ABSTRACT

Palynology of the Berea Sandstone
and Cuyahoga Group of
Northeastern Ohio

By

Leonard Eugene Eames

A taxonomic and biostratigraphic palynologic study of the Berea Sandstone and overlying Cuyahoga Group (Orangeville, Sharpsville, and Meadville Formations) of northeastern Ohio has been completed. A total of forty-seven outcrop samples from three sections have been composited into a section spanning the Devonian-Mississippian boundary.

Palynomorphs consisting primarily of spores and acritarchs are abundant, diverse, and well-preserved. They are represented by ninety-seven species of spores assigned to forty-four genera with twenty-three species of acritarchs representing thirteen genera and four miscellaneous groups. The palynomorphs have been separated into three assemblages; Upper Devonian, Lower Mississippian, and transitional.

Two range charts have been constructed on earliest and latest occurrences and relative abundances are indicated. These provide data for defining the Devonian-Mississippian

boundary. The Upper Devonian-Lower Mississippian assemblages of the study area are shown to be equivalent to the Upper Famennian and Lower Tournaisian of the European standard section.

The geographic and stratigraphic comparisons of these (Late) Devonian and (Early) Mississippian palynomorph assemblages with those discussed in recent literature present strong evidence for a reinterpretation of the age assignments for the Bedford and Berea formations of northeastern Ohio. The Bedford Shale and Berea Sandstone previously have been assigned a Lower Mississippian age. Results of the present study indicate an Upper Devonian age for the Bedford and Berea and a Lower Mississippian (Kinderhookian) age for the overlying Cuyahoga Group (Orangeville, Sharpsville, and Meadville Formations).

PALYNOLOGY OF THE BEREA SANDSTONE AND CUYAHOGA GROUP OF NORTHEASTERN OHIO

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Geology

1974

DEDICATION

This thesis is dedicated to those students that when given the opportunity, may choose a goal and attain a horizon beyond their expectations.

ACKNOWLEDGEMENTS

Deep appreciation is expressed to Professor Aureal T. Cross for his guidance and encouragement throughout the course of this study. Appreciation is expressed to my committee members, Drs. C. E. Prouty, R. L. Anstey, and S. N. Stephenson, for their suggestions and constructive criticisms.

Appreciation is expressed to Drs. Charles F. Upshaw, Gerald L. Waanders, David R. Mishell, Evan J. Kidson, Richard W. Hedlund, Herbert J. Sullivan, and members of the laboratory staff of Amoco Production Company, Research Center, Tulsa, Oklahoma, for invaluable discussions, suggestions, technical assistance, and facilities as needed for the completion of this research.

Dr. Charles Downie, Sheffield University, England, Dr. John B. Richardson, Kings College, England, and Dr. Maurice Streel, University of Liege, Belgium, have provided invaluable discussions pertaining to the Upper Devonian and Lower Mississippian acritarchs and spores.

Understanding, encouragement, endurance, and love from Carol and the children have prevailed over the course of my studies. Carol has typed the drafts and final manuscript.

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INTRODUCTION

Objectives of This Study

1. Identify, describe and illustrate the spore and acritarch floras from the Berea Sandstone and Cuyahoga Group of northeastern Ohio.
2. Establish the stratigraphic ranges of the palynomorphs in the study area using a composite stratigraphic section from 3 localities.
3. Construct stratigraphic range charts showing earliest and latest occurrences for the palynomorphs.
4. Delineate zones or sub-zones within the studied stratigraphic sequence, if possible.
5. Evaluate palynomorphs which have restricted and transitional ranges, with reference to the Devonian-Mississippian boundary, using relative abundances.
6. Compare the palynomorphs from the Late Devonian-Early Mississippian of northeastern Ohio with palynomorphs reported in other areas and from related stratigraphic sequences.
7. Apply the stratigraphic interpretations of the studied floras to an evaluation of the present age assignments for the Berea Sandstone and overlying Cuyahoga Group which have been made on the basis of other types of paleontologic or geologic evidence.

Results are presented for a taxonomic and biostratigraphic palynological analysis of 47 outcrop samples collected at 3 localities from the Devonian-Mississippian strata of northeastern Ohio. Samples were collected from the Berea Sandstone and Cuyahoga Group (Orangeville Shale, Sharpsville Sandstone, and Meadville Shale). Abundant, well-preserved spores and acritarchs have been recovered from most samples. No barren samples were encountered. In addition, megaspores occur sporadically in some samples, but are not considered in the present study. The geographic locations of the 3 sample localities are shown in Figure 1.

Previous Palynologic Studies in the Area

Previous palynologic studies on rocks from the area include those of Winslow (1962), Boneham (1967), and Eames (1968). Winslow (1962) presented the first detailed palynologic study from Ohio, and probably North America, concerning an Upper Devonian and Lower Mississippian sequence. She studied the palynomorphs from 10 localities (6 outcrops or quarries and 4 wells or cores). She also examined some additional samples, principally for *Tasmanites*. Winslow described 76 taxa of megaspores, microspores, and acritarchs. At the time of her research, which began in 1955 but was not published until 1962, there was very little palynologic literature for taxonomic and stratigraphic comparisons based on rocks from this part of geologic time.

Boneham (1967) reported on Devonian *Tasmanites* from several localities, three of which are in the Cleveland, Ohio

area. All of Boneham's sampling was of pre-Berea sediments and his study was limited to Tasmanites.

Eames (1968), in an unpublished M.A. thesis, Kent State University, Kent, Ohio, studied the microspores from the Cleveland Shale Member of the Ohio Shale and the overlying Bedford Shale. The study was principally taxonomic and was from the pre-Berea section at the Tinkers Creek locality only. The present range charts include the occurrences of the pre-Berea palynomorphs from that study.

Similar stratigraphic units and equivalent horizons have been investigated for palynomorphs by McGregor (1970) from southwestern Ontario, Canada. McGregor's study did not involve detailed sampling, range charts or relative abundances but was intended only to indicate the assemblages of palynomorphs as they occur with Hymenozonotriletes lepidophytus.

GEOLOGY

Local Geologic Setting

The study area (Figure 1) is within the glaciated portion of northeastern Ohio. Formations exposed in the area include, in ascending order, the Huron Shale, Chagrin Shale, Cleveland Shale, Bedford Shale, Berea Sandstone, Orangeville Shale. Sharpsville Sandstone, Meadville Shale, and Sharon Conglomerate. The above formations range in age from Upper Devonian to Lower Pennsylvanian. The age relationships and stratigraphic sequence are shown in (Figure 2) from Pepper, de Witt, and Demarest (1954) with the right hand column added from the present study.

The topography of the area has been influenced by glacial features and resistant ridges of sandstone outcrops. To the west, in Lorain and western Cuyahoga Counties, the surface geology consists of low relief glacial moraines and beach ridges northward towards Lake Erie. The Berea Sandstone is the youngest rock unit present in the western portion and is generally exposed only in road cuts, quarries, and river valleys. To the east and south, in Cuyahoga and Summit Counties, the relief becomes greater as the area rises towards the western edge of the Appalachian Plateau. Here the surface geology consists of well-developed glacial

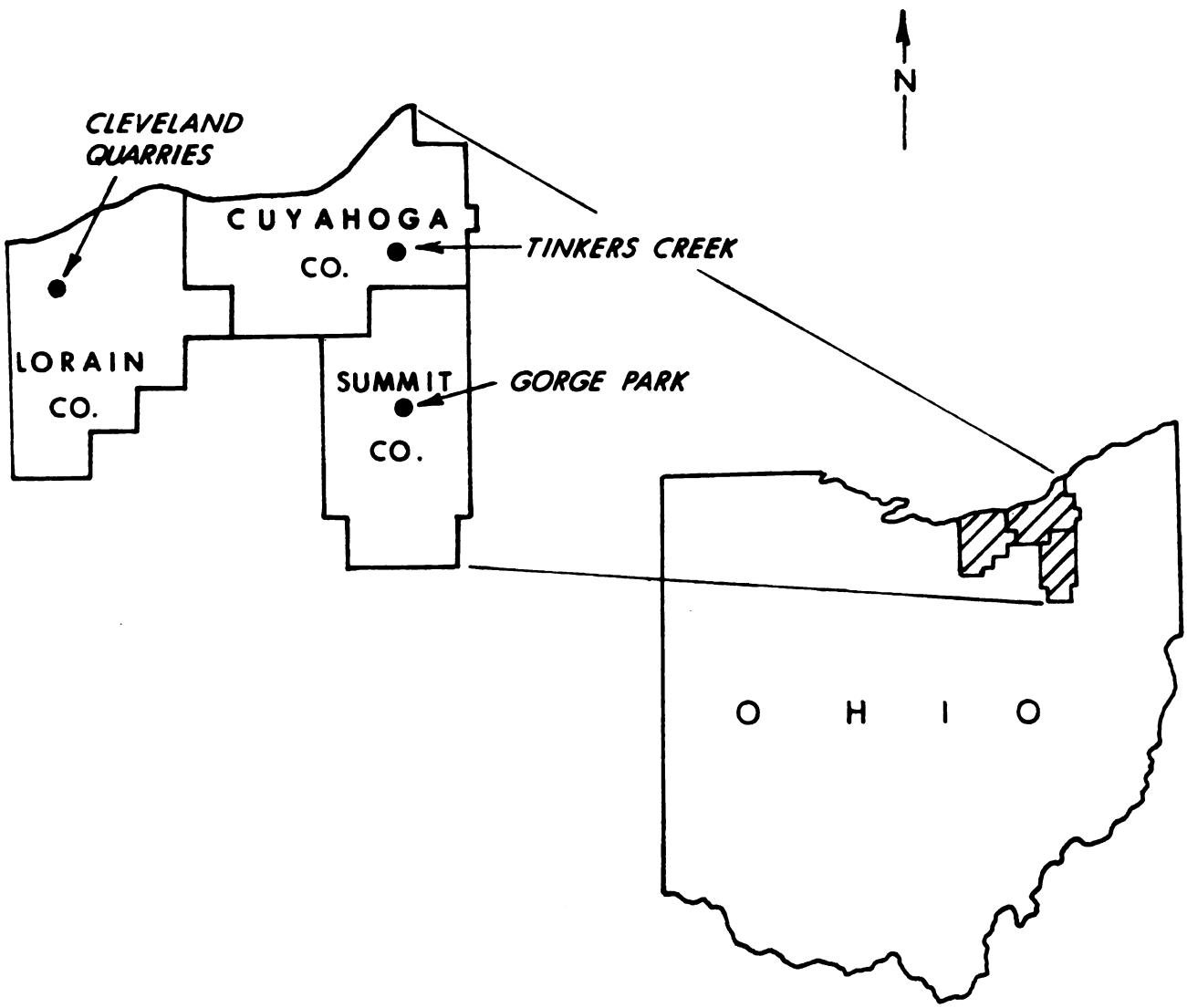
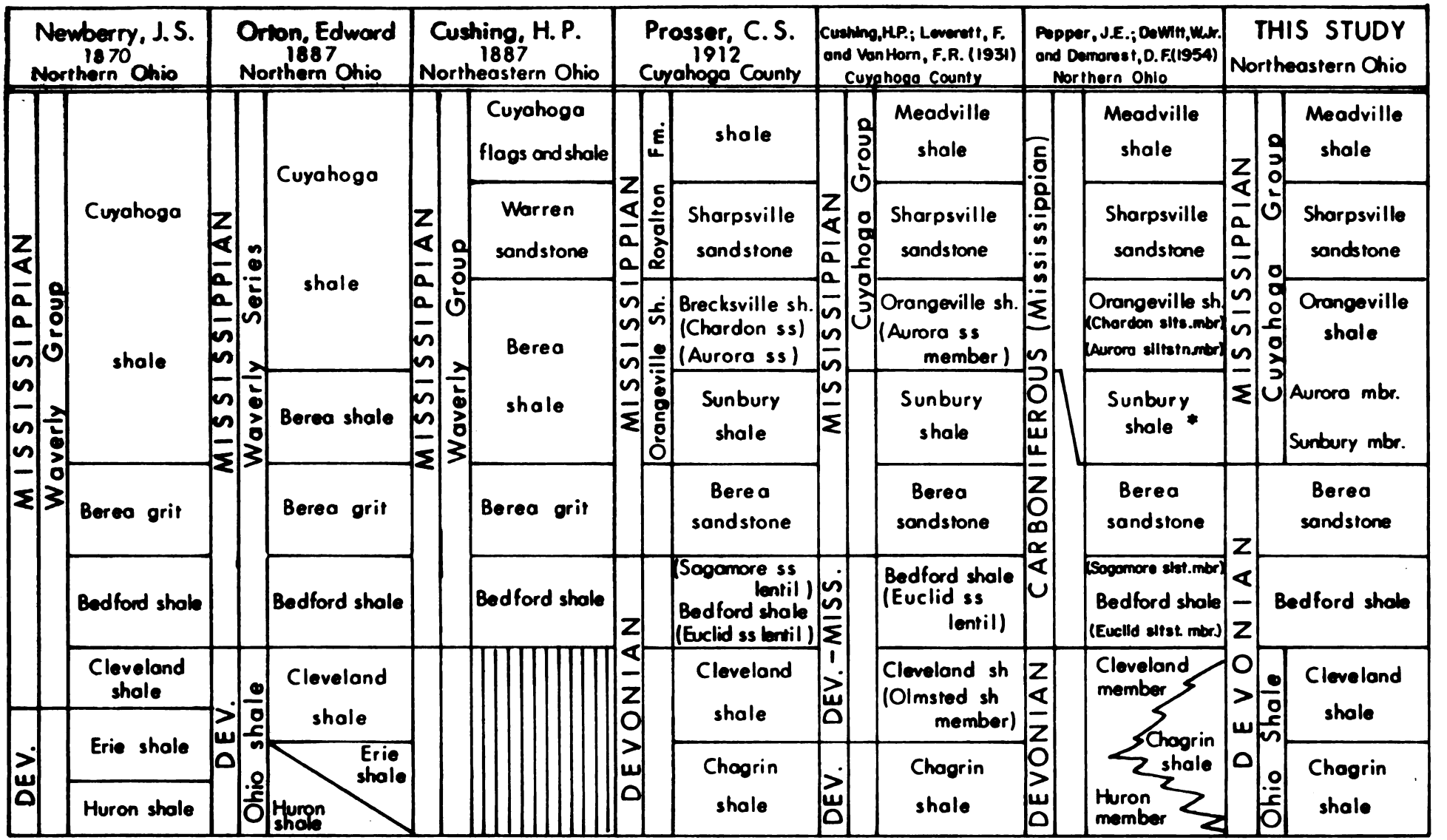


Fig. 1 Outcrop and quarry localities studied in northeastern Ohio



*Sunbury shale considered as basal member of Orangeville shale East of Berea, Ohio.

Fig. 2 Chart of previous age assignments and stratigraphic nomenclature for rocks of Northeastern Ohio. (From Pepper, de Witt & Demarest, 1954; right-hand column added, this study)

moraines and kame deposits with prominent hills and ridges formed by the resistant Sharon Conglomerate (Pennsylvanian).

The general geology of the area has been discussed in detail by Newberry (1870), Prosser (1912), Cushing, Leverett, and Van Horn (1931), Rothrock (1949), de Witt (1951 and 1970), Pepper, de Witt, and Demarest (1954) and Winslow (1962).

Stratigraphy of the Sample Localities

The formations involved in the present study include the Berea Sandstone (Newberry, 1870), and the overlying Cuyahoga Group (Cushing, et al., 1931). The Cuyahoga Group consists of three formations, the Orangeville Shale (White, 1880) including two of its members; the Sunbury Shale Member (de Witt, 1946) and Aurora Sandstone Member (Prosser, 1912) later designated as the Aurora Siltstone Member (de Witt, 1951), the Sharpsville Sandstone (White, 1880) and the Meadville Shale White, 1880). The formations within the Cuyahoga Group are not readily separated at many of their outcroppings. The group consists of a shale-sandstone-shale sequence, with the sandstone portion (Sharpsville) consisting of interbedded siltstones and shales. Hall (1958) and Szmuc (1958) have considered the Cuyahoga Group of Ohio to be a formation because of the difficulty in maintaining lateral separation of the formations within the group. However, the Orangeville, Sharpsville, and Meadville Formations are separable at the Gorge Park Locality. Dr. E. J. Szmuc of the Geology Department, Kent State University, accompanied the

author in the field on several occasions including the Gorge Park locality.

Berea Sandstone

The Berea Sandstone was samples at the Cleveland Quarries Company, Quarry 6X, north of Ohio highway 113, adjacent to Quarry Road, just south of the Ohio Turnpike, Amherst Twp., Lorain Co., South Amherst, Ohio (Vermillion Quadrangle). This locality is immediately to the west of locality 5, Quarry 6 (Winslow. 1962), which was inaccessible at the time of this collection. Exposures of the type Berea Sandstone occur several miles to the east in Berea, Ohio. There, the outcrops are extensively weathered in water-filled, abandoned quarries. The lateral distribution and stratigraphic correlatives of the Berea Sandstone have been discussed by de Witt (1951), Pepper,et al. (1954), and Schiner and Kimmel (1972).

The Quarry 6X Locality (Figure 3) was selected because of a more expanded section with fresh exposures that were currently being quarried. Approximately 100 feet of the Berea is exposed in this quarry. Nine samples were collected, six samples represent about 75 feet of the sandstone from the south wall of the quarry. Three samples were collected from the northwest corner of the quarry in a small shale lens five feet thick within the Berea Sandstone. An unknown thickness of the Berea has been removed at the surface as evidenced by glacial grooves on the present surfaces, some filled with glacial till.

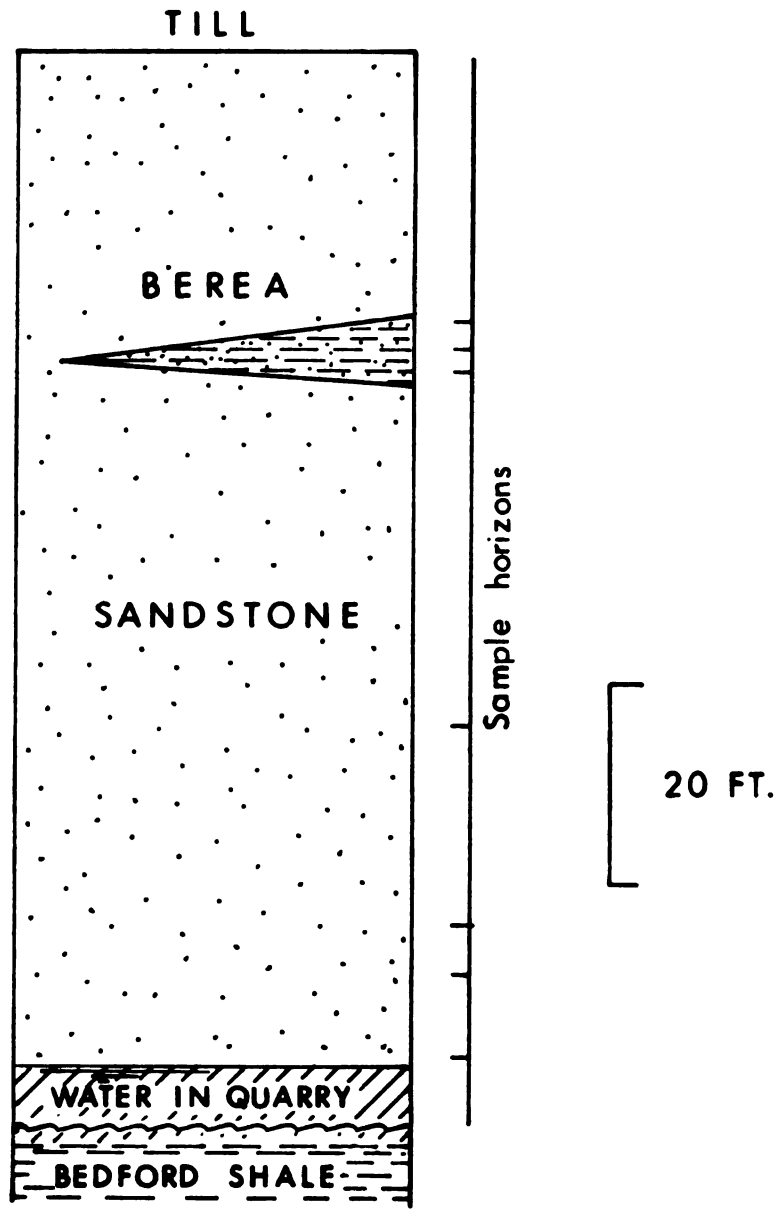


Fig. 3 Cleveland Quarries Co., Quarry 6-X, Lorain County, South Amherst, Ohio.

Lowermost Cuyahoga Group

The lowermost Cuyahoga Group was sampled at the Tinkers Creek Locality north of Eggbert Road, Bedford Twp., Cuyahoga Co., Bedford, Ohio (Cleveland Quadrangle). This locality is on the south side of Tinkers Creek opposite Locality 3 of Winslow (1962) and is a continuation upsection from the section studied by Eames (1968).

The Tinkers Creek Locality (Figure 4) was selected because the Berea-Cuyahoga Group contact is well-exposed there and because of the presence of the two lower members of the Orangeville Shale. The total section exposed at this locality includes the uppermost 6 feet of grey marine Chagrin Shale, 21 feet of black fissile marine Cleveland Shale, 85 feet of dark grey to grey siliceous Bedford Shale, about 40 feet of highly quartzose Berea Sandstone, and 15 feet of the predominately shaly lower Cuyahoga Group (grey marine Orangeville Shale, dark grey to black fissile marine Sunbury Shale Member, and brownish grey Aurora Siltstone Member). The sample horizons indicated on Figure 4 for the Bedford and Cleveland Shales were collected for my earlier study (Eames, 1968).

The nine samples collected at this locality for the present study include one sample of uppermost Berea Sandstone, three samples of the Sunbury Shale Member (basal Orangeville), two samples from the Aurora Siltstone Member, and three samples of the Orangeville Shale. The section is truncated at this locality by glaciation and erosion and is overlain by Pleistocene till.

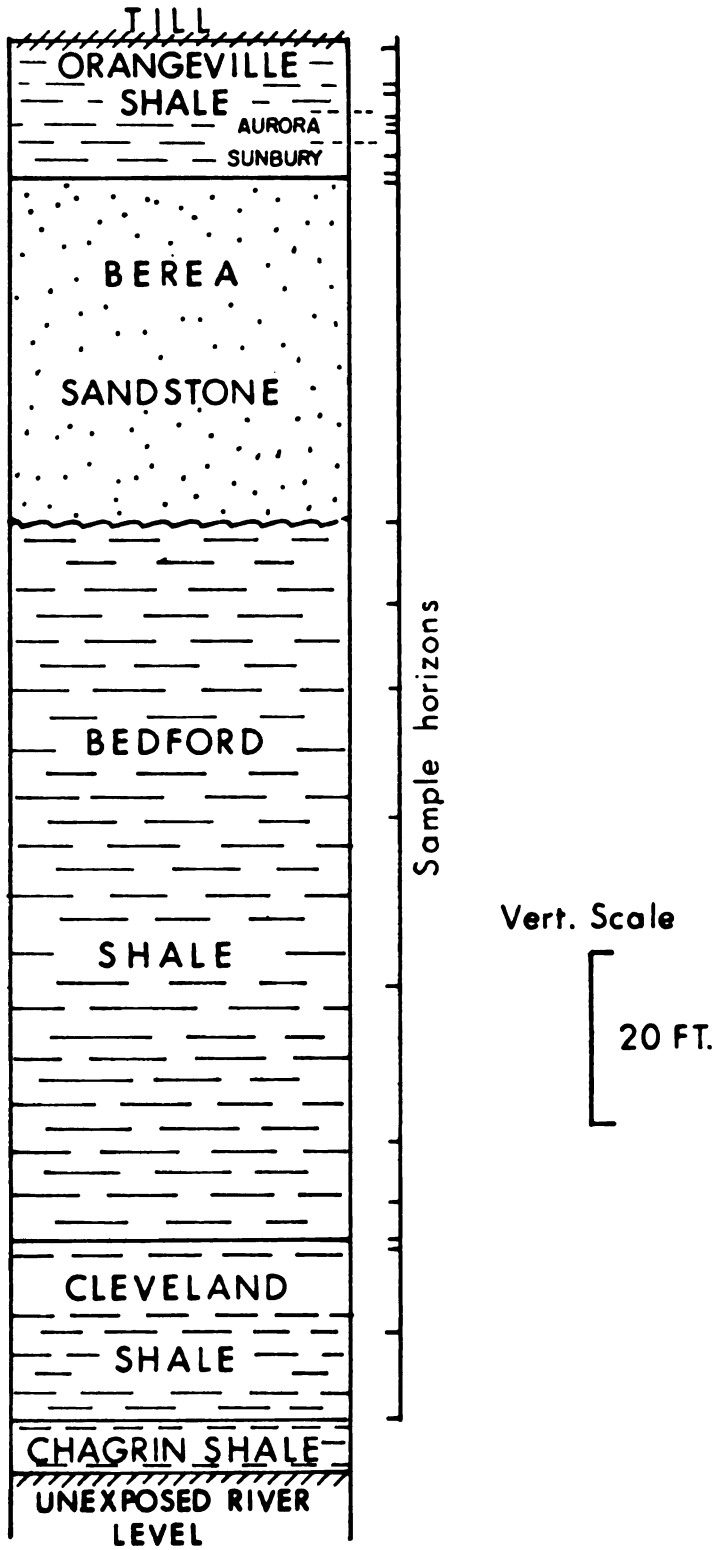


Fig. 4 Tinkers Creek, Cuyahoga County, Bedford, Ohio

Cuyahoga Group

The remainder of the Cuyahoga Group was sampled at the Gorge Park Locality, north of Ohio Route 59 and east and southeast of Ohio Route 8, Summit Co., Cuyahoga Falls, Ohio (Akron East and West Quadrangles). The section extends along the east and north banks of the Cuyahoga River. This is a walk-up section with the oldest strata exposed at river level to the north and west. Crossing the river to the west or south would be in Akron, Ohio rather than Cuyahoga Falls, Ohio. This locality is the same as Locality 2 of Osgood and Szmuc (1972).

The Gorge Park Locality (Figure 5) provides the most complete section of the Cuyahoga Group in the area. This section is also one of the few where the Orangeville-Sharpsville-Meadville contacts are clear. Twenty-nine samples were collected at this locality with the following representation. Samples began at river level with four samples representing the upper 12 feet of Orangeville Shale, which is a soft, grey marine shale. The overlying Sharpsville Sandstone is exposed in its entirety with fourteen samples representing 51 feet of exposure. The Sharpsville is comprised of flaggy, siliceous siltstones and interbedded silty shales. At the 32 foot level, within the Sharpsville, there is a two-foot thick, calcareous siltstone horizon. The Meadville-Sharpsville contact is marked by a prominent zone of the trace fossil Zoophycos. The Meadville is 109 feet thick and composed mainly of soft, grey marine shales with some ironstone concretionary beds.

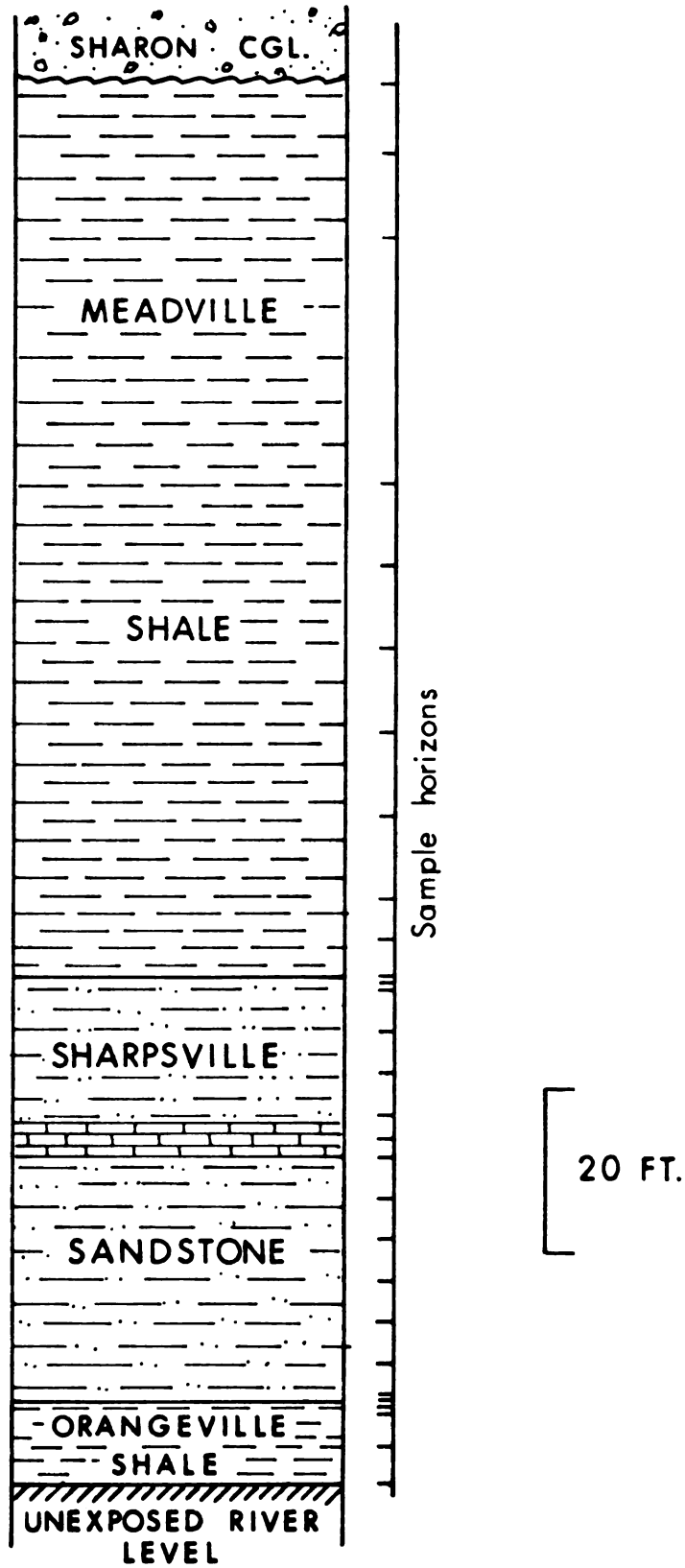


Fig . 5 Gorge Park, Summit County, Cuyahoga Falls, Ohio

Eleven samples were collected from the Meadville. The Meadville Shale represents the youngest stratum sampled in the area. It is unconformably overlain by the Sharon Conglomerate (Pennsylvanian-Pottsvillian).

A listing of all samples used for this study from the above localities is provided (arranged in descending stratigraphic order) in Appendix 1. The stratigraphic relationships of the three localities are shown in Figure 6 as a composite section for the area. There is a sample gap within the Orangeville Shale of approximately 100 feet. The composite section is not drawn to scale for the vertical arrangement and does not show this sample gap. The break in samples within the Orangeville is indicated with approximate footage on the range charts (Figures 8 and 9).

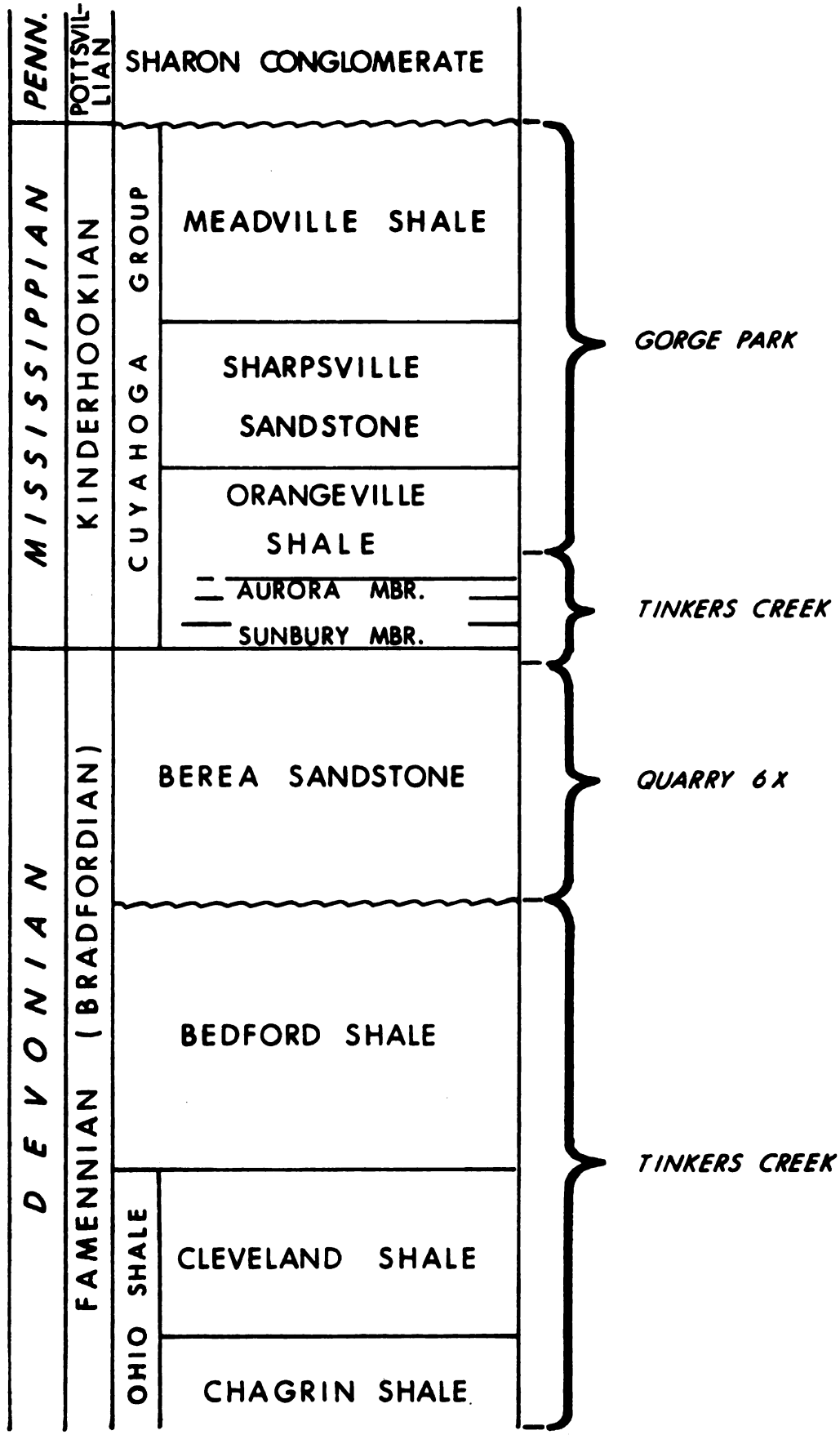


FIG. 6 COMPOSITE SECTION OF NORTHEASTERN OHIO SAMPLE LOCALITIES

METHODS OF STUDY

Sample Collection

Forty-seven outcrop samples were collected and analysed for palynomorphs from three localities in northeastern Ohio. The geographic locations have been shown in Figure 1 with position of the individual samples from those localities indicated on the sections illustrated in Figures 3, 4, and 5. In addition all samples are listed in Appendix 1 in descending order by Pb number, gross lithology, formation with relative stratigraphic position, and locality where collected.

Individual samples were collected from spot horizons, that is collected in an area of about 10 inches in diameter, at varied stratigraphic intervals. Where lithologies appeared to be similar, samples were collected at 5 or 10 feet intervals. I deviated from this procedure in the areas of formational contacts or lithologic changes, where samples were collected often at intervals as close as one foot apart. With the exception of the Quarry 6X locality, samples were dug from fresh excavations in the outcrops to avoid externally weathered surfaces. Another sampling technique which proved to be very satisfactory was to collect samples from within the small stream beds, actually in the running water.

These samples were quite soft and the covering of water had prevented the periodic drying and weathering of the surface.

All samples were collected in plastic bags labeled with formation name and relative stratigraphic position. The samples were then placed in labeled cloth sample bags to prevent tearing while in transit.

Laboratory and Slide Preparation

Laboratory macerations were performed using standard palynologic processing techniques with the following exceptions to standard procedures being used.

Samples were mostly shales, siltstones, and sandstones. Samples were crushed to approximately ¼ inch size pieces. Aliquots of 50-100 grams of shales and siltstones were macerated. Sandstone samples required larger amounts of ca. 200 grams.

All samples with carbonates present were then treated with HCl for as much as 18 hours. This was followed with 70% HF until silicates were completely broken down. Samples were then treated with warm HCl for a short time, washed until neutral and the organic residue separated from heavier mineral matter with heavy liquid (zinc bromide, specific gravity 2.2). The sink fraction was examined for palynomorphs and those found to be barren discarded. Samples of sink fraction still containing palynomorphs were reseparated. All samples were then diluted gradually with water and centrifuged to remove the nonpalynomorph detritus that was trapped in the float. These dilution and centrifuging steps

required checks of the residues by microscope to avoid loss of palynomorph.

Recovered palynomorphs were not carbonized sufficiently to require any bleaching or severe oxidation procedure. In some instances, prior to sieving, a few samples were treated briefly, less than 5 minutes, in hot nitric acid or Schulze solution. Potassium hydroxide treatment was omitted. This was used only to remove finely-divided organic materials and to clean the surfaces of the palynomorphs.

The residues were then sieved (Kidson and Williams, 1969) and concentrated. The fractions obtained for slide preparations included a -20μm fraction, +20μm-210μm fraction, and a +210μm fraction.

Slides were prepared of all three sieved fractions, with the +20μm-210μm fraction being used for analysis. Residues were mounted on large coverglasses in Clearcol[1] and then mounted to the slides with Elvacite 2044 resin.[2]

Relative Abundance Counts

Relative abundance counts of palynomorphs were made only for the purpose of showing the relative abundances of taxa as they occurred in any one sample. That is to suggest to the readers the frequency of specific taxa. Also the

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[1]Clearcol, H. W. Clark, 33 South High St., Melrose, Mass. 02176

[2]Elvacite 2044 Resin Mfg. by E. I. DuPont DeNemours & Co. Inc., Wilmington, Delaware, 19898. Available at Brainard Chemical Co. Inc., Sheridan at 42nd St., Tulsa, Okla. 74145.

stratigraphic sequence deals with a systemic boundary where relative abundances could be useful in evaluating a transitional palynoflora.

A count of 250 specimens was made on most samples. Some samples were not counted because of poor preservation, rather than lack of abundance. It was believed that counts based on these poorly preserved samples would be invalid because of tenuous identifications.

The abundance categories for both the acritarchs and spores in the systematic descriptions are relative abundances based on counts of the first 250 identifiable palynomorphs encountered in the sample. All counts were commenced in the upper right hand corner of the coverglass, as viewed through the microscope with all traverses being made horizontally from upper to lower position on the coverglass, successively. The entire coverglass area of 2 slides per sample was examined for palynomorph occurrences in addition to those encountered in the count. The occurrences recorded in the Systematics section (p. 22 et seq.) are listed in relative percent for the sample or by sample number alone if present, but not recorded in the count.

Microscopy and Photography

The microscope work was done on a Leitz Orthoplan microscope, serial number 746931 (property of Amoco Production Co., Research Center, Tulsa, Okla.). Photographs were taken on Kodak Panatomic-X 35 mm. film with a Leitz Orthomat

camera. The enlargement of the prints was varied depending on specimen dimensions and features important for illustrations. The magnifications, as well as the size for individual specimens, are indicated in the plate legends.

The microscope slides used in this study for counts and/or illustrations are deposited in the palynology collection of Michigan State University, Geology Department, East Lansing, Michigan. A conversion table of coordinates of the Leitz Orthoplan to the Leitz Ortholux are included with the slides. All coordinates referred to in this study are recorded with the horizontal coordinate first followed by the vertical coordinate (i.e. horizontal=38.7, vertical=92.3) with both written as 38.7 X 92.3. Also, to facilitate use with other microscopes, the coordinates of the upper left-hand corner of the coverslip (as positioned on the microscope with the slide label to the left) are recorded on each slide label. This permits a simple mathematical calculation to locate recorded specimens with other microscopes. Assuming the stage micrometer calibrations to be in mm. an example would be, the upper left-hand corner of the coverslip as positioned on the microscope is at the coordinates 38.7 X 92.3 with the specimen located at coordinates 24.1 X 103.6, then the specimen would be located 14.6 mm. to the right and 11.3 mm. down.

SYSTEMATICS

Spores

The spores recovered in this study are classified alphabetically by genus and species. This arrangement is believed to be the most practical and simple to use because fossil spores are classified on the basis of morphology within a generic category. Other systems which use categories of higher taxonomic rank than genus usually imply phylogenetic relationships between genera where few have been proven to exist. There are many instances where distantly related or even unrelated plants produce morphologically similar spore types (Schopf, 1964).

Acritarchs

The classification of acritarchs used here is that of Downie, Evitt, and Sarjeant (1963) and Staplin, Jansonius, and Pocock, (1965). Although the group name, Acritarcha, introduced by Evitt (1963), means "of uncertain origin", considerably more work has been done with the acritarchs regarding their morphologic lineages. Therefore, they are classified using morphologic subgroups as well as taxa of generic and specific rank. An index of the acritarch taxa arranged alphabetically is provided in Appendix II.

SPORES

Genus Acanthotriletes (Naumova, 1937) emend. Potonie and Kremp, 1954

Type species: Acanthotriletes ciliatus (Knox, 1950) Potonie and Kremp, 1954, p. 133, pl. 20, fig. 95.

cf. Acanthotriletes hacquebardii Playford, 1964

Plate 1, Fig. 1

1964 Acanthotriletes hacquebardii Playford, p. 20-22, pl. 4, figs. 1-4.

Description: Specimens conform to the original description given by Playford (1964).

Discussion: Specimens are identified as cf. Acanthotriletes hacquebardii Playford, 1964 because their rarity precluded detailed comparison. It is also suspected that these specimens as well as those of Playford (1964) may be variants of Spinozonotriletes uncatus Hacquebard, 1957. This is based on the weak zonate nature of S. uncatus as evidenced by analysis of large populations. Therefore it is felt that end members of both species may be morphologically inseparable.

Occurrences and Stratigraphic Range: Lower Mississippian, Horton Group (Playford, 1964 and Varma, 1969). In samples Pb5690 and Pb5694 of this study as single occurrences. The known range of the species is Lower Mississippian based on few reported occurrences.

Genus Anapiculatisporites (Potonie and Kremp, 1954) emend. Smith and Butterworth, 1967

Type species: Anapiculatisporites isselburgensis Potonie and Kremp, 1954, p. 133, pl. 20, fig. 97.

Anapiculatisporites ampullaceus (Hacquebard, 1957) Playford, 1964

Plate 1, Fig. 5

1957 Raistrickia ampullacea Hacquebard, p. 310, pl. 1, figs. 21, 22.

1957 Raistrickia sp. A Hacquebard, p. 311, pl. 2, fig. 3.

1964 Anapiculatisporites ampullaceus (Hacquebard, 1957) Playford, p. 16, pl. 3, figs. 16, 17.

Description: Specimens conform to the original descriptions as given by Hacquebard (1957) and Playford (1964).

Discussion: Two figured specimens in Lanzoni and Magloire (1969), figs. 15 and 16, identified as Raistrickia sp. no. 3256, appear to be similar morphologically to Anapiculatisporites ampullaceus. However no description was given so this assumption is based only on comparison of their illustrations. Specimens recovered by von Almen (1970a) identified as Anapiculatisporites cf. ampullaceus and Anapiculatisporites sp. A may also be synonyms of A. ampullaceus based on von Almen's description and illustrations. Varma (1969) has described and illustrated Anapiculatisporites ampullaceus but his description and illustration give a larger size range than that of Hacquebard (1957) and of Playford (1964). Varma's illustrated specimen appears to be more

like Spinozonotriletes uncatus than Anapiculatisporites ampullaceus.

Occurrences and Stratigraphic Range: Lower Mississippian Horton Group (Hacquebard, 1957; Playford, 1964; and Varma, 1969); Tournaisian (Kaiser 1970a, 1970b; Lanzoni and Magloire, 1969); Kinderhookian (Brown, 1968); Upper Devonian or Lower Mississippian, Hickory Creek Outcrop (Von Almen, 1970a); Upper Devonian, Portishead Beds, Old Red Sandstone (Utting and Neves, 1970). Present in samples Pb5662, Pb5665, and Pb5671 of this study from the Orangeville Shale.

Anapiculatisporites ampullaceus has been found in both Upper Devonian and Lower Mississippian sediments but it is most common in the Lower Mississippian.

Anapiculatisporites retusus Winslow, 1962

Plate 2, Fig. 2

1962 Anapiculatisporites? retusus Winslow, p. 63, 64, pl. 18, figs. 15, 20, pl. 22, fig. 12.

?1972 Umbonatisporites medaensis Playford, p. 307, 308, 310, figs. 14-22, 23A.

Description: As originally described by Winslow (1962, p. 63, 64) with the following exceptions: The overall size range is slightly smaller 48-68μm; the ornamentation consists of conae and verrucae as well as apiculae and tubercles; there is occasional development of lips or raised structures adjacent to the sutures.

Discussion: Winslow (1962) questioned the assignment of this species to Anapiculatisporites on the

basis of the age differences of existing species of Anapiculatisporites. This is not thought as a significant exclusion and Anapiculatisporites appears as the best generic choice.

Lanzoni and Magloire (1969, pl. 4, figs. 5, 6) have illustrated two specimens identified as Raistrickia cf. baculosa. These appear more variable than R. baculosa as observed by the author. Although no description was provided these specimens appear to be more like Anapiculatisporites retusus. Playford (1972) has described Umbonatisporites medaensis from the Visean of Australia. Both the description and illustrations are very similar to Anapiculatisporites retusus. Umbonatisporites medaensis is questioned as being synonymous with Anapiculatisporites retusus, but actual observation of Playford's material would be needed for definitive comparison of the two species. Naumova (1953) has described Lophotriletes atratus, which was also described by Kedo (1963). Descriptions of this taxon by both authors are relatively simple, but the illustrations show considerable morphologic similarity to Anapiculatisporites retusus.

Separation of Anapiculatisporites retusus and A. ampullaceus is somewhat difficult when large populations of the former are encountered. The two species are best separated on the basis of the consistant type of ornamentation on A. ampullaceus and the highly variable ornamentation of A. retusus.

Occurrences and Stratigraphic Range: Upper Devonian and Lower Mississippian (Winslow, 1962). Present in all samples of this study except Pb5693. Greatest frequency is in sample Pb5663 where the species constitutes 6% of the assemblage. Known occurrences of the species are Upper Devonian and Lower Mississippian. In the event Umbonatisporites medaensis Playford, 1972 is a synonym, the range would be extended upward to the Upper Mississippian (Visean).

Genus Anaplanisporites Jansonius, 1962

Type species: Anaplanisporites (al. Anapiculatisporites) telephorus Klaus, 1960, p. 124, 125, pl. 29, fig. 17.

Anaplanisporites baccatus (Hoffmeister, Staplin, and Malloy, 1955b) Smith and Butterworth, 1967

Plate 2, Fig. 3

For a detailed synonymy see (Bertelsen, 1972, p. 33, 34).

Description: Spores radial, trilete; amb sub-circular to rounded-triangular; diameter 25-38µm; laesurae more or less distinct, straight, often accompanied by low folds, extending almost entire spore radius; exine thin ca. one µm, rarely folded; curvaturae present in some specimens, ornamentation consisting of distal and equatorial cones, often blunted, height of conae ca. two µm.

Discussion: The density of the ornamentation appears quite variable when comparing the descriptions and illustrations. Except for the spore margin the present specimens compare best to the holotype and description of Hoffmeister, Staplin, and Malloy (1955b).

Occurrences and Stratigraphic Range: The genus ranges from the Devonian of the present study to Triassic (Jansonius, 1962). The species ranges from Tournaisian to Westphalian or Uppermost Devonian to Middle Pennsylvanian based on the following occurrences: Hoffmeister, Staplin, and Malloy, 1955b; Butterworth and Williams, 1958; Love, 1960; Staplin, 1960; Sullivan and Marshall, 1966; Smith and Butterworth 1967; Jachowicz, 1967; Llewellyn, Backhouse, and Hoskin, 1969; Marshall and Williams, 1970; Clayton, 1971; Kalibova, 1971; and Bertelsen, 1972. Specimens were recovered during this study from Pb5651-0.8%, Pb5652-0.4%, Pb5653-0.4%, Pb5654, Pb5658-0.4%, and Pb5659-0.4%.

Genus Ancyrospora (Richardson, 1960)
emend. Richardson, 1962

Type species: Ancyrospora grandispinosa (Richardson 1960, p. 55, 56, pl. 14, fig. 7, text-figs. 5, 6c.) emend. Richardson, 1962, p. 175, 176, pl. 27, figs. 3-5, text-fig. 4.

The genus Ancyrospora represents a complex group of spores possessing a central body and ornamented with variably furcated appendages. The genus Dicrospora Winslow, 1962 is in part synonymous with Ancyrospora and Hystricosporites.

Ancyrospora? capillata Dolby and Neves, 1970

Plate 1, Figs. 2, 6

1968 Hystricosporites quadrifurcatus (mms. name) Eames, p. 57, p. 109, fig. 32.

1970 Ancyrospora? capillata Dolby and Neves, p. 639, pl. 2, figs. 7-10.

Description: Specimens conform to the description of Dolby

and Neves (1970). One minor exception noted in this study is the length of the setae on the exoexine, which have been found to rarely exceed four µm in length.

Discussion: This species is similar to Hystricosporites (Dicrospora) multifurcatus (Winslow, 1962) Mortimer and Chaloner, 1967 and differs only in the setose ornamentation of the exoexine. The extreme variability of many features of the two species may ultimately result in their being considered synonymous. Hystricosporites quadri-furcatus (mms. name) described and figured in Eames (1968) is considered to be Ancyrospora? capillata Dolby and Neves, 1970.

Occurrences and Stratigraphic Range: Lower Tournaisian-Tn-1 (Dolby and Neves, 1970, Combaz and Streel, 1970, Paproth and Streel, 1970, and Utting and Neves, 1970). Specimens are present in samples Pb5651, Pb5652, Pb5654, Pb5655 Pb5656, Pb5658, Pb5659, and a probable reworked specimen was found in Pb5680. The species range is restricted to the uppermost Devonian. This species as well as the other two species differentiated in this study are plotted together on the range charts as Ancyrospora spp., because they all occurred in the same sample horizons.

Ancyrospora multifurcata (Winslow, 1962) comb. nov.

Plate 1, Figs. 3, 4

1962 Dicrospora multifurcata Winslow, p. 53, 54, pl. 12, figs. 8, 8a, 8b, pl. 13, figs. 1-9, pl. 22, fig. 16.

1967 Hystricosporites multifurcatus (Winslow, 1962) Mortimer and Chaloner, p. 195, 196, pl. 26, figs.5-9.

Description: Specimens conform to the original diagnosis of Winslow (1962) and the more recent description of Mortimer and Chaloner (1967).

Discussion: The general morphology and central body with a flange or pseudoflange observed here in the specimens of Ancyrospora multifurcata (Winslow, 1962) comb. nov., allows the species to be reassigned to Ancyrospora rather than Hystricosporites. Mortimer and Chaloner (1967) observed a central body in only 50% of their specimens and were reluctant to accept this as of specific value. However, the presence of a central body, flange, or pseudoflange conforms to Richardson's (1960 and 1962) interpretation of Ancyrospora. This consequently excludes assignment to Hystricosporites McGregor (1960), which is azonate and lacks a central body.

Occurrences and Stratigraphic Range: Middle-Upper Devonian of Ohio (Winslow, 1962); Middle and Upper Devonian (Mortimer and Chaloner, 1967); Tournasian Tn-1 (Combaz and Streel, 1970); Bedford Shale and Horton Group of Canada (McGregor, 1970). Present in samples Pb5651, Pb5652, Pb5654, Pb5655, Pb5656, Pb5658, and Pb5659 of this study. The species is known from Middle and Upper Devonian horizons.

Ancyrospora sp.

Plate 2, Fig. 1

Description: Spores radial, trilete; amb rounded-triangular; diameter 98-125µm less ornamentation; laesurae indistinct, simple, extending entire radius of spore body;

two-layered exine, exoexine thin often torn or wrinkled, intexine 2-3μm thick; ornamentation consisting of bifurcating spines 8-16μm in length, 2-5μm basal width; ornamentation distal and equatorial.

Discussion: Specimens of Ancyrospora sp. are morphologically similar to Ancyrospora grandispinosa Richardson, 1960, but are considerably smaller in overall dimensions. Perotrilites bifurcatus Richardson, 1962 is also similar except the central body is larger and the spore is described as perinate.

Occurrences and Stratigraphic Range: Ancyrospora sp. is represented by only two specimens as single occurrences in samples Pb5658 and Pb5680. The occurrence in Pb5680 may be due to reworking because representatives of Ancyrospora are confined generally to the Devonian.

Genus Apiculatisporis Potonie and Kremp, 1956

Type species: Apiculatisporis (al. Apiculati-sporites) aculeatus (Ibrahim, 1933) Potonie and Kremp, 1956, p. 94.

?Apiculatisporis sp.

Plate 2, Fig. 4

Description: Spores radial, trilete; amb rounded-triangular; diameter 26-35μm; laesurae generally distinct, straight, simple, extending more than 3/4 spore radius; exine thin ca. one μm rarely folded or ruptured; ornamentation, dense apiculae less than two μm high, less than one μm in basal width; ornamentation primarily distal and equatorial,

occasionally some proximal ornaments; ?curvaturae occasionally developed.

Discussion: Specimens are tentatively assigned to Apiculatisporis. The presence of curvaturae and regular ornamentation prevent a firm assignment to the genus at this time. Granulatisporites frustulentus Balme and Hassell, 1962 is superficially similar, but is ornamented with grana and is larger in overall size than ?Apiculatisporis sp. Acanthotriletes intonsus Playford, 1971 appears somewhat similar, but has lipped laesurae and slightly longer ornaments.

Occurrences and Stratigraphic Range: Specimens were observed in the following samples: Pb5685-0.4%, Pb5688-7.6%, Pb5689-2.0%, Pb5690-7.2%, Pb5691, Pb5692, Pb5693, Pb5694-8.0%, and Pb5695-2.0%.

Genus Auroraspora Hoffmeister, Staplin, and Malloy, 1955b

Type species: Auroraspora solisortus Hoffmeister, Staplin, and Malloy, 1955b, p. 381, pl. 37, fig. 3.

Auroraspora macra Sullivan, 1968

Plate 2, Fig. 5

1968 Auroraspora macra Sullivan, p. 124, 125, p. 27, figs. 6-10.

1968 Auroraspora minutigranulata Brown, (mms. name) p. 112, 113, pl. 4. figs. 39-42.

Description: Spores radial, trilete; amb circular-subcircular-irregular due to folding; diameter 27-58µm overall, central body 23-45µm; exoexine thin ca. one

µm, often torn, folded and pitted: intexine 1-3µm thick; ornamentation of exoexine surface psilate-scabrate-granulate; laesurae, straight, simple, extending ca. 3/4 central body radius.

Discussion: Specimens are generally smaller than those described by Sullivan (1968), which range from 48-68µm. Comparisons of Sullivan's materials has aided in the identification of the species. The specimens described and illustrated as Auroraspora minutigranulata in Brown's unpublished thesis (1968) appear to be synonymous with the specimens from northeastern Ohio. Although Brown's material was not examined his specimens are best included in Auroraspora macra Sullivan, 1968. Two forms illustrated and described in von Almen's unpublished thesis (1970a) as Perotrilites luteolus and P. evanidus may be related, but close comparison has not been made. The generic relationship, if any, and comparisons of Auroraspora and Perotrilites are discussed preceding the treatment of spores presently assigned to Perotrilites.

Occurrences and Stratigraphic Range: Representatives of the genus range from Devonian (Richardson, 1960) to Upper Mississippian (Hoffmeister, Staplin and Malloy, 1955b). The species is known from the Devonian-Tournaisian (Utting and Neves, 1970), Tournaisian/Lower Carboniferous (Sullivan, 1968; Llewellyn, Backhouse, and Hoskin, 1969; Llewellyn, Hoskin, and Backhouse, 1970; Johnson and Marshall, 1971; Clayton, 1971; Playford, 1971; Bertelsen, 1972), and Lower

Mississippian (Brown, 1968). Specimens were recovered during the present study in samples Pb5654-2.4%, Pb5655-0.4%, Pb5656, Pb5657-0.8%, Pb5658-0.4%, Pb5660-0.4%, Pb5661-2.0%, Pb5662-1.2%, Pb5665-2.0% Pb5666, Pb5670, Pb5671-2.4%, Pb5675, Pb5676, Pb5679-0.4%, Pb5680, Pb5682, Pb5684-0.4%, Pb5685, Pb5686-0.8%, Pb5687-6.4% Pb5688-22.8%, Pb5689-17.2%, Pb5690-26.4%, Pb5691, Pb5692, Pb5693, Pb5694-14.4% Pb5695-6.4% and Pb5696.

The range of the species is from Upper Devonian through Lower Visean (Middle Mississippian) based on the occurrences and range given by Neves, et al. (1972).

Genus Baculatisporites Pflug and Thomson, 1953 in Thomson and Pflug, 1953

Type species: Baculatisporites (al. Pteris) primarius (Wolff) Pflug and Thomson in Thomson and Pflug, 1953, p. 56, pl. 2, fig. 51.

Baculatisporites sp.

Plate 2, Fig. 7

Description: Spores radial, trilete; amb rounded-triangular; diameter 38-48μm; laesurae, simple, straight, generally distinct, extending more than 3/4 spore radius; exine ca. two μm, rarely folded; ornamentation consisting of short baculae 2-4μm high, ca. two μm in basal width; surface of ornaments and spore psilate.

Discussion: Specimens assigned to Baculatisporites are not comparable to any other spores of Devonian-Mississippian age. The species described in this study is assigned to Baculatisporites although the genus was established

by Thomson and Pflug (1953) from material of Tertiary age.

Occurrences and Stratigraphic Range: The present occurrences would extend the generic range downward to the Upper Devonian. Previous oldest reports of the genus have been by Sullivan (1968), Llewellyn, Backhouse, and Hoskin (1969), Streel (1970), Johnson and Marshall (1971), Clayton (1971), and Bertelsen (1972) all of which are Tournaisian in age. Specimens have been recovered in this study from sample Pb5654. It is rather strange that occurrence of this species has been limited to a single sample, because there were several specimens on each slide.

Genus Calamospora Schopf, Wilson, and Bentall, 1944

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

Calamospora breviradiata Kosanke, 1950

Plate 2, Fig. 8

1950 Calamospora breviradiata Kosanke, p. 41, pl. 9, fig. 4.

Description: Spores radial, trilete; amb circular; diameter 43-74µm; laesurae distinct, straight, slightly raised (lips), extending less than ½ spore radius; contact area darkened, exine thin, 1-2µm, often folded; surface psilate.

Discussion: Although the present assignment of specimens to Calamospora breviradiata Kosanke represents much older occurrences than commonly expected, the morphologic features are consistent with those described by Kosanke (1950).

Occurrences and Stratigraphic Range: The genus is known from Lower Devonian (McGregor, 1973) to Lower Permian (Hoffmeister, Staplin, and Malloy, 1955a). The species ranges from the Upper Devonian strata of the present study to Upper Pennsylvanian-Westphalian D (Smith and Butterworth, 1967). Specimens were found in this study in samples Pb5655, Pb5657-0.4%, Pb5658-1.2%, Pb5660, Pb5661, Pb5662-0.4%, Pb5663, Pb5664-0.4%, Pb5665-0.8%, Pb5672, Pb5674, Pb5675, Pb5679, Pb5687, Pb5688, Pb5689-0.4%, Pb5691 and Pb5695-0.4%.

Calamospora cf. pannucea Richardson, 1965

Plate 2, Fig. 6

1965 Calamospora pannucea Richardson, p. 563, pl. 88, fig. 3.

Description: Spores radial, trilete; amb circular to subcircular; diameter 88-138µm; laesurae generally distinct, straight, simple, extending less than ½ spore radius; contact area darkened; exine thin, ca. one µm, folding common, surface psilate.

Discussion: Specimens are referred to Calamospora cf. pannucea Richardson, 1965 because they are of infrequent occurrence and also because of the absence of the characteristic crumpled/wrinkled exine as described by Richardson (1965). Calamospora mutabilis (Loose) Schopf, Wilson, and Bentall, 1944, as described in Smith and Butterworth (1967), is similar in size, but lacks a darkened contact area. Calamospora sp. A in Winslow (1962) may belong to C. pannucea, but the exine is thicker and rays of laesurae are longer.

Occurrences and Stratigraphic Range: The species is known from Middle Devonian (Richardson, 1965), Lower and Middle Devonian (McGregor, 1973) and from the present study in samples Pb5659-0.4%, Pb5675, and ?Pb5696.

Genus Converrucosisporites Potonie and Kremp, 1954

Type species: Converrucosisporites triquetrus (Ibrahim, 1933) Potonie and Kremp, 1954, p. 137, pl. 6, fig. 18.

Converrucosisporites sp.

Plate 3, Fig. 1

Description: Spores radial, trilete; amb rounded-triangular; diameter 38-50μm; laesurae more or less indistinct, simple, straight, extending more than 3/4 spore radius; exine 2-4μm thick, rarely folded; ornamentation consists of closely spaced verrucae, variably irregular at base, occasionally fused to form short irregular ridges; verrucae 1-4μm high, basal width 3-7μm; equatorial margin lobate in appearance.

Discussion: Specimens of Converrucosisporites sp. are similar to C. parvinodosus Playford, 1964, but lack lip development and have higher and slightly coarser verrucae. An examination of specimens from Playford (1964) may show C. sp. to be conspecific. However, for the present, this assignment cannot be made. Verrucosisporites sp. in Winslow (1962) may possibly be similar to the present specimens of Converrucosisporites sp.

Occurrences and Stratigraphic Range: The genus is known to range from Lower Mississippian (Playford, 1964) to Lower Permian (Hoffmeister, Staplin, and Malloy, 1955a). Specimens found during the present study occur in samples Pb5661, Pb5668, Pb5671, Pb5675, and Pb5679.

Genus Convolutispora Hoffmeister, Staplin, and Malloy, 1955b

Type species: Convolutispora florida Hoffmeister, Staplin, and Malloy, 1955b, p. 384, pl. 38, figs. 5, 6.

The genus Convolutispora contains a large number of species, which are separated from each other by minor size differences (overall diameter) and width and height of ornament. Undoubtedly there is considerable synonymy within this genus, which would require an examination of type slides and a monograph of the genus. Therefore, comparison of other species to those recovered here will be limited to materials of similar age.

Convolutispora florida Hoffmeister, Staplin, and Malloy, 1955b

Plate 3, Fig. 2

1955b Convolutispora florida Hoffmeister, Staplin, and Malloy p. 384, pl. 38, figs. 5, 6.

Description: Specimens conform to the original diagnosis of Hoffmeister, Staplin, and Malloy (1955b) with the single exception of the size range which is 36-56μm overall diameter. This is a slightly broader range than given in the original description.

Discussion: Convolutispora florida is generally distinguished from other species of the genus by coarser ornamentation and smaller overall size. Most forms observed here tend to be sub-circular rather than circular but this may be only a preservational feature.

Occurrences and Stratigraphic Range: The genus ranges from Middle Devonian (Owens, 1971) to probable Stephanian (Barss, 1967). Convolutispora florida has been found commonly in the Upper Mississippian-Lower Pennsylvanian (Hoffmeister, Staplin, and Malloy, 1955b; Butterworth and Williams, 1958; Balme, 1960a; Love, 1960; Sullivan, 1964a; Upshaw and Creath, 1965; Sullivan and Marshall, 1966; Barss, 1967; Smith and Butterworth, 1967; Playford, 1971; and Spinner and Clayton, 1973).

Specimens have been recovered during this study from samples Pb5669-0.4%, Pb5674, Pb5675, Pb5690, and Pb5695-0.4%. The occurrence of Convolutispora florida in this study extends the species range downward to the Lower Mississippian.

Convolutispora mellita Hoffmeister, Staplin, and Malloy, 1955b

Plate 3, Fig. 4

1955b Convolutispora mellita Hoffmeister, Staplin and Malloy, p. 384, 385, pl. 38, fig. 10.

1962 Convolutispora sp. A. Winslow, p. 71, 72, pl. 17, figs. 24, 25.

1968 Convolutispora similis Eames (mms. name), p. 35, 36, fig. 22.

Description: Spores radial, trilete; amb circular to sub-circular; diameter 60-92μm; laesurae, simple,

straight, generally indistinct, extending 2/3 spore radius; exine 2-5μm thick; ornamentation consists of low convolute anastomosing ridges, height to 4μm, width 3-7μm, producing a reticulate appearance; surface of ornaments psilate; equatorial outline undulate.

Discussion: Specimens are slightly larger in overall diameter and occasionally have broader ridges than those described by Hoffmeister, et al. (1955b). Specimens figured in Butterworth and Williams (1958) as Convolutispora mellita and C. cf. mellita have been transferred to a new species C. jugosa by Smith and Butterworth (1967, p. 186). These specimens apparently have a larger overall diameter and thicker outline although Smith and Butterworth do not discuss the differences between the two.

Occurrences and Stratigraphic Range: The species is known from the Upper Devonian and Lower Mississippian (Winslow, 1962 and Eames, 1968). In other areas it is widely known from the Lower Mississippian/Tournaisian-Middle Pennsylvanian (Hoffmeister, Staplin, and Malloy, 1955b; Sullivan and Marshall, 1966; Barss, 1967; Sullivan, 1968; Hibbert and Lacy, 1969; Lanzoni and Magloire, 1969; Llewellyn, Backhouse, and Hoskin, 1969; Clayton, 1971; and Llewellyn, Hoskin, and Backhouse, 1971).

Specimens have been recovered during this study from samples Pb5654, Pb5659, Pb5660, Pb5661, Pb5662, Pb5663, Pb5664, Pb5665-0.4%, Pb5666, Pb5667, Pb5669-0.4%, Pb5670, Pb5675, Pb5676, Pb5680, Pb5683-0.8% Pb5685, Pb5686-0.4%, Pb5687, Pb5689-0.4%, and Pb5690.

Convolutispora tessellata Hoffmeister, Staplin, and Malloy, 1955b

Plate 3, Fig. 3

1955b Convolutispora tessellata Hoffmeister, Staplin, and Malloy, p. 385, pl. 38, fig. 9.

Description: Specimens conform to the original description given by Hoffmeister, Staplin and Malloy (1955b).

Discussion: Playford (1962, p. 592) has suggested that Convolutispora tessellata may be synonymous with C. tuberculata Waltz, 1938 in Luber and Waltz (1938). Only comparative observations of type materials would ultimately prove or disprove the similarities of the two species.

Occurrences and Stratigraphic Range: The species range is known from Tournaisian to Westphalian/Lower Mississippian to Middle Pennsylvanian from the following occurrences: Hoffmeister, Staplin, and Malloy, 1955b; Butterworth and Williams, 1958; Love, 1960; Staplin, 1960; Sullivan, 1964a; Barss, 1967; Smith and Butterworth, 1967; and Kaiser, 1970a.

Specimens have been recovered during this study from samples Pb5651-0.8%, Pb5652-0.4% Pb5653-0.4%, Pb5654, Pb5657-0.8%, Pb5658-0.8%, Pb5659-1.2%, Pb5661, Pb5662, Pb5663, Pb5664, Pb5665-2.8%, Pb5667-0.8%, Pb5668, Pb5669-0.4%, Pb5671-4.0%, Pb5672, Pb5674-1.6%, Pb5675-2.0%, Pb5676-1.6%, Pb5677, Pb5678, Pb5679, Pb5680-2.8% Pb5682, Pb5683-2.0%, Pb5684-0.4%, Pb5685-1.2%, Pb5686-1.2%, Pb5687-0.4%, Pb5688-0.4%, Pb5689-0.4%, Pb5690, Pb5692, Pb5694-0.4%, and Pb5696.

Convolutispora tuberosa Winslow, 1962

Plate 3, Fig. 7

1962 Convolutispora tuberosa Winslow, p. 71, pl. 17, figs. 20, 21, 22.

1968 Convolutispora cf. tuberosa Winslow, 1962 in Sullivan, p. 123, pl. 26, fig. 8.

?1971 Convolutispora circumvallata Clayton, p. 582, pl. 1, figs. 5, 6, 7.

Description: Specimens conform to the description of Winslow (1962), with the only exception being an occasional specimen with a larger overall diameter (65-112µm).

Discussion: Convolutispora circumvallata Clayton, 1971 is questionably considered synonymous with C. tuberosa. The only apparent difference between the two species is the presence of labra in C. circumvallata, which have not been observed in specimens of C. tuberosa. The variability of the specimens (Clayton, 1971) and dense ornamentation may obscure this feature.

Occurrences and Stratigraphic Range: The species is known from the Upper Devonian and Lower Mississippian/Tournaisian (Winslow, 1962; ?Clayton, 1971; Johnson and Marshall, 1971; and Sullivan, 1968). Specimens have been recovered during this study from samples Pb5654, Pb5659, Pb5660, Pb5661, Pb5662, Pb5663-1.2%, Pb5664-0.4%, Pb5667, Pb5668, Pb5671, Pb5672, Pb5674, Pb5675-1.2%, Pb5676-0.8%, Pb5679-0.8%, Pb5680-1.2%, Pb5682, Pb5683-0.4%, Pb5684-1.6%, Pb5685, Pb5686, Pb5687-0.8%, Pb5688, Pb5689, Pb5690-0.8%, Pb5692, Pb5694-0.4%, Pb5695-2.0%, Pb5696, and Pb5697.

Convolutispora vermiformis Hughes and Playford, 1961

Plate 3, Fig. 6

1957 Convolutispora flexuosa forma minor Hacquebard, p. 312, pl. 2, fig. 10.

1961 Convolutispora vermiformis Hughes and Playford, p. 30, pl. 1, figs. 2, 3, 4.

Description: Specimens conform to the descriptions given by Hughes and Playford (1961) and Playford (1962 and 1971)

Discussion: Convolutispora flexuosa forma minor was represented by only two specimens in the original description. This description based on only two specimens for an infraspecific taxon appears to support its conspecific position with C. vermiformis (Playford, 1962, p. 593). I would also agree with Playford (1971, p. 28) that specimens figured by Allen (1965) as C. vermiformis are probably a different taxon.

Occurrences and Stratigraphic Range: The species is known from Devonian (Emsian) to Upper Mississippian (Visean) (Hacquebard, 1957; McGregor, 1960; Hughes and Playford, 1961; Playford, 1962, 1964, and 1971; Barss, 1967; Moreau-Benoit, 1967; Hibbert and Lacy, 1969; Llewellyn, Backhouse, and Hoskin, 1969; Varma, 1969; Kaiser, 1970a; Mortimer, Chaloner, and Llewellyn, 1970; Johnson and Marshall, 1971; Llewellyn, Hoskin, and Backhouse, 1971; Bertelsen, 1972; and Kalibova-Kaiserova, 1972). The most common occurrences for the species are from the Tournaisian.

Specimens have been recovered during the present study from samples Pb5676, Pb5678, and Pb5679.

Convolutispora sp.

Plate 3, Fig. 5

Description: Spores radial, trilete; amb circular to subcircular; diameter 48-62μm; laesurae, simple, straight, extending 2/3 spore radius, generally indistinct; exine 1-3μm thick, rarely folded; ornamentation consisting of low convolute anastomosing irregular ridges, 2-4μm high, 1-3μm wide, surface of ridges very irregular, scabrate-rugulate in appearance.

Discussion: The highly irregular nature of the ridges along with their rough scabrate surface makes Convolutispora sp. distinct from other described species. Because the specimens are not overly abundant the rough scabrate surface of the ornament may represent a corrosion feature rather than a true morphologic feature.

Occurrences and Stratigraphic Range: Specimens have been found in samples Pb5676, Pb5683-0.4%, Pb5684-0.4%, and Pb5686-0.4%.

Genus Corbulispora Bharadwaj and Venkatachala, 1961

Type species: Corbulispora retiformis Bharadwaj and Venkatachala, 1961, p. 24, pl. 2, figs. 32-34.

?Corbulispora subalveolaris (Luber, 1938) Sullivan, 1964b

Plate 3, Fig. 8

1938 Azonotriletes subalveolaris Luber in Luber and Waltz, p. 24, pl. 5, fig. 72.

1955 Dictyotriletes subalveolaris (Luber, 1938) Potonie and Kremp, p. 108.

1964b Corbulispora subalveolaris (Luber, 1938) Sullivan, p. 1253, pl. 1, figs. 16-20.

Description: Specimens conform to the descriptions of Sullivan (1964b) and Dolby and Neves (1970).

Discussion: The questionable assignment of this taxon to Corbulispora is based on the uncertain nature of the generic assignment. The specimens found during this study are similar to those identified in the literature as Corbulispora subalveolaris. An in-depth discussion of the generic confusion between Corbulispora and Dictyotriletes is provided in the treatment of Dictyotriletes. It is entirely possible that specimens assignable to Corbulispora subalveolaris may ultimately be transferred on a firm basis to Dictyotriletes. Besides C. subalveolaris, one other species here placed in Dictyotriletes as D. cancellatus may also be a synonym. However, for the present the two species appear separable. See discussion in treatment of Dictyotriletes cancellatus.

Occurrences and Stratigraphic Range: The genus is known from the Tournaisian (post Tn-1a--Lower Mississippian) to Visean (lower Upper Mississippian) or primarily from Mississippian sediments. The species is restricted to the Tournaisian (Luber and Waltz, 1938; Love, 1960; Sullivan, 1964a & 1964b; Barss, 1967; Butterworth and Spinner, 1967; Combaz and Streel, 1970; Dolby, 1970; Dolby and Neves, 1970; Neves

and Dolby, 1967; McGregor, 1970; Paproth and Streel, 1970; Utting and Neves, 1970; Johnson and Marshall, 1971; and ?Bertelsen, 1972).

Specimens have been recovered during the present study from samples Pb5651-0.4%, Pb5652-0.4% Pb5653, Pb5654, Pb5663, Pb5665, Pb5682, Pb5687-0.8%, Pb5689-2.0%, Pb5690, Pb5691, Pb5692, Pb5693, Pb5694, Pb5695-4.4%, Pb5696, and Pb5697.

Genus Crassispora Bharadwaj, 1957

Type species: Crassispora ovalis Bharadwaj, 1957, p. 126, pl. 25, figs. 73-76.

Crassispora sp.

Plate 4, Figs. 1, 2

Description: Spores radial, trilete; amb subcircular to rounded-triangular; diameter 80-135µm; laesurae variable distinct-indistinct, often accompanied by raised sinuous folds, extending more than 3/4 spore radius; equatorial crassitude present, variably thickened, encompassing 1/7-1/5 spore radius; exine thickness difficult to obtain, apparently 2-4µm thick; ornamentation of biform echinate-verrucate elements, distally and equatorially, height to 4µm, basal diameter to 5µm; surface of spore scabrate between ornamentation.

Discussion: The specimens recovered in this study appear to be distinct from other species of Crassispora.

Occurrences and Stratigraphic Range: The genus is known to range from Tournaisian (Sullivan, 1964a, p. 376) to Upper Pennsylvanian (Bharadwaj, 1957). Specimens have

been recovered during the present study from samples Pb5661, Pb5662-0.4%, Pb5663-0.4%, Pb5664-0.4%, Pb5665, Pb5666, Pb5667-0.4% Pb5668, Pb5669, Pb5670, Pb5671-3.2%, Pb5672, Pb5673, Pb5674-2.0%, Pb5675-6.4% Pb5676-6.8%, Pb5677, Pb5678, Pb5679-4.4%, Pb5680-6.0%, Pb5681, Pb5682, Pb5683-7.6%, Pb5684-4.8%, Pb5685-9.2%, Pb5686-8.0%. Pb5687-1.2%, Pb5688, Pb5689-0.4%, Pb5690, Pb5691, Pb5692, Pb5693, Pb5694-0.4%, and Pb5695-1.2%. This species has been found only in the post-Berea sediments.

Genus Cyclogranisporites Potonie and Kremp, 1954

Type species: Cyclogranisporites leopoldi (Kremp, 1952) Potonie and Kremp, 1954, p. 126, 129, pl. 20, fig. 103.

Cyclogranisporites cf. aureus (Loose, 1934) Potonie and Kremp, 1955

Plate 4, Fig. 3

1934 Reticulati-sporites aureus Loose, p. 155, pl. 7, fig. 24.

1944 Punctati-sporites aureus (Loose, 1934), Schopf, Wilson, and Bentall, p. 30.

1950 Plani-sporites aureus (Loose, 1934), Knox, p. 315.

1955 Cyclogranisporites aureus (Loose, 1934), Potonie and Kremp, p. 61, pl. 13, figs. 184-186.

Description: Specimens conform to the description of Smith and Butterworth (1967, p. 142, 143).

Discussion: The present specimens are referred to C. aureus with the realization that C. aureus is primarily restricted to the Pennsylvanian. However, probably due to the generalized morphologic features exhibited by the species, it is quite common in sediments from Devonian to Permian. One

other possible choice for assignment might have been Cyclogranisporites plicatus of Allen (1965), but the present specimens exhibit no curvaturae and the laesurae are longer.

Occurrences and Stratigraphic Range: The genus is known to range from Lower Devonian (Allen, 1965) to Upper Pennsylvanian (Hoffmeister, Staplin, and Malloy, 1955a). The species range is not given here because the occurrences are primarily Pennsylvanian, which is beyond the scope of the present study. The occurrences in this study would represent the oldest records for the species.

Specimens seen in this study are from samples Pb5652-0.8% Pb5655-0.4%, Pb5656-0.4%, Pb5658, Pb5660, Pb5661-1.6%, Pb5662-1.6%, Pb5663-1.2%, Pb5664-1.6%, Pb5665-0.4%, Pb5667-0.4%, Pb5669-1.6% Pb5670-0.8% Pb5671-6.0%, Pb5673, Pb5674-1.2%, Pb5675, Pb5676-0.4%, Pb5678, Pb5679-0.8%, Pb5680-0.4%, Pb5681, Pb5682, Pb5683-0.4%, Pb5684-1.2%, Pb5685, Pb5686-0.4%, Pb5687, Pb5689, Pb5690, Pb5691, Pb5693, Pb5694, Pb5696 and Pb5697-0.4%.

Cyclogranisporites commodus Playford, 1964

Plate 4, Fig. 4

1964 Cyclogranisporites commodus Playford, p. 12, 13, pl. 2, figs. 3-5.

Description: Specimens conform to the original description given by Playford (1964, p. 12, 13).

Discussion: Bertelsen (1972) has referred to his specimens as Cyclogranisporites cf. commodus because of their having a slightly thicker exine than those of Playford

(1964) and Butterworth and Spinner (1967). However, his specimens only differed by about one µm, which is probably within the expected range of the species because Playford (1964) states the exine is about one µm thick. One additional species that may be synonymous is C. mcallisteri of Varma (1969). The description of Varma's species differs only in defining a triangular, more or less thickened, contact area. This feature does not show in Varma's illustrations and because his material is from the Horton Group, as was Playford's, this new species may be suspect.

Occurrences and Stratigraphic Range: The species is known primarily from Tournaisian and Visean sediments and thus ranges from uppermost Devonian to Upper Mississippian based on the following occurrences: Playford, 1964; Barss, 1967; Butterworth and Spinner, 1967; Brown, 1968; Varma, 1969; von Almen, 1970a; Kaiser, 1970a; Clayton, 1971; and Bertelsen, 1972.

Specimens in the present study occurred in samples Pb5651-3.6%, Pb5652-3.2%, Pb5653-4.4%, Pb5654-2.0%, Pb5655-0.8%, Pb5656, Pb5657-0.8%, Pb5659-0.8%, Pb5660, Pb5661-2.0%, Pb5663-0.4%, Pb5664-0.4%, Pb5667, Pb5668-0.8%, Pb5669, Pb5670, Pb5672, Pb5674-2.0%, Pb5675-4.8%, Pb5676-2.4%, Pb5678, Pb5679-1.6%, Pb5680-6.0%, Pb5683-4.0%, Pb5684-2.8%, Pb5685-1.6% Pb5686-1.6%, Pb5687-5.2%, Pb5688, Pb5689-1.2%, Pb5690-2.4%, Pb5693, Pb5694-0.4%, and Pb5696.

Genus Densosporites (Berry, 1937) emend. Butterworth, Jansonius, Smith, and Staplin, 1964 in Staplin and Jansonius, 1964

Type species: Densosporites covensis Berry, 1937, p. 157, fig. 11.

Densosporites sp. A.

Plate 4, Fig. 5

1962 Densosporites sp. A. Winslow, p. 49, pl. 22, fig. 13.

Description: Spores radial, trilete; amb rounded-triangular; diameter 35-45μm overall, corpus diameter 20-30μm; laesurae, distinct, occasionally sinuous, slightly raised, extending entire radius of corpus; central body less dense than cingulum, psilate; cingulum 4-8μm wide, variably thickened, occasionally crenulate at equatorial margin, psilate on surface, separation between cingulum and corpus variable, occasionally forming a groove.

Discussion: The specimens found in this study superficially resemble Densosporites anulatus (Loose) Smith and Butterworth, 1967. Densosporites sp. A differs from D. anulatus by having distinct laesurae, lacking apical papillae, and occasionally having a crenulate margin. An examination of known specimens assigned to D. anulatus would be warrented before publication of Densosporites sp. A as a new taxon.

Occurrences and Stratigraphic Range: The genus ranges from Devonian (Richardson, 1960 and Allen, 1965) to Upper Pennsylvanian (Hoffmeister, Staplin, and Malloy 1955a). Densosporites sp. A has been found during this study in

samples Pb5661-0.8%, Pb5662-0.4%, Pb5663, Pb5664-1.2%, Pb5665-1.6%, Pb5667-0.8%, Pb5668-2.8%, Pb5669-2.0%, Pb5670-0.4%, Pb5671-0.4%, Pb5674-2.0%, Pb5675-2.4%, Pb5676-2.0%, Pb5677, Pb5678, Pb5679-1.6%, Pb5680-2.0%, Pb5681, Pb5682, Pb5683-1.6%. Pb5684-2.4% Pb5685-4.8%, Pb5686-1.2%, Pb5687-0.4%, Pb5688, Pb5690, Pb5691, and Pb5694.

Densosporites sp. B.

Plate 4, Fig. 6

Description: Spores radial, trilete; amb rounded-triangular; diameter 44-84μm overall, corpus diameter 18-26μm; laesurae indistinct, sinuous, slightly raised, extending entire radius of corpus; corpus less dense than cingulum, psilate; cingulum 15-25μm wide, thinner toward equatorial margin; ornamented with grana and occasionally small cones to 4μm in length; equatorial margin ragged in appearance.

Discussion: Specimens of Densosporites sp. B were generally poorly preserved with many oriented at oblique angles. The recovered specimens are somewhat like Densosporites landesii of Staplin (1960), which has subsequently been redescribed and assigned to Cingulizonates by Staplin and Jansonius (1964). Because of the generally poor quality and quantity of the present specimens, assignment is made only as Densosporites sp. B.

Occurrences and Stratigraphic Range: Specimens of Densosporites sp. B were recovered only from the Berea Sandstone from samples Pb5654, Pb5659, and Pb5660.

Genus Dictyotriletes (Naumova, 1937) emend. Smith and Butterworth, 1967

Type species: Dictyotriletes bireticulatus (Ibrahim, 1932) emend. Smith and Butterworth, 1967, p. 194, 195, pl. 11, figs. 14, 15.

There is considerable variation in the interpretation of Dictyotriletes, Corbulispora, Reticulatisporites, Knoxisporites and in some instances Convolutispora. The circumscriptions of these genera in many cases seem to overlap and are somewhat arbitrary. Various authors have created many new combinations and transfers from one genus to the others based on their personal interpretations. Thus as papers appear the same species appears under different generic assignment. Ultimately a study of the above genera in a single investigation of type materials may be the only solution to this confusion.

The present interpretation for separation of these genera is based on the most recent generic emendations and descriptions (Neves, 1961; Bharadwaj and Venkatachala, 1961; Sullivan, 1964b; Neves and Playford, 1961; Neves, 1964; and Smith and Butterworth, 1967). The presence of a cingulum separates Reticulatisporites and Knoxisporites from Dictyotriletes, Corbulispora and Convolutispora, which are acingulate. Reticulatisporites and Knoxisporites are then separated by the character of the cingulum (cf. Neves, 1964) with Reticulatisporites having a complex cingulum and Knoxisporites a simple or uniform cingulum. The acingulate forms, Dictyotriletes, Corbulispora, and Convolutispora may

be separated on ornament character. In Convolutispora the ornamentation occurs both distally and proximally with a pseudoreticulate pattern occasionally formed when the convolute ridges anastomose. Dictyotriletes, and Corbulispora are both clearly reticulate with isolated lumina present and differ mainly by the distal and proximal ornament (Corbulispora) versus primarily distal ornament (Dictyotriletes) (H. J. Sullivan, personal communication). This distal or overall (distal and proximal) ornamentation appears to be slightly variable and is generally omitted in most descriptions for the genera and species. The study of species of Corbulispora and Dictyotriletes by the scanning electron microscope may be the only solution to this dilemma concerning ornamentation.

Dictyotriletes cancellatus (Waltz, 1938)
Potonie and Kremp, 1954

Plate 4, Fig. 4

1938 Azonotriletes cancellatus Waltz in Luber and Waltz, p. 13, pl. 1, fig. 8, pl. 5, fig. 73.

1954 Dictyotriletes cancellatus (Waltz, 1938) Potonie and Kremp, p. 108.

1955 Sphenophyllotriletes cancellatus (Waltz, 1938) Luber, p. 41, 42 pl. 4, figs. 78a, 78b, 79.

1956 Dictyotriletes cancellatus (Waltz, 1938) Ishchenko, p. 43, pl. 7, figs. 88, 89.

1957 Reticulatisporites varioreticulatus Hacquebard and Barss, p. 17, pl. 2, figs. 15, 16.

1958 Dictyotriletes cancellatus (Waltz, 1938) Ishchenko, p. 55, pl. 5, fig. 63.

1961 Corbulispora cancellata (Waltz, 1938) Bharadwaj and Venkatachala, p. 24.

1962 Reticulatisporites cancellatus (Waltz, 1938) Playford, p. 597, 598, pl. 82, figs. 11, 12, 13, pl. 83, figs. 1, 2.

1963 Dictyotriletes cancellatus (Waltz, 1938) Ischenko in Kedo, p. 54, pl. 4, fig. 93.

1967 Reticulatisporites cancellatus (Waltz, 1938) Playford in Jachowicz, p. 30, pl. 16, fig. 6, pl. 17, fig. 1.

1969 Dictyotriletes cancellatus (Waltz, 1938) Potonie and Kremp, in Hibbert and Lacy, p. 427, pl. 79, fig. 11.

1970 Corbulispora cancellata (Waltz, 1938) Bharadwaj and Venkatachala in Dolby and Neves, p. 637.

1972 Dictyotriletes cancellatus (Waltz, 1938) Potonie and Kremp in Bertelsen, p. 46, pl. 15, fig. 1.

Description: Specimens conform to the description given in Bertelsen (1972, p. 46).

Discussion: The specimens assigned to Dictyotriletes cancellatus differ from specimens encountered in this study which have been assigned to ?Corbulispora subalveolaris by the ornamentation being primarily distal for D. cancellatus and both distal and proximal for ?C. subalveolaris. The muri also seem to be higher in D. cancellatus than in C. subalveolaris. Some authors have suggested that the two species are synonymous (Butterworth and Spinner, 1967; Dolby and Neves, 1970; and Bertelsen, 1972). The species generally occur in the same sample horzons and are separated by only minor differences. They have been treated separately here, but may eventually be included as one species.

Occurrences and Stratigraphic Range: The genus ranges from Upper Devonian (Streel, 1970) to Upper Pennsylvanian (Smith and Butterworth, 1967). The species range is

from Upper Devonian to Upper Mississippian and it is most common in the Lower Mississippian (established from references in the synonymy and discussion). Specimens have been recovered during this present study from samples Pb5674, Pb5675-0.4%, Pb5676, Pb5683, Pb5685-0.4%, and Pb5686-0.4%.

Dictyotriletes cheveriensis (Playford, 1964) Bertelsen, 1972

Plate 5, Fig. 1

1964 Reticulatisporites cheveriensis Playford, p. 30, 31, pl. 9, figs. 1, 2, 3.

1972 Dictyotriletes cheveriensis (Playford, 1964) Bertelsen, p. 46, 47, pl. 14, figs. 1, 2, 3.

Description: Specimens conform to the original description as given in Playford (1964, p. 30, 31).

Discussion: Dictyotriletes cheveriensis is apparently both distal and proximal in ornament (Playford, 1964). This raises the question as to the correct generic assignment with the only other possibility being Corbulispora at this time. It is retained in Dictyotriletes for the present, pending a possible future combination of Dictyotriletes and Corbulispora.

Occurrences and Stratigraphic Range: The species apparently has not been widely recognized. Recorded occurrences are from the Lower Mississippian, Horton Group of Canada (Playford, 1964), from the Lower Carboniferous of Denmark (Bertelsen, 1972) and the present study. From these it is probably restricted to the Lower Mississippian/Tournaisian. Specimens have been recovered during this study

from samples Pb5661-0.4%, Pb5662, Pb5663, Pb5665, Pb5666, Pb5667, Pb5671, Pb5673, Pb5674-1.6%, Pb5675, Pb5676-1.2%, Pb5677, Pb5678, Pb5679, Pb5683, Pb5684-0.8%, Pb5685-0.4%, Pb5686-1.6%, Pb5687, Pb5688, Pb5689, Pb5690, Pb5691, Pb5692, Pb5693, Pb5694-1.2%, and Pb5696.

Dictyotriletes fimbriatus (Winslow, 1962) Kaiser, 1970a

Plate 5, Fig. 2

1962 Reticulatisporites? fimbriatus Winslow, p. 58, 59, pl. 14, figs. 1, 1a, 1b, 2, 2a, 3, 3a, pl. 22, fig. 21.

1970a Dictyotriletes fimbriatus (Winslow, 1962) Kaiser, p. 95, pl. 19, figs. 4, 5, 6.

Description: Specimens conform to the description given in Winslow (1962, p. 58, 59).

Discussion: The inclusion of this species in Dictyotriletes is acceptable on the basis that the equatorial margin is not a true cingulum, but represents an extension of the muri. This feature was not mentioned by Kaiser (1970a) when the transfer to Dictyotriletes was made. However, the illustrations of Kaiser's from the scanning electron microscope indicate the ornament to be both distal and proximal. Thus the problem between Dictyotriletes and Corbulispora arises again.

The specimens referred to Reticulatisporites fimbriatus by McGregor (1970) and Combaz and Streel (1970) should be included in Dictyotriletes.

The presence of intermediate forms between the species and R. fimbriatus var. spathulatus (Winslow, 1962) in the

present study would indicate that only taxon of specific rank need be recognized. The spathulate ornamented from represents an extreme variation of the purely fimbriate form.

Occurrences and Stratigraphic Range: The species is known from the Upper Devonian and Lower Mississippian or Tn-1 (Winslow, 1962; Kaiser, 1970a; Combaz and Streel, 1970; and McGregor, 1970). Specimens have been recovered during the present study from samples Pb5654-0.4%, Pb5656, Pb5658-1.2%, Pb5659-2.0%, Pb5661, Pb5664-0.4%, Pb5667-0.4%, Pb5674, Pb5675, Pb5678, ?Pb5680, Pb5683, Pb5685-0.8%, and Pb5686.

Dictyotriletes submarginatus Playford, 1964

Plate 5, Fig. 4

1964 Dictyotriletes submarginatus Playford, p. 29, 30, pl. 8, figs. 9-13.

?1971 Cristatisporites colliculus Playford, p. 40, 41, pl. 14, figs. 1, 2, pl. 15, figs. 1-6.

1972 Dictyotriletes cf. submarginatus Playford in Bertelsen, p. 48, pl. 13, figs. 5-9, text-fig. 8.

Description: Specimens conform to the original diagnosis of Playford (1964) with one exception. In usage here, some individuals with coarser muri have been included. This was also noted by Bertelsen (1972).

Discussion: A species described by Playford (1971) as Cristatisporites colliculus is questionably included in the synonymy. This species although described slightly differently by Playford appears to be identical to Dictyotriletes submarginatus in illustrations 1 and 2, pl. 14 of Playford (1971). A comparison of type material from the

Horton Group and Playford's Bonaparte Gulf Basin material may result in emendation of D. submarginatus and the inclusion of Cristatisporites colliculus.

Occurrences and Stratigraphic Range: The species ranges from uppermost Devonian (L. Tournaisian) to Upper Mississippian (Visean) and has been recorded in the following studies: Playford, 1964; Varma, 1969; Hibbert and Lacy, 1969; Kaiser, 1970a; Mortimer, Chaloner, and Llewellyn, 1970; and Bertelsen, 1972. Specimens have been recovered during this study from samples Pb5654, Pb5661, Pb5663-0.4%, Pb5667, Pb5670, Pb5671-0.8%, Pb5674, Pb5675, Pb5676, Pb5677, Pb5679-0.8%, Pb5684-0.4%, Pb5687-0.4%, Pb5688, Pb5689-0.4%, Pb5690-0.4%, and Pb5694-0.4%.

Dictyotriletes cf. trivialis (Naumova in litt.) Kedo, 1963

Plate 5, Fig. 3

Description: Spores radial, trilete; amb circular to subcircular; diameter 60-86µm; laesurae straight, simple, often partially indistinct due to ornamentation, extending 3/4 spore radius; ornamentation of low flat-topped muri 4-8µm in width, 2-5µm high, forming a reticulate pattern, lumina somewhat irregular in shape; surface of muri and lumina psilate; exine 3-5µm thick.

Discussion: The specimens found in this study are slightly smaller than those in Combaz and Streel (1970). Kedo (1963) gives only a single measurement of 60µm diameter. The specimens are also somewhat similar to Dictyotriletes sp.

(SL224SM) of Bertelsen (1972) and the flat-topped muri is a feature of Reticulatisporites planus of Hughes and Playford (1961). No synonymy is given at this time due to differences and uncertain nature of the specimens compared. The specimens are referred to D. cf. trivialis (Naumova in litt.) Kedo, 1963 for the present.

Occurrences and Stratigraphic Range: The range of the species is considered to be Upper Devonian to Lower Mississippian (Tn-1a--Tn-2a) as given in Combaz and Streel (1970). Specimens have been recovered during the present study from samples Pb5675-0.4%, Pb5676-0.4%, Pb5679, Pb5683-0.4%, Pb5684-0.4%, Pb5688-0.8%, Pb5689, Pb5690-0.8%, Pb5694, and Pb5695-0.4%.

Dictyotriletes sp.

Plate 5, Fig. 5

Description: Spores radial, trilete; amb circular to subcircular; diameter 32-44μm; laesurae straight, simple, generally indistinct, extending 3/4 spore radius; ornamentation low muri 2-4μm high, 1-3μm wide, forming a fine reticulate pattern, lumina polygonal 3-6μm broad, surface of muri and lumina psilate; exine 1-3μm thick.

Discussion: The recovered specimens identified as Dictyotriletes sp. are considerably smaller than any named specimens of similar age. At present they are regarded as new.

Occurrences and Stratigraphic Range: Specimens have been recovered from samples Pb5671, Pb5675, Pb5676-0.4%, Pb5679, and Pb5683-0.4%.

Genus Emphanisporites McGregor, 1961

Type species: Emphanisporites rotatus (McGregor, 1961, p. 3, pl. 1, figs. 1, 2, 3, 4) emend. McGregor 1973, p. 46, 47, pl. 6, figs. 9-13.

Emphanisporites annulatus McGregor, 1961

Plate 5, Fig. 6

For a detailed synonymy see McGregor (1973, p. 45).

Description: Specimens conform to the descriptions of McGregor (1961 and 1973).

Discussion: Specimens in the present study have sporadic occurrence. The presence of Emphanisporites annulatus may be the result of reworking because the species is commonly found in the Middle Devonian (D. C. McGregor, personal communication).

Occurrences and Stratigraphic Range: The genus is known from the Upper Silurian (Richardson and Ioannides, 1973) to Lower Mississippian (Winslow, 1962). Specimens have been recovered in the present study from samples Pb5666, Pb5673, and Pb5687.

Emphanisporites rotatus (McGregor, 1961) emend. McGregor, 1973

Plate 5, Figs. 7, 8

For a detailed synonymy see McGregor (1973, p. 46, 47).

Description: Specimens conform to the descriptions given by McGregor (1961 and 1973).

Discussion: The recent emendation of Emphanisporites rotatus to include E. robustus by McGregor (1973) agrees with gradations observed in the present study. Spore assigned to E. rotatus were originally split into two groups to include E. robustus, but many gradational forms were encountered and the division could not be maintained. The individual occurrences indicated on the range charts as E. robustus (e.g. pl. 5, fig. 8) should be included under E. rotatus.

Occurrences and Stratigraphic Range: The species is known from the Upper Silurian (Richardson and Ioannides, 1973) to Lower Mississippian (Winslow, 1962 and Brown, 1968). These occurrences in the Lower Mississippian recorded by Winslow, as well as from the present study, are the only known occurrences in rocks younger than Devonian age.

Specimens were recovered during the present study from samples Pb5651-0.4%, Pb5654, Pb5659, Pb5660, Pb5661, Pb5662-0.4%, Pb5663, Pb5664-0.4%, Pb5665, Pb5666, Pb5667, Pb5668, Pb5670-0.4%, Pb5671-0.8%, Pb5672, Pb5674, Pb5675-0.8%, Pb5676, Pb5679, Pb5680-0.8%, Pb5681, Pb5683-0.4%, Pb5684-0.4%, Pb5685-0.4%, Pb5686-0.4%, Pb5687, Pb5688, Pb5689-0.4%, Pb5690-0.4%, Pb5694-0.4%, Pb5696, and Pb5697.

Genus Endosporites Wilson and Coe, 1940

Type species: Endosporites ornatus Wilson and Coe, 1940, p. 184, fig. 2.

Although the genus stands unemended at the present time

there appears to be considerable debate regarding interpretation of some species assignable to the genus. This controversey is based on the interpretation of the presence or absence of an equatorial limbus. This feature not included in the original diagnosis has been interpreted as important by several authors (Potonie and Kremp, 1954; Bharadwaj, 1957; Chaloner, 1953 and 1958). The saccate genera Auroraspora and Discernisporites are separated from Endosporites primarily on the absence of a limbus by Richardson (1960) and Neves and Owens (1966), respectively. This discussion has been pointed out by several workers (e.g. Playford, 1963; Smith and Butterworth, 1967; von Almen, 1970a; and Brown, 1968). Because Auroraspora and Discernisporites exclude limbate forms the problem centers on those species that are variably limbate. The recent extension of the generic diagnosis for Endosporites as given in Smith and Butterworth (1967, p. 270) is followed at this time. Only a restudy of type materials from the three genera may allow a future interpretation, which for the present seems to rely on subjective personal preferences.

Endosporites micromanifestus Hacquebard, 1957

Plate 6, Fig. 1

1948 Type 43K, Knox, p. 6, fig. 51.

1950 Endosporites sp. A, Schemel, p. 240. pl. 40, fig. 4.

1955b Spore type A, Hoffmeister, Staplin, and Malloy, p. 397, pl. 37, fig. 9.

1956 Hymenozonotriletes aff. variabilis Naumova in Ishchenko, p. 62, pl. 11, figs. 129, 130.

1957 Endosporites micromanifestus Hacquebard, p. 317, pl. 3, fig. 16.

1958 Discernisporites concentricus Neves, p. 5, pl. 3, fig. 7.

1960 Endosporites sp. A. Staplin, p. 33, pl. 7, fig. 17.

1960 Auroraspora micromanifestus (Hacquebard, 1957) Richardson, p. 51.

1961 Endosporites micromanifestus Hacquebard in Hughes and Playford. p. 44, pl. 4, fig. 8.

1965 Auroraspora micromanifestus (Hacquebard, 1957) Richardson, 1960 in Richardson, p. 586, pl. 93, fig. 1.

1970a, b Discernisporites concentricus Neves in von Almen, p. 65, pl. 10, figs. 1-3, and pl. 29, fig. 13.

1971 Discernisporites micromanifestus (Hacquebard, 1957) Sabry and Neves, p. 1445, pl. 3, fig. 11.

1971 Endosporites micromanifestus Hacquebard in Playford, p. 52, pl. 17, fig. 17.

1972 Discernisporites cf. micromanifestus (Hacquebard, 1957) Neves and Belt 1970 in Bertelsen, p. 60, pl. 22, fig. 6.

1973 Discernisporites micromanifestus (Hacquebard, 1957) Sabry and Neves in Spinner and Clayton, p. 162.

Description: Specimens conform to the descriptions of Hacquebard (1957) and Playford (1963). The specimens noted here are variably limbate.

Discussion: The species has been frequently recorded by many workers and, as seen by the synonymy and discussion following the genus, the taxonomic position is in a state of flux. The taxonomic position will depend on future emendations of the genus and an agreeable solution to the importance of the limbus both for the appropriate species and the genus. Because of the uncertainties the original assignment of the species seems to create the least confusion.

Occurrences and Stratigraphic Range: The genus ranges from Devonian to Permian (Hoffmeister, Staplin, and Malloy, 1955a). The species ranges from Middle Devonian to Lower Pennsylvanian based on the following occurrences; Ishchenko, 1956, Hacquebard, 1957; Love, 1960; Richardson, 1960 and 1965; Hughes and Playford, 1961; Playford, 1963, 1964, and 1971; Doubinger and Rauscher, 1966; Sullivan and Marshall, 1966; Felix and Burbridge, 1967; Butterworth and Spinner, 1967; Barss, 1967; Brown, 1968, Evans, 1968; Sullivan, 1968; Hibbert and Lacy, 1969; Varma, 1969; Neves, 1958; Neves and Belt, 1970; Sabry and Neves, 1971; Utting and Neves, 1970; von Almen, 1970a and 1970b; Clayton, 1971; Johnson and Marshall, 1971; Bertelsen, 1972· and Spinner and Clayton, 1973.

Specimens have been recovered during the present study from samples Pb5654, Pb5665, Pb5667, Pb5668, Pb5670, Pb5671, Pb5674, Pb5675, Pb5676-0.4%, Pb5683, Pb5685, Pb5688, Pb5690, Pb5694-0.4% Pb5695, and Pb5697.

Endosporites minutus Hoffmeister, Staplin, and Malloy, 1955b

Plate 6, Fig. 2

1955b Endosporites minutus Hoffmeister, Staplin, and Malloy, p. 387, 388, pl. 37, fig. 6.

Description: Specimens conform to the original diagnosis of Hoffmeister, Staplin, and Malloy (1955b) with two exceptions. The diameter of specimens encountered in the present study is 36 to 46μm overall and a limbus is present

at the equator. Although not mentioned in the text, their illustrations show a weak limbus.

Discussion: Specimens of Endosporites minutus have not been widely reported. However, Bouckaert, et al. (1969, p. 732) and Combaz and Streel (1970, p. 234) have referred to some slightly larger specimens as "Endosporites gr. minutus". Although these spores were not specifically identified they are believed to be representatives of the E. minutus complex. Staplin (1960) has also used the reference for larger specimens to the E. pallidus-E. minutus group of spores. These group assignments would indicate that these other spores are morphologically similar but may differ only by being larger in dimensions.

Occurrences and Stratigraphic Range: The species has been recorded by Hoffmeister, Staplin, and Malloy, 1955b; Sullivan, 1964b; and Barss, 1967. On the basis of these occurrences and the present study, the species ranges from Lower Mississippian to Lower Pennsylvanian. Specimens have been recovered during the present study from samples Pb5661, Pb5663, and Pb5670.

Endosporites sp.

Plate 6, Figs. 3, 4

Description: Spores radial, trilete; amb rounded-triangular; diameter 48 to 60µm overall; central body 38-51µm; intexine ca. one µm; exoexine ca. one µm, generally folded at juncture of central body and flange; surface of central body and exoexine scabrate; laesurae slightly sinuous,

accompanied by exoexinal folds which rarely extend to equator, but always extend at least to the edge of the central body; equatorial margin variably limbate.

Discussion: Endosporites sp. differs from described species of the genus by the presence of arcuate folds at the juncture of the central body. The folds adjacent to the sutures that rarely extend to the equator also appear to be distinctive. These specimens probably represent a new species of Endosporites. The limbate feature, which is quite common, would indicate assignment to Endosporites.

Occurrences and Stratigraphic Range: At present the species is known from the Lower Mississippian. Specimens are present in samples Pb5672, Pb5675, Pb5676, Pb5679, Pb5680-0.4%, Pb5681, Pb5684, Pb5687-1.2%, Pb5688, Pb5690-1.2%, Pb5691 and Pb5694.

Genus "Filiformispora" gen. nov.

"Filiformispora filiformis" gen. et sp. nov.

Plate 6, Figs. 10, 11

1968 Filiformispora filiformis Eames (mms. name), p. 52, 53. fig. 1.

Description: Spores radial, trilete, saccate; amb subcircular to broadly rounded-triangular; diameter 80-138μm overall, central body 45-63μm; intexine 1-2μm; exoexine 1-2μm, often folded or torn; surface of central body and exoexine psilate-scabrate; exoexine ornamented with filamentous threads, primarily distal, slightly bulbous at base 4-5μm wide, generally 1-2μm wide away from attachment point;

thread quite variable in length to 200μm for longest measured thread, short threads are probably broken; laesurae, straight to sinuous, extending entire central body radius, accompanied by raised folds often extending to equator.

Discussion: Specimens of "Filiformispora filiformis" are distinct from any known spores. Even poorly preserved and broken specimens are readily recognizable. The specimen illustrated in Plate 6, Fig. 11 is from sample BDF-3 of Eames (1968) and was illustrated because of the excellent orientation and preservation.

Occurrences and Stratigraphic Range: It is believed that specimens of "Filiformispora filiformis" may be of stratigraphic value for the uppermost Devonian although their occurrences are rare. Specimens have been recovered during the present study from samples Pb5654, Pb5658, and Pb5659.

Genus Geminospora (Balme, 1960b) emend. Owens, 1971

Type species: Geminospora lemurata Balme, 1960b, p. 5, pl. 1, figs. 5-10.

Geminospora sp. A.

Plate 6, Figs. 5, 6

Description: Spores radial, trilete camerate; amb rounded-triangular; diameter 35-50μm overall, central portion 28-38μm; laesurae, straight to slightly sinuous, extending entire radius of central portion, slight lip development; intexine thin ca. one μm, exoexine 1-3μm thick and generally folded; ornamentation of minute cones and

grana, primarily distal. Figure 6 represents a single questionable specimen with a dense/thicker exoexine.

Discussion: The specimens recovered in this study are similar in morphology but smaller than Geminospora lemurata of Balme (1960b) and Geminospora antaxios (Chibrikova, 1962) Owens in Owens (1971). The present specimens almost always contain folds in the exoexine. The species of Balme (1960b) and Owens (1971) are from lower Upper Devonian and Middle Devonian respectively.

Occurrences and Stratigraphic Range: The genus is restricted to the Devonian and most commonly ranges from Lower Devonian (McGregor, 1973) to Upper Devonian (Frasnian) (Balme, 1960b). It has not been reported before in Famennien-Upper Devonian sediments. Specimens recovered during the present study are from samples Pb5651-0.4%, Pb5652-0.8%, Pb5653-0.8%, Pb5654-1.6%, Pb5655-0.8%, Pb5656, Pb5657-0.4%, Pb5658, Pb5659-0.8%, and a single questionable specimen from Pb5681.

Genus Grandispora (Hoffmeister, Staplin, and Malloy, 1955b) emend. McGregor, 1973

Type species: Grandispora spinosa Hoffmeister, Staplin, and Malloy, 1955b, p. 388, 389, pl. 39, figs. 10, 14.

A thorough discussion of the genus is provided by Playford (1971, p. 45-47). The main exception taken with Playford's discussion is the assignment of Spinozonotriletes to Grandispora. At present the genus Spinozonotriletes is not seen as being clearly pseudosaccate and is retained. This is further

discussed in McGregor (1973, p. 58, 59). Additional comments will follow in the discussion of Spinozonotriletes.

Grandispora echinata Hacquebard, 1957

Plate 7, Fig. 1

1957 Grandispora echinata Hacquebard, p. 317, pl. 3, fig. 17.

Description: Specimens conform to the original diagnosis of Hacquebard (1957) and subsequent remarks of Playford (1964). The only difference noted in this study was that some smaller forms are present which extend the overall size range to 50-93μm as compared to 62-93μm as given by Hacquebard (1957).

Discussion: Grandispora echinata is generally distinct in comparison with other species of the genus. However, Playford (1971) compares it with a new species of his G. debilis, which in the authors opinion is not similar.

Occurrences and Stratigraphic Range: The genus ranges from Middle Devonian (Richardson, 1960) to Lower Pennsylvanian (Felix and Burbridge, 1967). The species ranges from Upper Devonian to Lower Pennsylvanian and is most common in the Lower Mississippian based on the following reported occurrences: Hacquebard, 1957; Playford, 1964; Neves and Owens, 1966; Sullivan and Marshall, 1966; Barss, 1967; Felix and Burbridge, 1967; Neville, 1968; Sullivan, 1968; Llewellyn, Backhouse, and Hoskin, 1969; Varma, 1969; Dolby, 1970; Kaiser, 1970a; Llewellyn, Hoskin, and Backhouse, 1970; McGregor, 1970; Marshall and Williams, 1970; Paproth and

Streel, 1970; Streel, 1970; Utting and Neves, 1970: Johnson and Marshall, 1971; Bertelsen, 1972; Sandberg, Streel, and Scott, 1972; and Spinner and Clayton, 1973.

Specimens have been recovered during the present study from samples Pb5651-0.8%, Pb5654, Pb5658-0.4%, Pb5659, Pb5661-0.4%, Pb5662-0.8%, Pb5663-0.8%, Pb5664, Pb5665, Pb5667, Pb5668-0.4%, Pb5669, Pb5671-0.4%, Pb5674, Pb5675-0.4%, Pb5676-0.4%, Pb5677, Pb5679-0.8%, Pb5680, Pb5681, Pb5683, Pb5684-0.8%, Pb5685, Pb5686-0.4%, Pb5687, Pb5688, Pb5689, Pb5690-0.4%, and Pb5691.

Genus Granulatisporites (Ibrahim, 1933) emend. Potonie and Kremp, 1954

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

Granulatisporites crenulatus Playford, 1964

Plate 6, Figs. 7, 8

1964 Granulatisporites crenulatus Playford, p. 11, pl. 2, figs. 8-10.

1968 Granulatisporites bedfordii Eames (mms. name) p. 54, fig. 35.

1971 Discernisporites crenulatus (Playford, 1964) emend. Clayton, p. 583, 584, pl. 2, figs. 2-4.

1972 Granulatisporites sp. Bertelsen, p. 29, pl. 3, figs. 5, 6.

Description: Specimens conform to the original diagnosis of Playford (1964) with the only exception being some individuals which have a smaller overall diameter 24-44μm (36-54μm; Playford, 1964).

Discussion: The recent transfer and emendation by Clayton

(1971) is not followed at this time. It is the opinion of the writer that the camerate feature should be used only for spores that are clearly two-layered rather than forms like Granulatisporites crenulatus, which are not thought to be clearly two-layered. The specimens of Eames (1968) as Granulatisporites bedfordii (mms. name) are considered to belong to G. crenulatus. The specimens recorded as Granulatisporites sp. in Bertelsen (1972) appear to be forms of G. crenulatus.

Occurrences and Stratigraphic Range: The generic range is from Lower Devonian (Allen, 1967) to Lower Permian (Hoffmeister, Staplin, and Malloy, 1955a). The species is known from the Tournaisian (uppermost Devonian to Lower Mississippian) from the following occurrences: Playford, 1964; Barss, 1967; Brown, 1968; Varma, 1969; Clayton, 1971; and Bertelsen, 1972.

Specimens have been recovered commonly during the present study from samples Pb5651-0.4%, Pb5652-0.4%, Pb5660, Pb5661-2.8% Pb5662-0.8%, Pb5663-1.6%, Pb5664-3.6%, Pb5665-5.6%, Pb5666, Pb5667-3.2%, Pb5668-6.0%, Pb5669-1.6%, Pb5670-5.6%, Pb5671-8.4% Pb5672, Pb5673, Pb5674-6.0%, Pb5675-5.6%, Pb5676-4.4% Pb5677, Pb5678, Pb5679-6.0%, Pb5680-9.2%, Pb5681, Pb5682, Pb5683-6.0%, Pb5684-7.2%, Pb5685-7.6%, Pb5686-6.4%, Pb5687-3.6%, Pb5688-3.6%, Pb5689-2.4%, Pb5690, Pb5691, Pb5694-0.4%, and Pb5697.

Granulatisporites frustulentus (Balme and Hassell, 1962) emend. Playford, 1971

Plate 6, Fig. 9

A detailed synonymy is provided in Playford (1971, p. 13).

Description: Specimens conform to the original diagnosis of Balme and Hassell (1962) and subsequent emendation and description of Playford (1971).

Discussion: The specimens identified here as Granulatisporites frustulentus are the only known records outside Australia. A comprehensive discussion of the taxon is given in Playford (1971, p. 13, 14).

Occurrences and Stratigraphic Range: The species is known to range from Upper Devonian to Upper Carboniferous from the following occurrences: Balme, 1960a and 1964; Balme and Hassell, 1962; de Jersey, 1966; and Playford, 1971).

Specimens have been recovered during the present study from samples Pb5656, Pb5660, Pb5662-0.4%, Pb5663, and ?Pb5681.

Genus Hymenozonotriletes (Naumova, 1937?, 1939) Potonie, 1958

Type species: Hymenozonotriletes polyacanthus Naumova, 1953, p. 41, pl. 4, figs. 11, 12; designated by Potonie, 1958, p. 29.

The genus Hymenozonotriletes is poorly circumscribed. This has resulted in an extremely large number of spores being assigned to the genus, many of which may better be included in other zonate genera. Only the examination of the genotype and holotypes of the many species involved would resolve this taxonomic problem. This would be an extensive

project in itself. Because only three species in this study have been assigned to this problematic generic category, additional resolution at this time would be premature. The three species discussed here are retained in Hymenozonotriletes to which they have generally been assigned.

Hymenozonotriletes explanatus (Luber, 1941 in Luber and Waltz) Kedo, 1963

Plate 7, Fig. 2

1941 Zonotriletes explanatus Luber in Luber and Waltz, vyp. 139, pl. 1, fig. 4.

1963 Hymenozonotriletes explanatus (Luber, 1941) Kedo, 1963, p. 67, pl. 6, figs. 144-147.

1967 Samarisporites Streel, p. 71, pl. 1, fig. 1.

1968 Spinozonotriletes globosus Eames (mms. name) p. 79, 80, fig. 61.

1969 Hymenozonotriletes explanatus (Luber, 1941) Kedo, 1963, in Bouckaert, et al., p. 733.

Description: Spores radial, trilete, zonate; amb sub-circular to rounded-triangular; diameter 50-84µm overall, central body 40-60µm diameter; laesurae distinct, slightly raised, often sinuous, extending entire radius of central body; exoexine thin less than two µm, intexine 1-3µm thick, exoexine often folded and distorted at equatorial margin; ornamentation, primarily distal, consisting of cones and short spines, often blunted, sharp tipped, and biform: maximum spine length 10µm, generally 4-8µm in length; basal diameter of spines 3-8µm; a dense zona often appears at the juncture of the central body and flange.

Discussion: This species has been noted by several workers, but it has generally not been figured or described. Kaiser (1970a, p. 110, 111) has given a brief description and, as is evident from his illustration, the specimens were poorly preserved. The two invalid species described by Eames (1968) were assigned to Spinozonotriletes. It is possible that subsequent comparison may allow transfer of this taxon to Spinozonotriletes from Hymenozonotriletes. Playford (1971, p. 45, 46) has suggested that Spinozonotriletes is synonymous with Grandispora. He did not attempt to resolve the problem of their relation to Hymenozonotriletes in that discussion. Future assignment of H. explanatus may be with Grandispora or Spinozonotriletes.

Occurrences and Stratigraphic Range: The stratigraphic range of the genus is of no great significance, but occurrences are known from various references from Devonian-Permian. The species is known from Upper Devonian and Lower Mississippian (Tournaisian) from the following records: (Luber and Waltz, 1941; Kedo, 1963; Streel, 1967, 1969, and 1970; Bouckaert, Streel, Thorez, and Mound, 1969; Kaiser, 1970a; Paproth and Streel, 1970; Eames, 1968; and McGregor, 1970.

Specimens have been recovered during the present study from samples Pb5652, Pb5654, Pb5655-0.4%. Pb5656, Pb5657-0.4%, Pb5659-0.8%, Pb5660 and Pb5674.

Hymenozonotriletes famenensis Kedo, 1963

Plate 7, Figs. 4, 5

?1960 Costaspora radiosa Staplin and Jansonius in Staplin, p. 17, pl. 3, figs. 27, 28.

1963 Hymenozonotriletes famenensis Kedo, p. 59, pl. 5, fig. 109.

1966 Unidentified, McGregor and Owens, p. 62, 63, pl. 28, figs. 17, 18, 21.

1968 Converrucosisporites planus Eames (mms. name) p. 35, fig. 16.

1968 Costaspora obscura Eames (mms. name) p. 37, 38, fig. 17.

1968 Neoconvolutispora sinuosa Eames (mms. name) p. 66, 67, fig. 2.

1968 Neoconvolutispora ambigua Eames (mms. name) p. 67, 68, fig. 3.

1971 Fossulatisporites triangularis Bharadwaj, Tiwari, and Venkatachala, p. 31, pl. 1, figs. 17-21, text-fig. 1.

1973 Hymenozonotriletes famenensis Kedo in Warg and Traverse, p. 40, pl. 1, fig. 4.

Description: Spores radial, trilete, weakly zonate; amb sub-circular to rounded-triangular; diameter 48-68µm overall, central body 40-60µm in diameter; laesurae generally distinct, straight, occasionally folded, extending entire radius of central body; exoexine and intexine both thin generally less than two µm thick; folds uncommon; ornamentation, distal, low, convoluted, anastomosing ridges; sinuous in appearance with interrupted ridges forming a beaded effect; ridges radially disposed, extending to equatorial margin; zona tapered, comprising 1/7 or less of spore radius.

Discussion: Although the species has been figured and recorded by several authors, no adequate

descriptions have appeared to date. The description and text-figure of Bharadwaj. Tiwari. and Venkatachala (1971) of Fossulatisporites triangularis does not mention or show the zonate character (admittedly very weak in the present specimens). Their plates show specimens identical with those of Eames (1968) from the Cleveland Shale and of McGregor and Owens (1966) from the Kettle Point Shale (included in synonymy). The pitting they mention is typical in specimens from lithologies such as the Cleveland, Kettle Point, and New Albany and may represent pyritic invasion or bacterial corrosion.

A questionable inclusion in the synonymy is Costaspora radiosa Staplin and Jansonius in Staplin (1960). This form is included because Retispora florida Staplin. 1960 is a part of the same assemblage and is considered synonymous with Hymenozonotriletes lepidophytus. Streel (personal communication) believes Staplin's specimens of Retispora represent reworked material. Therefore because Hymenozonotriletes famenensis and H. lepidophytus occur commonly together Costaspora radiosa may also be reworked.

Occurrences and Stratigraphic Range: The species has been recorded from the Upper Devonian (Famennian) and Lower Tournaisian (pre--Tn-2). which is all considered Upper Devonian. The records are from the following occurrences: (Kedo, 1963; McGregor and Owens, 1966; Neves and Dolby, 1967; Eames. 1968· Combaz and Streel 1970; Dolby, 1970; McGregor,

1970; Owens and Streel, 1970; Paproth and Streel, 1970; Streel, 1970; Utting and Neves, 1970; Bharadwaj, Tiwari, and Venkatachala, 1971; Sandberg, Streel, and Scott, 1972; and Warg and Traverse, 1973).

Specimens have been recovered during the present study from samples Pb5651-0.8%, Pb5652-0.4%, Pb5653-2.0%, Pb5654-10.4%, Pb5655-2.4%, Pb5656-1.6%, Pb5657-3.2%, Pb5658-2.0%, Pb5659-1.2%, Pb5660-1.2%, and Pb5683 single specimen possibly reworked.

Hymenozonotriletes lepidophytus Kedo, 1957

Plate 7, Figs. 3, 6, 7, 8

1957 Hymenozonotriletes lepidophytus Kedo, p. 24, pl. 2, figs. 19-21.

1960 Retispora florida Staplin, p. 32, pl. 7, figs. 1, 13.

1962 Leiozonotriletes naumovae Balme and Hassell, p. 18, 20, pl. 4, figs. 10-12, text-fig. 4.

1962 Endosporites lacunosus Winslow, p. 44, 45, pl. 16, figs. 1-5, text-fig. 4.

1967 Hymenozonotriletes lepidophytus Kedo in Owens and Streel, p. 141-149, pl. 1, figs. A-G.

Description: Specimens conform to the descriptions provided by Streel (1966) and Owens and Streel (1967). Because this taxon has had such wide attention there are many other descriptions from the synonymies and occurrences that also apply.

Discussion: Hymenozonotriletes lepidophytus has received wide attention both in stratigraphic value and its widespread geographical distribution. There is little

point in pursuing a discussion here, because of the extensive coverage in Streel (1966), Owens and Streel (1967), and Sandberg, Streel and Scott (1972). Additional discussions may be reached through the bibliographies of those papers.

Occurrences and Stratigraphic Range: The occurrences are numerous with most being included in Streel (1970). The occurrences reported since Streel (1970) or not included there, are Brown (1968), Eames (1968), Sandberg, Streel, and Scott (1972), Kimyai (1972), and Warg and Traverse (1973). The species has a stratigraphic range of Upper Famennian-Lower Tournaisian (Strunian-Uppermost Devonian) or Fa-2c--Tn-1b.

Specimens have been recovered during the present study from samples Pb5651-65.6%, Pb5652-69.6%, Pb5653-65.6%, Pb5654-65.6%, Pb5655-82.0%, Pb5656-91.2%, Pb5657-85.2%, Pb5658-72.0%, Pb5659-74.0%, Pb5660-4.8%, Pb5661-0.4%, Pb5662-0.4%, Pb5663-0.4%, Pb5664-0.4%, Pb5665-0.4%, Pb5667-0.8%, Pb5668, Pb5671-1.2%, Pb5672, Pb5673, Pb5674-0.4%, Pb5675-0.4%, Pb5676-0.8%, Pb5677, Pb5678, Pb5679-0.8%, Pb5680-1.6%, Pb5681, Pb5682, Pb5683-0.8%, Pb5684-2.4%, Pb5685-0.4%, Pb5686-0.8%, and Pb5687.

Genus Hystricosporites McGregor, 1960

Type species: H. delectabilis McGregor, 1960, p. 32, pl. 11, figs. 13, 14, text-fig. 1.

Hystricosporites delectabilis McGregor, 1960

Plate 8, Figs. 1, 2, 4

1960 Hystricosporites delectabilis McGregor, p. 32, pl. 11, figs. 13, 14, text-fig. 1.

1962 Dicrospora porcata Winslow, p. 52, 53, pl. 11, figs. 4, 5, 5a, pl. 12, fig. 5, pl. 22, fig. 15.

1964 Hystricosporites costatus Vigran, p. 14, 15, pl. 5, figs. 3-5.

1965 Hystricosporites porcatus (Winslow, 1962) Allen, p. 699, pl. 95, figs. 4-6.

1970 Hystricosporites sp. A. Brideaux and Radforth, p. 38, 39, pl. 4, fig. 31.

Description: Specimens conform to the descriptions of McGregor (1960) and Winslow (1962).

Discussion: Allen (1965) has suggested that Hystricosporites delectabilis of McGregor (1960) has proximal radial muri. This feature is not always strong and is often difficult to discern. The present opinion is that McGregor's species is the same as Dicrospora porcata Winslow, 1962, thus McGregor's species having priority would make a D. porcata a junior synonym.

Occurrences and Stratigraphic Range: The genus is restricted to Devonian rocks, with a range of upper Lower Devonian to uppermost Devonian (Mortimer and Chaloner, 1967). The species range is also upper Lower Devonian to uppermost Devonian based on the following occurrences: McGregor, 1960; Winslow, 1962; Vigran, 1964; Allen, 1965; and Brideaux and Radforth, 1970. Because the occurrence of the genus is considered stratigraphically important this species and H. cf. obscuras are plotted as Hystricosporites spp. on the range charts.

Specimens of the genus were recovered during this study from samples Pb5651-0.4%, Pb5652-0.4%, Pb5653-0.4%, Pb5654, Pb5655, Pb5656, Pb5657, Pb5658-0.4%, Pb5659-4.8%, Pb5660-0.4%, and Pb5673 single abraded specimen, probably reworked.

Hystricosporites cf. *obscurus* Mortimer and Chaloner, 1967

Plate 8, Fig. 3

1967 *Hystricosporites obscurus* Mortimer and Chaloner, p. 196, 197, pl. 27, figs. 1-5.

Description: Spores radial, trilete; amb rounded-triangular; diameter 90µm without spines; exine ca. 8µm thick; ornamentation of prominent anchor-tipped spines; longest spine to 85µm, basal width to 10µm, tips of spines with single bifurcation; surface of spines and exine, psilate; laesurae obscured, probably straight and raised.

Discussion: A single specimen here referred to *Hystricosporites* cf. *obscurus*, was observed. Although the specimen is considerably smaller than those described by Mortimer and Chaloner (1967) it appears morphologically very similar to their specimen figured in pl. 27, fig. 1.

Occurrences and Stratigraphic Range: The species is known from lower Upper Devonian (Mortimer and Chaloner, 1967). Combaz and Streel (1970) have reported specimens identified as *Hystricosporites* cf. *obscurus* which are smaller than those reported by Mortimer and Chaloner (1967), but larger than the specimen recovered here. Combaz and Streel (1970) give a range of Fa-1a--Tn-1 or Famennian-Lowermost

Tournaisian. The single specimen recorded in the present study was from the Berea Sandstone in sample Pb5654 and is plotted for the genus on the range charts.

Genus Knoxisporites (Potonie and Kremp, 1954) emend. Neves and Playford, 1961

Type species: Knoxisporites hageni Potonie and Kremp, 1954, p. 147, 148, pl. 20, fig. 105.

Knoxisporites literatus (Waltz, 1938) Playford, 1963

Plate 9, Figs. 1, 2

For a detailed synonymy see Playford (1971, p. 34). The following taxa are included for the purpose of bringing that list of synonyms to a greater percent of completeness.

1962 Knoxisporites sp. Balme and Hassell, p. 12, pl. 3, figs. 12, 13.

1962 Canthospora cracens Winslow, p. 69, 70, pl. 15, figs. 2, 3, text-figs. 9a, 9b.

1968 non Knoxisporites triradiatus Hoffmeister, Staplin, and Malloy, 1955b, in Eames, p. 59, fig. 83.

Description: Specimens conform to the description given by Playford (1963) except for size range. Winslow (1962) described Canthospora cracens, now considered a synonym of Knoxisporites literatus, her description expanded the size range for the species, but otherwise conforms to that of Playford.

Discussion: Although Canthospora cracens Winslow, 1962 incorporated specimens considerably larger (80-170μm) than commonly given for Knoxisporites literatus (56-102μm) the larger forms are quite rare and are not separable from

the normal sized K. literatus specimens. The largest specimens observed in this study were 150μm in diameter.

Occurrences and Stratigraphic Range: The genus ranges from Upper Devonian (Balme and Hassell, 1962) to Middle Pennsylvanian (Hoffmeister, Staplin, and Malloy, 1955a). The species ranges from Upper Devonian to Namurian (Playford, 1963) and is most common in the Tournaisian (Tn-1--Tn-2a) Combaz and Streel (1970). In addition to the occurrences mentioned in the synonomy and discussion of Playford (1971) and those mentioned above, the species has been recorded by Butterworth and Spinner, 1967; Hibbert and Lacy, 1969; Llewellyn, Backhouse, and Hoskin, 1969; Dolby, 1970; McGregor, 1970; Llewellyn, Hoskin, and Backhouse, 1970; Paproth and Streel, 1970; Utting and Neves, 1970; Clayton, 1971; Kalibova, 1971; and Bertelsen, 1972.

Specimens have been recovered during the present study from samples Pb5652-0.4%, Pb5653-0.4%, Pb5654, Pb5655, Pb5656, Pb5658, Pb5659-0.8%, Pb5660, Pb5661, Pb5662, Pb5663-0.4%, Pb5664, Pb5665, Pb5667, Pb5668-0.4%, Pb5671, Pb5674-0.4%, Pb5675, Pb5676-0.8%, Pb5678, Pb5679-0.4%, Pb5682, Pb5683-0.4%, Pb5684, Pb5685-0.4%, Pb5686, Pb5687, Pb5688, Pb5689-0.4%, Pb5690-1.2%, Pb5691, Pb5694-0.4%, Pb5695-0.8%, and Pb5696.

Genus Laevigatosporites Ibrahim, 1933

Type species: Laevigatosporites vulgaris Ibrahim, 1933, p. 39, 40, pl. 2, fig. 16, pl. 5, figs. 37-39.

Laevigatosporites sp.

Plate 8, Fig. 5

Description: Spores bilateral, monolete; longitudinal amb oval to reniform; dimensions 40-65μm in length, 20-33μm in width; laesurae distinct, straight, occasionally slightly raised; exine, 2-3μm thick; surface psilate.

Discussion: The specimens most closely resemble Laevigatosporites ovalis of Kosanke (1950). The specific assignment of the present species is withheld at this time because L. ovalis is widely known only from Pennsylvanian age sediments. An examination of type materials containing L. ovalis is needed for confirmation.

The present species is believed to be the same as those assigned to L. ovalis by Eames (1968) and as Laevigatosporites sp. by Winslow (1962, figs. 1, 9, 10). The present specimens as well as those of Eames (1968), Winslow (1962), and McGregor (1970) are thought to be the oldest occurrences of psilate, reniform, monolete spores.

Occurrences and Stratigraphic Range: The genus is known from Upper Devonian-Upper Permian based on the occurrences here and in the discussion as well as the range given by Hoffmeister, Staplin, and Malloy (1955a). Specimens were recovered during the present study from samples Pb5654, Pb5657, Pb5675, Pb5685, and Pb5690.

Genus Leiotriletes (Naumova, 1937) emend. Potonie and Kremp, 1954

Type species: Leiotriletes sphaerotriangulus (Loose, 1932) Potonie and Kremp, 1954, p. 120.

Leiotriletes inermis (Waltz, 1938) Ishchenko, 1952

Plate 8, Fig. 6

1938 Azonotriletes inermis Waltz in Luber and Waltz, p. 11, pl. 1, fig. 3, pl. 5, fig. 58, pl. A, fig. 2.

1952 Leiotriletes inermis (Waltz, 1938) Ishchenko, p. 9, pl. 1, figs. 2, 3.

1955 Asterocalamotriletes inermis (Waltz, 1938) Luber, p. 40, pl. 1, figs. 20, 21.

1955 Leiotriletes inermis (Waltz, 1938) Potonie and Kremp, p. 37.

Description: Specimens conform to the description in Playford (1962). The present specimens are almost entirely convex sided rather than straight.

Discussion: Spores of Leiotriletes are quite long-ranging stratigraphically and species are separated primarily by overall dimensions and laesurae character. There are undoubtedly many similar forms with the present assignment of specimens to L. inermis, based on conforming descriptions and similar stratigraphic occurrences.

Occurrences and Stratigraphic Range: The genus ranges from Lower Devonian (McGregor, 1973, al. Deltoidospora) to Upper Permian (Hoffmeister, Staplin, and Malloy, 1955a). With the inclusion of Deltoidospora and Cyathidites as similar morphologic genera the morphotype would range well into the Tertiary. The species is known from the references in the synonomy and (Playford, 1962; Smith and Butterworth, 1967; and Brown, 1968). From these the species ranges from Upper Devonian to Upper Mississippian.

Specimens have been recovered during the present study from samples Pb5651-1.2%, Pb5652-0.4%, Pb5653-1.2%, Pb5654-0.8%, Pb5660, Pb5661, Pb5663, Pb5667, Pb5668, Pb5670, Pb5671, Pb5673, Pb5674, Pb5687, Pb5688, Pb5689, Pb5690-0.8%, Pb5691, Pb5694, and Pb5698-0.4%.

Leiotriletes ornatus Ishchenko, 1956

Plate 8, Figs. 7, 8

1956 *Leiotriletes ornatus* Ishchenko, p. 22, pl. 2, figs. 18-21.

1960 Spore type 1, Love, p. 122, pl. 2, fig. 9, text-fig. 12.

1962 *Leiotriletes ornatus* Ishchenko, 1956 *in* Playford, p. 575, pl. 78, figs. 7, 8.

Description: Specimens conform to the description in Playford (1962) with the single exception that some specimens are of smaller diameter ca. 27μm (pl. 8, fig. 8).

Discussion: Similar problems of speciation apply to *Leiotriletes ornatus* as discussed previously in *L. inermis*. *L. tumidus* is similar to *L. ornatus*, but possesses folds rather than lipped laesurae.

Occurrences and Stratigraphic Range: The species is known from strata studied by Playford, 1962; Love, 1960; Dolby, 1970; Paproth and Streel, 1970; and Utting and Neves, 1970. The range is Tournaisian-Visean (Mississippian). Specimens have been recovered during the present study from samples ?Pb5658, Pb5661, Pb5662-0.8%, Pb5663, Pb5664, Pb5671, Pb5675, Pb5685, and Pb5690.

Genus Lophozonotriletes (Naumova, 1953) emend. Potonie, 1958

Type species: Lophozonotriletes lebedianensis Naumova, 1953, p. 119, pl. 17, fig. 42.

Lophozonotriletes bellus Kedo, 1963

Plate 9, Fig. 3

1963 Lophozonotriletes bellus Kedo, p. 87, 88, pl. 10, fig. 243, 244.

Description: Specimens conform to Lophozonotriletes bellus as described by Clayton (1971). Most of the present specimens contain regular rounded cones as ornamentation with sutures accompanied by weak lip development.

Discussion: The specimens recovered here are most like the specimens figured by Clayton (1971). Both these and Clayton's specimens appear less variable in ornamentation than those of Kedo (1963). These specimens are somewhat similar to Lophozonotriletes dentatus but are slightly smaller. L. excisus Naumova, 1953, is also similar in size and morphology, but ornamentation appears to be proximal as suggested by Potonie (1958) and Hughes and Playford (1961).

Occurrences and Stratigraphic Range: The genus has primarily a Devonian-Mississippian range. The species is known from limited occurrences (Kedo, 1963 and Clayton, 1971) and is known from the Tournaisian. Specimens have been recovered during the present study from samples Pb5658 and Pb5687.

Lophozonotriletes cristifer (Luber, 1941 in Luber and Waltz) Kedo, 1957

Plate 9, Figs. 4, 5

1941 Azonotriletes cristifer Luber in Luber and Waltz, vyp. 139, pl. 1, fig. 10.

1957 Lophozonotriletes cristifer (Luber, 1941) Kedo, vyp. 2, pl. 4, fig. 15.

1960 Anisozonotriletes fabus Yushko, vyp. 3, pl. 2, figs. 41, 42.

1961b Torispora? tiara Staplin, p. 1228, 1230, text-fig. 1, figs. 1-4.

1962 Cyrtospora clavigera Winslow, p. 67, pl. 22, figs. 18, 19, 20.

1963 Lophozonotriletes cristifer (Luber, 1941) Kedo, 1957, in Kedo, 1963, p. 91, pl. 11, figs. 253-255.

1968 ?Lophozonotriletes cristifer (Luber, 1941) Kedo, 1957, in Brown, p. 118, 119, pl. 5, fig. 46.

1969 Raistrickia sp. no. 2928 Lanzoni and Magloire, pl. 4, figs. 17, 18.

Description: Specimens conform to the descriptions given by Winslow (1962, p. 67) for Cyrtospora clavigera, a junior synonym of Lophozonotriletes cristifer. The only difference is the weak zonate nature observed here and in other discussions of L. cristifer.

Discussion: The question arises as to whether the weak zonate character represents a true zona or a thickened wall structure. The present specimens are assigned to Lophozonotriletes cristifer for which this morphologic feature, the zona, is most commonly known. If the spores are not truly zonate, but possibly patinate, they may ultimately be reassigned. The best possibility at the present would seem to be the genus Cyrtospora of Winslow (1962).

The other possibility would be Torispora as questionably assigned by Staplin (1961b). However, the monoletoid suture character as applied to Torispora would exclude the present forms which are clearly trilete.

Occurrences and Stratigraphic Range: The species is known from Upper Devonian and Lower Mississippian sediments from the following occurrences in addition to those included in the synonymy (McGregor and Owens, 1966 and McGregor, 1970). Winslow (1962) noted the greatest abundance in the Cuyahoga Formation. Specimens have been recovered during the present study from samples Pb5660 single specimen, Pb5661-4.8%, Pb5662-0.8%, Pb5663-2.4%, Pb5664-6.4%, Pb5665-5.6%, Pb5666, Pb5667-8.8%, Pb5668-3.2%, Pb5669-6.0%, Pb5670-1.2%, Pb5671-0.4%, Pb5673, Pb5674-1.6%, Pb5675-1.2%, Pb5676-1.2%, Pb5677, Pb5679-0.4%, Pb5683-0.4%, Pb5684, Pb5685-4.4%, Pb5686-0.4%, Pb5687-1.6%, Pb5688-0.8%, Pb5689-2.0%, Pb5690-0.8%, Pb5691, Pb5692, Pb5693, Pb5694-9.6%, Pb5695-21.6%, Pb5696, and Pb5697.

Lophozonotriletes dentatus Hughes and Playford, 1961

Plate 9, Fig. 6

1961 Lophozonotriletes dentatus Hughes and Playford, p. 36, 37, pl. 3, figs. 8-10.

Description: Specimens conform to the original description given by Hughes and Playford (1961).

Discussion: The species has been reported commonly by many authors with comparisons to other morphologically similar taxa generally not discussed. Although direct

comparisons would be needed the following taxa not considered synonymous, but bearing morphologic similarities are: Acanthotriletes dentatus, A. uncatus, Lophozonotriletes excisus, L. gibberulus and L. scurrus of Naumova (1953) and in Kedo (1963) L. bellus (larger and more irregular forms) L. aff. excisus, L. excisus, L. major and one of the specimens of L. malevkensis (Fig. 242, Kedo, 1963). This illustration of Kedo's of L. malevkensis appears to be an extreme of the general type of L. malevkensis as described later in this study.

The weakly zonate forms of L. dentatus are also somewhat similar to Pustulatisporites gibberosus which is azonate.

Occurrences and Stratigraphic Range: The species ranges from Upper Devonian to Lower Mississippian based on the following known records; Hughes and Playford, 1961; Playford, 1963; McGregor and Owens, 1966; Brown, 1968; Eames, 1968; Kaiser, 1970a; Mortimer, Chaloner, and Llewellyn, 1970; von Almen, 1970a, 1970b; and Johnson and Marshall, 1971.

Specimens have been recovered during the present study from samples Pb5654, Pb5655, Pb5656-0.4%, Pb5657-0.8%, Pb5658-0.4%, Pb5661-0.4%, Pb5662-0.4%, Pb5663-1.6%, Pb5664-0.8%, Pb5665-0.4%, Pb5666, Pb5667, Pb5669-0.4%, Pb5670, Pb5674-0.4%, Pb5675-0.4%, Pb5678, Pb5685-0.4%, Pb5687-0.4%, Pb5688, Pb5690, Pb5691, and Pb5692.

Lophozonotriletes malevkensis (Naumova in litt.) Kedo, 1963

Plate 9, Fig. 7

1963 Lophozonotriletes malevkensis (Naumova in litt.) Kedo p. 87, pl. 10, figs. 240-242.

Description: Spores radial, trilete, zonate; amb sub-circular to broadly rounded-triangular; diameter 33-50μm overall; corpus 20-40μm diameter; laesurae, simple, distinct, extending entire radius of central body; ornamentation, distal; tubercles, 2-8μm high, 4-10μm basal width, rarely extending onto zona; surface of tubercles and spore coat psilate; zona 4-10μm wide, generally crenulate at equatorial margin; exoexine thin 1-2μm, intexine thin 1-2μm, folds rare.

Discussion: The species has not been widely reported. The present specimens are most like those described by Kedo (1963, figs. 240 and 241). Fig. 242 of Kedo (1963) represents a form that appears to be outside of the general type for the species described here. Lophozonotriletes malevkensis is somewhat similar to L. rarituberculatus, but is consistently smaller overall with a crenulate margin and smaller ornamentation.

Occurrences and Stratigraphic Range: The species is known from the uppermost Devonian and Lower Mississippian and is most common in the Lower Mississippian based on the following records: Kedo, 1963; Dolby, 1970; McGregor, 1970; Utting and Neves, 1970; and Sandberg, Streel and Scott, 1972. Specimens have been recovered during the present study from samples Pb5661-0.4%, Pb5662, Pb5663-0.8%, Pb5664-0.8%, Pb5665, Pb5667, Pb5668, Pb5669-0.4%, Pb5670-0.4%, Pb5671-0.4%, Pb5674-0.4%, Pb5675, Pb5679, Pb5683, Pb5684, Pb5685-1.6%, Pb5687-1.2%,

Pb5688, Pb5689, Pb5690-0.4%, Pb5691, Pb5692, Pb5694-2.4%, Pb5695-0.8%, Pb5696, and Pb5697.

Lophozonotriletes rarituberculatus (Luber, 1941) Kedo, 1957

Plate 9, Fig. 9

1941 Zonotriletes rarituberculatus Luber in Luber and Waltz, p. 10, 30, pl. 1, fig. 5, pl. 5, fig. 76.

1956 Euryzonotriletes rarituberculatus (Luber, 1941) Ishchenko var. triangulatus Ishchenko, p. 51, pl. 8, fig. 104.

1957 Lophozonotriletes rarituberculatus (Luber, 1941) Kedo, p. 1166, pl. 4, figs. 23, 24, 25, non Naumova, 1953.

1961 Lophozonotriletes triangulatus Hughes and Playford, p. 35, 36, pl. 3, figs. 5-7.

1963 Lophozonotriletes rarituberculatus (Luber, 1941) Kedo in Kedo, p. 90, pl. 9, fig. 252.

Description: Specimens conform to the description as given in Hughes and Playford (1961).

Discussion: The species has been widely reported with a comprehensive discussion and a list of occurrences known prior to 1963 given by Playford (1963, p. 639).

Occurrences and Stratigraphic Range: The known range of the species is Upper Devonian to Lower Mississippian based on occurrences listed in the synonymy and the following records: Playford, 1963; Streel, 1966; McGregor and Owens, 1966; Barss, 1967; Brown, 1968; Bouckaert, Streel, Thorez, and Mound, 1969; Kaiser, 1970a, b; McGregor, 1970; Mortimer, Chaloner and Llewellyn, 1970; Paproth and Streel, 1970; and Sandberg, Streel, and Scott, 1972. Specimens have been recovered during the present study from samples Pb5661, Pb5663-0.8%, Pb5665-0.4%, Pb5667, Pb5668, Pb5670, and Pb5691.

Lophozonotriletes variverrucatus Playford, 1963

Plate 9, Fig. 8

1963 Lophozonotriletes variverrucatus Playford, p. 640, 641, pl. 91, figs. 6, 7, text-fig. 10c.

1964 Tumulispora variverrucata (Playford, 1963) Staplin and Jansonius, p. 110, 111, pl. 20, figs. 9-13, 16-19, 21-23, text-fig. 2m.

Description: Specimens conform to the description in Playford (1963, p. 640, 641).

Discussion: The erection of a new genus Tumulispora and transfer of Lophozonotriletes variverrucatus to that genus by Staplin and Jansonius (1964) is not accepted at this time. The author's opinion is that the type species of Lophozonotriletes does not differ in width of the zona from L. variverrucatus as stated by Staplin and Jansonius (1964). This feature as well as others of many species of Lophozonotriletes are similar enough between species to maintain the previous assignments to Lophozonotriletes.

Occurrences and Stratigraphic Range: The species has been infrequently recorded with the occurrences of Playford (1963), Staplin and Jansonius (1964) and the present study being the only known records. Based on these records the species is known only from the Lower Mississippian (Tournaisian). Specimens have been recovered during the present study from samples Pb5661, Pb5662-0.4%, Pb5663-0.4%, Pb5664-0.4%, Pb5665-0.8%, Pb5667, Pb5668-0.4%, Pb5669, Pb5670-0.4%, Pb5671, Pb5674-0.4%, Pb5675-0.8%, Pb5676, Pb5679-0.4%, Pb5685, Pb5688-0.8%, Pb5689-0.4%, Pb5690, and Pb5694.

Genus Microreticulatisporites (Knox, 1950) emend. Potonie and Kremp, 1954

Type species: Microreticulatisporites lacunosus (Ibrahim, 1933) Knox, 1950, p. 320, pl. 18, fig. 240.

Microreticulatisporites hortonensis Playford, 1964

Plate 9, Fig. 11

1957 Microreticulatisporites sp. A Hacquebard, p. 311, pl. 2, fig. 6.

1964 Microreticulatisporites hortonensis Playford, p. 28, pl. 8, figs. 3, 4.

Description: Specimens conform to the description in Playford (1964), the only exception being an occasional specimen with a larger overall diameter 40-66µm (Playford, 1964, 41-58µm).

Discussion: The species is similar to some representatives of the genus Foveolatisporites. This has been discussed by Playford (1964, p. 28).

Occurrences and Stratigraphic Range: The genus ranges from Lower Mississippian (Playford, 1964) to Permian (Hoffmeister, Staplin, and Malloy, 1955a). The species has had infrequent occurrences, but the following records indicate a Mississippian range: Hacquebard, 1957; Playford, 1964; Barss, 1967; Varma, 1969; Kaiser, 1970a; and Sabry and Neves, 1971. Specimens have been recovered during the present study from samples Pb5660, Pb5668, Pb5673, Pb5674, and Pb5679.

Genus "Peltatispora" gen. nov.

"Peltatispora peltata" gen. et sp. nov.

Plate 9, Fig. 10

Spores trilete; amb sub-circular to rounded-triangular; exine psilate to verrucate; possessing a distally thickened shield "patina"; sutures generally distinct, simple.

Description: Spores radial, trilete; amb rounded-triangular; diameter 27-40μm; exine 1-3μm thick; surface psilate to slightly granulate; possessing a distal shield; laesurae, simple, straight, extending 3/4 of spore radius.

Discussion: The above taxon is treated informally and is thought to represent a new genus. Existing genera that must be considered before validation of this new genus are Tumulispora of Staplin and Jansonius (1964) and Stereisporites of Pflug in Thompson and Pflug (1953). The inclusion of verrucate forms is based on undescribed specimens from the Bedford Shale (Eames, 1968).

Occurrences and Stratigraphic Range: Specimens referred to this informal genus are known from the Upper Devonian and Lower Mississippian in the present study and are present in samples Pb5660, Pb5664, Pb5671-1.2%, Pb5674-0.4%, Pb5675-0.4%, Pb5676, and Pb5684-0.4%. This species and the verrucate form from the Bedford are plotted on the range charts as "Peltatispora" spp.

Genus Perotrilites Erdtman, 1947 ex Couper, 1953

Type species: Perotrilites granulatus Couper, 1953, p. 31, 32, pl. 3, figs. 28, 29.

Generic Discussion: The genus Perotrilites has been loosely defined (Couper, 1953) from the Jurassic. Other genera with morphologic similarities are Diaphanospora of Balme and Hassell (1962), Auroraspora of Hoffmeister, Staplin, and Malloy (1955b), and Hymenozonotriletes of Naumova (1953). The differences between Diaphanospora and the latter two have been discussed by Balme and Hassell (1962). This leaves Perotrilites and Diaphonospora both of which are defined similarly as the remaining possibilities for the two species recorded here.

Because of the differences in geologic age occurrences, Perotrilites (Jurassic) and Diaphonospora (Devonian), Balme and Hassell (1962) have excluded Perotrilites. Exclusion of usage based on geologic age has been rejected by Playford (1962) and Brown (1968).

Recently Evans (1970), by emendation of Perotrilites and Diaphanospora, has attempted to alleviate the problems between these genera. In so doing Evans has compounded the problem by interpreting Perotrilites as zonate and distally apiculate and Diaphanospora as having a relatively thick intexine and ?tapetal globules distally and equatorially. In addition no mention was made of transfer or new combinations of taxa beyond those of Balme and Hassell (1962) and Couper (1953).

Due to the continued confusion of the two genera the specimens recovered here have been retained in Perotrilites sensu Couper (1953). The problem remains and can only be

resolved by comparison of all species within the genera, which at this time is beyond the scope of this study.

Perotrilites magnus Hughes and Playford, 1961

Plate 10, Fig. 1

1961 Perotrilites magnus Hughes and Playford, p. 33, pl. 2, figs. 5, 6.

Description: Specimens conform to the original description of Hughes and Playford (1961). The present specimens have been generally in poor condition with the outer spore coat extending slightly further from the central body than as originally described. This feature is variable and does not preclude the specific assignment.

Discussion: As previously mentioned this taxon is retained in Perotrilites because at the present time, the alternative (i.e., Diaphanospora), is not clearly defined.

Occurrences and Stratigraphic Range: The genus is known to range from Lower Devonian (Allen, 1965) to Jurassic (Couper, 1953). The species range is Upper Devonian to Lower Mississippian based on the following records: Hughes and Playford, 1961; Playford, 1962 and 1964; Barss, 1967; Sullivan, 1968; Hibbert and Lacy, 1969; Mortimer, Chaloner, and Llewellyn, 1970; Clayton, 1971; Johnson and Marshall, 1971; Bertelsen, 1972; and Kalibova-Kaiserova, 1972.

Specimens have been recovered in the present study from samples Pb5672, Pb5673, Pb5674, Pb5675, Pb5685, Pb5687, Pb5688, Pb5689, Pb5690, Pb5691, and Pb5695.

Perotrilites perinatus Hughes and Playford, 1961

Plate 10, Fig. 4

1961 Perotrilites perinatus Hughes and Playford, p. 33, pl. 2, figs. 7-10.

1962 Calamospora obtecta Winslow, p. 56, 57, pl. 17, figs. 4, 5, 7, 8.

Description: Specimens conform to the description of Hughes and Playford (1961).

Discussion: The specimens described in Winslow (1962) as Calamospora obtecta have a perisporal? membrane and are considered synonymous with Perotrilites perinatus. Other spores which may be synonymous with P. perinatus, but not included at this time due to the uncertain generic assignment, discussed previously, are Diaphanospora perplexa of Balme and Hassell (1962) and Hymenozonotriletes (Diaphanospora) perplexa Balme and Hassell in Kimyai (1972).

Occurrences and Stratigraphic Range: The species has a stratigraphic range of Upper Devonian to Lower Pennsylvanian based on the following occurrences: Hughes and Playford, 1961; Winslow, 1962; Playford, 1962 and 1964; Sullivan and Marshall, 1966; Barss, 1967; Butterworth and Spinner, 1967; Felix and Burbridge, 1967; Brown, 1968; Bouckaert, Streel, Thorez, and Mound, 1969; Hibbert and Lacy, 1969; Llewellyn, Backhouse, and Hoskin, 1969; Varma, 1969; Kaiser, 1970a, b; Llewellyn, Hoskin, and Backhouse, 1970; Marshall and Williams, 1970; Paproth and Streel, 1970; Utting and Neves, 1970; von Almen, 1970a, 1970b; Clayton, 1971; Johnson and Marshall, 1971; Bertelsen, 1972; Kalibova-Kaiserova,

1972; Sandberg, Streel, and Scott, 1972; and Spinner and Clayton, 1973.

Specimens have been recovered during the present study from samples Pb5651-0.4%, Pb5652-0.4%, Pb5654-0.4%, Pb5655, Pb5656-1.2%, Pb5657-0.8%, Pb5658-2.8%, Pb5659-3.6%, Pb5660, Pb5662-0.4%, Pb5663-0.4%, Pb5665-0.4%, Pb5666, Pb5667-0.8%, Pb5670, Pb5671-1.6%, Pb5673, Pb5674-2.0%, Pb5675-2.0%, Pb5676-1.2%, Pb5678, Pb5679-1.2%, Pb5680-0.8%, Pb5681, Pb5683-1.2%, Pb5684-2.0%, Pb5685-1.6%, Pb5686-1.2%, Pb5687, Pb5688-0.8%, Pb5689-0.4%, Pb5690-0.4%, Pb5691, and Pb5692.

Genus Punctatisporites (Ibrahim, 1933) emend. Potonie and Kremp, 1954

Type species: Punctatisporites punctatus Ibrahim, 1933, p. 21, pl. 2, fig. 18.

Punctatisporites debilis Hacquebard, 1957

Plate 10, Fig. 8

1957 Punctatisporites debilis Hacquebard, p. 308, pl. 1, figs. 5, 6.

Description: Specimens conform to the original description in Hacquebard (1957) with the exception of having a slightly broader size range 25-60μm (Hacquebard, 1957, 41-58μm).

Discussion: Punctatisporites debilis appears to be morphologically identical to P. irrasus except it is smaller in overall diameter. P. nitidus is similar in size but has a slightly thicker exine and generally lacks a gapping laesurae.

Occurrences and Stratigraphic Range: The genus is long-ranging, from the Lower Devonian upward through the Paleozoic. The Mesozoic genus Todisporites of Couper (1958) is considered to be synonymous. The species has been recorded in Upper Devonian to Upper Mississippian sediments based on the following occurrences: Hacquebard, 1957, Playford, 1964; Barss, 1967; Butterworth and Spinner, 1967; Brown, 1968; Eames, 1968; Varma, 1969; Kaiser, 1970a, b; and Spinner and Clayton, 1973. Specimens have been recovered during the present study from samples Pb5656, Pb5660-1.6%, Pb5661-0.4%, Pb5662-0.8%, Pb5663-1.6%, Pb5664-2.0%, Pb5665-2.4%, Pb5667-4.4%, Pb5668-1.2%, Pb5669-0.8%, Pb5670-0.8%, Pb5671-1.6%, Pb5672, Pb5673, Pb5674-8.4%, Pb5675-9.6%, Pb5676-7.2%, Pb5677, Pb5678, Pb5679-4.4%, Pb5680-4.0%, Pb5682, Pb5683-6.8%, Pb5684-4.0%, Pb5685-2.0%, Pb5686-3.2%, Pb5687-1.6%, Pb5688, Pb5689-1.2%, Pb5690-2.4%, Pb5691, Pb5692, Pb5694-0.4%, and Pb5695-0.8%.

Punctatisporites densiminutus Staplin, 1960

Plate 10, Figs. 5, 6

1960 Punctatisporites densiminutus Staplin, p. 7, pl. 1, fig. 19.

Description: Specimens conform to the description by Staplin (1960).

Discussion: Punctatisporites densiminutus is differentiated from P. nitidus and P. debilis by its small size and thick exine. Many of the specimens exhibit some curvaturae, a character of the genus Retusotriletes. The present specimens are retained in Punctatisporites.

Occurrences and Stratigraphic Range: The species has not been widely reported. The known occurrences are those of Staplin (1960), Sullivan and Marshall (1966), and the present study. From these occurrences the range is Upper Devonian to Upper Mississippian. Specimens have been recovered during the present study from samples Pb5651-4.4%, Pb5652-3.6%, Pb5653-4.4%, Pb5654-0.8%, Pb5655, Pb5657, Pb5660, Pb5665, Pb5672, and Pb5681.

Punctatisporites fissus Hoffmeister, Staplin, and Malloy, 1955b

Plate 10, Fig. 7

1955b Punctatisporites fissus Hoffmeister, Staplin, and Malloy, p. 393, pl. 36, fig. 8.

Description: Spores radial, trilete; amb circular to subcircular; diameter 50-66μm; exine 3-4μm thick, arcuate folds often present; laesurae, simple, straight, often split open and folded; surface of exine granular-scabrate.

Discussion: The species has not been widely recorded. Although the laesurae and surface character combination are distinct from other species of Punctatisporites.

Occurrences and Stratigraphic Range: The species is known only from Devonian and Mississippian sediments as reported by Hoffmeister, Staplin, and Malloy (1955b) and Eames (1968), and from samples analyzed in the present study. Specimens have been recovered from samples Pb5675-0.8%, Pb5680-0.4%, Pb5684-0.8%, and Pb5686-0.8%.

Punctatisporites irrasus Hacquebard, 1957

Plate 10, Fig. 11

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

Description: Specimens conform to the description by Hacquebard (1957) with the single exception of being slightly broader size range 62-85μm (Hacquebard, 1957, 67-83μm).

Discussion: The major differences of Punctatisporites irrasus compared to other species of the genus is its larger size and thin easily folded exine.

Occurrences and Stratigraphic Range: The species has been reported from Upper Devonian to Lower Pennsylvanian sediments from the following occurrences: Hacquebard, 1957; Playford, 1964; Sullivan, 1964b; Streel, 1966; Barss, 1967; Neves and Dolby, 1967; Felix and Burbridge, 1967; Sullivan, 1968; Bouckaert, Streel, Thorez, and Mound, 1969; Hibbert and Lacy, 1969; Llewellyn, Backhouse, and Hoskin, 1969; Dolby, 1970; Dolby and Neves, 1970; Llewellyn, Hoskin, and Backhouse, 1970; Mortimer, Chaloner, and Llewellyn, 1970; Paproth and Streel, 1970; Utting and Neves, 1970; Clayton, 1971; and Johnson and Marshall, 1971.

Specimens have been recovered in the present study from samples Pb5658-0.4%, Pb5660-1.2%, Pb5661-2.0%, Pb5662-1.6%, Pb5663-1.2%, Pb5664-1.2%, Pb5665-0.4%, Pb5666, Pb5667-1.6%, Pb5668-0.8%, Pb5671-1.2%, Pb5672, Pb5673, Pb5674-3.2%, Pb5675-1.2%, Pb5676-0.4%, Pb5677, Pb5678, Pb5679-5.2%, Pb5680,

Pb5681, Pb5683-2.0%, Pb5684-0.4%, Pb5685-0.8%, Pb5686-1.6%, Pb5687-1.2%, Pb5688, Pb5689-2.0%, Pb5690-1.2%, Pb5691, Pb5695, Pb5696, and Pb5697.

Punctatisporites nitidus Hoffmeister, Staplin, and Malloy, 1955b

Plate 10, Fig. 3

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

Description: Specimens conform to the original description of Hoffmeister, Staplin, and Malloy (1955b) and the subsequent description in Smith and Butterworth (1967).

Discussion: Playford (1962) has considered Punctatisporites nitidus to be a synonym of P. glaber (Naumova) Playford. Smith and Butterworth (1967, p. 127) have rejected Playford's synonymy on the basis of surface texture and folding characteristics. The present specimens of P. nitidus exhibit arcuate folds and are regarded as separable from P. glaber. Because of Playford's synonymy, occurrences of P. glaber since 1962 are included with those of P. nitidus due to the uncertainty of separating the two species from descriptions and illustrations.

Occurrences and Stratigraphic Range: The species is known from Upper Devonian-Lower Pennsylvanian sediments based on the following occurrences: Hoffmeister, Staplin and Malloy, 1955b; Playford, 1962; Winslow, 1962; Smith and Butterworth, 1967; Barss, 1967; Brown, 1968; Hibbert and Lacy, 1969; Llewellyn, Backhouse, and Hoskin, 1969; Llewellyn,

Hoskin, and Backhouse, 1970; von Almen, 1970a; Clayton, 1971; Johnson and Marshall, 1971; Bertelsen, 1972; and Spinner and Clayton, 1973.

Specimens have been recovered during the present study from samples Pb5652, Pb5654-0.4%, Pb5655-0.4%, Pb5656-0.4%, Pb5660, Pb5661-5.2%, Pb5662-12.4%, Pb5663-6.0%, Pb5664-15.6%, Pb5665-24.0%, Pb5666, Pb5667-26.8%, Pb5668-31.6%, Pb5669-35.2%, Pb5670-44.4%, Pb5671-40.4%, Pb5672, Pb5673, Pb5674-44.8%, Pb5675-36.4%, Pb5676-48.0%, Pb5677, Pb5678, Pb5679-50.4%, Pb5680-40.8%, Pb5681, Pb5682, Pb5683-42.4%, Pb5684-47.2%, Pb5685-40.0%, Pb5686-44.8%, Pb5687-37.2%, Pb5688-35.2%, Pb5689-29.6%, Pb5690-31.2%, Pb5691, Pb5692, Pb5694-34.4%, Pb5695-34.8%, Pb5696, and Pb5697.

Punctatisporites planus Hacquebard, 1957

Plate 10, Figs. 2, 9

1957 Punctatisporites planus Hacquebard, p. 308, pl. 1, fig. 12.

1957 Punctatisporites solidus Hacquebard, p. 308, pl. 1, fig. 13.

1962 Punctatisporites sp. A Winslow, p. 60, 61, pl. 17, figs. 13, 15.

1962 Punctatisporites sp. B Winslow, p. 61, pl. 17, fig. 19, pl. 23, fig. 14.

Description: Spores radial, trilete; amb circular to sub-circular; diameter 48-72µm; laesurae, generally simple, occasionally with weak lip development; straight, extending 2/3-3/4 spore radius, one ray occasionally longer than the other two; exine 2-4µm thick, rarely folded; surface, psilate to infragranulose.

Discussion: The above redescription encompasses the two species listed in the synonymy. The two are considered synonymous because when they occur together in large numbers separation cannot be maintained. Both species as originally described (Hacquebard, 1957), from a small number of specimens, are basically similar. The specific name of P. planus is prefered over P. solidus because of several other "solid" appearing species of Punctatisporites in the literature.

Occurrences and Stratigraphic Range: The species is known from Upper Devonian to Lower Pennsylvanian based on the following occurrences: Hacquebard, 1957; Balme and Hassell, 1962; Winslow, 1962; Playford, 1964; Barss, 1967; Felix and Burbridge, 1967; Brown, 1968; Eames, 1968; Sullivan, 1968; Llewellyn, Backhouse, and Hoskin, 1969; Varma, 1969; Llewellyn, Hoskin, and Backhouse, 1970; Mortimer, Chaloner, and Llewellyn, 1970; and Clayton, 1971.

Specimens have been recovered during the present study from samples Pb5651-2.4%, Pb5652-1.6%, Pb5653-2.8%, Pb5654-1.6%, Pb5656-0.4%, Pb5657-0.8%, Pb5658-1.6%, Pb5659-1.2%, Pb5660-1.2%, Pb5661-2.4%, Pb5662-0.4%, Pb5663, Pb5664, Pb5665-0.8%, Pb5667-0.4%, Pb5668-0.4%, Pb5670-0.8%, Pb5671, Pb5673, Pb5675-1.2%, Pb5685, and Pb5686-0.4%.

Genus Pustulatisporites (Potonie and Kremp, 1954) emend. Imgrund, 1960

Type species: Pustulatisporites pustulatus Potonie and Kremp, 1954, p. 134, 137, pl. 20, fig. 93.

Pustulatisporites gibberosus (Hacquebard, 1957) emend. Playford, 1964

Plate 10, Fig. 10

1957 Raistrickia? gibberosa Hacquebard, p. 310, pl. 2, fig. 1.

1964 Pustulatisporites gibberosus (Hacquebard, 1957) emend. Playford, p. 18, 19, pl. 3, figs. 18-20.

Description: Specimens conform to the emended diagnosis of Playford (1964).

Discussion: Occasional specimens of Lophozonotriletes dentatus with weakly developed zona are somewhat similar to Pustulatisporites gibberosus.

Occurrences and Stratigraphic Range: The genus ranges from Lower Mississippian (Playford, 1964) to Lower Permian (Imgrund, 1960). The species range is primarily Lower Mississippian (post--Tn-1a, Tournaisian) based on the following occurrences: Hacquebard, 1957; Playford, 1964; Barss, 1967; Brown, 1968; Sullivan, 1968; Varma, 1969; Combaz and Streel, 1970; Kaiser, 1970a; Paproth and Streel, 1970; Utting and Neves, 1970; von Almen, 1970a, 1970b; Johnson and Marshall, 1971; and Sandberg, Streel, and Scott, 1972. Specimens have been recovered during the present study from samples Pb5661-0.4%, Pb5662, Pb5663-0.4%, Pb5664, Pb5665, Pb5668-0.4%, Pb5670, Pb5674, Pb5675, Pb5683, Pb5685-0.4%, Pb5688, Pb5689, Pb5690, Pb5695-0.4%, and Pb5696.

Pustulatisporites sp. A

Plate 10, Fig. 12

Description: Spores radial, trilete; amb circular to subcircular; diameter 56-74µm; laesurae, simple,

straight, distinct, extending 2/3 to 3/4 spore radius; exine 2-4μm thick, occasionally with arcuate folds near equatorial margin; ornamentation, smooth pustulate elements, irregularly distributed distally and equatorial, 1-3μm high, 1-3μm basal width; individual ornaments are circular in outline when viewed from above.

Discussion: These specimens are distinct from described species of Pustulatisporites and are therefore considered to belong to a new species.

Occurrences and Stratigraphic Range: Specimens referred to Pustulatisporites sp. were found only in samples of Mississippian rocks during the present study. Specimens are present in samples Pb5663, Pb5665, Pb5679, Pb5683, Pb5684, Pb5685, Pb5686-0.4%, and Pb5690-0.4%.

Genus Raistrickia (Schopf, Wilson, and Bentall, 1944) emend. Potonie and Kremp, 1954

Type species: Raistrickia grovensis Schopf in Schopf, Wilson, and Bentall, 1944, p. 55, 56, text-fig. 3.

Raistrickia baculosa Hacquebard, 1957

Plate 11, Figs. 2, 3

1957 Raistrickia baculosa Hacquebard, p. 310, pl. 1, figs. 23, 24.

?1971 Raistrickia pinguis Playford, p. 22, 23, pl. 5, figs. 9-12.

Description: Specimens conform to the original description in Hacquebard (1957) with two exceptions. The present specimens were consistently smaller 42-72μm than those reported by Hacquebard (72-107μm) and ornamentation

has generally been denser.

Discussion: The species Raistrickia pinguis of Playford (1971) is considered as questionably conspecific with R. baculosa. This is based on the smaller size of the present specimens here assigned to R. baculosa. Although Playford (1971) did not compare R. pinguis to R. baculosa they appear to be identical, except for the smaller size of R. pinguis, than that given for R. baculosa in the original description by Hacquebard (1957).

Occurrences and Stratigraphic Range: The genus ranges from Middle Devonian (Chaloner, 1967) to Middle Pennsylvanian (Hoffmeister, Staplin, and Malloy, 1955a). The species range is Upper Devonian to Upper Mississippian based on the following occurrences: Hacquebard, 1957; Playford, 1964, 1971; Barss, 1967; Eames, 1968; and Varma, 1969.

Specimens have been recovered during the present study from samples Pb5654, Pb5659, Pb5661, Pb5663-0.4%, Pb5668, Pb5669, Pb5671, Pb5672, Pb5674-0.4%, Pb5675-0.8%, Pb5681, Pb5682, Pb5683, Pb5684-0.8%, Pb5686-0.4%, Pb5687, Pb5688, Pb5689, Pb5690-1.2%, Pb5694-1.6%, Pb5695-0.8%, and Pb5696.

Raistrickia clavata (Hacquebard, 1957) emend. Playford, 1964

Plate 11, Fig. 1

1957 Raistrickia clavata Hacquebard, p. 310, pl. 1, fig. 25.

1957 Raistrickia pistillata Hacquebard, p. 310, 311, pl. 2, fig. 2.

1964 Raistrickia clavata (Hacquebard) emend. Playford, p. 24, 25, pl. 6, figs. 5-10.

?1968 Raistrickia accincta Playford and Helby, p. 109, pl. 9, figs. 13, 14.

Description: Specimens conform to the emended diagnosis of Playford (1964). Occasional specimens in the present study are smaller than those of Playford (1964) and Hacquebard (1957).

Discussion: Raistrickia accincta of Playford and Helby (1968) has a smaller size range, but may be a synonym of R. clavata. Playford and Helby (1968) separate R. accincta from R. clavata, but the differences are minor and may be gradational.

Occurrences and Stratigraphic Range: The species range is Upper Devonian to Upper Mississippian and is most commonly Lower Mississippian based on the following occurrences: Hacquebard, 1957; Playford, 1964; Barss, 1967; Eames, 1968; Playford and Helby, 1968; Sullivan, 1968; Hibbert and Lacy, 1969; Varma, 1969; and Utting and Neves, 1970.

Specimens have been recovered during the present study from samples Pb5659, Pb5661, Pb5664-0.4%, Pb5665-0.8%, Pb5666, Pb5667-0.4%, Pb5671, Pb5673, Pb5674-1.2%, Pb5675-0.8%, Pb5676, Pb5678, Pb5679, Pb5680-0.4%, Pb5684, Pb5685-0.4%, Pb5691, and Pb5695-0.4%.

Raistrickia corynoges Sullivan, 1968

Plate 11, Fig. 4

1963 Acanthotriletes macrurus (non Luber and Waltz, 1938, p. 30, pl. 7, fig. 94) Kedo, p. 44, pl. 3, fig. 57.

1963 Acanthotriletes sphaerites Kedo, p. 44, pl. 3, fig. 58.

1964b Raistrickia sp. A. Sullivan, p. 1252, pl. 1, fig. 8.

1966 Raistrickia sp. A. Sullivan, 1964, in Streel, p. 82, 83, pl. 2, figs. 18, 19.

1967 Raistrickia sp. Neves and Dolby, pl. 1, fig. 4.

1968 Raistrickia corynoges Sullivan, p. 119, 120, pl. 25, figs. 6-8, text-fig. 2.

1970 Raistrickia variabilis Dolby and Neves, p. 636, 637, pl. 1, fig. 6.

Description: Specimens conform to the original description of Sullivan (1968).

Discussion: The variability of the processes in Raistrickia corynoges is extensive (Sullivan, 1968). Dolby and Neves (1970) separate R. corynoges from their species of R. variabilis on the basis of the terminal process variations. Because this variability of process termination may be quite extensive for both of the above species and because their stratigraphic occurrences are similar (Upper Devonian-Lower Mississippian) the two species are considered synonymous.

An additional species Raistrickia macrura (Luber) Dolby and Neves, 1970 may ultimately be included in the above synonymy. This could only be considered after a study of the specimens of Dolby and Neves (1970), Ishchenko (1952), Luber and Waltz (1938) and the specimens of Kedo (1963) attributed to the species.

Occurrences and Stratigraphic Range: The species range is from Upper Devonian to Middle Mississippian based on the following occurrences: Sullivan, 1964b, 1968; Kedo, 1963; Streel, 1966; Neves and Dolby, 1967; Eames, 1968; Bouckaert, Streel, Thorez, and Mound, 1969; Combaz and Streel,

1970; Dolby and Neves, 1970; Dolby, 1970; Mortimer, Chaloner, and Llewellyn, 1970; Paproth and Streel, 1970; Utting and Neves, 1970; Clayton, 1971; Johnson and Marshall, 1971; Bertelsen, 1972; Neves, et al. 1972; and Warg and Traverse, 1973.

Specimens have been found during the present study in samples ?Pb5656, ?Pb5658, Pb5666, Pb5668, Pb5669, Pb5674, Pb5678, Pb5680-0.4%, Pb5681, Pb5682, ?Pb5683, Pb5684, Pb5687-1.2%, Pb5688, Pb5689-2.4%, Pb5690-1.2%, Pb5691, Pb5692, Pb5694-0.4%, Pb5695-1.6%, and Pb5696.

Genus Reticulatisporites (Ibrahim, 1933) emend. Neves, 1964

Type species: Reticulatisporites reticulatus Ibrahim, 1933, p. 33, pl. 1, fig. 3.

Reticulatisporites crassus Winslow, 1962

Plate 11, Fig. 5

1962 Reticulatisporites crassus Winslow, p. 58, pl. 14, figs. 8, 9, 10, 10a, pl. 22, fig. 23.

Description: Specimens conform to the original description of Winslow (1962, p. 58).

Discussion: The specimens assigned here to Reticulatisporites crassus Winslow, 1962 appear quite variable with reference to the features of the zona. Their ultimate position regarding assignment to Reticulatisporites is uncertain with possible future assignment to the genus Knoxisporites. However, for the present they are assigned to Reticulatisporites crassus.

Occurrences and Stratigraphic Range: The genus ranges from Devonian (Emsian) (Chaloner, 1967) to Upper Pennsylvanian (Hoffmeister, Staplin, and Malloy, 1955a). The species range is Upper Devonian to Lower Mississippian based on the following occurrences: Winslow, 1962; and Mortimer, Chaloner, and Llewellyn, 1970. Specimens have been recovered during the present study from samples Pb5651-0.4%, Pb5653-0.4%, Pb5659, Pb5669-0.4%, Pb5670, Pb5671, Pb5674, and Pb5687.

Reticulatisporites papillatus (Naumova, 1938) emend. Playford, 1971

Plate 11, Fig. 6

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, 1938) Byvscheva, p. 39, pl. 2, figs. 3-5.

1971 Reticulatisporites papillatus (Naumova, 1938) emend. Playford, p. 31, 32, pl. 10, figs. 11, 12.

Description: Specimens were extremely rare. They conform to the descriptions given by Playford (1962 and 1971).

Discussion: The two forms included in the synonymy have not been observed by the present author, but are included and discussed by Playford (1971).

Occurrences and Stratigraphic Range: The species range is from Lower Mississippian to lowermost Pennsylvanian based on the following occurrences: Playford, 1962, 1971; Playford and Barss, 1963; Barss, 1967; Felix and

Burbridge, 1967; Kaiser, 1970a; and Lanzoni and Magloire, 1969. Specimens have been found during the present study in a single sample, Pb5675 from the Sharpsville Sandstone.

Genus Retusotriletes (Naumova, 1953) emend. Streel, 1964

Type species: Retusotriletes simplex Naumova, 1953, p. 29, pl. 2, fig. 9.

Retusotriletes incohatus Sullivan, 1964b

Plate 12, Fig. 2

1964b Retusotriletes incohatus Sullivan, p. 1251, 1252, pl. 1, figs. 5-7.

Description: Specimens conform to the original description of Sullivan (1964b).

Discussion: Since the validation of Retusotriletes incohatus by Sullivan (1964b), the species has been frequently recorded. There are undoubted synonymies either in the Russian literature or species attributed to Russian types. Because the comparisons of the majority of these species are unavailable no attempt has been made at this time to propose the synonymy of the species.

Occurrences and Stratigraphic Range: The genus ranges from Silurian (Richardson and Ioannides, 1973) to Upper Mississippian, with the youngest occurrences being records of Retusotriletes incohatus. The species range is Upper Devonian to Upper Mississippian based on the following occurrences: Sullivan, 1964b, 1968; Streel, 1966, 1970; Barss, 1967; Butterworth and Spinner, 1967; Neves and Dolby, 1967; Brown, 1968; Eames, 1968; Llewellyn, Backhouse, and Hoskin,

1969; Combaz and Streel, 1970; Dolby, 1970; Dolby and Neves, 1970; Kaiser, 1970a; Llewellyn, Hoskin and Backhouse, 1970; McGregor, 1970; Mortimer, Chaloner, and Llewellyn, 1970; Paproth and Streel, 1970; Utting and Neves, 1970; von Almen, 1970a; Clayton, 1971; Johnson and Marshall, 1971; and Sandberg, Streel, and Scott, 1972.

Specimens have been recovered during the present study from samples Pb5651-2.0%, Pb5652-2.0%, Pb5653-1.2%, Pb5654-3.6%, Pb5655, Pb5656, Pb5657, Pb5658-1.6%, Pb5659-0.8%, Pb5660-1.2%, Pb5661-61.2%, Pb5662-65.2%, Pb5663-66.4%, Pb5664-59.2%, Pb5665-43.2%, Pb5666, Pb5667-46.0%, Pb5668-45.2%, Pb5669-35.2%, Pb5670-37.2%, Pb5671-10.8%, Pb5672, Pb5673, Pb5674-7.2%, Pb5675-7.2%, Pb5676-6.0%, Pb5677, Pb5679-6.0%, Pb5680-8.0%, Pb5681, Pb5683-8.8%, Pb5684-9.6%, Pb5685-10.8%, Pb5686-8.8%, Pb5687-12.8%, Pb5688-16.8%, Pb5689-22.8%, Pb5690-9.2%, Pb5691, Pb5692, Pb5694-17.2%, Pb5695-11.6%, Pb5696, and Pb5697.

Retusotriletes cf. *greggsii* McGregor, 1964

Plate 12, Fig. 1

1964 *Retusotriletes greggsii* McGregor, p. 8, 9, 10, pl. 1, figs. 1-12.

Description: Specimens conform to the description of McGregor (1964) with the exception of the character of the ornamentation. The present specimens appear to be slightly corroded precluding firm definition of the ornament types.

Discussion: The poor state of preservation and unclear ornament type precludes firm identification

and assignment to Retusotriletes greggsii. In the event these specimens are determined to be truly apiculate-conate they would best be refered to Apiculiretusispora (Streel, 1964) emend. Streel, 1967.

Occurrences and Stratigraphic Range: The species is known from Middle to Upper Devonian based on the following occurrences: McGregor, 1964; Kaiser, 1970a, 1970b; and von Almen, 1970a. Specimens have been recovered during the present study from samples Pb5654, Pb5659, ?Pb5680, and Pb5681 single specimen.

Genus Rhabdosporites Richardson, 1960

Type species: Rhabdosporites langii (Eisenack, 1944) Richardson, 1960, p. 54, pl. 14, figs. 8, 9, text-figs. 4, 6b.

Rhabdosporites firmus Guennel, 1963

Plate 11, Fig. 7

1963 Rhabdosporites firmus Guennel, p. 256, 257, fig. 12.

Description: Specimens conform to the description of Guennel (1963), the only exception being the overall size. The present specimens range from 80-130μm, while those reported by Guennel (1963) are 100-124μm overall diameter.

Discussion: Rhabdosporites firmus differs from other species of Rhabdosporites in having a triangular central body and less well developed rod-like ornamentation.

Occurrences and Stratigraphic Range: The genus range is Lower to Upper Devonian (Chaloner, 1967). The present occurrences represent the youngest known records of

the genus; therefore extending the range from Lower Devonian to Lower Mississippian. The only previously known occurrences of the species are Devonian (Guennel, 1963). The present study would give the species a Devonian to Lower Mississippian range. Specimens have been recovered during the present study from samples Pb5654, Pb5658, Pb5659, Pb5660, Pb5664, Pb5666, Pb5673, Pb5674, Pb5675, Pb5678, Pb5680-1.2%, Pb5681, Pb5682, Pb5683-0.4%, Pb5684-0.4%, Pb5685-0.8%, Pb5686-0.4%, Pb5687, Pb5688, Pb5690, Pb5691, Pb5694, Pb5695-0.4%, Pb5696, and Pb5697.

Genus Secarisporites Neves, 1961

Type species: Secarisporites lobatus Neves, 1961, p. 261, 262, pl. 32, figs. 6, 7.

cf. Secarisporites sp. A

Plate 12, Figs. 3, 4

1968 Secarisporites congestus Eames (mms. name) p. 77, 78, fig. 47.

Description: Spores radial, trilete; amb sub-circular to rounded triangular; diameter 45-74µm overall; laesurae, straight, simple or slightly raised, generally indistinct, extending entire radius of central portion; ornamentation distal and equatorial, irregular lobate elements, up to 12µm high and wide; ornament surfaces psilate; equatorial margin lobate, as great as 12µm wide.

Discussion: The density of the ornamentation may obscure the ridges and warts, which are a generic character (Neves, 1961). Because of this indistinct feature,

these spores may only be refered to the genus Secarisporites. Figure 4 of Plate 12 represents a single occurrence of cf. Secarisporites ?sp. A, which is circular in outline and it may be that it could be separated from cf. Secarisporites sp. A if more specimens could be observed.

Occurrences and Stratigraphic Range: The genus has been recorded from Lower Mississippian (Utting and Neves, 1970) to Upper Pennsylvanian (Sabry and Neves, 1971). The specimens of Eames (1968) and these refered to Secarisporites may be the oldest occurrences (Upper Devonian). Specimens of cf. Secarisporites sp. A have been recovered during the present study from samples Pb5661-0.4%, Pb5662, Pb5663-0.8%, Pb5664-0.4%, Pb5665-0.4%, Pb5668, Pb5670, Pb5674-0.4%, Pb5675-0.8%, Pb5694, and ?Pb5695.

Genus Simozonotriletes (Naumova, 1937) emend. Potonie and Kremp, 1954

Type species: Simozonotriletes intortus (Waltz in Luber and Waltz, 1938, pl. 2, fig. 24) Potonie and Kremp, 1954, p. 159, pl. 12, fig. 5.

Simozonotriletes spp.

Plate 12, Figs. 5, 6

Two forms of spores refered to as Simozonotriletes spp. have been encountered with rarity. Attempts to identify these froms have been unsuccessful primarily due to the confusion between the cingulate genera Murospora, Simozonotriletes, Cincturasporites, Westphalensisporites, and possibly Knoxisporites cf. (Sullivan, 1958; Playford, 1962; Hacquebard and Barss, 1957; and Smith and Butterworth, 1967).

The forms assigned to Simozonotriletes spp. are documented but not described at this time. They appear on the range chart as Simozonotriletes spp. Specimens have been recovered during the present study from samples Pb5654, Pb5659, ?Pb5664, ?Pb5667, and Pb5690 single specimen.

Genus Spelaeotriletes Neves and Owens, 1966

Type species: Spelaeotriletes triangulus Neves and Owens, 1966, p. 342, pl. 1, figs. 1-3.

Spelaeotriletes crassispinosus (Winslow, 1962) comb. nov.

Plate 12, Fig. 7

1962 Endosporites ? crassispinosus Winslow, p. 47, 48, pl. 18, figs. 7-11, pl. 19, fig. 4, text-figs. 7a, b.

1968 Spinozonotriletes speciosus Eames (mms. name) p. 81, fig. 60.

1969 Hymenozonotriletes sp. no. 2967 Lanzoni and Magloire, pl. 7, figs. 8, 9.

1969 Hymenozonotriletes sp. no. 2388 Lanzoni and Magloire, pl. 7, fig. 19, pl. 8, fig. 1.

Description: Specimens conform to the original description of Winslow (1962).

Discussion: Winslow (1962) assigned her species questionably to Endosporites. The species is considered here as being better placed in Spelaeotriletes of Neves and Owens (1966) based on the distinctly mixed ornament. Spelaeotriletes crassispinosus (Winslow, 1962) comb. nov. is here proposed.

Occurrences and Stratigraphic Range: The genus is known from Upper Devonian (Eames, 1968) to Upper Pennsylvanian (Sabry and Neves, 1971). The species range is Upper Devonian

to Lower Mississippian based on the following records: Winslow, 1962; Eames, 1968; and Lanzoni and Magloire, 1969. Specimens have been recovered during the present study from samples Pb5654, Pb5655, Pb5658, Pb5661-0.4%, Pb5664, Pb5665-0.4%, Pb5666, Pb5667, Pb5671-0.4%, Pb5672, Pb5673, Pb5675-0.4%, Pb5676, Pb5677, Pb5678, Pb5679, Pb5680-0.4%, Pb5681, Pb5682, Pb5683-0.4%, Pb5684, Pb5685-0.4%, Pb5686-0.4%, Pb5695, Pb5696, and Pb5697.

Spelaeotriletes sp. A

Plate 13, Fig. 2

Description: Spores radial, cavate, trilete; amb subcircular to broadly rounded triangular; diameter 42-62µm overall, central body 30-50µm in diameter; laesurae, simple, straight, extending entire radius of central body; exoexine, thin, ca. one µm, folds common; intexine, thin, ca. one µm; ornamentation, distal and equatorial, consisting of densely arranged, small cones and verrucae, to two µm high to two µm width.

Discussion: Specimens identified as Spelaeotriletes sp. A are similar to S. arenaceus Neves and Owens, 1966, but are consistently smaller by 20µm. The present form is distinct from other described species of Spelaeotriletes.

Occurrences and Stratigraphic Range: The specimens have been recovered during the present study in the Lower Mississippian section only from samples Pb5671, Pb5675, Pb5676-0.8%, Pb5677, Pb5679, Pb5680-0.8%, Pb5681, Pb5683-1.2%,

Pb5684, Pb5686, Pb5687, Pb5688-0.4%, Pb5690, Pb5691, Pb5694, and Pb5695.

Genus Spinozonotriletes (Hacquebard, 1957) emend. Neves and Owens, 1966

Type species: Spinozonotriletes uncatus Hacquebard, 1957, p. 316, pl. 3, figs. 8-10.

Spinozonotriletes uncatus Hacquebard, 1957

Plate 13, Figs. 1, 3

1957 Spinozonotriletes uncatus Hacquebard, p. 316, pl. 3, figs. 8-10.

1966 Grandispora sp. A Sullivan and Marshall, p. 282, pl. 4, fig. 6.

1968 Acanthotriletes bedfordensis Eames (mms. name) p. 26, fig. 4.

1968 Acanthotriletes immanis Eames (mms. name) p. 26, 27, fig. 8.

1969 Sporetrilete a grandes epines no. 3268 Lanzoni and Magloire, p. 464, 465, pl. 6, figs. 3, 4.

1969 Spinozonotriletes sp. Varma, p. 312, pl. 3, fig. 7.

1969 Grandispora reticulatus Hibbert and Lacy, p. 434, pl. 83, figs. 1, 2, 4, 5, 10.

1969 Corystisporites sp. A Brideaux and Radforth, p. 36, pl. 2, fig. 15.

1971 Grandispora uncata (Hacquebard, 1957) Playford, p. 47, 49.

Description: Specimens conform to the descriptions of Hacquebard (1957) and Playford (1963), the only exception being individuals which are found rarely as small as 64μm. The smallest size of Hacquebard (1957) was 82um and of Playford (1963), 74μm.

Discussion: Specimens of Spinozonotriletes uncatus have

been quite common in this study. The minor variations noted in this relatively large population have been the basis for the present synonymies. It was felt these species were separated on minor characters all well within the morphorange of S. uncatus.

The generic assignment has been disputed by Playford (1971). Irrespective of Playford's convincing argument, the compressional folding so common in Grandispora is not demonstrated in Spinozonotriletes and the two are considered separable here. Neves and Owens (1966) and Bertelsen (1972) also separated these two genera.

Occurrences and Stratigraphic Range: The genus range is Middle Devonian (Chaloner, 1967) to Upper Mississippian (Neves and Owens, 1966). The species range is given as Lower Mississippian to Upper Mississippian by Neves, et al. (1972), however, the species range is Upper Devonian to Upper Mississippian, based on the following records: Hacquebard, 1957; Playford, 1963, 1964, 1971; Sullivan, 1964b; Neves and Owens, 1966; Sullivan and Marshall, 1966; Streel, 1966, 1967; Barss, 1967; Eames, 1968; Brideaux and Radforth, 1969; Hibbert and Lacy, 1969; Bouckaert, Streel, Thorez, and Mound, 1969; Lanzoni and Magloire, 1969; Varma, 1969; Dolby, 1970; Dolby and Neves, 1970; Kaiser, 1970a, 1970b; McGregor, 1970; Paproth and Streel, 1970; Utting and Neves, 1970; Clayton , 1971; Johnson and Marshall, 1971; Sandberg, Streel, and Scott, 1972; and Spinner and Clayton, 1973.

Specimens have been recovered during the present study from samples Pb5654, Pb5655, Pb5657-0.4%, Pb5658-0.4%, Pb5659-0.8%, Pb5660-0.4%, Pb5661, Pb5662, Pb5663, Pb5664, Pb5665-0.4%, Pb5666, Pb5667-0.4%, Pb5668, Pb5669-0.4%, Pb5670, Pb5671-0.4%, Pb5672, Pb5673, Pb5674-0.4%, Pb5675-0.8%, Pb5676, Pb5678, Pb5679, Pb5681, Pb5682, Pb5683-0.4%, Pb5684, Pb5685-1.6%, Pb5686, Pb5687-0.8%, Pb5688, Pb5689-0.4%, Pb5690-0.8%, Pb5691, Pb5692, Pb5693, Pb5694-1.2%, Pb5695-2.0%, and Pb5696.

?Spinozonotriletes sp.

Plate 13, Fig. 5

Description: Spores radial, trilete, zonate; amb subcircular; diameter 60-90µm overall; laesurae, indistinct; ornamentation, spines, 7-20µm in length, to 5µm in width, spines often bent or recurved, occasionally expanded midway, ornament may be both distal and proximal; body of spore extremely dense, but apparently zonate.

Description: The above species are questionably referred to the genus Spinozonotriletes. Their infrequent occurrence has precluded certain identification.

Occurrences and Stratigraphic Range: Specimens have been recovered during the present study from samples Pb5659, Pb5664, and Pb5665-0.4%.

Genus Stenozonotriletes (Naumova, 1937) emend. Potonie, 1958

Type species: Stenozonotriletes conformis Naumova, 1953, p. 36, pl. 3, fig. 15.

Stenozonotriletes clarus Ishchenko, 1958

Plate 13, Fig. 4

1958 Stenozonotriletes clarus Ishchenko, p. 74, pl. 1, fig. 136.

Description: Specimens conform to the description in Hughes and Playford (1961).

Discussion: Specimens of Stenozonotriletes clarus Ishchenko, 1958, are similar to S. extensus var. major Naumova, 1953 in Hacquebard (1957) and Playford (1964). The only difference being the overall size range and width of the cingulum. S. clarus is the preferred binomial based on description and the authors preference to use the specific level rather than varieties.

Occurrences and Stratigraphic Range: The genus ranges from Lower Devonian (Chaloner, 1967) to Lower Pennsylvanian-Naumurian (Smith and Butterworth, 1967). The species range is Upper Devonian to Upper Mississippian based on the following records: Ishchenko, 1958; Hughes and Playford, 1961; Playford, 1962; Barss, 1967; Brideaux and Radforth, 1970; and Kalibova, 1971. Specimens have been recovered during the present study from samples Pb5654, Pb5655, Pb5656, Pb5658, Pb5660-1.2%, ?Pb5661, Pb5662-0.4%, Pb5665-0.4%, Pb5671-0.4%, Pb5675, and ?Pb5692.

Genus Umbonatisporites (Hibbert and Lacy, 1969) emend. Clayton, 1971

Type species: Umbonatisporites variabilis Hibbert and Lacy, 1969, p. 423, pl. 78, fig. 1.

Umbonatisporites distinctus Clayton, 1971

Plate 13, Figs. 6-8

1960a Apiculatisporites sp. Balme, p. 28, pl. 4, figs. 10, 11.

1971 Umbonatisporites distinctus Clayton, p. 591, 592, pl. 4, figs. 4-6.

1971 Acanthotriletes turriculaeformis Kemp and Playford in Playford, p. 20, pl. 6, figs. 7-15.

1972 Umbonatisporites distinctus Clayton, 1971, in Playford, p. 305, 307, figs. 2-13, 23b.

Description: Specimens conform to the descriptions of Clayton (1971) and Playford (1972).

Discussion: Other taxa which appear to be similar on the basis of descriptions and illustrations are Umbonatisporites abstrusus (Playford, 1964) Clayton, 1971 and Acanthotriletes rarisetosus (Kedo, 1963, fig. 43). Umbonatisporites abstrusus has several types of biform elements on individual specimens thus being separated specifically from U. distinctus. Acanthotriletes rarisetosus has elements described by Kedo (1963) as short, simple bristles, therefore excluding it from Umbonatisporites distinctus.

Occurrences and Stratigraphic Range: The genus ranges from Lower Mississippian-post Tn-1b (Clayton, 1971) to Upper Mississippian-Visean (Hibbert and Lacy, 1969). The species range is Lower Mississippian-post Tn-1b to Upper Mississippian-Visean based on the following records: Balme, 1960; Clayton, 1971; Playford, 1971, 1972; and Neves, et al., 1972. Specimens have been recovered during the present study from samples ?Pb5667, Pb5668, Pb5670, Pb5671-0.4%, Pb5672,

Pb5674-1.6%, Pb5675-0.8%, Pb5676, Pb5677, Pb5678, Pb5679-0.4%, Pb5680-0.8%, Pb5681, Pb5682, Pb5683-0.8%, Pb5684, Pb5686-0.4%, Pb5687-1.2%, Pb5688-0.8%, Pb5689-2.4%, Pb5690-0.8%, Pb5691, Pb5692, Pb5693, Pb5694-0.4%, and Pb5695-0.4%.

Umbonatisporites sp.

Plate 14, Fig. 1

Description: Spores radial, trilete; amb sub-circular to rounded-triangular; diameter 120-160µm overall; laesurae, indistinct, represented by infolding of exine; exine, ca. 4-5µm thick, often folded or split; ornamentation, biform elements of clavate-capitate-spinate nature, less than 10µm high, ca. 3-4µm basal width, sparsely distributed distally and equatorially.

Discussion: Specimens of Umbonatisporites sp. are very rare, but except for the larger overall size are similar to U. distinctus. It is possible Umbonatisporites sp. is an extremely large form of U. distinctus.

Occurrences and Stratigraphic Range: Specimens have been recovered during the present study from samples Pb5671, Pb5686, and Pb5694.

Genus Vallatisporites Hacquebard, 1957

Type species: Vallatisporites vallatus Hacquebard, 1957, p. 312, 313, pl. 2, fig. 12.

Vallatisporites pusillites (Kedo, 1957) Dolby and Neves, 1970

Plate 14, Figs. 3-5

1957 Hymenozonotriletes pusillites Kedo, v. 1, pl. 1, fig. 1.

1960a Cirratriradites sp. A Balme, pl. 5, fig. 23.

1960a Cirratriradites sp. B Balme, pl. 5, fig. 24.

1960a Cirratriradites sp. C Balme, pl. 5, fig. 25.

1960a cf. Cirratriradites sp. Balme, pl. 5, fig. 27.

?1960a ?Densosporites sp. Balme, pl. 5, fig. 22.

1962 Cirratriradites hystricosus Winslow, p. 41, 42, pl. 18, fig. 5.

1962 Cirratriradites sp. A Winslow, p. 42, pl. 18, figs. 1, 2.

1962 Cirratriradites sp. B (pars.) Winslow, p. 42, pl. 18, figs. 6, 12.

1964 Vallatisporites banffensis Staplin and Jansonius, p. 112, 113, pl. 21, figs. 7-12, text-fig. 21.

?1968 ?Vallatisporites sp. Brown, p. 120, 121, pl. 5, figs. 48, 49.

1968 Vallatisporites acanthus Eames (mms. name) p. 85, 86, fig. 63.

1968 Vallatisporites delicatus Eames (mms. name) p. 86, 87, fig. 64.

1968 Vallatisporites sullivanii Eames (mms. name) p. 88, 89, fig. 62.

1969 ?Vallatisporites sp. no. 2954 Lanzoni and Magloire, pl. 2, fig. 6, 7.

1969 Densosporites sp. no. 3241 Lanzoni and Magloire, pl. 2, figs. 10, 11.

1969 Cristatisporites sp. no. 3233 Lanzoni and Magloire, pl. 2, figs. 18, 19.

?1969 Cingulizonates sp. no. 3282 Lanzoni and Magloire, pl. 2, fig. 20, pl. 3, figs. 1, 2.

?1969 Densosporites sp. no. 2913 Lanzoni and Magloire, pl. 3, figs. 5, 6.

?1970a Cingulizonates sp. A von Almen, p. 58, 59, pl. 9, figs. 3, 6.

?1970a Cingulizonates sp. B von Almen, p. 59, 60, pl. 9, figs. 4, 5, 7, 8, 10.

1970 Vallatisporites pusillites (Kedo, 1957) Dolby and Neves, p. 639, pl. 2, figs. 1-4.

1971 ?Hymenozonotriletes spinosus Kalibova, p. 307, 308, pl. 4, figs. 8-13.

?1971 Hymenozonotriletes sp. A Kalibova, p. 308, pl. 4, fig. 17.

1972 ?Hymenozonotriletes spinosus Kalibova in Kalibova-Kaiserova pl. 4, figs. 16, 17.

?1972 Cristatisporites sp. A Kalibova-Kaiserova, pl. 4, fig. 14.

Description: Specimens conform to the description in Dolby and Neves (1970).

Discussion: Although the species has been reported in numerous studies there have been no previous attempts to assemble a list of synonymous specimens. The above synonymy is based on descriptions and illustrations, with many of the questionable assignments representing illustrated but undescribed forms. The extreme variability of the species is evident in the illustrations of Kedo (1963). The most important geographic and stratigraphic occurrences are discussed in Streel (1970).

Occurrences and Stratigraphic Range: The genus is reported from the upper Lower Devonian (Chaloner, 1967) to Middle Pennsylvanian (Peppers, 1970) with the most common occurrences in the Upper Devonian and Mississippian. The species has frequent records (see synonymy and Streel, 1970). The range of the species is Upper Devonian-Lower Mississippian based on the above records and the following post-1970

occurrences: Neves, et al. 1972; Sandberg, Streel, and Scott, 1972; and Warg and Traverse, 1973.

Specimens have been recovered during the present study from samples Pb5651-2.4%, Pb5652-2.4%, Pb5653-1.6%, Pb5654-1.6%, Pb5655-2.8%, Pb5656-1.2%, Pb5657-2.0%, Pb5658-6.4%, Pb5659-2.4%, Pb5660, Pb5662, Pb5663-0.4%, Pb5665-0.4%, Pb5667-0.4%, Pb5668, Pb5671-3.6%, Pb5672, Pb5673, Pb5674-4.4%, Pb5675-4.4%, Pb5676-4.8%, Pb5677, Pb5678, Pb5679-4.8%, Pb5680-3.2%, Pb5681, Pb5682, Pb5683-4.0%, Pb5684-2.8%, Pb5685-1.2%, Pb5686-8.8%, Pb5687-0.8%, Pb5688, Pb5689, and Pb5690-0.8%.

Vallatisporites splendens Staplin and Jansonius, 1964

Plate 14, Fig. 12

1964 Vallatisporites splendens Staplin and Jansonius, p. 113, pl. 21, figs. 13, 14, text-fig. 2k.

Description: Specimens conform to the original description of Staplin and Jansonius (1964) with the exception of a larger overall size range 56-72μm, whereas that of Staplin and Jansonius (1964) is 59-61μm.

Discussion: The wart-like irregular verrucae with apiculi distinguish this species from other forms of Vallatisporites.

Occurrences and Stratigraphic Range: The species range is Upper Devonian to Lower Mississippian, but primarily Lower Mississippian based on the following records: Staplin and Jansonius, 1964; Eames, 1968; and Lanzoni and Magloire, 1969. Specimens have been recovered during the

present study from samples Pb5671-0.4%, Pb5672, Pb5674, Pb5675, Pb5676-0.8%, Pb5677, Pb5678, Pb5679, Pb5680-0.8%, Pb5683-0.8%, Pb5684, Pb5686-0.4%, and Pb5687.

Vallatisporites vallatus Hacquebard, 1957

Plate 15, Figs. 1, 2

1957 Vallatisporites vallatus Hacquebard, p. 312, 313, pl. 2, fig. 12.

1969 Radiizonates sp. no. 2922 Lanzoni and Magloire, pl. 2, figs. 14, 15.

?1969 Vallatisporites sp. Varma, p. 313, pl. 3, fig. 10.

Description: Specimens conform to the descriptions of Hacquebard (1957) and Staplin and Jansonius (1964).

Discussion: Although no description was given, Radiizonates sp. no. 2922 in Lanzoni and Magloire (1969) is believed to represent Vallatisporites vallatus. Varma (1969) has described Vallatisporites sp., a form that is larger than V. vallatus, but otherwise it appears to be conspecific.

Occurrences and Stratigraphic Range: The species range is Upper Devonian to Lower Mississippian based on the following records: Hacquebard, 1957; Playford, 1964; Staplin and Jansonius, 1964; Barss, 1967; Eames, 1968; Sullivan, 1968; Hibbert and Lacy, 1969; Lanzoni and Magloire, 1969; Varma, 1969; Combaz and Streel, 1970; Dolby, 1970; Johnson and Marshall, 1971; and Sandberg, Streel, and Scott, 1972.

Specimens have been recovered during the present study from samples Pb5652, Pb5654, Pb5667, Pb5681, and Pb5688.

Vallatisporites verrucosus Hacquebard, 1957

Plate 14, Figs. 6-8

1957 Vallatisporites verrucosus Hacquebard, p. 313, pl. 2, fig. 13.

1957 Lycospora torulosa Hacquebard, p. 312, pl. 2, fig. 11.

1962 Lycospora sp. A Winslow, p. 40, 41, pl. 18, figs. 3, 3a, 4, 4a.

1964 Lycospora torulosa Hacquebard, 1957 in Playford, p. 35, pl. 10, fig. 6.

1967 Lycospora torulosa Hacquebard, 1957 in Barss, pl. 4, fig. 3.

1968 Lycospora torulosa Hacquebard, 1957 in Sullivan, p. 123, pl. 26, fig. 10.

1969 Densosporites sp. no. 3225 Lanzoni and Magloire, pl. 3, figs. 3, 4.

?1969 Vallatisporites microgalearis Hibbert and Lacy, p. 433, pl. 82, figs. 4, 5, 7, 9-12.

Description: Specimens conform to the description of Hacquebard (1957) with the only exception being a broader size range due to the inclusion of specimens formerly assigned to Lycospora torulosa. The present size range is 35-68µm.

Discussion: Lycospora torulosa is considered to be synonymous with Vallatisporites verrucosus because the species as described and illustrated by several authors (see synonymy) are not clearly separable. Playford (1964) has mentioned the similar morphology of the two species.

Vallatisporites microgalearis of Hibbert and Lacy (1969) is considered as a questionable synonym because although the character of the ornament of V. verrucosus is variable, the

biform elements microgaleae may be more common on Hibbert and Lacys' specimens. This is a minor variation and the two species may ultimately be considered as conspecific.

Occurrences and Stratigraphic Range: The species range is from Upper Devonian to Middle Mississippian based on the following records: Hacquebard, 1957; Winslow, 1962; Playford, 1964; Barss, 1967; Eames, 1968; Sullivan, 1968; Hibbert and Lacy, 1969; Varma, 1969; Dolby, 1970; and Sandberg, Streel, and Scott, 1972.

Specimens have been recovered during the present study from samples Pb5651-2.8%, Pb5652-3.2%, Pb5653-2.0%, Pb5654-1.2%, Pb5655-6.8%, Pb5656-1.6%, Pb5657-1.6%, Pb5658-4.4%, Pb5659-0.8%, Pb5660, Pb5662-0.8%, Pb5663, Pb5664-0.8%, Pb5665-1.2%, Pb5667-0.8%, Pb5668-0.4%, Pb5671-0.4%, Pb5672, Pb5674, Pb5675-0.4%, Pb5676, Pb5679-0.4%, Pb5681, Pb5684, and Pb5685.

Vallatisporites sp. A

Plate 14, Fig. 2

1962 Cirratriradites sp. B Winslow, p. 42, pl. 18, figs. 6, 12.

1963 Hymenozonotriletes pusillites Kedo, 1957, var. major Kedo, p. 66, 67, pl. 6, fig. 143.

1968 Kraeuselisporites murispinosus Eames (mms. name) p. 60, 61, fig. 41.

1968 Kraeuselisporites splendens Eames (mms. name), p. 61, 62, fig. 37.

1969 Vallatisporites sp. no. 3324 Lanzoni and Magloire, pl. 3, figs. 7, 8.

1972 Vallatisporites pusillites var. major (Kedo) Dolby and Neves in Sandberg, Streel, and Scott, pl. 4, fig. 10.

Description: Spores radial, trilete, cavate; amb rounded-triangular; diameter 72-106μm overall; central body 45-70μm; laesurae, simple, straight, generally distinct; rays accompanied by raised sinuous folds in the exoexine, extending entire radius of central body; folds adjacent to rays occasionally extend to equator; ornamentation of distal and equatorial spines, generally simple, occasionally with expanded bases and fused to adjacent elements; spines 5-12μm in length, 2-6μm basal width; spines quite variable in density; equatorial spines reduced in size and numbers; exoexine, thin, rarely folded, separated from denser intexine by a cuniculus (Vallati-groove).

Discussion: The above species is believed to be conspecific with Hymenozonotriletes pusillites Kedo, 1957 var. major Kedo, 1963. Dolby and Neves (1970) assigned the species in a new combination to Vallatisporites, but did not treat the variety in their discussion. Sandberg, Streel, and Scott (1972) have illustrated a specimen representing the variety V. pusillites var. major and have included it in the Dolby and Neves new combination with Vallatisporites. This usage is invalid because the variety was not included in Dolby and Neves new combination. Because the variety is distinct and separable from Vallatisporites pusillites it would be best assigned to a new species of Vallatisporites to which it clearly belongs.

Vallatisporites sp. A is distinguished from V. pusillites on the basis of its larger size, larger ornament, and lack

of a bizonate-appearing flange. The overall size range for V. sp. A is 72-106μm as contrasted with V. pusillites 42-73μm.

Occurrences and Stratigraphic Range: The species has been recorded in Upper Devonian and Lower Mississippian sediments based on the synonymy occurrences. Specimens have been recovered during the present study from samples Pb5654-0.4%, Pb5655-0.4%, Pb5656-0.4%, Pb5657-0.4%, Pb5658-1.6%, Pb5659-0.8%, Pb5660, Pb5674, and Pb5675.

Vallatisporites sp. B

Plate 14, Fig. 9

1968 Kraeuselisporites galeispinosus Eames (mms. name) p. 59, 60, fig. 42.

Description: Spores radial, trilete, cavate; amb rounded-triangular, diameter 50-73μm overall; central body 36-48μm; laesurae simple, straight, distinct, extending entire radius of central body; exoexinal folds often raised accompanying rays and extending almost to equatorial margin; ornamentation distal, galeae and biform spines to 10μm in length and 3-6μm basal width; ornament reduced on zona; equatorial margin slightly serrate; exoexine thin separated from thin intexine by a cuniculus.

Discussion: Specimens of Vallatisporites sp. B may be related to V. ciliaris (Luber, 1938) Sullivan, 1964a, V. communis Sullivan, 1964b, V. galearis Sullivan, 1964a, and Hymenozonotriletes? hastulus Sullivan, 1968. Because of the minor differences between the above species direct comparisons of the type materials would be advisable prior to

establishment of Vallatisporites sp. B as a new form. The significance of the comparisons of the descriptions and illustrations is unsatisfactory at the present time.

Occurrences and Stratigraphic Range: The specimens that are believed to be most similar to Vallatisporites sp. B type are most common in the Lower Mississippian (Sullivan, 1964a, 1968). Specimens of Vallatisporites sp. B have been recovered during the present study from samples Pb5651, Pb5652-0.4%, Pb5654, and Pb5660.

Vallatisporites sp. C

Plate 14, Figs. 10, 11

1968 Vallatisporites annulatus Eames (mms. name) p. 86, fig. 55.

Description: Spores radial, trilete, cavate; amb rounded-triangular; diameter 23-34µm overall; central body 16-23µm; laesurae simple, straight, generally distinct, extending entire radius of central body; rays accompanied by exoexinal folds, appearing sinuous and raised; folds extending rarely to equatorial margin; ornamentation distal, grana and simple spines; spines best developed at equator; maximum spine length 5µm; exoexine and intexine thin, separated from each other by a cuniculus.

Discussion: The Vallatisporites sp. C type has not been reported in the literature. This is believed to represent a new species. This form is the smallest representative of Vallatisporites known. The species included in the synonymy of Eames (1968) has been described as slightly larger than those of the present assemblage; however, they

are conspecific. Figure 10 of Plate 14 is a specimen 27um in diameter from Eames (1968).

Occurrences and Stratigraphic Range: Specimens of Vallatisporites sp. C have been found only in the Upper Devonian (Eames, 1968) and from the present study in samples Pb5651-2.4%, Pb5652-2.4%, Pb5653-4.4%, Pb5654-0.4%, Pb5655-1.2%, Pb5656-0.4%, Pb5657-0.4%, Pb5659-0.4%, and Pb5660.

Vallatisporites sp. D

Plate 15, Figs. 3, 4

1968 Vallatisporites tenuispinosus Eames (mms. name) p. 89, fig. 65.

Description: Spores radial, trilete, cavate; amb broadly rounded triangular; diameter 42-58μm overall; central body 30-40μm; laesurae simple, straight, generally distinct, extending entire radius of central body; rays accompanied by exoexinal folds, appearing raised and extending almost to equatorial margin; ornamentation distal and equatorial slender spines, variable in density, occasionally with expanded bases, 4-10μm in length, generally less than 5μm basal width; spines most prominent at equatorial margin; exoexine and intexine thin, separated by a cuniculus, occasionally indistinct.

Discussion: The illustrations of Vallatisporites sp. D. here are extreme forms, showing maximum differences of the species variation. It is entirely possible that V. sp. D may represent more than one species. However, this form is used to distinguish forms with prominent spinose margins of generally simple spines.

Occurrences and Stratigraphic Range: The species is known from Upper Devonian (Eames, 1968) and Lower Mississippian sediments. Specimens have been recovered during the present study from samples Pb5651-0.4%, Pb5653-0.4%, Pb5654-1.2%, Pb5656, Pb5658-0.4%, ?Pb5675, and Pb5680.

Genus Verrucosisporites (Ibrahim, 1933) emend. Smith and Butterworth, 1967

Type species: Verrucosisporites verrucosus (Ibrahim, 1932) Ibrahim, 1933, p. 25, pl. 2, fig. 17.

Verrucosisporites depressus Winslow, 1962

Plate 15, Figs. 5, 6

1962 Verrucosisporites depressus Winslow, p. 63, pl. 19, fig. 7.

Description: Spores radial, trilete; amb circular to subcircular; diameter 28-75µm (commonly 43-56µm); laesurae distinct, dependent on orientation, simple, straight, extending 2/3 to 3/4 spore radius; exine 1-3µm thick, rarely folded or split; ornamentation dense, small verrucae, generally less than two µm in height, basal diameter less than three µm, distribution comprehensive; ornamentation consistent on individual specimens.

Discussion: Specimens differ only slightly from the description of Winslow (1962). The noted differences are the broader size range and slightly thicker exine in the specimens observed in this study. Cyclogranisporites commodus Playford, 1964, has a thinner exine and is commonly folded. Granulatisporites crenulatus Playford, 1964, is ornamented

with grana approaching the smallest elements of Verrucosisporites depressus Winslow, 1962, but is triangular in outline.

Occurrences and Stratigraphic Range: The genus ranges from upper Lower Devonian (Chaloner, 1967) to Lower Permian (Hoffmeister, Staplin, and Malloy, 1955a). Similar morphologic forms are known from Mesozoic and Cenozoic sediments by other generic names. The species has had infrequent records in the Upper Devonian and Lower Mississippian (Winslow, 1962, and Eames, 1968).

Specimens have been recovered during the present study from samples Pb5652-0.4%, Pb5654-0.8%, Pb5659-0.4%, Pb5660, Pb5661-3.6%, Pb5662-0.8%, Pb5663, Pb5664, Pb5667, Pb5668, Pb5669-0.4%, Pb5670-0.4%, Pb5671-0.8%, Pb5674-1.2%, Pb5675-0.8%, Pb5683, Pb5684, Pb5685, Pb5686-0.4%, Pb5687, Pb5688, Pb5689, Pb5694, and Pb5697.

Verrucosisporites nitidus (Naumova, 1953) Playford, 1964

Plate 15, Figs. 7, 8

1953 Lophotriletes grumosus Naumova, p. 57, pl. 7, figs. 14, 15.

1956 Lophotriletes aff. grumosus Naumova, 1953 in Ishchenko, p. 40, pl. 7, fig. 74.

1964 Verrucosisporites nitidus (Naumova, 1953) Playford nom. nov., p. 13, 14, pl. 3, figs. 3-6.

1964b Verrucosisporites grumosus (Naumova, 1953) Sullivan, p. 1252, 1253, pl. 1, figs. 9-15.

1969 Verrucosisporites sp. no. 2904 Lanzoni and Magloire, pl. 4, figs. 3, 4.

1971 "Verrucosisporites grumosus" (Naumova, 1953) Sullivan, 1968, in Johnson and Marshall, pl. 23, fig. 1.

1971 Verrucosisporites nitidus (Naumova, 1953) Playford nom. nov. 1964, in Playford, p. 15, 16, pl. 3, figs. 1-6.

Description: Specimens conform to the descriptions given in Playford (1964 and 1971) and Sullivan (1964b).

Discussion: The combination of Sullivan (1964b) was invalid because of the preoccupied status of the specific epithet Verrucosisporites grumosus of Ibrahim (1933), which was pointed out in Playford (1964) where the new name was established. The variability of Verrucosisporites nitidus has been discussed briefly by Playford (1971). Further variability which confuses specific assignments are the overlapping size range of ornamentation and overall dimensions between V. nitidus and V. congestus. However, considering both species as synonymies would create a much greater range of variability than now exists.

Occurrences and Stratigraphic Range: The species range is Upper Devonian to Lower Mississippian based on the following records: Naumova, 1953; Ishchenko, 1956; Playford, 1964 and 1971; Sullivan, 1964b; Barss, 1967; Brown, 1968; Eames, 1968; Varma, 1969; Combaz and Streel, 1970; Dolby, 1970; Dolby and Neves, 1970; Paproth and Streel, 1970; Utting and Neves, 1970; Clayton, 1971; Johnson and Marshall, 1971; Bertelsen, 1972; and Neves, et al. 1972.

Specimens have been recovered during the present study from samples Pb5660, Pb5661, Pb5662-0.4%, Pb5663-0.8%, Pb5664-0.4%, Pb5665-0.4%, Pb5667, Pb5668, Pb5669-1.2%, Pb5670-0.4%, Pb5671-2.4%, Pb5674-0.8%, Pb5675-0.8%, Pb5676-2.8%, Pb5677, Pb5678, Pb5679-2.4%, Pb5680-0.8%, Pb5681, Pb5682, Pb5683-

2.4%, Pb5684-2.4%, Pb5685-0.8%, Pb5686-0.8%, Pb5687-3.2%, Pb5688-4.8%, Pb5689-5.6%, Pb5690-3.2%, Pb5691, Pb5693, Pb5694-2.4%, Pb5695-0.8%, and Pb5696.

Verrucosporites cf. nitidus (Naumova, 1953) Playford, 1964

Plate 15, Figs. 10, 11

Description: Spores radial, trilete; amb circular to subcircular; diameter 36-48µm overall; laesurae generally indistinct, straight, simple, extending 3/4 spore radius; ornamentation large, irregular verrucae, 8 to 14µm in basal width, to 6µm high; surface of verrucae and spore psilate; equatorial margin lobate, dependent on orientation; exine 2-4µm thick, rarely folded.

Discussion: During the course of the study these small diameter large verrucate forms were encountered. These forms referred to as Verrucosisporites cf. nitidus fall within the range of V. nitidus. However, the coarse forms occurred only in the Lower Mississippian section and were tabulated separately.

Occurrences and Stratigraphic Range: Specimens of Verrucosisporites cf. nitidus were recovered from samples Pb5671, Pb5674-0.4%, Pb5675-0.4%, Pb5676, Pb5677, Pb5678, Pb5679, Pb5680-0.8%, Pb5681, Pb5682, Pb5683, Pb5684-0.4%, Pb5687-0.8%, Pb5688-0.4%, Pb5690, Pb5691, and Pb5694.

Verrucosisporites papulosus Hacquebard, 1957

Plate 15, Fig. 9

1957 Verrucosisporites papulosus Hacquebard, p. 311, pl. 2, figs. 4, 5.

Description: Specimens conform to the descriptions of Hacquebard (1957) and Playford (1964).

Discussion: Playford (1964) stated that the arcuate folding was uncommon, while Hacquebard (1957) considered the folds to be common. Virtually all of the specimens encountered here have arcuate folds present.

Occurrences and Stratigraphic Range: The species is known primarily from Lower Mississippian sediments with Upper Devonian occurrences uncommon. The species has been recorded by: Hacquebard, 1957; Playford, 1964; Barss, 1967; Eames, 1968; Varma, 1969; and Kaiser, 1970a.

Specimens have been recovered during the present study from samples Pb5658, Pb5661-0.8%, Pb5662-0.4%, Pb5663-0.8%, Pb5665, Pb5667, Pb5670, Pb5671-2.0%, Pb5674-1.6%, Pb5675-1.2%, Pb5676-1.6%, Pb5677, Pb5679-2.0%, Pb5680-0.8%, Pb5681, Pb5682, Pb5683-0.8%, Pb5684-1.6%, Pb5685, Pb5686-1.2%, Pb5687-0.4%, Pb5688-0.4%, Pb5689-1.2%, Pb5692, and ?Pb5694.

Group ACRITARCHA Evitt, 1963

Subgroup Acanthomorphitae Downie, Evitt, and Sarjeant, 1963

Genus Baltisphaeridium (Eisenack, 1958) emend. Downie and Sarjeant, 1963

Type species: Baltisphaeridium (al. Ovum hispidum) longispinosum (Eisenack, 1931, p. 110, pl. 5, figs. 6-17) Eisenack, 1958.

Baltisphaeridium lucidum (Deunff, 1958) Downie and Sarjeant, 1963

Plate 16, Figs. 1, 2

1958 Hystrichosphaeridium lucidum Deunff, p. 25, 26, pl. 9, figs. 80, 82, 83, 85-89.

1962 Hystrichosphaeridium cf. H. longispinosum (Eisenack) Eisenack, 1938, in Winslow, p. 76, 77, pl. 19, figs. 3, 3a, pl. 22, figs. 5-7.

1963 Baltisphaeridium lucidum (Deunff, 1958) Downie and Sarjeant, p. 90.

Description: Acanthomorphic acritarchs; vesical variably circular-subcircular-polygonal in outline, diameter 20-34μm; processes (10-22) uniformly distributed, gently tapered to a single point, 18-34μm in length, 2-6μm basal width; processes hollow at base becoming closed or solid near tips; wall psilate, ca. 1μm thick, generally hyaline in appearance.

Discussion: Baltisphaeridium lucidum is morphologically similar to Micrhystridium stellatum Deflandre, 1945. The two species are separated only by vesicle size as is true also at the generic level, i.e., Baltisphaeridium vesicle > 20μm and Micrhystridium vesicle < 20μm. The

recent emendation of Baltisphaeridium by Eisenack (1969) greatly restricts the genus. Because B. lucidum was not discussed at that time the ultimate assignment of the species is uncertain. Thus until this very large genus is treated monographically and the many problematic species of Baltisphaeridium are sorted out, this species is retained as B. lucidum.

Occurrences and Stratigraphic Range: The genus ranges from Cambrian (Naumova, 1950) to Recent (Churchill and Sarjeant, 1963). This generic range would be restricted to pre-Silurian forms if Eisenack (1969) were to be followed. The species is known from the Middle Ordovician (Deunff, 1958), the Chagrin, Cleveland, and Bedford shales of Ohio (Winslow, 1962), the Dinantian (Stockmans and Williere, 1966), the Lower Mississippian (Brown, 1968) and the Devonian-Mississippian of this study in samples Pb5658, Pb5660, Pb5661, Pb5662, Pb5665, Pb5669, Pb5670, Pb5673, Pb5687, Pb5688, Pb5689, Pb5690, Pb5691, Pb5694, and Pb5695. The species is very common in the Meadville Shale with occurrences up to 13% of the total assemblage in sample Pb5687.

Genus Gorgonisphaeridium Staplin, Jansonius, & Pocock, 1965

Type species: Gorgonisphaeridium winslowii Staplin, Jansonius & Pocock, 1965, p. 193, pl. 19, figs. 11, 18-20; text-fig. 4.

Gorgonisphaeridium ohioensis (Winslow, 1962) n. comb.

Plate 16, Figs. 4, 5

1962 Hystrichosphaeridium ohioensis Winslow, p. 77, pl. 19, fig. 1, pl. 22, fig. 9.

1964 Baltisphaeridium ohioensis (Winslow, 1962) Downie & Sarjeant, p. 93.

Description: Specimens conform to the diagnosis given by Winslow (1962, p. 77). An additional important part of the description not mentioned by Winslow is that of solid or hollow processes. All specimens observed in this study have solid processes.

Discussion: The above species is transferred to Gorgonisphaeridium on the basis of its having solid processes and other generic characters described by Staplin, Jansonius, and Pocock (1965, p. 192). The assignment to Baltisphaeridium ohioensis (Winslow, 1962) Downie and Sarjeant, 1964 was correct at that time. However, the recent emendation of Baltisphaeridium by Eisenack (1969) greatly restricts the genus making Baltisphaeridium no longer suitable for this species. Staplin, Jansonius, and Pocock (1965) suggested the transfer to Gorgonisphaeridium, but probably could not establish the solid process character from Winslow's description or illustrations. Two specimens in Lanzoni and Magloire (1969) figured as Baltisphaeridium sp. no. 419-47, may be synonymous, but no description was provided.

Occurrences and Stratigraphic Range: The generic range is given by Staplin, Jansonius, and Pocock (1965) as basal Upper Devonian through Lower Carboniferous. Recently Lister (1970) has described specimens assignable to the

genus from Wenlockian (Middle Silurian). From these occurrences the genus ranges from Middle Silurian (Wenlockian) through Lower Carboniferous. The species has been reported by Winslow (1962) from the Ohio Shale, Bedford Shale, and Berea Sandstone in Ohio, and in this study, Devonian-Mississippian of Ohio, in samples Pb5654, Pb5659, Pb5661, Pb5671, Pb5674, and Pb5684.

Gorgonisphaeridium cf. spicatum (Staplin, 1961a) Staplin, Jansonius, and Pocock, 1965

Plate 16, Fig. 3

1961a Multiplicisphaeridium spicatum Staplin, p. 411, pl. 49, fig. 21, text-fig. 91.

Description: Acanthomorphic acritarch; vesicle circular in outline; wall rigid, ca. one µm in thickness; surface psilate to chagrinate; dense, solid processes; bases bulbous, two µm in width, ca. five µm in length, tips bifurcated; diameter of vesicle 30µm for one single specimen found in this study.

Discussion: This specimen is considerably smaller than those originally described by Staplin (1961a) 63-72µm in diameter. In the absence of more specimens the recovered specimen, although morphologically similar, cannot be firmly identified as being conspecific.

Occurrences and Stratigraphic Range: Staplin (1961a) Upper Devonian, Duvernay Formation, Alberta and in this study a single occurrence from the Berea Sandstone in sample Pb5654.

Gorgonisphaeridium winslowii Staplin, Jansonius, and Pocock, 1965

Plate 16, Figs. 8, 9

1965 Gorgonisphaeridium winslowii Staplin, Jansonius, and Pocock, p. 193, figs. 11, 18-20; text-fig. 4.

Description: Morphology is as described by Staplin, Jansonius, and Pocock (1965) with the exception of a slightly broader size range. The specimens range from 38μm to 58μm in vesicle diameter.

Discussion: Gorgonisphaeridium winslowii is differentiated from G. ohioensis on the basis of simple and branched process tips as opposed to simple processes only. Combaz and Streel (1970) report a size range of 20-25μm for G. winslowii from Pas-de-Calais, France. Their size range considered with that of Staplin, Jansonius, and Pocock (1965) includes a rather broad size range for the species of 20μm-80μm.

Occurrences and Stratigraphic Range: Staplin, Jansonius, and Pocock (1965) Lower Mississippian Banff Formation, southern Alberta. Combaz and Streel (1970) as the dominant acritarch in the Lower Tournaisian, Pas-de-Calais, France. This study Berea Sandstone (Devonian) of Ohio in samples Pb5654 and Pb5659. In addition Combaz and Streel (1970) suggest the possibility of the species being a stratigraphic marker for the Tn-1 (uppermost Devonian).

Genus Micrhystridium (Deflandre, 1937) emend. Lister, 1970

Type species: Micrhystridium (al. Hystrichosphaera) inconspicum (Deflandre, 1935) p. 233, pl. 9, figs. 11, 12. Deflandre, 1937, p. 79.

For a detailed discussion of the genus, see Lister (1970).

Micrhystridium cf. bistchoensis Staplin, 1961a

Plate 16, Figs. 6, 7

1961a Micrhystridium bistchoensis Staplin, p. 409, pl. 48, fig. 15.

Description: Acanthomorphic acritarchs; vesicles circular to subcircular in outline, 15-20μm in diameter; processes broad at base, 5-10μm in length, pointed at apices; surface of vesicle and processes psilate.

Discussion: Specimens are referred to the species of Staplin (1961a) although they are consistantly smaller in overall diameter. However, specimens described by Brown (1968) as Micrhystridium bistchoensis Staplin appear to be identical to those recovered in this study.

Occurrences and Stratigraphic Range: The genus ranges from Cambrian to Tertiary (Downie, 1973). The species has been found in the Upper Devonian (Staplin, 1961a) and Lower Mississippian (Brown, 1968). Specimens have been recovered during the present study from samples Pb5660 and Pb5670.

Micrhystridium echinosum Staplin, 1961a

Plate 16, Figs. 10, 11

1961a Micrhystridium echinosum Staplin, p. 408, pl. 48, fig. 14.

Description: Acanthomorphic acritarchs; vesicle subcircular in outline, 19-22um in diameter; processes, dense, echinate with rounded apices, 2-4um in length; surface between processes psilate.

Discussion: Specimens conform to those described by Staplin (1961a).

Occurrences and Stratigraphic Range: The species has been reported only from the Upper Devonian (Staplin, 1961a). Specimens have been recovered during the present study from samples Pb5653, Pb5665, and Pb5678.

Micrhystridium stellatum Deflandre, 1945

Plate 17, Figs. 1, 2

For a detailed synonomy and description of the species, see Lister (1970).

Description: Acanthomorphic acritarchs; vesicles subcircular to subpolygonal in outline, 14-20μm in diameter; processes variable in number and dimensions, generally 5-18μm in length and consistant in any single specimen; surface of vesicle and processes psilate.

Discussion: This species represents a complex spectrum that appears quite heteromorphic between end members. This variability within the species is well illustrated in the plates of Wall and Downie (1963). The species is rightfully often referred to as the "M. stellatum complex".

Occurrences and Stratigraphic Range: A comprehensive list of occurrences with a stratigraphic range of Lower Silurian to Lower Triassic is given for the species by Lister (1970). Specimens have been recovered during the present study from samples Pb5654, Pb5660, Pb5668, Pb5669, Pb5670, Pb5687, Pb5688, Pb5690, and Pb5695.

Genus Multiplicisphaeridium (Staplin, 1961a) emend. Lister, 1970

Type species: Multiplicisphaeridium ramispinosum Staplin, 1961a, p. 411, pl. 48, fig. 24, text-figs. 9g, 9h.

Multiplicisphaeridium ramispinosum Staplin, 1961a

Plate 17, Fig. 4

1961a Multiplicisphaeridium ramispinosum Staplin, p. 411, pl. 48, fig. 24, text-figs. 9g, 9h.

Description: Specimens conform to the diagnosis given by Staplin (1961a).

Discussion: The complexity of the genus as well as its controversial aspects have been discussed in detail by Lister (1970). Differences between Multiplicisphaeridium ramispinosum and geologically older species are slight, but no comparisons or recombinations are reasonable here since only 2 specimens were found during this study.

Occurrences and Stratigraphic Range: The genus ranges from Upper Ordovician to Lower Carboniferous (Downie, 1973). The range of the species is Upper Devonian (Staplin, 1961a), Middle Devonian (von Almen, 1970a), and in the present study single occurrences in samples Pb5664 and Pb5673. These occurrences cannot be used with certainty for age assignment because their occurrence here, in the Cuyahoga Group (Lower Mississippian), may be due to reworking or they could represent an extension of range. The species is generally considered to be restricted to the Devonian.

Multiplicisphaeridium sp.

Plate 17, Fig. 3

Description: Acanthomorphic acritarchs; vesicle subcircular in outline, diameter 24-30μm; processes 13 at equator, uniform, multifurcated, to 10μm in length, ca. two μm in width, apparently hollow, flattened in appearance; vesicle wall thin, psilate.

Discussion: The flattened appearance of the processes as well as the length do not compare with any of the described species of Multiplicisphaeridium. The two specimens found during this study do not permit an adequate description or comparison.

Occurrences and Stratigraphic Range: Specimens were recovered from samples Pb5669 and ?Pb5680.

Subgroup POLYGONOMORPHITAE Downie, Evitt, and Sarjeant, 1963

Genus Veryhachium (Deunff, 1958) emend. Downie and Sarjeant, 1963

Type species: Veryhachium (al. Hystrichosphaeridium) trisulcum (Deunff, 1951) Deunff, 1958, p. 27, pl. 1, figs. 4-13.

Veryhachium downiei Stockmans and Williere, 1962

Plate 17, Fig. 5

1962 Veryhachium downiei Stockmans and Williere, p. 47, 48, pl. 2, figs. 20-22, text-fig. 2.

Description: Polygonomorphic acritarchs; vesicle triangular in outline, sides convex or straight continuing

to form spines at the apices, diameter 16-26μm; processes simple, 7-16μm in length; surface psilate.

Discussion: The literature is replete with trispinose forms of Veryhachium many of which are undoubtedly synonyms. Because the trispinose types are generally of little stratigraphic value, no attempt has been made at this time to prepare a synonymy and combine the many species. The choice of Veryhachium downiei to include the acritarchs under consideration was based on its occurrences in sediments of similar age. The specimens recovered by Winslow (1962) identified as Hystrichosphaeridium trispinosum Eisenack, 1938 are in part synonymous with the specimens recovered during this study.

Occurrences and Stratigraphic Range: The genus ranges from Cambrian to possibly Recent (Downie, 1973). Veryhachium downiei Stockmans and Williere has been recovered from the Upper Devonian (Stockmans and Williere, 1962), Upper Devonian of Ohio (Winslow, 1962), the Lower Mississippian (Brown, 1968), and Lower Tournaisian (Combaz and Streel, 1970), and during the present study from samples Pb5651, Pb5652, Pb5654, Pb5658, Pb5660, Pb5661, Pb5662, Pb5663, Pb5665, Pb5667, Pb5669, Pb5670, Pb5681, Pb5687, and Pb5690.

Veryhachium cf. formosum Stockmans and Williere, 1960

Plate 17, Fig. 6

1960 Veryhachium formosum Stockmans and Williere, p. 2, pl. 2, fig. 28.

Description: As given by Stockmans and Williere (1960) also see remarks of Wall and Downie (1963, p. 783).

Discussion: Because only a single specimen was found during this study, certain identification is not possible. The complexity of the variation of this species as well as others that are morphologic variants or part of a lineage are discussed by Wall and Downie (1963) and illustrated in their text-fig. 1.

Occurrences and Stratigraphic Range: The species is known from the Upper Devonian (Stockmans and Williere, 1960) and the Permian (Wall and Downie, 1963). A single specimen was recovered during this study from sample Pb5651.

Veryhachium lairdi (Deflandre, 1946)
Deunff, 1954, 1959

Plate 17, Fig. 7

1946 Hystrichosphaeridium lairdi Deflandre, card 1112, 1 text-fig.

1954 Veryhachium lairdi (Deflandre, 1946) Deunff, p. 306.

1959 Veryhachium lairdi (Deflandre, 1946) Deunff, p. 28, pl. 8, figs. 75-79.

Description: As given by Cramer (1964) and Stockmans and Williere (1969).

Discussion: Other forms that are basically similar are Veryhachium valiente Cramer 1964, which has a square central body and V. carminae Cramer 1964 which has sculptured surfaces.

Occurrences and Stratigraphic Range: Based on the occurrences summarized by Cramer (1964) and Stockmans and

Williere (1969) the species ranges from Lower Ordovician through Famennian. A single specimen was found during the present study from Pb5651.

Veryhachium rhomboidium Downie, 1959

Plate 17, Figs. 8, 9

1959 Veryhachium rhomboidium Downie p. 62, 63, pl. 12, fig. 10.

Description: Polygonomorphic acritarchs; vesicle rhomboidal in outline, 16-22μm in diameter, surface psilate; processes consisting of four apical spines with up to six additional spines present, spines simple 7-20μm in length.

Discussion: The specimens found conform to Downie's original description (Downie, 1959) and appear to be the same as Veryhachium rhomboidium forma-3 of Wall and Downie (1963). There may be some gradational forms that tend to appear to be more like Micrhystridium stellatum. It has been suggested that Veryhachium minor Staplin, 1961a is conspecific with Wall and Downie's forma-1. None of these shorter-spined varieties have been observed here.

Occurrences and Stratigraphic Range: The species is known from the Silurian (Downie, 1959), Permian (Wall and Downie, 1963), Lower Mississippian (Brown, 1968), and this study from samples Pb5660 and Pb5691.

Veryhachium cf. thyrae Cramer, 1964

Plate 17, Fig. 10

1964 Veryhachium thyrae Cramer, p. 316, 317, pl. 12, fig. 10, 13, text-fig. 30: 5, 6.

Description: Polygonomorphic acritarchs; vesicle more or less tetrahedral, ca. 20μm diameter, surface psilate-scabrate; processes 20-40μm in length, generally six in number, furcate at tips, apparently hollow and flexuous.

Discussion: Specimens are one-half as large as those described by Cramer (1964), but are morphologically similar. Due to the smaller size and occurrences in younger strata they are referred to as Veryhachium cf. thyrae.

Occurrences and Stratigraphic Range: The species is known from the Ludlovian (Cramer, 1964), Famennian and Tournaisian (Stockmans and Williere, 1969), and during the present study from samples Pb5658, ?Pb5673, Pb5674, and Pb5680.

Veryhachium sp.

Plate 17, Fig. 11

Description: Polygonomorphic acritarchs; vesicle tetrahedral, 15-18μm in diameter, wall thin ca. one μm; processes six, flexuous, 30-40μm in length; surface of vesicle and processes psilate.

Discussion: Specimens appear somewhat similar to Evittia remota (Deunff, 1955) Lister 1970, but lack granular vesicles and branched processes.

Occurrences and Stratigraphic Range: Specimens were recovered from samples Pb5673 and Pb5675.

Subgroup SPHAEROMORPHITAE Downie, Evitt, and Sarjeant, 1963

Genus Leiosphaeridia (Eisenack, 1958) emend. Downie and Sarjeant, 1963

Type species: Leiosphaeridia baltica Eisenack, 1958, p. 8, pl. 2, fig. 5.

Leiosphaeridia wenlockia Downie, 1959

Plate 18, Fig. 2

1959 Leiosphaeridia wenlockia Downie, p. 65, pl. 12, figs. 2-4.

1961a Protoleiosphaeridium orbiculatum Staplin, p. 405, pl. 48, fig. 12.

1963 Leiosphaeridia orbiculata (Staplin, 1961a) Downie and Sarjeant, p. 95.

1968 Tasmanites minutus Eames (mms. name), p. 84, fig. 54,

1970 Leiosphaeridia linebacki Boneham (pars.), p. 261, 262, fig. 3, ills., 1-3.

Description: Sphaeromorphic acritarchs; inaperturate; circular to sub-circular in outline; diameter of vesicle 20-52μm, surface psilate; wall 1-3μm thick (generally ca. one μm), usually having sinuous random folds; wall often ruptured or split; corroded specimens may appear punctate.

Discussion: The specimens recovered here conform to the description of Downie (1959). Protoleiosphaeridium orbiculatum Staplin, 1961a is similarly described with the exception of its being "relatively thick-walled". However, Staplin's illustrated specimen appears to be not necessarily thick-walled. Downie (1963) has suggested Staplin's species may be conspecific with Leiosphaeridia wenlockia. Tasmanites minutus (mms. name) of Eames (1968)

was interpreted to be punctate, but observation with the scanning electron microscope has made possible this reinterpretation. Leiosphaeridia linebacki Boneham, 1970 although having a larger overall size range (35-95μm) than L. wenlockia (20-52μm) is in part synonymous.

Occurrences and Stratigraphic Range: Silurian (Wenlockian) of England (Downie, 1959); Upper Devonian of Alberta (Staplin, 1961a); Lower Carboniferous of Saudi Arabia (Hemer and Nygreen, 1967); Upper Devonian (Cleveland and Bedford Shales) of Ohio (Eames, 1968); Lower Mississippian (Hannibal Formation) of Missouri and Illinois (Brown, 1968); Devonian-Mississippian (New Albany Shale) of southern Indiana (Boneham, 1970); Devonian-Mississippian of Ohio in this study in samples Pb5651, Pb5652, Pb5654, Pb5660, Pb5661, Pb5662, Pb5667, Pb5668, Pb5669, Pb5670, Pb5674, and Pb5676 with frequencies up to 5% in some samples.

The stratigraphic range of the species is Silurian-Mississippian and of the genus Precambrian-Tertiary, (C. Downie, personal communication). The value of "Leiospheres" is most useful as an indication of marine environments but they are of little stratigraphic significance.

Genus Lophosphaeridium Timofeyev, 1959 ex Downie, 1963

Type species: Lophosphaeridium rarum Timofeyev, 1959, p. 29, pl. 2, fig. 5.

Lophosphaeridium spp.

Plate 18, Figs. 1, 3

Description: Sphaeromorphic acritarchs; inaperturate; circular to sub-circular in outline; diameter of vesicles 26-40μm, wall ca. 2μm thick; surface with granae or blunted cones 2μm high; occasional compression folds.

Discussion: Specimens recovered here are representative of more than one species. The scarcity of these palynomorphs has precluded specific assignment at this time.

Occurrences and Stratigraphic Range: The genus ranges from Lower Cambrian-Upper Devonian (C. Downie, personal communication). Specimens present in this study are from samples Pb5660, Pb5661, Pb5663, and Pb5671.

Subgroup NETROMORPHITAE Downie, Evitt, and Sarjeant, 1963

Genus Navifusa Combaz, Lange, and Pansart, 1967

Type species: Navifusa navis Eisenack, 1938, pl. 4, 11, (designated by Combaz, Lange, and Pansart, 1967, p. 293).

Navifusa brasiliensis (Brito and Santos, 1965) Combaz, Lange, & Pansart, 1967

Plate 18, Figs. 4, 5, 6

1965 Leiofusa brasiliensis Brito and Santos p. 15, pl. 1, fig. 2; pl. 2, fig. 3.

1967 Navifusa brasiliensis (Brito and Santos, 1965) Combaz, Lange, and Pansart, p. 295.

Description: Netromorphic acritarchs, inaperturate, elongate-cylindircal with rounded poles, length 170μm, width 32μm, wall thin, surface ornamentation of small grana.

Discussion: This species may also be synonomous with Navifusa procera (Deunff, 1966) Combaz, Lange, and Pansart 1967 as suggested by von Almen (1970a). Detailed studies of the wall structure of Navifusa brasiliensis, as well as other species of the Navifusa complex by electron microscopy may ultimately result in reassignment to Quisquilites (Wilson and Urban 1963) emend. Wilson and Urban 1971.

Occurrences and Stratigraphic Range: Lower and Middle Devonian of Brazil (Brito and Santos, 1965); Upper Devonian of this study in Pb5654 (single specimen). The range of the genus is Ordovician through Devonian (Combaz, Lange, and Pansart, 1967, p. 300).

Subgroup HERKOMORPHITAE Downie, Evitt, and Sarjeant, 1963

Genus Cymatiosphaera (O. Wetzel, 1933) emend. Deflandre, 1954

Type species: Cymatiosphaera radiata O. Wetzel, 1933, p. 27, pl. 4, fig, 8.

Cymatiosphaera wenlockia Downie, 1959

Plate 18, Fig. 7

1959 Cymatiosphaera wenlockia Downie, p. 63, 64, pl. 11, fig. 4.

Description: Specimens recovered here conform to the diagnosis given by Downie (1959). However, Downie's size range does not clearly indicate dimensions of the body or overall diameter. Measurements in this study; body diameter 22-34μm; overall diameter 20-45μm.

Discussion: The genus Cymatiosphaera has become rather large (ca. 70 species) and contains many unrelated species (C. Downie, personal communication). There is, apparently, a need for a complete review of the genus. However, at the present time the specimens from Ohio are best assigned to Cymatiosphaera wenlockia.

Occurrences and Stratigraphic Range: The genus is long ranging Lower Ordovician (Deunff, 1961) to Eocene (Deflandre and Cookson, 1955). Cymatiosphaera wenlockia Middle Silurian (Downie, 1959); Tournaisian of France and Devonian of Belgium and France (Combaz and Streel, 1970); Upper Devonian and Lower Mississippian of this study in samples Pb5651, Pb5652, Pb5653, Pb5654, Pb5655, Pb5660, Pb5665, Pb5671, Pb5673, Pb5680, Pb5683, and Pb5694.

Genus Dictyotidium (Eisenack, 1955) emend. Staplin, 1961a

Type species: Dictyotidium (al. Leiosphaera) dictyotum (Eisenack, 1938, p. 27, pl. 3, figs. 8a, b, c) Eisenack, 1955.

Dictyotidium cf. polygonium Staplin, 1961a

Plate 18, Fig. 8

1961a Dictyotidium polygonium Staplin, p. 417, pl. 49, fig. 14.

Description: Herkomorphic acritarchs, vesicle circular; surface ornamented with muri, low, distinct; lumina irregular to polygonal, variable in width 4-10μm wide, granular surface within lumina; diameter 20-30μm.

Discussion: Recovered specimens lack the central granule in polygons and polygons are more variable than as

described by Staplin (1961a). It is suspected that gradations exist between Cymatiosphaera and Dictyotidium, because Dictyotidium occurs in samples containing Cymatiosphaera and the former has not been widely reported.

Occurrences and Stratigraphic Range: The genus is known from the Upper Silurian (Eisenack, 1955); Upper Devonian (Staplin, 1961a), Lower Mississippian (Brown, 1968); Berea Sandstone, northeast Ohio, of this study in sample Pb5660.

Subgroup PTEROMORPHITAE Downie, Evitt, and Sarjeant, 1963

Genus Duvernaysphaera (Staplin, 1961a) emend. Deunff, 1964

Type species: Duvernaysphaera tenuicingulata Staplin, 1961a p. 414-416, pl. 49, figs. 10, 11.

Duvernaysphaera cf. stellata Deunff, 1964

Plate 18, Fig. 9

1964 Duvernaysphaera stellata Deunff, p. 212, 214, fig. 4.

1967 Duvernaysphaera radiata Brito, p. 477, 479, pl. 1, figs. 1, 2.

1969 cf. Duvernaysphaera radiata Brito in Lanzoni and Magloire, p. 468, 469, pl. 8, figs. 9, 10.

Description: Pteromorphic acritarch, inaperturate, outline more or less circular, flattened; central body stellate, ca. 36µm in diameter, surface psilate, surrounded by a thin transparent membrane 8µm in width, membrane supported by spokelike thickenings, surface psilate; overall diameter 52µm.

Discussion: The single specimen recovered is slightly larger than those described by Deunff (1964). The lack of more than a single specimen precludes more than tentative identification to Deunff's species. Brito (1967) makes no reference to Deunff's species or publication and apparently was unaware of it when he named Duvernaysphaera radiata. Lanzoni and Magloire (1969) figure two specimens as cf. Duvernaysphaera radiata Brito, but no description or discussion is provided. The appearance of Lanzoni and Magloire's specimens are identical to those of Brito's. Brito's description is nearly the same as Deunff's. The specimens are here considered synonymous.

Occurrences and Stratigraphic Range: Devonian of Tunisia (Deunff, 1964); Middle Devonian of Brazil (Brito, 1967); Upper Devonian of Algeria (Lanzoni and Magloire, 1969); Upper Devonian of Ohio this study, sample Pb5654.

The genus has not been reported in sediments younger than Devonian. The range of the genus is Silurian to Devonian (C. Downie, personal communication).

Genus Tornacia Stockmans and Williere, 1966

Type species: Tornacia sarjeanti Stockmans and Williere, 1966, p. 473-475, pl. 1, figs. 22-24, text-fig. 6.

Tornacia sarjeanti Stockmans and Williere, 1966

Plate 18, Fig. 10

1966 Tornacia sarjeanti Stockmans and Williere, p. 473-475, pl. 1, figs. 22-24, text-fig. 6.

Description: Pteromorphic acritarchs, vesicle more or less circular in outline, 16-20μm in diameter, disc like or axially depressed based on orientation with processes distributed equatorially; processes mammalate, 3-6μm in length, generally expanded at base; surface of vesicle and processes psilate.

Discussion: Although the present description varies from that given by Stockmans and Williere (1966) the recovered specimens are believed to be conspecific. Stockmans and Williere (1966) placed the genus in the subgroup Acanthomorphitae. However, based on the few specimens recovered here the genus is best placed in the subgroup Pteromorphitae because of the axiallary depressed nature of the specimens. The orientation of the figured specimens illustrated by Stockmans and Williere (1966) supports this assignment.

Occurrences and Stratigraphic Range: The genus is considered Tournaisian (Stockmans and Williere, 1966). The species range is also Tournaisian (Stockmans and Williere, 1966) Specimens recovered in the present study were from samples Pb5651 and Pb5669.

Subgroup TASMANITITAE Staplin, Jansonius, and Pocock, 1965

Genus Tasmanites (Newton, 1875) emend. Schopf, Wilson, and Bentall, 1944

Type species: Tasmanites punctatus Newton, 1875, p. 389, pl. 10, figs. 1-9.

Tasmanites sinuosus Winslow, 1962

Plate 18, Fig. 11

1962 Tasmanites sinuosus Winslow, p. 83, 84, pl. 20, figs. 1-3, text-fig. 20.

Description: As given by Winslow (1962, p. 83).

Discussion: Tasmanites sinuosus Winslow 1962 has been relatively rare in the post Bedford sediments. Although not discussed in Eames (1968), T. sinuosus was extremely abundant in the Cleveland Shale. It is interesting to note while not abundant in the present study the youngest occurrences are in the Sunbury Member of the Orangeville Shale, which is lithologically similar at the base to the Cleveland Shale.

Occurrences and Stratigraphic Range: Upper Devonian and Lower Mississippian of Ohio (Winslow, 1962); Upper Devonian of Ohio, Michigan, and S.W. Ontario (Boneham, 1967); Lower Mississippian of Missouri and Illinois (Brown, 1968); and from this study in samples Pb5654, Pb5658, and Pb5663. The genus is known to range from Ordovician (Eisenack, 1962) to Recent (Wall, 1962).

Affinities: A comprehensive discussion of the affinities of the genus Tasmanites is provided by Schopf (1969) in Tschudy and Scott (1969, p. 180-187). This places Tasmanites in the algal class Prasinophyceae. However, Schopf (1969) points out the problem of projecting the life cycle to the distant Paleozoic with the alliance of Tasmanites to Pachysphaera. For the present Tasmanites is classified with the acritarchs in the subgroup Tasmanititae Staplin, Jansonius,

and Pocock (1965), since the genus remains as a form genus not assignable to a family (Staplin,et al., 1965, p. 174).

CHITINOZOANS

Chitinozoan sp.

Plate 19, Fig. 1

A single Chitinozoan was recovered from the present study in sample Pb5653. The specimen probably represents Hoegisphaera scabiosa (Wilson and Hedlund, 1964) Wilson and Dolly, 1964. Because the samples were not processed specifically for chitinozoans and only a single specimen has been recovered, no taxonomic treatment is included at this time.

SCOLECODONTS

Scolecodont spp.

Plate 19, Figs. 2, 4, 6

Scolecodonts were infrequent in the present study and there is no attempt here to treat them taxonomically. Several genera are probably represented, but all scolecodonts are included in a single category as Scolecodont spp. on the range charts. Specimens have been recovered from the present study in samples Pb5662, Pb5663, Pb5669-1.2%, Pb5682, Pb5684, Pb5685-0.4%, Pb5686, and Pb5691.

PLANT FRAGMENTS

Vascular Tissue

Plate 19, Fig. 5

Many samples contained abundant plant fragments of tracheids and cuticular fragments. A broken tracheid

showing bordered pits is illustrated from Pb5653 from the Berea Sandstone. These dissociated fragments of higher plants are not included on the range charts. The figure shown illustrates two pit groups from a radial wall of a tracheid of Callixylon, a progymnosperm, commonly considered to be an index fossil of the Upper Devonian. Each of the pits shows the typical crossed pit apertures.

INCERTAE SEDIS

Unknown fossil

Plate 19, Fig. 3

Description: Organized body, oval in outline; dimensions 32x50μm; body consisting of four ?chambers; chambers more or less wedge-shaped, each with a single protuberance on the equator, each protuberance surrounded by an annular thickening; body surface psilate; wall ca. two μm thick.

Discussion: The unusual morphology of this single specimen from sample Pb5668 has prompted its inclusion in the illustrations. No known acritarchs or spores have morphology similar to this specimen. It may represent a fungal spore, chitinozoan, or undescribed acritarch. Because only a single specimen has been observed no new taxon can be established at this time.

RESULTS

The forty-seven samples analyzed in this study have yielded abundant, diverse, and well-preserved palynomorph assemblages. A total of 124 spores, acritarchs and miscellaneous taxa have been illustrated, described, and identified (with published taxa), where possible. The plant microfossil assemblages are compared to assemblages reported from rocks of Upper Devonian and Lower Mississippian ages. The relative ages for the stratigraphic units in this study, based on palynology, are listed below and are discussed more fully in the following text.

1. Berea Sandstone--Devonian (Upper Famennian).
2. Orangeville Shale--Mississippian (Kinderhookian).
3. Sharpsville Sandstone--Mississippian (Kinderhookian).
4. Meadville Shale--Mississippian (Kinderhookian).

The ranges of twenty-four selected palynomorphs which are of greatest importance for defining the Devonian-Mississippian boundary are shown in Figure 7 as they relate to the North American and European age classifications. The spore zones of Paproth and Streel (1970) and Neves, et al. (1972) are also shown in Figure 7 to enable a comparison of their positions to the northeastern Ohio palynomorph assemblages. Range charts of 119 taxa or groups of taxa have been constructed showing their stratigraphic distribution

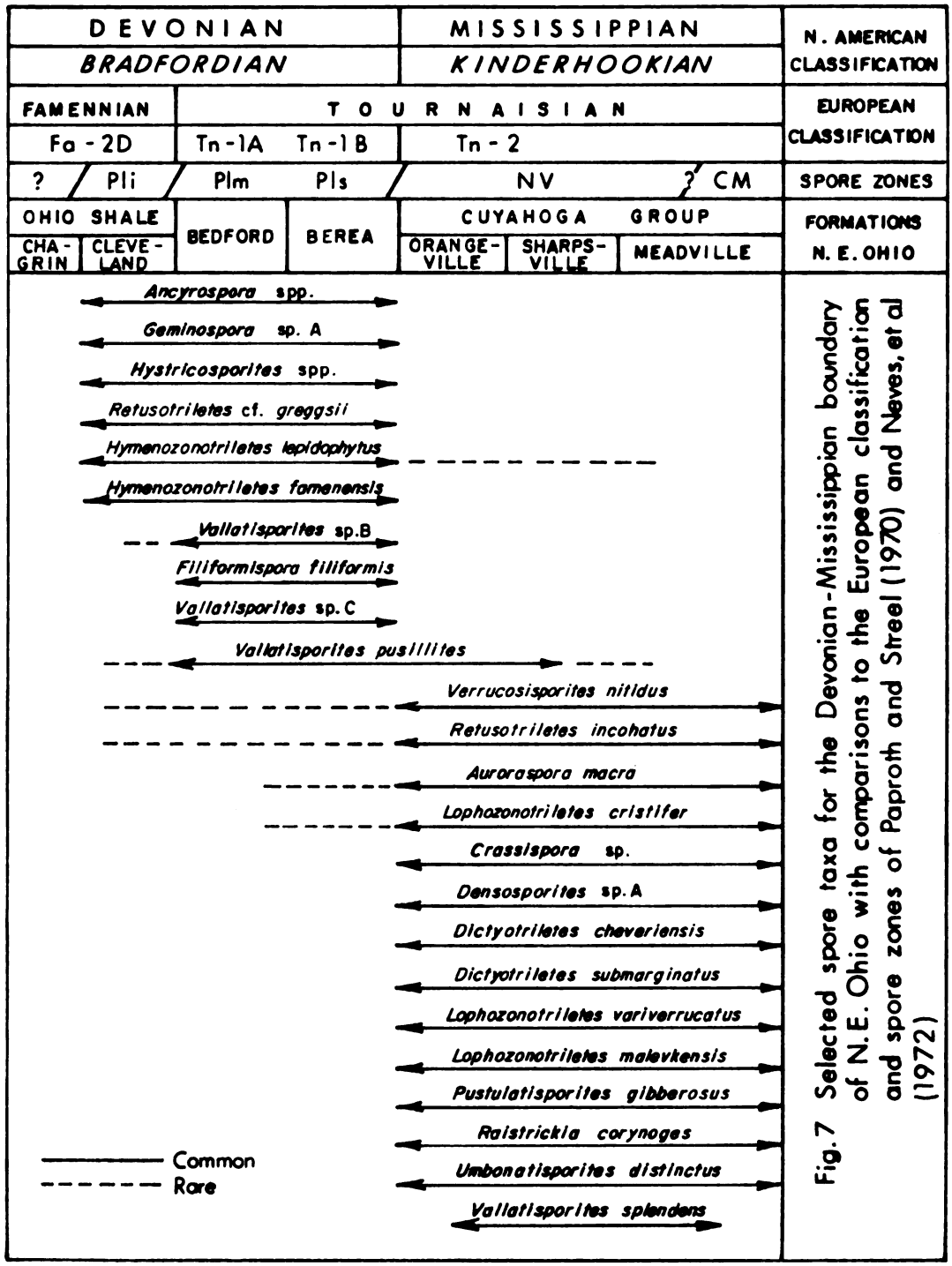

Fig. 7 Selected spore taxa for the Devonian-Mississippian boundary of N.E. Ohio with comparisons to the European classification and spore zones of Paproth and Streel (1970) and Neves, et al (1972)

and relative abundances for the composite section. The range charts (in pocket) are constructed by aligning the latest occurrences together (tops of ranges) (Figure 8) and by aligning earliest occurrences together (bottom of stratigraphic ranges) (Figure 9) for the three localities representing the composite section shown in Figure 6. The plotted sections represent approximately 472 feet of strata and include ranges from the samples of Eames (1968) for completeness. The vertical footages of Figures 8 and 9 are not precisely to scale because of closely spaced sample intervals. The high diversity and abundance of palynomorphs allow a critical evaluation of transitional and restricted taxa. While the ranges of the majority of palynomorphs transgress the systemic boundary, many are important in a semiquantitative sense in defining the Devonian-Mississippian boundary.

Palynomorph Biostratigraphy

The palynomorphs are represented by 124 taxa or groups of taxa. The previously discussed taxa in the systematics portion include 97 species assignable to 44 genera of spores, 23 species assignable to 13 genera of acritarchs, and 4 miscellaneous groups (a scolecodont, a chitinozoan, plant vascular tissue, and an unknown organic entity). From these, three age categories of palynomorph assemblages can be recognized: 1) Upper Devonian indicators based on latest occurrences in the section (top of ranges, Figure 8) and high

relative abundances; 2) Lower Mississippian indicators based on first occurrences (base of ranges, Figure 9) and high relative abundances; and 3) Transitional assemblage characteristic of the Devonian-Mississippian boundary.

Upper Devonian Assemblage

The Berea Sandstone has yielded a palynomorph assemblage considered to be characteristic of the Upper Devonian. Those taxa with tops of ranges in the uppermost Devonian useful in defining the upper limit of Devonian time are: Ancyrospora? capillata, Ancyrospora multifurcata, Baculatisporites sp., Densosporites sp. B, Dictyotidium cf. polygonium, Duvernaysphaera cf. stellata, Filiformispora filiformis, Geminospora sp. A, Gorgonisphaeridium cf. spicatum, Gorgonisphaeridium winslowii, Hymenozonotriletes famenensis, Hymenozonotriletes lepidophytus, Hystricosporites delectabilis, Hystricosporites cf. obscurus, Navifusa brasiliensis, Retusotriletes cf. greggsii, Vallatisporites sp. B, Vallatisporites sp. C, and Veryhachium lairdi. In addition, Anaplanisporites baccatus was found only in the Berea Sandstone. However, its occurrences are considered as unreliable because of known occurrences of this species in strata as young as Middle Pennsylvanian (Smith and Butterworth, 1967).

All of the preceding taxa have upper limits of their range in the Berea with the exception of Hymenozonotriletes lepidophytus. The value of H. lepidophytus in defining the upper limit of Devonian time has been pointed out in many

studies and is best summarized in Owens and Streel (1967). Owens (1970), Streel (1970), and Sandberg, et al. (1972). In the present study, H. lepidophytus occurs in low relative frequency (generally less than 1%) as high in the section as the lower Meadville Shale (Lower Mississippian-Kinderhookian). These post-Devonian occurrences of H. lepidophytus may be considered as reworked from earlier strata or as a possible range extension of the species. The consideration of re-working is based on the fact that H. lepidophytus is the dominant form in the Bedford and Berea, with occurrences up to 91% in one sample in the Berea. Thus, any erosion and recycling of the Berea sediments during the deposition of the sediments of the later deposited overlying Cuyahoga Group would provide a logical source and an abundance of these spores for dilution of the later floras. Another basis for this consideration for re-working could be the durability of this spore. The consideration of a range extension for H. lepidophytus is supported by the fact that the majority of the studies on the Devonian-Mississippian boundary have not actually spanned the boundary, but represent either Upper Devonian or Lower Mississippian rocks. Winslow (1962) reported only two specimens of Endosporites lacunosus, considered as a synonym here of Hymenozonotriletes lepidophytus, above the Sunbury Shale. She also noted an abundance of this taxon in the uppermost Cleveland, Bedford, and Berea formations. Therefore, the present occurrences of H. lepidophytus are younger for the area than previously recorded.

The present minor occurrences in the Lower Mississippian do not reduce the importance of the species as an indicator of an Upper Devonian age. Owens and Streel (1967), Warg and Traverse (1973), and Streel (personal communication) have found the presence of H. lepidophytus to be overwhelmingly abundant in the uppermost Devonian.

The taxa, based on relative abundances, found to have a higher frequency of occurrence in the Upper Devonian Berea Sandstone are: Dictyotriletes fimbriatus, Hymenozonotriletes explanatus, Leiosphaeridia wenlockia, Lophosphaeridium spp., Tasmanites sinuous, Vallatisporites sp. A, and Vallatisporites sp. D. These taxa occur here with higher relative abundance in the Upper Devonian and with infrequent occurrences in the Lower Mississippian.

Lower Mississippian Assemblages

The Cuyahoga Group has yielded a palynomorph assemblage considered to be characteristic for the Lower Mississippian (Kinderhookian). Those taxa with first occurrences (bases) in the Orangeville Shale, lower Cuyahoga Group, or within the Cuyahoga Group useful in defining the lower limits of Mississippian time are: cf. Acanthotriletes hacquebardii, Anapiculatisporites ampullaceus, ?Apiculatisporis sp., Convolutispora sp., Convolutispora vermiformis, Crassispora sp., Densosporites sp. A, Dictyotriletes cancellatus, Dictyotriletes cheveriensis, Dictyotriletes cf. trivialis, Endosporites minutus, Endosporites sp., Lophozonotriletes malevkensis,

Lophozonotriletes raritubercula tus, Lophozonotriletes vari-verrucatus, Perotrilites magnus, Punctatisporites fissus, Pustulatisporites gibberosus, Pustulatisporites sp. A, Raistrickia corynoges, cf. Secarisporites sp. A, Spelaeo-triletes sp. A, Umbonatisporites distinctus, Umbonatispor-sp., Vallatisporites splendens, and Verrucosisporites cf. nitidus.

The taxa, based on relative abundances, found to have a higher frequency of occurrence in the Lower Mississippian (Cuyahoga Group) than in the Upper Devonian are: Auroraspora macra, Calamospora breviradiata, Convolutispora mellita, ?Corbulispora subalveolaris, Cyclogranisporites commodus, Dictyotriletes submarginatus, Dictyotriletes sp., Endospor-ites micromanifestus, Grandispora echinata, Granulatisporites crenulatus, Knoxisporites literatus, Leiotriletes ornatus, Lophozonotriletes cristifer, Lophozonotriletes dentatus, Microreticulatisporites hortonensis, Punctatisporites debilis, Punctatisporites nitidus, Raistrickia baculosa, Raistrickia clavata, Retusotriletes incohatus, Rhabdosporites firmus, Verrucosisporites nitidus, and Verrucosisporites papulosus. All of the above taxa do occur with varying abundances in the Upper Devonian section but they occur with higher frequency (relative percent) in the Lower Mississippian section. The presence of these taxa is characteristic for Lower Mississippian assemblages.

Transitional Assemblage

The following taxa do not appear to be particularly important for distinguishing between the Devonian and Mississippian ages. These taxa are not restricted to nor do they have consistently higher frequency of abundance in either the Berea or Cuyahoga Group. They are considered to be members of the transitional assemblage for the northeastern Ohio area. Palynomorphs recovered in this category are: Anapiculatisporites retusus, Baltisphaeridium lucidum, Calamospora cf. pannucea, Converrucosisporites sp., Convolutispora florida, Convolutispora tessellata, Convolutispora tuberosa, Cyclogranisporites cf. aureus, Cymatiosphaera wenlockia, Emphanisporites annulatus, Emphanisporites rotatus, Gorgonisphaeridium ohioensis, Granulatisporites frustulentus, Laevigatosporites sp., Leiotriletes inermis, Lophozonotriletes bellus, Micrhystridium cf. bistchoensis, Micrhystridium echinosum, Micrhystridium stellatum, Multiplicisphaeridium ramispinosum, Multiplicisphaeridium sp., Peltatispora peltata, Perotrilites perinatus, Punctatisporites densiminutus, Punctatisporites irrasus, Punctatisporites planus, Reticulatisporites crassus, Simozonotriletes spp., Spelaeotriletes crassispinosus, Spinozonotriletes uncatus, ?Spinozonotriletes sp., Stenozonotriletes clarus, Tornacia sarjeanti, Vallatisporites pusillites, Vallatisporites vallatus, Vallatisporites verrucosus, Verrucosisporites depressus, Veryhachium downiei, Veryhachium cf. formosum, Veryhachium rhomboidium, Veryhachium cf. thyrae, and Veryhachium sp.

Many of the above taxa, although not considered diagnostic in the present study, are important additions to the palynofloras known from the Upper Devonian & Lower Mississippian strata. Several of the above taxa represent range extensions, both in younger and older sediments, than they have been known to occur.

Several taxa, which are included in the transitional assemblage, deviate significantly from their expected geologic ranges. Emphanisporites annulatus is generally restricted to the middle and lower Upper Devonian based on literature reports cited in the Systematics section. The presence of E. annulatus in the Ohio samples is regarded as probably due to reworking. Emphanisporites rotatus is also typically a Devonian species. However, the occurrences throughout the studied section as well as the occurrences in the Lower Mississippian reported by Winslow (1962) and Brown (1968), indicate a range extension for E. rotatus. The occurrence of a species of Laevigatosporites in the present study is believed to represent the oldest record for psilate, reniform, monolete spores, which are most common in Upper Mississippian and Pennsylvanian sediments. The occurrences of specimens referred to Simozonotriletes spp. also represents earlier occurrences than commonly reported (Middle and Upper Mississippian). The acritarch Multiplicisphaeridium ramispinosum has generally been considered to be an Upper Devonian form, but it occurs infrequently in the Lower Mississippian section in the present study. Because of the infrequent

occurrences its presence here may represent reworking rather than a range extension.

Comparisons with Other Assemblages

Palynomorph assemblages of Upper Devonian and Lower Mississippian, similar to those reported here and from the earlier study (Eames, 1968), have been reported on a world-wide scale by a number of workers. The studies considered most important for comparisons to the assemblages from north-eastern Ohio are those of Clayton (1971), Combaz and Streel (1970), Dolby (1970), Dolby and Neves (1970), Hacquebard (1957), Kedo (1963), Lanzoni and Magloire (1969), McGregor (1970), Playford (1964), Sandberg, et al. (1972), Streel (1966, 1967, and 1969), Sullivan (1964b and 1968), Utting and Neves (1970) and Winslow (1962). A more detailed discussion of these studies and others is provided in the following text arranged geographically.

North American Assemblages

Assemblages of similar ages are known through studies of several collections from the United States and Canada. Boneham (1967 and 1970) has briefly discussed acritarchs and tasmanitids from Michigan, Ontario, northern Ohio and southern Indiana. Some of the taxa reported in Boneham's studies are present in the Berea Sandstone assemblage. Brown (1968) has recovered an assemblage of spores and acritarchs from the Hannibal Formation (Lower Mississippian) of northeastern Missouri and western Illinois. Brown's

assemblages compare favorably with the Lower Mississippian Cuyahoga Group of this study. Bharadwaj, et al. (1971) have described an Upper Devonian palynomorph assemblage from the New Albany Shale of Kentucky. The assemblage they report is very similar to that found in the Cleveland Shale (Eames, 1968), but contains a few taxa important in the Upper Devonian assemblage of the present study. Warg and Traverse (1973) have described a Devonian-Mississippian assemblage from central Pennsylvania. Their assemblage compares well with the assemblages from the Cleveland Shale and Bedford Shale (Eames, 1968) and the present assemblage from the Berea Sandstone. Warg and Traverse's assemblage is probably Upper Devonian rather than transitional, based on their comment of the overwhelming abundance of Hymenozonotriletes lepidophytus. Allen and Urban (1972, oral presentation) discussed an assemblage from the Louisiana Formation of Missouri and Illinois, which they considered to be uppermost Devonian in age. Their assemblage compares well with those of the Cleveland Shale, Bedford Shale, and Berea Sandstone. In a study from south-central Oklahoma, von Almen (1970a and 1970b) has discussed and described assemblages from the Devonian-Mississippian Woodford Formation. Although there are a few similar taxa found in this study, a direct comparison of von Almen's assemblages is difficult. The lack of comparisons between von Almen's assemblages with this study is based on his Devonian section representing an older age than the section in northeastern Ohio. His Devonian section represents an age

no younger than lower Upper Devonian (Senecan). Therefore, only the longer ranging taxa from his area were found in this study. His Lower Mississippian (Kinderhookian) assemblage, although diagnostic for the stage, did not contain as large an assemblage as is usually present in this age strata. Environmental conditions or provinciality may have been responsible for the reduced number of taxa in von Almen's Lower Mississippian section. Sandberg, Streel, and Scott (1972) in a study including comparisons of the conodont zonation and spore assemblages from the western and central U.S. have discussed an assemblage very similar to that of the Cleveland, Bedford, and Berea of northeastern Ohio. In their opinion a comparison with Winslow (1962) and McGregor (1970) points to an Upper Devonian age for the Cleveland, Bedford, and possibly Berea. Sandberg, et al. (1972) qualify their opinion for the Berea assemblage with the possibility it may represent reworking because it is a sandstone. However, the present findings from both the quartzose and shaly lithology of the Berea are believed to indicate the indigenous nature of the Berea assemblage. Winslow (1962) has studied essentially the same stratigraphic horizons, from the same general area, as in the study. Winslow's assemblages are directly comparable to those presently recovered with the exception of some additional identifications and proposed new taxa. Most of the taxa she recorded have been discussed in the preceding Systematics section. Winslow has considered the Bedford, Berea, and Cuyahoga Group as being Lower Mississippian. The

present age interpretation, which is different from Winslow's, is discussed later in the relative age interpretation section, is of course, a matter of opinion. Her interpretations were based on comparison with very few other areas, of necessity, because of the extreme paucity of studies of the palynology of comparable stratigraphic sequences up to that date.

Several studies have been made from eastern Canada on the Horton Group (Lower Mississippian). Reports by Hacquebard (1957), Playford (1964) and Varma (1969) discuss assemblages characteristic of those found in the Cuyahoga Group of northeastern Ohio. Barss (1967) has illustrated and supplemented the assemblages of Hacquebard and Playford. Reports on assemblages of Upper Devonian and Lower Mississippian acritarchs from western Canada are given by Staplin (1961a). and Staplin, et al. (1965). Many of the taxa which are identified in the latter report are also present in the samples studied here. Staplin (1961b) recorded the presence of Lophozonotriletes cristifer from Famennian and Tournaisian beds of western Canada. The species is common in the Lower Mississippian from the Cuyahoga Group. Staplin and Jansonius (1964) discuss various densospore types from the Devonian-Mississippian of western Canada, some of which are present in this study. McGregor and Owens (1966) have illustrated Upper Devonian spores from the Kettle Point Formation of Ontario, which is in part equivalent to the Cleveland Shale (Eames, 1968). McGregor (1970) has obtained assemblages containing Hymenozonotriletes lepidophytus from

the Lower Horton Group, Imperial Formation, and the Kettle Point, Bedford and Sunbury Formations of southern Ontario. McGregor's assemblages are in part from the same stratigraphic sequence as in Winslow (1962), Eames (1968), and this study. In broad terms, McGregor (1970) considers the Bedford, Berea, and possibly Sunbury to be of late Devonian age. This agrees with the present findings with the exception of the Sunbury (basal Orangeville) which is considered to be Lower Mississippian rather than Upper Devonian. Walton and Mason (1967, unpublished Ms.) discuss assemblages from western Canada that compare closely to those reported by Winslow (1962) and concluded that the Bedford and Berea are of latest Devonian age. Their assemblages are similar to the Upper Devonian assemblage of this study and in agreement with the present conclusions.

European Assemblages

Occurrences of similar palynomorph assemblages from Europe are extensive with many good comparisons with the assemblages from northeastern Ohio. These assemblages have been important in arriving at the present age interpretation for the northeastern Ohio section.

Studies from Belgium, France, and Great Britain have been extensive in recent years. Some of the studies from Belgium and French localities of particular importance to the analysis of the Ohio floras are those of Streel (1966, 1967, and 1969), Paproth and Streel (1970), and Combaz and

Streel (1970). Assemblages represented by these studies are directly comparable to the Upper Devonian assemblages of northeastern Ohio. Streel and his coworkers have delineated the Devonian-Carboniferous boundary on the basis of spores, conodonts, and other paleontological data. A direct comparison of the spore zones delineated by Paproth and Streel (1970) as equated to the Devonian section in Ohio, is shown in Figure 7. A study on some Famennian-Tournaisian strata of Belgium by Caro-Moniez (1962) contains several taxa similar to those in the Upper Devonian section in Ohio. A large number of the forms identified by Caro-Moniez were described as new taxa which makes direct comparisons difficult. A number of important studies from Great Britain have dealt with the Upper Devonian and Lower Mississippian (Tournaisian post Tn-1b). The studies involving the Upper Devonian that compare best with the Upper Devonian of Ohio are: Dolby (1970), Dolby and Neves (1970), Neves and Dolby (1967), and Utting and Neves (1970). Those studies with palynomorph assemblages comparable to the Lower Mississippian in Ohio are by Clayton (1971), Johnson and Marshall (1971), Llewellyn, Backhouse, and Hoskin (1969), Llewellyn, Hoskin, and Backhouse (1970), Mortimer, Chaloner, and Llewellyn (1970), and Sullivan (1964b and 1968). Kaiser (1970a and 1970b), has recovered an assemblage of Devonian-Mississippian palynomorphs from Bear Island in part comparable to the assemblages from the Ohio section. Much of Kaiser's Mississippian assemblage appears younger than the Ohio Lower Mississippian. Bertelsen

(1972) has published on a Lower Carboniferous assemblage from a borehole in the Island of Falster (Denmark). Bertelsen's assemblage compares well with the Lower Mississippian assemblage from Ohio, but also includes some younger Mississippian taxa. Assemblages reported in several European studies, although younger in age, contain many taxa common in the Lower Mississippian of Ohio. Hughes and Playford (1961) and Playford (1962, 1963) have recovered upper Tournaisian assemblages from Spitsbergen. Butterworth and Spinner (1967) and Hibbert and Lacy (1969) have reported on assemblages from Great Britain of upper Tournaisian palynomorphs. Kalibova (1971) has reported a Lower Carboniferous spore assemblage from eastern Bohemia. More recently Kalibova-Kaiserova (1972) has reported further on the same assemblage. Both studies contain a few taxa recovered in the Lower Mississippian assemblage of Ohio, but direct comparison is difficult due to their slightly younger age.

Asian Assemblages

Comparable palynomorph assemblages from Asia are few. However, some of the assemblages from Russia represent important earlier reports on palynomorph floras from strata near the Devonian-Mississippian boundary. Probably the most useful for comparison here are the reports by Kedo (1957a, 1957b, 1962, 1963, and 1967). Kedo's studies have placed some of the most important taxa for the Devonian-Carboniferous boundary into a zonal system from the upper Famennian

and Tournaisian of the Pripyat depression. Many of her taxa which have worldwide distribution are present in the Ohio section as well. Other Russian studies that have dealt with Kinderhookian assemblages with some taxa in common to the Ohio section are those of Luber and Waltz (1941), and Ishchenko (1956 and 1958). There are undoubtedly other Russian studies relating to this boundary but comparisons have not been made at this time. Two assemblages from Saudi Arabia from the Lower Carboniferous are also known. Hemer (1965) briefly discusses an assemblage containing some characteristic Lower Mississippian taxa. Hemer and Nygreen (1967), reporting on some unusual acritarchs from the Lower Carboniferous of Saudi Arabia, have recorded the sphaeromorph acritarch Leiosphaeridia wenlockia, which is very common in the Upper Devonian of Ohio. Most recently Kimyai (1972) has discussed an Upper Devonian assemblage from central Elburz, Iran, that contains a few taxa common to the Upper Devonian section in Ohio.

Australian Assemblages

Assemblages of palynomorphs from the Upper Devonian and Lower Mississippian of Australia that are comparable to the Ohio assemblages are not numerous. Balme (1960a) discussed a Carboniferous microflora from western Australia which includes some taxa similar to those of the Cuyahoga Group in Ohio. In addition, Balme (1960b), from a study of upper Frasnian spores, figures several taxa that persist into the

Upper Devonian strata of Ohio. Balme and Hassell (1962) have discussed an Upper Devonian spore assemblage that has many taxa in common with those from the Upper Devonian section in Ohio. Evans (1968) has discussed briefly a transitional palynomorph assemblage from New South Wales characteristic of an Upper Devonian-Lower Carboniferous assemblage similar to that of Ohio and elsewhere. Playford (1971 and 1972) has discussed two assemblages of Lower Mississippian spores from northwestern Australia. These assemblages are slightly younger than the Ohio Lower Mississippian section. However, they contain many taxa which represent a younger range extension of some of those that are represented as important as first occurrences into defining the Lower Mississippian of Ohio.

South American Assemblages

Palynomorphs of Upper Devonian and Lower Mississippian ages from South America have been little studied and no reports involving spores of this stratigraphic interval are known. Brito (1967) and Brito and Santos (1965) have recorded a few acritarch taxa from older Devonian rocks that are found in the Upper Devonian assemblage of Ohio. Stover (1967) used acritarchs to date the Carrizal Formation of eastern Venezuela. Stover considers the assemblage to be late Devonian-early Mississippian. There are some similarity of the forms or taxa reported but direct comparison is not possible due to brief descriptions and because identifications have been made to generic level only.

African Assemblages

Knowledge of assemblages of Upper Devonian and Lower Mississippian palynomorphs from Africa is limited. The most extensive assemblage reported is that of Lanzoni and Magloire (1969) from the Algerian Sahara. That assemblage represents an Upper Devonian-Lower Mississippian sequence of considerable taxonomic diversity and compares well with the assemblage from northeastern Ohio. Wray (1964) has figured an assemblage of Paleozoic palynomorphs from Libya. A few of the forms include taxa from the Devonian-Mississippian boundary. No direct comparison can be made of Wray's assemblage to the northeastern Ohio section largely due to the broad age units to which he assigned those Libyan palynomorphs.

Paleoecology

The paleogeography and environmental composition of the Bedford and Berea formations have been comprehensively discussed by Pepper , et al. (1954). Kohout and Malcuit (1969) have reviewed the environment of deposition for the Cleveland, Bedford, and Berea formations based on an evaluation of information in the literature and upon new lithologic criteria. Most recently, Osgood and Szmuc (1972) have found the trace fossil Zoophycos to be a depth indicator of shallow conditions for the Meadville of the Cuyahoga Group. Additional studies on the paleoecology for the Cuyahoga Group are in progress (Dr. E. J. Szmuc, personal communication). Results

of these studies have indicated the nonmarine, deltaic, transitional, and shallow marine character for the section.

Results of the present study based on acritarchs, microspores, and megaspores adds little to the previous results, which were based on megafossils and lithologic criteria. Acritarchs were found in most of the samples studied here, thereby indicating a marine influence in the section. The abundance of microspores and megaspores is believed indicative of the close proximity to land masses or current patterns. The only megafossils of any abundance are brachiopods of the linguloid and orbiculoid types, which are probably indicators of shallow marine conditions.

RELATIVE AGE INTERPRETATIONS

Prior to the discussion of the present age interpretations it is important to compare and equate the European and North American stratigraphic classifications relative to the Devonian-Mississippian boundary. The nomenclature for the pertinent European stages, in ascending order, is Famennian, Strunian, and Tournaisian. Further subdivisions of the stages, commonly used in the literature, are: Upper Famennian (Fa-2a, Fa-2b, Fa-2c, and Fa-2d), the Strunian, equivalent to the uppermost Famennian and lowermost Tournaisian (Tn-1a and Tn-1b) all of which is considered to be latest Devonian age by Bouckaert, et al. (1968), Paproth and Streel (1970) and Streel (personal communication). The remainder of the Tournaisian (Tn-2a, Tn-2b, Tn-2c, Tn-3a, Tn-3b, and Tn-3c) is considered to be of Lower Carboniferous (Lower Mississippian) age.

These subdivisions of the European stages are equivalent to the North American Bradfordian and Kinderhookian stages. Therefore, the uppermost Devonian in North America (Bradfordian not widely used) is equivalent to the upper Famennian and Strunian (Fa-2a, Fa-2b, Fa-2c, Fa-2d, Tn-1a, and Tn-1b). The Lowermost Mississippian (Kinderhookian) is equivalent to the Tournaisian Tn-2 subdivisions, with the Tournaisian Tn-3

subdivisions approximately equal to the lower and middle Osagean (H. R. Lane, oral communication, 1974).

The widespread geographic occurrences of many important palynomorphs (Streel, 1970) and the preceding comparisons of assemblages reported in other studies with the present Upper Devonian and Lower Mississippian assemblages, are the basis for the following relative age interpretations in northeastern Ohio.

Results of the present palynomorph study indicate the desirability of a revision of the systemic assignment of the Bedford Shale and Berea Sandstone. The Devonian-Mississippian boundary is placed here between the Berea Sandstone and Orangeville Shale (basal Cuyahoga Group) (Figure 7). The following comparisons of the northeastern Ohio section with the European system of classification can be made using palynomorph assemblages. The Cuyahoga Group (Meadville, Sharpsville, and Orangeville formations) is equivalent to the lower Tn-2 of Europe and is considered Lower Mississippian (Kinderhookian). The Berea and Bedford are representative of the Tn-1 (Strunian) therefore Upper Devonian. The Cleveland is equivalent to the Fa-2d or Upper Famennian. The relationships of the above are shown in Figure 7.

The age assignments and stratigraphic nomenclature for the study area have been the subject of numerous investigations (Figure 2). The age assignments generally accepted have been those of Pepper, et al. (1954). Most recently de Witt (1970) has maintained these age assignments.

Existing age assignments of Pepper, et al. (1954) and de Witt (1970) place the Devonian-Mississippian boundary near the base of the Bedford Shale. This places the majority of the Bedford, all of the Berea and Orangeville, as well as the lower two-thirds of the Sharpsville in the Kinderhookian. The remainder of the Sharpsville and entire Meadville are placed in the Osagean.

Conodont evidence presented by Hass (1947) indicates the basal portion of the Bedford to be probably Devonian and the basal Orangeville (Sunbury Member) to be Lower Mississippian. Sandberg, et al. (1972) have discussed the relationships of these conodonts to those of the spores, concluding that the age of the Bedford and Berea remains as a problem for this geographic area.

The review and comparisons of assemblages of Upper Devonian and Lower Mississippian age indicates that several palynologists, after comparing their results with the age interpretations used by Winslow (1962), have questioned the age assignments used in northeastern Ohio. Winslow's investigation was one of the earlier studies on the Devonian-Mississippian boundary with little literature available on comparable palynofloras at that time. Winslow had little reason to question the age assignments of Pepper, et al. (1954) whose studies involved the same sections she studied.

Sanford (1967), in a study of the Devonian of Ontario and Michigan, proposed age changes for the Bedford and Berea on the basis of palynologic comparisons and claimed this

interpretation was supported by D. C. McGregor, Canadian Geol. Surv. Owens and Streel (1967) questioned a Mississippian age assignment for the Bedford and Berea because of the abundance of Hymenozonotriletes lepidophytus. McGregor (1970), on the basis of studies of the Kettle Point Shale (Cleveland equivalent), Bedford, Berea, and Sunbury (basal Orangeville) Formations, identified assemblages which indicated latest Devonian age with probably age equivalence to the Strunian of Belgium. Bouckaert, et al. (1968) consider the Strunian as latest Famennian to earliest Tournaisian. Streel (1970) in a geographic and stratigraphic summary of palynomorph assemblages from the Devonian-Carboniferous boundary compares the Bedford and Sunbury to the Tn-1 zone of Belgium. Paproth and Streel (1970) have placed the majority of the Tn-1 zone in the Upper Devonian and have established spore zones, Pli, Plm, and Pls, for the Upper Devonian, as were identified in this study, and shown in Figure 7, from the Cleveland, Bedford, and Berea formations. Neves, et al. (1972) have delineated the NV spore zone and place it in the Tn-2, here considered as lowermost Mississippian, which is represented from the Orangeville, Sharpsville and possibly the lower Meadville formations. The CM spore zone of Neves, et al. (1972) may be present or beginning in the upper Meadville.

An additional age discrepancy in the study area is believed to exist for the Osagean age assignment of the upper Shaprsville and overlying Meadville formations. This

question arises from recent paleontological studies of ammonoids by Manger (1971a and 1971b) from the upper Cuyahoga Group and Logan Formation of southern Ohio. Manger has found the upper Cuyahoga Group as well as the stratigraphically higher Logan Formation to be of Kinderhookian age. The positions of the Sharpsville and Meadville are in the middle Cuyahoga Group, which would allow the previous Osagean age assignment to be questioned. However, this discrepancy could not be resolved at the present time.

CONCLUSIONS AND SUMMARY

Conclusions

1. Descriptions of 124 palynomorph taxa or groups here, including 2 new genera and 21 new species, enhances the potential for stratigraphic application of these fossils to future studies involving the resolution of the position of the Devonian-Mississippian boundary.

2. Range charts of 119 taxa or taxonomic groups plotted by latest and earliest occurrences, with an indication of relative abundances, provides detailed stratigraphic information pertinent to the identification of the Devonian-Mississippian boundary.

3. The placement of the Devonian-Mississippian boundary at the top of the Berea and the base of the Orangeville Shale of the Cuyahoga Group for northeast Ohio is proposed, based on this palynologic study.

4. Three assemblages of palynomorphs, Upper Devonian, Lower Mississippian and transitional, have been identified and their usefulness discussed for defining the Devonian-Mississippian boundary.

5. The wide distribution of the palynomorph assemblages is demonstrated by comparison with palynofloras reported from a number of geographically distant localities.

6. The assemblages reported here from northeastern Ohio show good correlations with European spore zones of Paproth and Streel (1970) and Neves, et al. (1972).

7. Evidence of Kinderhookian age of stratigraphically higher Cuyahoga Group strata from southern Ohio indicates that only the lower portion of the Kinderhookian was sampled and studied here.

Summary

Outcrop samples spanning the Devonian-Mississippian boundary in northeastern Ohio have been analyzed palynologically. Recovery of palynomorphs was exceptional and no barren samples were encountered. There were, however, some gaps in the sampling from the Berea Sandstone and the Orangeville Shale. Those horizons in the Berea were inaccessible on the quarry walls and the gap in the Orangeville sampling was the result of having no continuous section available. Of the taxa and taxonomic groups identified during this palynologic study, 21 are new and are described here. All other taxa have been compared to literature descriptions and illustrations of previously reported taxa.

Two range charts have been constructed using the earliest and latest occurrences of ranges which provide data for defining the Devonian-Mississippian boundary on the basis of palynomorph assemblages. The Upper Devonian-Lower Mississippian (Bradfordian-Kinderhookian) palynofloras of the subject area are equivalent to the Upper Famennian-Lower Tournaisian of the European standard section.

The Bedford Shale and Berea Sandstone previously have been assigned a Mississippian age. An Upper Devonian age is suggested for these two formations, based on the palynomorphs reported here and their comparison with recent North American literature and European palynofloras.

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APPENDICES

APPENDIX I

SAMPLES

Maceration Number	Gross Lithology	Formation and position above base	Locality
Pb5697	Shale	Meadville (Top 109')	Gorge Pk
Pb5696	Shale	Meadville (100')	Gorge Pk
Pb5695	Shale	Meadville (90')	Gorge Pk
Pb5694	Shale	Meadville (60')	Gorge Pk
Pb5693	Shale	Meadville (50')	Gorge Pk
Pb5692	Shale	Meadville (40')	Gorge Pk
Pb5691	Shale	Meadville (30')	Gorge Pk
Pb5690	Shale	Meadville (20')	Gorge Pk
Pb5689	Shale	Meadville (10')	Gorge Pk
Pb5688	Shale	Meadville (5')	Gorge Pk
Pb5687	Shale	Meadville (Base)	Gorge Pk
Pb5686	Silty Shale	Sharpsville (Top 51')	Gorge Pk
Pb5685	Silty Shale	Sharpsville (50')	Gorge Pk
Pb5684	Silty Shale	Sharpsville (45')	Gorge Pk
Pb5683	Silty Shale	Sharpsville (40')	Gorge Pk
Pb5682	Silty Shale	Sharpsville (35')	Gorge Pk
Pb5681	Calc. Siltstone	Sharpsville (32')	Gorge Pk
Pb5680	Silty Shale	Sharpsville (30')	Gorge Pk
Pb5679	Silty Shale	Sharpsville (25')	Gorge Pk
Pb5678	Silty Shale	Sharpsville (20')	Gorge Pk

Pb5677	Silty Shale	Sharpsville (15')	Gorge Pk
Pb5676	Silty Shale	Shaprsville (10')	Gorge Pk
Pb5675	Silty Shale	Sharpsville (5')	Gorge Pk
Pb5674	Silty Shale	Sharpsville (1')	Gorge Pk
Pb5673	Silty Shale	Sharpsville (Base)	Gorge Pk
Pb5672	Shale	Orangeville (Top)	Gorge Pk
Pb5671	Shale	Orangeville (-1')	Gorge Pk
Pb5670	Shale	Orangeville (-5')	Gorge Pk
Pb5669	Shale	Orangeville (-10')	Gorge Pk
Pb5668	Shale	Orangeville (15')	Tinkers Crk
Pb5667	Shale	Orangeville (11')	Tinkers Crk
Pb5666	Sandy Siltstone	Aurora Member (10')	Tinkers Crk
Pb5665	Sandy Siltstone	Aurora Member (7')	Tinkers Crk
Pb5664	Shale	Orangeville (6.5')	Tinkers Crk
Pb5663	Dark Shale	Sunbury Member (6')	Tinkers Crk
Pb5662	Dark Shale	Sunbury Member (3')	Tinkers Crk
Pb5661	Dark Shale	Sunbury Member (Base)	Tinkers Crk
Pb5660	Quartzose Sandst.	Berea (Top)	Tinkers Crk
Pb5659	Silty Shale	Berea (80')	Quarry 6X
Pb5658	Silty Shale	Berea (77')	Quarry 6X
Pb5657	Silty Shale	Berea (75')	Quarry 6X
Pb5656	Quartzose Sandst.	Berea (40')	Quarry 6X
Pb5655	Quartzose Sandst.	Berea (40')	Quarry 6X
Pb5654	Quartzose Sandst.	Berea (20')	Quarry 6X
Pb5653	Quartzose Sandst.	Berea (15')	Quarry 6X
Pb5652	Grey Quartzose S.S.	Berea (Base)	Quarry 6X
Pb5651	Grey Quartzose S.S.	Berea (Base)	Quarry 6X

*BDF-15	Silty Shale	Bedford (Top 85')	Tinkers Crk
*BDF-13	Silty Shale	Bedford (75')	Tinkers Crk
*BDF-11	Silty Shale	Bedford (65')	Tinkers Crk
*BDF-9	Silty Shale	Bedford (50')	Tinkers Crk
*BDF-7	Silty Shale	Bedford (30')	Tinkers Crk
*BDF-5	Shale	Bedford (12')	Tinkers Crk
*BDF-3	Shale	Bedford (5')	Tinkers Crk
*BDF-1	Shale	Bedford (Base)	Tinkers Crk
*CLE-5	Dark Shale	Cleveland (Top 21')	Tinkers Crk
*CLE-3	Dark Shale	Cleveland (10')	Tinkers Crk
*CLE-1	Dark Shale	Cleveland (Base)	Tinkers Crk

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*Samples from Eames (1968), included in range chart data, but not discussed here in text.

APPENDIX II

ALPHABETIC LISTING OF ACRITARCH TAXA

Taxon	Descrip./Page	Plate/Fig.
Baltisphaeridium lucidum	139	16/1, 2
Cymatiosphaera wenlockia	155	18/7
Dictyotidium cf. polygonium	156	18/8
Duvernaysphaera cf. stellata	157	18/9
Gorgonisphaeridium ohioensis	140	16/4, 5
Gorgonisphaeridium cf. spicatum	142	16/3
Gorgonisphaeridium winslowii	143	16/8, 9
Leiosphaeridia wenlockia	152	18/2
Lophosphaeridium spp.	153	18/1, 3
Micrhystridium cf. bistchoensis	144	16/6, 7
Micrhystridium echinosum	144	16/10, 11
Micrhystridium stellatum	145	17/1, 2
Multiplicisphaeridium ramispinosum	146	17/4
Multiplicisphaeridium sp.	147	17/3
Navifusa brasiliensis	154	18/4, 5, 6
Tasmanites sinuosus	160	18/11
Tornacia sarjeanti	158	18/10
Veryhachium downiei	147	17/5
Veryhachium cf. formosum	148	17/6
Veryhachium lairdi	149	17/7
Veryhachium rhomboidium	150	17/8, 9

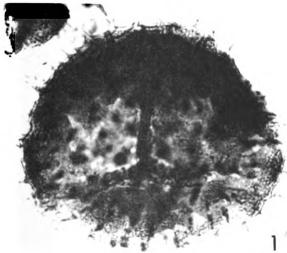
Veryhachium cf. thyrae	150	17/10
Veryhachium sp.	151	17/11

PLATES

PLATE 1

Figure	Figures X800, except where indicated	Page
1	cf. Acanthotriletes hacquebardii Playford, 1964; Pb5690-2, 31.9 x 102.6, 83μm less spines.	22
2, 6	Ancyrospora? capillata Dolby and Neves, 1970; 2. Pb5654-2, 31.6 x 100.3, X500, 62μm less processes; 6. Pb5658-7, 30.9 x 103.7, 78μm less processes.	27
3, 4	Ancyrospora multifurcata (Winslow, 1962) comb. nov.; 3. Pb5658-7, 32.7 x 108.2, X500, 87μm less processes; 4. Pb5659-2, 39.5 x 110.9, individual multifurcate process X800.	28
5	Anapiculatisporites ampullaceus (Hacquebard, 1957) Playford, 1964; Pb5663-2, 34.5 x 111.9, 40μm.	23

PLATE 1



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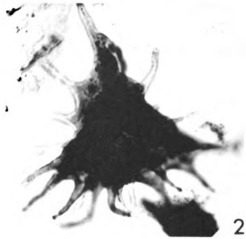

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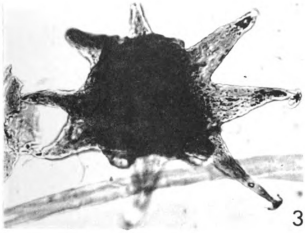

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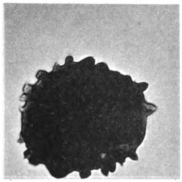

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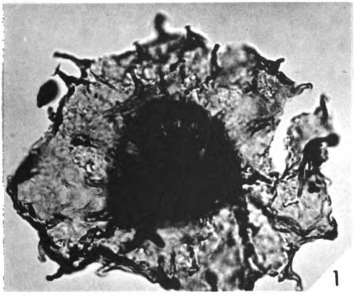
PLATE 2

Figure	Figures X800, except where indicated	Page
1	Ancyrospora sp.; Pb5680-2, 44.7 x 103.1, 105µm	29
2	Anapiculatisporites retusus Winslow, 1962; Pb5661-4, 13.1 x 95.4, 50µm	24
3	Anaplanisporites baccatus (Hoffmeister, Staplin, and Malloy, 1955b; Pb5654-2, 38.4 x 95.3, 38µm	26
4	?Apiculatisporis sp.; Pb5688-2, 11.5 x 113.2, X1200, 29µm.	30
5	Auroraspora macra Sullivan, 1968; Pb5689-2, 13.5 x 103.4, 40µm	31
6	Calamospora cf. pannucea Richardson, 1965; Pb5675-2, 41.0 x 109.8, 92µm.	35
7	Baculatisporites sp.; Pb5654-2, 39.7 x 103.7, 48µm	33
8	Calamospora breviradiata Kosanke, 1950; Pb5675-2, 32.8 x 100.4, 51µm.	34

PLATE 2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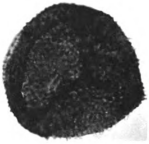
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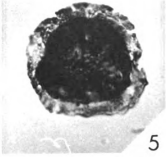
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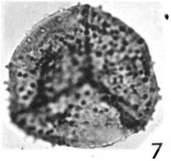
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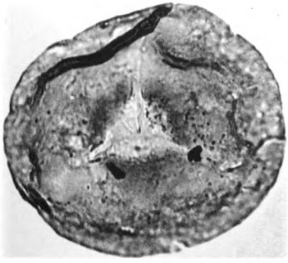
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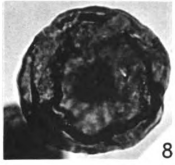
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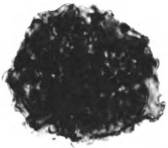
PLATE 3

Figure	Figures X800, except where indicated	Page
1	Converrucosisporites sp.; Pb5679-2, 18.9 x 94.3, 45µm	36
2	Convolutispora florida Hoffmeister, Staplin, and Malloy, 1955b; Pb5695-2, 14.9 x 110.6, 49µm.	37
3	Convolutispora tessellata Hoffmeister, Staplin, and Malloy, 1955b; Pb5654-2, 7.8 x 102.5, 63µm	40
4	Convolutispora mellita Hoffmeister, Staplin, and Malloy, 1955b; Pb5669-2, 40.3 x 105.3, 68µm.	38
5	Convolutispora sp.; Pb5684-2, 15.7 x 112.6, 55µm	43
6	Convolutispora vermiformis Hughes and Playford, 1961; Pb5679-2, 22.7 x 97.5, 63µm.	42
7	Convolutispora tuberosa Winslow, 1962; Pb5675-2, 17.0 x 93.7, 88µm	41
8	?Corbulispora subalveolaris (Luber, 1938) Sullivan, 1964b; Pb5663-2, 11.1 x 93.9, 77µm.	43

PLATE 3

1



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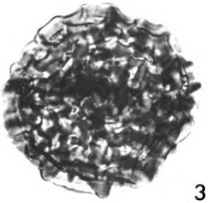

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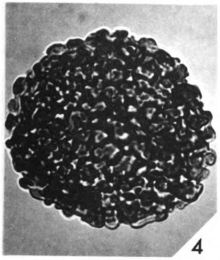

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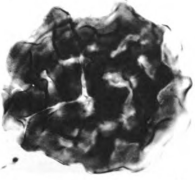

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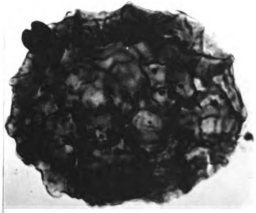

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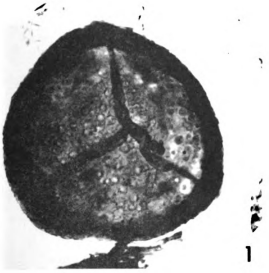
PLATE 4

PLATE 4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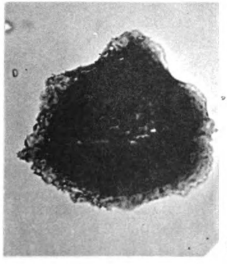
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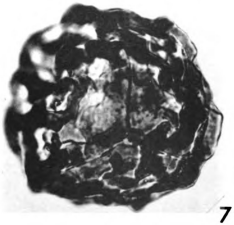
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PLATE 5

PLATE 5


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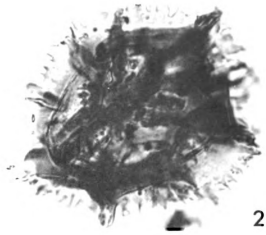
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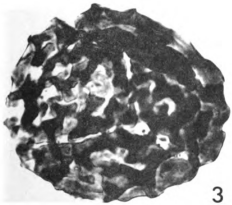
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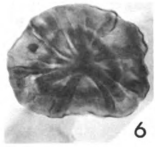
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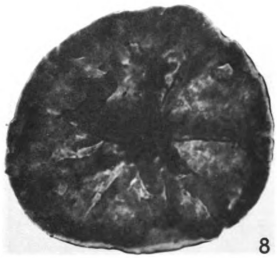
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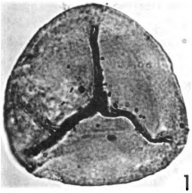
PLATE 6

Figure	Figures X800, except where indicated	Page
1	Endosporites micromanifestus Hacquebard, 1957; Pb5654-2, 33.0 x 104.6, 64µm. . . .	61
2	Endosporites minutus Hoffmeister, Staplin and Malloy, 1955b; Pb5663-2, 27.4 x 107.7, 39µm.	63
3, 4	Endosporites sp.; 3. Pb5679-2, 29.0 x 100.4, 56µm; 4. Pb5690-3, 26.4 x 107.8, 48µm.	64
5, 6	Geminospora sp. A; 5. Pb5654-2, 42.4 x 95.3, 42µm; 6. Pb5655-3, 7.7 x 107.3, 40µm.	66
7, 8	Granulatisporites crenulatus Playford, 1964; 7. Pb5686-2, 19.0 x 101.3, 34µm; 8. Pb5675-2, 29.7 x 103.1, 36µm	69
9	Granulatisporites frustulentus (Balme and Hassel, 1962) emend. Playford, 1971; Pb5663-2, 33.8 x 103.5, 38µm.	71
10, 11	"Filiformispora filiformis" gen. et sp. nov.; 10. Pb5658-2, 30.4 x 108.8, X500, 135µm; 11. BDF-3-6, 38.6 x 105.8, X500, 103µm	65

PLATE 6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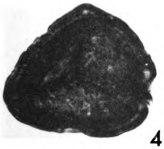
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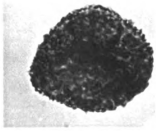
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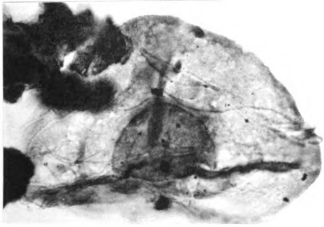
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PLATE 7

Figure	Figures X800, except where indicated	Page
1	Grandispora echinata Hacquebard, 1957; Pb5690-2, 35.4 x 110.4, 60µm.	68
2	Hymenozonotriletes explanatus (Luber, 1941) Kedo, 1963; Pb5654-2, 6.8 x 108.5, 62µm.	72
3, 6, 7, 8	Hymenozonotriletes lepidophytus Kedo, 1957; 3. Pb5654-4, 37.4 x 93.3, 52µm; 6. Pb5654-2, 32.6 x 105.7, 56µm; 7. Pb5658-7, 35.8 x 100.7, tetrad; 8. Pb5654-2, 42.5 x 93.2, 70µm	76
4, 5	Hymenozonotriletes famenensis Kedo, 1963; 4. Pb5654-2, 23.7 x 109.7, 60µm; 5. Pb5654-4, 41.0 x 93.2, 60µm	74

PLATE 7

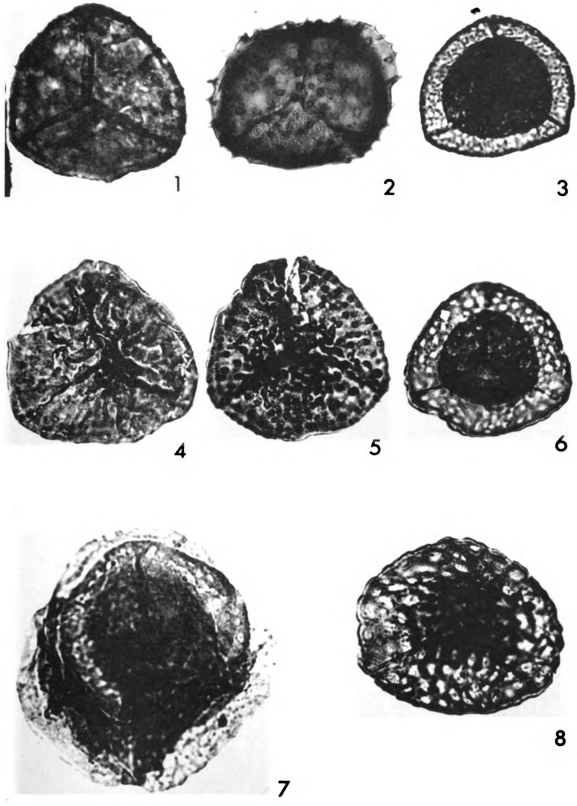
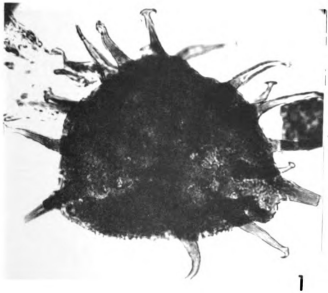


PLATE 8

Figure	Figures X800, except where indicated	Page
1, 2, 4	Hystricosporites delectabilis McGregor, 1960; 1. Pb5658-2, 17.1 x 105.3, X500, 110μm; 2. Pb5658-2, 13.2 x 104.2, X500, partial tetrad, individual specimens ca. 95μm; 4. Pb5658-2, 29.5 x 99.0, X500, 120μm	77
3	Hystricosporites cf. obscurus Mortimer and Chaloner, 1967; Pb5654-3, 45.0 x 112.5, X500, 90μm	79
5	Laevigatosporites sp.; Pb5654-2, 12.9 x 99.4, 30 x 42μm	82
6	Leiotriletes inermis (Waltz, 1938) Ishchenko, 1952; Pb5663-2, 23.4 x 105.6, 34μm.	83
7, 8	Leiotriletes ornatus Ishchenko, 1956; 7. Pb5690-2, 6.8 x 112.6, 48μm; 8. Pb5661-2, 20.7 x 107.2, 28μm.	84

PLATE 8



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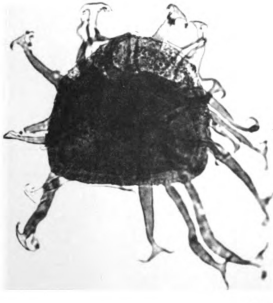

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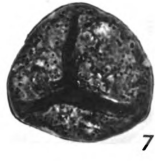

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PLATE 9

Figure	Figures X800, except where indicated	Page
1, 2	Knoxisporites literatus (Waltz, 1938) Playford, 1963; 1. Pb5675-2, 9.9 x 105.9, 95µm; 2. Pb5658-2, 15.4 x 103.7, 67µm. .	80
3	Lophozonotriletes bellus Kedo, 1963; Pb5658-2, 34.8 x 107.8, 32µm.	85
4, 5	Lophozonotriletes cristifer (Luber, 1941) Kedo, 1957; 4. Pb5693-1, 23.3 x 101.6, 45µm proximal face; 5. Pb5675-2, 20.0 x 98.1, 38µm proximal face.	86
6	Lophozonotriletes dentatus Hughes and Playford, 1961; Pb5688-2, 24.8 x 109.5, 46µm.	87
7	Lophozonotriletes malevkensis (Naumova in litt.) Kedo, 1963; Pb5685-2, 28.1 x 111.4, 38µm	88
8	Lophozonotriletes variverrucatus Playford 1963; Pb5663-2, 21.0 x 103.7, 60µm. . . .	91
9	Lophozonotriletes rarituberculatus (Luber 1941) Kedo, 1957; Pb5663-2, 31.5 x 110.9, 60µm.	90
10	"Peltatispora peltata" gen. et sp. nov.; Pb5671-2, 28.7 x 113.4, 32µm.	93
11	Microreticulatisporites hortonensis Playford, 1964; Pb5668-2, 18.3 x 108.3, 61µm.	92

PLATE 9

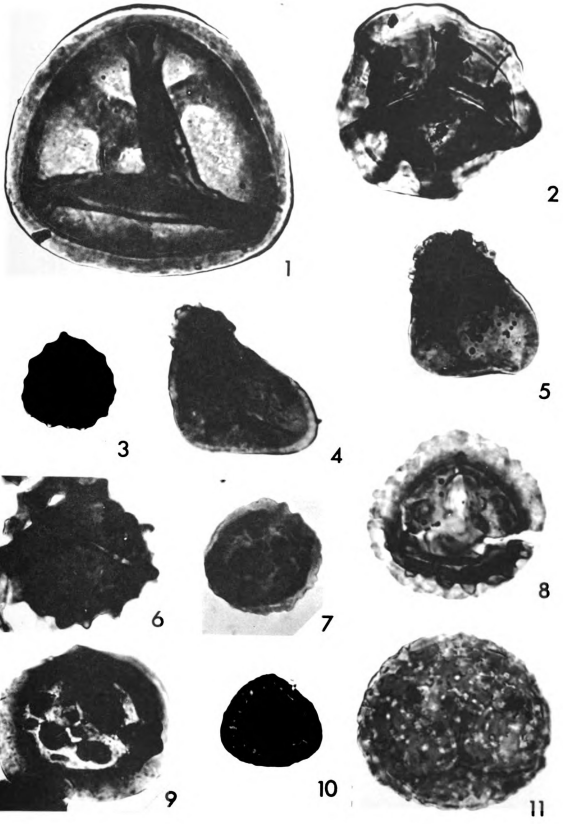

PLATE 10

Figure	Figures X800, except where indicated	Page
1	Perotrilites magnus Hughes and Playford, 1961; Pb5685-2, 16.4 x 108.0 X500, 118µm	95
2, 9	Punctatisporites planus Hacquebard, 1957; 2. Pb5686-2, 31.8 x 112.0, 50µm; 9. Pb 5685-2, 20.6 x 103.3, 60µm.	102
3	Punctatisporites nitidus Hoffmeister, Staplin, and Malloy, 1955b; Pb5670-2, 27.9 x 105.9, 34µm.	101
4	Perotrilites perinatus Hughes and Playford, 1961; Pb5656-2, 26.0 x 103.4, 58µm.	96
5, 6	Punctatisporites densiminutus Staplin, 1960; 5. Pb5660-3, 13.4 x 99.2, 25µm; 6. Pb5681-2, 35.7 x 110.9, 30µm	98
7	Punctatisporites fissus Hoffmeister, Staplin, and Malloy, 1955b; Pb5684-2, 31.9 x 111.3, 62µm.	99
8	Punctatisporites debilis Hacquebard, 1957; Pb5671-2, 29.8 x 110.0, 41µm. . . .	97
10	Pustulatisporites gibberosus (Hacquebard, 1957) emend. Playford, 1964; Pb5670-2, 19.5 x 106.0, 50µm.	104
11	Punctatisporites irrasus Hacquebard, 1957; Pb5675-2, 24.6 x 93.8, 71µm	100
12	Pustulatisporites sp. A; Pb5685-2, 31.3 x 102.9, 72µm	104

PLATE 10

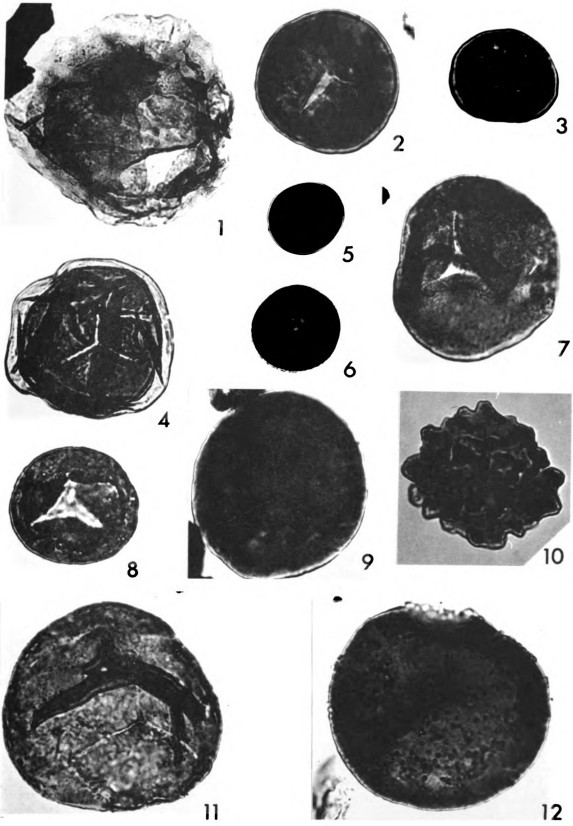

PLATE 11

Figure	Figures X800, except where indicated	Page
1	Raistrickia clavata (Hacquebard, 1957) emend. Playford, 1964; Pb5680-2, 17.9 x 100.1, 49µm	106
2, 3	Raistrickia baculosa Hacquebard, 1957; 2. Pb5674-2, 17.2 x 98.4, 46µm; 3. Pb 5663-2, 33.2 x 107.8, 60µm.	105
4	Raistrickia corynoges Sullivan, 1968; Pb5689-2, 23.7 x 108.4, 64µm.	107
5	Reticulatisporites crassus Winslow, 1962; Pb5670-2, 17.4 x 102.5, 80µm.	109
6	Reticulatisporites papillatus (Naumova, 1938) emend. Playford, 1971; Pb5675-2, 5.2 x 112.3, 78µm	110
7	Rhabdosporites firmus Guennel, 1963; Pb5654-4, 28.1 x 103.9, X500, 130µm . . .	113

PLATE 11

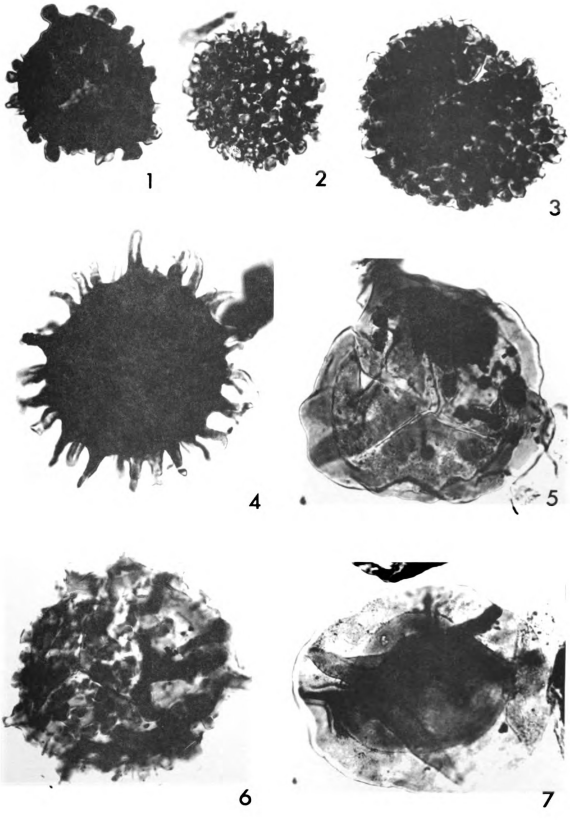

PLATE 12

Figure	Figures X800, except where indicated	Page
1	Retusotriletes cf. greggsii McGregor, 1964, Pb5654-2, 36.9 x 101.8, 60µm. . . .	112
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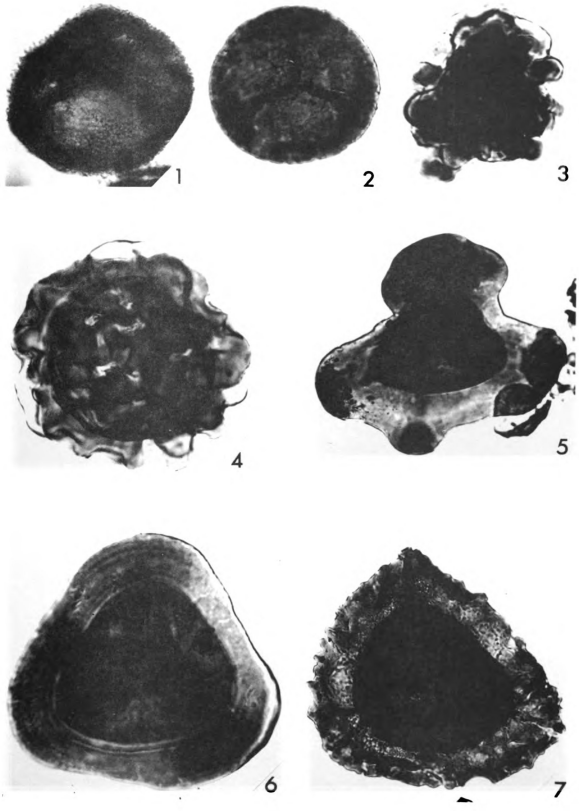
PLATE 12



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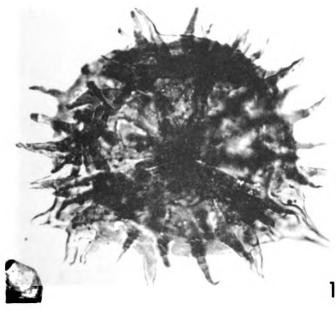
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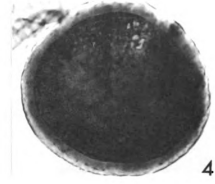
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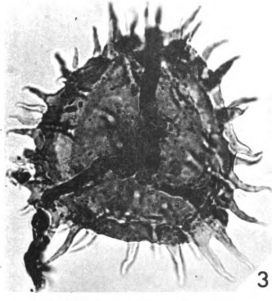
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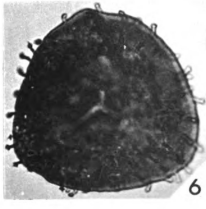
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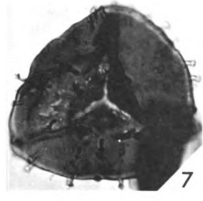
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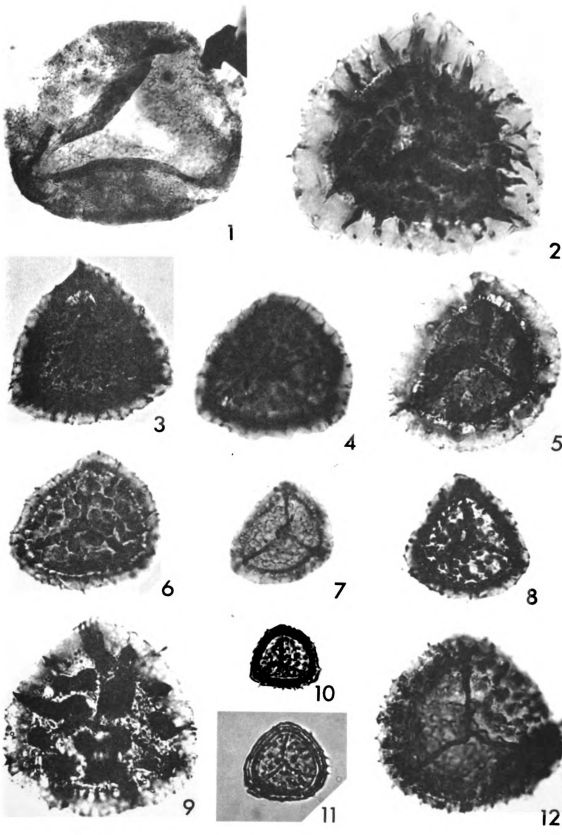

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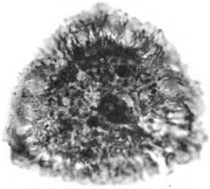
PLATE 15



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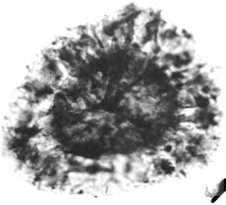

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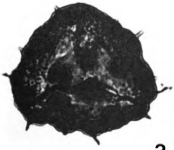

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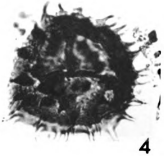

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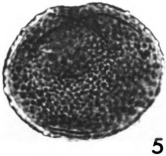

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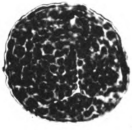

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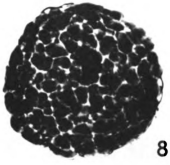

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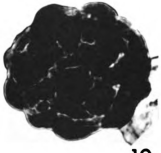

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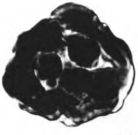

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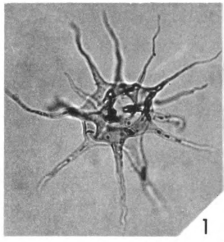
PLATE 16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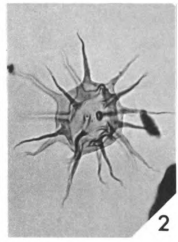
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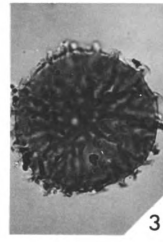
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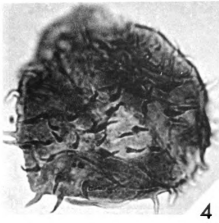
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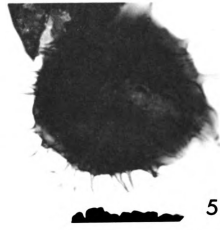
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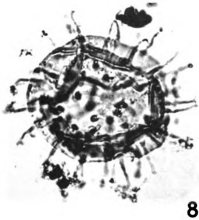
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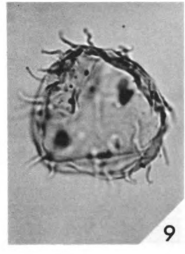
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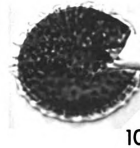
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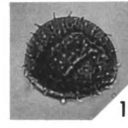
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PLATE 17

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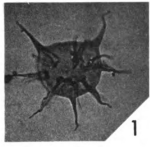
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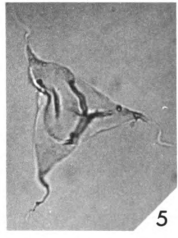
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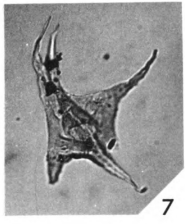
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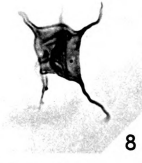
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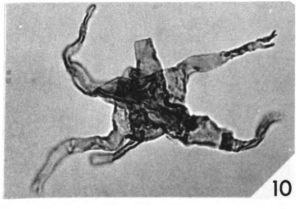
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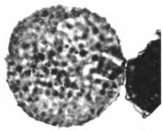
PLATE 18

PLATE 18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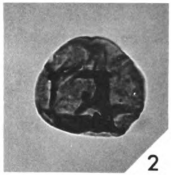
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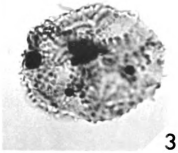
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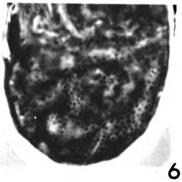
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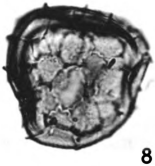
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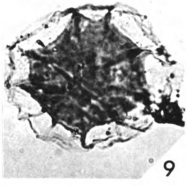
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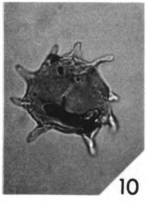
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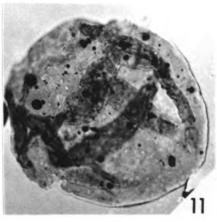
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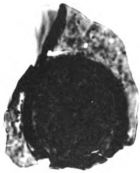
PLATE 19



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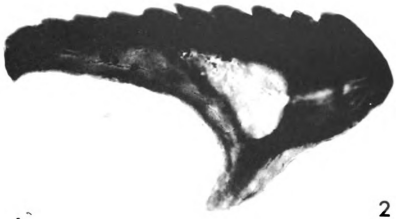

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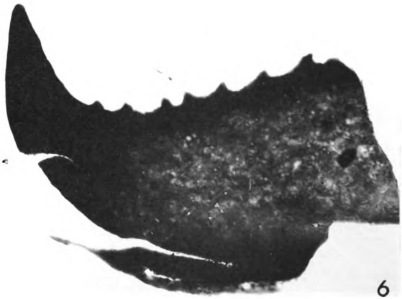

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