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MORPHOLOGY AND TAXONOMY OF FUNGAL SPORES

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M.V. SHEFFY AND D. L. DILCHER

DEPARTMENT OF BOTANY, INDIANA UNVERSITY

BLOOMINGTON, INDIANA

With plates 13—16

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Contents

INTRODUCTION

Fossil fungi are known from Precambrian to recent times. Nonseptate hyphae bearing some similarity to the Phycomycetes (Barghoorn & Tyler 1965) were reported from the middle Precambrian (1.9×10^{-9} yrs. B.P.), reproductive cells similar to those of the Ascomycetes (Schopf & Barghoorn 1969) are reported from the late Precambrian ($.8 \times 10^{-9}$ yrs. B.P.) and petrified clamp connections typical of the Basidiomycetes are reported (Dennis 1969) from the Pennsylvanian (3.5×10^{-8} yrs. B.P.). Thus the major groups of fungi are recognized early but almost nothing is known of their subsequent evolution from the fossil record. Dilcher (1965) indicates that many of the modern genera epiphytic upon leaves in the Ascomycetes were recognizable by early Tertiary times. Wolf (1969a and b) has also identified the teliospores of *Puccinia* sp. in Eocene sediments and the chlamydospores with supporting mycelium of the Phycomycetes, *Endogone* sp. from Pleistocene sediments.

The most frequently encountered remains of fungi found by paleobotanists are vegetative hyphae and isolated spores. Little use has been made of either of these by the paleobotanist because these types of remains can rarely be used to relate the fossils to any modern taxa. Mycologists, palynologists and stratigraphers are beginning to look more closely at fungal spores found in sediments and to report them hoping that enough data will be available soon from several sources so that stratigraphic correlations can be made and identifications with modern taxa will be possible. Not to report the material presented here would only further delay the availability of this information.

Fungal spores are extremely resistant to decay and often provide excellent material for study. Wolf (1966b) quotes temperature tolerance of some spores as (300° C) and concentrated acids (15 % HCL and 80 % acetic acid) and bases (30 % NaOH). However most palynologists ignore fungal spores in their samples when reporting their data. The argument for withholding information on fungal spores is often heard that there is little or nothing known about them so they contribute nothing to the results, however this attitude perpetuates our present ignorance of the fossil record of fungal spores.

Fungal spores are often produced in large quantities which provides an abundance of fossil spores in sediments. According to Graham (1962), it is possible for *Calvatia gigantia* (Pers.) Lloyd (giant puff ball) to produce an estimated 760,000,000,000 spores. Wilson (1962) writes that the abundant *Tilletia tritici* growth in eastern Washington may deposit five million smut spores on each square foot of soil.

Although little work has been done, it is thought that fungal spore data could provide supplementary data for pollen analysis. Fungal data could be used to describe vegetative history and to contribute to paleoecological interpretations since modern fungi are known to have specific ecological limitations, host specificity, and definite distribution patterns. This part of paleomycology has been almost completely ignored, because of the yet unsolved problems involving preliminary taxonomic work.

Fungal spores show morphological variation in shape, number of cells, number of pores, sculpture and number of layers in the cell wall. Still there is much uncertainty in identifying modern isolated fungal spores to specific and sometimes generic levels. It is often necessary to germinate similar spores for correct identification. In contrast to pollen studies, extensive modern reference collections have not yet been prepared. Increased knowledge of modern fungal forms is needed to clarify the fossil spore taxonomy, although it may remain impossible to assign some isolated spores to generic and specific groups.

NOMENCLATURE

Any study designed to show evolutionary relationships of the fungi, geographic distribution, or to indicate paleoecological trends should be based on a natural system of nomenclature. Rao (1958), Dilcher (1965) and other workers using vegetative hyphae or fruiting bodies in addition to the spores give new specific names to the fossils but place them in higher modern groups on the basis of unique features of the hyphae or fruiting bodies. For example, the new species *Meliola anfracta* is designated by Dilcher (1965) for vegetative hyphae and associated spores, and is assigned to the modern family Meliolaceae because of the very characteristic nature of the two-celled hyphopodia of the vegetative hyphae. This procedure has often been followed when fruiting bodies or other diagnostic fungal material is found.

Although problems involving a natural system of nomenclature and dispersed spores have already been mentioned, several authors have tentatively assigned modern names to some dispersed fungal spores. They include Bradley (1931, 1967), Ramanujam & Ramachar (1962), Rouse (1962), Graham (1965), and notably Wolf (1966a, 1966b, 1967a, 1967b), and Wolf & Cavaliere (1966c). However, it is generally agreed that spores should be attached to diagnostic macrofossil material or fruiting bodies to correctly assign them to modern taxa.

Bhardwaj (1955) realizes that nothing definite can be stated about the identity of parent plants of most dispersed spores but suggests that these spores can be used for ecological and floristic studies and to detect floral-breaks used in delimiting and correlating stratigraphic horizons. According to Bhardwaj this involves distinguishing spores belonging to each species and genus of the parent flora. Therefore he proposes that the taxonomic treatment of Sporae Dispersae should involve spore taxa as nearly equivalent to natural plant species and genera as possible. BHARDWAJ strongly supports the use of organ genera using the morphology of spores as a means to a phyletic grouping and believes that with few exceptions the use of a type species for each genus, will automatically lead to more or less natural genera. BHARDWAJ & VENKATACHALA (1968) illustrate this idea by successfully regrouping Sporae Dispersae of the Cryptogams such as Lycopsida, Sphenopsida and Pteropsida into a suprageneric classification which is based upon both distinctive morphology and phylogeny. The idea of a similar natural classification paralleling that for parent plants is well founded, however, morphology in fungal spores is not always a means to phylogenetic groups. In many cases only a few morphological characteristics can be observed and often almost identical spores can be produced by unrelated fungi. A natural system as proposed by BHARDWAJ may be appropriate for other types of spores but it is not acceptable for fungal spores.

Although most authors agree with SCHOPF (1938) in using natural nomenclature as much as possible, researchers concerned only with isolated fossil fungal spores have commonly resorted to completely artificial systems for types with doubtful affinities. NOREM (1955), in studying Sporae Dispersae for geological applications, uses a numerical reference for each type of spore. This procedure seems to he useful for stratigraphic diagnosis, however, the procedure would be inefficient for a large number of spores and difficult for several authors to use in the comparison of different deposits.

Most often the dispersed spores are assigned to form genera. Several types of systems have been used in the literature. WILSON (1962) assigns a new generic and specific name which refers to the morphology of the fossil spore, however, he does not propose a completely artificial system of nomenclature. Further, assignment of the form genus to a modern order of Fungi Imperfectae is questionable. A large number of distinctive fungal spores seem to warrant a consistent nomenclature for generic names which has not been followed by autbors reporting one or two spore types.

RUEDA-GAXIOLA (1969) in an extensive study proposes an orderly and consistent system of nomenclature for both pollen and spores. Form genera are used for algal and fungal spores and are assigned to five suprageneric categories. RUEDA-GAXIOLA's classification is not accepted or used in this paper because one fungus may produce four or five completely different spores each which might fall into completely different suprageneric categories proposed. Further, the use of subgroup, division and series in order to include information about the number of cells, number of apertures present and the type of spore ornamentation is cumbersome and unnecessary when the same information is also available in the generic and specific name. The use of an excessive number of categories only adds to confusion when dealing witb dispersed fungal spores.

Another procedure is followed by HAMMEN (1954a and b), ROUSE (1959, 1962), CLARKE (1965), and ELSIK (1968). The spores are included under Sporae Dispersae and placed in a morphological classification of form genera. The names do not refer to any extant fungi since the spores are not found *in situ* in fruiting bodies or associated with diagnostic vegetative hyphae. The genera are based on spore shape, number of cells and number of pores present. According to NOREM (1958) spore apertures are assumed to be genetically stable. The size of the spores, however, appears to be variable. BHARDWAJ (1955) has found that the size of cryptogamic miospores varies witbin a single species and that the range shows a proportionate increase as the size of the spore increases and can vary from 25—40 % of the normal spore size. Similar increases may apply to fungal spores and less emphasis is placed on this characteristic. The suffix *-sporites* is usually used to indicate fungal affinity, however, CLARKE (1965) suggests that *-sporonites* should be used for new genera since *-sporites* has priority as a generic suffix for spores of the Pteridophyte and the Bryophyte.

This nomenclatural system followed by HAMMEN (1954a and b), ROUSE (1959, 1962), CLARKE (1965), and ELSIK (1968) seems most satisfactory for the classification of fossil fungal spores and it is adopted in this paper. The dispersed fungal spores are classified according to morphological characteristics of spore shape, cell and aperture number, and surface ornamentation and this information is denoted in the generic and specific names. The narrow morphological limits of organ genera are attained with the use of the specific names of the form genera. An orderly system is still retained and an excessive number of genera is avoided. In the case of modern fungi, dispersed spores of several species within the same genus cannot be separated. It would be impossible to assign specific names for many organ genera. In the present system only generic and specific names are used.

Since an artificial system of nomenclature is used in this study, no modern taxa are used. However reference is made to the modern and fossil relationships of the spores described in the comments following the descriptions whenever possible.

SOURCE OF MATERIAL AND METHODS

The fungal assemblage described and illustrated in this report represents a limited amount of material isolated from the clays collected at the Puryear clay pit located one-half mile south of Puryear, Tennessee in Henry County, Tennessee. The clay in the Puryear pit is in the Claiborne Formation of middle Eocene age (DILCHER 1965). This clay pit is the same pit from which BERRY (1916 b) collected many of his fossil leaves.

The clay samples containing the polymorphs were processed according to techniques found in the Preparation Procedures of the Paleontology and Stratigraphy Branch, U.S. Geological Survey. The treatment included wetting with Varsol, ultrasonic vibration, zinc bromide flotation and mounting in glycerine jelly.

WOLF & CAVALIERE (1966 c) have noted differential recovery of pigmented spores using the acetolysis treatment. They found that both hyaline and pigmented spores are resistant to decay and that the hyaline spores or spores containing hyaline and pigmented cells become discolored by the acetolysis treatment. No acetolysis was used in the preparation of the samples for this research and spores with different shades of pigment were observed. WOLF (1968 b) shows that some spores are destroyed by acetolysis and decay and he suggests that this is partly due to the differences in the chemistry of the cell walls. ELSIK (1968) also mentions that presence of dark pigment may obscure the number of layers in the spore wall, a characteristic often used to delimit some species.

Contamination of samples, another hazzard, can be avoided by drying the sediment or storing the sample in acid at low temperatures. The samples used in this investigation were air dryed after collection. It may also be possible to detect contamination on prepared slides since WOLF & CAVALIERE (1966 c) noted that fossil spores are completely empty as compared to extant members. No evidence of contamination was found in the material used in this investigation.

DESCRIPTIONS OF FOSSIL FUNGAL SPORES

Sporae Dispersae

Inapertisporites (HAMMEN) emend.

Emended Description: Fungal or algal spores unicellate, nonseptate, and inaperturate. Shape globular or subglobular; outline smooth or often uneven because of wrinkles or folds. Ornamentation variable. Size range 5—11μ.

Type Species: *Inapertisporites pseudoreticulatis* ROUSE 1959.

Comments: The present emendment is primarily based on the description by ROUSE (1959). A second emended description, ELSIK (1968), limits the sculpture to psilate. Since many spores published by HAMMEN (1954) and ROUSE (1959, 1962) are not psilate the sculpture description is revised.

Inapertisporites vulgaris sp. nov.
Pl. 13, fig. 1; Pl. 15, fig. 1

Description: Spherical spore, unicellular, inaperturate, pigment solid, medium to dark, psilate; diameter ranges from 6.8—14.5μ (ten specimens).[1] Holotype: Puryear Palynomorph Slide (1)[2] 17.2×114.4, diameter 11.6μ.

Comments: The specific name indicates that the spore is a common form. Some of these single celled spores may correspond to ascospores reported by SCOTT (1956). He illustrates ascospores of *Cryptocolax clarensis*

[1] The number of specimens observed for each species is noted in the description when more than one example was found.

[2] The slides used in this study are deposited in the Indiana University Paleobotanical Collection. Puryear Palynomorph Slide material is abbreviated P.P.S. hereafter in the paper. The slide number and co-ordinates are given for each holotype.

and *Cryptocolax parvula.* The former is 5.8μ wide, 8—10μ long, the latter is globose to ellipsoidal 6.0—7.5μ long, 4.5—6.0μ wide. SCOTT also suggests that identical material has been interpreted by BERRY (1916a) as oospores of *Peronosporoides palmi.* Other circular shaped spores illustrated by BERRY are recorded as conidia of *Cladosporites fasciculatus.* Although BERRY describes them as fusiform in outline and somewhat variable in length, 2.0 × 4.0μ, 2.0 × 12.0μ, they appear similar to *I. vulgaris.*

Inapertisporites circularis sp. nov.
Pl. 13, fig. 2; Pl. 15, fig. 2

Description: Spherical fungal spore, unicellular, inaperturate, psilate; wall distinct, 1.0μ thick. Diameter ranges from 9.7—11.6μ (three specimens). Holotype: PPS (1) 22.3 × 113.8, diameter 11.6μ.

Comments: This spore resembles *Inapertisporites laevigatus,* ROUSE (1959, Pl. 2, fig. 30), however it has a thick wall and shows no germinal aperture. A similar type spore is illustrated by GRAHAM (1965, Pl. 19, fig. 2) but description and dimensions are lacking. GRAHAM refers the spore type to Class Basidiomycetes, Order Ustilaginales. *I. circularis* also resembles the conidiospore *Pelicothallos villous,* Order Microthyriales, Family Trichopelteae, DILCHER (1965, Pl. 14, figs. 114, 115). The dimensions, however, do not correspond.

Inapertisporites ovalis sp. nov.
Pl. 13, fig. 3; Pl. 15, fig. 3

Description: Oval psilate fungal spore, nonseptate, wall smooth 1.0μ thick. Size ranges from 4.8 × 10.2μ —7.7 × 14.5μ (two specimens). Holotype: PPS (1) 22.0 × 114.1, size 7.7 × 14.5μ.

Comments: A similar type spore is illustrated by GRAHAM (1965, Pl. 19, fig. 3) but description and dimensions are lacking. GRAHAM refers the spore type to Class Ascomycetes, Order Sphaeriales, Family Xylariaceae, Genus *Sordaria.*

Inapertisporites subcapsularis sp. nov.
Pl. 13, fig. 4; Pl. 15, fig. 4

Description: Capsilate, psilate, unicellular spore, inaperturate slightly constricted along one side. Size ranges from 11.6 × 17.4μ—17.9 × 26.6μ (three specimens). Holotype: PPS (1) 14.6 × 115.9, size 12.1 × 21.8μ.

Inapertisporites reticulatus sp. nov.
Pl. 13, fig. 5; Pl. 15, fig. 5

Description: Oblong spore 12.6 × 48.4μ, slightly tapered at one end, dark pigment, reticulate, inaperturate. Holotype: PPS (1) 16.9 × 111.6.

Inapertisporites longissimus sp. nov.
Pl. 13, fig. 6; Pl. 15, fig. 6

Description: Oblong spore 12.6 × 40.6μ, one longitudinal side slightly indented. Psilate, medium pigment. A longitudinal fold at one end appears to be the result of preservation. Holotype: PPS (1) 22.3 × 106.4.

Inapertisporites subovoideus sp. nov.
Pl. 13, fig. 7; Pl. 15, fig. 7

Description: Egg-shaped unicellular with flattened apex. Psilate, inaperturate, wall 0.5—1.0μ thick. Size ranges from 4.8 × 9.2μ—14.5 × 19.3μ (three specimens). Holotype: PPS (1) 18.5 × 115.3, 4.8 × 12.6μ.

Comments: The flat hase is somewhat slanted on one specimen, another specimen has two lateral folds in the center.

Inapertisporites disciformis sp. nov.
Pl. 13, fig. 8; Pl. 15, fig. 8

Description: Disk-shaped spore 6.8×16.4μ, psilate, medium pigment, wall 1.0μ thick. Holotype: PPS (1) 17.6×101.2.

Comments: An irregular longitudinal crease appears to be the result of preservation.

Inapertisporites obscurus sp. nov.
Pl. 13, fig. 9; Pl. 15, fig. 9

Description: Capsular spore 15.5×26.1μ, psilate, dark solid pigment. Holotype: PPS (1) 17.6×108.4.

Comments: The small rectangular projection found at one end of the spore appears to be an artifact.

Inapertisporites minutus HAMMEN 1954
Pl. 13, fig. 10; Pl. 15, fig. 10

Comments: The Puryear specimen is spherical, unicellular, inaperturate, scabrate or pitted, light pigment, diameter 9.1μ.

Inapertisporites nodulus sp. nov.
Pl. 13, fig. 11; Pl. 15, fig. 11

Description: Spherical, unicellular with small spherical projection, 14.6μ in diameter, psilate, nonseptate. Spore dark pigment, light colored projection. Holotype: PPS (1) 17.0×104.8.

Comments: KEDVES (1961, Pl. 2, fig. 10) illustrates a spore with similar dimensions and shape, however, the projection has dark pigment and a thick layered wall is visible.

Inapertisporites elongatus ROUSE 1962
Pl. 13, fig. 12; Pl. 15, fig. 12

Comments: The Puryear specimen is oval or broadly elliptic 7.7×13.5μ, psilate, light pigment. Wall smooth, two layers 1.0μ thick.

Inapertisporites vittatus sp. nov.
Pl. 13, fig. 13; Pl. 15, fig. 13

Description: Elliptical spore 11.2×31.4μ, terminal ends tapered abruptly, psilate, wall two layers 3.4μ thick, first layer forms a wide opaque band. Holotype: PPS (1) 12.7×11.8.

Comments: The specific name refers to the opaque band formed by one layer of the cell wall.

Inapertisporites irregularis sp. nov.
Pl. 13, fig. 14; Pl. 15, fig. 14

Description: Subspherical spore 7.7×14.0μ, with small oblong projection. Nonseptate, granular, wall 0.7μ thick continuous into projection. Holotype: PPS (1) 16.0×103.4.

Inapertisporites obpyriformis sp. nov.
Pl. 13, fig. 15; Pl. 15, fig. 15

Description: Spherical spore 11.6×19.3μ, with smaller round neck-like projection. Psilate, nonseptate, pigment even througbout spore. Holotype: PPS (1) 13.9×115.8.

Inapertisporites subcurvatus sp. nov.
Pl. 13, fig. 16; Pl. 15, fig. 16

Description: Oblong spore 7.7×28.0μ with blunt terminal ends, slight bend at equator. Psilate, medium pigment, wall 0.7μ thick. Holotype: PPS (1) 13.2×94.7.

Inapertisporites scabridus sp. nov.
Pl. 13, fig. 17; Pl. 15, fig. 17

Description: Subspherical spore 14.5μ in diameter with small spherical projection, coarsely pitted, nonseptate. Wall 0.7μ thick continuous into projection. Holotype: PPS (1) 10.6×111.7.

Inapertisporites pulvinatus sp. nov.
Pl. 13, fig. 18; Pl. 15, fig. 18

Description: Oblong spore rounded at terminal ends, 7.7×26.1μ. Nonseptate, medium pigment. Spore shows double layered wall along one longitudinal side, 1.0μ thick. Holotype: PPS (1) 8.5×105.0.

Comments: The specific name *pulvinatus* means cushioned, convex or rather flattened referring to the terminal ends of the spore.

Inapertisporites reniformis sp. nov.
Pl. 13, fig. 19; Pl. 15, fig. 19

Description: Reniform spore 8.7×23.2μ slightly tapered at one end. Psilate, medium pigment with lateral fold at wider end of spore. Holotype: PPS (1) 2.7×98.2.

Monoporisporites (HAMMEN 1954) emend.

Emended Description: Monoporate, nonseptate, psilate to finely punctate fungal or algal spores. Shape spherical to subspherical, hilate or monoporate.

Type Species: *Monoporisporites minutus* HAMMEN 1954.

Comments: The present emendment combines two previously emended descriptions; CLARKE (1965) defines the sculpture as psilate to finely punctate and adds the word hilate for he considers the "pore" to be either a hyaline area or a pore, ELSIK (1968) applies the genus to both fungal and algal spores. The description is now expanded to include the punctate species *Monoporisporites glubosus* CLARKE, *M. burgli* HAMMEN, and *M. minutus* HAMMEN, the type species.

Monoporisporites annulatus HAMMEN 1954
Pl. 13, fig. 20; Pl. 15, fig. 20

Description: Fungal spore unicellular, subspherical, psilate, monoporate, pore unsymmetrical with raised annulus, cell wall two layers, 1.1μ thick, size 8.7×12.6μ.

Monoporisporites ovalis sp. nov.
Pl. 13, fig. 21; Pl. 15, fig. 21

Description: Oval spore, 13.5×19.3μ, psilate, medium pigment. Pore asymmetrical at one end of spore, wall 1.0μ thick. Holotype: PPS (1) 22.3×111.3.

Monoporisporites singularis sp. nov.
Pl. 13, fig. 22; Pl. 15, fig. 22

Description: Spherical spore 14.5μ in diameter, unicellular, psilate with dark pigment. Single asymmetrical pore with annulus; wall three layers, 1.5μ thick. Holotype: PPS (1) 16.4×111.3.

Comments: This spore is similar to *M. grandis* HAMMEN having psilate wall, dark color and a large pore with annulus. However the size, the completely spherical shape and triple layered wall warrants a distinct name. The specific name *singularis*, refers to these unusual characteristics.

Monoporisporites cupuliformis sp. nov.
Pl. 13, fig. 23; Pl. 15, fig. 23

Description: Subspherical spore 9.6×11.6μ, flat on one side, pore on opposite side. Dark pigment, psilate, wall three layers 1.5μ thick. Holotype: PPS (1) 21.9×103.5.

Comments: The specific name refers to the cup-shape of the spore.

Monoporisporites abruptus sp. nov.

Pl. 13, fig. 24; Pl. 15, fig. 24

Description: Oval spore 7.7×15.5μ, flat along extended sides, tapered abruptly at one end, forming flat neck with pore. Psilate, dark pigment, wall 1μ thick. Holotype: PPS (1) 17.4×109.0.

Dicellaesporites (ELSIK 1968) emend.

Emended Description: Inaperturate fungal spores or algal bodies. Two cells, uniseptate, shape variable. Sculpture psilate to scabrate.

Type Species: *Dicellaesporites popovii* ELSIK 1968.

Dicellaesporites levis sp. nov.

Pl. 13, fig. 25; Pl. 15, fig. 25

Description: Dicellate spore, cells unequal in size, rounded at the apices, septum opaque, disk shaped, slight equatorial constriction. Wall psilate, 0.5—1.0μ thick. Size ranges from 9.7×27.1μ—9.7×27.6μ (two specimens). Holotype: PPS (1) 2.6×114.0, 9.7×27.1μ.

Comments: This spore is similar in shape but slightly smaller than one illustrated by BRADLEY (1931, Pl. 20, fig. 1). BRADLEY suggests that it may be either a conidiospore belonging to the genus *Trichothecium* or an ascospore belonging to *Mycosphaerella* or *Didymella*.

Dicellaesporites aculeolatus sp. nov.

Pl. 13, fig. 26; Pl. 15, fig. 26

Description: Dicellate spore, slightly tapered at both ends. Single opaque septum, wall smooth 0.5—1.0μ thick with small irregular folds. Size ranges from 5.8×18.4μ—6.8×21.3μ (two specimens). Holotype: PPS (1) 19.6×96.0, 6.8×21.3μ.

Comments: The specific name refers to the spore apices which are somewhat pointed.

Dicellaesporites granuliformis sp. nov.

Pl. 13, fig. 27; Pl. 15, fig. 27

Description: Spore 7.7×13.1μ, terminal ends rounded, one end slightly tapered toward one side of the longitudinal axis. Light pigment, granular, uniseptate, slight equatorial constriction. Holotype: PPS (1) 13.9×116.4.

Dicellaesporites sp.

Pl. 13, fig. 28; Pl. 15, fig. 28

Description: Oval spore 10.6×20.3μ, granular, wall 1.0μ thick. Septum fragmented into three portions, one segment folded into hook like structure.

Comments: The material attached to the spore wall above the septum appears to be an artifact. No specific name was given for the fragmented septum may be the result of poor preservation.

Dicellaesporites fusiformis sp. nov.

Pl. 13, fig. 29; Pl. 15, fig. 29

Description: Fusiform, fungal spore 8.7×17.4μ, psilate, light pigment. Septum disk shaped, wall 1.0μ thick. Holotype: PPS (1) 18.2×107.1.

Dicellaesporites appendiculatus sp. nov.

Pl. 13, fig. 30; Pl. 15, fig. 30

Description: Capsular, dicellate spore 9.7×19.3μ, pore in one cell leading to a flat basal attachment. Psilate, opaque equatorial septum, 2.9μ thick. Medium pigment, wall 0.7μ thick. Holotype: PPS (1) 14.6×110.6.

Dicellaesporites disphaericus sp. nov.
Pl. 13, fig. 31; Pl. 15, fig. 31

Description: Two-celled spore, 16.4×26.4μ, cells spherical slightly flattened at one end. Dark pigment, wall rough scabrate, 1.0μ thick, opaque equatorial septum and pronounced constriction. Holotype: PPS (1) 13.4×102.5.

Dicellaesporites fragilis sp. nov.
Pl. 13, fig. 32; Pl. 15, fig. 32

Description: Oval, psilate fungal spore, 5.8×6.8μ, acute to slightly rounded apices. Light pigment, walls of cells overlapping at boundary to form disk shaped septum, 0.5μ thick. Holotype: PPS (1) 21.6×111.5.

Dicellaesporites ? sp.
Pl. 13, fig. 33; Pl. 15, fig. 33

Description: Fusiform spore 25.1×54.2μ, dark pigment, psilate, slight equatorial constriction marked by thick opaque septum 3.4×5.6μ with large central pore 0.6μ wide. Wall smooth, 1.5μ thick, one end fragmented.

Comments: Fragmented end prevents definite identification of aperture type. The spore is placed in the genus *Dicellaesporites* until more complete material can be obtained.

Dicellaesporites ? sp.
Pl. 13, fig. 34; Pl. 15, fig. 34

Description: Two-celled spore, psilate, 3.9×16.4μ. Terminal cell tapers into narrow round neck, other cell has two end wall projections, additional cell or cells may be torn away. Linear septum, wall 0.7μ thick.

Comments: This spore appears to be a fragment of a longer chain of cells. It is temporarily placed under *Dicellaesporites*.

Didymoporisporonites gen. nov.

Description: Spore dicellate, uniseptate, pore at apex of one cell. Sculpture psilate to punctate, shape variable.

Type Species: *Didymoporisporonites psilatus* sp. nov.

Didymoporisporonites psilatus sp. nov.
Pl. 13, fig. 35; Pl. 15, fig. 35

Description: Oval, two-celled, psilate fungal spore. Cells unequal in size, single pore in smaller cell, larger cell with darker pigment. Septum opaque, wall 0.5—1.0μ thick. Size ranges from 6.3×10.6μ—6.8×11.1μ (two specimens). Holotype: PPS (1) 13.0×102.8, 6.8×11.1μ.

Didymoporisporonites normalis sp. nov.
Pl. 13, fig. 36; Pl. 15, fig. 36

Description: Two-celled spore, slight constriction at boundary of cells. Psilate, opaque septum, wall 0.5—1.0μ thick, pore at one end. Size ranges from 3.9×9.7μ—5.8×13.5μ (two specimens). Holotype: PPS (1) 22.2×114.6, 5.8×13.5μ.

Didymoporisporonites inaequalis sp. nov.
Pl. 13, fig. 37; Pl. 15, fig. 37

Description: Two-celled spore, 7.7×12.6μ, cells of unequal size, round to subspherical, walls overlap at boundary to form disk-shaped septum. Potential thin walled germinal pore in terminal end of smaller cell, wall 0.5μ thick. Holotype: PPS (1) 21.7×97.6.

Comments: The spore is similar in shape and dimensions to *Shortensis memorabilis*, Order Microthyriales, Family Stomiopeltoideae, DILCHER (1965, Pl. 20, figs. 157—159). The present material, however, does not show a hyaline sheath nor lighter pigment in the smaller cell. The potential germinal pore is not recorded for *Shortensis memorabilis* but DILCHER does note on p. 30, that "the small hyaline cell of the spore develops into the initial hyphal cell which produces a terminal hypha and an obliquely disposed lateral hypha in opposite directions (Pl. 21, fig. 161)."

Didymoporisporonites obtectus sp. nov.
Pl. 13, fig. 38; Pl. 15, fig. 38

Description: Capsular, punctate; equatorial constriction with single opaque septum 3.4μ thick. One end flat with large pore 2.8μ wide; wall 1.5μ thick, heavily punctate. Psilate sheath encloses spore. Holotype: PPS (1) 22.0×104.5.

Comments: The specific name refers to the presence of an external psilate sheath.

Dyadosporonites (HAMMEN 1954) ELSIK 1968

Comments: This genus was also defined by CLARKE (1965). All parts of this description are included or expanded in the emended form by ELSIK (1968).

Dyadosporonites didymus sp. nov.
Pl. 14, fig. 39; Pl. 16, fig. 39

Description: Psilate didymospore 5.8×22.2μ, equatorial septum and constriction separating identical cells. Pore at the end of each cell, wall 1.0μ thick. Holotype: PPS (1) 21.4×111.0.

Dyadosporonites subovalis sp. nov.
Pl. 14, fig. 40; Pl. 16, fig. 40

Description: Dicellate, psilate fungal spore 6.3×10.6μ. Pores in both terminal ends, one apex round, the opposite apex flat. Single septum is opaque, wall 1.0μ thick. Holotype: PPS (1) 14.6×109.9.

Multicellaesporites (ELSIK 1968) emend.

Emended Description: Inaperturate, psilate to scabrate fungal spores or algal bodies of three or more cells; two or more septae. Shape variable around a long axis.

Type Species: *Multicellaesporites nortonii* ELSIK 1968.

Comments: The description was emended to include a wider range of ornamentation as found in the type species.

Multicellaesporites nortonii ELSIK 1968
Pl. 14, fig. 41; Pl. 16, fig. 41

Comments: The Puryear specimen is fusiform 10.2×32.4μ, pentacellate with light pigment. It is inaperturate, granular or slightly punctate; wall 0.5μ thick.

Multicellaesporites simplicissimus sp. nov.
Pl. 14, fig. 42; Pl. 16, fig. 42

Description: Ovate tricellate fungal spore 7.7×14.0μ. Psilate, inaperturate, two opaque septa 0.2μ thick, wall 1.0μ thick. Holotype: PPS (1) 10.1×95.0.

Multicellaesporites irregularis sp. nov.
Pl. 14, fig. 43; Pl. 16, fig. 43

Description: Phragmospore 9.7×48.4μ, uniseries of thirteen irregular oblong cells, ends tapered, one end with flat basal attachment. Psilate, inaperturate, septa parallel, opaque, varying thickness. Wall scabrous, 0.7μ thick. Holotype: PPS (1) 9.8×115.7.

Multicellaesporites ovatus sp. nov.
Pl. 14, fig. 44; Pl. 16, fig. 44

Description: Ovate, tetracellate spore 9.2×18.4μ, slightly tapered at one end. Psilate, inaperturate, three opaque septa, wall 1.0μ thick. Holotype: PPS (1) 9.2×96.1.

Comments: This spore is similar to line drawing by WOLF (1967d, Fig. 2, no. 71, 75, 88, 107) identified as *Pleospora*.

Multicellaesporites pandus sp. nov.
Pl. 14, fig. 45; Pl. 16, fig. 45

Description: Pentacellate spore 6.8×13.5μ, curved at one end, cells decrease in size toward opposite end, slight constrictions between cells. Psilate, wall 0.5μ thick. Holotype: PPS (1) 11.4×100.8.

Comments: *M. pandus* appears to have two bodies attached by a light pigmented wall. Individual bodies are dicellate and tricellate with opaque septa. The specific name *pandus* means bent, crooked, curved which describes the shape of the spore. The shape and septation of this spore resembles the material which BRADLEY (1931, Pl. 19, fig. 5) referred to *Septonema*, however, the spore illustrated consists of two elongated spores and has larger dimensions.

Multicellaesporites elongatus sp. nov.
Pl. 14, fig. 46; Pl. 16, fig. 46

Description: Phragmospore 7.7×47.4μ, seven cells flattened at common boundaries, convex on sides. One terminal cell tapered forming flat basal attachment. Psilate, septa opaque, wall 1.0μ thick. Holotype: PPS (1) 13.0×101.2.

Comments: This spore resembles the shape of teliospores of *Xendochus* SCHECT., RAMANUJAM & RAMACHAR (1963, fig. 4), however, *M. elongatus* differs in number of cells and lacks pores.

Multicellaesporites capsularis sp. nov.
Pl. 14, fig. 47; Pl. 16, fig. 47

Description: Capsular fungal spore 14.0×27.1μ, tricellate, inaperturate. Psilate, opaque septa 2.8—3.4μ thick, nonparallel, wall 1.0μ thick, flat portion to one side of longitudinal center at one end of spore. Holotype: PPS (1) 13.9×94.7.

Multicellaesporites attenuatus sp. nov.
Pl. 14, fig. 48; Pl. 16, fig. 48

Description: Phragmospore 8.7×31.9μ, six irregular oblong cells. Tapered slightly toward both ends, one terminal cell round, the opposite end flat. Psilate, pentaseptate opaque, varying in width, wall 1.0μ thick. Holotype: PPS (1) 16.9×98.9.

Comments: Flat terminal end may be a septum separated from a longer chain of cells. The opening at the apex appears to be a tear, not a pore.

Multicellaesporites ellipticus sp. nov.
Pl. 14, fig. 49; Pl. 16, fig. 49

Description: Tetracellate elliptical shaped spore 7.7×19.3μ, slight constriction between center cells. Psilate, inaperturate, light pigment. Triseptate, septa and wall 1.0μ thick. Holotype: PPS (1) 17.4×111.8.

Multicellaesporites fusiformis sp. nov.
Pl. 14, fig. 50; Pl. 16, fig. 50

Description: Fusiform, tetracellate spore 5.8×20.3μ, psilate, inaperturate. Slight constriction between two central cells, central cells overlap smaller tapered cells on either end of spore, wall 0.5μ thick. Holotype: PPS (1) 19.2×113.0.

Comments: This spore resembles the material which BRADLEY (1931, Pl. 19, fig. 2) identified as *Leptosphaeria*.

Multicellaesporites grandiusculus sp. nov.
Pl. 14, fig. 51; Pl. 16, fig. 51

Description: Phragmospore, pentacellate, 15.5 × 35.8μ, cells flattened along common boundaries, convex on sides, end cells rounded. Psilate, inaperturate, septa opaque, wall 1.0μ thick. Holotype: PPS (1) 18.4 × 111.0.

Comments: The material attached to the walls appears to be an artifact. The specific name indicates that the spore is somewhat large in size. This spore resembles an unidentified spore illustrated by Wolf (1966a, Fig. 4, no. 26), and material which Wolf & Cavaliere (1966c, Pl. 1, no. 17) identified as *Calonectria*. It is also similar to spore of *Meliola spinksii*, Family Meliolaceae, Order Erysiphales, Dilcher (1965, Pl. 2, figs. 9, 10, 11).

Multicellaesporites allomorphus sp. nov.
Pl. 14, fig. 52; Pl. 16, fig. 52

Description: Tetracellate spore 5.3 × 18.4μ. Central constriction in second cell, opposite end blunt. Three disk shaped septa, wall light pigment, granular, 0.5μ thick. Holotype: PPS (1) 6.0 × 95.1.

Comments: The specific name *allomorphus* refers to the strange shape of the spore.

Multicellaesporites didymus sp. nov.
Pl. 14, fig. 53; Pl. 16, fig. 53

Description: Tetracellate spore 6.8 × 21.3μ, psilate inaperturate. Constricted in center, triseptate, equatorial septum thick, opaque. Light pigment, wall 0.5μ thick. Longitudinal walls of center cells slightly convex. Holotype: PPS (1) 22.2 × 104.1.

Comments: The specific name *didymus* means twin or similar pairs referring to the two pairs of cells separated by the equatorial constriction. This spore resembles an unidentified spore illustrated by Wolf (1966b, Pl. 3, no. 34), but is somewhat smaller.

Multicellaesporites sacciformis sp. nov.
Pl. 14, fig. 54; Pl. 16, fig. 54

Description: Oblong, tetracellate 10.6 × 30.9μ, round at apex, tapering toward basal cell. Psilate, pore between basal cell and basal attachment, three opaque septa decreasing in width toward the base, wall 1.0μ thick. Holotype: PPS (1) 4.0 × 99.5.

Multicellaesporites bigeminatus sp. nov.
Pl. 14, fig. 55; Pl. 16, fig. 55

Description: Tetracellate 3.9 × 21.3μ. Cell wall continuous constricted in center separating two didymospore configurations each having a disk-shaped septum. Psilate, light pigment, wall 0.5μ thick. Holotype: PPS (1) 17.6 × 94.8.

Comments: The specific name refers to the pair of dicellate bodies.

Multicellaesporites ? sp.
Pl. 14, fig. 56; Pl. 16, fig. 56

Description: Oblong-oval spore 19.3 × 46.4μ, pentacellular, psilate. One end cell folded, wall irregular in outline 1.0μ thick, tetraseptate. Spore appears folded longitudinally through septa and end wall.

Comments: Spore is folded at one apex and definite aperture type cannot be determined.

Multicellaesporites ? sp.
Pl. 14, fig. 57; Pl. 16, fig. 57

Description: Tetracellate phragmospore, 8.7 × 18.4μ, psilate, one apex blunt, opposite apex torn. Three septa irregular, folded, torn, wall 1.0μ thick.

Comments: Type of aperture cannot be determined because of fragmented spore wall. Spore is temporarily assigned to the genus *Multicellaesporites*.

Pluricellaesporites (HAMMEN 1954) emend.

Emended Description: Monoporate, psilate to scabrate fungal or algal spores of three or more cells; two or more septa. Cells linear along one long axis.

Type Species: *Pluricellaesporites typicus* HAMMEN 1954.

Comments: The emended description of ELSIK (1968) includes spores with three or more cells. It does not mention a slit-like opening through the septa as found in the generic description of CLARKE (1965). The present description introduces psilate to scabrate ornamentation.

Pluricellaesporites simplicissimus sp. nov.
Pl. 14, fig. 58; Pl. 16, fig. 58

Description: Tricellate, monoporate fungal spore 5.8×12.6μ, cells flattened at common boundaries, convex at sides. Wall psilate 1.0μ thick, septa opaque 2.0μ thick. Holotype: PPS (1) 21.4×112.8.

Pluricellaesporites subcapsilaris sp. nov.
Pl. 14, fig. 59; Pl. 16, fig. 59

Description: Capsular, tricellate fungal spore with flattened basal attachment and round apex with single pore. Wall 1.0μ thick, psilate, two opaque septa 4.0—7.0μ thick. Size ranges from 14.2×21.3μ—16.4×26.6μ (two specimens). Holotype: PPS (1) 16.8×110.8, 14.5×21.3μ.

Comments: This spore is similar to an unidentified spore illustrated by WOLF (1966b, Fig. 4, no. 36).

Pluricellaesporites longicollus sp. nov.
Pl. 14, fig. 60; Pl. 16, fig. 60

Description: Tricellate, psilate fungal spore 6.0×24.2μ. Wall 1.0μ thick, light pigment, two disk shaped septa present. One end cell is highly tapered into a neck with a single pore. Holotype: PPS (1) 11.0×103.0.

Comments: The specific name of the spore refers to the presence of a long terminal neck.

Pluricellaesporites ovatus sp. nov.
Pl. 14, fig. 61; Pl. 16, fig. 61

Description: Ovate pentacellate fungal spore 11.6×22.2μ, psilate, tapering slightly toward one end. Pore to the side of the longitudinal axis at wide end of spore. Four opaque septa present, wall 0.7μ thick. Holotype: PPS (1) 17.9×113.5.

Pluricellaesporites tenuis sp. nov.
Pl. 14, fig. 62; Pl. 16, fig. 62

Description: Phragmospore 3.9×26.6μ, six irregular shaped cells, slight constriction between some cells. Pigment light, psilate, pore in terminal tapered cell. Five translucent septa, wall 0.5μ thick. Holotype: PPS (1) 5.7×115.3.

Comments: The specific name describes the long slender shape of the spore.

Pluricellaesporites serratus sp. nov.
Pl. 14, fig. 63; Pl. 16, fig. 63

Description: Phragmospore 8.7×30.9μ consisting of five irregular oblong cells. Cell at one end is rounded with opaque disk shaped plate, pore at opposite end. Four opaque septa with irregular outline, 2.5μ thick, wall 1.0μ thick. Holotype: PPS (1) 22.3×99.4.

Commenrs: The specific name *serratus* means jagged and refers to the appearance of the septa.

Pluricellaesporites minusculus sp. nov.
Pl. 14, fig. 64; Pl. 16, fig. 64

Description: Tricellate spore 4.8×12.6μ, slightly granular, round terminal cell with pore, other terminal cell tapered and flat. Septa opaque forming flat cell boundaries, side walls convex 1.0μ thick. Holotype: PPS (1) 21.5×116.0.

Pluricellaesporites suboblongatus sp. nov.
Pl. 14, fig. 65; Pl. 16, fig. 65

Description: Tetracellate, oblong, psilate fungal spore 7.3×19.3μ. Rounded apex with germinal pore, opening in basal cell leading to basal attachment, wall 0.7μ thick, three opaque septa. Holotype: PPS (1) 15.5×100.7.

Diporicellaesporites ELSIK 1968
Diporicellaesporites acuminatus sp. nov.
Pl. 14, fig. 66; Pl. 16, fig. 66

Description: Tricellate, psilate fungal spore 4.8×11.6μ, apex tapered to point, opposite end flat. Wall 1.0μ thick, two opaque septa. Holotype: PPS (1) 16.5×95.0.

Comments: The specific name describes the pointed spore apex.

Diporicellaesporites puryearensis sp. nov.
Pl. 14, fig. 67; Pl. 16, fig. 67

Description: Tetracellate body 5.3×16.4μ, equatorial cross wall and constriction appears to connect two dicellate spores, each has an opaque equatorial septum and slight constriction at cell boundaries. Wall smooth 0.7μ thick. Holotype: PPS (1) 6.8×115.1.

Comments: The specific name is taken from the name of the pit where the material was collected. This spore resembles a spore illustrated by BRADLEY (1931, Pl. 19, fig. 6). Tbe illustration shows isolated spores and a chain of spores. BRADLEY suggests that it is an ascospore group or a chain of conidia similar to the genus *Bispora*.

Diporicellaesporites tetralocularis sp. nov.
Pl. 14, fig. 68; Pl. 16, fig. 68

Description: Tetracellate spore 5.8×18.4μ, psilate, one terminal cell rounded, the opposite blunt, small pore at both ends. Slight constriction between end cells and two center cells, wall 0.5μ, curves inward to form two layers of the septum, triseptate. Holotype: PPS (1) 16.4×109.5.

Lacrimasporonites (CLARKE 1965) ELSIK 1968
Lacrimasporonites levis CLARKE 1965
Pl. 14, fig. 69; Pl. 16, fig. 69

Comments: This spore from Puryear is spatulate, unicellular, psilate, dark pigment, wall 1.5μ thick, large apical pore 1.0—2.0μ wide. Size ranges from 8.7×14.5μ—14.5×18.4μ (three specimens).

Lacrimasporonites basidii ELSIK 1968
Pl. 14, fig. 70; Pl. 16, fig. 70

Comments: This fossil spore from Puryear is spatulate, unicellular. Psilate, medium pigment, wall two layers 1.0—1.5μ thick tapering to small apical pore. Size ranges from 4.8×7.7μ—7.8×11.6μ (two specimens).

Lacrimasporonites singularis sp. nov.
Pl. 14, fig. 71; Pl. 16, fig. 71

Description: Oval-oblong fungal spore 10.6×16.4μ, flat area with pore at terminal end to one side of longitudinal center. Psilate, wall 1.0μ tbick. Holotype: PPS (1) 22.0×110.2.

Comments: The specific name indicates that the shape of the spore is not of usual spatulate form.

Fractisporonites CLARKE 1965
Fractisporonites ordinatus sp. nov.
Pl. 14, fig. 72; Pl. 16, fig. 72

Description: Psilate fungal spore, uniseriate, fragment consists of nine rectangular cells, width variable. Spote ca. 4.4×56.1μ, wall 1.5μ thick, septa complete and opaque. Holotype: PPS (1) 17.9×116.0.

Fusiformisporites (Rouse 1962) Elsik 1968

Fusiformisporites rugosus sp. nov.

Pl. 14, fig. 73; Pl. 16, fig. 73

Description: Fusiform, inaperturate, dicellate fungal spore 19.3×43.5μ. Rounded at one apex with flat basal attachment at other end. Wall with longitudinal folds and tears, 1.0μ thick; opaque equatorial septum 2.0—3.0μ thick. Holotype: PPS (1) 22.3×111.5.

Comments: The specific name refers to the irregular creases in the cell wall.

Fusiformisporites lineolatus sp. nov.

Pl. 14, fig. 74; Pl. 16, fig. 74

Description: Fusiform fungal spore 18.4×33.8μ, inaperturate bearing 6—7 continuous longitudinal ribs. Two cells separated by an opaque septum 1.0μ thick. Holotype: PPS (1) 19.9×112.0.

Comments: The specific name *lineolatus* refers to the continuous longitudinal lines.

Tricellaesporonites gen. nov.

Description: Tricellate, cells spherical or subspherical, inaperturate, shape variable. Diseptate or triseptate, ornamentation psilate to punctate.

Type Species: *Tricellaesporonites triangularis* sp. nov.

Tricellaesporonites triangularis sp. nov.

Pl. 14, fig. 75; Pl. 16, fig. 75

Description: Cells spherical in triangular cluster, each cell 4.8μ in diameter. Spore psilate, inaperturate, medium pigment, three linear septa.

Tricellaesporonites semicircularis sp. nov.

Pl. 14, fig. 76; Pl. 16, fig. 76

Description: Tricellate, cells spherical 6.8μ in diameter, arranged in a half circle, light pigment, psilate. Cells separated by two linear septa, two layers thick, wall 1.0μ thick.

Staphlosporonites gen. nov.

Description: Inaperturate, psilate to punctate fungal or algal bodies of four or more irregular cells. Cells in clusters, shape variable along more than one axis.

Type Species: *Staphlosporonites conoideus* sp. nov.

Staphlosporonites conoideus sp. nov.

Pl. 14, fig. 77; Pl. 16, fig. 77

Description: Seven or more irregular cells arranged in conical shaped body 13.5×24.2μ. Psilate, wall and septa opaque, varying in thickness. Holotype: PPS (1) 22.0×113.2.

Staphlosporonites tristratosus sp. nov.

Pl. 14, fig. 78; Pl. 16, fig. 78

Description: Eight or more irregular cells arranged in an ovate structure 10.6×19.3μ, two to three cells wide. Psilate, light pigment, septa opaque varying in thickness, continuous with wall 0.7μ thick. Holotype: PPS (2) 11.4×101.7.

Comments: The specific name refers to the arrangement of the cells into three layers.

Staphlosporonites ovalis sp. nov.

Pl. 14, fig. 79; Pl. 16, fig. 79

Description: Dictyospore 9.7×20.3μ, oval with twelve or more irregular cells visible in two rows. Psilate, light pigment, wall 1.0μ thick. Holotype: PPS (1) 16.8×108.3.

Staphlosporonites allomorphus sp. nov.
Pl. 14, fig. 80; Pl. 16, fig. 80

Description: Eight or more irregular cells arranged in oblong structure 10.2 × 30.9μ, two cells in width tapering to a single cell. Psilate, light pigment, septa variable in width, continuous with wall, wall 1.0μ thick. Holotype: PPS (1) 17.9 × 113.0.

Comments: The specific name refers to the strange shape of the spore. The spore resembles several illustrated by WOLF (1967b, Fig. 4, no. 19); WOLF (1968a, Pl. 2, no. 49 and Pl. 3, no. 8, 61). The spore is also similar to one illustrated by GRAHAM (1965, Pl. 19, fig. 6), however, description and dimensions are lacking. GRAHAM refers the spore type to Fungi Imperfecti, Order Moniliales (Hyphomyceteae), Genus *Alternaria*.

Triporisporonites gen. nov.

Description: Unicellate fungal spore, psilate, nonseptate, triporate. Shape variable.
Type Species: *Triporisporonites ovalis* sp. nov.

Triporisporonites ovalis sp. nov.
Pl. 14, fig. 81; Pl. 16, fig. 81

Description: Oval spore, unicellate, 5.8 × 12.1μ. Three asymmetrical pores along periphery of spore wall. Psilate, wall 0.5μ thick. Holotype: PPS (1) 14.4 × 110.0.

DISCUSSION

The spores described include fourteen genera and seventy-six species. Many of the spores are similar to spores recorded by BERRY (1916a) from the Eocene of Tennessee, HAMMEN (1954a) from the late Cretaceous to early Tertiary coals of Colombia (South America), SCOTT (1956) from the Eocene of Oregon, ROUSE (1959) from the Upper Jurassic of Western Canada, KEDVES (1961) from the Tertiary of Europe, DILCHER (1965) from the Eocene of Tennessee, GRAHAM (1965) from the Miocene of Oregon, WOLF (1966a, 1966b, 1967b, 1967d, 1968a) and WOLF & CAVALIERE (1966c) from the Pleistocene of Africa and North Carolina. Other spores are identical to some identified as *Inapertisporites minutus* HAMMEN (1954a) and *Monoporisporites annulatus* HAMMEN (1954a) from the late Cretaceous to early Tertiary of Colombia, *Inapertisporites elongatus* ROUSE (1962) from the Eocene of British Columbia, *Multicellaesporites nortonii* ELSIK (1968) and *Lacrimasporonites basidii* ELSIK (1968) from the Paleocene of Texas and *Lacrimasporonites levis* CLARKE (1965) from the late Cretaceous of central Colorado.

Since the spores were obtained from a limited sample this study includes only identifications and illustrations and no stratigraphical or ecological conclusions. Other recent studies have attempted botanical and geological applications of fungal spore data with limited success. CLARKE (1965) was not able to use fungal spores for zoning the Vermejo Formation coal beds of upper Cretaceous due to the sparse number and variety of spores present. WOLF & CAVALIERE (1966c) have attempted to study the differences in the number and variety of spores at different levels in Recent sediments of two African lakes. Little to no stratification of fungal spores was found and no conclusions could be made concerning previous plant cover or vegetational changes. WOLF (1967d) was unable to interpret changes of flora surrounding the lake from fungal spore data of the lake sediments.

VARMA & RAWAT (1963) found diporate spores with restricted vertical range and wide horizontal distribution in Tertiary horizons of India. Seven of the thirteen spores which showed stratigraphic distribution are identified as fungal spores by ELSIK (1968). The distribution of spores from Miocene to middle Eocene could be correlated in two regions 1400 kilometers apart but an inter-regional study was not done.

The usefulness of fungal spore analysis depends on systematic and widespread sampling. Further contributions to a more extensive reference list of isolated fungal spores is also necessary, before more valuable floristic, ecological or stratigraphic interpretations can be made.

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Explanation of Plates[1]

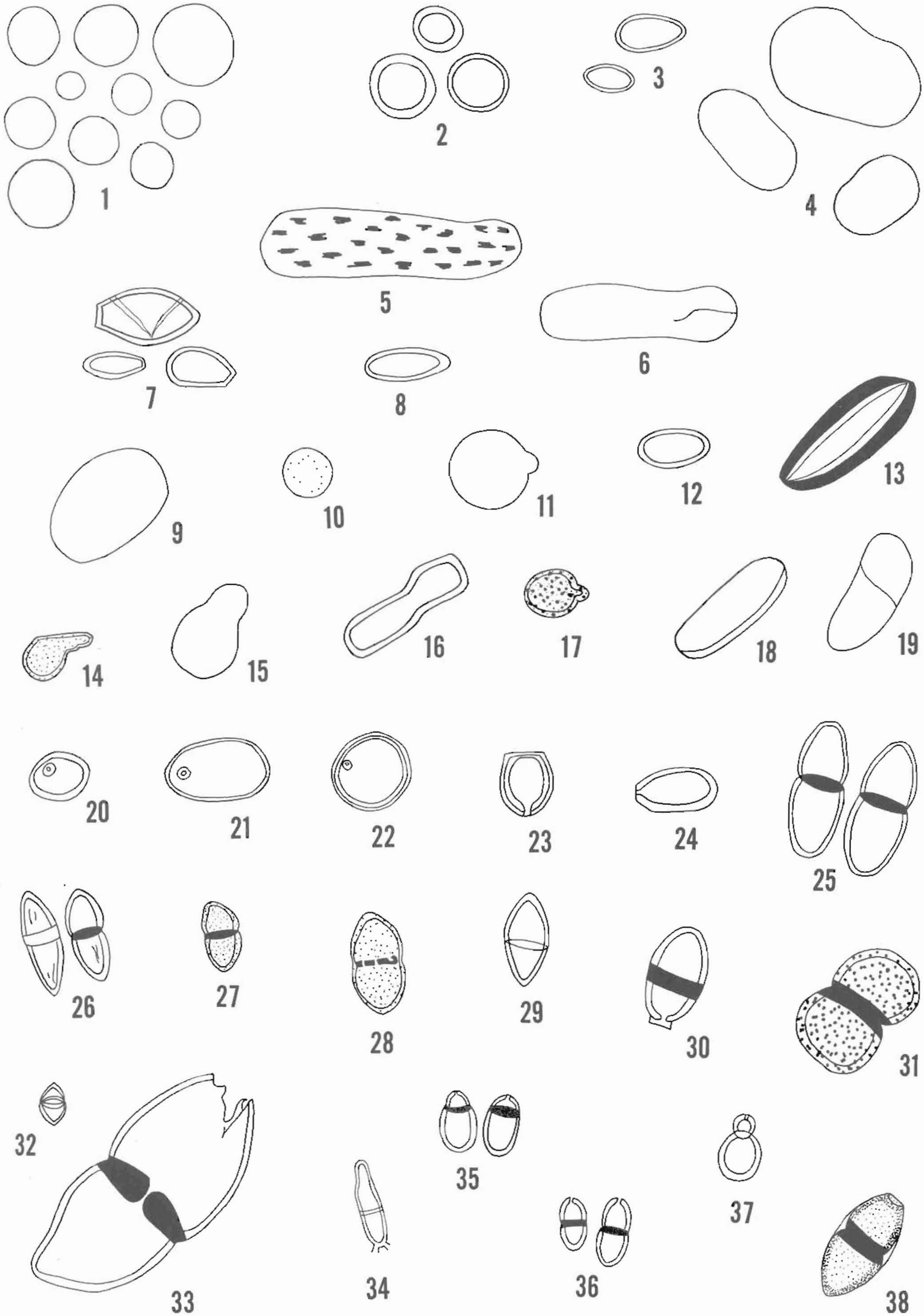
Plates 13 and 15

Fig. 1. *Inapertisporites vulgaris*
Fig. 2. *I. circularis*
Fig. 3. *I. ovalis*
Fig. 4. *I. subcapsularis*
Fig. 5. *I. reticulatus*
Fig. 6. *I. longissimus*
Fig. 7. *I. subovoideus*
Fig. 8. *I. disciformis*
Fig. 9. *I. obscurus*
Fig. 10. *I. minutus*
Fig. 11. *I. nodulus*
Fig. 12. *I. elongatus*
Fig. 13. *I. vittatus*
Fig. 14. *I. irregularis*
Fig. 15. *I. obpyriformis*
Fig. 16. *I. subcurvatus*
Fig. 17. *I. scabridus*
Fig. 18. *I. pulvinatus*
Fig. 19. *I. rentiformis*
Fig. 20. *Monoporisporites annulatus*
Fig. 21. *M. ovalis*
Fig. 22. *M. singularis*
Fig. 23. *M. cupuliformis*
Fig. 24. *M. abruptus*
Fig. 25. *Dicellaesporites levis*
Fig. 26. *D. aculeolatus*
Fig. 27. *D. granuliformis*
Fig. 28. *D.* sp.
Fig. 29. *D. fusiformis*
Fig. 30. *D. appendiculatus*
Fig. 31. *D. disphaericus*
Fig. 32. *D. fragilis*
Fig. 33. *D.* ? sp.
Fig. 34. *D.* ? sp.
Fig. 35. *Didymoporisporonites psilatus*
Fig. 36. *D. normalis*
Fig. 37. *D. inaequalis*
Fig. 38. *D. obtectus*

Plates 14 and 16

Fig. 39. *Dyadosporonites didymus*
Fig. 40. *D. subovalis*
Fig. 41. *Multicellaesporites nortonii*
Fig. 42. *M. simplicissimus*
Fig. 43. *M. irregularis*
Fig. 44. *M. ovatus*
Fig. 45. *M. pandus*
Fig. 46. *M. elongatus*
Fig. 47. *M. capsularis*
Fig. 48. *M. attenuatus*
Fig. 49. *M. ellipticus*
Fig. 50. *M. fusiformis*
Fig. 51. *M. grandiusculus*
Fig. 52. *M. allomorphus*
Fig. 53. *M. didymus*
Fig. 54. *M. sacciformis*
Fig. 55. *M. bigeminatus*
Fig. 56. *M.* ? sp.
Fig. 57. *M.* ? sp.
Fig. 58. *Pluricellaesporites simplicissimus*
Fig. 59. *P. subcapsilaris*
Fig. 60. *P. longicollus*
Fig. 61. *P. ovatus*
Fig. 62. *P. tenuis*
Fig. 63. *P. serratus*
Fig. 64. *P. minusculus*
Fig. 65. *P. suboblongatus*
Fig. 66. *Diporicellaesporites acuminatus*
Fig. 67. *D. puryearensis*
Fig. 68. *D. tetralocularis*
Fig. 69. *Lacrimasporonites levis*
Fig. 70. *L. basidii*
Fig. 71. *L. singularis*
Fig. 72. *Fractisporonites ordinatus*
Fig. 73. *Fusiformisporites rugosus*
Fig. 74. *F. lineolatus*
Fig. 75. *Tricellaesporonites triangularis*
Fig. 76. *T. semicircularis*
Fig. 77. *Staphlosporonites conoideus*
Fig. 78. *S. tristratosus*
Fig. 79. *S. ovalis*
Fig. 80. *S. allomorphus*
Fig. 81. *Triporisporonites ovalis*

[1] All line drawings and photographs are magnified ×1000.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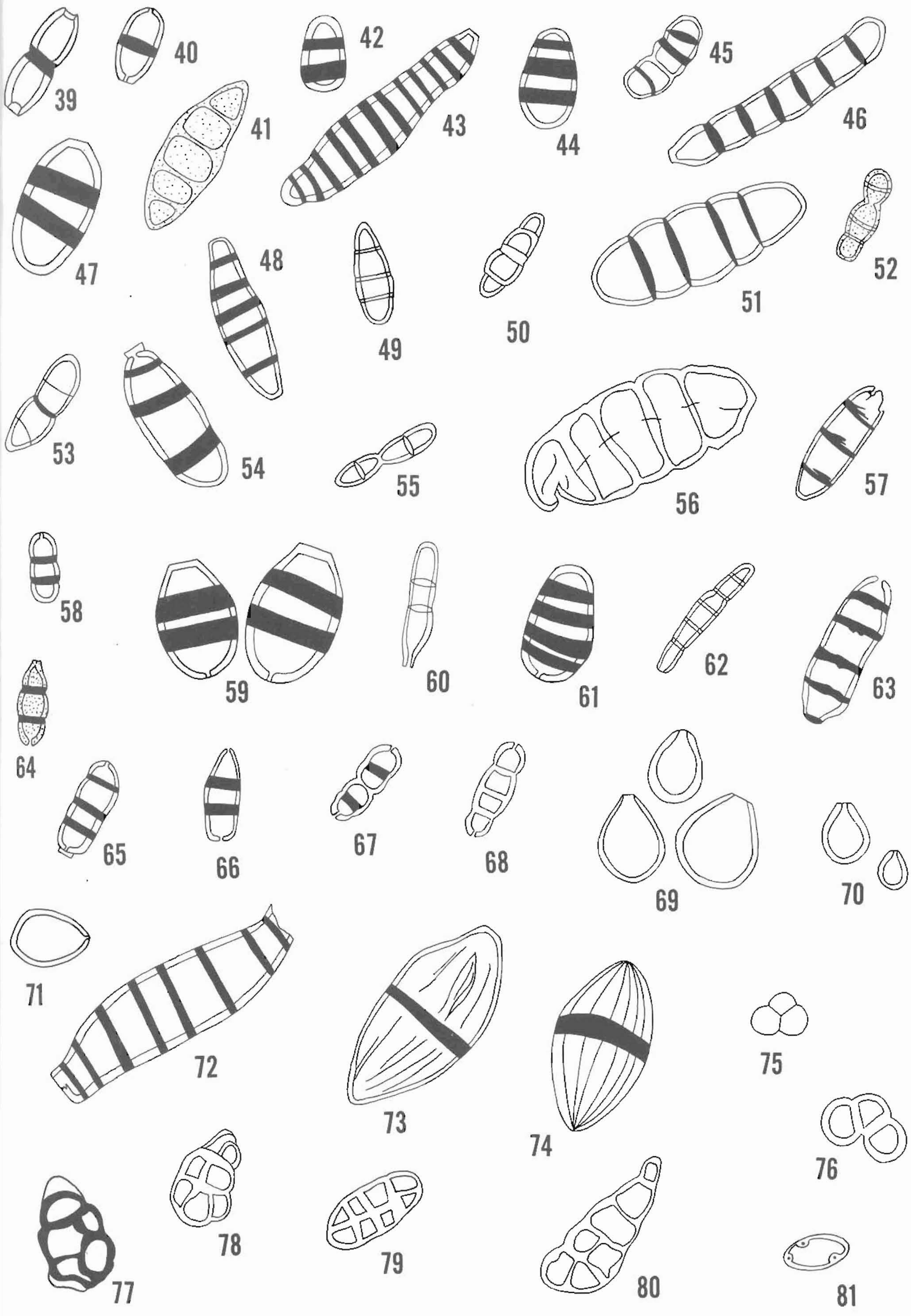
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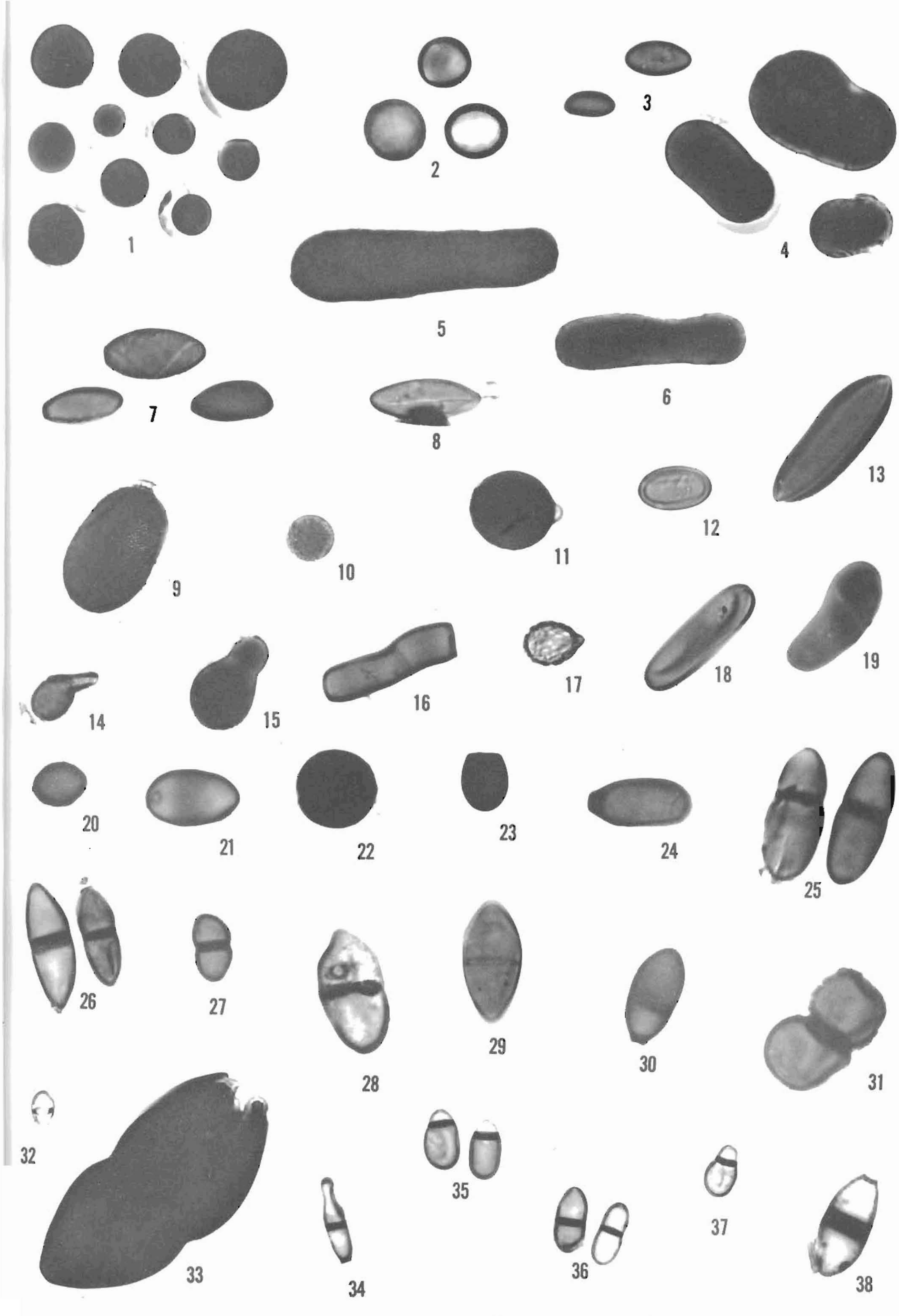

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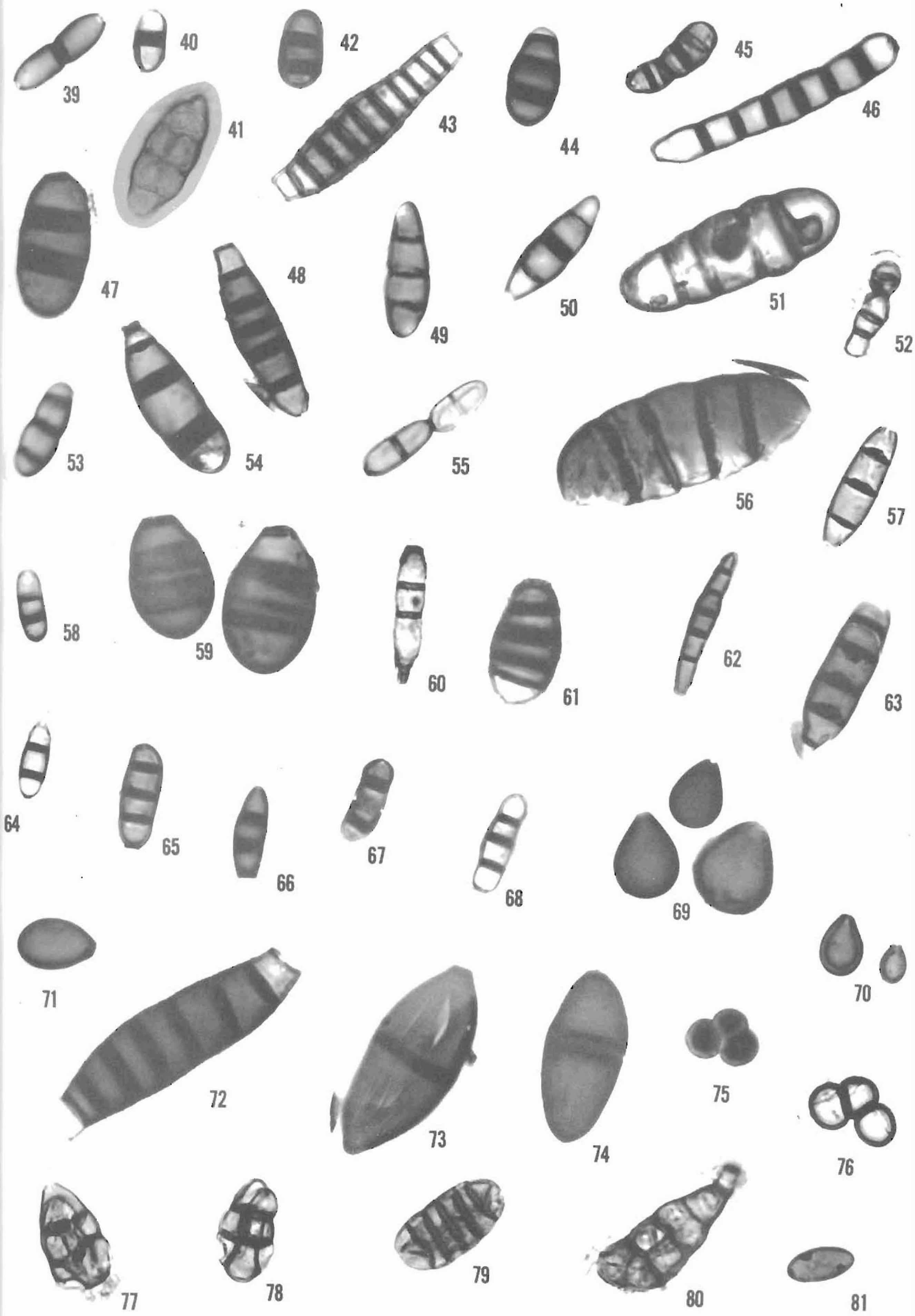

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