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# Taxonomy Online 2: The 'Bernard Owens Collection' of single grain mount palynological slides: Carboniferous spores part I

Research Report RR/06/05





BRITISH GEOLOGICAL SURVEY

RESEARCH REPORT RR/06/05

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## *Front cover*

*Reinschospora speciosa* (Loose)  
Schopf, Wilson & Bentall, 1944

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# Foreword

The aim of 'Taxonomy Online' is to use the internet as a forum to illustrate fossil specimens held in the collections of the British Geological Survey (BGS) and collaborating institutes, and to outline their taxonomic and biostratigraphical importance. As such, our web-based publications supplement, but do not replace, traditional hardcopy palaeontological publications by allowing easy access to illustrations of specimens, descriptions, and to information about stratigraphical distribution.

For convenience, data are presented as web-based packages so that amateur, student and professional palaeontologists will have easy access to the information. However, websites do not have publication status and for this reason a formal publication is produced in .pdf format in the Research Report Series of the British Geological

Survey. They are available as a free download. These reports, which have been assigned ISBN numbers and deposited with the copyright libraries, have been reviewed by two referees internal to the BGS and two further independent and experienced palaeontologists. It is to the research report that bibliographical reference should be made in formal taxonomic research.

In some cases where these databases have commercial application, a 'professional' version has been additionally produced. These have a number of further images of all species and detailed data concerning age, distribution, etc. The 'professional' versions have been produced on CD ROM together with a hard copy version primarily for the commercial sector, and can be purchased through the BGS.

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# 1 Introduction

This report contains information on the first 68 taxa of the Bernard Owens single mount palynology collection, running from BGS collections number MPK 6958 to 7806. The complete collection of 145 taxa will eventually be included. The report is the hardcopy counterpart to an online database illustrating, describing and giving stratigraphical details of taxa from the Bernard Owens collection. The database can be accessed at <http://www.bgs.ac.uk/taxonomy/home.html>.

## 1.1 THE 'BERNARD OWENS COLLECTION'

The collection of single grain mount slides which is partly illustrated is possibly the most important collection of single grain Late Palaeozoic palynomorphs in the world with over 145 taxa represented by many specimens (up to 25 specimens per taxon), showing a wide range of preservation and natural variation. The specimens were collected from localities worldwide but are most closely associated with the UK and north-west Europe. Many of the taxa illustrated and described are integral to the biozonation of the Carboniferous of north-west Europe published by Clayton et al. (1977) and to earlier regional biozonations of smaller stratigraphical intervals within the UK (Smith and Butterworth, 1967; Neves et al., 1972, 1973; Owens and Burgess, 1965; Owens et al., 1977).

Each single grain mount slide is associated with a unique BGS collections number prefixed with MPK. All slides are held in the BGS Palaeontology Collections at Keyworth, Nottingham. For information on the collection and on slide loans please contact Dr Mike Howe, Chief Curator, BGS, Keyworth phone 0115 936 3105.

## 1.2 INFORMATION LAYOUT

For each taxon, a description, sources of alternative descriptions, details of size and stratigraphical range are given, compiled from the literature sources listed in the reference section and the personal records of the authors.

### 1.2.1 Descriptions of palynomorphs

The descriptions present features in a common format and, as far as practical, to a common standard. They are based on original descriptions and emendations, as well as on the specimens in the collection. Original descriptions and emendations vary considerably in detail, completeness, terminology and the style and order of presentation of features. Alternative descriptions are listed; these may include the author's diagnosis or other subsequent descriptions. Descriptive terminology follows Punt et al. (1994).

### 1.2.2 Ranges of palynomorphs

Stratigraphical assignments and ages given on the data sheets are taken from the original literature sources or the personal records of the authors. Records are from material of known origin (borehole core or cuttings or outcrop samples) or unknown origin.

The chronostratigraphy used includes a global stage interpretation with regional substages shown in square brackets. The regional substages represent a finer resolution, and a closer approximation to the biozonal data included in this report. In many cases the global stages have not yet been formally defined and when they are, conodonts are likely to be the biozonal indices, so there is still some uncertainty about how the miospore biozones will equate with the global stages. Until further information becomes available, the authors are following the guidance published by Heckel and Clayton (2006) which provides a simplified equivalence of regional and global stratigraphy.

### 1.2.3 Details of specimens

Sample details and sometimes description (where this adds to the concept of the taxon) are given alongside the photographed specimens. Each specimen has an MPK code that corresponds to a single slide that identifies it as part of the collection.

## 1.3 LIST OF TAXA

*Angulisporites splendidus* Bhradwaj, 1954

*Auroraspora macra* Sullivan, 1968

*Bellisporites nitidus* (Horst) Sullivan, 1964

*Cheiledonites major* Doubringer, 1957

*Cingulizonates bialatus* (Waltz) Smith & Butterworth, 1967

*Cingulizonates capistratus* (Hoffmeister, Staplin & Malloy) Staplin & Jansonius, 1974

*Cirratriradites saturni* (Ibrahim) Schopf, Wilson & Bentall, 1944

*Colatisporites decorus* (Bharadwaj & Venkatachala) Williams in Neves et al., 1973

*Convolutispora circumvallata* Clayton, 1971

*Convolutispora major* (Kedo) Turnau, 1978

*Crassispora aculeata* Neville, 1968

*Crassispora kosankei* (Potonié & Kremp) Bharadwaj, 1957

*Crassispora maculosa* (Knox) Sullivan, 1964

*Crassispora trychera* Neves & Ioannides, 1974

*Densosporites anulatus* (Loose) Smith & Butterworth, 1967

*Dictyotriletes fimbriatus* (Winslow) Kaiser, 1970  
*Dictyotriletes muricatus* (Kosanke) Smith & Butterworth, 1967  
*Endosporites zonalis* (Loose) Knox, 1950  
*Grandispora lupata* Turnau, 1975  
*Grandispora spinosa* Hoffmeister, Staplin & Malloy, 1955  
*Grumosisorites varioreticulatus* (Neves) Smith & Butterworth, 1967  
*Grumosisorites verrucosus* (Butterworth & Williams) Smith & Butterworth, 1967  
*Hystricosporites multifurcatus* (Winslow) Mortimer & Chaloner, 1967  
*Knoxisorites hederatus* (Ishchenko) Playford, 1962  
*Knoxisorites stephanephorus* Love, 1960  
*Knoxisorites triangularis* Higgs, Clayton & Keegan, 1988  
*Knoxisorites triradiatus* Hoffmeister, Staplin & Malloy, 1955  
*Kraeuselisporites echinatus* Owens, Mishell & Marshall, 1976  
*Kraeuselisporites hibernicus* Higgs, 1975  
*Kraeuselisporites ornatus* (Neves) Owens, Mishell & Marshall, 1976  
*Labiadensites fimbriatus* (Waltz) Hacquebard & Barss, 1957  
*Lophozonotriletes malevkensis* Naumova in litt. Kedo, 1963  
*Lycospora pusilla* (Ibrahim) Somers, 1972  
*Monilospora moniloformis* Hacquebard & Barss, 1957  
*Murospora parthenopia* Neves & Ioannides, 1974  
*Radiizonates aligerens* (Knox) Staplin & Jansonius, 1964  
*Raistrickia clavata* Hacquebard emend. Playford, 1964  
*Raistrickia condylosa* Higgs, 1975  
*Raistrickia corynoges* Sullivan, 1968  
*Raistrickia fulva* Artüz, 1957  
*Reinschospora speciosa* (Loose) Schopf, Wilson & Bentall, 1944  
*Remysporites magnificus* (Horst) Butterworth & Williams, 1958  
*Reticulatisporites carnosus* (Knox) Neves, 1964  
*Retispora lepidophyta* (Kedo) Playford, 1976  
*Rotaspora fracta* Schemel, 1950  
*Rotaspora knoxi* Butterworth & Williams, 1958  
*Schopfites claviger* Sullivan, 1968  
*Schulzospora campyloptera* (Waltz) Hoffmeister, Staplin & Malloy, 1955  
*Schulzospora ocellata* (Horst) Potonié & Kremp, 1956  
*Schulzospora rara* Kosanke, 1950  
*Spelaeotriletes arenaceus* Neves & Owens, 1966  
*Spelaeotriletes balteatus* (Playford) Higgs, 1975  
*Spelaeotriletes cabotii* Utting, Keppie & Giles, 1989  
*Spelaeotriletes giganteus* Loboziak & Clayton, 1988  
*Spelaeotriletes owensi* Loboziak & Alpern, 1978  
*Spinozonotriletes uncatius* Hacquebard, 1957  
*Torispora securis* (Balme) Alpern, Doubinger & Horst, 1973  
*Tripartites trilinguis* (Horst) Smith & Butterworth, 1967  
*Tripartites vetustus* Schemel, 1950  
*Triquitrites sculptilis* (Balme) Smith & Butterworth, 1967  
*Triquitrites trivalvis* (Waltz) Potonié & Kremp, 1956  
*Umbonatisporites distinctus* Clayton, 1971  
*Umbonatisporites variabilis* Hibbert & Lacey, 1969  
*Vallatisporites agadesi* Loboziak & Alpern, 1978  
*Vallatisporites drybrookensis* Playford & McGregor, 1993  
*Vallatisporites hystricosus* (Winslow) Byvsheva, 1985  
*Vallatisporites vallatus* Hacquebard, 1957  
*Vallatisporites verrucosus* Hacquebard, 1957

## 2 List of curated specimens

Taxon	BGS collection number MPK
<i>Angulisporites splendidus</i>	7049-7055
<i>Auroraspora macra</i>	7475-7479, 7490
<i>Bellisporites nitidus</i>	7762-7768
<i>Cheiledonites major</i>	7701-7702, 7705-7706, 7708
<i>Cingulizonates bialatus</i>	6977-6988
<i>Cingulizonates capistratus</i>	6958-6976
<i>Cirratiradites saturni</i>	7303-7309
<i>Colatisporites decorus</i>	7671-7672, 7674-7675, 7677
<i>Convolvutispora circumvallata</i>	7421-7426
<i>Convolvutispora major</i>	7192-7202
<i>Crassispora aculeata</i>	7013-7018
<i>Crassispora kosankei</i>	7001-7011
<i>Crassispora maculosa</i>	7074-7079
<i>Crassispora trychera</i>	7012
<i>Densosporites anulatus</i>	7655, 7659-7661, 7663-7664
<i>Dictyotriletes fimbriatus</i>	7593-7595, 7597-7598
<i>Dictyotriletes muricatus</i>	7583-7586
<i>Endosporites zonalis</i>	7499-7503
<i>Grandispora lupata</i>	7286-7296
<i>Grandispora spinosa</i>	7130-7135
<i>Grumosporites varioreticulatus</i>	7623-7626, 7628
<i>Grumosporites verrucosus</i>	7726-7730
<i>Hystricosporites multifurcatus</i>	7267-7268
<i>Knoxisporites hederatus</i>	7297-7302
<i>Knoxisporites triangularis</i>	7031-7036
<i>Knoxisporites stephanephorus</i>	7037-7048
<i>Knoxisporites triradiatus</i>	7715, 7717-7720
<i>Kraeuselisporites echinatus</i>	7056-7061
<i>Kraeuselisporites hibernicus</i>	7443-7448
<i>Kraeuselisporites ornatus</i>	7690-7693
<i>Labiadensites fimbriatus</i>	7257-7266
<i>Lophozonotriletes malevkensis</i>	7455-7465
<i>Lycospora pusilla</i>	7631, 7633-7638, 7640-7641, 7643
<i>Murospora moniliformis</i>	7230-7244
<i>Murospora parthenopia</i>	7165-7179
<i>Radiizonates aligerens</i>	6989-7000
<i>Raistrickia clavata</i>	7392-7403
<i>Raistrickia condylosa</i>	7415-7420
<i>Raistrickia corynoges</i>	7374-7379
<i>Raistrickia fulva</i>	7380-7391
<i>Reinschospora speciosa</i>	7432-7442
<i>Remysporites magnificus</i>	7511-7516
<i>Reticulatisporites carnosus</i>	7019-7030
<i>Retispora lepidophyta</i>	7124-7129

<i>Rotaspora fracta</i>	7569-7572
<i>Rotaspora knoxi</i>	7802-7804, 7806-7809
<i>Schopfites claviger</i>	7782-7787
<i>Schulzospora campyloptera</i>	7136-7146
<i>Schulzospora ocellata</i>	7180-7191
<i>Schulzospora rara</i>	7274-7285
<i>Spelaeotriletes arenaceus</i>	7147-7158
<i>Spelaeotriletes balteatus</i>	7112-7123
<i>Spelaeotriletes cabotii</i>	7738-7742
<i>Spelaeotriletes giganteus</i>	7253-7256
<i>Spelaeotriletes owensi</i>	7245-7252
<i>Spinozonotriletes uncatus</i>	7449, 7450
<i>Torispora securis</i>	7092-7111
<i>Tripartites trilinguis</i>	7559-7565, 7566
<i>Tripartites vetustus</i>	7555-7558, 7564
<i>Triquirites sculptilis</i>	7215-7229
<i>Triquirites trivalvis</i>	7750-7757
<i>Umbonatisporites distinctus</i>	7427
<i>Umbonatisporites variabilis</i>	7428-7431
<i>Valatisporites agadesi</i>	7340-7348
<i>Vallatisporites drybrookensis</i>	7080-7091
<i>Vallatisporites hystricosus</i>	7062-7072
<i>Vallatisporites vallatus</i>	7325-7339
<i>Vallatisporites verrucosus</i>	7310-7324

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# Appendix 1 Spores

## *Angulisporites splendidus* Bhardwaj, 1954

### DESCRIPTION

Radial, trilete, camerate miospores. Amb rounded triangular to subcircular or oval. Miospores consist of inner body conformable in outline with equatorial margin, surrounded by exoexinal body with thickened equatorial rim approximately 5 µm wide. Trilete mark distinct, sutures straight, extending at least as far as the margin of the inner body; simple or accompanied by relatively low elevated, flexuous folds of the exoexine that extend decreasing in height to the equatorial margin of spore. Intexine relatively thick; forms inner body which occupies between two-thirds and three-quarters of the spore diameter. Exoexine thicker; extent of separation of exoexine from intexine difficult to ascertain but inner body commonly possesses independent compression folds suggesting separation in, at least, the equatorial region and part of the distal surface. Exoexine has thickened equatorial rim, similar to a cingulum, which occupies up to half the width of exoexinal extension. Exoexine infrapunctate.

### OTHER DESCRIPTIONS

Bhardwaj, 1954, p. 516, text-fig. 4

### SIZE

Overall equatorial diameter 70(83)105 µm

Diameter of inner body 50(64)76 µm

### REMARKS

The presence of the cingulum-like thickening at the equatorial margin of the exoexinal body distinguishes representatives of this genus from *Endosporites*.

### RANGE

Late Pennsylvanian to Early Permian; [latest Westphalian D (Asturian) to early Autunian]; VC Biozone (Sánchez de Posada et al., 2002; Clayton et al., 1977)

	<p>Figure 1a Sample L. 1349, Naukuieres VIII, Decazeville, Central France; [Stephanian B], ST Biozone, Specimen MPK <b>7049</b>. Specimen maximum dimension 100 µm</p>
	<p>Figure 1b Sample L. 1349, Naukuieres VIII, Decazeville, Central France; [Stephanian B], ST Biozone, Specimen MPK <b>7050</b>. Specimen maximum dimension 105 µm</p>

## *Auroraspora macra* Sullivan, 1968

### DESCRIPTION

Radial, trilete, camerate miospores. Amb circular to subcircular, frequently irregular due to folding. Trilete mark distinct, sutures straight, extend at least two-thirds of the radius of the inner body, commonly accompanied by low thickened labra with irregular outer margins, which extend to the equatorial margin of spore. Intexine thin forming well defined inner body. Exoexine thin, variably separated from intexine, commonly folded, densely infrapunctate. Exoexine thickened in the equatorial plane to form limbus-like structure of variable width.

### OTHER DESCRIPTIONS

Sullivan, 1968, pp. 124–125, pl. 27, figs. 6–10

Clayton, 1971, p. 580, pl. 1, fig. 3

Higgs et al., 1988, p. 69, pl. 9, figs 17–19

### SIZE

Overall equatorial diameter 48(58)78  $\mu\text{m}$

Diameter of inner body 26(31)35  $\mu\text{m}$

### REMARKS

The distinctive thickened equatorial margin of the exoexine renders this species readily distinguishable from all other taxa assigned to the genus. *Auroraspora solisortus* Hoffmeister, Staplin & Malloy 1955 is larger, lacks the thickened exoexinal equatorial rim and possesses a radially oriented series of exoexinal folds. *A. hyalina* (Naumova) Streel in Becker et al. 1974 is slightly smaller in size and possesses a more filmy exoexine.

### RANGE

Uppermost Devonian to Mississippian; Strunian to early Viséan; LL to Pu biozones (Higgs et al., 1988)

	<p>Figure 2a</p> <p>Pinskey Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Tournaisian, CM Biozone, Sample MPA 292, Specimen MPK <b>7475</b>. Ovoid camerate miospore with extensively folded inner body surrounded by loose-fitting exoexine. Trilete mark indistinct, sutures open. Exoexine folded, finely infrapunctate, with ill-defined thickening at equatorial margin.</p> <p>Specimen maximum dimension 75 <math>\mu\text{m}</math></p>
	<p>Figure 2b</p> <p>Pinskey Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Tournaisian, CM Biozone, Sample MPA 2699, Specimen MPK <b>7476</b>. Specimen showing independent peripheral compression folds affecting the inner body and indicating separation of exine layers. Trilete mark distinct, sutures extending to equator of inner body. Exoexinal body with marked thickening in the equatorial region.</p> <p>Specimen maximum dimension 55 <math>\mu\text{m}</math></p>

## ***Bellisporos nitidus* (Horst) Sullivan, 1964**

### DESCRIPTION

Radial, trilete, acamerate, cingulate miospores. Amb triangular with concave or more rarely straight sides and rounded apices. Outline crenulate. Trilete mark distinct, sutures straight, simple or with low narrow thickened labra, extending to the inner margin of the cingulum. Intexine thin, forming wall of spore body. Exoexine closely adpressed over both proximal and distal surfaces but extended in the equatorial plane to form irregular narrow cingulum, 2–5 µm wide, with irregular crenulate margin but of more or less uniform thickness. Distal surface ornamented with thickened Y-shaped structure with the three components extending from the distal pole to the cingulum which they join in the radial positions. Margins of distal thickened ribs crenulate in the same style as the cingulum, individual ribs up to 10 µm wide. Proximal surface laevigate, distal surface including distal thickened ribs and the cingulum foveolate, with foveolae less than 2 µm in diameter. Foveolae may be randomly distributed or arranged in rows. Distal thickened ribs often bear two rows of foveolae running down their length.

### OTHER DESCRIPTIONS

Horst, 1955, p. 181, pl. 24, fig. 81

Artüz, 1957, p. 255, pl. 7, fig. 49

Sullivan, 1964, p. 375

### SIZE

Overall equatorial diameter 27(36)45 µm

### REMARKS

Smith and Butterworth (1967) suggested that *Bellisporos bellis* Artüz 1957 and *Simozonotriletes trilinearis* Artüz 1957 are synonymous with *Bellisporos nitidus*.

### RANGE

Mississippian to Pennsylvanian; late Visean [Brigantian] to Bashkirian [early Duckmantian]; VF to NJ biozones (Clayton et al., 1977; Owens et al. 2004)

	<p>Figure 3a</p> <p>Passage Group, Saltgreen Borehole, West Lothian, Scotland; [?Kinderscoutian–Marsdenian], KV–FR Biozones, Sample MPA 30051, Specimen MPK <b>7762</b>. Oblique compression with distal focus showing well defined Y-shaped crenulate thickening on distal surface.</p> <p>Specimen maximum dimension 43 µm</p>
	<p>Figure 3b</p> <p>Passage Group, Saltgreen Borehole, West Lothian, Scotland; [?Kinderscoutian–Marsdenian], KV–FR Biozones, Sample MPA 30051, Specimen MPK <b>7763</b>.</p> <p>Specimen maximum dimension 43 µm</p>

## ***Cheiledonites major* Doubinger, 1957**

### DESCRIPTION

Pollen grains with oval or fusiform outline. Specimens characterised by well-developed furrow which extends almost the complete length of the grain. Furrow sometimes contorted by folding, or accompanied on either side by thickened lip-like folds. Remainder of exine also folded with axes of irregular folds parallel to long axis of grain. Exine surface finely infrapunctate.

### OTHER DESCRIPTIONS

Doubinger, 1957, pp. 125–133, fig. 3

### SIZE

Length of grain 35–42  $\mu\text{m}$

Width of grain 18–20  $\mu\text{m}$

### REMARKS

Few formal descriptions of this species exist. The specimens described by Doubinger (1957) were recovered from Stephanian B sediments from Decazeville, France. The material documented in the present study is from Stephanian C–D sediments in north-west France, and appears to be closely comparable to Doubinger's material in all but one respect, size. The present specimens have a maximum length of 120  $\mu\text{m}$ .

The longitudinal furrow bordered by narrow folds distinguishes this species from representatives of the genus *Entylissa*. *Cheiledonites potonie* Doubinger 1957, also described from Stephanian B sediments from Decazeville, France is distinguished by its smaller size.

### RANGE

Late Pennsylvanian to Permian; late Kazimovian [late Stephanian A (Barruelian)] to ?Early Permian; ST Biozone (Clayton et al., 1977)

	<p>Figure 4a</p> <p>Littry, north-west France; Gzhelian [Stephanian C–D], NBM Biozone, Sample NBM, Specimen MPK <b>7705</b>. Elongate, ovoid miospore or pollen grain with distinct longitudinal folds. Inner body appears to be present.</p> <p>Specimen maximum dimension 86 <math>\mu\text{m}</math></p>
	<p>Figure 4b</p> <p>Littry, north-west France; Gzhelian [Stephanian C–D], NBM Biozone, Sample NBM, Specimen MPK <b>7712</b>.</p> <p>Specimen maximum dimension 89 <math>\mu\text{m}</math></p>

## *Cingulizonates bialatus* (Waltz) Smith & Butterworth, 1967

### DESCRIPTION

Radial, trilete, cingulate miospores. Amb rounded triangular to subcircular. Trilete mark usually obscure, occasionally distinct, sutures simple, straight, extending to margin of inner body. Intexine thin, laevigate, forming rounded triangular or subcircular inner body, Exoexine extending in the equatorial plane to form bizonate cingulum. Inner zone thicker and wider than outer zone; inner zone overlaps the equatorial margin of the inner body on the distal surface. Outer margin of inner thicker zone bears numerous tubercular processes that project across outer thinner zone. Numerous radially oriented thickened ribs or plications extend across both zones of cingulum. Thinner outer zone of cingulum may be ornamented on its distal surface with small conical processes less than 1  $\mu\text{m}$  in height.

### OTHER DESCRIPTIONS

Smith and Butterworth, 1967, pp. 260–261, pl. 21, figs. 3–4

### SIZE

Overall equatorial diameter 25(54)77  $\mu\text{m}$

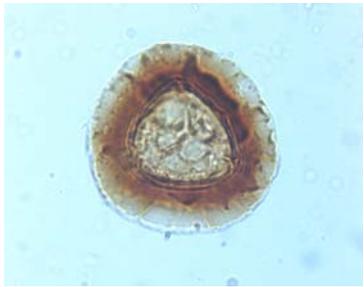
Diameter of inner body 20(27)35  $\mu\text{m}$

### REMARKS

The specimens originally described by Butterworth and Williams as *Densosporites striatus* were transferred to *C. bialatus* by Smith and Butterworth (1967). *Cingulizonates loricatus* (Loose) Butterworth & Smith 1964 is similar but lacks the development of tubercles on the outer margin of the inner thick zone of the cingulum.

### RANGE

Mississippian to Pennsylvanian; Visean to Bashkirian [Duckmantian]; VF to NJ biozones (unpublished information)

	<p>Figure 5a</p> <p>Shales below Swinstone House Marine Band, Mousegill Beck, Stainmore, Cumbria, England; Bashkirian [Marsdenian], FR Biozone, Sample T96, Specimen MPK <b>6977</b>. Proximal focus. Trilete mark simple; sutures extending to equator of subcircular inner body. Cingulum bizonate, darker thicker inner zone wider than thinner outer zone. Outer zone also appears to bear scattered ornament of small conical processes.</p> <p>Specimen maximum dimension 44 <math>\mu\text{m}</math></p>
	<p>Figure 5b</p> <p>Shales below Swinstone House Marine Band, Mousegill Beck, Stainmore, Cumbria, England; Bashkirian [Marsdenian], FR Biozone, Sample T96, Specimen MPK <b>6978</b>. Distal focus showing that the dark inner zone of the cingulum overlaps the equatorial margin of the inner body on the distal surface. Note tubercular outgrowths on the equatorial border of the inner thicker zone of cingulum.</p> <p>Specimen maximum dimension 45 <math>\mu\text{m}</math></p>

***Cingulizonates capistratus* (Hoffmeister, Staplin & Malloy) Staplin & Jansonius, 1974**

DESCRIPTION

Radial, trilete, cingulate miospores. Amb convexly rounded triangular with rounded or roundly pointed apices. Trilete mark distinct to obscure, sutures straight, simple or accompanied by low, narrow, thickened labra, extending to equatorial margin of inner body. Intexine thin, laevigate, forming rounded triangular inner body. Exoexine normally closely adpressed to intexine and extended in the equatorial plane to form differentially thickened cingulum. Minor separation may exist in the equatorial plane between the intexine and exoexine. Cingulum bizonate, consisting of narrow, thick, inner zone and wider, thin, outer zone. Thin outer zone divisible into two components: an inner section containing a large number of radially orientated elongate vacuoles separated by narrow walls, and an outer part that is weakly striated and may bear an ornament of small con. Cingulum approximately half spore radius in width.

OTHER DESCRIPTIONS

Smith and Butterworth, 1967, pp. 261–262, pl. 21, figs. 5–6

SIZE

Overall equatorial diameter 41(51)60 µm

REMARKS

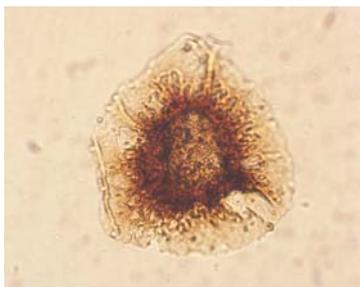
*Radiizonates aligerens* (Knox) Staplin & Jansonius 1964 differs in having longer trilete rays and a wider cingulum which has more prominent radiating struts separating internal vacuoles.

REMARKS

Brindley and Spinner (1989) noted the onset of common *Cingulizonates* cf. *capistratus* sensu Smith and Butterworth 1967 at a level within the NC Biozone, which they considered to coincide with the Visean–Namurian boundary in sequences of the Midland Valley of Scotland, northern England and Northern Ireland. However, Owens et al. (2004) have shown that the onset of common *C. cf. capistratus* occurs within the late Visean [Brigantian].

RANGE

(*Cingulizonates* cf. *capistratus* sensu Smith & Butterworth 1967) Mississippian; late Visean to early Serpukhovian [early Arnsbergian]; Cc to TK biozones (Owens et al., 2004).

	<p>Figure 6a</p> <p>Lower Limestone Group, Tirfergus Glen, Machrihanish, Argyll, Scotland; Serpukhovian [Pendleian], NC Biozone, Sample MPA 33341, Specimen MPK 6958.</p> <p>Specimen maximum dimension 60 µm</p>
	<p>Figure 6b</p> <p>Lower Limestone Group, Tirfergus Glen, Machrihanish, Argyll, Scotland; Serpukhovian [Pendleian], NC Biozone, Sample MPA 33341, Specimen MPK 6960. Note more extensive development of vacuoles, several of which extend almost to the equatorial margin. Cingulum distal surface has small con. Trilete mark indistinct; sutures appear to extend to the body margin.</p> <p>Specimen maximum dimension 60 µm</p>

## *Cirratriradites saturni* (Ibrahim) Schopf, Wilson & Bentall, 1944

### DESCRIPTION

Radial, trilete, cingulizone, camerate miospores. Amb rounded triangular to subcircular. Trilete mark distinct, sutures straight, extending to the equatorial margin of inner body, often obscured by elevated flexuous folds of the exoexine that extend decreasing in height to the equator of spore. Intexine thin, granulate, forming rounded triangular inner body. Exoexine relatively thick, extended in the equatorial plane to form differentially thickened zona consisting of two parts, an inner thickened part which appears to overlap the margin of the inner body on the distal surface and a wider thinner outer part which frequently appears faintly radially striated. Thinner outer section of zona may contain small radially orientated internal vacuoles. Distal exoexine bears prominent foveola in the polar region. Margin of foveola thickened to produce low thickened rim. A single foveola may be present with a circular or 'clover leaf' shape. Specimens with up to three separate distal foveolae also occur.

### OTHER DESCRIPTIONS

Smith and Butterworth, 1967, pp. 258–259, pl. 21, figs. 1–2

### SIZE

Overall equatorial diameter 59(73)100  $\mu\text{m}$

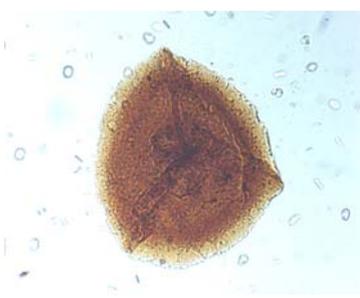
Diameter of inner body 45(58)79  $\mu\text{m}$

### REMARKS

Distinguished from other taxa assigned to the genus by the presence of a broad striate zona and one to three distal fovea. Smith and Butterworth (1967) considered that *Cirratriradites flabelliformis* Wilson & Kosanke was synonymous with *C. saturni*. *C. flabelliformis* was originally described as having three foveolae but Smith and Butterworth (1967) provided evidence that complete gradation exists between forms with one to three foveolae.

### RANGE

Late Mississippian to Pennsylvanian; Serpukhovian [Pendleian] to Kazimovian, [Stephanian A (Barruelian)]; NC to ST biozones (Clayton et al., 1977)

	<p>Figure 7a</p> <p>Shales above Mousegill Marine Band, Crag House Gill, Stainmore, Cumbria, England; Bashkirian [Kinderscoutian], KV Biozone, Sample CHG 1a, Specimen MPK <b>7303</b>. Distal focus. Equatorial outline of miospore and inner body both convexly rounded triangular. Inner body outline obscured by thickened zone. Zona bizonate; inner thicker zone appears to overlap the inner body margin on the distal surface, outer thinner zone radially striated. Distal polar foveola shows evidence of constriction into three components.</p> <p>Specimen maximum dimension 100 <math>\mu\text{m}</math></p>
	<p>Figure 7b</p> <p>Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [Langsettian], RA Biozone, Sample ASB, Specimen MPK <b>7304</b>. Proximal focus showing strongly bizonate zona. Inner body rounded triangular with indication of separation in the equatorial plane of intexine from exoexine. Trilete sutures extend almost to equatorial margin of inner body, in part obscured by elevated flexuous folds of exoexine, which extend to equatorial margin of spore. Two zones of zona approximately equal in width, outer zone shows faint radial striations and bears fine conate ornament. Distal polar foveola indistinct; suggestion of constriction into three components.</p> <p>Specimen maximum dimension 94 <math>\mu\text{m}</math></p>

***Colatisporites decorus* (Bharadwaj & Venkatachala) Williams in Neves et al., 1973**

DESCRIPTION

Radial, trilete, camerate miospores. Amb circular, subcircular or rounded triangular. Trilete mark distinct or indistinct, sutures extending to margin of intexine; straight, simple or accompanied by elevated narrow folds or labra, extending to or almost to the equatorial margin where they fuse laterally with the curvaturae. Intexine sometimes clearly separated from the exoexine, otherwise closely adpressed. Intexine may form indistinct inner body occupying at least four-fifths of the spore diameter. Degree of cameration variable but exoexine probably attached to intexine on both proximal and distal surfaces. Exoexine relatively thick, strongly infrapunctate.

OTHER DESCRIPTIONS

Bharadwaj and Venkatachala, 1961, p. 39, pl. 10, figs. 142–164

Williams in Neves et al., 1973, p. 41, pl. 2, figs. 11–13

SIZE

Overall equatorial diameter 40(53)75 µm

REMARKS

*Colatisporites denticulatus* Neville in Neves et al., 1973 differs by possessing an exoexinal ornament of small spinae, bacula, coni and grana.

RANGE

Mississippian; Tournaisian; PC to CM biozones (Higgs et al., 1988)

	<p>Figure 8a</p> <p>Pinsky Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Mississippian, Tournaisian, CM Biozone, Sample MPA 302, Specimen MPK <b>7671</b>. Miospore with circular amb and closely adpressed intexine and exoexine. Trilete suture simple, extending approximately half of spore radius.</p> <p>Specimen maximum dimension 61 µm</p>
	<p>Figure 8b</p> <p>Pinsky Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Mississippian, Tournaisian, CM Biozone, Sample MPA 292, Specimen MPK <b>7672</b>. Clear evidence of separation of exoexine from intexine in the equatorial plane. Trilete mark open, suture simple extending approximately three-quarters of the radius. Exoexine finely infrapunctate. Minor secondary folds.</p> <p>Specimen maximum dimension 58 µm</p>

## *Convolutispora circumvallata* Clayton, 1971

### DESCRIPTION

Radial trilete acamerate miospores. Amb circular–subcircular. Trilete mark distinct or obscured by ornamentation, sutures simple or accompanied by wide labra, extending more than three-quarters of spore radius. Ornament on entire distal surface and equatorial portion of proximal surface consists of rounded anastomosing ridges, some of which may be fused together to form an imperfect reticulum. Ridges variable in width along length and often have expanded tops particularly where ridges join. The channels and irregular lumina between the ridges are normally equal to or wider than the mean width of the ridges. Ridges 3–12  $\mu\text{m}$  high and 5–15  $\mu\text{m}$  wide. Exine up to 5  $\mu\text{m}$  thick.

### OTHER DESCRIPTIONS

Clayton, 1971, p. 582, pl. 1, figs. 5–7

Higgs, Clayton and Keegan, 1988, p. 63, pl. 6, fig. 12

### SIZE

Overall equatorial diameter 64(90)112  $\mu\text{m}$

### REMARKS

The range of morphological variability displayed by this species is wide but few specimens display a sufficiently well developed reticulation to justify inclusion within the genus *Dictyotriletes*. *Reticulatisporites ancoralis* Balme & Hassell 1962 is superficially similar but has a better developed reticulum and a thinner exine.

### RANGE

Mississippian; Tournaisian to Viséan; CM to Pu biozones (Clayton et al., 1977)

	<p>Figure 9a</p> <p>Pinsky Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Mississippian, Tournaisian, CM Biozone, Sample MPA 302, Specimen MPK <b>7421</b>. Distal focus. Subcircular miospore, trilete mark obscured by heavy convolute ornament. Distal surface and equatorial portion of proximal surface of exine ornamented with dense network of wide, round-topped ridges, which coalesce to form incomplete reticulate pattern.</p> <p>Specimen maximum dimension 101 <math>\mu\text{m}</math></p>
	<p>Figure 9b</p> <p>Pinsky Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Mississippian, Tournaisian, CM Biozone, Sample MPA 302, Specimen MPK <b>7422</b>. Heavy convolute round-topped ridges form irregular pattern. Trilete mark distinct, sutures extend at least three quarters of spore radius and accompanied by low broad labra.</p> <p>Specimen maximum dimension 94 <math>\mu\text{m}</math></p>

## *Convolutispora major* (Kedo) Turnau, 1978

### DESCRIPTION

Radial, trilete miospores. Amb rounded triangular to subcircular, equatorial margin undulate. Trilete mark distinct to indistinct; often obscured by ornamentation. Sutures straight, accompanied by low broad labra, up to 8  $\mu\text{m}$  wide, extending at least 50 % of spore radius and sometimes reaching almost to equatorial margin. Exine up to 11  $\mu\text{m}$  thick (including ornament). Distal surface and more equatorial portion of proximal surface ornamented by dense irregular, imperfect reticulum of anastomosing variably thickened ridges, individual ridges 6–10  $\mu\text{m}$  wide, 6  $\mu\text{m}$  high, rounded in profile. Lumina irregular, branched, 3–10  $\mu\text{m}$  wide. Ridges on equatorial portion of proximal surface shorter and occasionally wart-like. Contact areas often smooth.

### OTHER DESCRIPTIONS

Turnau, 1978, p. 8, pl. 2, figs. 18a, b and 19

### SIZE

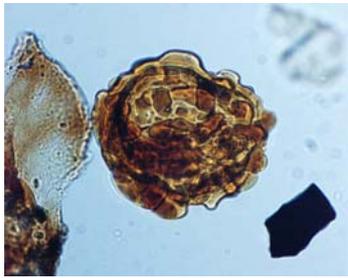
Equatorial diameter 69(95)119  $\mu\text{m}$

### REMARKS

The coarse ornament of convolute ridges forming an imperfect reticulum distinguishes this species from others assigned to *Convolutispora*. *Convolutispora harlandi* Playford 1962 has coarse convolute ridges but these are irregularly and densely arranged and do not form a reticulum. *C. labiata* Playford 1962 has similar broad, low, thickened labra accompanying the trilete sutures, but differs from *C. major* in possessing an ornament of fine convolute ridges.

### RANGE

Mississippian; Tournaisian (Turnau, 1978).

	<p>Figure 10a</p> <p>Bialy Bor No.1 Borehole, 2788.8 m, west Pomerania, Poland; Mississippian, Tournaisian, Ma Biozone, Sample MPA 33201/1, Specimen MPK <b>7192</b>. Subcircular thick walled miospore with dense ornament of coarse irregular ridges that anastomose to form loose reticulate pattern. Projecting ridges in equatorial region produce undulate margin of spore.</p> <p>Specimen maximum dimension 82 <math>\mu\text{m}</math></p>
	<p>Figure 10b</p> <p>Bialy Bor No.1 Borehole, 2788.8 m, west Pomerania, Poland; Mississippian, Tournaisian, Ma Biozone, Sample MPA 33201/2, Specimen MPK <b>7197</b>.</p> <p>Specimen maximum dimension 115 <math>\mu\text{m}</math></p>

## *Crassispora aculeata* Neville, 1968

### DESCRIPTION

Radial, trilete miospores. Amb subcircular to rounded triangular. Trilete mark distinct, sutures straight, extending to or nearly to the spore margin; accompanied by elevated flexuous folds that extend, decreasing in height, to the inner margin of the equatorial crassitude with which they fuse laterally. Apical papillae common in the intertectal areas. Exine laevigate or infrapunctate, thickened in the equatorial region to form ill-defined crassitude with weak inner margin. Crassitude invaginated in the radial positions where it fuses with folds accompanying trilete sutures to form clearly defined curvaturae which run just on the proximal side of the equatorial margin. Distal surface of exine and equatorial margin ornamented with spinae and rare coni; elements 1.5–15  $\mu\text{m}$  in height, and 1–5.5  $\mu\text{m}$  in basal diameter. Approximately 20 elements project at the equatorial margin, elements normally discrete and more or less constant in size on individual specimens.

### OTHER DESCRIPTIONS

Neville, 1968, pp. 443–446, pl. 2, figs. 5–6

### SIZE

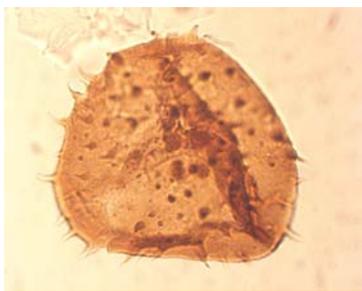
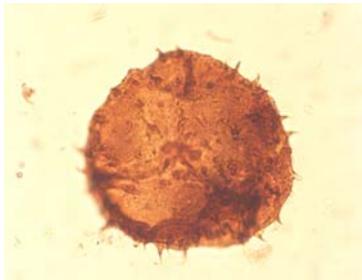
Overall equatorial diameter 56(74)96  $\mu\text{m}$

### REMARKS

*Crassispora maculosa* (Knox) Sullivan 1964 is similar in size, but is distinguished by possessing an ornament of more densely distributed smaller coni.

### RANGE

Mississippian; Visean to early Serpukhovian [Pendleian]; TC to NC Biozones (Clayton et al., 1977).

	<p>Figure 11a</p> <p>Shales below Hurlet Limestone, Hurlet Borehole, 130.68 m, Scotland; Mississippian, Visean, VF Biozone, Sample MPA 9158, Specimen MPK <b>7013</b>. Subcircular trilete miospore with ill-defined equatorial crassitude. Ends of trilete sutures may merge into invaginated extension of ill-defined inner margin of equatorial crassitude. Well-developed spinose ornament over entire distal surface and more equatorial portion of proximal surface. Elements with bulbous bases and sharply pointed tops.</p> <p>Specimen maximum dimension 70 <math>\mu\text{m}</math></p>
	<p>Figure 11b</p> <p>Shales below Hurlet Limestone, Hurlet Borehole, 130.68 m, Scotland; Mississippian, Visean, VF Biozone. Sample MPA 9158, Specimen MPK <b>7014</b>. Note elevated folds accompanying trilete mark.</p> <p>Specimen maximum dimension 76 <math>\mu\text{m}</math></p>

## *Crassispora kosankei* (Potonié & Kremp) Bharadwaj, 1957

### DESCRIPTION

Radial, trilete, camerate-acamerate miospores. Amb circular to subcircular or oval. Trilete mark distinct to indistinct; rays either simple, straight, extending almost to the inner margin of the equatorial crassitude or split open to form triangular tear in the polar region. Exine characteristically thickened in the equatorial region to form crassitude; inner margin of crassitude ill-defined and commonly invaginated in radial positions. Distal surface of exine ornamented with numerous discrete coni up to 2 µm height and basal diameter. Elements project at equatorial margin but appear absent from the proximal surface. Apical papillae commonly present. Exine surface between coni, densely infrapunctate. Secondary folding common.

### OTHER DESCRIPTIONS

Potonié and Kremp, 1955, p. 71, pl. 13, figs. 208–213

Smith and Butterworth, 1967, pp. 254–255, pl. 19, figs. 2–4

### SIZE

Overall equatorial diameter 40(64)105 µm

### REMARKS

*Crassispora ovalis* Bharadwaj 1957 originally distinguished only by size from *Crassispora kosankei*, was incorporated within the circumscription of the latter species by emendation of Smith and Butterworth (1967). The size ranges recorded for different populations of the species are known to reflect different oxidation procedures.

Owens et al. (1977) and Clayton et al. (1977) considered that *Crassispora kosankei* becomes abundant at the base of the KV Biozone, approximately at the Alportian–Kinderscoutian boundary, being infrequent or rare in the earliest Namurian. Later Owens in Ramsbottom (1981) reported abundant *C. kosankei* in palynomorph assemblages from the boundary stratotype section of the Chokierian.

### RANGE

Late Mississippian to Pennsylvanian; Serpukhovian to Kasimovian [Pendleian to Stephanian]; NC to NBM biozones (Clayton et al., 1977)

	<p>Figure 12a</p> <p>BGS Offshore Borehole 74/12, 18.07 m, Firth of Forth, Scotland; Bashkirian [Duckmantian], NJ Biozone, Sample CSA 1231, Specimen MPK 7001. Subcircular trilete spore with ill-defined equatorial crassitude. Trilete mark indistinct, represented by open triangular tear. Exine surface infrapunctate but also bears dense ornament of small discrete coni which project at equatorial margin. Minor exinal folding present.</p> <p>Specimen maximum dimension 78 µm</p>
	<p>Figure 12b</p> <p>BGS Offshore Borehole 74/13, 18.07 m, Firth of Forth, Scotland; Bashkirian [Duckmantian], NJ Biozone, Sample CSA 1231, Specimen MPK 7002. Specimen showing trilete mark split into triangular tear in polar region but displaying rays extending almost to the equatorial margin. Ends of trilete sutures become fused with minor invagination of equatorial crassitude in equatorial region. Well-defined ornament of densely distributed small coni.</p> <p>Specimen maximum dimension 72 µm</p>

## *Crassispora maculosa* (Knox) Sullivan, 1964

### DESCRIPTION

Radial, trilete, camerate miospores. Amb circular to subcircular. Trilete mark distinct, sutures straight, extending half to three-quarters of spore radius, accompanied by low relatively narrow, thickened labra, individually up to 4  $\mu\text{m}$  wide, which fuse equatorially into the variably defined equatorial crassitude which is frequently slightly invaginated in the radial positions. Crassitude narrow, weakly developed with ill-defined inner margin. When seen in off-polar compressions, the crassitude simulates curvaturae. Exine up to 3  $\mu\text{m}$  thick, with dense granulate infrastructure. Distal surface of exine ornamented with scattered broad-based coni up to 2–3  $\mu\text{m}$  in height, projecting at equatorial margin. Proximal surface laevigate.

### OTHER DESCRIPTIONS

Knox, 1950, p. 318

Smith and Butterworth, 1967, pp. 235–236, pl. 18, figs. 7–8, pl. 19, fig. 1

### SIZE

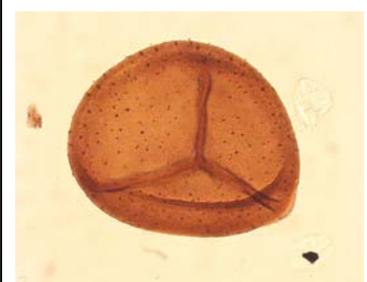
Overall equatorial diameter 76(94)120  $\mu\text{m}$

### REMARKS

*Crassispora kosankei* (Potonié & Kremp) Bharadwaj 1957 is smaller, has a wider equatorial crassitude and a more densely distributed conate ornament.

### RANGE

Mississippian; Visean to Serpukhovian [Brigantian to Arnsbergian] (Smith and Butterworth, 1967).

	<p>Figure 13a</p> <p>Shales below Faraday House Sill, Argill Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian], NC Biozone, Sample NC, Specimen MPK <b>7074</b>. Oblique compression. Note thick exine and narrow equatorial crassitude. Trilete mark distinct, sutures accompanied by elevated folds or ridges, which extend to the crassitude. Distal surface of exine ornamented with relatively coarse conate ornament.</p> <p>Specimen maximum dimension 97 <math>\mu\text{m}</math></p>
	<p>Figure 13b</p> <p>Shales below Hurlet Limestone, Hurlet Borehole 160.70 m, Scotland; Visean, VF Biozone, Sample MPA 9162, Specimen MPK <b>7075</b>. Proximal focus of slightly obliquely compressed specimen. Equatorial crassitude, narrow, poorly defined. Exine relatively thick. Proximal surface smooth, distal surface bears fine granular or conate ornament that protrudes at equator. Minor compression fold present.</p> <p>Specimen maximum dimension 90 <math>\mu\text{m}</math></p>

## *Crassispora trychera* Neves & Ioannides, 1974

### DESCRIPTION

Radial, trilete, variably camerate miospores, intexine probably attached proximally and separated to variable degrees over the distal surface. Amb subcircular, oval or irregular due to folding. Trilete mark usually distinct, sutures straight or sinuous, simple or accompanied by narrow flexuous folds, extending almost to the equatorial margin where they fuse laterally with curvaturae that are coincident for most of their length with the equatorial margin. Exoexine densely sculptured with coni and pilate elements, 1–3.5  $\mu\text{m}$  high and 0.5–2.5  $\mu\text{m}$  in width, with grana up to 1  $\mu\text{m}$  in height and width, interspersed between elements. Distribution of ornament variable, sometimes dense but elsewhere sparse with unornamented areas. Equatorial margin thickened to form ill-defined crassitude with poorly delimited inner margin. Secondary compression folds commonly arranged in a concentric style close to the equatorial margin.

### OTHER DESCRIPTIONS

Neves and Ioannides, 1974, p. 78, pl. 7, figs. 6–8

### SIZE

Overall equatorial diameter 48(58)67  $\mu\text{m}$

### REMARKS

*Endoculeospora gradzinskii* Turnau 1975 possesses an ornament similar to that of *Crassispora trychera* but is distinctly camerate and has a small inner body. *Crassispora kosankei* (Potonié & Kremp) Bharadwaj is less extensively folded and possesses a more uniform conate ornament. *Crassispora maculosa* (Knox) Sullivan 1964 is larger with a thicker exine and heavier conate ornamentation.

### RANGE

Mississippian; Tournaisian to early Viséan; PC to Pu biozones (Clayton et al., 1977)

	<p>Figure 14a</p> <p>Cementstone Group, Bracken Bay, Heads of Ayr, Ayrshire; Mississippian, Tournaisian, CM Biozone, Sample MPA 29832, Specimen MPK <b>8161</b>. Intexine forms well defined inner body. Trilete mark distinct, sutures obscured by low elevated folds that extend, decreasing in height, two-thirds of distance to equatorial margin where they fuse with low ridge like curvaturae. Entire distal surface, and that portion of proximal surface equatorial to the curvaturae, densely ornamented with coni and bacula that project at equatorial margin. Equatorial crassitude ill-defined.</p> <p>Specimen maximum dimension 65 <math>\mu\text{m}</math></p>
	<p>Figure 14b</p> <p>Pinsky Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Mississippian, Tournaisian, CM Biozone, Sample MPA 302, Specimen MPK <b>8162</b>. Proximal focus shows well-defined curvaturae devoid of ornamentation.</p> <p>Specimen maximum dimension 69 <math>\mu\text{m}</math></p>

***Densosporites anulatus* (Loose) Smith & Butterworth, 1967**

DESCRIPTION

Radial, trilete, cingulate miospores. Amb rounded triangular to subcircular. Trilete mark indistinct, sutures simple, straight, extending to margin of inner body. Intexine thin, laevigate, forming rounded triangular to subcircular inner body. Exoexine thin in polar regions but extended and thickened in the equatorial plane to form undifferentiated cingulum of more or less uniform thickness. Cingulum narrow, 4(8)12 µm in width, tapering very slightly towards the equator, surface laevigate. Depending on compression, cingulum may appear to overlap equatorial portion of inner body. Two exine layers normally closely adpressed but sometimes showing weak evidence of separation in the equatorial plane. Cingulum occupies up to 40 % of total spore radius.

OTHER DESCRIPTIONS

Smith and Butterworth, 1967, p. 239, p1. 19, figs. 5–6

SIZE

Overall equatorial diameter 26(40)56 µm

REMARKS

*Densosporites anulatus* is distinguished from most other species of *Densosporites* by its lack of ornament. *D. sphaerotriangularis* Kosanke 1950 appears similar but has a cingulum with a verrucose or spinose ornamentation. *D. simplex* Staplin 1960 and *D. tripapillatus* Staplin 1960 differ from *D. anulatus* in having broader cingula.

RANGE

Mississippian to Pennsylvanian; Visean to Moscovian [early Bolsovian] (from Smith and Butterworth, 1967)

	<p>Figure 15a</p> <p>Shales below Swinstone House Marine Band, Mousegill Beck, Stainmore, Cumbria, England; Bashkirian, [Marsdenian], FR Biozone, Sample T96, Specimen MPK <b>7655</b>. Subcircular trilete cingulate miospore. Trilete mark distinct, suture simple, extending to inner margin of cingulum and accompanied by low narrow folds of exoexine. Evidence of minor separation in the equatorial plane between the intexine of the inner body and the exoexine of the cingulum. Cingulum occupies approximately one-third of spore radius, more or less uniform in structure and tapering slightly to the equator. Exoexine of inner body and cingulum laevigate.</p> <p>Specimen maximum dimension 55 µm</p>
	<p>Figure 15b</p> <p>Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [uppermost Langsettian], RA Biozone, Sample ASB, Specimen MPK <b>7659</b>. Specimen showing indication of minor intexine–exoexine separation in the equatorial plane.</p> <p>Specimen maximum dimension 62 µm</p>

***Dictyotriletes fimbriatus* (Winslow) Kaiser, 1970**

DESCRIPTION

Radial, trilete, acamerate miospores. Amb rounded triangular to subcircular. Trilete mark distinct or obscured by ornamentation, sutures simple, straight, extending between half and two-thirds of spore radius. Exine bears characteristic reticulate ornament, muri present on proximal surface, reduced in height and density but commonly developed parallel to sutures of trilete mark. Muri 8–20 µm high and approximately 3 µm wide at base, with distinctive papillate crests. Muri enclose a variable number of large lumina up to 30 µm in diameter, variable in shape. Crests of muri deeply incised to about half their height to form blunt, slightly pointed or clavate papillae.

OTHER DESCRIPTIONS

Winslow, 1962, pp. 58–59, pl. 14, figs. 1–3, pl. 22, fig. 21

Kaiser, 1970, p. 95, pl. 19, figs. 4–6

SIZE

Overall equatorial diameter 69–115 µm

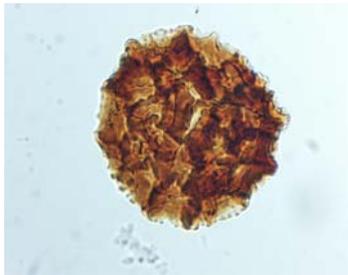
Diameter excluding ornament 52–80 µm

REMARKS

The distinctive papillate crested muri forming the reticulate ornamentation of this species render it readily distinct from all other taxa assigned to this genus.

RANGE

Late Devonian (Strunian) to Mississippian; Tournaisian; LL to HD Biozones (Higgs et al., 1988).

	<p>Figure 16a</p> <p>Bedford Shale, Big Walnut Creek, Sunbury, Ohio, USA; uppermost Devonian, Strunian, LL Biozone, Sample 5133, Specimen MPK <b>7595</b>. Distal focus of specimen with relatively fine low muri enclosing smaller denser lumina. Trilete mark distinct, sutures simple, straight, extend at least three-quarters of spore radius with indication of muri-like structures running parallel to sutures.</p> <p>Specimen maximum dimension 73 µm</p>
	<p>Figure 16b</p> <p>Bedford Shale, Big Walnut Creek, Sunbury, Ohio, USA; uppermost Devonian, Strunian, LL Biozone, Sample 5133, Specimen MPK <b>7597</b>. Specimen showing papillate character of muri projecting at equatorial margin. Oblique compression in proximal focus.</p> <p>Specimen maximum dimension 78 µm</p>

## *Dictyotriletes muricatus* (Kosanke) Smith & Butterworth, 1967

### DESCRIPTION

Radial, trilete, acamerate miospores. Amb circular to rounded triangular. Trilete mark distinct or obscured by the ornamentation, sutures simple straight, extending between half and three-quarters of spore radius. Exine ornamented on entire distal surface and equatorial portion of proximal surface with muri which are up to 2 µm wide and 6–12 µm high. Muri enclose variable number of polygonal lumina which are of more or less uniform size on any individual but vary in size and number between individuals. Lumina vary in diameter up to 25 µm. Exine of lumina laevigate although infrequent small coni and spinae may occur.

### OTHER DESCRIPTIONS

Kosanke, 1950, p. 27, pl. 4, fig. 7

Smith and Butterworth, 1967, pp. 197–198, pl. 11, figs. 25–26

### SIZE

Overall equatorial diameter 68(83)97 µm

### REMARKS

Some specimens assigned to this species may possess lumina which are closely comparable in size and form to those of *Reticulatisporites reticulatus* (Ibrahim) Ibrahim 1933. The latter species is however readily distinguished by possessing a differentially thickened cingulum.

### RANGE

Pennsylvanian; Bashkirian to Moscovian [Langsettian to early Bolsovian] (Smith and Butterworth, 1967)

	<p>Figure 17a</p> <p>Thin coal below <i>Carbonicola pseudorobusta</i> Shell Bed, Crag House Gill, Stainmore, Cumbria, England; Bashkirian [earliest Langsettian], SS Biozone, Sample CHG8, Specimen MPK <b>7583</b>. Subcircular reticulate miospore. Trilete mark obscured by ornament but probably open and rays extending at least half spore radius. Exine ornamented with thin, high muri that enclose variable shaped lumina. Muri project at the equator to produce irregular, flange-like projection.</p> <p>Specimen maximum dimension 74 µm</p>
	<p>Figure 17b</p> <p>Thin coal below <i>Carbonicola pseudorobusta</i> Shell Bed, Crag House Gill, Stainmore, Cumbria, England; Bashkirian [earliest Langsettian], SS Biozone, Sample CHG8, Specimen MPK <b>7592</b>. Exine ornamented with narrow, relatively tall muri enclosing irregular lumina.</p> <p>Specimen maximum dimension 77 µm</p>

## ***Endosporites zonalis* (Loose) Knox, 1950**

### DESCRIPTION

Radial, trilete, camerate miospores. Amb of body and saccus circular to rounded triangular. Trilete mark distinct, sutures straight, extending to or almost to margin of inner body, accompanied by elevated flexuous folds of the exoexine which extend, decreasing in height, almost to the equatorial margin of the exoexinal body. Ends of elevated exoexinal folds connected laterally with narrow, fine, curvatural ridges that in proximo-distal compression are located, for much of their length coincident with the equatorial margin of the saccus, the exception being in the radial positions where minor invagination takes place. Intexine thinner than exoexine, forms inner body that may possess peripheral taper-point compression folds, indicating significant separation of the two exine layers. Exoexine thin, granulate with fine narrow limbus, forms saccus and is commonly extensively folded.

### OTHER DESCRIPTIONS

Loose, 1934, p. 148, p. 17, fig. 5

Smith and Butterworth, 1967, pp. 272–273, pl. 22, figs. 3–4

### SIZE

Overall equatorial diameter 61(82)104  $\mu\text{m}$

Diameter of inner body 33(50)61  $\mu\text{m}$

Ratio of inner body to saccus diameter 46(59)77  $\mu\text{m}$

### REMARKS

Almost identical to *Endosporites globiformis* (Ibrahim) Schopf, Wilson & Bentall except the ratio of the inner body to saccus is consistently larger and the exoexine appears slightly thicker.

### RANGE

Pennsylvanian; Bashkirian to Moscovian [late Langsettian to Asturian] (Smith and Butterworth, 1967).

	<p>Figure 18a</p> <p>Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [uppermost Langsettian], RA Biozone, Sample ASB, Specimen MPK <b>7499</b>. Subcircular–rounded triangular camerate miospore with well-defined inner body occupying more than half of spore radius. Laesurae straight extending to body margin, partly obscured by compression fold. Exoexine laevigate, equatorial margin limbate. Note suggestion of curvaturae just inside equatorial margin at one radial apex.</p> <p>Specimen maximum dimension 94 <math>\mu\text{m}</math></p>
	<p>Figure 18b</p> <p>Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [uppermost Langsettian], RA Biozone, Sample ASB, Specimen MPK <b>7500</b>. Note trilete suture obscured by thickened elevated exoexinal folds that extend to margin of inner body.</p> <p>Specimen maximum dimension 90 <math>\mu\text{m}</math></p>

## *Grandispora lupata* Turnau, 1975

### DESCRIPTION

Radial, trilete camerate miospores. Amb rounded triangular with convex sides and rounded apices. Trilete mark distinct, sutures straight, accompanied by elevated flexuous folds of the exoexine which extend, decreasing in height, towards the equatorial margin of spore. Exoexine separated from intexine at least in the equatorial region and over part of distal surface. Intexine thin, forming rounded triangular inner body occupying up to three-quarters of the total spore diameter. Exoexine finely infrapunctate, relatively thick over distal surface and equatorial portion of proximal surface, thinner over contact areas which occupy approximately two-thirds of spore radius. Ornamentation of exoexine confined to the distal surface and consists of spinae with bulbous bases and sharply pointed terminations. Elements up to 2.5  $\mu\text{m}$  high and 1.5  $\mu\text{m}$  in basal diameter, varying between 1.5 and 9  $\mu\text{m}$  (commonly 5  $\mu\text{m}$ ) apart.

### OTHER DESCRIPTION

Turnau, 1975, pp. 517–518, pl. 6, figs. 1–3

### SIZE

Overall equatorial diameter 64(75)95  $\mu\text{m}$

### REMARKS

*Grandispora echinata* Hacquebard 1957, is distinguished by possessing a thinner exoexine which is of uniform thickness, and a more obvious intexine forming the inner body. *Grandispora gracilis* (Kedo) Stree in Becker et al. 1974 is smaller, has a thinner exoexine and possesses a finer ornamentation. *Grandispora* cf. *uncata* (Hacquebard) Playford 1971, is smaller and has a relatively coarser but less densely distributed ornamentation.

### RANGE

Devonian; Famennian (from Higgs et al., 2000)

	<p>Figure 19a</p> <p>Babilon Borehole 2626.6 m, west Pomerania, Poland; Late Devonian, Strunian (Tn 1A), Lu Biozone (Turnau, 1978), Sample MPA 33203, Specimen MPK <b>7286</b>. Rounded triangular miospore consisting of indistinct spore body surrounded by exoexine forming ? flange which appears thickened in the equatorial region. Trilete mark distinct, extending to margin of inner body and accompanied by narrow elevated exoexinal folds that taper towards the margin. Distal equatorial exoexine ornamented with small sharply pointed spinae surmounting small, bulbous bases. Ornament projects at equatorial margin.</p> <p>Specimen maximum dimension 64 <math>\mu\text{m}</math></p>
	<p>Figure 19b</p> <p>Babilon Borehole, 2624.6 m, west Pomerania, Poland; Late Devonian, Strunian (Tn 1A), Lu Biozone (Turnau 1978), Sample MPA 33203, Specimen MPK <b>7292</b>. Proximal focus showing indistinct inner body, trilete sutures accompanied by elevated exoexinal folds that extend almost to equator. Proximal surface laevigate.</p> <p>Specimen maximum dimension 75 <math>\mu\text{m}</math></p>

## *Grandispora spinosa* Hoffmeister, Staplin & Malloy, 1955

### DESCRIPTION

Radial, trilete, camerate miospores. Amb circular, subcircular or rounded triangular, outline of inner body more or less conformable and occupying two-thirds to four fifths of the spore diameter. Trilete mark distinct or obscured by folding, sutures straight, extending at least three-quarters of the inner body radius, commonly accompanied by elevated flexuous folds of the exoexine that extend decreasing in height to the equatorial margin of spore. Intexine thin, laevigate, forms well-defined inner body with independent compression folds indicating major separation of the two exine layers. Exoexinal body wall 1–2.5  $\mu\text{m}$  thick; exoexine infrapunctate, ornamented over entire distal surface and equatorial portion of proximal surface with sharply pointed conical elements and spines, many of which may have bulbous bases. Elements with bulbous bases more commonly located in the polar regions with simple, sharply-pointed conical elements and spines at the equator. Elements 2–8  $\mu\text{m}$  high (commonly 2–5  $\mu\text{m}$ ) and 2–4  $\mu\text{m}$  in basal diameter. Exoexine commonly folded due to compression.

### OTHER DESCRIPTIONS

Hoffmeister, Staplin and Malloy, 1955, pp. 388–389, pl. 39, figs. 10 and 14

Sullivan and Marshall, 1966, p. 280, pl. 4, fig. 5

### SIZE

Overall equatorial diameter 80(105)165  $\mu\text{m}$

Diameter of inner body 62(89)107  $\mu\text{m}$

### REMARKS

Distinguished from *Grandispora echinata* Hacquebard 1957, by its larger size and ornament of more widely spaced, bulbous-based spines and conical elements.

### RANGE

Mississippian; late Viséan to Serpukhovian [Arnsbergian]; VF to SO biozones (Clayton et al., 1977; Turner et al., 1994)

	<p>Figure 20a</p> <p>Shales below Faraday House Sill, Argill Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian], NC Biozone, Sample LCS, Specimen MPK <b>7130</b>. Extensively folded camerate miospore. Inner body subcircular with indication that simple trilete sutures extend to equator of body. Exoexinal body thin-walled, extensively folded with suggestion of limbate margin. Exoexine bears ornament of stout, bulbous-based conical elements, many of which project at equator.</p> <p>Specimen maximum dimension 163 <math>\mu\text{m}</math></p>
	<p>Figure 20b</p> <p>Shales below Holme Wood Marine Band, Mousegill Beck, Stainmore, Cumbria, England; Serpukhovian [Arnsbergian], TK Biozone, Sample M21, Specimen MPK <b>7131</b>. Specimen with relatively large inner body. Inner body extensively folded independently of exoexine. Equatorial margin of exoexine limbate. Exoexine ornamented with scattered, stout conical elements on distal surface.</p> <p>Specimen maximum dimension 125 <math>\mu\text{m}</math></p>

***Grumosisporites varioreticulatus* (Neves) Smith & Butterworth, 1967**

DESCRIPTION

Radial, trilete, camerate miospores. Amb subcircular to oval. Trilete mark distinct, sometimes obscured, sutures straight, simple or with low, broad, thickened labra, extending between two-thirds and three-quarters of the spore radius. Intexine thin, forming irregular to sub-triangular inner body. Exoexine 2–3.5  $\mu\text{m}$  thick, ornamented with often poorly defined reticulate sculpture. Muri narrow, up to 2  $\mu\text{m}$  high enclosing lumina of irregular shape which may be up to 15  $\mu\text{m}$  in diameter. Muri project at equatorial margin as low, broad-based conate projections. Reticulum best developed on distal surface and is most apparent at slightly elevated levels of focus.

OTHER DESCRIPTIONS

Neves, 1961, p. 8, pl. 2, figs. 1a–b

Smith and Butterworth, 1967, p. 232, pl. 17, figs. 8–10

SIZE

Overall equatorial diameter 70–110  $\mu\text{m}$

REMARKS

The poorly defined reticulate ornament on the exoexine distinguishes *G. varioreticulatus* from other species assigned to the genus.

RANGE

Pennsylvanian; Bashkirian to Moscovian [Bolsoviaian]; KV to SL biozones (Clayton et al., 1977).

	<p>Figure 21a</p> <p>BGS Offshore Borehole 74/13, 18.07 m, Firth of Forth, Scotland; [Duckmantian], NJ Biozone, Sample CSA 1231, Specimen MPK <b>7623</b>. Circular trilete miospore with undulate equatorial margin. Trilete mark distinct, sutures straight; length approximately three-quarters of spore radius, accompanied by low, ill-defined, thickened labra. Intexine separated from exoexine to form subcircular inner body. Intexine thin and probably folded. Exoexine ornamented with low muri forming reticulate pattern enclosing irregular lumina of variable size. Muri project at equator as low, cone-shaped projections.</p> <p>Specimen maximum dimension 83 <math>\mu\text{m}</math></p>
	<p>Figure 21b</p> <p>BGS Offshore Borehole 74/13, 18.07 m, Firth of Forth, Scotland; [Duckmantian], NJ Biozone, Sample CSA 1231, Specimen MPK <b>7624</b>. Evidence of rounded triangular inner body. Exoexine ornamented with low muri that project at equator as low, conate projections and form ill-defined, reticulate pattern.</p> <p>Specimen maximum dimension 86 <math>\mu\text{m}</math></p>

***Grumosisporites verrucosus* (Butterworth & Williams) Smith & Butterworth, 1967**

DESCRIPTION

Radial, trilete, camerate miospores. Amb circular to rounded-triangular with undulating equatorial margin. Trilete mark distinct, sutures straight, simple or with low, narrow, thickened labra; extending between two-thirds and the full spore radius. Intexine thin, forms irregular, extensively folded, inner body which is separated from the exoexine over a significant part of its surface. The two layers appear to be in contact at least at the contact areas. Exoexine 1–4 µm in thickness, ornamented with variably shaped verrucae which show basal coalescence to form short, irregular ridges. Elements densely distributed and separated by narrow channels of unornamented exoexine. Up to 30 elements project at the equator to produce undulating margin. Verrucae up to 3 µm high at equator. Ornament reduced or absent on the proximal surface.

OTHER DESCRIPTIONS

Butterworth and Williams, 1958, p. 369, pl. 2, figs. 2–3

Smith and Butterworth, 1967, pp. 232–233, pl. 18, figs. 1–6

SIZE

Overall equatorial diameter 42(53)64 µm

REMARKS

*Grumosisporites rufus* (Butterworth & Williams) Smith & Butterworth 1967 possesses a thicker exoexine and a less regular ornamentation. *Camptotriletes corrugatus* (Ibrahim) Potonié & Kremp 1956 has a coarser ornament and lacks evidence of separation of the exine layers.

RANGE

Mississippian; late Visean to Serpukhovian [Arnsbergian]; VF to NC biozones (Clayton et al., 1977).

	<p>Figure 22a</p> <p>Coal above Lower Stonesdale Limestone, Coldkeld Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian], NC Biozone, Sample CB21, Specimen MPK <b>7726</b>. Well-developed ornament of verrucose elements fused into short irregularly orientated ridges. Exine thick, simulating narrow cingulum.</p> <p>Specimen maximum dimension 61 µm</p>
	<p>Figure 22b</p> <p>Coal above Lower Stonesdale Limestone, Coldkeld Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian], NC Biozone, Sample CB21, Specimen MPK <b>7727</b>. Note simple trilete mark with laesurae extending between half to almost full spore radius.</p> <p>Specimen maximum dimension 62 µm</p>

## *Hystricosporites multifurcatus* (Winslow) Mortimer & Chaloner, 1967

### DESCRIPTION

Radial, trilete, acamerate miospores-megaspores. Amb, excluding projecting ornament, rounded triangular with straight or slightly convex sides and rounded apices. Proximal surface flattened, low, pyramidal; distal surface inflated, hemispherical. Trilete mark distinct, sutures straight, extending at least four-fifths of spore radius, accompanied by elevated flexuous folds of the exoexine which form an apical prominence up to 50  $\mu\text{m}$  high. Folds decrease in height toward the equator. No obvious indication of separation of exine layers. Exine thick, surface scabrate, ornamented with long, parallel-sided or gently tapering processes which have expanded bases. Fusion between adjacent processes may occur at their bases and in the lower parts of the processes. Shafts of the processes appear hollow and have finely striated surfaces. Process termini are solid and characteristically ornamented with up to five recurved spinae producing a grapnel-like appearance. Processes 70–120  $\mu\text{m}$  long, and excluding the expanded base, up to 10  $\mu\text{m}$  wide. Recurved spinae creating grapnel terminations 1–5  $\mu\text{m}$  long and 1–1.5  $\mu\text{m}$  wide. Processes appear to be developed over entire distal surface with concentration in the equatorial region; 8–15 elements project at the equatorial margin. Some specimens show weak indication of ill-defined internal body.

### OTHER DESCRIPTIONS

Winslow, 1962, p. 52, pl. 11, figs. 4–5; p1. 12, fig. 5, p1. 22, fig. 15

### SIZE

Overall equatorial diameter excluding projecting ornament 90(173)233  $\mu\text{m}$

### REMARKS

The distinctive ‘grapnel’ termini of its long slender processes distinguishes *H. multifurcatus* from all other taxa assigned to the genus. Mid and Late Devonian species of *Hystricosporites* have characteristic radially orientated ribs within the contact areas of the proximal surface; these are not present in *H. multifurcatus*.

### RANGE

Devonian to Mississippian; Strunian to early Viséan (from unpublished information).

	<p>Figure 23a</p> <p>Bedford Shale, Big Walnut Creek, Sudbury, Ohio, USA; Late Devonian, Strunian, LL Biozone, Sample SB3, Specimen MPK <b>7267</b>. Lateral compression showing almost flat proximal surface and inflated distal hemisphere. Proximal surface has elevated apical prominence formed by folds of the exoexine protecting the trilete mark. Surface of body scabrate. Specimen has prominent ornament of long processes that terminate in distinctive multifurcate appendages (see detail). Some processes appear to be bifurcate, while others split into up to five recurved spinae.</p> <p>Specimen maximum dimension, excluding projecting ornament, 131 <math>\mu\text{m}</math></p>
	<p>Figure 23b</p> <p>Bedford Shale Big Walnut Creek, Sudbury, Ohio, USA; Late Devonian, Strunian, LL Biozone, Sample SB3, Specimen MPK <b>7268</b>.</p> <p>Specimen maximum dimension, excluding projecting ornament, 94 <math>\mu\text{m}</math></p>

## ***Knoxisporites hederatus* (Ishchenko) Playford, 1962**

### DESCRIPTION

Radial, trilete, cingulate miospores. Amb circular to subcircular, consisting of circular to subcircular spore body surrounded by more or less conformable cingulum. Trilete mark distinct, sutures simple, or accompanied by low, thickened labra up to 8  $\mu\text{m}$  wide, which extend to the margin of the spore body. Sutures straight, extending between three-quarters to almost the full radius of the spore body. Exoexine extended in the equatorial plane to form undifferentiated cingulum, 6–16  $\mu\text{m}$  in width. Distal surface bears conspicuous, widely spaced, relatively low, broad, smooth, rounded muri that are connected in several places to each other and to the cingulum. Muri slightly sinuous, irregular in pattern, 8–17  $\mu\text{m}$  wide and 4–7  $\mu\text{m}$  high. Remainder of exine laevigate.

### OTHER DESCRIPTIONS

Ishchenko, 1956, pp. 58–59, pl. 10, fig. 121

Playford, 1962, pp. 634–635, pl. 90, figs. 9–12

### SIZE

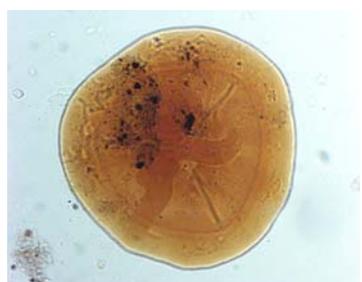
Overall equatorial diameter 67(86)112  $\mu\text{m}$

### REMARKS

The irregular development of low, broad muri on the distal surface distinguishes this species from other taxa assigned to *Knoxisporites*. Playford (1963) made no mention of the presence of low broad labra accompanying the trilete sutures that are a common feature of the Mattson Formation specimen illustrated here.

### RANGE

Mississippian; Tournaisian to Visean (Playford, 1962)

	<p>Figure 24a</p> <p>Visean lignite, Moscow Basin, Russia; Visean, MA Biozone (Playford, 1962), Sample MOS, Specimen MPK <b>7297</b>. Spore body surrounded by undifferentiated cingulum of uniform width. Trilete sutures simple, straight, extending to spore body margin. Distal surface bears irregular, low, broad, smooth muri. Exine laevigate.</p> <p>Specimen maximum dimension 92 <math>\mu\text{m}</math></p>
	<p>Figure 24b</p> <p>Mattson Formation, south face of Twisted Mountain, north-west of South Nahanni, Northwest Territories, Canada; Visean, MA Biozone (Playford, 1962), Sample MATT, Specimen MPK <b>7299</b>. Trilete mark extending to spore body margin, accompanied by low, thickened, broad labra.</p> <p>Specimen maximum dimension 94 <math>\mu\text{m}</math></p>

## *Knoxisporites stephanephorus* Love, 1960

### DESCRIPTION

Radial, trilete, cingulate miospores. Amb circular, subcircular to rounded triangular. Trilete mark distinct, sutures straight, extending to margin of spore body, simple or accompanied by low narrow thickened labra which typically become expanded equatorially to form triangular thickened areas that fuse to the proximal surface of the cingulum. Exine laevigate. Intexine forming spore body rarely discernible. Exoexine closely adpressed to intexine but extended in the equatorial plane to form thickened, undifferentiated cingulum, 5–15 µm wide. Exoexine developed into second ring of thickening mid way between the equator and the distal pole with irregular, radially-orientated thickened ribs in the inter-radial positions sometimes connecting it to the cingulum. A distal polar thickening 5–10 µm in diameter is also developed on the exoexine.

### OTHER DESCRIPTIONS

Love, 1960, pp. 118–119, pl. 2, figs. 1–2

### SIZE

Overall equatorial diameter 40–90 µm

### REMARKS

*Knoxisporites rotatus* Hoffmeister, Staplin & Malloy 1955 is distinguished by the absence of the distal polar thickening and by the presence of more prominent, radially-orientated ribs connecting the cingulum to the distal, circular ring of thickening.

### RANGE

Mississippian to Pennsylvanian; Visean to Moscovian [Asturian]; TS to OT biozones (Clayton, 1985, and unpublished information)

	<p>Figure 25a</p> <p>Shales below Swinstone House Marine Band, Mousegill Beck, Stainmore, Cumbria, England; Bashkirian [Marsdenian-Yeadonian], FR Biozone. Sample T96, Specimen MPK <b>7042</b>.</p> <p>Specimen maximum dimension 46 µm</p>
	<p>Figure 25b</p> <p>Halesowen Beds, Callow Brook, Staffordshire, England; Moscovian [Asturian], UP Biozone, Sample MPA 12628, Specimen MPK <b>7048</b>. Proximal focus showing development of thickenings, at the end of trilete sutures, which fuse onto cingulum.</p> <p>Specimen maximum dimension 45 µm</p>

## *Knoxisporites triangularis* Higgs, Clayton & Keegan, 1988

### DESCRIPTION

Radial, trilete, cingulate miospores. Amb subcircular to rounded triangular. Trilete mark distinct, sutures straight, sometimes open, extending to the inner margin of the cingulum, accompanied by broad prominent labra up to 20 µm in overall width. Intexine relatively thin; forms rounded triangular to subcircular inner body. Exoexine extended in equatorial plane to form undifferentiated cingulum, up to 14 µm wide. Proximal surface laevigate. Distal surface ornamented with three muri arranged in a triangular pattern with the apices of the triangle joining the cingulum in the inter-radial positions. Muri vary between 8–12 µm in width and are often slightly expanded where they fuse with the cingulum. Remainder of exine laevigate to scabrate.

### OTHER DESCRIPTIONS

Higgs, Clayton and Keegan, 1988, p. 66, pl. 8, figs. 3,6

### SIZE

Overall equatorial diameter 79(91)121 µm

### REMARKS

The distinctive triangular structure created from three muri on the distal surface distinguish this species from others assigned to the genus *Knoxisporites*. Higgs, Clayton and Keegan (1988) elevated this form to specific status, considering that it was sufficiently distinct from *Knoxisporites literatus* (Waltz) Playford 1963 within which it had previously been allocated varietal status.

### RANGE

Mississippian; Tournaisian; Tn1b to Tn3c, VI to CM biozones (Higgs et al., 1988)

	<p>Figure 26a</p> <p>Pinskey Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Tournaisian, CM Biozone, Sample MPA 292, Specimen <b>7031</b>. Subcircular–pentagonal cingulate miospore. Trilete mark distinct, sutures accompanied by low, broad labra that extend almost to equatorial margin of spore body. Cingulum thick, uniform. Distal surface of spore bears three straight thickened ridges that form a distinctive triangular structure. Apices of triangle fused to distal surface of cingulum in the inter-radial positions. Exine surface laevigate or very finely roughened.</p> <p>Specimen maximum dimension 105 µm</p>
	<p>Figure 26b</p> <p>Cementstone Group, Bracken Bay, Heads of Ayr, Ayrshire, Scotland; Tournaisian, CM Biozone, Sample MPA 29832, Specimen MPK <b>7033</b>. Rounded triangular miospore with uniform, thick, cingulum. Trilete mark distinct, sutures apparently without thickened labra extend to equator of spore body. Characteristic triangular shaped thickening on the distal surface appears to show minor expansion at the apices where it fuses with cingulum surface.</p> <p>Specimen maximum dimension 83 µm</p>

## ***Knoxisporites triradiatus* Hoffmeister, Staplin & Malloy, 1955**

### DESCRIPTION

Radial, trilete, acamerate miospores. Amb subcircular, sometimes rounded triangular. Trilete mark distinct, sutures straight, extending to, or almost to, the equatorial margin of the spore body; sutures accompanied by low, broad, thickened labra. Intexine probably thin; forms inner spore body conformable in outline with the equatorial margin. Exoexine closely adpressed to intexine over proximal and distal surfaces but extended in the equatorial plane to form thick undifferentiated relatively narrow cingulum. Distal surface of exoexine bears thickened, Y-shaped structure with ribs of uniform thickness, extending from the distal pole to fuse with the cingulum in the inter-radial positions.

### OTHER DESCRIPTIONS

Hoffmeister, Staplin & Malloy, 1955, p. 391, pl. 37, figs. 11–12

### SIZE

Overall equatorial diameter 50–88  $\mu\text{m}$

### REMARKS

The regular form of the Y-shaped thickening on the distal surface, and the narrow undifferentiated cingulum distinguish this species from others assigned to the genus *Knoxisporites*. *Knoxisporites semiradiatus* appears to have thickenings associated with the proximal trilete mark.

### RANGE

Mississippian; Visean to Serpukhovian [Arnsbergian]; TS to SO biozones (Clayton, 1985, and unpublished information)

	<p>Figure 27a</p> <p>Shales below Cove Lower Marine Band, Cove Harbour, Berwickshire, Scotland; Visean, NM Biozone, Sample MPA 18247, Specimen MPK <b>7715</b>. Well-developed uniform cingulum and broad thickened low labra. Distal Y-shaped thickening positioned eccentrically.</p> <p>Specimen maximum dimension 58 <math>\mu\text{m}</math></p>
	<p>Figure 27b</p> <p>Shales below Cove Lower Marine Band, Cove Harbour, Berwickshire, Scotland; Visean, NM Biozone, Sample MPA 18247, Specimen MPK <b>7718</b>. Distal focus; clearly defined Y-shaped distal structure and indication of thickened broad labra accompanying trilete mark.</p> <p>Specimen maximum dimension 60 <math>\mu\text{m}</math></p>

## *Krauselisporites echinatus* Owens, Mishell & Marshall, 1976

### DESCRIPTION

Radial, trilete, camerate, zonate miospores. Amb rounded triangular to subcircular. In lateral compression proximal surface low, pyramidal; distal surface hemispherical. Trilete mark distinct, sutures straight, extending to margin of inner body, accompanied and obscured by elevated, flexuous folds of the exoexine, up to 8  $\mu\text{m}$  high in the polar region but decreasing in height to the equatorial margin. Intexine thin, forming rounded triangular to subcircular inner body. Exoexine extended in the equatorial plane to produce strongly bizonate zona up to 25  $\mu\text{m}$  wide. Exoexine thicker over distal surface of inner body and extending into the inner part of the zona, outer part of zona thinner and weakly striated. Two exine layers normally closely adpressed but minor separation may occur in the equatorial plane and over the more equatorial portions of the distal surface. Exoexine surface finely infrapunctate, distal surface bears distinctive ornament of large pointed conical elements with expanded bases; height of elements 4–14  $\mu\text{m}$ , basal diameter 2–7  $\mu\text{m}$ . Elements variable in distribution with maximum concentration usually occurring on the inner thicker zone of the zona close to the margin of the spore body.

### OTHER DESCRIPTIONS

Owens, Mishell and Marshall, 1976, pp. 148–153, pl. 1, figs. 1–6, pl. 2, fig. 1

### SIZE

Overall equatorial diameter 74(104)147  $\mu\text{m}$

Maximum equatorial diameter of inner body 54(71)82  $\mu\text{m}$

### REMARKS

*Krauselisporites ornatus* (Neves) Owens, Mishell & Marshall 1976, differs by possessing an ornament of apparently smaller, delicate conical elements and spines. *Krauselisporites scorpius* Balme & Hassell 1962, described from the Upper Devonian of the Canning Basin, Western Australia is distinguished by possessing a narrower flange and a more densely distributed ornament of shorter, stouter, broad-based conical elements, spines and irregular baculae.

### RANGE

Mississippian to Pennsylvanian; late Visean to Bashkirian [Marsdenian]; VF to KV biozones (Clayton et al., 1977, and unpublished information)

	<p>Figure 28a</p> <p>Shales below Peasah Wood Limestone, Mousegill Beck, Stainmore, England; Serpukhovian [Arnsbergian], SO Biozone, Sample M18, Specimen MPK <b>7056</b>. Distal ornament consists of coarse discrete spinose elements on both body and zona, with tendency for highest concentration in polar region.</p> <p>Specimen maximum dimension 120 <math>\mu\text{m}</math></p>
	<p>Figure 28b</p> <p>Shales below Faraday House Sill, Argill Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian], NC Biozone, Sample NC, Specimen MPK <b>7057</b>. Note ornament of long slender spines with maximum concentration of elements developed adjacent to the boundary between inner body and zona. Only a limited number of small elements are developed on the zona.</p> <p>Specimen maximum dimension 113 <math>\mu\text{m}</math></p>

## *Krauselisporites hibernicus* Higgs, 1975

### DESCRIPTION

Radial, trilete, camerate miospores. Amb subcircular to rounded triangular with convex sides and rounded or slightly pointed apices. Trilete mark distinct or obscure; sutures straight or sinuous, extending to margin of spore body, accompanied by elevated flexuous folds of the exoexine which extend, decreasing in height, to the equatorial margin of the spore. Intexine thin, forming subcircular to rounded triangular inner body. Exoexine slightly thicker over distal surface and extended in the equatorial plane to form slightly fibrous zona 8–18  $\mu\text{m}$  in width. Distal and more equatorial portions of proximal surface of exoexine ornamented with sparse to closely spaced spini, coni and grana. Elements either discrete or fused at their bases to form short irregular cristae or rugulae. Spinae 1–5  $\mu\text{m}$  high and 0.5–2  $\mu\text{m}$  in basal diameter, coni 1–3  $\mu\text{m}$  in height and grana up to 1  $\mu\text{m}$  high. Exoexine of proximal surface thin and crumpled and in many cases folded along the line of the margin of the intexine.

### OTHER DESCRIPTIONS

Higgs, 1975, p. 400, pl. 6, figs. 11–12

Higgs, Clayton and Keegan, 1988, p. 79, pl. 16, fig. 3

### SIZE

Overall equatorial diameter 64(85)116  $\mu\text{m}$

Diameter of the inner body 40(53) 70  $\mu\text{m}$

### RANGE

Mississippian; Tournaisian; HD to CM biozones (Higgs et al., 1988)

	<p>Figure 29a</p> <p>Pinskey Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Tournaisian, CM Biozone, Sample MPA 302, Specimen MPK 7443. Rounded triangular miospore with subcircular inner body subrounded in equatorial plane by weakly biozonate flange. Exoexine extended equatorially to form wide zona that occupies up to half spore radius. A narrow zone of thickening is developed adjacent to the inner body, which it appears to overlap. Remainder of flange thin and extensively plicated. Distal surface and more equatorial portion of proximal surface of exoexine bears ornament of small discrete coni.</p> <p>Specimen maximum dimension 109 <math>\mu\text{m}</math></p>
	<p>Figure 29b</p> <p>Pinskey Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Tournaisian, CM Biozone, Sample MPA 292, Specimen MPK 7444. Distal focus showing clearly defined narrow thickened zone of distal exoexine where it overlaps inner body. Conate ornament appears coarser and more densely distributed in the distal polar region than over remainder of spore.</p> <p>Specimen maximum dimension 94 <math>\mu\text{m}</math></p>

## *Krauselisporites ornatus* (Neves) Owens, Mishell & Marshall, 1976

### DESCRIPTION

Radial, trilete, cingulizone, camerate miospores. Amb rounded triangular to subcircular, in lateral profile proximal surface flattened, low or pyramidal; distal surface hemispherical. Trilete mark distinct, sutures straight, extending to, or almost to, the equatorial margin of spore body, accompanied by elevated flexuous folds of the exoexine which extend decreasing in height to the margin. Exine composed of two layers. Intexine, thin, forms rounded triangular to subcircular inner body. Exoexine normally closely adpressed to the intexine but displays limited separation in the equatorial region. Exoexine extends to form bizonate cingulum. Maximum thickness of the exoexine developed over the distal surface and in the region of the cingulum adjacent to inner body margin. Outer zone of cingulum thinner and wider; sometimes appears weakly striated. Distal surface of exoexine ornamented with sharply pointed conical and spinose elements. Elements 2–10  $\mu\text{m}$  high (commonly 3–5  $\mu\text{m}$ ) with the longest most slender elements located close to the junction of the body and cingulum.

### OTHER DESCRIPTIONS

Neves, 1961, p. 269, pl. 33, fig. 3

Owens, Mishell and Marshall, 1976, pp. 153–154, pl. 2, figs. 2–4

### SIZE

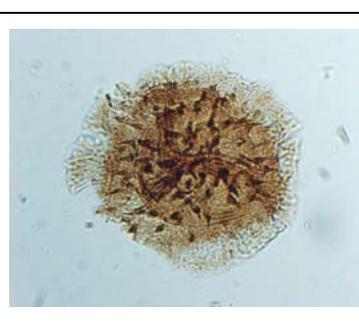
Overall equatorial diameter 76–110  $\mu\text{m}$

### REMARKS

*Krauselisporites ornatus* is distinguished from *K. echinatus* Owens, Mishell & Marshall 1976, by its smaller overall size and its proportionately smaller ornament of shorter, more slender conical and spinose elements.

### RANGE

Mississippian to Pennsylvanian; Serpukhovian to Bashkirian [Arnsbergian to Langsettian]; SO to RA biozones (Clayton et al., 1977)

	<p>Figure 30a</p> <p>Shales below <i>Gastrioceras cumbriense</i> Marine Band, Waters Farm Borehole (14.50 m), England; Bashkirian [Yeadonian], (<math>G_1</math>) FR Biozone, Sample MPA 18197, Specimen MPK 7690. Median focus showing well-defined inner body surrounded by wide, striated zona. Distal surface bears ornament of sharply pointed spinose elements; elements appear to be rare on the zona. Minor evidence of separation between intexine and exoexine in the equatorial plane.</p> <p>Specimen maximum dimension 78 <math>\mu\text{m}</math></p>
	<p>Figure 30b</p> <p>Shales above Mousegill Marine Band, Argill Beck, Stainmore, Cumbria, England; Bashkirian [Kinderscoutian], (<math>R_1</math>), KV Biozone, Sample A25, Specimen MPK 7693. Distal focus showing spinose ornament concentrated in distal polar region. Largest elements near to distal pole, equatorial elements mainly conical.</p> <p>Specimen maximum dimension 92 <math>\mu\text{m}</math></p>

***Labiadensites fimbriatus* (Waltz) Hacquebard & Barss, 1957**

DESCRIPTION

Radial, trilete, cingulate miospores. Amb circular to subcircular. Trilete mark distinct, sutures straight, extending almost to spore body margin, accompanied by broad, flat labra, extending 6–10  $\mu\text{m}$  on either side of the sutures and having undulate outer margins. Intexine laevigate to infrapunctate, forms circular to subcircular inner body. Exoexine extended in the equatorial plane to form smooth dense cingulum surrounded by more transparent, less robust, equatorial border which has a frilled membranous appearance. Boundary between the two parts of the cingulum is smooth. In some specimens outer membranous part of the cingulum appears to overlap thicker inner part particularly on the distal surface. Thinner outer membranous section may be variable in width creating undulate equatorial margin.

OTHER DESCRIPTIONS

Hacquebard and Barss, 1957, p. 28, pl. 4, fig. 2

Playford, 1962, pp. 632–633, pl. 90, figs. 1–3

SIZE

Overall equatorial diameter 90(115)144  $\mu\text{m}$

Diameter of the inner body 50(69)88  $\mu\text{m}$

REMARKS

Playford (1963) pointed out that those specimens in which the thinner membranous zone of the cingulum has been partly removed appear as transitional forms with *Anulatisporites labiatus* Hughes & Playford 1961, which has a smooth undifferentiated cingulum.

RANGE

Mississippian; Tournaisian to Visean (Playford, 1962)

	<p>Figure 31a</p> <p>Mattson Formation, south face of Twisted Mountain, north-west of South Nahanni, Northwest Territories, Canada; Visean, MA Biozone (Playford, 1962), Sample MATT, Specimen MPK 7257. Proximal focus. Subcircular inner body with open trilete mark, sutures extending approximately three-quarters of body radius, accompanied by broad, low, thickened labra. Note evidence of separation between intexine and exoexine in the equatorial plane. Bizonate cingulum has ill-defined junction between inner thicker and outer thinner sections. Exine surface infrapunctate.</p> <p>Specimen maximum dimension 109 <math>\mu\text{m}</math></p>
	<p>Figure 31b</p> <p>Mattson Formation, south face of Twisted Mountain, north-west of South Nahanni, Northwest Territories, Canada; Visean, MA Biozone (Playford, 1962), Sample MATT, Specimen MPK 7259. Trilete mark slightly open but clearly accompanied by broad, low, thickened labra with crenulate outer margins.</p> <p>Specimen maximum dimension 101 <math>\mu\text{m}</math></p>

## *Lophozonotriletes malevkensis* Naumova in litt. Kedo, 1963

### DESCRIPTION

Radial, trilete, cingulate miospores. Amb rounded triangular to subcircular, inner body conformable in outline with the equatorial margin. Trilete mark distinct to indistinct, sutures simple, straight, extending to margin of the inner body, sometimes accompanied by low narrow labra. Intexine thin, laevigate, forms inner body conformable in outline with the equatorial margin. Exoexine closely adpressed to intexine over both proximal and distal surfaces but extended in the equatorial plane to form more or less undifferentiated uniform cingulum which occupies 20–35 % of the spore radius. Distal surface of exoexine ornamented in the region underlying the inner body with prominent rounded tubercles and verrucae, elements normally discrete but variable in size, height up to 6 µm and basal diameter varying between 3–15 µm. Elements commonly distributed in a concentric manner in the region adjacent to the body-cingulum boundary with a single, frequently larger, element developed in the distal polar region. Ornamentation absent from the majority of cingulum, margin smooth or minutely indented. Surface of exoexine between verrucose elements smooth or minutely granulate.

### OTHER DESCRIPTIONS

Kedo, 1963, p. 87, pl. 10, figs. 240–241

Turnau, 1978, p. 9, pl. 3, fig. 8

Higgs, Clayton and Keegan, 1988, p. 67, pl. 8, figs. 11–13

### SIZE

Overall equatorial diameter 32(42)52 µm

### REMARKS

Playford (1991) considered *L. malevkensis* and *L. rarituberculatus* (Luber) Kedo to be synonymous and to be more appropriately accommodated in *Tumulispora* Staplin & Jansonius 1964. In the present work the two taxa are maintained and retained in *Lophozonotriletes*, which is considered to be adequately differentiated from *Tumulispora*. *Lophozonotriletes malevkensis* and *L. rarituberculatus* differ in the following ways.

1. *L. malevkensis* (32(42)52 µm; present study) is smaller than *L. rarituberculatus* (54(76)100 µm; present study).
2. The ornamentation of verrucae and tubercles is smaller in *L. malevkensis*.
3. The distribution of the verrucate ornament in *L. malevkensis* is restricted to the more polar regions of the distal surface and is largely absent from the cingulum resulting in a smooth equatorial margin. In *L. rarituberculatus* some of the ornament projects at the equator.

### RANGE

Late Devonian to Mississippian; Strunian to Tournaisian; LN–PC biozones (Clayton et al., 1977)

	<p>Figure 32a</p> <p>Imperial Formation, Richardson Mountains, Northwest Territories, Canada; Late Devonian, Strunian, LL Biozone, Sample 159G, Specimen MPK <b>7459</b>.</p> <p>Specimen maximum dimension 51 µm</p>
	<p>Figure 32b</p> <p>Imperial Formation, Richardson Mountains, Northwest Territories, Canada; Late Devonian, Strunian, LL Biozone, Sample 159G, Specimen MPK <b>7463</b>.</p> <p>Specimen maximum dimension 49 µm</p>

## *Lycospora pusilla* (Ibrahim) Somers, 1972

### DESCRIPTION

Radial, trilete, cingulizone miospores. Amb circular to very broadly rounded triangular, outline smooth or finely indented. Trilete mark distinct, sutures simple or accompanied by low narrow flexuous exoexinal folds which extend decreasing in height to equatorial margin. Sutures extend to inner body margin. Intexine thin forming rounded triangular inner body. Exoexine thin, extended in the equatorial plane to form narrow bizonate cingulum consisting of a narrow, inner, darker zone which may in part overlap the equatorial margin of the inner body and a wider, thinner, outer zone. Total width of cingulum up to 4  $\mu\text{m}$ . Distal surface of exoexine and cingulum finely granulate or in some cases conate. Folding common.

### OTHER DESCRIPTIONS

Schopf, Wilson and Bentall, 1944, p. 54

Smith and Butterworth, 1967, pp. 251–252, pl. 20, figs. 10–12

Somers, 1972, pp. 66–70, pl. 1, figs. 5–33, pl. 2, figs. 3–20

### SIZE

Overall equatorial diameter 20(27)40  $\mu\text{m}$

### REMARKS

*Lycospora noctuina* Butterworth & Williams 1958, is distinguished from *L. pusilla* by the presence of rugulae or verrucae on the distal surface. *L. orbicula* (Potonié & Kremp) Smith & Butterworth 1967, differs in possessing a very narrow cingulum. (See Somers, 1972, for detailed appraisal of *L. pusilla* and its relationships to other members of the genus.)

### RANGE

Mississippian to ?Permian; Visean to ?Asselian; Pu to *Granulatisporites confluens* biozones (various sources)

	<p>Figure 33a</p> <p>Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [uppermost Langsettian], RA Biozone, Sample ASB, Specimen MPK <b>7631</b>. Rounded triangular cingulate miospore. Trilete mark distinct, sutures obscured by low elevated ridges or folds that extend to equatorial margin. Cingulum narrow, bizonate. Inner thicker zone of cingulum narrow and probably overlapping inner body margin on distal surface. Outer thinner zone slightly wider than inner thicker zone.</p> <p>Specimen maximum dimension 39 <math>\mu\text{m}</math></p>
	<p>Figure 33b</p> <p>Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [uppermost Langsettian], RA Biozone, Sample ASB, Specimen MPK <b>7633</b>.</p> <p>Specimen maximum dimension 40 <math>\mu\text{m}</math></p>

## *Monilospora moniloformis* Hacquebard & Barss, 1957

### DESCRIPTION

Radial, trilete, cingulizone miospores. Amb subcircular to rounded triangular, with straight to slightly concave or convex sides and rounded apices. Trilete mark distinct, sutures simple, straight; extending from two-thirds to almost the full body radius, frequently open. Intexine thin, laevigate, forming inner body. Exoexine normally closely adpressed to intexine, although minor separation may occur in the equatorial plane. Exoexine extended in the equatorial plane to form trizonate differentiated cingulum consisting of a broad, thickened inner zone of uniform thickness with a sharp outer margin, a thinner median zone which is commonly narrow, and a distinctive crenulate, outer, thickened zone which varies considerably in form and intensity of crenulation. Surface of exoexine laevigate.

### OTHER DESCRIPTIONS

Hacquebard and Barss, 1957, p. 38, pl. 5, figs. 8, 9

### SIZE

Overall equatorial diameter 58–86  $\mu\text{m}$

### RANGE

Mississippian, late Visean, [Asbian] NM Biozone (unpublished information)

	<p>Figure 34a</p> <p>Mattson Formation, south face Twisted Mountain, north-west of South Nahanni, Northwest Territories, Canada; Visean, MA Biozone (Playford, 1962), Sample MATT, Specimen MPK 7231. Proximal focus showing simple trilete sutures extending to margin of inner body. Note evidence of minor separation of intexine from exoexine in equatorial region adjacent to spore body margin.</p> <p>Specimen maximum dimension 62 <math>\mu\text{m}</math></p>
	<p>Figure 34b</p> <p>Mattson Formation, south face Twisted Mountain, north-west of South Nahanni, Northwest Territories, Canada; Visean, MA Biozone (Playford, 1962), Sample MATT, Specimen MPK 7244. Note coarse nature of segments in outer crenulate zone of cingulum.</p> <p>Specimen maximum dimension 67 <math>\mu\text{m}</math></p>

## ***Murospora parthenopia* Neves & Ioannides, 1974**

### DESCRIPTION

Radial, trilete, cingulate miospores. Amb rounded triangular with concave, rarely straight sides, and variably rounded apices. Spore body rounded triangular with concave sides and rounded apices. Trilete mark distinct, sutures simple, straight, sometimes open, extending to equatorial margin of spore body. Exoexine extended in the equatorial plane to produce equatorial cingulum of variable width, expanded in the apical regions to form thickened valvae, 3–15 µm high and 9–20 µm wide. Inner margin of thickening may transgress onto the spore body on the distal surface; outer margin smooth or indented owing to minor fluting. Inter-radially, cingulum is variable in form, sometimes the same width as valvae but not thickened; or alternatively narrow to almost absent. Distal surface of spore body may develop rudimentary thickened kyrtome-like structures. Exine laevigate.

### OTHER DESCRIPTIONS

Neves and Ioannides, 1974, pp. 77–78, pl. 6, figs. 14–15

### SIZE

Overall equatorial diameter 26(34)50 µm

### REMARKS

Neves and Ioannides (1974) considered this species to be synonymous with specimens recorded as *Triquitrites coesfeldens* by Bharadwaj and Venkatachala (1961).

### RANGE

Mississippian; late Viséan; NM Biozone (DP to ME sub-biozones) (Clayton et al., 1978)

	<p>Figure 35a</p> <p>Shales below Cove Lower Marine Band, Cove Harbour, Berwickshire, Scotland; Viséan, NM Biozone, Sample MPA 18247, Specimen MPK <b>7166</b>. Proximal focus showing well-defined inner body with slightly concave or convex sides and rounded apices. Trilete mark simple, sutures extending to body margin. Cingulum of variable width but expanded in apical region to form valvae-like structures.</p> <p>Specimen maximum dimension 42 µm.</p>
	<p>Figure 35b</p> <p>Shales below Cove Lower Marine Band, Cove Harbour, Berwickshire, Scotland; Viséan, NM Biozone, Sample MPA 18247, Specimen MPK <b>7177</b>. Abnormal variant with thick, uniformly wide cingulum but also showing tendency for extra thickening and incipient valvae development in radial positions.</p> <p>Specimen maximum dimension 47 µm</p>

## *Radiizonates aligerens* (Knox) Staplin & Jansonius, 1964

### DESCRIPTION

Radial, trilete, cingulizionate miospores. Amb rounded triangular to subcircular. Trilete mark indistinct, sutures when seen, simple, straight or flexuous, extending to, or almost to, inner body margin. Intexine thin, laevigate, forming poorly defined inner body that may show evidence of minor separation from the exoexine in the equatorial plane. Exoexine extended in the equatorial plane to form weakly bizonate cingulum consisting of a narrow darker inner zone which appears to overlap the equatorial margin of the inner body, particularly over the distal surface, and a wider thinner outer zone. Outer zone of cingulum bears a variable number of radially orientated elongate vacuoles that appear to be independently developed at two levels, presumably underlying both proximal and distal surfaces. Exoexine surface also bears numerous radially orientated striations and plications, which extend to the equatorial margin. Vacuoles separated by narrow walls. Distal polar exoexine may bear scattered grana or small verrucae.

### OTHER DESCRIPTIONS

Knox, 1950, p. 329, pl. 19, fig. 288

Staplin and Jansonius, 1964, p. 106, pl. 18, figs. 23–28

Smith and Butterworth, 1967, p. 263, pl. 21, figs. 9–11

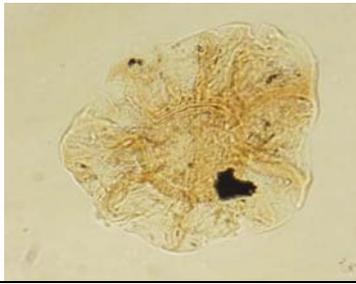
### SIZE

Overall equatorial diameter 47(60)85  $\mu\text{m}$

Width of cingulum 14(19)27  $\mu\text{m}$

### RANGE

Pennsylvanian; Bashkirian [Langsettian]; RA Biozone (Clayton et al., 1977)

	<p>Figure 36a</p> <p>Coal below Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [late Langsettian], RA Biozone, Sample A17, Specimen MPK <b>6989</b>. Subcircular cingulizionate miospores. Inner body small, less than half spore radius, trilete mark obscure. Cingulum weakly bizonate, consisting of narrow darker inner zone that appears to overlap the inner body, particularly over the distal surface and a wide thin outer zone. Outer zone bears a variable number of radially orientated striations that, in part, appear to be independently developed on both proximal and distal surfaces. Striations and plications extend to equatorial margin.</p> <p>Specimen maximum dimension 70 <math>\mu\text{m}</math></p>
	<p>Figure 36b</p> <p>Coal below Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [late Langsettian], RA Biozone, Sample A17, Specimen MPK <b>6993</b>. Note narrow row of pits at margin of the inner body suggesting that limited separation takes place in the equatorial region between intexine and exoexine.</p> <p>Specimen maximum dimension 85 <math>\mu\text{m}</math></p>

***Raistrickia clavata* Hacquebard 1957 emend. Playford, 1964**

DESCRIPTION

Radial, trilete, acamerate miospores. Amb rounded to convexly triangular. Trilete mark distinct or obscured by ornamentation; sutures simple, straight, extending up to three-quarters of spore radius. Exine 2–3  $\mu\text{m}$  thick and ornamented with conspicuous discrete, short, club-shaped, baculate processes. Elements 5–10  $\mu\text{m}$  high, 2–4  $\mu\text{m}$  in basal diameter with slightly tapering shafts before expanding into a bulbous or flattened termination 3–7  $\mu\text{m}$  in width. Ornament predominantly developed on distal surface with minor elements on more equatorial portion of proximal surface.

OTHER DESCRIPTIONS

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

Playford, 1964, pp. 24–25, pl. 6, figs. 5–10

Higgs, Clayton and Keegan, 1988, p. 56, pl. 4, fig. 13

SIZE

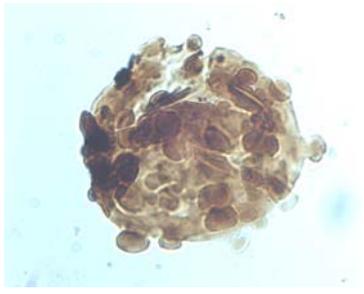
Overall equatorial diameter 55(62)94  $\mu\text{m}$

REMARKS

*Raistrickia ponderosa* Playford 1964 is distinguished from *R. clavata* by being larger and possessing a thicker, more uniformly sculptured exine and a more constantly circular outline. *R. strumosa* Playford 1976 possesses a similar style of ornamentation but may differ in possessing more densely distributed processes and by having a thicker exine.

RANGE

Mississippian; Tournaisian; PC to CM biozones (Higgs et al., 1988)

	<p>Figure 37a</p> <p>Horton Bluff Formation, Horton Bluff, Nova Scotia, Canada; Tournaisian, VV Biozone, AD Sub-biozone (Utting et al., 1989), Sample P6400, Specimen MPK <b>7392</b>. Subcircular specimen split open along line of trilete suture. Distal surface and equatorial portion of proximal exine ornamented with distinctive baculate elements. Elements typically consist of broad base, tapering short shaft and expanded round-topped bulbous termination.</p> <p>Specimen maximum dimension 66 <math>\mu\text{m}</math></p>
	<p>Figure 37b</p> <p>Horton Bluff Formation, Horton Bluff, Nova Scotia, Canada; Tournaisian, VV Biozone, AD Sub-biozone (Utting et al., 1989), Sample P6400, Specimen MPK <b>7393</b>. Trilete sutures obscured by ornamentation.</p> <p>Specimen maximum dimension 71 <math>\mu\text{m}</math></p>

## *Raistrickia condylosa* Higgs, 1975

### DESCRIPTION

Radial, trilete, acamerate, miospores. Amb circular-subcircular. Trilete mark distinct or obscured by ornament, sutures simple, straight, extending between half and two-thirds spore radius. Exine 1–3  $\mu\text{m}$  thick, bearing prominent baculose ornament, which may be densely or sparsely distributed but reduced on the proximal surface. Elements with slender shaft, long, parallel sided, slightly curved; surmounted by rounded or more commonly bulbous termination. Pointed elements rare. Bases of individual elements normally discrete but may fuse laterally to form low ridges 1–3  $\mu\text{m}$  in height. Elements 5–30  $\mu\text{m}$  long, 1–4  $\mu\text{m}$  in width, bases 3–7  $\mu\text{m}$  in diameter and bulbous terminations up to 6  $\mu\text{m}$  wide.

### OTHER DESCRIPTIONS

Higgs, 1975, p. 396, pl. 2, figs. 15–16

Higgs, Clayton and Keegan, 1988, p. 56, pl. 4, figs. 15–16

### SIZE

Equatorial diameter excluding projecting ornament 66(87)120  $\mu\text{m}$

### REMARKS

*Raistrickia strumosa* Playford 1976 has a similar style of ornament to *R. condylosa* but its elements are more robust and more densely distributed. *Acanthotriletes halei* Varma 1969 appears superficially similar but may be distinguished by possessing longer sutures and pointed ornamentation elements.

### RANGE

Mississippian; Tournaisian; PC to CM biozones (unpublished information)

	<p>Figure 38a</p> <p>Cementstone Group, Bracken Bay, Heads of Ayr, Ayrshire, Scotland; Tournaisian, CM Biozone, Sample MPA 29832, Specimen MPK <b>7415</b>. Subcircular trilete miospore, sutures obscured by dense baculate ornament. Bacula long slender with broad bases that are often confluent with adjacent elements. Terminations of bacula rounded or expanded and bulbous.</p> <p>Specimen maximum dimension 70 <math>\mu\text{m}</math></p>
	<p>Figure 38b</p> <p>Pinsky Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Tournaisian, CM Biozone, Sample MPA 292, Specimen MPK <b>7416</b>. Oblique compression showing absence of baculate ornament from contact areas. Baculate elements densely distributed, particularly in the equatorial region. Individual elements long, slender, sometimes bent with rounded or bulbous terminations.</p> <p>Specimen maximum dimension 73 <math>\mu\text{m}</math></p>

## ***Raistrickia corynoges* Sullivan, 1968**

### DESCRIPTION

Radial, trilete, acamerate miospores. Amb subcircular. Trilete mark distinct to obscured, sutures simple or with narrow thickened labra, extending at least three-quarters of spore radius. Exine 2–3  $\mu\text{m}$  thick bearing dense ornament of prominent bacula. Bases of individual elements wide and sometimes coalescent. Shafts are commonly parallel sided, but may taper slightly, sometimes with terminal constrictions. Terminations truncated, rounded or pointed, rarely weakly multifurcate. Length of elements 8–26  $\mu\text{m}$ , width 2–7  $\mu\text{m}$ .

### OTHER DESCRIPTIONS

Sullivan, 1968, p. 119–120, pl. 25, figs. 6–8

Higgs, Clayton and Keegan, 1988, p. 58, pl. 4, fig. 11

### SIZE

Equatorial diameter excluding projecting ornament 60(73)95  $\mu\text{m}$

### REMARKS

*Raistrickia variabilis* Neves & Dolby 1970 differs by possessing more robust, more densely distributed bacula that are often fused at their bases. *R. macrura* (Luber) Dolby & Neves 1970 is distinguished by possessing bacula which are smaller and more tapered in profile.

### RANGE

Mississippian; Tournaisian; VI to CM biozones (Higgs et al., 1988)

	<p>Figure 39a</p> <p>Pinsky Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Tournaisian, CM Biozone, Sample MPA 292, Specimen MPK <b>7374</b>. Subcircular trilete spore. Trilete suture obscured by ornamentation. Exine relatively thick, bearing dense baculate ornament on entire distal surface and equatorial portion of proximal surface. Bacula variable in form but most are broad based, parallel-sided, slender shafts with rounded or multifurcate terminations.</p> <p>Specimen maximum dimension 73 <math>\mu\text{m}</math></p>
	<p>Figure 39b</p> <p>Cementstone Group, Bracken Bay, Heads of Ayr, Ayrshire, Scotland; Tournaisian, CM Biozone, Sample MPA 29832, Specimen MPK <b>7376</b>. Note densely distributed baculate ornament that is variable in character.</p> <p>Specimen maximum dimension 77 <math>\mu\text{m}</math></p>

## *Raistrickia fulva* Artüz, 1957

### DESCRIPTION

Radial, trilete, acamerate miospores. Amb rounded triangular. Trilete mark distinct, sutures simple, straight, extending two-thirds to three-quarters of spore radius. Distal surface and equatorial portion of proximal surface of exine bears predominantly baculate ornament with infrequent coni and verrucae. Baculae rarely exceed 3 µm in height, basal diameter exceptionally up to 10 µm but commonly less, terminations truncate or apiculate. Density of ornament variable with 15–20 processes commonly protruding at the equator. Exine between processes laevigate; up to 5 µm thick.

### OTHER DESCRIPTIONS

Artüz, 1957, p. 246, pl. 3, fig. 19

Smith and Butterworth, 1967, pp.180–181, pl. 8, figs. 17–20

### SIZE

Overall equatorial diameter 39(52)69 µm

### REMARKS

*Raistrickia irregularis* Kosanke 1950 is larger. No other species assigned to the genus *Raistrickia* has such low, broad-based baculae.

### RANGE

Pennsylvanian; Bashkirian [Kinderscoutian to Duckmantian]; KV to NJ biozones (Clayton et al., 1977)

	<p>Figure 40a</p> <p>BGS Offshore Borehole 74/13, 18.07 m, Firth of Forth, Scotland; Bashkirian [Duckmantian], NJ Biozone, Sample CSA 1231, Specimen MPK <b>7380</b>. Rounded triangular miospore with densely distributed ornament of broad-based low bacula with tapering sides and rounded or multifurcate terminations. Remainder of exine laevigate.</p> <p>Specimen maximum dimension 57 µm</p>
	<p>Figure 40b</p> <p>BGS Offshore Borehole 74/13, 18.07 m, Firth of Forth, Scotland; Bashkirian [Duckmantian], NJ Biozone, Sample CSA 1231, Specimen MPK <b>7382</b>. Specimen with simple, straight, trilete sutures extending at least three-quarters of spore radius. Larger of the broad-based baculate ornament elements appear to be located at the equatorial margin; elements over remainder of distal surface appear smaller and organised in sub-concentric manner.</p> <p>Specimen maximum dimension 69 µm</p>

## ***Reinschospora speciosa* (Loose) Schopf, Wilson & Bentall, 1944**

### DESCRIPTION

Radial, trilete, miospores. Amb including corona rounded triangular to circular. Outline of spore body triangular with rounded apices and concave sides. Trilete mark distinct, sutures simple or with weak narrow low labra; straight, extending almost to equatorial margin. Well-developed corona composed of setae up to 1  $\mu\text{m}$  wide and more or less in full lateral contact throughout their length. Corona attached to exine just proximally of the equatorial margin. Maximum width of corona, including overlap on proximal side, 17–28  $\mu\text{m}$ ; occurs in the inter-radial position. In the radial positions the corona may be as narrow as 2  $\mu\text{m}$  and may be attached nearer to the proximal pole so that on compression it may appear to cross the angles of the spore body. Exine moderately thick, laevigate to scabrate, folding rare.

### OTHER DESCRIPTIONS

Schopf, Wilson and Bentall, 1944, p. 53, fig. 2

Smith and Butterworth, 1967, pp. 211–212, pl. 13, figs. 13–14

### SIZE

Equatorial diameter of spore body 50(58)95  $\mu\text{m}$

### REMARKS

*Reinschospora triangularis* Kosanke 1950 is distinguished from *R. speciosa* in possessing straight sides, labra, and setae which are discrete and commonly partate. *R. magnifica* Kosanke 1950, differs by having broader angles to the spore body and a corona composed of discrete elements.

### RANGE

Pennsylvanian; Bashkirian to Moscovian [Kinderscoutian to Bolsovian] (Smith and Butterworth, 1967, and unpublished information)

	<p>Figure 41a</p> <p>Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [uppermost Langsettian], RA Biozone, Sample ASB, Specimen MPK <b>7433</b>. Strongly concave triangular spore body with well-developed trilete mark, sutures accompanied by low, narrow, thickened labra extending to equator. Exine relatively thick. Corona composed of densely arranged setae, longest in inter-radial region. Corona attached to equatorial portion of proximal surface.</p> <p>Specimen maximum dimension 94 <math>\mu\text{m}</math></p>
	<p>Figure 41b</p> <p>Passage Group, Diddup Borehole, 7.20 m, Scotland; Bashkirian [earliest Langsettian], SS Biozone, Sample MPA 4578, Specimen MPK <b>7435</b></p> <p>Specimen maximum dimension 52 <math>\mu\text{m}</math></p>

## ***Remysporites magnificus* (Horst) Butterworth & Williams, 1958**

### DESCRIPTION

Radial trilete camerate miospores. Amb ovoid to circular. Margin smooth to minutely undulating. Trilete mark distinct or obscured by elevated exoexinal folds which extend, decreasing in height, to equatorial margin. Sutures, when seen, extend almost to inner body margin. Intexine relatively thick, laevigate, with independent compression folds indicating complete separation from exoexine over most of its surface. Exoexine thin, forms highly folded exoexinal body; surface laevigate to microreticulate. Exoexine of contact areas may develop fine vermiculate ornament.

### OTHER DESCRIPTIONS

Horst, 1955, p. 194, pl. 21, fig. 37

Butterworth and Williams, 1958, p. 386, pl. 4, figs. 7–9

Smith and Butterworth, 1967, p. 278, pl. 33, fig. 8

### SIZE

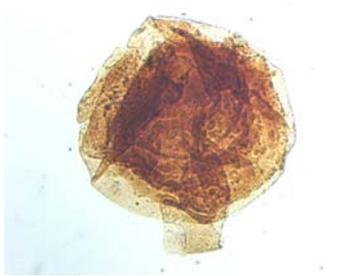
Overall equatorial diameter 84–255  $\mu\text{m}$

### REMARKS

Smith and Butterworth (1967) considered that *Remysporites albertensis* Staplin 1960 is synonymous with the present species.

### RANGE

Mississippian; late Visean to Serpukhovian [Asbian to Arnsbergian] (Smith and Butterworth, 1967, and unpublished information)

	<p>Figure 42a</p> <p>Holme Wood Coal, River Belah, Stainmore, Cumbria, England; Serpukhovian [Arnsbergian], TK Biozone, Sample RB 120, Specimen MPK <b>7511</b>. Camerate miospore with smooth subcircular equatorial outline. Inner body well defined but partly obscured by folding. ‘Saccus’ thin, extensively folded, surface smooth to microreticulate. Trilete suture accompanied by exoexinal folds obscured by folding.</p> <p>Specimen maximum dimension 156 <math>\mu\text{m}</math></p>
	<p>Figure 42b</p> <p>Holme Wood Coal, River Belah, Stainmore, Cumbria, England; Serpukhovian [Arnsbergian], TK Biozone, Sample RB 120, Specimen MPK <b>7513</b>. Well-defined inner body and more or less laevigate exoexine. Trilete sutures obscure, possibly as a result of being split open.</p> <p>Specimen maximum dimension 136 <math>\mu\text{m}</math></p>

## ***Reticulatisporites carnosus* (Knox) Neves, 1964**

### DESCRIPTION

Radial, trilete, cingulate miospores. Amb broadly rounded triangular to subcircular, margin usually smooth, but occasionally undulate to uneven or highly involute. Trilete mark distinct, sutures straight, simple or with low narrow labra, extending to inner margin of the cingulum. Intexine relatively thin forming subcircular to rounded triangular inner body. Exoexine extended equatorially to form differentially thickened cingulum consisting of three zones, each varying from 5 to 17  $\mu\text{m}$  in width. The inner thickened zone is broader and more prominent than the outer marginal thickened zone, which is commonly reduced or discontinuous. The thinner median zone may be reduced to a mere line but in other specimens may be of significant width. Radially orientated thickenings may be present on the distal surface and take the form of a Y-shaped structure attached to the cingulum in the inter-radial positions. Faint proximal thickenings may arise from the radial positions but they scarcely extend poleward beyond the inner thickened zone of the cingulum.

### OTHER DESCRIPTIONS

Knox, 1950, p. 329, pl. 19, fig. 290

Smith and Butterworth, 1967, pp. 220–221, pl. 14, figs. 11–12

### SIZE

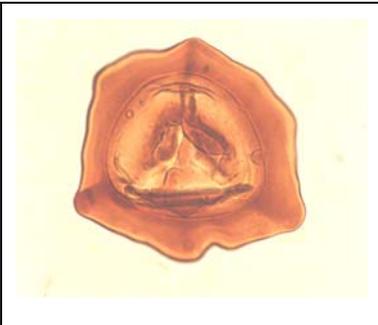
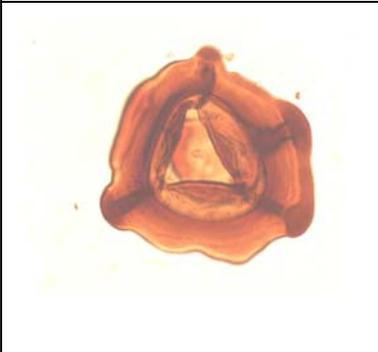
Overall equatorial diameter 67(84)90  $\mu\text{m}$

### REMARKS

Distinguished from other species assigned to the genus by the absence of any elaborate pattern of distal thickenings. In some specimens assigned to this species a distal pattern of thickenings comparable to those in *Reticulatisporites polygonalis* (Ibrahim) Neves 1964 may occur, in which case *R. carnosus* is distinguished by the discontinuous nature of the outermost thickened zone of its cingulum.

### RANGE

Mississippian to Pennsylvanian; late Visean to Bashkirian [early Langsettian]; NC to SS biozones (Clayton et al., 1977; Smith and Butterworth, 1967)

	<p>Figure 43a</p> <p>Diddup Borehole, 7.20 m, Scotland; Bashkirian [early Langsettian], SS Biozone, Sample MPA 4597, Specimen MPK <b>7019</b>. Equatorial focus of specimen with polygonal equatorial outline but rounded triangular-subcircular inner body. Trilete mark distinct, open, sutures extend to outer margin of inner body. Cingulum thick and weakly trizonate. Minor thickenings developed on proximal surface of cingulum extending from equatorial margin to ends of trilete rays.</p> <p>Specimen maximum dimension 72 <math>\mu\text{m}</math></p>
	<p>Figure 43b</p> <p>Diddup Borehole, 7.20 m, Scotland; Bashkirian [early Langsettian], SS Biozone, Sample MPA 4579, Specimen MPK <b>7024</b>. Trilete mark open but with sutures which appear to extend to equatorial margin of body. Well-developed differentially thickened cingulum with relatively wide thickened inner zone, narrow thinner median zone and discontinuously developed thicker outer zone. Radial thickenings well developed on proximal surface, extending from equatorial margin to join up with ends of trilete rays.</p> <p>Specimen maximum dimension 82 <math>\mu\text{m}</math></p>

## ***Retispora lepidophyta* (Kedo) Playford, 1976**

### DESCRIPTION

Radial, trilete, camerate miospores. Amb convexly rounded triangular to subcircular. Trilete mark distinct; sutures straight or slightly curved, extending to margin of the inner body, accompanied by elevated flexuous folds of the exoexine which extend decreasing in height to almost the equatorial margin of the spore. Ends of exoexinal folds fuse laterally with *curvaturae imperfectae*, which are slightly invaginated in the radial position but are coincident with the equatorial margin for much of their length. Intexine thin; forms subcircular to rounded triangular inner body which occupies half to three-quarters of the spore diameter. Sometimes eccentrically placed, suggesting proximal attachment only. Exoexine ornamented with distal reticulum consisting of subcircular, polygonal or irregularly shaped lumina separated by narrow muri. Muri 0.5–2 µm wide; bear an ornament of small conical spines up to 2 µm high. Muri commonly exhibit progressive breakdown to form short rugulae or eventually residual conical spines and verrucae. Lumina up to 4 µm in diameter, variable in shape and size even on same specimen. Narrow limb may be present at the equatorial margin, which may in part coincide with *curvaturae imperfectae*. Apical papillae sometimes present. Compressional folds common.

### OTHER DESCRIPTIONS

Kedo, 1957, p. 24, pl. 2, figs. 19–21

Streel *in* Becker et al., 1974, p. 26

Playford, 1976, p. 45, pl. 10, figs. 1–15

Higgs, Clayton and Keegan, 1988, pp. 71–72, pl. 11, figs. 12–17

### SIZE

Overall equatorial diameter 40(57)92 µm

### REMARKS

The following taxa may be synonymous with *Retispora lepidophyta*: *Leiozonotriletes naumovae* Balme & Hassell 1962, *Endosporites lacunosus* Winslow 1962, *Archaeozonotriletes fenestratus* Caro-Moniez 1962 and *Hymenozonotriletes reticulatus* Caro-Moniez 1962.

### RANGE

Devonian; late Famennian to early Tournaisian; LL–LN biozones (Richardson and McGregor, 1986; Higgs et al., 1988)

	<p>Figure 44a</p> <p>Sample SB1, Bedford Shale, Big Walnut Creek, Sudbury, Ohio, USA; Late Devonian, Strunian, LL Biozone, Specimen MPK <b>7124</b>. Subcircular camerate spore, inner body conformable in shape with equatorial margin. Radius of body about two-thirds of spore radius. Distal surface of exoexine reticulate. Narrow muri enclosing subcircular, polygonal or irregular lumina. Muri ornamented with small conical spines.</p> <p>Specimen maximum dimension 77 µm</p>
	<p>Figure 44b</p> <p>Sample S133, Bedford Shale, Big Walnut Creek, Sudbury, Ohio, USA; Late Devonian, Strunian, LL Biozone, Specimen MPK <b>7126</b>. Distinctive reticulum on distal exoexine; muri enclose variably shaped lumina.</p> <p>Specimen maximum dimension 90 µm</p>

## ***Rotaspora fracta* Schemel, 1950**

### DESCRIPTION

Radial, trilete acamerate miospores. Amb circular, subcircular or rounded triangular, spore body triangular with slightly concave sides and rounded apices. Trilete mark distinct, sutures straight, simple or accompanied by low narrow labra, extending almost to spore body margin. Width of zona more or less constant, with narrow thickening at the periphery forming equatorial rim. In compressed specimens the zona lies over the distal surface of the body in the radial positions thereby appearing narrower than in the inter-radial areas. Exine of body and zona laevigate. Folding rare.

### OTHER DESCRIPTIONS

Schemel, 1950, p. 242, pl. 40, fig. 8

Smith and Butterworth, 1967, p. 227, pl. 15, figs. 8–11

### SIZE

Overall equatorial diameter 24–40  $\mu\text{m}$

Diameter of spore body 17–24  $\mu\text{m}$

### REMARKS

Distinguished from *Rotaspora knoxi* Butterworth and Williams 1958, by its slightly smaller size, thinner exine and spore body with concave sides.

### RANGE

Mississippian; late Viséan to Serpukhovian [Pendleian]; VF to NC biozones (Clayton et al., 1977, and unpublished information)

	<p>Figure 45a</p> <p>Lower Limestone Group, Drumlemble Borehole A, 3336 feet, Machrihanish, Argyll, Scotland; Viséan, NC Biozone, Sample MPA 33328, Specimen MPK <b>7569</b>. Distal focus. Spore body triangular, sides straight to slightly concave, apices sharply rounded. Trilete mark distinct, sutures straight, extending to body margin, accompanied by low narrow thickened labra. Evidence of zona being reduced in width at radial margins but folded onto distal surface. Exine of body and zona laevigate.</p> <p>Specimen maximum dimension 40 <math>\mu\text{m}</math></p>
	<p>Figure 45b</p> <p>Lower Limestone Group, Drumlemble Borehole A, 3336 feet, Machrihanish, Argyll, Scotland; Viséan, NC Biozone, Sample MPA 33328, Specimen MPK <b>7572</b>.</p> <p>Specimen maximum dimension 33 <math>\mu\text{m}</math></p>

## ***Rotaspora knoxi* Butterworth & Williams, 1958**

### DESCRIPTION

Radial, trilete, acamerate miospores. Amb subtriangular, with broadly rounded apices, to subcircular, outline of body more triangular. Trilete mark distinct; sutures straight, simple or with low narrow labra, extending between three-quarters and almost the full radius of the body. Exine laevigate. Zona widest (up to 6  $\mu\text{m}$ ) in the inter-radial position but significantly reduced at the apices. Zona normally bizonate with inner thicker zone of more or less uniform width, apparently overlapping margin of inner body at least on the distal surface. Outer thinner zone variable in width.

### OTHER DESCRIPTIONS

Butterworth and Williams, 1958, p. 378, pl. 3, figs. 21–23

Sullivan and Marshall, 1966, p. 272, pl. 2, figs. 16–17

Smith and Butterworth, 1967, p. 228, pl. 15, figs. 15–17

### SIZE

Overall equatorial diameter 26(32)44  $\mu\text{m}$

### REMARKS

*Rotaspora fracta* Schemel 1950, is distinguished by its smaller size, its concavely triangular spore body, its thinner exine and the tendency of its zona to be folded over the body in the radial positions.

### RANGE

Mississippian; late Visean to Serpukhovian [Arnsbergian]; VF to TK biozones (Clayton et al., 1977).

	<p>Figure 46a</p> <p>Coal above Lower Stonesdale Limestone, Coldkeld Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian (<math>E_1</math>)], NC Biozone. Sample YC, Specimen MPK <b>7802</b>. Specimen with well-defined bizonate zona that is widest in the inter-radial region and reduced to almost absent in the radial positions. Trilete sutures extend almost to equatorial margin. Rays simple with triangular darkened region at the proximal pole.</p> <p>Specimen maximum dimension 30 <math>\mu\text{m}</math></p>
	<p>Figure 46b</p> <p>Coal above Lower Stonesdale Limestone, Coldkeld Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian (<math>E_1</math>)], NC Biozone. Sample CB2 1, Specimen MPK <b>7805</b>.</p> <p>Specimen maximum dimension 30 <math>\mu\text{m}</math></p>

## *Schopfites claviger* Sullivan, 1968

### DESCRIPTION

Radial, trilete, acamerate or camerate miospores. Amb subcircular or circular. Trilete mark distinct or indistinct, sutures simple, straight, extending almost to the equatorial margin. Intexine thin (1–1.5 µm), indistinctly separated from the exoexine to form indistinct inner body occupying approximately three-quarters of spore diameter. Distal surface and equatorial region of exoexine ornamented with pila, rounded bacula and rare verrucae and coni. Elements 1–5 µm high and 1–3 µm in width (Higgs et al., 1988, quoted mean height and width as 3 µm and 1 µm respectively). Elements are normally discrete, although the density and distribution of the ornament is variable, giving rise to a patchy appearance on individual specimens. Proximal surface of exoexine laevigate. Exine thickness 1–2 µm.

### OTHER DESCRIPTIONS

Sullivan, 1968, p. 121, pl. 25, figs. 9–10

Higgs, Clayton and Keegan, 1988, pp. 59–60, pl. 5, figs. 6–8 and 13

### SIZE

Overall equatorial diameter 40(55)68 µm

### REMARKS

Although complete morphological intergradation is thought to exist between *Schopfites claviger* and *S. delicatus* Higgs 1975, the latter species is distinguished by possessing an ornament of finer sculptural elements that does not include rare coni and verrucae.

### RANGE

Mississippian; late Tournaisian to early Viséan; CM–Pu biozones (Higgs et al., 1988).

	<p>Figure 47a</p> <p>Mattson Formation, south face of Twisted Mountain, north-west of South Nahanni, Northwest Territories, Canada; Viséan, MA Biozone (Playford, 1962), Sample MATT, Specimen MPK <b>7782</b>. Distal/median focus showing distribution of pila over distal surface.</p> <p>Specimen maximum dimension 41 µm</p>
	<p>Figure 47b</p> <p>Cementstone Group, Bracken Bay, Heads of Ayr, Ayrshire, Scotland; late Tournaisian, CM Biozone, Sample MPA 29832, Specimen MPK <b>7783</b>. Specimen showing coarse pila and rare coni.</p> <p>Specimen maximum dimension 51 µm</p>

## *Schulzospora campyloptera* (Waltz) Hoffmeister, Staplin & Malloy, 1955

### DESCRIPTION

Radial, trilete, camerate miospores with a bilaterally symmetrical appearance due to the presence of an elliptical saccus-like exoexinal structure. Amb oval but occasionally sub-circular. Trilete mark distinct to indistinct; sutures straight, extending up to two-thirds of spore body radius, sutures often of unequal length on individual specimens. Intexine forms circular to oval inner body; long axis of inner body rarely orientated obliquely to the long axis of the miospore. Exoexine infrapunctate with a narrow dark zone often occurring where the saccus overlies the equatorial margin of the spore body. Radial compression folds infrequently developed.

### OTHER DESCRIPTIONS

Sullivan and Marshall, 1966, pp. 274–275, pl. 3, figs. 13–14

Smith and Butterworth, 1967, pp. 274–275, pl. 23, fig. 1

### SIZE

Long axis dimension 76(94)114  $\mu\text{m}$

Diameter of inner body 46(54)70  $\mu\text{m}$

### REMARKS

*Schulzospora rara* Kosanke 1950 is distinguished from *S. campyloptera* by its more rounded equatorial outline and its proportionately larger spore body. The long axis of the inner body of *S. campyloptera* is not normally orientated obliquely to the long axis of the miospore, a characteristic which is typical of *S. ocellata* (Horst) Potonié & Kremp 1956. Intermediate forms may occur but it is not known if these represent morphological intergradations or are the result of compressional effects.

### RANGE

Mississippian; Visean to Serpukhovian [Arnsbergian]; TC to SO biozones (Clayton et al. 1977, and Varker et al., 1990)

	<p>Figure 48a</p> <p>Shales below Hurler Limestone, Hurler Borehole, 181.35 m, Strathclyde, Scotland; Visean, VF Biozone, Sample MPA 9165, Specimen MPK 7137. Equatorial outline ovoid but long axis of ovoid inner body at right angles to long axis of miospore. Trilete mark distinct, sutures simple, straight; extending up to two-thirds of inner body radius. Note darkened zone where exoexine overlaps inner body.</p> <p>Specimen maximum dimension 89 <math>\mu\text{m}</math></p>
	<p>Figure 48b</p> <p>Shales below Hurler Limestone, Hurler Borehole, 181.35 m, Strathclyde, Scotland; Visean, VF Biozone, Sample MPA 9165, Specimen MPK 7145.</p> <p>Specimen maximum dimension 86 <math>\mu\text{m}</math></p>

## *Schulzospora ocellata* (Horst) Potonié & Kremp, 1956

### DESCRIPTION

Radial, trilete, camerate miospores with a bilateral appearance due to the presence of an elliptical saccus-like exoexinal structure. Amb oval to subcircular, body oval to subcircular. Trilete mark distinct to indistinct; sutures simple, straight, extending between two-thirds and almost the full body radius. Exoexine infrapunctate with a narrow dark zone often occurring where the saccus overlies the equatorial margin of the spore body. Longest axis of the inner body usually oblique to the long axis of the miospore, rarely at right angles to it. Folding infrequent.

### OTHER DESCRIPTIONS

Horst, 1955, p. 195, pl. 21, figs. 40a and b

Smith and Butterworth, 1967, pp. 275–276, pl. 23, fig. 6

### SIZE

Overall equatorial diameter 61(90)130  $\mu\text{m}$

Diameter of inner body 56(66)77  $\mu\text{m}$

### REMARKS

Smith and Butterworth (1967) considered this to be the largest of the species of *Schulzospora*. The specimens illustrated here fall at the smaller end of the size range quoted by them. The characteristic used to distinguish the species is the obliquity of the inner body within the saccus-like exoexinal structure. Morphological intergradation, is however, known to occur with *Schulzospora campyloptera* (Waltz) Hoffmeister, Staplin & Malloy 1955. *Schulzospora rara* Kosanke 1950 has a rounder, less elongated overall outline than *Schulzospora ocellata*.

### RANGE

Mississippian; late Visean to Serpukhovian [Arnsbergian]; NC to SO biozones (unpublished information, and Varker et al., 1990)

	<p>Figure 49a</p> <p>Shales below Hurlet Limestone, Upper Sedimentary Group, Hurlet Borehole, 160.70 m; Visean, VF Biozone, Sample MPA 9162, Specimen MPK <b>7180</b>. Long axis of the body oblique to short axis of miospore overall. Trilete mark distinct; sutures simple, straight, extending approximately to half the body radius.</p> <p>Specimen maximum dimension 76 <math>\mu\text{m}</math></p>
	<p>Figure 49b</p> <p>Coal above Lower Stonesdale Limestone, Coldkeld Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian], NC Biozone, Sample CB21, Specimen MPK <b>7181</b>. Note marked obliquity of inner body within saccus-like exoexinal structure, and dark margin of inner body.</p> <p>Specimen maximum dimension 61 <math>\mu\text{m}</math></p>

## *Schulzospora rara* Kosanke, 1950

### DESCRIPTION

Radial, trilete, camerate miospores with a bilaterally symmetrical appearance due to presence elliptical saccus-like exoexinal structure. Amb oval to ovoid. Inner body circular to oval with long axis parallel to the long axis of the miospore overall. Trilete mark not always visible; sutures simple, straight extend to, or almost to, inner body margin. Two of the sutures are commonly orientated parallel or nearly parallel to the long axis of the miospore with the third suture at right angles to them. Intexine of inner body relatively thin, laevigate or finely infrapunctate; long axis of inner body approximately three-quarters of miospore long axis, short axis of inner body almost equal in width to the short axis of the miospore. Exoexine thicker than intexine, laevigate to finely infrapunctate.

### OTHER DESCRIPTIONS

Kosanke, 1950, p. 53–54, pl. 13, figs. 5–8

Smith and Butterworth, 1967, pp. 276–277, pl. 23, figs. 2–3

### SIZE

Overall equatorial diameter 52(77)105  $\mu\text{m}$

Diameter of inner body 40(59)80  $\mu\text{m}$

### REMARKS

*Schulzospora rara* is similar in size to *S. campyloptera* (Waltz) Hoffmeister, Staplin & Malloy 1955, but may be distinguished by its more rounded, less elliptical shape and the proportionately larger size of the spore body.

### RANGE

Mississippian to Pennsylvanian; Visean to Bashkirian [Langsettian] (Smith and Butterworth, 1967)

	<p>Figure 50a</p> <p>Throckley Borehole, 72–75 ft., Northumberland, England; Bashkirian [early Langsettian], RA Biozone, Sample Th 72–75, Specimen MPK <b>7276</b>. Subcircular inner body with short trilete sutures.</p> <p>Specimen maximum dimension 77 <math>\mu\text{m}</math></p>
	<p>Figure 50b</p> <p>Argill Shell Bed, Argill Beck, Stainmore, Cumbria, England; Bashkirian [uppermost Langsettian], RA Biozone, Sample ASB, Specimen MPK <b>7277</b>.</p> <p>Specimen maximum dimension 80 <math>\mu\text{m}</math></p>

## *Spelaeotriletes arenaceus* Neves & Owens, 1966

### DESCRIPTION

Radial, trilete, camerate miospores. Amb convexly triangular, or subcircular to oval when secondarily folded. Trilete mark distinct; sutures simple, straight, extending to equatorial margin of spore body, commonly accompanied by narrow elevated folds of the exoexine which extend, decreasing in height, almost to the equatorial margin of the spore, where they fuse into the invaginated narrow ridge of the curvaturae. Curvaturae coincident with equatorial margin over most of their length. Intexine thin, forms indistinct inner body. Exoexine thin, attached to exoexine, only in the region of the proximal surface, forms saccus-like structure. Exoexine surface infrapunctate, bears a composite ornament of small squat bacula, rounded and flat topped verrucae, pila, and pointed and truncated conic elements 1–2  $\mu\text{m}$  high and 1–2.5  $\mu\text{m}$  in basal diameter. Ornament variably distributed but mainly on distal surface with minor encroachment onto proximal surface in the radial positions. Elements normally discrete but occasionally showing basal fusion with adjacent elements to create short irregular ridges.

### OTHER DESCRIPTIONS

Neves and Owens, 1966, p. 345–346, pl. 2, figs. 1–3

### SIZE

Overall equatorial diameter 82–144  $\mu\text{m}$

Diameter of inner body 44–90  $\mu\text{m}$

### REMARKS

*Spelaeotriletes arenaceus* is distinguished from *S. triangulus* Neves & Owens 1961 and *S. balteatus* (Playford) Higgs 1975 by the fine character of the ornamentation of the exoexine. *S. balteatus* is also smaller.

### RANGE

Mississippian to Pennsylvanian; late Visean to Bashkirian [early Langsettian]; NM to SS biozones (Clayton et al., 1977)

	<p>Figure 51a</p> <p>Shales above Mousegill Marine Band, Crag House Gill, Stainmore, Cumbria, England; Bashkirian [Kinderscoutian], KV Biozone, Sample CHG 1, Specimen MPK <b>7147</b>. Rounded triangular camerate miospore. Intexine forms poorly defined rounded triangular inner body. Trilete mark distinct, sutures extend to margin of inner body, accompanied by elevated exoexinal folds that extend to equatorial margin where they fuse with invaginated equatorial thickening, which may represent curvaturae. Exoexine densely ornamented with small conic, grana and baculae, some of which show basal fusion between adjacent elements to form short irregular ridges.</p> <p>Specimen maximum dimension 122 <math>\mu\text{m}</math></p>
	<p>Figure 51b</p> <p>Shales below Hurllet Limestone, Hurllet Borehole, 37.50 m, Scotland; Visean, VF Biozone, Sample MPA 9147, Specimen MPK <b>7149</b>. Note evidence on uppermost trilete ray to indicate that exoexinal folds accompanying trilete sutures merge in the radial position with narrow curvatural ridge just inside the equatorial margin. Curvaturae extend laterally and become coincident with the limbate equatorial margin.</p> <p>Specimen maximum dimension 110 <math>\mu\text{m}</math></p>

## *Spelaotriletes balteatus* (Playford) Higgs, 1975

### DESCRIPTION

Radial, trilete, camerate miospores. Amb rounded triangular to subcircular. Trilete mark distinct to obscure; sutures, when seen, extend to margin of ill-defined inner body, straight and accompanied by narrow sinuous exoexinal folds which extend to or almost to equatorial margin. Ends of exoexinal folds fuse laterally with curvaturae which are more or less coincident with equatorial margin except in radial positions where minor invagination occurs. Intexine often barely perceptible; forms ill-defined inner body, which occupies approximately half miospore diameter with outline conformable with equatorial margin. Exoexine thicker than intexine. Proximal surface laevigate except at the radial margins. Distal surface densely and uniformly ornamented with small, wide-based spinae up to 3 µm in height together with infrequent coni and grana. Elements may be discrete or may be basally fused to form low rugulae or cristae. Equatorial margin of exoexine thickened due to presence of curvatural ridges.

### OTHER DESCRIPTIONS

Playford, 1962, p. 657, pl. 95, figs. 4–6

Sullivan, 1964, p. 376

Higgs, 1975, p. 400, pl. 6, fig. 10

Higgs, Clayton and Keegan, 1988, p. 73, pl. 13, figs. 1–3

### SIZE

Overall equatorial diameter 42–102 µm

Diameter of inner body 30–62 µm

### REMARKS

*Spelaotriletes obtusus* Higgs 1975 is similar but is distinguished by having a non-apiculate ornament. *Aratrisporites saharaensis* Loboziak, Clayton & Owens 1986 is smaller and, although possessing similar exoexinal ornamentation, is readily distinguished by its monolete suture.

### RANGE

Mississippian; Tournaisian; BP to CM biozones (Higgs et al., 1988). May extend into the Visean in the Rhadames Basin of Western Libya (Loboziak and Clayton, 1988).

	<p>Figure 52a</p> <p>Sample 9379, north-east Libya; Carboniferous, late Visean, SG Biozone, OA Sub biozone (Loboziak and Clayton, 1988), Specimen MPK 7117. Distal ornament mainly discrete coni, spini and baculae that project at equatorial margin.</p> <p>Specimen maximum dimension 67 µm</p>
	<p>Figure 52b</p> <p>Sample 9379, north-east Libya; Carboniferous, late Visean, SG Biozone, OA Sub biozone (Loboziak and Clayton, 1988), Specimen MPK 7123.</p> <p>Specimen maximum dimension 69 µm</p>

## *Spelaotriletes cabotii* Utting, Keppie & Giles, 1989

### DESCRIPTION

Radial, trilete, camerate miospores. Amb sub-triangular with rounded apices and convex to straight sides. Intexinal inner body poorly defined but when visible conformable in outline with equatorial margin. Inner body occupies 50–80 % of overall diameter. Trilete mark distinct; sutures straight, extending almost to margin of intexine, accompanied by elevated sinuous exoexinal folds up to 2 µm high which extend, decreasing in height to the equatorial margin. Curvaturae rarely visible. Exoexine up to 2 µm thick; infragranulate. Distal surface of exoexine ornamented with closely spaced verrucae with rounded outlines and rounded profiles (up to 5.5 µm in basal diameter, 1–2 µm high); individual verrucae usually surmounted by single small spina or conus (up to 1 µm high and 1 µm in basal diameter). Rare small conic, spinae and baculae may occur between verrucae. Verrucae may coalesce towards distal pole to form rugulae. Small conic, spini and baculae more common in equatorial region than in distal polar region.

### OTHER DESCRIPTIONS

Utting et al., 1989, p. 133, pl. 5.3, figs. 8–13 and 15

### SIZE

Overall 49(69)93 µm

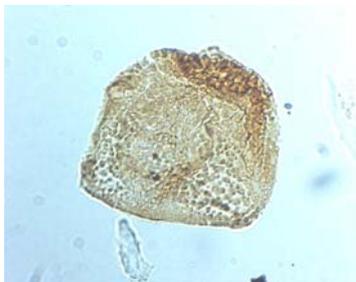
Inner body 36(46)65 µm

### REMARKS

Smaller and with more densely distributed ornament of verrucae than *Spelaotriletes pretiosus* (Playford) Neves & Belt 1970. In *S. pretiosus*, the verrucose ornament shows no tendency to form rugulae near the distal pole. *S. balteatus* differs in possessing an ornament of small simple spinae.

### RANGE

Mississippian; Tournaisian to ?Visean (Utting et al., 1989)

	<p>Figure 53a</p> <p>Horton Bluff Formation, Nova Scotia, Canada; Tournaisian, VV Biozone, SC Sub-biozone (Utting et al., 1989), Sample P2618, Specimen MPK <b>7738</b>. Equatorial focus showing outline of thin walled inner-body. Note apparent thickening at the equatorial margin, which may be a combination of exoexine wall thickness and feature coincident with narrow curvaturae imperfectae. Exoexine ornament variable, consisting of verrucae with smaller numbers of grana and conic.</p> <p>Specimen maximum dimension 70 µm</p>
	<p>Figure 53b</p> <p>Horton Bluff Formation, Nova Scotia, Canada; Tournaisian, VV Biozone, SC Sub-biozone (Utting et al., 1989), Sample P2618, Specimen MPK <b>7739</b>. Showing trilete rays extending to the equatorial margin of inner body. Thickening near equator not always coincident with equatorial margin, suggesting possible interpretation as curvaturae. Ornament dominated by fine conic and grana.</p> <p>Specimen maximum dimension 80 µm</p>

## *Spelaeotriletes giganteus* Loboziak & Clayton, 1988

### DESCRIPTION

Radial, trilete, camerate miospores. Amb convexly rounded triangular to almost circular. Trilete mark distinct; sutures straight, commonly accompanied by elevated folds which extend, decreasing in height, almost to the equatorial margin of the spore where they fuse with *curvaturae perfectae* which are invaginated in radial positions. Exine slightly thickened at the equatorial margin to form *limbus*. Exoexine scabrate to punctate; irregularly ornamented on the distal surface, at the equatorial margin and around the *curvaturae* with mixed rounded elements which are typically *grana* but may include sparse *verrucae*. Apiculate and biform elements are rare. Ornament reduced or absent in the contact areas. Intexine of inner body thin, laevigate; inner body rarely distinct, occupies one-third to one half of the spore diameter, attached to exoexine on proximal surface only.

### OTHER DESCRIPTIONS

Loboziak and Clayton, 1988, p. 131, pl. 23, figs. 1–5

### SIZE

Overall equatorial diameter 105(142)171  $\mu\text{m}$

### REMARKS

*Spelaeotriletes giganteus* is distinguished from all other representatives of the genus by its large size and fine irregular ornament.

### RANGE

Mississippian; Visean to Serpukhovian; SG to RT biozones (Loboziak and Clayton, 1988).

	<p>Figure 54a</p> <p>North-east Libya; Mississippian, early Visean, SG Biozone, PO Sub-biozone (Loboziak and Clayton, 1988), Sample 9396, Specimen MPK <b>7254</b>. Intexine indistinct, obscured by thicker exoexine. Exoexine surface scabrate and ornamented with <i>grana</i>, <i>coni</i> and widely spaced <i>verrucae</i>. Ornament projects at equatorial margin.</p> <p>Specimen maximum dimension 105 <math>\mu\text{m}</math></p>
	<p>Figure 54b</p> <p>North-east Libya; Mississippian, early Visean, SG Biozone, PO Sub-biozone (Loboziak and Clayton, 1988), Sample 9396, Specimen MPK <b>7255</b>. Anomalous specimen showing very coarse verrucose elements some of which tend towards <i>baculae</i> in form. Well-developed curvatural ridges ornamented with lines of discrete <i>verrucae</i>.</p> <p>Specimen maximum dimension 133 <math>\mu\text{m}</math></p>

## *Spelaeotriletes owensi* Loboziak & Alpern, 1978

### DESCRIPTION

Radial, trilete, camerate miospores. Amb rounded triangular to subcircular. Trilete mark distinct, sutures obscured by elevated sinuous folds of the exoexine which extend, decreasing in height, to the equatorial margin. Well-defined inner body formed by thin intexine; outline circular to subcircular. Equatorial margin of exoexine together with that part of the proximal surface which is invaginated opposite the ends of the trilete sutures, thickened to form equatorial border. Equatorial border and distal surface ornamented with fine vermiculate or reticulate ridges. Ridges surmounted by small spinae. Exoexine of contact areas laevigate.

### OTHER DESCRIPTIONS

Loboziak and Alpern, 1978, pp. 60–61, pl. 2, figs. 15–17

### SIZE

Equatorial diameter 60(77)109  $\mu\text{m}$

Diameter of inner body 32(46) 68  $\mu\text{m}$

### REMARKS

This species is readily distinguished from all other species assigned to the genus *Spelaeotriletes* on the basis of possessing a well-defined inner body, by having a thickened equatorial exoexinal border which extends onto the proximal surface in the radial positions, and by having a fine vermiculate/reticulate ornament.

### RANGE

Mississippian; Visean to early Serpukhovian (Loboziak and Clayton, 1988)

	<p>Figure 55a</p> <p>North-east Libya; Mississippian, late Visean, SG Biozone, OA Sub-Biozone (Loboziak and Clayton, 1988), Sample 6314, Specimen MPK 7245. Sub-circular camerate miospore with well-defined subcircular inner body. Trilete mark distinct and accompanied by elevated folds of exoexine which extend almost to the equatorial margin. Elevated folds accompanying trilete mark merge into the equatorial margin. Exoexine ornament finely reticulate to vermiculate. Muri surmounted by small conic.</p> <p>Specimen maximum dimension 82 <math>\mu\text{m}</math></p>
	<p>Figure 55b</p> <p>North-east Libya; Mississippian, late Visean, SG Biozone, OA Sub-Biozone (Loboziak and Clayton, 1988), Sample 6314, Specimen MPK 7248.</p> <p>Specimen maximum dimension 88 <math>\mu\text{m}</math></p>

## *Spinozonotriletes uncatu*s Hacquebard, 1957

### DESCRIPTION

Radial, trilete, camerate miospores. Amb convexly rounded triangular. Trilete mark distinct, sutures straight though often obscured; extend to margin of inner body, accompanied by elevated flexuous folds of exoexine which extend decreasing in height, to the equatorial margin. Intexine thin, forms inner body, which is conformable in outline with the amb of the spore and occupies approximately three-quarters of the total spore diameter. Exoexine 3–6  $\mu\text{m}$  thick, extended in the equatorial plane to form solid flange. Exoexine prominently ornamented with large spini which are concentrated in the equatorial region, commonly reduced in the distal polar region and completely absent from contact areas of proximal surface. Spini have broad, often bulbous bases and sharply pointed terminations; height 4–19  $\mu\text{m}$  and basal diameter 2–6  $\mu\text{m}$ . Spina size variable between specimens but uniform on any one specimen.

### OTHER DESCRIPTIONS

Hacquebard, 1957, p. 316, pl. 3, figs. 8–10

Playford, 1962, p. 657, pl. 94, figs. 4–6

Neves and Owens, 1966, pp. 355–356, pl. 3, figs. 2–3

### SIZE

Overall equatorial diameter excluding projecting ornament 74(104)150  $\mu\text{m}$

### REMARKS

*Spinozonotriletes conspicuus* Playford 1964, and *S. tenuispinosus* Hacquebard 1957, are both similar but lack the elevated, flexuous, sutural folds present in *S. uncatu*s.

### RANGE

Devonian to Mississippian; Tournaisian; LL to CM biozones (Higgs et al., 1988)

	<p>Figure 56a</p> <p>Pinskey Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Tournaisian, CM Biozone, Sample MPA 298, Specimen MPK <b>7449</b>. Proximal focus. Rounded triangular zonate miospore with convex sides and roundly pointed apices. Inner body subcircular. Exoexine extended equatorially to form undifferentiated flange. Entire distal and equatorial portions of proximal surface of exoexine ornamented with stout bulbous-based spinae. Elements sharply pointed and commonly curved. Elements more or less evenly distributed.</p> <p>Specimen maximum dimension 114 <math>\mu\text{m}</math></p>
	<p>Figure 56b</p> <p>Pinskey Gill Beds, Wygarth Gill Borehole, Ravenstonedale, Cumbria, England; Tournaisian, CM Biozone, Sample MPA 302, Specimen MPK <b>7450</b>. Proximal surface flattened, distal surface hemispherical. Note proximal apical structure formed by exoexinal folds accompanying trilete sutures. Spinose ornament more or less evenly distributed over entire distal surface.</p> <p>Specimen maximum dimension 120 <math>\mu\text{m}</math></p>

## ***Torispora securis* (Balme) Alpern, Doubinger & Horst, 1973**

### DESCRIPTION

Monolete miospores. Amb ovoid, subtriangular or irregular. Miospore consists of ovoid to subcircular spore body with a pronounced patinate crassitude either over the distal surface or the distal and lateral surfaces. Monolete mark usually distinct, suture straight or curved; simple; length approximately three-quarters or more of the spore body radius. Suture commonly parallel to the long axis of the spore. Intexine of spore body relatively thin, laevigate. Exoexine thickened over part of the distal surface or at least in part in the equatorial plane to form patinate crassitude which may in some cases overlap a significant part of the spore body on the proximal surface. Profile of crassitude in compressed specimens crescentic or sub-rectangular, surface smooth or finely roughened. Boundary between crassitude and spore body gradational or abrupt.

### OTHER DESCRIPTIONS

Balme, 1952, p. 183

Smith and Butterworth, 1967, pp. 293–294, pl. 24, figs. 31–34

### SIZE

Overall equatorial diameter 26(34)44  $\mu\text{m}$

Diameter of inner body 15(21)28  $\mu\text{m}$

### REMARKS

Smith and Butterworth (1967) did not differentiate *Torispora securis*, *T. granulata* Alpern 1959, *T. laevigata* Bharadwaj 1957 and *T. verrucosa* Alpern 1958.

### RANGE

Pennsylvanian; Moscovian to Gzhelian [Bolsovian to ?early Autunian]; SL to ?VC biozones (Clayton et al., 1977)

	<p>Figure 57a</p> <p>Radwood Borehole, 3008 ft., West Midlands, England; Moscovian [Bolsovian], SL Biozone, Sample C, Specimen MPK <b>7092</b>. Distal focus showing body protruding from patinate structure.</p> <p>Specimen maximum dimension 30 <math>\mu\text{m}</math></p>
	<p>Figure 57b</p> <p>Radwood Borehole, 3008 ft., West Midlands, England; Moscovian [Bolsovian], SL Biozone, Sample C, Specimen MPK <b>7093</b>.</p> <p>Specimen maximum dimension 27 <math>\mu\text{m}</math></p>

## *Tripartites trilinguis* (Horst) Smith & Butterworth, 1967

### DESCRIPTION

Radial trilete miospores. Amb triangular, sides highly concave, apices rounded, giving trifoliate appearance. Trilete mark distinct, sutures simple, straight; extending half to two-thirds of spore radius. Exine extended laterally in the equatorial plane to form prominent rounded plicated or corrugated auriculae in the radial positions. Thickness of auriculae up to 6  $\mu\text{m}$ , width 24–32  $\mu\text{m}$ . Inter-radial areas deeply incised, narrow, occupied by markedly reduced inter-radial crassitude. Proximal exine laevigate but distal exine bears small well-spaced grana on the radial apices in an arc-shaped pattern between the ends of the trilete sutures and the inner margin of the auriculae. Exine of spore body thin.

### OTHER DESCRIPTIONS

Horst, 1955, p. 176, pl. 23, figs. 55–56

Smith and Butterworth, 1967, pp. 208–209. p1. 13, figs. 6–9

### SIZE

Overall equatorial diameter 32(44)51  $\mu\text{m}$

### REMARKS

*Tripartites trilinguis* differs from *T. vetustus* in possessing more laterally expanded auriculae producing a markedly trifoliate appearance, and in possessing an arcuate distribution of grana between the ends of the trilete sutures and the inner margin of the auriculae. *T. trilinguis* also lacks the characteristic plications of the auriculae which characterise *T. vetustus*.

### RANGE

Mississippian; ?late Visean to early Serpukhovian [early Arnsbergian]; ?VF to TK biozones (Clayton et al., 1977, Owens et al., 1977)

	<p>Figure 58a</p> <p>Shales below Faraday House Sill, Argill Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian], NC Biozone, Sample LCS, Specimen MPK <b>7559</b>. Note auriculae wrapped around radial apices and extending significant distance into inter-radial areas. Inter-radial areas concave with narrow crassitudes connecting the auriculae.</p> <p>Specimen maximum dimension 51 <math>\mu\text{m}</math></p>
	<p>Figure 58b</p> <p>Shales above Faraday House Sill, Argill Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian], NC Biozone, Sample MPA 31161, Specimen MPK <b>7566</b>. Note auriculae wrapped around radial apices and extending significant distance into inter-radial areas. Trilete mark distinct, sutures simple, straight, extending to equatorial margin.</p> <p>Specimen maximum dimension 34 <math>\mu\text{m}</math></p>

## *Tripartites vetustus* Schemel, 1950

### DESCRIPTION

Radial, trilete, miospores. Amb triangular, sides slightly to strongly concave, apices rounded or truncated. Trilete mark distinct; sutures straight simple or accompanied by low narrow labra extending within a very short distance of the equatorial margin. Exine extended laterally in the equatorial plane to form well-developed auriculae in the radial positions, inter-radial connections between auriculae reduced or absent. Distal surface of auriculae plicated; remainder of exine laevigate.

### OTHER DESCRIPTIONS

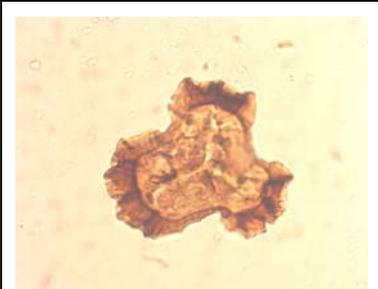
Schemel, 1950, p. 243, pl. 40, fig. 11

### SIZE

Overall equatorial diameter 30(42)50  $\mu\text{m}$

### RANGE

Mississippian; late Visean to early Serpukhovian [early Arnsbergian], VF to TK biozones (Clayton et al., 1977, Owens et al., 1977)

	<p>Figure 59a</p> <p>Shales below Hurlet Limestone, Hurlet Borehole 85.50 m, Scotland; Visean, VF Biozone, Sample MPA 9155, Specimen MPK <b>7555</b>. Specimen with slightly concave inter-radial margins and rounded apices. Well-developed plicated auriculae present at radial margins with no obvious inter-radial thickenings.</p> <p>Specimen maximum dimension 39 <math>\mu\text{m}</math></p>
	<p>Figure 59b</p> <p>Shales below Faraday House Sill, Argill Beck, Stainmore, Cumbria, England; Serpukhovian [Pendleian], NC Biozone, Sample LCS, Specimen MPK <b>7556</b>. Simple trilete mark with indication of minor labra development; sutures extend more than three-quarters of spore radius. Radial margins bear prominent plicated auriculae that are connected by narrower inter-radial crassitudes.</p> <p>Specimen maximum dimension 47 <math>\mu\text{m}</math></p>

## *Triquitrites sculptilis* (Balme) Smith & Butterworth, 1967

### DESCRIPTION

Radial, trilete, acamerate miospores. Amb irregularly triangular with more or less straight sides and rounded, flat or lobate apices. Shape dependent on the extent of exine ornamentation. Proximal surface flattened, distal surface inflated hemispherical. Trilete mark distinct to indistinct, sutures simple, straight; extending from two-thirds to the full spore radius. Proximal exine laevigate but distal exine ornamented with irregular pattern of ridges and verrucae. Verrucae variable in size and distribution; frequent fusion occurs between the bases of adjacent elements to produce an ill-defined reticulate pattern. Thickening of the exine at radial apices occurs to produce a variable crassitude. When associated with verrucae, this projects at the equatorial margin. Crassitudes, may in some cases, extend into inter-radial areas. Crassitudes vary from 2–7  $\mu\text{m}$  across when measured along a given radius, and are 10–17  $\mu\text{m}$  in width. Exine moderately thick.

### OTHER DESCRIPTIONS

Balme, 1952, p. 181, text-fig. 1g

Smith and Butterworth, 1967, p. 204, pl. 12, figs. 10–15

### SIZE

Overall equatorial diameter 25(37)45  $\mu\text{m}$

### REMARKS

Smith and Butterworth (1967) regarded *Triquitrites bucculentus* Guenel 1958, and *T. coesfeldens* Bharadwaj 1957, as forms which fall within the extremes of the range of morphological variation displayed by *T. sculptilis*.

### RANGE

Pennsylvanian; Moscovian [late Duckmantian to early Asturian] (Smith and Butterworth, 1967)

	<p>Figure 60a</p> <p>Shafton Top coal seam, Gate Farm Borehole, Yorkshire Coalfield, England; Moscovian [Bolsovian], SL Biozone, Sample C4, Specimen MPK 7222.</p> <p>Specimen maximum dimension 40 <math>\mu\text{m}</math></p>
	<p>Figure 60b</p> <p>Shafton Top coal seam, Gate Farm Borehole, Yorkshire Coalfield, England; Moscovian [Bolsovian], SL Biozone, Sample C4, Specimen MPK 7224. Proximal focus demonstrating variable character of radial and inter-radial crassitude.</p> <p>Specimen maximum dimension 43 <math>\mu\text{m}</math></p>

## ***Triquitrites trivalvis* (Waltz) Potonié & Kremp, 1956**

### DESCRIPTION

Radial, trilete, acamerate miospores. Amb triangular to sub-triangular with rounded apices and straight to concave sides. Trilete mark distinct; sutures simple, straight, extend from two-thirds to the full radius of the spore body. Spore body more or less laevigate. Exoexine extended in the equatorial plane to produce variable cingulum which is narrow (2–4 µm) in the inter-radial areas but greatly expanded in the radial positions to form prominent auriculae. Outer margins of auriculae thickened and laterally expanded to create large, homogenous cushion-like caps with a smooth to crenulate surface. Caps approximately 7 µm across when measured along a radius, and are 30 µm wide.

### OTHER DESCRIPTIONS

Potonié and Kremp, 1956, p. 88

Playford, 1962, pp. 602–603, pl. 85, figs. 13–14

### SIZE

Overall equatorial diameter 38(51)66 µm

Diameter of spore body 24(34)44 µm

### RANGE

Mississippian; ?late Visean to early Serpukhovian [early Arnsbergian]; ?VF to TK biozones (Clayton et al., 1977, and Owens et al., 1977)

	<p>Figure 61a</p> <p>Lower Limestone Group, Tirfergus Glen, Machrihanish, Argyll, Scotland; Serpukhovian [Pendleian], NC Biozone, Sample MPA 33341, Specimen MPK <b>7755</b>. Specimen with straight-sided inner body with rounded apices. Equatorial cingulum narrow inter-radially, but expanded radially to form wide auriculae which are capped by expanded crenulate pads. Trilete rays simple extending to body margin.</p> <p>Specimen maximum dimension 41 µm</p>
	<p>Figure 61b</p> <p>Lower Limestone Group, Drumlemble Borehole A, Machrihanish, Argyll, Scotland; Serpukhovian [Pendleian], NC Biozone, Sample MPA 33328, Specimen MPK <b>7757</b>.</p> <p>Specimen maximum dimension 43 µm</p>

## *Umbonatisporites distinctus* Clayton, 1971

### DESCRIPTION

Radial, trilete, acamerate miospores. Amb circular, subcircular or oval. Trilete mark often distinct; sutures when seen, simple, straight, extending between one-third and one-half the spore radius. Exine, 1–3  $\mu\text{m}$  thick, ornamented on distal surface and equatorial portion of proximal surface with cylindrical shaft-like elements which are 2–10  $\mu\text{m}$  high and 1–3  $\mu\text{m}$  wide, with a prominent constriction near the top and a second near the base. Terminus of each shaft-like element normally flat but commonly surmounted by a single spina or conus up to 4.5  $\mu\text{m}$  high. Rare small conis and spini may be interspersed between the longer biform elements. Ornamentation elements variable in size between specimens but commonly uniform on any single specimen. Contact areas laevigate.

### OTHER DESCRIPTIONS

Clayton, 1971, pp. 591–592, pl. 4, figs. 4–6

### SIZE

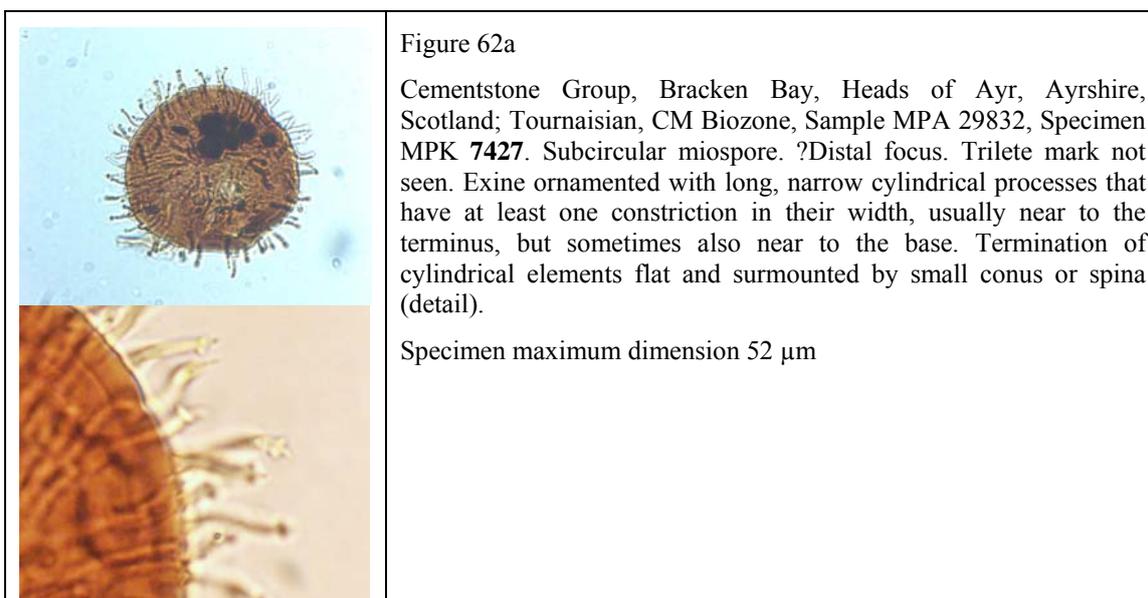
Overall equatorial diameter excluding ornamentation 43(70)126  $\mu\text{m}$

### REMARKS

*Umbonatisporites distinctus* is distinguished from *U. abstrusus* (Playford) Clayton 1971 and *U. variabilis* Hibbert & Lacey 1969 by possessing cylindrical processes with flat or slightly concave tops surmounted by a single conus or spina, and by the uniformity of its ornamentation on any single specimen.

### RANGE

Mississippian; Tournaisian; HD to CM biozones (Higgs et al., 1988)



***Umbonatisporites variabilis* Hibbert & Lacey, 1969**

DESCRIPTION

Radial, trilete, acamerate miospores. Amb circular to subcircular. Trilete mark frequently indistinct or torn; sutures when seen are short, simple and straight, extending up to one-sixth of spore radius. Exine 1–2 µm thick, ornamented on distal surface and equatorial portion of the proximal surface with variable squat biform baculate or pilate projections arranged randomly over the surface. Elements variable in shape and size on any one specimen; individual elements up to 4.5 µm high and 1.0–1.5 µm in basal diameter, widening towards the apex. At the terminus of each element are one to three rounded heads, each surmounted by a single thin tapering spina. Between the larger biform elements, slender tapering spinae 2–4 µm long and up to 1 µm wide may occur.

OTHER DESCRIPTIONS

Hibbert & Lacey, 1969, pp. 423–424, pl. 78, figs. 12–13, pl. 79, figs. 1–3

SIZE

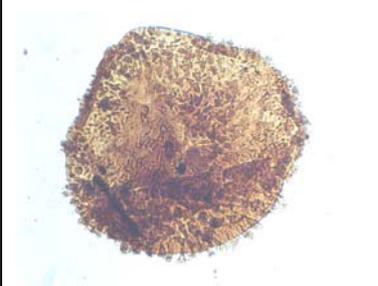
Overall equatorial diameter excluding projecting ornament 95(106)134 µm

REMARKS

Distinguished from *Umbonatisporites distinctus* Clayton 1971 by the multiple character of the spinose terminations surmounting the expanded baculate projections.

RANGE

Mississippian; Visean to Serpukhovian [early Arnsbergian] (Hibbert and Lacey, 1969, and unpublished information)

	<p>Figure 63a</p> <p>Shales below Holme Wood Marine Band, Mousegill Beck, Stainmore, Cumbria, England; Serpukhovian [Arnsbergian], TK Biozone, Sample M21, Specimen MPK <b>7429</b>. Specimen showing bulbous based processes with tapering shafts surmounted by small spinose projections. Exine relatively thick. Few elements appear to be located in the equatorial region.</p> <p>Specimen maximum dimension 119 µm</p>
	<p>Figure 63b</p> <p>Greengate Well Limestone, Tipalt Burn, Northumberland, England; Serpukhovian [Pendleian], NC Biozone, Sample MPA 31137, Specimen MPK <b>7430</b>. Densely ornamented specimen. Elements consist of slender-based processes which expand significantly to flat or rounded topped termini which bear one to three small, sharply pointed spinose projections.</p> <p>Specimen maximum dimension 101 µm</p>

## *Vallatisporites agadesi* Loboziak & Alpern, 1978

### DESCRIPTION

Radial, trilete, cingulizone miospores. Amb sub-triangular to subcircular. Trilete mark distinct, sutures obscured by elevated flexuous folds of the exoexine which extend, decreasing in height, to the equatorial margin. Exine composed of two layers. Intexine forming inner body, thin with several concentric plications. Exoexine rugulate, completely enclosing inner body and extended in the equatorial plane to form a wide cingulizone containing a large number of small, radially orientated, internal vacuoles. Maximum thickness of cingulizone developed in the region adjacent to inner body. Distal surface of exoexine bears vermiculate to coarsely reticulate ornamentation. Ornamentation elements variable; irregular convolutions and rugulae common; verrucae and coni infrequent.

### OTHER DESCRIPTIONS

Loboziak & Alpern, 1978, pp. 58–59, pl. 2, figs. 9–12

### SIZE

Equatorial diameter 60(69)80  $\mu\text{m}$

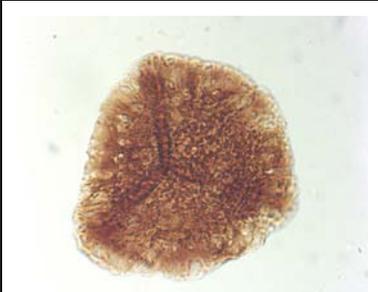
Width of cingulizone 10(13)18  $\mu\text{m}$

### REMARKS

Distinguished from *Vallatisporites banffensis* Staplin & Jansonius 1964, by the more coalescent nature of the ornament developed on the distal surface and the more obvious internal vacuolation of the zona. *V. splendens* Staplin & Jansonius 1964, differs by possessing a coarser ornament of more varied processes on the distal surface of the central body and less well-developed internal vacuolation of the cingulizone.

### RANGE

Mississippian; late Tournaisian to early Serpukhovian (Loboziak and Clayton, 1988)

	<p>Figure 64a</p> <p>North-east Libya; Carboniferous, late Visean, SG Biozone, OA Sub-Biozone (Loboziak and Clayton, 1988), Sample 6314, Specimen MPK <b>7341</b>. Specimen showing trilete sutures accompanied by elevated flexuous folds of exoexine extending to equatorial margin. Note fine vermiculate ornament developed in distal polar region.</p> <p>Specimen maximum dimension 97 <math>\mu\text{m}</math></p>
	<p>Figure 64b</p> <p>North-east Libya; Carboniferous, late Visean, SG Biozone, OA Sub-Biozone (Loboziak and Clayton, 1988), Sample 6314, Specimen MPK <b>7343</b>. Proximal focus. Trilete sutures accompanied by elevated flexuous, exoexinal folds which extend decreasing in height to equatorial margin. Note evidence of separation, at least in the equatorial plane, of the intexine of the inner body from the exoexine. Well-developed radially orientated vacuoles occur within zona adjacent to inner body.</p> <p>Specimen maximum dimension 84 <math>\mu\text{m}</math></p>

## *Vallatisporites drybrookensis* Playford & McGregor, 1993

### DESCRIPTION

Radial, trilete, cingulizone miospores. Amb rounded triangular with convex sides and rounded apices, sometimes subcircular. Trilete mark distinct; sutures straight, extending to the margin of the inner body, accompanied by elevated flexuous folds of the exoexine which extend, decreasing in height, to the equatorial margin. Intexine thin, forming rounded triangular inner body, frequently folded independently and withdrawn from the exoexine at least in the equatorial plane. Exoexine thin over proximal surface but thicker over distal surface and extended in the equatorial plane to form variably thickened cingulizone consisting of two zones. Inner thinner zone contains numerous internal radially orientated vacuoles separated by thin walls. Outer zone thicker and separated from the inner thinner zone by an irregular boundary coinciding with the limits of vacuolation. Distal surface of exoexine ornamented with pointed or rounded conical up to 3 µm high and 3.5 µm in basal diameter, interspersed with galeae consisting of a bulbous base surmounted by a small sharply pointed conus. Ornamentation reduced over the outer part of the cingulum to small conical. Well-developed cuniculus developed in the equatorial plane adjacent to the margin of the intexine.

### OTHER DESCRIPTIONS

Sullivan, 1964, pp. 370–371, pl. 59, figs. 14–15

Playford and McGregor, 1993, pp. 33–34, pl. 18, figs. 5, 6a,b, 7, 8a,b

### SIZE

Overall equatorial diameter 50(62)70 µm

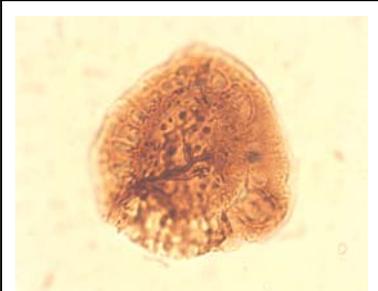
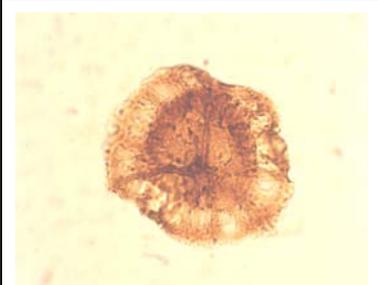
### REMARKS

Playford and McGregor (1993) considered that specimens assigned by Sullivan (1964) to his new combination *Vallatisporites (Zonotriletes) ciliaris* (Luber & Waltz) Sullivan 1964 were incorrectly identified. Consequently they erected *Vallatisporites drybrookensis* to include Sullivan's specimens and designated a specimen of Sullivan's as holotype.

The well-developed conate/galeate ornamentation and extensively internally vacuolate inner cingulizone distinguishes *V. ciliaris* from other species assigned to the genus *Vallatisporites*.

### RANGE

Mississippian to Pennsylvanian: early Tournaisian to ?Kazimovian/Gzhelian [Stephanian] (Playford and McGregor, 1993)

	<p>Figure 65a</p> <p>Basement Beds, Menai Straits, North Wales; Visean, TC Biozone, Sample MPA 18030, Specimen MPK <b>7081</b>. Specimen showing densely distributed, radially orientated vacuoles in the thinner inner zone of zona. Outer zone of cingulizone variably thickened. Note presence of clearly defined cuniculus at the equatorial margin of inner body.</p> <p>Specimen maximum dimension 63 µm</p>
	<p>Figure 65b</p> <p>Basement Beds, Menai Straits, North Wales; Visean, TC Biozone, Sample MPA 18030, Specimen MPK <b>7083</b>. Proximal focus. Trilete mark prominent, trilete rays obscured by low elevated exoexinal folds that extend to equatorial margin. Note significant development of internal vacuoles within the thinner inner part of the cingulizone. Outer, thicker part of cingulizone relatively narrow.</p> <p>Specimen maximum dimension 56 µm</p>

***Vallatisporites hystricosus* (Winslow) Byvsheva, 1985**

DESCRIPTION

Radial, trilete, cinguli-camerate miospores. Amb rounded triangular to subcircular. Outline of inner body may be conformable with equatorial margin of spore or more circular resulting in the equatorial cinguli-zonate structure being wider in the radial positions. Trilete mark distinct, sutures straight, extending to margin of inner body, accompanied by elevated, flexuous folds of the exoexine, up to 4 µm in the polar region but decreasing in height and extending to the equatorial margin. Intexine thin, laevigate or finely infrapunctate, forming inner body. Exoexine closely adpressed to intexine except in the equatorial plane where a well developed cuniculus indicates limited separation. Exoexine extended in the equatorial plane to form bizonate cingulum consisting of a thinner, inner, extensively vacuolated zone with closely spaced radially orientated vacuoles separated by narrow walls, and a thicker, outer zone. Distal surface of exoexine bears galeate ornament of variable density; elements are largest and most densely distributed in the distal polar region and finer and less densely distributed towards the equatorial margin. Small, sharply pointed coni may be located in the spaces between the galeate elements. Individual galeae up to 10 µm high and 7 µm in basal diameter, consisting of a rounded basal boss surmounted by a sharply pointed, slender spina. Fusion between bases of adjacent elements forms irregular vermiculate elements with common spinose crests, particularly in the polar region. Numerous elements project at the equatorial margin.

OTHER DESCRIPTIONS

Winslow, 1962, pp. 41–42, pl. 18, fig. 5

SIZE

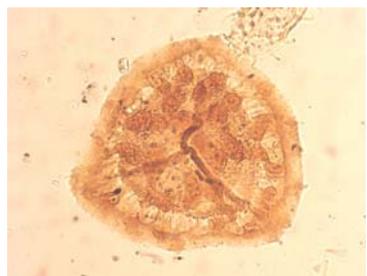
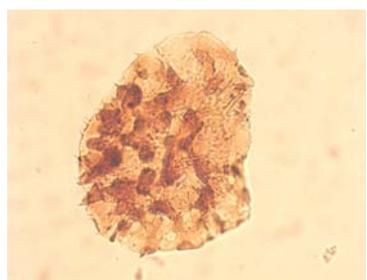
Overall equatorial diameter 46–84 µm

REMARKS

*Vallatisporites pusillites* (Kedo) Dolby & Neves 1970 is similar in many respects to *Cirratiradites hystricosus* but is distinguished by possessing relatively finer ornamentation in which non-galeate elements are more common. It is probable that complete morphological gradation exists between the two species. *Vallatisporites verrucosus* Hacquebard 1957 is distinguished by possessing a verrucose ornament. *Vallatisporites galearis* Sullivan 1964 is smaller and possesses an ornament of galeae with cone-shaped rather than long, spinose terminations.

RANGE

Late Devonian to Mississippian; Strunian to Tournaisian (Winslow, 1962)

	<p>Figure 66a Sample 5133, Bedford Shale, Big Walnut Creek, Sudbury, Ohio, USA; Late Devonian, Strunian, LL Biozone, Specimen MPK <b>7062</b>. Specimen maximum dimension 82 µm</p>
	<p>Figure 66b Sample 5133, Bedford Shale, Big Walnut Creek, Sudbury, Ohio, USA; Late Devonian, Strunian, LL Biozone, Specimen MPK <b>7063</b>. Distal focus. Note coarse galeate character of spinae that are most densely distributed over the polar part of the exine. In equatorial region, the ornamentation is less densely distributed and significantly smaller in size. Minor evidence of vacuolation of the cingulum. Specimen maximum dimension 84 µm</p>

## *Vallatisporites vallatus* Hacquebard, 1957

### DESCRIPTION

Radial, trilete, camerate, cingulizone miospores. Amb convexly rounded triangular. Trilete mark distinct to indistinct, sutures straight, extending to margin of inner body, accompanied by low, slightly elevated exoexinal folds which decrease in height towards the ends of the sutures. Height of folds in polar region approximately 2.5  $\mu\text{m}$ . Exine two layered. Intexine thin, forms inner body conformable in outline with equatorial margin, surface laevigate. Exoexine closely adpressed to intexine over proximal and distal surface but separated at least to some extent in the equatorial plane where a well-developed narrow cuniculus is developed. Exoexine thin over proximal surface but slightly thicker distally and extended in the equatorial plane to form differentially thickened tapering cingulum. Cingulum consists of inner thicker zone that appears in part to overlap the equatorial margin of the inner body, up to 8  $\mu\text{m}$  wide. In many specimens large numbers of small elongate internal vacuoles, separated by narrow walls, appear to be located within this portion of the cingulum. Individual vacuoles up to 5  $\mu\text{m}$  in length. Outer part of cingulum thin and sometimes weakly radially striated. Distal exoexine bears a dense ornament of coni, grana and small spini, elements up to 3  $\mu\text{m}$  in height and 2  $\mu\text{m}$  in basal diameter. Elements normally discrete but some basal coalescence occurs. Ornament more sparsely distributed on the cingulum and at the equatorial margin is limited to small conate projections.

### OTHER DESCRIPTIONS

Hacquebard, 1957, pp. 312–313, pl. 2, fig. 12

Staplin and Jansonius, 1964, p. 112, pl. 21, figs. 1–6

Higgs, Clayton and Keegan, 1988, pp. 80–81, pl. 16, figs. 19–20

### SIZE

Overall equatorial diameter 50(59)70  $\mu\text{m}$

Diameter of spore body 35–44  $\mu\text{m}$

### REMARKS

*Vallatisporites vallatus* is distinguished from *V. verrucosus* Hacquebard 1957 by possessing a fine densely distributed ornament of coni, grana and infrequent spini that are less than 3  $\mu\text{m}$  in height. *V. pusillites* (Kedo) Dolby & Neves 1960, differs by possessing an ornament of coarser coni and galeae 4–12  $\mu\text{m}$  high with bases up to 6  $\mu\text{m}$  in diameter.

### RANGE

Late Devonian to Mississippian; Tournaisian, VI to CM biozones (Higgs et al., 1988)

	<p>Figure 67a</p> <p>Bedford Shale, Big Walnut Creek, Sunbury, Ohio, USA; Uppermost Devonian, Strunian, LL Biozone, Sample 5133, Specimen MPK 7325. Distal surface of exoexine over both body and cingulum bears densely distributed ornament of coni and small spinae; smaller elements occur on the cingulum.</p> <p>Specimen maximum dimension 61 <math>\mu\text{m}</math></p>
	<p>Figure 67b</p> <p>Horton Bluff Formation, Horton Bluff, Nova Scotia, Canada; Tournaisian, VV Biozone, AD Sub-biozone, Sample P6400, Specimen MPK 7328.</p> <p>Specimen maximum dimension 65 <math>\mu\text{m}</math></p>

## *Vallatisporites verrucosus* Hacquebard, 1957

### DESCRIPTION

Radial, trilete, camerate, cingulizone miospores. Amb convexly rounded triangular. Trilete mark distinct or indistinct if obscured by ornament; sutures straight, extending to margin of inner body, simple or accompanied by elevated flexuous folds of the exoexine, up to 4  $\mu\text{m}$  high in polar region, which extend, decreasing in height, to the margin of the body or onto the cingulum. Exine two layered. Intexine thin, laevigate, forms inner body conformable with the equatorial outline. Exoexine closely adpressed to intexine in proximal and distal positions but separated from intexine in the equatorial plane where a well-developed cuniculus is located. Exoexine extended in the equatorial plane to form poorly differentiated bizonate cingulum. Inner thicker zone of cingulum overlaps the equatorial margin of inner body and may contain numerous internal radially orientated vacuoles. Outer zone of cingulum thinner and narrower. In some specimens differentiation of the cingulum is difficult to discern. Distal surface of exoexine densely ornamented with discrete or confluent verrucae up to 6  $\mu\text{m}$  in diameter. Elements may fuse to form short irregular ridges. Verrucae are most densely distributed in the distal polar region where the largest elements are also located. Towards the equatorial margin, elements become progressively smaller and more sparsely distributed. Equatorial margin uneven but rarely displays coarse projecting ornamentation. Verrucae surmounted by small mammoid coni may be present in the distal polar region.

### OTHER DESCRIPTIONS

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

### SIZE

Overall equatorial diameter 55–75  $\mu\text{m}$

Diameter of inner body 41–47  $\mu\text{m}$

### REMARKS

Almost identical in structure to *Vallatisporites vallatus* Hacquebard 1957, but distinguished by possessing an ornament of verrucate elements and by the poorly differentiated bizonate cingulum.

### RANGE

Late Devonian to Mississippian; Strunian to Tournaisian; LN to CM biozones (Higgs et al., 1988)

	<p>Figure 68a</p> <p>Horton Bluff Formation, Horton Bluff, Nova Scotia, Canada; Tournaisian, VV Biozone, AD Sub-biozone (Utting et al., 1989), Sample P6400, Specimen MPK <b>7311</b>. Specimen with well-defined inner body and wide differentiated cingulum. Cingulum separated from inner body by well-defined cuniculus. Inner zone of cingulum appears lighter in colour as a result of internal vacuolation. Outer zone more or less uniform in thickness. Distal surface of exoexine bears coarse verrucae, variable in shape and size, normally discrete. Ornament reduced in size and density over cingulum where it may be at least in part replaced by conate elements.</p> <p>Specimen maximum dimension 70 <math>\mu\text{m}</math></p>
	<p>Figure 68b</p> <p>Horton Bluff Formation, Horton Bluff, Nova Scotia, Canada; Tournaisian, VV Biozone, AD Sub-biozone (Utting et al., 1989), Sample P6400, Specimen MPK <b>7312</b>. Distal focus showing coarse verrucate ornament on exoexine with tendency for elements to be arranged in a loose concentric manner and showing basal fusion to form short ridges. Ornament reduced on cingulum. Inner part of cingulum shows development of internal vacuolation.</p> <p>Specimen maximum dimension 60 <math>\mu\text{m}</math></p>