) described a species (*L. calvatus*) from the Lower Cretaceous of Alberta that he considered to be an alete pollen grain. I consider this species to be improperly assigned to *Leioaletes.*

Leioaletes circularis Ravn and Fitzgerald 1982

(Plate 35, figures 16, 17)

1982 *Leioaletes circularis* Ravn and Fitzgerald, p. 150, pl. 12, figs. 1-5.

Occurrence -- Rare, observed in the Wildcat Den and Wyoming Hill Coals.

Genus *PUNCTATOSPORITES* Ibrahim emend. Alpern and Doubinger 1973

Type species -- *P. minutus* Ibrahim emend. Alpern and Doubinger 1973.

Remarks -- Taxonomic distinction of this genus and several other monolete genera is complex and not agreed upon universally. Smith and Butterworth (1967) noted the confusion created by the name, which implies a punctate sculpture, despite the fact that the type species and most others assigned to the genus are distinctly granulose. Ravn (1979) noted variability of sculpture from granulose to punctate among small monolete spores; the species *Punctatisporites minutus* Kosanke emend. Peppers 1964 varies from monolete to trilete and has a granulose-punctate sculpture. The generic distinctions do not cover such forms adequately.

In this paper, *Punctatosporites* is applied strictly to monolete spores showing no tendency toward trilete forms within their populations, and having distinctly granulose sculpture. This practice accords fairly well with the emendation of the genus by Alpern and Doubinger (1973).

Paleobotanical affinities -- Marattialean (Laveine, 1969, 1970; Millay, 1979b; Jennings and Millay, 1979; Millay and Taylor, 1984; Lesnikowska and Millay, 1985). Lesnikowska and Millay (1985) noted that a minority of the spores observed *in situ* were vestigially trilete.

Punctatosporites granifer Potonié and Kremp emend. Alpern and Doubinger 1973

(Plate 33, figure 5)

1956a *Punctatosporites granifer* Potonié and Kremp, p. 142, pl. 19, fig. 442.
1973 *Punctatosporites granifer* Potonié and Kremp emend. Alpern and Doubinger, p. 45, pl. 12, figs. 1-37.
1979 *Laevigatosporites globosus* auct. non Schemel 1951; Ravn, in part, pl. 15, fig. 6.

Remarks -- As noted in the synonymy, the specimen designated *Laevigatosporites globosus* by Ravn (1979, pl. 15, fig. 6) is more properly assignable to *P. granifer*; it is reillustrated in this report.

Occurrence -- Rare to occasionally frequent, observed in most coals from the Blackoak upward throughout the section.

Punctatosporites minutus Ibrahim emend. Alpern and Doubinger 1973

(Plate 33, figs. 1, 2)

1933 *Punctato-sporites minutus* Ibrahim, p. 40, pl. 5, fig. 33.
1938 *Azonotriletes minutus* (Ibrahim) Luber, in Luber and Waltz, pl. 8, fig. 112.
1944 *Laevigato-sporites minutus* (Ibrahim) Schopf, Wilson and Bentall, p. 37.
1957a *Granulatosporites minutus* (Ibrahim) Dybová and Jachowicz, p. 191.
1973 *Punctatosporites minutus* Ibrahim emend. Alpern and Doubinger, p. 42, pl. 11, figs. 1-26.

Remarks -- Ravn (1979) listed this species under *Laevigatosporites minutus*.

Occurrence -- Rare, the Kilbourn Formation; common to abundant from the Blackoak Coal upward throughout the section. Generally from the Carruthers Coal upward, the clearly monolete *Punctatosporites minutus* is more abundant than the transitionally monolete/trilete, more or less round *Punctatisporites minutus*; in the Blackoak, Cliffland and Laddsdale Coals the converse tends to be true.

Punctatosporites punctatus (Kosanke) Alpern and Doubinger 1973

(Plate 33, figures 12-14)

1950 *Laevigato-sporites punctatus* Kosanke, p. 30, pl. 5, fig. 3.
1973 *Punctatosporites punctatus* (Kosanke) Alpern and Doubinger, p. 40, pl. 10, figs. 1-20.

Occurrence -- Rare, observed only in the Cliffland Coal.

Punctatosporites rotundus Bhardwaj emend. Alpern and Doubinger 1973

(Plate 33, figures 3, 4)

1957a *Punctatosporites rotundus* Bhardwaj, p. 111, pl. 29, fig. 16.
1957a *Granulatosporites altus* Dybová and Jachowicz, p. 192, pl. 64, figs. 1-4.
1973 *Punctatosporites rotundus* Bhardwaj emend. Alpern and Doubinger, p. 52, pl. 14, figs. 1-37.

Occurrence -- Rare, observed only in the Blackoak and Cliffland Coals.

Genus *THYMOSPORA* Wilson and Venkatachala 1963

Type species -- *T. thiessenii* (Kosanke) Wilson and Venkatachala 1963.

Paleobotanical affinity -- Marattialean (Moore, 1946; Potonié, 1962; Barthel, 1967; Doubinger and Grauvogel-Stamm, 1972; Millay, 1979b; Millay and Taylor, 1984).

Thymospora pseudothiessenii (Kosanke) Wilson and Venkatachala 1963

(Plate 34, figures 16-20)

1950 *Laevigato-sporites pseudothiessenii* Kosanke, p. 30, pl. 5, fig. 10.
1956a *Verrucososporites pseudothiessenii* (Kosanke) Potonié and Kremp, p. 144.
1963b *Thymospora pseudothiessenii* (Kosanke) Wilson and Venkatachala, p. 125, pl. 1, figs. 1-11, pl. 2, figs. 1-12.
1973 *Thymospora pseudothiessenii* (Kosanke) Wilson and Venkatachala emend. Alpern and Doubinger, pl. 76, pl. 18, figs. 1-28.
(for additional synonymy, see Alpern and Doubinger, 1973).

Occurrence -- Rare to frequent, observed regularly from the unnamed coal of the Floris Formation upward throughout the section. Questionable specimens (designated by Ravn, 1979, as *T.* cf. *pseudothiessenii* were observed very rarely in the Blackoak and Laddsdale Coals.

Genus *TORISPORA* Balme emend Doubinger and Horst 1961

Type species -- *T. securis* Balme emend. Alpern, Doubinger and Horst 1965.

Paleobotanical affinities -- Several studies (Horst, 1957; Guennel and Neavel, 1961; Doubinger and Horst, 1961; Artüz, 1962) have demonstrated that spores corresponding to *Torispora* represent the outermost cells of a sporangial mass of monolete spores; the inner cells, lacking the crassitude, are assignable to *Laevigatosporites*, *Punctatosporites* or *Thymospora* depending on their ornamentation. Laveine (1969, 1970) recovered spores assignable to *Torispora* from marattialean fructifications containing also spores assignable to these other genera. Stach (1975) suggested a pteridospermous affinity for *Torispora*, but this is unlikely.

Torispora securis Balme emend. Alpern, Doubinger and Horst 1965

(Plate 34, figures 21-23)

1952 *Torispora securis* Balme, p. 183, text-figs. 3a-d.
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* Dyvbová and Jachowicz, p. 198, pl. 68, figs. 1-4.
1958 *Crassosporites triletoides* Alpern, p. 81, pl. 2, fig. 42.
1958 *Crassosporites punctatus* Alpern, p. 81, pl. 2, fig. 43.
1965 *Torispora securis* Balme emend. Alpern, Doubinger and Horst, p. 570-571, pl. 1, fig. 1.

Occurrence -- Rare to occasionally common in the Blackoak, Cliffland and Laddsdale Coals. Observed rarely in the unnamed coal of the Floris Formation and the Mystic Coal. The appearance in significant numbers of *Torispora* in the Blackoak Coal represents a significant biostratigraphic event that is widely traceable throughout North America and Europe (e.g., Smith and Butterworth, 1967; Clayton et al., 1977; Owens et al., 1978; Peppers, 1979, 1984; Kosanke, 1984).

Genus *SPINOSPORITES* Alpern 1958

Type species -- *S. spinosus* Alpern 1958.

Remarks -- Jansonius and Hills (1976b) suggested that *Spinosporites* was a probable junior synonym of *Tuberculatosporites* Imgrund 1960 (originally proposed in Imgrund's 1952 thesis). Both are monolete with more or less spinose sculptural elements, but those of *Spinosporites* are densely crowded, whereas those of *Tuberculatosporites* are much more loosely arranged (Imgrund, 1960). I believe this to be a valid characteristic for generic distinction. In any case, if the two genera are considered synonymous, *Spinosporites* must be regarded as having priority, because *Tuberculatosporites* was not validly published until 1960. As noted by Jansonius and Hills (1976b), the initial use of the name *Tuberculatosporites* by Imgrund (1952) is a *Nomen nudum* as it was not validly published. Potonié and Kremp (1954, 1955)

Derivation -- The generic name is constructed to suggest the similarity of ornament to many species assigned to the trilete genus, *Dictyotriletes*.

Paleobotanical affinity -- Unknown. Millay (1979b) isolated irregularly reticulate monolete spores from a species of the marattialean fern *Scolecopteris*, but these are much less regularly ornamented than *D. swadei* and probably represent ontogenetic or preservational variants of spores assignable to *Thymospora*. Many small monolete spores, however, have been established as of marattialean affinity, and such a relationship seems probable for the type species of *Dictyomonolites*, as well.

Dictyomonolites swadei n. sp.

(Plate 34, figures 1-8)

1979 *Dictyotriletes castaneaeformis* (Horst) Sullivan 1964; Ravn, in part, pl. 2, figs. 2, 3.

Diagnosis -- Miospores conforming to the characteristics of the genus. Laesura often indistinct or obscured by ornament, sometimes irregular, seldom open, extends 2/3 to 3/4 of spore length. Muri 2-4 μm high, 2-3 μm wide, usually reduced on the proximal surface adjacent to the laesura; 10-15 muri project along spore margin. Muri tend to be slightly sinuose, enclosing irregularly polygonal lumina 4-8 μm in maximum dimension; muri sometimes are incomplete. In cross-section, the tops of the muri are flat to slightly rounded. Exine except for muri thin, laevigate.

Size -- (30 specimens) 20-34 μm long, 12-20 μm wide.

Remarks -- Ravn (1979) suggested the possibility of a monolete laesura in the species *Dictyotriletes castaneaeformis* (Horst) Sullivan 1964. Smith and Butterworth (1967, p. 195) regarded that species as 'apparently alete', and no mention of a laesura was made in the original diagnosis (first published by Horst, 1955). The status of the holotype is unknown. Smith and Butterworth considered the species *Dictyotriletes clatriformis* as probably synonymous with *D. castaneaeformis*, but *D. clatriformis* apparently is trilete (Artuz, 1957). The specimen illustrated as *D. castaneaeformis* by Smith and Butterworth (1967, pl. 11, figs. 16, 17) appears to be very similar to *D. swadei* n. sp., and even shows a suggestion of a monolete laesura.

Specimens observed in Iowa coals were uniformly oval and monolete. In view of the confusion discussed above, I consider erection of a new species to be appropriate. Should the holotype of *Dictyotriletes castaneaeformis* prove to be monolete and to correspond to the species described here, it would take precedence, and transfer to *Dictyomonolites* would be desirable.

Derivation -- The species is named in honor of the late John W. Swade of the Department of Geology, University of Iowa, for his close and much appreciated cooperation in parallel conodont studies for the Iowa Geological Survey during the period of investigation for this report.

Type material -- Designation and location of type specimens is given in the plate captions.

Type location and horizon -- Core CP-73 unit 36, Wapello County Iowa (see Gregory, 1982, p. 202); Cliffland Coal, Kalo Formation, basal Desmoinesian Series.

Occurrence -- Rare to occasionally frequent, observed in the Blackoak, Cliffland and Laddsdale Coals. One questionable occurrence was noted in the Wyoming Hill Coal.

The following species is appropriately assignable to *Dictyomonolites* n. gen. and is transferred:

Dictyomonolites antarcticus (Kemp) n. comb.:
1972 *Reticuloidosporites antarcticus* Kemp, p. 117, pl. 56, figs. 1-3.

Remarks -- *D. antarcticus* differs from *D. swadei* in having a distinctly bounded, smooth contact area surrounding the laesura, and in being much larger.

treated the genus as being validly published, and gave a generic diagnosis, but they did not publish an illustration of the holotype. An illustration was published by Imgrund (1960), thus validating the genus.

Paleobotanical affinity -- Marattiales. Spores of *Scolecopteris monothrix* Ewart, described and illustrated by Millay (1979b) correspond to *Spinosporites exiguus* Upshaw and Hedlund 1967 (Millay and Taylor, 1984).

Spinosporites exiguus Upshaw and Hedlund 1967

(Plate 34, figures 9-11)

1967 *Spinosporites exiguus* Upshaw and Hedlund, p. 152, pl. 4, figs. 17-19.
1970 *Apiculatisporis lappites* Peppers, p. 100, pl. 6, figs. 14, 15; text-fig. 21.

Remarks -- Peppers (personal communication, 1986) now regards *Apiculatisporis lappites* Peppers 1970, a trilete form of similar size and ornamentation, to be synonymous with *S. exiguus*, in a complex that varies from monolete to trilete. In all specimens on which a scar could be seen in the material examined for this study, the spores were monolete.

Occurrence -- Rare to occasionally frequent, observed in nearly all coals from the Blackoak through the Wheeler.

Spinosporites sp. 1

(Plate 34, figure 12)

Description -- Miospore monolete, bean-shaped, laesura extending approximately 3/4 of spore length. Exine moderately thick, surface ornamented evenly with minute spines 1-2 μm in height, 1 μm or less in thickness. Distance between spines 1-3 μm.

Size of illustrated specimen -- Length 42.9 μm, excluding ornament.

Remarks -- No other described species of *Spinosporites* exhibits such a typically *Laevigatosporites*-like outline in combination with the densely and finely spinose ornament observed. This spore was first observed by B. E. Egner during her thesis study (Egner, 1981); I gratefully acknowledge her permission to describe and illustrate the specimen here.

Occurrence -- Extremely rare, observed only in the Cliffland Coal.

MONOLETE OF UNKNOWN AFFINITIES

Genus *DICTYOMONOLITES* n. gen.

Type species -- *D. swadei* n. sp.

Diagnosis -- Miospores monolete, bilateral, amb oval, lateral outline bean-shaped. Distinct, coarsely reticulate ornament over entire exine, reduced or absent in region of laesura; height of muri equal to or greater than width.

Comparison -- *Dictyomonolites* is proposed to accommodate monolete spores having a coarsely reticulate sculpture. Several genera have been described for monolete spores having foveolate, microreticulate or finely reticulate/rugulate sculpture, but none is appropriate for the coarsely reticulate forms assigned here to the newly described type species, *D. swadei*. The only previous report known to me of monolete reticulate spores from Carboniferous strata is that of Butterworth and Mahdi (1982), who described small, finely reticulate spores from the Namurian of England under the name *Reticuloidosporites reticulatus*. The type species of *Reticuloidosporites* (*R. dentatus* Pflug, in Thomson and Pflug, 1953) has a peculiar foveolate/rugulate sculpture that does not closely resemble the sculpture of *D. swadei*.

Genus *TUBERCULATOSPORITES* Imgrund 1960

non 1968 *Tuberculatosporites* Jain, p. 15.

Type species -- *T. anicystoides* Imgrund ex Imgrund 1960.

Remarks -- See Remarks under *Spinosporites.*

Tuberculatosporites robustus (Kosanke) Peppers 1970

(Plate 35, figures 18, 19)

1950 *Laevigato-sporites robustus* Kosanke, p. 30, pl. 5, fig. 9.
1956a *Latosporites robustus* (Kosanke) Potonié and Kremp, p. 140.
1966 *Tuberculatosporites spinoplicatus* Habib, p. 644, pl. 107, figs. 1-3.
1970 *Tuberculatosporites robustus* (Kosanke) Peppers, 127, pl. 13, figs. 1, 2.
1973 *Spinosporites spinoplicatus* (Habib) Alpern and Doubinger, p. 80.

Occurrence -- Rare, observed in most coals from the Kilbourn Formation through the Wheeler.

Genus *RENISPORITES* Winslow 1959

Type species -- *R. confossus* Winslow 1959.

Remarks -- Alpern and Doubinger (1973) regarded *Renisporites* as synonymous with *Laevigatosporites*, but this view is not accepted here. *Renisporites* accommodates large, thick-walled monolete spores that bear characteristic groups of punctae, usually along the sides. The genus is best regarded at present as being monospecific. The assignment by Gupta (1969) of small, questionably punctate spores to *Renisporites* is inappropriate.

Renisporites confossus Winslow 1959

(Plate 34, figures 13-15)

1959 *Renisporites confossus* Winslow, p. 65-66, pl. 15, figs. 4, 5; text-figs. 4, 5.

Remarks -- Kosanke (1969) observed that specimens of these large spores did not pass through sample screens readily, and thus tended to be removed selectively from the miospore residues of some samples. I did not observe this difficulty during the course of this project, although it might be difficult to detect.

Occurrence -- Rare, observed in the Blackoak and Cliffland Coals; one questionable occurrence noted in the Wildcat Den Coal.

ALETE OF UNKNOWN AFFINITIES

Genus *SPACKMANITES* Habib 1966 emend.

Type species -- *S. ellipticus* Habib 1966 emend.

Emended diagnosis -- Alete miospores; outline spherical to elliptical. Densely ornamented with rods or bacula that may be discrete individual elements or may coalesce, especially at their apices, to form a complex sculptural network.

Remarks -- The original diagnosis of this genus (Habib, 1966) refers to trilete spores. I consider the descriptions of the type species and also of *S. facierugosus* (Loose) Habib 1966 to be erroneous.

Habib's illustrations of these species do not show the presence of a trilete mark, and none of the hundreds of specimens of these distinctive spores examined during the course of this study showed any haptotypic markings. Other previously illustrated specimens assignable to *Spackmanites* (e.g., Barss, 1967; Gray, 1967; Peppers, 1970) likewise show no evidence of a trilete mark. In some specimens the bacula may separate slightly in some areas due to compression or preservation, and leave an irregular gap in the ornament that can resemble a trilete scar. On specimens in which some of the bacula are torn away, revealing the underlying smooth spore exine, I saw no trace of a trilete mark during this study. In order to provide clear distinction of *Spackmanites* from truly trilete genera that accommodate baculate spores (e.g., *Raistrickia*) the generic diagnosis is emended to restrict it to alete forms.

Peppers (1970) discussed the issue of the possible presence or absence of a trilete mark among spores assigned to *Spackmanites* and suggested the possibility that *Spackmanites* might be synonymous with the Triassic genus *Enzonalasporites* Leschik 1956, as interpreted by Clarke (1965). The structure and ornamentation of *Enzonalasporites* are not clearly understood, however, and from published illustrations (e.g., Clarke, 1965; Visscher and Krystyn, 1978; Dunay and Fisher, 1979) do not appear to correspond to the characteristics of *Spackmanites*.

Habib (1968) described a third species, *S. rotundus*, which is definitely trilete. This species is indistinguishable from *Verrucosisporites morulatus*, with which it has been placed in synonymy earlier in this report.

Spackmanites ellipticus Habib 1966 emend.

(Plate 35, figures 12-14)

1966 *Spackmanites ellipticus* Habib, p. 638, pl. 105, figs. 17, 18.
1979 *Spackmanites facierugosus* (Loose) Habib 1966; Ravn, in part, pl. 8, fig. 11 only.

Emended diagnosis -- Miospores conforming to the characdteristics of the genus. Outline generally elliptical, but may be circular. Exine uniformly and profusely ornamented with discrete rod-shaped bacula 2-4 μm wide, 3-8 μm high, with blunt or irregularly rounded apices. Apices of bacula often, but not always, slightly thickened to give the individual element a clavate appearance. Sides of bacula usually longitudinally striate, and apices of bacula may be partly fused to one another. On occasional specimens the bacula may be torn away from portions of the spore, revealing a thin, featureless exine.

Size -- (25 specimens measured in this study) 50-67 μm maximum total diameter; Habib (1966) listed a size range of 45-68 μm maximum total diameter, and 34-49 μm diameter of main spore body exclusive of bacula.

Occurrence -- Rare, observed in most coals from the Kilbourn Formation through the Laddsdale Coals.

Spackmanites habibii n. sp.

(Plate 35, figures 9-11)

1966 *Spackmanites facierugosus* (auct. non Loose) Habib, p. 638, pl. 105, fig. 19.
non 1934 *Reticulati-sporites facierugosus* Loose, p. 155, pl. 7, fig. 26.
?non 1954 *Verrucososporites facierugosus* (Loose) Butterworth and Williams, p. 754, pl. 18, fig. 6.
non 1967 *?Verrucososporites facierugosus* (Loose) Butterworth and Williams 1954; Barss, pl. 8, fig. 7.
1970 *Spackmanites* cf. *facierugosus* (Loose) Habib 1966; Peppers, p. 109, pl. 8, figs. 17-20.
1979 *Spackmanites facierugosus* (Loose) Habib 1966; Ravn, p. 32, pl. 8, figs. 9, 10 (non fig. 11).
non 1979 *Verrucosisporites facierugosus* (Loose) Butterworth and Williams 1954; Ettensohn and Peppers, pl. 1, fig. 11.

Emended diagnosis -- Miospores conforming to the characteristics of the genus. Outline circular. Exine uniformly and profusely ornamented with discrete rod-shaped bacula, 2-4 μm wide, 2-5 μm high, with blunt or irregularly rounded apices. Bacula rarely clavate. Sides of bacula often longitudinally striate, but this characteristic is visible only on specimens with moderately coarse sculpture. On specimens in which bacula are removed, underlying exine is thin and featureless.

Size -- (50 specimens) 25-41 μm maximum diameter including ornament.

Comparison -- *S. habibii* differs from *S. ellipticus* in being smaller, more consistently round in outline and having a proportionally coarser baculate ornament with bacula that are not fused at their apices.

Remarks -- Erection of the new species *S. habibii* is necessary as a result of the interpretation that the spore illustrated as *S. facierugosus* (Loose) Habib 1966 n. comb. does not correspond to *Reticulatisporites facierugosus* Loose 1934, which Habib (1966) cited as the basionym. Loose's illustration is a line drawing that most closely resembles the spores illustrated as *Verrucososporites facierugosus* (Loose) Butterworth and Williams 1954 by Barss (1967) and as *Verrucosisporites facierugosus* (Loose) Butterworth and Williams 1954 by Ettensohn and Peppers (1979), as listed in the synonymy above. Barss (1967) also illustrated unnamed spores specimens corresponding to *S. habibii* and Peppers (1970) illustrated as *S.* cf. *facierugosus* equivalent spores, indicating that both disagree with the recombination of Habib (1966). As a recombination, Habib (1966) did not designate a type specimen; erection of a new species with designation of type material is therefore necessary to validate the species.

Derivation -- The species is named in honor of Dr. Daniel Habib, who first illustrated the form.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-10 unit 49, Appanoose County, Iowa (see Gregory, 1982, p. 140); Blackoak Coal, Kalo Formation, uppermost Atokan Series.

Occurrence -- Rare to occasionally frequent, observed in most coals from the Kilbourn Formation through the Summit.

Spackmanites irregularis n. sp.

(Plate 36, figures 1-4)

Diagnosis -- Miospores conforming to the characteristics of the genus. Outline of compressed specimens usually circular but sometimes modified by irregular ornamentation. Main spore body thin, round, usually perceptible, densely ornamented with irregularly shaped bacula or clavae which are partly fused to one another; fusing most evident at the apices of the bacula, but also occurs to some degree along the entire length. Height of bacula approximately equal to or slightly greater than radius of spore body. Width of bacula at apices highly variable because of fusing.

Size -- (10 specimens) 54-63 μm maximum diameter.

Comparison -- *S. irregularis* is characterized by the irregular and variable fusing of the bacula. It is larger than *S. habibii*, and the sculptural elements are much less uniform than those of *S. ellipticus*.

Derivation -- The specific epithet refers to the irregular nature of the ornament.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-49 unit 7, Davis County, Iowa (see Gregory, 1982, p. 190); Cliffland Coal, Kalo Formation, basal Desmoinesian Series.

Occurrence -- Rare, observed only in the Cliffland Coal.

Spackmanites sp. 1

(Plate 35, figure 15)

1982 *Spackmanites* sp. 1 Ravn and Fitzgerald, p. 126, pl. 4, figs. 8, 9.

Remarks -- *S.* sp. 1 resembles *S. habibii* except for the possession of extremely fine bacula which are so crowded as to appear hair-like. These may represent a variant of the normal morphology, but they were observed only in the Caseyville Formation, where spores more normally assignable to *S. habibii* were not seen. Therefore, forms corresponding to *S.* sp. 1 may be of stratigraphic utility.

Occurrence -- Rare, observed only in the Wildcat Den Coal.

Genus *MACULATASPORITES* Tiwari 1964

Type species -- *M. indicus* Tiwari 1964.

Paleobotanical affinity -- Unknown. Segroves (1967) considered specimens he assigned to *Maculatasporites* from the Permian of Australia to be of non-vascular plant origin, but the presence of species morphologically assignable to the genus from Pennsylvanian (Peppers, 1970) and Permian (Tiwari, 1964; Foster, 1975, 1979) coals containing abundant vascular plant miospores suggests that at least those species are of land-plant origin. *Maculatasporites* species described by Tiwari and Schaarschmidt (1975) from Lower and Middle Devonian strata in Germany clearly are acritarchs and are more properly assignable to the acritarch genus *Dictyotidium.*

Maculatasporites asperatus n. sp.

(Plate 35, figures 1-8)

Diagnosis -- Miospores radial, alete, outline circular, originally spherical. Exine (?exoexine) thick, uniformly reticulate; muri 2-4 μm wide, 3-5 μm high, often bearing small, irregular coni or grana 1 μm or less high, that project at the margin, giving the spore a roughened outline. Lacunae irregularly polygonal, 3-8 μm in maximum dimension, showing no preferred orientation.

Size -- (50 specimens) 36-86 μm maximum diameter; most specimens are smaller than 50 μm.

Comparison -- Assignment of this species to *Maculatasporites* is made with some reservation because an endexine has not been seen; this may be due, however, simply to the thickness of the reticulate exine or exoexine. *M. asperatus* more closely resembles other species of *Maculatasporites* (e.g., *M. punctatus* Peppers 1970) than it does species of any other reticulate genus. *M. asperatus* differs from *M. punctatus* in bearing small coni on the muri which produce a roughened spore margin. The lacunae of *M. asperatus* are somewhat larger and more distinctly polygonal than those of *M. punctatus* and the muri generally are narrower in *M. asperatus* than in *M. punctatus.* Certain miospores illustrated as unknown types by Gray (1967) from Appalachian coals resemble *M. asperatus.*

Derivation -- The specific epithet is derived from the roughened (*asperatus*) appearance of the spore margin.

Type material -- Designation and location of type specimens is given in the plate captions.

Type locality and horizon -- Core CP-66 unit 9, Wapello County, Iowa; Laddsdale Coal, Floris Formation, lower Desmoinesian Series.

Occurrence -- Rare to occasionally common in the Laddsdale Coals and in the unnamed coal of the Floris Formation. One questionable occurrence noted in an unnamed coal of the Kilbourn Formation.

POLYPLICATE PROBABLE GYMNOSPERMS

Genus *AUMANCISPORITES* Alpern 1958

Type species -- *A. striatus* Alpern 1958

Paleobotanical affinity -- Not known from paleobotanical study of *in situ* material, but pollen grains having this kind of polyplicate or striate morphology have been associated with the Ephedraceae and other gymnospermous plants in post-Carboniferous strata.

Aumancisporites striatus Alpern 1958

(Plate 37, figures 1, 2)

1958 *Aumancisporites striatus* Alpern, p. 84-86, pl. 2, figs. 53, 54.

Remarks -- To my knowledge, the occurrence of *A. striatus* in the Iowa Pennsylvanian represents the oldest known report of polyplicate grains.

Occurrence -- Rare, observed only in the Blackoak Coal.

MONOSACCATE GYMNOSPERMS

Remarks -- Although the specific paleobotanical affinity or affinities for many infrareticulate saccates have not been established through *in situ* examinations of the pollen grains, their general affinities to gymnospermous plants is clear. However, gymnosperms comprise a large and varied group, almost certainly of polyphyletic origin, containing plants from many different paleoecological niches. Further knowledge of the specific affinities of saccate pollen and prepollen grains would be very helpful in elucidating the paleoecology of Carboniferous coal-forming swamps. Unless otherwise noted, the paleobotanical affinities of the following genera are not specifically known; they are considered gymnospermous by virtue of their morphology.

Genus *SCHULZOSPORA* Kosanke 1950

Type species -- *S. rara* Kosanke 1950.

Paleobotanical affinity -- Pteridospermous (Remy and Remy, 1955b).

Schulzospora elongata Hoffmeister, Staplin and Malloy 1955

(Plate 36, figure 8)

1955 *Schulzospora elongata* Hoffmeister, Staplin and Malloy, p. 396, pl. 39, fig. 2.

Occurrence -- Rare to frequent, observed in the Wildcat Den and Wyoming Hill Coals.

Schulzospora rara Kosanke 1950

(Plate 36, figures 6, 7)

1950 *Schulzospora rara* Kosanke, p. 53, pl. 13, figs. 5-8.

Occurrence -- Rare to frequent, observed in Caseyville Formation coals.

Genus *COLATISPORITES* Williams, in Neves et al., 1973

Type species -- *C. decorus* (Bharadwaj and Venkatachala) Williams, in Neves et al., 1973.

Paleobotanical affinity -- Not known from *in situ* examination, but the pseudosaccus and central body morphology are very similar to those of *Schulzospora* suggesting a pteridospermous affinity.

Colatisporites decorus (Bharadwaj and Venkatachala) Williams, in Neves et al., 1973

(Plate 36, figure 5)

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 in the Wildcat Den Coal, a shale sample from the basal Kilbourn Formation in core CP-6 and the Blackoak Coal.

Genus *PALEOSPORA* Habib 1966

Type species -- *P. fragila* Habib 1966.

Paleospora fragila Habib 1966

(Plate 36, figures 9, 10)

1966 *Paleospora fragila* Habib, p. 647-648, pl. 108, figs. 1, 2.

Occurrence -- Rare, observed in most coals from the unnamed coal of the Caseyville Formation through the Whitebreast.

Genus *TINNULISPORITES* Dempsey 1967

Type species -- *T. microsaccus* Dempsey 1967.

Remarks -- A number of radially symmetrical, trilete, monosaccate form genera of upper Paleozoic miospores have been erected. *Wilsonites* accommodates forms with indistinct central bodies. *Guthoerlisporites* Bhardwaj 1954 was erected to cover forms with central bodies free of the saccus on the proximal surface, but Peppers (1970) has questioned both the morphological interpretation of Bhardwaj (1954) and the utility of the genus in general; Nygreen and Bourn (1967) also noted continuous morphological transition among spores assignable to several monosaccate form genera including *Guthoerlisporites* within a population. *Tinnulisporites* bears a superficial resemblance to *Auroraspora* Hoffmeister, Staplin and Malloy 1955, but the former has a characteristically gymnospermous infrareticulate saccus, whereas the latter does not. *Cordaitina* Samoilovich 1953 has shorter trilete rays and displays radial folding of the saccus not seen in *Tinnulisporites*.

Tinnulisporites microsaccus Dempsey 1967

(Plate 37, figures 3-6)

1967 *Tinnulisporites microsaccus* Dempsey, p. 115, pl. I, figs. F-N.
? 1965 *Guthoerlisporites* sp. A Upshaw and Creath, p. 444, pl. 4, fig. 7.
1969 *Guthoerlisporites desmoinensis* Gupta, p. 183, pl. 33, fig. 112.

Occurrence -- Rare, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation, a shale sample from the basal Kilbourn Formation in core CP-6, the Laddsdale Coals and the unnamed coal of the Floris Formations. The presence of this species as reported originally by Dempsey (1967) in the Upper and Lower McAlester Coals of Oklahoma suggests a possible correlation of these coals with the Laddsdale complex in which *T. microsaccus* is most regularly observed in Iowa.

Genus *WILSONITES* Kosanke 1959

Type species -- *W. vesicatus* (Kosanke) Kosanke 1959.

Wilsonites circularis (Guennel) Peppers and Ravn, in Ravn, 1979

(Plate 37, figure 8)

1958 *Endosporites circularis* Guennel, p. 51, pl. 1, figs. 18, 19; text-fig. 12.
1979 *Wilsonites circularis* (Guennel) Peppers and Ravn, in Ravn, p. 50, pl. 20, fig. 3.

Occurrence -- Rare, observed in a shale sample from the basal Kilbourn Formation in core CP-6, the Blackoak and Laddsdale Coals.

Wilsonites delicatus (Kosanke) Kosanke 1959

(Plate 37, figure 11)

1950 *Wilsonia delicata* Kosanke, p. 54, pl. 14, fig. 4.
1959 *Wilsonites delicatus* (Kosanke) Kosanke, p. 700.
1965a *Wilsonipollenites delicatus* (Kosanke) Laveine, p. 135.
1966 *Guthoerlisporites delicatus* (Kosanke) Habib, p. 646, pl. 107, fig. 9.

Occurrence -- Rare, observed in the Wildcat Den Coal, a shale sample from the basal Kilbourn Formation in core CP-6 and most coals from the Blackoak upward throughout the section.

Wilsonites vesicatus (Kosanke) Kosanke 1959

(Plate 37, figures 9, 10)

1950 *Wilsonia vesicatus* Kosanke, p. 54, pl. 14, figs. 1-3.
1957b *Guthoerlisporites velensis* Bhardwaj, p. 130, pl. 26, fig. 120.
1959 *Wilsonites vesicatus* (Kosanke) Kosanke, p. 700.
1965a *Wilsonipollenites vesicatus* (Kosanke) Laveine, p. 135.

Occurrence -- Rare, observed in most coals throughout the section.

Genus *FLORINITES* Schopf, in Schopf, Wilson and Bentall, 1944

Type species -- *F. mediapudens* (Loose) Potonié and Kremp 1956 (= *F. antiquus* Schopf, in Schopf, Wilson and Bentall, 1944).

Paleobotanical affinities -- Cordaites (Delevoryas, 1953; Wilson, 1960; Brush and Barghoorn, 1962; Potonié, 1969; Millay and Taylor, 1974, 1976) and pteridosperms (Long, 1977b).

Florinites mediapudens (Loose) Potonié and Kremp 1956

(Plate 37, figures 13, 14)

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.
1956a *Florinites mediapudens* (Loose) Potonié and Kremp, p. 169, pl. 21, figs. 468-471.
1957a *Florinites circularis* Bhardwaj, p. 116, pl. 30, figs. 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.

Occurrence -- Rare in Caseyville Formation coals; frequent to occasionally dominant from Kilbourn Formation upward throughout the section.

Florinites millottii Butterworth and Williams 1954

(Plate 38, figure 5)

1954 *Florinites millotti* Butterworth and Williams, p. 760, pl. 18, figs. 7, 8.
1966 *Florinipollenites millotti* (Butterworth and Williams) Coquel, p. 21, pl. 2, figs. 14, 15.

Occurrence -- Rare to occasionally frequent, observed in Blackoak, Cliffland, Laddsdale and Whitebreast Coals.

Florinites occultus Habib 1966

(Plate 37, figure 12)

1966 *Florinites occultus* Habib, p. 649, pl. 108, figs. 4, 5a, 5b.

Occurrence -- Rare, observed in the Blackoak and Cliffland Coals; one questionable occurrence noted in the Wildcat Den Coal.

Florinites similis Kosanke 1950

(Plate 38, figure 6)

1950 *Florinites similis* Kosanke, p. 49, pl. 12, fig. 2.

Remarks -- Assignment to this species follows the practice of Peppers (1970), who noted the common presence of a distinct trilete mark, a feature not described by Kosanke (1950). Peppers also discussed the taxonomic complexities surrounding *F. similis* and similar forms.

Occurrence -- Rare, observed in nearly all coals from the Wildcat Den through the Laddsdale; one occurrence noted in the Mystic Coal.

Florinites visendus (Ibrahim) Schopf, Wilson and Bentall 1944

(Plate 37, figure 15)

1933 *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, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation and the Blackoak Coal.

Florinites sp. cf. *F. volans* (Loose) Potonié and Kremp 1956

(Plate 37, figure 7)

cf. 1932 *Sporonites volans* Loose, in Potonié, Ibrahim and Loose, p. 451, pl. 18, fig. 6.
cf. 1933 *Reticulata-sporites volans* (Loose) Ibrahim, p. 36.
cf. 1934 *Zonales-sporites volans* (Loose) Loose, p. 149.
cf. 1944 *Endosporites volans* (Loose) Schopf, Wilson and Bentall, p. 46.
cf. 1956a *Florinites volans* (Loose) Potonié and Kremp, p. 170, pl. 21, fig. 462.
cf. 1966 *Guthörlipollenites volans* (Loose) Coquel, p. 21, pl. 2, fig. 21.
cf. 1971 *Guthörlisporites volans* (Loose) Loboziak, p. 87, pl. 13, fig. 11.
1979 *Florinites* cf. *volans* (Loose) Potonié and Kremp 1956; Ravn, p. 49, pl. 19, figs. 5, 6.

Remarks -- For discussion of the species designated here as *F.* sp. cf. *F. volans* see Ravn (1979).

Occurrence -- Rare, observed in the Kilbourn Formation and the Blackoak Coal.

Genus *POTONIEISPORITES* Bhardwaj 1954

Type species -- *P. novicus* Bhardwaj 1954.

Paleobotanical affinity -- Conifers; Rothwell (1982) recovered pollen grains corresponding to *Potonieisporites* from the primitive conifer *Lebachia.*

Potonieisporites elegans (Wilson and Kosanke) Wilson and Venkatachala 1964

(Plate 39, figures 13, 14)

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) Wilson and Venkatachala emend. Habib, p. 648-649, pl. 108, fig. 3.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Laddsdale.

Potonieisporites solidus Ravn 1979

(Plate 38, fig. 11)

1979 *Potonieisporites solidus* Ravn, p. 49, pl. 19, figs. 7-9.

Occurrence -- Rare, observed in the Blackoak and Laddsdale Coals.

Genus *COSTATASCYCLUS* Felix and Burbridge emend. Urban 1971

Type species -- *C. crenatus* Felix and Burbridge emend. Urban 1971.

Costatascyclus crenatus Felix and Burbridge emend. Urban 1971

(Plate 38, figures 9, 10)

1967 *Costatascyclus crenatus* Felix and Burbridge, p. 411, pl. 64, fig. 6.
1971 *Costatascyclus crenatus* Felix and Burbridge emend. Urban, p. 114-115, pl. 25, figs. 4-9.

Occurrence -- Rare, observed in the Wildcat Den Coal, the unnamed coal of the Caseyville Formation and the Blackoak Coal.

Genus *CORDAITINA* Samoilovich 1953

Type species -- *C. uralensis* (Luber) Samoilovich 1953.

Paleobotanical affinities -- Probably cordaitalean. Many species of this genus have been described from the Permian (Hart, 1965); these may include pollen of various gymnospermous affinities.

Cordaitina? sp. 1

(Plate 38, figures 3, 4)

Description -- Radial, trilete, monosaccate prepollen grains. Amb circular to oval. Trilete mark indistinct, approximately 1/3 the radius of the central body. Central body distinct, circular to oval, faintly punctate (?infrasculpture). Saccus infrareticulate, lumina arranged in a faint radial pattern, attached to central body both proximally and distally. Width of saccus extension from central body more or less uniform, 1/4 to 1/3 of total miospore radius.

Size of illustrated specimens -- 47.3 and 55.8 μm maximum diameter including saccus.

Remarks -- This species is assigned questionably to *Cordaitina* because if its distinct central body and the lack of radial crenulations of the saccus characteristic of most species of *Cordaitina*. It resembles *C. trileta* (Alpern) Hart 1965 in general appearance, but is smaller. *Cordaitina* species have been recorded primarily from younger Carboniferous and Permian strata, although the species *C. coalensis* (Dempsey) Kirkland and Frederiksen 1970 has been reported as abundant in the Middle Pennsylvanian of Oklahoma and Texas (Dempsey, 1967; Kirkland and Frederiksen, 1970; Gupta, 1970).

Occurrence -- Rare, observed in an unnamed coal of the Kilbourn Formation and in the Cliffland Coal.

Genus *PEPPERSITES* Ravn 1979

Type species -- *P. ellipticus* Ravn 1979.

Peppersites ellipticus Ravn 1979

(Plate 38, figures 7, 8)

1979 *Peppersites ellipticus* Ravn, p. 51, pl. 21, figs. 1-4.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Laddsdale.

Genus *WAPELLITES* Ravn 1979

Type species -- *W. variabilis* Ravn 1979.

Wapellites variabilis Ravn 1979

(Plate 38, figure 12)

1979 *Wapellites variabilis* Ravn, p. 52, pl. 22, figs. 1-3.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Blackoak.

Genus *QUASILLINITES* Ravn and Fitzgerald 1982

Type species -- *Q. diversiformis* (Kosanke) Ravn and Fitzgerald 1982.

Remarks -- Ravn and Fitzgerald (1982) proposed *Quasillinites* as a new name to replace *Pseudoillinites* Ravn 1979, which is a functional junior homonym of the Triassic genus *Pseudillinites* Mädler 1964.

Quasillinites diversiformis (Kosanke) Ravn and Fitzgerald 1982

(Plate 38, figures 1, 2)

1950 *Florinites diversiformis* Kosanke, p. 49, pl. 12, fig. 5.
non 1976 *Florinites* cf. *diversiformis* Kosanke 1950; Tillement, Peniguel and Guillemin, p. 439, pl. 1, fig. 29.
1979 *Pseudoillinites diversiformis* (Kosanke) Ravn, p. 51, pl. 21, figs. 9-11.
1980 *Illinites diversiformis* (Kosanke) Jansonius and Hills, card 3750.
1982 *Quasillinites diversiformis* (Kosanke) Ravn and Fitzgerald, p. 153, pl. 13, fig. 6.

Occurrence -- Rare, observed in most coals from the Wildcat Den through the Laddsdale.

BISACCATE GYMNOSPERMS

Genus *PITYOSPORITES* Seward emend. Manum 1960

Type species -- *P. antarcticus* Seward 1914.

Paleobotanical affinity -- Not specifically known, but the overall morphology of the genus is strikingly similar to that of many modern conifer pollen grains.

Pityosporites westphalensis Williams 1955

(Plate 39, figure 12)

1955 *Pityosporites westphalensis* Williams, p. 467, pl. 6, figs. 1-6; text-figs. 1, 2.

Occurrence -- Rare, observed in the Blackoak, Cliffland, Laddsdale and Bevier Coals.

Genus *PLATYSACCUS* Naumova ex Potonié and Klaus 1954

Type species -- *P. papilionis* Potonié and Klaus 1954.

Platysaccus saarensis (Bhardwaj) Jizba 1962

(Plate 39, figures 6, 7)

1957a *Alisporites saarensis* Bhardwaj, p. 117-118, pl. 31, figs. 14, 15.
1962 *Platysaccus saarensis* (Bhardwaj) Jizba, p. 885, pl. 124, figs. 59-61.
1966 *Vesicaspora saarensis* (Bhardwaj) Habib, p. 649, pl. 108, fig. 9.

Occurrence -- Rare, observed in the Blackoak, Summit and Mystic Coals.

Genus *VESICASPORA* Schemel emend. Wilson and Venkatachala 1963

Type species -- *V. wilsonii* Schemel emend. Wilson and Venkatachala 1963.

Paleobotanical affinity -- Paleobotanical studies have clearly established the relationship of pollen grains corresponding to *V. wilsonii* with pteridosperms of the Callistophytaceae (Millay and Eggert, 1970, Millay and Taylor, 1970, 1974, 1976; Stidd and Hall, 1970; Hall and Stidd, 1971; Rothwell, 1972a, 1972b).

Vesicaspora wilsonii Schemel emend. Wilson and Venkatachala 1963

(Plate 39, figures 4, 5)

1951 *Vesicaspora wilsonii* Schemel, p. 745-750, figs. 1, 3.
1963c *Vesicaspora wilsonii* Schemel emend. Wilson and Venkatachala, p. 142-143, pl. 1, figs. 1-15, pl. 2, figs. 1-15.

Remarks -- In proximal-distal orientation, the distinction of *V. wilsonii* from the monosaccate *Florinites millottii* can be difficult.

Occurrence -- Rare to frequent, observed regularly from the Carruthers Coal upward throughout the section. One questionable occurrence noted in the Cliffland Coal and one occurrence noted in a coal of the Laddsdale complex.

Genus *LIMITISPORITES* Leschik emend. Potonié 1958

Type species -- *L. monstruosus* (Luber and Waltz) Hart 1965 (= *L. rectus* Leschik 1956).

Limitisporites sp. 1

(Plate 39, figures 10, 11)

Description -- Bilateral, bisaccate, haploxyonoid prepollen grains. Central body irregularly oval to subcircular in outline, bearing a monolete laesura approximately 1/2 the width of the central body. Exine of central body thick, dark, faintly punctate or granulose (?infrasculpture). Sacci finely infrareticulate, approximately equal to or slightly smaller than the central body in size. Strongly developed, more or less straight compression folds occur transverse to the laesura along the zones of attachment of the sacci to the central body.

Size of illustrated specimens -- 109.3 and 113.6 μm maximum dimension including sacci.

Remarks -- Miospores designated *L.* sp. 1 are larger than most other previously described species of the genus. *Limitisporites* species are widely reported from Permo-Triassic strata, but have been reported only rarely from the Pennsylvanian (e.g., Peppers, 1964). In overall size and general appearance, *L.* sp. 1 resembles *Quasillinites diversiformis* but the latter is monosaccate.

Occurrence -- Rare, observed in the Blackoak and Cliffland Coals.

Genus *ILLINITES* Kosanke emend. Helby 1966

Type species -- *I. unicus* Kosanke emend. Helby 1966.

Illinites unicus Kosanke emend. Helby 1966

(Plate 39, figures 1-3)

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) Bhardwaj, p. 137, pl. 2, figs. 16, 17.
1962 *Complexisporites polymorphus* Jizba, p. 869, pl. 121, figs. 1-14.
1966 *Illinites unicus* Kosanke emend. Helby, p. 680-681, pl. 8, figs. 9-18, pl. 9, fig. 1, ?figs. 3, 4.
1966 *Complexisporites chalonerii* Habib, p. 650, pl. 108, fig. 10.
1970 *Kosankeisporites elegans* (Kosanke) Bhardwaj emend. Peppers, p. 133-134, pl. 14, figs. 6-8; text-fig. 29.

Remarks -- As noted by Ravn (1979), the synonymy constructed by Helby (1966) so broadened the concept of this species as to constitute a *de facto* emendation, although Helby did not formally propose an emendation.

Occurrence -- Rare, observed in most coals from the Wildcat Den to the Mystic.

Genus *PHILLIPSITES* Ravn 1979

Type species -- *P. tenuis* Ravn 1979.

Phillipsites tenuis Ravn 1979

(Plate 39, figures 8, 9)

1979 *Phillipsites tenuis* Ravn, p. 52, pl. 21, figs. 6-8.

Occurrence -- Rare, observed only in the Blackoak Coal.

MEDULLOSAN PTERIDOSPERMS

Genus *ZONALOSPORITES* Ibrahim 1933

1933 *Zonalosporites* Ibrahim, p. 40.
1936 *Monoletes* Ibrahim ex Schopf, p. 107.
non 1954 *Monoletes* van der Hammen, p. 83.
1954 *Schopfipollenites* Potonié and Kremp, p. 180.
1963 *Cymbospora* Venkatachala, p. 40.

Type species -- *Z. vittatus* Ibrahim 1933.

Remarks -- Although the names *Monoletes* and *Schopfipollenites* have been used by most previous authors for these characteristically large monolete prepollen grains, Potonié (1970) and Kaiser (1976) have recognized the priority of *Zonalosporites*. Schopf, Wilson and Bentall (1944) noted the close similarity of *Zonalosporites* and *Monoletes*, but did not suggest synonymy.

Paleobotanical affinity -- Prepollen grains corresponding to various species of *Zonalosporites* have been recovered from numerous medullosan fructifications (Florin, 1937; Schopf, 1938, 1948; Delevoryas, 1964; Eggert and Kryder, 1969; Leisman and Peters, 1970; Taylor, 1971, 1978; Stidd, Leisman and Phillips, 1977; Millay, Eggert and Dennis, 1978; Eggert and Rothwell, 1979; Good et al., 1982; Rothwell and Mickle, 1982).

Zonalosporites ellipsoides (Ibrahim) n. comb.

(Plate 40, figures 6, 7)

1932 *Sporonites ellipsoides* Ibrahim, in Potonié, Ibrahim and Loose, p. 449, pl. 17, fig. 29.
1933 *Laevigato-sporites ellipsoides* (Ibrahim) 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; pl. 6, figs. 5, 6.
1938 *Monoletes ovatus* Schopf, p. 43-45, pl. 1, figs. 3-5; pl. 6, figs. 1-4.
1946 *Monoletes ellipsoides* (Ibrahim) Dijkstra, p. 62.
1954 *Schopfipollenites ellipsoides* (Ibrahim) Potonié and Kremp, p. 180.

Remarks -- Kaiser (1976) transferred to *Zonalosporites* the variety of this species designated *S. ellipsoides* var. *corporeus* Neves 1961, but did not formally cite the basionym of the species itself. Many authors have commented on the close similarity of *Monoletes ovatus* to *Monoletes ellipsoides* as their morphologic differentiation is questionable at best and their reported stratigraphic occurrences are virtually identical, I have chosen here to regard them as synonymous.

Occurrence -- Because these large pollen grains often do not pass through the coarse screen used to separate the miospore fraction of the residue, quantitative assessment of their occurrence in miospore assemblages is not meaningful. Both whole specimens and fragments were observe in most coals throughout the section.

Zonalosporites magnus (Venkatachala) n. comb.

(Plate 40, figures 1, 2)

1963 *Cymbospora magna* Venkatachala, p. 40-41, pl. 1, figs. 5, 6.
1979 *Schopfipollenites* sp. 1 Ravn, p. 53, pl. 22, figs. 8-10.

Remarks -- Venkatachala (1963) distinguished *Cymbospora* from *Schopfipollenites* on the basis of its 'different organization.' The principal difference between *C. magna* and other species assignable to *Zonalosporites* (= *Schopfipollenites*) is the conspicuously wrinkled outer surface of the exine in the former. In other respects, particularly in the infrastructure of the exine, both the descriptions and illustrations of *C. magna* in Venkatachala (1963) and in Venkatachala and Bharadwaj (1964) appear to conform to *Zonalosporites*. The specimen described as *S.* sp. 1 by Ravn (1979) is slightly larger than the size range originally reported for *C. magna* but it is otherwise indistinguishable. *C. magna* therefore is transferred to *Zonalosporites* without descriptive emendation. The synonymy of *Cymbospora* with *Laevigatosporites* suggested by Alpern and Doubinger (1973) is unacceptable.

Occurrence -- Extremely rare, observed only in the Blackoak and Cliffland Coals. As for *Z. ellipsoides*, quantitative assessment probably is misleading because of the large size of these palynomorphs.

Zonalosporites shansiensis (Ouyang) Kaiser 1976

(Plate 40, figures 8, 9)

1964 *Schopfipollenites shansiensis* Ouyang.
1966 *Schopfipollenites varius* Clendening, p. 170, pl. 1, figs. 1-4, pl. 2, figs. 1-4, pl. 3, figs. 3, 4.
1976 *Zonalosporites shansiensis* (Ouyang) Kaiser, p. 135, pl. 15, figs. 4-7.

Remarks -- *Z. shansiensis* is distinguished from *Z. ellipsoides* by the absence of distal grooves. Schopf (1948) demonstrated that pollen corresponding to *Z. ellipsoides* with modifying grooves on the distal surface originated in the medullosan fructification *Dolorotheca*, whereas pollen corresponding to *Z. shansiensis* is associated with the fructification *Codonotheca*. Rothwell and Mickle (1982) also observed pollen similar to *Z. shansiensis* in the medullosan pollen organ *Rhetinotheca patens*.

Occurrence -- Rare, observed in the Laddsdale, Wheeler, Bevier and Summit Coals.

The following species are transferred to *Zonalosporites*:

Zonalosporites signatus (Wilson) n. comb.:
1962 *Schopfipollenites signatus* Wilson, p. 31, pl. 1, fig. 10.

Zonalosporites tenuis (Pi-Radondy and Doubinger) n. comb:
1968 *Schopfipollenites tenuis* Pi-Radondy and Doubinger, p. 426, pl. 4, figs. 4, 5; pl. 5, fig. 1.

Zonalosporites winslowae (Urban) n. comb:
1971 *Monoletes winslowi* Urban, p. 133, pl. 35, figs. 11, 12, pl. 36, figs. 1-3.

Genus *PARASPORITES* Schopf 1938

Type species -- *P. maccabei* Schopf 1938.

Remarks -- Sabry and Neves (1971) erroneously cited the generic name as *Paraspora* in assigning to this genus the species *P. macanensis*.

Paleobotanical affinity -- The medullosan pteridosperm *Parasporotheca* (Millay, Eggert and Dennis, 1978; Dennis and Eggert, 1978).

Parasporites maccabei Schopf 1938

(Plate 40, figure 3)

1938 *Parasporites maccabei* Schopf, p. 48, pl. 7, fig. 1.

Occurrence -- Reservations similar to those for *Zonalosporites* species apply to the quantitative assessment of the occurrence of *P. maccabei.* Specimens were observed only during preparation of an unscreened sample of a Laddsdale Coal for examination by the SEM.

FUNGI

Genus *TRIHYPHAECITES* Peppers 1970

Type species -- *T. triangulatus* Peppers 1970.

Trihyphaecites triangulatus Peppers 1970

(Plate 40, figures 4, 5)

1970 *Trihyphaecites triangulatus* Peppers, p. 135, pl. 14, figs. 13-16.

Occurrence -- Rare, observed in most coals from the Wildcat Den to the Cliffland.

TABLE 1

Data on Table 1 represents the observed stratigraphic occurrences of miospore species in this study (* indicates firm identification, ? indicates uncertain identification of the species or uncertainty about the stratigraphic position of the sample or samples in which the species was observed). Letter designations across the top of each page of the table indicate stratigraphic units: WD = Wildcat Den Coal; C = unnamed coal of the Caseyville Formation; Wy = Wyoming Hill Coal; 6 = shale sample from the base of the Kilbourn Formation in core CP-6; K = unnamed coals of the Kilbourn Formation; Bl = Blackoak Coal; Cl = Cliffland Coal; L = Laddsdale Coal Member of the Floris Formation; F = unnamed coal of the Floris Formation; Ca = Carruthers Coal; Wb = Whitebreast Coal; Wh = Wheeler Coal; Bv = Bevier Coal; Mu = Mulky Coal; Su = Summit Coal; My = Mystic Coal; O = Ovid Coal.

	WD	C	Wy	6	K	Bl	Cl	L	F	Ca	Wb	Wh	Bv	Mu	S	My	O
DELTOIDOSPORA																	
gracilis				*		*	*	*					*				
levis						*	*	*			*	*	*		*	*	
ornata	*		*	*	*	*											
priddyi	*			*	*	*	*	*	*	*	*	*	*			*	
smithii	*				*	*		*									
sphaerotriangula	*				*	*		*	*								
subadnatoides				*	*	*		*			*	*					
subintorta v. *rotundata*	*	*		*	*												
PUNCTATISPORITES																	
aerarius						*	*	*									
edgarensis						*		*		*							
flavus	*	*			*		*	*				*					
glaber			*	*	*	*	*	*	*								
sp. cf. *P. incomptus*	*																
irrasus	*		*		*												
kankakeensis						*								*			
minutus	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
sp. cf. *P. nudus*	*			*		*	*	*									
obesus	*	*		*	*	*	*	*	*			*					
GRANULATISPORITES																	
adnatus	*	*	*	*	*	*	*	*	*								
granularis	*			*	*	*	*	*			*						
granulatus	*				*	*	*	*	*			*					
microgranifer					*	*	*	*		*	*						
minutus	*		*	*	*	*	*	*	*		*	*	*	*	*	*	
pallidus	*				*	*	*	*			*		*			*	
parvus	*					*	*	*									
sp. cf. *G. piroformis*	*	*	*	*	*												
verrucosus	*				*	*	*		*		*						
CYCLOGRANISPORITES																	
aureus					*	*	*	*		*	*	*		*			
lasius	*			*													
leopoldii						*	*	*							*		
micrograntus						*	*	*	*		*	*					
minutus	*	*		*		*	*	*	*			*				*	
obliquus	(see *Laevigatosporites globosus*)																
orbicularis						*	*	*				*					
peppersii												*					
staplinii						*	*	*		*		*				*	
sp. 1												*					
VERRUCOSISPORITES																	
donarii						*	*	*	*		*						
microtuberosus					*	*	*	*	*	*	*						
morulatus	*		*	*													
sp. cf. *V. nitidus*	*																
sifatii						*	*	*									
verrucosus	*		*		*	*	*	*									
LOPHOTRILETES																	
commissuralis	*			*		*	*	*	*		*	*	*				
copiosus						*	*	*									
gibbosus					*	*	*	*				*	*				
? *granoornatus*						*		*									
ibrahimii						*	*	*									
microsaetosus	*	*		*	*	*	*	*	*		*	*	*	*			
mosaicus	*			*	*	*	*										

Table 1. Observed occurrences of miospore species.

	WD	C	Wy	6	K	Bl	Cl	L	F	Ca	Wb	Wh	Bv	Mu	S	My	O
LOPHOTRILETES																	
pseudaculeatus					*	*	*	*					*				
rarispinosus						*		*			*	*					
sp. cf. *L. tuberifer*					*	*											
APICULATASPORITES																	
aculeatus				*	*	*											
latigranifer	*			*		*											
saetiger					*	*	*	*				*					
setulosus	*		*		*		*	*			*	*	*		*	*	
spinososaetosus				*	*	*	*	*			*	*					
spinulistratus				*		*		*									
valvatus													*				
variocorneus	*		*	*	*	*											
variusetosus							*										
sp. 1					*												
PILOSISPORITES																	
aculeolatus					*	*		*			*						
dimorphus					*		*	*						*			
sp. cf. *P. falcatus*						*											
triquetrus					*	*	*	*	*	*			*	*	*	*	
williamsii	*				*	*	*	*									
RAISTRICKIA																	
? abdita	*		*		*	*		*	*		*				*	*	
breveminens	*	*	*		*		*	*	*		*	*					
sp. cf. *R. clavata*												*					
crinita												*	*	*	*	*	
irregularis						*	*	*					*				
lacerata	*					*											
lowellensis					*	*	*	*				*					
sp. cf. *R. macra*						*											
pilosa				*	*	*							*				
protensa						*											
saetosa	*		*	*	*	*	*	*	*	*		*		*	*		
subcrinita											*	*	*	*	*	*	*
superba					*	*	*										
sp. 1								*									
CONVOLUTISPORA																	
cerina						*	*										
florida	*	*			*	*	*	?									
fromensis	*		*			*											
mellita	*			*	*	*	*										
papillosa	*																
sp. cf. *C. varicosa*												*					
sp. 1						*											
MICRORETICULATISPORITES																	
concavus	*			*													
futilis	*					*											
harrisonii	*		*		*	*											
hortonensis	*																
lacunosus						*											
nobilis						*	*	*	*	*	*		*				
sulcatus						?	?	*	*	*	*	*	*		*		
sp. 1					*												

Table 1 (continued).

	WD	C	Wy	6	K	Bl	Cl	L	F	Ca	Wb	Wh	Bv	Mu	S	My	O
RETICULITRILETES																	
clatriformis	*																
densoreticulatus						*											
distortus					*	*											
falsus	*	*			*			*									
mediareticulatus	*			*		*											
reticulocingulum					*	*	*	*	*								
CAMPTOTRILETES																	
bucculentus	*				*	*	*										
certus						*											
confertus						*											
sp. cf. *C. superbus*						*											
triangularis	*			*		*		*				*					
SAVITRISPORITES																	
asperatus	*																
concavus	*			*	*												
majus				*		*	*										
nux	*		*	*	*	*											
robustus	*																
sp. 1						*	*										
KNOXISPORITES																	
dissidius	*			*													
seniradiatus	*																
stephanephorus	*			*	*	*	*	*					*				
triradiatus	*			*	*	*											
CALAMOSPORA																	
breviradiata	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
flexilis					*	*	*						*				
hartungiana	*			*	*	*	*	*	*	*	*	*	*	*	*	*	
liquida	*	*	*	*	*	*	*						*				
mutabilis	*		*		*	*	*				*	*					
nebulosa	*					*	*										
parva	*			*													
pedata					*	*				*	*			*	*	*	
straminea						*	*	*			*	*			*	*	*
ELATERITES																	
triferens					*	*											
RETICULATISPORITES																	
sp. cf. *R. magnidictyus*	*																
muricatus	*				*			*									
polygonalis	*	*		*	*	*	*										
reticulatus						*	*	*	*	*							
VESTISPORA																	
clara						*	*	*									
costata					*		*										
fenestrata					*	*	*	*	*		*	*	*	*	*	*	
foveata						*	*	*			*						
irregularis							*										
laevigata					*	*	*	*	*		*	*		*	*	*	
lucida	*																
profunda						*	*										
pseudoreticulata				*	*	*	*		*			*					
sp. cf. *V. reticulata*						*											
wanlessii						*											

Table 1 (continued).

	WD	C	Wy	6	K	Bl	Cl	L	F	Ca	Wb	Wh	Bv	Mu	S	My	O
ANACANTHOTRILETES																	
paucispinosus						*	*										
spinosus	*	*	*		*	*	*	*		*	*	*			*	*	
GRANASPORITES																	
medius	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CRASSISPORA																	
annulata				*	*	*											
kosankei	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
DENSOSPORITES																	
aculeatus	*			*													
annulatus	*		*	*	*	*											
irregularis	*		*	*	*	*											
sphaerotriangularis	*	*		*	*	*	*	*	*	*	*						
spinifer				*	*	*											
triangularis	*	*		*	*	*	*	*	*	*	*						
variabilis	*																
LYCOSPORA																	
granulata	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
micropapillata	*	*	*	*	*	*	*		*	*	*	*	*			*	
noctuina	*																
orbicula	*		*														
pellucida	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
rotunda	*				*	*	*	*		*	*		*				
? tripapillata	*					*		*									
? sp. 1					*			*									
CIRRATRIRADITES																	
annuliformis					*	*		*	*						*		
maculatus					*	*	*	*	*					*	*	*	*
reticulatus						*											
saturnii				*		*	*	*	*		*						
sp. 1	*	*	*	*													
CRISTATISPORITES																	
connexus		*															
indignabundus	*	*	*	*	*	*											
CINGULIZONATES																	
loricatus	*	*	*			*											
RADIIZONATES																	
difformis				*	*	*											
striatus	*	*	*														
SPENCERISPORITES																	
radiatus	*	*															
ENDOSPORITES																	
globiformis				*	*	*	*	*	*	*	*	*	*	*	*	*	*
plicatus						*	*	*	*		*	*		*			
zonalis	*		*	*	*	*	*	*									
ADELISPORITES																	
multiplicatus	*				*	*	*					*					
GULISPORITES																	
torpidus	*																
LATIPULVINITES																	
kosankii						*											
PLANISPORITES																	
granifer						*	*	*			*						
CUNEISPORITES																	
rigidus						*	*	*									

Table 1 (continued).

	WD	C	Wy	6	K	Bl	Cl	L	F	Ca	Wb	Wh	Bv	Mu	S	My	O
TETANISPORITES																	
granulatus						*	*										
CADIOSPORA																	
magna								?				*		*	*	*	*
SINUSPORES																	
sinuatus	*		*		*												
WALTZISPORA																	
polita	*	*		*													
prisca	*	*		*	*			*									
sagittata	*			*		*											
CONVERRUCOSISPORITES																	
armatus				*	*							*					
vermiformis						*											
sp. 1	*																
SCHOPFITES																	
carbondalensis										?							
dimorphus								*			*	*	*		*	*	*
PUSTULATISPORITES																	
crenatus	*			*	*			*			*						
papillosus	*			*													
pustulatus					*			*									
verrucifer								*									
sp. 1	*																
ANAPICULATISPORITES																	
baccatus	*					*		*									
sp. cf. *A. globulus*						*											
protuberatus	*																
vegrandis						*	*										
PILEATISPORITES																	
bakerii	*			*	*												
NEORAISTRICKIA																	
muscatinensis	*				*												
ECHINATISPORIS																	
knoxiae						*	*	*									
PROCORONASPORA																	
stellata	*					*											
TRICIDARISPORITES																	
arcuatus	*			*													
DICTYOTRILETES																	
bireticulatus	*	*		*	*	*		?									
CORBULISPORA																	
sp. cf. *C. subalveolaris*						*											
CORDYLOSPORITES																	
papillatus	*			*													
FOVEOSPORITES																	
insculptus							*										
ANAFOVEOSPORITES																	
avcinii	*			*													
SECARISPORITES																	
remotus	*	*			*												
TRILOBATES																	
bellii						*											
TANTILLUS																	
triquetrus	*			*	*	*		*									
INDOSPORA																	
boleta						*											

Table 1 (continued).

	WD	C	Wy	6	K	Bl	Cl	L	F	Ca	Wb	Wh	Bv	Mu	S	My	O
TRIQUITRITES																	
additus						*	*	*	*	*	*	*		*	*	*	*
crassus						*	*	*									
minutus						*	*	*	*	*	*						
sculptilis					*	*	*	*	*		*	*	*				
spinosus											*	*	*	*	*	*	*
subspinosus						*	*	*			*	*					
tribullatus						*	*	*	*	*	*	*	*	*	*	*	*
MOOREISPORITES																	
inusitatus							?	*	*	*	*	*	*		*	*	
AHRENSISPORITES																	
exertus						*	*	*									
guerickei	*	*		*	*	*											
ornatus	*	*		*	*												
sinanii				*	*												
TRINIDULUS																	
diamphidios	*																
REINSCHOSPORA																	
speciosa	*	*			*	*	*	*									
triangularis	*		*			*	*	*		*	*						
MUROSPORA																	
kosankei							*	*	*								
SIMOZONOTRILETES																	
intortus	*				*	*											
STENOZONOTRILETES																	
occultus									*								
sp. 1	*																
ZOSTEROSPORITES																	
triangularis	*			*		*	*	*									
BELLISPORES																	
nitidus	*																
GORGONISPORA																	
sp. cf. *G. minima*	*																
VALLATISPORITES																	
sp. cf. *V. foveolatus*	*																
GRUMOSISPORITES																	
rufus						*	*		*								
varioreticulatus	*		*		*												
RETISPORA																	
staplinii	*	*			*	*											
SPELAEOTRILETES																	
triangulus	*																
ALATISPORITES																	
hoffmeisterii						*	*	*	*								
pustulatus				*	*	*	*										
trialatus/hexalatus							*	*	*	*	*						
KEWANEESPORITES																	
appressus					*	*	*	*									
DIAPHANOSPORA																	
parvigracila	*		*			*		*	*								
sp. 1	*																
HYMENOSPORA																	
sp. cf. *H. caperata*	*				*												
multirugosa	*			*	*	*	*		*								
paucirugosa								*									

Table 1 (continued).

	WD	C	Wy	6	K	Bl	Cl	L	F	Ca	Wb	Wh	Bv	Mu	S	My	O
RUGOSPORA																	
gracilirugosa	*			*	*												
radiata	*																
THYSANITES																	
densus						*											
LAEVIGATOSPORITES																	
contactus	*	*	*														
desmoinesensis	*			*		*	*	*	*		*	*	*				
globosus/Cyc. obliquus						*	*	*	*	*	*	*	*	*	*	*	*
maximus	*	*		*	*		*										
medius	*			*	*	*	*	*	*	*	*	*	*		*	*	
minor				*	*	*	*	*	*	*	*	*	*	*	*	*	*
minor f. *striatus*						*	*	*	*			*					
vulgaris						*	*	*	*		*	*		*	*	*	
sp. cf. *L. vulgaris*						*		*									
LEIOALETES																	
circularis	*		*														
PUNCTATOSPORITES																	
granifer						*	*	*			*	*	*		*	*	
minutus					*	*	*	*	*	*	*	*	*	*	*	*	*
punctatus							*										
rotundus						*	*										
THYMOSPORA																	
pseudothiessenii						?		?	*	*	*	*	*	*	*	*	*
TORISPORA																	
securis						*	*	*	*							*	
SPINOSPORITES																	
exiguus						*	*	*	*		*	*					
sp. 1							*										
DICTYOMONOLITES																	
swadei			?			*	*	*									
TUBERCULATOSPORITES																	
robustus					*	*	*	*			*	*					
RENISPORITES																	
confossus	?					*	*										
SPACKMANITES																	
ellipticus					*	*	*	*									
habibii					*	*	*	*			*				*		
irregularis							*										
sp. 1	*																
MACULATASPORITES																	
asperatus					?			*	*								
AUMANCISPORITES																	
striatus						*											
SCHULZOSPORA																	
elongata	*		*														
rara	*	*	*														
COLATISPORITES																	
decorus	*			*		*											
PALEOSPORA																	
fragila		*			*	*	*	*		*	*						
TINNULISPORITES																	
microsaccus	*	*		*				*	*								

Table 1 (continued).

	WD	C	Wy	6	K	Bl	Cl	L	F	Ca	Wb	Wh	Bv	Mu	S	My	O
WILSONITES																	
circularis				*		*		*									
delicatus	*			*		*			*		*	*	*	*	*	*	*
vesicatus	*	*		*		*	*	*	*	*	*	*	*	*	*	*	
FLORINITES																	
mediapudens	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
millottii						*	*	*			*						
occultus	?					*	*										
similis	*	*	*	*	*	*		*								*	
visendus	*	*				*											
sp. cf. *F. volans*				*	*	*											
POTONIEISPORITES																	
elegans	*		*		*	*	*	*									
solidus						*		*									
COSTATASCYCLUS																	
crenatus	*	*				*											
CORDAITINA																	
? sp. 1					*		*										
PEPPERSITES																	
ellipticus	*	*			*	*	*	*									
WAPELLITES																	
variabilis	*		*		*	*											
QUASILLINITES																	
diversiformis	*			*	*	*	*	*									
PITYOSPORITES																	
westphalensis						*	*	*					*				
PLATYSACCUS																	
saarensis						*									*	*	
VESICASPORA																	
wilsonii							?	*		*	*	*	*	*	*	*	*
LIMITISPORITES																	
sp. 1						*	*										
ILLINITES																	
unicus	*			*		*		*					*	*	*	*	
PHILLIPSITES																	
tenuis						*											
ZONALOSPORITES																	
ellipsoides	*		*		*	*	*	*	*		*	*			*		
magnus						*											
shansiensis								*				*	*		*		
PARASPORITES																	
maccabei								*									
TRIHYPHAECITES																	
triangulatus	*	*				*	*										

Table 1 (concluded).

APPENDIX I:

INDEX TO GENERA

APPENDIX II:

IS THE DES MOINES DESMOINESIAN? AN EXERCISE IN SEMANTIC SRATIGRAPHY

'Granted that the purpose of nomenclature is to facilitate unambiguous discussion, we must somehow specify the semantic content of terms utilized and seek to eliminate or clarify words that now mean different things to different people.'
(Cloud and Glaessner, 1982, p. 784.)

One of the major purposes of this project initially was to relate the age of the section being examined to Pennsylvanian sections in other areas of Midcontinent North America. Early examination of samples from IGS cores indicated clearly that a significant portion of the Cherokee Group would correlate to the Abbott Formation of Illinois (see text-fig. 12), which is considered Atokan in age (Hopkins and Simon, 1975). Proposal to use the term 'Atokan' as a matter of practicality in relating the ages of units in Iowa and Illinois provoked questions of how strata from the type area of the 'Desmoinesian Series' could legitimately be viewed as correlative to the underlying 'Atokan Series.' Attempts to wrestle with this compound correlation and nomenclatural difficulty in order to express simply the obvious age-equivalence of the Iowa and Illinois sections always culminated in a frustratingly cumbersome and digressive tangle of stratigraphic terminology.

A review of the literature pertaining to stratigraphic nomenclature in the Midcontinent Pennsylvanian has revealed a fundamental historical problem in the definition and circumscription of litho- and chrono-stratigraphic units. Although essentially semantic in nature, this problem has resulted in considerable misconceptions about the correlations and age-relationships of major lithologic units across the Midcontinent region. Accordingly a review of the presently accepted practices of stratigraphic nomenclature, their historical development and their implications for classification and designation of stratigraphic units in the Midcontinent Pennsylvanian is in order.

The traditional hierarchy of stratigraphic nomenclature divides the Midcontinent Pennsylvanian System into five Series, in ascending order, Morrow (or Morrowan), Atoka (Atokan), Des Moines (Desmoinesian), Missouri (Missourian), Virgil (Virgilian). Each Series encompasses various locally designated lithostratigraphic groups and formations. Certain variants of this scheme are recognized in some states, as in Kansas, where Lower, Middle and Upper Pennsylvanian Series are formally designated and subdivided into Morrow, Atoka, Des Moines, Missouri and Virgil Stages (Jewett, O'Connor and Zeller, 1968).

This widely accepted stratigraphic subdivision blurs an essential distinction in nomenclature, that of chronostratigraphic vs. lithostratigraphic units. A vast amount of literature now exists devoted to the recognition of chronostratigraphic Stage and Series boundaries in the Midcontinent Pennsylvanian based on biostratigraphic analyses. Nevertheless, in practice and by definition, the designation of Series and/or Stage units is almost always based on lithologic (interformational) boundaries. Formations constitute a Group, Groups constitute a Stage or Series. By this practice, the Stages and Series of the Midcontinent Pennsylvanian, as historically applied, must be regarded as de facto lithostratigraphic units. The use of Series and Stages in this sense is in direct conflict with presently accepted nomenclature systems as established by the North American Commission on Stratigraphic Nomenclature (1983). Therein lies the crux of the nomenclatural difficulty relating to definition of an Atokan/Desmoinesian boundary in Iowa.

At this point, a cautionary observation from W. J. Arkell (1956a, p. 466), one of the major influences on stratigraphic thought in this century, is appropriate: 'In stratigraphic procedure, it is not what terms an author uses that matters, but whether he knows what he is talking about.' If the 'Series' terminology used in the Midcontinent Pennsylvanian were clearly specified to refer to units of rock defined on purely lithologic bases, little difficulty would exist in clear communication. However, the need for adequately defined chronostratigraphic terms would still exist.

In practice, very few stratigraphers working in the Midcontinent Pennsylvanian have been so careful about their application of terms. The use of Series and Stage terminology today has an automatic connotation of time for the reader. The distinction between lithostratigraphic and chronostratigraphic units blurs when Series and Stage terminology is applied to both, and meaningful discussion about the ages of rocks becomes a constantly digressive battle with language: Is the Des Moines Series all Desmoinesian? If the Desmoinesian Series by definition overlies the Atokan Series, how can the lower parts of the Des Moines Series correlate to the Atoka Series? It is as though we were trying to describe the relationship of an orange to an apple, and the only word we could use for both fruits was 'apple.'

R. C. Moore, the man perhaps most directly responsible for the principal advances in our knowledge of Midcontinent Pennsylvanian stratigraphy, expressed the problem most clearly: 'The main source of difficulty in making a consistent, thoroughly sound approach to classification and nomenclature of stratigraphic units as a whole is prevalent failure by geologists to exclude concepts of time from consideration of the objective data on which alone properly defined rock units are differentiated. Recognition of the essential distinctions in the nature of time units, time-rock units and rock units is needed as basis for satisfactory stratigraphic classification and terminology.' (Moore, 1947, p. 520)

The distinction between lithostratigraphic and chronostratigraphic units is not an idle one of sheer semantics. It is, instead, fundamental to our ability to correlate rock units on a time scale, and thus to understand correctly their depositional histories. Unfortunately, at least in the literature on the Midcontinent Pennsylvanian, this 'failure' of distinction remains as 'prevalent' today as it was for Moore in 1947. The bulk of the difficulty seems ultimately to stem from the historical development of the meaning of the term 'Series.'

The concepts of the three major categories of stratigraphic units (time, time-rock and rock units of Moore) evolved slowly following the early observations of William Smith on the superposition of fossils. Time units are purely chronologic. The early biostratigraphers (e.g., Lyell, d'Orbigny, Oppel, Huxley) tended to be interested primarily in unravelling the record of geologic time, rather than in describing the physical characteristics that distinguish rock units. In the mid-19th Century, no tools existed for determination of the absolute ages of rocks, and 'geologic time' was a totally relative concept based on empirical observations of fossil superposition. The Devonian System (strata containing Devonian fossils) lay atop the Silurian System and was overlain by the Carboniferous System. The Devonian Period (the time during which these organisms lived and the strata containing them were formed) came after the Silurian Period and preceded the Carboniferous Period. The strata, therefore, recorded the time.

The idea of strata seems to have been a concept different from that of physical rock units; although not formally defined as such, it approached what we now conceive of as time-rock, or chronostratigraphic, units. Strata were layers of rock that contained time information; in contrast, rock (lithostratigraphic) units were physical bodies having observable lithologic continuity, bodies of sandstone, of shale, of limestone. Although not formally codified for many years, the recognition of fundamental distinction between these two concepts occurred to some workers early in the 19th Century (see Hancock, 1977). Despite observations among early geologists that one kind of rock unit, a shale for example, could be traced laterally into a different kind of rock unit, a sandstone, the importance of the lithostratigraphic concept later to be known as 'facies' tended to be subordinated to the obsession among paleontologists and biostratigraphers with geologic time. Consideration of the characteristics of the physical rock units was secondary; they were the mortar that held the fossils together. Some paleontologists doubtless found this unfortunate, as if often made the fossils difficult to study.

Many geologists of the latter part of the 19th Century and the early part of the 20th (e.g., E. O. Ulrich, who exercised profound influence over stratigraphic thought and practices) regarded physical rock units as strata bounded by surfaces that represented essentially synchronous horizons in the geologic record. For them, no distinction existed between rock and time-rock units. Formations and Groups, the commonly accepted lithostratigraphic units, were viewed as recording the progression of geologic time, and were collected into the larger units known as Series, a term originally derived from biostratigraphic investigations (Hedberg, 1948). In this atmosphere, the major Midcontinent Pennsylvanian Series were described. Little or no thought was given to their definition as rock or time-rock units.

By the 1930's, stratigraphers were beginning to rethink the relationships of rock units and geologic time. As biostratigraphic work became more sophisticated, clear conflicts became evident in many areas between the described rock-unit stratigraphy and biostratigraphic correlations. One of the first to face this problem squarely was Kleinpell (1938, p. 88), in his monograph on the foraminiferal biostratigraphy of the Miocene formations of California: 'The limits of the California Formations do not, in many instances, correspond with horizons which on paleontologic grounds appear to be chronologically the most significant. Furthermore, excellent cartographic units though they be, the Formations are hopelessly inadequate as stratigraphic units with accurate chronologic connotation, and their use in this sense has led to much confusion.'

In order to resolve this confusion, Kleinpell established a nomenclatural system for the chronostratigraphic stages completely independent of the existing lithostratigraphic units. This involved not only the use of separate hierarchies of terms (stages for chronostratigraphy, formations for lithostratigraphy), but the erection of chronostratigraphic names derived independently of the formation names: 'The use of established Formation names even as roots for Stage names has also been avoided, primarily because of the confusion of cartography with chronology . . . (The Formation names) were originally coined for cartographic purposes largely on the basis of roughly homogeneous lithology and similar origin and not upon the basis of an accurately delimited stratigraphic relation to a geologic time scale . . .' (Kleinpell, 1938, p. 92).

Schenck and Muller (1941) argued forcefully for adoption of Kleinpell's strategy of dual nomenclature as a standard solution to the problems of distinguishing chronostratigraphic units from lithostratigraphic units. This influential paper set in motion a dialog that ultimately led to the establishment in 1952 of the International Subcommission on Stratigraphic Classification. Moore (1947), however, expressed an opinion on the matters discussed by Kleinpell and others that would have a profound effect on subsequent Pennsylvanian stratigraphic nomenclature in the Midcontinent. Moore acknowledged the need for recognition of the distinction between chronostratigraphic and lithostratigraphic units, but he felt that no problem existed in the adaption of lithostratigraphic unit names as roots for chronostratigraphic units. He proposed instead that -an or -ian suffixes be attached to the names to make the chronostratigraphic connotation clear; thus came into being the Morrowan, Atokan, Desmoinesian, Missourian and Virgilian Series names.

The long-time chairman and chief architect of the proposals of the International Subcommission on Stratigraphic Nomenclature, H. D. Hedberg, stepped even farther away from the Kleinpell strategy. Hedberg (1948) considered Moore's proposal for distinct suffixes unnecessary, viewing the distinction between chronostratigraphic and lithostratigraphic units as being clear through the use of the appropriate terms (e.g., Stage, Series) and through the context of how the terms were applied in individual cases. Later, Hedberg (1951) openly opposed Moore's suffixes as awkward and confusing (!). In these and later papers, Hedberg (1954, 1959, 1965, 1968) proposed most of the approaches toward the various kinds of stratigraphic nomenclature now widely accepted in codes such as that commonly used in North America (North American Commission on Stratigraphic Nomenclature, 1983). No requirement exists for the use of dual nomenclature as advocated by Kleinpell (1938), nor for the suffixes of Moore (1947), although both these systems can be and are applied in various stratigraphic intervals and geographic areas, dependent on the discretion of the individual stratigraphers.

Hedberg's faith in the clarity of context unfortunately has proved to be misplaced. Despite the great amount of discussion and debate over the paroper use of terms, some stratigraphers persisted in using Series in a purely lithostratigraphic sense (e.g., Arkell, 1956b; as noted previously, he held a low opinion of the benefits of standardized terminology). In retrospect, Moore's proposal of suffixes attached to originally lithostratigraphic names seems most unfortunate for the subsequent confusion in the stratigraphic nomenclature on the Midcontinent Pennsylvanian. Had he embraced Kleinpell's strategy in 1947, his influence doubtless would have been felt; few stratigraphers have expressed their views as eloquently and convincingly as R. C. Moore.

Not everyone agrees with all the thinking of the International Subcommission. Much of the disagreement centers around the distinction between biostratigraphy and chronostratigraphy, which can be fuzzy, and which some authors (e.g., Dunbar and Rodgers, 1957; Hancock, 1977) believe to be entirely artificial and superfluous. Others (e.g., Weller, 1960) consider the distinction more useful (see also discussions in Krumbein and Sloss, 1963, and Raup and Stanley, 1978). Virtually no one, however, seriously objects any longer to the concept of clear distinction between physically differentiated rock units and stratigraphic units incorporating the concept of geologic time. Rock units by their very nature are diachronous. Deltas prograde through time; shorelines move back and forth with transgressions and regressions of the sea, dragging beach and bar sand bodies slowly across the geologic time grid established by fossil appearances and extinctions. Most contacts between different lithologies (i.e., formation boundaries) are probably to some degree diastemic or unconformable, even if not detectable as so by the resolution of present biostratigraphic scales. Aside from volcanic ashfalls, virtually no stratigraphically significant sedimentologic event occurs instantaneously in geologic time.

Therefore, continued use of the clearly chronostratigraphic terms 'Series' and (in Kansas terminology) 'Stage' as de facto lithostratigraphic units must be discouraged. In recognition of this necessity, the Iowa Geological Survey has recently proposed a revision of Pennsylvanian stratigraphic nomenclature in the state (Ravn et al., 1984), which, among other things, adopts the use of the term 'Supergroup' as the acceptable lithostratigraphic unit above the level of Group (American Geological Institute Glossary, 1974). In Iowa, the major lithostratigraphic units (aside from the Caseyville Formation outliers in Scott and Muscatine Counties; Ravn and Fitzgerald, 1982) are the Des Moines, Missouri and Virgil Supergroups.

Application of chronostratigraphic subdivisions to these rock units requires both definition of the time lines used as boundaries, and clear definition of the terms. My prejudice toward the Kleinpell approach is obvious, but, unfortunately, no acceptable terms exist other than those historically derived from the lithostratigraphy, and it is beyond the scope or interest of this study to propose new ones. The adaption of lithostratigraphic names for the major chronostratigraphic Series of the Midcontinent Pennsylvanian is so ingrained into previous literature that one hesitates to propose their elimination in favor of new names for fear of producing an even greater confusion of communication. As a matter of sheer practicality and to avoid as much nomenclatural confusion as possible, Moore's (1947) practice of adding suffixes to indicate chronostratigraphic meaning is applied for the Series designations: Morrowan, Atokan, Desmoinesian, Missourian, Virgilian.

Practical recognition of these Series in the Iowa strata examined during this study is based solely on comparison of palynostratigraphic data with those available from the well-documented coal-bearing section of the Illinois Basin (specific coal-to-coal correlations are described in the text of this paper and illustrated on text-figure 12). Strata examined in this study essentially span the lower three Midcontinent Pennsylvanian Series; thus two boundaries require recognition. By comparison with the Illinois Basin coal sequence outlined by Hopkins and Simon (1975), strata of the Morrowan Series in Iowa occur only in the Caseyville Formation in Scott and Muscatine Counties, and are recognized by the presence of *Schulzospora rara*, whose extinction in Illinois occurs prior to the Atokan Reynoldsburg Coal of the Abbott Formation. The top of the Atokan Series in Iowa is recognized by the final regular appearance of *Dictyotriletes bireticulatus*, which occurs in the Blackoak Coal, corresponding to the uppermost Abbott Formation Pope Creek Coal in Illinois. By this criterion, Des Moines Supergroup strata from the Blackoak Coal downward to the Mississippian surface in the Western Interior Basin are considered Atokan in age.

This application of Series terminology exists for the immediate purpose of practicality of communication, and is in no way designed to attack the more theoretical problems of typification of the Atokan and Desmoinesian Series, which have bedeviled stratigraphers for years. Ideally, of course, if the Series names are to be based on lithostratigraphic units, one would desire to establish the biostratigraphic criteria for boundary distinction on data from the type areas. For the Atokan Series, however, no such typification is possible. The inadequacies of the Atoka Formation as a base for series definition have been described in detail by Lane and West (1984); among these is the fundamental problem that no type section for the Atoka Formation was ever designated. Further information relevant to this problem is given by Zachry and Sutherland (1982) and Shaver (1984). Establishment of a biostratigraphic identity for the base of the Des Moines Supergroup appears equally unsatisfactory, as the Mississippian-Pennsylvanian contact in the type area of the Des Moines is a major unconformity. Basal Des Moines Supergroup strata in cores examined for this study are strongly diachronous (nearly as old as the Caseyville Formation in at least one IGS core, CP-6, to as young as the Floris Formation in several others).

Lane and West (1984) described these typification problems in detail, and suggested a solution of the establishment of Lower, Middle and Upper Pennsylvanian Series with properly documented boundary stratotypes. Langenheim (1982) proposed a boundary stratotype for the Atokan Series based on a well-documented section in Nevada, although if such a stratotype proves useful and acceptable, it might be more proper to eliminate the name 'Atokan' altogether and employ a new one derived from the stratotype locality. The boundary stratotype approach is really the only means for firm establishment of meaningful chronostratigraphic units, but it will require a great deal of future study and debate. In lieu of boundary stratotypes, the only acceptable solution to the problem of clear communication of chronostratigraphic and lithostratigraphic information is to establish and specify the criteria on which units are applied in a given area. For this study, I have attempted to adhere scrupulously to the distinction between lithostratigraphic and chronostratigraphic terminology. I hope that this appendix has been of use in clarifying the need for such distinction.

REFERENCES

ABBOTT, M. L. 1961. A coenopterid fern fructification from the Upper Freeport (No. 7) Coal in southeastern Ohio. Jour. Paleont., 35: 981-985.
ABBOTT, M. L. 1963. Lycopod fructifications from the Upper Freeport (No. 7) Coal in southeastern Ohio. Palaeontographica B, 112: 93-118.
ABBOTT, M. L. 1968. Lycopsid stems and roots and sphenopsid fructifications and stems from the Upper Freeport Coal of southeastern Ohio. Palaeontographica Americana, 6: 5-49.
AGASIE, J. M. 1969. Late Cretaceous palynomorphs from northeastern Arizona. Micropaleontology, 29: 13-30.
AGRALI, B. 1964a. Valeur stratigraphique des genres *Densisporites* et *Lycosisporites* et leur utilisation pour l'établissement des subdivisions palynologiques dans le houiller d'Asmara. Ann. Soc. Géol. Nord, 84: 9-17.
AGRALI. B. 1964b. Nouveau genre et espèces nouvelles de sporomorphes du bassin houiller d'Asmara, Turquie. C. r. Acad. Sci., 258: 5023-5026.
AGRALI, B., and E. AKYOL. 1967. Étude palynologique des charbons de Hazro et considerations sur l'âge des horizons lacustres du Permo-Carbonifère. Maden Tet. Arama Enst. Bull., 68: 1-26.
AGRALI, B., E. AKYOL, Y. KONYALI, P. M. CORSIN and J.-P. LAVEINE. 1965. Nouvelles formes des spores et pollens provenant de charbons primaires et tertiaires de divers gisements turcs. Ann. Soc. Géol. Nord, 85: 169-176.
ALLEN, K. C. 1965. Lower and Middle Devonian spores of North and Central Vestspitsbergen. Palaeontology, 8: 687-748.
ALLEN, K. C. 1980. A review of *in situ* Late Silurian and Devonian spores. Rev. Palaeobot. Palynology, 29: 253-270.
ALPERN, B. 1958. Description de quelque microspores du Permo-Carbonifère français. Rev. micropaléontologie, 1: 75-86.
ALPERN, B. 1959. Contribution à l'étude palynologique et pétrographique des charbons français. Ph.D. thesis, l'Université de Paris: 1-314 (privately published).
ALPERN, B., and J. DOUBINGER. 1973. Les microspores monolètes de Paleozoique. C. I. M. P. fasc. 6: 1-103.
ALPERN, B., J. DOUBINGER and U. HORST. 1965. Révision du genre *Torispora* Balme. Pollen et Spores, 7: 565-572.
AMERICAN GEOLOGICAL INSTITUTE. 1974. Glossary of Geology. Amer. Geol. Inst., Washington, D.C.: 1-805.
ANDERSEN, S. T. 1965. Mounting media and mounting techniques. In Handbook of Paleontological Techniques, B. Kummel and D. Raup, eds., Freeman and Co., San Francisco: 587-598.
ANDERSON, J. M. 1977. The biostratigraphy of the Permian and Triassic, part 3: A review of Gondwana Permian palynology with particular reference to the Northern Karoo Basin, South Africa. Mem. Bot. Surv. S. Africa, 41: 1-67, 1-133(9.3), 1-12(9.4), 1-187(9.5).
ANDREWS, H. N., Jr., and S. N. AGASHE. 1963. A new sporangium from the American Carboniferous. Palaeobotanist, 1962, 11: 46-48.
ANDREWS, H. N., Jr., and S. H. MAMAY. 1948. A *Crossotheca* from northern Illinois. Ann. Missouri. Bot. Garden, 35: 203-206.
ANDREWS, H. N., Jr., and S. H. MAMAY. 1958. A new American species of *Bowmanites*. Bot. Gaz., 113: 158-165.
ANDREWS, H. N., Jr., and E. PANNELL. 1942. Contributions to our knowledge of American Carboniferous floras II. *Lepidocarpon*. Ann. Missouri Bot. Garden, 29: 19-35.
ANTONESCU, E., and J. TAUGOURDEAU-LANTZ. 1973. Considerations sur les mégaspores et microspores du Trias inférieur et moyen du Roumanie. Palaeontographica B, 144: 1-10.
ARKELL, W. J. 1956a. Comments on stratigraphic procedure and terminology. Amer. Jour. Sci., 54: 257-267.
ARKELL, W. J. 1956b. Jurassic Geology of the World. Oliver and Boyd, Edinburgh: 1-806.
ARNOLD, W. J. 1944. A heterosporous species of *Bowmanites* from the Michigan Coal Basin. Amer. Jour. Botany, 31: 466-469.
ARTÜZ, S. 1957. Die *Sporae dispersae* der Turkischen Steinkohle von Zonguldak-Gebiet. Rev. fac. sci., l'Univ. Istanbul, ser. B, t. 22, fasc. 4: 239-263.
ARTÜZ, S. 1962. About genus *Torispora* (Balme, B. E., 1952). Istanbul Univ. Fen. Fak. Mecm. B27: 2-14.
BAIN, H. F. 1894. Structure of the Mystic Coal Basin. Iowa Acad. Sci., 4(1): 33-36.

BALBACH, M. K. 1966. Microspore variation in *Lepidostrobus* and comparison with *Lycospora*. Micropaleontology, 12: 334-342.
BALBACH, M. K. 1967. Paleozoic lycopsid fructifications -- 3. Conspecificity of British and North American *Lepidostrobus* petrifactions. Amer. Jour. Botany, 54: 867-875.
BALME, B. E. 1952. On some spore specimens from British Upper Carboniferous coals. Geol. Mag., 89: 175-184.
BALME, B. E. 1957. Spores and pollen grains from the Mesozoic of Western Australia. Commonw. Sci. Ind. Res. Org., Fuel Res., Coal Sec., Tech. Comm., 25: 1-48.
BALME, B. E., and M. A. BUTTERWORTH. 1952. The stratigraphical significance of certain fossil spores in the central group of British coalfields. Trans. Inst. Min. Eng., London, 111: 870-875.
BALME, B. E., and C. W. HASSELL. 1962. Upper Devonian spores from the Canning Basin, Western Australia. Micropaleontology, 8: 1-28.
BALME, B. E., and J. P. F. HENNELLY. 1956. Trilete sporomorphs from Australian Permian sediments. Austr. Jour. Botany, 4: 240-260.
BARSS, M. S. 1967. Carboniferous and Permian spores of Canada. Can. Geol. Survey Pap. 67-11: 1-94
BARSS, M. S., and G. L. WILLIAMS. 1973. Palynology and nannofossil processing techniques. Can. Geol. Survey Pap. 73-26: 1-25.
BARTHEL, M. 1967. Sporen *in situ* aus dem Erzgebirgischen and Dohlener Becken. Mber. dt. Akad. Wiss. Berlin, 9: 345-352.
BAXTER, R. W. 1950. *Peltastrobus reedae*: A new sphenopsid cone from the Pennsylvanian of Indiana. Bot. Gaz., 112: 174-182.
BAXTER, R. W. 1959. The sporangium of *Cystosporites varius*. Trans. Kansas Acad. Sci., 62: 47-52.
BAXTER, R. W. 1963. *Calamocarpon insignis* a new genus of heterosporous, petrified calamitean cones from the American Carboniferous. Amer. Jour. Botany, 54: 748-754.
BAXTER, R. W. 1971. *Carinostrobus foresmani*, a new lycopod cone genus from the Middle Pennsylvanian of Kansas. Palaeontographica B, 134: 124-130.
BAXTER, R. W., and G. A. LEISMAN. 1967. A Pennsylvanian calamitean cone with *Elaterites* triferens spores. Amer. Jour. Botany, 54: 748-754.
BECK, C. B. 1967. Current status of the Progymnospermopsida. Rev. Palaeobot. Palynology, 21: 5-23.
BERRY, W. 1937. Spores from the Pennington Coal, Rhea County, Tennessee. Amer. Midl. Naturalist, 18: 155-160.
BERTELSEN, F. 1972. A Lower Carboniferous microflora from the Ørslev No. 1 borehole, Island of Falster, Denmark. Danmark geol. Unters., 2 rk., 99: 1-78.
BHARADWAJ, D. C. 1962. The miospore genera in the coals of the Raniganj Stage (Upper Permian), India. Palaeobotanist, 9 (1960): 68-106.
BHARADWAJ, D. C., and R. S. TIWARI. 1977. Permian-Triassic Miofloras from the Raniganj Coalfield, India. Palaeobotanist, 24: 26-49.
BHARADWAJ, D. C., and B. S. VENKATACHALA. 1962. Spore assemblage out of a Lower Carboniferous shale from Spitzbergen. Palaeobotanist, 10 (1961): 18-47.
BHARDWAJ, D. C. 1954. Einige neue Sporengattungen des Saarkarbons. N. Jahrb. Geol. Paläontol., Monatsh., 11: 512-525.
BHARDWAJ, D. C. 1955. The spore genera from the Upper Carboniferous coals of the Saar and their value in stratigraphical studies. Palaeobotanist, 4: 119-149.
BHARDWAJ, D. C. 1957a. The palynological investigations of the Saar coals. Palaeontographica B, 101: 73-125.
BHARDWAJ, D. C. 1957b. The spore flora of the Velener Schichten (lower Westphalian D) in the Ruhr Coal Measures. Palaeontographica B, 102: 110-138.
BHARDWAJ, D. C. 1958. On *Porostrobus zeilleri* Nathorst and its spores with remarks on the systematic position of *P. bennholdi* Bode and the phylogeny of *Densosporites* Berry. Palaeobotanist, 7: 67-75.
BLESS, M. J. M., and M. STREEL. 1976. The occurrence of reworked miospores in a Westphalian C microflora from South Limburg (the Netherlands) and its bearing on paleogeography. Med. Rijks Geol. Dienst, N. S., 27: 1-39.
BOLKHOVITINA, A. N. 1953. Characteristic spores and pollen from the Cretaceous of the central part of the U.S.S.R. Trans. Inst. Geol. Sci., Acad. Sci. U.S.S.R., 145, Geol. Ser. 61: 1-184 (In Russian).
BOSE, M. N., and R. K. KAR. 1966. Palaeozoic *Sporae dispersae* from Congo. I. Kindu-Kalima and Walikale regions. Ann. Mus. roy. Afr. centr., Ser. 8o, Sci. geol. 53: 1-238.
BOUREAU, E. 1964. Traité de paléobotanique. III. Sphenophyta et Noeggerathiophyta. Masson, Paris: 1-544.

BRACK, S. D., and T. N. TAYLOR. 1972. The ultrastructure and organization of *Endosporites*. Micropaleontology, 18: 101-109.
BRAMAN, D. R., and L. V. HILLS. 1977. Palynology and paleoecology of the Mattson Formation, Northwest Canada. Bull. Can. Petrol. Geol., 25: 582-630.
BRAMAN, D. R., and L. V. HILLS. 1980. The stratigraphic and geographic distribution of Carboniferous megaspores. Palynology, 4: 23-41.
BRENNER, G. J. 1963. The spores and pollen of the Potomac Group of Maryland. Maryland Dept. Geol., Mines Water Res., Bull. 27: 1-215.
BROWN, C. A. 1960 Palynological Techniques. Univ. Louisiana Press, Baton Rouge (reprint, 1967): 1-188.
BRUNNER, J. 1978. The man who understood Carboniferous flora. Fant. Sci. Fic., 59: 30-101.
BRUSH, G. S., and E. S. BARGHOORN. 1962. Identification and structure of cordaitean pollen. Jour. Paleont., 37: 1357-1360.
BRUSH, G. S., and E. S. BARGHOORN. 1964. The natural relationships of some Carboniferous microspores. Jour. Paleont., 38: 325-330.
BURBRIDGE, P. P., and C. J. FELIX. 1976. Stratigraphic and morphologic development in the spore genus *Spencerisporites*. Geoscience and Man, 15: 87-94.
BURGGRAF, D. R., Jr., H. J. WHITE and C. G. LINDSAY. 1981. Facies and depositional environments of the Cherokee Group in Webster County, Iowa. In Cherokee Sandstones and Related Facies of Central Iowa, J. Lemish, D. R. Burggraf, Jr., and H. J. White, eds., Field Trip Guide, North-Central Section, Geol. Soc. America; Iowa Geol. Survey Guidebook Ser. 5: 23-50.
BUTTERWORTH, M. A. 1966. The distribution of densospores. Palaeobotanist, 15: 16-28.
BUTTERWORTH, M. A., J. JANSONIUS, A. H. V. SMITH and F. L. STAPLIN. 1964. *Densosporites* (Berry) Potonié and Kremp, and related genera. Report of C. I. M. P. working group no. 2, 5ème Cong. Internat. Strat. Géol. du Carb., Paris, 1963, C. r., 3: 1049-1057.
BUTTERWORTH, M. A., and S. A. MAHDI. 1982. Namurian and basal Westphalian A miospore assemblages from the Featherstone Area, Northern England. Pollen et Spores, 24: 481-510.
BUTTERWORTH, M. A., and J. O'N. MILLOTT. 1954. Microspore distribution in the seams of the North Staffordshire, Cannock Chase and North Wales coalfields. Trans. Inst. Min. Eng., London, 114: 501-520.
BUTTERWORTH, M. A., and J. O'N. MILLOTT. 1956. The Lancashire coalfield: The correlation by microspores of certain seams at Bradford and Wheatsheaf collieries and in the Prestwich boreholes. Trans. Inst. Min. Eng., London, 116: 3-19.
BUTTERWORTH, M. A., and E. SPINNER. 1967. Lower Carboniferous spores from northwest England. Palaeontology, 10: 1-24.
BUTTERWORTH, M. A., and R. W. WILLIAMS. 1954. Descriptions of nine small species of spores from the British Coal Measures. Ann. Mag. Nat. Hist., 7: 753-764.
BUTTERWORTH, M. A., and R. W. WILLIAMS. 1958. The small spore floras of the coals in the Limestone Coal Group and Upper Limestone Group of the Lower Carboniferous of Scotland. Trans. Royal Soc. Edinburgh, 63: 353-392.
BYVSCHEVA, T. V. 1957. A spore-pollen description of the terrigenic rock complex of the Lower Carboniferous of the Melekas and Busuluk deep wells. Dokl. Akad. Nauk S. S. S. R., 116: 1009-1011 (In Russian).
BYVSCHEVA, T. V. 1963. Some Viséan spores in characteristic complexes of Lower Carboniferous terrigenous strata of the Volga-Ural region. Trudy vses. Nauchno-issled. geol. rasv. neft. Inst., 106: 18-46 (In Russian).
CHADWICK, A. V. 1983. *Cappasporites*, a common Middle Pennsylvanian palynomorph. Palynology, 7: 205-210.
CHALONER, W. G. 1951. On *Spencerisporites* gen. nov. and *S. karczewskii* (Zerndt), the isolated spores of *Spencerites insignis* Scott. Ann. Mag. Nat. Hist., 4: 861-873.
CHALONER, W. G. 1953a. On the megaspores of four species of *Lepidostrobus*. Ann. Bot., 17: 263-293.
CHALONER, W. G. 1953b. A new species of *Lepidostrobus* containing unusual spores. Geol. Mag., 90: 97-110.
CHALONER, W. G. 1954. Notes on the spores of two British Carboniferous lycopods. Ann. Mag. Nat. Hist., 7: 81-91.
CHALONER, W. G. 1958a. The Carboniferous upland flora. Geol. Mag., 45: 261-262.
CHALONER, W. G. 1958b. A Carboniferous *Selaginellites* with *Densosporites* microspores. Palaeontology, 1: 245-253.
CHALONER, W. G. 1958c. *Polysporia mirabilis* Newberry, a fossil lycopod cone. Jour. Paleont., 32: 199-209.
CHALONER, W. G. 1962. A *Sporangiostrobus* with *Densosporites* microspores. Palaeontology, 5: 73-85.

CHAPHEKAR, M., and K. L. ALVIN. 1972. On the fertile parts of the coenopterid fern *Metaclepsydropsis duplex* (Williamson). Rev. Palaeobot. Palynology, 14: 63-76.
CHÂTEAUNEUF, J.-J. 1973. Palynologie des faisceaus productifs du bassin central des Asturies (Espagne). 7ème Cong. Internat. Strat. Géol. du Carb., Krefeld, 1971, C. r., 2: 297-321.
CHRISTOPHER, R. A. 1978. Quantitative palynologic correlation of three Campanian and Maestrichtian sections (Upper Cretaceous) from the Atlantic Coastal Plain. Palynology, 2: 1-28.
CHRISTOPHER, R. A. 1981. A review of quantitative interval-zone and assemblage-zone biostratigraphy (abstr.). Program and Abstracts, 14th Ann. Mtg., Amer. Assoc. Strat. Palynologists, p. 16 and suppl.
CLAPHAM, W. B., Jr. 1972. Numerical analysis and group formation in palynology. Geoscience and Man, 4: 73-86.
CLARKE, R. F. A. 1965. Keuper miospores from Worcestershire, England. Palaeontology, 8: 294-321.
CLAYTON, G. 1972. Compression structures in the Lower Carboniferous miospore *Dictyotriletes admirabilis* Playford. Palaeontology, 15: 121-124.
CLAYTON, G., R. COQUEL, J. DOUBINGER, K. J. GUEINN, S. LOBOZIAK, B. OWENS and M. STREEL. 1977. Carboniferous miospores of western Europe: Illustration and zonation. Med. Rijks Geol. Dienst, N. S., 29: 1-71.
CLENDENING, J. A. 1966. *Schopfipollenites* in the Washington Formation, Dunkard Group, Upper Pennsylvanian of West Virginia and Pennsylvania. Proc. W. Va. Acad. Sci., 38: 169-176.
CLENDENING, J. A. 1975. Palynological evidence for a Pennsylvanian age assignment of the Dunkard Group in the Appalachian Basin: Part I. Proc. 1st I. C. White Mem. Symposium, 'The Age of the Dunkard,' W. Va. Geol. Econ. Survey: 195-216.
CLOUD, P., and M. F. GLAESSNER. 1982. The Ediacarian Period and System: Metazoa inherit the earth. Science, 218: 783-792.
COQUEL, R. 1966. Étude des microscopes contenues fans des stériles du Westphalien C inférieur. Corrélations palynologiques entre les groupes de Béthune-Noeux et d'Auchel-Bruay. Ann. Soc. Geol. Nord, 86: 15-33.
COQUEL, R. 1973. Étude au microscope electronique a balayage de l'ornamentation de *Lycospora pusilla* (Ibrahim) Somers, spore trilete du Carbonifère. Ann. Soc. Géol. Nord, 93: 237-240.
COQUEL, R. 1976. Étude palynologique de la serie houillere dans l'unité de production de Valenciennes du bassin houiller du nord de la France. Palaeontographica B, 156: 12-64.
CORSIN, P., R. COQUEL and S. LOBOZIAK. 1967. Sur la composition palynologique verticale et horizontale d'un cycle sedimentaire du terrain houiller. Palaeog., Palaeocl., Palaeoecol., 3: 167-184.
COURVOISIER, J. M., and T. L. PHILLIPS. 1975. Correlation of spores from Pennsylvanian coal-ball fructifications with dispersed spores. Micropaleontology, 21: 45-59.
CRIDLAND, A. A. 1966. *Biscalitheca kansana* sp. nov. (Coenopteridales, Zygopteridaceae), a compression from the Lawrence Shale (Upper Pennsylvanian), Kansas, U.S.A. Amer. Jour. Botany, 53: 987-994.
DANZÉ-CORSIN, P., and J.-P. LAVEINE (in BRICHE, P., P. DANZÉ-CORSIN and J.-P. LAVEINE). 1963. Flore Infraliassique du Boulonnais. Mem. Soc. géol. Nord, 13: 57-143.
DeDECKER, K. A. 1980. The correlation and palynology of some Cherokee (Pennsylvanian) coals from Appanoose, Davis and Wapello Counties, Iowa. M. S. thesis, Dept. of Earth Sciences, Iowa St. Univ., Ames, Iowa: 1-98 (unpublished).
de JERSEY, N. J. 1959. Jurassic spores and pollen from the Rosewood Coalfield. Queensland Gov. Min. Jour., 60: 346-366 (re-published 1960, Geol. Survey Queensland Pub. 294: 1-14).
DELCOURT, A. F., and G. SPRUMONT. 1955. Les spores et grains de pollen du Wealdien du Hainaut: Soc. Belge Géol., Mem., n. s. 4, 5: 1-73.
DELEVORYAS, T. 1953. A new male cordaitean fructification from the Kansas Carboniferous. Amer. Jour. Botany, 40: 144-150.
DELEVORYAS, T. 1955. A *Palaeostachya* from the Pennsylvanian of Kansas. Amer. Jour. Botany, 42: 481-488.
DELEVORYAS, T. 1964. A probable pteridosperm microsporangiate fructification from the Pennsylvanian of Illinois. Palaeontology, 7: 60-63.
DEMPSEY, J. E. 1967. Sporomorphs from Lower and Upper McAlester Coals (Pennsylvanian) of Oklahoma: An interim report. Rev. Palaeobot. Palynology, 5: 111-118.
DENNIS, R. L., and D. A. EGGERT. 1978. *Parasporotheca* Gen. Nov., and its bearing on the interpretation of the morphology of permineralized medullosan pollen organs. Bot. Gaz., 139: 117-139.
DIJKSTRA, S. J. 1955. Megasporas carboníferas españolas y su empleo en la correlación estratigráfica. Estud. geol. Inst. Mallada, 11: 277-354.
DIJKSTRA, S. J. and P. H. VAN VIERSSEN TRIP. 1946. Eine monographische Bearbeitung der

karbonischen Megasporen mit besonderer Berücksichtigung von Südlimburg (Niederlande). Med. geol. Sticht., Ser. C-III-1: 1-101.
DiMICHELE, W. A., J. F. MAHAFFY, and T. L. PHILLIPS. 1979. Lycopods of Pennsylvanian age coals: *Polysporia*. Can. Jour. Botany, 57: 1740-1753.
DOHER, L. I. 1980. Palynomorph preparation procedures currently used in the paleontology and stratigraphy laboratories, U. S. Geological Survey. U. S. Geol. Survey Circ. 830: 1-29.
DORING, H. 1965. Die sporenpaläontologische Gliederung des Wealden in Westmecklenburg (Struktur Werle). Geologie, 47: 1-118.
DOUBINGER, J. 1961. Spores de quelques fructifications fossiles du Stéphanien et de l'Autunien. Pollen et Spores, 3: 353-372.
DOUBINGER, J., and L. GRAUVOGEL-STAMM. 1972. Presence de spores du genre *Thymospora* chez *Pecopteris hemitelioides* du Mont Pélé (Stéphanien moyen du Bassin d'Autun). Pollen et Spores, 12: 598-607.
DOUBINGER, J., and U. HORST. 1961. *Torispora, Crassosporites* and *Bicolaria*. Comm. Internat. Microflore Paleozoïque, Krefeld, C. r.: 29.
DOUBINGER, J., and R. RAUSCHER. 1966. Spores du Viséen marin de Bourbach-le-Haut dans les Vosges du Sud. Pollen et Spores, 8: 361-405.
DUNAY, R. E., and M. J. FISHER. 1979. Palynology of the Dockum Group (Upper Triassic), Texas, U.S.A. Rev. Palaeobot. Palynology, 28: 61-92.
DUNBAR, C. O., and J. RODGERS. 1957. Principles of Stratigraphy. John Wiley and Sons, Inc., New York: 1-356.
DYBOVA, S., and A. JACHOWICZ. 1957a. Microspores of the Upper Silesian coal measures. Prace Inst. Geol., 23: 1-328 (In Polish and Czech).
DYBOVA, S., and A. JACHOWICZ. 1957b. Microspore-zones of the Carboniferous of the Ostrava-Karvina region. Sbornik UUG, 24: 167-206 (In Polish and Czech).
EGGERT, D. A., and T. DELEVORYAS. 1967. Studies of Paleozoic ferns: *Sermaya* gen. nov. and its bearing on filicinean evolution in the Paleozoic. Palaeontographica B, 120: 169-180.
EGGERT, D. A., and R. W. KRYDER. 1969. A new species of *Aulotheca* (Pteridospermales) from the Middle Pennsylvanian of Iowa. Palaeontology, 12: 414-419.
EGNER, B. E. 1981. A palynological analysis of fourteen coals from the Cherokee Group (Pennsylvanian), Marion County, Iowa. M. S. thesis, Dept. of Geology, Univ. of Iowa, Iowa City, Iowa: 1-166 (unpublished).
ELIAS, M. K. 1961. Translation of 'Pollen and spores from the Permian of the Cis-Urals' by S. R. Samoilovich. Okla. Geol. Survey Circ. 56: 7-102.
ELSIK, W. C. 1966. Biologic degradation of fossil pollen grains and spores. Micropaleontology, 12: 515-518.
ETTENSOHN, F. R., and R. A. PEPPERS. 1979. Palynology and biostratigraphy of Pennington shales and coals (Chesterian) at selected sites in northeastern Kentucky. Jour. Paleont., 53: 453-474.
EVANS, P. R. 1970 Revision of the miospore genera *Perotrilites* Erdtm. ex Couper 1953 and *Diaphanospora* Balme and Hassell 1962. In Paleontological Papers 1968, Austr. Bur. Min. Resources, Geol. Geophys. Bull. 116: 65-82.
EWART, R. B. 1961. Two new members of the genus *Scolecopteris*. Ann. Missouri Bot. Garden, 48: 275-289.
FELIX, C. J. 1954. Some American arborescent lycopod fructifications. Ann. Missouri Bot. Garden, 41: 351-394.
FELIX, C. J., and P. P. BURBRIDGE. 1961. *Pteroretis*, a new Mississippian spore genus. Micropaleontology, 7: 491-495.
FELIX, C. J., and P. P. BURBRIDGE. 1967. Palynology of the Springer Formation of southern Oklahoma, U.S.A. Palaeontology, 10: 349-425.
FELIX, C. J., and P. PADEN. 1964. A new Lower Pennsylvanian spore genus. Micropaleontology, 10: 330-332.
FITZGERALD, D. J. 1977. Petrology of the Pennsylvanian sandstones of Muscatine County, Iowa. M. S. thesis, Dept. of Geology, Univ. of Iowa, Iowa City, Iowa: 1-215 (unpublished).
FLORIN, R. 1937. On the morphology of the pollen-grains in some Palaeozoic pteridosperms. Svensk bot. Tidskr., 31: 305-338.
FOSTER, C. B. 1975. Permian plant microfossils from the Blair Athol Coal Measures, central Queensland, Australia. Palaeontographica B, 154: 121-171.
FREDERIKSEN, N. O. 1972. The rise of the Mesophytic Flora. Geoscience and Man, 4: 17-28.
GALTIER, J., and L. GRAMBAST. 1972. Observations nouvelles sur les structures reproductrices attribuées a *Zygopteris lacattei* (Coenopteridales de l'Autuno-Stéphanien français). Rev. Palaeobot. Palynology, 14: 101-111.
GALTIER, J., and A. C. SCOTT. 1979. Studies of some Paleozoic ferns: On the genus *Corynepteris*; a redescription of the type and some other European species. Paleontographica B, 170: 81-

125.
GASTALDO, R. A. 1981. *Palaeostachya dircei* n. sp., an authigenically cemented equisitalean strobilus from the Middle Pennsylvanian of southern Illinois. Amer. Jour. Bot., 68: 1306-1318.
GENSEL, P. C. 1980. Devonian *in situ* spores: A survey and discussion. Rev. Palaeobot. Palynology, 30: 101-132.
GIBSON, L. B., and R. T. CLARKE. 1968. Floral succession and palynological correlation. Jour. Paleont., 42: 576-581.
GILLESPIE, W. H., J. A. CLENDENING and H. W. PFEFFERKORN. 1978. Plant fossils of West Virginia. W. Va. Geol. Econ. Survey Educ. Ser. ED-3A: 1-172.
GOOD, C. W. 1975. Pennsylvanian-age calamitean cones, elater-bearing spores, and associated vegetative organs. Palaeontographica B, 153: 28-99.
GOOD, C. W. 1976. Taxonomic and stratigraphic significance of the dispersed spore genus *Calamospora*. In Geobotany, R. C. Romans, ed., Plenum Press, New York: 43-64.
GOOD, C. W. 1979. *Botryopteris* pinnules with abaxial sporangia. Amer. Jour. Botany, 66: 19-25.
GOOD, C. W. 1981. A petrified fern sporangium from the British Carboniferous. Palaeontology, 24: 483-492.
GOOD, C. W., G. W. ROTHWELL and T. N. TAYLOR. 1982. A new *Stephanospermum* from the Appalachian Basin of North America. Rev. Palaeobot. Palynology, 36: 231-240.
GOOD, C. W., and T. N. TAYLOR. 1974. The establishment of *Elaterites triferens* spores in *Calamocarpon insignis* microsporangia. Amer. Micro. Soc. Trans., 93: 148-151.
GOOD, C. W., and T. N. TAYLOR. 1975. The morphology and systematic position of calamitean elater-bearing spores. Geoscience and Man, 11: 133-139.
GRAUVOGEL-STAMM, L., and J. DOUBINGER. 1975. Deux fougères fertiles du Stéphanien du Massif Central (France). Geobios: Paleont., Stratig., Paleoecol., 8: 409-421.
GRAY, J. 1965. Palynological techniques. In Handbook of Paleontological Techniques, B. Kummel and D. Raup, eds., Freeman and Co., San Francisco: 471-481.
GRAY, L. R. 1967. Palynology of four Allegheny coals, northern Appalachian coal field. Palaeontographica B, 121: 65-86.
GREBE, H. 1971. A recommended terminology and descriptive method for spores. C. I. M. P. fasc. 4: 11-34.
GREGORY, J. L. 1982. The stratigraphy and depositional environments of the Kalo Formation (Pennsylvanian), of south-central Iowa. M. S. thesis, Dept. of Geology, Univ. of Iowa, Iowa City, Iowa: 1-218 (unpublished).
GUENNEL, G. K. 1958. Miospore analysis of the Pottsville coals of Indiana. Indiana Dept. Conserv. Geol. Survey, 13: 1-101.
GUENNEL, G. K. Devonian spores in a Middle Silurian reef. Grana Palynologica, 4: 245-261.
GUENNEL, G. K., and R. C. NEAVEL. 1961. *Torispora securis* (Balme): Spore or sporangial wall cell? Micropaleontology, 7: 207-212.
GUPTA, S. 1969. Palynology of the Upper Strawn Series (Upper Pennsylvanian) of Texas above the *Fusulina* zone. Palaentographica B, 125: 150-196.
GUPTA, S. 1970. Miospores from the Desmoinesian-Missourian boundary formations of Texas and the age of the Salesville Formation. Geoscience and Man, 1: 67-82.
GUPTA, S. 1977. Miofloral succession and interpretation of the base of the Permian System in the Eastern Shelf of north central Texas, U.S.A. Rev. Palaeobot. Palynology, 24: 49-66.
GUPTA, S., and O. W. BOOZER. Spores and pollen from the Rock Lake Shale at Garnett locality of Kansas. J. Sen Mem. Vol., Bot. Soc. Bengal: 69-91.
HABIB, D. 1966. Distribution of spore and pollen assemblages in the Lower Kittanning Coal of western Pennsylvania. Palaeontology, 9: 629-666.
HABIB, D. 1968. Spore and pollen paleoecology of the Redstone Seam (Upper Pennsylvanian) of West Virginia. Micropaleontology, 14: 199-220.
HABIB, D. 1970. Middle Cretaceous palynomorph assemblages from clays near the Horizon Beta deep-sea outcrop. Micropaleontology, 16: 345-379.
HACQUEBARD, P. A. 1957. Plant spores in coal from the Horton Group (Mississippian) of Nova Scotia. Micropaleontology, 3: 301-324.
HACQUEBARD, P. A., and M. S. BARSS. 1957. A Carboniferous spore assemblage, in coal from the South Nahanni River area, Northwest Territories. Bull. Can. Geol. Survey, 40: 1-63.
HAGEMANN, H.-W. 1966a. Sporen aus kohlig erhaltenen Lepidophytenzapfen des Westfals. Fortschr. Geol. Rhein. Westf., 13: 317-338.
HAGEMANN, H.-W. 1966b. Vergleichende mikropetrographische und sporologische Untersuchungen der Flöze Zollverein 105 aus den Mittleren Essener Schichten (Westfal B) des Ruhrkarbons im Rahmen der Flözparallelisierung. Fortschr. Geol. Rhein. Westf., 13: 787-860.
HALL, J. W., and B. M. STIDD. Ontogeny of *Vesicaspora*, a late Pennsylvanian pollen grain. Palaeontology, 14: 431-436.
HAMER, J. J., and G. W. ROTHWELL. 1983. *Phillipopteris* gen. nov., anatomically preserved

sporangial fructifications from the Upper Pennsylvanian of the Appalachian Basin. Amer. Jour. Botany, 70: 1378-1385.
HANCOCK, J. M. 1977. The historical development of biostratigraphic correlation. In Concepts and Methods of Biostratigraphy, E. G. Kauffman and J. E. Hazel, eds., Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pa.: 3-22.
HARRIS, T. M. 1961. The Yorkshire Jurassic flora, part 1 -- Thallophyta-Pteridophyta. Brit. Mus. (Nat. Hist.), London: 1-212.
HART, G. F. 1965. The systematics and distribution of Permian miospores. Witwatersrand Univ. Press, Johannesburg: 1-252.
HECKEL, P. H., L. L. BRADY, W. J. EBANKS, Jr., and R. K. PABIAN. 1979. Field guide to Pennsylvanian cyclic deposits in Kansas and Nebraska. In Pennsylvanian Cyclic Platform Deposits in Kansas and Nebraska, 9th Int. Cong. Carb. Strat. Geol., Urbana, Ill., Kansas Geol. Survey Guidebook Ser. 4: 8-60.
HEDBERG, H. D. 1948. Time-stratigraphic classification of sedimentary rocks. Geol. Soc. America Bull., 59: 447-462.
HEDBERG, H. D. 1951. Nature of time-stratigraphic units and geologic time units. Amer. Assoc. Petroleum Geologists Bull., 37: 1077-1081.
HEDBERG, H. D. 1954. Procedure and terminology in stratigraphic classification. Int. Geol. Cong. 19 (Alger), 13: 205-233.
HEDBERG, H. D. 1959. Towards harmony in stratigraphic classification. Amer. Jour. Sci., 257: 674-683.
HEDBERG, H. D. 1965. Chronostratigraphy and biostratigraphy. Geol. Mag., 102: 451-461.
HEDBERG, H. D. 1968. Some views on chronostratigraphic classification. Geol. Mag., 105: 192-199.
HEDLUND, R. W. 1966. Palynology of the Red Branch Member of the Woodbine Formation (Cenomanian), Bryan County, Oklahoma. Okla. Geol. Survey Bull. 112: 1-69.
HELBY, R. J. 1966. Sporologische Untersuchungen an der Karbon/Perm-Grenze im Pfälzer Bergland. Fortschr. Geol. Rhein. Westf., 13: 645-704.
HERSHEY, H. G. 1969. Geologic Map of Iowa. Iowa Geol. Survey.
HIBBERT, F. A., and D. A. EGGERT. 1965. A new calamitalean cone from the Middle Pennsylvanian of southern Illinois. Palaeontology, 8: 681-686.
HIBBERT, F. A., and W. S. LACEY. 1969. Miospores from the Lower Carboniferous Basement Beds in the Menai Straits region of Caernarvonshire, North Wales. Palaeontology, 12: 420-440.
HIGGS, K. 1975. Upper Devonian and Lower Carboniferous miospore assemblages from Hook Head, County Wexford, Ireland. Micropaleontology, 21: 393-419.
HINDS, H. 1909. Coal deposits of Iowa. In S. Calvin, Annual Report, 1908, Iowa Geol. Survey, 19: 21-396.
HOFFMEISTER, W. S., F. L. STAPLIN and R. E. MALLOY. 1955. Mississippian plant spores from the Hardinsburg Formation of Illinois and Kentucky. Jour. Paleont., 29: 372-399.
HOLMES, J. C. 1981. The Carboniferous fern *Psalixochlaena* as found in Westphalian A coal balls from England -- Part II. The frond and fertile parts. Palaeontographica B, 176: 147-173.
HOPKINS, M. E., and J. A. SIMON. 1975. Pennsylvanian System. In Handbook of Illinois Stratigraphy, H. B. Willman et al., Ill. St. Geol. Survey Bull. 95: 163-201.
HORST, U. 1943. Mikrostratigraphischer Beitrag zum Vergleich des Namurs von West-Oberschleisen und Mährisch-Ostrau. Die Mega- und Mikrosporen der hauptsächlichen Flöze beider Reviere. Thesis, Tech. Hochsch. Berlin.
HORST, U. 1955. Die *Sporae dispersae* des Namurs von Westoberschleisen und Mährisch-Ostrau; stratigraphischer Vergleich der Beiden Gebiete an Hand der Sporendiagnose. Palaeontographica B, 98: 137-232.
HORST, U. 1957. Ein Leitfossil der Lugau-Oesnitzer Steinkohlenflöze. Geologie, 6: 698-721.
HOSKINS, J. H., and M. L. ABBOTT. 1956. *Selaginellites crassicinctus*, a new species from the Desmoinesian Series of Kansas. Amer. Jour. Botany, 43: 36-46.
HOWES, M. R. 1983. The occurrence of sphalerite in Des Moines Supergroup (Pennsylvanian) coals of south-central Iowa. M. S. thesis, Dept. of Geology, Univ. of Iowa: 1-150 (unpublished).
HUGHES, N. F., and C. A. CROXTON. 1973. Palynologic correlation of the Dorset 'Wealden.' Palaeontology, 16: 567-601.
HUGHES, N. F., and J. C. MOODY-STUART. 1967. Proposed method of recording pre-Quaternary palynological data. Rev. Palaeobot. Palynology, 3: 347-358.
HUGHES, N. F., and J. C. MOODY-STUART. 1969. A method of stratigraphic correlation using early Cretaceous spores. Palaeontology, 12: 84-111.
HUGHES, N. F., and G. PLAYFORD. 1961. Palynological reconnaissance of the Lower Carboniferous of Spitsbergen. Micropaleontology, 7: 27-44.
IBRAHIM, A. C. 1933. Sporenformen des Ägirhorizonts des Ruhr-Reviers. Konrad Triltsch, Würz-

burg: 1-47.
IBRAHIM-OKAY, A. C., and S. ARTÜZ. 1964. Die Mikrosporen der Steinkohlenflöze Domuzcu und Çay (Westfal A) im Zonguldak-Gebiet (Turkei). Fortschr. Geol. Rhein. Westf., 12: 271-284.
IMGRUND, R. 1952. Die Sporites des Kaipingbeckens, ihre paläontologische und stratigraphische Bearbeitung im Hinblick auf eine Parallelisierung mit dem Ruhrkarbon und dem Pennsylvanian von Illinois. Thesis, Tech. Hochsch. Aachen.
IMGRUND, R. 1960. *Sporae dispersae* des Kaipingbeckens, ihre paläontologische und stratigraphische Bearbeitung im Hinblick auf eine Parallelisierung mit dem Ruhrkarbon und dem Pennsylvanian von Illinois. Geol. Jb., 77: 143-204.
INOSOVA, K. J., A. Kh. KRUSINA and E. G. SHWARTSMAN. 1976. Atlas of microspores and pollen from the Upper Carboniferous and Lower Permian of the Donets Basin. Min. Geol. USSR: 1-159.
INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE. 1978. Adopted by the 12th International Botanical Congress, Leningrad, 1975. Bohn, Scheltema and Holkema, Utrecht: 1-457.
ISHCHENKO, A. M. 1952. Atlas of the microspores and pollen of the middle Carboniferous of the western part of the Donets Basin. Izd. Akad. Nauk Ukr. S. S. R., Inst. Geol. Nauk: 1-83 (In Russian).
ISHCHENKO, A. M. 1956. Spores and pollen of the Lower Carboniferous deposits of the western extension of the Donets Basin and their stratigraphical importance. Akad. Nauk Ukr. S. S. R. Trudy Inst. Geol. Nauk, Ser. Strat. Palaeont., 11: 1-185 (In Russian).
ISHCHENKO, A. M. 1958. Spore and pollen analysis of the Lower Carboniferous Deposits of the Dniepr-Donets Basin. Akad. Nauk Ukr. S. S. R. Trudy Inst. Geol. Nauk, Ser. Strat. Palaeont., 17: 1-188 (In Russian).
JANSONIUS, J. 1962. Palynology of Permian and Triassic sediments, Peace River area, western Canada. Palaeontographica B, 110: 35-98.
JANSONIUS, J., and L. V. HILLS. 1976a. Genera file of fossil spores. Spec. Pub. Dept. Geol., Univ. Calgary, card 1960.
JANSONIUS, J., and L. V. HILLS. 1976b. Genera file of fossil spores. Spec. Pub. Dept. Geol., Univ. Calgary, card 2659.
JANSONIUS, J., and L. V. HILLS. 1976c. Genera file of fossil spores. Spec. Pub. Dept. Geol., Univ. Calgary, card 25.
JANSONIUS, J., and L. V. HILLS. 1980. Genera file of fossil spores. Spec. Pub. Dept. Geol., Univ. Calgary, card 3750.
JANSONIUS, J., and L. V. HILLS. 1981. Genera file of fossil spores. Spec. Pub. Dept. Geol., Univ. Calgary, card 3831.
JENNINGS, J. R. 1976. The morphology and relationships of *Rhodea*, *Telangium*, *Telangiopsis* and *Heterangium*. Amer. Jour. Botany, 63: 1119-1133.
JENNINGS, J. R., and D. A. EGGERT. 1977. Preliminary report on permineralized *Senftenbergia* from the Chester Series of Illinois. Palaeontology, 22: 913-920.
JENNINGS, J. R., and M. A. MILLAY. 1979. Morphology of fertile *Pecopteris unita* from the Middle Pennsylvanian of Illinois. Palaeontology, 22: 913-920.
JEWETT, J. M., H. G. O'CONNOR and D. E. ZELLER. 1968. Pennsylvanian System. In The Stratigraphic Succession in Kansas, D. E. Zeller, ed., Kansas St. Geol. Survey Bull. 189: 21-43.
JIZBA, K. M. M. 1962. Late Paleozoic bisaccate pollen from the United States midontinent area. Jour. Paleont., 36: 871-887.
KAISER, H. 1971. Die Oberdevon-Flora der Bareninsel, 4: Mikroflora der Misery-Serie und der Flözleeren Sandstein-Serie. Palaeontographica B, 135: 127-164.
KAISER, H. 1976. Die Permische Mikroflora der Cathaysia-Schichten von Nordwest Schansi, China. Palaeontographica B, 159: 83-157.
KAR, R. K., and M. N. BOSE. 1967. Palaeozoic *Sporae dispersae* from Congo. III. Assise des schistes noirs de la Lukuga. Ann. Mus. roy. Afr. Centr., Ser. 8o, Sci. geol. 54: 2-59.
KEMP, E. M. 1970. Aptian and Albian miospores from southern England. Palaeontographica B, 131: 73-143.
KEMP, E. M. 1972. Lower Devonian palynomorphs from the Horlick Formation, Ohio Range, Antarctica. Palaeontographica B, 139: 105-124.
KEMP, E. M., B. E. BALME, R. J. HELBY, R. A. KYLE, G. PLAYFORD and P. L. PRICE. 1977. Carboniferous and Permian palynostratigraphy in Australia and Antarctica: A review. Bur. Min. Res. Jour. Austr. Geol. Geophys., 2: 177-208.
KIRKLAND, D. W., and N. O. FREDERIKSEN. 1970. *Cordaitina* pollen from Pennsylvanian strata of Oklahoma and Texas. Rev. Palaeobot. Palynology, 10: 221-231.
KLEINPELL, R. M. 1938. Miocene stratigraphy of California. Amer. Assoc. Petroleum Geologists: 1-450.
KNOX, E. M. 1948. Microspores in coals of the Limestone Group in Scotland. Trans. Inst. Min.

Eng., London, 107: 155-163.
KNOX, E. M. 1950. The spores of *Lycopodium*, *Phylloglossum*, *Selaginella* and *Isoëtes* and their value in the study of microfossils of Palaeozoic age. Bot. Soc. Edinburgh Trans. and Proc., 35: 209-357.
KOSANKE, R. M. 1943. The characteristic plant microfossils of the Pittsburgh and Pomeroy Coals of Ohio. Amer. Midl. Naturalist, 29: 119-132.
KOSANKE, R. M. 1950. Pennsylvanian spores of Illinois and their use in correlation. Ill. St. Geol. Survey Bull. 74: 1-128.
KOSANKE, R. M. 1955. *Mazostachys* -- A new calamite fructification. Ill. St. Geol. Survey Rep. Invest. 180: 1-37.
KOSANKE, R. M. 1973. Palynological studies of the coals of the Princess Reserve District in northeastern Kentucky. U. S. Geol. Survey Prof. Pap. 839: 1-22.
KOSANKE, R. M. 1977. Coal palynology and petrology. In Geology of Rocky Mountain Coal: A Symposium, 1976, D. K. Murray, ed., Colo. Geol. Survey Res. Ser. 1: 1-7.
KOSANKE, R. M. 1984. Palynology of selected coal beds in the proposed Pennsylvanian System stratotype in West Virginia. U. S. Geol. Surv. Prof. Pap. 1318: 1-44.
KOSANKE, R. M., J. A. SIMON, H. R. WANLESS and H. B. WILLIAMS. 1960. Classification of the Pennsylvanian strata of Illinois. Ill. St. Geol. Survey Rep. Invest. 214: 1-84.
KREMP, G. O. W. 1952. Sporen-Vergellschaftungen und Mikrofaunen-Horizonte im Ruhrkarbon. Cong. Avanc. Étude Strat. Carb., Heerlen, 1951, C. r., 1: 347-357.
KREMP, G. O. W. 1965. Morphologic Encyclopedia of Palynology. Univ. Arizona Press, Tucson: 1-163.
KRUMBEIN, W. C., and L. L. SLOSS. 1963. Stratigraphy and Sedimentation (2nd ed.). Freeman and Co., San Francisco: 1-660.
KRUTZSCH, W. 1963. Atlas der mittel- und jungtertiären dispensen Sporen- und Pollensowie der Mikroplanktonformen des nordlichen Mitteleuropas. L. III. Sphagnaceoide und selaginellacoide Sporenformen. VEB Deutsch. Verlag Wiss., Berlin: 1-128.
KURMANN, M. H., and T. N. TAYLOR. 1984. Comparative ultrastructure of the sphenophyte spores *Elaterites* and *Equisetum* Grana, 23: 109-116.
LACHKAR, G. 1975. Les mégaspores du bassin houiller Sarro-Lorrain. Etude systematique et statistique appliquee a la stratigraphie du Carbonifere superieur. Palaeontographica B, 150: 1-123.
LANDIS, O. J. 1965. Coal resources of Iowa. Iowa Geol. Survey Tech. Pap. 4: 1-141.
LANE, R. H., and R. R. WEST. 1984. The inadequacies of Carboniferous serial nomenclature: North American examples. In The Atokan Series (Pennsylvanian) and Its Boundaries -- a Symposium, P. K. Sutherland and W. L. Manger, eds., Okla. Geol. Surv. Bull. 136: 91-100.
LANGENHEIM, R. L., Jr. 1982. Atokan of the Bird Spring Group, Arrow Canyon, Clark County, Nevada, a potential stratotype sequence (abstr.). Geol. Soc. America Abstr. w. Progr., South-Central Sec.: 115.
LAVEINE, J.-P. 1965a. Contribution à l'étude des microspores de differents niveaux du Westphalien C inférieur. Correlations palynologiques entre les groupes d'Auchel-Bruay et de Bethune-Noeux. Ann. Soc. Géol. Nord, 85: 129-153.
LAVEINE, J.-P. 1965b. Les spores de la Subdivision Operculatitriletes nov. subdiv. C. r. Acad. Sci., 260: 2556-2558.
LAVEINE, J.-P. 1969. Quelques pecopteridinées houilleres a la lumière de la palynologie. Pollen et Spores, 11: 619-668.
LAVEINE, J.-P. 1970. Quelques pecopteridinées houilleres a la lumière de la palynologie (II): Implications paléobotaniques et stratigraphiques. Pollen et Spores, 12: 235-297.
LEARY, R. L. 1980. *Lacoea* with sporangia and *Calamospora* spores from Rock Island, Illinois. Rev. Palaeobot. Palynology, 29: 23-28.
LEARY, R. L., and H. W. PFEFFERKORN. 1977. An Early Pennsylvanian flora with *Megalopteris* and Noeggerathiales from west-central Illinois. Ill. St. Geol. Survey Circ. 500: 1-77.
LEISMAN, G. A. 1962. A *Spencerites* sporangium and associated spores from Kansas. Micropaleontology, 8: 396-402.
LEISMAN, G. A. 1970. A petrified *Sporangiostrobus* and its spores from the Middle Pennsylvanian of Kansas. Palaeontographica B, 129: 166-177.
LEISMAN, G. A., and C. GRAVES. 1964. The structure of the fossil sphenopsid cone, *Peltastrobus reedae*. Amer. Midl. Naturalist, 72: 426-437.
LEISMAN, G. A., and J. S. PETERS. 1970. A new pteridosperm male fructification from the Middle Pennsylvanian of Illinois. Amer. Jour. Botany, 57: 867-873.
LEISMAN, G. A., and T. L. PHILLIPS. 1979. Megasporangiate and microsporangiate cones of *Achlamydocarpon varius* from the Middle Pennsylvanian. Palaeontographica B, 168: 100-128.
LEISMAN, G. A., and R. L. RIVERS. 1973. On the reproductive organs of *Lepidodendron serratum* Felix. 7ème Cong. Internat. Strat. Géol. Carb., Krefeld, 1971, C. r., 3: 351-366.
LEISMAN, G. A., and P. A. SPOHN. 1962. The structure of a *Lepidocarpon* strobilus from south-

eastern Kansas. Palaeontographica B, 111: 113-125.
LEMISH, J., R. E. CHAMBERLAIN and E. W. MASON. Introduction and regional geology. In Cherokee Sandstones and Related Facies of Central Iowa, J. Lemish, D. R. Burggraf, Jr., and H. J. White, eds., Field Trip Guide, North-Central Sec., Geol. Soc. America; Iowa Geol. Survey Guidebook Ser. 5: 1-22.
LEMISH, J., and R. C. PALMQUIST. 1980. Final report, the geology of the deep coal in Iowa. U. S. Dept. Energy Report, Contract No. DE AC21-77ET12523: 1-104.
LESCHIK, G. 1956. Die Keuperflora von Neuewelt bei Basel. II. Die Iso- und Mikrosporen. Schweiz. Palaeont. Abh, 72: 3-70.
LESNIKOWSKA, A. D., and M. A. MILLAY. 1985. Studies of Paleozoic marattialeans: New species of *Scolecopteris* (Marattiales) from the Pennsylvanian of North America. Amer. Jour. Botany, 72: 649-658.
LEVET-CARETTE, J. 1964. Étude de la microflore bajocienne d'un sondage effectué dans le sous-sol de Boulogne-sur-Mer (P.-de-C.). Ann. Soc. Géol. Nord, 84: 91-121.
LEVITTAN, E. D., and E. S. BARGHOORN. 1948. *Sphenostrobus thompsonii*: A new genus of the Sphenophyllales? Amer. Jour. Botany, 35: 350-358.
LOBOZIAK, S. 1971. Les micro- et mégaspores de la partie occidentale du bassin houiller du Nord de la France. Palaeontographica B, 132: 1-127.
LOBOZIAK, S. 1972. Une microflore d'âge Namurien ou Westphalien inférieur de la carrier Napoleon, Ferques (Pas-de-Calais), France. Rev. Palaeobot. Palynology, 13: 125-146.
LOBOZIAK, S. 1974. Considerations palynologiques sur le Westphalien d'Europe occidentale. Rev. Palaeobot. Palynology, 18: 271-289.
LOBOZIAK, S., and N. DIL. 1973. Sur l'age Westphalien inférieur des couches de charbon sous la faille du Midi de las galerie 200/34400A des mines de Caydamar (Turquie) d'apres leur étude palynologique (microspores et mégaspores). Rev. Palaeobot. Palynology, 15: 287-299.
LONG, A. G. 1968. Some specimens of *Mazocarpon*, *Achlamydocarpon* and *Cystosporites* from the Lower Carboniferous rocks of Berwickshire. Trans. Royal Soc. Edinburgh, 67: 359-370.
LONG, A. G. 1977a. Some Lower Carboniferous pteridosperm cupules bearing ovules and microsporangia. Trans. Royal Soc. Edinburgh, 70: 1-11.
LONG, A. G. 1977b. Observations on Carboniferous seeds of *Mitrospermum*, *Conostoma* and *Lagenostoma*. Trans. Royal Soc. Edinburgh, 70: 37-60.
LOOSE, F. 1934. Sporenformen aus dem Flöz Bismarck des Ruhrgebietes. Arb. Inst. Paläobot. Berlin, 4: 127-164.
LOVE, L. G. 1960. Assemblages of small spores from the Lower Oil-Shale Group of Scotland. Proc. Royal Soc. Edinburgh, sec. B, 67: 99-126.
LOVE, L. G., and R. NEVES. 1963. Palynological evidence on the Carboniferous of Inninmore. Trans. Geol. Soc. Glasgow, 25: 61-70.
LUBER, A. A. 1955. Atlas of the spore and pollen grains of the Palaeozic deposits of Kazakhstan. Izd. Akad. Nauk Kasakh S.S.R., Alma-Ata: 1-125 (In Russian).
LUBER, A. A., and I. E. WALTZ. 1938. Classification and stratigraphical value of spores of some Carboniferous coal deposits in the USSR. Trav. Inst. geol. U.R.S.S., 104: 1-45 (In Russian).
LUBER, A. A., and I. E. WALTZ. 1941. Atlas of microspores and pollen grains of the Palaeozoic of the U.S.S.R. Trans. All-Un. sci. Res. Inst. geol. (VSEGEI), 139: 1-107 (In Russian).
LUGN, A. L. 1926. Geology of Lucas Co. Iowa Geol. Survey Ann. Report, 1925 and 1926, 32: 101-237.
LUNDBLAD, B. 1950. On a fossil *Selaginella* from the Rhaetic of Hyllinge, Scania. Svensk bot. tidskr., 44: 477-487.
MÄDLER, K. 1964a. Die geologische Verbreitung von Sporen und Pollen in der Deutschen Trias. Geol. Jahrb. Beih., 65: 3-147.
MÄDLER, K. 1964b. Bemerkenswerete Sporenformen aus dem Keuper und unteren Lias. Fortschr. Geol. Rheinl. Westf., 12: 169-200.
MAHER, L. J., Jr. 1972. Nomograms for computing 0.95 confidence limits of pollen data. Rev. Palaeobot. Palynology, 23: 85-94.
MAHESHWARI, H. K., and M. N. BOSE. 1969. Palaeozoic *Sporae dispersae* from Congo. 7. Coal measures near Lake Tanganyika, south of Albertville. Ann. Mus. roy. Afr. Cent., Sci. geol., 63: 1-60.
MAMAY, S. H. 1950. Some American Carboniferous fern fructifications. Ann. Missouri Bot. Garden, 37: 409-476.
MAMAY, S. H. 1954a. A new sphenopsid cone from Iowa. Ann. Bot., 18: 229-239.
MAMAY, S. H. 1954b. Two new plant genera of Pennsylvanian age from Kansas coal balls. U. S. Geol. Survey Prof. Pap. 254-D: 81-95.
MAMAY, S. H. 1957. *Biscalitheca*, a new genus of Pennsylvanian coenopterids, based on its fructification. Amer. Jour. Botany, 44: 229-239.
MANUM, S. 1960. On the genus *Pityosporites* Seward 1914 with a new description of *Pityosporites*

antarcticus Seward. Nytt Mag. Bot., 8: 11-15.
MAPES, G., and J. T. SCHABILION. 1979. A new species of *Acitheca* (Marattiales) from the Middle Pennsylvanian of Oklahoma. Jour. Paleont., 53: 685-694.
MARSHALL, A. E., and A. H. V. SMITH. 1965. Assemblages of miospores from some Upper Carboniferous coals and their associated sediments in the Yorkshire coalfield. Palaeontology, 7: 656-673.
McGREGOR, D. C. 1973. Lower and Middle Devonian spores of eastern Gaspe, Canada, I: Systematics. Palaeontographica B, 142: 1-77.
MENÉNDEZ, C. A. 1965. Contenido palinológico en sedimentos con '*Rhacopteris ovata*' (McCoy) Walk. de la Sierra de Famatina, La Rioja. Rev. Mus. Arg. Cien. Nat. 'B. Rivadavia' Paleont. 1: 45-80.
MENÉNDEZ, C. A., and E. D. PÖTHE DE BALDIS. 1967. Devonian spores from Paraguay. Rev. Palaeobot. Palynology, 1: 161-172.
MEYERS, W. C. 1967. Palynological correlation of the Henryetta Coal, Oklahoma. Okla. Geol. Notes, 27: 34-38.
MICKLE, J. E. 1980. *Ankyropteris* from the Pennsylvanian of eastern Kentucky. Bot. Gaz., 141: 230-243.
MILLAY, M. A. 1979a. The morphology and probable affinities of *Telangium pygmaeum* Graham (abstr.). Abstr. of Papers, 9th Int. Cong. Carb. Strat. Geol., Urbana: 138.
MILLAY, M. A., 1979b. Studies of Paleozoic marattialeans: A monograph of the American species of *Scolecopteris*. Palaeontographica B, 169: 1-69.
MILLAY, M. A. 1982. Studies of Paleozoic marattialeans: An early Pennsylvanian species of the fertile fern *Scolecopteris*. Amer. Jour. Botany, 69: 728-733.
MILLAY, M. A., and D. A. EGGERT. 1970. *Idanothekion* gen. n., a synangiate pollen organ with saccate pollen from the Middle Pennsylvanian of Illinois. Amer. Jour. Botany, 57: 60-61.
MILLAY, M. A., D. A. EGGERT and R. L. DENNIS. 1978. Morphology and ultrastructure of four Pennsylvanian prepollen types. Micropaleontology, 24: 303-315.
MILLAY, M. A., and T. N. TAYLOR. 1970. Studies of living and fossil saccate pollen grains. Micropaleontology, 16: 463-470.
MILLAY, M. A., and T. N. TAYLOR. 1974. Morphological studies of Paleozoic saccate pollen. Palaeontographica B, 147: 75-99.
MILLAY, M. A., and T. N. TAYLOR. 1976. Evolutionary trends in fossil gymnosperm pollen. Rev. Palaeobot. Palynology, 21: 65-91.
MILLAY, M. A., and T. N. TAYLOR. 1982. The ultrastructure of Paleozoic fern spores. I. *Botryopteris* Amer. Jour. Botany, 69: 1148-1155.
MILLAY, M. A., and T. N. TAYLOR. 1984. The ultrastructure of Paleozoic fern spores. II. *Scolecopteris* (Marattiales). Palaeontographica B, 194: 1-13.
MOHR, B. A. R. 1984. Die Mikroflora der Obermiozänen bis Unterpliozänen Deckschichten der Rheinischen Braunkohle. Palaeontographica B, 191: 29-133.
MÖLLER, G. W. 1966. Mikrofloristische und mikropetrographische Untersuchungen der Flöze 10-17 aus den Mittleren Alsdorfer Schichten (Westfal B) der Schachtanlange Emil Mayrisch im Aachener Steinkohlenrevier. Fortschr. Geol. Rhein. Westf., 13: 861-920.
MOORE, L. R. 1946. On the spores of some Carboniferous plants: Their development. Geol. Soc. London Quart. Jour., 102: 251-298.
MOORE, P. D., and J. A. WEBB. 1978. An Illustrated Guide to Pollen Analysis. John Wiley and Sons, New York: 1-133.
MOORE, R. C. 1947. Note 2 -- Nature and classes of stratigraphic units. Amer. Assoc. Petroleum Geologists Bull., 31: 519-528.
MORBEY, S. J. 1975. The palynostratigraphy of the Rhaetian Stage, Upper Triassic in the Kendelbachgraben, Austria. Palaeontographica B, 152: 1-75.
MORGAN, J. L. 1955. Spores of McAlester Coal. Okla. Geol. Survey Circ. 36: 1-52.
MOSIMANN, J. E. 1965. Statistical methods for the pollen analyst: Multinominal and negative multinominal techniques. In Handbook of Paleontological Techniques, B. Kummel and D. Raup, eds., Freeman and Co., San Francisco: 636-673.
MURDY, W. H., and H. N. ANDREWS, Jr. 1957. A study of *Botryopteris globosa* Darrah. Torrey Bot. Club Bull., 84: 252-267.
MURILLO, M. T., and M. J. M. BLESS. 1974. Spores of Recent Colombian Pteridophyta, I: Trilete spores. Rev. Palaeobot. Palynology, 18: 223-269.
NAUMOVA, S. N. 1938. Microspores from the coals of the Moscow Basin. Trudy vses. nauchno. issled. Inst. min. Syr'ya, 119: 21-32 (In Russian).
NAUMOVA, S. N. 1953. Spore-pollen complexes of Upper Devonian of the Russian Platform and their significance for stratigraphy. Trans. Inst. Geol. Sci., Acad. Sci. USSR, Rel. 143, Geol. Ser. 60: 1-202 (In Russian).
NEVES, R. 1958. Upper Carboniferous plant spore assemblages from the *Gastrioceras subcrenatum*

horizon, North Staffordshire. Geol. Mag., 95: 1-19.
NEVES, R. 1961. Namurian plant spores from the southern Pennines, England. Palaeontology, 4: 247-279.
NEVES, R. 1964a. *Knoxisporites* (Potonié and Kremp) Neves 1961. 5ème Cong. Internat. Strat. Géol. Carb., Paris, 1963, C. r., 3: 1063-1069.
NEVES, R. 1964b. The stratigraphic significance of the small spore assemblages of the Camocha Mine, Gijon, N. Spain. 5ème Cong. Internat. Strat. Géol. Carb., Paris, 1963, C. r., 3: 1229-1238.
NEVES, R., K. J. GUEINN, G. CLAYTON, N. S. IOANNIDES, R. S. W. NEVILLE and K. KRUSZEWSKA. 1973. Palynological correlations within the Lower Carboniferous of Scotland and northern England. Trans. Royal Soc. Edinburgh, 69: 23-70.
NEVES, R. and N. S. IOANNIDES. 1974. Palynology of the Lower Carboniferous (Dinantian) of the Spilmersford borehole, East Lothian, Scotland. Bull. Geol. Survey Gt. Britain, 45: 73-97.
NEVES, R., and B. OWENS. 1966. Some Namurian camerate miospores from the English Pennines. Pollen et Spores, 8: 337-360.
NEVES, R., and G. PLAYFORD. 1961. The dispersed spore genus *Knoxisporites* Potonié and Kremp 1954. Comm. Internat. Microflore Paléozoïque, Krefeld, C. r.: 9.
NEVES, R., and H. J. SULLIVAN. 1964. Modification of fossil spore exines associated with the presence of pyrite crystals. Micropaleontology, 10: 443-452.
NEVILLE, R. S. W. 1968. Ranges of selected spores in the upper Viséan of the East Fife coast section between St. Monace and Pittenweem. Pollen et Spores, 10: 431-462.
NILSSON, T. 1958. Über das Vorkommen eines mesozoischen sapropelgesteins in Schönen. Pub. Inst. Miner. Paleont. Quat. Geol., Univ. Lund, 53: 1-111.
NORRIS, G. 1965. Triassic and Jurassic miospores and acritarchs from the Beacon and Ferrar Groups, Victoria Land, Antarctica. New Zealand Jour. Geol. Geophys., 8: 236-277.
NORRIS, G. 1969. Miospores from the Purbeck Beds and marine Upper Jurassic of southern England. Palaeontology, 12: 574-620.
NORTH AMERICAN COMMISSION ON STRATIGRAPHIC NOMENCLATURE. 1983. North American stratigraphic code. Amer. Assoc. Petroleum Geologists Bull., 67: 841-875.
NORVICK, M. S., and D. BURGER. 1975. Palynology of the Cenomanian of Bathurst Island, Northern Territory, Australia. Austr. Bur. Min. Res., Geol. Geophys. Bull. 151: 1-169.
NYGREEN, P. W., and O. B. BOURN. 1967. Morphological variation of *Potonieisporites* in a late Pennsylvanian florule. Rev. Palaeobot. Palynology, 3: 325-332.
O'BRIEN, D. E. 1977. Stratigraphy, petrology and depositional sequence of the Marmaton, Pleasanton and lowermost Kansas City Groups (late Middle and early Upper Pennsylvanian) in a core from south-central Iowa. M. S. thesis, Dept. of Geology, Univ. of Iowa, Iowa City, Iowa: 1-120 (unpublished).
ORBELL, G. 1973. The palynology of the British Rhaeto-Liassic. Bull. Geol. Surv. Great Britain, 44: 1-44.
OWENS, B. 1971. Miospores from the Middle and Early Upper Devonian rocks of the western Queen Elizabeth Islands, Arctic Archipelago. Geol. Surv. Canada Pap. 70-38: 1-157.
OWENS, B., S. LOBOZIAK and V. K. TETERIUK. 1978. Palynological subdivision of the Dinantian to Westphalian deposits of northwest Europe and the Donetz Basin of the U.S.S.R. Palynology, 2: 69-91.
PABIAN, R. K., and H. L. STRIMPLE. 1978. Suggested reevaluation of the South Bend Limestone (Late Pennsylvanian -- Missourian) of southeastern Nebraska and southeastern Kansas based upon crinoids (abstr.). Proc. Neb. Acad. Sci., 88th Ann. Mtg.: 45.
PANT, D. D., and G. K. SRIVASTAVA. 1965. Some lower Gondwana miospores from Brazil. Micropaleontology, 11: 468-478.
PEPPERS, R. A. 1964. Spores in strata of late Pennsylvanian cyclothems in the Illinois Basin. Ill. St. Geol. Survey Bull. 90: 1-89.
PEPPERS, R. A. 1970. Correlation and palynology of coals in the Carbondale and Spoon Formations (Pennsylvanian) of the northeastern part of the Illinois Basin. Ill. St. Geol. Survey Bull. 93: 1-173.
PEPPERS, R. A. 1979. Development of coal-forming floras during the early part of the Pennsylvanian in the Illinois Basin. In Depositional and Structural History of the Pennsylvanian System of the Illinois Basin, J. E. Palmer and R. R. Dutcher, eds., 9th Int. Cong. Carb. Strat. Geol., Urbana, Ill. St. Geol. Survey Guidebook Ser. 15a, pt. 2: 8-14.
PEPPERS, R. A. 1984. Comparison of miospore assemblages in the Pennsylvanian System of the Illinois Basin with those in the Upper Carboniferous of Western Europe. 9th Internat. Cong. Carb. Strat. Geol., Urbana, 1979, C. r., 2: 483-502.
PEPPERS, R. A., and H. H. DAMBERGER. 1969. Palynology and petrography of a Middle Devonian coal in Illinois. Ill. St. Geol. Survey Circ. 445: 1-34.
PEPPERS, R. A., and J. T. POPP. 1979. Stratigraphy in the lower part of the Pennsylvanian System in southeastern Illinois and adjacent portions of Indiana and Kentucky. In Depositional and

Structural History of the Pennsylvanian System of the Illinois Basin, J. E. Palmer and R. R. Dutcher, eds., 9th Internat. Cong. Carb. Strat. Geol., Urbana, Ill. St. Geol. Survey Guidebook Ser. 15a, 2: 65-72.
PFEFFERKORN, H. W., R. A. PEPPERS and T. L. PHILLIPS. 1971. Some fern-like fructifications and their spores from the Mazon Creek compression flora of Illinois (Pennsylvanian). Ill. St. Geol. Survey Circ. 463: 1-56.
PHILLIPS, T. L. 1979. Reproduction of heterosporous arborescent lycopods in the Mississippian-Pennsylvanian of Euramerica. Rev. Palaeobot. Palynology, 27: 239-289.
PHILLIPS, T. L., and H. N. ANDREWS, Jr. 1965. A fructification of *Anachoropteris* from the Middle Pennsylvanian of Illinois. Ann. Missouri Bot. Garden, 52: 251-261.
PHILLIPS, T. L., R. A. PEPPERS, M. J. AVCIN and P. F. LAUGHNAN. 1974. Fossil plants and coal: Patterns of change in Pennsylvanian coal swamps of the Illinois Basin. Science, 184: 1367-1369.
PHILLIPS, T. L., and S. W. ROSSO. 1970. Spores of *Botryopteris globosa* and *Botryopteris americana* from the Pennsylvanian. Amer. Jour. Botany, 57: 543-551.
PIÉRART, P. 1962. Observations sur la palynologie du Westphalien B et C de la partie occidentale du Massif du Borinage. Centre Nat. Géol. houil., pub. 5: 103-110.
PI-RADONDY, M., and J. DOUBINGER. 1968. Spores nouvelles de Stéphanien (Massif Central français). Pollen et spores, 10: 411-430.
PLAYFORD, G. 1962. The Lower Carboniferous microfloras of Spitsbergen, pt. 1. Palaeontology, 5: 550-618.
PLAYFORD, G. 1963. The Lower Carboniferous microfloras of Spitsbergen, pt. 2. Palaeontology, 5: 619-678.
PLAYFORD, G. 1964. Miospores from the Mississippian Horton Group, eastern Canada. Bull. Can. Geol. Survey, 107 (1963): 1-47.
PLAYFORD, G. 1971a. Palynology of Lower Cretaceous (Swan River) strata of Saskatchewan and Manitoba. Palaeontology, 14: 533-565.
PLAYFORD, G. 1971b. Lower Carboniferous spores from the Bonaparte Gulf Basin, Western Australia and Northern Territory. Austr. Bur. Min. Res. Bull. 115: 1-104.
PLAYFORD, G. 1976. Plant microfossils from the Upper Devonian and Lower Carboniferous of the Canning Basin, Western Australia. Palaeontographica B, 158: 1-71.
PLAYFORD, G. 1977. A Lower Carboniferous palynoflora from the Drummond Basin, east-central Queensland. Proc. Royal Soc. Queensland, 88: 75-81.
PLAYFORD, G. 1978. Lower Carboniferous spores from the Ducabrook Formation, Drummond Basin, Queensland. Palaeontographica B, 167: 105-160.
PLAYFORD, G. 1982. A latest Devonian Palynoflora from the Buttons Beds, Bonaparte Gulf Basin, Western Australia. Austr. Bur. Min. Res., Jur. Geol. Geophys., 7: 149-157.
PLAYFORD, G., and R. HELBY. 1968. Spores from a Carboniferous section in the Hunter Valley, New South Wales. Jour. Geol. Soc. Australia, 15: 103-119.
PLAYFORD, G., J. F. RIGBY and D. C. ARCHIBALD. 1982. A Middle Triassic flora from the Moolayember Formation, Bowen Basin, Queensland. Geol. Survey Queensland Pub. 380: 1-52.
PLAYFORD, G., and D. F. SATTERTHWAIT. 1985. Lower Carboniferous (Viséan) spores of the Bonaparte Gulf Basin, northwestern Australia: Part one. Palaeontographica B, 195: 129-152.
POCOCK, S. A. J. 1970. Palynology of the Jurassic sediments of western Canada -- Part 1. Terrestrial species. Palaeontograpica B, 130: 12-136.
POTONIÉ, R. 1958. Synopsis der Gattungen der *Sporae dispersae*. Teil II. Beih. Geol. Jahrb., 31: 1-114.
POTONIÉ, R. 1960. Synopsis der Gattungen der *Sporae dispersae*. Teil III. Beih. Geol. Jahrb., 39: 1-189.
POTONIÉ, R. 1962. Synopsis der *Sporae in situ*. Beih. Geol. Jahrb., 52: 1-204.
POTONIÉ, R. 1966. Synopsis der Gattungen der *Sporae dispersae*. Teil IV: Beih. Geol. Jahrb., 72.
POTONIÉ, R. 1969. The spores of *Cordaianthus* Grand'Eury 1877. J. Sen Mem. Vol., Bot. Soc. Bengal: 1-5.
POTONIÉ, R. 1970. Synopsis der Gattungen der *Sporae dispersae*. Teil VI. Beih. Geol. Jahrb., 94: 3-18.
POTONIÉ, R., A. C. IBRAHIM and F. LOOSE. 1932. Sporenformen aus den Flözen Ägir und Bismarck des Ruhrgebietes. Neues Jahrb. Min. usw., Beil-Bd., 67: 483-544.
POTONIÉ, R., and G. O. W. KREMP. 1954. Die Gattungen der palaeozoischen *Sporae dispersae* und ihre Stratigraphie. Beih. Geol. Jahrb., 69: 111-194.
POTONIÉ, R., and G. O. W. KREMP. 1955. Die *Sporae dispersae* des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte, Teil I. Palaeontographica B, 98: 1-136.
POTONIÉ, R., and G. O. W. KREMP. 1956a. Die *Sporae dispersae* des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte, Teil II.

Palaeontographica B, 99: 85-191.
POTONIÉ, R., and G. O. W. KREMP. 1956b. Die *Sporae dispersae* des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte, Teil III. Palaeontographica B, 100: 65-121.
RADFORTH, N. W. 1938. An analysis and comparison of the structural features of *Dactylotheca plumosa* Artis sp. and *Senftenbergia ophiodermatica* Göppert sp. Trans. Royal Soc. Edinburgh, 59: 385-396.
RADFORTH, N. W. 1939. Further contributions to our knowledge of the fossil Schizaeaceae: Genus *Senftenbergia.* Trans. Royal Soc. Edinburgh, 59: 745-761.
RAUP, D. M., and S. M. STANLEY. 1978. Principles of Paleontology (2nd ed.). W. H. Freeman and Co., San Francisco: 1-481.
RAVN, R. L. 1979. An introduction to the stratigraphic palynology of the Cherokee Group (Pennsylvanian) coals of Iowa. Iowa. Geol. Survey Tech. Pap. 6: 1-117.
RAVN, R. L. 1981a. Stratigraphy, petrography and depositional history of the Hertha Formation (Upper Pennsylvanian), Midcontinent North America. Ph.D. thesis, Dept. of Geology, Univ. of Iowa, Iowa City, Iowa: 1-274 (unpublished).
RAVN, R. L. 1981b. Palynostratigraphy of Lower and Middle Pennsylvanian coals of Iowa, with special reference to the Atokan-Desmoinesian boundary (abstr.). Geol. Soc. America Abstr. w. Progr., North-Central Sec.: 314.
RAVN, R. L. 1983. Paleobotanical relationships and stratigraphic importance of the Carboniferous miospore genus *Vestispora* and questionably allied genera. Jour. Paleont., 57: 568-580.
RAVN, R. L., M. A. BUTTERWORTH, T. L. PHILLIPS and R. A. PEPPERS. In press. Proposed synonymy of *Granasporites* Alpern 1959 emend. and *Cappasporites* Urban emend. Chadwick 1983, miospore genera from the Carboniferous of Europe and North America. Pollen et Spores.
RAVN, R. L., and D. J. FITZGERALD. 1982. A Morrowan (Upper Carboniferous) miospore flora from eastern Iowa, U.S.A. Palaeontographica B, 183: 108-172.
RAVN, R. L., J. W. SWADE, M. R. HOWES, J. L. GREGORY, R. R. ANDERSON and P. E. VAN DORPE. 1984. Stratigraphy of the Cherokee Group and revision of Pennsylvanian stratigraphic nomenclature in Iowa. Iowa Geol. Survey Tech. Info. Ser., 12: 1-76.
REED, F. D. 1938. Notes on some plant remains from the Carboniferous of Illinois. Bot. Gaz., 100: 324-325.
REINHARDT, P. 1964. Über die *Sporae dispersae* der Thüringer Trias. Mber. Dt. Akad. Wiss. Berlin, 6: 46-56.
REMY, R. 1959. Die Sporen von *Cingularia typica* Weiss. Mber. dt. Akad. Wiss. Berlin, 1: 257-260.
REMY, R. 1960. *Bowmanites mindeli* n. sp. Mber. dt. Akad. Wiss. Berlin, 2: 122-125.
REMY, R. 1961. Beitrage zur Flora des Autunien III, *Bowmanites simoni* n. sp. Mber. dt. Akad. Wiss. Berlin, 3: 331-336.
REMY, R., and W. REMY. 1955a. Mitteilungen über Sporen, die aus inkohlten Fruktifikationen von echten Farnen des Karbons gewonnen wurden. Abh. dt. Akad. Wiss. Berlin Jg. 1955, 1: 41-48.
REMY, R., and W. REMY. 1955b. *Simpliotheca silesiaca* n. gen. et sp. Abh. dt. Akad. Wiss. Berlin Jg. 1955, 2: 3-7.
REMY, R., and W. REMY. 1961. Beitrage zur Flora des Autunien II, *Tristachya crokensis* n. sp. Mber. dt. Akad. Wiss. Berlin, 3: 213-225.
REMY, W. 1954. Die Systematik der Pteridospermen unter Berücksichtigung ihres Pollen. Geologie, 3: 312-325.
REMY, W. 1955. Untersuchungen von kohlig erhaltenen fertilen und sterilen Sphenophyllen und Formen unsicherer systematischer Stellung. Abh. dt. Akad. Wiss. Berlin Jg. 1955, 1: 1-40.
REMY, W., and R. REMY. 1957. Durch Mazeration fertiler Farne des Paläozoikums gewonne Sporen. Palaont. Zeitschr., 31: 55-65.
REMY, W., and R. REMY. 1975. *Sporangiostrobus puertollanensis* n. sp. und *Puertollania sporangiostrobifera* n. gen., n. sp. aus dem Stefan von Puertollano, Spain. Arg. Palaeobot., 4: 13-29.
RETTSCHLAG, R., and W. REMY. 1954. Beitrage zur Kenntnis einiger palaeozoischer Fruktifikationen. Geologie, 3: 590-603.
RICHARDSON, J. B., and N. IOANNIDES. 1973. Silurian palynomorphs from the Tannezzuft and Acacus Formations, Tripolitania, North Africa. Micropaleontology, 19: 257-307.
ROMANS, R. C. 1975. Palynology of some Upper Cretaceous coals of Black Mesa, Arizona. Pollen et Spores, 17: 273-329.
ROTHWELL, G. W. 1972a. Evidence of pollen tubes in Paleozoic pteridosperms. Science, 175: 772-774.
ROTHWELL, G. W. 1972b. Pollen organs of the Pennsylvanian Callistophytaceae (Pteridospermopsida). Amer. Jour. Botany, 59: 993-999.
ROTHWELL, G. W. 1976. A new pteropsid fructification from the Middle Pennsylvanian of Kansas.

Palaeontology, 19: 307-315.
ROTHWELL, G. W. 1978. *Doneggia complura* gen. et sp. nov., a filicinean fern from the Upper Pennsylvanian of Ohio. Can. Jour. Botany, 56: 3096-3104.
ROTHWELL, G. W. 1982. New interpretations of the earliest conifers. Rev. Palaeobot. Palynology, 37: 7-28.
ROTHWELL, G. W., and J. E. MICKLE. 1982. *Rhetinotheca patens* n. sp., a medullosan pollen organ from the Upper Pennsylvanian of North America. Rev. Palaeobot. Palynology, 36: 361-374.
ROUSE, G. E. 1957. The application of a new nomenclatural approach to Upper Cretaceous plant microfossils from Western Canada. Can. Jour. Botany, 35: 349-375.
SABRY, H., and R. NEVES. 1971. Palynology evidence concerning the unconformable Carboniferous basal measures in the Sanquhar Coal-field, Dumfriesshire, Scotland. 6ème Cong. Internat. Strat. Géol. Carb., Sheffield, 1967, C. r., 4: 1441-1458.
SAMOILOVICH, S. R. 1953. Pollen and spores from the Permian deposits of the Cherdinsk and Aktyubinsk areas, Cis-Urals. Paleobot. sbornik: V. Nauk Geol. Inst., Leningrad, Trudy, n. s., 75: 1-56. (In Russian; English translation by Elias, 1961).
SCHEMEL, M. P. 1951. Small spores of the Mystic Coal of Iowa. Amer. Midl. Naturalist, 46: 743-750.
SCHENCK, H. G., and S. W. MULLER. 1941. Stratigraphic terminology. Geol. Soc. America Bull., 52: 1419-1426.
SCHLANKER, C. M., and G. A. LEISMAN. 1969. The herbaceous lycopod *Selaginella fraiponti* comb. nov. Bot. Gaz., 130: 35-41.
SCHOPF, J. M. 1936. The paleobotanical significance of plant structure in coal. Ill. St. Acad. Sci. Trans. (1935), 28: 106-110.
SCHOPF, J. M. 1938. Spores from the Herrin (No. 6) Coal bed of Illinois. Ill. Geol. Survey Rep. Invest. 50: 1-73.
SCHOPF, J. M. 1941. Contributions to Pennsylvanian paleobotany, *Mazocarpon oedipternum* sp. nov. and sigillarian relationships. Ill. Geol. Survey Rep. Invest. 75: 1-53.
SCHOPF, J. M. 1948. Pteridosperm male fructifications: American species of *Dolorotheca*, with notes regarding certain allied forms. Jour. Paleont., 22: 681-724.
SCHOPF, J. M. 1969. Systematics and nomenclature in palynology. In Aspects of Palynology, R. H. Tschudy and R. A. Scott, eds., John Wiley and Sons, New York: 49-77.
SCHOPF, J. M., L. R. WILSON and R. BENTALL. 1944. An annotated synopsis of Paleozoic fossil spores and the definition of generic groups. Ill. Geol. Survey Rep. Invest. 91: 1-73.
SCHULZ, E. 1965. *Sporae dispersae* aus der Trias von Thüringen. Mitt. Zentr. Geol. Inst., 1: 257-287.
SCHULZ, E. 1966. Über einige neue *Sporae dispersae* aus dem älteren Mesophytikum Deutschlands. Beih. Geologie, 15: 130-151.
SCHULZ, E. 1967. Sporenpaläontologische Untersuchungen rätoliassischer Schichten im Zentralteil des Germanischen Beckens. Palaont. Abh. B, II, 3: 427-633.
SCHUURMAN, W. M. L. 1977. Aspects of Late Triassic palynology. 2. Palynology of the 'Grès et Schiste à *Avicula contorta*' and 'Argiles de Levallois' (Rhaetian) of NE France and S Luxembourg. Rev. Palaeobot. Palynology, 23: 159-253.
SCOTT, A. C. 1978. Sedimentological and ecological control of Westphalian B plant assemblages from West Yorkshire. Proc. Yorkshire Geol. Soc., 41: 461-508.
SCOTT, A. C., J. GALTIER and G. CLAYTON. 1985. A new late Tournaisian (Lower Carboniferous) flora from the Kilpatrick Hills, Scotland. Rev. Palaeobot. Palynology, 44: 81-99.
SEGROVES, K. L. 1967. Cutinized microfossils of probable nonvascular origin from the Permian of Western Australia. Micropaleontology, 13: 289-305.
SEN, J. 1958. Notes on the spores of four Carboniferous lycopods. Micropaleontology, 4: 159-164.
SETLIK, J., C. BROUSMICHE, R. COQUEL, J.-P. LAVEINE and S. LOBOZIAK. 1979a. Les spores de *Pecopteris aspidioides* Sternberg (abstr.). Abstracts of Papers, 9th Int. Cong. Carb. Strat. Geol., Urbana: 200.
SETLIK, J., C. BROUSMICHE, R. COQUEL, J.-P. LAVEINE and S. LOBOZIAK. 1979b. *Radiitheca dobranyana* nov. gen., nov. sp., fougère fossile du Carbonifère, productrice de spores de type *Microreticulatisporites* (Knox) Pot. et Kr. (abstr.). Abstracts of Papers, 9th Int. Cong. Carb. Strat. Geol., Urbana: 200.
SHAVER, R. H. 1984. Atokan Series concepts with special reference to the Illinois Basin and Iowa. In The Atokan Series (Pennsylvanian) and Its Boundaries -- a Symposium, P. K. Sutherland and W. L. Manger, eds., Okla. Geol. Surv. Bull. 136: 101-113.
SINGH, C. 1964. Microflora of the Lower Cretaceous Mannville Group, east-central Alberta. Res. Council Alberta Bull. 15: 1-239.
SINGH, C. 1971. Lower Cretaceous microfloras of the Peace River area, northwestern Alberta. Res. Council Alberta Bull. 28: 1-542.
SINGH, H. P. 1964. A miospore assemblage from the Permian of Iraq. Palaeontology, 7: 240-265.

SINGH, R. Y. 1977. Stratigraphy and palynology of the Tura Formation in the type area; part II (descriptive palynology). Palaeobotanist, 23: 189-205.
SKARBY, A. 1964. The status of the spore genus *Cibotiidites* Ross. Stockholm Contr. Geol., 28: 1-7.
SKOG, J. E., H. N. ANDREWS, Jr., and S. H. MAMAY. 1969. *Canipa quadrifida* gen. et sp. nov., a synangial fructification from the Middle Pennsylvanian of West Virginia. Bull. Torrey Bot. Club, 96: 276-287.
SMITH, A. H. V. 1957. The sequence of microspore assemblages associated with the occurrence of crassidurite in coal seams of Yorkshire. Geol. Mag., 94: 345-363.
SMITH, A. H. V. 1962. The palaeoecology of Carboniferous peats based on the miospores and petrography of bituminous coals. Proc. Yorkshire Geol. Soc., 33: 423-474.
SMITH, A. H. V. 1964a. Zur Petrologie und Palynologie der Kohlenflöze des Karbons und ihrer Begleitschichten. Fortschr. Geol. Rhein. Westf., 12: 285-302.
SMITH, A. H. V. 1964b. Paleoecology of Carboniferous peats. In Problems in Palaeoclimatology, A. E. M. Nairn, ed., John Wiley and Sons, London: 57-66.
SMITH, A. H. V. 1968. Seam profiles and seam characters. In Coal and Coal-Bearing Strata, D. Murchison and T. S. Westoll, eds., Oliver and Boyd, Edinburgh: 31-40.
SMITH, A. H. V. 1971. Genus *Verrucosisporites* Ibrahim 1933 emend. C. I. M. P. fasc. 4: 35-87.
SMITH, A. H. V., and M. A. BUTTERWORTH. 1967. Miospores in the coal seams of the Carboniferous of Great Britain. Spec. Pap. Palaeontology, 1, Palaeont. Assoc., London: 1-324.
SMITH, D. L. 1962. Three fructifications from the Scottish Lower Carboniferous. Palaeontology, 5: 225-237.
SOMERS, G. 1952. Fossil spore content of the Lower Jubilee seam of the Sydney coalfield, Nova Scotia. Nova Scotia Res. Found.: 1-30.
SOMERS, Y. 1971. Étude palynologique du Westphalien du Bassine Campine et révision du genre *Lycospora*. Thèse de Doctorat, Univ. de Liège (privately published).
SOMERS, Y. 1972. Révision du genre *Lycospora* Schopf, Wilson and Bentall. C. I. M. P. fasc. 5: 1-110.
SPINNER, E. G., and G. CLAYTON. 1973. Viséan spore assemblages from Skateraw, East Lothian, Scotland. Pollen et Spores, 15: 139-165.
SRIVASTAVA, S. K. 1977. Microspores from the Fredericksburg Group (Albian) of the southern United States. Paleobiologie Continentale, 6: 1-119.
STACH, E. 1975. The microscopically recognizable constituents of coal. In Textbook of Coal Petrology, E. Stach and others, eds., Gerbruder Borntraeger, Berlin: 54-108.
STAPLIN, F. L. 1960. Upper Mississippian plant spores from the Golata Formation, Alberta, Canada. Palaeontographica B, 107: 1-40.
STAPLIN, F. L., and J. JANSONIUS. 1964. Elucidation of some Paleozoic densospores. Palaeontographica B, 114: 95-117.
STIDD, B. M. 1978. An anatomically preserved *Potoniea* with *in situ* spores from the Pennsylvanian of Illinois. Amer. Jour. Botany, 65: 677-683.
STIDD, B. M., and J. W. HALL. *Callandrium callistophytoides* gen. et sp. n., the probable pollen-bearing organ of the seed fern *Callistophyton*. Amer. Jour. Botany, 57: 827-836.
STIDD, B. M., G. A. LEISMAN and T. L. PHILLIPS. 1977. *Sullitheca dactylifera* gen. et sp. n.: A new Medullosan pollen organ and its evolutionary significance. Amer. Jour. Botany, 64: 994-1002.
STIDD, B. M., M. O. RISCHBIETER and T. L. PHILLIPS. 1985. A new lyginopterid pollen organ with alveolate pollen exines. Amer. Jour. Botany, 72: 501-508.
STOOKEY, D. G. 1935. Stratigraphy of the Des Moines Series of southeastern Iowa. Ph.D. dissertation, Dept. of Geology, Univ. of Iowa, Iowa City, Iowa (unpublished).
STUBBLEFIELD, S. P., T. N. TAYLOR and C. P. DAGHLIAN. 1982. Compressed plants from the Lower Pennsylvanian of Kentucky (U.S.A.). I. *Crossotheca kentuckiensis* n. sp. Rev. Palaeobot. Palynology, 36: 197-204.
SULLIVAN, H. J. 1958. The microspore genus *Simozonotriletes*. Palaeontology, 1: 125-138.
SULLIVAN, H. J. 1964a. Miospores from the Drybrook Sandstone and associated measures in the Forest of Dean Basin, Gloucestershire. Palaeontology, 7: 351-392.
SULLIVAN, H. J. 1964b. Miospores from the Lower Limestone Shales (Tournaisian) of the Forest of Dean Basin, Gloucestershire. 5ème Cong. Internat. Strat. Géol. Carb., Paris, 1963, C. r., 3: 1249-1260.
SULLIVAN, H. J., and A. E. MARSHALL. 1966. Viséan spores from Scotland. Micropaleontology, 12: 265-285.
SULLIVAN, H. J., and R. NEVES. 1966. *Triquitrites* and related genera. Rep. C. I. M. P. Working Group No. 7, 5ème Cong. Internat. Strat. Géol. Carb., Paris, 1963. C. r., 3: 1079-1093.
SWADE, J. W. 1985. Conodont distribution, paleoecology, and preliminary biostratigraphy of the Upper Cherokee and Marmaton Groups (Upper Desmoinesian, Middle Pennsylvanian) from two cores in south-central Iowa. Iowa Geol. Survey Tech. Inf. Ser., 14: 1-71.

TAYLOR, T. N. 1967. On the structure and phylogenetic relationships of the fern *Radstockia* Kidston. Palaeontology, 10: 43-46.
TAYLOR, T. N. 1971. *Halletheca reticulatus* gen. et. sp. nov.: A synangiate Pennsylvanian pteridosperm pollen organ. Amer. Jour. Botany, 58: 300-308.
TAYLOR, T. N. 1972. A new Carboniferous sporangial aggregation. Rev. Palaeobot. Palynology, 14: 309-318.
TAYLOR, T. N. 1978. The ultrastructure and reproductive significance of *Monoletes* (Pteridospermales) pollen. Can. Jour. Botany, 56: 3105-3118.
TAYLOR, T. N. 1986. Ultrastructure of sphenophyllalean spores. Rev. Palaeobot. Palynology, 47: 105-128.
TAYLOR, T. N., and S. D. BRACK-HANES. 1976. *Achlamydocarpon varius* comb. nov.: Morphology and reproductive biology. Amer. Jour. Botany, 63: 1257-1265.
TAYLOR, T. N., and D. A. EGGERT. 1969. Preliminary study of spores from Carboniferous fructifications utilizing the scanning electron microscope. Engis Stereoscan Colloq. Proc.: 97-107.
TAYLOR, T. N., and M. A. MILLAY. 1981. Additional information on the pollen organ *Halletheca.* Amer. Jour. Botany, 68: 1403-1407.
THOMAS, B. A. 1969. A new British Carboniferous calamite cone, *Paracalamostachys spadiciformis.* Palaeontology, 12: 253-261.
THOMAS, B. A., and D. M. CRAMPTON. 1971. A fertile *Zeilleria avoldensis* from the British Upper Carboniferous. Rev. Palaeobot. Palynology, 11: 283-295.
THOMSON, P. W., and H. PFLUG. 1953. Pollen und Sporen des mitteleuropaischen Tertiärs. Palaeontographica B, 94: 1-138.
TILLEMENT, B. A., G. PENIGUEL and J. P. GUILLEMIN. 1976. Marine Pennsylvanian rocks in Hudson Bay. Bull. Can. Petrol. Geol., 24: 418-439.
TIWARI, R. S. 1964. New miospore genera in the coals of Barakar Stage (Lower Gondwana) of India. Palaeobotanist, 12: 250-259.
TIWARI, R. S., and F. SCHAARSCHMIDT. 1975. Palynological studies in the Lower and Middle Devonian of the Prüm Syncline, Eifel (Germany). Abh. Senck. Natur. Gesell. 534: 1-129.
TRAVERSE, A., H. T. AMES and W. SPACKMAN, eds. 1973. Catalog of Fossil Spores and Pollen. Penn. St. Univ., 37: 1-236.
TURNAU, E. 1978. Spore zonation of uppermost Devonian and Lower Carboniferous deposits of western Pomerania. Med. Rijks Geol. Dienst, 30: 1-35.
UPSHAW, C. F., and W. B. CREATH. 1965. Pennsylvanian miospores from a cave deposit in Devonian Limestone, Callaway County, Missouri. Micropaleontology, 11: 431-448.
UPSHAW, C. F., and R. W. HEDLUND. 1967. Microspores from the upper part of the Coffeyville Formation (Pennsylvanian, Missourian), Tulsa County, Oklahoma. Pollen et Spores, 9: 143-170.
URBAN, J. B. 1971. Palynology and the Independence Shale of Iowa. Bull. Amer. Paleont., 60: 103-189.
URBAN, L. L. 1966. *Cappasporites*, a new Pennsylvanian spore genus from the Des Moines Series of Oklahoma. Okla. Geol. Notes, 26: 111-114.
VAN DORPE, P. E. 1980a. The lithologic comparison of Lower Cherokee (Pennsylvanian) rocks from three cores in southeastern Iowa. M. S. thesis, Wayne St. Univ., Detroit, Mich. (unpublished).
VAN DORPE, P. E. 1980b. A bibliography of Pennsylvanian geology and coal in Iowa. Iowa Geol. Survey Open File Rep.: 1-125.
VAN WIJHE, D. H., and M. J. M. BLESS. 1974. The Westphalian of the Netherlands with special reference to miospore assemblages. Geol. Mijnb., 53: 295-328.
VARMA, C. P. 1969. Lower Carboniferous miospores from the Albert Oil Shales (Horton Group) of New Brunswick, Canada. Micropaleontology, 15: 301-324.
VENKATACHALA, B. S. 1963. On some new spore genera from the Upper Carboniferous coals of Lothringen-Saar-Pfalz Basin. Palaeobotanist, 11: 38-42.
VENKATACHALA, B. S., and D. C. BHARADWAJ. 1964. Sporological study of the coals from Falkenberg (Faulquemont) Colliery, Lothringen (Lorraine), France. Palaeobotanist, 11: 159-207.
VENKATACHALA, B. S., and R. K. KAR. 1965. Two new trilete spore genera from the Permian of India. Palaeobotanist, 13: 337-340.
VENKATACHALA, B. S., and S. K. SALUJHA. 1971. Pollen and spores from the pre-Verne cyclical formation of the Saginaw Group, Grand Ledge, Michigan, U.S.A. Contr. Mus. Paleont. Univ. Michigan, 23: 263-281.
VISSCHER, H. 1966. Palaeobotany of the Mesophytic. III. Plant microfossils from the upper Bunter of Hengelo, the Netherlands. Acta Bot. Neerlandica, 15: 316-375.
VISSCHER, H., and L. KRYSTYN. 1978. Aspects of Late Triassic palynology. 4. A palynological assemblage from ammonoid-controlled Late Karnian (Tuvalian) sediments of Sicily. Rev. Palaeobot. Palynology, 26: 93-112.
WALTON, J. 1957. On *Protopitys* (Göppert): With a description of a fertile specimen '*Protopitys*

scotica' sp. nov. from the Calciferous Sandstone series of Dunbartonshire. Trans. Royal Soc. Edinburgh, 63: 333-339.
WELLER, J. M. 1960. Stratigraphic Principles and Practice. Harper, New York: 1-725.
WELLER, J. M., H. R. WANLESS, L. M. CLINE and D. G. STOOKEY. 1942. Interbasin Pennsylvanian correlations, Illinois and Iowa. Amer. Assoc. Petroleum Geologists Bull., 26: 1585-1593.
WHITE, C. A., and O. H. ST. JOHN. 1870. Report on the geological survey of the state of Iowa, 2 vols., 1: 1-319.
WILLIAMS, R. W. 1955. *Pityosporites westphalensis* sp. nov., an abietineous type pollen grain from the Coal Measures of Britain. Ann. Mag. Nat. Hist., 8: 465-473.
WILSON, L. R. 1943. Elater-bearing spores from the Pennsylvanian strata of Iowa. Amer. Midl. Naturalist, 30: 518-523.
WILSON, L. R. 1960. *Florinites pelucidus* (*sic*) and *Endosporites ornatus* with observations on their morphology. Okla. Geol. Notes, 20: 29-33.
WILSON, L. R. 1962. Permian plant microfossils from the Flowerpot Formation. Okla. Geol. Survey Circ. 49: 1-50.
WILSON, L. R. 1963. *Elaterites triferens* from a Kansas coal ball. Micropaleontology, 9: 101-102.
WILSON, L. R. 1966. Type species of *Cirratriradites* Wilson and Coe 1940. Okla. Geol. Notes, 26: 38-42.
WILSON, L. R. 1976. Desmoinesian coal seams of northeastern Oklahoma and their palynological content. In Coal and Oil Potential of the Tri-State Area, Tulsa Geol. Soc. Field Trip Guidebook, R. W. Scott, ed.: 19-32.
WILSON, L. R., and E. A. COE. 1940. Description of some unassigned plant microfossils from the Des Moines Series of Iowa. Amer. Midl. Naturalist, 23: 182-186.
WILSON, L. R., and W. S. HOFFMEISTER. 1956. Plant microfossils of the Croweburg Coal. Okla. Geol. Survey Circ. 32: 1-57.
WILSON, L. R., and R. M. KOSANKE. 1944. Seven new species of unassigned plant microfossils from the Des Moines Series of Iowa. Iowa Acad. Sci. Proc., 51: 329-333.
WILSON, L. R., and B. S. VENKATACHALA. 1963a. An emendation of *Vestispora* Wilson and Hoffmeister 1956. Okla. Geol. Notes, 23: 94-100.
WILSON, L. R., and B. S. VENKATACHALA. 1963b. *Thymospora*, a new name for *Verrucososporites*. Okla. Geol. Notes, 23: 75-79.
WILSON, L. R., and B. S. VENKATACHALA. 1963c. A morphologic study and emendation of *Vesicaspora* Schemel 1951. Okla. Geol. Notes, 23: 142-149.
WILSON, L. R., and B. S. VENKATACHALA. 1964. *Potonieisporites elegans* (Wilson and Kosanke) comb. nov. Okla. Geol. Notes, 24: 67-68.
WILSON, L. R., and B. S. VENKATACHALA. 1967. *Circlettisporites* Miller 1966, a synonym of *Leschikisporis* Potonié 1958. Pollen et Spores, 9: 363-365.
WINGATE, F. H. 1980. Plant microfossils from the Denton Shale Member of the Bokchito Formation (Lower Cretaceous, Albian) in southern Oklahoma. Okla. Geol. Surv. Bull. 130: 1-93.
WINSLOW, M. R. 1959. Upper Mississippian and Pennsylvanian megaspores and other plant microfossils from Illinois. Ill. St. Geol. Surv. Bull. 86: 1-135.
YBERT, J.-P., J. NAHUYS and B. ALPERN. 1971. Étude palynologique et pétrographique de quelques charbons du sud du Brésil. 6ème Cong. Internat. Strat. Géol. Carb., Sheffield, 1967, C. r., 4: 1605-1627.
ZACHRY, D. L., and P. K. SUTHERLAND. 1982. Stratigraphy and depositional framework of the Atoka Formation, Arkoma Basin of Arkansas and Oklahoma (abstr.). Geol. Soc. America Abstr. w. Progr., South-Central Sec.: 141.
ZERNDT, J. 1934. Les mégaspores du bassin houiller polonais. I. Trav. Geol., 1: 1-56.
ZHANG, L.-J. 1980. Late Triassic spores and pollen, Qinling Range. Nanjing Inst. Geol. Palaeont., Paper for 5th Int. Palynol. Conf.

PLATES

Figures are magnified 800X except as noted otherwise. Dimensions noted in micrometers (μm) refer to the maximum diameter of the specimen, unless qualified. Coordinates cited in parentheses refer respectively to the horizontal X vertical Vernier scales of the Leitz Wetzlar microscope, serial number 826091, at the Department of Geology, University of Iowa. Specimens examined with the scanning electron microscope were not retained.

PLATE 1

1. *Deltoidospora gracilis* (Imgrund) n. comb.; Blackoak Coal, CP-10-49 slide C-2 (121.0 X 66.2), 22.8 μm.
2. *Deltoidospora subadnatoides* (Bhardwaj) n. comb.; Blackoak Coal, CP-19-4 slide DB1Y (121.0 X 62.5), 23.9 μm.
3. *Deltoidospora priddyi* (Berry) McGregor 1973; Blackoak Coal, CP-19-4 slide 1C4 (135.9 X 42.7), 33.1 μm.
4. *Deltoidospora sphaerotriangula* (Loose) n. comb.; Blackoak Coal, CP-19-4 slide 1C4 (127.0 X 35.7), 42.8 μm.
5. *Deltoidospora levis* (Kosanke) n. comb.; Wheeler Coal, CP-77-137 slide 9 (122.2 X 70.5), 43.4 μm.
6. *Deltoidospora ornata* (Ishchenko) Braman and Hills 1977; unnamed coal in the Kilbourn Formation, CP-69-144 slide 7 (121.6 X 56.2), 30.4 μm.
7. *Deltoidospora ornata* (Ishchenko) Braman and Hills 1977; Wildcat Den Coal, F-WH4 slide M-15 (138.9 X 53.4), 27.9 μm.
8. *Deltoidospora subintorta* (Waltz) Braman and Hills 1977 var. *rotundata* Waltz; Wildcat Den Coal, F-WH4 slide A-9 (119.9 X 54.5), 49.2 μm.
9. *Punctatisporites minutus* Kosanke emend. Peppers 1964; Blackoak Coal, CP-19-4 slide 1W1 (119.1 X 71.4), 28.5 μm.
10. *Deltoidospora smithii* n. name; Wildcat Den Coal, F-1 slide 32 (124.5 X 58.5), 57.6 μm. Proximal focus showing laesura.
11. Same as 10, distal focus revealing thickness of exine at equator.
12. *Deltoidospora smithii* n. name; SEM 1200X, Wildcat Den Coal, WH4. Proximal view showing external surface expression of laesura.
13. Detail of 12, 2500X, showing suboptically punctate surface in region of proximal pole.
14. *Punctatisporites* sp. cf. *P. incomptus* Felix and Burbridge 1967; Wildcat Den Coal, F-WH4 slide M-1 (126.0 X 60.3), 45.6 μm.
15. *Punctatisporites irrasus* Hacquebard 1957; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-3 (138.6 X 63.2), 55.3 μm.
16. *Punctatisporites irrasus* Hacquebard 1957; Wildcat Den Coal, F-I slide 15 (134.1 X 66.4), 53.0 μm.
17. *Punctatisporites* sp. cf. *P. nudus* Artüz 1957; Blackoak Coal, CP-19-4 slide 1W2 (123.0 X 59.1), 51.3 μm.
18. *Punctatisporites glaber* (Naumova) Playford 1962; Blackoak Coal, CP-19-4 slide 5F4 (133.8 X 44.2), 37.1 μm.
19. *Punctatisporites glaber* (Naumova) Playford 1962; Blackoak Coal, CP-10-49 slide C-1 (123.8 X 59.0), 58.1 μm.

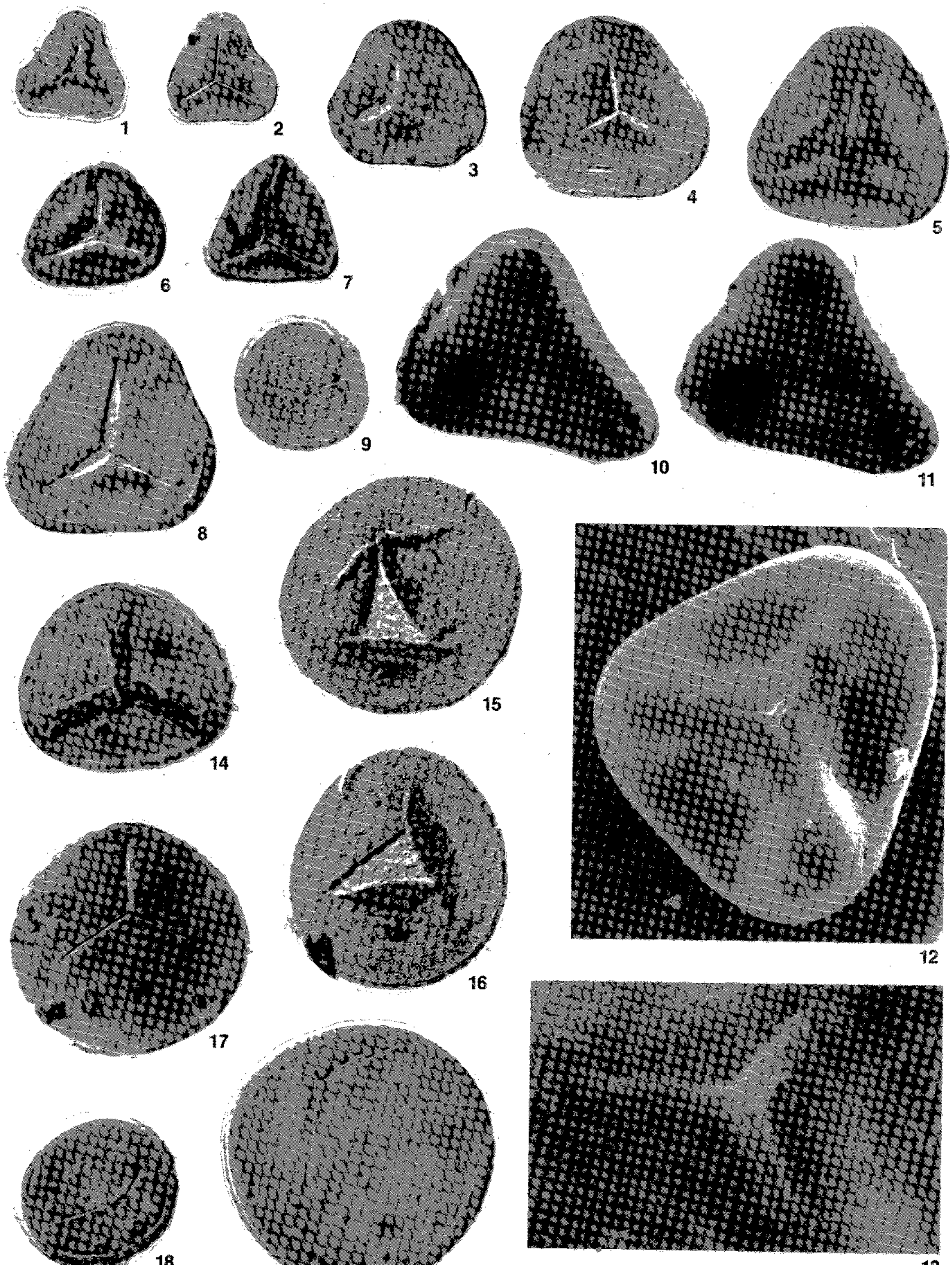

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

PLATE 2

1. *Granulatisporites adnatus* Kosanke 1950; unnamed coal in the Kilbourn Formation, CP-17-13 slide A-6 (119.9 X 55.2), 26.8 μm.
2. *Granulatisporites adnatus* Kosanke 1950; Wildcat Den Coal, WH4 slide Z-5 (125.1 X 41.8), 31.9 μm.
3. *Granulatisporites granularis* Kosanke 1950; Cliffland Coal, CP-41-48 slide M-3 (120.6 X 62.0), 23.9 μm.
4. *Granulatisporites granularis* Kosanke 1950; Blackoak Coal, CP-19-4 slide 1C4 (137.8 X 43.4), 25.7 μm.
5. *Granulatisporites microgranifer* Ibrahim 1933; Blackoak Coal, CP-37-126 slide 11 (125.0 X 67.7), 18.8 μm.
6. *Granulatisporites microgranifer* Ibrahim 1933; Blackoak Coal, CP-19-4 slide 1C4 (122.3 X 56.8), 22.8 μm.
7. *Granulatisporites* sp. cf. *G. piroformis* Loose 1934; Wildcat Den Coal, F-I slide 38 (121.5 X 48.8), 22.8 μm.
8. *Granulatisporites* sp. cf. *G. piroformis* Loose 1934; Wildcat Den Coal, F-I slide 38 (121.1 X 34.9), 25.7 μm.
9. *Granulatisporites granulatus* Ibrahim 1933; Blackoak Coal, CP-19-4 slide 1C6 (119.4 X 71.4), 28.5 μm.
10. *Granulatisporites pallidus* Kosanke 1950; Wildcat Den Coal, WH4 slide Z-7 (128.6 X 46.6), 46.7 μm.
11. *Granulatisporites minutus* Potonié and Kremp 1955; Blackoak Coal, CP-37-126 slide 11 (120.0 X 52.2), 21.6 μm.
12. *Granulatisporites minutus* Potonié and Kremp 1955; Wildcat Den Coal, F-II slide 14 (122.8 X 59.5), 23.4 μm.
13. *Granulatisporites* sp. cf. *G. piroformis* Loose 1934; SEM 2000X, unnamed coal in the Kilbourn Formation, CP-17-13.
14. *Granulatisporites parvus* (Ibrahim) Potonié and Kremp 1955; Wildcat Den Coal, WH4 slide A-8 (131.0 X 51.5), 42.8 μm.
15. *Punctatisporites flavus* (Kosanke) Potonié and Kremp 1955; Wildcat Den Coal, WH4 slide A-10 (125.8 X 56.2), 100.8 μm.
16. *Punctatisporites aerarius* Butterworth and Williams 1958; Cliffland Coal, CP-73-299 slide 9 (135.1 X 55.0), 73.0 μm.
17. *Punctatisporites obesus* (Loose) Potonié and Kremp 1955; unnamed coal in the Kilbourn Formation, CP-80-411 slide 6 (125.8 X 39.0), 68.4 μm.
18. *Punctatisporites obesus* (Loose) Potonié and Kremp 1955; Cliffland Coal, CP-25-8 slide 9 (132.2 X 64.1), 113.6 μm; 600X.
19. *Punctatisporites edgarensis* Peppers 1970; Laddsdale Coal, 416804-2 slide 6 (119.7 X 43.8), 99.4 μm.
20. *Punctatisporites kankakeensis* Peppers 1970; Blackoak Coal, CP-19-4 slide 5A9 (120.0 X 66.2), 68.7 μm.
21. *Punctatisporites kankakeensis* Peppers 1970; Bevier Coal, 1207791-7 slide 5 (130.3 X 57.6), 54.2 μm.

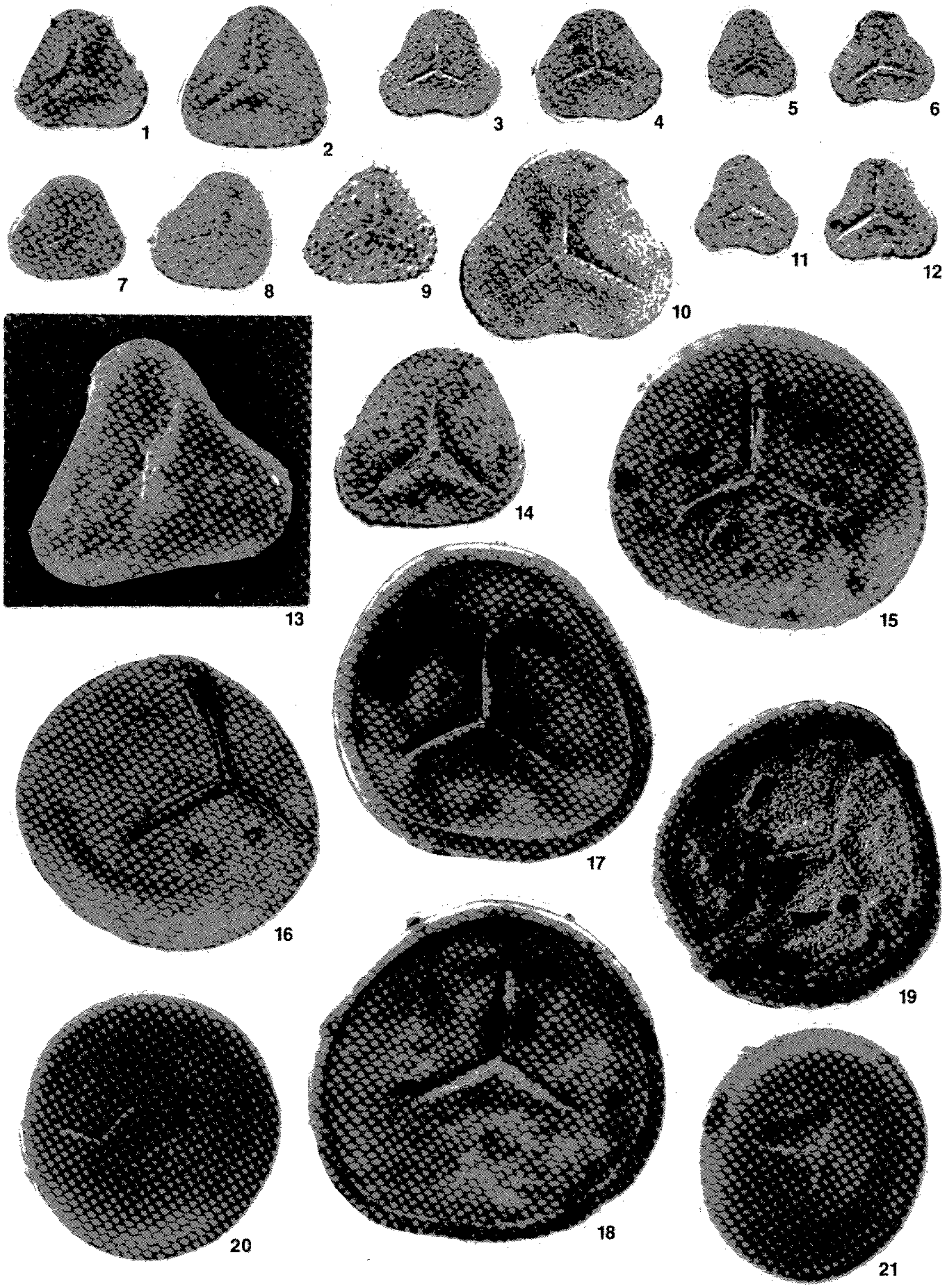

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

PLATE 3

1. *Granulatisporites verrucosus* (Wilson and Coe) Schopf, Wilson and Bentall 1944; Wildcat Den Coal, F-II slide 40 (127.4 X 60.0), 37.6 μm.
2. *Granulatisporites verrucosus* (Wilson and Coe) Schopf, Wilson and Bentall 1944; unnamed coal in the Kilbourn Formation, CP-17-13 slide D-5 (125.1 X 69.8), 37.6 μm.
3. *Cyclogranisporites minutus* Bhardwaj 1957 emend.; Blackoak Coal, CP-19-4 slide 1X2 (128.0 X 41.5), 28.5 μm.
4. *Cyclogranisporites minutus* Bhardwaj 1957 emend.; Blackoak Coal, CP-19-4 slide 1Y6 (125.1 X 50.2), 31.4 μm. Note darkened contact area characteristic of the species *C. parvus* Bhardwaj 1957, considered in this report to be conspecific with *C. minutus*.
5. *Cyclogranisporites orbicularis* (Kosanke) Potonié and Kremp 1955; Blackoak Coal, CP-19-4 slide 1B8 (132.2 X 48.8), 39.3 μm.
6. *Cyclogranisporites obliquus* (Kosanke) Upshaw and Hedlund 1967; Bevier Coal, 1207791-7 slide 6 (139.8 X 63.2), 33.1 μm.
7. *Cyclogranisporites obliquus* (Kosanke) Upshaw and Hedlund 1967; Laddsdale Coal, CP-43-23 slide 5 (123.9 X 70.8), 35.9 μm.
8. *Cyclogranisporites obliquus* (Kosanke) Upshaw and Hedlund 1967; Laddsdale Coal, CP-43-23 slide 7 (127.9 X 55.5), 47.3 μm.
9. *Cyclogranisporites leopoldii* (Kremp) Potonié and Kremp 1955; Laddsdale Coal, 416804-2 slide 3 (121.4 X 41.3), 36.5 μm.
10. *Cyclogranisporites leopoldii* (Kremp) Potonié and Kremp 1955; Laddsdale Coal, ISU-I slide 7 (122.0 X 37.1), 27.9 μm.
11. *Cyclogranisporites aureus* (Loose) Potonié and Kremp 1955; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-3 (132.6 X 38.1), 51.3 μm.
12. *Cyclogranisporites aureus* (Loose) Potonié and Kremp 1955; Mulky Coal, CP-41-2 slide 13 (132.4 X 51.8), 74.7 μm.
13. *Cyclogranisporites peppersii* n. name; Bevier Coal, 1207791-7 slide 4 (137.1 X 62.0), 86.6 μm; 600X.
14. *Cyclogranisporites peppersii* n. name; Bevier Coal, 1207791-7 slide 2 (125.5 X 45.9), 85.2 μm; 600X.
15. *Cyclogranisporites lasius* (Waltz) Playford 1962; Wildcat Den Coal, F-III slide 35 (126.6 X 44.9), 61.0 μm.
16. *Cyclogranisporites lasius* (Waltz) Playford 1962; SEM 1000X, Wildcat Den Coal, F-WH4.
17. *Cyclogranisporites microgranus* Bhardwaj 1957; Blackoak Coal, CP-19-4 slide 1Y3 (123.9 X 40.4), 45.0 μm.
18. *Cyclogranisporites microgranus* Bhardwaj 1957; SEM 1000X, Laddsdale Coal, 416804-2. Distal surface.
19. *Cyclogranisporites* sp. 1; Wheeler Coal, CP-77-137 slide 10 (131.1 X 73.4), 65.6 μm.

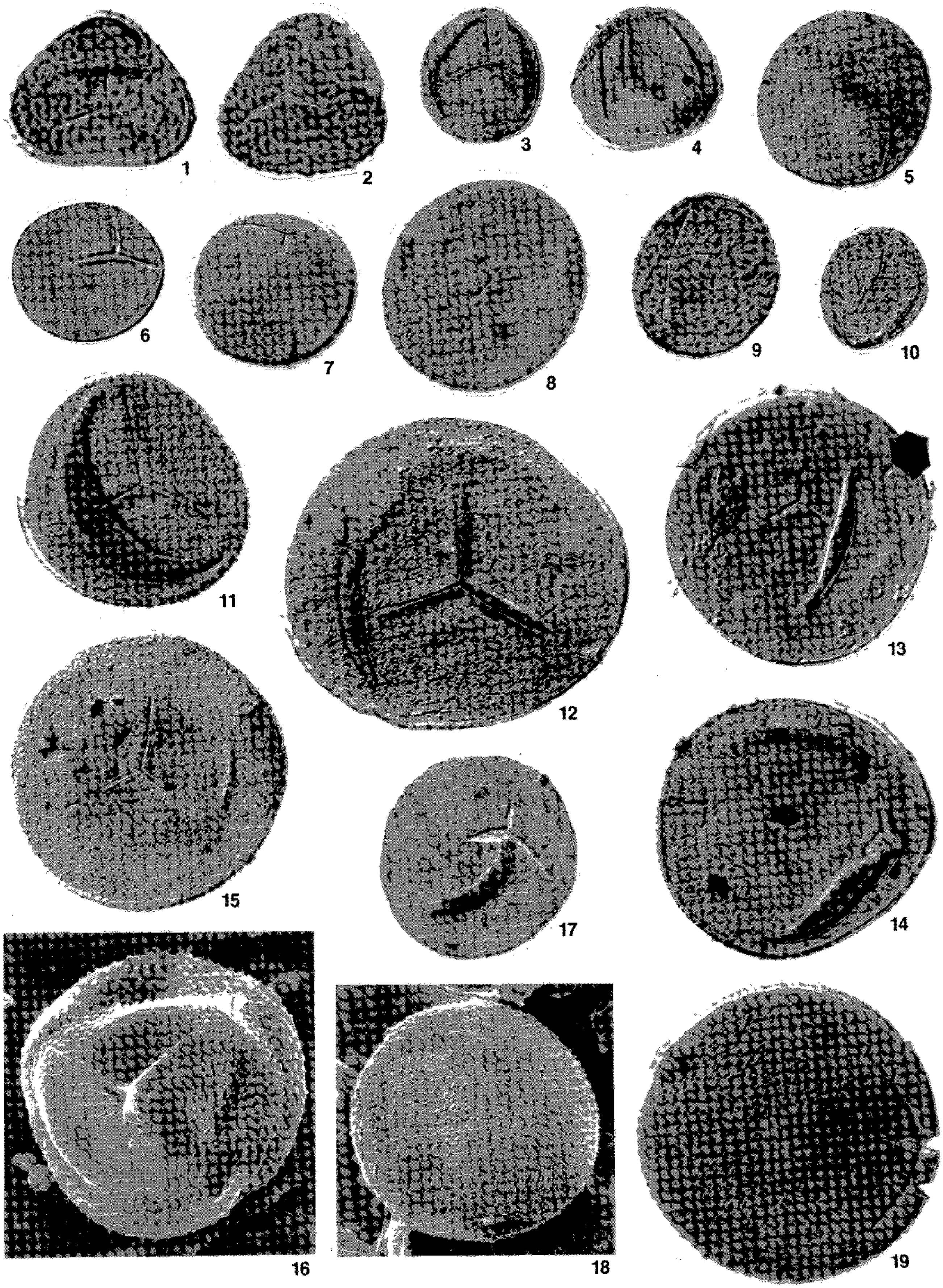

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

PLATE 4

1. *Lophotriletes commissuralis* (Kosanke) Potonié and Kremp 1955; Wildcat Den Coal, F-WH4 slide Z-4 (128.6 X 38.1), 29.1 μm.
2. *Lophotriletes commissuralis* (Kosanke) Potonié and Kremp 1955; Wildcat Den Coal, F-II slide 36 (130.8 X 46.0), 30.2 μm.
3. *Lophotriletes rarispinosus* Peppers 1970; Blackoak Coal, CP-19-4 slide 1C1 (138.8 X 57.2), 26.2 μm.
4. *Lophotriletes rarispinosus* Peppers 1970; Blackoak Coal, CP-19-4 slide 1C4 (127.0 X 42.7), 22.8 μm.
5. *Lophotriletes microsaetosus* (Loose) Potonié and Kremp 1955; Blackoak Coal, CP-19-4 slide DB1Y (125.9 X 61.4), 28.5 μm.
6. *Lophotriletes microsaetosus* (Loose) Potonié and Kremp 1955; Wildcat Den Coal, F-WH4 slide A-16 (124.0 X 41.5), 32.5 μm.
7. *Lophotriletes mosaicus* Potonié and Kremp 1955; Blackoak Coal, CP-37-126 slide 15 (133.0 X 43.3), 31.9 μm.
8. *Lophotriletes mosaicus* Potonié and Kremp 1955; unnamed coal in the Kilbourn Formation, CP-17-13 slide B-3 (120.8 X 40.1), 33.1 μm.
9. *Lophotriletes? granoornatus* Artüz 1957; Blackoak Coal, CP-19-4 slide 1C2 (128.9 X 57.2), 31.9 μm.
10. *Verrucosisporites* sp. cf. *V. nitidus* Playford 1964; Wildcat Den Coal, F-WH4 slide Z-13 (135.0 X 66.6), 37.6 μm.
11. *Verrucosisporites morulatus* (Knox) Smith and Butterworth 1967; Wyoming Hill Coal, F-WH2 slide 5 (135.0 X 47.1), 47.3 μm.
12. *Verrucosisporites morulatus* (Knox) Smith and Butterworth 1967; Wyoming Hill Coal, F-WH2 slide 8 (137.2 X 54.2), 46.7 μm.
13. *Verrucosisporites microtuberosus* (Loose) Smith and Butterworth 1967; Blackoak Coal, CP-19-4 slide 1C4 (129.0 X 46.4), 90.0 μm; 600X.
14. *Verrucosisporites verrucosus* (Ibrahim) Ibrahim 1933; Wildcat Den Coal, F-III slide 37 (134.2 X 71.0), 78.8 μm.
15. *Verrucosisporites verrucosus* (Ibrahim) Ibrahim 1933; Cliffland Coal, CP-63-1 slide 4 (121.5 X 38.9), 77.0 μm.
16. *Verrucosisporites sifatii* (Ibrahim) Smith and Butterworth 1967; Blackoak Coal, CP-19-4 slide 7M1 (123.2 X 38.5), 110.8 μm; 600X.
17. *Verrucosisporites sifatii* (Ibrahim) Smith and Butterworth 1967; SEM 500X, Blackoak Coal, CP-10-49.
18. *Verrucosisporites donarii* Potonié and Kremp 1955; Blackoak Coal, CP-19-4 slide 6Z6 (134.1 X 73.0), 43.9 μm.
19. *Verrucosisporites donarii* Potonié and Kremp 1955; Blackoak Coal, CP-19-4 slide 1C2 (128.0 X 53.6), 41.6 μm.
20. *Verrucosisporites morulatus* (Knox) Smith and Butterworth 1967; SEM 1000X, Wyoming Hill Coal, F-WH2. Proximal surface.

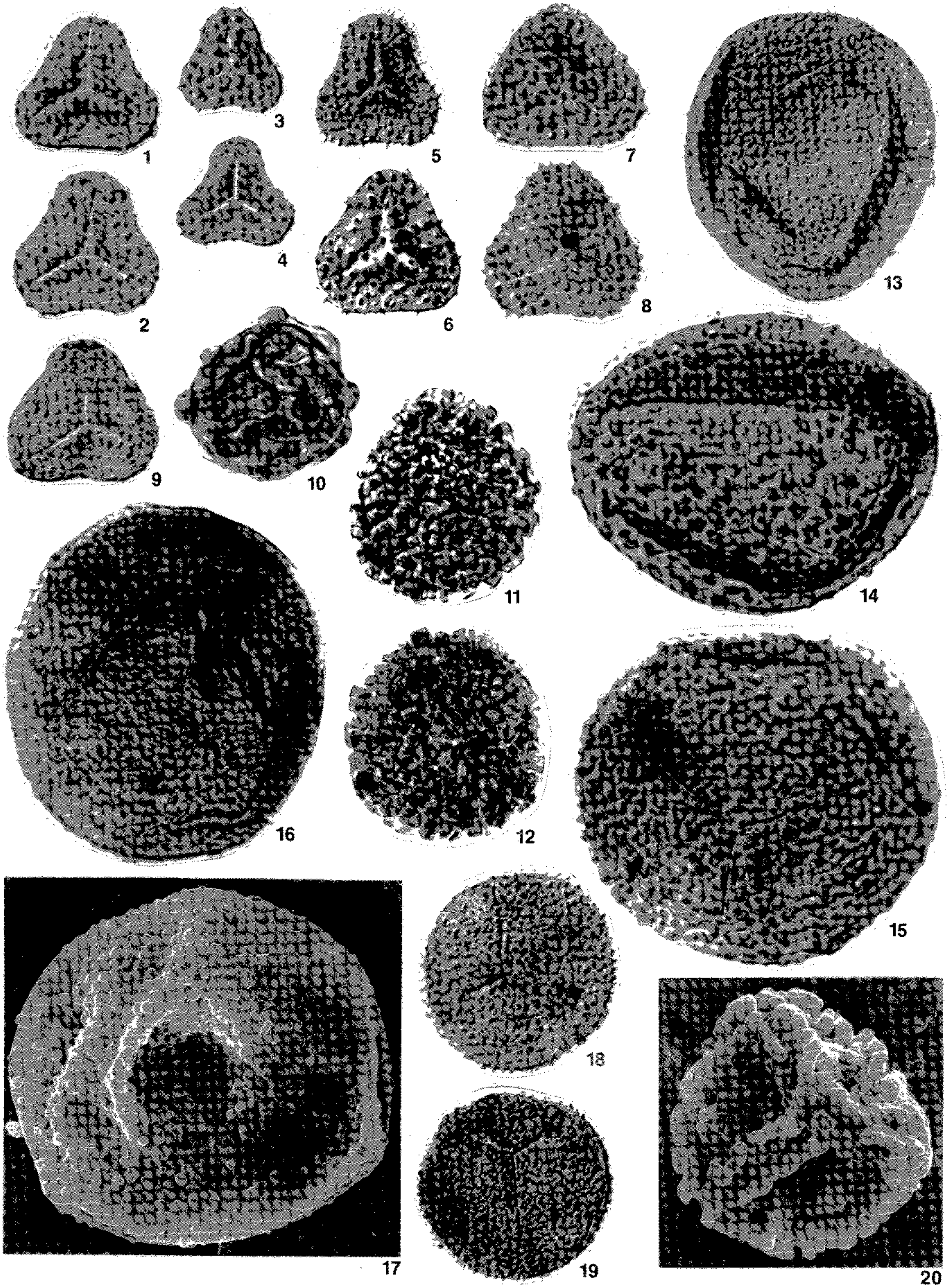

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

PLATE 5

1. *Lophotriletes copiosus* Peppers 1970; Blackoak Coal, CP-19-4 slide 1C6 (121.1 X 46.1), 36.5 μm.
2. *Lophotriletes pseudaculeatus* Potonié and Kremp 1955; Blackoak Coal, CP-10-49 slide C-3 (119.4 X 69.3), 33.1 μm excluding ornament.
3. *Lophotriletes pseudaculeatus* Potonié and Kremp 1955; unnamed coal in the Kilbourn Formation, CP-17-13 slide A-2, (126.8 X 41.4), 41.7 μm excluding ornament.
4. *Lophotriletes* sp. cf. *L. tuberifer* (Imgrund) Potonié and Kremp ex Imgrund 1960; Blackoak Coal, CP-19-4 slide 1Y3 (124.0 X 39.3), 37.1 μm.
5. *Lophotriletes* sp. cf. *L. tuberifer* (Imgrund) Potonié and Kremp ex Imgrund 1960; unnamed coal in the Kilbourn Formation, CP-17-13 slide A-2 (138.9 X 48.0), 38.8 μm.
6. *Apiculatasporites aculeatus* (Ibrahim) n. comb.; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-5 (118.0 X 45.2), 42.8 μm.
7. *Apiculatasporites aculeatus* (Ibrahim) n. comb.; unnamed coal in the Kilbourn Formation, CP-17-13 slide A-3 (136.8 X 63.1), 44.6 μm.
8. *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp 1955; Blackoak Coal, CP-19-4 slide 1D6 (136.9 X 40.0), 43.9 μm.
9. *Camptotriletes confertus* (Ravn) n. comb.; Blackoak Coal, CP-19-4 slide 2J2 (127.7 X 41.0), 43.3 μm (holotype).
10. *Camptotriletes confertus* (Ravn) n. comb.; Blackoak Coal, CP-19-4 slide 2J6 (128.0 X 28.8), 50.2 μm (paratype).
11. *Lophotriletes ibrahimii* (Peppers) Pi-Radondy and Doubinger 1968; SEM stereopair 700X, Cliffland Coal, CP-73-299.
12. *Lophotriletes ibrahimii* (Peppers) Pi-Radondy and Doubinger 1968; Cliffland Coal, CP-7-43 slide 7 (129.4 X 67.6), 41.7 μm excluding ornament.
13. *Lophotriletes ibrahimii* (Peppers) Pi-Radondy and Doubinger 1968; Cliffland Coal, CP-73-299 slide 7 (129.3 X 34.7), 38.8 μm excluding ornament.
14. *Apiculatasporites spinulistratus* (Loose) Ibrahim 1933; Laddsdale Coal, CP-66-185 slide 6 (122.9 X 70.0), 58.7 μm.
15. *Apiculatasporites spinulistratus* (Loose) Ibrahim 1933; Blackoak Coal, CP-19-4 slide 7R3 (131.0 X 42.2), 62.7 μm.
16. *Apiculatasporites saetiger* (Peppers) n. comb.; Cliffland Coal, CP-31-9 slide 5 (133.2 X 67.5), 25.1 μm.
17. *Apiculatasporites variusetosus* (Peppers) n. comb.; Cliffland Coal, QCC-1003791 slide 6 (130.0 X 37.8), 68.4 μm excluding ornament.
18. *Apiculatasporites spinososaetosus* (Loose) n. comb.; Blackoak Coal, CP-10-49 slide B-7 (132.6 X 47.6), 51.3 μm excluding ornament.
19. *Apiculatasporites* sp. 1; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-1 (138.2 X 62.4), 53.0 μm excluding ornament.

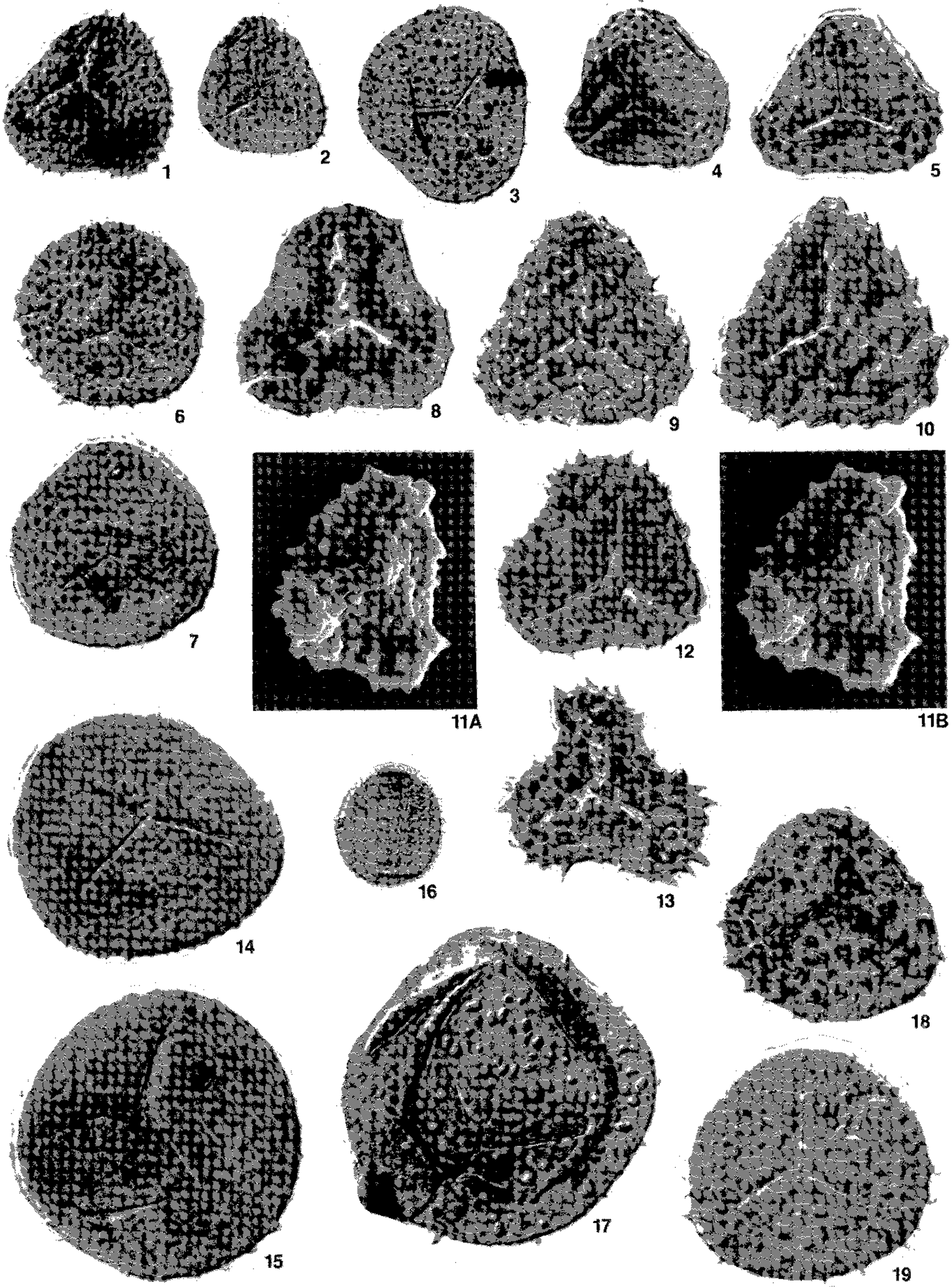

1
2
3
4
5
6
8
9
10
7
11A
12
11B
14
16
13
18
17
15
19

PLATE 6

1. *Raistrickia? abdita* (Loose) Schopf, Wilson and Bentall 1944; Wildcat Den Coal, F-WH4 slide Z-11 (123.5 X 45.8), 51.3 μm excluding ornament; proximal focus.
2. Same as 1, distal focus.
3. *Raistrickia? abdita* (Loose) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-19-4 slide 3A4 (132.5 X 30.8), 68.4 μm.
4. *Raistrickia irregularis* Kosanke 1950; Laddsdale Coal, CP-66-185 slide 1 (135.9 X 58.9), 46.2 μm.
5. *Raistrickia irregularis* Kosanke 1950; SEM 700X, Blackoak Coal, CP-10-49. Distal surface.
6. *Apiculatasporites setulosus* (Kosanke) n. comb.; Wildcat Den Coal, F-III slide 40 (130.2 X 49.7), 62.7 μm excluding ornament.
7. *Apiculatasporites latigranifer* (Loose) n. comb.; Wildcat Den Coal, F-WH4 slide A-18 (127.9 X 71.0), 68.1 μm.
8. *Apiculatasporites variocorneus* (Sullivan) n. comb.; Wildcat Den Coal, F-WH4 slide M-15 (130.5 X 36.7), 61.0 μm excluding ornament; proximal focus.
9. Same as 8, distal focus.
10. *Apiculatasporites valvatus* n. sp.; Bevier Coal, 1207791-7 slide 6 (131.1 X 40.0), 50.1 μm (holotype).
11. *Apiculatasporites valvatus* n. sp.; Bevier Coal, 1207791-7 slide 10 (131.0 X 42.2), 62.7 μm (paratype).
12. *Apiculatasporites valvatus* n. sp.; Bevier Coal, 1207791-7 slide 5 (138.5 X 62.5), 54.2 μm (paratype).

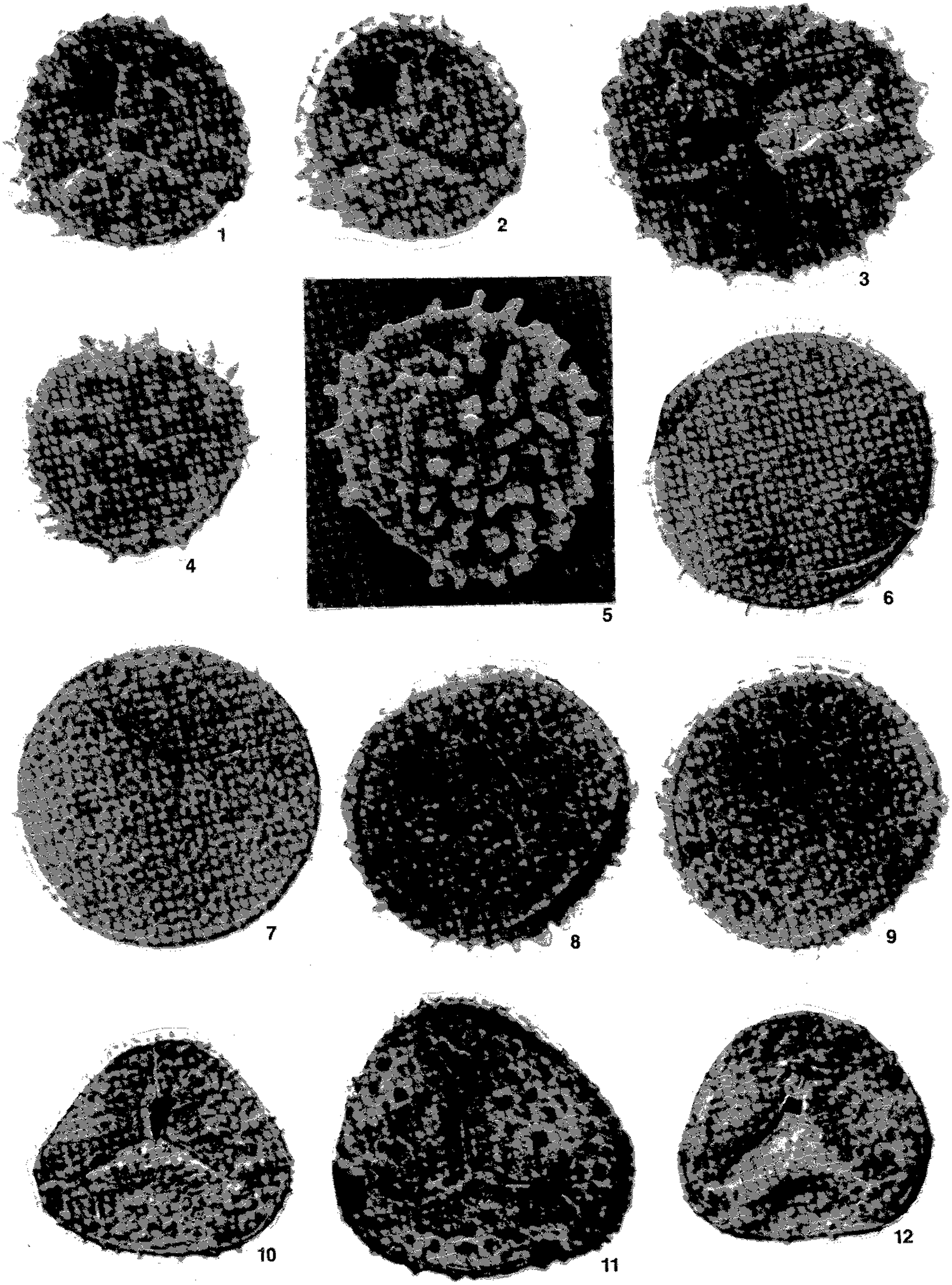

1
2
3
4
5
6
7
8
9
10
11
12

PLATE 7

1. *Pilosisporites williamsii* n. sp.; Blackoak Coal, CP-19-4 slide 1Z2 (138.8 X 69.5), 25.7 μm excluding ornament (holotype).
2. *Pilosisporites williamsii* n. sp.; unnamed coal in the Kilbourn Formation, CP-17-13 slide B-6 (123.6 X 73.1), 28.5 μm excluding ornament (paratype).
3. *Pilosisporites williamsii* n. sp.; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-1 (118.0 X 39.8), 25.7 μm excluding ornament (paratype).
4. *Pilosisporites knoxiae* n. name; Cliffland Coal, CP-43-23 slide 109 (129.0 X 56.0), 22.7 μm excluding ornament.
5. *Pilosisporites aculeolatus* (Kosanke) n. comb.; Blackoak Coal, CP-19-4 slide 1C4 (126.6 X 67.2), 33.1 μm.
6. *Pilosisporites triquetrus* (Smith and Butterworth) n. comb.; Blackoak Coal, CP-19-4 slide 3M6 (121.8 X 57.7), 24.5 μm excluding ornament.
7. *Pilosisporites triquetrus* (Smith and Butterworth) n. comb.; SEM stereopair 1000X, Blackoak Coal, CP-10-49. Distal surface.
8. *Pilosisporites dimorphus* (Habib) n. comb.; Bevier Coal, 1207791-7 slide 5 (134.0 X 71.4), 38.2 μm excluding ornament.
9. *Pilosisporites dimorphus* (Habib) n. comb.; unnamed coal in the Kilbourn Formation, CP-17-13 slide B-4 (125.2 X 35.8), 36.5 μm excluding ornament.
10. *Pilosisporites* sp. cf. *P. falcatus* (Knox) n. comb.; Blackoak Coal, CP-19-4 slide 2H4 (124.1 X 30.5), 45.6 μm excluding ornament.
11. *Raistrickia pilosa* Kosanke 1950; Blackoak Coal, CP-19-4 slide 4M2 (133.0 X 46.9), 24.5 μm excluding ornament.
12. *Raistrickia* sp. cf. *R. macra* Bhardwaj 1957; Cliffland Coal, CP-73-299 slide 7 (133.3 X 42.2), 45.6 μm excluding ornament.
13. *Raistrickia superba* (Ibrahim) Schopf, Wilson and Bentall 1944; unnamed coal in the Kilbourn Formation, CP-17-13 slide A-3 (128.8 X 37.7), 50.1 μm excluding ornament.
14. *Raistrickia* sp. cf. *R. clavata* Hacquebard emend. Playford 1964; Wheeler Coal, CP-79-189 slide 7 (134.1 X 40.5), 59.3 μm excluding ornament.
15. *Raistrickia subcrinita* Peppers 1970; Bevier Coal, 1207791-7 slide 9 (118.0 X 66.2), 42.8 μm excluding ornament.
16. *Raistrickia subcrinita* Peppers 1970; Wheeler Coal, CP-23-2 slide 6 (125.1 X 59.2), 47.3 μm excluding ornament.
17. *Raistrickia crinita* Kosanke 1950; Summit Coal, CP-22-165 slide 11 (118.8 X 54.5), 50.7 μm excluding ornament.
18. *Raistrickia crinita* Kosanke 1950; SEM 700X, Summit Coal, CP-22-165. Proximal surface.
19. *Raistrickia crinita* Kosanke 1950; Bevier Coal, 1207791-7 slide 9 (118.5 X 59.3), 51.9 μm excluding ornament.

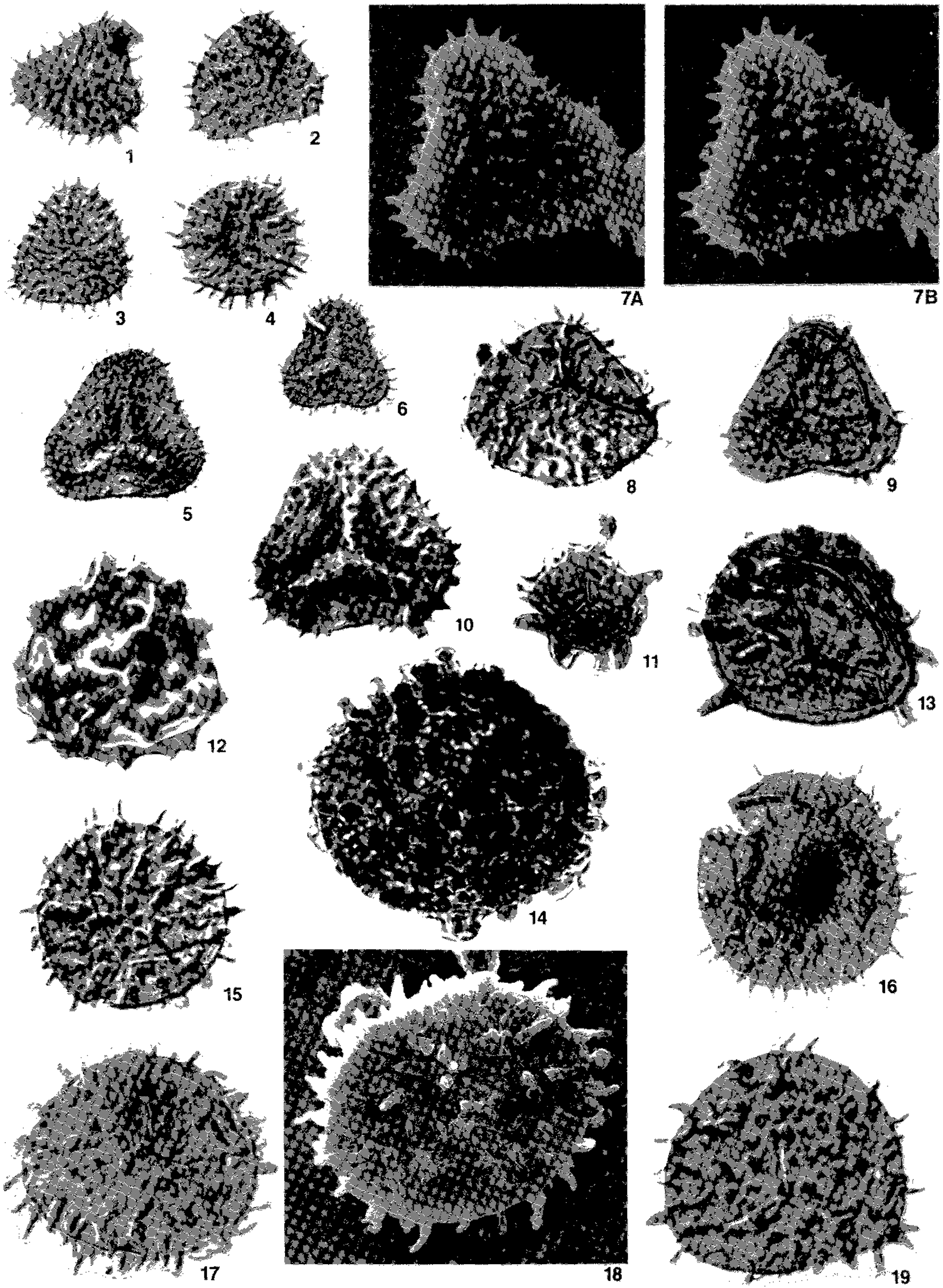

1
2
3
4
5
6
7A
7B
8
9
10
11
12
13
14
15
16
17
18
19

PLATE 8

1. *Raistrickia breveminens* Peppers 1970; Wildcat Den Coal, F-III slide 37 (119.1 X 36.0), 61.0 μm excluding ornament.
2. *Raistrickia breveminens* Peppers 1970; unnamed coal in the Kilbourn Formation, CP-41-67 slide 15 (124.4 X 60.9), 50.2 μm excluding ornament.
3. *Raistrickia breveminens* Peppers 1970; SEM 800X, unnamed coal in the Kilbourn Formation, CP-41-67. Proximal surface.
4. *Raistrickia protensa* Kosanke 1950; Blackoak Coal, CP-19-4 slide 2J3 (136.5 X 50.2), 46.2 μm excluding ornament.
5. *Raistrickia lowellensis* Peppers 1970; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-3 (133.7 X 66.6), 58.1 μm excluding ornament.
6. *Raistrickia lowellensis* Peppers 1970; Blackoak Coal, CP-19-4 slide 6Z4 (130.1 X 32.6), 55.9 μm excluding ornament.
7. *Raistrickia lacerata* Peppers 1970; Wildcat Den Coal, F-WH4 slide M-3 (130.9 X 44.8), 52.4 μm excluding ornament.
8. *Raistrickia lacerata* Peppers 1970; Blackoak Coal, CP-19-4 slide 5C3 (131.1 X 39.6), 55.4 μm excluding ornament.
9. *Raistrickia saetosa* (Loose) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-19-4 slide 5A4 (134.3 X 61.6), 61.6 μm excluding ornament.
10. *Convolutispora cerina* Ravn 1979; Blackoak Coal, CP-19-4 slide 3M6 (133.9 X 31.5), 43.9 μm (paratype).
11. *Convolutispora cerina* Ravn 1979; Laddsdale Coal, AM-1 slide 4 (135.6 X 46.7), 50.2 μm.
12. *Raistrickia* sp. 1; Laddsdale Coal, CP-66-185 slide 5 (136.9 X 58.2), 66.7 μm excluding ornament.

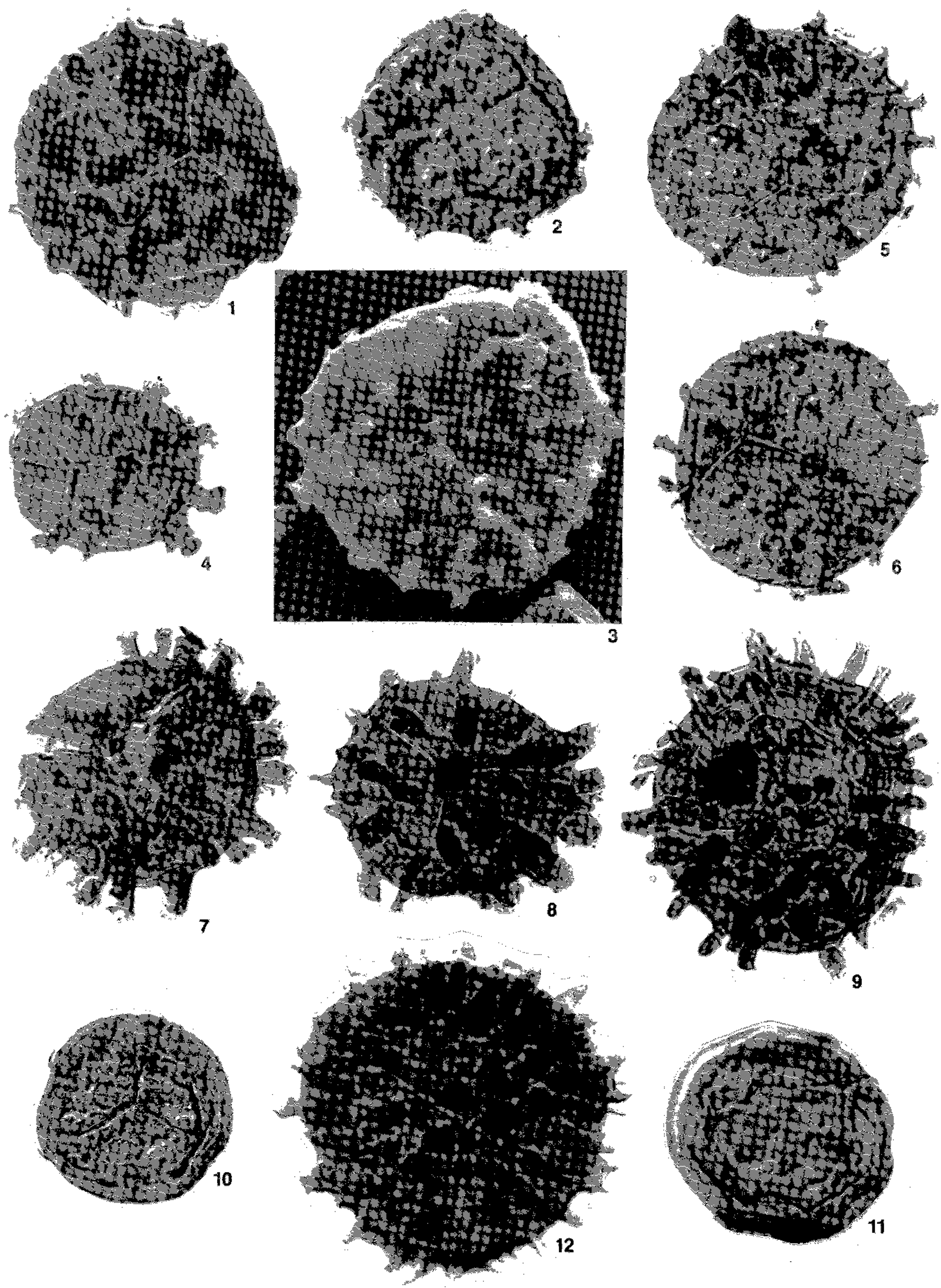

1
2
5
3
4
6
7
8
9
10
12
11

PLATE 9

1. *Convolutispora florida* Hoffmeister, Staplin and Malloy 1955; Cliffland Coal, CP-41-48 slide Y-5 (135.9 X 70.7), 42.8 μm; proximal focus.
2. Same as 1, distal focus.
3. *Convolutispora florida* Hoffmeister, Staplin and Malloy 1955; SEM 700X, Wildcat Den Coal, F-II.
4. *Convolutispora florida* Hoffmeister, Staplin and Malloy 1955; Wildcat Den Coal, F-WH4 slide M-10 (130.0 X 61.2), 42.8 μm.
5. *Convolutispora florida* Hoffmeister, Staplin and Malloy 1955; Wildcat Den Coal, F-II slide 38 (126.1 X 54.9), 42.8 μm.
6. *Convolutispora florida* Hoffmeister, Staplin and Malloy 1955; Wildcat Den Coal, F-II slide 39 (132.9 X 38.0), 41.7 μm.
7. *Convolutispora fromensis* Balme and Hassell 1962; Blackoak Coal, CP-10-49 slide B-7 (132.4 X 66.3), 41.7 μm.
8. *Microreticulatisporites hortonensis* Playford 1964; Wildcat Den Coal, F-WH4 slide Z-8 (131.2 X 58.2), 41.7 μm.
9. *Convolutispora* sp. cf. *C. varicosa* Butterworth and Williams 1958; Bevier Coal, 1207791-7 slide 3 (120.4 X 50.7), 55.3 μm.
10. *Microreticulatisporites concavus* Butterworth and Williams 1958; Wildcat Den Coal, F-I slide 38 (125.3 X 45.9), 34.2 μm.
11. *Microreticulatisporites harrisonii* Peppers 1970; Blackoak Coal, CP-19-4 slide 1C4 (121.1 X 51.6), 32.5 μm.
12. *Microreticulatisporites harrisonii* Peppers 1970; Wildcat Den Coal, F-III slide 31 (138.8 X 54.2), 34.2 μm.
13. *Microreticulatisporites harrisonii* Peppers 1970; Blackoak Coal, CP-42-32 slide 14 (121.0 X 57.6), 29.1 μm.
14. *Convolutispora papillosa* (Ibrahim) n. comb.; Wildcat Den Coal, F-WH4 slide M-20 (121.1 X 62.2), 63.3 μm; medial focus revealing thickness of exine.
15. Same as 14, distal focus revealing external sculpture.
16. *Convolutispora mellita* Hoffmeister, Staplin and Malloy 1955; unnamed coal in the Kilbourn Formation, CP-63-5-361 (131.1 X 70.7), slide 2, 59.9 μm.
17. *Convolutispora mellita* Hoffmeister, Staplin and Malloy 1955; Wildcat Den Coal, F-II slide 39 (133.0 X 34.4), 64.4 μm.
18. *Convolutispora mellita* Hoffmeister, Staplin and Malloy 1955; SEM 600X, Wildcat Den Coal, F-WH4. Distal surface.
19. *Convolutispora* sp. 1; Blackoak Coal, CP-10-49 slide C-7 (130.2 X 56.9), 58.7 μm.

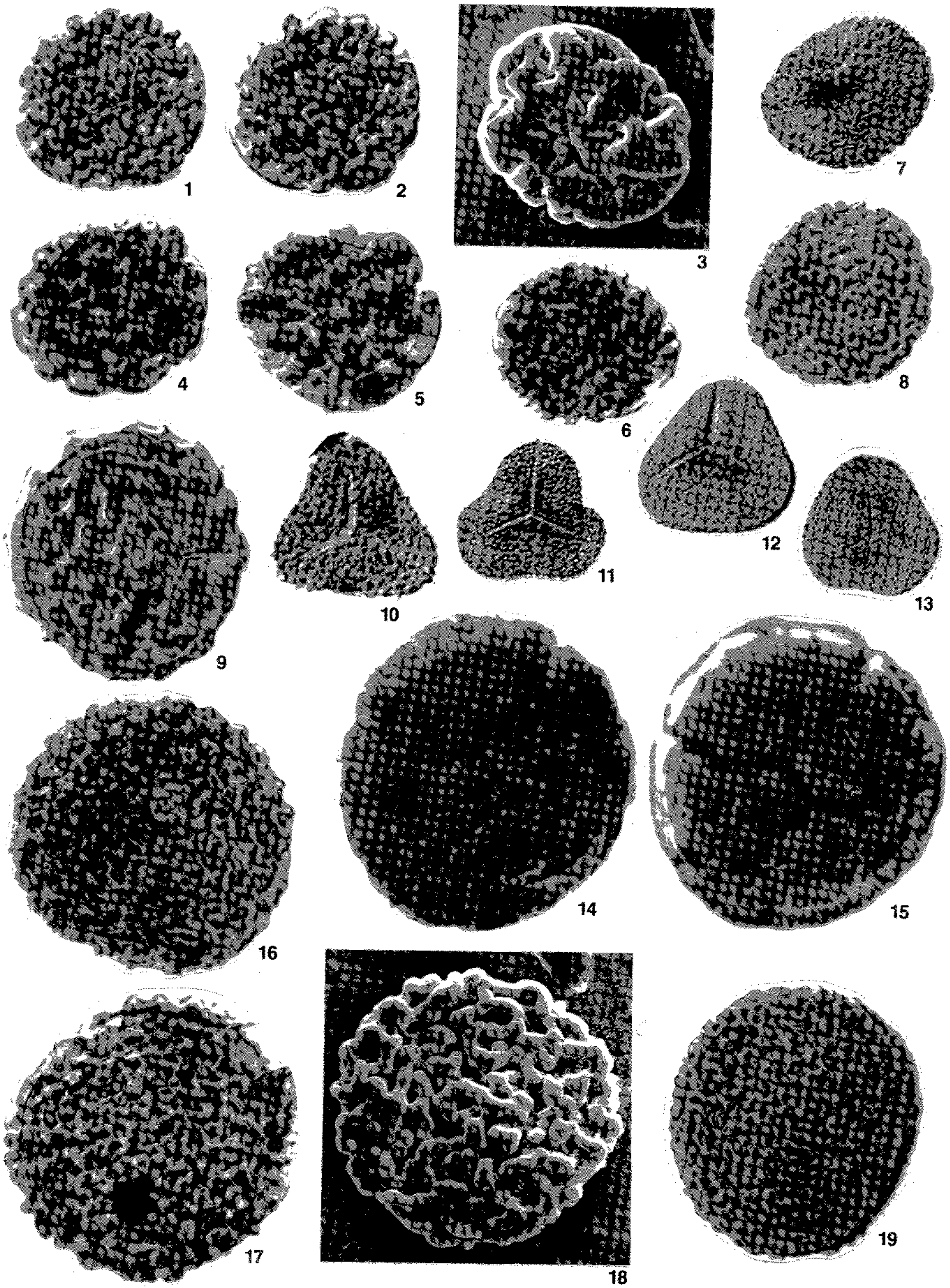


PLATE 10

1. *Microreticulatisporites nobilis* (Wicher) Knox 1950; Blackoak Coal, CP-19-4 slide 6V4 (119.5 X 52.4), 34.2 μm.
2. *Microreticulatisporites nobilis* (Wicher) Knox 1950; Laddsdale Coal, CP-39-16 slide 1 (120.8 X 49.0), 37.1 μm.
3. *Microreticulatisporites nobilis* (Wicher) Knox 1950; SEM stereopair 800X, Blackoak Coal, CP-45-13-103. Distal surface.
4. *Microreticulatisporites lacunosus* (Ibrahim) Knox 1950; Blackoak Coal, CP-43-44 slide 1 (132.0 X 47.2), 51.1 μm.
5. *Microreticulatisporites sulcatus* (Wilson and Kosanke) Smith and Butterworth 1967; Laddsdale Coal, CP-39-16 slide 7 (128.9 X 43.8), 45.1 μm.
6. *Microreticulatisporites sulcatus* (Wilson and Kosanke) Smith and Butterworth 1967; Laddsdale Coal, CP-39-16 slide 7 (125.2 X 44.2), 46.2 μm.
7. *Microreticulatisporites sulcatus* (Wilson and Kosanke) Smith and Butterworth 1967; Laddsdale Coal, CP-39-16 slide 1 (129.4 X 72.7), 42.8 μm.
8. *Microreticulatisporites sulcatus* (Wilson and Kosanke) Smith and Butterworth 1967; SEM 800X, Laddsdale Coal, CP-39-16. Proximal surface.
9. *Microreticulatisporites sulcatus* (Wilson and Kosanke) Smith and Butterworth 1967; SEM 800X, Laddsdale Coal, CP-39-16. Distal surface.
10. *Camptotriletes triangularis* Peppers 1970; Bevier Coal, 1207791-7 slide 6 (130.1 X 44.4), 42.8 μm.
11. *Camptotriletes triangularis* Peppers 1970; Laddsdale Coal, CP-39-16 slide 3 (132.9 X 49.0), 45.6 μm.
12. *Microreticulatisporites* sp. 1; Blackoak Coal, CP-37-126 slide 16 (119.1 X 54.9), 22.8 μm.
13. *Camptotriletes certus* Venkatachala and Bharadwaj 1964; Blackoak Coal, CP-19-4 slide 1Z6 (120.0 X 50.8), 41.0 μm.
14. *Camptotriletes bucculentus* (Loose) Potonié and Kremp 1955; Blackoak Coal, CP-37-126 slide 12 (127.3 X 68.6), 56.4 μm.
15. *Camptotriletes bucculentus* (Loose) Potonié and Kremp 1955; Wildcat Den Coal, F-III slide 34 (130.9 X 66.2), 53.0 μm.
16. *Camptotriletes* sp. cf. *C. superbus* Neves 1961; Laddsdale Coal, ISU-I slide 9 (132.8 X 53.2), 75.2 μm.

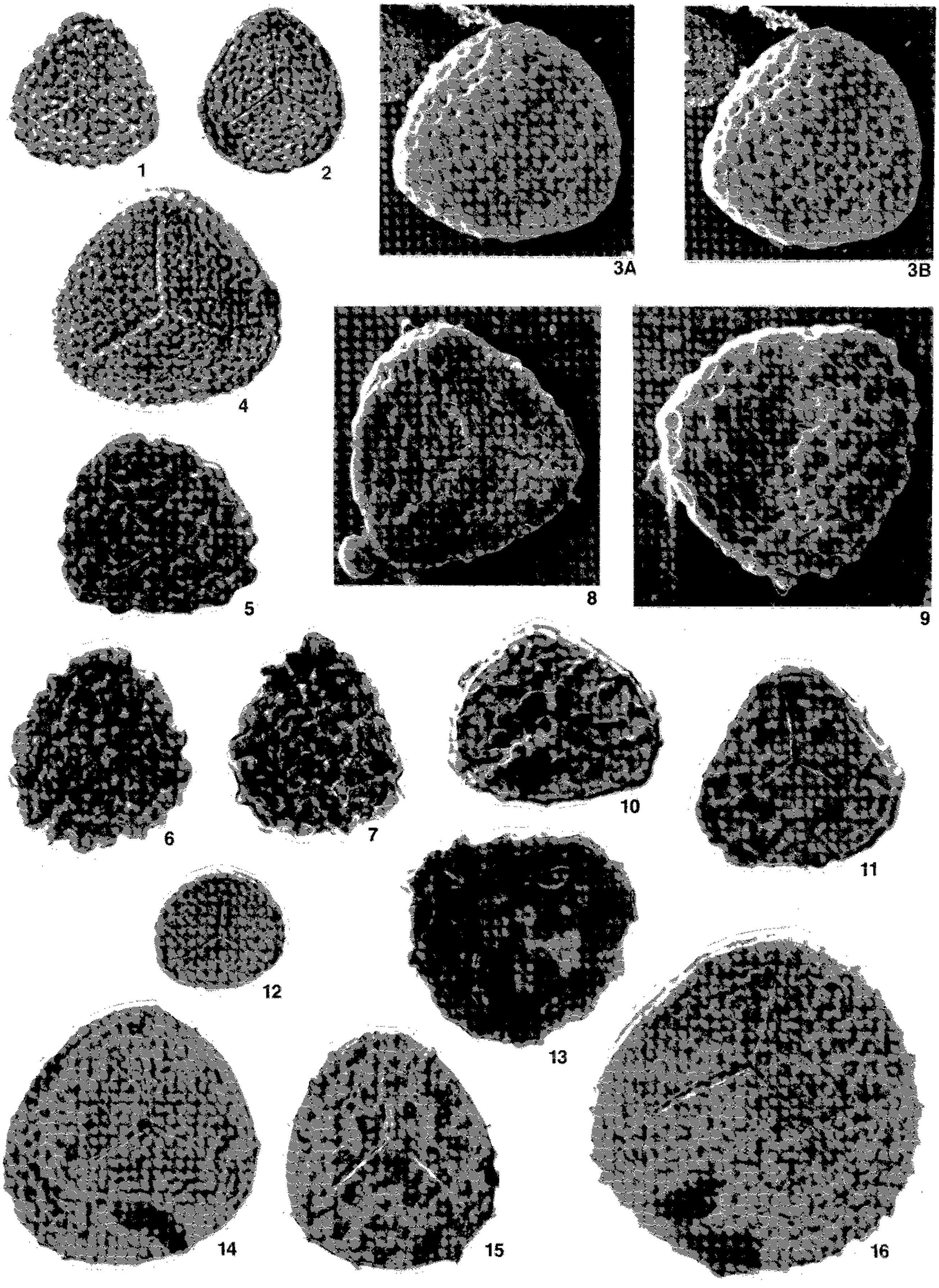

1
2
3A
3B
4
5
8
9
6
7
10
11
12
13
14
15
16

PLATE 11

1. *Savitrisporites concavus* Marshall and Smith 1965; Wildcat Den Coal, F-1 slide 36 (130.3 X 41.0), 30.2 μm.
2. *Savitrisporites asperatus* Sullivan 1964; Wildcat Den Coal, F-WH4 slide M-5 (125.5 X 46.8), 51.3 μm.
3. *Savitrisporites asperatus* Sullivan 1964; SEM 750X, Wildcat Den Coal, F-WH4. Proximal surface showing ridged trilete laesura and three small apical papillae.
4. *Savitrisporites asperatus* Sullivan 1964; Wildcat Den Coal, F-WH4 slide M-18 (129.9 X 63.8), 48.9 μm; proximal focus.
5. Same as 4, distal focus.
6. *Savitrisporites majus* Bhardwaj 1957; Cliffland Coal, CP-73-299 slide 3 (123.1 X 73.2), 58.1 μm.
7. *Savitrisporites majus* Bhardwaj 1957; SEM 750X, Cliffland Coal, CP-73-299. Distal surface.
8. *Savitrisporites majus* Bhardwaj 1957; Blackoak Coal, CP-37-126 slide 13 (132.6 X 69.7), 36.5 μm.
9. *Savitrisporites majus* Bhardwaj 1957; Cliffland Coal, CP-73-299 slide 7 (126.0 X 49.2), 47.9 μm.
10. *Savitrisporites nux* (Butterworth and Williams) Sullivan emend. Smith and Butterworth 1967; Wildcat Den Coal, F-WH4 slide M-7 (125.1 X 53.6), 58.7 μm.
11. *Savitrisporites nux* (Butterworth and Williams) Sullivan emend. Smith and Butterworth 1967; Wildcat Den Coal, F-III slide 31 (129.0 X 69.4), 46.7 μm.
12. *Savitrisporites nux* (Butterworth and Williams) Sullivan emend. Smith and Butterworth 1967; unnamed coal in the Kilbourn Formation, CP-80-411 slide 9 (127.1 X 65.2), 45.6 μm.
13. *Savitrisporites nux* (Butterworth and Williams) Sullivan emend. Smith and Butterworth 1967; Blackoak Coal, CP-22-444 slide 2 (134.4 X 71.4), 54.2 μm.
14. *Savitrisporites robustus* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-WH4 slide M-4 (136.3 X 44.9), 62.7 μm (holotype).
15. *Savitrisporites robustus* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-WH4 slide Z-5 (126.0 X 52.0), 70.2 μm (paratype).

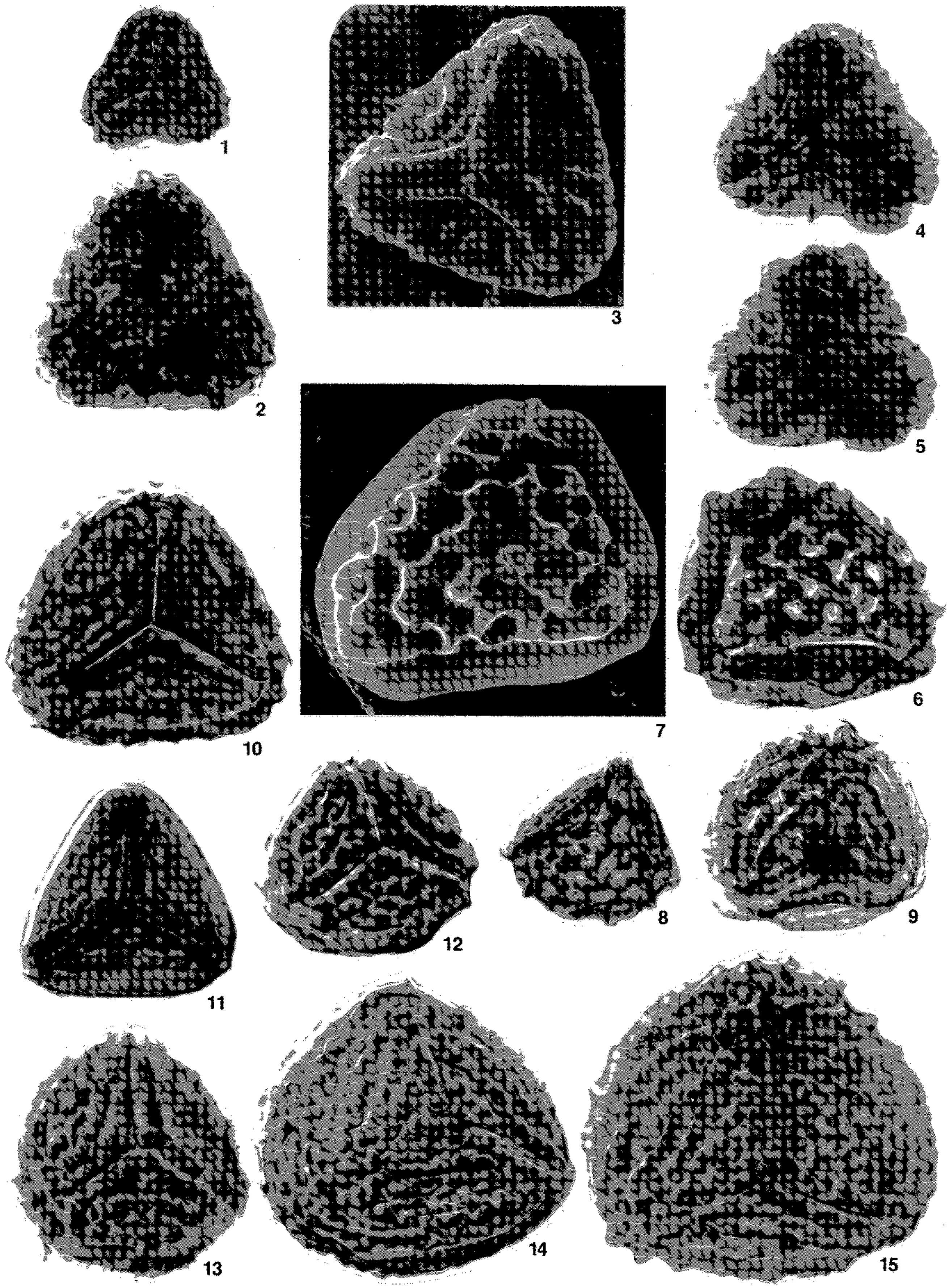

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

PLATE 12

1. *Savitrisporites* sp. 1; Blackoak Coal, CP-19-4 slide 6R2 (119.4 X 65.0), 54.7 μm.
2. *Savitrisporites* sp. 1; Cliffland Coal, CP-43-23 slide 8 (131.2 X 70.9), 58.1 μm; proximal focus.
3. Same as 3, distal focus.
4. *Calamospora straminea* Wilson and Kosanke 1944; Blackoak Coal, CP-19-4 slide 1W2 (120.4 X 64.8), 35.9 μm.
5. *Calamospora parva* Guennel 1958; Wildcat Den Coal, F-I slide 40 (126.2 X 62.8), 37.1 μm.
6. *Calamospora liquida* Kosanke 1950; Wildcat Den Coal, F-III slide 11 (122.1 X 67.0), 74.1 μm.
7. *Calamospora nebulosa* Ravn 1979; Blackoak Coal, CP-19-4 slide 6Z4 (130.0 X 32.7), 87.0 μm (paratype); 600X.
8. *Calamospora nebulosa* Ravn 1979; Blackoak Coal, CP-19-4 slide 6Z4 (139.1 X 35.1),, 85.2 μm (holotype); 600X.
9. *Calamospora flexilis* Kosanke 1950; unnamed coal in the Kilbourn Formation, CP-17-13 slide A-6 (137.9 X 57.1), 70.3 μm.
10. *Calamospora flexilis* Kosanke 1950; Cliffland Coal, CP-73-299 slide 7 (127.8 X 38.9), 65.6 μm.
11. *Calamospora flexilis* Kosanke 1950; SEM 600X, Summit Coal, CP-22-165. Proximal surface showing raised, folded trilete laesura.
12. *Calamospora mutabilis* (Loose) Schopf, Wilson and Bentall 1944; Wildcat Den Coal, F-WH4 slide Z-1 (121.1 X 55.5), 174.7 μm; 600X.

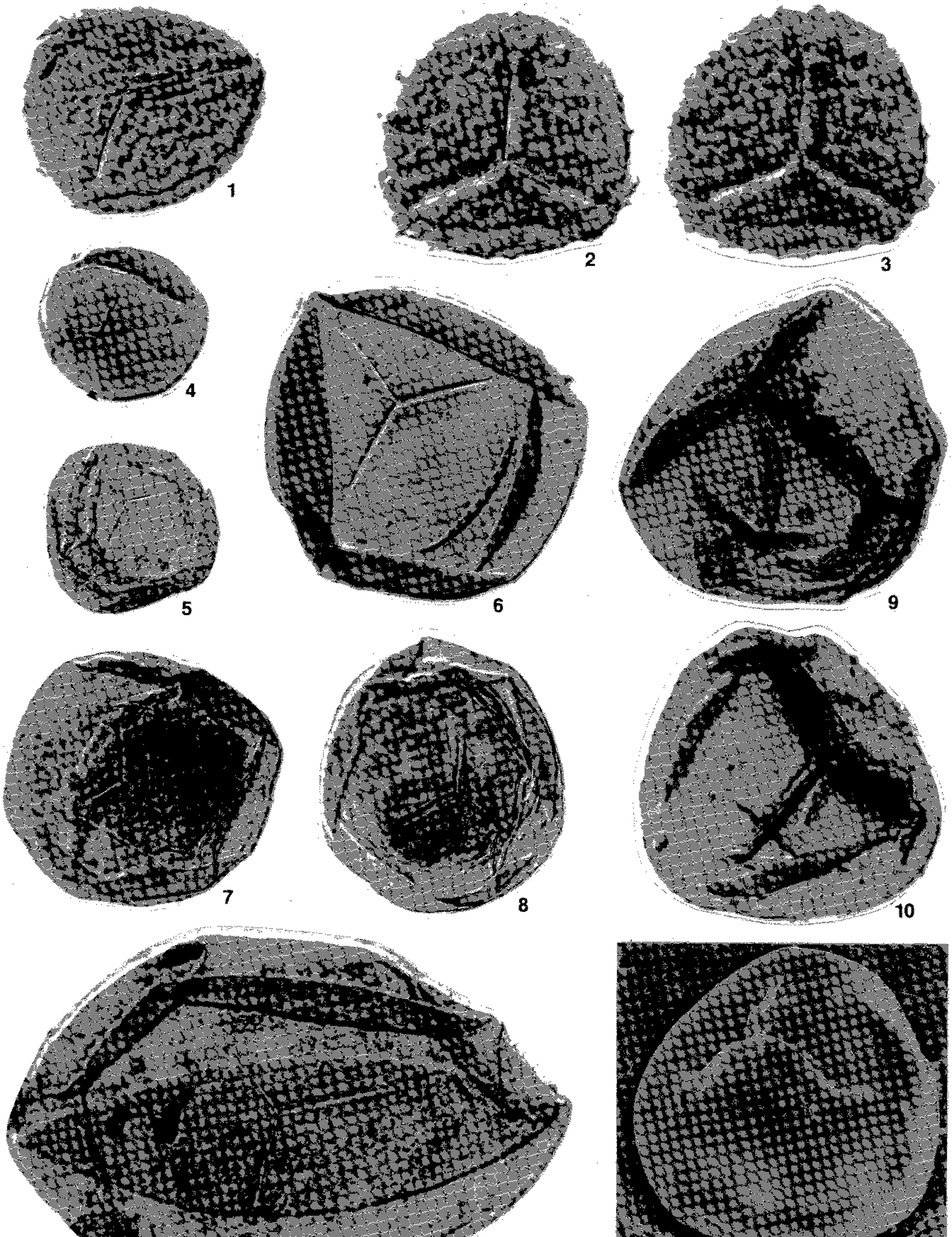

1
2
3
4
5
6
9
7
8
10
12
11

PLATE 13

1. *Calamospora breviradiata* Kosanke 1950; Blackoak Coal, CP-19-4 slide 1Z3 (121.2 X 49.0), 50.7 μm.
2. *Cordylosporites papillatus* (Naumova) Playford and Satterthwait 1985; Wildcat Den Coal, F-III slide 32 (124.9 X 57.5), 66.1 μm.
3. *Cordylosporites papillatus* (Naumova) Playford and Satterthwait 1985; SEM 600X, Wildcat Den Coal, F-WH4. Oblique view of proximal surface.
4. *Reticulatisporites reticulatus* (Ibrahim) Ibrahim 1933; Carruthers Coal, CP-22-32 slide 6 (129.1 X 65.8), 76.4 μm.
5. *Reticulatisporites reticulatus* (Ibrahim) Ibrahim 1933; Laddsdale Coal, 416804-2 slide 6 (132.3 X 61.1), 71.3 μm; proximal focus.
6. Same as 5, distal focus.
7. *Reticulatisporites reticulatus* (Ibrahim) Ibrahim 1933; SEM 600X, Cliffland Coal, CP-3-1. Distal surface.
8. *Calamospora pedata* Kosanke 1950; Blackoak Coal, CP-19-4 slide 6Z2 (133.0 X 56.6), 92.3 μm; 600X.
9. *Calamospora pedata* Kosanke 1950; Mulky Coal, CP-41-2 slide 16 (125.1 X 50.9), 57.6 μm.
10. *Reticulatisporites polygonalis* (Ibrahim) Smith and Butterworth 1967; SEM 600X, Blackoak Coal, CP-10-49. Distal surface; note finely scabrate sculpture on muri.
11. *Reticulatisporites polygonalis* (Ibrahim) Smith and Butterworth 1967; Wildcat Den Coal, F-1 slide 23 (135.4 X 14.6), 90.9 μm; 600X.
12. *Calamospora hartungiana* Schopf, in Schopf, Wilson and Bentall 1944; Wildcat Den Coal, F-II slide 26 (121.2 X 43.1), 75.3 μm; 600X.

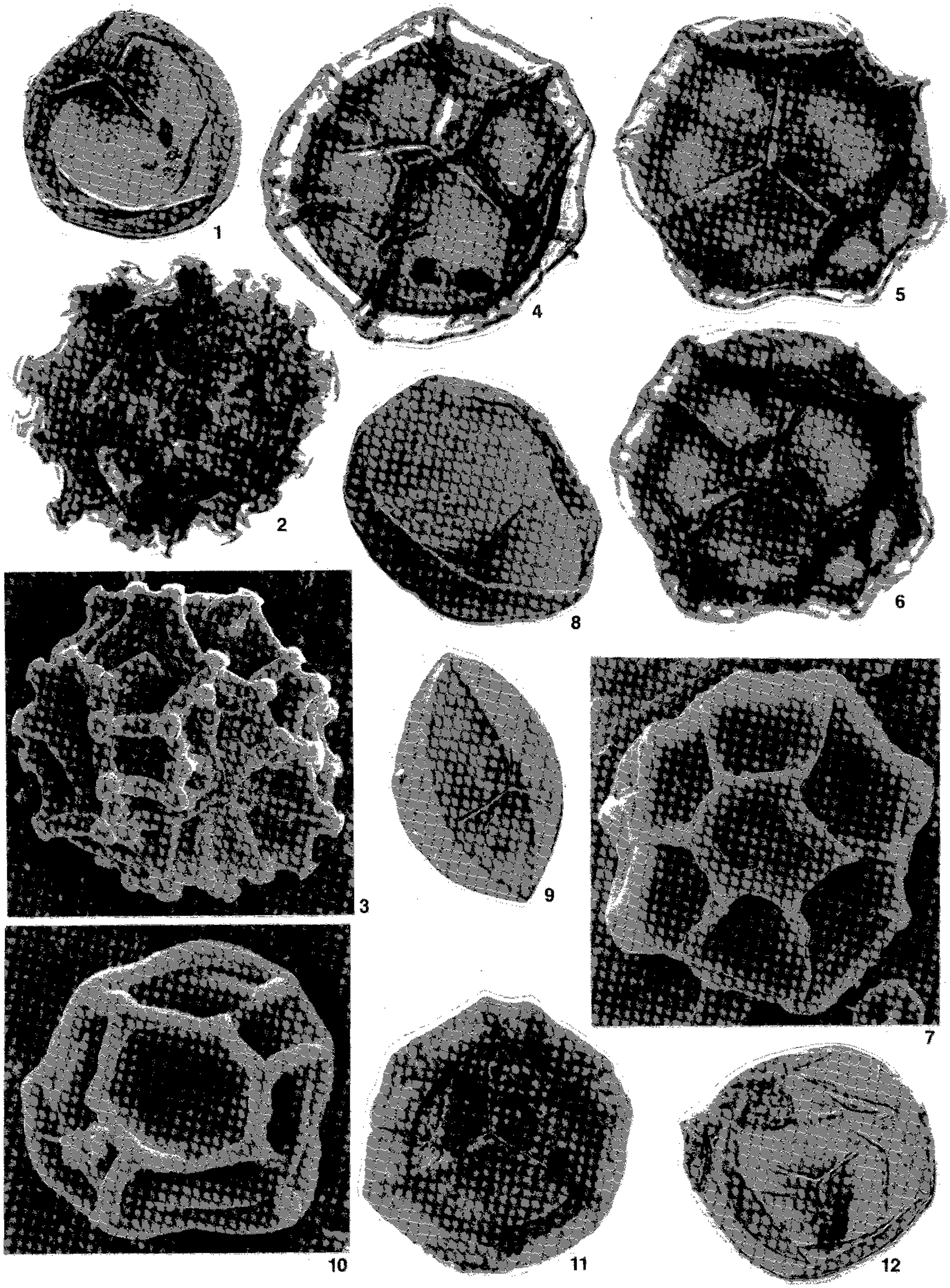

1
2
3
4
5
6
7
8
9
10
11
12

PLATE 14

1. *Vestispora costata* (Balme) Bhardwaj emend. Spode, in Smith and Butterworth, 1967; Cliffland Coal, CP-73-299 slide 4 (129.1 X 58.8), 39.3 μm; detached operculum.
2. *Vestispora costata* (Balme) Bhardwaj emend. Spode, in Smith and Butterworth, 1967; Cliffland Coal, CP-73-299 slide 3 (135.9 X 63.9), 69.0 μm.
3. *Reticulatisporites muricatus* Kosanke 1950; unnamed coal in the Kilbourn Formation, CP-41-67 slide 11 (137.0 X 66.2), 75.8 μm.
4. *Reticulatisporites muricatus* Kosanke 1950; SEM 600X, Cliffland Coal, CP-73-299. Distal surface.
5. *Vestispora laevigata* Wilson and Venkatachala 1963; Laddsdale Coal, CP-43-23 slide 7 (119.1 X 65.6), 95.1 μm.
6. *Reticulatisporites* sp. cf. *R. magnidictyus* Playford and Helby 1968; Wildcat Den Coal, F-WH4 slide A-3 (118.5 X 53.7), 63.3 μm.
7. *Vestispora laevigata* Wilson and Venkatachala 1963; Blackoak Coal, CP-19-4 slide DB1Z (133.8 X 58.0), 68.0 μm.
8. *Vestispora profunda* Wilson and Hoffmeister 1956; Blackoak Coal, CP-10-49 slide B-3 (128.6 X 46.9), 81.5 μm.
9. *Vestispora lucida* (Butterworth and Williams) Potonié 1960; Wildcat Den Coal, F-WH4 slide Z-7 (137.1 X 50.5), 98.0 μm; 600X.
10. *Elaterites triferens* Wilson 1943; Blackoak Coal, CP-19-4 slide DB1Y (124.0 X 52.1), 62.7 μm.
11. *Vestispora ludica* (Butterworth and Williams) Potonie 1960; Wildcat Den Coal, F-WH4 slide Z-16 (122.5 X 63.2), 89.5 μm; 600X.

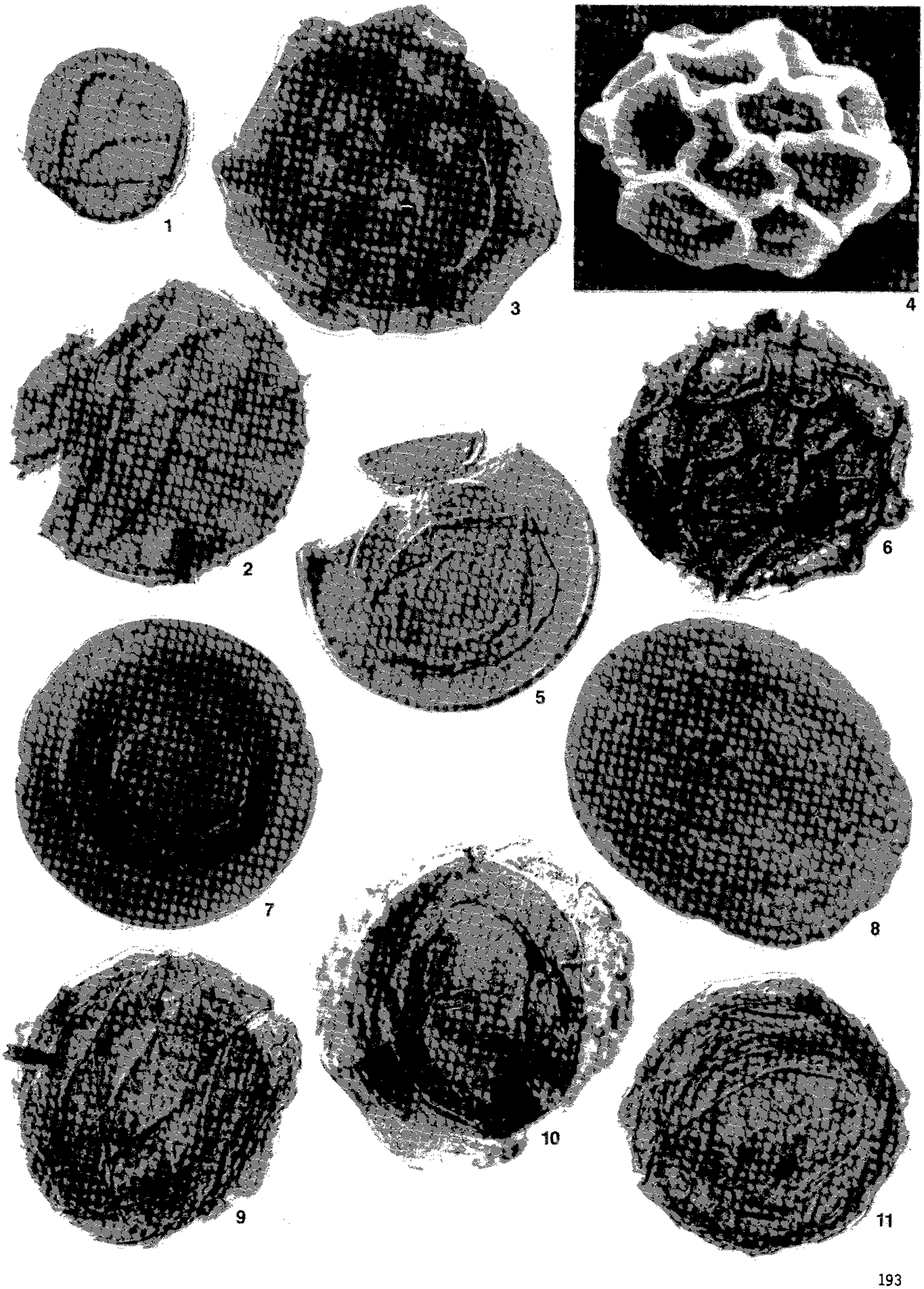

1
2
3
4
5
6
7
8
9
10
11

PLATE 15

1. *Vestispora fenestrata* (Kosanke and Brokaw) Wilson and Venkatachala emend. Spode, in Smith and Butterworth, 1967; Cliffland Coal, CP-3-1 slide 11 (122.4 X 64.3), 67.8 μm.
2. *Vestispora fenestrata* (Kosanke and Brokaw) Wilson and Venkatachala emend. Spode, in Smith and Butterworth, 1967; Blackoak Coal, CP-37-126 slide 11 (120.6 X 68.1), 37.1 μm; detached operculum.
3. *Vestispora fenestrata* (Kosanke and Brokaw) Wilson and Venkatachala emend. Spode, in Smith and Butterworth, 1967; Blackoak Coal, CP-37-126 slide 16 (136.7 X 57.9), 68.4 μm.
4. *Vestispora fenestrata* (Kosanke and Brokaw) Wilson and Venkatachala emend. Spode, in Smith and Butterworth, 1967; SEM 500X, Blackoak Coal, CP-22-444. Distal surface.
5. *Vestispora clara* (Venkatachala and Bharadwaj) n. comb.; Blackoak Coal, CP-19-4 slide 6Z2 (133.4 X 46.5), 43.9 μm; detached operculum.
6. *Vestispora clara* (Venkatachala and Bharadwaj) n. comb.; Laddsdale Coal, CP-66-185 slide 6 (132.4 X 55.1), 83.9 μm.
7. *Vestispora irregularis* (Kosanke) Wilson and Venkatachala 1963; Cliffland Coal, CP-3-1 slide 5 (126.0 X 59.0), 57.6 μm.
8. *Vestispora pseudoreticulata* Spode, in Smith and Butterworth, 1967; Laddsdale Coal, CP-66-185 slide 4 (119.2 X 61.8), 65.5 μm.
9. *Vestispora foveata* (Kosanke) Wilson and Venkatachala 1963; Wheeler Coal, CP-80-123 slide 10 (133.1 X 58.7), 65.0 μm.
10. *Vestispora foveata* (Kosanke) Wilson and Venkatachala 1963; SEM 700X, Cliffland Coal, CP-73-299. Oblique view of proximal surface and equatorial area, with operculum visible at lower right.
11. *Vestispora foveata* (Kosanke) Wilson and Venkatachala 1963; Cliffland Coal, CP-49-7 slide 10 (129.1 X 48.3), 63.3 μm; proximal focus.
12. Same as 11, distal focus.

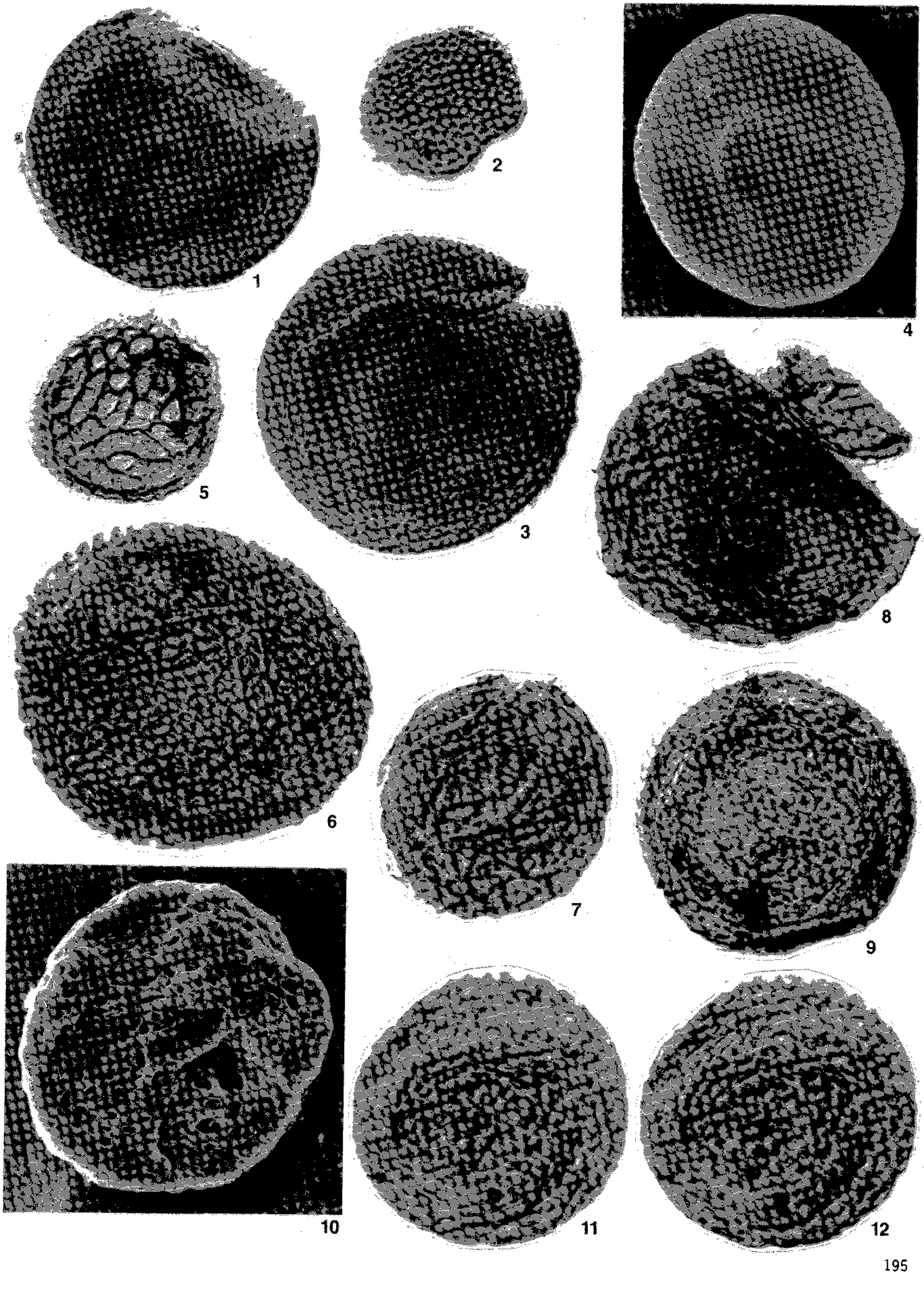

1
2
3
4
5
6
7
8
9
10
11
12

PLATE 16

1. *Anapiculatisporites vegrandis* (Upshaw and Creath) n. comb.; Cliffland Coal, CP-41-48 slide M-3 (136.4 X 70.6), 24.5 μm.
2. *Anapiculatisporites vegrandis* (Upshaw and Creath) n. comb.; Blackoak Coal, CP-10-49 slide C-108 (126.1 X 52.0), 25.4 μm.
3. *Anapiculatisporites vegrandis* (Upshaw and Creath) n. comb.; Cliffland Coal, CP-41-48 slide M-5 (131.4 X 39.2), 25.1 μm.
4. *Anacanthotriletes spinosus* (Kosanke) n. comb.; Cliffland Coal, CP-41-48 slide Y-5 (127.5 X 73.6), 25.1 μm.
5. *Anacanthotriletes spinosus* (Kosanke) n. comb; Blackoak Coal, CP-19-4 slide 1Y2 (127.0 X 54.4), 22.8 μm.
6. *Anacanthotriletes spinosus* (Kosanke) n. comb.; Laddsdale Coal, LOV-I slide 2 (129.1 X 71.7), 25.7 μm.
7. *Anacanthotriletes spinosus* (Kosanke) n. comb.; Cliffland Coal, CP-41-48 slide Q-5 (122.5 X 36.9), 29.6 μm.
8. *Anacanthotriletes spinosus* (Kosanke) n. comb.; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-1 (132.9 X 60.2), 26.8 μm.
9. *Anacanthotriletes paucispinosus* n. sp.; Blackoak Coal, CP-10-49 slide C-6 (120.0 X 65.6), 26.8 μm (holotype).
10. *Anacanthotriletes paucispinosus* n. sp.; Blackoak Coal, CP-10-49 slide C-3 (123.4 X 45.8), 27.4 μm (paratype).
11. *Anacanthotriletes paucispinosus* n. sp.; Cliffland Coal, CP-25-8 slide 10 (127.3 X 35.2), 24.5 μm (paratype).
12. *Anacanthotriletes paucispinosus* n. sp.; Blackoak Coal, CP-10-49 slide C-9 (128.5 X 58.5), 26.8 μm (paratype).
13. *Anacanthotriletes paucispinosus* n. sp.; Blackoak Coal, CP-10-49 slide C-1 (126.0 X 55.8), 23.4 μm (paratype).
14. *Anacanthotriletes paucispinosus* n. sp.; Blackoak Coal, CP-10-49 slide C-4 (133.0 X 52.0), 26.2 μm (paratype).
15. *Vestispora* sp. cf. *V. reticulata* (Laveine) Loboziak 1971; Blackoak Coal, CP-19-4 slide 1X1 (127.0 X 39.6), 83.8 μm; proximal focus.
16. Same as 15, distal focus.
17. *Vestispora wanlessii* Peppers 1970; Cliffland Coal, CP-49-7 slide 1 (128.7 X 57.8), 73.4 μm.
18. *Crassispora kosankei* (Potonié and Kremp) Bhardwaj emend. Smith and Butterworth 1967; Blackoak Coal, CP-42-32 slide 14 (123.1 X 44.8), 57.0 μm.
19. *Crassispora kosankei* (Potonié and Kremp) Bhardwaj emend. Smith and Butterworth 1967; Blackoak Coal, CP-19-4 slide 6V2 (123.8 X 55.0), 48.5 μm.
20. *Crassispora kosankei* (Potonié and Kremp) Bhardwaj emend. Smith and Butterworth 1967; Wildcat Den Coal, F-II slide 38 (133.8 X 63.0), 68.4 μm. Note large size and unusually strong development of equatorial crassitude, characteristic of specimens observed in coals of the Caseyville Formation.
21. *Crassispora annulata* Ravn 1979; Blackoak Coal, CP-19-4 slide 6V3 (131.4 X 48.6), 49.6 μm (holotype).
22. *Crassispora annulata* Ravn 1979; Blackoak Coal, CP-19-4 slide 6V2 (124.8 X 47.3), 52.0 μm.

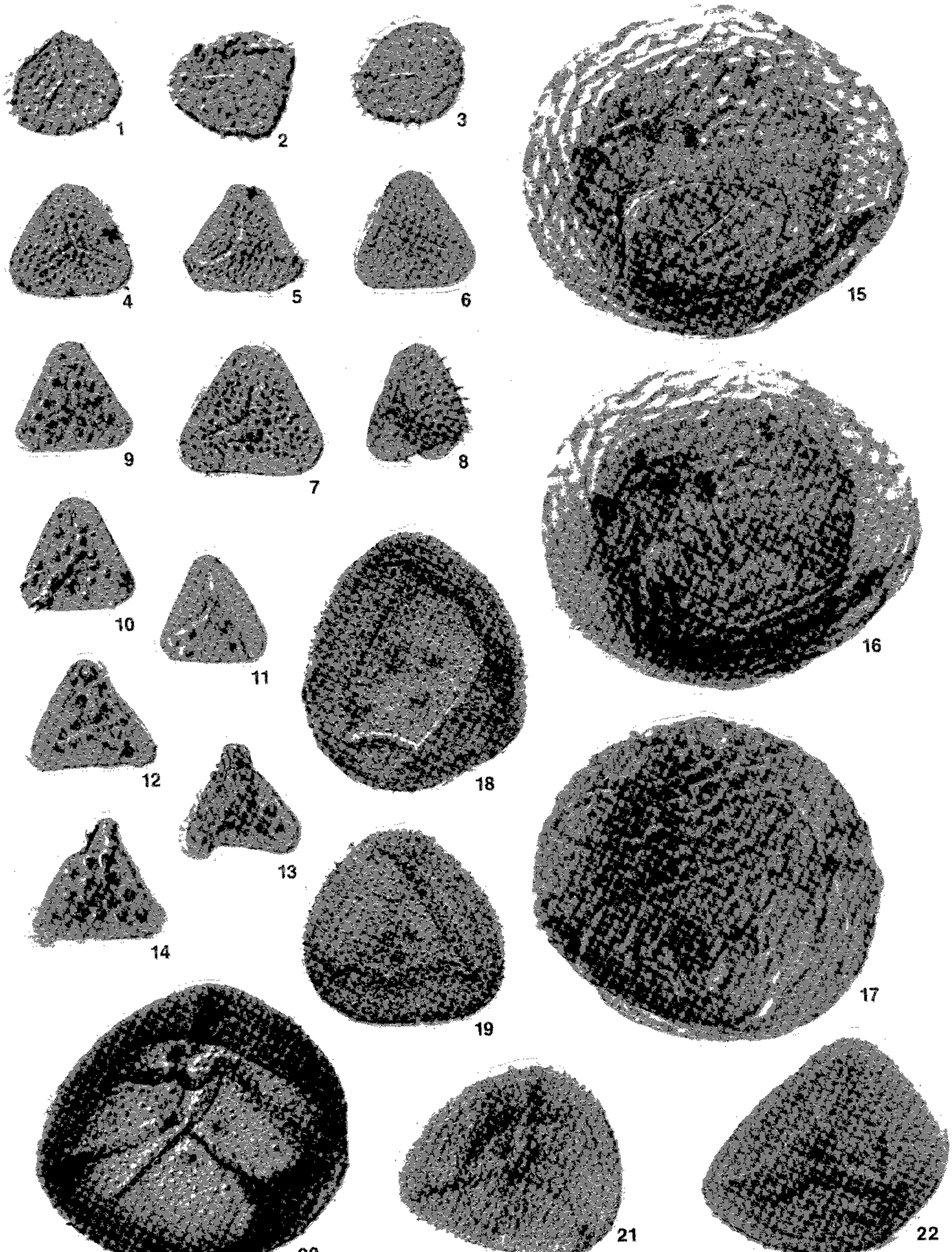

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 17

1. *Granasporites medius* (Dybová and Jachowicz) Ravn, Butterworth, Phillips and Peppers, in press; Blackoak Coal, CP-10-49 slide A-6 (130.0 X 57.2), 47.9 μm.
2. *Granasporites medius* (Dybová and Jachowicz) Ravn, Butterworth, Phillips and Peppers, in press; Wildcat Den Coal, F-WH4 slide Z-11 (131.4 X 72.5), 43.4 μm.
3. *Granasporites medius* (Dybová and Jachowicz) Ravn, Butterworth, Phillips and Peppers, in press; Blackoak Coal, CP-19-4 slide 1B8 (138.0 X 62.1), 53.0 μm.
4. *Granasporites medius* (Dybová and Jachowicz) Ravn, Butterworth, Phillips and Peppers, in press; Blackoak Coal, CP-19-4 slide 5A4 (133.8 X 62.9), 55.9 μm.
5. *Granasporites medius* (Dybová and Jachowicz) Ravn, Butterworth, Phillips and Peppers, in press; SEM 900X, Wildcat Den Coal, F-WH4. Distal surface.
6. Detail from 5, 1600X, showing doubly granulose to granulose-punctate sculpture.
7. *Granasporites medius* (Dybová and Jachowicz) Ravn, Butterworth, Phillips and Peppers, in press; SEM 900X, Blackoak Coal, CP-10-49. Distal surface; large spherical objects on lower left of specimen are resin globules, not morphological features of the spore.
8. *Granasporites medius* (Dybová and Jachowicz) Ravn, Butterworth, Phillips and Peppers, in press; Blackoak Coal, CP-19-4 slide B-7 (122.2 X 52.3), 45.6 μm.
9. *Densosporites annulatus* (Loose) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-43-44 slide 7 (125.9 X 42.7), 35.9 μm.
10. *Densosporites aculeatus* Playford 1963; Wildcat Den Coal, F-WH4 slide Z-1 (120.5 X 35.8), 31.4 μm, proximal focus.
11. Same as 10, distal focus.
12. *Densosporites variabilis* (Waltz) Potonié and Kremp 1956; Wildcat Den Coal, F-WH4 slide M-1 (122.9 X 57.1), 47.3 μm.
13. *Densosporites irregularis* Hacquebard and Barss 1957; SEM 900X, Wildcat Den Coal, F-WH4. Distal surface showing "excavations" in cingulum.
14. *Densosporites irregularis* Hacquebard and Barss 1957; unnamed coal in the Kilbourn Formation, CP-17-13 slide A-1 (120.9 X 45.6), 49.0 μm.
15. *Densosporites irregularis* Hacquebard and Barss 1957; Wildcat Den Coal, F-WH4 slide A-5 (129.0 X 38.8), 43.9 μm.
16. *Radiizonates difformis* (Kosanke) Staplin and Jansonius 1964; Blackoak Coal, CP-19-4 slide 1W2 (132.9 X 52.0), 35.3 μm.
17. *Radiizonates striatus* (Knox) Staplin and Jansonius 1964; Wyoming Hill Coal, F-WH2 slide 6 (129.1 X 64.2), 38.8 μm.
18. *Radiizonates striatus* (Knox) Staplin and Jansonius 1964; Wyoming Hill Coal, F-WH2 slide 4 (138.2 X 55.5), 44.5 μm.

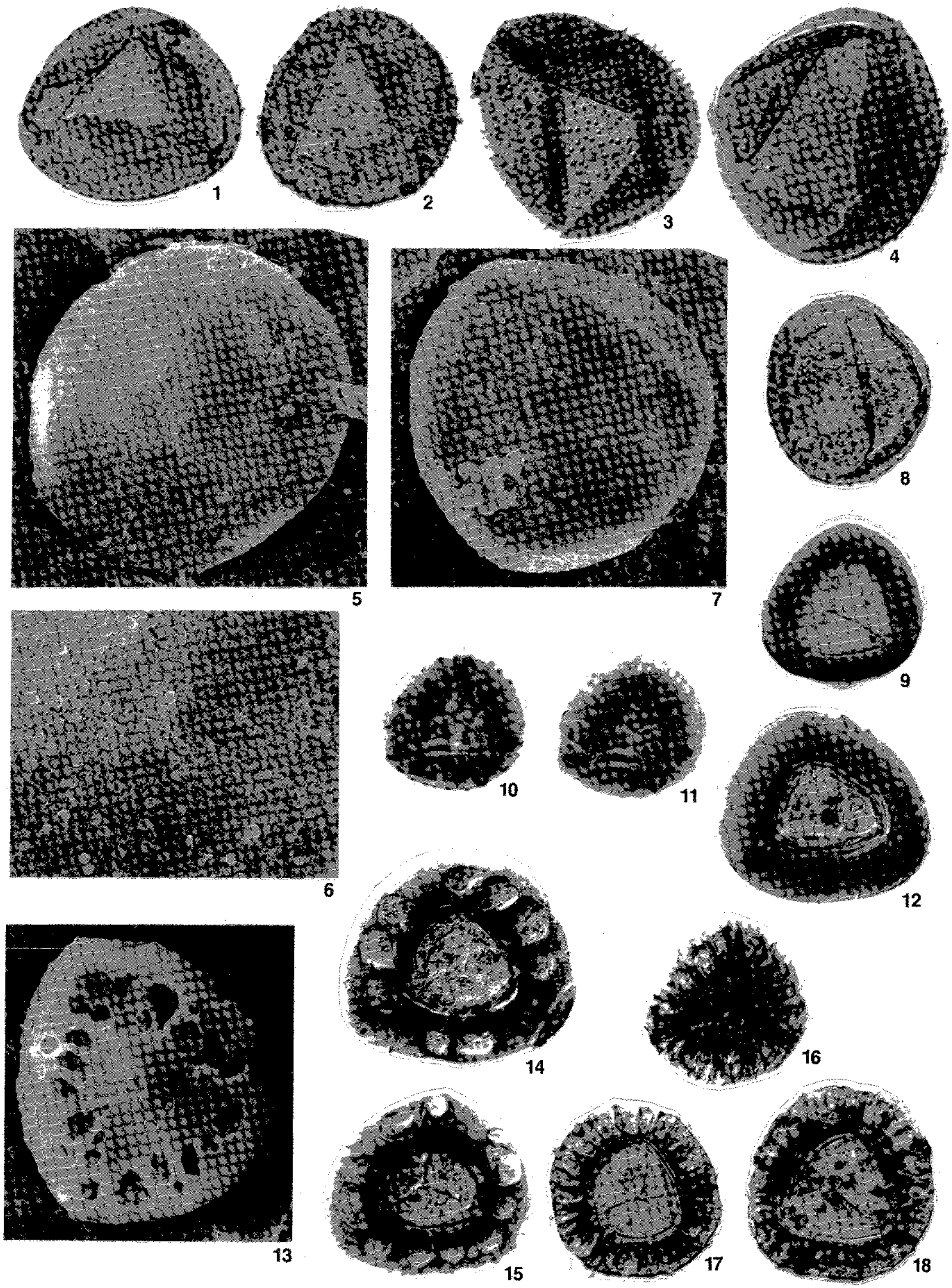

1
2
3
4
5
7
8
6
9
10
11
12
14
16
13
15
17
18

PLATE 18

1. *Lycospora micropapillata* (Wilson and Coe) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-19-4 slide 10H4 (139.5 X 53.7), 23.9 μm.
2. *Lycospora micropapillata* (Wilson and Coe) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-10-49 slide C-1 (132.2 X 71.1), 23.9 μm.
3. *Lycospora orbicula* (Potonié and Kremp) Smith and Butterworth 1967; Wyoming Hill Coal, F-WH2 slide 11 (121.4 X 45.8), 27.4 μm.
4. *Lycospora orbicula* (Potonié and Kremp) Smith and Butterworth 1967; Wyoming Hill Coal, F-WH2 slide 10 (128.5 X 45.0), 27.4 μm.
5. *Lycospora rotunda* Bhardwaj 1957; Laddsdale Coal, CP-66-185 slide 5 (118.3 X 46.6), 31.4 μm.
6. *Lycospora rotunda* Bhardwaj 1957; Blackoak Coal, CP-10-49 slide C-10 (130.2 X 56.2), 27.4 μm.
7. *Lycospora pellucida* (Wicher) Schopf, Wilson and Bentall 1944; Wildcat Den Coal, F-III slide 31 (137.6 X 55.7), 35.3 μm.
8. *Lycospora pellucida* (Wicher) Schopf, Wilson and Bentall 1944; Wildcat Den Coal, F-III slide 31 (139.4 X 56.0), 34.2 μm.
9. *Lycospora pellucida* (Wicher) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-19-4 slide 2H6 (121.4 X 64), 36.5 μm.
10. *Lycospora noctuina* Butterworth and Williams 1958; Wildcat Den Coal, F-II slide 36 (138.7 X (66.6), 31.4 μm.
11. *Lycospora noctuina* Butterworth and Williams 1958; Wildcat Den Coal, F-WH4 slide A-17 (131.1 X 50.9), 37.6 μm.
12. *Lycospora granulata* Kosanke 1950; Blackoak Coal, CP-42-32 slide 13 (137.1 X 57.2), 28.5 μm.
13. *Lycospora granulata* Kosanke 1950; Wildcat Den Coal, F-WH4 slide A-8 (133.0 X 54.7), 29.6 μm.
14. *Lycospora granulata* Kosanke 1950; Blackoak Coal, CP-19-4 slide 1Z4 (123.4 X 69.9), 29.6 μm.
15. *Densosporites sphaerotriangularis* Kosanke 1950; Wildcat Den coal, F-WH4 slide Z-7 (120.8 X 58.0), 51.9 μm.
16. *Densosporites sphaerotriangularis* Kosanke 1950; Blackoak Coal, CP-19-4 slide 6Z6 (132.2 X 49.3), 40.5 μm.
17. *Densosporites sphaerotriangularis* Kosanke 1950; SEM 800X, Wildcat Den Coal, F-WH4. Distal surface.
18. *Densosporites spinifer* Hoffmeister, Staplin and Malloy 1955; Blackoak Coal, CP-19-4 slide 6Z6 (136.1 X 48.2), 33.6 μm excluding equatorial spines.
19. *Densosporites spinifer* Hoffmeister, Staplin and Malloy 1955; Blackoak Coal, CP-19-4 slide 6Z4 (129.8 X 33.1), 35.9 μm excluding equatorial spines.
20. *Densosporites triangularis* Kosanke 1950; Wildcat Den Coal, F-WH4 slide M-10 (119.0 X 45.5), 47.9 μm.
21. *Densosporites triangularis* Kosanke 1950; Blackoak Coal, CP-19-4 slide 1X2 (126.4 X 57.5), 48.5 μm.
22. *Densosporites triangularis* Kosanke 1950; SEM 900X, Cliffland Coal, CP-41-48. Distal surface.
23. Detail of 20, 1800X. Distal surface showing finely vermiculate-foveolate sculpture.

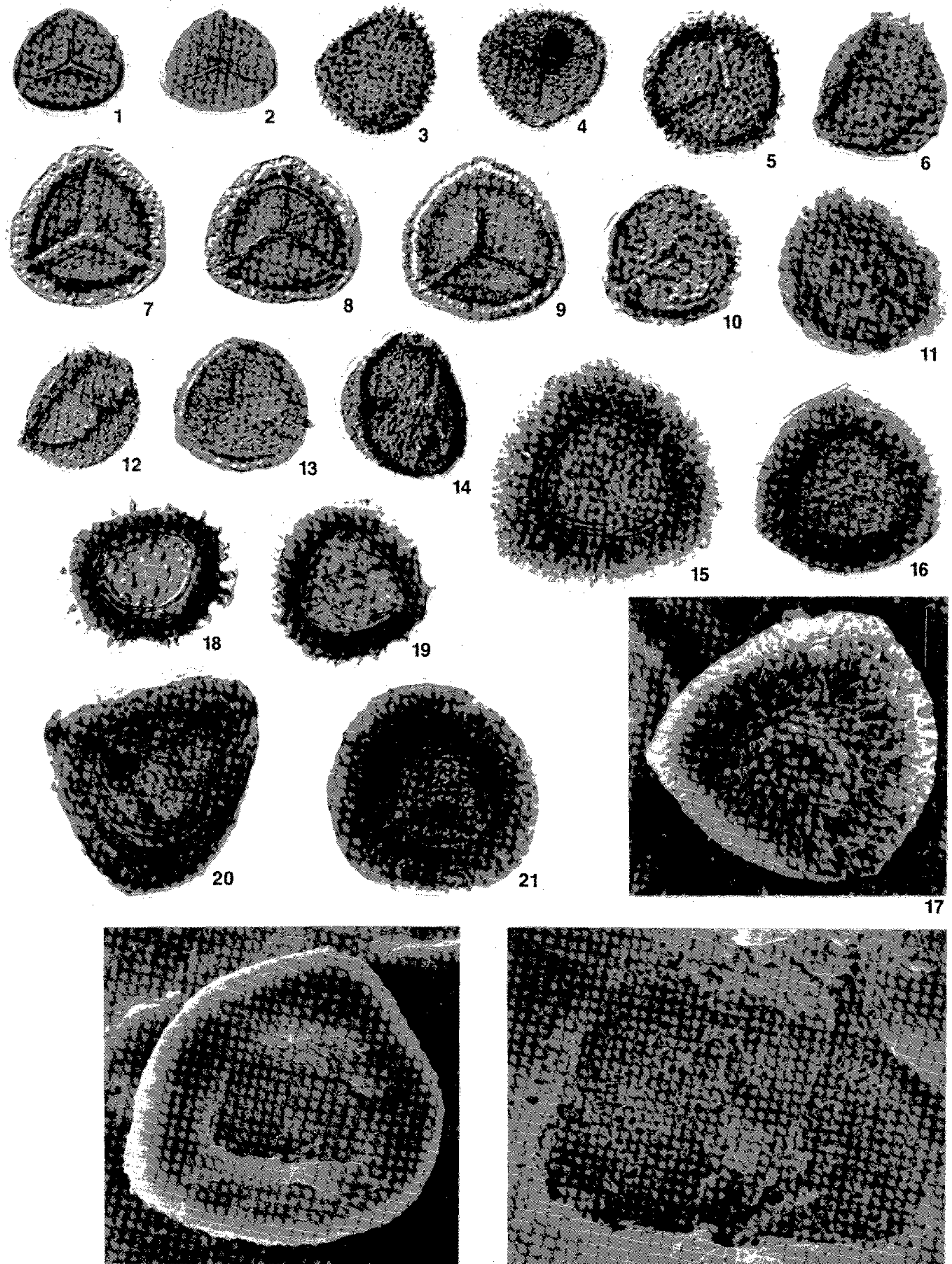

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
18
19
20
21
17
22
23

PLATE 19

1. *?Lycospora tripapillata* n. sp.; Blackoak Coal, CP-10-49 slide C-8 (129.9 X 48.8), 29.1 μm (holotype).
2. *?Lycospora tripapillata* n. sp.; Wildcat Den Coal, F-WH4 slide Z-4 (128.4 X 62.2), 31.9 μm (paratype).
3. *?Lycospora tripapillata* n. sp.; Laddsdale Coal, CP-39-16 slide 10 (122.2 X 46.9), 31.9 μm (paratype).
4. *?Lycospora tripapillata* n. sp.; Laddsdale Coal, CP-39-16 slide 10 (130.0 X 70.4), 27.4 μm (paratype).
5. *?Lycospora tripapillata* n. sp.; Blackoak Coal, CP-73-317 slide 4 (133.2 X 48.7), 27.9 μm (paratype).
6. *?Lycospora* sp. 1; Laddsdale Coal, CP-73-231 slide 6 (135.2 X 35.8), 33.6 μm.
7. *?Lycospora* sp. 1; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-3 (138.9 X 47.5), 48.3 μm.
8. *Cingulizonates loricatus* (Loose) Butterworth and Smith, in Butterworth et al., 1964; Blackoak Coal, CP-19-4 slide 6T3 (120.5 X 50.2), 37.6 μm.
9. *Cingulizonates loricatus* (Loose) Butterworth and Smith, in Butterworth et al., 1964; Wildcat Den Coal, F-WH4 slide M-7 (124.2 X 61.4), 44.0 μm.
10. *Cristatisporites connexus* Potonié and Kremp 1955; unnamed coal in the Caseyville Formation, F-WH3 slide 12 (124.4 X 38.7), 54.2 μm.
11. *Cristatisporites connexus* Potonié and Kremp 1955; unnamed coal in the Caseyville Formation, F-WH3 slide 8 (130.3 X 36.0), 62.7 μm.
12. *Cristatisporites indignabundus* (Loose) Staplin and Jansonius 1964; unnamed coal in the Caseyville Formation, F-WH3 slide 12 (130.1 X 37.8), 52.4 μm.
13. *Cristatisporites indignabundus* (Loose) Staplin and Jansonius 1964; Blackoak Coal, CP-19-4 slide 5A6 (130.1 X 52.1), 48.6 μm.
14. *Cristatisporites indignabundus* (Loose) Staplin and Jansonius 1964; Wildcat Den Coal, F-WH4 slide M-5 (130.3 X 62.2), 59.9 μm. An extremely spinose specimen; this morphologic variant was observed only in Caseyville Formation coals.
15. *Cristatisporites indignabundus* (Loose) Staplin and Jansonius 1964; SEM 700X, Wildcat Den Coal, F-WH4. Proximal surface.
16. *Cristatisporites indignabundus* (Loose) Jansonius 1964; SEM 700X, Wildcat Den Coal, F-WH4. Distal surface.
17. *Cirratriradites reticulatus* Ravn 1979; Blackoak Coal, CP-19-5 slide Y-4 (124.4 X 32.9), 52.4 μm (holotype).
18. *Cirratriradites annuliformis* Kosanke 1950; Blackoak Coal, CP-19-4 slide 6H2 (129.9 X 73.0), 59.3 μm.
19. *Cirratriradites maculatus* Wilson and Coe 1940; Blackoak Coal, CP-19-4 slide 1Z1 (122.2 X 58.6), 75.3 μm; 600X.
20. *Cirratriradites maculatus* Wilson and Coe 1940; Blackoak Coal, CP-10-49 slide C-108 (138.2 X 37.2), 78.2 μm; 600X.

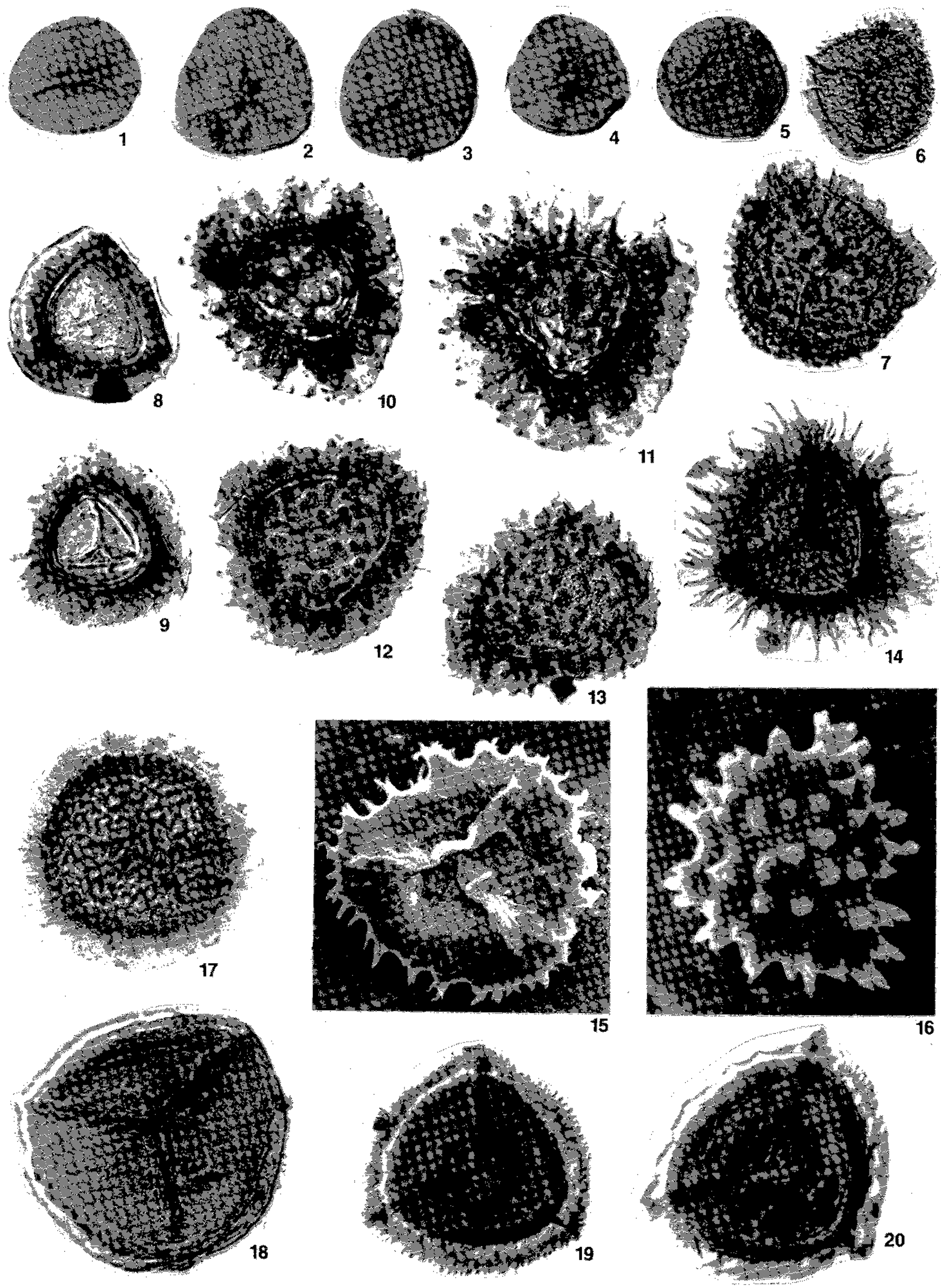

1
2
3
4
5
6
8
10
11
7
9
12
13
14
17
15
16
18
19
20

PLATE 20

1. *Cirratriradites saturnii* (Ibrahim) Schopf, Wilson and Bentall 1944; Laddsdale Coal, 416804-2 slide 8 (118.1 X 67.8), 61.6 μm; proximal focus.
2. Same as 1, distal focus.
3. *Cirratriradites saturnii* (Ibrahim) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-10-49 slide C-108 (126.7 X 55.5), 80.5 μm; 600X.
4. *Cirratriradites saturnii* (Ibrahim) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-45-103 slide 109 (126.4 X 44.0), 75.9 μm; 600X.
5. *Cirratriradites* sp. 1; Wildcat Den Coal, F-WH4 slide A-19 (134.5 X 54.2), 96.3 μm; 600X.
6. *Cirratriradites* sp. 1; SEM 600X, Wildcat Den Coal, F-WH4. Distal surface.
7. *Cirratriradites* sp. 1; SEM 1250X, Wildcat Den Coal, F-WH4. Detail of polar region on distal surface showing spinose ornament and poorly defined fovea (not the same specimen as figure 6).
8. *Endosporites zonalis* (Loose) Knox 1950; Blackoak Coal, CP-19-4 slide 1Z4 (130.9 X 47.8), 85.2 μm; 600X.
9. *Endosporites zonalis* (Loose) Knox 1950; Wildcat Den Coal, F-WH4 slide M-9 (121.2 X 66.0), 79.5 μm; 600X.
10. *Endosporites globiformis* (Ibrahim) Schopf, Wilson and Bentall 1944; Cliffland Coal, CP-78-479 slide 7 (135.3 X 48.1), 95.1 μm; 600X.
11. *Endosporites globiformis* (Ibrahim) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-42-32 slide 15 (129.0 X 65.6), 122.1 μm; 600X.

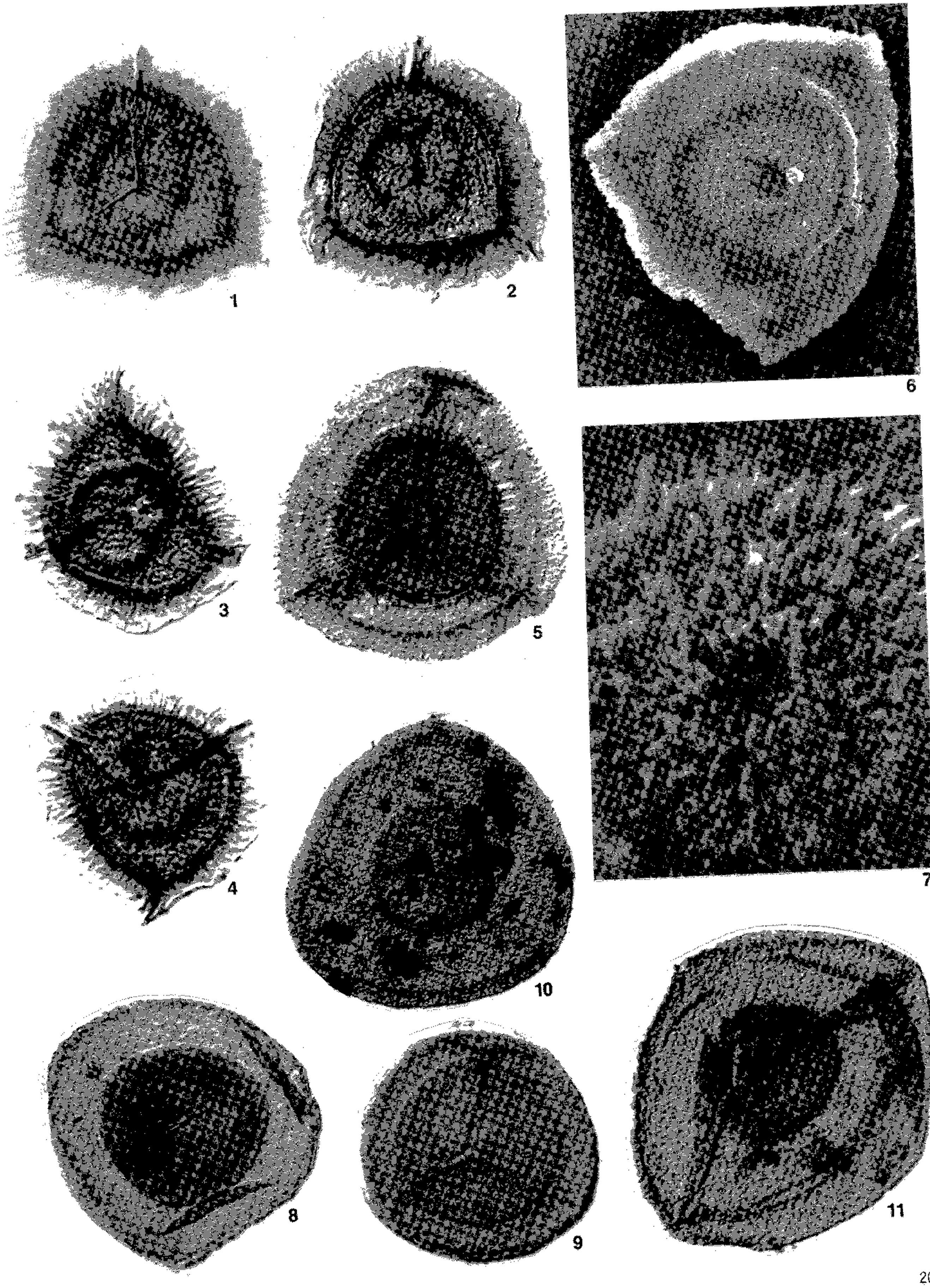

1
2
6
3
5
4
7
10
8
9
11

PLATE 21

1. *Endosporites plicatus* Kosanke 1950; Wheeler Coal, CP-23-2 slide 4 (139.7 X 71.9), 61.0 μm.
2. *Adelisporites multiplicatus* Ravn 1979; Blackoak Coal, CP-19-4 slide 1C2 (136.5 X 60.1), 26.8 μm (holotype).
3. *Adelisporites multiplicatus* Ravn 1979; Blackoak Coal, CP-73-317 slide 4 (128.4 X 86.3), 31.9 μm.
4. *Adelisporites multiplicatus* Ravn 1979; Blackoak Coal, CP-19-4 slide 5H2 (119.9 X 52.7), 23.4 μm (paratype).
5. *Adelisporites multiplicatus* Ravn 1979; Wildcat Den Coal, F-1 slide 30 (121.9 X 66.2), 30.8 μm.
6. *Adelisporites multiplicatus* Ravn 1979; Blackoak Coal, CP-10-49 slide C-9 (130.0 X 62.0), 25.1 μm (paratype).
7. *Adelisporites multiplicatus* Ravn 1979; SEM 1400X, Wildcat Den Coal, F-I. Proximal surface.
8. *Spencerisporites radiatus* (Ibrahim) Felix and Parks 1959; unnamed coal in the Caseyville Formation, F-WH3 slide 17 (122.4 X 63.9), 326.4 μm; 200X.
9. *Waltzispora polita* (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967; Wildcat Den Coal, F-III slide 29 (124.9 X 57.4), 25.7 μm.
10. *Waltzispora sagittata* Playford 1962; Wildcat Den Coal, F-WH4 slide A-2 (138.5 X 53.6), 29.1 μm.
11. *Waltzispora prisca* (Kosanke) Sullivan 1964; Wildcat Den Coal, F-II slide 25 (132.8 X 40.0), 33.1 μm.
12. *Waltzispora prisca* (Kosanke) Sullivan 1964; unnamed coal in the Kilbourn Formation, CP-44-73 slide 15 (127.9 X 54.2), 46.2 μm.
13. *Waltzispora prisca* (Kosanke) Sullivan 1964; SEM 900X, Wildcat Den Coal, F-II. Proximal surface.
14. *Converrucosisporites armatus* (Dybová and Jachowicz) Smith and Butterworth 1967; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-1 (119.1 X 41.7), 34.2 μm.
15. *Converrucosisporites armatus* (Dybová and Jachowicz) Smith and Butterworth 1967; unnamed coal in the Kilbourn Formation, CP-17-13 slide B-6 (136.9 X 36.8), 41.7 μm.
16. *Converrucosisporites armatus* (Dybová and Jachowicz) Smith and Butterworth 1967; Bevier Coal, 1207791-7 slide 9 (122.8 X 43.1), 45.1 μm.
17. *Converrucosisporites vermiformis* n. sp.; Blackoak Coal, CP-10-49 slide C-9 (137.1 X 70.6), 39.3 μm (holotype).
18. *Converrucosisporites vermiformis* n. sp.; Blackoak Coal, CP-10-49 slide A-3 (124.0 X 63.4), 45.6 μm (paratype).
19. *Converrucosisporites vermiformis* n. sp.; Blackoak Coal, CP-10-49 slide C-5 (134.4 X 42.7), 43.4 μm (paratype).
20. *Converrucosisporites vermiformis* n. sp.; Blackoak Coal, CP-10-49 slide C-9 (128.1 X 53.6), 47.3 μm (paratype).
21. *Converrucosisporites* sp. 1; Wildcat Den Coal, F-II slide 31 (138.9 X 54.4), 45.6 μm.
22. *Cyclobagranisporites staplinii* (Peppers) Peppers 1970; Blackoak Coal, CP-10-49 slide C-8 (132.6 X 36.2), 58.7 μm.

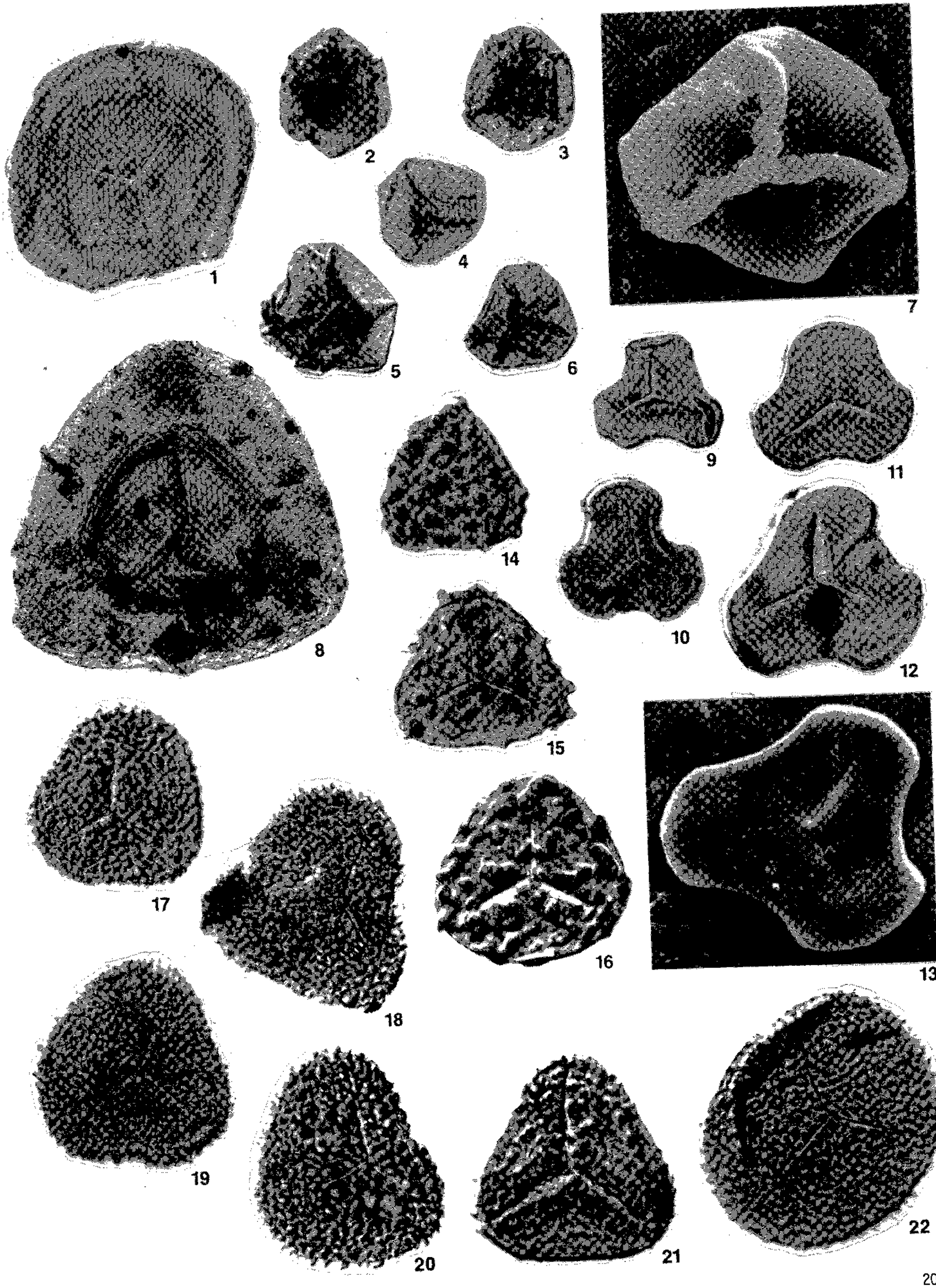

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 22

1. *Latipulvinites kosankei* Peppers 1964; Blackoak Coal. CP-19-4 slide 1Y5 (119.5 X 70.9), 34.8 μm.
2. *Gulisporites torpidus* Playford 1964; Wildcat Den Coal, F-II slide 38 (121.3 X 45.6), 72.4 μm.
3. *Cuneisporites rigidus* Ravn 1979; Blackoak Coal, CP-19-4 slide 2H2 (128.1 X 55.5), 47.3 μm (holotype).
4. *Cuneisporites rigidus* Ravn 1979; Blackoak Coal, CP-10-49 slide B-9 (127.2 X 69.4), 45.6 μm (paratype).
5. *Cuneisporites rigidus* Ravn 1979; Blackoak Coal, CP-19-4 slide 2H3 (125.0 X 39.8), 41.0 μm (paratype).
6. *Tetanisporites granulatus* Ravn 1979; Blackoak Coal, CP-19-4 slide 6V3 (134.4 X 50.9), 45.6 μm (paratype).
7. *Tetanisporites granulatus* Ravn 1979; Blackoak Coal, CP-10-7 slide 12 (119.1 X 58.1), 49.7 μm (paratype).
8. *Tetanisporites granulatus* Ravn 1979; SEM 900X, Blackoak Coal, CP-10-49. Proximal surface showing raised, thickened area adjacent to trilete laesura.
9. *Pustulatisporites pustulatus* Potonié and Kremp 1954; unnamed coal in the Kilbourn Formation, CP-46-31 slide 10 (125.2 X 37.8), 53.0 μm.
10. *Pustulatisporites crenatus* Guennel 1958; Blackoak Coal, CP-10-7 slide 11 (123.4 X 50.7), 39.3 μm.
11. *Pustulatisporites crenatus* Guennel 1958; Wildcat Den Coal, F-III slide 37 (128.4 X 68.9), 42.3 μm.
12. *Pustulatisporites verrucifer* (Kosanke) n. comb.; Laddsdale Coal, CP-6-16 slide 3 (135.9 X 72.5), 50.7 μm.
13. *Pustulatisporites papillosus* (Knox) Potonié and Kremp 1955; Wildcat Den Coal, F-WH4 slide A-10 (138.8 X 41.1), 39.3 μm.
14. *Planisporites granifer* (Ibrahim) Knox 1950; Blackoak Coal, CP-73-317 slide 10 (130.4 X 59.7), 68.4 μm.
15. *Cadiospora magna* Kosanke 1950; Wheeler Coal, CP-23-2 slide 7 (131.8 X 49.8), 82.3 μm; 600X.
16. *Cadiospora magna* Kosanke 1950; Summit Coal, CP-22-165 slide 15 (119.1 X 54.4), 74.1 μm.

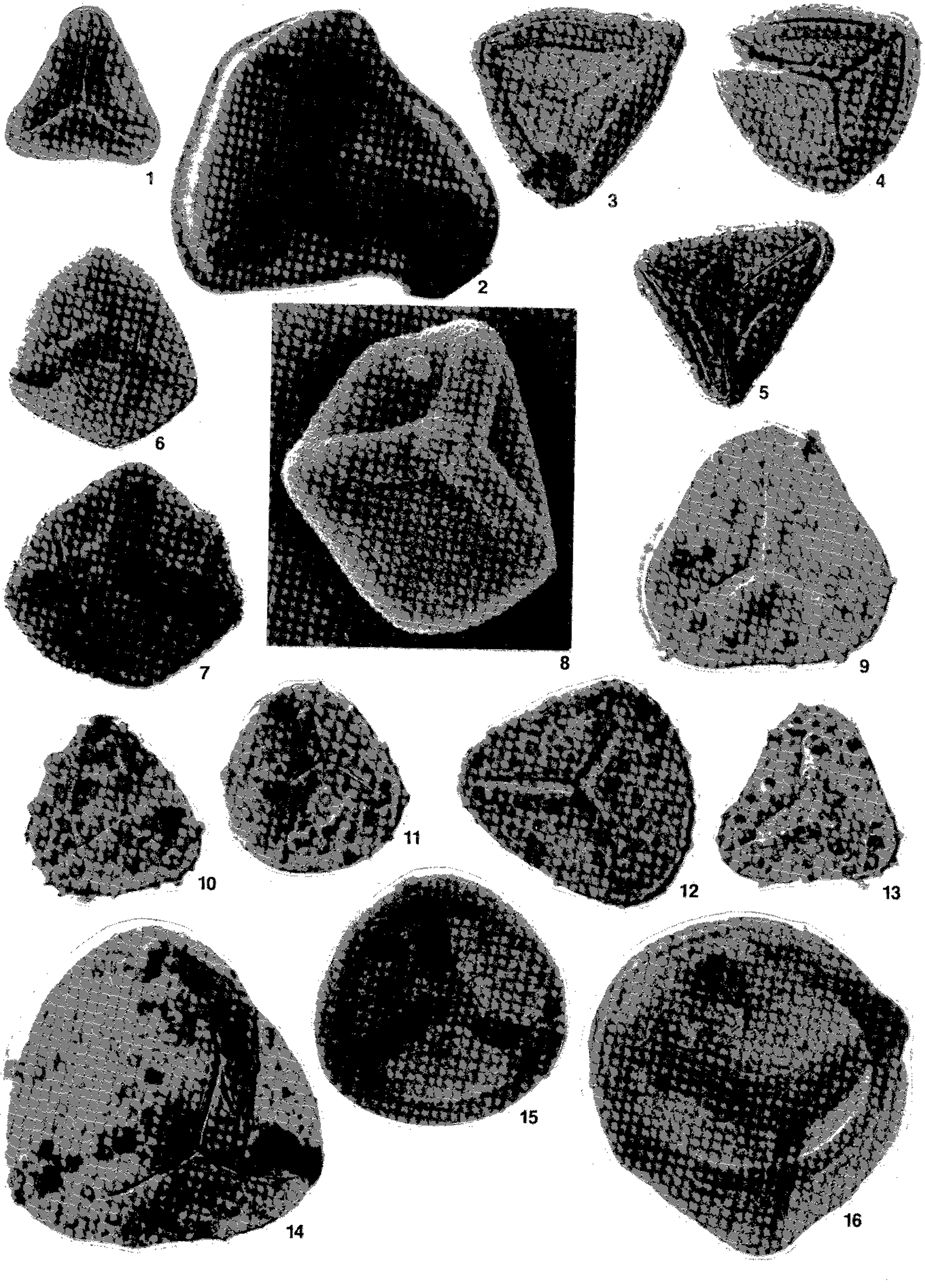

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

PLATE 23

1. *Pustulatisporites* sp. 1; Wildcat Den Coal, F-II slide 33 (128.1 X 53.9), 37.1 μm.
2. *Anapiculatisporites baccatus* (Hoffmeister, Staplin and Malloy) n. comb.; Blackoak Coal, CP-19-4 slide 5A2 (132.9 X 61.7), 26.2 μm.
3. *Anapiculatisporites baccatus* (Hoffmeister, Staplin and Malloy) n. comb.; Wildcat Den Coal, F-WH4 slide M-4 (133.0 X 33.2), 31.3 μm.
4. *Anapiculatisporites protuberatus* (Hagemann) n. comb.; Wildcat Den Coal, F-WH4 slide Z-5 (135.6 X 70.2), 24.5 μm.
5. *Anapiculatisporites* sp. cf. *A. globulus* (Butterworth and Williams) n. comb.; Blackoak Coal, CP-19-4 slide 6Z2 (123.9 X 36.5), 34.8 μm.
6. *Neoraistrickia muscatinensis* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-I slide 25 (118.0 X 60.4), 30.8 μm excluding ornament (holotype).
7. *Neoraistrickia muscatinensis* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-WH4 slide M-19 (132.2 X 67.5), 32.4 μm excluding ornament (paratype).
8. *Neoraistrickia muscatinensis* Ravn and Fitzgerald 1982; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-4 (128.9 X 48.5), 26.2 μm excluding ornament.
9. *Sinuspores sinuatus* Artüz emend.; Wildcat Den Coal, F-III slide 33 (123,2 X 70.0), 117.9 um; 600X.
10. *Sinuspores sinuatus* Artüz emend.; unnamed coal in the Kilbourn Formation, CP-46-31 slide 109 (139.0 X 32.3), 108.1 μm; 600X.
11. *Sinuspores sinuatus* Artüz emend.; SEM 600X, unnamed coal in the Kilbourn Formation, CP-46-31.
12. *Sinuspores sinuatus* Artüz emend.; SEM stereopair 600X, Wildcat Den Coal, F-WH4.

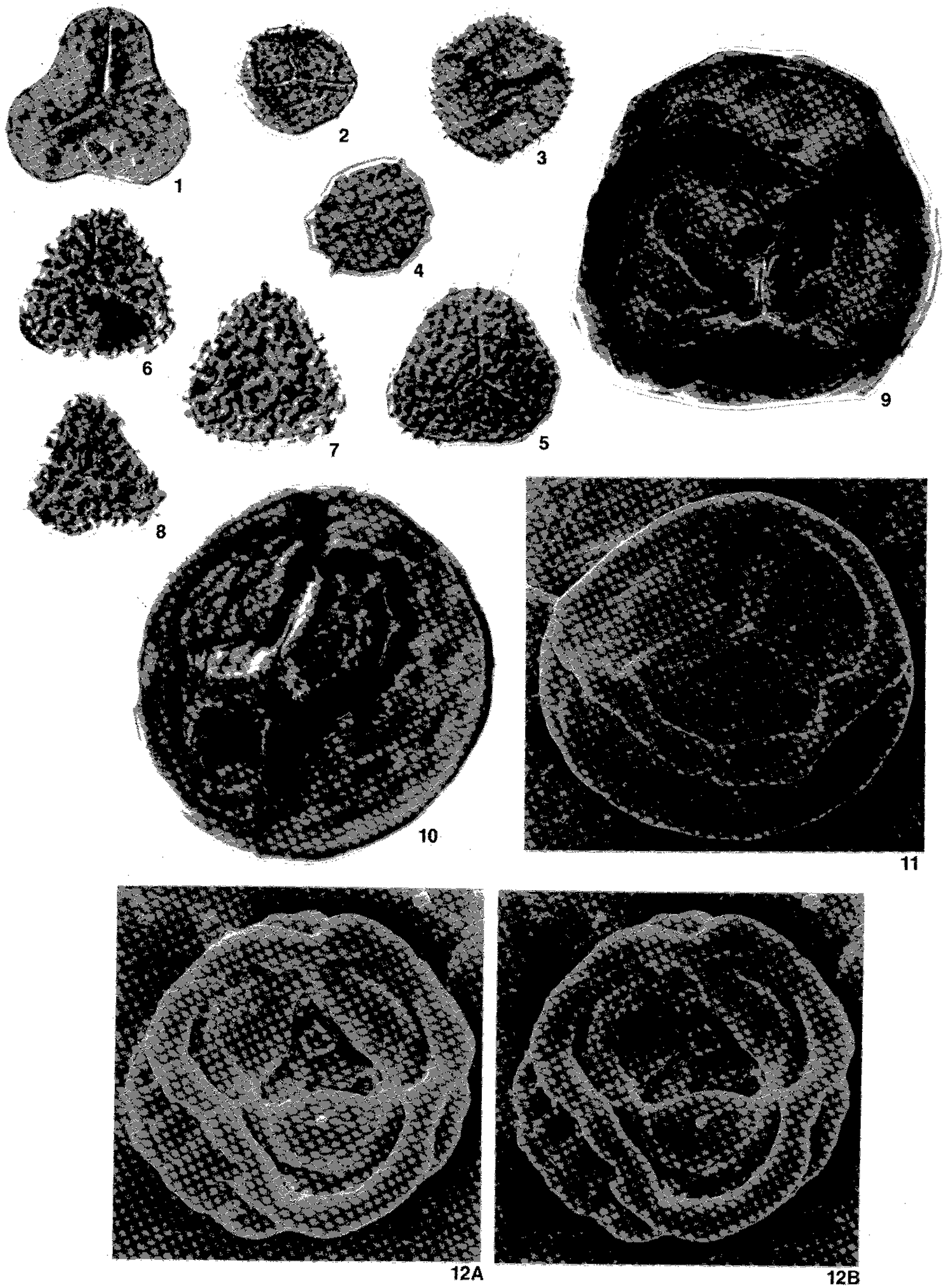

1
2
3
4
5
6
7
8
9
10
11
12A
12B

PLATE 24

1. *Procoronaspora stellata* n. sp.; Blackoak Coal, CP-10-49 slide A-10 (129.2 X 44.4), 30.8 μm excluding ornament (holotype).
2. *Procoronaspora stellata* n. sp.; Blackoak Coal, CP-10-49 slide A-8 (124.9 X 41.1), 31.4 μm excluding ornament (paratype); orthoscopic illumination.
3. Same as 2, interference contrast illumination.
4. *Procoronaspora stellata* n. sp.; Blackoak Coal, CP-10-49 slide C-5 (118.9 X 44.0), 31.4 μm excluding ornament (paratype);
5. Same as 4, interference contrast illumination.
6. *Pileatisporites bakerii* Ravn and Fitzgerald 1982; unnamed coal in the Kilbourn Formation, CP-17-13 slide B-6 (135.1 X 42.2),. 37.1 μm.
7. *Pileatisporites bakerii* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-WH4 slide Z-6 (124.0 X 60.7), 35.9 μm (holotype).
8. *Pileatisporites bakerii* Ravn and Fitzgerald 1982; SEM 1000X, Wildcat Den Coal, F-I. Distal surface.
9. *Tricidarisporites arcuatus* Neville, in Neves et al., 1973; Wildcat Den coal, F-II slide 38 (139.1 X 50.5), 41.7 μm excluding ornament.
10. *Schopfites carbondalensis* Peppers 1970; Carruthers Coal (?), CP-75-161 slide 4 (133.9 X 50.6), 39.9 μm.
11. *Schopfites dimorphus* Kosanke 1950; Laddsdale Coal, 416804-2 slide 3 (127.0 X 48.2), 61.6 μm.
12. *Schopfites dimorphus* Kosanke 1950; Bevier Coal, 1207791-7 slide 4 (131.2 X 51.3), 66.7 μm; proximal focus.
13. Same as 12, distal focus.
14. *Schopfites dimorphus* Kosanke 1950; SEM 600X, Wheeler Coal, CP-77-137. Oblique view of distal surface and equator.
15. *Schopfites dimorphus* Kosanke 1950; SEM 600X, Wheeler Coal, CP-77-137. Oblique view of distal surface and equator.
16. *Reticulitriletes densoreticulatus* (Potonié and Kremp) n. comb.; Blackoak Coal, CP-19-4 slide 1Z5 (118.4 X 40.2), 61.0 μm.

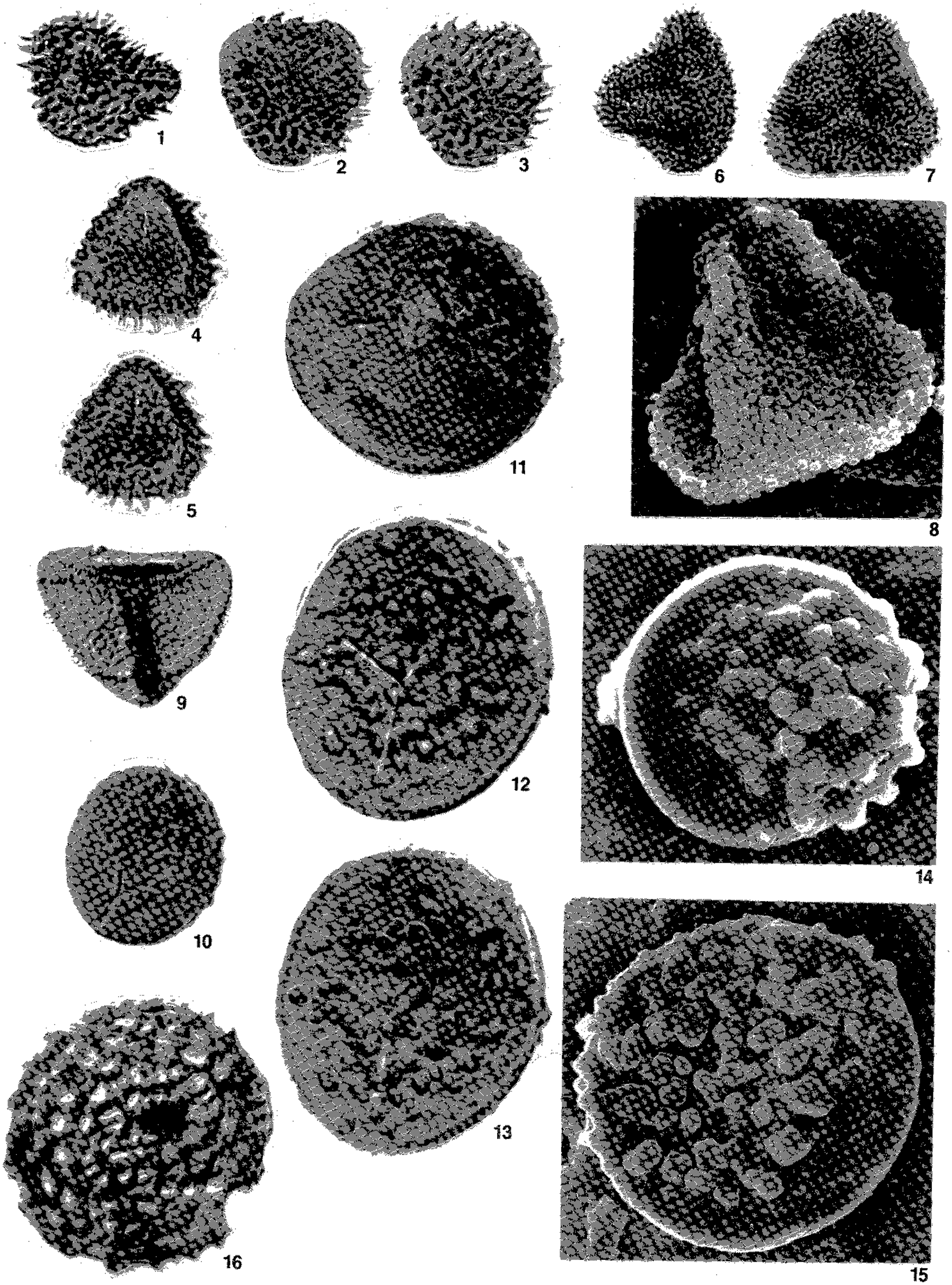

1
2
3
6
7
4
11
8
5
9
12
14
10
13
16
15

PLATE 25

1. *Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp emend. Smith and Butterworth 1967; Wildcat Den Coal, F-WH4 slide Z-5 (124.2 X 49.8), 42.8 μm.
2. *Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp emend. Smith and Butterworth 1967; Blackoak Coal, CP-10-49 slide A-4 (119.4 X 55.5), 41.1 μm.
3. *Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp emend. Smith and Butterworth 1967; SEM 900X, unnamed coal in the Kilbourn Formation, CP-41-67. Proximal surface.
4. *Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp emend. Smith and Butterworth 1967; SEM 900X, Blackoak Coal, CP-10-49. Distal surface.
5. *Reticulitriletes mediareticulatus* (Ibrahim) n. comb.; unnamed coal in the Caseyville Formation, F-WH3 slide 108, 44.1 μm.
6. *Reticulitriletes mediareticulatus* (Ibrahim) n. comb.; Blackoak Coal, CP-10-49 slide 108 (134.0 X 63.3), 44.1 μm.
7. *Reticulitriletes reticulocingulum* (Loose) n. comb.; unnamed coal in the Kilbourn Formation, CP-41-67 slide 13 (139.1 X 53.2), 42.3 μm. Specimen displaying coarse reticulum.
8. *Reticulitriletes reticulocingulum* (Loose) n. comb.; Blackoak Coal, CP-19-4 slide 1Z1 (119.6 X 48.0), 41.6 μm. Specimen displaying fine reticulum.
9. *Reticulitriletes reticulocingulum* (Loose) n. comb.; SEM 900X, Blackoak Coal, CP-10-49. Distal surface.
10. *Reticulitriletes falsus* (Potonié and Kremp) n. comb.; Wildcat Den Coal, F-WH4 slide A-6 (137.6 X 66.0), 48.5 μm; orthoscopic illumination.
11. Same as 10, interference contrast illumination, proximal focus.
12. *Reticulitriletes falsus* (Potonié and Kremp) n. comb.; unnamed coal in the Kilbourn Formation, CP-41-67 slide 16 (130.1 X 69.4), 49.6 μm.
13. *Reticulitriletes insculptus* (Sullivan and Marshall) n. comb.; Wildcat Den Coal, F-WH4 slide Z-4 (131.6 X 36.7), 40.5 μm.
14. *Reticulitriletes distortus* (Peppers) n. comb.; Blackoak Coal, CP-19-4 slide 6F5 (138.5 X 49.1), 38.2 μm.
15. *Reticulitriletes clatriformis* (Artüz) n. comb.; Wildcat Den Coal, F-WH4 slide Z-15 (129.1 X 46.6), 31.4 μm; proximal focus.
16. Same as 15, distal focus.
17. *Corbulispora? subalveolaris* (Luber) Sullivan 1964; Blackoak Coal, CP-10-49 slide C-3 (137.0 X 41.2), 51.9 μm; orthoscopic illumination.
18. Same as 17, interference contrast illumination.
19. *Corbulispora? subalveolaris* (Luber) Sullivan 1964; Blackoak Coal, 52803-3 slide 3 (133.9 X 54.4), 47.9 μm.
20. *Secarisporites remotus* Neves 1961; Wildcat Den Coal, F-WH4 slide M-20 (126.4 X 62.7), 47.3 μm.

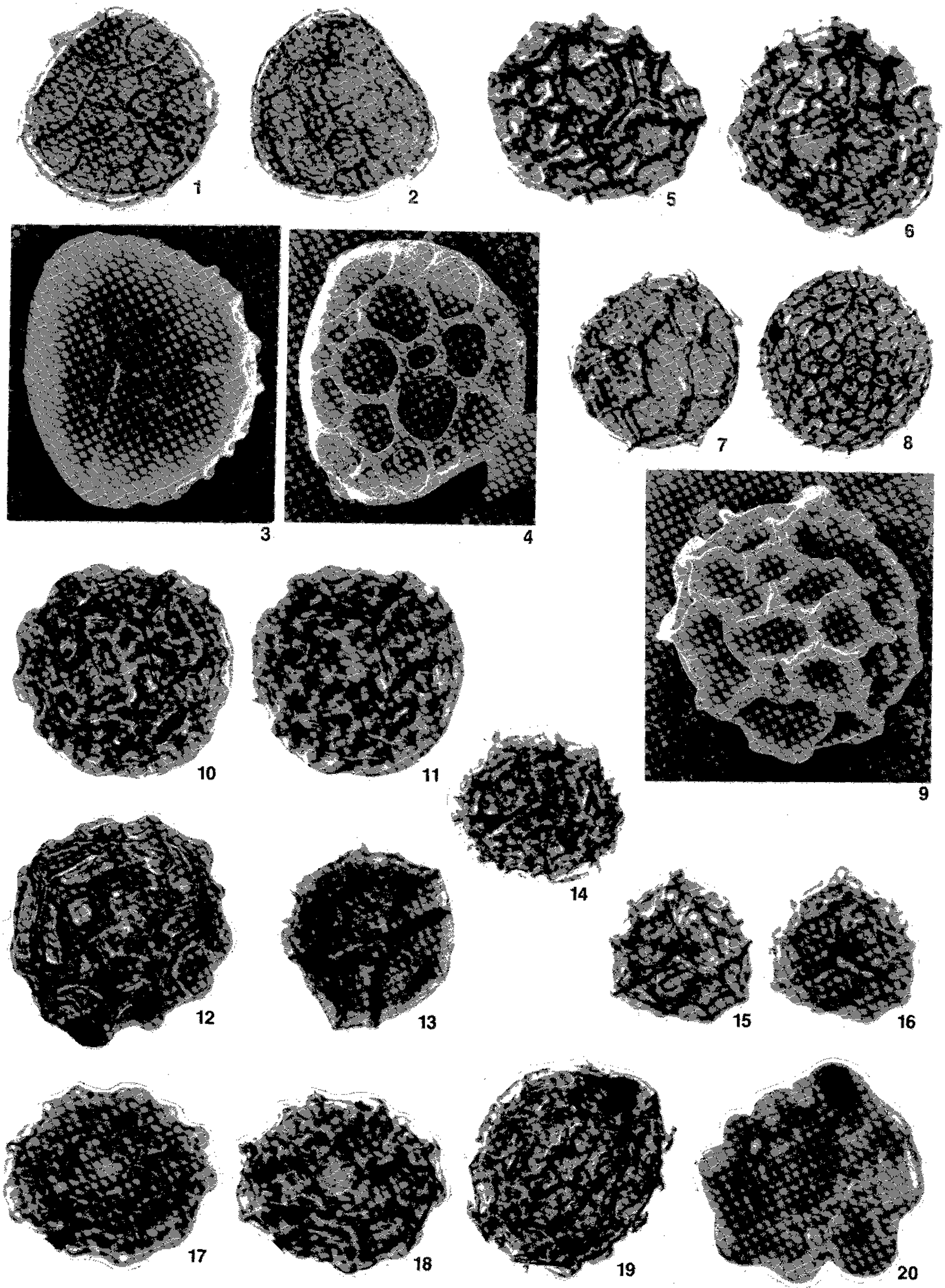

1
2
5
6
3
4
7
8
9
10
11
14
12
13
15
16
17
18
19
20

PLATE 26

1. *Microreticulatisporites futilis* (Felix and Burbridge) n. comb.; Wildcat Den Coal, F-II slide 39 (130.2 X 55.2), 38.2 μm.
2. *Microreticulatisporites futilis* (Felix and Burbridge) n. comb.; Blackoak Coal, CP-19-5 slide Y-4, 40.6 μm (specimen illustrated in Ravn, 1979, pl. 9, fig. 12 (131.2 X 38.1), as *Microreticulatisporites nobilis*).
3. *Foveosporites insculptus* Playford 1962; Laddsdale Coal, LOV-I slide 6 (124.1 X 39.1), 65.0 μm.
4. *Anafoveosporites avcinii* (Ravn and Fitzgerald) n. comb.; Wildcat Den Coal, F-WH4 slide Z-1 (123.9 X 50.0), 57.0 μm (holotype).
5. *Anafoveosporites avcinii* (Ravn and Fitzgerald) n. comb.; Wildcat Den Coal, F-I slide 16 (120.9 X 62.6), 44.5 μm (paratype).
6. *Anafoveosporites avcinii* (Ravn and Fitzgerald) n. comb.; Wildcat Den Coal, F-WH4 slide M-6 (138.0 X 49.8), 54.2 μm (paratype); proximal focus.
7. Same as 6, distal focus.
8. *Anafoveosporites avcinii* (Ravn and Fitzgerald) n. comb.; SEM 800X, Wildcat Den Coal, F-WH4. Distal surface.
9. *Triquitrites minutus* Alpern 1958; Blackoak Coal, CP-19-4 slide 2F2 (125.4 X 61.9), 25.1 μm.
10. *Triquitrites tribullatus* (Ibrahim) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-19-4 slide 3A2 (121.1 X 56.5), 25.7 μm.
11. *Triquitrites tribullatus* (Ibrahim) Schopf, Wilson and Bentall 1944; Carruthers Coal, CP-23-8 slide 5 (130.0 X 46.1), 28.5 μm.
12. *Triquitrites tribullatus* (Ibrahim) Schopf, Wilson and Bentall 1944; Cliffland Coal, WTCH-I slide 3 (133.4 X 48.8), 30.2 μm.
13. *Triquitrites sculptilis* Balme emend. Smith and Butterworth 1967; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-3 (138.6 X 40.7), 39.3 μm.
14. *Triquitrites sculptilis* Balme emend. Smith and Butterworth 1967; Blackoak Coal, CP-19-4 slide 6Z4 (135.9 X 54.0), 34.8 μm.
15. *Triquitrites sculptilis* Balme emend. Smith and Butterworth 1967; Bevier Coal, 1207791-7 slide 5 (132.0 X 37.0), 33.1 μm.
16. *Triquitrites sculptilis* Balme emend. Smith and Butterworth 1967; Bevier Coal, 1207791-7 slide 5 (124.9 X 45.4), 25.7 μm.
17. *Triquitrites sculptilis* Balme emend. Smith and Butterworth 1967; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-5 (122.8 X 61.3), 43.9 μm.
18. *Triquitrites sculptilis* Balme emend. Smith and Butterworth 1967; Bevier Coal, 1207791-7 slide 1 (122.9 X 59.6), 26.8 μm.
19. *Triquitrites subspinosus* Peppers 1970; Blackoak Coal, CP-19-4 slide 3Z6 (126.2 X 59.8), 39.9 μm.
20. *Triquitrites spinosus* Kosanke 1950; Wheeler Coal, CP-79-189 slide 3 (132.4 X 44.1), 46.7 μm.
21. *Triquitrites crassus* Kosanke 1950; Blackoak Coal, CP-19-5 slide A-4 (126.5 X 33.0), 45.6 μm.
22. *Triquitrites crassus* Kosanke 1950; SEM 800X, Blackoak Coal, CP-10-49. Distal surface showing rough "trilete" alignment of sculpture.

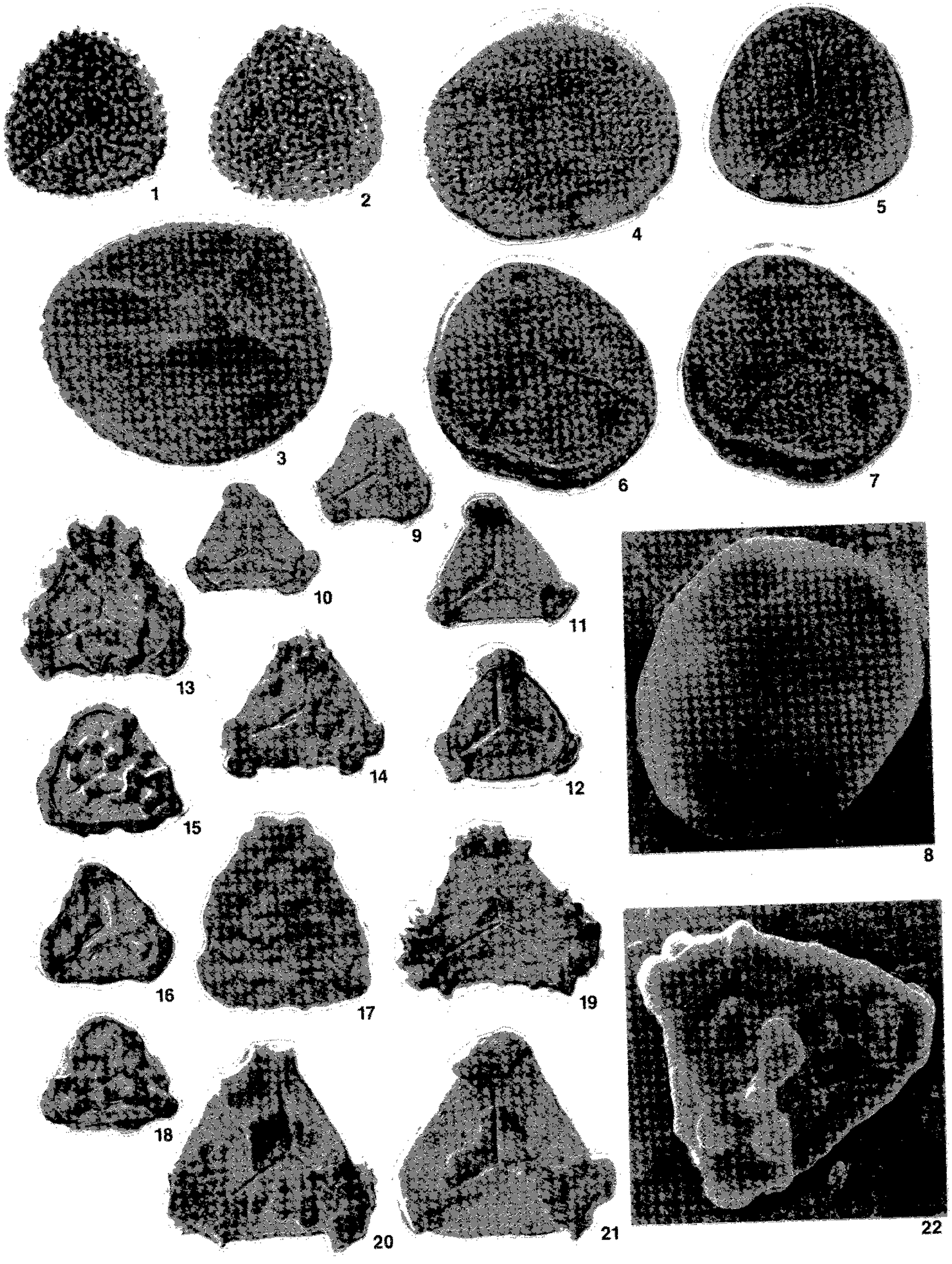

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 27

1. *Triquitrites additus* Wilson and Hoffmeister 1956; Blackoak Coal, CP-19-4 slide 5Z3 (138.9 X 41.2), 31.9 μm.
2. *Triquitrites additus* Wilson and Hoffmeister 1956; Blackoak Coal, CP-19-4 slide 5A3 (124.2 X 60.0), 35.3 μm.
3. *Indospora boleta* Peppers 1970; Blackoak Coal, CP-19-4 slide 6T2 (129.1 X 58.8), 22.2 μm excluding ornament.
4. *Ahrensisporites exertus* Peppers 1964; Blackoak Coal, CP-19-4 slide 5Z1 (133.5 X 44.9), 37.1 μm.
5. *Ahrensisporites exertus* Peppers 1964; Cliffland Coal, CP-3-1 slide 13 (122.2 X 53.0), 43.9 μm.
6. *Ahrensisporites guerickei* (Horst) Potonié and Kremp 1954; Wildcat Den Coal, F-II slide 27 (136.1 X 71.6), 45.9 μm.
7. *Ahrensisporites guerickei* (Horst) Potonié and Kremp 1954; SEM 800X, Wildcat Den Coal, F-WH4. Distal surface.
8. *Ahrensisporites ornatus* (Neves) n. status; Wildcat Den Coal, F-I slide 13 (124.0 X 55.3), 35.3 μm.
9. *Ahrensisporites ornatus* (Neves) n. status; unnamed coal in the Kilbourn Formation, CP-80-411 slide 6 (121.4 X 36.6), 52.4 μm.
10. *Ahrensisporites ornatus* (Neves) n. status; SEM 700X, Wildcat Den Coal, F-WH4. Distal surface.
11. *Ahrensisporites sinanii* (Artüz) n. comb.; unnamed coal in the Kilbourn Formation, CP-44-73 slide 16 (122.2 X 71.9), 41.7 μm.
12. *Mooreisporites inusitatus* (Kosanke) Neves 1958; Carruthers (?) Coal, CP-75-161 slide 5 (123.2 X 65.1), 47.5 μm.
13. *Mooreisporites inusitatus* (Kosanke) Neves 1958; Wheeler Coal, CP-21-2 slide 14 (125.8 X 50.0), 51.3 μm.
14. *Simozonotriletes intortus* (Waltz) Potonié and Kremp 1954; Blackoak Coal, CP-10-49 slide C-10 (118.6 X 73.8), 53.0 μm.
15. *Simozonotriletes intortus* (Waltz) Potonié and Kremp 1954; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-4 (132.2 X 48.5), 54.2 μm.
16. *Simozonotriletes intortus* (Waltz) Potonié and Kremp 1954; SEM 700X, Wildcat Den Coal, F-WH4. Proximal surface.

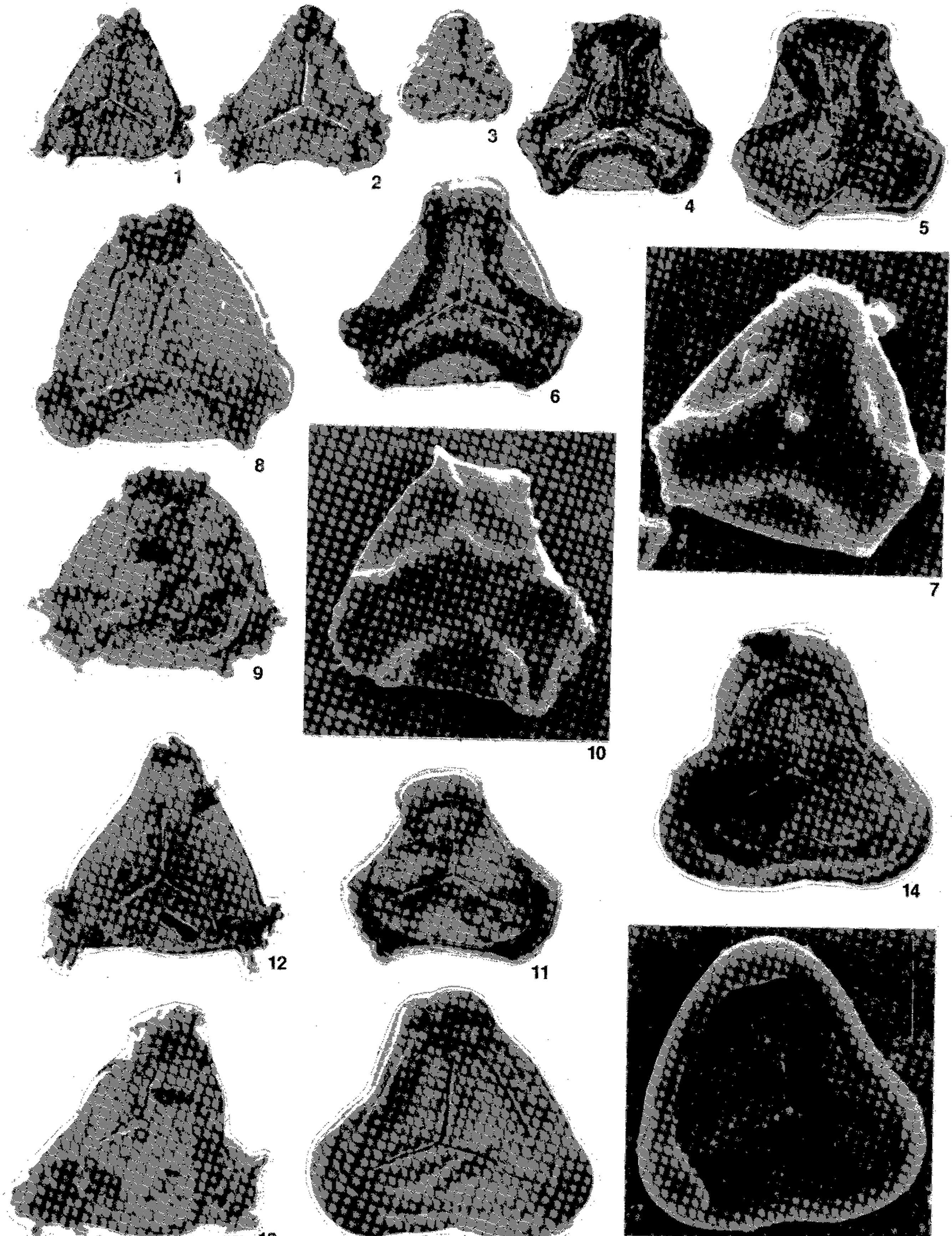

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

PLATE 28

1. *Trilobates bellii* Somers 1952; Blackoak Coal, CP-19-4 slide 5A7 (122.5 X 63.6), 26.2 μm.
2. *Tantillus triquetrus* Felix and Burbridge 1967; Blackoak Coal, CP-19-4 slide 6Z1 (131.2 X 64.0), 19.9 μm.
3. *Tantillus triquetrus* Felix and Burbridge 1967; unnamed coal in the Kilbourn Formation, CP-44-73 slide 15 (137.7 X 55.4), 22.8 μm.
4. *Tantillus triquetrus* Felix and Burbridge 1967; Blackoak Coal, CP-43-44 slide 4 (122.2 X 48.7), 21.7 μm.
5. *Trinidulus diamphidios* Felix and Paden 1964; Wildcat Den Coal, F-WH4 slide Z-14 (120.8 X 59.1), 45.6 μm.
6. *Trinidulus diamphidios* Felix and Paden 1964; SEM 900X, Wildcat Den Coal, F-WH4. Proximal surface.
7. *Reinschospora speciosa* (Loose) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-10-49 slide C-5 (132.1 X 55.6), 57.6 μm excluding ornament. Note the torn "perisporial" outer layer in lower right-hand corner.
8. *Reinschospora speciosa* (Loose) Schopf, Wilson and Bentall 1944; unnamed coal in the Caseyville Formation, F-WH3 slide 5 (135.3 X 51.1), 59.6 μm excluding ornament. Circular object along lower right-hand edge is a specimen of *Lycospora pellucida.*
9. *Reinschospora speciosa* (Loose) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-19-4 slide 5A3 (132.1 X 38.0), 51.1 μm excluding ornament.
10. *Murospora kosankei* Somers 1952; Cliffland Coal, CP-73-299 slide 10 (127.1 X 48.0), 34.8 μm.
11. *Murospora kosankei* Somers 1952; Cliffland Coal, CP-73-299 slide 11 (119.1 X 34.9), 35.3 μm.
12. *Bellispores nitidus* (Horst) Sullivan 1964; Wildcat Den Coal, F-WH4 slide M-4 (122.9 X 59.1), 34.2 μm.
13. *Reinschospora triangularis* Kosanke emend. Ravn 1979; unnamed coal in the Caseyville Formation, F-WH3 slide 4 (136.4 X 61.8), 62.7 μm excluding ornament.
14. *Reinschospora triangularis* Kosanke emend. Ravn 1979; Blackoak Coal, CP-19-4 slide 1Z3 (134.3 X 60.9), 57.0 μm excluding ornament.
15. *Reinschospora triangularis* Kosanke emend. Ravn 1979; SEM stereopair 500X, Blackoak Coal, CP-10-49. Distal surface showing pseudotrilete fringe.

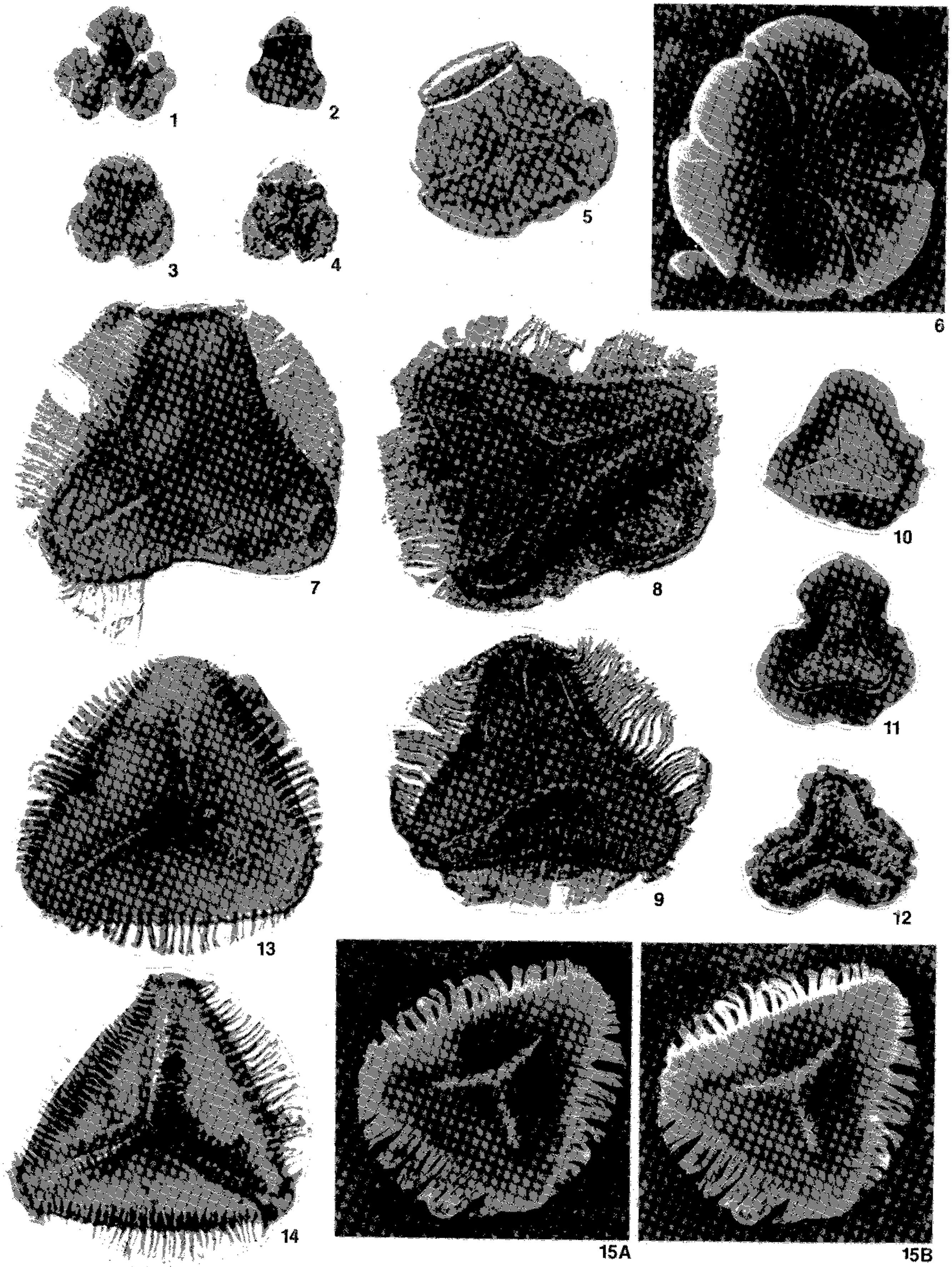

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15A
15B

PLATE 29

1. *Stenozonotriletes occultus* n. sp.; unnamed coal in the Floris Formation, CP-65-114 slide 5 (134.2 X 75.1), 46.2 μm (holotype).
2. *Stenozonotriletes occultus* n. sp.; unnamed coal in the Floris Formation, CP-65-114 slide 5 (127.8 X 73.1), 51.3 μm (paratype).
3. *Stenozonotriletes occultus* n. sp.; unnamed coal in the Floris Formation, CP-65-114 slide 6 (139.0 X 49.8), 48.5 μm (paratype).
4. *Stenozonotriletes occultus* n. sp.; unnamed coal in the Floris Formation, CP-65-114 slide 5 (121.1 X 60.9), 47.9 μm (paratype).
5. *Stenozonotriletes occultus* n. sp.; unnamed coal in the Floris Formation, CP-65-114 slide 9 (122.0 X 60.7), 48.5 μm (paratype).
6. *Stenozonotriletes occultus* n. sp.; unnamed coal in the Floris Formation, CP-65-114 slide 5 (120.5 X 45.6), 57.0 μm (paratype).
7. *Knoxisporites dissidius* Neves 1961; Wildcat Den Coal, F-WH4 slide M-12 (119.5 X 41.7), 41.7 μm.
8. *Knoxisporites seniradiatus* Neves 1961; Wildcat Den Coal, F-II slide 12 (133.0 X 67.0), 51.3 μm.
9. *Knoxisporites seniradiatus* Neves 1961; Wildcat Den Coal, F-II slide 33 (122.4 X 50.2), 53.6 μm.
10. *Stenozonotriletes* sp. 1; Wildcat Den Coal, F-WH4 slide A-12 (119.1 X 57.8), 57.0 μm; proximal focus showing granulose external sculpture.
11. Same as 10, medial focus showing clusters of infrasculptural punctae adjacent to the trilete laesura.
12. *Knoxisporites stephanephorus* Love 1960; Wildcat Den Coal, F-WH4 slide M-11 (122.3 X 56.0), 52.4 μm; proximal focus.
13. Same as 12, distal focus.
14. *Knoxisporites stephanephorus* Love 1960; Blackoak Coal, CP-19-4 slide 6R2 (133.1 X 41.8), 41.6 μm.
15. *Knoxisporites stephanephorus* Love 1960; Laddsdale Coal, CP-39-16 slide 10 (133.0 X 73.4), 45.6 μm.
16. *Knoxisporites triradiatus* Hoffmeister, Staplin and Malloy 1955; Wildcat Den Coal, F-II slide 26 (128.7 X 51.7), 61.6 μm.
17. *Knoxisporites triradiatus* Hoffmeister, Staplin and Malloy 1955; unnamed coal in the Kilbourn Formation, CP-80-411 slide 5 (126.2 X 63.3), 63.3 μm.
18. *Knoxisporites triradiatus* Hoffmeister, Staplin and Malloy 1955; SEM 500X, Wildcat Den Coal, F-II. Distal surface.

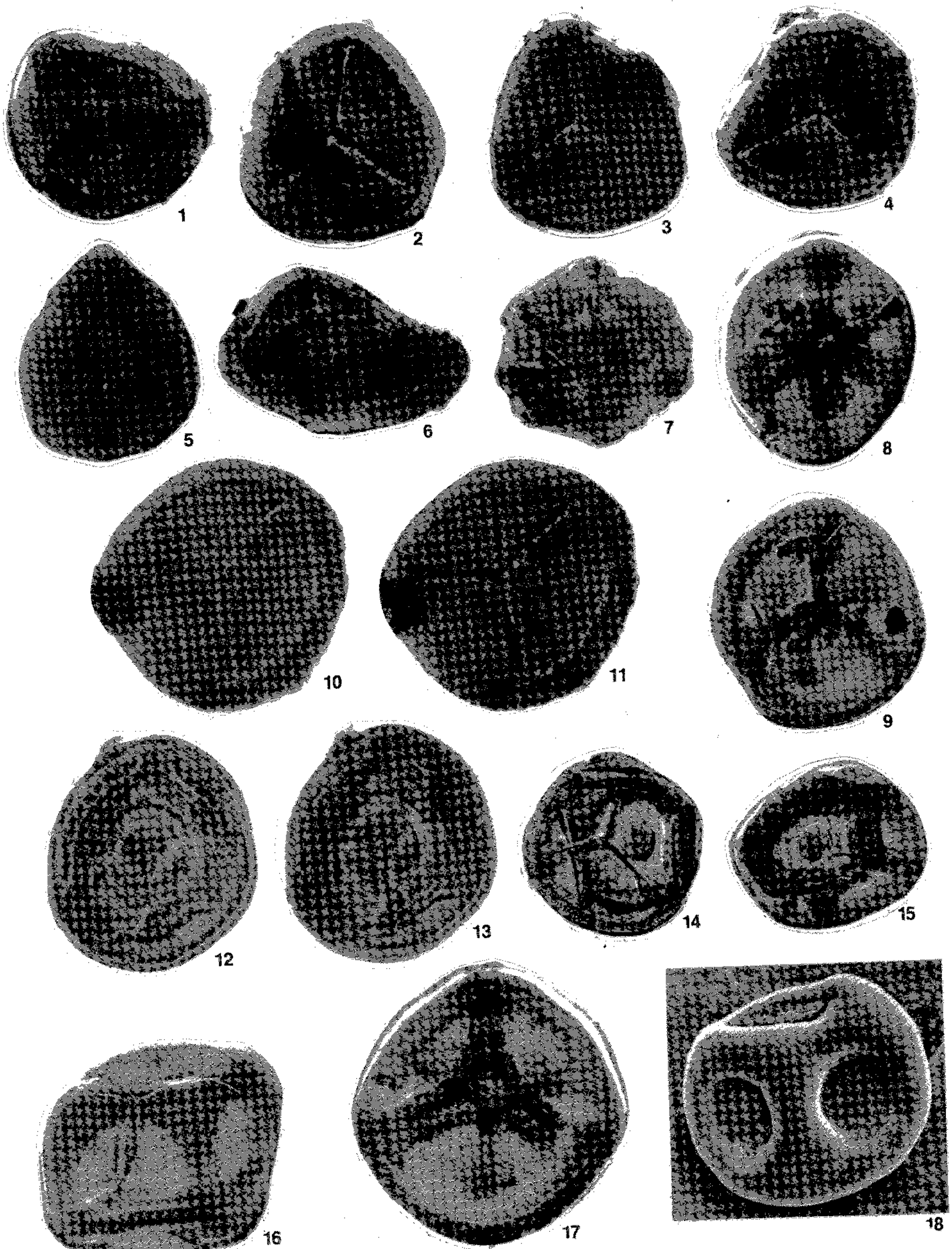

1
2
3
4
5
6
7
8
10
11
9
12
13
14
15
16
17
18

PLATE 30

1. *Zosterosporites triangularis* Kosanke 1973; Blackoak Coal, CP-19-4 slide 1W2 (137.1 X 51.4), 27.9 μm.
2. *Zosterosporites triangularis* Kosanke 1973; Cliffland Coal, CP-73-299 slide 10 (120.0 X 63.3), 31.4 μm.
3. *Zosterosporites triangularis* Kosanke 1973; Blackoak Coal, CP-19-4 slide 1X1 (126.9 X 59.5), 31.4 μm.
4. *Spelaeotriletes triangulus* Neves and Owens 1966; Wildcat Den Coal, F-WH4 slide Z-20 (136.1 X 67.6), 82.4 μm.
5. *Vallatisporites* sp. cf. *V. foveolatus* (Hughes and Playford) Sullivan 1964; Wildcat Den Coal, F-WH4 slide A-16 (120.9 X 40.0), 63.8 μm.
6. *Gorgonispora* sp. cf. *G. minima* (Felix and Burbridge) n. comb.; Wildcat Den Coal, F-I slide 11 (120.8 X 62.4), 49.6 μm.
7. *Grumosisporites varioreticulatus* (Neves) Smith and Butterworth 1967; unnamed coal in the Kilbourn Formation, CP-41-67 slide 14 (120.3 X 63.1), 62.6 μm; 600X.
8. *Grumosisporites varioreticulatus* (Neves) Smith and Butterworth 1967; Wildcat Den Coal, F-WH4 slide Z-3 (119.0 X 41.1), 106.5 μm; 600X.
9. *Grumosisporites varioreticulatus* (Neves) Smith and Butterworth 1967; SEM 600X, Wildcat Den Coal, F-WH4. Proximal surface.
10. *Grumosisporites rufus* (Butterworth and Williams) Smith and Butterworth 1967; Laddsdale Coal, CP-73-231 slide 7 (122.1 X 66.9), 46.2 μm.
11. *Kewaneesporites appressus* n. sp.; Cliffland Coal, CP-4-10 slide 9 (125.4 X 65.1), 39.9 μm (paratype).
12. *Kewaneesporites appressus* n. sp.; unnamed coal in the Kilbourn Formation, CP-17-13 slide B-4 (124.8 X 48.1), 41.7 μm, proximal focus (paratype).
13. Same as 12, distal focus.
14. *Kewaneesporites appressus* n. sp.; unnamed coal in the Kilbourn Formation, CP-17-13 slide B-4 (134.9 X 59.4), 49.0 μm, proximal focus (holotype).
15. Same as 14, medial focus.
16. *Kewaneesporites appressus* n. sp.; SEM 900X, Blackoak Coal, CP-10-49. Oblique view of proximal surface; trilete laesura, obscured by membranous outer layer of exine, is present in the upper left-center portion of the specimen.

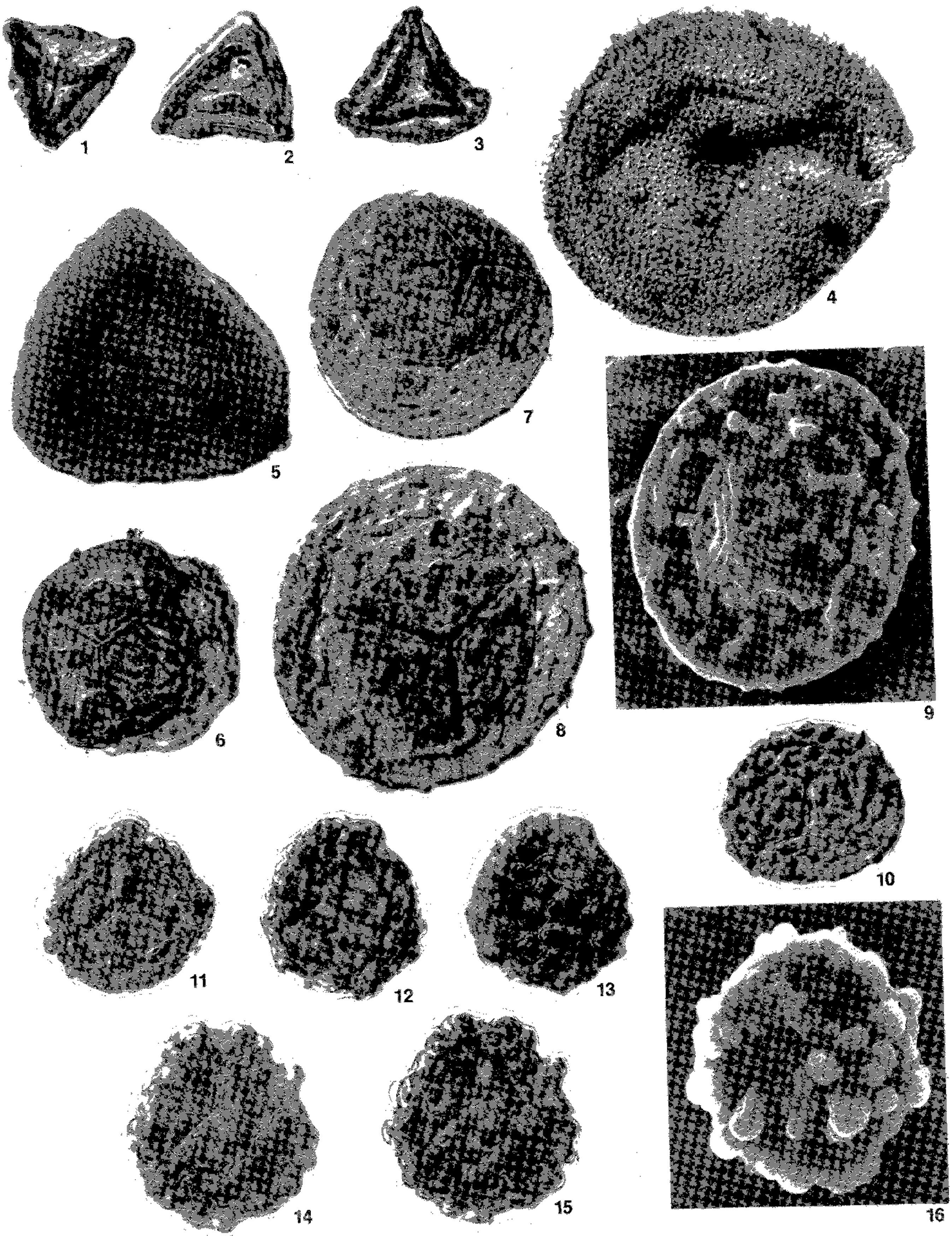

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

PLATE 31

1. *Alatisporites trialatus* Kosanke 1950; Laddsdale Coal, 416804-2 slide 9 (121.8 X 57.1), 87.0 μm; 600X.
2. *Alatisporites trialatus* Kosanke 1950; Carruthers Coal, CP-23-8 slide 8 (123.1 X 60.7), 72.1 μm.
3. *Alatisporites pustulatus* (Ibrahim) Ibrahim 1933; Blackoak Coal, CP-19-4 slide 3A2 (120.9 X 58.0), 90.0 μm; 600X.
4. *Alatisporites pustulatus* (Ibrahim) Ibrahim 1933; SEM 600X, unnamed coal in the Kilbourn Formation, CP-63-5-361. Proximal surface, showing folds of exoexine across spore body.
5. *Alatisporites hoffmeisterii* Morgan 1955; Blackoak Coal, CP-19-4 slide 1Y4 (126.4 X 45.9), 55.4 μm excluding bladders; 600X.
6. *Alatisporites hoffmeisterii* Morgan 1955; SEM 600X, Blackoak Coal, CP-10-49. Proximal surface.
7. *Alatisporites hexalatus* Kosanke 1950; Laddsdale Coal, 416804-2 slide 2 (123.9 X 64.0), 51.3 μm excluding bladders.
8. *Retispora staplinii* (Gupta and Boozer) Ravn and Fitzgerald 1982; Wildcat Den Coal, F-II slide 31 (129.8 X 45.5), 42.8 μm.
9. *Retispora staplinii* (Gupta and Boozer) Ravn and Fitzgerald 1982; Blackoak Coal, CP-10-49 slide C-1 (123.8 X 66.9), 38.2 μm.
10. *Retispora staplinii* (Gupta and Boozer) Ravn and Fitzgerald 1982; Wildcat Den Coal, F-II slide 36 (130.0 X 67.9), 44.6 μm. Large specimen showing unusually complete distal reticulum.
11. *Retispora staplinii* (Gupta and Boozer) Ravn and Fitzgerald 1982; SEM 800X, unnamed coal in the Caseyville Formation, F-WH3. Distal surface.
12. Detail of 11, 1500X, showing vague, incomplete muri.

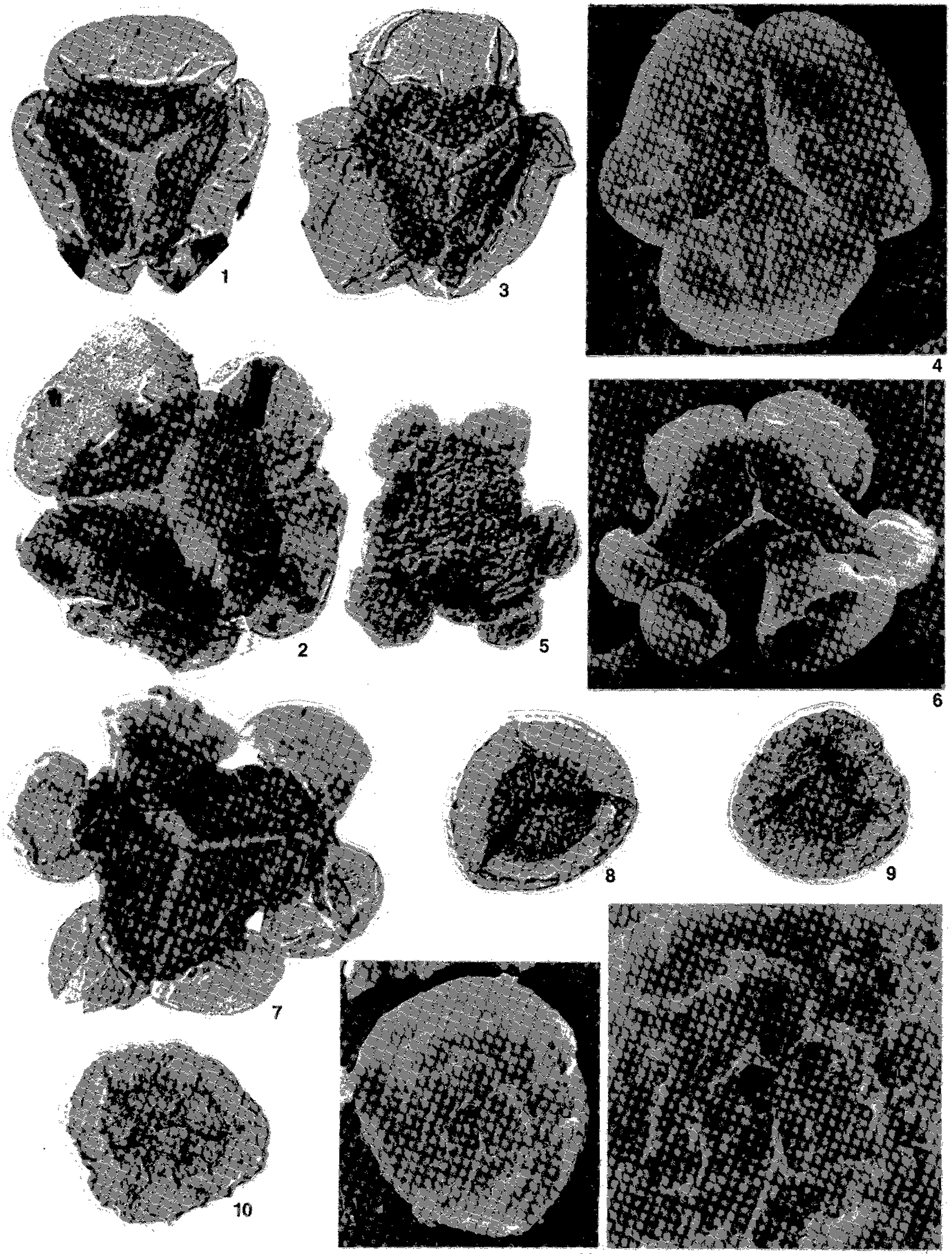

1
3
4
2
5
6
7
8
9
10
11
12

PLATE 32

1. *Hymenospora multirugosa* Peppers 1970; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-1 (118.5 X 64.4), 33.7 µm.
2. *Hymenospora multirugosa* Peppers 1970; Wildcat Den Coal, F-II slide 33 (126.5 X 45.8), 38.8 µm.
3. *Hymenospora multirugosa* Peppers 1970; SEM stereopair 800X, unnamed coal in the Kilbourn Formation, CP-17-13. Proximal surface showing external expression of trilete laesura.
4. *Diaphanospora parvigracila* (Peppers) Ravn 1979; Blackoak Coal, CP-19-4 slide 6R6 (135.0 X 36.5), 39.9 µm excluding perispore.
5. *Diaphanospora parvigracila* (Peppers) Ravn 1979; Wildcat Den Coal, F-I slide 25 (127.1 X 62.5), 42.9 µm excluding perispore.
6. *Rugospora gracilirugosa* n. sp.; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-2 (127.9 X 62.0), 42.3 µm (holotype).
7. *Rugospora gracilirugosa* n. sp.; Wildcat Den Coal, F-I slide 33 (133.0 X 55.2), 43.9 µm (paratype).
8. *Rugospora gracilirugosa* n. sp.; unnamed coal in the Kilbourn Formation, CP-17-13 slide C-1 (122.5 X 47.4), 38.8 µm (paratype).
9. *Hymenospora* sp. cf. *H. caperata* Felix and Burbridge 1967; Wildcat Den Coal, F-II slide 37 (139.1 X 53.2), 42.8 µm; orthoscopic illumination.
10. Same as 9, interference contrast illumination.
11. *Hymenospora* sp. cf. *H. caperata* Felix and Burbridge 1967; unnamed coal in the Kilbourn Formation, CP-17-13 slide A-5 (124.8 X 40.0), 55.3 µm.
12. *Diaphanospora* sp. 1; Wildcat Den Coal, F-WH4 slide M-15 (127.1 X 71.0), 45.1 µm; proximal focus.
13. Same as 12, distal focus.
14. *Rugospora radiata* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-II slide 35 (130.3 X 41.7), 47.3 µm (paratype).
15. *Rugospora radiata* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-WH4 slide A-1 (118.5 X 34.2), 62.7 µm (holotype).
16. *Rugospora radiata* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-WH4 slide A-17 (129.1 X 62.9), 64.4 µm (paratype).
17. *Hymenospora paucirugosa* Peppers 1970; Laddsdale Coal, 416804-2 slide 5 (123.0 X 58.1), 69.5 µm.
18. *Thysanites densus* Ravn 1979; Blackoak Coal, CP-19-4 slide 1X5 (119.7 X 60.0), 30.2 µm excluding flange (holotype).
19. *Thysanites densus* Ravn 1979; Blackoak Coal, CP-10-49 slide C-5 (137.1 X 63.0), 32.7 µm excluding flange.
20. *Thysanites densus* Ravn 1979; Blackoak Coal, CP-19-4 slide 1C1 (132.1 X 44.9), 31.4 µm excluding flange (paratype).

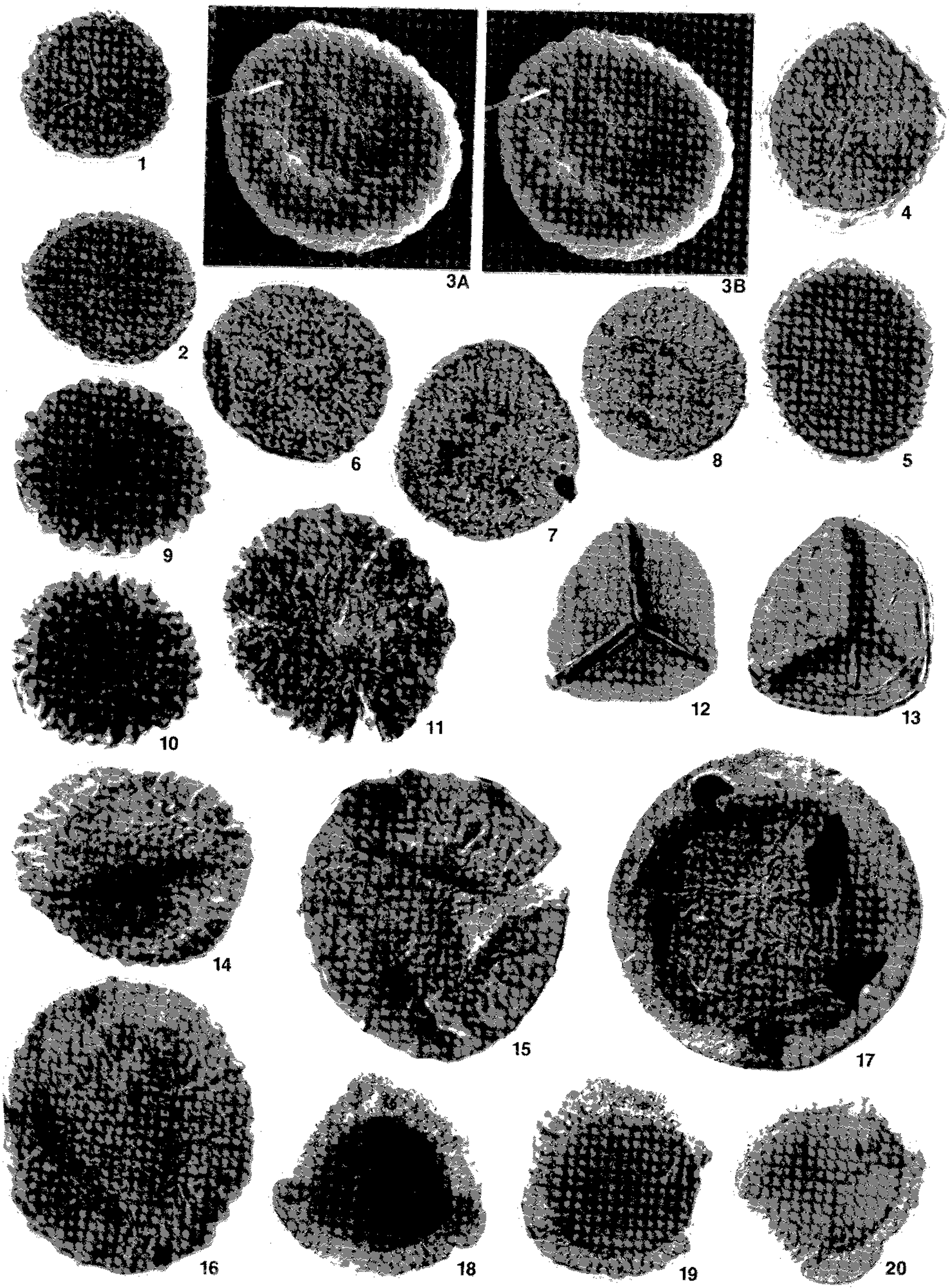

1
3A
3B
4
2
6
8
5
9
7
12
13
10
11
14
15
17
16
18
19
20

PLATE 33

1. *Punctatosporites minutus* Ibrahim emend. Alpern and Doubinger 1973; Blackoak Coal, CP-19-4 slide 3Z6 (121.9 X 49.1), 20.4 μm.
2. *Punctatosporites minutus* Ibrahim emend. Alpern and Doubinger 1973; Bevier Coal, 1207791-7 slide 10 (127.2 X 48.8), 23.4 μm.
3. *Punctatosporites rotundus* Bhardwaj emend. Alpern and Doubinger 1973; Blackoak Coal, CP-37-126 slide 14 (122.2 X 61.9), 21.7 μm.
4. *Punctatosporites rotundus* Bhardwaj emend. Alpern and Doubinger 1973; Cliffland Coal, CP-7-43 slide 7 (130.0 X 64.2), 23.4 μm.
5. *Punctatosporites granifer* Potonie and Kremp emend. Alpern and Doubinger 1973; Blackoak Coal, CP-19-4 slide DB1Z (126.3 X 60.4), 31.4 μm.
6. *Laevigatosporites globosus* Schemel 1951; Blackoak Coal, CP-19-4 slide 6H1 (122.8 X 53.5), 27.9 μm.
7. *Laevigatosporites medius* Kosanke 1950; Blackoak Coal, CP-19-4 slide 1X1 (123.4 X 53.3), 35.9 μm.
8. *Laevigatosporites medius* Kosanke 1950; Blackoak Coal, CP-19-4 slide 1Z6 (131.8 X 45.1), 33.1 μm.
9. *Laevigatosporites minor* Loose 1934; unnamed coal in the Kilbourn Formation, CP-63-5-361 slide 4 (125.0 X 44.0), 46.7 μm.
10. *Laevigatosporites desmoinesensis* (Wilson and Coe) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-19-4 slide 1Z1 (129.9 X 74.0), 63.3 μm.
11. *Laevigatosporites minor* Loose 1934; SEM 750X, unnamed coal in the Kilbourn Formation, CP-41-67.
12. *Punctatosporites punctatus* (Kosanke) Alpern and Doubinger 1973; Cliffland Coal, CP-73-299 slide 4 (133.0 X 66.6), 45.6 μm.
13. *Punctatosporites punctatus* (Kosanke) Alpern and Doubinger 1973; Laddsdale Coal, 416804-2 slide 2 (133.8 X 51.6), 37.6 μm; proximal focus.
14. Same as 13, distal focus.
15. *Laevigatosporites minor* f. *striatus* (Alpern) n. status; Blackoak Coal, CP-19-4 slide 5A2 (130.4 X 63.9), 51.9 μm.
16. *Laevigatosporites minor* f. *striatus* (Alpern) n. status; Blackoak Coal, CP-19-4 slide 5A4 (135.1 X 46.2), 56.4 μm.
17. *Laevigatosporites contactus* Ravn and Fitzgerald 1982; Wyoming Hill Coal, F-WH2 slide 18 (126.8 X 65.5), 61.6 μm (paratype).
18. *Laevigatosporites contactus* Ravn and Fitzgerald 1982; Wyoming Hill Coal, F-WH2 slide 8 (123.0 X 38.9), 58.7 μm (paratype).
19. *Laevigatosporites vulgaris* (Ibrahim) Ibrahim 1933; Blackoak Coal, CP-19-4 slide 6Z3 (130.6 X 32.3), 84.4 μm.
20. *Laevigatosporites* sp. cf. *L. vulgaris* (Ibrahim) Ibrahim 1933; Blackoak Coal, CP-19-4 slide 2H2 (129.0 X 46.4), 90.9 μm.
21. *Laevigatosporites maximus* Loose emend. Potonié and Kremp 1956; unnamed coal in the Kilbourn Formation, CP-17-13 slide W-6 (135.3 X 58.7), 116.4 μm; 600X.
22. *Laevigatosporites maximus* Loose emend. Potonié and Kremp 1956; Wildcat Den Coal, F-WH4 slide Z-1 (136.9 X 70.0), 120.7 μm; 600X.

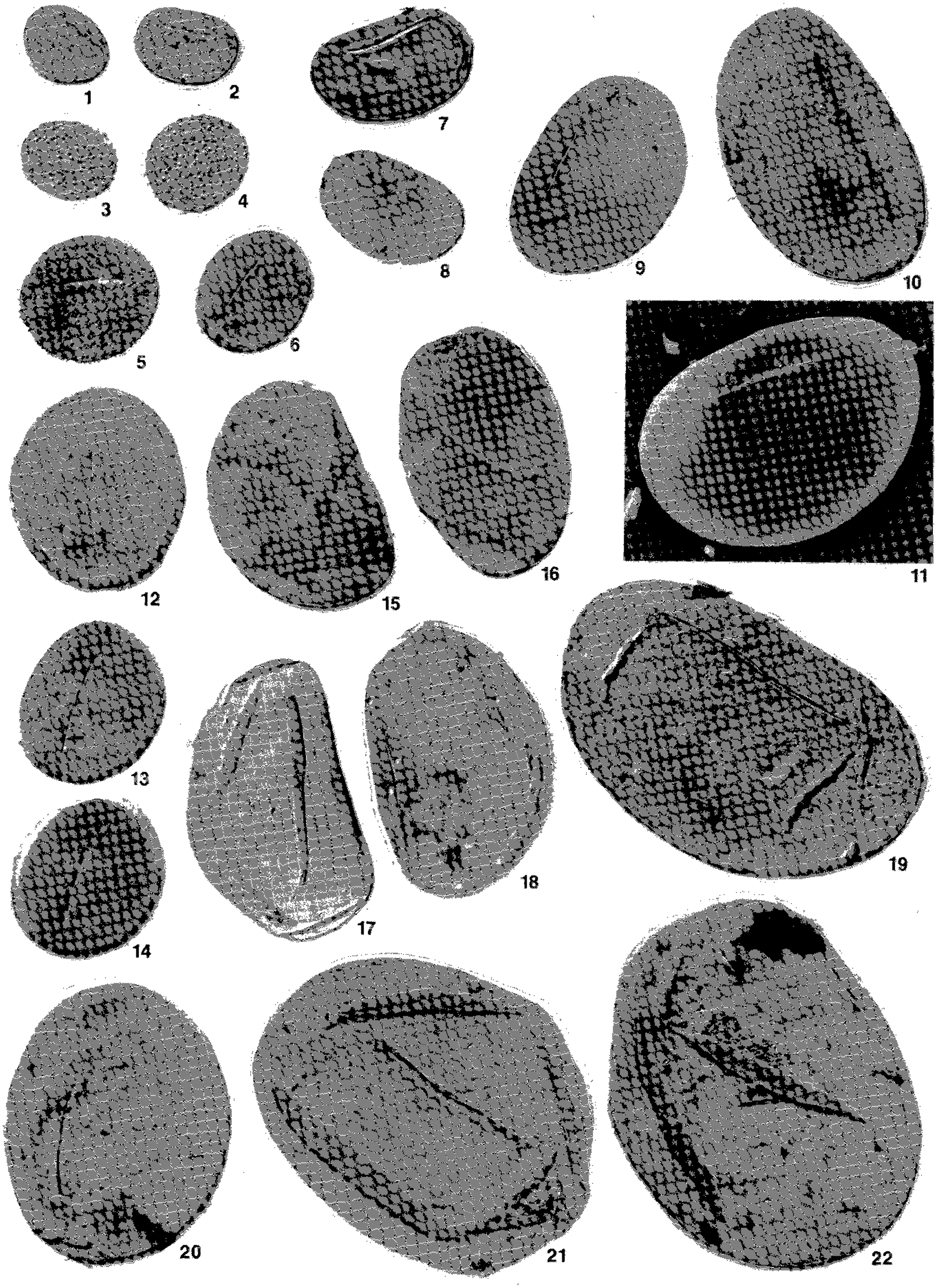

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 34

1. *Dictyomonolites swadei* n. sp.; Cliffland Coal, CP-73-299 slide 6 (128.1 X 49.9),, 29.6 μm (holotype).
2. *Dictyomonolites swadei* n. sp.; Cliffland Coal, CP-73-299 slide 3 (131.4 X 52.3), 30.7 μm (paratype).
3. *Dictyomonolites swadei* n. sp.; Blackoak Coal, CP-73-317 slide 7 (123.8 X 48.6), 32.9 μm (paratype).
4. *Dictyomonolites swadei* n. sp.; Blackoak Coal, CP-19-4 slide 5A3 (123.1 X 50.2), 26.2 μm (paratype); specimen illustrated by Ravn (1979, pl. 9, fig. 3) as *Dictyotriletes castaneaeformis* (Horst) Sullivan 1964.
5. *Dictyomonolites swadei* n. sp.; SEM stereopair 1000X, Cliffland Coal, CP-73-299. Oblique view of distal surface, showing discontinuous nature of muri.
6. *Dictyomonolites swadei* n. sp.; Blackoak Coal, CP-42-32 slide 13 (135.5 X 53.4), 28.5 μm (paratype); proximal focus.
7. Same as 6, distal focus.
8. *Dictyomonolites swadei* n. sp.; SEM 1250X, Cliffland Coal, CP-73-299. Oblique view of proximal surface, showing raised monolete laesura.
9. *Spinosporites exiguus* Upshaw and Hedlund 1967; Carruthers Coal, CP-22-32 slide 9 (132.4 X 68.7), 16.0 μm excluding ornament; magnifications of 600X and 1000X.
10. *Spinosporites exiguus* Upshaw and Hedlund 1967; Carruthers Coal, CP-22-32 slide 8 (133.2 X 66.2), 14.8 μm excluding ornament; magnifications of 600X and 1000X.
11. *Spinosporites exiguus* Upshaw and Hedlund 1967; Carruthers Coal, CP-22-32 slide 5 (132.0 X 57.0), 12.5 μm excluding ornament; magnifications of 600X and 1000X. Note faint monolete laesura slightly to the right of center of the specimen.
12. *Spinosporites* sp. 1; Cliffland Coal, CP-41-48 slide Y-6 (127.9 X 52.6), 42.9 μm excluding ornament.
13. *Renisporites confossus* Winslow 1959; Blackoak Coal, CP-63-4 slide 1 (120.1 X 38.0), 120.7 μm; 600X.
14. *Renisporites confossus* Winslow 1959; Cliffland Coal, CP-25-8 slide 10 (118.5 X 64.1), 163.3 μm; 600X.
15. Detail of cluster of lateral punctae from 14, 1000X.
16. *Thymospora pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963; Mystic Coal, CP-22-7 slide 2 (129.7 X 73.1), 26.9 μm.
17. *Thymospora pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963; Wheeler Coal, CP-77-137 slide 10 (120.9 X 69.4), 31.4 μm.
18. *Thymospora pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963; Bevier Coal, 1207791-7 slide 2 (135.0 X 56.3), 29.6 μm.
19. *Thymospora pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963; Whitebreast Coal, CP-9-11 slide 11 (123.1 X 48.1), 29.6 μm.
20. *Thymospora pseudothiessenii* (Kosanke) Wilson and Venkatachala 1963; Mystic Coal, CP-22-7 slide 13 (121.9 X 53.2), 34.2 μm; note *Torispora*-like crassitude.
21. *Torispora securis* Balme emend. Alpern, Doubinger and Horst 1965; Cliffland Coal, CP-3-1 slide 15 (133.8 X 57.1), 39.9 μm.
22. *Torispora securis* Balme emend. Alpern, Doubinger and Horst 1965; Blackoak Coal, CP-10-49 slide B-6 (139.) X 52.8), 40.6 μm.
23. *Torispora securis* Balme emend. Alpern, Doubinger and Horst 1965; Blackoak Coal, CP-10-49 slide B-6 (135.1 X 35.6), 48.4 μm.

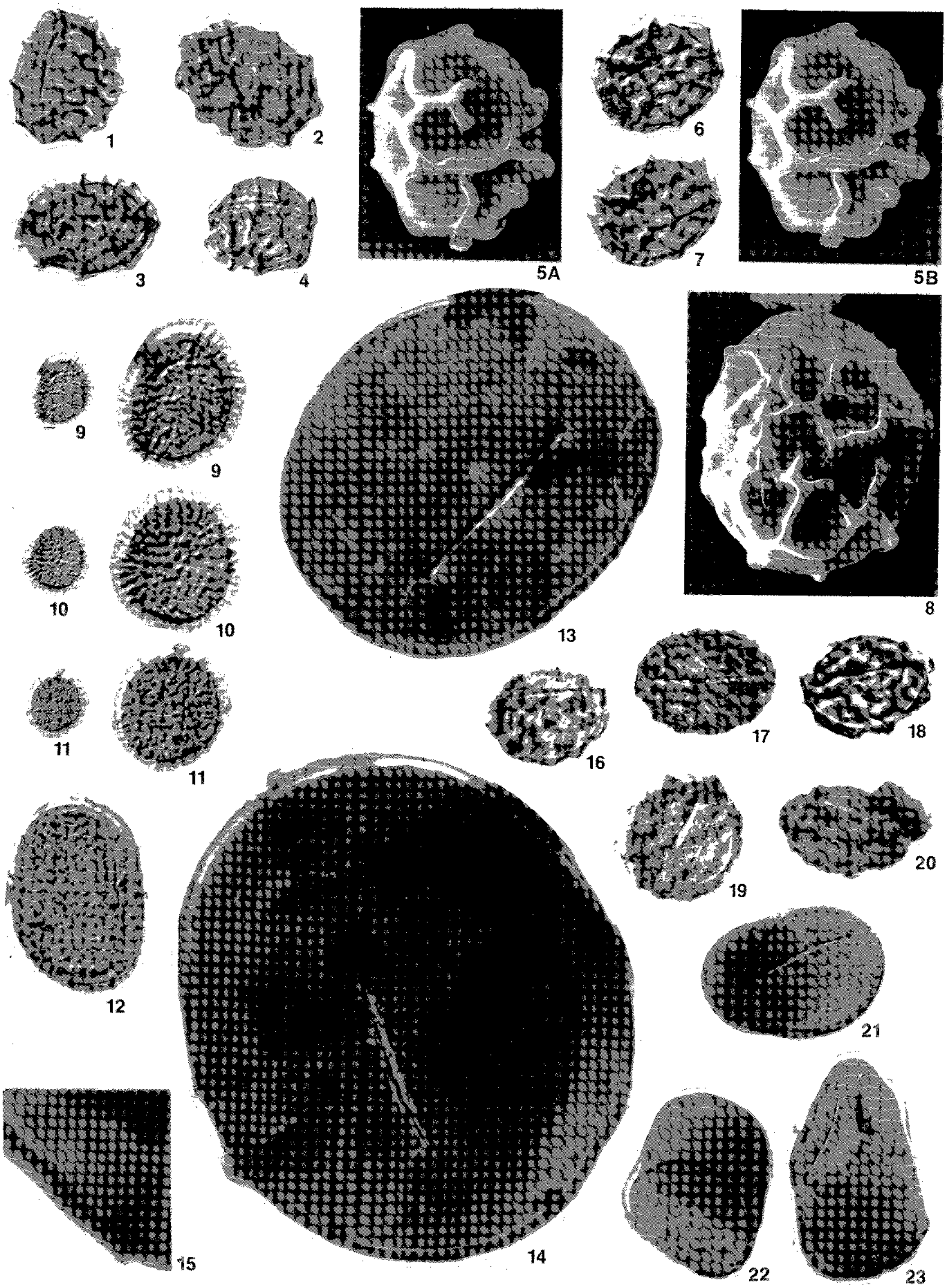

1
2
3
4
5A
6
7
5B
9
9
10
10
11
11
12
13
8
16
17
18
19
20
21
14
15
22
23

PLATE 35

1. *Maculatasporites asperatus* n. sp.; Laddsdale Coal, CP-66-185 slide 6 (119.5 X 44.0), 49.0 µm (holotype).
2. *Maculatasporites asperatus* n. sp.; SEM stereopair 600X, Laddsdale Coal, CP-66-185.
3. *Maculatasporites asperatus* n. sp.; Laddsdale Coal, CP-66-185 slide 4 (127.2 X 41.3), 38.2 µm (paratype).
4. *Maculatasporites asperatus* n. sp.; Laddsdale Coal, CP-66-185 slide 6 (121.0 X 60.9), 50.7 µm (paratype).
5. *Maculatasporites asperatus* n. sp.; Laddsdale Coal, CP-66-185 slide 4 (129.1 X 53.7), 43.9 µm (paratype).
6. *Maculatasporites asperatus* n. sp.; Laddsdale Coal, CP-66-185 slide 4 (127.3 X 51.7), 38.2 µm (paratype).
7. *Maculatasporites asperatus* n. sp.; Laddsdale Coal, CP-66-185 slide 6 (126.0 X 43.2), 44.6 µm (paratype).
8. *Maculatasporites asperatus* n. sp.; SEM 800X, Laddsdale Coal, CP-66-185. Note minute conate ornament along muri.
9. *Spackmanites habibii* n. sp.; Blackoak Coal, CP-19-4 slide 5A2 (125.1 X 59.4), 29.6 µm (paratype).
10. *Spackmanites habibii* n. sp.; Blackoak Coal, CP-10-49 slide C-7 (134.2 X 50.5), 30.8 µm (holotype); orthoscopic illumination.
11. Same as 10, interference contrast illumination.
12. *Spackmanites ellipticus* Habib emend.; unnamed coal in the Kilbourn Formation, CP-80-411 slide 2 (119.1 X 60.0), 46.7 µm.
13. *Spackmanites ellipticus* Habib emend.; Blackoak Coal, CP-22-444 slide 8 (134.9 X 66.2), 51.3 µm.
14. *Spackmanites ellipticus* Habib emend.; SEM 800X, Cliffland Coal, CP-73-299.
15. *Spackmanites* sp. 1; Wildcat Den Coal, F-II slide 31 (121.6 X 33.9), 37.1 µm.
16. *Leioaletes circularis* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-III slide 39 (124.1 X 71.7), 57.0 µm (paratype).
17. *Leioaletes circularis* Ravn and Fitzgerald 1982; Wildcat Den Coal, F-III slide 27 (120.0 X 67.0), 55.3 µm (holotype).
18. *Tuberculatosporites robustus* (Kosanke) Peppers 1970; Blackoak Coal, CP-19-4 slide 1C1 (123.9 X 62.2), 73.8 µm; 600X.
19. *Tuberculatosporites robustus* (Kosanke) Peppers 1970; Blackoak Coal, CP-19-4 slide 1C6 (137.1 X 55.1), 105.1 µm; 600X.

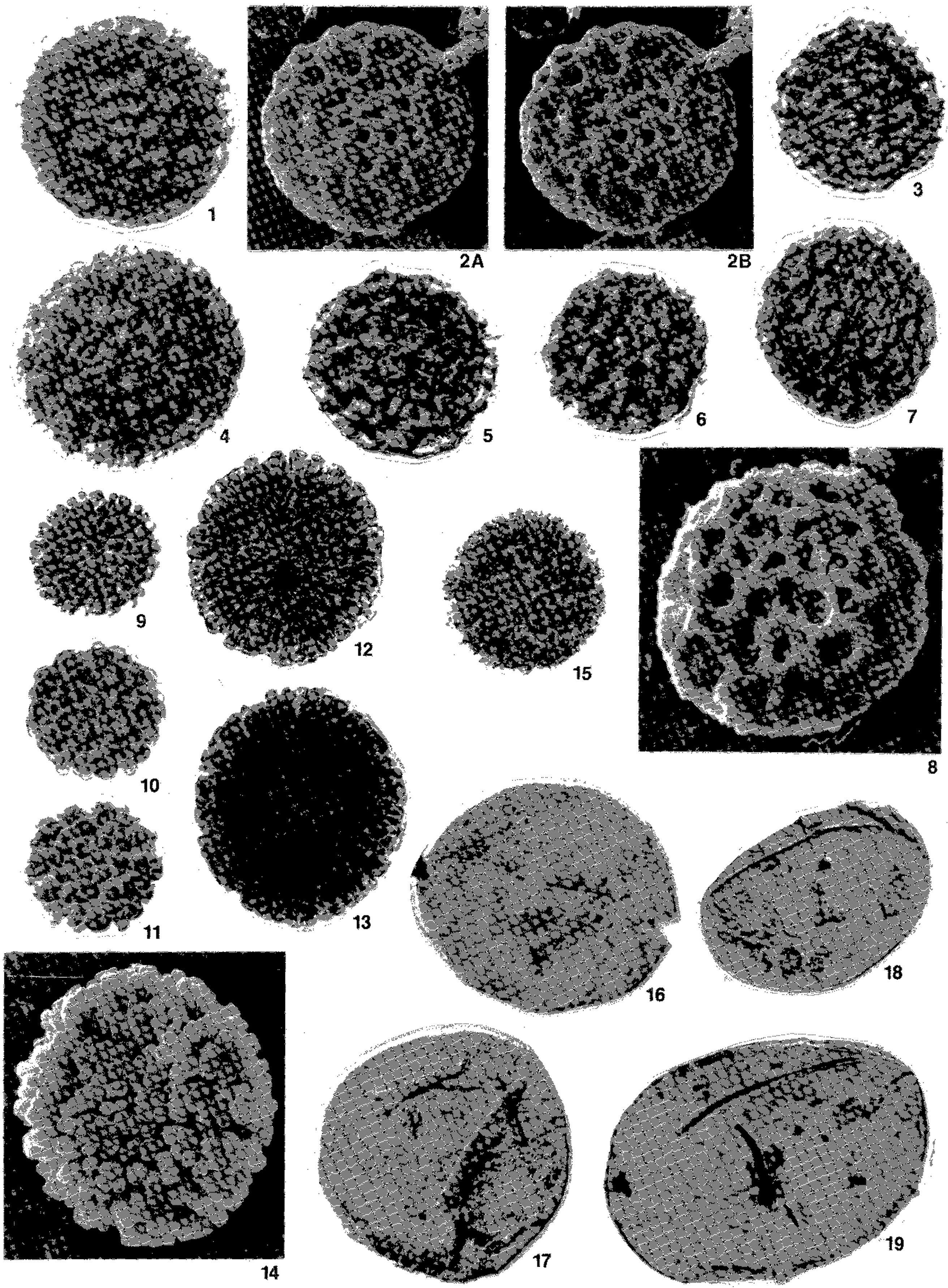

1
2A
2B
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

PLATE 36

1. *Spackmanites irregularis* n. sp.; Cliffland Coal, CP-49-7 slide 6 (128.1 X 52.5), 62.7 μm (holotype).
2. *Spackmanites irregularis* n. sp; SEM stereopair 600X, Cliffland Coal, CP-73-299.
3. *Spackmanites irregularis* n. sp; Cliffland Coal, CP-73-299 slide 7 (120.3 X 34.0), 62.7 μm (paratype).
4. *Spackmanites irregularis* n. sp; Cliffland Coal, CP-49-7 slide 1 (124.8 X 59.5) 54.2 μm (paratype).
5. *Colatisporites decorus* (Bharadwaj and Venkatachala) Williams, in Neves et al., 1973; Wildcat Den Coal, F-III slide 33 (138.0 X 66.2), 51.3 μm.
6. *Schulzospora rara* Kosanke 1950; Wildcat Den Coal, F-III slide 26 (136.4 X 32.6),, 88.0 μm; 600X.
7. *Schulzospora rara* Kosanke 1950; Wildcat Den Coal, F-II slide 33 (137.7 X 55.5), 62.7 μm.
8. *Schulzospora elongata* Hoffmeister, Staplin and Malloy 1955; Wildcat Den Coal, F-III slide 21 (124.4 X 37.8), 46.7 μm.
9. *Paleospora fragila* Habib 1966; Blackoak Coal, CP-10-49 slide A-7 (118.7 X 34.3), 181.8 μm; 600X.
10. *Paleospora fragila* Habib 1966; unnamed coal in the Caseyville Formation, F-WH3 slide 2 (140.2 X 73.2), 159.0 μm; 600X.

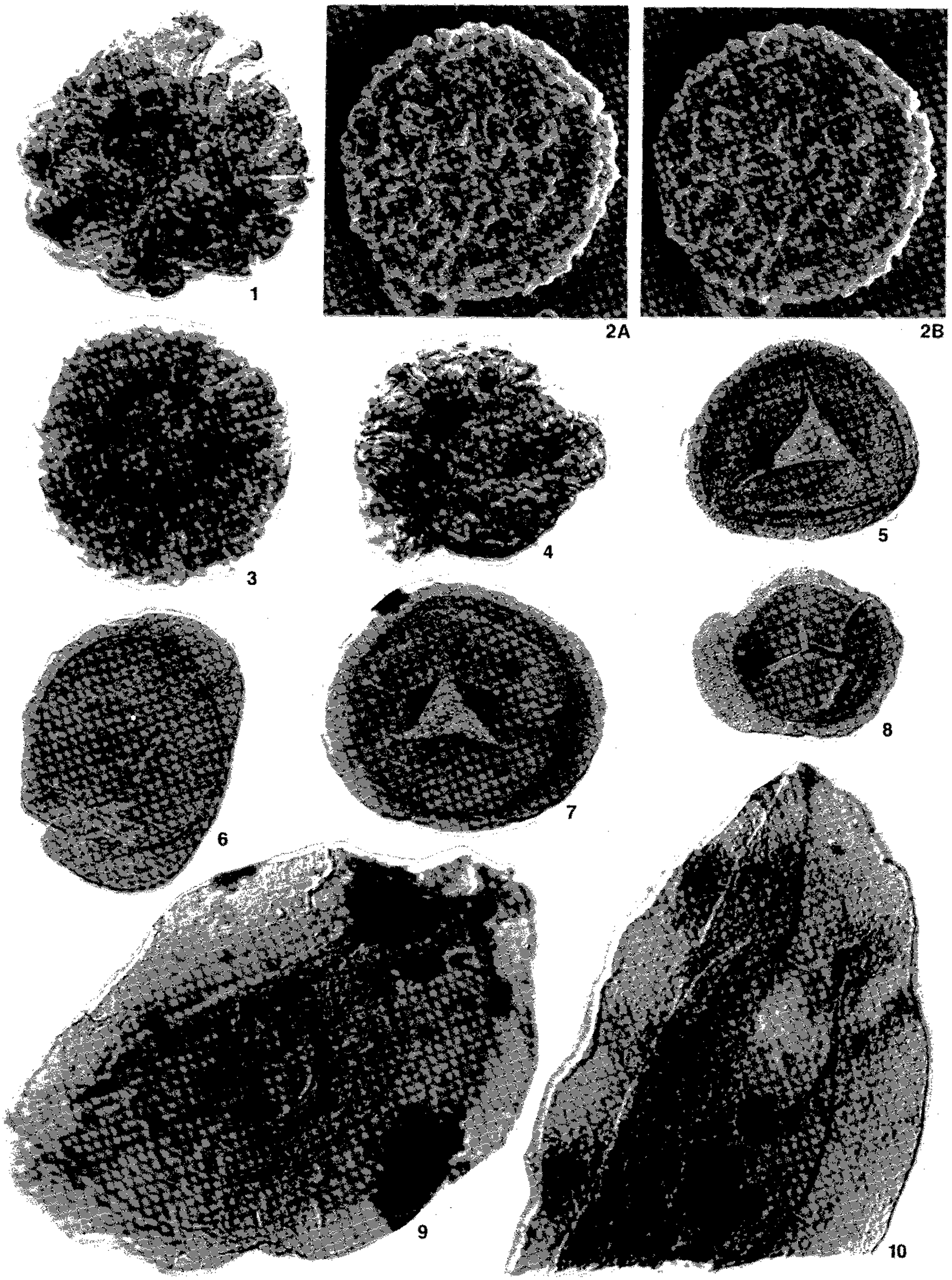

1
2A
2B
3
4
5
6
7
8
9
10

PLATE 37

1. *Aumancisporites striatus* Alpern 1958; Blackoak Coal, CP-19-4 slide 1C6 (139.0 X 63.9), 54.2 μm.
2. *Aumancisporites striatus* Alpern 1958; Blackoak Coal, CP-19-4 slide 1C2 (134.2 X 60.9), 62.7 μm.
3. *Tinnulisporites microsaccus* Dempsey 1967; Laddsdale Coal, CP-39-16 slide 9 (135.1 X 58.5), 46.2 μm.
4. *Tinnulisporites microsaccus* Dempsey 1967; Wildcat Den Coal, F-II slide 32 (127.4 X 52.9), 54.2 μm.
5. *Tinnulisporites microsaccus* Dempsey 1967; Laddsdale Coal, CP-39-16 slide 10 (137.2 X 47.8), 47.3 μm.
6. *Tinnulisporites microsaccus* Dempsey 1967; Laddsdale Coal, CP-39-16 slide 10 (130.0 X 55.1), 47.3 μm.
7. *Florinites* sp. cf. *F. volans* (Loose) Potonié and Kremp 1956; Blackoak Coal, CP-19-4 slide 1Z4 (133.9 X 52.1), 78.1 μm.
8. *Wilsonites circularis* (Guennel) Peppers and Ravn, in Ravn, 1979; Blackoak Coal, CP-19-4 slide 1Y6 (133.8 X 43.4), 45.6 μm.
9. *Wilsonites vesicatus* (Kosanke) Kosanke 1959; Bevier Coal, 1207791-7 slide 5 (123.0 X 65.6), 62.1 μm.
10. *Wilsonites vesicatus* (Kosanke) Kosanke 1959; Wildcat Den Coal, F-II slide 11 (122.5 X 67.2), 60.4 μm.
11. *Wilsonites delicatus* (Kosanke) Kosanke 1959; Blackoak Coal, CP-19-4 slide 1Z4 (123.1 X 54.3), 86.6 μm; 600X.
12. *Florinites occultus* Habib 1966; Blackoak Coal, CP-19-4 slide 1Z6 (133.9 X 58.0),, 67.6 μm.
13. *Florinites mediapudens* (Loose) Potonié and Kremp 1956; Blackoak Coal, CP-19-4 slide 1Z2 (128.1 X 45.8), 75.3 μm; 600X.
14. *Florinites mediapudens* (Loose) Potonié and Kremp 1956; Blackoak Coal, CP-19-4 slide 3A2 (134.0 X 44.2), 79.5 μm; 600X.
15. *Florinites visendus* (Ibrahim) Schopf, Wilson and Bentall 1944; Blackoak Coal, CP-19-4 slide 5A6 (127.4 X 46.6), 147.7 μm; 600X.

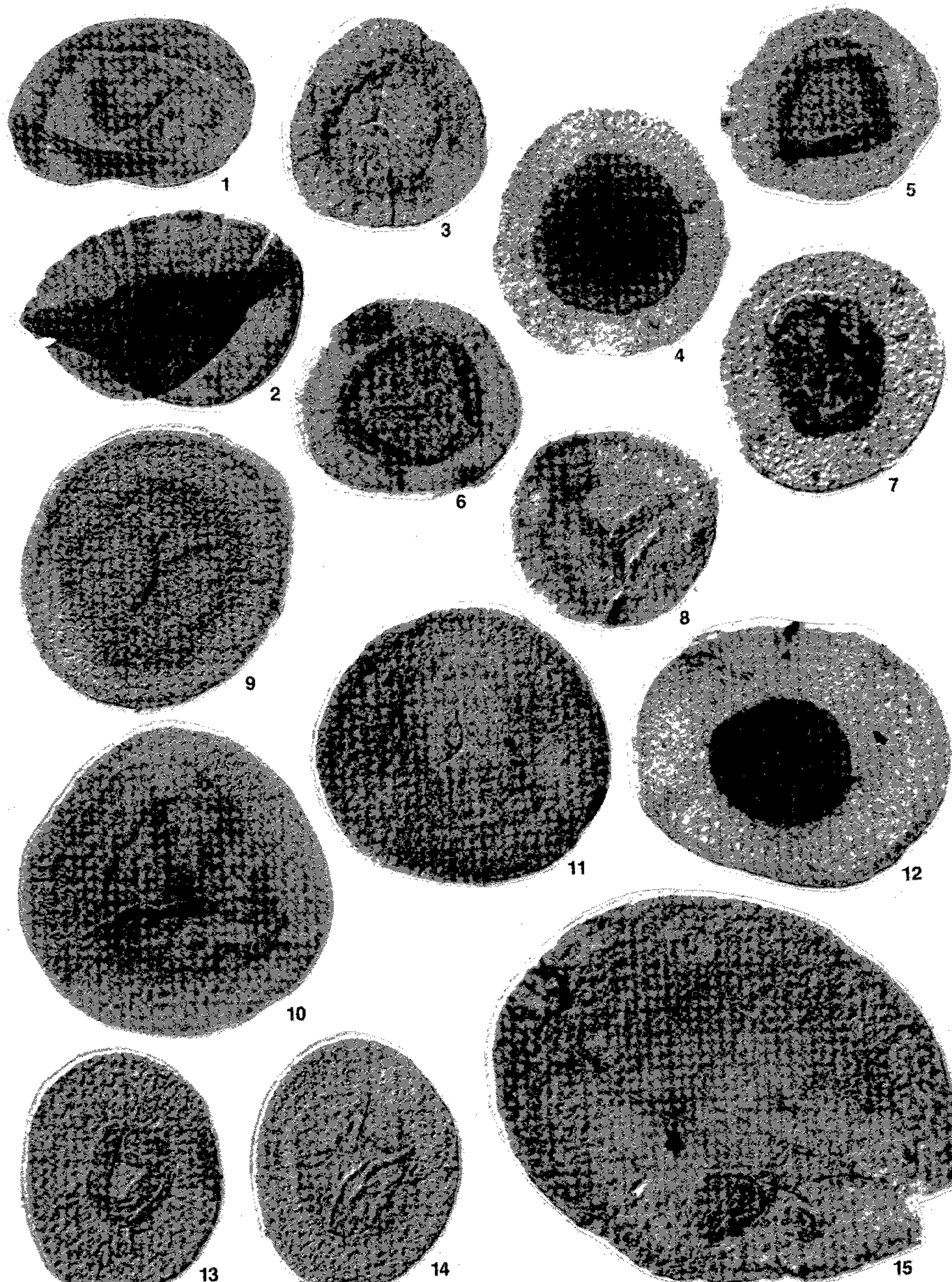

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

PLATE 38

1. *Quasillinites diversiformis* (Kosanke) Ravn and Fitzgerald 1982; Blackoak Coal, CP-19-4 slide 1Z4 (124.2 X 60.8), 102.3 μm; 600X.
2. *Quasillinites diversiformis* (Kosanke) Ravn and Fitzgerald 1982; Blackoak Coal, CP-19-4 slide 1Z2 (133.9 X 45.2), 109.3 μm; 600X.
3. *Cordaitina?* sp. 1; unnamed coal in the Kilbourn Formation, CP-17-13 slide B-3 (129.6 X 50.3), 55.8 μm.
4. *Cordaitina?* sp. 1; Cliffland Coal, CP-73-299 slide 4 (127.1 X 71.0), 47.3 μm.
5. *Florinites millottii* Butterworth and Williams 1958; Blackoak Coal, CP-19-4 slide 1C2 (129.0 X 57.1), 42.2 μm.
6. *Florinites similis* Kosanke 1950; Cliffland Coal, CP-43-23 slide 9 (134.8 X 61.9), 116.4 μm; 600X.
7. *Peppersites ellipticus* Ravn 1979; Laddsdale Coal, CP-66-185 slide 2 (121.0 X 56.7), 64.4 μm.
8. *Peppersites ellipticus* Ravn 1979; Blackoak Coal, CP-19-4 slide 1C4 (130.3 X 61.9), 61.0 μm (paratype).
9. *Costatascyclus crenatus* Felix and Burbridge emend. Urban 1971; unnamed coal in the Caseyville Formation, F-WH3 slide 15 (121.9 X 42.0), 136.3 μm; 600X.
10. *Costatascyclus crenatus* Felix and Burbridge emend. Urban 1971; Blackoak Coal, CP-19-4 slide 1W2 (125.1 X 38.2), 153.3 μm; 600X.
11. *Potonieisporites solidus* Ravn 1979; Cliffland Coal, CP-43-23 slide 7 (120.0 X 55.2), 122.1 μm; 600X.
12. *Wapellites variabilis* Ravn 1979; Wildcat Den Coal, F-WH4 slide M-15 (128.1 X 38.5), 96.6 μm.

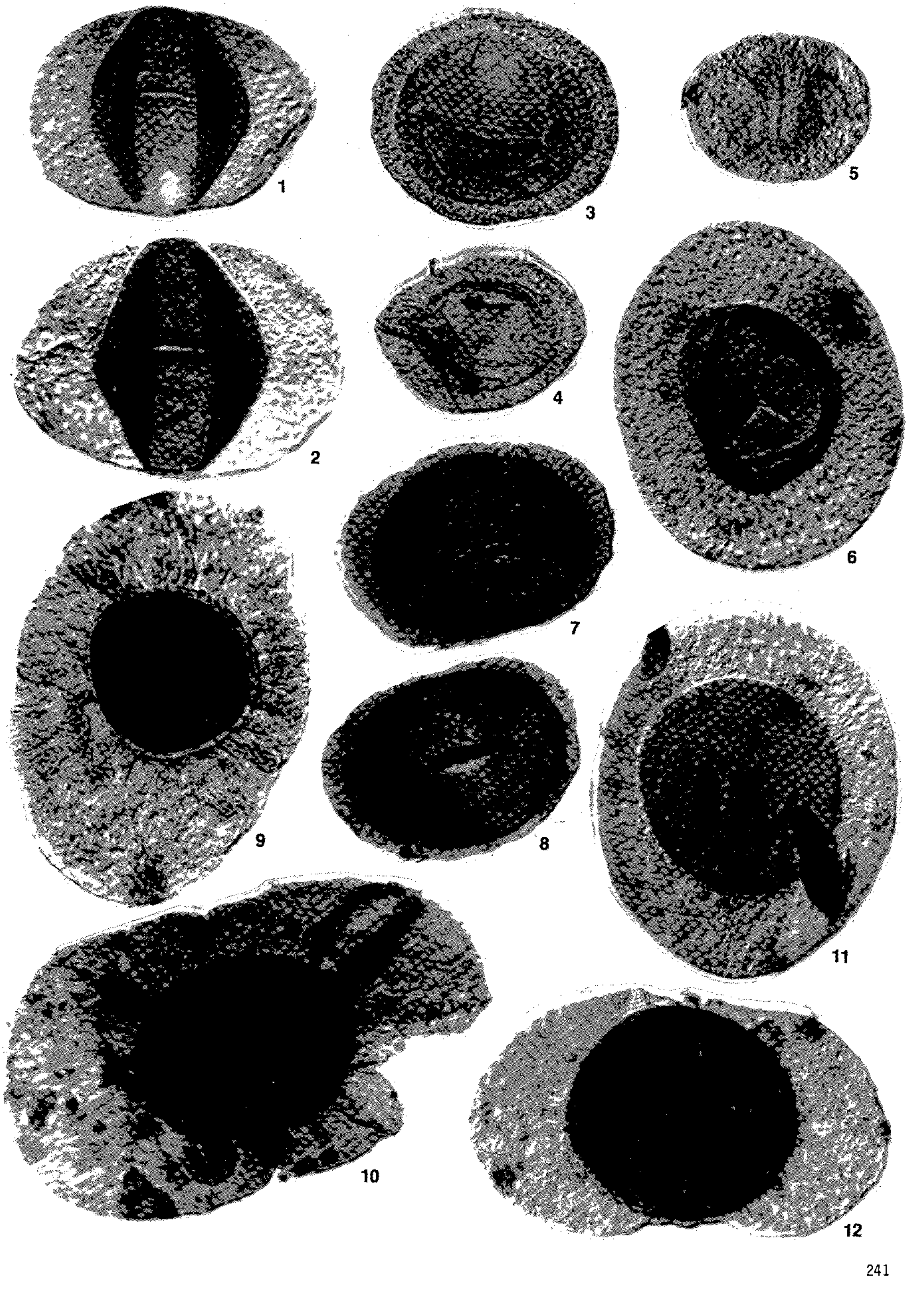

1
3
5
2
4
6
7
9
8
11
10
12

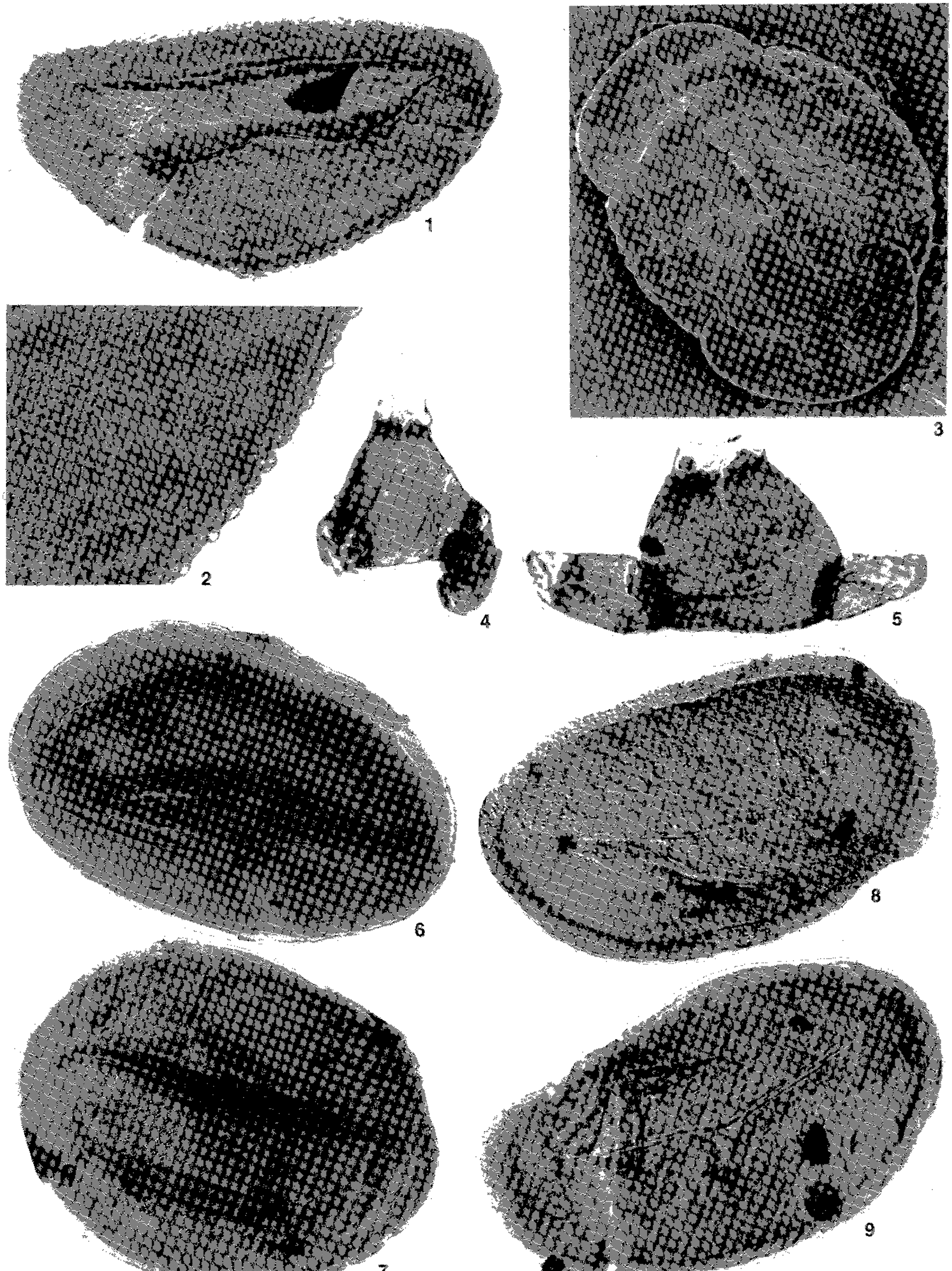
PLATE 39

1. *Illinites unicus* Kosanke emend. Helby 1966; Bevier Coal, 1207791-7 slide 5 (137.8 X 72.4), 72.4 μm.
2. *Illinites unicus* Kosanke emend. Helby 1966; Mulky Coal, CP-41-2 slide 6 (132.5 X 68.0), 62.1 μm.
3. *Illinites unicus* Kosanke emend. Helby 1966; Wildcat Den Coal, F-WH4 slide Z-3 (133.1 X 34.9), 57.0 μm.
4. *Vesicaspora wilsonii* Schemel emend. Wilson and Venkatachala 1963; Carruthers Coal, CP-22-32 slide 9 (122.5 X 69.6), 39.3 μm.
5. *Vesicaspora wilsonii* Schemel emend. Wilson and Venkatachala 1963; Carruthers Coal, CP-22-32 slide 9 (125.1 X 69.1), 37.1 μm.
6. *Platysaccus saarensis* (Bhardwaj) Jizba 1962; Blackoak Coal, CP-19-4 slide 3R1 (133.9 X 49.0), 47.3 μm.
7. *Platysaccus saarensis* (Bhardwaj) Jizba 1962; Blackoak Coal, CP-19-4 slide 3Z5 (134.2 X 50.0), 45.6 μm.
8. *Phillipsites tenuis* Ravn 1979; Blackoak Coal, CP-19-4 slide 1X4 (123.6 X 46.7), 99.4 μm (paratype); 600X.
9. *Phillipsites tenuis* Ravn 1979; Blackoak Coal, CP-19-4 slide 1Z6 (126.9 X 43.4), 115.0 μm (holotype); 600X.
10. *Limitisporites* sp. 1; Cliffland Coal, CP-27-12 slide 5 (125.5 X 58.2), 109.3 μm; 600X.
11. *Limitisporites* sp. 1; Blackoak Coal, CP-43-44 slide 3 (130.1 X 55.2), 113.6 μm; 600X.
12. *Pityosporites westphalensis* Williams 1955; Blackoak Coal, CP-19-4 slide 2L1 (133.1 X 47.3), 52.4 μm.
13. *Potonieisporites elegans* (Wilson and Kosanke) Wilson and Venkatachala 1964; Blackoak Coal, CP-19-4 slide 1C4 (133.0 X 64.1), 153.3 μm; 600X.
14. *Potonieisporites elegans* (Wilson and Kosanke) Wilson and Venkatachala 1964; Blackoak Coal, CP-19-4 slide DB1Z (137.2 X 53.0), 177.5 μm; 600X.


1
2
3
4
5
6
7
8
9
10
11
12
13
14

PLATE 40

1. *Zonalosporites magnus* (Venkatachala) n. comb.; Blackoak Coal, CP-19-4 slide 8Z1 (127.0 X 55.5), 242.9 μm; 375X.
2. Detail of figure 1, 750X.
3. *Parasporites maccabei* Schopf 1938; SEM 150X, Laddsdale Coal, 416804-2.
4. *Trihyphaecites triangulatus* Peppers 1970; Blackoak Coal, CP-19-4 slide 1Z1 (134.4 X 62.9), 31.9 μm (central body).
5. *Trihyphaecites triangulatus* Peppers 1970; unnamed coal in the Caseyville Formation, F-WH3 slide 15 (127.8 X 73.7), 42.9 μm (central body).
6. *Zonalosporites ellipsoides* (Ibrahim) n. comb.; Wildcat Den Coal, F-WH4 slide A-20 (134.9 X 53.6), 238.6 μm; 375X.
7. *Zonalosporites ellipsoides* (Ibrahim) n. comb.; Blackoak Coal, CP-19-4 slide 1Y11 (119.2 X 63.5), 308.1 μm; 260X.
8. *Zonalosporites shansiensis* (Ouyang) Kaiser 1976; Bevier Coal, 1207791-7 slide 5 (130.8 X 65.3), 143.4 μm; 600X.
9. *Zonalosporites shansiensis* (Ouyang) Kaiser 1976; Laddsdale Coal, 416804-2 slide 2 (121.1 X 66.2), 147.7 μm; 600X.


1
2
3
4
5
6
7
8
9