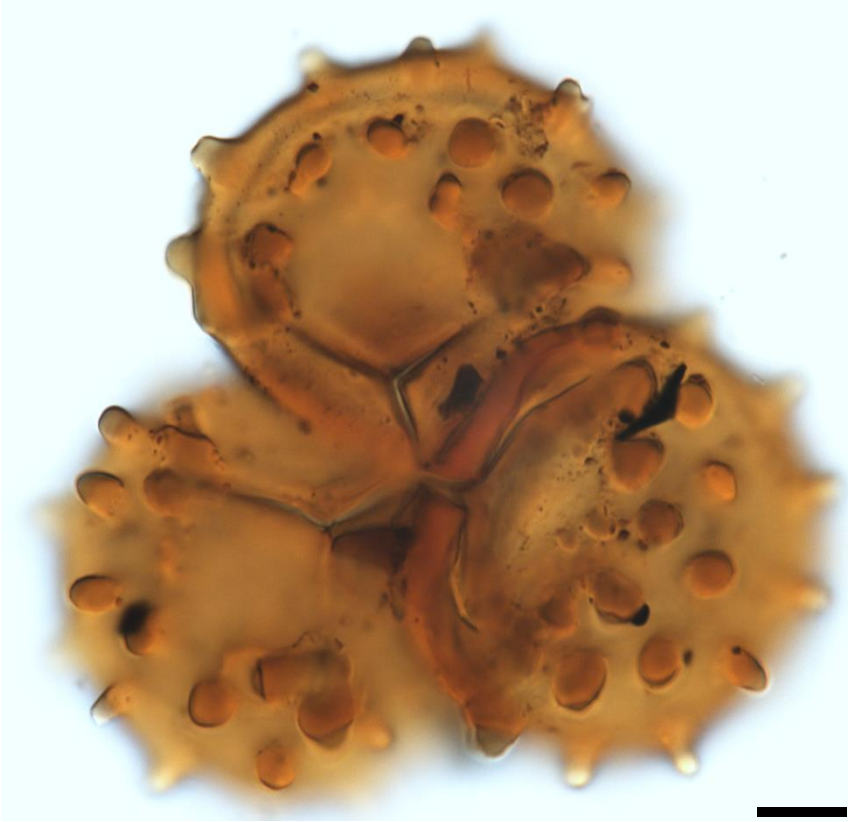
British Geological Survey

Taxonomy Online 3: the 'Bernard Owens Collection' of single grain mount palynological slides: Carboniferous pollen and spores part II

Biostratigraphy and Palaeontology Laboratory - Rock Volume Characterisation Laboratory Cluster

Open Report OR/21/038



BRITISH GEOLOGICAL SURVEY

BIOSTRATIGRAPHY AND PALAEONTOLOGY LABORATORY - ROCK VOLUME CHARACTERISATION LABORATORY CLUSTER PROGRAMME

Taxonomy Online 3: the 'Bernard Owens Collection' of single grain mount palynological slides: Carboniferous pollen and spores part II

Alessandro Carniti & Jan A. I. Hennissen

Keywords

BGS Collections; Palynology; Palaeontology; Carboniferous.

Front cover

Raistrickia nigra Love 1960, incomplete spore tetrad; scale bar = 10 µm.

Bibliographical reference

CARNITI, A. & HENNISSEN, J. A. I. 2020. Taxonomy Online 3: the 'Bernard Owens Collection' of single grain mount palynological slides: Carboniferous pollen and spores part II. *British Geological Survey Open Report*, OR/21/038. 71pp.

Keyworth, Nottingham British Geological Survey 2020

BRITISH GEOLOGICAL SURVEY

The full range of our publications is available from BGS shops at Nottingham, Edinburgh, London and Cardiff (Welsh publications only) see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications, including maps, for consultation.

We publish an annual catalogue of our maps and other publications; this catalogue is available online or from any of the BGS shops.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as basic research projects. It also undertakes programmes of technical aid in geology in developing countries.

The British Geological Survey is a component body of UK Research and Innovation.

British Geological Survey offices

Nicker Hill, Keyworth,
Nottingham NG12 5GG
Tel 0115 936 3100

BGS Central Enquiries Desk
Tel 0115 936 3143
email enquiries@bgs.ac.uk

BGS Sales
Tel 0115 936 3241
email sales@bgs.ac.uk

The Lyell Centre, Research Avenue South,
Edinburgh EH14 4AP
Tel 0131 667 1000
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road,
London SW7 5BD
Tel 020 7589 4090
Tel 020 7942 5344/45
email bgslondon@bgs.ac.uk

Cardiff University, Main Building, Park Place,
Cardiff CF10 3AT
Tel 029 2167 4280

Maclean Building, Crowmarsh Gifford,
Wallingford OX10 8BB
Tel 01491 838800

Geological Survey of Northern Ireland, Department of Enterprise, Trade and Investment, Dundonald House, Upper Newtownards Road, Ballymiscaw,
Belfast, BT4 3SB
Tel 01232 666595
www.bgs.ac.uk/gsni/

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU
Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

UK Research and Innovation, Polaris House,
Swindon SN2 1FL
Tel 01793 444000
www.ukri.org

Website www.bgs.ac.uk
Shop online at www.geologyshop.com

Foreword

The original aim of the ‘Taxonomy Online’ report series is to use the internet as a forum to illustrate fossil specimens held in the collections of The British Geological Survey (BGS) and associated institutes. Our web-based publications (http://www.bgs.ac.uk/taxonomy/home.html) supplement, but do not replace, traditional hardcopy palaeontological publications by allowing easy access to examples of specimens, species diagnosis and information on their stratigraphical distribution. For convenience, data are presented as web-based publications so that amateur, student and professional palaeontologists will have easy access to palaeontological information held in the BGS collections. However, websites do not have publication status and for this reason a formal publication is produced in pdf in the Research Report Series of the BGS. They are available as a free download and have been internally reviewed by two BGS members of staff.

Acknowledgements

The authors would like to thank Max Page for reviewing an earlier version of this manuscript and Prof. Michael Stephenson for internally reviewing the finished report.

Contents

FIGURES

PLATES

TABLES

No table of figures entries found.

Summary

The Bernard Owens Collection comprises single grain mounts of some 145, mostly Palaeozoic, miospore and pollen taxa, each represented by many specimens displaying the most diagnostic features of the original holotype diagnosis and a wide range of preservation states and natural morphological variations. It is very likely the most important collection of single grain, Late Palaeozoic palynomorphs. The specimens were collected worldwide but because Bernard's studies laid the foundation of the Carboniferous miospore biozonation across Western Europe (e.g. Clayton et al., 1977; McLean et al., 2018; Owens et al., 1978; Owens et al., 2004; Owens et al., 2005; Owens et al., 1977), examples of the Carboniferous in the UK and mainland Europe form the bulk of the source material of the palynomorphs discussed in the rest of this report.

This is the second report describing the Bernard Owens Collection, following Stephenson and Owens (2006).

1 Introduction

This report is the third in the Taxonomy Online series, the second report on the 'Bernard Owens' single grain mount collection of Carboniferous palynology following the compilation of the diagnosis and microphotographs of 68 taxa by Stephenson and Owens (2006) (BGS collections number MPK6958 to 7806). In this report, we include the diagnosis and images of an additional 33 pollen and spore taxa and of scolecodonts (paragraph 2). We also, for the first time, include a full index of the entire Bernard Owens single grain mount collection of Carboniferous palynology (Appendix 1, Table 1).

1.1 THE 'BERNARD OWENS SINGLE GRAIN MOUNT COLLECTION'

The collection as a whole is the legacy of Dr. Bernard Owens who produced thousands of single grain mounts which were distributed to many instutions nationally and internationally. However, the majority of the collection is curated in the BGS collections. Bernard Owens (1938–2019) worked at the Institute of Geological Sciences/The British Geological Survey from 1965 until 1998 as a palynologist and manager and championed palynology and palaeontology with the BGS and its parent organisation the Natural Environmental Research Council (NERC, now UK Research and Innovation, UKRI). Riding et al. (2020) compiled an overview of Bernard Owens' remarkable life and career in micropalaeontology.

The Bernard Owens Collection comprises some 145 taxa which are each represented by many specimens displaying the most diagnostic features of the original holotype diagnosis and a wide range of preservation states and natural morphological variations. It is very likely the most important collection of single grain, Late Palaeozoic palynomorphs. The specimens were collected worldwide but because Bernard's studies laid the foundation of the Carboniferous miospore biozonation across Western Europe (e.g. Clayton et al., 1977; McLean et al., 2018; Owens et al., 1978; Owens et al., 2004; Owens et al., 2005; Owens et al., 1977), examples of the Carboniferous in the UK and mainland Europe form the bulk of the source material of the palynomorphs discussed in the rest of this report.

Each single grain mount slide is associated with a unique BGS collections number (including the prefix 'MPK'). All slides are held at the National Geological Repository at the British Geological Survey, Environmental Science Centre, Nicker Hill, Keyworth, Nottingham NG12 5GG. For information on slide loans please contact enquiries@bgs.ac.uk or the corresponding author (janh@bgs.ac.uk).

1.2 REPORT LAYOUT

Paragraph 2 forms the main body of the report and contains the information on 34 palynomorphs. It contains the holotype diagnosis of the taxon (where possible), gives it reported size range and lists its stratigraphic range and geographical distribution. For some species, we included references to alternate taxonomic descriptions and/or remarks. Each diagnosis is accompanied by two microphotographs that highlight the most diagnostic features of the taxon. Our aim was to restrict the discussion of each taxon to one side of an A4 page for ease of use of a hardcopy version of the report alongside a microscope. Because of this, we were not able to include all microphotographs in the report's main body. Therefore, additional microphotographs that further illustrate the morphological variation of selected taxa is included in four plates in Appendix 1.

Images were taken using a Nikon 80i microscope equipped with differential interference contrast (DIC) capabilities and a Nikon DS-Fi2 camera. Microphotographs were taken according to the techniques recommended by Riding and Head (2018). The caption of each figure indicates whether the image was taken using unfiltered transmitted white light (0) or using DIC (N2) followed by the magnification of the objective. The ocular magnification of the microscope is 10X.

2 The Taxonomy Online 3 taxa

2.1 *AHRENSISPORITES SINANII* (ARTÜZ) RAVN 1986 (PLATE I, FIGS. 1A-B)

2.1.1 DIAGNOSIS

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 (1–2 µm) in the inter-radial areas but greatly expanded in the radial positions to form auriculae, with broad smooth tips with sharp edges. Auriculae approximately 6 µm high, up to 18–20 µm large. Exine laevigate. Distal surface bears 6 radial thickenings connecting the distal pole to the edges of the auriculae.

2.1.2 SIZE

Overall equatorial diameter (including auriculae): 35–40 µm.

Diameter of spore body: 30 µm on average.

2.1.3 RANGE AND LOCALITIES

Westphalian A (British Micropalaeontological Society Palynology Group, 1984).
Europe. USA.

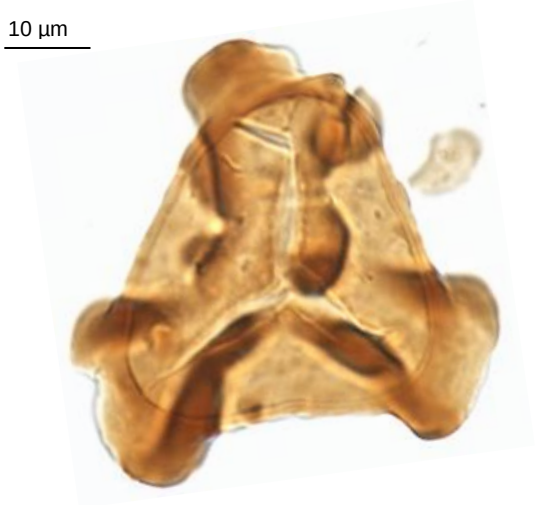


Figure 1: *Ahrensisporites sinanii* MF (7964).

Specimen 7964 (MPA 4578). BGS Offshore Bh 74/13 - Forth, Scotland. Westphalian B. Distal view. Median focus. 0/100x (oil).

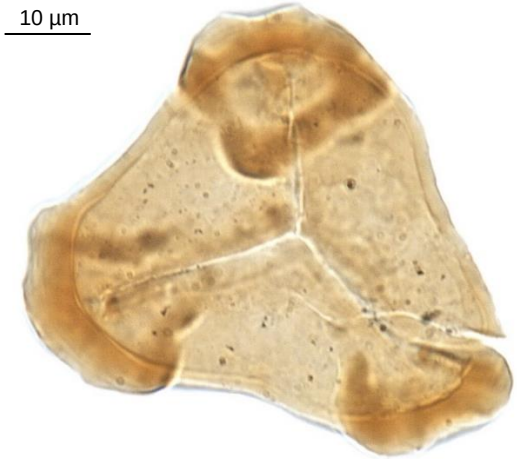


Figure 2: *Ahrensisporites sinanii* PF (7968).

Specimen 7968 (CSA 1231). BGS Offshore Bh 74/13 - Forth (Scotland). Westphalian B. Distal view. Proximal focus showing distinct spore body and trilete mark. Note distal exine thickenings connecting the polar region to the edges of the auriculae. 0/100x (oil).

2.2 *CIRRATRIRADITES RARUS* (IBRAHIM) SCHOPF, WILSON AND BENTALL 1944 (PLATE I, FIGS. 2A-B)

2.2.1 DIAGNOSIS

Radial, trilete, cingulizonate, camerate miospores. Amb triangular to slightly rounded, with slightly convex sides. Trilete mark distinct, sutures straight, often obscured by elevated flexuous folds of the exoexine that go slightly beyond the central bodies; their extension to the edge of the zona is not always recognizable. Surface of the central body densely spotted or grained; rounded triangular. The width of the zona corresponds to the length of the radius of the central body or is slightly larger. The distal exoexine bears no foveola (modified after Potonié and Kremp, 1956).

2.2.2 SIZE

Overall equatorial diameter: 60–100 µm.

2.2.3 REMARKS

C. rarus differs from *C. saturni* (Ibrahim) Schopf, Wilson and Bentall and *C. flabelliformis* Wilson and Kosanke 1944 (considered by Smith and Butterworth, 1967, as a synonymous with *C. saturni*) by the lack of foveola.

2.2.4 RANGE AND LOCALITIES

Chokierian to Yeadonian (middle to upper Namurian; British Micropalaeontological Society. Palynology Group, 1984). Northern hemisphere; South America.

Figure 3: *Cirratriradites rarus* DF (8822).

Specimen 8822. England/Wales. Distal view. Distal focus showing granules on the surface of spore body exine. 2N-100x (oil).

Figure 4: *Cirratriradites rarus* PF (8822).

Specimen 8822. England/Wales. Distal view. Proximal focus. Note flexuous radial exine folds in radial positions extending to the edge of the zona. Note the vacuoles in the outer zone of cingulum. 2N-100x (oil).

2.3 *CRISTATISPORITES CONNEXUS* POTONIÉ AND KREMP, 1955 (PLATE II, FIGS. 5A-B)

2.3.1 DIAGNOSIS

Radial, trilete, cingulate miospores. Amb subcircular. Trilete mark usually indistinct, may extend into the cingulum. Central body or intexine thin, laevigate. Central proximal area of exoexine granulate. Cingulum and central distal area verrucate; verrucae closely packed and arranged in ridges or cristae on the cingulum, more widely spaced in the distal area. Margin modified by projecting verrucae, some with setose tips; 22 to 50 verrucae have been counted on the equator (modified after Smith and Butterworth, 1967).

2.3.2 SIZE

Overall equatorial diameter (including ridges): 60–90 µm.

2.3.3 RANGE AND LOCALITIES

Upper Westphalian A to Westphalian B (Smith and Butterworth, 1967).
Europe. USA.

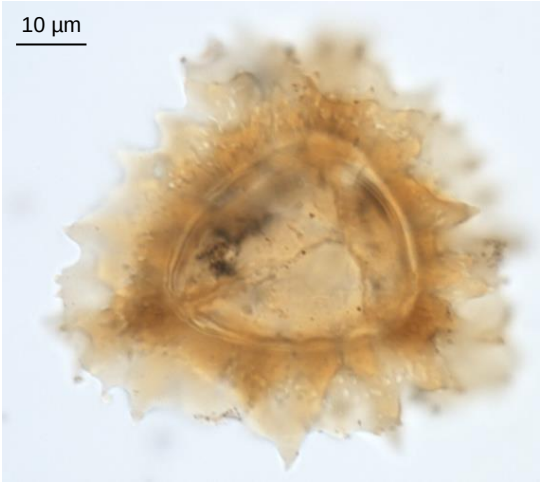


Figure 5: *Cristatisporites connexus* PF (7979).

Specimen 7979 (A5a 1414). Listeri Marine Band, Coal above Argill Shale Bed. Westphalian B (Langsettian Substage). Argill Beck, Stainmore. Proximal view. Proximal focus showing distinct inner body with ill-defined trilete mark. Inner portion of cingulum granulate. Verrucae fused to form ridges projecting at the equator. 2N-100x (oil).

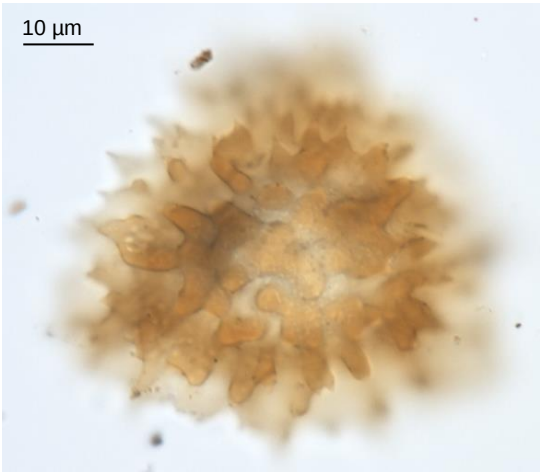


Figure 6: *Cristatisporites connexus* DF (7979).

Specimen 7979 (A5a 1414). Listeri Marine Band, Coal above Argill Shale Bed. Westphalian B (Langsettian Substage). Argill Beck. Proximal view. Distal focus showing verrucae on the distal surface. Verrucae may bear spinose terminations or coni. 2N-100x (oil).

2.4 *CRISTATISPORITES INDIGNABUNDUS* (LOOSE) STAPLIN AND JANSONIUS, 1964

2.4.1 DIAGNOSIS

Radial, trilete, cingulate miospores. Amb subcircular to subtriangular. Trilete mark distinct to indistinct, sutural ridges flush with or slightly raised above the central proximal surface, narrow, often indistinct, terminated at the row of setae. Intexine lines cavity of exoexine, but seldom seen. Central proximal area of exoexine roughened to finely granulose, bounded by an irregular ring of hooked setose spines up to 2-5 µm long and 1-2 µm wide at their bases. Zona beyond the setae almost laevigate or bears scattered small granules or conical apiculae; spore margin irregular with scattered small coni that often have minute setose tips; on specimens where the distal sculpture carries to the equator, the margin is strongly irregular. Distal surface sculptured with prominent warts that in part connect at their bases, individual warts up to 6 µm high and 4 µm wide, some have setose tips. Inner wall of exoexine minutely foveolate distally. Zona not clearly marked, width (measured from equator to outside of ring of setose spines) generally less than half spore radius (from Staplin and Jansonius, 1964, *fide* Smith and Butterworth, 1967).

2.4.2 OTHER DESCRIPTIONS

Potonié and Kremp, 1955 (German).

2.4.3 SIZE

Overall equatorial diameter: 50–80 µm.

2.4.4 RANGE AND LOCALITIES

Westphalian B (Smith and Butterworth, 1967). Upper Yeadonian (upper Namurian) - Westphalian B (British Micropalaeontological Society. Palynology Group, 1984).
Europe. USA.

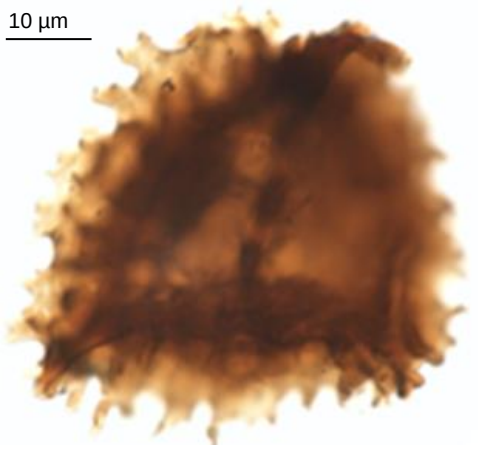


Figure 7: *Cristatisporites indignabundus* PF (6379).

Specimen 6379 (MPA 12549/12). Middle Carboniferous boundary. Stone Head Beck, Cowling, West Yorkshire (England). Distal view. Proximal focus showing ill-defined spore body with trilete mark accompanied by flexuous exine folds. Cingulum laevigate, with irregular margin bearing coni and spinae, due to the equatorial projection of coalescent distal equatorial baculae (2N-100x oil).

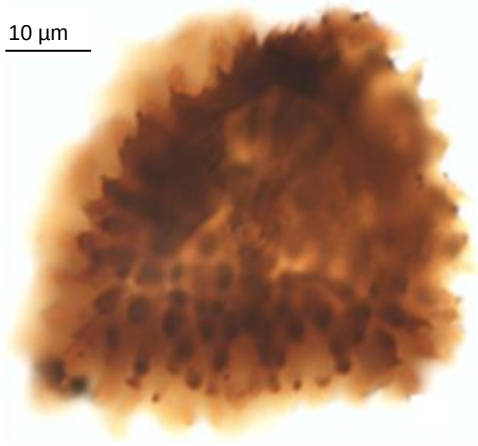


Figure 8: *Cristatisporites indignabundus* DF (6379).

Specimen 6379 (MPA 12549/12). Middle Carboniferous boundary. Stone Head Beck, Cowling, West Yorkshire (England). Distal view. Distal focus showing heavy ornament of baculae with setose or spinose tips (0-100x oil).

2.5 *DENSOSPORITES DUPLICATUS* (NAUMOVA) POTONIÉ AND KREMP, 1956

2.5.1 DIAGNOSIS

Radial, trilete, cingulate miospores. Amb roundly subtriangular to subcircular. Trilete mark distinct, sutures straight, length equal to, or slightly less than, spore-body radius; usually accompanied by minor lip development - lips individually about 3 µm broad, with somewhat irregular outer margins. Spore body concavely or convexly subtriangular to subcircular; laevigate to finely granulate. Exoexine extended and thickened in the equatorial plane to form undifferentiated cingulum of more or less uniform thickness. Outer margin of cingulum strongly and characteristically differentiated into numerous laterally projecting processes which are approximately 10–15 µm long, 3–4 µm in basal diameter, and are conspicuously expanded and thickened apically into crescentic (mushroom-shaped) caps. These prominent peltate processes are usually very closely packed, often appearing to lie in more than one horizontal plane. Cingulum otherwise laevigate, colour slightly darker than body (modified after Playford, 1962).

2.5.2 RANGE AND LOCALITIES

Tournasian–Visean (Potonie and Kremp, 1956); Visean – possibly to Namurian A (Playford, 1962).

Ex U.S.S.R., Canada.

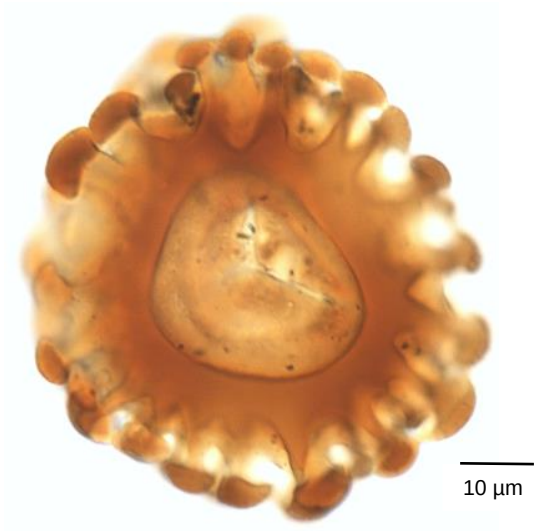


Figure 9: *Densosporites duplicatus* DF (7855).

Specimen 7855. Distal view. Median focus. Specimen showing well defined inner body, trilete mark distinct, slightly opened, extending almost to spore body margin. Spore body finely granulate. Outer margin of cingulum differentiated in numerous processes, appearing to lie in at least two horizontal planes. Note mushroom shaped caps. Cingulum laevigate. 0-100x (oil).

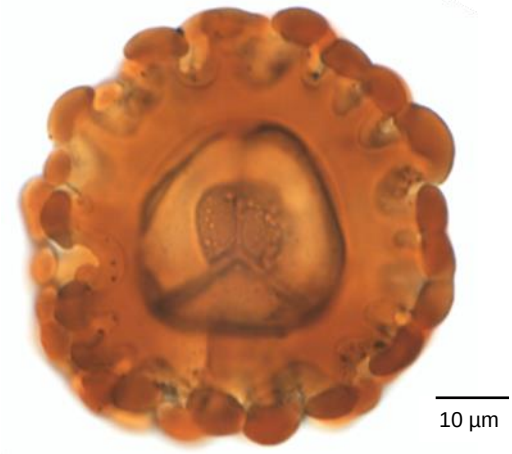


Figure 10: *Densosporites duplicatus* PF (7858).

Specimen 7858. Proximal view. Proximal focus. Specimen showing well defined inner body. Trilete mark distinct accompanied by minor lip development. Spore body finely granulate. 0-100x (oil).

2.6 *DICTYOTRILETES BIRETICULATUS* (IBRAHIM) SMITH AND BUTTERWORTH, 1967

2.6.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb rounded-triangular with convex sides and rounded angles; in equatorial view proximal profile slightly, distal profile strongly, convex; outline in polar view smooth to gently undulate, but in other compressions the muri project about 2 µm from margin. Laesurae not often visible, simple, straight, three quarters or more of spore radius. Reticulation covers entire distal surface but does not extend beyond the equator. Polygonal-shaped lumina number between 15 and 25. Except in the peripheral region the shape and size of lumina are very regular, diameter about 10 µm. Muri approximately square in section; width somewhat less than 1-5 µm. Exine thin, proximally laevigate, distally punctate in lumina.

2.6.2 OTHER DESCRIPTIONS

Potonié and Kremp, 1955 (German).

2.6.3 SIZE

Overall equatorial diameter: 40–60 µm.

2.6.4 REMARKS

D. probireticulatus Butterworth and Mahdi 1982 differs from *D. bireticulatus* in its larger size and in the greater number of lumina present on the distal surface (20–34); the exine of *D. probireticulatus* is slightly thicker and the laesurae are more frequently discernible (Butterworth and Mahdi, 1982). Playford (1978) describes *Dictyotriletes* sp. A which is very similar to *D. bireticulatus* from Australia, probably conspecific.

2.6.5 RANGE AND LOCALITIES

Westphalian A to lowest part of Westphalian C (Smith and Butterworth, 1967). Middle Namurian C to middle Westphalian C (Clayton et al., 1977). Upper Yeadonian (upper Namurian) to middle Westphalian C (British Micropalaeontological Society Palynology Group, 1984).

Europe; USA; China; Egypt.

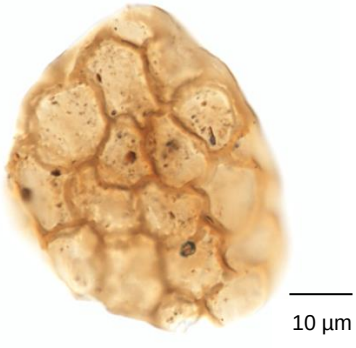


Figure 11: *Dictyotriletes bireticulatus* DF (7603).

Specimen 7603 (ASB 90-21). Listeri Marine Band, Argill Shale Bed. Westphalian B (Langsettian Substage). Argill Beck, Stainmore, England. Distal view. Distal focus showing reticulum. 2N-100x (oil).

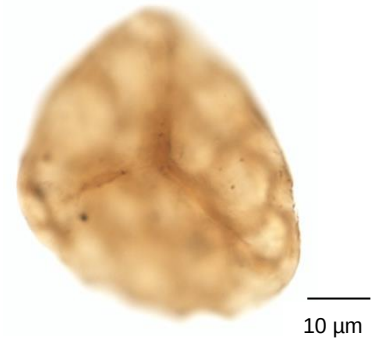


Figure 12: *Dictyotriletes bireticulatus* PF (7603).

Specimen 7603 (ASB 90-21). Listeri Marine Band, Argill Shale Bed. Westphalian B (Langsettian Substage). Argill Beck, Stainmore, England. Distal view. Proximal focus showing thin laevigate proximal exine with ill-defined trilete mark. 2N-100x (oil).

2.7 *DICTYOTRILETES FIMBRIATUS* (IBRAHIM) (WINSLOW) KAISER 1970

2.7.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb subcircular; laterally compressed specimens shorter in axial than transverse dimensions. Trilete mark distinct, suturae 21–28 µm long, usually partly obscured by flattened muri in compressions. Labial elaboration absent: rays bordered by muri, less delicately fringed than distal muri. Contact areas not delimited. Reticulation consists of extremely high muri, papillate fringed, that form a distinct rim slightly proximal to the geometrical equator, and muri radiating distally to form a distal network of 7 to 9 large lacunae as much as 31 µm in breadth. Muri also usually extend along the rays and sometimes extend onto inter-radial surfaces. Muri 8–21 µm high and about 3 µm wide (tangential to surface), highest at mural intersections. Muri incised deeply along the top to about half their height, appear fringed; papillate segments 1.6–3 µm in diameter. Papillae blunt, clavate or slightly taper pointed; often curved on compressed specimens. No peri-sporal layer is differentiated. Spore coat ranges from a minimum of 2.1 µm to 3.1 µm but can be much thicker along muri. Surface smooth; coat yellow to orange and dark brown by transmitted light (modified from Winslow, 1962).

2.7.2 SIZE

Overall equatorial diameter: 75–130 µm

2.7.3 RANGE AND LOCALITIES

LL (Upper Devonian) -HD (lower Tournasian) Biozones (Higgs et al., 1988).
Europe; North Africa; USA; Canada; South America.

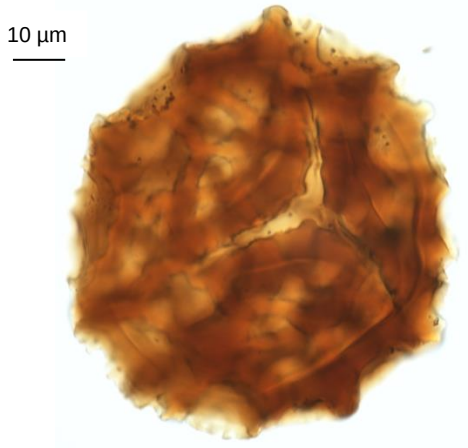


Figure 13: *Dictyotriletes fimbriatus* PF (7595).

Specimen 7595 (SB3 90-991). Bedford Shale. Big Walnut Creek, Ohio, USA. Distal view. Proximal focus showing distinct trilete mark, sutures opened accompanied by broad laevigate muri. Equatorial margin bearing papillate muri; papillae projecting at the equator. 0-100x (oil).

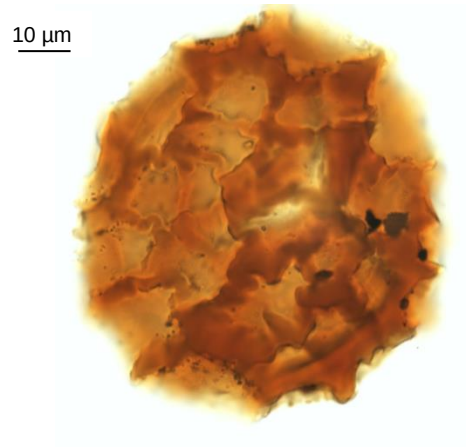


Figure 14: *Dictyotriletes fimbriatus* DF (7595).

Specimen 7595 (SB3 90-991). Bedford Shale. Big Walnut Creek, Ohio, USA. Distal view. Distal focus showing irregular reticulum with papillate muri. 0-100x (oil).

2.8 *DICTYOTRILETES MURICATUS* (KOSANKE) SMITH AND BUTTERWORTH, 1967 (PLATE IV, FIGS. 1A-B)

2.8.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb circular, outline irregularly crenulated. Trilete mark distinct, but often concealed by ornament, about two thirds radius. The body, distinct to indistinct, often shows a darker peripheral zone due to the overlapping of the body by the muri arising near the equator. Exine reticulate with large lumina and thin, but high, and frequently folded, twisted muri. Muri 1–2 µm in thickness, extend 6–12 µm beyond the body. Number and size of lumina often difficult to determine but size appears to be up to 25 µm in diameter. The high muri cover entire spore with the exception of contact area where they are either absent or reduced in height. Apiculate elements, which do not exceed the height of fully developed muri, sometimes occur on the muri and on the lumina. The high muri give the compressed spore body the appearance of having a membranous flange. Exine of lumina generally laevigate, but may be pustulate or granulate (modified after Smith and Butterworth, 1967).

2.8.2 SIZE

Overall equatorial diameter: 70–90 µm.

2.8.3 RANGE AND LOCALITIES

Upper Westphalian A to lower Westphalian C (Smith and Butterworth, 1967). Middle Yeadonian (upper Namurian) - middle Westphalian C (British Micropalaeontological Society. Palynology Group, 1984).
Europe; USA; China; Egypt.

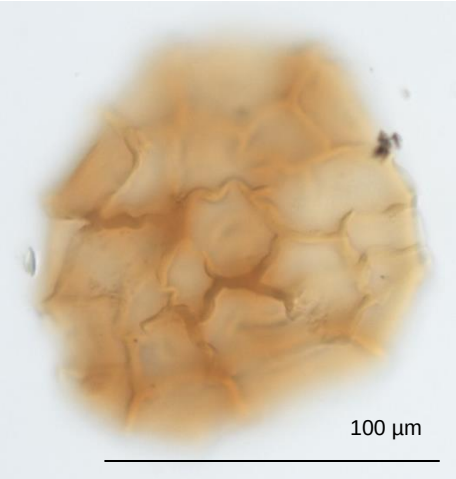


Figure 15: *Dictyotriletes muricatus* PF (7590).

Specimen 7590 (CHG8 90-104). Basal Westphalian A. Crag House Gill, Stainmore, England. Lateral-distal view. Distal focus showing reticulum with flexuous muri and arched coni on them. Lumina laevigate. 2N-60x.

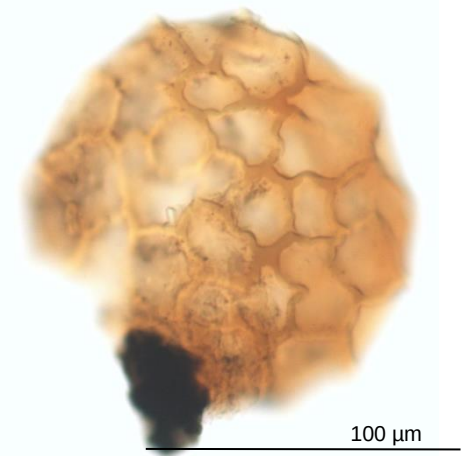


Figure 16: *Dictyotriletes muricatus* DF (7589).

Specimen 7589 (CHG8 90-8). Basal Westphalian A. Crag House Gill, Stainmore, Cumbria, England. Distal view. Distal focus showing reticulum with flexuous muri and laevigate lumina. 2N-60x.

2.9 *DISACCITES NON-STRIATITI* PANT, 1956

2.9.1 DIAGNOSIS

Bisaccate miospores (pollen grains). The two sacci are symmetrically placed with regard to the central body. The proximal exine of the central body is not striate. Proximal aperture (monolete, dilete, trilete) may or not be present (modified after Hart, 1965)

2.9.2 OTHER DESCRIPTIONS

Pant, 1954. Coquel, 1976.

2.9.3 SIZE

I-a: 17–164 µm (Hart, 1965)

2.9.4 REMARKS

Disaccites non-striatiti is a non-formal taxonomic group for bisaccate pollen grains without striae on the pollen body (Coquel, 1976), including all forms in the Infraturma DISACCIATRILETI (Leshik, 1956) and Infraturma DISACCITRILETI (Leshik, 1956) of the Subturma DISACCITES (Cookson, 1947). *Disaccites non-striatiti* comprises a large number of pollen genera and species, many of which are very important in the Early Permian. It is advisable not to use this taxonomic term anymore and instead use the appropriate species names (preservation allowing), in order to have a clear taxonomy of pre-pollen and pollen grains in the Upper Carboniferous. This would be helpful both for the understanding of the evolution of the Permian pollen flora and for the biostratigraphic zonation of the Carboniferous-Permian boundary.

2.9.5 RANGE AND LOCALITIES

RA Zone (Westphalian A) - Permian (Clayton et al., 1977). Middle Westphalian - Permian (Coquel, 1976). Upper Carboniferous - Mesozoic (Hart, 1965). Cosmopolitan.

Figure 17: *Disaccites non striatiti* MF (7204).

Specimen 7204 (NBM 995). NBM Zone. Stephanian C-D (Autunian). Lally, France. Lateral view. Median focus showing infra-reticulate sacci and laevigate proximal cappa. 2N-100x (oil).

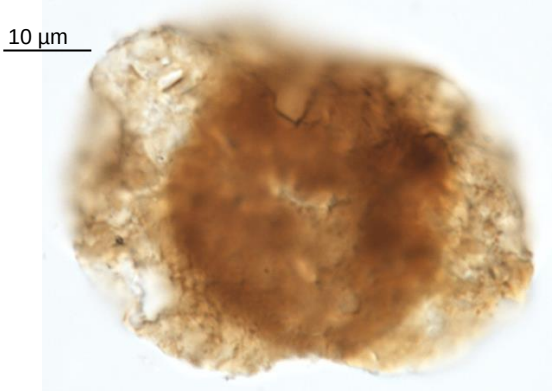


Figure 18: *Disaccites non striatiti* (7206).

Specimen 7206 (Vc 996). DS Zone. Autunian. Lally, France. Distal view. Median focus showing infra-reticulate sacci and laevigate spore body. 2N-100x (oil).

2.10 *DISACCITES STRIATITI* PANT, 1954

2.10.1 DIAGNOSIS

Bisaccate miospores (pollen grains). Two sacci in equatorial position, more often inclined towards the distal surface than the proximal, symmetrically placed with regard to the central body. Y-shaped mark usually indistinct. The two sacci are usually linked by a poorly defined thickening of the exine. The proximal cappa has striati, i.e. it is divided into ribs and striae, which are normally longitudinally directed. Rare forms may have their ribs and striae disoriented so that they run obliquely or even transversely (modified after Hart, 1965).

2.10.2 OTHER DESCRIPTIONS

Pant, 1954. Potonié, 1958 (German). Coquel, 1976.

2.10.3 SIZE

l-a: 20-185 µm (Hart, 1965).

2.10.4 REMARKS

The informal taxonomic term *Disaccites striatiti* includes all forms of bisaccate pollen grains with striated central body: Subturma DISACCITES (Cookson, 1947), Infraturma STRIATITI (Pant, 1956). *Disaccites striatiti* comprises a large number of pollen genera and species, many of which are very important in the Early Permian. It would be advisable not to use this taxonomic term anymore and instead, to use the appropriate species names, in order to have a clear taxonomy of pre-pollen and pollen grains in the Upper Carboniferous. This would be helpful both for the understanding of the evolution of the Permian pollen flora and for the biostratigraphic zonation of the Carboniferous-Permian boundary.

2.10.5 RANGE AND LOCALITIES

SL Zone (Westphalian C) - Permian (Clayton et al., 1977). Uppermost Carboniferous - Lower Jurassic (Hart, 1965). Cosmopolitan.

Figure 19: *Disaccites striatiti* (7205).

Specimen 7205 (8016 90-2). Autunian. Lally, France. Distal view. Distal focus showing infra-reticulate sacci. Pollen body with ill-defined proximal striae. N2-100x(oil).

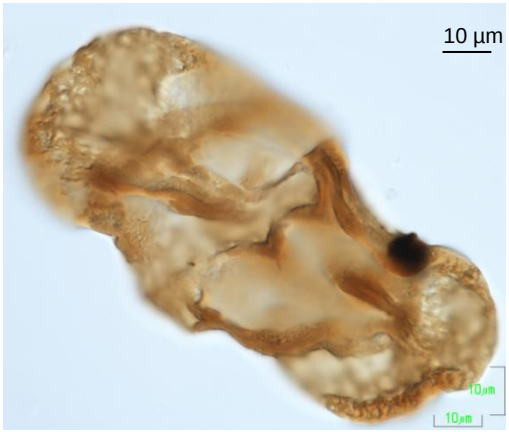


Figure 20: *Disaccites striatiti* (7208).

Specimen 7208 (8082 90-1). Autunian. Lally. Distal view? Distal focus? showing infra-reticulate sacci and ill-defined pollen body. Irregular exine thickenings and folds between the two sacci.

2.11 *ENDOSPORITES GLOBIFORMIS* (IBRAHIM) SCHOPF, WILSON AND BENTALL, 1944

2.11.1 DIAGNOSIS

Radial, trilete, pseudo-saccate miospores. Amb of pseudosaccus and body round to rounded triangular. Trilete mark distinct to indistinct, weakly ridged, straight or flexuous, extending from one-half to entire radius of body, although folds or other marks on the exoexine may appear to give an extension to the pseudosaccus margin. Body laevigate, slightly thicker than the pseudosaccus membrane, through which it shows distinctly. Body sometimes shows peripheral compression folds and may show a more or less distinctly darker peripheral zone, due to the separation of the exine layers for a short distance proximally from the equator of the body. Apical (interradial) papillae sometimes faintly visible. Pseudosaccus thin, appears granulate, or even finely microreticulate (granules visible at margin). Limbus 4–6 µm in width. Pseudosaccus often folded (modified after Smith and Butterworth, 1967).

2.11.2 SIZE

Overall equatorial diameter (maximum): 60–160 µm. Diameter of spore body: 30–70 µm.

2.11.3 REMARKS

When body/pseudosaccus ratio <50 %, species is assigned to *E. globiformis*. When this ratio exceeds 50%, the species will be assigned to *E. zonalis*.

2.11.4 RANGE AND LOCALITIES

Upper Westphalian A to Westphalian D (Smith and Butterworth, 1967; British Micropalaeontological Society. Palynology Group, 1984). Europe; USA; Canada; North Africa.

Figure 21: *Endosporites globiformis* DF (7506).

Specimen 7506. Distal focus showing finely granulate pseudosaccus and well-defined spore body. Exine irregularly folded. 2N-60x.

Figure 22: *Endosporites globiformis* PF (7506).

Specimen 7506. Proximal focus showing distinct trilete mark. Spore body presents a thin dark thickening at the equatorial edge. 2N-60x.

2.12 *FLORINITES JUNIOR* POTONIÉ AND KREMP, 1956

2.12.1 DIAGNOSIS

Radial, alete (vestigial trilete mark sometimes discernible), saccate pollen. Amb more or less oval, outline fairly smooth to very slightly wavy due to folding. Inner body distinct, with radius less than saccus radius, with ratio usually 3:4, sometimes less or more. Long axis CB conformable of long axis of the saccus. Saccus infra-reticulate with a laevigate or slightly granulate external ornament. Saccus and body fused at the distal pole, proximal surface of CB free of saccus. Folding typically occurs around the margins of the body. (modified after Potonié and Kremp, 1956).

2.12.2 SIZE

Overall equatorial diameter (maximum): 70-100 µm.

2.12.3 REMARKS

F. antiquus Schopf 1944 differs from *F. junior* in its relatively narrower saccus, which is not wider than the length of the central body radius (Potonié and Kremp, 1956).

2.12.4 RANGE AND LOCALITIES

Upper Westphalian B to Westphalian D (Potonié and Kremp, 1956). RA Zone (upper Westphalian A) to Westphalian D (British Micropalaeontological Society. Palynology Group, 1984). Northern hemisphere.

Figure 23: *Florinites junior* PF (8758).

Specimen 8758 (CSA 1231 90-63). Westphalian B. BGS Offshore Bh 74/13, Forth, Scotland. Proximal focus showing distinct spore body, with radius 1:2 than saccus radius, irregularly folded. Vestigial trilete mark distinct, opened. Folds occurring at the equatorial margin of the saccus. Saccus infrareticulate. 0-100x (oil).

Figure 24: *Florinites junior* DF (8758).

Specimen 8758 (CSA 1231 90-63). Westphalian B. BGS Offshore Bh 74/13, Forth, Scotland. Distal view. 1-Distal focus showing infrapunctate exine on distal surface. Note infrareticulation of the saccus. 0-100x (oil).

2.13 *GRANDISPORA ECHINATA* HACQUEBARD, 1957

2.13.1 DIAGNOSIS

Radial, trilete, camerate miospores. Amb rounded triangular. Trilete mark distinct, sutures straight, usually obscured by exine folds above the rays, up to 7 µm high, extending almost to the equator of the spore. Intexine thin and translucent, margin usually clearly defined. Proximal surface of exoexine is laevigate; distal and equatorial surfaces ornamented with galae or spines, rarely with cones. Ornamentation elements 1.5–2.5 µm high and 1–1.5 µm wide, spaced about 3 µm apart. Exoexine about 2 µm thick, finely infrapunctate (modified after Sullivan and Marshall, 1966).

2.13.2 SIZE

Overall equatorial diameter: 59–96 µm (mean 73 µm). Diameter of spore body: 42–76 µm (mean 58µm).

2.13.3 REMARKS

Grandispora spinosa has processes 2–8 µm long spaced 8–25 µm apart (Hoffmeister et al., 1955).

2.13.4 RANGE AND LOCALITIES

Mississippian (Hacuqebard, 1957). PL Zone (Lower Tournasian) - PU Zone (Lower Visean) (Clayton et al., 1977).
Cosmopolitan.

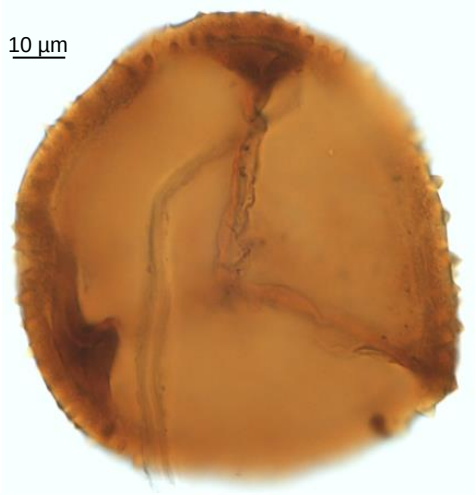


Figure 25: *Grandispora echinata* PF (8864).

Specimen 8864 (MPA 302 90-78). Pinskey, Gill Beds. Wygarth Gill Bh, Ravenstonedale, England. Proximal view. Proximal focus. Specimen showing distinct trilete mark accompanied by flexuous exine folds extending to the spore body margin where they fuse with equatorial radial thickenings. Proximal equatorial exine and radial thickenings infragranulate. 0-100x (oil).

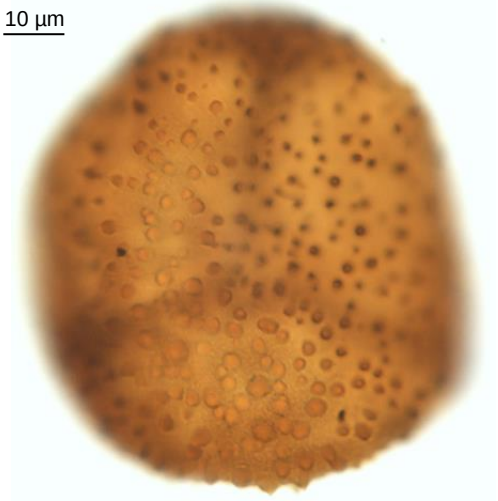


Figure 26: *Grandsipora echinata* DF (8864).

Specimen 8864 (MPA 302 90-78). Pinskey, Gill Beds. Wygarth Gill Bh, Ravenstonedale, England. Proximal view. Distal focus showing ornamented exine with dense galae and spinae, also projecting at the equator. Exine between galae infragranulate. 0-100x (oil).

2.14 *IBRAHIMISPORES BREVISPINOSUS* NEVES, 1961

2.14.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb rounded-triangular to subcircular. Trilete mark usually associated with dark, flexuous folds of the exine: approximately three quarters radius of the spores. Inner body indistinct. The ornamentation elements are short, hollow spines more or less uniform tapering to the sharply pointed, solid tip. Spines are thickened at the tips. Spines 6–10 µm high, 3-5 µm wide at the base and are densely spaced; forty to fifty elements occur at the equatorial outline (after Neves, 1961).

2.14.2 OTHER DESCRIPTIONS

Sullivan and Marshall, 1966.

2.14.3 SIZE

Overall equatorial diameter: 70–100 µm.

2.14.4 REMARKS

Raistrickia microhorrida (Horst) Potonié and Kremp 1955 is more circular in outline and the spines appear to be solid and without thickened tips.

2.14.5 RANGE AND LOCALITIES

Upper Visean - lower Westphalian A (*Triquitrites sinanii* Zone); British Micropalaeontological Society. Palynology Group, 1984).
Europe; Greenland; USA.

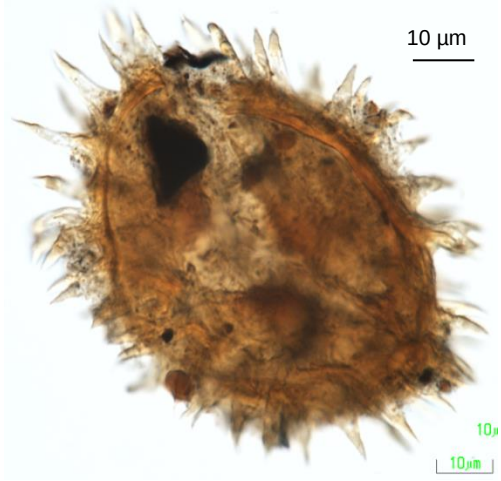


Figure 27: *Ibrahimispores brevispinosus* PF (8648).

Specimen 8648 (MPA30059 90-6). Shale below Faradau, House Sill. Argill Beck, Stainmore. Distal view. Proximal focus showing ill-defined opened trilete mark. Spines projecting at the equator. 2N-100x (oil).

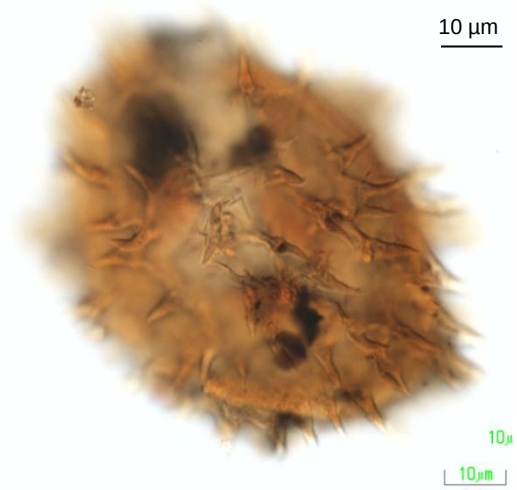


Figure 28: *Ibrahimispores brevispinosus* DF (8648).

Specimen 8648 (MPA30059 90-6). Shale below Faradau, House Sill. Argill Beck, Stainmore (Owens B Masterpack 3 Carboniferous Palynostratigraphy The Arctic to N Africa). Distal view. Distal focus showing distal ornament of spinae. Note solid thickened tip of the spines. 2N-100x (oil).

2.15 *LAEVIGATOSPORITES* SPP. (IBRAHIM) SCHOPF, WILSON AND BENTALL, 1944 (PLATE I, FIGS. 5–6)

2.15.1 DIAGNOSIS

Bilateral, monolete spores. Originally broadly bean-shaped; elongate oval in the plane of longitudinal symmetry, round or oval in the transverse plane. When compressed the spores tend to be folded variously depending on the size and morphology of the various specific types. Haptotypic structures consisting of a simple monolete linear suture, generally without lips specially distinguished, and usually continued for more than half the total length of the spore. The suture may be very inconspicuous if it coincides in position with the edge of a compressed spore, or with the axis of a longitudinal fold. Ends of very delicate arcuate ridges are sometimes distinguishable flaring laterally from both ends of the suture line. Spore coat varying somewhat in thickness relative to the other dimensions; the spore coat is oftentimes thin and translucent. The internal cavity is sometimes more "bean-shaped" than the external outline due to internal thickening of the spore coat in the central proximal region. Exine smooth to finely punctate, apiculate or rugose; rarely showing pronounced reticulation or strong apiculae (Schopf et al., 1944).

2.15.2 SIZE

Spores of various species range from about 20 to over 130 µm in their long dimensions.

2.15.3 RANGE AND LOCALITIES

Upper Namurian A (SO zone)–Permian (Clayton, 1977).
Cosmopolitan.

Figure 29: *Laevigatosporites vulgaris*? (8110).

Specimen 8110. *Listeri* Marine Band. Langsettian Substage (upper Bashkirian) Argill Beck, Stainmore. Scotland. Distal view. Median focus showing monolete mark on proximal surface, exine fold on distal surface. 0-100x (oil).

Figure 30: *Laevigatosporites* spp. (8113).

Specimen 8113. Listeri Marine Band. Langsettian Substage (upper Bashkirian) Argill Beck, Stainmore. Scotland. Lateral view?. Note exine fold probably associated with suture. 0-100x (oil).

2.16 *LEIOTRILETES TUMIDUS* (BUTTERWORTH AND WILLIAMS, 1958)

2.16.1 DIAGNOSIS

Radial, trilete miospores. Amb subtriangular, sides straight or convex, angles rounded. Trilete mark distinct, simple, sutures straight, extending two third of radius or greater, frequently reaching almost to equator. Prominent folds, often of unequal length, frequently accompany the laesurae. Inner body indistinct. Exine less than 2 µm in thickness, laevigate. Proximal hemisphere tumid (modified after Smith and Butterworth, 1967).

2.16.2 OTHER DESCRIPTIONS

Butterworth and Williams, 1958. Playford, 2015.

2.16.3 SIZE

Overall equatorial diameter: 34–52 µm (mean 42 µm).

2.16.4 REMARKS

L. inermis (Walts) Ishchenko is very similar but lacks the characteristic folds. *L. ornatus* Ishchenko 1956 is of comparable size (32–63 µm, mean 46 µm) and shape, but differs in possessing prominent lips. *L. sphaerotriangulus* (Loose) Potonié and Kremp differs in its shape, thicker exine, and in the absence of folds associated with the laesurae. *Granulatisporites triconvexus* Staplin 1960, with a size range of 35-44 µm, may show folding along the laesurae, but is very finely granulate under oil (Smith and Butterworth, 1967).

2.16.5 RANGE AND LOCALITIES

Visean to Namurian (Smith and Butterworth, 1967). Visean to Westphalian A (British Micropalaeontological Society Palynology Group, 1984).
Northern hemisphere, Australia (Visean).

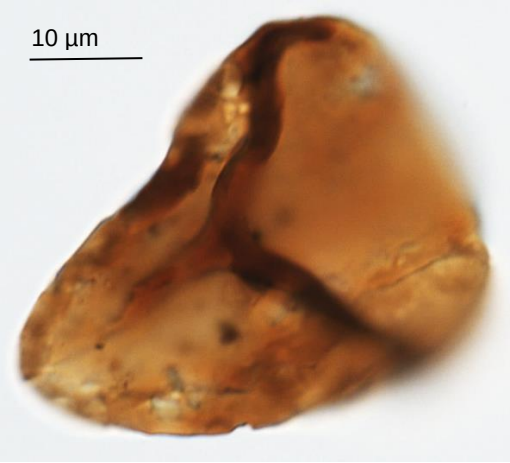


Figure 31: *Leiotriletes tumidus* PF (6377).

Specimen 6377 (MPA 12543/17). Mid Carboniferous boundary. Stone Head Beck, Cowling, West Yorkshire, England. Proximal view. Proximal focus showing distinct trilete mark accompanied by flexuous exine folds extending to the equator. Exine laevigate, irregularly folded, in particular on the equatorial margin. 0-100x (oil).

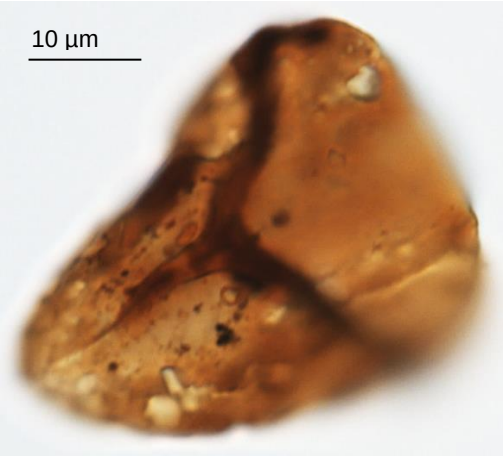


Figure 32: *Leiotriletes tumidus* DF (6377).

Specimen 6377 (MPA 12543/17). Mid Carboniferous boundary. Stone Head Beck, Cowling, West Yorkshire, England (Varker et al., 1991). Proximal view. Median focus showing irregular corrosion pits on the exine. 0-100x (oil).

2.17 *LYCOSPORA SUBTRIQUETRA* (LUBER) POTONIÉ AND KREMP, 1956 (PLATE II, FIGS. 2A-B)

2.17.1 DIAGNOSIS

Radial, trilete, cingulizonate miospores. Amb circular, outline smooth. Trilete mark distinct, or accompanied by low narrow flexuous, exoexinal folds which extend decreasing in height to the equatorial margin. Sutures extend to inner body margin. Intexine forming rounded triangular inner body. Exoexine extended in the equatorial plane to form broad cingulum. Typically, prominent verrucate and granulate sculpture on the distal surface. Some dispersed specimens have a zona that is either reduced or seems almost absent. Based on this observation it seems possible that either taphonomy or sample preparation may play a role in the preservation of this feature (modified after Bek, 2012).

2.17.2 SIZE

Overall equatorial diameter: 40 µm in average.

2.17.3 RANGE AND LOCALITIES

SO (upper Namurian A) to RA (upper Westphalian A) zones (Clayton et al., 1977). Middle Arnsbergian (lower Namurian) to Westphalian A (British Micropalaeontological Society Palynology Group, 1984).
Ex U.S.S.R.; China; Europe; North Africa.

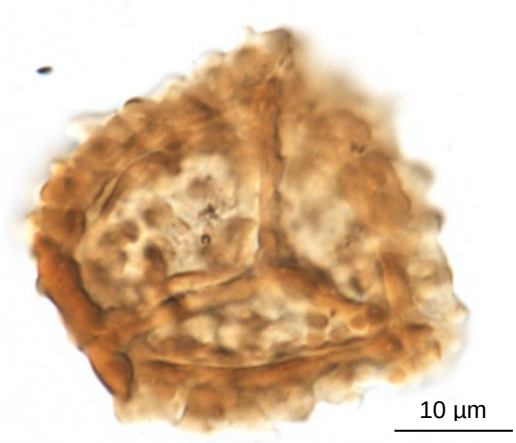


Figure 33: *Lycospora subtriquetra* PF (8743).

Specimen 8743 (A25 90-27). Shale above Mousegill Marine Beds. Kinderscoutian Substage. Argill Beck, Stainmore, England. Distal view. Proximal focus showing distinct trilete mark accompanied by flexuous exinal folds. Note distinct inner body and cingulum at the equatorial margin. 2N-100x (oil).

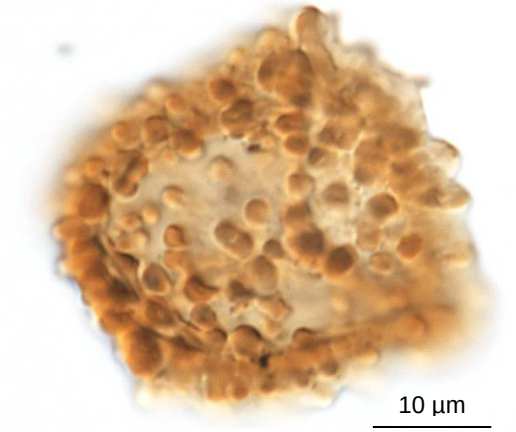


Figure 34: *Lycospora subtriquetra* DF (8743).

Specimen 8743 (A25 90-27). Shale above Mousegill Marine Beds. Kinderscoutian Substage. Argill Beck, Stainmore, England. Distal view. Distal focus showing verrucose ornament on distal surface. 2N-100x (oil).

2.18 *MOOREISPORITES FUSTIS* (NEVES, 1958) (PLATE III, FIGS. 1A-B)

2.18.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb triangular, sides straight to moderately concave, angles narrowly rounded. Trilete mark distinct, sutures extending about one-half of spore radius, flexuous, frequently open. Inner body usually indistinct. Triangular angles with bacula, up to 16 µm long, 5–9 µm wide, branching; bases frequently joined to form a thickened pad either on the amb or slightly towards the distal pole; similar bacula and verrucae present on distal and proximal surface of the exine; particularly at the distal pole. Exine approximately 2 µm thick, occasionally folded (after Smith and Butterworth, 1967).

2.18.2 SIZE

Overall equatorial diameter (excluding baculae): 40–90 µm.

2.18.3 RANGE AND LOCALITIES

?Namurian to Westphalian B (Smith and Butterworth, 1958). Europe. USA.

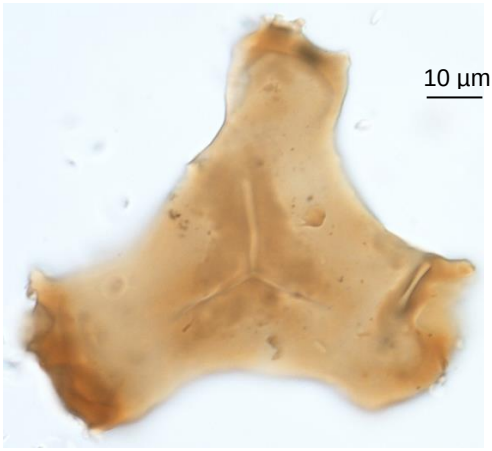


Figure 35: *Mooreisporites fustis* PF (8660).

Specimen 8660 (A25-4). Shales above Mousegill Marine Band. Kinderscoutian Substage. Argill Beck, Stainmore, England. Proximal view. Proximal focus showing distinct trilete mark, sutures opened, straight, accompanied by broad labra. Spore body indistinct. Exine laevigate. 0-100x (oil).

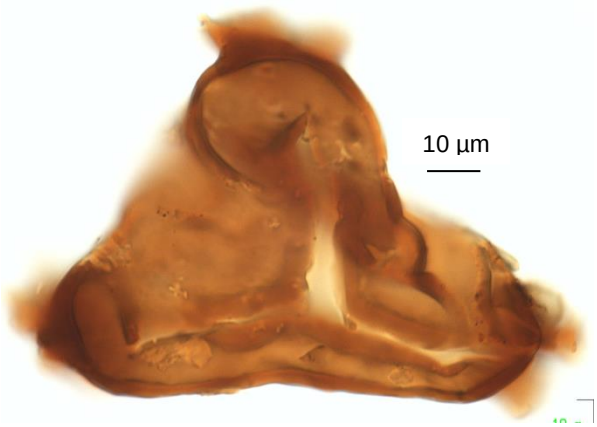


Figure 36: *Mooreisporites fustis* PF (8658).

Specimen 8658 (MPA 4578 90-1). Passage Group. Diddup Bh, Ayrshire, Scotland. Proximal view. Proximal focus showing distinct trilete mark, sutures opened, straight, accompanied by wide labra. Exine irregularly folded, particularly on the equatorial margin where folds may be fused with curvaturae. Exine laevigate to infragranulate. 0-100x (oil)

2.19 *MOOREISPORITES TRIGALLERUS* NEVES, 1961 (PLATE III, FIGS. 2A-B)

2.19.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb triangular, sides straight to moderately concave, apices expanded due to the projecting baculae. Trilete mark distinct, sutures short, usually accompanied by thin lips. Inner body usually indistinct. Exine ornamented overall with small, scattered coni. At the apices of the spore body short baculae are developed, size 8–10 µm high; these elements are often fused laterally in the lower part (after Neves, 1961).

2.19.2 SIZE

Overall equatorial diameter (excluding baculae): 55–80 µm.

2.19.3 RANGE AND LOCALITIES

Namurian A (Neves, 1961). Middle Pendleian (lower Namurian)–Kinderscoutian (upper Namurian; British Micropalaeontological Society Palynology Group, 1984). Europe, USA.

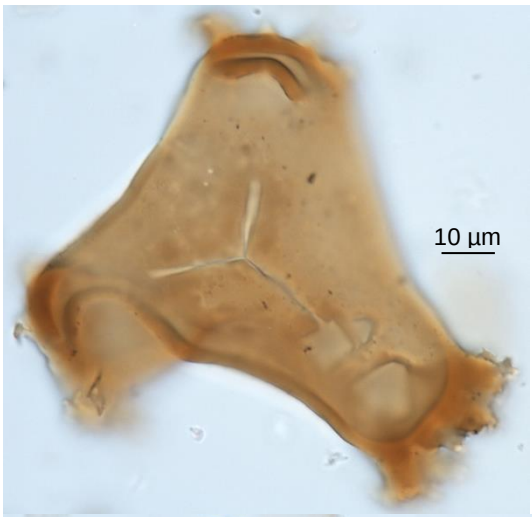


Figure 37: *Mooreisporites trigallerus* PF (8659).

Specimen 8659 (M156-93). Shales above Mousegill Marine Band. Mousegill Beck, Stainmore, England. Proximal view. Proximal focus showing distinct trilete mark. Sutures slightly opened, extending half of spore radius. Equatorial margin of inner body distinct, fusing with irregular exine folds. Exine laevigate. 0-100x (oil).

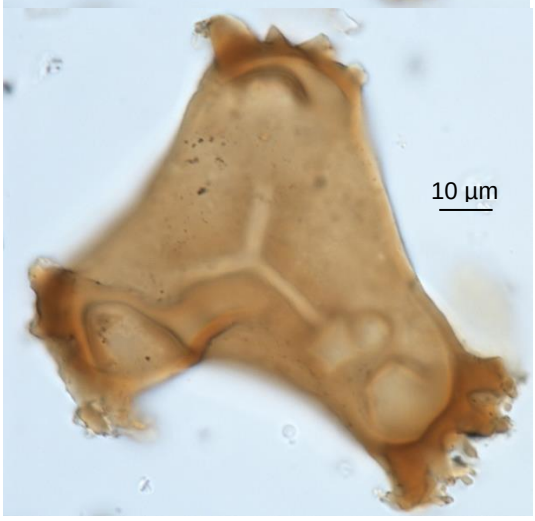


Figure 38: *Mooreisporites trigallerus* DF (8659).

Specimen 8659 (M156-93). Shales above Mousegill Marine Band. Mousegill Beck, Stainmore, England. Proximal view. Distal focus showing laevigate distal pole. Baculae are confined to radial equatorial margin. 0-100x (oil).

2.20 *MUROSPORA AURITA* (WALTZ) PLAYFORD, 1962

2.20.1 DIAGNOSIS

Radial, trilete, cingulate miospores. Amb subtriangular to irregular, margin smooth to undulating. Trilete mark distinct, sutures straight, reaching spore body margin or almost so, bordered by more or less distinct, smooth, broad, slightly elevated lips, individually 3.5–6.5 µm wide. Spore body well defined, subtriangular, with convex sides and pointed or rounded apices; laevigate. Cingulum laevigate; uniform, showing marked variation in width and/or thickness. Overlapping of the cingulum on spore body is not a constant attribute. Cingulate thickenings peripheral, commonly situated at one or more of apices, but placement often highly irregular; up to five in number on any one specimen (modified after Playford, 1962).

2.20.2 OTHER DESCRIPTIONS

Hibbert and Lacey, 1969.

2.20.3 SIZE

Overall equatorial diameter: 45–94 µm (mean 68 µm).

2.20.4 REMARKS

M. varia Staplin 1960 is conspecific with *M. aurita*. The same applies to *Cincturasporites auritus* (Waltz) Hacquebard and Barss 1957 and *C. irregularis* Hacquebard and Barss 1957, thought the genus *Murospora* is distinct from *Cincturasporites* by the fact that the overlap of the cingulum is not a constant feature. *M. intorta* (Waltz) Playford 1962 shows similar cingulate variation to *M. aurita* but is distinguishable in having simple laesurae, together with a spore body which in equatorial outline is decidedly less roundly triangular. The cingulum of *Zonotriletes sulcatus* Waltz (in Lüber and Waltz 1938) shows distinct, concentric furrowing. *Zonotriletes turgidus* Waltz (in Lüber and Waltz, 1941) is subcircular and has a narrow, uniform cingulum (Playford, 1962).

2.20.5 RANGE AND LOCALITIES

Upper Mississippian (Playford, 1962).
Barents Sea; ex U.S.S.R.; China; Canada.

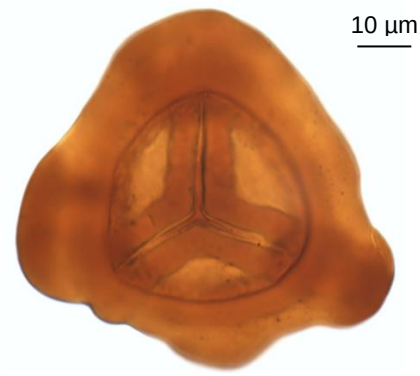


Figure 39: *Murospora aurita* PF (8977).

Specimen 8977 (Matt 91-5). Mattson Formation. Viséan. South Nahanni River, NW Canada. Distal view. Proximal focus. Note broad cingulum with irregular thickenings, mostly in radial positions. 0-100x (oil).

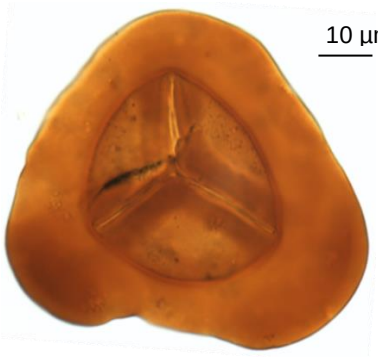


Figure 40: *Murospora aurita* MF (8980).

Specimen 8980 (Matt 91-94). Mattson Formation. Viséan. South Nahanni River, NW Canada. Proximal view. Median focus. 0-100x (oil).

10 µm

2.22 *MUROSPORA MARGODENTATA* BEJU, 1970

2.22.1 DIAGNOSIS

Radial, trilete, cingulate miospores. Amb subtriangular to subcircular, margin undulating to irregular. Trilete mark distinct to indistinct, sutures straight, simple or accompanied by low, broad labra, reaching the spore body margin or almost so. Spore body well defined, subtriangular to subcircular, with convex to straight sides and rounded apices; laevigate. Cingulum showing marked variation in width and/or thickness. Thickening may occur up to 15 µm high, 30 µm in width; the largest elements usually show crenulate tips. Elements may be just on radial positions (auriculae) or irregularly disposed. Cingulum in interradial positions commonly 3–5 µm wide. Exine may be irregularly folded and thickened on both proximal and distal surface; laevigate.

2.22.2 SIZE

Overall equatorial diameter (maximum): 40–80µm.

2.22.3 REMARKS

M. margodentata differs from *Tripartites vetustus* Shemel 1950 by having auriculae with more crenulate tips and with no obvious inter-radial thickenings connecting them. Auriculae lack striate pattern that is present in *T. vetustus*.

2.22.4 RANGE AND LOCALITIES

Upper NM zone (ME sub-zone) to lower VF zone (upper Asbian to lower Brigantian, Visean; British Micropalaeontological Society. Palynology Group, 1984).
Western Europe.

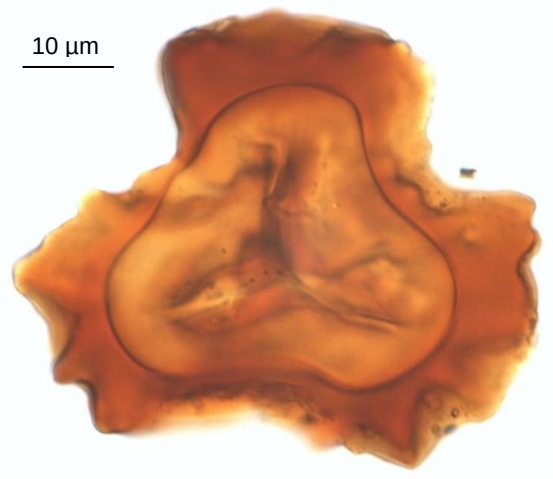


Figure 41: *Murospora margodentata* MF (8675).

Specimen 8675 (MPA 18247). Shale below Cove Lower Marine Band. Cove Harbour, Berwickshire, Scotland. Distal? view. Median focus showing distinct triangular spore body with distinct trilete mark. Sutures straight, accompanied by low broad labra. Cingulum laevigate, presenting thickenings mainly in radial positions, with crenulate tips (resembling auriculae). Cingulum variously thickened also on the inner portion in interradial positions. 0-100x (oil).

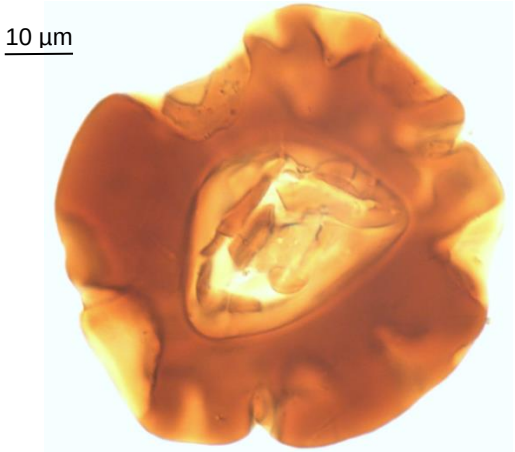


Figure 42: *Murospora margodentata* MF (8676).

Specimen 8676 (MPA 18247 90-7). Shale below Cove Lower Marine Band. Cove Harbour, Berwickshire, Scotland. Proximal? view. Median focus showing cingulum with an irregular disposal of crenulate thickenings. Exine laevigate, variously thickened on proximal? surface. 0-100x (oil).

2.23 *PEROTRILITES TESSELATUS* (STAPLIN) NEVILLE IN NEVES ET AL., 1973

2.23.1 DIAGNOSIS

Radial, trilete, camerate miospores. Amb subcircular to irregular due to strong folding of the exine. Trilete mark usually indistinct, when visible sutures simple, extending about half to two-thirds radius of the spore body. Spore body distinct, darker than exoexine, circular to oval, frequently folded. Intexine enclosed by the exoexine which appears to be attached to both surfaces; the equatorial margin of the latter being often incised giving a lobate appearance due to folding. Frequently, the exoexine projects beyond the spore body on one side only, due to compression. The major line of exoexine attachment may be up to half spore body radius from the spore body margin on both surfaces. Over the remainder of the distal surface, the exoexine is closely appressed to the intexine and possesses wrinkles and folds which vary greatly in intensity and amplitude on individual specimens and between specimens. On the proximal surface the exoexine appears only lightly folded (modified from Neves et al., 1973).

2.23.2 SIZE

Overall equatorial diameter: 50–120 µm, spore body 40–110 µm.

2.23.3 RANGE AND LOCALITIES

TC to middle VF zones (Visean; Clayton et al., 1977).
Cosmopolitan.

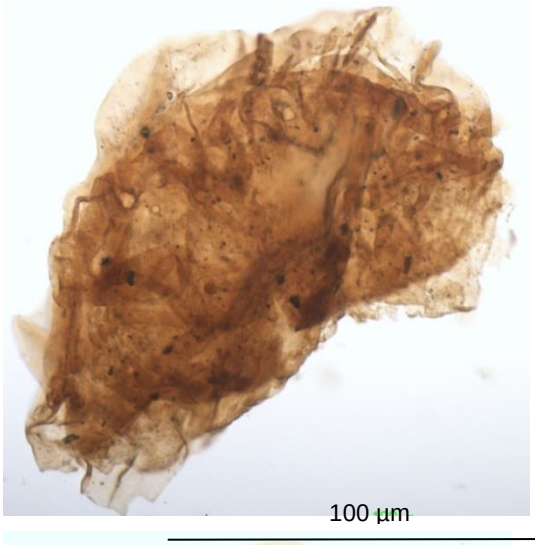


Figure 43: *Perotrilites tesselatus* (8188).

Specimen 8188 (Matt 90-10). Mattson Formation. Viséan. South Nahanni River, NW Canada. Note strong exoexine and (probably) intexine folding resulting in irregular spore shape. Exine laevigate. 0-60x.

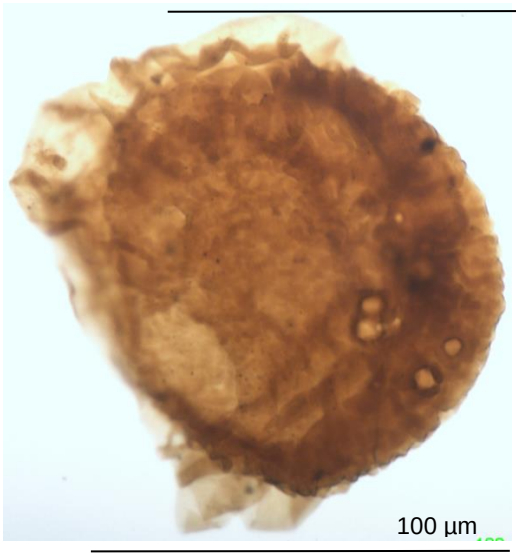


Figure 44: *Perotrilites tesselatus* (8189).

Specimen 8189 (Matt 90-51). Mattson Formation. Viséan. South Nahanni River, NW Canada. Distal view? Proximal focus. Note crinkly aspect of the folded exoexine and (probably) of the intexine. 0-60x.

2.24 *POTONIÉISPORITES DELICATUS* PLAYFORD, 1962

2.24.1 DIAGNOSIS

Radial, trilete, cingulate miospores. Amb subtriangular, conformable with spore-body outline. Trilete mark distinct, sutures simple, straight, length slightly less than spore-body radius. Spore body laevigate to infrapunctate; subtriangular with rounded apices and markedly concave to slightly convex sides. Equatorial girdle entirely laevigate; abruptly and uniformly differentiated into a prominent, dark, thickened, inner part and a thin, outer, diaphanous zone which is frequently folded and torn. Approximately half to two-thirds of the total girdle width is occupied by the inner thickened portion (modified after Playford, 1962).

2.24.2 SIZE

Overall equatorial diameter: 50–70 µm. Diameter of spore body: 23–33 µm (mean 27 µm).

2.24.3 REMARKS

P. bizonales Artüz 1957 (p. 254; pl. 6, fig. 47) differs from *P. delicatus* in possessing longer laesurae and a relatively broader outer membranous zone. *Hymenozonotriletes concavus* Ishchenko 1956 (p.63; pl. 12, fig. 134) has a much larger spore body together with somewhat irregular differentiation of the equatorial girdle.

2.24.4 RANGE AND LOCALITIES

Upper TC (lower Visean) - SO (upper Namurian A) Zone (Clayton et al., 1977; Lindström, 2003).

Europe; Barents Sea; USA; Canada.

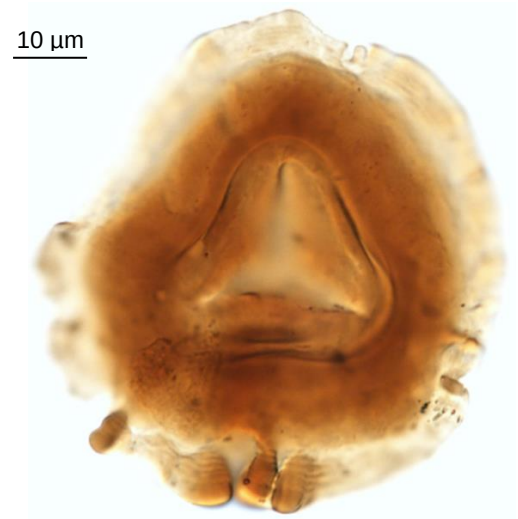


Figure 45: *Potoniéisporites delicatus* MF (7923).

Specimen 7923 (Matt 90-402). Mattson Formation. Viséan. South Nahanni River, NW Canada. Distal view. Median focus. Note characteristic radial folds in the outer portion of the cingulum. 2N-100x (oil).

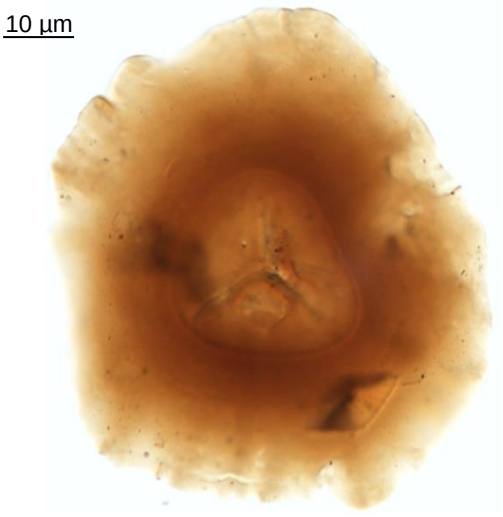


Figure 46: *Potoniéisporites delicatus* DF (7924).

Specimen 7924 (Matt 90-425). Mattson Formation. Viséan. South Nahanni River, NW Canada. Distal view. Distal focus. Note minor separation occurring between inner body and exine (thin white line). 0-100x (oil).

2.25 *PUNCTATISPORITES SINUATUS* (ARTÜZ) NEVES, 1961 (PLATE IV, FIGS. 3A-B)

2.25.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb circular to subcircular, margin smooth. Trilete mark distinct: sutures simple or slightly ridged, sometimes slightly open, extending three quarters of he radius. Exine laevigate and with fine infra-sculpture up to 5 µm in thickness, usually highly folded. Characteristically the folds are broad and situated around the periphery of the spore (forming a dark colored, structureless girdle zone, 15–17 µm abroad) but they sometimes follow the laesurae, when they give the appearance of broad lips; occasionally the exine is thrown into low, broad, sinuous corrugations in addition to marginal folds (modified after Smith and Butterworth, 1967).

2.25.2 SIZE

Overall equatorial diameter: 80–150 µm.

2.25.3 RANGE AND LOCALITIES

Namurian A to Westphalian A (Smith and Butterworth, 1967; Clayton et al., 1977; British Micropalaeontological Society. Palynology Group, 1984). Namurian C - Lower Westphalian B of France (Coquel, 1974). Western Europe. USA.

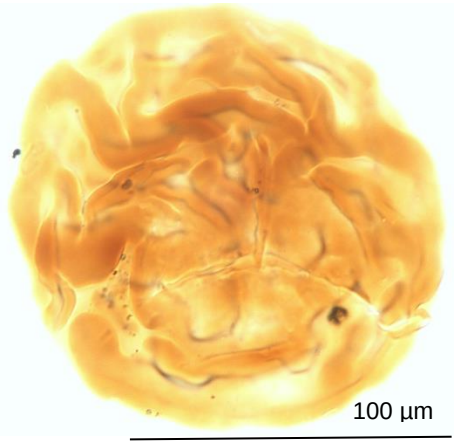


Figure 47: *Punctatisporites sinuatus* PF (8670).

Specimen 8670 (T96 91-4). Shale below Swinstone House Marine Band. Mousegill Beck, Stainmore, England. Proximal view. Proximal focus showing distinct trilete mark, sutures opened. Exine folds accompanying the laesurae. Exine laevigate. 0-60x.

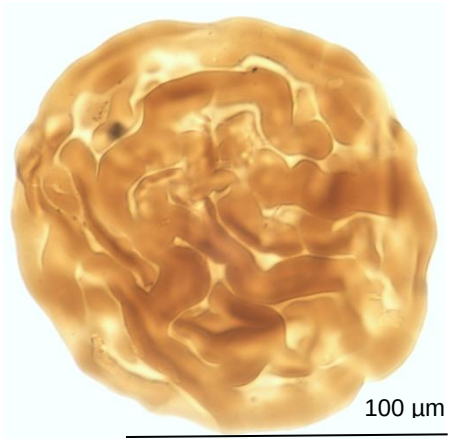


Figure 48: *Punctatisporites sinuatus* DF (8670).

Specimen 8670 (T96 91-4). Shale below Swinstone House Marine Band. Mousegill Beck, Stainmore, England. Proximal view. Distal focus showing distal ornament of exine folds. Exine laevigate. 0-60x.

2.26 *PUNCTATOSPORITES GRANIFER* (POTONIÉ AND KREMP) ALPERN AND DOUBINGER, 1973

2.26.1 DIAGNOSIS

Monolete, acamerate miospores. Shape in polar view, oval to near circular; in equatorial longitudinal view, the proximal profile is more or less flat to convex, distal profile convex. Laesura simple, straight, curved, or flexed, and distinct, but quite often not seen in equatorial view, or when spore is viewed from distal surface; length greater than one-half of the longest dimension, often reaching nearly to the equator. In one assemblage about 10% showed incipient trilete condition. Grana about 0.5 µm in diameter, apices under oil immersion appear somewhat pointed; granulate ornament varies in degree of prominence; in some forms the exine appears almost laevigate at low powers of magnification. Exine relatively thick. Folds rare. (after Smith and Butterworth, 1967)

2.26.2 OTHER DESCRIPTIONS

Potonié and Kremp, 1956 (German).

2.26.3 SIZE

Overall equatorial diameter: 20–50 µm.

2.26.4 RANGE AND LOCALITIES

Westphalian C and D (Smith and Butterworth, 1967).

Europe; Arabia; Oman; North Africa; USA; Canada; China?

Figure 49: *Punctatosporites granifer* PF (7950).

Specimen 7950 (20 90-10). Bristol Coalfield. Westphalian D. Bristol, England. Lateral view. Proximal focus showing distinct monolete mark and finely granulate exine. 0-100x (oil).

Figure 50: *Punctatosporites granifer* DF (7950).

Specimen 7950 (20 90-10). Bristol Coalfield. Westphalian D. Bristol, England. Lateral view. Median focus showing granules on exine. 0-100x (oil).

2.27 *RAISTRICKIA NIGRA* LOVE, 1960 (PLATE II, FIGS. 1A-B)

2.27.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb circular to rounded triangular. Trilete mark distinct; sutures straight, simple, extending for half of the radius of the spore. Inner body obscured. Exine 3-4 µm thick, laevigate, but may be pitted due to corrosion. Exine ornamented with broadly rounded or blunted elements 2–7 µm high and wide. Ornamentation fairly well dispersed, 3–7 µm apart, mainly confined to the distal surface, but cones and bacula are often present in extra-tectal areas of the proximal surface. 15–17 baculae on any circumference spaced with room for one or two more between any adjacent pair. Projections occasionally coalescent at bases, but normally discrete. Exine between baculae (and of contact faces) laevigate. Secondary folds absent (modified after Sullivan and Marshall, 1966).

2.27.2 SIZE

Overall equatorial diameter (excluding baculae): 50–70µm.

2.27.3 RANGE AND LOCALITIES

NM Zone (upper Visean) - NC Zone (lower Namurian) (Clayton et al., 1977). Asbian (upper Visean) - Pendleian (lower Namurian) (British Micropalaeontological Society. Palynology Group, 1984).
Western Europe; Barents Sea; Australia; China.

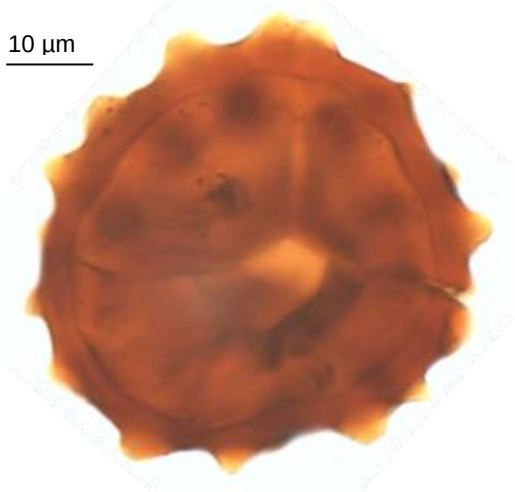


Figure 51: *Raistrickia nigra* PF (8721).

Specimen 8721 (MPA 9158 90-1). Shales below Hurlet Limestone. Brigantian. Hurlet Bh, Midlothian, Scotland. Distal view. Proximal focus showing laevigate spore body; trilete mark distinct. Baculae projecting at the equator. 0-100x (oil).

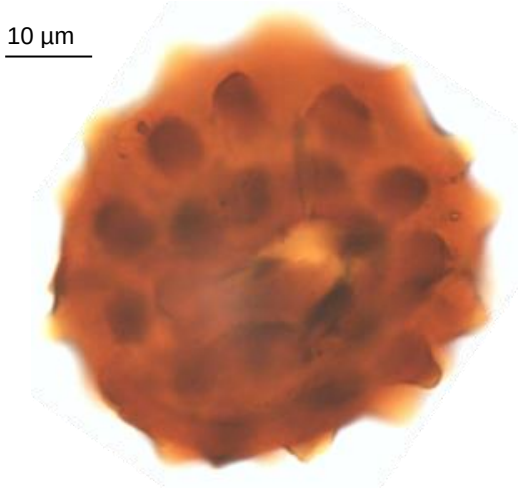


Figure 52: *Raistrickia nigra* DF (8721).

Specimen 8721 (MPA 9158 90-1). Shales below Hurlet Limestone. Brigantian. Hurlet Bh, Midlothian, Scotland. Distal view. Distal focus. 0-100x (oil).

2.28 *RAISTRICKIA SAETOSA* (LOOSE) SCHOPF, WILSON AND BENTALL, 1944 (PLATE II, FIGS. 4A-B)

2.28.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb round to oval. Trilete mark usually indistinct, concealed by ornament. Sutures, when discernible, simple, straight, extending to two-thirds of the total radius. Inner body indistinct. Exine mostly covered by baculae whose length depends on spore size but may reach 14 µm in large specimens. Bases and tips of baculae sometimes expanded; maximum width seldom exceeds 5 µm; apices usually truncate, apiculate or cleaved, but may be rounded. The majority of the baculae is of the same size and form on any one individual. Surface of exine and baculae laevigate. Exine moderately thick; major compression folds usually absent (modified after Smith and Butterworth, 1967).

2.28.2 SIZE

Overall equatorial diameter (including baculae): 70–80 µm.

2.28.3 RANGE AND LOCALITIES

Westphalian A to D (Smith and Butterworth, 1967). Yeadonian to Westphalian D (British Micropalaeontological Society. Palynology Group, 1984). Cosmopolitan.

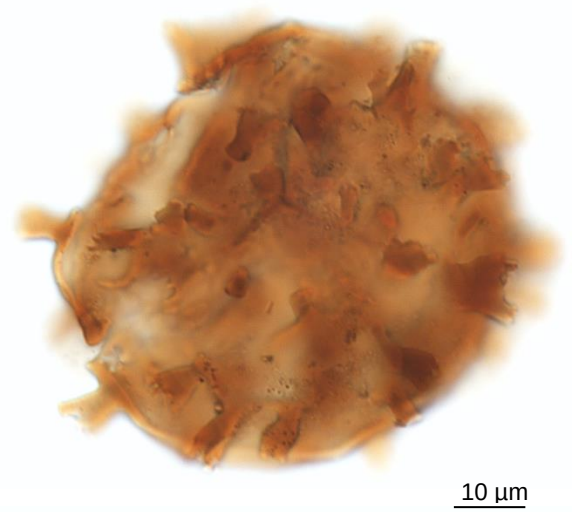


Figure 53: *Raistrickia saetosa* PF (7408).

Specimen 7408 (MPA 4578 90-3). Passage Group. Diddup Bh, Ayrshire, Scotland. Proximal view. Proximal focus showing distinct trilete mark, sutures simple, straight, extending half spore radius. Exine laevigate with scattered apiculate or cleaved baculae. 0-100x (oil).

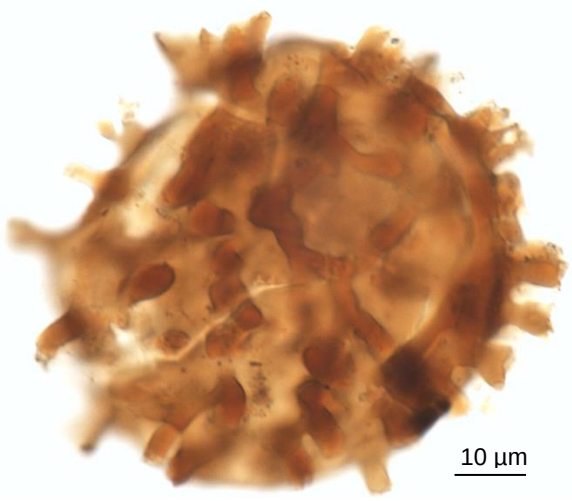


Figure 54: *Raistrickia saetosa* DF (7408).

Specimen 7408 (MPA 4578 90-3). Passage Group. Diddup Bh, Ayrshire, Scotland. Distal focus showing denser baculate ornamentation. Baculae projecting at the equatorial margin. 0-100x (oil).

2.29 *RETICULATISPORITES POLYGONALIS* (IBRAHIM) SMITH & BUTTERWORTH, 1967

2.29.1 DIAGNOSIS

Radial, trilete, cingulizonate miospores. Amb more or less polygonal in polar compression, but shape very variable due to oblique compression and folding; outline smooth and undulate, due to radial thickenings. Trilete mark usually distinct, sutures simple, or if ridged, elevation slight; extending one half to two thirds of radius. Intexine forming rounded inner body. Two zones of cingulum clearly defined, the inner broader than the outer zone. The degree of separation of these thickened zones varies. Exine ornament on distal surface prominent, but reduced proximally; pattern varies in detail but distally consists essentially of a single triangle, or a more or less polygonal structure formed by the bands which connect to the cingulum at inter-radial positions by three prominent muri (reticulate pattern). Width of distal bands 4–10 µm; width varies in any individual. Proximally three bands arising in radial positions pass poleward from the cingulum to meet the laesurae; bands of thickening may also pass towards the proximal pole for short distances from other positions on the cingulum. Exine laevigate or scabrate, moderately thick (modified after Potonié and Kremp, 1955 fide Smith and Butterworth, 1967).

2.29.2 SIZE

Overall equatorial diameter: 80–110 µm.

2.29.3 REMARKS

R. polygonalis differs from *R. corporeus* (Loose) Neves 1964 in being somewhat larger and in possessing a distal ornament which does not form a reticulate pattern and from *R. carnosus* in being more or less polygonal rather than round in shape, in lacking the involute margin, and in the narrower inner zone of the cingulum (Smith and Butterworth, 1967).

2.29.4 RANGE AND LOCALITIES

Westph. A to lowest C (Smith and Butterworth, 1967). Upper Visean to lowest Westph. C (British Micropalaeontological Society Palynology Group, 1984). Europe; Canada; USA; Arabia.

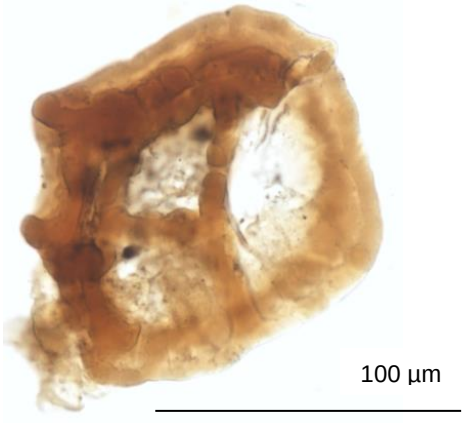


Figure 55: *Reticulatisporites polygonalis* DF (7943).

Specimen 7943 (CHG8 90-10). Earliest Westphalian A. Craghouse Gill, Stainmore, England. Proximo-lateral view. Distal focus showing reticulate polygonal ornament on distal surface. Broad muri define a polygonal area. Muri extending to the outer portion of cingulum at least in three positions. Cingulum bizonate: inner portion thicker, wider. Minor separation between the two portions of cingulum. 0-60x.

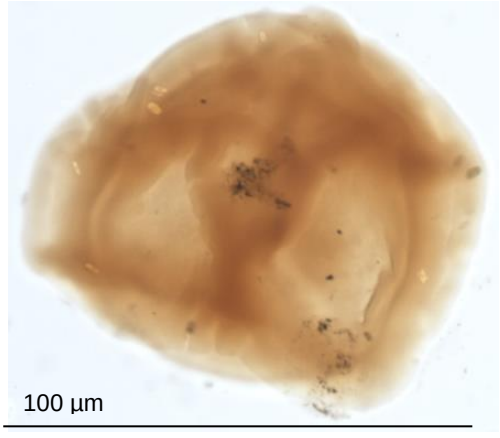


Figure 56: *Reticulatisporites polygonalis* DF (7945).

Specimen 7945 (Th 72-75 90-9). Earliest Westphalian A. Throckley Bh, NE England. Proximal view. Distal focus. N2-60x

2.30 *RETUSOTRILETES INCOHATUS* SULLIVAN 1964 (PLATE I, FIGS. 4A-B)

2.30.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb circular to subcircular. Trilete mark distinct, sutures straight, extending one-half to three quarters of spore body, with fine lips. Contact areas depressed, delimited by perfect or imperfect curvaturae. Spore body obscure. Exine infragranulate (modified after Duénas and Césari, 2005).

2.30.2 SIZE

Overall equatorial diameter: 30–65 µm.

2.30.3 REMARKS

R. incohatus has a thicker exine and less prominent ornament than *Apiculiretusispora multiseta*. It is smaller than *A. brandtii* Steel (1964, pp. 8–10, fig. 2, pl. 1, figs. 6–10), which has a thinner exine (Butterworth et al., 1967).

2.30.4 RANGE AND LOCALITIES

Upper Fammenian - lower Visean (PU Zone; Clayton et al., 1977).
Europe; ex U.S.S.R.; China; North Africa; Middle East; America.

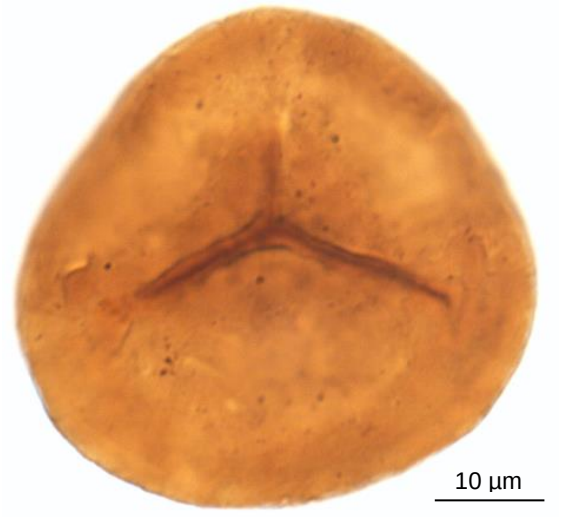


Figure 57: *Retusotriletes incohatus* PF (8996).

Specimen 8996 (MPA 7530 90-29). Basement Beds. Caldow Low Bh., Derby, England. Distal view. Proximal focus showing distinct trilete mark, extending half of spore radius. Sutures straight, accompanied by low, narrow labra. Exine infrapunctate. 0-100x (oil).

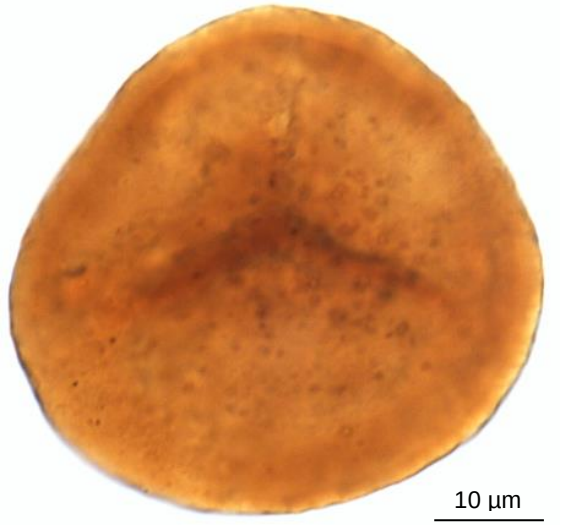


Figure 58: *Retusotriletes incohatus* DF (8996).

Specimen 8996 (MPA 7530 90-29). Basement Beds. Caldow Low Bh., Derby, England. Distal view. Distal focus showing infrapunctate exine. 0-100x (oil).

2.31 *TRIPARITITES DISTINCTUS* WILLIAMS (IN NEVES ET AL., 1973).

2.31.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb triangular with concave or occasionally straight sides and truncated apices. Trilete mark distinct, sutures simple, straight, sometimes gaping, reach spore body margin. Spore body triangular with concave or occasionally straight sides and rounded apices. Equatorial crassitude of variable width, 4–9 µm interradially, and 6–12 µm radially. In the radial positions distal surface of equatorial crassitude and spore body usually bears U- or V-shaped thickenings, the limbs of which are 8–22 µm in radial length and 6-10 µm in width; the thickenings extend up to 10 µm poleward from the inner margin of the crassitude and the limbs often project beyond the outer margin of the crassitude, thus modifying the spore outline. Occasionally the thickenings are not U shaped; the limbs of the thickenings are separate and, instead of extending on to the spore body, they extend for a short distance inter-radially where they thin and merge into the crassitude (modified after Neves et al., 1973).

2.31.2 SIZE

Overall equatorial diameter (maximum): 40–70 µm.

2.31.3 RANGE AND LOCALITIES

NM-VF zones (upper Visean; Neves et al., 1973).

Western Europe.

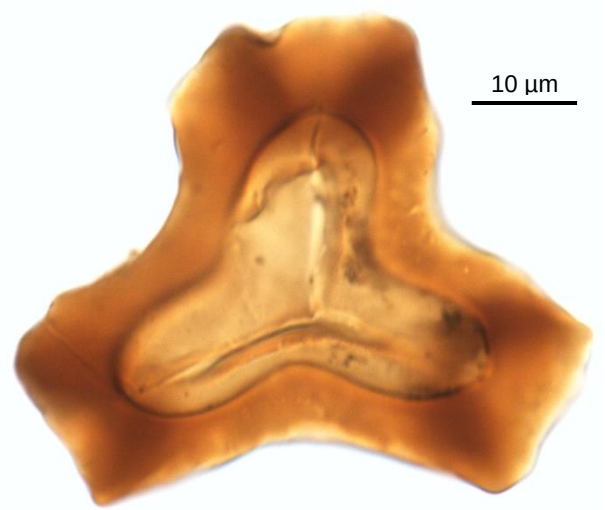


Figure 59: *Tripartites distinctus* PF (7996).

Specimen 7996 (MPA 18247 90-25). Shale below Cove Lower Marine Band. Cove Harbour, Berwickshire, Scotland. Distal view. Proximal focus showing distinct trilete mark and spore body. Note U-shaped exine thickenings in radial position on the distal surface. 0-100x (oil).

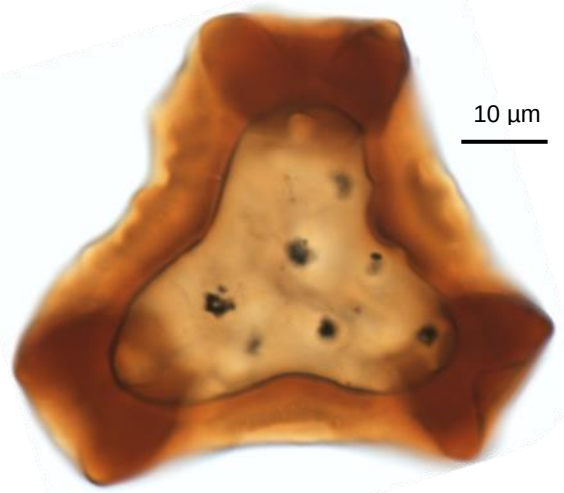


Figure 60: *Tripartites distinctus* DF (7997).

Specimen 7997 (MPA 18247). Shale below Cove Lower Marine Band. Cove Harbour, Berwickshire, Scotland. Distal view. Distal focus showing radial thickenings of the crassitude. 0-100x (oil).

2.31 *VALLATISPORITES PUSILLITES* (KEDO) DOLBY AND NEVES, 1970 (PLATE I, FIGS. 7A-B)

2.32.1 DIAGNOSIS

Radial, trilete, camerate, cingulizonate miospores. Amb usually convexly triangular; subtriangular to subcircular. Trilete mark distinct, sutures distinct to obscured, bordered by ray folds up to 5 µm in height, which appear to extend the suturae to the spore margin. Intexine distinct, laevigate to infragranulate, outline conformable with the amb and extending approximately one half to three quarters of the total spore diameter. Exoexine extended equatorially forming a thin cingulum. The cingulum bears a row of radially aligned vacuoles, 3–7 µm in radial length along the inner margin. The outer part of the cingulum is 4–10 µm in width. Separation between the intexine and exoexine sometimes occurs, which results in continuous light-colored zone, 1.5–3 µm in width, along the outer margin of the intexine (cuniculus). The distal and equatorial exoexine are ornamented with spinae and galae, 4–12 µm in height and up to 6 µm in basal diameter. Elements discrete, approximately 6 µm apart, or fused at their bases, usually in groups of two or three (modified after Higgs et al., 1988).

2.32.2 SIZE

Overall equatorial diameter: 50–80 µm. Diameter of spore body: 40–60 µm.

2.32.3 RANGE AND LOCALITIES

PL (upper Devonian) - LN Biozones (lower Tournasian) (Clayton et al., 1977).
Europe, ex-U.S.S.R., Canada, USA, Australia.

Figure 61: *Vallatisporites pusillites* PF (8748).

Specimen 8748 (SB3 1053). Bedford Shale. Big Walnut Creek, Ohio, USA. Distal view. Strunium Bedford Shale Ohio. Proximal focus. 2N-100x (oil).

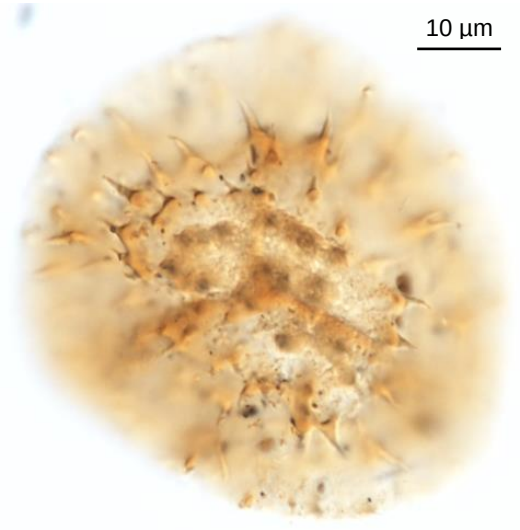


Figure 62: *Vallatisporites pusillites* DF (8748).

Specimen 8748 (SB3 1053). Bedford Shale. Big Walnut Creek, Ohio, USA. Distal view. Strunium Bedford Shale Ohio. 1-Distal focus showing ornament of long spines on bulbous bases. Some bases are fused, forming irregular ridges. 2N-100x (oil).

2.33 *VERRUCOSISPORITES NITIDUS* (NAUMOVA) PLAYFORD, 1964 (PLATE I, FIGS. 3A-B)

2.33.1 DIAGNOSIS

Radial, trilete, acamerate miospores. Amb circular, subcircular or roundly subtriangular. Trilete mark perceptible to obscure (often semi-hidden by sculpture), sutures simple, straight to sinuous; length one half to four fifths of amb radius. Spore body usually obscure, hidden by sculpture; when visible large, with outline conformable to spore amb, laevigate. Comprehensive, present on both proximal and distal surfaces, relatively coarse sculpture consisting of numerous, smooth, discrete, non-overlapping verrucae that are rounded in lateral view and possess circular to roundly polygonal basal outlines. Height of verrucae 1–3 µm, greatest basal diameter 2–12 µm (average 5 µm). Verrucae typically closely spaced, thus separated by a more or less regular continuous negative microreticulum which is usually sharply defined in low focus. Exine thickness (including sculpture) 2-4 µm (modified after Playford, 1963).

2.33.2 SIZE

Overall equatorial diameter: 30–60 µm.

2.33.3 RANGE AND LOCALITIES

Upper Frasnian – Tournaisian – Namurian? (Playford, 1963). LN (upper Devonian) to PU (lower Viséan) zones (Clayton et al., 1977).
Northern hemisphere, Australia.

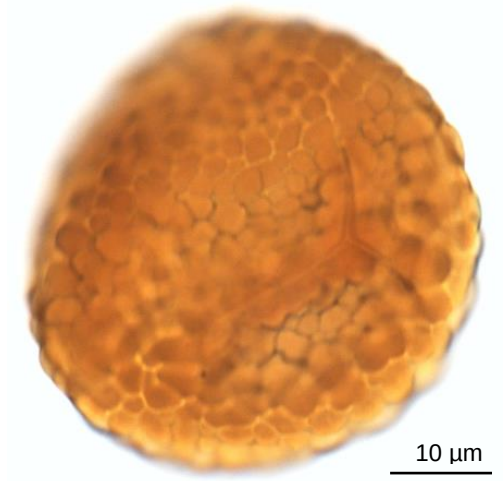


Figure 63: *Verrucosisporites nitidus* PF (8021).

Specimen 8021 (SB3-771). Bedford Shale. Big Walnut Creek, Sandbury, Ohio, USA. Distal view. Proximal focus showing distinct trilete mark, sutures simple, straight. Note exine sculpture also in the contact areas. 0-100x (oil).

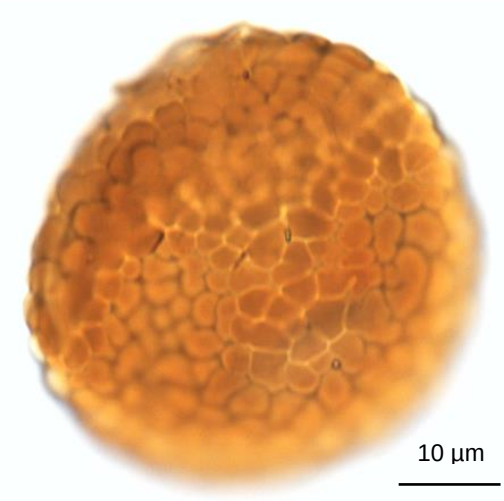


Figure 64: *Verrucosisporites nitidus* DF (8021).

Specimen 8021 (SB3-771). Bedford Shale. Big Walnut Creek, Sandbury, Ohio, USA (Owens B Carboniferous Palynostratigraphy The Arctic to North Africa). Distal view. Distal focus showing exine sculpture. 0-100x (oil).

2.34 *VESTISPORA COSTATA* (BALME, 1952) SPODE IN SMITH AND BUTTERWORTH, 1967

2.34.1 DIAGNOSIS

Hilate, acamerate miospores. Amb circular (spherical spores). Outline of spore body seldom seen. The operculum of the hilum is frequently detached. The exine is costate: costae generally 10–20 µm apart but may appear closer because of folding. The muri are arranged circum-centrically around the spore and are rarely branched. They intersect to enclose large polygonal lumina (after Smith and Butterworth, 1967).

2.34.2 SIZE

Overall equatorial diameter: 60–100 µm (mean 80 µm). Diameter of spore body: 45–85 µm (mean 60 µm).

2.34.3 REMARKS

Distinguished from other Westphalian species by its unmodified costae which are seldom branched (Smith and Butterworth, 1967). Distinctions made by Spode between the species *V. costata* and *V. tortuosa* Spode (in Smith and Butterworth, 1967) are very minor and do not serve adequately to permit assignment of specimens to one or the other. As the stratigraphic ranges cited by Smith and Butterworth (1967) are nearly identical, continued recognition of these species as distinct from one another is not justified. Detached opercula relating to this species have been described under the names *Reticulatasporites facetus* (Ibrahim) Potonié and Kremp 1955 and *Reticulatasporites taciturnus* (Ibrahim) Potonié and Kremp 1955, a practice no longer followed (Ravn, 1986).

2.34.4 RANGE AND LOCALITIES

Westphalian B and C (Smith and Butterworth, 1967). SS (Westphalian A) - middle OT (Westphalian D) zones (Clayton et al., 1977). Middle Westphalian A to Westphalian C (British Micropalaeontological Society. Palynology Group, 1984).
Europe; Barents Sea; ex U.S.S.R.; China; USA; Canada.

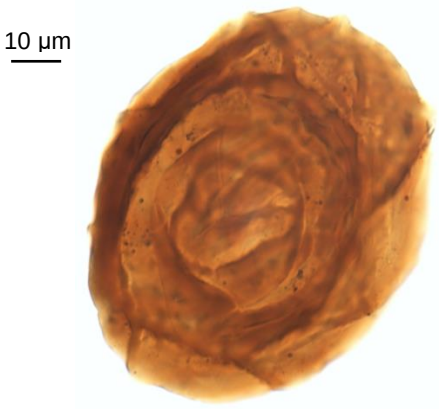


Figure 65: *Vestispora costata* PF (8011).

Specimen 8011 (ASB 90-19). Argill Shell Bed. Westphalian A-B. Argill Beck, Stainmore, Cumbria, England. Proximal view. Proximal focus showing distinct trilete mark; sutures simple, straight. Exine irregularly folded, with concentric costae and folds. 0-100x (oil).

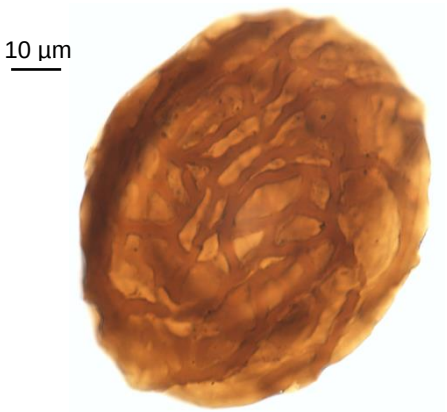


Figure 66: *Vestispora costata* DF (8011).

Specimen 8011 (ASB 90-19). Argill Shell Bed. Westphalian A-B. Argill Beck, Stainmore, Cumbria, England. Proximal view. Distal surface showing reticulate pattern formed by simple costae intersecting one another. 0-100x (oil).

2.35 SCOLECODONT

Scolecodonts are the chitinous mouth-parts of marine polychaete worms. They are organic and are commonly found as disassociated elements in association with acritarchs and chitinozoans in marine shales (Armstrong and Brasier, 2005).

2.35.1 DIAGNOSIS

Variable morphology: most are elongated double-walled plates, denticulated along one margin. Edgar (1984) described a typical scolecodont jaw apparatus as comprising three groups of elements, antero-ventral maxillae, antero-dorsal mandibles and posterior carriers. Taxonomic difficulties occur due to the disassociated nature of fossil finds and the fact that some element types in different species are morphologically very similar (Armstrong and Brasier, 2005).

2.35.2 SIZE

100–200 µm

2.35.3 RANGE AND LOCALITIES

Lower Ordovician – Recent (Armstrong and Brasier, 2005).

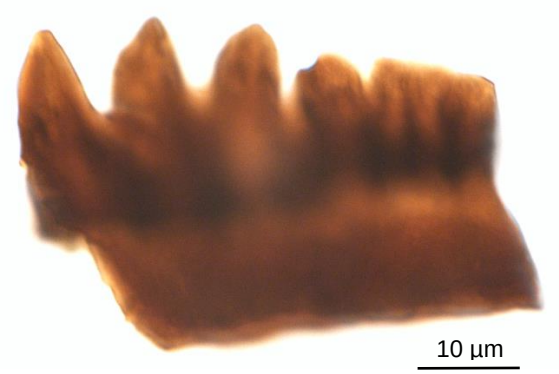


Figure 67: Scolecodont.

Specimen 6396 (MPA 12539/15). Mid Carboniferous boundary. Stone Head Beck, Cowling, W Yorkshire, England. 0-100x (oil).

Figure 68: Scolecodont.

Slide MPK7370 (SB3 90-42). Bedford Shale. Tournasian. Big Walnut Creek, Ohio, USA. 0-60x.

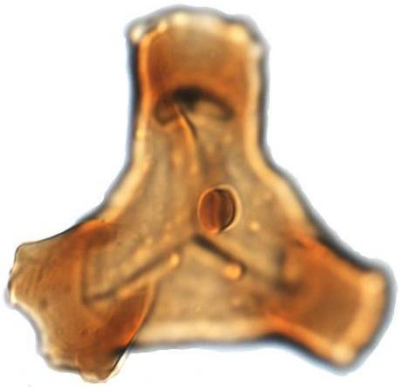
Appendix 1 Additional microphotographs

PLATE I

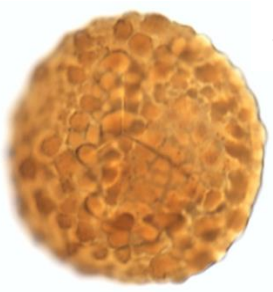
1. *Ahrensisporites sinanii* (Artüz) Ravn, 1986. Specimen 7965 (MPA 4578). BGS Diddup BH - Ayrshire (Scotland). Earliest Westphalian. Distal view. 1a- distal focus showing radial thickenings projecting from auricolae in the direction of the distal pole; 0-100x (oil). 1b- proximal focus showing auriculae; 0-100x (oil).
2. *Cirratriradites rarus* Schopf, Wilson and Bentall, 1944. Specimen 8823. England/Wales. Proximal view. 2a- distal focus showing granules on the surface of the inner body; 2N-100x (oil). 2b- proximal focus showing distinct trilete mark accompanied by flexuous folds extending to the outer border of zona. Note bizonate cingulum: inner portion darker and thicker, overlapping the inner body; outer part thinner (flange) bearing irregular vacuoles; 2N-100x (oil).
3. *Verrucosisporites nitidus* (Naumova) Playford, 1964. Specimen 8024 (MPA302 90-74). Pinskey Gill Beds. Wygarth Bh, Ravenstonedale, Cumbria, England. Proximal view. 3a- proximal focus. Note rounded large edge of verrucae; some project at the equator. Spore body faintly distinct, large. Trilete mark extending one half of spore body radius; 0-100x (oil). 3b- distal focus. Note verrucae are distinct, never coalescent at the base; 0-100x (oil).
4. *Retusotriletes incohatus* Sullivan 1964. Specimen 8999 (MPA298 90-32). Pinkskey Gill Beds. Wygarth Gill Bh, Ravenstonedale, Cumbria, England. Proximal view. 4a- proximal focus showing depressed contact areas with distinct trilete mark and curvaturae imperfectae; 0-100x (oil). 4b- distal focus showing infrapunctate exine; 0-100x (oil).
5. *Laevigatosporites* spp. Specimen 8116 (ASB 90-2). Argill Shell Bed. Westphalian A. Argill Beck, Stainmore, Scotland Lateral view showing monolete mark accompanied by low exoexine folds, lips. Exine laevigate; 0-100x (oil).
6. *Laevigatosporites* spp. Specimen 8109 (ASB 90-28). Argill Shell Bed. Westphalian A. Argill Beck, Stainmore, Scotland. Polar view showing distinct monolete mark, suture simple, straight, and flexuous irregular folds on the exine; 0-100x (oil).
7. *Vallatisporites pusillites* (Kedo) Dolby and Neves, 1970. Specimen 8747 (SB3 90-402). Bedford Shale. Big Walnut Creek, Ohio, USA. Distal view. 7a- proximal focus showing well defined inner body and vacuoles on inner margin of the cingulum; 2N-100x (oil). 7b- distal focus showing granulate exine bearing sparse long spinae with bulbous bases; 2N-100x (oil).

Plate I

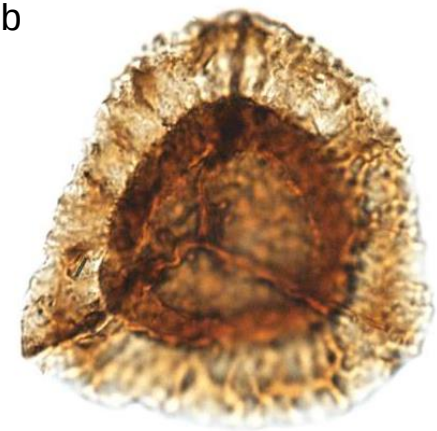
1b



3a



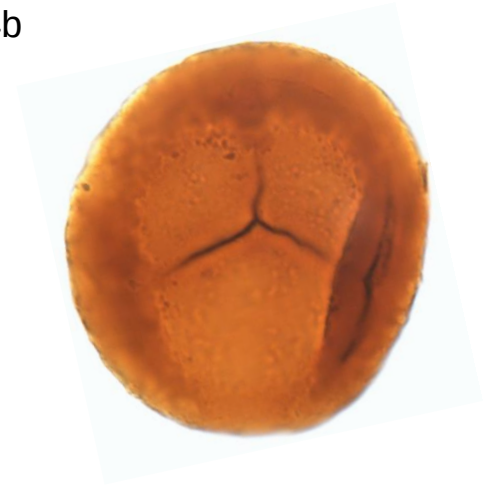
2b



3b

5

4b



10 µm

6

7a

7b

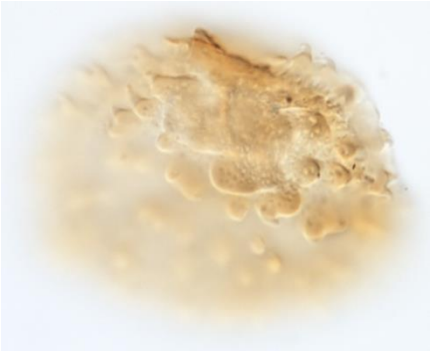
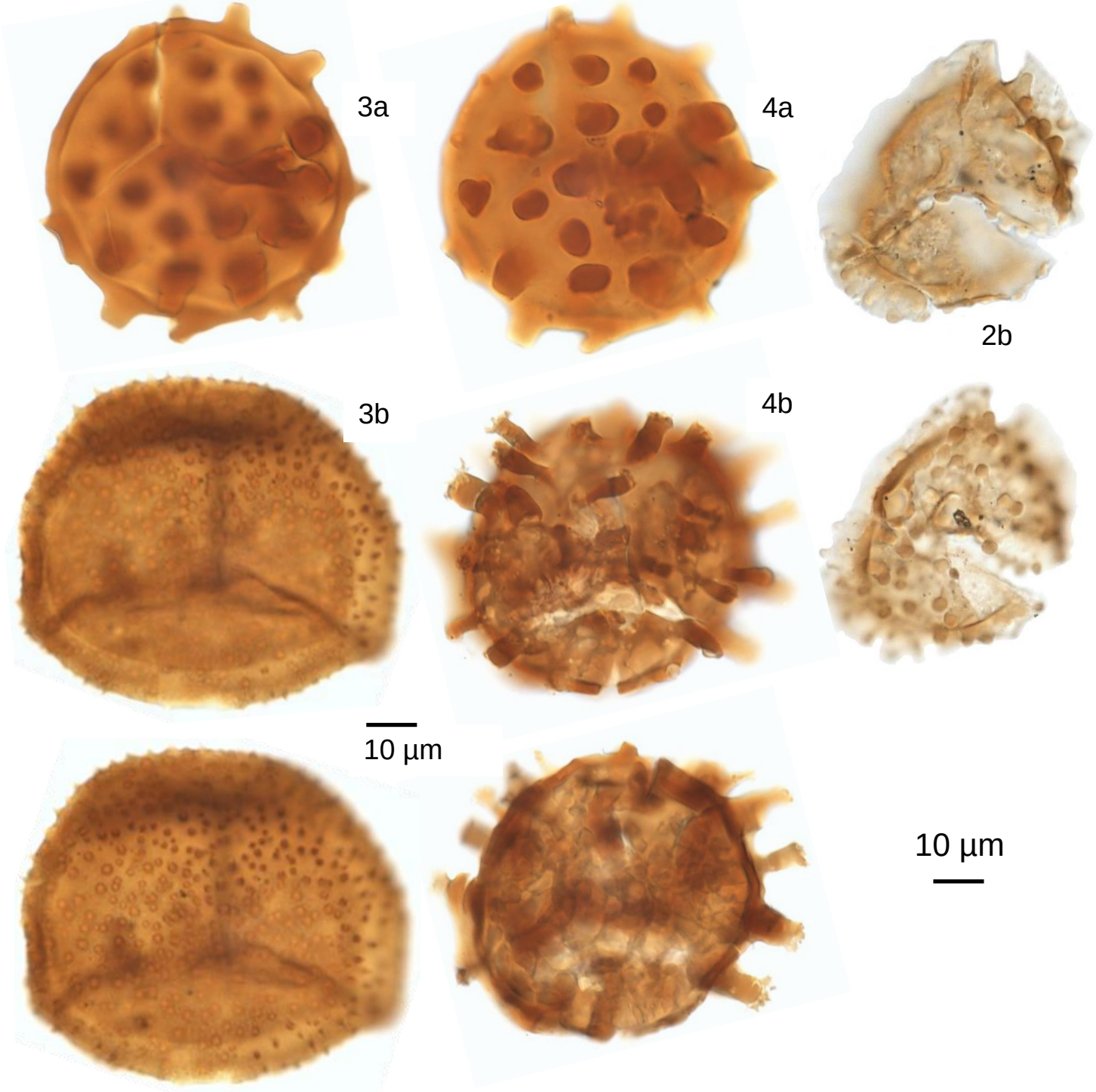
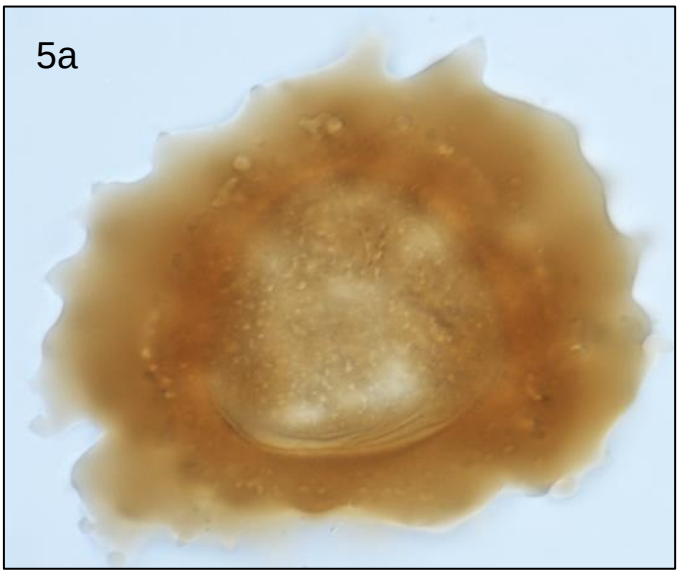


PLATE II

1. *Raistrickia nigra* Love, 1960. Specimen 8724 (MPA 18247 90-153). Shale below Cove Lower Marine Band. Cove Harbour, Berwickshire, Scotland. Distal view. 1a- median focus. Trilete mark distinct, simple, laesurae straight. Contact zone laevigate; 0-100x (oil). 1b- distal focus; 0-100x (oil).
2. *Lycospora subtriquetra* (Luber) Potonié and Kremp, 1956. Specimen 8731 (A25 90-47). Shale above Mousegill Marine Beds. Kinderscoutian Substage. Argill Beck, Stainmore, England. Proximal view. 2a- median focus showing distinct trilete mark accompanied by flexuous exine folds. Note cingulum on equatorial margin; 2N-100x (oil). 2b- distal focus showing verrucose ornament; 2N-100x (oil).
3. *Grandispora echinata* Hacquebard, 1957. Specimen 8865 (MPA 302 90-60). Pinskey, Gill Beds. Wygarth Gill Bh, Ravenstonedale, England. Proximal view. 3a- median focus. Spore body distinct, extending two thirds of spore radius. Abundant spinae projecting at the equator; 0-100x (oil). 3b- distal focus; 0-100x (oil).
4. *Raistrickia saetosa* (Loose) Schopf, Wilson and Bentall, 1944. Specimen 7410 (MPA4578 90-25). Passage Group. Diddup Bh, Ayrshire, Scotland. Distal view? 4a- proximal focus? ; 0-100x (oil). 4b- distal focus? ; 0-100x (oil).
5. *Cristatisporites connexus* Potonié and Kremp, 1955. Specimen 7973 (A5a 90-34). Listeri Marine Band, Coal above Argill Shale Bed. Westphalian B (Langsettian Substage). Argill Beck, Stainmore, England. Distal view. 5a- proximal focus showing granulate exine. Vacuoles on the cingulum. Verrucae fused to form crista on the equatorial margin; 0-100x (oil). 5b- proximal focus showing granulate exine. Vacuoles on the cingulum. Verrucae fused to form crista on the equatorial margin; 0-100x (oil).


3a
4a
2b
3b
4b
10 µm
10 µm


5a

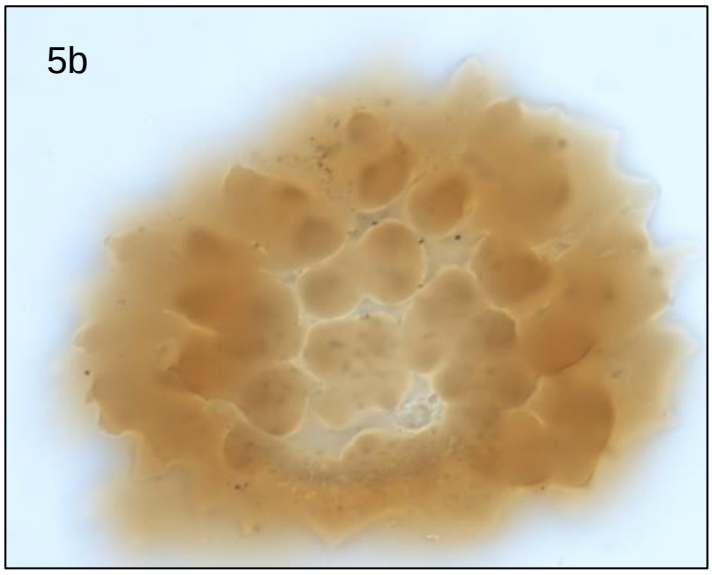

5b

PLATE III

1. *Mooreisporites fustis* (Neves, 1958). Specimen 8658 (MPA 4578 90-1). Passage Group. Diddup Bh., Ayrshire, Scotland. Proximal view. 1a- proximal focus showing distinct trilete mark, sutures opened, straight, accompanied by wide labra. Exine irregularly folded, particularly on the equatorial margin where folds may be fused with curvaturae. Exine laevigate to infragranulate; 0-100x (oil). 1b- median focus showing fused branching baculae in radial position, projecting from the distal portion of the equatorial margin of the exine; 0-100x (oil). 1c- distal focus showing baculae extending on distal surface; 0-100x (oil).
2. *Mooreisporites trigallerus* (Neves, 1961). Specimen 8662. Distal view. 2a- proximal focus showing opened sutures accompanied by broad labra. Inner body margin ill-defined; 0-100x (oil). 2b- distal focus showing laevigate exine; 0-100x (oil).

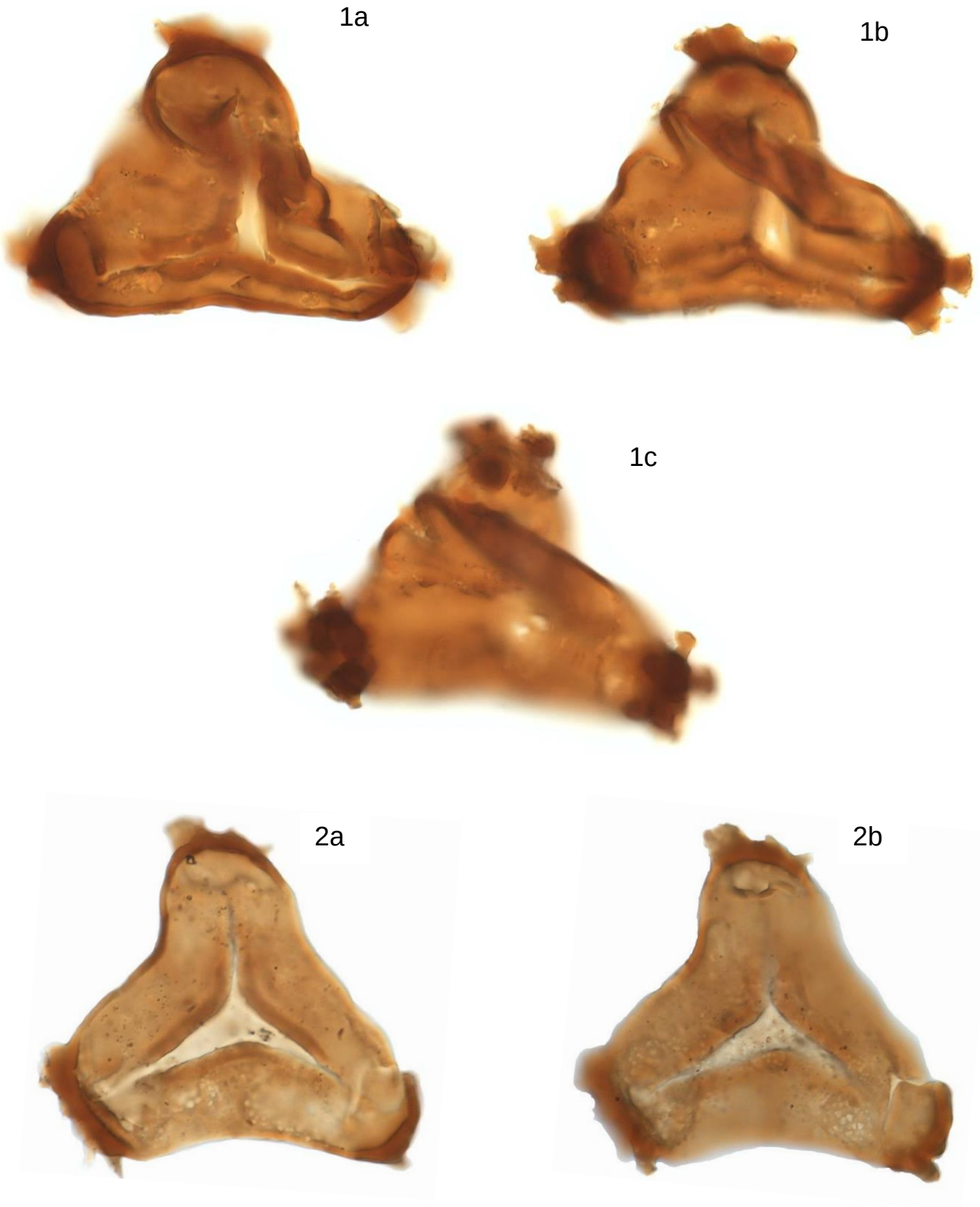
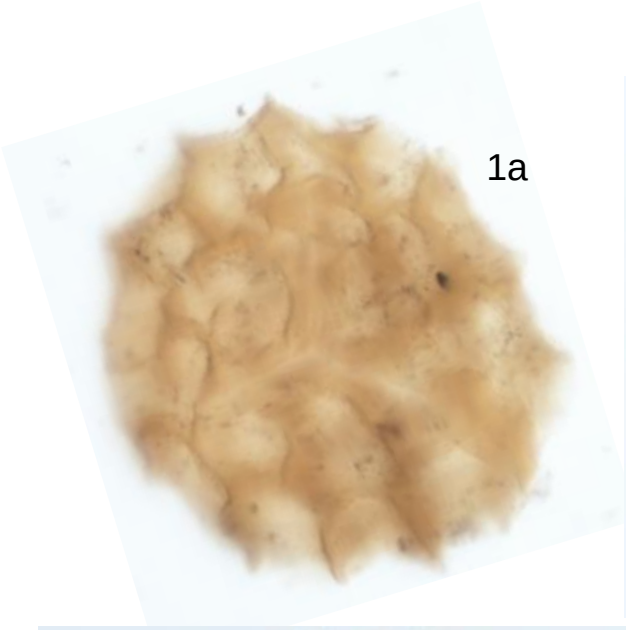
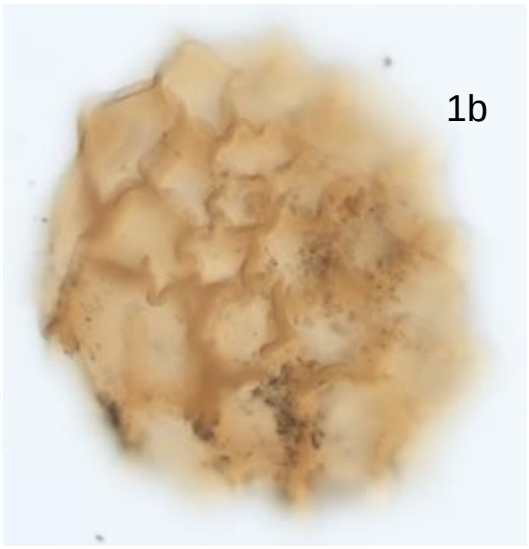

1a
1b
1c
2a
2b
15 µm

PLATE IV

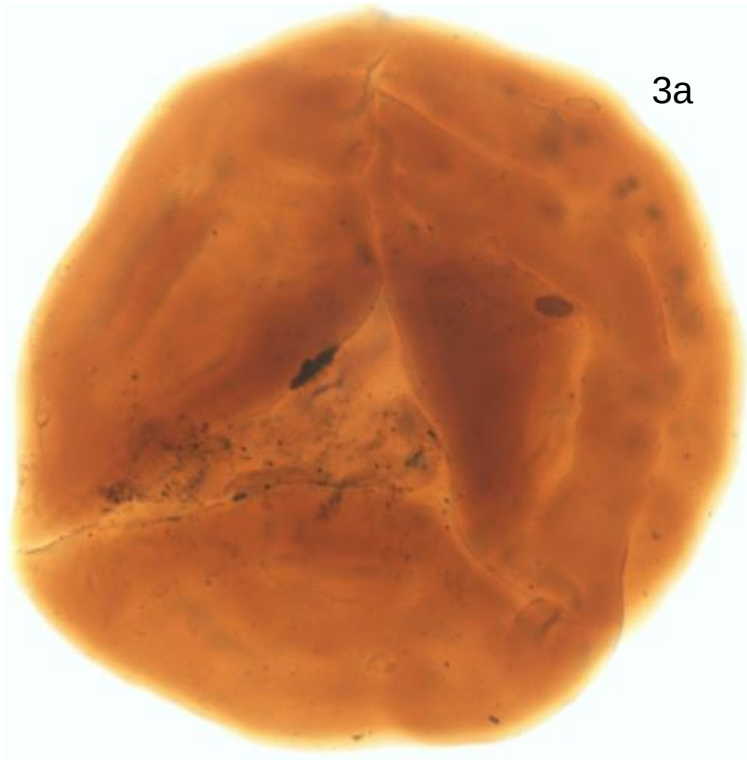
1. *Dictyotriletes muricatus* (Kosanke) Smith and Butterworth, 1967. Specimen 7585 (CHG8 90-103). Basal Westphalian A. Crag House Gill, Stainmore, England. Distal view. 1a- proximal focus showing distinct trilete mark. Note ill-defined reticulum in proximal contact areas. Coni on muri projecting at the equator; 2N-60x. 1b- distal focus showing flexuous muri bearing spines; 2N-60x.
2. *Endosporites globiformis* (Ibrahim) Schopf, Wilson and Bentall, 1944. Specimen 7509. Distal view. 2a- distal focus showing finely granulate pseudosaccus irregularly folded. Spore body distinct with limbus; 2N-60x. 2b- proximal focus showing distinct trilete mark accompanied by flexuous exine folds. Exine granulate; 2N-60x.
3. *Punctatisporites sinuatus* (Artüz) Neves, 1961. Specimen 8671 (T96 91-3). Shale below Swinstone House Marine Band. Mousegill Beck, Stainmore, England. Proximal view. 3a- proximal focus showing distinct trilete mark, sutures simple, straight. Note irregular folding of the exine and large fold on the equatorial margin resembling crassitude; 0-100x (oil). 3b- distal focus showing distinct ornamentation of irregular sinuous folds. Exine laevigate; 0-100x (oil).

Plate IV





50 µm



Appendix 2 Full index of the Bernard Owens single grain mount collection

Below is a list of all slides in the Bernard Owens Collection. Note that the modern taxon name is utilised while the taxon name on the label is listed between brackets.

Taxon (name on label)	BGS collection number (MPK)	Taxonomy Online 2 (Stephenson & Owens, 2006)	Taxonomy Online 3 (This report)
Acinosporites apiculatus	11934.	No.	No.
Acinosporites acanthomammillatus	12127.	No.	No.
Acinosporites parviornatus	12076.	No.	No.
Ahrensisporites guerickei-ornatus	6383.	No.	No.
Ahrensisporites sinanii	7960-7971.	No.	Yes (MPK 7964; MPK 7965; MPK 7968).
Alatisporites pustulatus	8080-8090.	No.	No.
Alisporites/Falcisporites cpx.	12266; 12324-12325; 12332-12333.	No.	No.
Anapiculatisporites spp.	12298.	No.	No.
Ancyrospora spp.	12503.	No.	No.
Ancyrospora nettersheimensis	11903.	No.	No.
Ancyrospora pulchra	12502.	No.	No.
Angulisporites splendidus	7049-7055	Yes (MPK 7049; MPK 7050).	No.
Knoxisporites literatus (Anulatisporites literatus)	12491.	No.	No.
Hymenozonotriletes biformis *(Apiculinatusispora* cf. *Hymenozonotriletes biformis)*	12075	No.	No.
Apiculiretusispora cf. *brandtii*	12139	No.	No.
Apiculiretusispora densiconata	12064; 12090; 12102; 12108; 12585; 12737.	No.	No.
Apiculiretusispora fructicosa	12597.	No.	No.
Apiculatisporites microconus	12028.	No.	No.
Apiculiretusispora? *multiseta*	12417; 12420.	No.	No.
Apiculiretusispora cf. *nitida*	11928.	No.	No.
Apiculiretusispora semisenta	12548.	No.	No.
Apiculiterusispora spp.	12179.	No.	No.

Aratrisporites centratus	12212; 12217; 12391.	No.	No.
Aratrisporites saharensis	8052-8067; 11944; (11948); 11978; 12440; 12442; 12469.	No.	No.
Aratrisporites saturni	12209; 12347; 12357; 12360.	No.	No.
Aratrisporites strigosus	12215.	No.	No.
Archaeozonotriletes spp.	12112.	No.	No.
Auroraspora asperella	12406; 12471.	No.	No.
Auroraspora hyalina	(12527)-12528.	No.	No.
Auroraspora macra	7475-7479; 7480-7489?; 7490-7498; 8786-8788; 8789?; 8790-8792; 8793?; 8794; 8796-8798.	Yes (MPK 7475; MPK 7476).	No.
Auroraspora macromanifesta	11923; 12025; 12123.	No.	No.
Baculatisporites spp.	12162.	No.	No.
Barakarites rotatus	12254; 12267; 12281; 12289; 12292; (12320); 12340.	No.	No.
Bellispores nitidus	6410; 7762-7781.	Yes (MPK 7762; MPK 7763).	No.
Botryococcus spp.	6415.	No.	No.
Brachysaccus ovalis	12303.	No.	No.
Brochotriletes libyensis	12021.	No.	No.
Cadiospora magna	7852; 7854.	No.	No.
Cadiospora spp.	7853.	No.	No.
Calamopsora cf. *atava*	12745.	No.	No.
Calamospora microrugosa	12450; 12470; 12603; 12606; 12661.	No.	No.
Calamospora pallida	12501.	No.	No.
Calyptosporites sp. A	12014.	No.	No.
Calyptosporites velatus	12042.	No.	No.
Camptozonotriletes cyrenaicus	12456; 12464. 7867–7872.	No.	No.

Cannanoropollis janakii	8091-8098; 12252; 12255-12256; 12302; 12316; 12320; 12342.	No.	No.
Cheiledonites major	7701-7714.	Yes (MPK 7705; MPK 7712).	No.
Chitinozoa	(12070); 12580	No.	No.
Cingulizonates bialatus	6977-6987.	Yes (MPK 6977; MPK 6978).	No.
Cingulizonates capistratus	6958-6976.	Yes (MPK 6958; MPK 6960).	No.
Cirratriradites rarus	6386-6388; 6404; 6407; 6412-6414; 8800-8823	No.	Yes (MPK 8822; MPK 8823).
Cirratriradites saturni	6392; 7303-7309.	Yes (MPK 7303; MPK 7304).	No.
Cirratriradites solaris	8664-8665.	No.	No.
Colatisporites? spp.	11972.	No	No
Colatisporites decorus	7671-7672; (7673).	Yes (MPK 7671; MPK 7672).	No.
Converrucosisporites spp.	12291.	No.	No.
Convolutispora circumvallata	7421-7426; 12013; 12516.	Yes (MPK 7421; MPK 7422).	No.
Convolutispora florida	6400.	No.	No.
Convolutispora major	7192-7202.	Yes (MPK 7192; MPK 7197).	No.
Convolutispora mellita	12007.	No.	No.
Convolutispora oppressa	12504.	No.	No.
Convolutispora spp.	(8192); 11929; 12027; 12052; 12422; 12448; 12458; 12479	No.	No.
Corbulispora cancellata	8708; 8709?; 8710-8719; 12490.	No.	No.
Corisaccites alutas	12211.	No.	No.
Corystisporites multispinosus	12095.	No.	No.
Corystisporites sp.	11925.	No.	No.
Craspedispora cf. *ghadamisensis*	12147.	No.	No.
Craspedispora sp. A	12114.	No.	No.
Craspedispora spp	12052; 12066; 12106.	No.	No.

Crassispora aculeata	7013-7016.	Yes (MPK 7013; MPK 7014).	No.
Crassispora kosankei	6381-6382; 6406; 6407; 7001-7011; 12270; 12309; 12341.	Yes (MPK 7001; MPK 7002).	No.
Crassispora maculosa	7074-7079.	Yes (MPK 7074; MPK 7075).	No.
Crassispora trychera	8160-8174.	Yes (MPK 8161; MPK 8162).	No.
Cristatisporites connexus	7972-7981.	No.	Yes (MPK 7973; MPK 7979).
Cristatisporites indignabundus	6379; 6409.	No.	Yes (6379).
Cristatisporites sp. A	12447 12559; 12565; 12568.	No.	No.
Cyclogranisporites spp.	12109; 12216; 12265; 12330; 12364-12365; 12378; 12686.	No.	No.
Cymbosporites catillus	12040; 12171.	No.	No.
Cymbosporites cyathus	12178; 12191.	No.	No.
Cymbosporites cf. *Retusotriletes tschibrikovii*	12054.	No.	No.
Cynatliosphaera spp.	12093.	No.	No.
Deltoidospora spp.	12207; 12269; 12363; 12384.	No.	No.
Densosporites anulatus	7655; 7656-7658?; 7659-7661; 7662?; 7663-7670; (8801); (11951); 11981.	Yes (MPK 7655; MPK 7659).	No.
Densosporites brevispinosus	6384.	No.	No.
Densosporites duplicatus	7855-7866.	No.	Yes (MPK 7855; MPK 7858).
Densosporites sphaerotriangularis	(7973); (7981).	No.	No.
Densosporites cf. *spitsbergensis*	12006.	No.	No.
Densosporites cf. *spongeosus*	6405.	No.	No.
Densosporites spp.	12439.	No.	No.
Densosporites variomarginatus	11951; 11979; 11999; 12010; 12430; 12555.	No.	No.
Densoisporites nejburgii	12218.	No.	No.

Diatomozonotriletes fragilis	11952; 11974; 11990; 11994; 11996.	No.	No.
Diatomozonotriletes cf. *variomarginatus*	11997.	No.	No.
Dibolisporites echinatus	12029.	No.	No.
Dibolisporites echinaceus (synonym??)	12149.	No.	No.
Dibolisporites gibberosus	12132.	No.	No.
Dibolisporites rhadamensis	12038.	No.	No.
Dibolisporites sp.	12148; 12494.	No.	No.
Dibolisporites varius	12142.	No.	No.
Dictyotriletes bireticulatus	7599-7622.	No.	Yes (MPK 7603).
Dictyotriletes fimbriatus	7593-7595; 7596?; 7598.	Yes (MPK 7595; MPK 7597).	Yes (MPK 7595).
Dictyotriletes muricatus	7583-7592.	Yes (MPK 7583; MPK 7592).	Yes (MPK 7585; MPK 7589; MPK 7590).
Dictyotriletes sp. A	12003.	No.	No.
Disaccites non-striatiti	7203-7204; 7206-7208; 7210.	No.	Yes (MPK 7204; MPK 7206).
Disaccites striatiti	7205; 7209; 7211-7214.	No.	Yes (MPK 7205; MPK 7208).
Discernisporites micromanifestus	12512; 12573.	No.	No.
Discernisporites minutus	6390.	No.	No.
Discernisporites spp**.**	12521.	No.	No.
Distriatites spp.	12286; 12360.	No.	No.
Divarisaccus lelei	12367.	No.	No.
Emphanisporites annulatus	11936; 12172.	No.	No.
Emphanisporites obscurus	12046; 12082; 12100; 12164; 12170.	No.	No.
Emphanisporites rotatus	11922; 12022; 12024; 12086; 12099;12189; 12198.	No.	No.
Endoculeospora spp.	12011; 12465.	No.	No.
Endosporites globiformis	7505-7510.	No.	Yes (MPK 7506; MPK 7509).
Endosporites zonalis	7499-7504.	Yes (MPK 7499; MPK 7500).	No.
Florinites junior	8758-8765.	No.	Yes (MPK 8758).

Florinites visendus	6393.	No.	No.
Foveosporites? *insculptus*	11987.	No.	No.
Fungal spore	12627.	No.	No.
Geminospora lemurata	11939; 12018; 12583.	No.	No.
Geminospora spp.	12184.	No.	No.
Grandispora douglastownense	12163.	No.	No.
Grandispora gabesensis	12015; 12032; 12043; 12122.	No.	No.
Grandispora echinata	8864-8874.	No.	Yes (MPK 8864; MPK 8865).
Grandispora inculta	12192.	No.	No.
Grandispora libyensis	11932; 12120; 12126; 12150.	No.	No.
Grandispora lupata	7286-7296.	Yes (MPK 7286; MPK 7292).	No.
Grandispora megaformis	12144.	No.	No.
Grandispora protea	12049; 12113.	No.	No.
Grandispora riegelii	11902; 11904; 11920; 11927; 12016; 12026; 12111; 12118; 12166; 121125; 12199; 12202.	No.	No.
Grandispora sp. 1	12110.	No.	No.
Grandispora spp.	12033-12034; 12156.	No.	No.
Grandispora spinosa	7130-7135.	Yes (MPK 7130, MPK 7131).	No.
Grandispora variospinosa	11906.	No.	No.
Grandispora velata	11935; 12045.	No.	No.
Grumosisporites varioreticulatus	7623-7626; (7627); 7629.	Yes (MPK 7623; MPK 7624).	No.
Grumosisporites verrucosus	7726-7737.	Yes (MPK 7726; MPK 7727)	No.
Hamiapollenites spp.	12364.	No.	No.
Hymenozonotriletes explanatus	8175-8186.	No.	No.
Hystricosporites gravis	12402.	No.	No.
Hystricosporites multifurcatus	7267-7268; 7629.	Yes (MPK 7267; MPK 7268).	No.
Hystricosporites porrectus	12409; 12510.	No.	No.
Ibrahimispores brevispinosus	6402; 8648-8657.	No.	Yes (MPK 8648; MPK 8655).

Indotriradites reidii	12293; 12361-12362; 12374; 12379.	No.	No.
Infernopollenites spp.	12326; 13228.	No.	No.
Klausipollenites schaubergeri	12383.	No.	No.
Knoxisporites hageni	6408.	No.	No.
Knoxisporites hederatus	7297-7302.	Yes (MPK 7297; MPK 7299).	No.
Knoxisporites literatus (Anulatisporites literatus)	12491.	No.	No.
Knoxisporites spp.	(7262).	No.	No.
Knoxisporites stephanephorus	?	Yes (MPK 7042; MPK 7048).	No.
Knoxisporites triangularis	?	Yes (MPK 7031; MPK 7033).	No.
Knoxisporites triradiatus	7715; (7716); 7717-7725.	Yes (MPK 7715; MPK 7718).	No.
Krauselisporites echinatus	?	Yes (MPK 7056; MPK 7057).	No.
Krauselisporites hibernicus	7443-7448.	Yes (MPK 7443; MPK 7444).	No.
Krauselisporites ornatus	6389; 6416-6417; 7690-7695; 7696?; 7697-7700; 12304.	Yes (MPK 7690; MPK 7693).	No.
Laevigatosporites spp. (*L. desmoinensis*).	8108-8119.	No.	Yes (MPK 8109; MPK 8116).
Labiadensites fimbriatus	7257-7266.	No.	No.
Latensina trileta	7881-7890.	No.	No.
Latosporites spp.	12190.	No.	No.
Leiotriletes struniensis	12454; 12489.	No.	No.
Leiotriletes tumidus	6377.	No.	Yes (MPK 6377).
Leiozonotriletes insignitus	12542; 12613.	No.	No.
Leuckisporites spp.	12338.	No.	No.
Cf. *Limitisporites*	12308.	No.	No.
Lophozonotriletes cristifer	7824-7839.	No.	No.
Lophozonotriletes malevkensis	7455-7474.	Yes (MPK 7459; MPK 7463).	No.
Lophozonotriletes rarituberculatus	7910-7921; 12509.	No.	No.
Lophozonotriletes spp.	12508; 12547.	No.	No.
Lundbladispora spp.	12349.	No.	No.

Lycospora pusilla	(6393); (6404); (7502); 7631; 7632?; 7633-7654; (7979); 12311; 12318; 12352.	Yes (MPK 7631; MPK 7633).	No.
Lycospora subtriquetra	8731-8745.	No.	Yes (MPK 8731; MPK 8743).
Lycospora spp.	(12285); 12594.	No.	No.
Massulites spp. (barely legible)	12607.	No.	No.
Microreticulatisporites spp.	9017-9029.	No.	No.
Monilospora moniloformis	7230-7244.	Yes (MPK 7231; MPK 7244).	No.
Monilospora mutabilis	8769; 8771-8772; 8774.	No.	No.
Mooreisporites fustis	8658; 8660.	No.	Yes (MPK 8658; MPK 8660).
Mooreisporites trigallerus	8659-8662.	No.	Yes (MPK 8659; MPK 8662).
Murospora aurita	8718; 8974-8985.	No.	Yes (MPK 8977; MPK 8980).
Murospora margodentata	8666; 8672-8682.	No.	Yes (MPK 8675; MPK 8676).
Murospora parthenopia	7165-7179; 8767.	Yes (MPK 7166; MPK 7177).	No.
Murospora spp.	8770.	No.	No.
Navifusa bacilla	12180.	No.	No.
Nodatitriletes spp.	7164.	No.	No.
Nuskoisporites spp.	12206.	No.	No.
Partitisporites granulatus morphon	12335.	No.	No.
Perotrilites magnus	12476.	No.	No.
Perotrilites perinatus - perinatus	12602.	No.	No.
Perotrilites tessellatus)	8187-8191.	No.	Yes (MPK 8188; MPK 8189).
Plicatipollenites malabarensis	7270-7273.	No.	No.
Potoniespores delicatus	7922-7933.	No.	Yes (MPK 7923; MPK 7924).
Potonieisporites novicus - bharadwaji	8099-8107.	No.	No.
Prolycospora spp.	8688-8707.	No.	No.
Protohaploxipinus fuscus	8857-8863.	No.	No.
Protohaploxipinus goraiensis	7875-7880.	No.	No.

Punctatisporites cf. *aerarius*	12591.	No.	No.
Punctatisporites planus	11960.	No.	No.
Punctatisporites sinuatus	8666-8671.	No.	Yes (MPK 8670; MPK 8671).
Punctatisporites solidus	11947; 12513; 12522; (12549).	No.	No.
Punctatosporites granifer	7946-7959.	No.	Yes (MPK 7950; MPK 7958).
Pustulatisporites gibbosus	11984.	No.	No.
Pustulatisporites sp. A	12441.	No.	No.
Pustulatisporites spp.	12443; 12462.	No.	No.
Radialetes costatus	12496.	No.	No.
Radiizonates aligerens	6989-7000; 11973; (11978).	Yes (MPK 6989; MPK 6993).	No.
Radiizonates genuinus	7934-7939; 11943; 12002; 12004; 12554.	No.	No.
Raistrickia aratra	12047; 12159.	No.	No.
Raistrickia clavata	7392-7403.	Yes (MPK 7392; MPK 7393).	No.
Raistrickia condylosa	7415-7420.	Yes (7415; 7416).	No.
Raistrickia corynoges	7374-7379.	Yes (MPK 7374; MPK 7376).	No.
Raistrickia fulva	7380-7391.	Yes (MPK 7380; MPK 7382).	No.
Raistrickia microhorrida	6378; 6401.	No.	No.
Raistrickia nigra	8720-8730.	No.	Yes (MPK 8721; MPK 8724).
Raistrickia saetosa	7404-7414.	No.	Yes (MPK 7408; MPK 7410).
Raistrickia spp.	12051; (12362); 12514; 12556.	No.	No.
Reinschospora speciosa	7432-7442.	Yes (MPK 7433; MPK 7435).	No.
Reinschospora triangularis	6385.	No.	No.
Remysporites albertensis	1266.	No.	No.
Remysporites magnificus	7511-7516.	Yes (MPK 7511; MPK 7513).	No.
Reticulatisporites carnosus	?	Yes (MPK 7019; MPK 7024).	No.
Reticulatisporites polygonalis	7941; 7943; 7945.	No.	Yes (MPK 7943; MPK 7945).

Reticulatisporites reticulatus	8986-8991.	No.	No.
Reticulatisporites spp.	6380.	No.	No.
Retispora lepidophyta	7124-7129; 7529-7540; 12401; 12404-12405; 12411; 12414; 12499-12500; 12518; 12523; 12527; 12533; 12540-12541.	Yes (MPK 7124; MPK 7126).	No.
Retispora lepidophyta var. *tener*	12413.	No.	No.
Retusotriletes crassus	12000; 12493.	No.	No.
Retusotriletes distinctus	11901.	No.	No.
Retusotriletes goensis	12035.	No.	No.
Retusotriletes incohatus	8993-9003.	No.	Yes (MPK 8996; MPK 8999).
Retusotriletes planus	12495.	No.	No.
Retusotriletes rotundus	12039; 12041; 12085.	No.	No.
Retusotriletes triangulatus	11921; 12053.	No.	No.
Rhabdosporites langii	12119.	No.	No.
Rhabdosporites parvulus	12194.	No.	No.
Rotaspora fracta	7568-7582.	Yes (MPK 7569; MPK 7572).	No.
Rotaspora knoxi	7802-7823.	Yes (MPK 7802; MPK 7805).	No.
Rugospora minuta	7982-7993.	No.	No.
Rugospora owensi	7528.	No.	No.
Rugospora polyptycha	9030-9035.	No.	No.
Rugospora rugosa	7523-7526; 7528.	No.	No.
Rugospora sp. A	7527.	No.	No.
Rugospora spp.	11976.	No.	No.
Samarisporites eximius	1270-12071; 12089; 12115; 12117; 12152.	No.	No.
Samarisporites praetervisus	12074; 12137; 12154.	No.	No.
Samarisporites spp.	12140; 12143; 12146; 12579.	No.	No.
Schopfites cf. *angustus*	12543; 12551.	No.	No.
Schopfites claviger	7782-7801.	Yes (MPK 7782; MPK 7783).	No.

Shopfites delicatus	8831-8838.	No.	No.
Schulzospora campyloptera	(6386); 6395; 6397; 7136-7146.	Yes (MPK 7137; MPK 7145).	No.
Schulzospora elongata	6394; 6411.	No.	No.
Schulzospora ocellata	7180-7191.	Yes (MPK 7180; MPK 7181).	No.
Schulzospora rara	7274-7285.	Yes (MPK 7276; MPK 7277).	No.
Scolecodont	6396; (7370); 12084.	No.	Yes (MPK 6396; MPK7370).
Solisphaeridium spinoglobosum	12526.	No.	No..
Spelaeotriletes cf. *illegible*	12596.	No.	No.
Spelaeotriletes arenaceus	7147-7158; 8683; 8686; 11941; 11948; 11959; 11988; 11993; 12080; 12423; 12546; 12575; 12577; 12582; 12587; 12624.	Yes (MPK 7147; MPK 7149).	No.
Spelaeotriletes balteatus	7112-7123; 12001.	Yes (MPK 7117; MPK 7123).	No.
Spelaeotriletes benghaziensis	11967; 12288; 12296; 12301; 12306; 12310; 12312; 12345; 12353.	No.	No.
Spelaeotriletes cabotii	7738-7749.	Yes (MPK 7738; MPK 7739).	No.
Spelaeotriletes crenulatus	12598.	No.	No.
Spelaeotriletes cf. *crustatus*	12412.	No.	No.
Spelaeotriletes giganteus	11985; 12426; 12487; 12515.	Yes (MPK 7254; MPK 7255).	No.
Spelaeotriletes obtusus	12451; 12457; 12481; 12536.	No.	No.
Spelaeotriletes owensi	7245-7252; 8033-8037; 8154-8159; (11978); 11991.	Yes (MPK 7245; MPK 7248).	No.
Spelaeotriletes pretiosus	7253-7256: 12419;12459; 12764: 12771.	No.	No.
Spelaeotrilietes sp. A	12604.	No.	No.

Spelaeotriletes spp.	12259; 12477; 12544; 12576; 12600.	No.	No.
Spelaeotriletes triangulus	11955; 12484.	No.	No.
Spinozonotriletes baccatus	12444.	No.	No.
Spinozonotriletes uncatus	7449-7454.	Yes (MPK 7449; MPK 7450).	No.
Stenozonotriletes spp.	12058; 12319: 12584.	No.	No.
Striatoabieites spp.	12258.	No.	No.
Striomonosaccites spp.	12299.	No.	No.
Stroterosporites indicus	8778-8785.	No.	No.
Tasmanites spp.	12055-12057; 12059; 12063; 12065;12077; 12079; 12094; 12098; 12101; 12104; 12134, 12136: 12589.	No.	No.
Tetraporina horologia	7891; 7893-7898; 78900-7909.	No.	No.
Tetraporina incrassata	7892; 7899.	No.	No.
Thymospora ipsviciensis	12213.	No.	No.
Thymospora spp.	8128-8145; 12213.	No.	No.
Torispora securis	7092-7093; 11971.	Yes (MPK 7092; MPK 7093).	No.
Triadispora crassa	12337.	No.	No.
Tricidarisporites fasciculatus	6399.	No.	No.
Tripartites distinctus	7994-8006; 8008.	No.	Yes (MPK 7996; MPK 7997).
Tripartites incisotrilobus	7840-7851.	No.	No.
Tripartites trilinguis	7554; 7559; 7561-7563; 7565-7566.	Yes (MPK 7559; MPK 7566).	No.
Tripartites vetustus	7555-7558; 7560; 7564; 7567; (7581).	Yes (MPK 7555; MPK 7556).	No.
Triquitrites sculptilis	7215-7229.	Yes (MPK 7222; MPK 7224).	No.
Triquitrites spp.	9004-9015.	No.	No.
Triquitrites trivalvis	7750-7761.	Yes (MPK 7755; MPK 7757).	No.
Tsugaepollenites oriens	12290.	No.	No.

Umbonatisporites baculatus	12449.	No.	No.
Umbonatisporites distinctus	7427; 12486.	Yes (MPK 7427).	No.
Umbonatisporites variabilis	7428-7431.	Yes (MPK 7429; MPK 7430).	No.
Vallatisporites agadesi	7340-7348; 11940.	Yes (MPK 7341; MPK 7343)	No.
Vallatisporites ciliaris	17091; 12437; 12550.	No.	No.
Vallatisporites drybrookensis	7080-7091.	Yes (MPK 7081; MPK 7083).	No.
Vallatisporites hystricosus	8753-8755.	Yes (MPK 7062; MPK 7063).	No.
Vallatisporites pusillites	7366; 8746-8752; 8756-8757.	No..	Yes (MPK 8747 ; MPK 8748).
Vallatisporites splendens	11958.	No.	No.
Vallatisporites vallatus	7316-7317; 7225-7339; 8756; 11953; 11970; (19971); 11983; 12446; 12460; 12466; 12468; 12473; 12480; 12552.	Yes (MPK 7325; MPK 7328).	No.
Vallatisporites verrucosus	7310-7315; 7318-7324; 11954; 11962; 12714.	Yes (MPK 7311; MPK 7312).	No.
Verruciretusispora dubia	12461.	No.	No.
Verruciretusispora famenensis	12524.	No.	No.
Verrucosisporites nitidus	8020-8031.	No.	Yes (MPK 8021; MPK 8024).
Verrucosisporites premnus	11924; 12121; 12128; 12185.	No.	No.
Verrucosisporites scurrus	12023; 12161; 12177.	No.	No.
Verrucosisporites tumulentus	12175.	No.	No.
Vestispora costata	8009-8019.	No.	Yes (MPK 8011; MPK 8012).
Vestispora fenestrata	8146-8151.	No.	No.
Vestispora magna	8120-8124; 8125-8126?: 8127.	No.	No.
Vestispora cf. *tortuosa*	8011.	No.	No.
Vittatina costabilis	(7882); 8068-8079.	No.	No.

Waltzispora planiangulata	6398.	No.	No.

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: https://envirolib.apps.nerc.ac.uk/olibcgi.

ARMSTONG, H., and BRASIER, M. 2005. *Microfossils – 2nd ed*. (Blackwell Publishing), 296pp. http://dx.doi.org/10.1002/9781118685440.

ARTÜZ, S. 1957. Die sporae dispersae der Türkischen Steinkohle vom Zonguldak-Gebiet. *Instanb. Üniv. Fen. Fak. Mecm.*, Vol. B22 (4), 239-63.

BEK JIŘÍ 2012. A review of the genus *Lycospora*. *Review of Palaeobotany and Palynology*, Vol. 174, 122–135. http://dx.doi.org/10.1016/j.revpalbo.2011.12.008.

BUTTERWORTH,M.A. and SPINNER, E. 1967. Lower Carboniferous spores from North-West England. *Palaeontology*, Vol. 10 (1), 1- 24.

BUTTERWORTH, M. A., and MAHDI, S. A. 1982. Namurian and basal Westphalian A miospore assemblages from the Featherstone area, Northern England. *Pollen et spores*, Vol. 24 (1), 481-510, 6 pls.

BUTTERWORTH, M. A., and WILLIAMS, R.W. 1958. The small spore floras of coals in the Limestone Coal Group and Upper Limestone Group of the Lower Carboniferous of Scotland. *Transactions of the Royal Society of Edinburgh. Earth Sciences*, Vol. 63 (2), 353-392.

BRITISH MICROPALEONTOLOGICAL SOCIETY, PALYNOLOGY GROUP 1984. Pollen and Spore Biostratigraphy of the Phanerozoic in North-West Europe. In *Palynology Group Meeting, Cambridge 1984*.

CLAYTON, G. 1996. Chapter 18C. Mississippian miospores. 589–596 in: *Palynology: principles and applications*. Jansonius, J. and McGregor, D.C. (editors). (American Association of Stratigraphic Palynologist Foundation, Vol. 2).

CLAYTON, G., COQUEL, R., DOUBINGER, J., GUEINN, K. J., LOBOZIAK, S., OWENS, B., and STREEL, M. 1977. Carboniferous Miospores of Western Europe: illustration and zonation. *Mededelingen Rijks Geologische Dienst*, Vol. 29, 1-71.

COQUEL, R. 1974. Etude palynologique de la série houillère dans l'unité de production de Valenciennes du bassin houller du Nord de la France. Unpublished master degree thesis, University of Lille.

COQUEL, R., DOUBINGER, J., and LOBOZIAK, S. 1976. Les microspores-Guides du Westphalian A á l'Autunien d'Europe Occidentale. *Revue de Micropaleontologie*, Vol. 18 (4), 200-212.

DUENÁS, H., and CÉSARI, S.N. 2005. Systematic study of Early Carboniferous palynological assemblages from the Llanos Orientales Basin, Colombia. *Rev. Mus. Argentino Cienc. Nat.,* Vol. 7 (2), 139-152. http://dx.doi.org/10.22179/revmacn.7.331.

EDGAR, D.R. 1984. Polychaetes of the lower and middle Paleozoic: a multi-element analysis and phylogenic outline. 39 in *6th International Palynology Conference, Calgary, abstracts*.

FELIX, C.J., and BURBRIDGE, P.P. 1967. Palynology of the Springer Formation of Southern Oklahoma, U.S.A. *Palaeontology*, Vol. 10 (3), 349-425, pls. 53-66.

HACQUEBARD, P.A. 1957. Plant spores in coal from the Horton group (Mississipian) of Nova Scotia. *Micropaleontology*, Vol. 3 (4), 301-324, pls. 1-3, text.figs 1-2, table 1. https://doi.org/10.4095/101497

HART, G. F. 1965. *The systematics and distribution of Permian Miospores*. (Johannesburg; Witwaterstrand University Press), 252pp.

HIBBERT, F.A., and LACEY, W.S. 1969. Miospores from the lower Carboniferous Basement Beds in the Menai Straits region of Caernarvonshire, North Wales. *Palaeontology*, Vol. 12 (3), 420-440, pl. 78-83.

HIGGS, K., CLAYTON, G., and KEEGAN, J.B. 1988. Stratigraphic and Systematic Palynology of the Tournaisian Rocks of Ireland. *The Geological Survey of Ireland, Special Papers*, Vol. 7, 93 pp., 17 pls.

HOFFMEISTER, W.S., STAPLIN, F.L., MALLOY, R.E., 1955. Mississippian plant spores from the Hardinsburg Formation of Illinois and Kentucky. *J. Paleontol*. 29, 372-399.

KAISER, H. 1970. Die oberdevon-flora der Bäreninsel. 3. Mikroflora des höheren oberdevons und des unterkarbons. *Palaeontographica Abt. B*, Vol.129, 71-124, 25 pls.

KOSANKE, R. M. 1950. Pennsylvanian spores of Illinois and their use in correlation. *Bull. Ill. geol. Surv.*, Vol. 74, 1-128.

LINDSTRÖM, S. 2003. Carboniferous palynology of the Loppa High, Barents Sea, Norway. *Norwegian Journal of Geology*, Vol. 83, 333-349.

LOVE, L.G. 1960. Assemblages of small spores from the lower Oil-Shale Group of Scotland. *Proceedings of the Royal Society of Edinburgh. Section B (Biology)*, Vol. 67, 99-126, 2 pls.

MCLEAN, D., OWENS, B., BODMAN, D.J. and MCLEAN, F.D. 2018. Miospores from the Brigantian stratotype section at Janny Wood, Cumbria. *Proc. Yorkshire Geol. Soc.*, Vol. 62, 89-100. https://doi.org/10.1144/pygs2017-004

NEVES, R. 1958. Upper Carboniferous spore assemblages from the *Gastrioceras subcrenatum* horizon, North Staffordshire. *Geological Magazine*, Vol. 95 (1), 1-19.

NEVES, R. 1961. Namurian plant spores from the southern Pennines, England. *Palaeontology*, Vol. 4 (2), 247-279, pls. 30-34.

NEVES, R., GUEINN, K.J., CLAYTON, G., IOANNIDES, N.S., NEVILLE, R.S.W., KRUSZEWSKA, K. 1973. Palynological correlations within the Lower Carboniferous of Scotland and Northern England. *Transactions of the Royal Society of Edinburgh*, Vol. 69, 23-70, 6 pls.

OWENS, B., LOBOZIAK, S., and TETERIUK, V.K. 1978. Palynological subdivision of the Dinantian to Westphalian deposits of Northwest Europe and the Donetz basin of the U.S.S.R. *Palynology*, Vol. 2, 69-91.

OWENS, B., MCLEAN, D., and BODMAN, D. 2004. A revised palynozonation of British Namurian deposits and comparisons with eastern Europe. *Micropaleontology*, Vol. 50, 89-103. https://doi.org/10.2113/50.1.89

OWENS, B., MCLEAN, D., SIMPSON, K.R.M, SHELL, P.M.J., and ROBINSON, R. 2005. Reappraisal of the Mississippian Palynostratigraphy of the East Fife Coast, Scotland, United Kingdom. *Palynology*, Vol. 29, 23-47. https://doi.org/10.2113/29.1.23

OWENS, B., NEVES, R., GUEINN, K.J., MISHELL, D.R.F., SABRY, H.S.M.Z., and WILLIAMS, J.E. 1977. Palynological division of the Namurian of Northern England and Scotland. *Proceedings of the Yorkshire Geological and Polytechnic Society*, Vol. 41, 381-398.

PANT, D.D. 1954. Suggestions for the classification and nomenclature of fossil spores and pollen grains. *The Botanical Review*, Vol. 20 (1), 33-60.

PLAYFORD, G. 1962. Lower Carboniferous microfloras of Spitsbergen. Part Two. *Palaeontology*, Vol. 5, 550-678.

PLAYFORD, G. 1964. Miospores from the Mississipian Horton Group, Eastern Canada. *Bulletin of the Geological Survey of Canada*, Vol. 107, 47 pp., 9 tables.

PLAYFORD, G. 1976. Plant microfossils from the upper Devonian and lower Carboniferous of the Canning Basin, Western Australia. *Palaeontographica Abt. B*, Vol. 158, 1-71.

PLAYFORD, G. 1978. Lower Carboniferous spores from the Ducabrook Formation, Drummond Basin, Queensland. *Palaeontographica Abt. B*, Vol. 167, 105-160, 13 pts., 10 fig., 3 tables.

PLAYFORD, G. 2016. Mississipian palynoflora from the northern Perth Basin, Western Australia: systematics and stratigraphical and palaeogeographical significance. *Journal of Systematic Palaentology*, Vol. 14 (9), 731–770. https://doi.org/10.1080/14772019.2015.1091792

POTONIÉ, R. 1958. Synopsis der Gattugen der Sporae dispersae. II Tell: Sporites (Nachträge), Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates. *Beih. Geol. Jb.*, Vol. 31, 1-114, 11 tables.

POTONIÉ, R. and KREMP, G. 1955. Die sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebeite und Zeitabschnitte: Teil I. *Palaeontographica B*, Vol. 98, 1-136.

POTONIÉ, R. and KREMP, G. 1956. Die sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebeite und Zeitabschnitte: Teil II. *Palaeontographica B*, Vol. 99, 85-191.

PUNT, W., HOEN, P.P., BLACKMORE, S., NILSSON, S., LE THOMAS, A., 2007. Glossary of pollen and spores terminology. *Review of Palaeobotany and Palynology*, Vol. 143, 1-81. http://dx.doi.org/10.1016/j.revpalbo.2006.06.008.

RAVN, R.L. 1986. Palynostratigraphy of the lower and middle Pennsylvanian coals of Iowa. *Iowa Geological Survey Technical Paper,* 7, 164 pp., 40 pls.

RIDING, J.B., and HEAD, M. J. 2018. Preparing photographic plates of palynomorphs in the digital age. *Palynology*, Vol. 42 (3), 354–365. http://dx.doi.org/10.1016/10.1080/01916122.2017.1364052.

RIDING, J.B., MCLEAN, D., and WELLMAN, C.H. 2020. Bernard Owens (1938–2019). *Palynology*, Vol. 44, 195-204. http://dx.doi.org/10.1080/01916122.2020.1739252

SCHWEITZER, H. J., and HOLSHER, S. 1991. Die sporae dispersae der Essner Schichten (unteres Westfal B) im östlichen ruhrgebiet und ihre brauchbarkeit für flözparallelisierungen. *Palaeontographica Abt. B*, Vol. 222: 121-209.

SMITH, A.H.V., and BUTTERWORTH, M.A. 1967. Miospores in the coal seams of the Carboniferous of Great Britain. *Special Papers in Palaeontology*, Vol. 1, 324 pp., 27 pls., 72 figs., 5 tables.

STAPLIN, F.L., and JANSONIUS, J. 1964. Elucidation of some Paleozoic densospores. *Palaeontographica Ab. B*, Vol. 114 (4), 95- 117.

STEPHENSON, M., and OWENS, B. 2006. Taxonomy Online 2: the “Bernard Owens collection” of single grain mount palynological slides: Carboniferous spores part I. *British Geological Survey Research Report*, RR/06/05, 80 pp.

SULLIVAN, H.J., and MARSHALL, A.E. 1966. Viséan spores from Scotland. *Micropaleontology*, Vol. 12 (3), 265–285, pls. 1-4.

TRAVERSE, A. 2007. *Paleopalynology. Second edition*. (Springer, Topics in Geobiology, Vol. 28), 613pp.

VARKER, W.J., OWENS, B., RILEY, N.J. 1990. Integrated biostratigraphy for the proposed mid-Cretaceous boundary stratotype Stonehead Beck, Cowling, North Yorkshire, England. *Courier Forschungsinstitut Senckenberg*, Vol. 130.

WINSLOW, M.R. 1962. Plant spores and other microfossils from Upper Devonian and lower Mississippian Rocks of Ohio. *United States Geological Survey Professional Paper*, Vol. 364, pp. 93, 22 pls.