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# A palynological investigation of samples from the Devonian of SW England

GEOLOGY & LANDSCAPE PROGRAMME, SOUTHERN  
BRITAIN

Internal Report IR/06/107



BRITISH GEOLOGICAL SURVEY

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INTERNAL REPORT IR/06/107

# A palynological investigation of samples from the Devonian of SW England

S G Molyneux

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## Contents

|                                       |           |
|---------------------------------------|-----------|
| <b>Acknowledgements</b> .....         | <b>i</b>  |
| <b>Contents</b> .....                 | <b>i</b>  |
| <b>1 Introduction</b> .....           | <b>1</b>  |
| <b>2 Preparation techniques</b> ..... | <b>1</b>  |
| <b>3 Results</b> .....                | <b>1</b>  |
| 3.1 MPA 53611.....                    | 1         |
| 3.2 MPA 53612.....                    | 2         |
| 3.3 MPA 53613.....                    | 3         |
| 3.4 MPA 53614.....                    | 3         |
| 3.5 MPA 53615.....                    | 5         |
| 3.6 MPA 53616.....                    | 5         |
| 3.7 MPA 53619.....                    | 5         |
| 3.8 MPA 53620.....                    | 6         |
| 3.9 MPA 53621.....                    | 6         |
| 3.10 MPA 54614.....                   | 7         |
| 3.11 MPA 54615.....                   | 7         |
| 3.12 MPA 54616.....                   | 7         |
| 3.13 MPA 7152.....                    | 8         |
| 3.14 MPA 7154.....                    | 8         |
| 3.15 MPA 7155.....                    | 9         |
| 3.16 MPA 7168.....                    | 10        |
| 3.17 MPA 7171.....                    | 10        |
| <b>References</b> .....               | <b>11</b> |
| <b>Plate 1</b> .....                  | <b>12</b> |
| <b>Plate 2</b> .....                  | <b>13</b> |
| <b>Plate 3</b> .....                  | <b>14</b> |
| <b>Plate 4</b> .....                  | <b>15</b> |
| <b>Plate 5</b> .....                  | <b>16</b> |

# 1 Introduction

The results of a palynological investigation aimed at determining the ages of 17 samples from the Devonian of SW England are reported. A key element in the extraction of determinable spores from these samples was successful oxidation of the material using a strong oxidising agent (fuming Schultze solution – a mixture of potassium chlorate,  $\text{KClO}_3$ , and fuming nitric acid,  $\text{HNO}_3$ ). This rendered originally opaque and therefore largely undeterminable spores translucent so that key morphological features on the surface of the spores could be seen. Stratigraphically important species are figured.

## 2 Preparation techniques

Initial preparation of the samples was by standard acid digestion (HF), followed by sieving and heavy liquid separation to concentrate the organic fraction. Examination of residues at this stage indicated the presence of opaque grains, some of which were identified as probable spores on the basis of size, shape and in some cases the presence of a spinose ornament. However, oxidation was required to render them translucent and therefore determinable.

Oxidation was by experimentation and varied with each sample. Schultze solution, a mixture of potassium chlorate,  $\text{KClO}_3$ , and nitric acid,  $\text{HNO}_3$ , was used initially, but was found to have little effect after 2 hours. At that point, the stronger fuming Schultze solution was substituted with some success. The effect of fuming Schultze solution on each sample was monitored, and the reaction stopped when translucent spores were seen in the residues in the laboratory. The oxidised residues were then strewn on glass cover slips and mounted on slides for optical microscopy. Oxidation times for each sample are indicated below.

Other workers have documented the need for lengthy oxidation of Devonian spore samples from southern Britain and Ireland. Higgs (1999), for example, reported that initially opaque spores from the Dingle Group of SW Ireland required 18-20 hours in Schultze solution to render them sufficiently translucent for identification.

## 3 Results

Palynological results from the 17 samples are listed below, ordered by BGS registered sample (MPA) number. Details of sample locality and grid references are included for each sample.

### 3.1 MPA 53611

*Collector's symbol and number:* LBE 114  
*1:50k sheet number:* 347  
*1:50k sheet name:* Bodmin  
*Grid reference:* SX 03780 48120  
*Locality:* 340 m NW of Black Head

#### *Sample preparation:*

Slide 1: 15 mins fuming Schultze solution  
Slide 2: 30 mins fuming Schultze solution  
Slide 3: 45 mins fuming Schultze solution.

*Results:* Opaque fragments only were recorded. No translucent spores were seen.

### 3.2 MPA 53612

Collector's symbol and number: LBE 115  
 1:50k sheet number: 347  
 1:50k sheet name: Bodmin  
 Grid reference: SX 03135 50515  
 Locality: 230 m E of Porthpean Church

#### Sample preparation:

Slide 1: 2 hrs in Schultz solution followed by 30 mins in fuming Schultz solution.  
 Slide 2: 2 hrs in Schultz solution followed by 37 mins in fuming Schultz solution.  
 Slide 3: 2 hrs in Schultz solution followed by 57 mins in fuming Schultz solution.  
 Slides 4, 5: 2 hrs in Schultz solution followed by 1 hr 7 mins in fuming Schultz solution.

*Results:* Slide 2 contained opaque fragments including probable spores. Translucent spores were recorded from slides 3, 4 and 5, following about 3 hours of oxidation including approximately 1 hour using the strongest oxidising agent. The following spore taxa were recorded:

*Camarozonotriletes sextantii?*  
*Dibolisporites eifeliensis?* or *D. wetteldorfensis?*  
*Emphanisporites annulatus*  
*Emphanisporites robustus*  
*Emphanisporites rotatus*  
*Emphanisporites schultzi*  
*Emphanisporites* spp.  
*Retusotriletes?* sp.  
*Verrucosisorites polygonalis*

Ranges of key species based on Richardson & McGregor (1986), Streel *et al.* (1987) and Steemans (1989) are as follows:

*Camarozonotriletes sextantii?*: uppermost *polygonalis-emsianensis* to lowermost *douglastownense-euryperota* zones of Richardson & McGregor (1986), approximately equivalent to AB and FD zones of Streel *et al.* (1987); Emsian.

*Dibolisporites eifeliensis?*: *polygonalis-emsianensis* to lower *velatus-langii* zones of Richardson & McGregor (1986), approximately equivalent to PoW to AP zones of Streel *et al.* (1987); Pragian (Siegenian)-Lower Eifelian.

*Dibolisporites wetteldorfensis?*: middle *polygonalis-emsianensis* to lowermost *douglastownense-euryperota* zones of Richardson & McGregor (1986), approximately equivalent to middle PoW (W) to FD zones of Streel *et al.* (1987); Pragian (Siegenian)-Emsian.

*Emphanisporites annulatus*: appears at base of *annulatus-sextantii* Zone of Richardson & McGregor (1986), equivalent to base of AB Zone of Streel *et al.* (1987), and approximately equivalent to base of Emsian. Probably ranges into the Famennian (Steemans 1989).

*Emphanisporites schultzi*: lower *annulatus-sextantii* to upper *douglastownense-euryperota* zones of Richardson & McGregor (1986), approximately equivalent to AB, FD and lower AP zones of Streel *et al.* (1987); Emsian to lower Eifelian. Steemans (1989) reported occurrences from the middle Siegenian (Pragian, Paß Zone of Streel *et al.*, 1987) to the Emsian.

*Verrucosisorites polygonalis*: base of *polygonalis-emsianensis* to top of *annulatus-sextantii* zones of Richardson & McGregor (1986), approximately equivalent to PoW to FD zones of Streel *et al.* (1987); Pragian (Siegenian)-lower Emsian.

The overlap of ranges indicates the *annulatus-sextantii* Zone of Richardson & McGregor (1986) or the AB-FD zones of Streel *et al.* (1987), and therefore an early Emsian age.

Age: Early Emsian.

### 3.3 MPA 53613

Collector's symbol and number: LBE 116  
 1:50k sheet number: 347  
 1:50k sheet name: Bodmin  
 Grid reference: SX 03865 51320  
 Locality: 500 m ENE of Duporth

*Sample preparation:*

Slide 1: 20 mins in fuming Schultz solution.  
 Slide 2: 40 mins in fuming Schultz solution.  
 Slides 3, 4: 55 mins in fuming Schultz solution.

*Results:* Slide 2 contained opaque fragments including probable spores. Translucent spores were recorded from slides 3 and 4 following 55 minutes oxidation using fuming Schultz solution. Spores recorded include the following:

*Apiculiretusispora?* spp.  
*Camarozonotriletes sextantii?*  
*Dibolisporites* sp.  
*Emphanisporites annulatus*  
*Emphanisporites foveolatus*  
*Emphanisporites rotatus*  
*Emphanisporites schultzii*  
*Punctatisporites?* sp.  
*Retusotriletes* sp.  
*Verrucosisporites polygonalis*

See discussion of MPA 53612 for information on the ranges of *Camarozonotriletes sextantii?*, *Emphanisporites annulatus*, *Emphanisporites schultzii* and *Verrucosisporites polygonalis*. Streele *et al.* (1987) recorded the first appearance *Emphanisporites foveolatus* at the base of the Fov. Interval Zone (= base of the FD Opperl Zone), which immediately overlies the AB Zone, but Steemans also reported it from the AB Zone. The co-occurrence of species is therefore considered to indicate the lower Emsian AB-FD zones of Streele *et al.* (1987), equivalent to the *annulatus-sextantii* Zone of Richardson & McGregor (1986).

Age: Early Emsian.

### 3.4 MPA 53614

Collector's symbol and number: LBE 117  
 1:50k sheet number: 347  
 1:50k sheet name: Bodmin  
 Grid reference: SX 05325 52170  
 Locality: W end of Carlyon Bay, 200 m SE of Hotel

*Sample preparation:*

Slide 1: 2 hrs in Schultz solution followed by 15 mins in fuming Schultz solution.  
 Slide 2: 2 hrs in Schultz solution followed by 25 mins in fuming Schultz solution.  
 Slides 3, 4: 2 hrs in Schultz solution followed by 35 mins in fuming Schultz solution.

*Results:* Slide 1 contained dark spores, not sufficiently translucent to discern diagnostic morphological features. The remaining slides contained translucent spores, including:

*Apiculatisporis?*  
*Apiculiretusispora* sp.



*Brochotriletes?*  
*Dibolisporites echinaceous*  
*Dibolisporites eifeliensis*  
*Dibolisporites wetteldorfensis?*  
*Dictyotriletes emsiensis*  
*Emphanisporites annulatus*  
*Emphanisporites erraticus?*  
*Emphanisporites obscurus*  
*Emphanisporites robustus?*  
*Emphanisporites rotatus*  
*Emphanisporites schultzi?*  
*Emphanisporites* spp.  
*Emphanisporites zavallatus?*  
 hilate cryptospore (*Artemopyra?* sp., reworked?)  
 ?*Retusotriletes maculatus*  
*Retusotriletes?* sp.

Also present are a small number of marine palynomorphs, including scolecodonts and the following acritarchs:

*Acanthodiacrodium spinum*  
*Acanthodiacrodium* spp.  
*Stelliferidium* sp.  
*Striatotheca* sp.  
*Veryhachium trispinosum*

See discussion of MPA 53612 for information on the ranges of *Dibolisporites eifeliensis*, *Dibolisporites wetteldorfensis?*, *Emphanisporites annulatus* and *Emphanisporites schultzi*.

Ranges of other species based on Richardson & McGregor (1986), Streele *et al.* (1987) and Steemans (1989) are as follows:

*Dibolisporites echinaceous*: Richardson & McGregor (1986) recorded this species from the lower *annulatus-sexantii* to mid *ovalis-bulliferus* zones, approximately equivalent to AB-BM zones of Streele *et al.* (1987) and to the Emsian-mid Frasnian interval, but Steemans (1989) also mentioned records from the upper Gedinnian to upper Famennian.

*Dictyotriletes emsiensis*: upper *breconensis-zavallatus* to the top of the *annulatus-sexantii* zones of Richardson & McGregor (1986), equivalent to the BZ (E) to FD? zones of Streele *et al.* (1987), approximately Siegenian [Pragian]-lower Emsian.

*Emphanisporites zavallatus?*: the species is restricted to the *breconensis-zavallatus* Zone in Richardson & McGregor's (1986) scheme, equivalent to the upper Lochkovian-lower Pragian (upper Gedinnian-lower Siegenian) BZ Zone of Streele *et al.* (1987), but is reported to range from the Gedinnian to the Emsian by Steemans (1989)

?*Retusotriletes maculatus*: *micronatus-newportensis* to *annulatus-sexantii* zones of Richardson & McGregor (1986), approximately equivalent to MN to FD zones of Streele *et al.* (1987); Lochkovian (Gedinnian)-Emsian.

The overlap of ranges, especially those of *D. emsiensis* and *E. annulatus*, indicates the *annulatus-sexantii* Zone of Richardson & McGregor (1986) and the lower Emsian AB-FD zones of Streele *et al.* (1987).

The acritarchs recorded are mostly Ordovician forms; *Acanthodiacrodium* and *Stelliferidium* probably indicate reworking of Tremadocian species whereas *Striatotheca* is from higher in the Ordovician (Lower-Middle Ordovician). *Veryhachium trispinosum* is long ranging and might also be a reworked Ordovician (or Silurian) form, or could be *in situ*. A single hilate cryptospore was recorded and is assigned to *Artemopyra?* sp. This might indicate reworking from the

Silurian.

Age: Early Emsian.

### 3.5 MPA 53615

Collector's symbol and number: LBE 118  
 1:50k sheet number: 347  
 1:50k sheet name: Bodmin  
 Grid reference: SX 06965 52300  
 Locality: 590 m WSW of Spit Point

*Sample preparation:*

Slide 1: 50 mins in fuming Schultz solution.  
 Slide 2: 1 hr 10 mins in fuming Schultz solution.  
 Slides 3, 4: 1 hr 30 mins in fuming Schultz solution.

*Results:* Slide 2 contained dark and opaque spores, the former not sufficiently translucent to reveal diagnostic morphological features. Slides 3 and 4 contained translucent spores, including:

*Dibolisporites?* sp.  
*Emphanisporites annulatus*  
*Emphanisporites robustus?*  
*Emphanisporites rotatus*  
*Emphanisporites schultzi* or *E. erraticus?*  
*Punctatisporites?*

Age: Probably Emsian to early Eifelian?, based on the co-occurrence of *Emphanisporites annulatus* and *Emphanisporites schultzi*? (see discussion of MPA 53612 for ranges). AB-lower AP zones of Streele *et al.* (1987), *annulatus-sexantii* to *douglastownense-euryperota* zones of Richardson & McGregor (1986), but could be younger if the determination of *E. schultzi*? is incorrect.

### 3.6 MPA 53616

Collector's symbol and number: LBE 119  
 1:50k sheet number: 347  
 1:50k sheet name: Bodmin  
 Grid reference: SX 09120 52170  
 Locality: 210 m W of Polkerris Post Office

*Sample preparation:*

Slide 1: 1 hr 20 mins in fuming Schultz solution.  
 Slide 2: 3 hrs 10 mins in fuming Schultz solution.

*Results:* Only opaque fragments, including possible spores, were recorded.

### 3.7 MPA 53619

Collector's symbol and number: LBE 104  
 1:50k sheet number: 353  
 1:50k sheet name: Mevaggissey  
 Grid reference: SX 02490 47490  
 Locality: Polrudden Cove, 210 m ENE of Polrudden Farm

*Sample preparation:*

Slide 1: 30 mins in fuming Schultz solution.  
 Slide 2: 1 hr in fuming Schultz solution.

Slide 3: 1 hr 30 mins in fuming Schultz solution.

*Results:* All slides yielded rare spores, including the following taxa.

*Dibolisporites?* sp.  
*Emphanisporites annulatus*  
*Emphanisporites schultzii*  
*Emphanisporites* spp.

*Age:* Emsian to early Eifelian?, based on the co-occurrence of *Emphanisporites annulatus* and *Emphanisporites schultzii* (see discussion of MPA 53612 for ranges); AB-lower AP zones of Strel *et al.* (1987), *annulatus-sextantii* to *douglastownense-euryperota* zones of Richardson & McGregor (1986). The determination of *E. schultzii* is based on an incomplete specimen, but the characteristic ornament of prominent striations converging on the centre of the inter-radial area is obvious.

### 3.8 MPA 53620

*Collector's symbol and number:* LBE 105  
*1:50k sheet number:* 353  
*1:50k sheet name:* Mevagissey  
*Grid reference:* SX 02728 47640  
*Locality:* Near Polrudden Cove, 460 m NE of Polrudden Farm

*Sample preparation:*

Slide 1: 30 mins in fuming Schultz solution.  
 Slides 2, 3: 1 hr 5 mins in fuming Schultz solution.

*Results:* Slide 1 contained only opaque material. Translucent spores were recorded from slides 2 and 3, and include the following:

*Apiculiretusispora?* sp.  
*Archaeozonotriletes?*  
*Brochotriletes?*  
 ?*Camptozonotriletes* cf. *caperatus* in Strel *et al.* 1981  
*Dibolisporites?*  
*Emphanisporites annulatus*  
*Emphanisporites rotatus?*  
*Emphanisporites* spp.  
*Punctatisporites* spp.

A single specimen of the marine acritarch *Veryhachium trispinosum* was also recorded.

*Age:* Emsian (AB Zone) or younger. *Emphanisporites annulatus* has its first appearance at the base of the AB Zone and is reported to range upwards into the Famennian (Steemans 1989). The other taxa recorded do not refine the age determination.

### 3.9 MPA 53621

*Collector's symbol and number:* LBE 106  
*1:50k sheet number:* 353  
*1:50k sheet name:* Mevagissey  
*Grid reference:* SX 03430 48049  
*Locality:* Drennick, 580 m WNW of Black Head

*Sample preparation:*

Slide 1: 35 mins in fuming Schultz solution.  
 Slides 2, 3: 1 hr 5 mins in fuming Schultz solution.

*Results:* All the slides from this sample contained rare, translucent spores, including the following:

*Emphanisporites annulatus*  
*Emphanisporites robustus?*  
*Emphanisporites rotatus?*  
*Emphanisporites schultzii*  
*Punctatisporites?* spp.  
*Retusotriletes?* spp.  
*Tetrahedraletes medinensis*

A single specimen of the marine acritarch genus *Acanthodiacrodium* was also recorded; this is considered to be reworked from Ordovician, probably Tremadocian strata. The occurrence of the cryptospore tetrad *Tetrahedraletes medinensis* is also anomalously high, given the age suggested here for the sample, and could be reworked from Middle-Upper Ordovician or Silurian strata.

*Age:* Emsian to early Eifelian?, based on the co-occurrence of *Emphanisporites annulatus* and *Emphanisporites schultzii* (see discussion of MPA 53612 for ranges); AB-lower AP zones of Streel *et al.* (1987), *annulatus-sextantii* to *douglastownense-euryperota* zones of Richardson & McGregor (1986).

### 3.10 MPA 54614

*Collector's symbol and number:* LH 21  
*1:50k sheet number:* 346  
*1:50k sheet name:* Newquay  
*Grid reference:* SW 7911 6167  
*Locality:* S end of Fistral Beach, Newquay

*Sample preparation:*  
 Slides 1, 2: 15 mins in fuming Schultz solution.

*Results:* The slides from the sample yielded opaque fragments and brown organic matter, including rare, dark spores. None of the latter could be determined.

### 3.11 MPA 54615

*Collector's symbol number:* LH 22  
*1:50k sheet number:* 346  
*1:50k sheet name:* Newquay  
*Grid reference:* SW 7580 5543  
*Locality:* Perran Beach, 100 m N of Cotty's Point

*Sample preparation:*  
 Slide 1: 35 mins in fuming Schultz solution.  
 Slides 2, 3: 1 hr 5 mins in fuming Schultz solution.

*Results:* The slides from the sample yielded opaque fragments only.

### 3.12 MPA 54616

*Collector's symbol and number:* LH 23  
*1:50k sheet number:* 346  
*1:50k sheet name:* Newquay  
*Grid reference:* SW 7601 5592  
*Locality:* Perran Beach, 150 m N of Millenium Steps

*Sample preparation:*

Slides 1, 2: 15 mins in fuming Schultz solution.

*Results:* The slides from the sample yielded numerous spores, including:

cavate spores  
*Grandispora famenensis?*  
*Grandispora* spp.  
*Lophozotriletes?*  
*Retusotriletes*  
*Verrucosisporites?*

Also present are rare acritarchs attributed to *Stellinium*, including *S. micropolygonale*, considered to be *in situ*.

Specimens that closely resemble *Grandispora famenensis* are relatively common. This species ranges from the lower part of the *torquata-gracilis* to the *nitidus-verrucosus* zones, from the middle Frasnian to the Tournaisian, but is particularly characteristic of the middle Frasnian to lower Famennian *torquata-gracilis* Zone (Richardson & McGregor 1986).

*Age:* Mid Frasnian to early Famennian?

### 3.13 MPA 7152

*1:50k sheet number:* 346  
*1:50k sheet name:* Newquay  
*Grid reference:* SW 8146 5390  
*Locality:* Shepherds No. 1 Bh  
*Depth:* 38.7 m

*Sample preparation:*

Slides 1-3: 15 mins in fuming Schultz solution.

*Results:* No spores or other palynomorphs were recorded.

### 3.14 MPA 7154

*1:50k sheet number:* 346  
*1:50k sheet name:* Newquay  
*Grid reference:* SW 8146 5390  
*Locality:* Shepherds No. 1 Bh  
*Depth:* 50 m

*Sample preparation:*

Slides 1, 2: 40 mins in fuming Schultz solution.

*Results:* A diverse assemblage of spores, accompanied by rare acritarchs, was recorded. Spores include the following:

*Apiculiretusispora?* sp.  
*Brochotriletes?*  
 Camerate spores?  
*Dibolisporites?*  
*Dictyotriletes? gorgoneus*  
*Dictyotriletes* sp.  
*Emphanisporites annulatus*  
*Emphanisporites erraticus?*  
*Emphanisporites rotatus?*  
*Emphanisporites* spp,

*Grandispora?* sp.  
 hilate cryptospore monads with split in hilum?  
*Laevolancis divellomedium?*  
*Punctatisporites* spp.  
*Retusotriletes* spp.

Acritarchs include:

acanthomorph acritarchs  
*Veryhachium trispinosum*

Rare scolecodonts were also recorded.

The *Dictyotriletes* sp. is a fragment of a specimen, but resembles *Dictyotriletes emsiensis*. If so, the co-occurrence of this species with *Emphanisporites annulatus* would suggest the lower Emsian *annulatus-sextantii* Zone of Richardson & McGregor (1986) or AB-FD zones of Streel *et al.* (1987). *Dictyotriletes? gorgoneus*, also recorded, is restricted to the *annulatus-sextantii* Zone in Richardson & McGregor's (1986) scheme, equivalent to the lower Emsian AB-FD zones of Streel *et al.* (1987), but has been reported to range from the Gedinnian to the Givetian by Steemans (1989). However, the presence of *Grandispora?* sp. might indicate a relatively high level in the Emsian, or a higher stratigraphic interval.

Specimens resembling hilate cryptospore monads with an equatorial thickening and a split in the hilum, often forming an irregular cross, are among the most common and distinctive forms of this assemblage, and have not been recorded from other samples.

Age: (Mid?) Emsian or younger?

### 3.15 MPA 7155

*1:50k sheet number:* 346  
*1:50k sheet name:* Newquay  
*Grid reference:* SW 8147 5360  
*Locality:* Shepherds No. 1 Bh  
*Depth:* 60 m

*Results:* The sample was not reprepared, but the recovery of spores from MPA 7154 prompted a re-examination of the original slides, as these had been reported previously to contain palynomorphs. Acritarchs are prominent in the sample, and include:

acanthomorph acritarchs  
*Ammonidium?* sp.  
*Cymatiosphaera?* sp.  
*Cymbosphaeridium?* sp.  
*Diexallophasis* sp.  
*Marrocanium?* sp.  
*Micrhystridium* sp.  
*Multiplicisphaeridium* sp.  
*Palacanthus ledanoisii*  
*Polygonium* sp.  
 polygonomorph acritarchs  
 sphaeromorph acritarchs  
*Stelliferidium* sp.  
*Striatostellula?* sp.  
*Striatotheca* sp.  
*Veryhachium trispinosum*

Spores include *Emphanisporites* spp.

Some acritarchs recorded, including *Marrocanium?* sp., *Stelliferidium* sp. and *Striatotheca* sp., are probably reworked from Ordovician strata; others, for example *Ammonidium?* sp. and *Diexallophasis* sp., might have been reworked from Silurian strata or may be *in situ*.

*Age:* Emsian, based on the age suggested for the overlying sample. *Palacanthus ledanoisii* is reported to range from the Emsian to the Frasnian, and possibly higher (Molyneux *et al.* 1996).

### 3.16 MPA 7168

*1:50k sheet number:* 346  
*1:50k sheet name:* Newquay  
*Grid reference:* SW 8147 5360  
*Locality:* Shepherds No. 2 Bh  
*Depth:* 68 m

#### *Sample preparation:*

Slide 1: 15 mins in fuming Schultz solution.  
Slides 2, 3: 55 mins in fuming Schultz solution.

*Results:* Slides contained brown – dark brown amorphous organic matter and opaque fragments. No spores or other palynomorphs were recorded.

### 3.17 MPA 7171

*1:50k sheet number:* 346  
*1:50k sheet name:* Newquay  
*Grid reference:* SW 8147 5360  
*Locality:* Shepherds No. 2 Bh  
*Depth:* 90.05 m

#### *Sample preparation:*

Slide 1: 15 mins in fuming Schultz solution.  
Slide 2: 35 mins in fuming Schultz solution.  
Slides 3, 4: 1 hr 5 mins in fuming Schultz solution.

*Results:* Slides contained brown – dark brown amorphous organic matter and opaque fragments. No spores or other palynomorphs were recorded.

## References

Most of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.

HIGGS, K T 1999. Early Devonian spore assemblages from the Dingle Group, County Kerry, Ireland. *Bollettino della Società Paleontologica Italiana*, Vol. 38, 187–196.

MOLYNEUX, S G, LE HÉRISSE, A. & WICANDER, R. 1996. Chapter 16, Paleozoic phytoplankton. In JANSONIUS, J & MCGREGOR, D C (eds), *Palynology: principles and applications*. American Association of Stratigraphic Palynologists Foundation, Vol. 2, 493-529.

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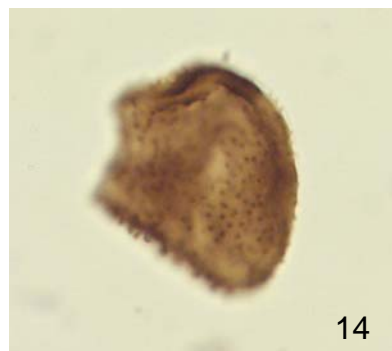
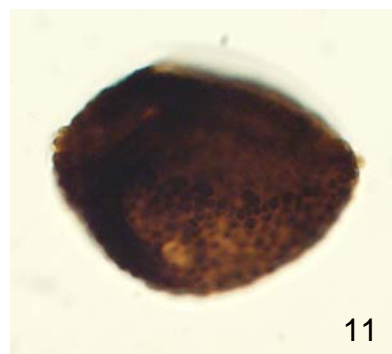
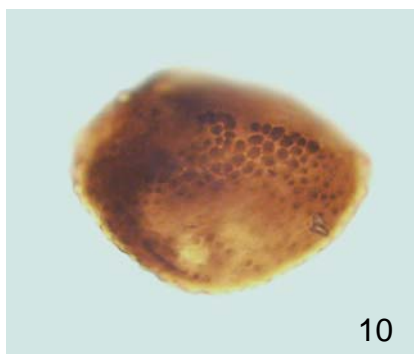
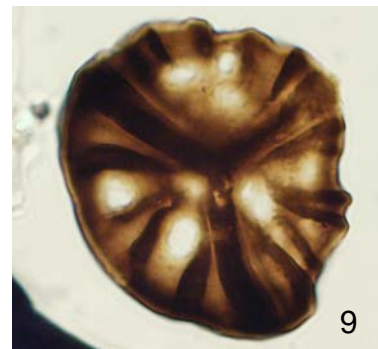
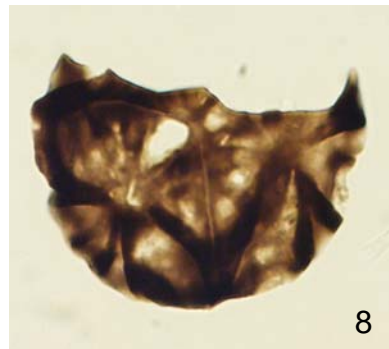
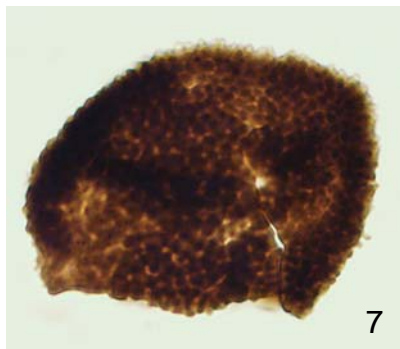
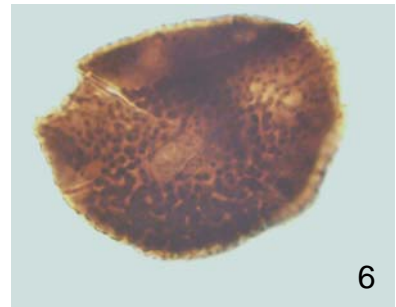
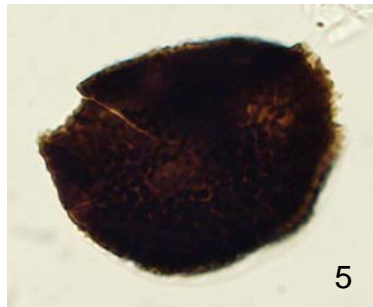
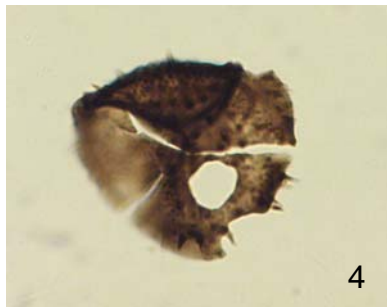
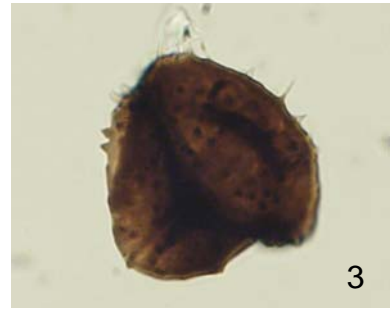
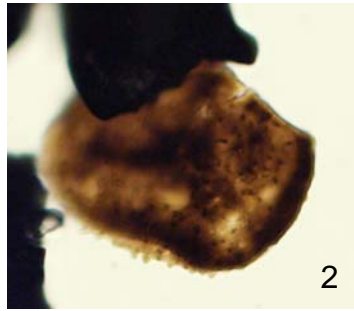
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Plate 1

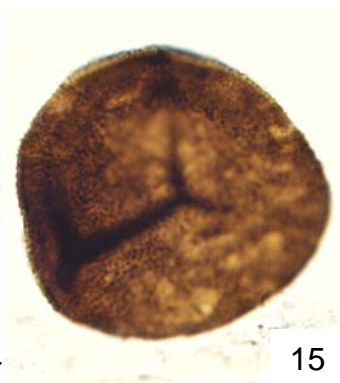
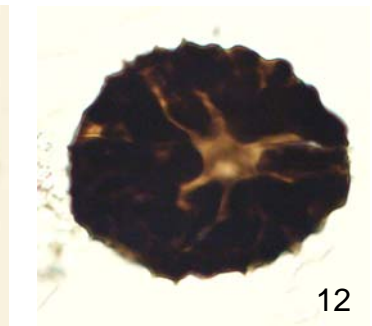
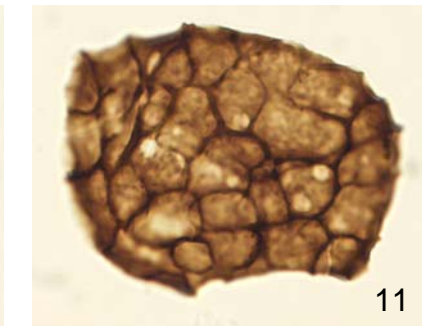
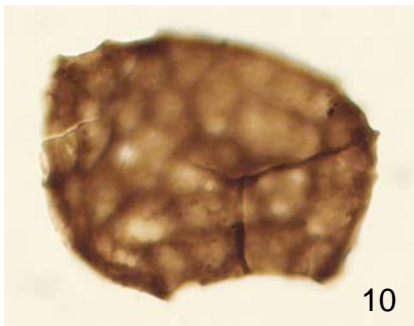
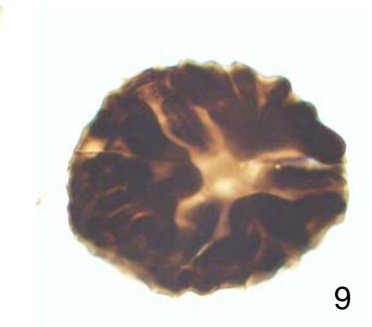
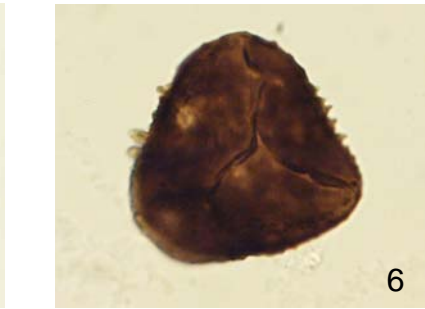
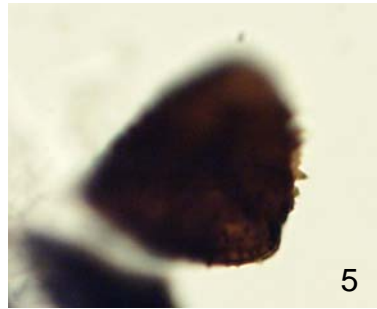
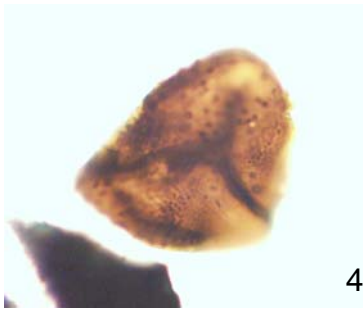
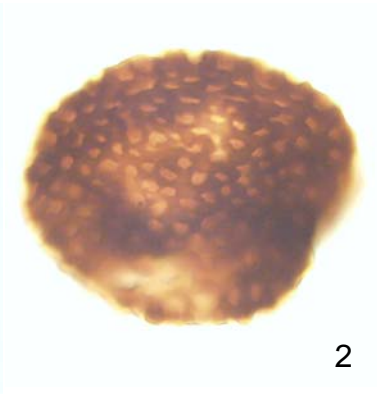
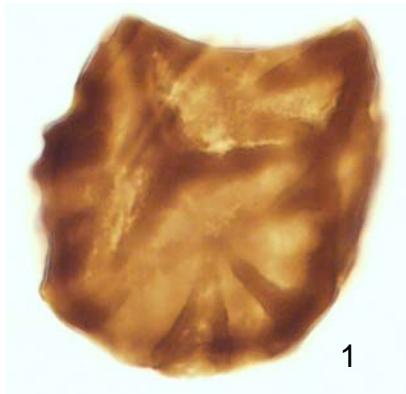


# Plate 1

All figures  $\times 1000$

1. *Emphanisporites annulatus*, MPA 53612, slide 5, 20.0/89.3.
2. *Camarozonotriletes sextantii?*, MPA 53612, slide 3, 13.2/84.5
3. *Dibolisporites wetteldorfensis*, MPA 53612, slide 5, 12.0/79.6
4. *Dibolisporites wetteldorfensis*, MPA 53612, slide 3, 5.7/82.6
5. *Verrucosisporites polygonalis*, MPA 53612, slide 4, 14.6/78.7
6. *Verrucosisporites polygonalis*, same specimen as 5, spot metered photograph
7. *Verrucosisporites polygonalis*, MPA 53612, slide 4, 14.4/93.4
8. *Emphanisporites schultzi*, MPA 53612, slide 3, 8.2/82.0
9. *Emphanisporites robustus*, MPA 53612, slide 5, 6.2/99.1
10. *Verrucosisporites polygonalis*, MPA 53613, slide 4, 19.6/87.5, spot meter
11. *Verrucosisporites polygonalis*, same specimen as 10, full frame meter
12. *Emphanisporites* sp., MPA 53613, slide 4, 16.5/86.5
13. *Camarozonotriletes sextantii?*, MPA 53613, slide 3, 17.7/83.7, equatorial focus
14. *Camarozonotriletes sextantii?* , same specimen as 13, distal focus
15. *Camarozonotriletes sextantii?* , same specimen as 13, proximal focus

Plate 2

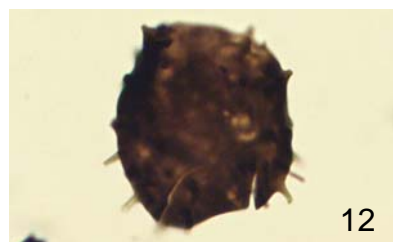
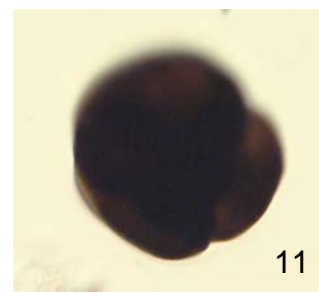
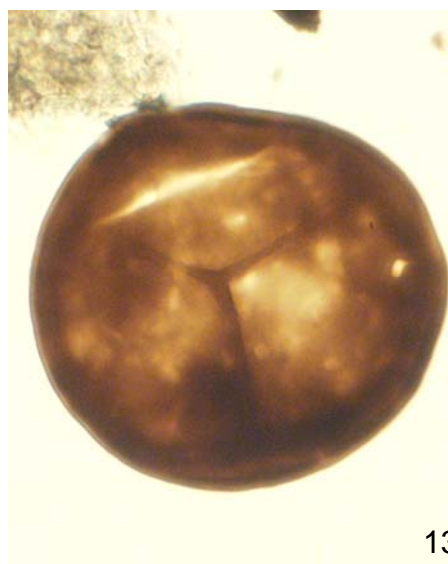
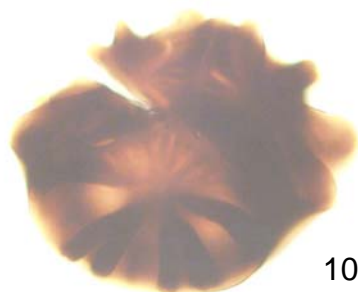
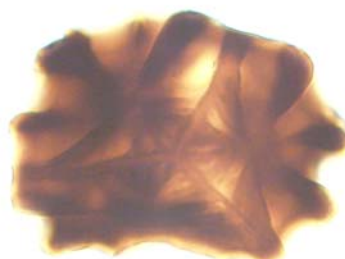
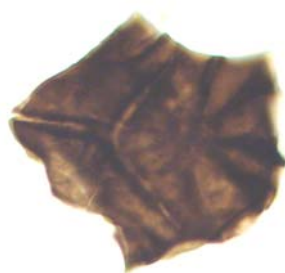
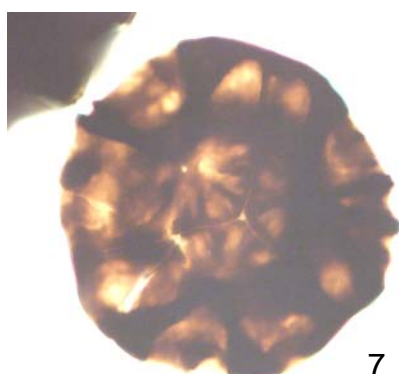
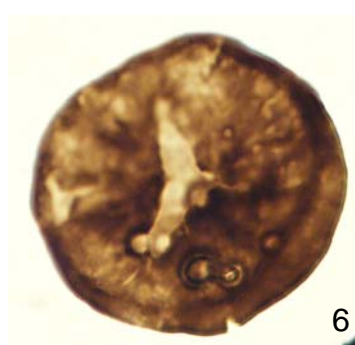
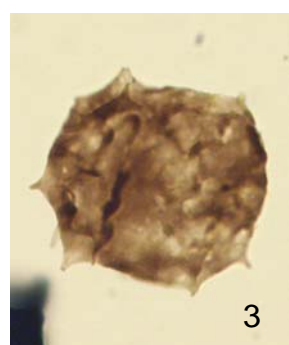
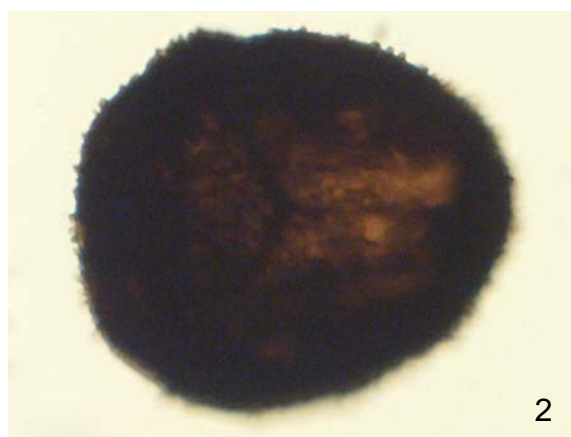
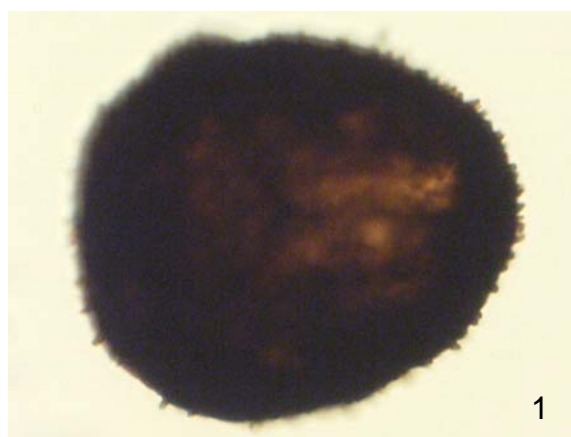


## Plate 2

All figures  $\times 1000$

1. *Emphanisporites schulzii*, MPA 53613, slide 3, 7.3/101.3
2. *Emphanisporites foveolatus*, MPA 53613, slide 3, 8.6/83.1, distal focus
3. *Emphanisporites foveolatus*, same specimen as 2, proximal focus
4. *Dibolisporites wetteldorfensis*, MPA 53614, slide 4, 11.0/104.1, spot meter
5. *Dibolisporites wetteldorfensis*, same specimen as 4, full frame meter
6. *Dibolisporites wetteldorfensis*, MPA 53614, slide 4, 20.4/100.2
7. *Dibolisporites eifeliensis*, MPA 53614, slide 2, 17.9/93.6
8. *Emphanisporites erraticus*, MPA 53614, slide 2, 10.0/101.8
9. *Emphanisporites zavallatus?*, MPA 53614, slide 4, 6.0/121.3, spot meter
10. *Dictyotriletes emsiensis*, MPA 53614, slide 3, 21.1/119.9, proximal focus
11. *Dictyotriletes emsiensis*, same specimen as 10, distal focus
12. *Emphanisporites zavallatus?*, same specimen as 9, full frame meter
13. *Dictyotriletes emsiensis*, MPA 53614, slide 4, 15.5/100.0
14. *Apiculiretusispora* sp. (cf. *A. brandtii?*), MPA 53614, slide 4, 19.7/115.4
15. *Apiculiretusispora* sp. (cf. *A. brandtii?*), MPA 53614, slide 4, 16.3/114.8

Plate 3

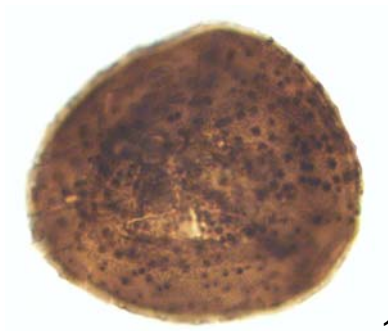


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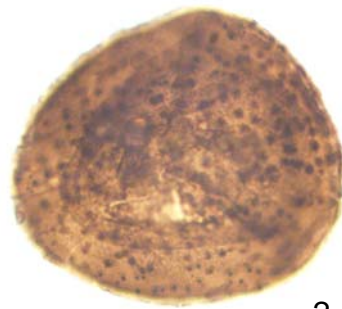
All figures  $\times 1000$

1. *Dibolisporites echinaceous*, MPA 53614, slide 4, 15.5/104.7, distal focus
2. *Dibolisporites echinaceous*, same specimen as 2, proximal focus
3. *Acanthodiacrodium* sp., MPA 53614, slide 2, 4.2/121.0, reworked Ordovician (Tremadocian) acritarch
4. *Acanthodiacrodium spinum*, MPA 53614, slide 3, 23.1/117.1, reworked Ordovician (Tremadocian) acritarch
5. *Stelliferidium* sp., MPA 53614, slide 3, 20.2/108.5, reworked Ordovician acritarch
6. *Artemopyra?* sp., MPA 53614, slide 4, 14.6/111.2, reworked(?) Silurian cryptospore
7. *Emphanisporites schulzii?*, MPA 53615, slide 4, 19.4/87.0
8. *Emphanisporites schulzii*, MPA 53619, slide 4, 21.8/105.2
9. *Emphanisporites schulzii*, MPA 53621, slide 2, 15.8/102.3
10. *Emphanisporites schulzii*, MPA 53621, slide 2, 4.0/85.3
11. *Tetraedraletes medinensis* MPA 53621, slide 2, 3.9/77.0, full frame meter
12. *Acanthodiacrodium* sp., MPA 53621, slide 3, 11.5/82.8, reworked Ordovician (Tremadocian) acritarch
13. *Retusotriletes* sp., MPA 53621, slide 3, 16.4/103.2
14. *Tetraedraletes medinensis*, same specimen as 11, spot meter, reworked(?) Ordovician-Silurian cryptospore

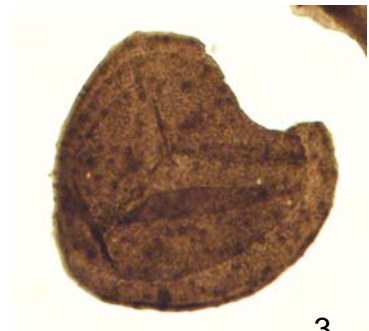
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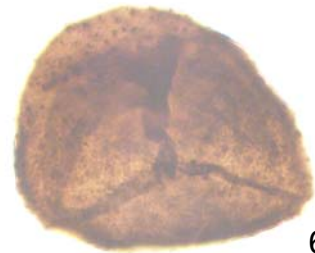
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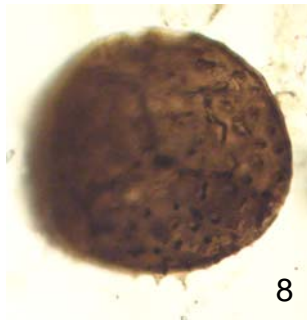
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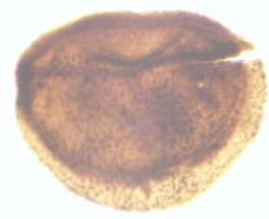
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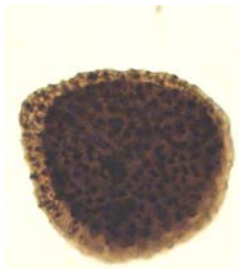
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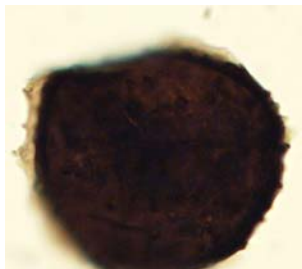
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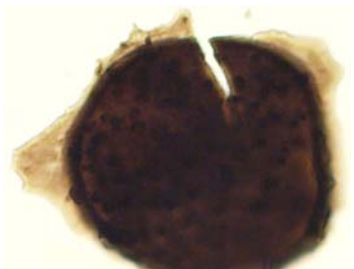
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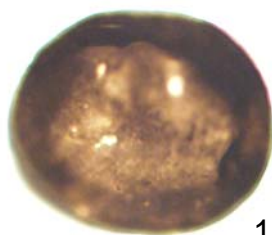
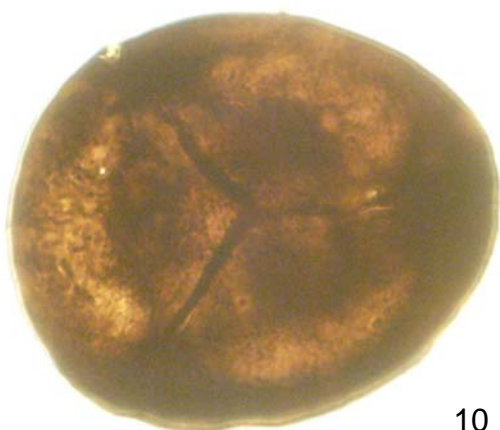
## Plate 4

All figures  $\times 1000$

1. *Grandispora famenensis?*, MPA 54616, slide 1, 18.6/74.0, full frame meter
2. *Grandispora famenensis?*, same specimen as 1, spot meter
3. *Grandispora famenensis?*, MPA 54616, slide 2, 19.0/83.2
4. *Grandispora famenensis?*, MPA 54616, slide 1, 8.4/95.4, spot meter
5. *Grandispora famenensis?*, same specimen as 4, full frame meter
6. *Grandispora famenensis?*, MPA 54616, slide 1, 7.4/90.0, spot meter
7. *Grandispora famenensis?*, MPA 54616, slide 1, 10.5/88.2, spot meter
8. *Grandispora?* sp., MPA 54616, slide 1, 18.7/88.9
9. *Grandispora?* sp., MPA 54616, slide 1, 21.4/87.5, full frame meter
10. *Grandispora?* sp., same specimen as 9, spot meter
11. *Grandispora?* sp., MPA 54616, slide 2, 17.9/94.6
12. cavate spore, MPA 54616, slide 1, 17.6/88.8
13. cavate spore, MPA 54616, slide 2, 19.9/97.2
14. cavate spore, MPA 54616, slide 1, 17.5/94.4
15. cavate spore, MPA 54616, slide 1, 23.4/92.5
16. cavate spore, MPA 54616, slide 1, 21.3/95.3
17. *Stellinium micropolygonale*, MPA 54616, slide 2, 12.5/82.6



Plate 5



## Plate 5

All figures  $\times 1000$

1. *Dictyotriletes* sp. cf. *D. emsiensis*, MPA 7154, slide 1, 14.9/98.2
2. *Dictyotriletes?* *gorgoneus*, MPA 7154, slide 1, 22.1/99.4
3. *Dibolisporites?* sp. (*D. eifeliensis?*), MPA 7154, slide 1, 21.0/83.8
4. hilate cryptospore monad?, with split in hilum, MPA 7154, slide 1, 18.2/86.8
5. hilate cryptospore monad?, with split in hilum, MPA 7154, slide 1, 10.5/95.0
6. hilate cryptospore monad?, with split in hilum, MPA 7154, slide 1, 7.8/100.8
7. hilate cryptospore monad?, with split in hilum, MPA 7154, slide 1, 5.3/93.6
8. hilate cryptospore monad?, with split in hilum, MPA 7154, slide 1, 7.6/102.2
9. *Grandispora?* sp., MPA 7154, slide 1, 13.5/75.7
10. *Apiculiretusispora* sp., MPA 7154, slide 1, 14.3/74.8
11. *Laevolancis divellomedium?*, MPA 7154, slide 1, 7.3/89.1
12. *Palacanthus ledanoisii*, MPA 7155, slide 1, 5.4/90.8