DOCTOR OF PHILOSOPHY

Studies on plant microfossils from the Carboniferous of North Wales

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Award date:
1966

Awarding institution:
Bangor University

Link to publication

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STUDIES ON PLANT MICROFOSSILS FROM THE CARBONIFEROUS OF NORTH WALES

A Thesis submitted to the University of Wales

For the Degree of Doctor of Philosophy

by

F. ALAN HIBBERT

April 1966.

ACKNOWLEDGMENTS

This Thesis is based upon work undertaken as a Research Student in the Department of Botany, University College of North Wales, Bangor. I wish to thank Professor P. W. Richards for placing the facilities of his Department at my disposal. I must also thank Professor H. Godwin, F. R. S., Botany School, University of Cambridge, for permitting me to complete the writing of the Thesis after moving to Cambridge. I also wish to acknowledge financial support from the Department of Scientific and Industrial Research during the period of study.

I am particularly indebted to Dr. W. S. Lacey, who suggested this work and whose continued interest in its progress, both in the field and in the laboratory, has been a constant encouragement and inspiration. I would also like to thank other members of the Department of Botany at Bangor for their willingness to discuss other problems connected with this study.

To Professor L. R. Moore, of the Department of Geology, University of Sheffield, I am deeply grateful for allowing me to spend a period of time in his Department during the early stages of the work and for the excellent facilities made available to me there. I am also grateful for much helpful discussion and assistance from Drs. R. Neves, H. J. Sullivan, E. Spinner, B. Owens and Mavis Butterworth during my stay in Sheffield and on many occasions since.

I would like to thank Dr. W. H. C. Ramsbottom of the Geological Survey of Great Britain, Leeds Office, for help in identifying faunal remains and that Office of the Geological Survey for supplying samples from the Abbey Mills Bore-hole.

Professor E. J. Corner, F. R. S., and Mr. P. D. Sell, Botany School, University of Cambridge, contributed invaluable advice and assistance in naming new taxa.

I thank my wife for much patience, for help with translations and for critically reading the manuscript.

I am also grateful to all the many farmers and landowners throughout North Wales who allowed me access to sites on their land and whose detailed local knowledge was always at my disposal.

Finally, I thank Mrs. M. Allen, Mr. H. T. Davies, Mr. H. Elborn and Mr. and Mrs. W. Neville for much technical assistance, both during the research work and in the production of the Thesis.

ABSTRACT

Miospore assemblages are described from the Carboniferous succession in North Wales. The assemblages fall into two groups; those from the Viséan and those from the Namurian. They do not form a continuous sequence as the Upper Viséan deposits yielded no recognisable microflora and a hiatus therefore exists between the two groups.

The Viséan assemblages were obtained from a series of non-marine shales. Palynological investigation indicates a Lower to Middle Viséan age for these deposits. Comparisons are made between the microflora of the North Wales deposits and other Lower Carboniferous assemblages from England (Forest of Dean), Russia, Spitsbergen and Mississippian assemblages from Canada.

The Namurian assemblages were obtained from a series of marine and non-marine shales, and from one coal seam; they ranged in age from Namurian A to Namurian C with reference to the standard sequence of goniatite stages. The composition of the Namurian microflora is shown to undergo progressive change throughout the period. Comparisons with other assemblages shows a degree of similarity between the North Wales deposits and deposits of the same age from Northern England (Pennines), Scotland and Europe.

The question of the existence of Carboniferous floral provinces, based on microfloras, is considered and an assessment of the present position is made.

In the systematic descriptions of the assemblages two new genera, <u>Umbonatisporites</u> and <u>Diversizonotriletes</u>, are proposed and a total of twenty-seven new species erected.

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INTRODUCTION

When used in conjunction with all other sources of available information, plant microfossils can be used to interpret and correlate virtually all kinds of sedimentary rock and also yield information on regional palaeo-ecology.

The study of plant microfossils is called palynology; a term first used by Hyde and Williams in 1944. The word comes from the Greek 'paluno', denoting a scattering type of distribution. Whilst palynology includes the study of all plant fragments, in a more restricted sense it is considered to be the study of fossil spores, pollen, phyto-plankton and fungi of microscopic size.

In 1884 Reinsch reported fossil spores from Carboniferous deposits but the first major studies in palynology were on deposits of Quaternary age; von Post worked on pollen in Scandinavia and was amongst the first to realise the potentialities of pollen analysis. It was not until a much later period that the significance of the method in the study of older sediments was realised. The information obtained from such studies was applied to stratigraphical and palaeo-ecological problems. Palynology has expanded greatly since the time of these pioneers, especially during the last thirty years; the use of plant microfossils as stratigraphical and palaeo-ecological indices is now a universal practice in deposits of all ages in which the fossils are found.

In the course of a detailed study of the macroflora from the

Lower Carboniferous deposits in North Wales, Lacey (1952a, 1952b, 1955, 1962) produced evidence that microfloras of a potential stratigraphic and palaeo-ecological value were present in the area.

On the basis of macroscopic plant and faunal remains, Lacey (1952a)suggested a correlation between the Lower Carboniferous Series of North Wales and that of Scotland and northern England.

The purpose of the present study is, firstly to describe systematically the spores present throughout the Viséan and Namurian sequence in North Wales, secondly to attempt to define the transition between Lower and Upper Carboniferous deposits on the basis of the microflora and thirdly to correlate the assemblages from the Carboniferous of North Wales with those from other parts of the United Kingdom and the World.

A detailed study of assemblages from shales within the Lower Carboniferous Series yielded disappointing results. From twenty-five samples examined only those from one locality, the Basement Series, produced a well preserved microflora, although several others contained a few poorly preserved spores. The samples obtained from the shales of the Upper Carboniferous Millstone Grit Series were in general of good quality, although in some instances the spores were poorly preserved. In addition to samples collected from natural exposures of the Upper Carboniferous, further material was obtained from a borehole, which provided the most complete sequence through the series in the North Flintshire area.

PALAEOGEOGRAPHY AND STRATIGRAPHY

The Carboniferous succession throughout North Wales rests unconformably on Lower Palaeozoic rocks and consists largely of a series of limestones, which are underlain by Basement Beds and which are followed by cherts, shales and sandstones. They were deposited in a series of shallow shelf seas and deltas and were, for the most part, accumulated in relatively shallow water, only a little distance from the shore. The limestones were laid down in a series of clear water, off-shore deposits. As time progressed the seas became shallower and gradually silted up, resulting in the succeeding rocks, the Millstone Grit and Coal Measures, being characteristically of delta and swamp facies.

In general throughout the main outcrop, the beds dip eastwards off the Lower Palaeozoic rocks. The basal conglomerates of the Lower Carboniferous Series are found towards the west of the region; to the east of these occur the massive Limestone Series. These are succeeded to the east of the Vale of Clwyd, by the Millstone Grit Series, which is itself followed by Coal Measures towards the English Border (Text-figure 1).

The strata of the Carboniferous system have been classified by means of faunal remains. The limestone is zoned by means of corals and brachiopods and has been shown to fall within the Dibunophyllum zone (Neaverson 1929, 1943, 1945, 1946). The upper limit of the Lower Carboniferous is marked by the lamellibranch Posidonia becheri (Neaverson,

Text–figure I Distribution of Carboniferous Deposits in North Wales

1943) and the base of the overlying Millstone Grit by _Posidonia corrugata_. The stratigraphy of the Millstone Grit has been worked out using faunal remains, especially goniatites, following the demonstration of the great value of these fossils by Bisat (1924). Throughout the area a complete section of the Millstone Grit sequence from the basal cherts to the Lower Coal Measures is found.

Text-figure 2 shows the sub-divisions of the Carboniferous succession in North Wales based on faunal remains and lithology.

The Basement Beds lie unconformably on Ordovician rocks in the Menai Straits region. Greenly (1928) indicates that the series consist of conglomerate-sandstones, shales and thin limestones and places them at the base of the D1 sub-zone. The shales of this series, which outcrop on the shore a little way to the west of the Railway bridge, have yielded plant remains. Walton (in Greenly, 1928) and Lacey (1952b) have described the following plant macrofossils from the locality:-

Knorria cf. _imbricata_ Sternberg.

Stigmaria ficoides Sternberg.

Rhodea sp.

Telangium sp.

Diplotmema sp.

and Lycopod megaspores and a seed-like structure.

In the same paper, Lacey (1952b) gave a preliminary indication of the rich microflora; more than thirty species assignable to thirteen genera were recorded.

The basal conglomerates are also found in the Lligwy area of

TEXT FIGURE 2

<table>
<tr><th colspan="2">AGE</th><th>LITHOLOGICAL SUBDIVISIONS</th><th colspan="2">FAUNAL SUBZONES</th></tr>
<tr><td rowspan="6">UPPER CARBONIFEROUS</td><td rowspan="6">NAMURIAN</td><td rowspan="6">Holywell Shales</td><td>Gastrioceras</td><td>G1</td></tr>
<tr><td rowspan="2">Reticuloceras</td><td>R2</td></tr>
<tr><td>R1</td></tr>
<tr><td>Homoceras</td><td>H</td></tr>
<tr><td rowspan="2">Eumorphoceras</td><td>E2</td></tr>
<tr><td>E1</td></tr>
<tr><td rowspan="5">LOWER CARBONIFEROUS</td><td rowspan="5">VISEAN</td><td>Upper Black Limestone</td><td>Posidonia</td><td>P1</td></tr>
<tr><td>Upper Grey Limestone</td><td rowspan="3">Dibunophyllum</td><td>D2</td></tr>
<tr><td>Middle White Limestone</td><td>D1</td></tr>
<tr><td>Lower Brown Limestone</td><td>D1</td></tr>
<tr><td>Basement Beds</td><td>Seminula - Dibunophyllum</td><td>S2-D1</td></tr>
</table>

Text-figure 2. Geological Succession in North Wales.

Anglesey resting on Devonian rocks (Greenly, 1919). From this area, to the south and east, along the coast to Red Wharf Bay and on to Puffin Island, there are further outcrops of limestone of the D1 and D2 sub-zones. The limestone forms the Great Orme and continues towards Colwyn Bay. From Old Colwyn, Llanddulas to Abergele, onto Denbigh and southward to the head of the Vale of Clwyd a belt of Lower Carboniferous rocks forms a fringe on the northern and eastern margin of the Denbigh Moors. The limestone rests unconformably on the edge of a dissected plateau of Silurian mudstones and grits. The region between Old Colwyn and Ruthin is in the D1 sub-zone, overlapped by a thick series of conformable, unfossiliferous purple sandstones, which are assigned to the D2 sub-zone by Neaverson (1945). The eastern side of the Vale of Clwyd is marked by small strips of faulted, Carboniferous limestone, which ranges from D1 to P in age.

Limestone quarries at four localities in this region have yielded assignable plant remains; (Lacey 1952b, 1955, 1962); they are in Denbighshire, at Graig quarry, Denbigh; Pen-y-craig quarry, Ruthin; and the Llanddulas quarries; in north Flintshire, quarries close to Dyserth. These localities are all in the D1 sub-zone and the following is a composite list of plants from all the localities.

Lepidostrobophyllum fimbriatum (Kidston) Allen

Lepidodendron perforatum Lacey

Lepidodendro~~n~~psis jonesii Lacey

Lepidodendropsis recurvifolia Lacey

Clwydia decussata Lacey

Archaeosigillaria stobbsii Lacey

Stigmaria ficoides Sternberg.

Archaeocalamites radiatus Brongniart.

Bowmanites tenerrimus Hoskins and Cross.

Bythotrepis plumosa Kidston.

B. nodosa Lacey

Knorria acicularis Göppert.

Rhacopteris subcuneata Kidston

R. weissi Walton

R. cf. geikiei Kidston.

Calathiops dyserthensis Lacey

Lycopod megaspores.

To the north and eastern side of the Clwyd range, the Carboniferous Limestone, along with the Millstone Grit, forms a fringe of conspicuous foothills. The development of the Limestone series in the northern area is considerably different from that of the Vale of Clwyd, yet both are of the D2 sub-zone. In this area the limestones show a rapid variation in facies.

From a quarry in the Black Limestone at Teilia, Flintshire, the following plants have been recorded (Kidston, 1889; Walton, 1926, 1928, 1931).

Archaeocalamites scrobiculatus Schloth.

Lepidodendron cf. calamitoides Nathorst.

L. cf. obovatum Sternberg.

Adiantites antiquus Ettingshausen.

Adiantites machaneki Stur.

A. tenuifolius Göppert.

Calathiops acularis Göppert.

C. glomerata Walton

C. Renieri Walton

Diplopteridium teilianum Walton

Diplotmema dissectum Brongniart.

D. bermudensiforme f. *typica* Kidston.

Holocospermum ellipsoideum Göppert.

Neuropteris antecedens Stur.

Rhacopteris machaneki Stur.

R. circularis Walton.

R. fertilis Walton.

R. petiolata Göppert.

R. robusta Kidston.

Rhodea tenuis Gothan

Spathulopteris ettingshauseni Feistmantel.

S. clavigera Kidston.

Sphenopteridium capillare Walton.

S. pachyrrachis Göppert.

S. crassum Lindley and Hutton.

Sphenopteris obfalcata Walton.

S. cf. *filiformis* Kidston.

In north Flintshire the Carboniferous Limestone is followed by a massive chert and a thick shale series called the Holywell Shales.

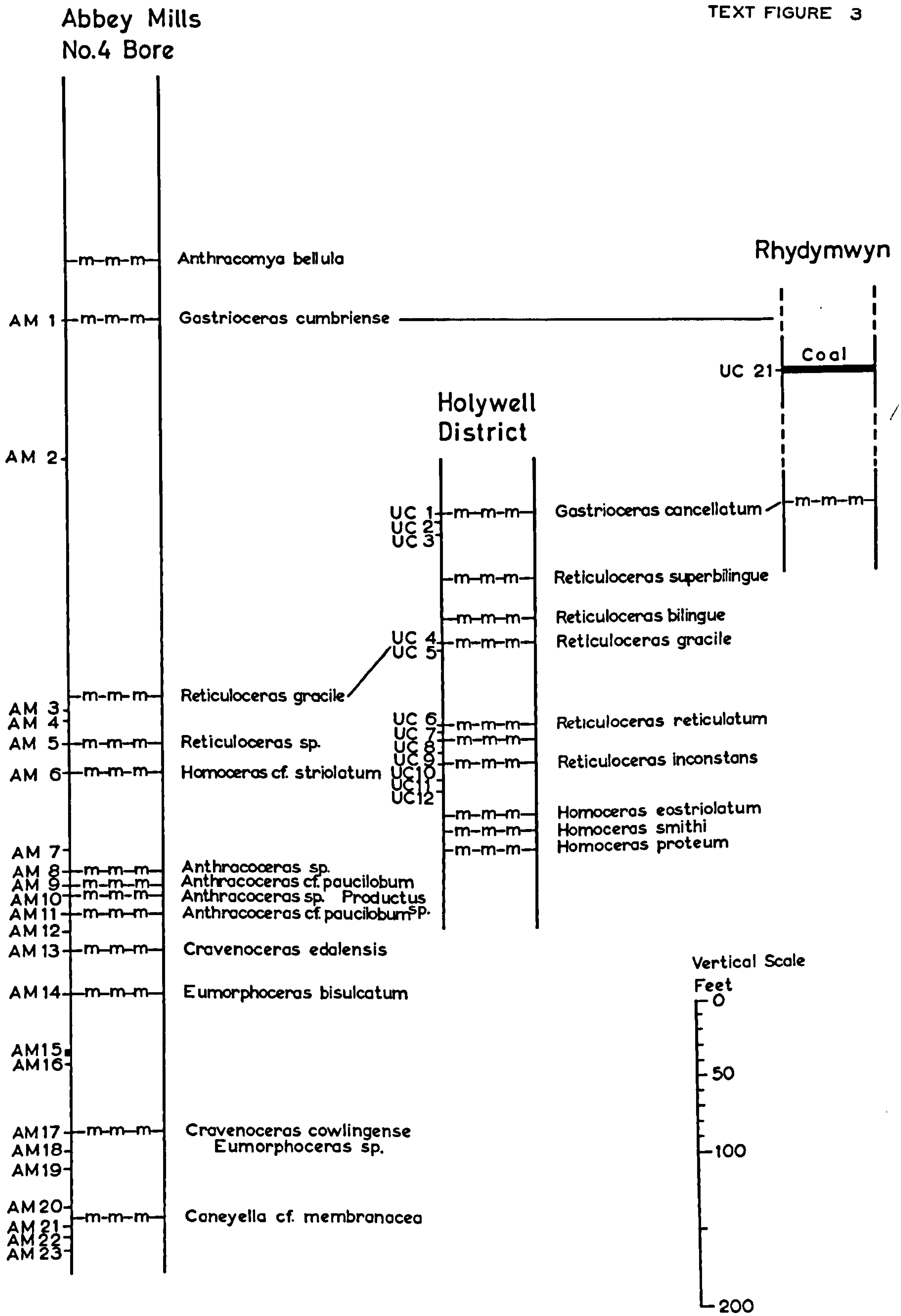
In Denbighshire, to the south, the limestone is overlain by a sandy series, the Cefn-y-Fedw sandstone. The Holywell Shales and Cefn-y-Fedw sandstone are of the same age, the difference in facies being due to the types of deposition. In the north the clear sea was sullied by muds, which were favourable to the establishment of a goniatite fauna, and formed the Holywell shales. At this time the area to the south was deposited in clear water and the formation was a sandstone with subordinate bands of sandy shales, cherts or limestones. The Holywell Shales are capped by the Gwespyr Sandstone and the Cefn-y-Fedw series by the Aqueduct Grit. These deposits mark the top of the Millstone Grit series in North Wales. Scattered plant remains are found throughout the region, but no well preserved flora has been described from this area.

Samples were taken from shale bands both in natural exposures and in quarries in the Lower Carboniferous Series throughout the area described above. The effects of weathering were reduced to a minimum by taking samples from well below the surface. Field samples from the Millstone Grit Series were confined to the Holywell Shales and taken from exposures in stream sections (Wood, 1936; Jones and Lloyd, 1943). The most complete section was from the core of the borehole sunk at Abbey Mills, Flintshire in 1933. Representative samples from this core were obtained from the Geological Survey Office, Leeds.

The location of the productive samples in the relevant parts of the sections at Abbey Mills, Holywell and Rhydymwyn are shown in Text-figure. 3.

Text-figure 3. Stratigraphical columns of the Abbey Mills No. 4 Bore, the exposures around Holywell and at Rhydymwyn.

TEXT FIGURE 3



The eleven foot shale band of the Basement Series exposed on the Caernarvonshire side of the Menai Straits in Vaynol Park has yielded a rich microflora. The varied nature of this assemblage indicates a more extensive macroflora than is realised from the previous records. Assemblages from the other Lower Carboniferous sites were poor. The majority contained no recognisable plant spores and the remainder had only poorly preserved microfloras with few species. This can be attributed in a large part to the parent rock, whose porous nature allows a great deal of natural oxidation, thus destroying the plant remains.

Many well preserved assemblages were recovered from outcrops of the Holywell Shales; in particular those from the _Reticuloceras_ Zone in Coed Pen-y-Maes, north of Holywell and those from the _Gastrioceras_ zone in Panton Hall Dingle, to the north-east of Holywell. From the Abbey Mills borehole twenty-three samples, ranging through the series, were examined (Text-figure 3). Of these, eleven yielded determinable microfloras, five had no remains at all and the remaining seven had poorly preserved plant remains.

One coal sample was obtained from the Gwespyr Sandstone of the Ruby Brick Works, Rhydymwyn (Jones and Lloyd, loc. cit.). This produced a microflora which is markedly different from those of the shale samples.

In all some seventy samples have been examined; details of locality and horizon are given in an Appendix.

Comparison of the standard Carboniferous stages of Europe with the Mississippian succession of North America has been the subject of much controversy (Table A). Early work by Moore (1937) established a direct correlation between the Kinderhook and Osage series of North America and the Tournaisian of Europe. Weller et al. (1948) further concluded that the Meramec series is to be correlated with the Viséan and that the Viséan-Namurian boundary of the European sequence could not be satisfactorily compared to the North American succession due to the earlier appearance of the goniatite Eumorphoceras there.

Using goniatites as evidence, Moore (loc. cit.) established the equivalence of the late Chester series of North America to the Eumorphoceras and part, or all, of the Homoceras zones in Europe. Elias (1956) came to the same conclusion and further states that the early Eumorphoceras species, which had been found in North America, were not the same as the early European ones. He concluded that the Lower Namurian was equivalent to the late Chester stage and that the Viséan-Namurian boundary was within the Chester series, approximately at the base of the Elvira group.

Higgins (1961) compared the results of his work using conodonts as stratigraphical indicators in North Staffordshire to similar studies in North America. The conclusion he reaches is that on the basis of conodont stratigraphy the correlation is similar to that obtained using goniatites (Table A).

TABLE A

<table>
<tr><th colspan="2">EUROPEAN CLASSIFICATION</th><th colspan="3">N. AMERICAN CLASSIFICATION</th></tr>
<tr><td>U. CARB.</td><td>NAMURIAN A.</td><td rowspan="6">MISSISSIPPIAN</td><td rowspan="3">CHESTER</td><td>Elvira Gp.</td></tr>
<tr><td rowspan="5">LOWER CARBONIFEROUS</td><td rowspan="3">VISEAN</td><td>Holmberg Gp.</td></tr>
<tr><td>New Design Gp.</td></tr>
<tr><td colspan="2">MERAMEC</td></tr>
<tr><td rowspan="2">TOURNAISIAN</td><td colspan="2">OSAGE</td></tr>
<tr><td colspan="2">KINDERHOOK</td></tr>
</table>

Table A. Comparison between the Lower Carboniferous Succession in Europe and the Mississippian in N. America

REVIEW OF CARBONIFEROUS PALYNOLOGY.

Henry Witham (1833) was the first person to investigate the microscopic structure of coal, with the object of proving its vegetable origin. He noted features which he was "inclined to consider indicative of a monocotyledonous plant". Bennie and Kidston (1886) commented that these features noted by Witham were in fact numerous microspores embedded in the coal. Binney (1870) recorded the occurrence of both micro- and megaspores from Carboniferous cones and Williamson (1878, 1880) described and figured many spores, both isolated and in association with sporangia.

The first major work concerned with Carboniferous microfloras was published by Reinsch (1884). In it both micro- and megaspores are described from a number of Carboniferous localities in central Russia and Saxony. Reinsch believed that certain of the microfossils he described were of algal origin and that the flange surrounding them was a parasitic growth. Two years later Bennie and Kidston (loc. cit.) refuted this theory and stated that the microfossils observed by Reinsch were indeed a type of spore and that the flange surrounding them was an integral part of their structure. The precise geological horizons are not stated in Reinsch's work but the work remains a useful reference for workers in the field of Carboniferous palynology.

Fresh impetus was given to the study of spores in coals when the technique of thin sectioning was developed; workers both in the United States of America (Theissen, 1920) and in the United Kingdom (Slater et al., 1930) used this method. In general, the true shape and morphology of the spores is difficult to work out from thin sections of coal but the method ha been extensively used in stratigraphical work.

Lower Palaeozoic microfloras became the centre of attraction for many workers in the 1930 s. In Germany Potonié (1931), Loose (1934) Ibrahim (1933), and Wicher (1934) worked mainly on Upper Carboniferous deposits. Potonié produced an artificial classification which he used for stratigraphic purposes. He gave the name 'Sporites' to all spores and added a descriptive pre-fix to designate a "genus".

In Russia, Luber and Waltz (1938) produced a systematic and statigraphical account of the microfloras from Russian coals of Tournaisian and Viséan age. The coals from horizons in European Russia, which are in part Tournaisian, in part Viséan in age, were characterised by a microflora dominated by zonate spores. The Karaganda Basin coals, which are of Viséan age, and so more or less contemporaneous, have microfloras dominated by prominent spinose-tuberculate sculptured, azonate spores. By reason of this difference in gross morphology, observed in spores from geographically separated assemblages of a similar age, Luber and Waltz concluded that the microflora of the Karaganda basin was "characterised by strict endemism". In 1941 Luber and Waltz extended their earlier work to cover deposits from the Devonian through to the Permian. Many of the spores were re-figured and, in addition, new species were described. The microfloral assemblage from the Lower Carboniferous of North Wales has many features in common with those described by these authors.

Detailed work on the study of dispersed spores in the United Kingdom was started by Raistrick and Simpson (1933), who attempted a correlation of coal seams from the Northumberland area on the basis of their microfloras. Raistrick continued these studies working mainly on assemblages from coals of the Lower Carboniferous series (1934, 1938), He made no attempt to assign his specimens to "genera"; each had an identifying letter and number.

The correlation of coal seams using spores was extended by Millot (1939) who described microspores from the coal seams of north Staffordshire.

Knox (1938, 1939) drew attention to the similarity in structure between the spores of modern Bryophyta and Pteridophyta and those found in Carboniferous coals. She concluded that whilst they had many features in common, no close comparisons could be drawn. This work was extended in 1950 to cover spores of extant Lycopodium, Phylloglossum, Selaginella and Isoetes and their possible relationship to Carboniferous spore types.

In 1937 Berry described spores from the Pennington coal of Tennessee, U.S.A., following the classification used by the German workers. Recognising the diversity which existed in the methods of classification, Schopf, Wilson and Bentall (1944) produced an annotated list of Palaeozoic spores, drawing together previously described species and assigning them to a definite position in their system of classification. They based their system on the International Rules of Botanical Nomenclature of 1931. Kosanke (1950) used plant spores in the correlation of Pennsylvanian coals from Illinois. The diversity of spore assemblages from different areas within the sequence was thought to be due to ecological factors.

Potonié and Kremp (1954) set out a morphographical system of classification which is now widely used. Potonié (1956, 1958 and 1960) has furthered this work, reviewing publications and setting out the described genera according to his classificatory system. The same authors in two publications (Potonié and Kremp, 1955, 1956) described spore assemblages from the Upper Carboniferous coals of Germany. Spores from the Lower Carboniferous sediments of the Donetz basin, in Russia, are described by Ishchenko (1956, 1958). The first paper has many new species from the western extension of the basin and sets out detailed stratigraphical ranges for the spores. The second is concerned with deposits from the Dnieper-Donetz basin; in it Ishchenko describes three microfloral suites, for the Tournaisian, Viséan and Namurian, all based on limited species distribution and relative abundance.

Hoffmeister, Staplin and Malloy (1955) described assemblages from coals and shales of the Hardinsburg formation in Illinois and Kentucky, U.S.A. This is in the Chester series of the Upper Mississippian and has been shown to be equivalent to Upper Viséan-NamurianA strata in Europe (Elias 1960, Higgins 1961). In this work, Hoffmeister et al., pointed out that spore and pollen counts from shales are more representative of the flora than those from coal deposits alone.

In 1957, Hacquebard and Barss published a paper on Carboniferous spore assemblages obtained from a coal in the South Nahanni River area, Canada. Recent work on the geology of the region (Hawker in Playford 1962a) has shown the coal to be of middle, perhaps upper Chesterian age, which places it equivalent to the Upper Viséan-Namurian A in Europe. Hacquebard and Barss showed the flora to be similar to those of a similar age from Russia and suggested the existence of a "northern" floral province in Lower Carboniferous times.

Hacquebard (1957) described microspore assemblages from the Horton series of Nova Scotia; These are of Tournaisian age and have much in common with Upper Devonian deposits from Russia. Hacquebard argues that there is an indication of a continuation of the Devonian microflora upward into the Lower Carboniferous, such as is seen in the upward continuation of the macroflora.

Small spore floras from the Scottish Limestone Coal group were first described by Knox (1948); the differences between the spore floras of these deposits and those from the productive Coal Measures were noted and the assemblage characterised by the occurrence of certain restricted species. The classification used in this study was similar to the alphabetical, numerical one used by Raistrick (loc. cit.).

This work was expanded and extended to include the Upper Limestone group by Butterworth and Williams (1958). The classification proposed by Potonié and Kremp (loc. cit.) was used and broad changes in the "characters of successive assemblages" were noted.

Using microspore species and characteristic assemblages from coals, Butterworth and Millot (1960) divided the British Carboniferous into zones.

Love (1960) described microspores from the Lower Oil Shale group in Scotland. He equated the microflora to the Camptotriletes verrucosus zone of Butterworth and Millot (loc. cit.). Several genera had their downward range extended to include the Lower Oil Shale group as a result of this work.

Coals and Shales from central England have been described by Neves

(1958, 1961). The work is based on a series of samples taken from the established sequence of goniatite stages and is valuable in correlation. Neves (1958) pointed out that different microspore assemblages are obtained in samples from differing lithologies.

Staplin (1960) described spore assemblages from the Golata formation of Alberta, Canada. This flora is of Lower Chesterian age. In the paper he designates a "typical Upper Mississippian assemblage" which is comparable to those from Russia (Luber and Waltz, 1941), and the Limestone Coal group of Scotland (Butterworth and Williams, 1958). With reference to work of the Imperial Oil Laboratories, Staplin states that the assemblage obtained by Hacquebard and Barss (1957) is from a somewhat older deposit than the Golata series.

In 1960 Hacquebard, Barss and Donaldson produced a paper on the stratigraphical significance of small spore genera, ranging from Namurian A to Westphalian B. In this paper a number of microspore suites are described which are important in defining the age of a deposit. The species used as indicators differ from those in the parallel study of Butterworth and Millot (loc. cit.); the samples were obtained from many different lithologies which may explain this discrepancy.

In 1961 Hughes and Playford gave a preliminary description of microspore assemblages from the Lower Carboniferous of Spitsbergen. The age of this series is considered to range from Tournaisian to Viséan and possibly into the Lower Namurian. The Tournaisian microflora is dominated by cingulate-zonate forms which have a relatively coarse detailed sculpture. A more detailed account of these assemblages is later given by Playford

(1962 and 1963). Two distinctive microfloras, the Raritüberculatus assemblage and the Aurita assemblage, were recognised. These occur in succession in a Sandstone which is otherwise unfossiliferous. The Raritüberculatus assemblage is characterised by the presence of Lophozonotriletes rarituberculatus (Luber) and is indicative of Tournaisian age; the Aurita assemblage by Murospora aurita (Waltz) indicating Viséan age.

Sullivan (1964a, 1964b) has recorded spore assemblages of Tournaisian, Viséan and Lower Westphalian age from the Forest of Dean basin, Gloucestershire. The Viséan assemblage is of a S2 age, which places it slightly lower than the deposits from the Basement series of North Wales. The latter has much in common with the deposits from the Forest of Dean. The occurrence of Tetrapterites visensis (Sullivan and Hibbert, 1964) in both of the deposits is of particular interest since these are the only two recorded finds of this genus so far.

Sullivan and Marshall (in press) have worked on Viséan spores from Scotland. Comparison with microfloras from other areas of a similar age indicates that a great amount of regional variation exists.

PREPARATION OF SAMPLES.

The majority of samples studied from the Carboniferous succession were dark, silty shales. Those from the Holywell Shale group ranged in colour from blue to blue-grey; towards the bottom of the succession the samples were more calcareous. The shales from the Limestone series were black, calcareous and highly friable. The shale from the Basement series was grey in colour and calcareous. One coal sample was studied from the top of the Millstone Grit series.

In the initial stages several varying methods of treatment were attempted until a standard procedure was established. During the preparations particular care was taken to ensure that all the apparatus was clean in order to avoid contamination.

In all cases the shale or coal sample was mechanically crushed to a size of about 3 mms. square, then transferred to a beaker and covered with 10% Hydrochloric acid to remove the carbonates. The sample was then washed with distilled water, placed in a polypropylene beaker, where it was covered with 40% "Analar" Hydrofluoric acid to remove all silicate minerals. At this stage the beaker was placed in a water bath maintained at 40° C and left until the shale had broken down. The length of treatment varied from three days for the friable shales, to five days for the harder, grey shales.

The residue was diluted and decanted to remove the acid. The remaining humic matter in the residue was then oxidised by fuming nitric acid; this step of the preparation was most critical as over-oxidation of the residue would selectively destroy the spores. A constant check was maintained over this period to ensure that the oxidation process did not affect the spores in any way. The residue was then transferred to a sinter-glass Buchner funnel of 15μ porosity, where it was washed with a solution of 5% potassium hydroxide to remove the products of oxidation. The fine organic debris remaining was removed by washing and filtration using the technique devised by Neves and Dale (1963). Here the sample, suspended in the washing water, is subjected to repeated, short periods of aeration which prevents the fine debris from blocking the pores of the sinter-glass filter and produces a "clean" sample suitable for microscopic examination.

The residues were stored in small phials; the spores had adequate natural colour and no staining was necessary.

Permanent slides using "Cellosize" (Jeffords and Jones, 1959) and Canada Balsam as the mountant were made. Later preparations used a mounting medium prepared from a thermo-setting plastic of the type used in embedding kits. This proved to be a satisfactory mountant, having a refractive index of about 1·53. It has been stated that preparations using such thermo-setting plastics have remained in good conditions, free from yellowing, after a period of ten years.

The coal sample was first placed in Hydrofluoric acid for twenty-four hours, washed, then placed in Schulze solution for a further period of eighteen hours; this latter oxidation stage is most critical and was carefully checked. When this stage had been completed the sample was washed and filtered to remove the fine debris as with the other shale samples. Storage and mounting were also the same.

In addition to the permanent mounts, open slide preparations were made using glycerine jelly as a mountant. From these it was possible to pick out single spores when required which were subsequently made up into single grain slides, sealing the glycerine jelly containing the spore with paraffin wax.

Systematic counting of the assemblages, using five hundred spores, enabled a quantitative assessment of the microfloras to be made. Some of the Holywell Shale and Limestone series samples yielded microfloras of such poor quality that counting was impossible.

A thorough morphological observation of species within the assemblage was based on an examination of all the prepared slides, in addition to those used in the counting.

CLASSIFICATION AND MORPHOLOGY.

"A natural classification of spores is at present practically impossible, since so few of the spores so far described have been found in organic connection with the parent plant. It is thus necessary to formulate an artificial system using the various morphological features which have been found to be of diagnostic value". In this statement Knox (1950) established the basis upon which the current classification is founded, emphasizing the difficulties involved in this type of work.

The great number of plant spores and pollens which have been described presents many problems in classification and this has led to much diversity of opinion. The need to establish a morphographic classification for dispersed spores was also emphasized by Potonié (1958a). In this work he pointed out that the use of form genera by palaeobotanists for classification of particular parts of plants implies no degree of natural affinity; it is necessary to have a "morphographic system which serves to review the whole material".

Such a morphographic system of classification was originally set up by Potonié and Kremp (1954) and later elaborated by them (Potonié and Kremp, 1955, 1956; Potonié, 1956, 1958, 1960). It is this system which is used in the present study. In it, species with significant characteristics are classified within the circumscription of form genera. These genera are grouped together according to certain definable,broad features into supra-generic ranks and so on.

Although the system established by Potonié and Kremp, using the binomial system is in general use amongst palynologists, it is nevertheless realised that the use of latinised nomenclature could be misleading, since the use of this might be taken to imply formal names for taxa within a natural system of classification.

From studies of fossilised fructifications, the botanical affinities of a number of dispersed spore genera are known (Allen, 1961; Chaloner 1953a, 1953b, 1954, 1958a, 1958b; Sen, 1958; Potonié, 1962; Hibbert and Eggert, 1965). The fossil record for "Sporae dispersae" far exceeds that for fructifications, so that the conclusions which can be drawn are limited. Wherever these affinities are known, attention is drawn to them in the following systematic descriptions.

Considerable confusion has arisen as a result of the rapid expansion of Palaeozoic palynology. Many closely similar species have been described under different names, and inadequate descriptions by various workers have added to the disorder. A review of the literature makes it apparent that a great deal of synonymy exists and much work remains to be carried out on the classification of dispersed spores before the problem can be resolved.

Schopf (1964) states that a species must have some "demonstrable time significance" in stratigraphy, in addition to having distinctive morphological features, in order to remain valid.

Terminology.

In this study the term miospore (Guennel, 1952) is used to indicate fossils which are smaller than 200 microns, "including homospores, true microspores, small megaspores, pollen grains, and pre-pollen" in preference to microspore. In Botanical usage a microspore is a product of reduction divison and subsequently produces the male gametophyte. It is not correct to assume that all dispersed spores of a size "less than 200μ" are microspores; the termmiospore is more acceptable. The botanical definition makes no reference to relative or specific size; rather is it a definition of function which is hardly detectable in "Sporae dispersae".

The morphological terminology followed in this present study is primarily that recommended to the International Commission for the Microflora of the Palaeozoic (Couper and Grebe 1961). Combinations of established terms are used to cover variations in ornamentation encountered, rather than the setting up of new terms.

The outer layer of the spore wall (exine) is called the exo-exine and this can bear structural and sculptural elements. The inner, undifferentiated layer is called the intexine (Potonié and Kremp, 1955).

The term laesurae is used to define the proximal polar dehiscence mark (Playford 1962). It is synonymous with the term Y-mark and commisures. It does not have the same meaning as laesurae used by Staplin and Jansonius (1964); here the term is confined to the proximal mark on the intexine. The term Haptotypic structure which combines the features of the proximal mark on both the exo-exine and the intexine, as used by Staplin and Jansonius, is synonymous with laesurae as used here. The term lips is used to describe conspicuous structures which are immediately adjacent to the laesurae (Playford loc. cit.).

The measurements of equatorial diameter were made on spores in full polar view; the maximum median length of triangular spores is taken as the equatorial diameter.

As an aid to the classification of the taxa recorded in the following systematic description, a catalogue of dispersed spores and pollens from the Palaeozoic was built up from abstractions of published work. Some 1,225 entries were filed according to the system established by Potonié and Kremp (1954).

In the following systematic descriptions of the miospores, type and other figured specimens are referred to by a preparation slide number, followed by 'east-west' and 'north-south' mechanical stage readings. The stage readings are from Leitz Laborlux No. 582096 in the Department of Botany, University College of North Wales, Bangor, where the material is deposited.

SYSTEMATIC DESCRIPTIONS.

Anteturma SPORITES H. Potonié 1893

Turma TRILETES (Reinsch) Potonié and Kremp 1954

Subturma AZONOTRILETES Luber 1935

Infraturma LAEVIGATI (Bennie and Kidston) R. Potonié 1956

Genus LEIOTRILETES (Naumova) Potonié and Kremp 1954

Type species L. sphaerotriangulus (Loose) Potonié and Kremp 1954

Discussion. Staplin (1960) assigned simple, laevigate, triangular, trilete spores of Mississippian age to the genus Deltoidospora Miner (1935). This genus had previously been confined to post Palaeozoic spores, Palaeozoic spores of this type being assigned to Leiotriletes. He stated that "the argument that there is a separation in time between Miner's species and species referable to Leiotriletes has little validity where form genera are concerned". Playford (1962), whilst agreeing with Staplin, assigns his spores from the Palaeozoic to Leiotriletes awaiting further resolution of the problem. The arguments put forward by Staplin are certainly worth considering, and may be expanded to cover several other genera of simple spores occuring over a wide range of the geological column. His reference to the Article 64 of the International Code of Botanical Nomenclature is somewhat vague as this deals with the rejection of names which are homonyms", that is if the name is spelled exactly like a name previously and validly published", which does not appear to be the position here. There is undoubtedly a need to establish the relationship between form genera based on similar characters, but from different horizons; until such a comprehensive study is undertaken, Leiotriletes is retained for simple, laevigate, triangular, trilete spores from Palaeozoic deposits.

Affinities. Species of *Leiotriletes* have been described from fern fructifications by W. and R. Remy (1957). Potonié (1962) has referred the spores of *Oligocarpia gutbieri* Göppert to *Leiotriletes adnatus* and those of *Oligocarpia cliveri* H. Potonié, to *Leiotriletes sphaerotriangulus*.

Leiotriletes inermis (Waltz) Ishchenko 1952

Plate 1, fig. 1.

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

1952 *Leiotriletes inermis* (Waltz) Ishchenko, p. 9; Plate 1, figs. 2, 3.

1955 *Asterocalamites inermis* (Waltz) Luber, p. 40; Plate 1, figs 20, 21.

1955 *Leiotriletes inermis* (Walz) Potonié and Kremp 1964 p. 37

Description of specimens. Spores radial, trilete; amb triangular with rounded apices, sides convex to almost straight. Laesurae distinct, straight, simple extending from one-half radius to almost the equatorial margin. Exine 1 - 2μ thick, laevigate.

Dimensions (40 specimens) Equatorial diameter 30 - 45μ (mean 41μ)

Remarks. The length of the laesurae on the specimens described here are often shorter than those described by Playford (1962). They approach the size given for L. inermis (Waltz) var. gracilis Ishchenko (1956).

Occurrence. Menai Straits Shales; Viséan.

Previous records. Lower Carboniferous of the U.S.S.R. and Spitsbergen, Upper Mississippian of Canada (Playford and Barss, 1963).

Leiotriletes subintortus (Waltz) Ishchenko 1952 var rotundatus Waltz 1941.

Plate 1, fig. 2.

1941 Azonotriletes subintortus Waltz var. rotundatus Waltz in Luber and Waltz, pp. 13 - 14; Plate 2 fig. 15b

1952 Leiotriletes subintortus (Waltz) Ishchenko var. rotundatus Waltz; Ishchenko, p. 11. Plate 1., fig. 7.

Description of specimens. Spores radial, trilete; amb sub-triangular with rounded apices, sides convex. Laesurae distinct, straight, simple extending almost to the smooth equatorial margin. Exine 1 - 2 μ thick, laevigate.

Dimensions. (50 specimens) Equatorial diameter 24 - 45μ (mean 36μ)

Occurrence. Menai Straits Shales; Viséan

Previous records. Russian Lower Carboniferous (Luber and Waltz 1951; Ischenko 1956, 1958) and the Lower Carboniferous of Spitsbergen (Playford, 1962).

Leiotriletes ornatus Ishchenko 1956

Plate 1. fig. 4

1956 Leiotriletes ornatus Ishchenko.

p. 22; Plate 2, figs. 18 - 21

1960 Spore type 1 (Love) in Playford 1962

Description of specimens. Spores radial, trilete; amb triangular with rounded apices. Laesurae straight, distinct, simple, length almost equal to the radius of the spore. Lips prominent and dark, 3 - 4µ wide, often thickened at the apices. Exine 3µ thick, laevigate.

Dimensions. (14 specimens) Equatorial diameter 30 - 51µ (mean 39µ).

Remarks. Although only a few specimens were found they were assigned to L. ornatus. L. turgidus (Marshall and Smith, 1965) is somewhat larger, has a thicker exine and wider lips. The equatorial exinal folding (Playford, 1962, p. 575) is observed in one specimen.

Occurrence. Menai Straits Shales, Holywell Shales; Viséan - Naumurian B.

Previous Records Middle Viséan to Namurian A of Russia (Ishchenko, 1956); Viséan of Scotland (Love, 1960); Lower Carboniferous of Spitsbergen (Playford, 1962) and the Tournaisian of South Wales (Sullivan, 1964).

Leiotriletes tumidus Butterworth and Williams 1958

Plate 1, fig. 3.

Description of specimens. Spores radial, trilete; amb sub-triangular with rounded apices and straight to slightly convex sides. Laesurae distinct, almost reaching to the equator of the spore, accompanied by folds parallel to the rays; lips 2 - 3µ wide. Exine approximately 2µ thick, laevigate.

Dimensions. (42 specimens) Equatorial diameter 30 - 52µ (mean 42µ)

Comparison. The thinner exine and less prominent lips serve to distinguish this spore from *L. ornatus*.

Occurrence. Menai Straits Shales, Holywell Shales; Viséan - Namurian C.

Previous records. Lower Namurian of Scotland (Butterworth and Williams, 1958). Namurian A of Stainmore (Owens and Burgess, 1965).

Leiotriletes auritus Ishchenko 1956

Plate 1, fig. 10.

1964 *Leiotriletes* sp. Vigran,

p. 7; Plate 1, figs. 1, 2.

Description of specimens. Spores radial, trilete; amb sub-triangular with rounded aspices and convex sides. Laesurae distinct, straight, length one-half to two-thirds spores radius; the raised lips, which are sinuous, expand at the termination of the laesurae. Exine 2 - 3.5µ thick, infrapunctate (oil immersion).

Dimensions. (5 specimens) Equatorial diameter 50 - 94µ. (mean 78µ).

Comparison. The size range is greater than that given by Ischenko for *L. auritus*, otherwise the two are similar. Vigran (1964) describes a spore which is closely similar to L. auritus; the variation which she describes in exine structure is probably due to preservation. In addition, Leiotriletes sp. is described as being indistinguishable from the inner body of the two-layered spore Calyptotriletes plicatus. There are no specimens of the latter type in this assemblage so no confusion arises. The spore described by Vigran is accordingly transferred to L. auritus.

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Lower Namurian of Russia; (Ishchenko 1956). Middle to Upper Devonian of Vestspitsbergen (Vigran 1964).

Genus PUNCTATISPORITES (Ibrahim) Potonie and Kremp 1954.

Type species P. punctatus Ibrahim 1933

Affinities Psilophytopsida
Punctatisporites glaber (Naumova) Playford 1962.
Plate 1, figs 5, 6, 8.

1941. Azonotriletes platirugosus Waltz in Luber and Waltz
p. Plate 1, Fig. 1.

1938 Azonotriletes glaber (Naumova) Waltz in Luber and Waltz,
p. 8; Plate 1, fig. 2, and Plate A, Fig. 3.

1952 Leiotriletes glaber (Waltz) Ishchenko,
pp. 13 - 14; Plate 2, Figs. 15, 16.

1955 Calamospora glabra (Naumova) Potonié and Kremp,
p. 47

1955 Punctatisporites nitidus Hoffmeister, Staplin and Malloy,
pp. 383 - 384; Plate 36, Fig. 4.

1955 Punctatisporites ? callosus Hoffmeister, Staplin and Malloy,

p. 392; Plate 39, Fig. 7.

1956 Leiotriletes glaber Naumova; Ishchenko,

pp. 18 - 19; Plate 1, Figs 7, 8.

1956 Leiotriletes platirugosus (Waltz) Ishchenko,

p. 16; Plate 1, Fig. 1.

1958 Punctatisporites cf. nitidus Hoffmeister, Staplin and Malloy; Butterworth and Williams,

p. 361; Plate 1, Figs. 7, 8.

1960 Punctatisporites curviradiatus Staplin,

p. 7; Plate 1, Figs, 17, 20.

1962 Punctatisporites glaber (Naumova) Playford,

pp. 566 - 7; Plate 78, Figs. 15, 16.

1964 Punctatisporites platirugosus (Waltz) Sullivan,

p. 3; Plate 57, Figs, 7, 9.

Description of specimens. Spores radial, trilete; amb circular. Laesurae distinct, simple, straight, length one-third to two-thirds spore radius. Exine about 1·5μ thick, rarely folded.

Dimensions. (50 specimens) Equatorial diameter 30 - 72μ. (mean 52μ).

Remarks. The only distinguishing feature between P. glaber and P. platirugosus was the presence of parallel sided equatorial folds in the latter. The presence of such a feature in a simple spore is likely to be due to compression; since both of these spores had a similar exine thickness it is not likely that P. platirugosus was inherently more susceptible to folding, accordingly the species is here included in P. glaber.

Occurrence. Menai Straits Shales, Holywell Shales; Viséan - Namurian A - C.

Previous records. The species is widely recorded from the Carboniferous successions in Europe, North America, Spitsbergen and Russia, Upper Mississippian of Canada (Playford and Barss, 1963).

Punctatisporites cf. obesus Neves 1958

Plate I, Fig. 9.

Description of specimens. These spores range in size from 88 - 117μ. The laesurae are not split open; distinct, straight and may have folds running alongside. In the original description, Potonié and Kremp (1954) distinguish P. obesus by the split of the laesurae, caused on compression. It has not yet been established whether this is of major significance to the specific diagnosis, or whether P. cf. obesus can be included in the original circumscription.

Occurrence. Menai Straits Shales; Holywell Shales; Viséan-Namurian A.

Previous records. Namurian C of North Staffordshire (Neves, 1958).

Punctatisporites irrasus Hacquebard 1957

Plate 1, Fig. 7

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight, one half of radius to almost equator in length. Occasionally low lips (1μ) are developed. Commonly the laesurae are gaping anddark areas around the contact faces can be seen which are caused by the folding back of the exine. Exine 1 - 2μ thick, laevigate to infrapunctate (oil immersion).

Dimensions. (30 specimens) Equatorial diameter 58 - 89μ (mean 74μ)

Remarks. Spores with "dark intertectal areas" were included in this species by Sullivan (1964a); none of this type was included in the original description by Hacquebard.

Occurrence. Menai Straits Shales; Viséan.

Previous records. West Gore, Horton Bluff, Canada (Hacquebard, 1957). Lower Limestone Shales, Forest of Dean, Gloucestershire, (Sullivan, 1964a).

Punctatisporites sinuatus (Artuz) Neves 1961.

Plate 1, Fig. 11.

1957 Sinuspores sinuatus Artuz
p. 254.

1958 Punctatisporites densoarcuatus Neves,
p. 6; Plate 2, Fig. 7.

1958 Punctatisporites coronatus Butterworth and Williams,
p. 360; Plate 1, Fig. 12.

1961 Punctatisporites sinuatus Neves,
p. 252 - 253.

Description of specimens. Spores radial, trilete; amb sub-circular to oval (compressed). Laesurae distinct, more or less straight, length one-half to two-thirds spore radius; accompanied by thin lips; on a few specimens the laesurae were split open. Exine laevigate to infrapunctate (oil immersion). Large broad folds are present around the equatorial periphery of the spore; there may also be several other smaller folds on the distal surface of the spore.

Dimensions. (30 specimens) Equatorial diameter 77 - 122μ. (mean 98μ).

Remarks. Neves transferred *Sinuspores sinuatus* (Artuz) to the genus *Punctatisporites* on the grounds that the small amplitude folds of the exine were secondary in nature. Certain specimens found in the course of this study seemed to indicate that these "folds" have the characteristics of low, rounded projections of the exine, Since insufficient numbers of the latter type were found to permit a thorough study, all were placed in *Punctatisporites sinuatus* pending further investigations.

Occurrence. Rhydymwyn coal; Namurian C.

Previous records. Westphalian A of Turkey, (Artuz, 1957), Namurian A of Scotland (Butterworth and Williams, 1958) and the Namurian B - C (Neves 1958, 1961). Horton Group of Eastern Canada (Playford, 1963b).

Genus *CALAMOSPORA* Schopf, Wilson and Bentall 1944

Type species *C. hartungiana* Schopf in Schopf, Wilson and Bentall 1944

Affinities. Spores comparable with *Calamospora* have been recovered from a wide range of fructifications. Sphenopsida; *Bowmanites delectus* Arnold, *Bowmanites stimulosus* Hartung, *Koinostachys* sp. Remy, *Sphenophyllum fertile* Scott, *Sphenophyllum hauchecornei* (Weiss) Remy, *Calamostachys solmsi* Weiss, *Calamostachys binneyana* Carruthers, *Mazostachys pendulata* Kosanke, *Macrostachys infundibuliformis* Brongniart, *Palaeostachya* ettinghauseni Kidston, Paracalamostachys heteospora R. and W. Remy, Eviostachya hoegi Stockmans,

Noeggerathiopsida: Noeggerathiostrobus vicinalis Weiss Discinites sp. (cf. bohemica Feistmantel).

Walton (1957) described spores of the Calamospora type from Protopitys scotica. He suggested that the plant had pteridophytic reproduction and suggested that the range in size of the spores indicated heterospory was in the course of evolution within the group.

Calamospora microrugosa (Ibrahim) Schopf, Wilson and Bentall

Plate 1, Figs 12, 19.

1932 Sporonites microrugosus Ibrahim in Potonié, Ibrahim and Loose, p. 447; Plate 14, Fig. 9.

1933 Laevigati-sporites microrugosus (Ibrahim) Ibrahim, p. 18; Plate 1, Fig. 9.

1938 Azonotriletes microrugosus (Ibrahim) Waltz in Luber and Waltz p. 10; Plate 1, Fig. 1 and Plate A. Fig. 7.

1944 Calamospora microrugosa (Ibrahim) Schopf, Wilson and Bentall p. 52.

1952 Leiotriletes microrugosus (Ibrahim) Ishchenko, p. 15; Plate 2, Fig. 19.

1955 Calamotriletes microrugosus (Waltz) Luber, p.36; Plate 1, Fig. 1 - 3

Description of specimens. Spores radial, trilete; amb circular to sub-circular, laesurae distinct, straight length one-half to two-thirds spore radius, occasionally there is slight lip development. Exine approximately 1µ. thick, laevigate or minutely granulate, characterised by strong folds.

Dimensions. (20 specimens) Equatorial diameter 60 - 89µ. (mean 80µ.)

Occurrence. Menai Straits Shales, Holywell Shales: Viséan - Namurian A and C.

Previous records. Numerous records from the Carboniferous of Europe, Russia and Spitsbergen.

Calamospora liquida Kosanke 1950

Plate 1, Fig. 13.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight, one-third to two-thirds spore radius, often with moderate lip development. The "area contagionis" is not present. The exine is 1µ thick, laevigate and has numerous taper-pointed folds.

Dimensions. (30 specimens) Equatorial diameter 69 - 91µ (mean 80µ)

Remarks. C. liquida is closely similar to C. microrugosa; Potonié and Kremp distinguish C. microrugosa by means of its shorter laesurae. The two are undoubtedly very close and critical comparison between the two holotypes is needed to resolve the position.

Occurrence. Holywell Shales; Namurian C.

Previous records. Pennsylvanian of the U.S.A. (Kosanke 1950), Namurian A of Scotland (Butterworth and Williams 1958).

GENUS CADIOSPORA Kosanke 1950

Type species C. magna Kosanke 1950

Cadiospora sp. A.

Description of specimens. Spores radial, trilete; amb circular. Laesurae distinct, straight, almost reaching to the spore equator; accompanied by thick lips, 3 - 4µ. wide, which taper off towards the equator then widen out to form Curvaturae perfectae. This feature is distinct and over-laps the equator of the spore in polar view. Exine 3µ. thick, laevigate, with fine infrapunctation (oil immersion).

Dimensions (2 specimens) 72 - 84µ.

Remarks. Only two specimens of this type were found, but were distinct enough to be placed in the genus Cadispora (Kosanke). Richardson (1965), in his emendation of the genus Retusotriletes Naumova, 1953) excludes spores from this genus which possess "well marked, thickened lips" along with curvaturae perfectae.

Occurrence. Menai Straits Shales; Viséan.

INFRATURMA APICULATI (Bennie and Kidston) R. Potonié 1956

SUBINFRATURMA GRANULATI Dybova and Jachowicz 1957

GENUS GRANULATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species G. granulatus Ibrahim 1933

Affinity. Filices; Todites recurvatus Harris.
Lygodium skottsbergii Halle.

Granulatisporites granulatus Ibrahim 1933

Plate 1, fig. 18

Description of specimens. Spores radial, trilete; amb triangular with concave sides. Laesurae distinct, straight, simple, length one-half to two-thirds spore radius. Exine ornamented with grana approximately 1μ. in basal diameter and 1μ. high, scattered, 1·5μ. apart over the exine.

Dimensions (35 specimens) Equatorial diameter 25 - 33μ. (Mean 28μ.)

Remarks. Butterworth and Williams (1958) recorded spores as G. cf. granulatus from the Namurian of Scotland. Their spores seem from the illustration to be identical to those from the Holywell Shales.

Occurrence. Menai Straits Shales, Holywell Shales, Rhydymwyn coal, Viséan Naumurian A - C.

Previous records. Westphalian of Germany (Ibrahim in Potonié and Kremp, 1955), Westphalian A of Forest of Dean, Gloucestershire (Sullivan, 1964b).

Granulatisporites micrograniifer Ibrahim 1933

Plate 1, Fig. 17

Description of Specimens. Spores radial, trilete; amb triangular with concave sides and rounded apices. Laesurae distinct, straight, simple, length from three quarters to equal, the radius of the spore. Exine ornamented with low grana, 0·5µ in basal diameter, densely spread over the entire surface of the spore, giving the equator a notched appearance.

Dimensions. (30 specimens) Equatorial diameter 28 - 39µ (mean 31µ.)

Remarks. The size range of these specimens is more restricted than that of Ibrahim (1933).

Occurrence. Menai Straits Shales, Holywell Shales, Rhydymwyn coal, Viséan;Namurian A - C.

Previousrecords. Westphalian of Germany (Ibrahim, in Potonié and Kremp, 1955).

Granulatisporites visensis sp. nov.

Plate 1, Fig. 14

Diagnosis. Spores radial, trilete; amb sub-triangular with concave inter-radial margins and rounded apices. Laesurae distinct, simple, straight, length from three-quarters, to equal, the radius of the spore; occasionally the laesurae are gaping. Exine covered with grana, about 1·5 - 4µ wide at the base and 2µ. high; the grana may coalesce to form short, verrucate ridges. The surface ornament is well developed at the triangular apices and forms an indented equatorial margin; the inter-radial margin is normally smooth, but may appear roughened when the exine becomes folded over. The exine has large punctations which occur in the thinner regions of the exine between the sculptural elements. The grana are more strongly developed on the distal surface and are often concentrated at the distal pole and along the triangular radii.

Dimensions. (26 specimens) 27 - 47μ. (mean 36μ.).

Holotype. Preparation L.C.11 b. 57·2 104·9

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 41μ. Laesurae almost reaching the equator; slightly gaping. Grana 1·5 - 3·5μ. in basal diameter, up to 2μ. high. Inter-radial margins smooth to slightly indented. Grana of the distal surface are coalesced into short vermiculate ridges, the punctations grade into shallow grooves between the ornament.

Remarks. These specimens are assigned to the genus Granulatisporites on the form of the ornament, the projections being flat to rounded and greater in basal diameter than height. The occurrence of irregular ridges of ornament is not significant enough to warrant other generic assignment.

Occurrence. Menai Straits Shales, Viséan.

Genus CYCLOGRANISPORITES Potonié and Kremp 1954

Type species. C. leopoldi (Kremp) Potonié and Kremp 1954

Affinity. Spores referable to this genus have been found in the sporangia of the following: Psilophytopsida; Sporogonites exuberans Halle; Noeggerathiopsida; Noeggerathiostrobus bohemicus Feistmantel, Noeggerathia foliosa Sternberg; Filices, Biscalitheca musata Mamay, Corynepteris silesiaca R. and W. Remy, Svalbardia polymorpha Høeg, Asterotheca (al. Pecopteris) miltoni Artis, Acitheca longifolia Brongniart (spore of the C. aureus (Loose) Potonié and Kremp type), Todites goeppertianus (Munster) Krasser, Todites hartzi Harris, Crossotheca schatzlarensis Kidston.

Cyclogranisporites lasius (Waltz) Playford 1962

Plate 1, Fig. 16.

1884 Type 524 of Reinsch, p. 52; Plate 32, Fig. 211 and Plate 42. Fig. 220.

1938 Azonotriletes lasius Waltz in Luber and Waltz, p.9; Plate 1, fig. 4, and Plate A, Fig. 4.

1955 Filicitriletes lasius (Waltz) Luber, p. 55; plate 2, Fig. 50.

Description of specimens. Spores radial, trilete; amb circular. Laesurae usually distinct, simple, straight, length two-thirds spore radius. Exine 1 - 2·5µ. thick, densely and finely granulate, frequently folded.

Dimensions. (25 specimens) Equatorial diameter 48 - 83μ. (mean 67μ.)

Remarks. Potonié and Kremp (1955) rejected Filicitriletes lasius Waltz and tentatively included Azonotriletes lasius within the genus Microreticulatisporites. Playford (1962) reassigned the species to Cyclogranisporites using the description given by Waltz (in Luber and Waltz, 1938).

Occurrence. Menai Straits Shales; Viséan.

Previous records. Lower Carboniferous of European Russia (Luber and Waltz, 1938, 1941; Luber 1955) and Lower Carboniferous of Spitsbergen (Playford, 1962).

Cyclogranisporites aureus (Loose) Potonié and Kremp 1954
Plate 1, Fig. 15.

1934 Reticulati-sporites aureus (Loose),

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae usually distinct, simple, straight, length one-half to two-thirds spore radius. Exine 1·5μ. thick, covered with small grana, or coni, 0·5μ - 1μ. in height and of similar basal diameter; commonly folded.

Dimensions. (12 specimens) Equatorial diameter 56 - 78μ. (mean 64μ.).

Occurrence. Holywell Shales; Namurian A - C, Rhydymwyn coal; Namurian C.

Previous records. Westphalian B - C. (Potonié and Kremp, 1955).

SUBINFRATURMA VERRUCATI Dybova and Jachowicz 1957

GENUS VERRUCOSISPORITES (Ibrahim) Smith 1964

Type species V. verrucosus Ibrahim 1932.

Remarks. This genus has been recently emended by a working party of the "International Commission for the Microflora of the Palaeozoic" under Smith; their work has clarified the type and dimension of ornamentation within the genus. The height of the verrucae is equal to, or less than the basal width, and the ornamentation is more or less of discrete elements which never anastomose to form ridges. The degree of this confluence is not specifically defined and still remains subject to personal judgment, which is especially difficult when discriminating between this genus and Camptotriletes or Convolutispora.

Affinities. Lycopsida, Sporangiostrobus rugosus Bode; Filices, Corynepteris silesiaca R. & W. Remy, Zygopteris sp. (spores of the V. firmus type) and Waldenburgia corynepteroides Gothan.

Verrucosisporites eximius Playford 1962
Plate 2, Figs. 5, 6.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight, length three-quarters to equal the spore radius; with smooth, conspicuous lips, 5 - 7μ. wide, bordering the laesurae on each side. Exine 6 - 9μ. thick including the sculpture) covered with smooth, flat-topped verrucae, which are closely packed; verrucae polygonal to elongated in surface view, 4 - 15μ. in longest diameter. Normally the surface is smooth; corroded specimens often show punctations. A fine network of channels lies between the verrucae; the equatorial outline of the spore is undulating.

Dimensions. (16 specimens) 62 - 89μ. (mean 82μ.)

Remarks. The size range of the present specimens is smaller than that quoted by Playford and the mean size is somewhat larger, however relatively few specimens were found. One specimen showed strong punctation which may have been due to natural corrosion.

Occurrence. Menai Straits Shales: Viséan.

Previous records. Lower Carboniferous of Spitsbergen Playford (1962)

Verrucosisporites tuberculatus sp. nov.

Plate 2, Figs. 8, 9; text figure 4 G.

Diagnosis. Spores radial, trilete; amb circular. Laesurae simple, straight, length two-thirds to three-quarters spore radius with slight lip development. Exine 3 - 5μ. thick (excluding ornament) covered with a sculpture of many, somewhat irregularly placed, verrucae which may be close together or more widely spaced. The basal diameter of the verrucae is from 5·5μ. to 16μ. and the height from 2 - 9μ; they have circular to elliptical bases with rounded apices. Surface between the verrucae is laevigate (infrapunctate on corroded specimens).

Dimensions. (8 specimens) Equatorial diameter 90 - 128μ. (mean 111μ.)

Holotype. Slide number M.S. 177

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 117μ, circular; laesurae two-thirds spore radius, straight. Exine thick, beset with irregular, widely spaced verrucae, 2·5μ. high; 5·5 - 12μ. in basal diameter and from 2 - 10μ. apart. Approximately twenty-two verrucae project around the equator.

Comparison. Verrucosisporites gobbetti (Playford, 1962) is smaller in size, has a smaller ornament and a thinner exine. Raistrickia ? gibberosa has smaller "tubercles" and is smaller in size.

Occurrence. Menai Straits Shales; Viséan.

Verrucosisporites verrucosus Ibrahim (1933)

Plate 2, Fig. 10.

1932 Sporonites verrucosus Ibrahim, in Potonié, Ibrahim and Loose. p. 448; Plate 15, Fig. 17.

Description of specimens. Spores radial trilete; amb circular to sub-circular. Laesurae not always distinct, simple, straight, two-thirds the spore radius. Exine thickly covered with closely set verrucae having rounded apices and irregularly shaped bases; verrucae from 2 - 4μ. in basal diameter and up to 2μ. high. Equatorial outline notched.

Dimensions.(15 specimens) Equatorial diameter 76 - 93μ. (mean 86μ.)

Remarks. The separation of V. verrucosus from V. donarii is very tentative and based on the former having slightly larger verrucae and being of a larger size range. In the present study there seems to be evidence of a continuous gradation between the two species; insufficient examples were found to provide grounds for their combination.

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Westphalian of Germany (Ibrahim in Potonié and Kremp, 1955).

Verrucosisporites morulatus (Knox) Smith and Butterworth 1964

Plate 2, Fig. 3.

1950 Verrucosisporites morulatus Knox

p. 318; Plate 18, Fig. 235.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae not always distinct, straight, length from one-half to two-thirds spore radius. Exine covered with discrete verrucae, of irregular basal shape and with rounded apices, 3 - 6μ. in basal diameter and 2 - 4μ. in height. Exine thin (1 - 1·5μ.) and sometimes folded.

Dimensions. (20 specimens) Equatorial diameter 54 - 79μ. (mean 62μ.)

Remarks. This species was redefined by Smith and Butterworth using a neotype from Knox (1948).

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Namurian A of Scotland and the Westphalian of Germany (Potonié and Kremp, 1956).

Verrucosisporites donarii Potonie and Kremp 1955.

Plate 2, Fig. 7

Description of specimens. Spores radial trilete; amb circular to sub-circular. Laesurae distinct, straight, length two-thirds spore radius, which are from 1 - 1·5μ in basal diameter and up to 2·5μ. high. They are of an irregular basal shape.

Dimensions. Equatorial diameter 64 - 79μ.

Remarks. The specimens were restricted to the coal samples and were therefore separated from the specimens of V. verrucosus of the lower horizons.

Occurrence. Rhydymwyn coal; Namurian C.

Previous records. Westphalian of Germany (Potonié and Kremp, 1955), Namurian C-Westphalian A. Stainmore (Owens and Burgess 1965).

GENUS ANAPICULATISPORITES Potonié and Kremp 1954

Type species. A. isselburgensis. Potonié and Kremp 1954

Affinity. Unknown.

Anapiculatisporites tenuispinosus sp. nov.

Plate 2, Fig. 4; Text Fig. 4C.

Diagnosis. Spores radial, trilete; amb sub-triangular with rounded apices and convex sides. Laesurae distinct, simple, straight, extending from two-thirds to three-quarters spore radius; occasionally gaping, a darker contact area is also present. The proximal surface of the spore is laevigate; distal surface strongly sculptured with tapering spines which project at the equator in the form of a "pseudo-flange". Spines 1μ. in basal diameter, from 1·5 - 3μ. long. The ornamentation is reduced to granules or is absent altogether from the triangular apices. Exine 1μ. thick, no folding.

Dimensions (4 specimens) 25 - 29μ.

Holotype. Preparation L.C.4 c, 44.3 98.8

Locus typicus. Vaynol Park, Caernarvonshire: Viséan.

Description. Holotype 26μ., convexly sub-triangular. Laesurae three-quarters of the spore radius, slightly gaping with a darker contact area along the laesurae. The distal surface of the spore is ornamented with spines up to 3μ. long, which become smaller towards, and are absent from, the triangular apices.

Remarks. The progressive reduction in the size of the ornament towards the apices is characteristic of this species. The development of projecting spines at the equator is not in the form of a corona (Butterworth and Williams, *Procoronospora*, 1958). It is likely that *Granulatisporites* ? *dumosus* (Staplin, 1960) is synonymous with *Anapiculatisporites tenuispinosus*; in the absence of a direct comparison of the two types no recombination is made; the spines are shorter (2μ.) than in the present species.

Occurrence. Menai Straits Shales; Viséan.

SUBINFRATURMA NODATI Dybova and Jachowicz 1957

GENUS ACANTHOTRILETES (Naumova) Potonié and Kremp 1954

Type species. _Acanthotriletes ciliatus_ (Knox) Potonié and Kremp, 1954

Affinity. Spores which may be assigned to this genus, have been found in sporangia of _Sphyropteris_ cf. _boenischi_ Stur, a member of the Filices; W. and R. Remy (1957) have shown that spores, which may be assigned to _Acanthotriletes_ or _Lophotriletes_, occur in this species.

Acanthotriletes cuspidens sp. nov.

Plate 3, Fig. 2. Text Fig. 4 D.

Diagnosis. Spores radial, trilete; amb circular to oval. Laesurae not always distinct, wavy when seen, length from two-thirds, to almost equal to, the spore radius, slight lip development, 1·5μ. wide. Exine of the spore is thin and is covered with evenly tapering spines which are often re-curved; from 5 - 15μ. long and 2 - 5μ. in basal diameter. The spines are confined to the distal surface and are more crowded towards the equatorial margin. Exine punctate between the sculpture.

Dimensions. (20 specimens) Equatorial diameter 54 - 72μ. (mean 63μ.)

Holotype. Preparation U.C.4a, 11·5 91·8.

Locus typicus. Coed Pen-y-Maes; Namurian A.

Description. Holotype 54μ., circular. Laesurae distinct, reaching almost to the equator, lips 1·2μ. wide, 1μ. high. Spines from 6 - 9μ. long and 2·5μ. in basal diameter, with both straight and recurved tips.

Remarks. This specimen is characterised by the loose arrangement of the distal ornament. Acanthotriletes sp. Butterworth and Williams, 1958 as illustrated on their Plate 1, Fig. 36 appears to be similar; Acanthotriletes galeritus Ishchenko, 1956 is of a similar size range, but has slightly different disposition of the ornament. In some of the specimens described here an irregular, thinner area is observed in places around the equator. This did not seem to be constant enough to represent a separation of the exine layers and there was an absence of folding. It is likely that the exine has been disrupted during preservation.

Occurrence. Holywell Shales: Namurian A - C.

Acanthotriletes horridus Hacquebard 1957

Plate 3, Fig. 8.

Description of specimens. Spores radial, trilete: amb circular to sub-circular. Laesurae indistinct, evidence of raised lips in one specimen. Exine covered with a dense ornament of spines 12 - 21μ. long and 4 - 9μ. wide at the base; taper of the spines is gradual and they may have rounded or sharply pointed tips. Exine finely granulose between the ornament (oil immersion).

Dimensions. (2 specimens) Equatorial diameter (excluding spines) 140 - 145μ.

Remarks. The two specimens agree with the description given by Hacquebard. One of the specimens is preserved laterally and shows what could be raised lip structure on the proximal pole. _A_ cf. _horridus_ Richardson (1965) has no evidence of raised lips and in general has longer spines.

Occurrence. Holywell Shales; Namurian B.

Previous records. Horton Group, Nova Scotia, Hacquebard (1957)

Acanthotriletes castanea Butterworth and Williams 1958

Plate 3, Fig. 1.

Description of specimens. Spores radial, trilete; amb sub-circular to rounded triangular. Laesurae indistinct. Exine thin, covered with slender spines which are slightly curved; spines up to 2µ. in basal diameter, 3 - 7µ. long; distance between spines 2 - 6µ.

Dimensions. (6 specimens) Equatorial diameter 38 - 44µ.

Remarks. Although only six specimens were found, they agree with the description given by Butterworth and Williams.

Occurrence. Holywell Shales; Namurian A.

Previous records. Namurian A of Scotland (Butterworth and Williams 1958) Namurian A of Stainmore (Owens and Burgess, 1965).

GENUS APICULATISPORIS Potonié and Kremp 1956

Type species. _Apiculatisporis_ (al. _Apiculatisporites_) _aculeatus_ Potonié and Kremp 1954.

Affinity. Unknown.

Remarks. The genus *Apiculatisporites* (Ibrahim, non Bennie and Kidston) Potonié and Kremp contained both mega- and microspores. The smaller miospores were removed from this genus by Potonié and Kremp (1956) and placed in a new genus *Apiculatisporis*. *Triletes* VI, which was the type species of *Apiculatisporites* Bennie and Kidston, was transferred to the genus *Tuberculatisporites* Ibrahim, along with other megaspores of the same type; the name *Apiculatisporites* was retracted ("Eingezogener Name").

Apiculatisporis cf. *variocorneus* Sullivan 1964b

Plate 3, Fig. 3.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight, length one-half to two-thirds spore radius, occasionally accompanied by thin, simple lips. Exine beset with a variety of rounded, sharply pointed spines; this variability is evident in any one sample. The spines are from 1·3 - 5μ. high and 0·5 to 3μ. in basal diameter. Exine from 1·5 - 2μ. thick.

Dimensions. (28 specimens) Equatorial diameter 61 - 70μ. (mean 66μ.)

Remarks. The range of variability covered in the original description of Sullivan (1964b) is found within the specimens described here. The laesurae are, however, somewhat longer. A definite statement of exine thickness is also included in the present description.

Occurrence. Rhydymwyn coal; Namurian C.

<u>Previous records</u>. Edgehills coal Westphalian A. Forest of Dean Basin, Gloucestershire (Sullivan 1964b).

<u>Apiculatisporis</u> <u>cambrensis</u> sp. nov.

Plate 3, Fig. 4; text-fig. 4 A

<u>Diagnosis</u>. Spores radial, trilete; amb sub-circular. Laesurae indistinct, often seen as a split in the exine, length one-half spore radius. Exine 1 - 2μ. thick, covered with a variable amount of sharply pointed spines. Truncated spines and cones up to 5μ. high, and 3μ. in basal diameter. The ornament is much reduced, or absent from the contact areas.

<u>Dimensions</u>. (11 specimens). Equatorial diameter 44 - 67μ. (mean 54μ.)

<u>Holotype</u>. Preparation U.C. 3a, 20·0 97·7.

<u>Locus typicus</u>. Panton Hall, Dingle, Flintshire; Namurian C.

<u>Description</u>. Holotype 67μ., laesurae split, length one-half spore radius. Exine 1μ. thick, covered with cones and spines up to 4μ. high and 2μ. in basal diameter, no ornament on the contact area.

<u>Remarks</u>. The spore is similar to <u>A</u>. <u>variocorneus</u> Sullivan (1964b), but is distinguished by the regular density of ornament and the greater average basal diameter of the cones.

<u>Occurrence</u>. Holywell Shales; Namurian C.

Explanation of Text-figure 4.

All figures X 500.

Fig.A. Apiculatisporis cambrensis sp. nov. Holotype. preparation U.C.3a, 20·0 97·7

Fig.B. Raistrickia rugosa sp. nov. Holotype: proximal surface; preparation L.C.4a, 54·8 97·0.

Fig. C. Anapiculatisporites tenuispinosus sp. nov. Holotype, distal surface; preparation L.C. 4c, 44·3 98·8.

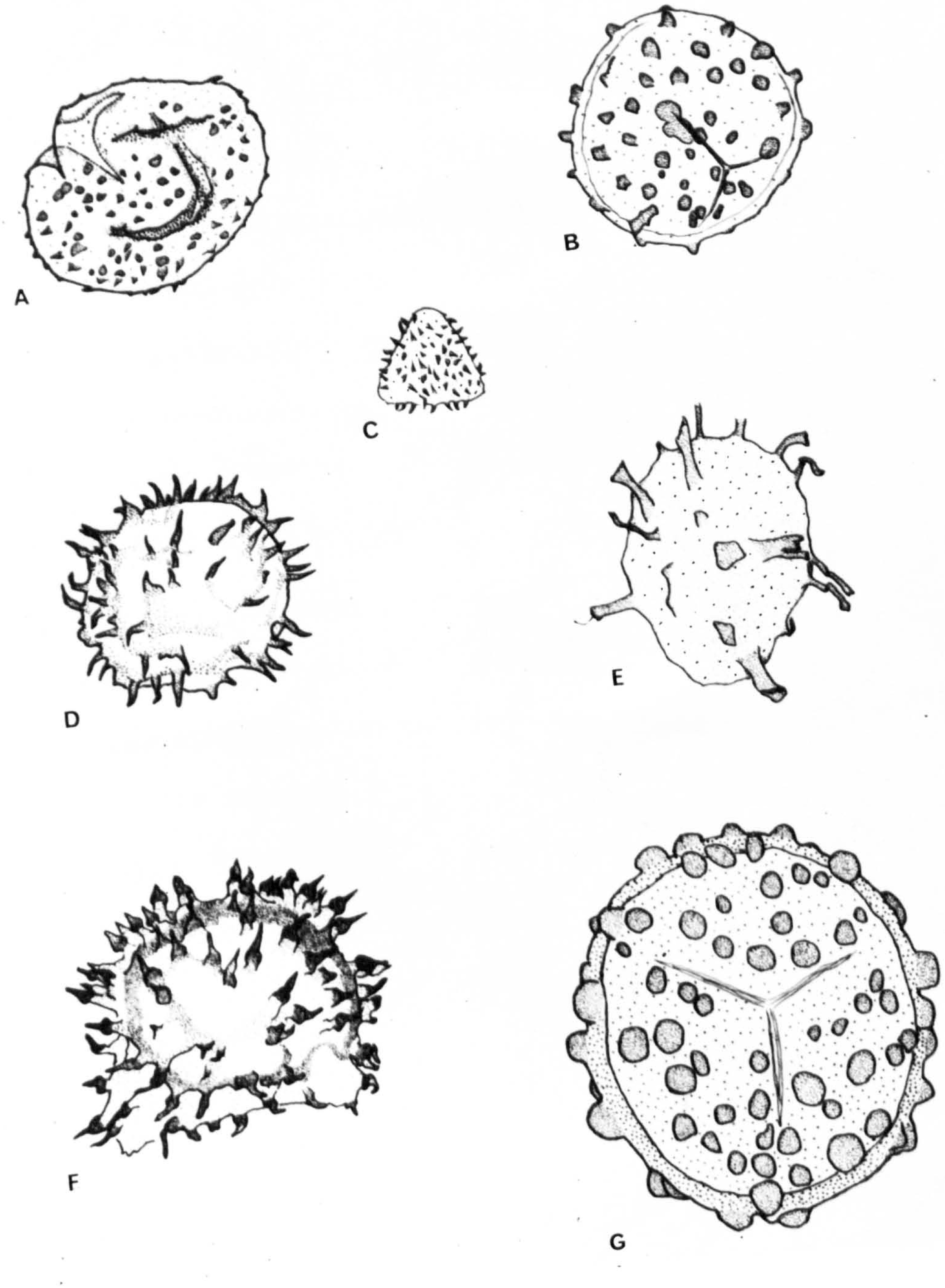
Fig.D. Acanthotriletes cuspidens sp. nov. Holotype: preparation U.C.4a. 11·5 91·8.

Fig.E. Raistrickia vulgaris sp. nov. Holotype; distal surface; preparation U.C.6c, 23·7 107·4.

Fig.F. Ibrahimisporis nobilis sp. nov. Holotype; preparation U.C. 4b, 48·9 108·9.

Fig.G. Verrucosisporites tuberculatus sp. nov. Holotype, proximal surface; preparation M.S. 177.

Text-figure 4



GENUS UMBONATISPORITES gen. nov.

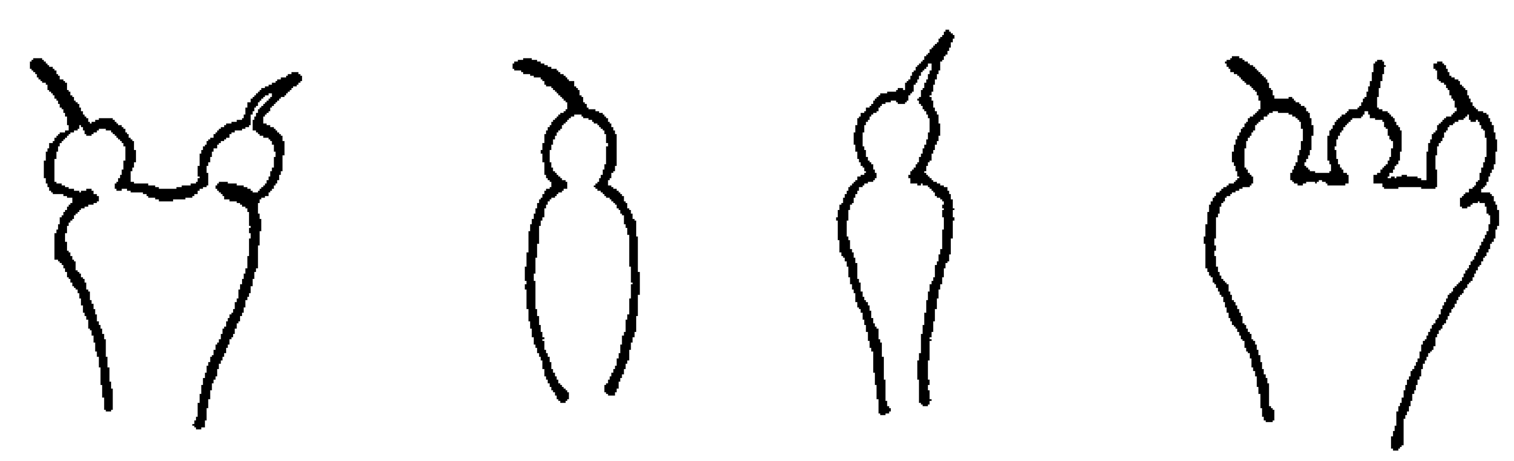
Type species. _U._ _variabilis_ gen. et sp. nov.

Affinity. Unknown

Diagnosis. Miospores radial, trilete; amb sub-circular. Laesurae indistinct, simple, straight, one-sixth spore radius. Sculpturing of the exine is arranged in indiscriminate wavy patterns; sculptural elements variable in shape, those of the distal side narrow at the base, widening towards the apex, terminating in a rounded head, which is topped by a sharply tapering spine (Text fig. 5). There may be from one to three rounded, head-like projections on the apex of the sculptural element, the proximal side is covered with sharply tapering spines. In polar view none of these elements appears on the equatorial amb. Exine folded.

Remarks. The scuptural elements are not characteristic of any other described miospore genus. Although only six specimens have been found the characteristics are sufficiently well defined to warrant the erection of a new genus.

Affinity. Unknown.



Text-figure 5. Sculptural elements of _Umbonatisporites variabilis_ (X3,500)

Umbonatisporites variabilis sp. nov.

Plate 2, Figs. 11, 12, 13; text-fig.5

Diagnosis. Spores radial, trilete; amb sub-circular. Laesurae distinct to indistinct, length one-sixth of the spore radius. Exine 1 - 2µ. thick, covered with a distinctive scultpuring, which is arranged in indiscriminate wavy patterns. Sculptural elements variable in shape; on the distal side up to 4•5µ. high and 1 - 1•5µ. in basal diameter, narrow at the base widening towards the apex, where they terminate in a rounded head which is topped with a thin tapering spine. There may be from one to three rounded head-like projections at the apex of the element. The proximal side is covered with spines 2 - 4µ. long and 0•5 - 1µ. wide at the base. In polar view few of the sculptural elements are seen around the equator. The exine is commonly folded.

Dimensions. (~~9~~6 specimens) 95 - 134µ. (mean 108µ.)

Holotype. Preparation L.C.2c, 14•6 106.8.

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 134µ., sub-circular. Laesurae distinct. The preservation of the spore is not in the equatorial plane and so the sculptural elements can be seen around the "equatorial amb". Ornament of the distal side is 2 - 4µ. high and up to 1•5u. basal diameter. All variations of the distal ornament are seen in one spore.

Occurrence. Menai Straits Shales; Viséan.

GENUS LOPHOTRILETES (Naumova) Potonié and Kremp 1954

Type species. L. gibbosus (Ibrahim) Potonié and Kremp 1954

Affinity. Filices. Spores of this type have been described from the fructification of Sphyropteris cf. boenischi Stur (W. and R. Remy 1957)

Lophotriletes tribulosus Sullivan 1964b

Plate 2, Fig. 2.

Description of specimens. Spores radial, trilete; amb triangular with straight to concave sides and rounded apices. Laesurae simple, straight, length from three quarters, to almost equal to, the spore radius. Exine 1 - 1·5μ. thick, ornamented with pointed to rounded cones which are up to 3μ. high and 3·5μ. in basal diameter.

Dimensions. (20 specimens) 28 - 35μ. (mean 31μ.)

Remarks. The size range given here varies from that of Sullivan, who quoted a size range of 30 - 45μ. (mean 36·5μ). The range of ornament given in the original description agrees well with that seen in the specimens from the Menai Straits material.

Occurrence. Menai Straits Shales; Viséan.

Previous records. Lower Carboniferous, Drybrook Sandstone of the Forest of Dean Basin, Gloucestershire, Viséan (Sullivan 1964b).

GENUS WALTZISPORA Staplin 1960

Type species. *W. lobophora* (Waltz) Staplin 1960

Affinity. Unknown.

Waltzispora planiangulata Sullivan 1964b

Plate 2, Fig. 1.

Description of specimens. Spores radial, trilete; amb triangular with bluntly rounded apices having angular junctions with the concave sides. Laesurae distinct, straight, simple, length from three quarters of the spore radius to the equator. Exine 1 - 1·5μ. thick, ornamented with grana and cones 0·5μ. in height and 1 - 1·5μ. in basal diameter; ornament absent from the proximal contact areas.

Dimensions. (15 specimens) 30 - 37μ. (mean 34μ.)

Remarks. The variation in ornament between specimens was not as apparent as Sullivan showed. The angular junction between the apex and the concave side was variable, but never approached the distinct angular junction seen in *W. lobophora* Staplin, 1960.

Occurrence. Menai Straits Shales; Viséan.

Previous records. Lower Carboniferous, Drybrook Sandstone, Forest of Dean Basin, Gloucestershire, Viséan (Sullivan 1964b).

GENUS IBRAHIMISPORES Artuz 1957

Type species. *I. microhorridus* Artuz 1957

Affinity. Unknown.

Discussion. The specimens of this genus from the Holywell Shales show what may be interpreted as a separation of the exine layers; indicating that the spines are formed from the outer layer. A similar feature may also be seen in the illustration of I. brevispinosus by Neves (1961, pl.31, fig.2). The solid, thickened tips of the spines would then be the point where the outer exine layer is fused together. The relationship of the exine layers is not clear from the surface views examined and further discussion is reserved until more specimens can be examined, preferably in sectional view.

Ibrahimispores brevispinosus Neves 1961

Plate 3, Fig. 5.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae generally indistinct, obscured by wavy and thickened lips, length three-quarters of spore radius when seen. Ornament of exine stout, hollow spines which are pointed and have solid, darker tips; 6 - 10μ. high and 3·5 - 5μ. in basal diameter. They are thickly set on the exine.

Dimensions. (5 specimens) 56 - 70μ.

Remarks. Neves (1961) gives 70μ. as the lower limit in the size range of this species. The specimens described here are smaller than this but agree otherwise with the original description and so are included within I. brevispinosus.

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Namurian A, B and C of the southern Pennines (Neves, 1961). Namurian A, B of Stainmore (Owens and Burgess, 1965).

Ibrahimispores nobilis sp. nov.

Plate 3, Figs. 6, 7, Text-fig. 4 F.

Diagnosis. Spores radial, trilete; amb. circular to sub-circular. Laesurae usually indistinct, wavy with thickened lips, length three-quarters spore radius when seen. Ornament of exine made up of hollow spines which have solid apices composed of a bulbous, "minaret-like" expansion below the sharply pointed tip. Spines 6 - 14μ. high and 3 - 5·5μ in basal diameter. The elements are closely spaced and appear to be features of a detached outer exine layer.

Dimensions. (6 specimens). Equatorial diameter 52 - 71μ. (excluding spines).

Holotype. Preparaton U.C.4b 48·9 108·9.

Locus typicus. Coed Pen-y-Maes, Flintshire; Namurian B.

Description. Holotype 67μ, amb sub-circular. Laesurae indistinct lips wavy, 2·5μ wide and 1·5μ high extending for three-quarters spore radius. Exine beset with spines each having a bulbous expansion below the tip; 5 - 14μ long and 3 - 5μ in basal diameter.

Occurrence. Holywell Shales; Namurian B - C.

Remarks. This spore is close to I. magnificus Neves, 1961, but is distinguished by the bulbous expansion of the spine below the tip.

Subinfraturma BACULATI Dybova and Jackowicz 1957

GENUS RAISTRICKIA Schopf, Wilson and Bentall 1944

Type species. R. grovensis Schopf 1944

Affinity. Spores of the Raistrickia type have been found in association with the following fossil plants. Lycopsida; Sigillariostrobus ciliatus Kidston. Filices; Botryopteris spinosa Mamay Ptychocarpus unitus Brongniart and Seftenbergia plumosa Artis.

Raistrickia rugosa sp. nov.

Plate 4, Figs. 4, 5; Text-fig. 4 B.

Diagnosis. Spores radial, trilete; amb circular to sub-circular Laesurae distinct, simple, straight, length one-third to one-half spore radius. Exine 2·3μ thick, covered with uniform baculae, 2 - 5μ high and 2 - 4·5μ in basal diameter; the baculae are often rounded. Ornament evenly distributed over the distal face of the spore, up to 11μ apart; the size of the ornament is much reduced on the contact area and forms low, round grana, 0·5 - 2μ in basal diameter and 0·5μ high.

Dimensions. (11 specimens) 58 - 67μ (mean 62μ).

Holotype. Preparation L.C. 4a, 54·8 97·0

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 62μ; amb circular. Laesurae one-third spore radius. Baculae 2 - 3μ high and of a similar basal diameter. Exine 2 - 3μ thick. The smaller grade in ornament is clearly shown on the proximal contact area.

Comparison. R. nigra Love, 1960 is similar but has a larger size range and its baculae are larger with an "equal length and width".

Occurrence. Menai Straits Shales; Viséan.

Raistrickia microhorrida (Horst) Potonié and Kremp 1965

Plate 4, Fig. 2.

Description of specimens. Spore radial, trilete; amb sub-circular Laesurae indistinct, straight when seen, length one-half spore radius. Exine 1 - 2µ. thick covered with baculae of numerous shapes, for the most part wider at the apex than the base and terminating in fimbrae. Baculae are 6 - 13µ high and 2·5 - 12 µ in basal diameter.

Dimensions (25 specimens). Equatorial diameter 44 - 58µ (excluding spines (mean 49µ).

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Horst (1943) recorded this species from the Namurian A of Mahrisch-Ostrau. Neves (1958) described the spore from the Namurian C of the Midlands. Owens and Burgess (1965) record the spore in deposits of Namurian A - C age from Stainmore.

Raistrickia vulgaris sp. nov.

Plate 4, Fig 3; text-fig. 4 E.

Diagnosis. Spores radial, trilete; amb circular to sub-circular Laesurae distinct, slightly sinuous, length three-quarters spore radius, accompanied by raised lips 2µ wide. Exine 1 - 1·5µ thick, ornament made up of two distinct types of baculae; one from 10 - 14μ high and 1 - 2μ in basal diameter, the other from 5·5μ high and 2 - 6μ in basal diameter. The baculae are sparse and widely distributed over the spore body, mainly towards the equator and on the distal side.

Dimensions. (20 specimens) Equatorial diameter 56 - 67μ (excluding ornament) (mean 61μ).

Holotype. Preparation U.C. 6c. 23·7 107·4.

Locus typicus. Coed Pen-y-Maes, Flintshire; Namurian B.

Description. Holotype 67μ, amb sub-circular. Laesurae distinct, length three-quarters spore radius. Exine 1μ thick, baculae 14μ high and 1μ in basal diameter and 11μ high and 4·5μ in basal diameter.

Remarks. The wide variation between the two distinct types of baculae and their dispersed nature are characteristic of this species.

Occurrence. Holywell Shales; Namurian B - C.

Raistrickia fulvus Artuz 1957

Plate 4, Fig. 1.

Description of specimens. Spores radial, trilete; amb sub-circular to rounded triangular, having convex sides and rounded apices. Laesurae occasionally indistinct; when seen simple, straight; length one-half to two-thirds spore radius. Exine 1·5 - 2·5μ thick with an ornament of baculae, blunt spines; baculae 1·5 - 2· high, and 2·7μ in basal diameter with frayed apices, spines 1 - 3μ high and 1·5 - 3μ in basal diameter.

The ornament is only sparsely scattered over the distal surface and is absent from the contact areas.

Dimensions. (33 specimens) Equatorial diameter 41 - 66μ (mean 53μ).

Comparison. The spore closely resembles *Raistrickia prisca* Kosanke, but lacks lip development and the thickening of the proximal exine to form an area contagionis, which are characteristic of that species.

Occurrence. Rhydymwyn coal; Namurian C.

Previous records. Westphalian A of Turkey (Artuz, 1957), Namurian C. of Stainmore (Owens and Burgess, 1965).

GENUS NEORAISTRICKIA Potonié 1956

Type species. *N. truncatus* (Cookson) Potonié 1956

Affinity. Unknown.

Neoraistrickia drybrookensis Sullivan 1964b.

Plate 4, Fig. 6

Description of specimens. Spores radial, trilete; amb triangular with rounded apices and straight, slightly concave or convex sides. Laesurae often indistinct, straight, length three-quarters spore radius, slight lip development in some specimens. The distal face of the spore is ornamented with cones, baculae and verrucae. The cones are often blunted, up to 3μ in height and 4μ in basal diameter; the baculae are up to 9μ high and 5μ in basal diameter; verrucae are from 3 - 7μ high and up to 9μ in their longest basal diameter. Exine 2 - 2·5μ thick.

Dimensions. (30 specimens) 31 - 53μ excluding ornament (mean 45μ).

Remarks. The specimens agree closely with the original description given by Sullivan (1964b); the size range is extended. The large verrucae when occurring on the equator, in particular towards the triangular apices, give the impression that the spore has a flange.

Occurrence. Menai Straits Shales; Viséan.

Previous records. Lower Carboniferous, Forest of Dean, Viséan (Sullivan, 1964b).

Infraturma MURONATI Potonié and Kremp 1954

GENUS CAMPTOTRILETES (Naumova) Potonié and Kremp 1954

Type species. *C. corrugatus* (Ibrahim) Potonié and Kremp 1954

Camptotriletes verrucosus Butterworth and Williams 1958

Plate 4, Fig. 8.

Description of specimens. Spores radial, trilete; amb sub-circular to circular. Laesurae distinct, simple, length up to two-thirds spore radius, occasionally gaping. Strongly developed ornament of irregular, somewhat convolute, low ridges, which connect more upstanding, verrucate-like elements. The ornament is loosely arranged, up to 4μ wide and separated by clearly defined channels.

Dimensions. (20 specimens) Equatorial diameter 49 - 58μ (mean 54μ).

Remarks. The specimens showed a wide range of variability in the arrangement of the ornament; some were similar to Convolutispora labiata (Playford), but lacked the development of lips.

Occurrence. Menai Straits Shales; Holywell Shales; Viséan - Namurian A.

Previous records. Limestone Coal Group of Scotland (Butterworth and Williams, 1958), Mid-Devonian of Scotland (Richardson, 1965), Lower Namurian A of the southern Pennines (Neves, 1961). Horton Group of Eastern Canada (Playford, 1963b).

Camptotriletes superbus Neves 1961

Plate 4, Fig. 7.

Description of specimens. Spores radial, trilete; amb sub-circular. Laesurae distinct, straight, length up to three-quarters spore radius, accompanied by low lips which become less obvious towards the equator. Exine ornamented with irregular, low ridges, which are discontinuous; they appear as verrucate to conate ornament at the equator, joined by low, irregular ridges; ornament up to 6µ high and 3 µ wide.

Dimensions. (11 specimens) Equatorial diameter 65-89µ. (mean 77µ).

Remarks. The specimens here are on the whole somewhat smaller than those described by Neves (1961). Comparatively few examples were found.

Occurrence. Rhydymwyn coal; Namurian C.

Previous records. Namurian B- Westphalian A of the southern Pennines (Neves 1961). Namurian B- C of Stainmore (Owen and Burgess, 1965).

GENUS CONVOLUTISPORA Hoffmeister, Staplin and Malloy 1955

Type species. C. florida Hoffmeister, Staplin and Malloy 1955

Affinity. Unknown

Convolutispora tuberculata (Waltz) Hoffmeister, Staplin and Malloy 1955

Plate 4, Fig. 9

1938 Azonotriletes tuberculatus Waltz in Luber and Waltz, p. 12, plate 1, fig. 12, plate 5, fig. 68 and plate A, fig. 6

1955 Verrucosisporites tuberculatus (Waltz) Potonié and Kremp, p. 66

1955 Filicitriletes tuberculatus (Waltz) Luber, p. 54; plate 2, Figs. 45 and 46.

1955 Convolutispora tuberculata (Waltz) Hoffmeister, Staplin and Malloy. p. 384

1955 Convolutispora tessellata Hoffmeister, Staplin and Malloy, p. 385; plate 38, fig. 9.

1956 Lophotriletes triletes tuberculatus (Waltz) Ishchenko, p. 40; plate 6, figs. 75, 76.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae usually obscured by sculpture, simple, straight, length one-third to two-third spore radius. Exine 1·5 - 2·5μ thick, ornamented with low, closely packed, anastomosing ridges or irregular elongated verrucae, lumina small and irregular, muri rounded to slightly pointed in cross section; from 1·5 - 6µ high and 2 - 5U broad; equatorial margin irregular.

Dimensions. (30 specimens) Equatorial diameter 38 - 79µ (mean 59µ)

Remarks. Playford (1962) emphasises the intra-specific variation shown by this species (Waltz in Luber and Waltz). He further suggests that *C. tessellata* Hoffmeister, Staplin and Malloy, 1955 and *C. punctatimura* Staplin, 1960 may be synonymous with *C. tuberculata*. In this present study a continuous variation in type of ornament from *C. tuberculata* to *C. tessellata* has been observed. In view of this and the comments made by Playford, spores of *C. tessellata* are included within *C. tuberculata*. *C. venusta* also falls within the size range of *C. tuberculata* but is characterized by arete (mountain ridge) type of ornament as seen in cross section.

Occurrence. Menai Straits Shales, Holywell Shales; Viséan to Namurian B.

Previous records. Extensively recorded from the Carboniferous of Russia, Lower Carboniferous of Moscow and Karaganda Basin by Luber and Waltz (1938, 1941); Upper Devonian - Namurian rocks of the Dnieper-Donetz Basin by Ischchenko (1956, 1958). The spore has also been recorded from the Carboniferous of Spitzbergen by Playford (1962) and the Hardinsburg formation of Illinois and Kentucky by Hoffmeister, Staplin and Malloy (1955). Upper Mississippian of Canada (Playford and Barss, 1962).

Convolutispora labiata Playford 1962

Plate 4, Figs. 10, 11. text-fig. 6 H,I

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight, length four-fifths spore radius, often bordered by lips formed from the muri adjacent to the laesurae; the lips are occasionally punctate. Exine 1 - 1·5μ thick (excluding ornament) covered with a strongly developed sculpture of sinuous muri, which are rounded in cross section and which anastomose and terminate frequently. The muri are from 1·5 - 5μ in width and 2 - 3·5μ high; they enclose clearly delimited lumina, which are from 2 - 8μ in longest diameter. The lumina may also contain rugulae-verrucae, in particular the lumina of the proximal face; the sculpture is more strongly developed on the distal face.

Dimensions. (20 specimens) Equatorial diameter 47 - 62μ (mean 55μ)

Comparison. The size range of Playford's original description is different (82 - 114μ mean 99μ). Camptotriletes verrucosus Butterworth and Williams, 1958 has a less regular development of anastomosing muri than C. labiata and lacks lips. The ornament of the proximal surface of Convolutispora labiata approaches the typical form seen in Camptotriletes.

Remarks. The predominance of more regular, anastomosing muri place this spore in Convolutispora; in no case does the ornament of verrucae and short rugulae become the most conspicuous type.

Occurrence. Menai Straits Shales; Viséan.

Convolutispora vermiformis Hughes and Playford 1961

Plate 4, Fig. 13

1957 Convolutispora flexuosa forma minor Hacquebard,

p. 312; Plate 2, Fig. 10.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight to sinuous, length from three-quarters to nearly equal to spore radius; accompanied by sculptural elements in the form of broad lips in many cases. Exine covered with low ridges which anastomose freely, from 4 - 6μ wide and 3 - 5μ high; rounded in equatorial outline. Exine 2 - 3·5μ thick.

Dimensions. (8 specimens) 51 - 73μ (mean 64μ).

Remarks. Although only eight specimens were found, apart from a lower average height of the muri, these specimens agreed with the original description of Hughes and Playford, 1961.

Occurrence. Menai Straits Shales; Viséan.

Convolutispora vermiculata sp. nov.

Plate 4, Figs. 12, 14.

Diagnosis. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, simple, straight, length one-half to two-thirds spore radius. Exine covered with broad low elevations 0·5 - 2μ high and 2·5 - 9μ wide, which are rounded in profile and sinuous. The lumina are rounded to polygonal, up to 14μ in longest diameter, frequently much smaller (3 - 6μ) Exine 2 - 4·5μ thick, distinctly infrapunctate (oil immersion).

Dimensions. (30 specimens) 59 - 71μ (mean 68μ).

Holotype. Preparation L.C.2b, 41·8 96·4

Locus typicus. Vaynol Park, Caernarvonshire: Viséan.

Description. Holotype 64μ, amb circular. Laesurae distinct, one-half spore radius. Ornament of low, anastomosing elevations, 1·5μ high, and 9μ wide; lumina irregular. Exine 2μ thick (excluding ridges) and infra-punctate.

Remarks. The spore is similar in general appearance to C.vermiformis Hughes and Playford, 1961. It lacks a definite, prominent sculpture, its laesurae are shorter and the exine is distinctly infra-punctate.

Occurrence. Menai Straits Shales; Viséan.

Convolutispora florida Hoffmeister, Staplin and Malloy 1955

Plate 5, Fig. 1.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae only occasionally distinct, obscured by ornament, when seen slightly sinuous, one-half to two-thirds spore radius. Exine 1 - 2μ thick (excluding ornament) ornament of closely packed, coarse, anastomosing ridges which are rounded to flattened in cross-section; muri 2 - 6·5μ wide and 2·5 - 5μ high. The lumina are relatively insignificant, often long and sinuous, from 0·5 - 1μ wide.

Dimensions. (22 specimens) Equatorial diameter 40 - 53μ (mean 49μ).

Comparison. The ridges are broader than C. tuberculata Hoffmeister, Staplin and Malloy, 1955 and the equatorial margin is smooth to only slightly undulating.

Remarks. In the original description, Hoffmeister, Staplin and Malloy gave no indication of the height of the ornament, nor of the size and nature of the lumina. The dimensions given here are considered to equate to the statement "closely packed" in the original description.

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Hardinsburg formation of Illinois and Kentucky, (Hoffmeister, Staplin and Malloy 1955)

Convolutispora mellita Hoffmeister, Staplin and Malloy 1955

Plate 5, Fig. 3.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae only occasionally distinct; when seen, slightly sinuous; length one-half to two-thirds spore radius. Exine ornamented with anastomosing ridges, 2 - 5·5μ wide and 2 - 3μ high; rounded to flattened in cross section. Lumina 1·5 - 3μ wide, slightly elongated and sinuous.

Dimensions. (21 specimens) 58 - 82μ (mean 69μ).

Comparison. *C. mellita* is distinguished from *C. florida* Hoffmeister, Staplin and Malloy 1955 by its greater size and the wider, more obvious lumina.

Remarks. The original circumscriptions of *C. florida* and *C. mellita* are not precise about the height of the muri nor the size of the lumina. It appears that *C. mellita* has more conspicuous lumina from the illustration

(Pl. 38, fig. 10); it is also said to have a "roughly reticulate" appearance. A great amount of variation is displayed in the present material; a continuous gradation from one species to the other can be recognised. The present delimitation of the two species is made on the size of the lumina. A re-examination of the type of material could well result in the two being combined.

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Hardinsburg formation of Illinois and Kentucky (Hoffmeister, Staplin and Malloy, 1955).

Convolutispora obliqua Neves 1961

Plate 5, Fig. 2.

Description of specimens. Spores radial, trilete; amb sub-circular. Laesurae only occasionally distinct; when seen, sinuous; length two-thirds spore radius, accompanied by narrow lips, 0·5μ wide. Exine 1μ thick (excluding ornament) ornament of anastomosing ridges, 1·5 - 3·5μ high. The lumina are small, 0·5 - 1·5μ in width. Equatorial margin undulating. Secondary folds present on the exine. The spore is often preserved in an oblique condition.

Dimensions. (10 specimens) 90 - 105μ (mean 96μ)

Occurrence. Upper Carboniferous, Holywell Shales, Namurian B.

Previous records. Namurian A of southern Pennines (Neves 1961). Namurian B of Stainmore region (Owens and Burgess 1965).

GENUS DICTYOTRILETES (Naumova) Potonié and Kremp 1954

Type species. D. bireticulatus (Ibrahim) Potonié and Kremp 1954

Affinity. Unknown.

Discussion. After an examination of the holotype of Reticulatisporites, Neves (1964) redefined that genus to include only those spores which have a narrow, differentiated cingulum and he placed it in the Turma Zonales. He further stated that the species now excluded from Reticulatisporites could be transferred to Dictyotriletes, "when the diagnosis for this genus is brought into line with the relatively upstanding muronate ornament of the type species". A study of the structural organization of zonate and azonate spores is currently being undertaken by a working group of "C.I.M.P" and the species now excluded from Reticulatisporites (Ibrahim) Neves are, in this study, placed in Dictyotriletes (Naumova) Potonié and Kremp. The broad interpretation of the genus is used to include azonate forms with a distal reticulum, or those specimens with a comprehensive ornament, the apparent flange being due to muri running in the equatorial plane.

Dictyotriletes radiatus sp. nov.

Plate 5, Figs 5, 6; text-fig. 6E

1960 Reticulatisporites sp. B. Love,

p. 117 - 118; plate 1, fig.11.

Diagnosis. Spores radial, trilete; amb circular to sub-circular. Laesurae not seen. Prominent reticulate ornament of thin muri on both faces of the spore, 0·5 - 2µ wide and up to 18µ high, clearly visible as radial projections at the equator. Lumina highly variable in shape, from 5 - 33μ in longest diameter. The reticulate nature of the spore is highly irregular and variable on each specimen. Due to their thinness, the muri are frequently folded and run in the equatorial plane giving a zonate effect. Exine 2 - 4μ thick (excluding ornament).

Dimensions. (25 specimens) 76 - 105μ (mean 94μ).

Holotype. Preparation L.C.5c, 16•2 106•8.

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 82μ sub-circular in outline. Muri 0•5 - 2μ thick and 14μ high; they show a reticulate pattern and are frequently folded. Exine 2•5 - 3μ thick. Lumina irregular in shape, 10 - 30μ in longest diameter.

Remarks. This spore is characterised by the high, thin muri, which appear to radiate at the equator. No laesurae were observed, probably obscured by the ornament. Love (1960) describes a Reticulatisporites sp.B with thin exine but gives no definite statement of the exact thickness. From the illustration there appears to be a darker zone around the equator of the central body which is similar to that seen as wall thickness in D. radiatus.

Occurrence. Menai Straits Shales; Viséan.

Previous records. Lower Oil Shale group of Scotland, Viséan, (Love 1960)

Dictyotriletes tesselatus sp. nov.

Plate 5, Figs 7,8; Text-fig. 6 L,M.

Diagnosis. Spores radial, trilete, amb circular to sub-circular. Laesurae distinct in most specimens, straight, length four-fifths to almost equal to, the spore radius. Prominent continuous lips, about 6μ broad on each side of the laesurae, formed from muri which are aligned alongside the mark; the lips have a variable number of blunt crests up to 5μ high. Spore is comprehensively sculptured with smooth, strongly developed muri, 2·5 - 4μ wide and up to 11μ high, with a characteristic clavate profile. The muri frequently are expanded at their junctions and on the proximal side terminate abruptly. Lumina very irregular in shape, from 5 - 27μ in longest diameter. Occasionally there are clavate projections within the lumina. Exine 2·5 - 4μ thick, excluding ornament.

Dimensions. (43 specimens) 78 - 105μ (mean 91μ)

Holotype. Preparation L.C.30 55·7 93·2.

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 95μ, amb circular. Laesurae distinct, straight, length equal to the spore radius; accompanied by prominent lips up to 6μ broad on each side of the laesurae and with a series of irregular blunt crests up to 5μ high. Muri 2·5 - 3·5μ wide and up to 10μ high, conspicuously clavate shaped in profile and expanded at their junctions. Lumina irregular, 8 - 20μ in longest diameter. Exine 3μ thick.

Comparison. *Reticulatisporites variolatus* Playford (1962) is also characterised by muri having a clavate profile. In that species the lumina are more regularly arranged, rounded or polygonal in shape; the exine is much thicker (9 - 12µ) and the laesurae are not accompanied by lips having the extensive development seen in Dictyotriletes tesselatus.

Occurrence. Menai Straits Shales; Viséan.

Dictyotriletes (Reticulatisporites) cancellatus (Waltz) Potonié and Kremp 1955

Plate 5, Fig. 9.

1884? Type 555 of Reinsch, p.54; pl.38, fig.271

1938 Azonotrilete cancellatus Waltz, in Luber and Waltz, p.11; Plate 1, fig. 8 and Plate 5, fig.73.

1955 Sphenophyllotriletes cancellatus (Waltz) Luber, pp. 41 - 42; plate 4, Figs. 78a, 78b, 79.

1955 Dictyotriletes cancellatus (Waltz) Potonié and Kremp p. 108.

1956 Dictyotriletes cancellatus (Waltz) Ishchenko, p. 45; Plate 7, figs. 88, 89.

1957 Dictyotriletes cancellatus (Watz) Naumova; Kedo, p. 1166.

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

1962 Reticulatisporites cancellatus (Waltz) Playford, p.597,; plate 82, figs.11-13, Plate 83, figs 1 & 2

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight, length equal to spore radius, accompanied by flat, elevated lips, 4 - 5μ wide, with a slight crenate outer margin. Prominent irregular sculpture of reticulate muri, enclosing polygonal lumina. Muri 2 - 6μ wide and up to 7μ high, frequently expanded at their junctions, enclosing lumina which are from 5 - 20μ in longest diameter. Exine 2 - 4·5μ thick, excluding muri.

Dimensions. (10 specimens) 67 - 93μ (mean 76μ).

Remarks. The range of variability in size and sculpture is smaller in this specimen than in those previously described.

Occurrence. Menai Straits Shales; Viséan.

Previous records. Lower Carboniferous of Russia (Luber and Waltz, 1938, 1941; Luber 1955 and Ishchenko 1956, 1958) North West Territories of Canada (Hacqubard and Barss 1957) and of Spitsbergen (Playford, 1962). Upper Missisippian of Canada (Playford and Barss, 1963).

Dictyotriletes peltatus (Playford) comb. nov.

1962 Reticulatisporites peltatus Playford,

p. 599; plate 84, figs 1 - 4.

Under the new definition of Reticulatisporites given by Neves (1964) those spores lacking a differentiated cingulum are excluded from the genus. Specimens which lack such a structure, assigned by Playford to Reticulatisporites are re-assigned to the genus Dictyotriletes.

Dictyotriletes cf. peltatus (Playford, 1962)

Plate 5, Fig. 4.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae indistinct. Exine sculptured with irregular muri, enclosing polygonal lumina which are 6 - 20μ in longest diameter. At the junction of the muri characteristic peltate processes are developed; these may be slightly broadened at the base, 5 - 14μ high, 5 - 7μ broad at the base. The elements are clearly shown in profile around the equator. Exine 2·5μ thick, excluding ornament.

Dimensions. (5 specimens) Equatorial diameter 79 - 105μ.

Remarks. There were no laesurae visible in any of the specimens examined; since only five specimens were recorded they are tentatively aligned with Dictyotriletes peltatus Playford.

Occurrence. Menai Straits Shales; Viséan.

Dictyotriletes piliformis sp. nov.

Plate 5, fig. 10; text-fig. 6 J, K.

Diagnosis. Spores radial, trilete; amb sub-circular to oval. Laesurae often obscured by the ornament; length one-half to two-thirds spore radius; accompanied by sinuous lips 0·5μ wide. Exinal sculpture of reticulate muri 3 - 5μ wide enclosing irregular lumina, from 5 - 19μ in longest diameter. Muri characterised by flattened, peltate structures arising from their junctions, processes 2·5 - 5μ high and 2 - 3μ in basal diameter. Spore azonate.

Dimensions. (23 specimens) Equatorial diameter 52 - 74µ (mean 60µ)

Holotype. Preparation U.C.8a 32·2 108·7

Locus typicus Coed Pen-y-Maes, Flintshire; Namurian B.

Description. Holotype 62µ amb sub-circular. Laesurae distinct, length two-thirds spore radius, lips 0·5µ wide, sinuous. Muri 4·5 - 6µ wide and 4µ high.

Comparison. This spore is very similar to R. peltatus Playford (1962). The ornament is much smaller here and the laesurae, when seen have slight lip development.

Occurrence. Holywell Shales; Namurian A - C.

Dictyotriletes tuberosus Neves 1961

Plate 5, Fig. 11

Description of specimens. Spores radial, trilete; amb sub-circular. Laesurae only occasionally seen, straight, length three-quarters spore radius. Exinal sculpture of heavy muri, 5 - 10µ wide and 5 - 6µ high. The lumina are variable in shape, 15 - 25µ in longest diameter.

Dimensions.(15 specimens) 72 - 101µ (mean 99µ)

Remarks. The specimens found here are identical to those from the Sabdenian stage of the southern Pennines (Neves, 1961). Only ten specimens were found by Neves and his size range was from 90 - 120µ.

Occurrence. Upper Carboniferous, Holywell Shales; Namurian B.

Previous records. Namurian A of southern Pennines (Neves 1961). Namurian B of Stainmore. (Owens and Burgess, 1965).

<u>Dictyotriletes vagus</u> sp. nov.

Plate 5, Figs 12, 13

<u>Diagnosis</u>. Spores radial, trilete; amb sub-circular to oval. Laesurae occasionally distinct, simple, straight, length two-thirds to three-quarters spore radius. Exinal sculpture of low, rounded muri, which enclose irregular lumina. Muri 1 - 2·5µ wide and 1 - 2µ high; lumina 4 - 16µ in longest diameter. Exine 1·5µ thick.

<u>Dimensions</u>. (20 specimens) 36 - 48µ (mean 42µ).

<u>Holotype</u>. Preparation U.C.9b 25·3 103·0

<u>Locus typicus</u>. Coed Pen-y-Maes, Flintshire, Namurian B.

<u>Description</u>. Holotype 45µ; amb oval. Laesurae distinct, length three-quarters spore radius. Muri 1 - 2·5µ wide, 1·5µ high; lumina 5 - 10µ in the longest diameter.

<u>Comparison</u>. <u>D</u>. <u>bireticulatus</u> (Ibrahim) Potonié and Kremp 1954 is a similar spore but has a more regular appearance and no laesurae.

<u>Occurrence</u>. Holywell Shales; Namurian A - B.

Subturma PERINOTRILETES Erdtman 1947

GENUS PEROTRILETES Erdtman ex Couper 1953

Type species. <u>P</u>. <u>granulatus</u> Couper 1953

<u>Affinity</u>. Unknown.

<u>Perotriletes</u> <u>magnus</u> Hughes and Playford 1961

Plate 6, Fig. 4.

Description of specimens. Spores radial, trilete, amb sub-circular. Laesurae distinct, simple, straight, length one-half to two-thirds spore radius. Perine thin and laevigate, in some specimens close-fitting, in others it is apparent some 6μ from the central body; frequently folded. Exine 1·5 - 3μ thick, laevigate and frequently folded.

Dimensions. (7 specimens) Equatorial diameter 101 - 154μ

Remarks. The perine is often seen torn off the central body.

Occurrence. Menai Straits Shales; Viséan.

Previous records. Lower Carboniferous of Spitsbergen (Hughes and Playford, 1961).

Perotriletes reticulatus sp. nov.

Plate 6, Figs. 1, 2.

Diagnosis. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, simple, straight, length one-half to two-thirds spore radius. Perine very thin, folded and wrinkled over the surface of the central body; in some cases the perine is folded in a reticulate pattern. Exine 1·5 - 2μ thick, sparsely punctate.

Dimensions. (8 specimens) 61 - 86μ (mean 69μ) central body 58 - 75μ (mean 64μ).

Holotype. Preparation L.C.2e, 43·4 99·1.

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype, 86μ; amb sub-circular, Laesurae distinct, simple, length one-half spore radius. Perine hyaline, closely attached to the central body, with wrinkles and small folds. Exine 2µ thick, minutely sparsely punctate.

Comparison. P. perinatus Hughes and Playford, 1961 is smaller and has a more triangular shape. The tendency for the perine to become folded in a reticulate manner is the diagnostic feature of P. reticulatus sp. nov.

Occurrence. Menai Straits Shales; Viséan.

Perotriletes punctatus sp. nov.

Plate 6, Fig. 3.

Diagnosis. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight, length two-thirds to equal the spore radius; often with thin lip development. Perine thin, distinctly punctate, extending from 2 - 7µ beyond the central body, occasionally folded. In the case of larger spores a darker zone is found towards the equator of the perine, this may indicate the presence of a limbus. Exine 1·5µ thick and punctate.

Dimensions. (8 specimens) Equatorial diameter 45 - 81µ (mean 64µ).

Holotype. L.C.2e, 29·1 94·6.

Locus typicus. Vaynol Park, Menai Straits; Viséan.

Description. Holotype 53µ, central body 48µ; amb sub-circular. Laesurae distinct, length two-thirds spore radius, accompanied by thin.

lips. Perine punctate, folded, torn away from the central body. Exine 1·5μ thick, punctate.

Remarks. This spore is distinguished by the punctate perine.

Occurrence. Lower Carboniferous, Menai Straits, Viséan.

Turma ZONALES (Bennie and Kidston) R. Potonié 1956

Subturma AURITOTRILETES Potonié and Kremp 1954

Infraturma AURICULATI (Schopf) Potonié and Kremp 1954

GENUS AHRENSISPORITES Potonié and Kremp 1954

Type species. A. guerickei (Horst) Potonié and Kremp 1954

Ahrensisporites guerickei (Horst) Potonié and Kremp 1954

Plate 6, Fig. 5.

Description of specimens. Spores radial, trilete; amb sub-triangular to triangular with straight to slightly convex sides. Laesurae usually distinct, straight, length up to two-thirds spore radius. Kyrtome folds of the distal surface distinct, the distal surface may also have other irregular thickenings.

Dimensions. (8 specimens) Equatorial diameter 66 - 74μ.

Remarks. These specimens are of the type described by Potonié and Kremp; the distal thickenings do not approach the magnitude of those described by Neves (1961) for A. guerickei var. ornatus.

Occurrence. Holywell Shales; Namurian C.

Previous records. Namurian of Upper Silesia (Horst, 1950); Namurian B - C. of the southern Pennines (Neves 1961); Namurian A of Scotland (Butterworth and Williams, 1958).

Subturma ZONOTRILETES Waltz 1935.

Infraturma CINGULATI Potonié and Klaus 1954

GENUS KNOXISPORITES Neves 1961

Type species. K. hageni Potonié and Kremp 1955.

Affinity. Unknown.

Remarks. The emended diagnosis of the genus by Neves (1961) excluded all the spores with a differentiated cingulum; the latter were included in the genus Reticulatisporites (Ibrahim) Neves 1964.

Knoxisporites triradiatus Hoffmeister, Staplin and Malloy 1955

Plate 6, Fig. 11.

Description of specimens. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight, length two-thirds to three-quarters spore radius; often with slight lip development. Cingulum 4·5 - 5μ broad, evenly tapering, often with dark inward projections at the radial positions which extend to the laesurae. Theproximal surface is laevigate and the distal ornamented with three bands of radial thickening, originating from the distal pole, which are rotated 60° relative to the rays of the trilete mark. Width of the bands variable (4 - 9μ).

Dimensions. (15 specimens) Equatorial diameter 51 - 79μ (mean 66μ)

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Hardinsburg formation of Illinois and Kentucky, (Hoffmeister, Staplin and Malloy, 1955); Namurian A of North Staffordshire (Neves 1958).

Knoxisporites seniradiatus Neves 1961

Plate 6, Fig. 12.

Description of specimens. Spores radial, trilete; amb sub-circular. Laesurae distinct, straight, length three-quarters spore radius, bordered by flat lips, which extend 3 - 6µ on either side of the laesurae. Cingulum 3 - 14µ wide, occasionally shows evidence of a polewards overlap on the proximal surface (4 - 5µ). The distal surface bears three radial bars of thickening, which are rotated 60° relative to the rays of the laesurae. Exine infrapunctate (oil immersion).

Dimensions. (16 specimens) Equatorial diameter 59 - 70µ (mean 65µ).

Remarks. The specimens described here are somewhat smaller than those originally described by Neves (60 - 105µ); they are sufficiently distinctive to be assigned to K. seniradiatus. They are distinguished from K. triradiatus by the present of lips associated with the laesurae.

Occurrence. Holywell Shales; Namurian B - C.

Previous records. Namurian B - C of the southern Pennines (Neves, 1961) Upper Namurian A to Lower Namurian C Stainmore, Westmorland (Owens and Burgess, 1965).

Knoxisporites concentricus sp. nov.

Plate 6, figs. 6, 7; Text fig.6C,D

Diagnosis. Spores radial, trilete; amb sub-circular. Laesurae distinct, straight, length two-thirds to three-quarters spore radius; accompanied by narrow, raised lips, which are slightly sinuous. The lips terminate in a thickening which widens towards the equatorial margin. Distal surface with a rounded pad of thickening at the pole, 6 - 16μ in longest diameter, surrounded at a short distance, by a ring of thickening, from 4 - 12μ in width. From one to three extensions of this ring run onto the cingulum. Cingulum 3 - 10μ wide, frequently showing an extension over to the proximal side of the spore body.

Dimensions. (14 specimens) Equatorial diameter 36 - 70μ (mean 53μ).

Holotype. Preparation U.C.6c 45·4 97·3.

Locus typicus. Coed Pen-y-Maes, Flintshire; Namurian B.

Description. Holotype 49μ; amb sub-circular. Laesurae distinct, length two-thirds spore radius, lips sinuous; terminating in expanded terminal thickenings. Distal ring of thickening 6 - 7μ wide; polar pad 7μ in longest diameter. Cingulum 8 - 9μ wide.

Remarks. The spore is characterised by the polar thickening, surrounded by a further ring of thickening. K. rotatus Hoffmeister, Staplin and Malloy, 1955 has a distal ring, with three distinct places where this ring joins onto the cingulum which are rotated 60° relative to the trilete rays of the proximal face. The spore also lacks the proximal pad of thickening.

Occurrence. Holywell Shales; Namurian A - B.

Knoxisporites cf. rotatus Hoffmeister, Staplin and Malloy, 1955

Plate 7, Fig. 1.

Description of specimens. Spores radial, trilete; amb sub-circular. Laesurae distinct, length two-thirds spore radius, accompanied by slightly raised, sinuous lips; these expand into a distinct radial thickening towards the equator. Distal surface ornamented with a circular band of thickening from 5 - 8 μ wide, which may be joined to the cingulum by up to three thickened arms. Cingulum 3·5 - 8μ wide.

Dimensions. (9 specimens) 41 - 69μ (mean 48μ).

Remarks. The three extensions of the distal ring are not rotated 60° from the position of the trilete rays as is found in K. rotatus. The specimens from the Namurian A sample are larger on average than those from the Naumurian B.

Occurrence. Holywell Shales; Namurian B - C.

Knoxisporites convolutus sp. nov.

Plate 6, Figs 8,9; text-figs 6 N,O

Diagnosis. Spores radial, trilete; amb sub-circular. Laesurae distinct, length up to the equator, accompanied by raised lips 2 - 3μ wide, which run onto the cingulum where they occasionally become laterally expanded. Exine ornamented on the distal side by an irregular reticulum of muri which run onto the distal side of the cingulum, muri 3 - 5μ wide. The cingulum is 9 - 11μ wide and tapers only slightly towards the equator; it generally overlaps the proximal surface of the spore body (2μ). Spore body laevigate to infra-punctate (oil immersion).

Dimensions. (10 specimens) Equatorial diameter 53 - 77μ (mean 62μ).

Holotype. Preparation L.C. 5c, 24·2 100·8.

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 61μ amb sub-circular. Laesurae distinct, reaching the equator of the central body; lip development slight, becoming expanded on the cingulum. Cingulum 9 - 10μ wide, with no evidence of poliward overlap. Distal ornament of muri, 2·5 - 4·5μ wide; exine infrapunctate.

Occurrence. Menai Straits Shales; Viséan.

GENUS LYCOSPORA (Schopf, Wilson and Bentall) Potonié and Kremp 1954

Type species. *L. micropapillata* (Wilson and Coe) Schopf, Wilson and Bentall, 1944.

Affinity. Lycopsida; *Barrandeina dusliana* (Krejc) Stur, *Lycopodites oosensis* Kräusel and Weyland, *Lepidodendron simile* Kidston, *Lepidostribus aristatus* Hoskins and Cross, *Lepidostrobus diversus* Felix, *Lepidostrobus dubius* Binney, *Lepidostrobus goldenbergii* Schimper (spore, *Lycospora parva*), *Lepidostrobus olyri* Zeiller, *Lepidostrobus ornatus* Brongniart, *Lepidostrobus pulvinatus* Felix, *Lepidostrobus russelianus* (Binney) Chaloner, *Lepidostrobus spinosus* Kidston, *Lepidostrobus variabilis* Lindley and Hutton; *Lepidocarpon* (al *Lepidostrobus*) *bohdanowiczii* (Bochenski), *Lepidocarpon magnificum* Andrews and Pannell (spore, *Lycospora punctata*).

Lycospora uber (Hoffmeister, Staplin and Malloy) Staplin 1960

Plate 7, fig. 10.

1938 Zonotriletes pusillus (non Ibrahim) Waltz, in Luber and Waltz, p. 15; plate 3, fig. 33 and plate A, Fig. 12.

1941 Zonotriletes pusillus (non Ibrahim) var. gracilis Waltz, in Luber and Waltz, p.35; plate 7, fig. 101b.

1952 Hymenozonotriletes pusillus (non Ibrahim) Ishchenko, p. 50; plate 13, fig. 122.

1955 Cirratriradites uber Hoffmeister, Staplin and Malloy, p. 383; plate 36, fig. 24.

1957 Hymenozonotriletes pusillus (non Ibrahim) Naumova; Byvsheva, p. 1010.

1958 Lycospora noctuina Butterworth and Williams, p. 376; plate 3, fig. 14,15.

1960 Lycospora uber (Hoffmeister, Staplin and Malloy) Staplin, p.20; plate 4, figs. 13,17, 18, 20.

Description of specimens. Spores radial, trilete; amb sub-triangular to sub-circular. Laesurae distinct, length equal to spore body radius, often passing onto the cingulum; accompanied by thin prominent lips. Spore body conformable to the amb, finely granulate to verrucate, the verrucae on the distal surface may be up to 2·5µ in diameter. Cingulum 2·5 - 5µ wide, laevigate, showing a darkening in colour towards the spore body; equatorial margin smooth. Spore body may show arcuate folding.

Dimensions. (50 specimens) Equatorial diameter 25 - 30µ (mean 32µ).

Remarks. The synonymy is fully discussed by Playford (1963a, p.636). A detailed appraisal of the whole genus, such as is suggested by Staplin, 1960 will be necessary to resolve the many cases of synonymy which exist in this genus. A complete gradation between all the previously described species was observed in these assemblages.

Previous records. The species is widely recorded from the Carboniferous of Russia (Luber and Waltz 1938, 1941; Ishchenko 1952, 1956, 1958); the Upper Mississippian of North America (Hoffmeister, Staplin and Malloy, 1955b; Hacquebard and Barss, 1957, Staplin, 1960); the Carboniferous of Spitsbergen (Playford, 1963a) and the Upper Carboniferous, Namurian A of Scotland, (Butterworth and Williams, 1958). Upper Mississippian of Canada (Playford and Barss, 1963).

Occurrence. Menai Straits Shales; Holywell Shales; Viséan to Namurian C.

GENUS DENSOSPORITES (Berry) Butterworth, Jansonius, Smith and Staplin 1964

Type Species *D. covensis* Berry 1937

Affinity. Lycopsida: *Selaginellites canonbiensis* Chaloner (spores, *Densosporites loricatus*), *Porostrobus zeilleri* (Nathorst, 1894) Nathorst (spores, *Densosporites lobatus*)

Densosporites striatus (Knox) Butterworth and Williams 1958

Plate 7, Fig. 5.

1950 *Cirratriradites striatus* Knox,
p.330; plate 19, fig. 289.

Description of specimens. Spores radial, trilete; amb sub-circular to sub-triangular. Laesurae indistinct. Cingulum differentiated into a thickened proximal region, with an irregular edge, and an outer, membranous region; dark area 4·5 - 7μ wide, lighter area 9 - 17μ wide. The outline of the central body may be more triangular than the equatorial amb. Specimens often corroded.

Dimensions (16 specimens) 49 - 58μ (mean 54μ).

Remarks. The specimens found here were not well preserved; in size and general morphology they were similar to *D. striatus*.

Occurrence. Holywell Shales; Namurian B.

Previous records. Lower Carboniferous of Scotland (Knox 1950); Namurian A of Scotland (Butterworth and Williams, 1958). Namurian A. Westphalian of Stainmore (Owens and Burgess, 1965).

Densosporites cuneiformis Hacquebard and Barss 1957

Plate 7, Fig. 9.

Description of specimens. Spores radial, trilete; amb sub-circular to sub-triangular. Laesurae indistinct, occasionally seen as a wide gape. Cingulum 8·5 - 15μ wide, laevigate bizonate, divided into a dense proximal region and a translucent equatorial region. The dense region is usually wider than the translucent one and has an irregular edge. The central body is finely granulose (oil immersion) and takes up just over one-half of the total diameter of the spore.

Dimensions. (25 specimens) Equatorial diameter, 34 - 44μ (mean 40μ) Diameter of central body 20 - 22μ.

Remarks. The spores described here are very like those of *D. cuneiformis* Hacquebard and Barss, 1957, but are of a smaller average size

(58 - 72μ) and the central body, in some cases, takes up less of the total spore diameter . In D. tenuis Hoffmeister, Staplin and Malloy 1955 the equatorial region is smaller in relation to the overall diameter of the spore, but is otherwise similar.

Occurrence. Holywell Shales; Namurian A - C.

Densosporites intermedius Butterworth and Williams 1958

Plate 7, Fig. 3.

1955 Densosporites tenuis Hoffmeister, Staplin and Malloy,
p. 387; plate 36, figs. 18, 23, non 19

1956 non Densosporites tenuis (Loose) Potonié and Kremp, 1956
p.

1958 Densosporites intermedius Butterworth and Williams,
p. 379; plate 3, figs. 38, 39.

1960 Densosporites cuneicinctus Staplin,
p. 26; (non pl. 5, fig. 15).

Description of specimens. Spores radial, trilete; amb sub-circular to rounded triangular. Laesurae not always distinct, straight to sinuous, length approximately equal to the spore radius. Cingulum from 6 - 12μ wide, bizonate; the proximal zone is thicker and thins gradually into the outer, lighter zone which has an irregular equatorial amb. The distal surface of the spore is finely punctuate to granulate (oil immersion).

Dimensions. (15 specimens) Equatorial diameter of spore 39 - 49μ (mean 42·5μ); equatorial diameter of the central body, 18 - 23μ (mean 21μ).

Comparison. The spore is distinguished from D. cuneiformis by the presence of a more gradual thinning towards the equator. D. pseudoannulatus (Butterworth and Williams, 1958) has a cingulum which is of a uniform thickness.

Remarks. The size range in these specimens is more restricted than that described originally by Butterworth and Williams (35 - 60μ). There seemed evidence of a continuous gradation in cingulum structure from the more regular, step-like structure found in D. cuneiformis to the gradual thinning of the present species. Further evidence on the true morphology of these two species could be usefully gained from the use of thin sections. Specimens of D. intermedius (Butterworth and Williams) are identical to specimens of D. tenuis (Hoffmeister, Staplin and Malloy). The name proposed by Hoffmeister et al. was already occupied; the correct procedure is now to adopt the name proposed by Butterworth and Williams.

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Hardinsburg formation of Illinois and Kentucky (Hoffmeister, Staplin and Malloy, 1955); Namurian A of Scotland (Butterworth and Williams, 1958) and the Golata formation of Canada (Staplin,1960).

Densosporites spinosus Dybova and Jachowicz 1957

Plate 7, Fig. 4.

Description of specimens. Spores radial, trilete; amb sub-circular to rounded triangular. Laesurae usually distinct, straight, length approximately equal to, or slightly greater than, the radius of the spore body, accompanied by raised lips, 0·5 - 1·5μ wide. Cingulum, bizonate, 9 - 17μ wide the proximal thicker zone grading into an equatorial, thinner zone. Distal surface of the spore ornamented with tapering spines, having slightly bulbous bases, length 3 - 7μ. Proximal surface laevigate to punctate. Equatorial amb deeply dissected to spinose.

Dimensions. (20 specimens) Equatorial diameter of spore 39 - 56μ (mean 46μ). Equatorial diameter of central body 17 - 31μ (mean 24μ).

Comparison. The ornament of D. spinifer Hoffmeister, Staplin and Malloy, 1955 is confined to the proximal and distal surfaces of the cingulum. D. rarispinosus. Playford 1963 has a non-tapering cingulum.

Occurrence. Holywell Shales; Namurian A - C.

Previous Records. Namurian of Silesia (Dybova and Jachowicz, 1957).

GENUS ANULATISPORITES (Loose) Potonié and Kremp 1954

Type species. Anulatisporites anulatus (Loose) Potonié and Kremp 1954
Plate 7, Fig. 2.

1932 Sporonites anulatus Loose in Potonié, Ibrahim and Loose,
p. 451; plate 18, fig. 44.

1934 Zonales-sporites annulatus Loose,
p. 151.

1934 Annulatisporites annulatus (Loose) Footnote p.151

1944 Densosporites anulatus (Loose) Schopf, Wilson and Bentall,
p. 40.

1954 Anulatisporites anulatus (Loose) Potonié and Kremp,
p. 159; plate 20, fig. 7.

1964 Densosporites anulatus (Loose) Schopf, Wilson and Bentall,
in Staplin and Jansonius,
p. 102; plate 18, fig. 3, 5, 29.

Description of specimens. Spores radial, trilete; amb sub-circular to rounded triangular. Laesurae occasionally distinct, straight, length equal to the radius of the central body, accompanied by thin lips. Cingulum 7 - 11µ in width, of equal thickness, often shows an abrupt equatorial thinning. The limit of the central body is sometimes marked by a row of minute, internal vacuoles. Distal and proximal surfaces of the spore body and cingulum laevigate, spore body wall thin and infra-punctate.

Dimensions (20 specimens) Equatorial diameter of spore 32 - 41µ (mean 36µ) equatorial diameter of central body 15 - 21µ (mean 18µ).

Comparison. Several spores with a radial fracture of the cingulum were found. Butterworth and Williams (1958) stated that Densosporites pseudoannulatus had a "characteristic radial fracture" and had a smooth to spinose cingulum. Those spores with a smooth cingulum and riadial fracture could not be distinguished from A. anulatus. It is likely that the presence of radial fractures is caused by preservation and is not an original morphological feature.

Occurrence. Holywell Shales: Namurian A - C.

Previous records. Upper Carboniferous of Germany (Loose, 1932). Upper Mississippian of Canada (Hacquebard and Barss, 1957). Upper Silesia coals, Namurian A - Westphalian C. (Dybova and Jackowicz) Lower Carboniferous of Spitzbergen (Playford, 1962). Upper Mississippian of Canada (Playford and Barss, 1963).

Explanation of Text-figure 6.

All figures × 500.

Figs. A, B. Vallatisporites microgalearis sp. nov. Holotype; A, proximal surface; B, distal surface; preparation L.C.10c, 24·5 101·9.

Figs. C, D. Knoxisporites concentricus sp. nov. Holotype; C, proximal surface; D, distal surface; preparation U.C. 6c 45·4 97·3.

Fig. E. Dictyotriletes radiatus sp. nov. Holotype, preparation L.C. 5c, 16·2 106·8.

Figs. F,G. Proprisporites glaber sp. nov. Holotype; F, proximal surface; G, distal surface; preparation U.C. 3c, 30·3 101·5.

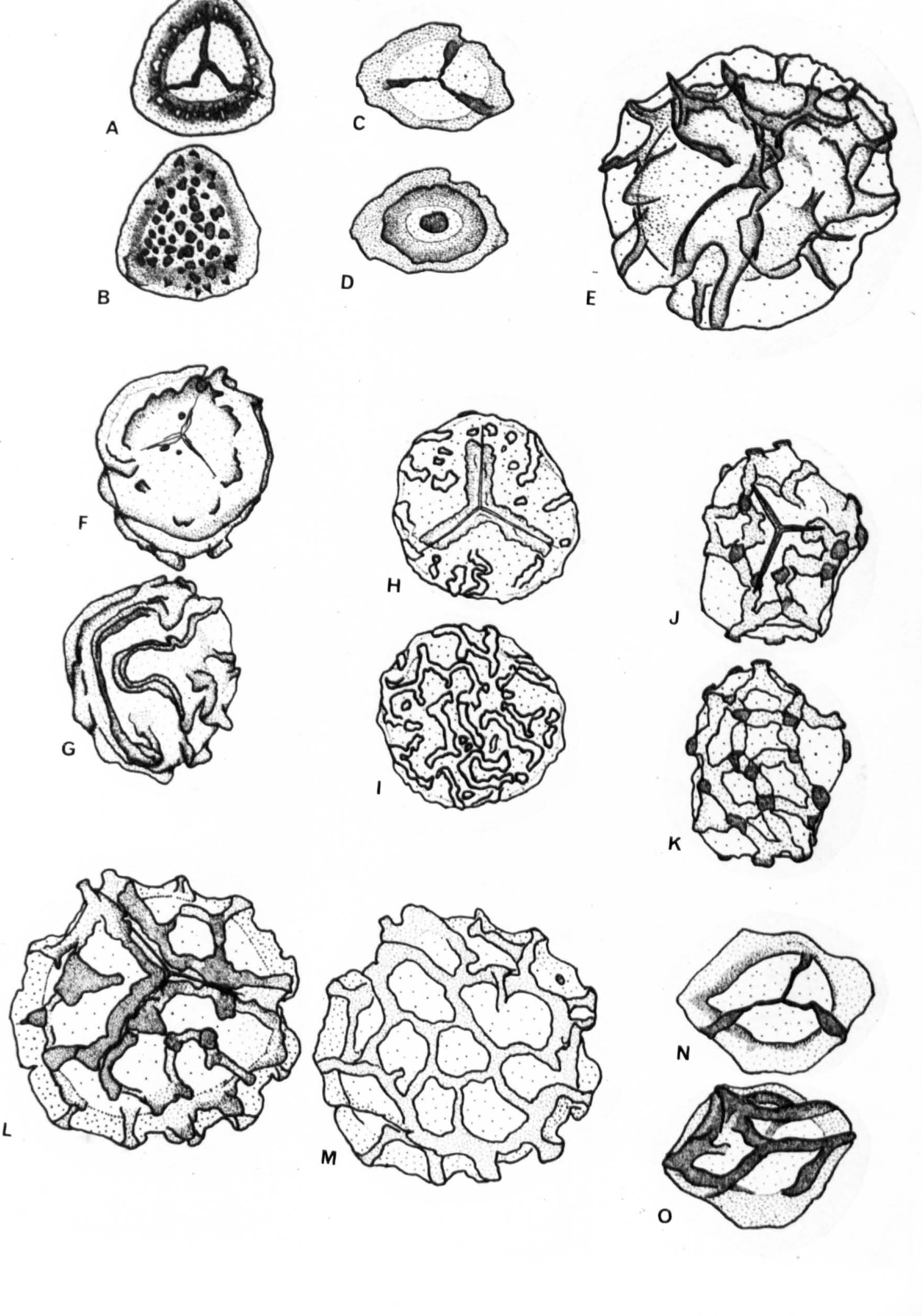
Figs. H, I. Convolutispora labiata Playford 1962. H, proximal surface; I, distal surface; preparation L.C. 2b 41·8 96·4.

Figs. J,K. Dictyotriletes piliformis, sp. nov. Holotype, J. proximal surface; K, distal surface; preparation U.C. 8a, 32·2 108·7.

Figs. L, M. Dictyotriletes tesselatus sp. nov. Holotype; L, proximal surface; M, distal surface; preparation L.C.3a, 55·7 93·2.

Figs. N, O. Knoxisporites convolutus sp. nov. Holotype; N, proximal surface; O, distal surface; preparation L.C. 5c, 24·2 100·8.

Text-figure 6



GENUS CRISTATISPORITES (Potonié and Kremp)

Butterworth, Jansonius, Smith and

Staplin, 1964

Type species. C. indignabundus (Loose) Potonié and Kremp 1954

Affinity. Lycopsida

Remarks. The emended genus is distinguished by the prominent distal ornament which is mammoid, or consists of verrucae with setose tips; no differentiation between the cingulum and the spore body.

Cristatisporites indignabundus (Loose) Potonié and Kremp 1955

Plate 7, Fig. 8.

1932 Sporonites indignabundus Loose in Potonié, Ibrahim and Loose, p. 451; plate 19, fig. 51.

1934 Apiculati-sporites indignabundus. Loose, p. 153.

Description of specimens. Spores radial, tilete; amb circular to sub-circular. Laesurae occasionally indistinct, slightly sinuous, length equal to radius of the spore body, accompanied by elevated lips, 2·5 -3µ wide, which may run onto the cingulum. Exine of the proximal surface laevigate to punctate, the distal surface ornamented with mammoid projections, arranged in more or less concentric circles; this is carried onto the cingulum where it appears as an equatorial feature giving the spore an irregular outline. The mammoid projections are 4 - 6µ high and 3·5 - 5µ in basal diameter.

Dimensions. (10 specimens) 51 - 70µ (mean 62µ)

Remarks. This species is distinguished from C. connexus Potonié and Kremp, by having a more densely set ornament. Certain of the specimens examined here had a more sparsely set ornament, yet retained the characteristics of the others. It would seem that there exists a range of variation, which is continuous, between the two species; owing to the small number found in the North Wales' material no definite conclusion is possible.

Occurrence. Holywell Shales; Namurian C.

Previous records. Westphalian of Germany (Loose, 1932; Potonié and Kremp, 1955).Namurian C of Stainmore (Owens and Burgess, 1965).

GENUS MUROSPORA Somers 1952

1952 Murospora Somers, p.20.

1954 Simozonotriletes (Naumova, 1939) ex. Potonié and Kremp,

1958 Simozonotriletes Potonié and Kremp, Sullivan pp. 126 - 127.

1958 Westphalensisporites Alpern, p. 78.

Type species M. kosankei Somers 1952

Affinity. Unknown

Remarks. The above synonymy has already received much consideration, Hacquebard and Barss (1957, p.34) thought that Murospora was cogeneric with Simozonotriletes; Staplin (1960, p.28 - 29) includes Westphalensisporites as a synonymous form. All these genera had included cingulate, more or less triangular, miospores.

Murospora intorta (Waltz) Playford 1962
Plate 6, Fig. 10

1938 Zonotriletes intortus Waltz, in Luber and Waltz, p.22; plate 2, fig. 24.

1954 Simozonotriletes intortus (Waltz) Potonié and Kremp, p.159

1956 Simozonotriletes intortus (Waltz) Ishchenko. pp. 88 - 89, plate 17, fig. 204.

Description of specimens. Spores radial, tilete; amb sub-triangular with straight to concave sides and with rounded apices. Laesurae distinct, simple, straight, length from two-thirds to equal the spore body radius. Spore body laevigate to infrapunctate (oil immersion). Cingulum laevigate, 6 - 12μ wide, may be wider and thicker at the apices, overlaps the central body on the proximal sie (3 - 5μ).

Dimensions. (20 specimens) Overall equatorial diameter 50 - 66μ (mean 57μ) diameter of spore body 32 - 39μ (mean 36μ).

Remarks. In a few of the specimens found the laesurae were accompanied by a distinct row of punctations, this apart, the spores agreed with the description by Playford (1962).

Occurrence. Menai Straits Shales; Viséan.

Previous records. Widely recorded from the Carboniferous in the Northern Hemisphere, Russia, Spitsbergen, England. Upper Mississippian of Canada (Playford and Barss, 1963).

Murospora aurita (Waltz) Playford 1962

Plate 6, Fig. 13.

1938 Zonotriletes auritus (Waltz) in Luber and Waltz,
p. 17; plate 2, fig. 23.

1956 Simonzonotriletes auritus (Waltz) Potonié and Kremp, p. 109

1957 Cincturasporites auritus (Waltz) Hacquebard and Barss,
p. 23, plate 3, fig. 1.

1957 Cincturasporites irregularis Hacquebard and Barss,
pp. 25 - 26, plate 3, fig. 19.

1960 Murospora varia Staplin, p. 30; plate 6, figs. 16, 18.

1960 Murospora sp. cf. M. varia Staplin.
p. 30: plate 6, fig. 19.

Description of specimens. Spores radial, trilete; amb basically sub-triangular, margin smooth to undulating. Laesurae distinct, straight, reaching to the equator of the spore central body, accompanied by lips, 2.5 - 6μ broad and slightly elevated. Spore body has a more regular triangular shape with straight to convex sides and more or less rounded apices; exine laevigate. Cingulum from 5 - 13μ wide, laevigate, showing marked variation in equatorial amb and thickness; thickenings commonly situated at the radial apices.

Dimensions (21 specimens). Overall equatorial diameter 49 - 73μ (mean 58μ), diameter of the central body 31 - 47μ (mean 35μ).

Remarks. Playford (1962) states that the overlap of the cingulum, characteristic of Cincturasporites does not appear to be a constant feature of M. aurita. In the samples from the Menai Straits there was an overlap apparent on more than half of the specimens examined.

Occurrence. Menai Straits Shales; Viséan.

Previous records. Widely recorded from Carboniferous sediments of Russia, (Luber and Waltz, 1938, 1941), the Upper Mississipian of Canada (Hacquebard and Barss, 1957; Playford and Barss, 1963) and the Lower Carboniferous of Spitsbergen (Hughes and Playford, 1961).

GENUS LOPHOZONOTRILETES (Naumova) Potonié 1958

Type species. L. lebedianensis Naumova 1953

Affinity. Unknown

Remarks. The emendation by Potonié of the genus included spores which were cingulate and had a prominent verrucate ornament. In defining Lophozonotriletes appendices (Hacquebard and Barss) Playford, 1963a, found an overlap of the cingulum onto the central body in rather less than one-half of the specimens examined. He discounted the presence of such an overlap in the genus Cincturasporites (Hacquebard and Barss 1958) and included the specimens in the genus Lophozonotriletes.

Lophozonotriletes muricatus sp. nov.

Plate 7, figs 6, 7; text-figs 7 A,B.

Diagnosis. Spores radial, trilete; amb convexly sub-triangular with rounded apices, occasionally irregular in outline. Laesurae distinct, straight, length two-thirds spore radius, occasionally accompanied by flat lips, 2·5 - 4µ wide or a line of punctations on each side of the mark. Cingulum darker in colour than the central body, shows evidence of thinning towards the equator, may show a poleward overlap in some cases, occasionally irregular in equatorial outline. Distal surface of the spore sculptured by a variable ornament of elongated and sinuous verrucae, from 5 - 24μ in longest diameter and up to 6μ wide. The ornament is found on the distal surface of both the cingulum and the central body.

Dimensions. (25 specimens) Overall diameter 50 - 66μ (mean 58μ), diameter of central body 33 - 41μ (mean 37μ).

Holotype. Preparation L.C.6b 46·7 101·4.

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 61μ; amb convexly sub-triangular. Laesurae straight, length equal to the length of the spore body, accompanied by a row of small vacuoles. Cingulum 11μ wide, overlaps the central body (4μ) equatorial amb regular and smooth. Distal ornament of discrete verrucae along with elongated verrucae, 10 - 26μ in longest axis and up to 8μ wide.

Remarks. L. appendices (Hacquebard and Barss) Playford 1963a, has an irregular distal ornament, but this species is larger and the ornament is not said to be elongated.

Occurrence. Menai Straits Shales; Viséan.

GENUS SAVITRISPORITES Bhardwaj 1955

Type species. S. triangularis.

Affinities. Unknown.

Savitrisporites nux (Butterworth and Williams) Sullivan 1964b

Plate 7, Figs. 11, 12.

1958 *Callisporites nux* Butterworth and Williams, p.377 plate 3, figs. 24, 25.

Description of specimens. Spores radial, trilete; amb sub-triangular with concave sides and rounded apices. Laesurae distinct, straight, extend to the spore body margin with low lips, 2·5 - 5μ wide on each side of the laesurae. The lips occasionally become expanded into lobes towards the equator. The distal surface of the spore body and the cingulum is ornamented with linear ridges which are formed from the basal fusion of verrucae; the verrucae form "high peaks" on the ridges (Bhardwaj, 1955, p.127). Outline of the ridges straight to sinuous. Cingulum of uniform thickness, up to one-quarter the total spore radius in width.

Dimensions. (27 specimens) Overall diameter 35 - 62μ (mean 48μ) diameter of the central body 28 - 57μ (mean 40μ).

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Namurian of Scotland (Butterworth and Williams, 1958) Westphalian A of the Forest of Dean Basin, Gloucestershire (Sullivan, 1964b).

GENUS VALLATISPORITES (Hacquebard) Staplin and Jansonius 1964

Type species. *V. vallatus* Hacquebard 1957

Affinity. Unknown.

Remarks. The groove, or rampart, said to be characteristic of this genus by Hacquebard was shown to exist in species within the Cingulizonates and Densosporites by Staplin and Jasonius (1964). The genus was defined having lip development of the laesurae, which commonly reaches the amb, distinct distal sculpture over the spore body and the cingulum, commonly shows the presence of radial vacuolations and does not have a strongly bi-zonate appearance.

Vallatisporites ciliaris (Luber) Sullivan 1964b

Plate 8, figs, 1,2.

1938 Zonotriletes ciliaris Luber, in Luber and Waltz, plate 6, fig. 82.

Description of specimens. Spores radial, trilete; amb sub-triangular with convex sides and rounded apices. Laesurae usually indistinct, raised lips (2- 4μ high) run to the equatorial amb of the spore. Spore body is two-layered, the intexine is thin and unornamented; the exo-exine is laevigate to infrapunctate over the proximal surface, yet is thicker and bears distinctive sculptural elements on the distal surface. The ornamentation is composed of galeae (Sullivan, 1964b); these have sharply pointed apices and are up to 4μ wide at the base and 2 - 4·5μ high. Broad based cones which may have sharp or blunt apices, up to 4·5μ in basal diameter and 5μ high are interspersed among the galeae. The cingulum is internally vacuolate, the vacuolae open out onto the distal surface and are radially arranged. The outer part of the cingulum is solid and has a more or less smooth amb.

Dimensions. (39 specimens) Overall diameter 53 - 72μ (mean 63μ).

diameter of the spore body 31 - 36μ (mean 34μ).

Remarks. Sullivan implied that the vacuoles on the distal surface of the cingulum were due to deposition of pyrite. It would seen that the variable extent to which they are present in otherwise similar specimens would support this theory. Within this variability it must be borne in mind that the form and extent of "pyritic deformity" is remarkably constant throughout the span of Geological time in which the species is found.

Occurrence. Menai Straits Shales; Viséan.

Previous records. Lower Carboniferous of Russia (Luber, 1938) Lower Carboniferous of the Forest of Dean, Gloucestershire (Sullivan, 1964b).

Vallatisporites cf. *ciliaris* (Luber) Sullivan 1964b

Remarks. Sullivan described this spore from the Viséan of the Forest of Dean area. It was said to be identical to *V. ciliaris* in shape and size, but lacking the distinctive distal ornament of cones and galeae. A limited number of spores conforming to this description were found in the Menai Straits deposits. The size ranged from 54 - 69μ (mean 63μ).

Vallatisporites spinosus sp. nov.

Plate 8, figs. 5, 6.

Diagnosis. Spores radial, trilete; amb sub-triangular with convex sides and rounded apices. Laesurae indistinct, with raised lips which are sinuous and extend to the margin of the spore. Distal exo-exine thickened and ornamented with spines, 2·5 - 3·5μ long and galeae up to 4μ in basal diameter and from 2·5 - 5μ high, the exine is infra-punctate between the ornament (oil immersion). In most cases the galeae constitute the typical form of ornament. The ornament is only rarely seen on the distal surface of the cingulum. The cingulum is internally vacuolate, the cavities opening out onto the distal surface; occasionally a ring of small vacuoles de-limits the intexine. Beyond the vacuoles the cingulum tapers gradually towards the equator, and is only occasionally bi-zonate.

Dimensions. (43 specimens) Overall equatorial diameter 45 - 64μ (mean 57μ) Diameter of the central body 27 - 36μ (mean 31μ).

Holotype. L.C.2e 28·9; 95·5.

Locus typicus. Lower Carboniferous, Menai Straits, Viséan.

Description. Holotype 52μ, amb sub-triangular with convex sides. Laesurae indistinct, lips elevated and sinuous, equal to the spore radius. Distal surface faintly infrapunctate, sculptured with dispersed galeae, 2 - 4.5μ in basal diameter and up to 3μ high. The ring of internal vacuolation is seen and defines the extent of the intexine. The distal surface of the cingulum has radially arranged vacuoles, 3·5 -4μ in longest diameter.

Comparison. This spore lies somewhere between V. galearis and V. communis Sullivan 1964b. The latter has a strong infrapunctation of the distal exoexine and has spines and galeae on the equatorial margin. The former has a much larger grade of ornament, which is also often seen on the equatorial amb.

Remarks. There is a great deal of intra-specific variability within the species of Vallatisporites. Further detailed research is necessary to clarify the position.

Occurrence. Menai Straits Shales; Viséan.

Vallatisporites microgalearis sp. nov.

Plate 8, figs. 3, 4; text-figs. 6 A, B.

Diagnosis. Spores radial, trilete; amb sub-triangular with convex sides. Laesurae indistinct, obscured by sinuous, elevated lips, which are equal to the spore radius in length. The distal surface of the spore is ornamented with verrucae and galeae, the bases of which are often fused; between the ornament the exine is punctate (this often appears to pass through the sculptural elements and therefore may be secondary). The cingulum is internally vacuolate, the distal surface of the cingulum often has large radially arranged vacuoles; there is a ring of smaller vacuoles de-limiting the intexine. There appears to be a slight poleward overlap of the cingulum onto the central area.

Dimensions. (24 specimens) Overall equatorial diameter 39 - 54μ (mean 47μ) diameter of central body 26 - 32μ (mean 29μ).

Holotype. Preparation L.C.10c 24·5 101·9

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 42μ, amb sub-triangular with convex sides and rounded apices. Laesurae indistinct with raised sinuous lips equal to the spore radius in length. Distal surface covered with galeae and rounded verrucae 1·5 - 4·5μ in basal diameter. The distal surface of the cingulum has radially arranged vacuoles, a ring of smaller internal vacuoles de-limits the central body.

Remarks. This spore is smaller than the others previously described; the distinctive body ornament is found on the distal surface of the cingulum and the cantral body. The indication of a poleward overlap is not a common feature of the genus.

Occurrence. Menai Straits Shales; Viséan.

GENUS DIVERSIZONOTRILETES gen. nov.

Type species. *D. intestinalis* sp. nov.

Affinity. Unknown.

Diagnosis. Miospores radial, trilete, amb sub-circular to rounded triangular. Laesurae distinct, straight, often gaping; length two-thirds of, to equal the radius of, the central body. Spores zonate, having concentric bands of thickening, an outer thick band, a further thickened zone adjacent to the central body and a thinner zone between the two. The zona is irregular in shape and has thickened lobes on its periphery. The distal surface of the central body is sculptured with vermiform ridges, a similar ornament reduced in size is also present on the proximal surface where, in specimens with a gaping laesurae, it may be difficult to clearly distinguish. Exine of the central body is infra-punctate.

Remarks. The genus is similar to Reticulatisporites (Ibrahim) Neves 1964 in having a concentrically thickened zone. It differs in the characteristically vermiform convolute nature of the ornament. Knoxisporites Potonié and Kremp) Neves 1961 whilst including spores with ornament similar to that described here, has a more or less uniform thickening of the zona.

Diversizonotriletes intestinalis sp. nov.

Plate 9, figs. 1, 2; text-figs. 7 F, G.

Diagnosis. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct, straight to slightly sinuous, length two-thirds to equal of the central body radius; the laesurae are often gaping and are occasionally accompanied by thin, raised lips. Zona from 10 - 19µ in width, with a poleward extension on the proximal side; the equatorial amb of the zona is irregular in shape and has several thickened lobes on its periphery. It is concentrically thickened, having a peripheral band of thickening, a further band of thickening adjacent to the central body with a thinner zone between the two. The distal surface of the central body is characterised by a system of vermiform ridges, 5 - 30µ in length and 4 - 9µ wide; these may be closely or loosely packed. The proximal surface of the central body has a similar ornament, which is reduced in size and absent from the contact faces. In specimens where the laesurae are gaping the proximal ornament is difficult to distinguish. Frequently the distal ornament is laterally displaced during preservation. Exine of the central body infra-punctate.

Dimensions. (35 specimens) Equatorial diameter 92 - 143μ (mean 107μ)

Holotype. Preparation L.C.3a. 36·0 98·9

Locus Typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 100μ; amb circular. Laesurae gaping, length equal to the radius of the central body. Cingulum 12μ wide, polar extension from 3 - 4μ. Distal surface of the central body sculptured with rather loosely arranged, vermiform muri, 4 - 7μ wide; proximal surface with a similar ornament 2·5 - 4μ wide. Equatorial amb of the cingulum is irregular with slightly thickened lobes. The differentially thickened cingulum is not too distinct in this specimen.

Remarks. In his emendation of Reticulatisporites, Neves (1964) states that the ornament of the exine is confined to the distal surface. Lophozonotriletes (Cincturasporites) appendices (Hacquebard and Barss) Playford (1962) when originally described was said to have a proximal ornament similar to that of the distal surface, but of a smaller grade, Playford did not find this, nor did the spore exhibit a differentially thickened cingulum.

Occurrence. Menai Straits Shales; Viséan.

Explanation of Text-figure 7.

All figures X 500

Figs. A, B. Lophozonotriletes muricatus sp. nov. Holotype; A, proximal surface; B, distal surface; preparation L.C.6b, 46·7 101·4.

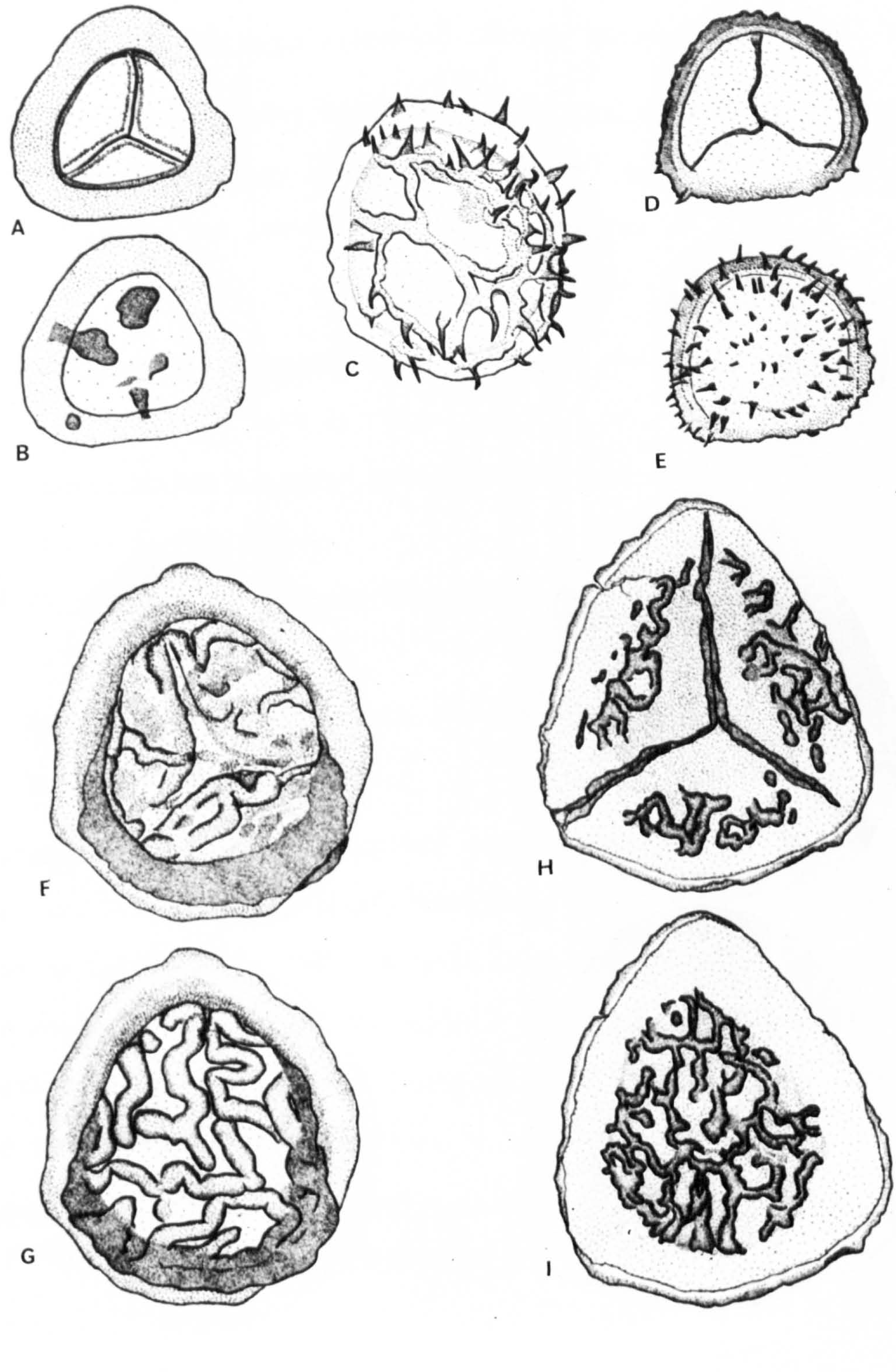
Fig. C. Spinozonotriletes reticulatus sp. nov. Holotype; distal surface; preparation L.C. 2e, 45·5 107·6.

Figs. D,E. Spinozonotriletes marginatus sp. nov. Holotype; D, proximal surface; E, distal surface; preparation L.C. 2e, 55·6 110·9.

Figs. F.G. Diversizonotriletes intestinalis gen. et sp. nov. Holotype, F, proximal surface, G, distal surface; preparation L.C. 3a, 36·0 98·9.

Figs. H, I. Discernisporites vermiformis sp. nov. Holotype; H, proximal surface; I, distal surface; preparation A.M. 22d, 56·2 106·2.

Text-figure 7



Infraturma ZONATI Potonié and Kremp 1954

GENUS CIRRATRIRADITES Wilson and Coe 1940

Type species C. saturni (Ibrahim) Schopf, Wilson and Bentall, 1944

Affinity. Pteridophyta, Lycopsida, Selaginellites suissei Zeiller has spores of the C. annulata (Kosanke and Brokaw) type; Selaginellites crassicinctus Hoskins and Abbott also contains spores of this type.

Cirratriradites elegans (Waltz) Potonié and Kremp 1956

Plate 7; Figs. 14, 15.

1938 Zonotriletes elegans Waltz in Luber and Waltz, p. 15; plate 3, fig. 32.

1956 Cirratriradites elegans (Waltz) Potonié and Kremp, p. 126.

1958 Hymenozonotriletes elegans (Waltz) Ishchenko, p. 67; plate 7, fig. 88.

Description of specimens. Spores radial, trilete; amb convex to sub-triangular. Laesurae distinct, straight, reaching onto the zona, accompanied by raised lips, 2·5 - 3µ wide on either side, the lips frequently reach the equator of the zona. The zona is often wider at the triangular apices; it shows a thinning towards the equator. The spore body and zona are finely punctate to scabrate.

Dimensions. (10 specimens) Overall equatorial diameter 63 - 76µ (mean 67µ) diameter of the spore body 36 - 47µ (mean 42µ).

Remarks. The specimens from North Wales are somewhat smaller than those previously described, but are otherwise similar.

Occurrence. Menai Straits Shales; Viséan.

Previous records. The Carboniferous of Russia (Luber and Waltz, 1938, Ishchenko, 1958); the Carboniferous of Spitzbergen (Playford, 1963a).

Cirratriradites ornatus Neves 1961

Plate 7, fig. 13

Description of specimens. Spores radial, trilete; amb circular. Laesurae distinct, length three-quarters of the spores radius, reaching onto the zona, accompanied by thin, raised lips. Proximal surface punctate; distal surface ornamented with small spines and cones, which are 0·5µ high, the exine is punctate between the ornament. Zona thin, extending 5 - 10µ beyond the spore body and having a dark band where it passes over the spore body.

Dimensions. (6 specimens) Equatorial diameter 69 - 85µ (mean 74µ) diameter of the spore body 64 - 79µ (mean 68µ).

Remarks. The spores described here are of a smaller size than those described by Neves; otherwise they are identical.

Occurrence. Holywell Shales; Namurian C.

Previous records. Namurian C. of the southern Pennines (Neves, 1961) Naumurian B. of Stainmore (Owens and Burgess 1965)

GENUS REINSCHOSPORA Schopf, Wilson and Bentall 1944

Type species. R. speciosa (Loose) Schopf, Wilson and Bentall 1944

Affinity. Unknown.

Reinschospora speciosa (Loose) Schopf, Wilson and Bentall 1944

Plate 8, Fig. 7

Description of specimens. Spores radial, trilete; amb triangular, the fimbrae give the spore an overall rounded triangular outline. The spore body has concave sides. Laesurae distinct, straight, reaching to the equator of the central body, occasionally show slight lip development. Fimbrae well developed in the inter-radial zones, 12 - 19µ long, becoming shorter towards the radial apices. The fimbrae appear to be fused together and are seldom seen as distinct units. Spore body laevigate to infrapunctate (oil immersion).

Dimensions. (12 specimens) Equatorial diameter, including fibrae, 56 - 69µ (mean 63µ).

Remarks. The spore is smaller than that described by Potonié and Kremp (1956).

Occurrence. Upper Carboniferous, Holywell Shales, Namurian B - C.

Previous records. Westphalian of Germany (Hörst, 1943 in Potonié and Kremp, 1956); Namurian B - C of Stainmore (Owens and Burgess, 1965).

Reinschospora cf. triangularis Kosanke 1950

Plate 8, Fig. 8

Description of specimens. Spores radial, trilete, amb triangular with convex sides; the central body has straight sides and rounded apices. Laesurae distinct, straight, length equal to the radiusof the central body; raised lips, from 2 to 2·5μ wide run along each side of the laesurae. Fimbrae 12 - 14μ long in the inter-radial zone, becoming shorter towards the radial apices. They are distinct, 1 - 1·5μ wide at their base, and have frayed tips, no fimbrae at the radial apices. Spore coat laevigate.

Dimensions. (4 specimens) Equatorial diameter, including fimbrae, 62 - 67μ.

Remarks. A precise designation of this type was not possible since only four specimens were found; they appear to be close to R. triangularis

Occurrence. Holywell Shales; Namurian B - C.

Infraturma MEMBRANATI Neves 1961

GENUS PROPRISPORITES Neves 1958

Proprisporites glaber sp. nov.

Plate 8, figs. 9, 11, 12; text-figs. 6 F, G.

Diagnosis. Spores radial, trilete; amb circular to sub-circular. Laesurae usually distinct, straight, length one-half to two-thirds spore radius, with simple lip development. The perisporal membrane is laevigate and folded, folds long and irregular, predominantly on the distal surface, running on to the periphery of the proximal surface. The folds appear as projections, 3·5 - 5μ on the equatorial margin. A number of shorter, verrucate-like projections occur on the distal surface. Exine 1·5μ thick, laevigate.

Dimensions. (20 specimens) 54 - 82μ (mean 68μ).

Holotype. Preparation U.C. 3c 30·3 101·5.

Locus typicus. Holywell Shales, Upper Carboniferous, Namurian C.

Description. Holotype 62μ. Laesurae straight, one-half radius, with well defined lips. The distal perisporal folds project 3·5μ from the amb.

Comparison. P. rugosus. Neves (1958) has higher perisporal projections and is distinguished from P. glaber by possessing strong punctation of the central body.

Occurrence. Holywell Shales; Namurian A - C.

Anteturma POLLENITES R. Potonié 1931

Turma SACCITES Erdtman 1947

Subturma MONOSACCITES (Chitaley) Potonié and Kremp 1954

Infraturma TRILETESACCITI Leschik 1955

Subinfraturma INTRORNATI Butterworth and Williams 1958

Genus REMYSPORITES Butterworth and Williams 1958

Type species R. magnificus (Horst) Butterworth and Williams 1958

Affinity. Spores of this type have been found in the Cycado-filicalean fructification Paracalathiops stachei (Stur) Remy.

Remysporites magnificus (Horst) Butterworth and Williams.

Plate 9, Fig. 3.

1955 Endosporites magnificus Horst, 1943, p. 194, plate 21, fig. 37.

Description of specimens. Spores radial, trilete; amb sub-circular to oval. Laesurae distinct, straight, length two-thirds of, to equal to, the radius of the spore body; accompanied by folds, which may be sinuous and extend beyond the spore body in length. Spore body is distinct, generally darker in colour than the bladder wall, 1·5 - 2·5μ thick, infra-punctate (oil immersion). The bladder is finely microreticulate internally, both the bladder and the spore body are commonly folded.

Dimensions. (24 specimens) Overall equatorial diameter 145 - 240μ (mean 184μ), diameter of the central body 103 - 179μ (mean 138μ).

Remarks. The genus Velosporites was set up by Hughes and Playford (1961) to incorporate specimens having a comprehensive bladder ornament; in other respects spores of this genus are like those of Remysporites. Originally it was stated that the bladder in Remysporites enveloped the central body except on the proximal side; subsequently re-examination of the type material by Playford (1963a) established that the bladder in R. magnificus does envelop the central body entirely. The genus Velosporites was retained because of the "characteristic sculpture and relatively thick spore wall".

Previous records. Namurian A of Scotland (Butterworth and Williams (1958); Namurian A of Stainmore (Owens and Burgess, 1965).

Occurrence. Menai Straits Shales; Holywell Shales; Viséan - Namurian A.

GENUS ENDOSPORITES Wilson and Coe 1940

Type species. *E. ornatus* Wilson and Coe 1940

Affinities. Lycopsida; spores of *E. globiformis* have been recovered from *Polysporia mirabilis* Newberry.

Remarks. Richardson (1960; p.49) transferred *E. micromanifestus* to the genus *Auroraspora* because the species lacked a limbus. Whilst several species within the genus *Endosporites* have been shown to exhibit a limbus, Playford pointed out (1963a; p. 651) that several species still retained within the genus do not have a limbus. It would seem necessary to re-examine the type material to establish the validity of a limbus as a morphological character diagnostic of *Endosporites.*

Endosporites micromanifestus Hacquebard 1957

Plate 8, Fig. 10.

1956 *Hymenozonotriles* cf. *variabilis* Maumova; Ishchenko, p. 62; plate 11, figs. 129, 130.

1957 *Endosporites micromanifestus* Hacquebard, p. 317; plate 3. fig. 16.

1960 _Auroraspora micromanifestus_ (Hacquebard) Richardson, p.51

Description of specimens. Spores radial, trilete; amb sub-triangular with concave sides and rounded apices. Laesurae usually indistinct, straight, length equal to, or slightly longer than, the radius of the spore body; accompanied by elevated lips, which are often sinuous and extend up to the equator. Central body thin, laevigate, outline more or less conformable with the spore outline, may be more circular. Bladder thin, occasionally folded, infragranular to infrapunctate (oil immersion).

Dimensions. (25 specimens) Overall equatorial diameter 54 - 96µ (mean 70µ) Diameter of central body 32 - 60µ (mean 47µ).

Remarks. A well defined limbus was not found in the specimens.

Occurrence. Menai Straits Shales, Holywell Shales; Viséan to Namurian C.

Previous records. Mississippian of Nova Scotia (Hacquebard, 1957); Lower Carboniferous of Spitsbergen (Hughes and Playford, 1961; Playford 1963a); Tournaisian, Viséan -- Namurian of Russia (Ishchenko, 1956) and the Viséan of Scotland (Love, 1960). Horton Group of Eastern Canada (Playford, 1963b).

GENUS SCHULZOSPORA Kosanke

Type species. _S. rara_ Kosanke 1950

Affinity. Spores of this type have been found in the Pteridospermopsid fructification, _Simplotheca silesiaca_ R. and W. Remy.

<u>Schulzospora rara</u> Kosanke 1950

Plate 10, Fig. 7.

<u>Description of specimens</u>. Spores bilateral, trilete; amb elliptical central body more or less circular. Laesurae generally indistinct, length one-third of the spore radius. The bladder and the central body are finely punctate.

<u>Dimensions</u>. (14 specimens) 69 - 87μ (mean 76μ).

<u>Remarks</u>. The overall size range is smaller than that originally described by Kosanke (1950). The spore was only found in the coal sample from Rhydymwyn.

<u>Occurrence</u>. Rhydymwyn coal; Namurian C.

<u>Previous records</u>. Westphalian A of Illinois (Kosanke, 1950), Namurian C of North Staffordshire (Neves, 1958).

<u>Schulzospora ocellata</u> (Horst) Potonié and Kremp, 1956

Plate 10, Fig. 6

<u>Descripian of specimens</u>. Spores bilateral, trilete: amb elliptical, sporebody elliptical. Laesurae generally indistinct, straight, length one-third of the spore radius. Spore body and bladder finely punctate.

<u>Dimensions</u>. (15 specimens) Equatorial diameter 59 - 76μ (mean 69μ)

<u>Remarks</u>. This species is close to <u>S</u>. <u>rara</u>, being only separated on the elliptical nature of the spore body and its characteristic oblique "tilt". The two species are also somewhat widely separated in geological time and the distiction is maintained.

Occurrence. Holywell Shales; Namurian A.

Previous records. Namurian of Germany (Horst, 1950); Lower Carboniferous of Scotland (Butterworth and Williams, 1958) and the Lower Carboniferous of the Forest of Dean basin (Sullivan, 1964b); Namurian A of Stainmore (Owens and Burgess, 1965).

Infraturma ALETESACCITI Leschik

GENUS FLORINITES Schopf, Wilson and Bentall 1944

Type species. *F. antiquus* Schopf, Wilson and Bentall 1944

Affinities. Pteridospermopsida; *Dictyothalamus schrollianus* Göppert, *Thuringia callipteroides* Remy, Coniferopsida; *Cordaianthus gemmifer* Grand 'Eury, *Cordaianthus saportianus* Renault, *Cordaianthus shuleri* Darrah.

Remarks. A large number of spores of the genus *Florinites* were recovered from the Namurian deposits of North Wales. They formed a continuous range of variation covering the two previously described species *F. elegans* Wilson and Kosanke 1944 and *F. similis* Kosanke 1950. Kosanke (1950) distinguished *F. similis* by its smaller size, but stated that the spore was "similar in shape and construction to *F. elegans*".

Florinites elegans Wilson and Kosanke 1944

Plate 9, Figs 4 - 6

1950 *Florinites similis* Kosanke, p.49; plate 12, fig. 2.

Description of specimens. Spores bilateral, apparently alete; amb.elliptical, spore body elliptical to circular. The spore body is often folded and granulose; bladder occasionally folded and internally reticulate from 0·5 - 2µ thick.

Dimensions. (100 specimens) Equatorial diameter 94 - 207µ (mean 146µ).

Remarks. The bladder is often torn exposing the central body (plate 9, fig. 5); the latter is often seen isolated in the samples as an oval to round, faintly granulose, alete body. The size range here completely covers that for the two species *F. elegans* and *F. similis*, which were previously separated on the basis of a difference in size. A continuous variation in the morphology of the North Wales spores is found and no distinction can be drawn on this basis; hence *F. similis* is included within *F. elegans*.

The mean size of the spores shows a marked variation in the Namurian, reaching a peak in the Namurian A - B and decreasing in the Namurian C (Text-figure 8).

Occurrence. Holywell Shales; Namurian A - C.

Previous records. Extensively recorded from the Namurian of England. (Neves, 1958, 1961; Owens and Burgess, 1965); Mississippian of U.S.A. (Wilson and Kosanke, 1944, Kosanke, 1950).

INCERTAE SEDIS

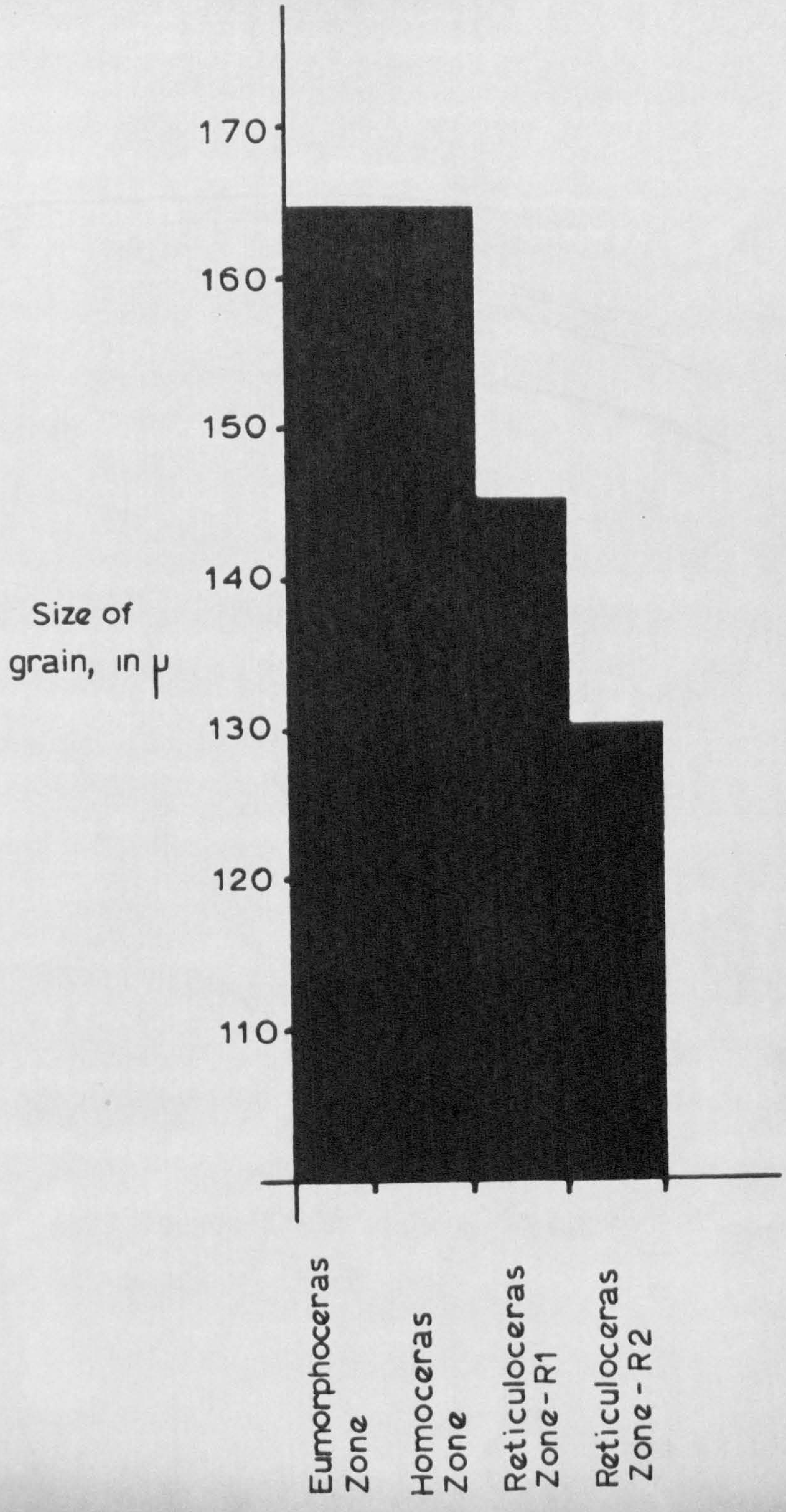
GENUS SPINOZONOTRILETES Hacquebard 1957

Type species. *S. uncatus* Hacquebard 1957

Affinity. Unknown.

Text-figure 8. Histogram showing the relation of size to distribution in *Florinites elegans*.

TEXT FIGURE 8



Remarks. The supra-generic position of this genus remains in some considerable doubt. A working party of the International Commission for the Microflora of the Palaeozoic is currently reviewing the position of cavate spores. Until the results are available the genus is not placed in a definite position in the classification.

Spinozonotriletes marginatus sp.nov.

Plate 10, Figs. 3 - 5; Text-figs. 7 D,E

Diagnosis. Spores radial, trilete; amb sub-circular to sub-triangular with convex sides and rounded apices. Laesurae often indistinct, straight, length equal to, or slightly greater than the spore body radius, obscured by raised lips which are slightly sinuous and reach almost to the equator of the spore, where they occasionally form "curvae imperfectae". Spore body outline conformable to that of the amb, punctate, bladder 2·5 - 3·5μ thick, its inner limit usually being marked by a line of fine punctations. The distal surface of the bladder is ornamented with well spaced spines, 2·5 - 5μ high and 1·5 - 3μ in basal diameter, the proximal surface of the bladder is punctate. The equatorial amb is often very irregular and membranous; the nature of this is not clear, it is thought to be the distal bladder surface folded over forming a projection at the equator. From a spore which is split open it can be seen that the spore is saccate with a close association of the two exine layers on the proximal side.

Dimensions. (28 specimens) Overall equatorial diameter 52 - 72µ (mean 60µ). Diameter of the central body 39 - 57µ (mean 43µ).

Holotype. Preparation L.C.2e 55·6 110·9

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 58µ, central body 42µ, amb sub-triangular. Laesurae indistinct, raised, sinuous lips run onto the equatorial amb. The thickness of the exo-exine (bladder) is 2·5µ; due to the slight oblique preservation of the spore the amb becomes obscured with an overlap of the saccus on one side of the spore. The distal ornament of spines is from 2·5 - 5µ high and 2·5µ in basal diameter and can be seen projecting at the equator in distal focus.

Occurrence. Menai Straits Shales; Viséan.

Comparison. Spinozonotriletes ? exiguus Staplin, 1960, is similar to the spore described here; it has a thick exine but has an ornament of wart-like to spinose projections, whilst that described here is distinctly spinose.

Spinozonotriletes reticulatus sp. nov.

Plate 10, Figs 1, 2; Text-fig. 7 C.

Diagnosis. Spores radial, trilete; amb circular to sub-circular. Laesurae distinct sinuous, length equal to the radius of the spore, with prominent folded flange-like lips which are up to 4µ wide and 5µ high. Exo-exine is sculptured on the distal surface with simple spines; these become reduced in size towards the equator. The spines are solid and are borne on broad-based extensions of the exo-exine; these run together and form a loose reticulate pattern on the distal side of the spore. The spines are from 5 - 15μ long and 2 - 3μ wide at the base. Exo-exine is strongly punctate and the central body (intexine) is distinct in most specimens and conformable to the spore body outline.

Dimensions. (20 specimens) Overall equatorial diameter 75 - 128μ (mean 95μ) diameter of central body 52 - 93μ (mean 71μ).

Holotype. L.C.2e, 45·5 107·6

Locus typicus. Vaynol Park, Caernarvonshire; Viséan.

Description. Holotype 82μ, amb sub-circular. Laesurae distinct, lips raised, length equal to the spore radius. Exo-exine sculptured with distinct spines, 4 - 8μ long, 2 - 3·5μ broad at the base. The raised "reticulum" of the distal exo-exine bears the ornament. Intexine distinct, conformable to the equatorial outline 64μ in diameter.

Remarks. The nature of the ornament and the close connection between the two exine layers on the proximal and distal faces places this spore in the genus Spinozonotriletes.

Occurrence. Menai Straits Shales; Viséan.

GENUS DISCERNISPORITES Neves 1958

Type species *D. irregularis* Neves 1958

Remarks. Sullivan, in collaboration with Neves, has established that the ornamentation, originally said to be confined to the proximal surface, is in fact, also present on the distal surface of the spore. In the North Wales specimens the precise nature of the spore wall layers is not clearly understood; some of them clearly showed a differentiated central area, others did not. In damaged specimens there was no indication that the spore had a central body. It would seem that the indication of a central area marks the position of separation between the exine layers (that is the extent of the intexine). Spores of this type, which have a characteristic equatorial separation of the exine layers are being discussed by a working party within the International Commission for the Microflora of the Palaeozoic and until these results are available the suprageneric position of *Discernisporites* remains in doubt.

Discernisporites vermiformis sp. nov.

Plate 10, Fig. 10; Text-figs 7 H,I.

Diagnosis. Spores radial, trilete; amb rounded triangular. Laesurae distinct, slightly sinuous, length equal to the radius of the spore; accompanied by distinct lips, from 2 - 3µ wide and up to 6µ high. Equatorial outline smooth. Exine of the distal surface is ornamented by reticulate to vermiculate ridges which frequently coalesce; this ornamentation may also be present in the inter-radial regions of the proximal surface. The ornamentation never extends to the equator. The central area (limit of the intexine) is occasionally indistinct, and is always greater than three-quarters spore radius. An equatorial limbus is seen in the majority of specimens.

Dimensions. (17 specimens) Equatorial diameter 58 - 99μ (mean 84μ).

Holotype. Preparation A.M. 22d 56•2 106•2.

Locus typicus. Abbey Mills, Borehole; Namurian A.

Description. Holotype 96μ rounded triangular. Laesurae distinct equal to the spore radius, lips 3 - 4μ wide and 4μ high. Exine of the equatorial region lighter in colour than that of the central area; ornamented on the distal surface with crowded vermiculate ridges, 1•7 - 3μ wide, and on the proximal surface, in the inter-radial regions, by vermiculate ridges 2•5 - 3μ wide. Central area forms 80% of the total spore radius. Distinct equatorial limbus.

Occurrence. Holywell Shales; Namurian A - C.

Discernisporites dentatus sp. nov.

Plate 10, Fig. 9.

Diagnosis. Spores radial, trilete; amb sub-circular to sub-triangular with convex sides and rounded apices. Laesurae distinct, slightly sinuous, length equal to the spore radius, lips well developed 2 - 3μ wide and up to 4μ high. Equatorial outline irregular with a number of papilla-like extensions especially in the inter-radial regions. Exine is sculptured on the distal surface with peg-like projections and loose vermiculate ridges; no ornament on the proximal surface. The margin of the intexine is clearly visible and forms less than 75% of the total spore radius.

Dimensions. (4 specimens) Equatorial diameter 49 - 90μ.

Holotype. Preparation U.C.5b 47·2 110·7

Locus typicus. Coed Pen-y-Maes, Flintshire; Namurian B.

Description. Holotype 90µ, sub-circular. Laesurae extend to the equator, slightly sinuous, lips 3 - 4µ wide and 3µ high. Exine ornamented with boss-like projections, 2µ in diameter, and loose vermiculate ridges 1·5 - 2·5µ wide. Central area distinctly marked by a narrow groove, one-half the total radius of the spore.

Remarks. This spore is distinguished from D. vermiformis by the presence of papillate projections in the inter-radial equatorial regions, also the smaller size of the central area.

Occurrence. Holywell Shales; Namurian B.

GENUS GRANDISPORA Hoffmeister, Staplin and Malloy 1955

Type species. G. spinosa Hoffmeister, Staplin and Malloy 1955

Affinity. Unknown.

Remarks. A considerable amount of uncertainty exists as to the true nature of the outer enveloping layer in this genus. The inner wall is loosely surrounded by the outer wall layer, the only point of contact between the two being on the proximal side, in particular in the region of the laesurae. Potonié called such a central body as that seen in Grandispora, a mesospore (Potonié, 1968, p. 21). The genus is to be distinguished from Spinozonotriletes (Hacquebard, 1957) by the relationship of the two exine layers. In Spinozonotriletes these are in contact over the whole of the proximal surface and over the greater part of the distal surface. The cavity is restricted to the equatorial region of the intexine (central body) and this becomes reduced towards the equatorial amb where the distal and proximal exo-exine layers become fused and form a flange. The two genera are at present under review by a working group on "Cavates" within the C.I.M.P.

<u>Grandispora</u> <u>spinosa</u> Hoffmeister, Staplin and Malloy 1955

Plate 10, Fig. 8.

<u>Description of specimens</u>. Spores radial, trilete; amb sub-circular. Laesurae indistinct. Central body and bladder granulose (oil immersion). Bladder covered with small spines, 2 - 4μ long and up to 18μ apart.

<u>Dimensions</u>. (10 specimens) Equatorial diameter 103 - 122μ, central body 78 - 86μ.

<u>Remarks</u>. This species appears to be characteristic of Lower Namurian horizons in North Wales and the Southern Pennines.

<u>Occurrence</u>. Holywell Shales; Namurian A.

<u>Previous records</u>. Hardinsburg Formation, Illinois (Hoffmeister, Staplin and Malloy, 1955), Namurian A of the Southern Pennines (Neves, 1961), Namurian A of Stainmore (Owens and Burgess, 1965).

GENUS TETRAPTERITES Sullivan and Hibbert 1964

Type species. *T. visensis*. Sullivan and Hibbert 1964

Tetrapterites visensis Sullivan and Hibbert 1964

Plate 11, Figs. 1 - 4

Description of specimens. Tetrahedral capsule with four prominent skiadions at the tetrahedral apical positions. Wall membrane opaque, reddish-brown in colour; in over-macerated specimens the wall may become translucent and details of the spores inside the capsule can be seen. The spores are of the dispersed genus *Punctatisporites*. The detached skiadions are the most common remains recognizable in the assemblages; occasionally these may still have the spore sitting in the cupule.

Dimensions.(50 specimens) of the capsule, 176 - 214μ; of the skiadion 103 - 150μ.

Remarks. The remains of this genus were confined to two of the horizons in the Menai Straits locality, in one, L.C.2 they were relatively abundant (4·1%). Examples of the wall membrane remaining after the dispersal of the skiadions are not easily seen, they are difficult to recognise; one good example was found (Plate 11, Fig. 4).

Occurrence. Menai Straits Shales; Viséan.

Previous records. Viséan of Forest of Dean and North Wales (Sullivan and Hibbert, 1964).

SPORE ASSEMBLAGE FROM THE VISEAN DEPOSITS

The following forty-eight species, of which seventeen are new, were recorded. Two new genera were also recorded.

Leiotriletes inermis (Waltz) Ishchenko 1952

L. subintortus (Waltz) Ishchenko 1952 var. *rotundatus* Waltz 1941

L. ornatus Ishchenko 1956

L. tumidus Butterworth and Williams.1958

Punctatisporites glaber (Naumova) Playford 1962

P. irrasus Hacquebard 1957

P. cf. *obesus* Neves 1958

Calamospora microrugosa (Ibrahim) Schopf, Wilson and Bentall 1944

Cadiospora sp. A.

Granulatisporites granulatus Ibrahim 1933

G. microgranifer Ibrahim 1933

G. visensis sp. nov.

Cyclogranisporites lasius (Waltz) Playford 1962

Verrucosisporites eximius Playford 1962

V. tuberculatus sp. nov.

Anapiculatisporites tenuispinosus sp.nov.

Waltzispora planiangulata Sullivan 1964

Lophotriletes tribulosus Sullivan 1964

Raistrickia rugosa sp.nov.

Neoraistrickia drybrookensis Sullivan 1964

Umbonatisporites variabilis gen. et sp. nov.

Camptotriletes verrucosus Butterworth and Williams 1958

<u>Convolutispora</u> <u>tuberculata</u> (Waltz) Hoffmeister, Staplin and Malloy 1955

<u>C</u>. <u>labiata</u> Playford 1962

<u>C</u>. <u>vermiformis</u> Hughes and Playford 1961

<u>C</u>. <u>vermiculata</u> sp. nov.

<u>Dictyotriletes cancellatus</u> (Waltz) Potonié and Kremp 1955

<u>D</u>. cf. <u>peltatus</u> Playford

<u>D</u>. <u>tesselatus</u> sp. nov.

<u>D</u>. <u>radiatus</u> sp. nov.

<u>Perotriletes</u> <u>magnus</u> Hughes and Playford 1961

<u>P</u>. <u>reticulatus</u> sp. nov.

<u>P</u>. <u>punctatus</u> sp. nov.

<u>Knoxisporites</u> <u>convolutus</u> sp. nov.

<u>Murospora</u> <u>intorta</u> (Waltz) Playford 1962

<u>M</u>. <u>aurita</u> (Waltz) Playford 1962

<u>Lycospora</u> <u>uber</u> (Hoffmeister, Staplin and Malloy) Staplin 1960

<u>Lophozonotriletes</u> <u>muricatus</u> sp. nov.

<u>Vallatisporites</u> <u>ciliaris</u> (Luber) Sullivan 1964

<u>V</u>. <u>spinosos</u> sp. nov.

<u>V</u>. <u>microgalearis</u> sp. nov.

<u>Diversizonotriletes</u> <u>intestinalis</u> gen. et sp. nov.

<u>Cirratriradites</u> <u>elegans</u> (Waltz) Potonié and Kremp 1956

<u>Remysporites</u> <u>magnificus</u> (Horst) Butterworth and Williams 1958

<u>Endosporites</u> <u>micromanifestus</u> Hacquebard 1957

<u>Spinozonotriletes</u> <u>reticulatus</u> sp. nov.

<u>S</u>. <u>marginatus</u> sp. nov.

<u>Tetrapterites visensis</u> Sullivan and Hibbert 1964

The foregoing list is based on the examination of ten samples from the Menai Straits locality. The samples were taken from a series of shale bands comprising the Basement Series, which underlies the Limestone (see Appendix P.186 - List of Localities). There was a considerable differenee in the microfloral composition of the samples; this must reflect changes in the macroflora during the time required for deposition of the total thickness of the sediments. Whilst these changes in microflora are clearly apparent, they do not enable subdivisions of the Basement Series to be made, since similar compositions are often recurrent. This emphasises the caution necessary when using the results of microflora examination of shale deposits to interpret stratigraphy. In the present study the characters of all the samples are combined to represent the typical composition of the assemblage from the one locality and horizon.

This variation in the composition of the assemblages (details of each sample can be seen in Text-figure 9), in what is a comparatively short range of geological time, plus the fact that the changes oscillate, underlines the necessity to assess the many factors which are likely to create such variations. The evolution of the macroflora is reflected by changes in the miospore assemblages. It has also been shown that widely different assemblages are found in sediments of different lithology (Hoffmeister, Staplin and Malloy, 1955a; Neves, 1958, 1961; and Staplin, 1960). It is likely that regional variation in climate and topography are also important in determining the composition of the macroflora, such as is seen in present day floral associations.

Text-figure 9. The miospore distribution throughout the Viséan (Menai Straits) samples. Figures are percentage occurrence; X indicates presence, but not included in count.

Assemblage \ Spore species	Leiotriletes inermis	L. subintortus	L. ornatus	L. tumidus	Punctatisporites glaber	P. irrasus	P. cf. obesus	Calamospora microrugosa	Cadiospora sp.	Granulatisporites granulatus	G. microgranifer	G. visensis	Cyclogranisporites lasius	Verrucosisporites eximius	V. tuberculatus	Anapiculatisporites tenuispinosus
LC 1	4.2		X	0.1	10.5	0.4		X	0.1			0.4	1.6			
2	2.0	1.0		0.4	3.4	1.1	0.1	0.1		0.9	0.2		2.5	X	X	
3	8.1	3.3	X		3.8	X	0.2	0.7		0.6	0.4	0.7	2.6	0.2	X	
4	3.5	3.3	0.2	1.8	10.6	0.3	X	X		0.3	0.7	1.1	1.1			0.3
5	3.6	2.1		1.3	15.3		0.4	0.5		0.1		X	2.4			0.1
6	1.0	1.0		1.4	25.6			0.3		0.3	0.3	0.3	4.1	0.1		
7	0.8	0.4		0.2	7.4	X		0.1		0.1	1.9	1.9	0.8			
8				2.3	20.3						0.3		20.0			
9	3.6	1.5		2.5	9.2	0.1		0.3			5.0	4.3	0.4	X		
10	2.4	3.1			8.8	0.7	4.3	0.1		X	0.2	0.1	0.2	0.2	0.1	

Assemblage \ Spore species	Waltzispora planiangulata	Lophotriletes tribullosus	Raistrickia rugosa	Neoraistrickia drybrookensis	Umbonatisporites variabilis	Camptotriletes verrucosus	Convolutispora tuberculata	C. labiata	C. vermiformis	C. vermiculata	Dictyotriletes cancellatus	D. tesselatus	D. radiatus	D. cf. peltatus	Perotriletes magnus	P. reticulatus
LC 1				1.1		0.5		0.2	X		7.0	0.2	0.3	0.1		
2	0.1		X	1.5	0.2	0.2	0.1	0.3	0.4	0.8	5.6		0.3		X	0.4
3	X	0.1	0.1	0.5		0.4	0.2	1.0			4.8	0.4	0.2	X	X	X
4		0.9	X	0.3			X		X		1.2		0.1			
5	X		0.2	1.0		0.6	0.3		0.3		7.3	0.2	0.3	X	0.2	
6			0.1	1.6					0.4		4.2		0.1	0.5		
7		0.1		1.9						0.1	4.3					
8				1.0							16.0					
9		1.7	0.1	1.3							1.8		X			
10		X		2.1			0.8	1.3	X	0.7	4.1	0.1	X	0.1	X	X

Assemblage \ Spore species	P. punctatus	Knoxisporites convolutus	Murospora intorta	M. aurita	Lycospora uber	Lophozonotriletes muricatus	Vallatisporites ciliaris	V. spinosus	V. microgalearis	Diversizonotriletes intestinalis	Cirratriradites elegans	Remysporites magnificus	Endosporites micromanifestus	Spinozonotriletes reticulatus	S. marginatus	Tetrapterites visensis
LC 1		0.1			52.0	0.1	2.8	12.1	6.1					X	0.1	
2	0.1	X	X	X	57.5	X	1.2	14.3	3.3		X	0.1	0.3	0.5	0.9	X
3		0.3	0.2	0.1	47.6	0.7	3.5	13.4	4.3	1.3	1.0	X	X	0.6	0.1	0.1
4		0.4			69.3	0.1	0.6	3.3	0.5	0.3	X				X	X
5		0.2	0.7		48.9	0.1	1.5	11.5	1.9	0.4		0.3	X	0.1		0.1
6		0.4		3.0	4.5	5.7	0.1	1.4	0.7	6.7		0.4		0.1		
7		X	0.2	0.2	59.2	2.2	0.6	15.9	2.7			X		0.1	0.2	
8			X	17.0	X	23.0										
9			X	0.6	25.1	0.5	0.3	33.9	5.4	0.1				X	0.4	
10		0.2	0.1		40.1	0.8	4.0	15.2	2.6	5.2	X	0.1		X	X	

TEXT FIGURE 9

SPORE ASSEMBLAGE FROM THE NAUMURIAN DEPOSITS

The following fifty-eight species, of which ten are new, were recorded.

Leiotriletes auritus Ischchenko 1956

L. ornatus Ishchenko 1956

L. tumidus Butterworth and Williams 1958

Punctatisporites glaber (Naumova) Playford 1962

P. sinuatus (Artuz) Neves 1961

P. cf. *obesus* Neves 1961

Calamospora liquida Kosanke 1950

C. microrugosa (Ibrahim) Schopf, Wilson and Bentall 1944

Granulatisporites granulatus Ibrahim 1933

G. microgranifer Ibrahim 1933

Cyclogranisporites aureus (Loose) Potonié and Kremp 1955

Verrucosisporites verrucosus Ibrahim 1933

V. morulatus (Knox) 1950 Smith and Butterworth 1964

V. donarii Potonié and Kremp 1955

Apiculatisporites cambrensis sp. nov.

A. cf. *variocorneus*.

Acanthotriletes horridus Hacquebard 1957

A. castanea Butterworth and Williams 1958

A. cuspidens sp. nov.

Ibrahimispores brevispinosus Neves 1961

I. nobilis sp. nov.

Raistrickia microhorrida (Horst) Potonié and Kremp 1955

R. fulvus Artuz 1957

R. vulgaris sp. nov.

Camptotriletes superbus Neves 1961

C. verrucosus Butterworth and Williams 1958

Convolutispora tuberculata (Waltz) Hoffmeister, Staplin and Malloy 1955

C. florida Hoffmeister, Staplin and Malloy 1955

C. mellita Hoffmeister, Staplin and Malloy 1955

C. obliqua Neves 1961

Dictyotriletes tuberosus Neves 1961

D. pili formis sp. nov.

D. vagus sp. nov.

Ahrensisporites guerickei (Horst) Potonié and Kremp 1954

Knoxisporites triradiatus Hoffmeister, Staplin and Malloy 1955

K. seniradiatus Neves 1961

K. concentricus sp. nov.

K. cf. rotatus Hoffmeister, Staplin and Malloy 1955

Lycospora uber (Hoffmeister, Staplin and Malloy) Staplin 1960.

Densosporites striatus (Knox) Butterworth and Williams 1958

D. cuneiformis Hacquebard and Barss 1957.

D. intermedius Butterworth and Williams 1958

D. spinosus Dybova and Jachowicz 1957

Anulatisporites anulatus (Loose) Potonié and Kremp 1954

Cristatisporites indignabundus (Loose) Potonié and Kremp 1955

Savitrisporites nux (Butterworth and Williams) Sullivan 1964

Cirratriradites ornatus Neves 1961

Reinschospora speciosa (Loose) Schopf, Wilson and Bentall 1944

R. cf. triangularis Kosanke 1950

Proprisporites glaber sp. nov.

Remysporites magnificus (Horst) Butterworth and Williams 1958

Endosporites magnificus Hacquebard 1957

Florinites elegans Wilson and Kosanke 1944

Schulzospora rara Kosanke 1950

S. ocellata (Horst) Potonié and Kremp 1955

Grandispora spinosa Hoffmeister, Staplin and Malloy 1955

Discernisporites vermiformis sp. nov.

D. dentatus sp. nov.

The majority of the assemblages from the Namurian sequence were recovered from non-marine shales, one (U.C.21) was from a coal deposit and the remainder from marine shales (see Appendix p.186 - List of Localities). The miospore assemblages from the marine and non-marine shales differed little (Text-figure 10). It is recognised that allochthonous deposits have a more or less common spore flora (Neves 1958, 1961; Staplin, 1960). The assemblage from the coal sample was different from the others and contained many species which were confined to this deposit. The microflora reflects a plant association, that of the coal swamp, totally different from the allochthonous deposits, which are largely representative of transported material. Whilst the majority of spores found in coal seams are from the plants growing on the "coal-forming peat", it may be possible to detect spores which are characteristic of other plant associations. These are overshadowed in such deposits and do not take a significant part in the composition of the assemblage.

Text-figure 10. The miospore distribution throughout the Namurian samples. Figures are percentage occurrence; X indicates presence, but not included in count.

Assemblage \ Spore species	Leiotriletes auritus	L. ornatus	L. tumidus	Punctatisporites glaber	P. sinuatus	P. cf. obesus	Calamospora liquida	C. microrugosa	Granulatisporites granulatus	G. microgranifer	Cyclogranisporites aureus	Verrucosisporites verrucosus	V. morulatus	V. donari	Apiculatisporites cambrensis	A. cf. variocorneus	Acanthotriletes cuspidens	A. castanea	A. horridus	Ibrahimisporites brevispinosus
UC 21					2.1		2.1	0.4		2.6	1.4			0.5		2.5	1.0	0.7		
1			0.7	1.9	0.3			1.7	2.8	4.2	3.9	0.7	1.0		1.4		0.7			
2	0.4			0.5	0.5		2.0		2.0		0.2						1.7			
3	X		0.7	X				0.4			0.4	X	X		1.0		1.2			
4		0.2							0.2			0.2	0.2				1.0			
5	0.1		0.1									0.2					0.1	X		0.2
6	0.2	0.4	0.2	X					0.2								0.8			
7										X		0.4					1.3			
8				X													1.0			0.2
9										X							1.1			
10									1.4		0.4									
11													0.1				0.2		0.2	
AM 3																	1.0	0.5		0.5
4										X	0.4						0.4			
5													X							
6									1.1	0.4		0.3					0.1			0.1
7	0.4									X		3.4					4.0			
16										4.0		X	2.0							
19		0.9	1.6	0.2		1.0			0.2		1.6	0.5	1.2				0.2			
22			0.7	2.4		1.4		1.7	8.3		2.1	0.7	0.4				1.0			
23			3.1			X			3.1		1.5		1.5							

Assemblage \ Spore species	I. nobilis	Raistrickia microhorrida	R. fulvus	R. vulgaris	Camptotriletes superbus	C. verrucosus	Convolutispora tuberculata	C. florida	C. mellita	C. obliqua	Dictyotriletes tuberosus	D. piliformis	D. vagus	Ahrensisporites guerickei	Knoxisporites triradiatus	K. seniradiatus	K. concentricus	K. cf. rotatus	Lycospora uber	Densosporites striatus
UC 21		0.2	7.3		1.1				0.3										77.0	
1		4.5			1.0			1.3	4.3			1.0		0.3	1.6	0.4	0.9	0.5	31.4	
2		2.7							0.5								0.8	0.4	82.6	
3		2.0							0.8			0.4		0.4	0.4		0.5		43.0	
4		0.5		0.7					0.8			0.5				0.3			X	
5	0.5	3.0							0.4			0.1				0.1	1.7		0.3	
6		1.2		1.9					1.1				1.5		1.2	0.4	0.3	1.3	2.1	
7		3.0		0.4			0.3	0.2	0.6			1.6			0.4	0.3	0.9		X	
8		3.7		0.3			1.7	0.8	1.8		0.3	1.7	0.3				0.4		3.0	
9		2.5							1.1		0.4	0.7	1.4		0.7		0.7		9.3	
10		2.1		1.8				0.7	1.4		0.7	2.5						0.4	1.4	
11	0.6	1.2						0.3	2.7		X	0.9	X		0.3					
AM 3	0.5								1.0											
4		0.4						1.3												
5		0.5						0.5	2.8						1.0				6.6	0.1
6		0.7					0.4	0.4	0.6	0.3									11.9	3.6
7		3.0						1.7	0.4	1.2		0.4	1.7				5.4		7.4	
16								1.0				2.0	1.0						X	
19		0.2				0.5	0.7	0.5	1.0			1.0	0.7		1.5		2.5		34.0	
22		0.3					2.4	1.7	2.7			0.3			0.3		0.6		47.3	
23						1.5									1.5		5.7		32.3	

Assemblage \ Spore species	D. cuneiformis	D. intermedius	D. spinosus	Anulatisporites anulatus	Cristatisporites indignabundus	Savitrisporites nux	Cirratriradites ornatus	Reinschospora speciosa	R. triangularis	Proprisporites glaber	Remysporites magnificus	Endosporites micromanifestus	Florinites elegans	Schulzospora rara	S. ocellata	Grandispora spinosa	Discernisporites vermiformis	D. dentatus
UC 21		0.8		0.9									0.2	0.6				
1	6.5	5.3	4.2	1.5	4.3	6.5	1.3	0.3	0.4	2.7		2.3	X				0.3	
2	1.4			2.8	0.7	1.4	0.7						0.5					
3	0.8	0.4	0.8		0.8	1.2				0.8			40.0					
4	0.5	0.2				0.3						0.2	94.0				0.2	X
5						0.1		0.1				0.1	95.0				0.1	0.1
6	3.7			1.7								0.8	86.0					
7		1.2	0.5			0.3		0.2	0.1			0.1	91.8					
8	1.1	0.8	2.1	0.7		0.1		0.1	0.1				80.1					
9	2.8	1.7	1.8					0.4				0.4	76.0					
10	1.4	0.4		0.4		0.4		0.6		0.4			84.9					
11		2.7		0.6									90.0					
AM 3								0.5		0.5			95.1					
4										1.3			96.0					
5			1.0			1.0				1.0			89.1					
6			5.6	0.2		0.1						0.1	75.0					
7	6.1		2.6	0.1						1.3		2.2	54.0		3.5			
16	33.0	1.0	4.0			1.0							51.0					
19	1.7	7.1		1.7		8.6				9.7	0.2	3.1	4.6		1.2	2.1	12.0	
22	0.3	0.3								1.1	2.4	12.2	4.1				5.4	
23	3.7									1.5	1.5	4.6	18.6		3.1	1.5	12.3	

TEXT FIGURE 10

SPORE DISTRIBUTION AND STRATIGRAPHY

Owing to the fact that no recognisable microfloras were obtained from the Upper Viséan sediments, a hiatus exists between those of the Basement Series, of presumed S2 - D1 age and those from the lowermost Pendleian stage, E1, at the base of the Abbey Mills Bore-hole. The microfloras of these two ages have very little in common, but because of the lack of evidence from intervening strata, it is not possible to determine at what age the change occurred; nor is it possible to determine whether the change was sudden, or took place gradually over a period of time.

Certain genera are confined to the Viséan: Waltzispora, Neoraistrickia, Umbonatisporites, Perotriletes, Murospora, Lophozonotriletes, Anapiculatisporites, Lophotriletes, Diversizonotriletes, Spinozonotriletes and Tetrapterites are allfound only in the Menai Straits Shales. Similarly certain species of some genera, which otherwise range through from Viséan to Namurian times, are likewise restricted to the Viséan sediments:- Leiotriletes inermis, Cyclogranisporites lasius, Verrucosisporites tuberculatus, Raistrickia rugosa, Convolutispora labiata, Dictyotriletes tesselatus, Dictyotriletes radiatus, D. cancellatus and Cirratriradites elegans. The presence of these characteristic genera and species enables a clear distinction to be made between the microflora of the Viséan, S2 - D1 age and that of the lowermost Namurian A deposits.

Punctatisporites cf. obesus, Leoitriletes tumidus, Camptotriletes verrucosus and Remysporites magnificus occur in the Viséan Shales and in the Naumurian, but there are restricted to the lowermost Namurian A deposits. Of these, Remysporites magnificus has not previously been recorded from Viséan deposits in the British Isles.

Other species, which are recorded from both Viséan and Namurian sediments, are not restricted to the lower Namurian age. For example, Convolutispora tuberculata and Leiotriletes ornatus extend to the top of the Namurian B, Punctatisporites glaber and Granulatisporites microgranifer are intermittently recorded up to the base of Namurian C age and Granulatisporites granulatus and Endosporites micromanifestus have a more complete record from the Viséan to the base of the Namurian C. Lycospora uber is present throughout the range of deposits examined. The Viséan records for Granulatisporites microgranifer and G. granulatus are the oldest so far made for these species.

Judging from the number of genera and species found in the Viséan deposits, but absent from those of the lowermost Namurian, it is apparent that a major change in the macroflora had taken place during that time. This change is shown from the miospore record to be of greater magnitude than any subsequent changes throughout the following Namurian period.

The macrofloral records from the Lower Carboniferous (Lacey, 1962; Walton, 1931) show that there is little marked change from the Lower Brown Limestone through the Black Limestone of D2 - D3 age, to the Lower Namurian flora. The flora described by Walton from the Teilia Quarry, in the Black Limestone, has more in common with the Upper Viséan-Namurian flora than with that described by Lacey from the Lower Brown Limestone; the order of magnitude of the change is not as great as is seen in the composition of the microfloras from the Basement Series and the Lower

Lower Namurian deposits. The macroflora of the Basement Beds is not well preserved and is poorly known, but it is shown by the large number of miospores present to have been much larger than the macro remains would suggest. Since no great change is recorded in the macroflora of the Limestone Series, apart from the presence of Lepidodendropsis at its base, the microflora recorded from the Basement Beds is presumed to be older than the Lower Brown Limestone, D1, and to represent an earlier stage in the transition from the typical Lower Viséan-Devonian flora to that of the Upper Viséan - Namurian age. The macroflora of the Lower Brown Limestone occupies an intermediate position and a later state in the same transition.

The composition of the microfloral assemblages undergoes a progressive change throughout the Namurian (Text-figure 11). The distribution pattern indicates the horizons at which these changes take place with the appearance and disappearance of certain species.

As already noted, there are in the lowermost Namurian A, Pendleian assemblages a number of species which are also found in the Viséan deposits. Along with Grandispora spinosa, which is only recorded from Pendleian deposits and is of great stratigraphical significance, these are characteristic of the lowermost assemblages. Lycospora uber is the dominant species (47%) and along with Granulatisporites granulatus (12%) and Florinites elegans (18·6%) makes up the majority of types present.

Text-figure 11. Chart showing the observed Stratigraphical ranges of Selected Spore Species in the Viséan and Namurian of North Wales.

TEXT FIGURE 11.

The beginning of the Arnsbergian stage is marked by the disappearance of *Punctatisporites* cf. *obesus*, and *Remysporites magnificus*, together with the appearance of *Densosporites spinosus* and *Dictyotriletes vagus*. These assemblages are dominated by *Florinites* which reaches values as high as 54%. Towards the top of this stage *Convolutispora obliqua* and *Leiotriletes auritus* are found; the former is of restricted range, ~~the former is of restricted range~~, the latter extends upwards into the younger Namurian deposits.

The Sabdenian stage is not well represented in the North Wales deposits; *Ibrahimispores brevispinosus* and *Densosporites striatus* appear at this stage. Again the assemblages are dominated by *Florinites* with values up to 75%. *Schulzospora ocellata* disappears at the onset of this stage.

The start of the Kinderscoutian, which marks the beginning of Namurian B, is marked by the disappearance of *Convolutispora obliqua*. During this stage several species make their first appearance: *Ibrahimispores nobilis*, *Knoxisporites seniradiatus*, *Reinschospora speciosa*, *Dictyotriletes tuberosus* and *Raistrickia vulgaris* and towards the end of the stage *Reinschospora triangularis* is recorded. The transition between the Kinderscoutian and Marsdenian stages is maked by the appearance of *Apiculatisporites cambrensis* and *Discernisporites dentatus*. In both of the stages the assemblages are completely dominated by *Florinites* (95%).

The beginning of the Namurian C Yeadonian stage is marked by the appearance of *Cirratriradites ornatus*, *Cristatisporata indignabundus*, *Calamospora liquida*, *Punctatisporites sinuatus* and *Camptotriletes superbus*.

The representation of Florinites drops to 0·5% and in one assemblage is not recorded from the count at all. This drop is accompanied by a sharp rise in the numbers of Lycospora uber present in the count; it becomes the dominant species with values up to 82%. The coal assemblage from Rhydymwyn, which is of Yeadonian age, differs from the allochthonous deposits of similar age; Raistrickia fulvus and Schulzospora rara are recorded only from this deposit. The dominant species is Lycospora uber (77%) inicating the presence of a large number of coal forming species in the area, at the same time Florinites can be detected in the assemblages; indicating that the high land flora was still present close-by.

PALAEOECOLOGY OF THE NAMURIAN

The absence of middle to lower Namurian coal deposits in North Wales indicates that the high land mass of St. Georges land, lying to the south, shelved steeply into the sea without providing areas of lowland which might have supported the coal forming swamps. Such conditions were present further to the north and east of the area and led to the formation of coal seams in early Namurian times. Along the nothern edge the sea was shallow enough, however, to allow estuarine mud deposits to form; within these, successive marine bands mark the changes in sea-level which took place during the period, and are useful stratigraphical markers.

Both the marine and non-marine shales have a large proportion of the genus Florinites in them; in some cases the representation rises as high as 95%. This genus of dispersed spores is known to have come from the plant Cordaites; spores of the type have been recovered from the fructification Cordaianthus. It is a saccate spore and could have been transported over long distances both by wind and water. The constant presence of this spore, at high frequencies, suggests that it came from an area little affected by the changes in sea-level which took place. The high land mass of St. Georges land provides such a place and, since the land is thought to have shelved steeply into the sea, it can be assumed that the principal component of the spore-rain was from that area. The high frequency of Florinites in the assemblages indicates that the high land flora was dominated by cordaitalean plants. The nature of such floras is not easy to determine due to the absence of suitable deposition areas in which fossils could now be found.

The spore Densosporites has been found in the cone of the herbaceous lycopod Selaginellites (Chaloner, 1958a). This plant was most likely associated with a predominantly herbaceous area of vegetation marginal to, and on higher ground than, the ground supporting coal swamp vegetation. In the absence of the latter areas in North Wales, during Namurian times, the herbaceous vegetation was likely to be marginal to the sea. With the changes in sea-level it is likely that this area of vegetation migrated towards the high land as the sea rose returning to lower ground as the sea-level fell. A rise in sea-level is likely to have occurred along with an amelioration in the climate, so that the higher altitudes would not have been a barrier to such a movement.

The genus Lycospora, which is thought to be representative of some components of the coal swamp flora, has a closely parallel distribution to Densosporites. Both these spores are almost entirely absent from the assemblage when Florinites rises to its highest levels. These high values are likely to be when the sea is adjusting its level and the marginal flora is reduced; since they coincide with non-marine deposits the flora is in the process of re-establishing itself. Apart from these frequencies, Lycospora rises to high levels at the beginning of the Namurian C period in the Holywell deposits. This is immediately before the establishment of the coal swamp flora in the region and these high values are probably representative of an early spread of the plants, characteristic of that association into the area.

The conventional reconstruction of the Carboniferous flora resembling something between a mangrove swamp and a tropical rain forest is only one aspect of the plant associations existing at that time; it is certainly the aspect best represented by macrofossils. The miospore evidence throws light on what may be two more "ecosystems" of Namurian times (Chaloner, 1958c). Firstly, that the high land masses were covered with a "forest", dominated by Cordaites and other forerunners of the Coniferae; and secondly that the areas of steeper ground, away from the "coastal plain" were covered with an association of plants which were largely herbaceous. It is probably due largely to the lack of suitable peats and other sedimentary deposits that there are very few fossil representatives of the high land flora, and to the less resistant nature of the herbaceous plants, that these are not more commonly found as fossils.

COMPARISON WITH OTHER MICROFLORAL ASSEMBLAGES

The Viséan assemblage.

Butterworth and Millot (1960) have set up a zonation based on microspores from coals throughout the British Isles. The North Wales Viséan assemblages fall within their *Camptotriletes verrucosus* zone, towards its base. Whilst this species is present in the assemblages the absence of others, characteristic of the zone, can be attributed to the nature of the deposits.

Sullivan (1964b) has described an assemblage from the Drybrook Sandstone of the Forest of Dean, Gloucestershire, which is of upper Viséan age. This assemblage contains spores which are also found in the North Wales deposits. Several of the species described for the first time from the Drybrook deposits also occur in the Menai Straits Shales; *Lophotriletes trilbullosus*, *Waltzispora planiangulata*, *Neoraistrickia drybrookensis* and *Vallatispora ciliaris* are common to both. The only described remains of *Tetrapterites visensis* are from these assemblages. It might be expected that the two floras have much in common since they are found to the North and South of the St. Georges land mass. Plants from this high land would be making up the majority of the spore rain falling on, and being transported to, the two areas of deposition. There are several differences between the two floras, notably the absence of the genus *Microreticulatisporites* and the occurrence of new taxa from North Wales. The new species found in North Wales might have been expected to occur also in the Gloucestershire deposits because of the close proximity of the two areas and the similarity in age. The macroflora, as far as it is represented in the Menai Straits area (Lacey, 1952b) is similar to that described by Lele and Walton (1962) from the Forest of Dean. Sullivan (loc. cit.) commented on the discrepancy between the poor microflora reported by Lele and Walton and that of the deposits he examined. This local variation, and that between the southern deposits considered together, compared to the Menai Straits indicates the possibility of regional variation in the flora. This is more clearly represented from the miospore assemblages than from the macro-remains.

An assemblage from the Lower Oil-Shales deposits in Scotland was described by Love (1960). The deposits are Viséan in age, but the miospore assemblages bear little resemblance to those from North Wales. The species described as Reticulatisporites type B by Love is thought to be synonymous with Dictyotriletes radiatus.

Playford (1962, 1963a) described assemblages from the Lower Carboniferous deposits of Spitsbergen; these had been the subject of a preliminary paper by Hughes and Playford in 1961. The deposits ranged from Tournaisian through the Viséan and possibly into the Lower Namurian. Playford divided the assemblages into two distinct groups; an older, Rarituberculatus assemblage, of Tournaisian age and a younger Aurita assemblage, of Viséan, possibly Namurian age. Zonate spores are characteristic of the latter and many of the species characteristic of this assemblage are also present in North Wales. Verrucosisporites eximius, Dictytriletes (al. Reticulatisporites) cancellatus, Convolutispora labiata, C. tuberculata, Murospora aurita, M. intorta, Cirratriradites elegans, Perotriletes magnus. The further presence of the genera Lycospora, Waltzispora and Remysporites would indicate a similar age for the two deposits. These three genera are absent from the Tournaisian deposits. A striking difference between the Spitsbergen and North Wales deposits is the absence of the genus Densosporites from the latter.

There is very little similarity between the microfloral assemblages described by Hacquebard and Barss from the North-West Territories and those from North Wales. The Canddian assemblages are mid-Chesterian in age, which would put them around the Namurian-Viséan boundary in the European zonation. Similarly the Lower Chesterian assemblages described by Staplin (1960) from the Golata formation of Canada bear no resemblance to the Menai Straits deposits.

The Horton group deposits described by Hacquebard (1957) have a similar occurrence of the genus Vallatisporites to that seen in the deposits of North Wales. A similar condition was reported by Playford (1963b) from the Horton deposits of Eastern Canada. These latter deposits also contained two further genera which are represented in the North Wales deposits; Perotriletes and Camptotriletes. The Horton group is Lower Mississippian in age and is comparable to the Tournasian deposits of Europe. The occurrence of the genus Lycospora from these Horton deposits is the oldest so far made and previously it was thought only to appear in Viséan rocks (Playford, 1963a). The upper Mississippian spore flora of Axel Heiberg, in the Canadian Arctic Archipelago, recorded by Playford and Barss (1963) is very similar to the Spitzbergen deposits (Playford, 1962, 1963a) and the assemblages from North Wales, the exception being the absence of the genus Densosporites from North Wales. The microfloral evidence from Axel Heiberg led the authors to believe that the area was part of a large floral province, of northern distribution in Viséan time, which included also Spitzbergen and Western Russia. The assemblages from the Russian platform (Luber and Waltz, 1938, 1941) and the Dnieper-Donetz Basin (Ishchenko, 1956, 1958) have much in common both with the Canadian-Spitsbergen microfloras and those at present under study from North Wales. Leiotriletes ornatus, Convolutispora tuberculata, Dictyotriletes cancellatus, Murospora intorta, M. aurita, Cirratriradites elegans and Endosporites macromanifestus are all common to the Russian and North Wales deposits.

The microfloral assemblages from North Wales would fit into the extensive floral province postulated by Playford and Barss (1963). The slight variation in species may be taken as a representation of the effect of regional differences in the macroflora. The Viséan assemblage described by Love (1960) from Scotland and that by Sullivan and Marshall (in press) do not resemble this northern floral province; characteristics of these floras indicate a late Viséan-early Namurian age. The marked difference between the microfloras of the Scottish area and those from North Wales are of too great a magnitude to be explained on a regional basis. It is likely that the Scottish samples are of a younger age than those from North Wales and the differences between them are a reflection of the change in macroflora which took place between lower and upper Viséan times.

Sullivan (~~in press~~ 1965) has recently reviewed the world literature and divides Upper Mississippian spore floras into three broad categories.

1. The Monilospora suite; the typical genera of which are *Monilospora*, *Cincturasporites*, *Labiadensites*, *Simozonotriletes*, *Tripartites*, *Tetraporina*, *Waltzispora* and *Retialetes*. Assemblages falling into this category are recorded from Northern Canada, Spitsbergen and western Russia. In general the assemblages are dominated by some spores which have "thick equatorial borders", along with others having "thickened and fluted apices".

2. The Grandispora suite, characterised by the following species; *Apiculatisporites baccatus*, *Tripartites vetustus*, *Rotaspora fracta*, *R. knoxi*, *Bellispores nitidus*, *Savitrisporites nux*, *Crassispora maculosa*, *Schulzospora campyloptera* and *Grandispora spinosa*. Assemblages from this suite are best known from the mid-continent of the United States of America and Scotland.

3. A restricted suite, known only from northern Kazakhstan.

Using the evidence of van Hilten to place Carboniferous palaeolatitudes, Sullivan fits his Monilospora suite north of the 20 N. line and the Grandispora suite between 20 S. and 20 N. He also notes the presence of several ubiquitous species which traverse these boundaries and occur in several suites. In defining these suites Sullivan made no reference to the likely change in the macroflora which might be expected to accompany such a change, nor did he refer to the "evolution" of the flora which takes place in Viséan times.

The assemblage from North Wales can be most easily placed in the Monilospora suite; it has much in common with the assemblages from Spitsbergen and western Canada. It does, however, lack certain of the genera characteristic of this suite. From its position between the palaeolatitudes 0 and 20 N it would be expected to yield a flora more characteristic of the Grandispora suite; in fact it has nothing in common with these assemblages and indeed the early Namurian assemblages from North Wales would more easily fit into the Grandispora suite. Very little work has been done on the Lower to Middle Viséan deposits from Europe and Sullivan's assumption that they will fit into the Grandispora suite may be premature, certainly on the evidence gained from the North Wales deposits.

It may well be that a drastic change of macroflora took place in late Viséan times, such as would produce a different microflora; this would be reflected in the suites proposed by Sullivan becoming successive rather than contemporary. Certainly the evidence obtained from the North Wales deposits, when considered in relation to those of a contemporary age from other parts of the world, would support the fact that the Monilospora suite is older than the Grandispora suite. The former representing the microflora from lower to mid-Viséan times and possibly older, the latter, the microflora from late Viséan to early Namurian time. This would accommodate the change in macroflora said to have taken place at that time by Jongmans (1952). If the Spitsbergen deposits do range up into early Namurian times then the microflora shows no drastic change in its composition comparable to that which seems to have taken place in North Wales and other parts of the world. The Spitsbergen deposits do lack species which are characteristic of the Viséan - Namurian boundary in other assemblages (Butterworth and Williams, 1958;, Sullivan, 1965 ~~in press~~; Sullivan and Marshall, in press). The climatic fluctuation responsible for the change in macroflora may not have affected Spitsbergen at the same time as it did other parts of the world; the palaeolatitude of Spitsbergen is not yet definitely known.

It can be seen then that the assemblage of Viséan age from North Wales does not fit precisely within any of the previously described microfloral assemblages. It has more features in common with the Viséan assemblage of Spitsbergen and that from the Forest of Dean than any other comparable floras. It contains a number of the ubiquitous species described by Sullivan in addition to members of his Monilospora suite. On this basis it may be concluded that the microflora is of lower to middle Viséan age, being deposited before the change in macroflora took place in late Viséan time. The few macrofloral remains that are available from the area indicate a similar age, fitting in with the *Lepidodendropsis-Rhacopteris* lower Viséan flora, proposed by Jongmans.

The Namurian Assemblages.

The North Wales deposits can be most directly compared with the Namurian assemblages described by Neves (1961) from the southern Pennines and those by Owens and Burgess (1965) from Stainmore, Westmorland.

The lower Pendleian stage of the southern Pennines has the following in common with the North Wales assemblages; *Discernisporites*, *Florinites*, *Grandispora spinosa*, and *Schulzospora ocellata*. It is of interest to note that the general *Rotaspora* and *Tripartites*, which are common in the "northern" deposits of Stainmore and Scotland are absent both from the southern Pennines and North Wales. Grandispora spinosa is very characteristic of lower Namurian deposits in England, yet is absent from the Namurian A of Scotland (Butterworth and Williams, 1955). The occurrence of this species in the Stainmore deposits, along with the presence of Rotaspora and Tripartites, places it in an intermediate position between the assemblages from the "southern" deposits and those from the "north". The large percentage of Lycospora found in the North Wales deposits is paralleled by similar results from Stainmore and Scotland.

Ibrahimispores brevispinosus is recorded from the Sabdenian stage of the southern Pennines and North Wales, yet makes a slightly earlier appearance, in the Arnsbergian, in Stainmore; as does Knoxisporites seniradiatus, which does not appear until the Kinderscoutian of North Wales and the southern Pennines.

A large number of species make their first appearance in the Kinderscoutian stage and persist through to the younger North Wales deposits. A similar situation is noted by Neves for the commencement of the Marsdenian, where many spores appear and "persist through into the Westphalian assemblages". It is likely that many of the species present in the North Wales assemblages have a distribution extending up into the Westphalian, (not represented in the present study).

The genus Proprisporites has a similar distribution pattern in deposits from Stainmore, the southern Pennines and North Wales.

A striking difference between the middle and upper Namurian deposits of the Pennines and those of North Wales is the absence of Crassispora *kosankei* from the latter. It is widely recorded from the British Isles and is of significance in dating the base of the Kinderscoutian.

The restricted range recorded by Neves for the species *Dictyotriletes tuberosus* was also found in the North Wales deposits; it has been recorded from younger sediments from the Stainmore area. The species *Punctatisporites sinuatus*, *Ahrensisporites guerickei* and *Cirratriradites ornatus* all have a Marsdenian-Yeadonian distribution in North Wales, similar to that recorded by Neves from the southern Pennines.

Raistrickia fulvus was reported by Owens and Burgess from a coal of lower Westphalian age; it is recorded from a coal of Yeadonian, Upper Namurian age from North Wales.

Considering the absence of coal samples from all but the uppermost Namurian deposits in North Wales close comparisons can be made with similar allochthonous deposits from the Pennines showing a degree of similarity between the two areas

Studies of Namurian samples from Europe are mostly limited to deposits of Namurian A age. Horst (1955) recorded an assemblage from Silesia which contained many elements which are also found in the North Wales deposits; amongst these are *Remysporites magnificus*, *Lycospora uber*, *Schulzospora ocellata*, *Granulatisporites granulatus*, *G. microgranifer*, and *Raistrickia microhorrida*. In addition he found *Rotaspora knoxi* and species of *Tripartites*, which in the British Isles are characteristic of the "northern" deposits.

Neves (1964a) describes an assemblage which he calls the *Remysporites* magnificus zone from lower Namurian deposits in Spain. This includes Convolutispora mellita, C. florida, Raistrickia microhorrida, Savitrisporites nux, Densosporites spinosus, Schulzospora ocellata, and Remysporites magnificus; all of these are typical of lower Namurian deposits from North Wales. His Dictyotriletes bireticulatis zone extends up into the Westphalian A zone and includes species found in the younger Naumurian deposits of North Wales; Punctatisporites sinuatus, Calamospora liquida, Cirratriradites ornatus, Ahrensisporites guerickei, Savitrisporites nux, Florinites sp. and Schulzospora rara.

The Upper Mississippian microfloras from the Chester Series of the United States, as far as they can be correlated, are from the Viséan - Namurian boundary (Hoffmeister, Staplin and Malloy, 1955; Kosanke, 1964, Wilson, 1959). They contain the genera Grandispora, Tripartites, Rotaspora and Schulzospora which are characteristic of the time of the Viséan-Namurian boundary; Rotaspora and Tripartites have not been recorded from North Wales.

Miscellaneous species which occur sporadically along with the more typical species of common occurrence throughout Europe reflect a regional variation in the composition of the microflora. There is a general similarity in composition of the microfloras between the Naumurian assemblages from North Wales and those from the rest of the British Isles and Europe. The macroflora of this time is not well represented in North Wales and no direct comparisons can be made.

SUMMARY

Elements of the Viséan assemblage from North Wales can be found in lower to middle Viséan assemblages from many other parts of the world but the assemblage as a whole is not directly comparable with any of these. The most similar assemblages are those making up the northern floral province defined by Playford and Barss, in particular the assemblages from Spitsbergen. The Viséan assemblages from the Forest of Dean described by Sullivan may also be included within this province. Minor differences exist between all of these assemblages which may be attributed to regional variation in the macroflora.

The Viséan assemblage from North Wales falls within the palaeolatitude of the Grandispora suite, 20 N. to 20 S., as defined by Sullivan for Upper Mississippian microfloras; yet it has none of the characters of that suite in spite of its Upper Mississippian age. It is concluded that the divisions created by Sullivan are historical rather than geographical. Whilst it is broadly true that vegetational belts today change with latitude, they are also affected by land masses and altitude. In the absence of more detailed knowledge concerning these facts it is impossible to create meaningful divisions simply on the basis of palaeolatitude. The Grandispora suite is taken to be typical of the late Upper Mississippian microfloras, of the Viséan-Namurian boundary in Europe, whilst the Monilospora suite, with which the North Wales assemblage has points in common, is of older Upper Mississippian age, Viséan in Europe.

The Lower Carboniferous macroflora has been divided into two groups by Jongmans. Those of the upper part, Upper Viséan in age, have more

in common with the succeeding Namurian flora, whilst those of Lower Viséan and Tournaisian age are more like the Devonian flora. Lacey states that the macroflora of the Lower Brown Limestone, from the S2 - D1 zone, appears to occupy an intermediate position, and suggested a middle to upper Viséan age. The evidence gained from this study of the microflora from the Basement beds would place these deposits, also in an intermediate position, of Lower to middle Viséan age.

The Namurian assemblages show a stratigraphical pattern from the older to the younger sediments throughout the period. These are related to the sequence of goniatite zones. The distribution pattern indicates that there are horizons at which significant changes take place in the composition of the microflora, permitting the recognition of specific horizons. Comparisons show a degree of similarity with the Namurian deposits of the southern Pennines and those from Europe.

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Explanation of Plate 1

All figures x450, unless otherwise stated.

Fig. 1. *Leiotriletes inermis* (Waltz) Ishchenko 1952. Preparation L.C.2b, 32·3 97·1

Fig. 2. *Leiotriletes subintortus* (Waltz) Ishchenko var. *rotundatus* Waltz 1952. Preparation L.C. 2 b, 21·4 96·0

Fig. 3. *Leiotriletes tumidus* Butterworth and Williams 1958. Preparation L.C. 1a, 23·0 109·4.

Fig. 4. *Leiotriletes ornatus* Ishchenko 1956. Preparation L.C.2e, 39·6 101·4

Figs. 5 6, 8. *Punctatisporites glaber* (Naumova) Playford 1962. 5 and 6, Preparation L.C.2e, 33·5 104·8 and 33·7 104·8; 8, Preparation L.C.10c, 26·6 109·7.

Fig. 7. *Punctatisporites irrasus* Hacquebard 1957. Preparation L.C. 5b, 21·3 110·0

Fig. 9. *Punctatisporites* cf. *obesus.* Neves 1958. Preparation A.M. 1c, 31·9 106.4. (x500)

Fig.10 *Leiotriletes auritus* Ishchenko 1956. Preparation A.M.7a, 27·4 105·7. (x500)

Fig.11 *Punctatisporites sinuatus* (Artuz) Neves 1961. Preparation AU.C. 21c, 45·2 103·2.

Fig.12, 19. *Calamospora microrugosa* (Ibrahim) Schopf, Wilson and Bentall 1944. 12, Preparation A.M. 22b, 20·0 109·2; 19, Preparation L.C. 2e, 25·6 102·0.

Fig.13 *Calamospora liquida* Kosanke 1950. Preparation U.C. 21b, 40·0 94·1

Fig. 14 *Granulatisporites visensis* sp. nov. Holotype, proximal surface; preparation L.C. 11b, 57·2 104·9

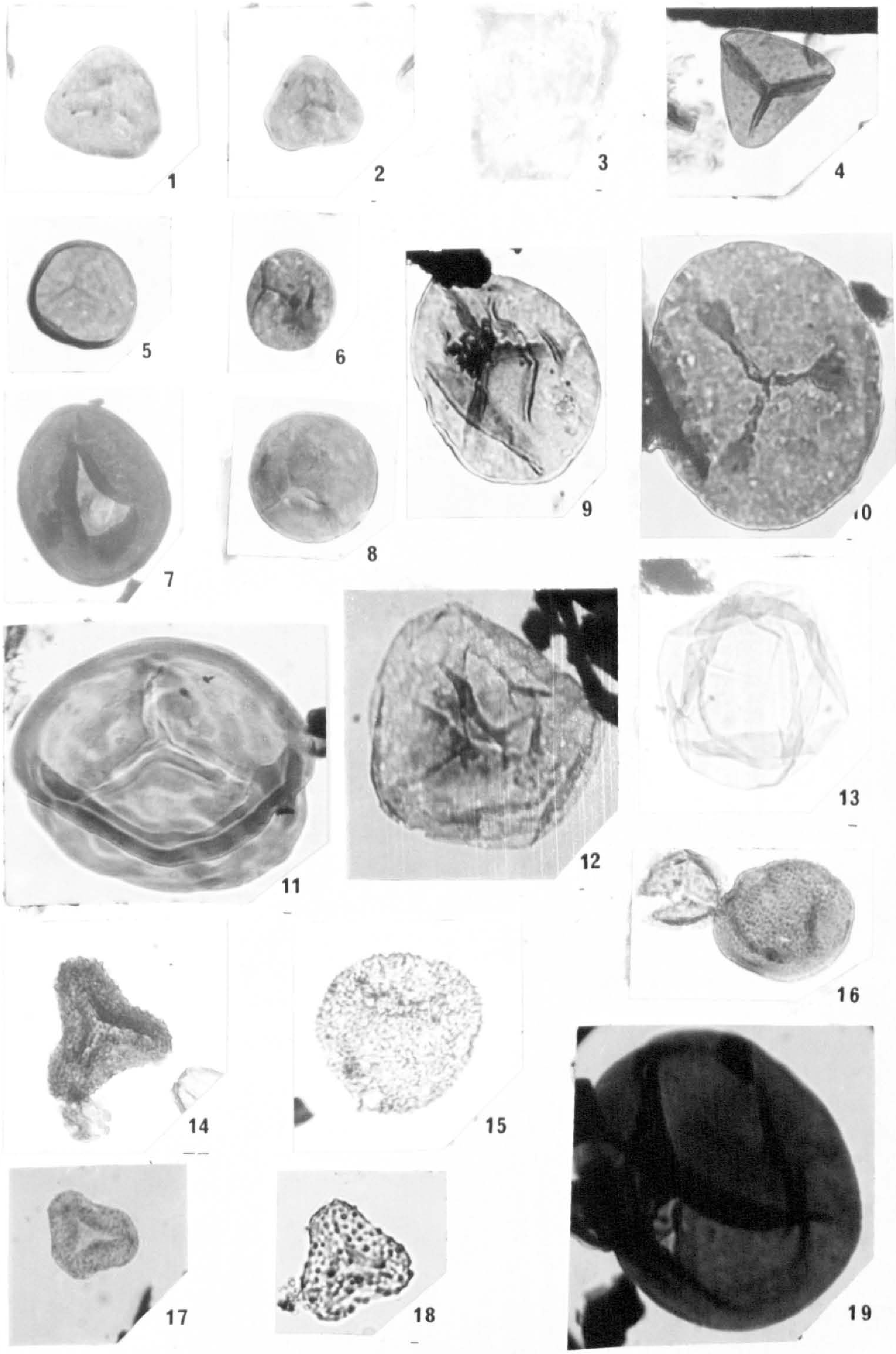
Fig.15 *Cyclogranisporites aureus* (Loose) Potonié and Kremp 1955 Preparation A.M. 23b, 55·4 92·9

Fig.16 *Cyclogranisporites lasius* (Watz) Playford 1962. Preparation L.C. 2e, 24·0 104·8

Fig. 17. Granulatisporites micrografer Ibrahim 1933
Preparation U.C. 1b, 45·2 102·4

Fig. 18. Granulatisporites granulatus Ibrahim 1933. Preparation
A.M. 18d, 53·7 107·6. (×500)

PLATE 1



Explanation of Plate 2

All figures ×450, unless otherwise stated.

Fig. 1. *Waltzispora planiangulata* Sullivan 1964. Preparation L.C.2. 41·4 101·7.

Fig. 2. *Lophotriletes tribullosus* Sullivan 1964. Preparation L.C. 9b. 33·3 95·4

Fig. 3. *Verrucosisporites morulatus* (Knox) Smith and Butterworth 1964. Preparation U.C. 4c, 33·2 99·4

Fig.4. *Anapiculatisporites tenuispinosus* sp. nov. Holotype, proximal surface; preparation L.C.4c, 44·3 98·8

Figs.5, 6 *Verrucosisporites eximius* Playford 1962. 5, proximal surface; Preparation M.S. 182. 6, proximal surface; Preparation M.S.144.

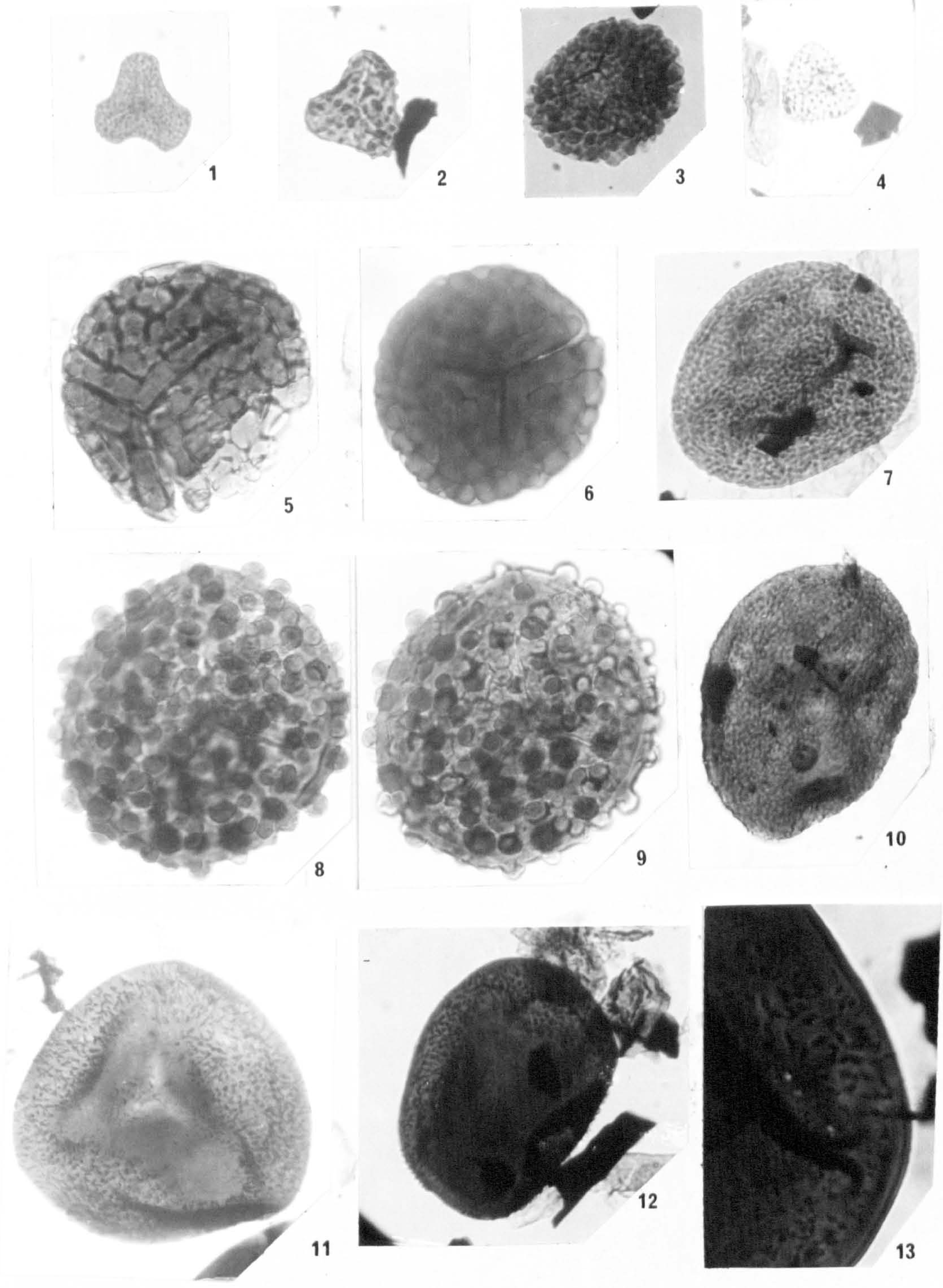
Fig.7. *Verrucosisporites donarii* Potonié and Kremp 1955. Preparation U.C. 21d, 44·0 105·9.

Figs. 8, 9 *Verrucosisporites tuberculatus* sp. nov. Holotype, showing distal ornament; preparation M.S. 177. 9, Holotype, proximal surface; Preparation M.S. 177.

Fig.10. *Verrucosisporites verrucosus* Ibrahim 1933. Preparation U.C.7c, 30·1 108·3

Figs.11, 12, 13. *Umbonatisporites variabilis* gen et sp. nov. 11, proximal surface; preparation L.C.2e, 44·4, 99·0. 12, distal surface; preparation L.C. 2c, 44·0 99·0. 13, detail of ornament; preparation L.C. 2c, 14·6 106·8 (oil immersion ×750)

PLATE 2



Explanation of Plate 3.

All figures X 450, unless otherwise stated.

Fig. 1. *Acanthotriletes castanea* Butterworth and Williams 1958. Preparation A.M. 19c, 45·0 107·0.

Fig. 2. *Acanthotriletes cuspidens* sp. nov. Holotype; Preparation U.C.4a, 11·5 91·8

Fig. 3. *Apiculatisporis* cf. *variocorneus* Sullivan 1964. Preparation U.C. 3a, 20.0 97·7.

Fig. 4. *Apiculatisporis cambrensis* sp. nov. Holotype; Preparation U.C.3a, 20·0 97·7.

Fig. 5. *Ibrahimisporis brevispinosus* Neves 1961. Preparation A.M.6c, 52·0 107·3 (x 500)

Figs. 6, 7. *Ibrahimisporis nobilis* sp. nov. 6, Holotype; 7, details of ornament (x750); Preparation U.C. 4b, 48·9 108·9

Fig.8. *Acanthotriletes horridus* Hacquebard. Preparation U.C.12c, 24·2 109·7.

PLATE 3

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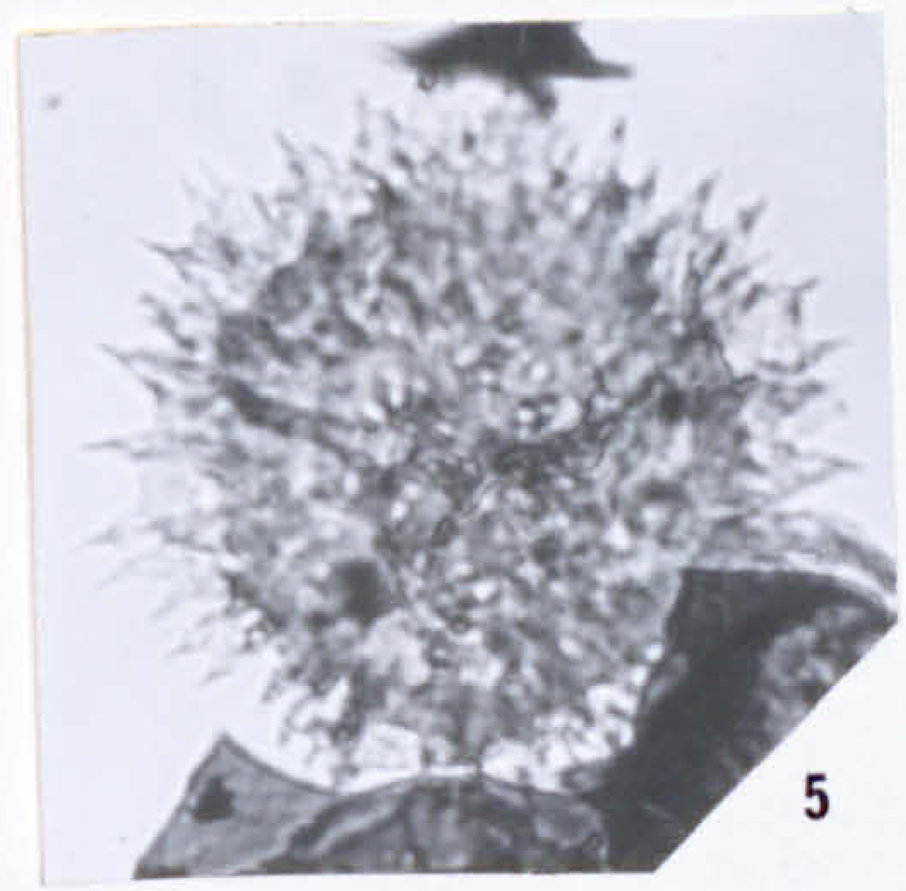

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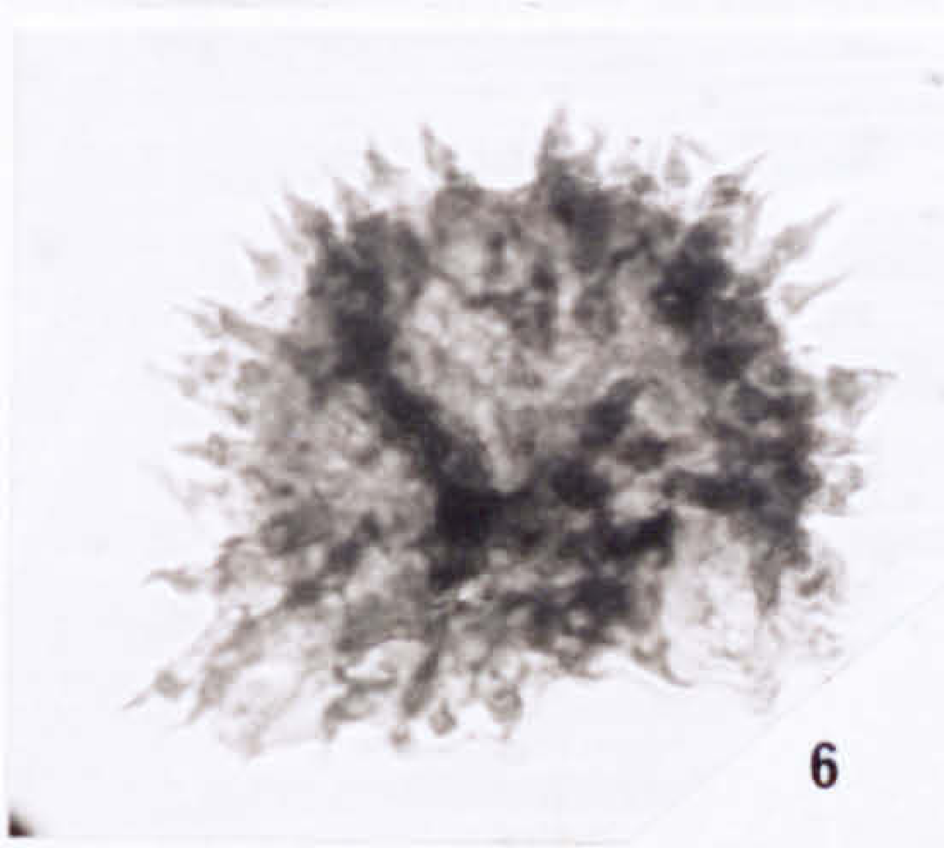

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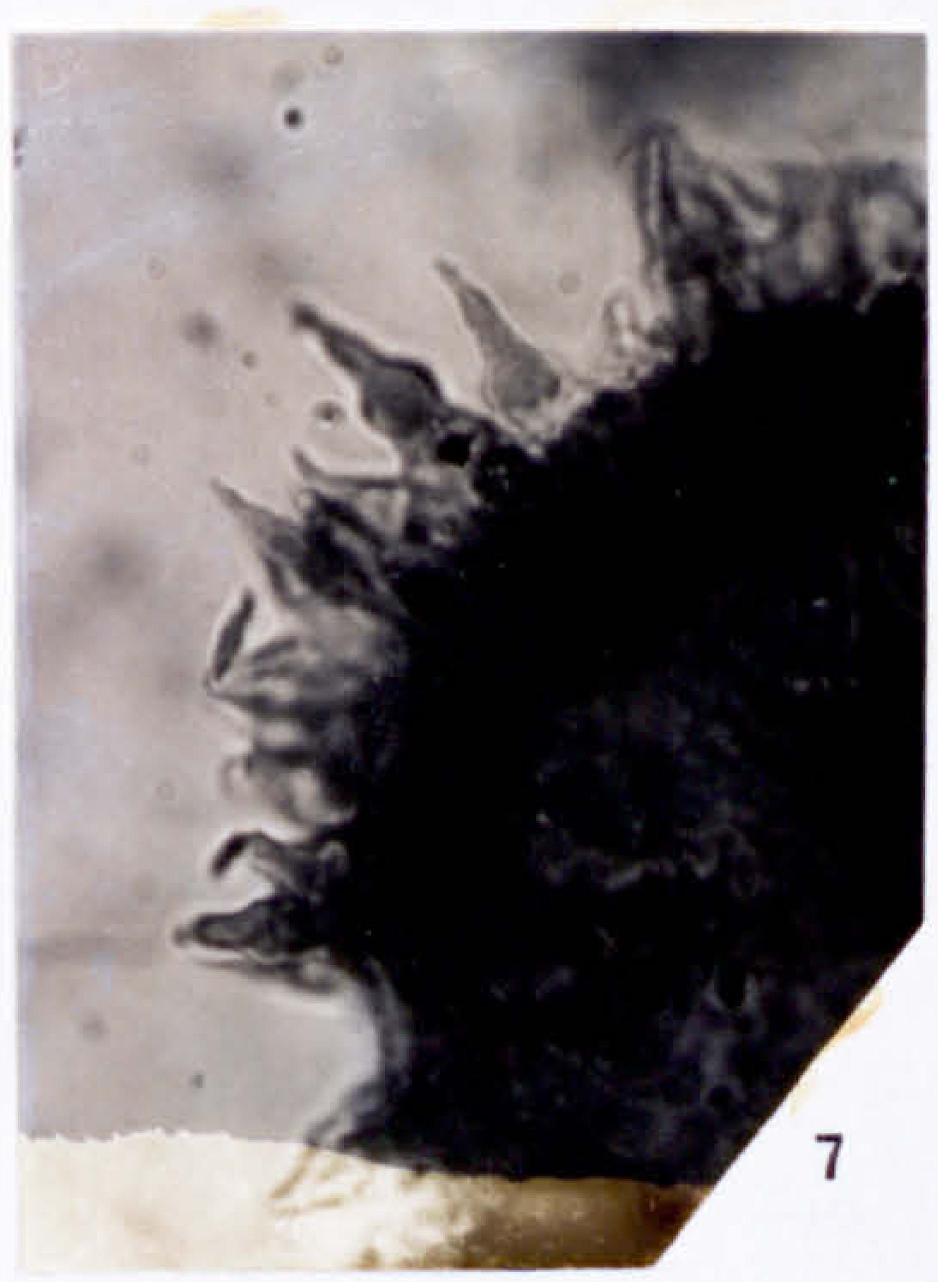

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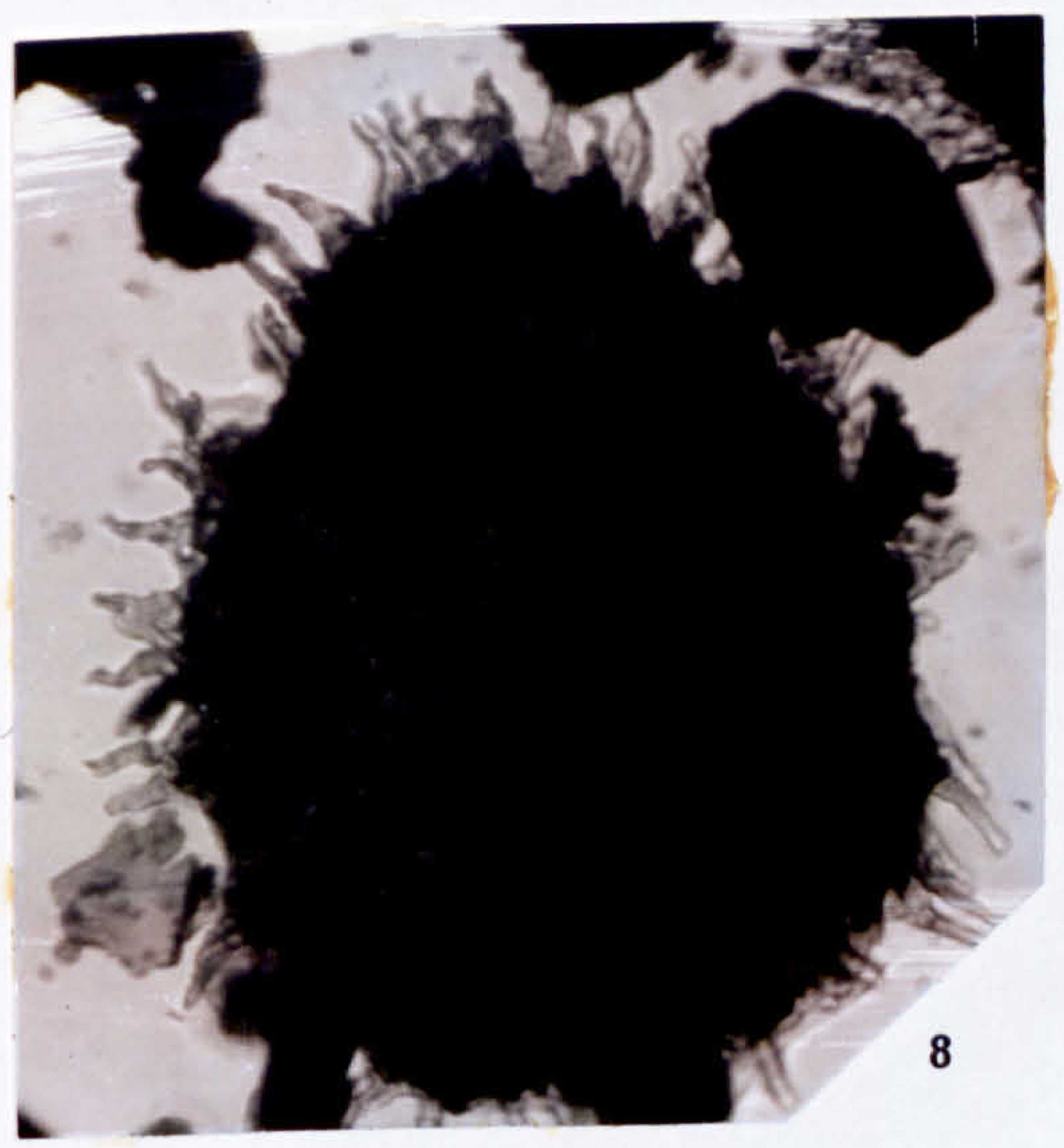

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Explanation of Plate 4.

All figures ×450, unless otherwise stated.

Fig. 1. *Raistrickia fulvus* Artuz 1957. Preparation U.C. 21d, 8·8 103·9

Fig. 2. *Raistrickia microhorrida* (Horst) Potonié and Kremp 1955. Preparation A.M. 7c, 38·4 95·5 (× 500.)

Fig. 3. *Raistrickia vulgaris* sp. nov. Holotype; Preparation U.C.6c, 23·7 107·4.

Figs. 4, 5. *Raistrickia rugosa* sp. nov. 4, Holotype, proximal surface; Preparation L.C. 4a, 54·8 97·0. 5, distal surface; preparation M.S. 170.

Fig. 6. *Neoraistrickia drybookensis* Sullivan 1964. Preparation L.C.5/2b, 23·0 100·2.

Fig. 7. *Camptotriletes superbus* Neves 1961. Preparation U.C.21c, 48·0 103·8.

Fig. 8. *Camptotriletes verrucosus* Butterworth and Williams 1958. Preparation L.C. 2e, 32·9 98·5.

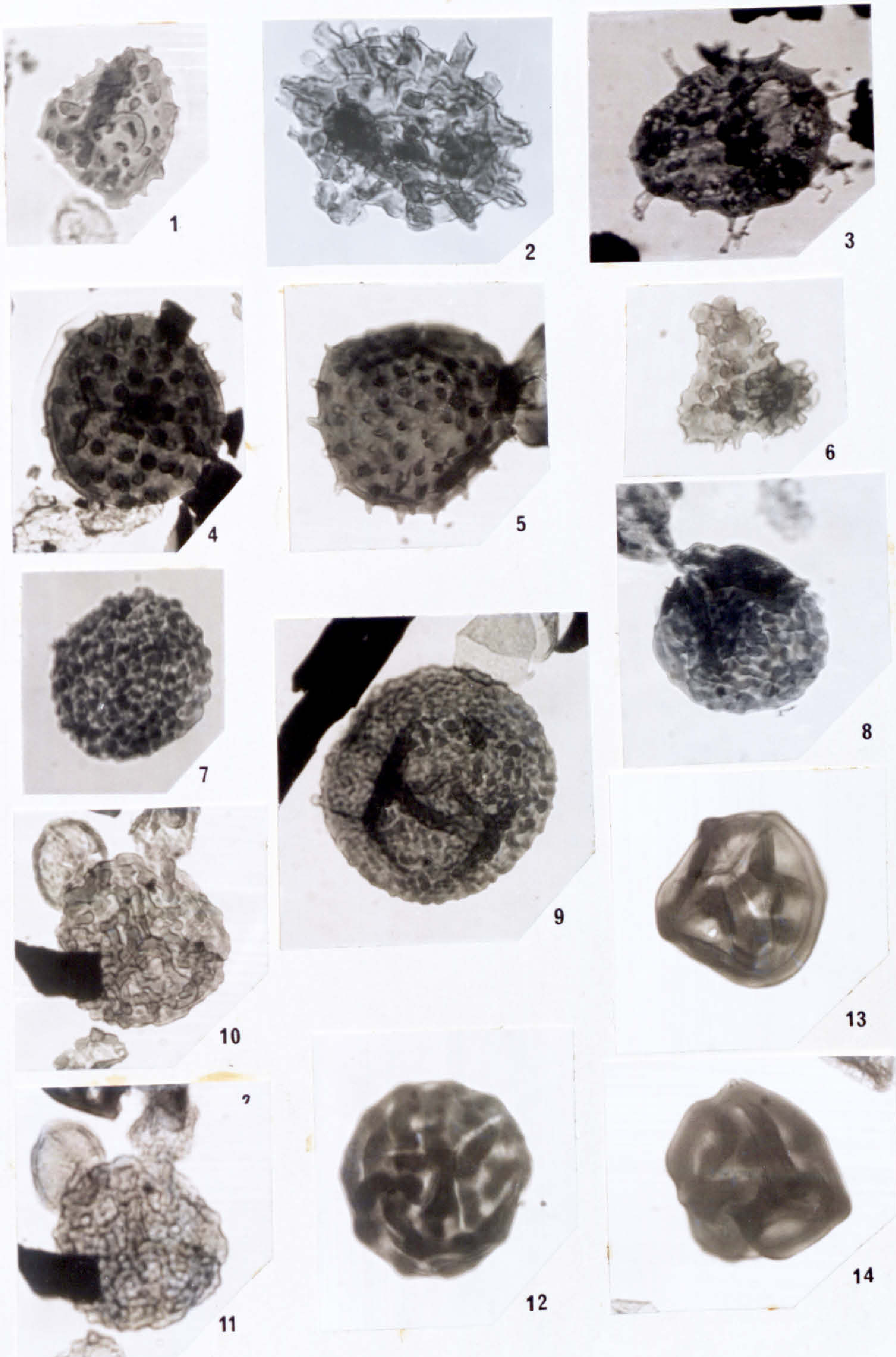
Fig. 9. *Convolutispora tuberculata* (Waltz) Hoffmeister, Staplin and Malloy 1955. Preparation A.M. 19g, 41·8 107·4.

Figs.10, 11. *Convolutispora labiata* Playford 1962. 10, proximal surface; Preparation L.C. 3a, 32·8 105·2. 11, distal surface; Preparation L.C.3a, 32·8 105·2.

Figs. 12, 14. *Convolutispora vermiculata* sp. nov. 12, Holotype, proximal surface; preparation L.C. 2b, 41·8 96·4 14, distal surface; preparation L.C. 2e, 32·8 105·2.

Fig. 13. *Convolutispora vermiformis* Hughes and Playford 1961. Proximal surface; preparation M.S. 65.

PLATE 4



Explanation of Plate 5

All figures x 450, unless otherwise stated.

Fig. 1. Convolutispora florida Hoffmeister, Staplin and Malloy 1955. Preparation A.M. 1c, 53·1 105·4 (x500)

Fig. 2. Convolutispora obliqua Neves 1961. Preparation A.M. 124.

Fig. 3. Convolutispora mellita Hoffmeister, Staplin and Malloy 1955. Preparation A.M.6a, 42·7 102·0 (x500).

Fig. 4. Dictyotriletes cf. peltatus Playford. Preparation L.C. 3a, 25·3 103.5

Figs. 5, 6 Dictyotriletes radiatus sp.nov. Holotype; 5, distal surface; 6 proximal surface; preparation L.C. 5c, 15·2 106·8.

Figs. 7, 8. Dictyotriletes tesselatus sp. nov. Holotype; 7, distal surface; 8, proximal surface; preparation L.C. 3a, 55·7 93·2.

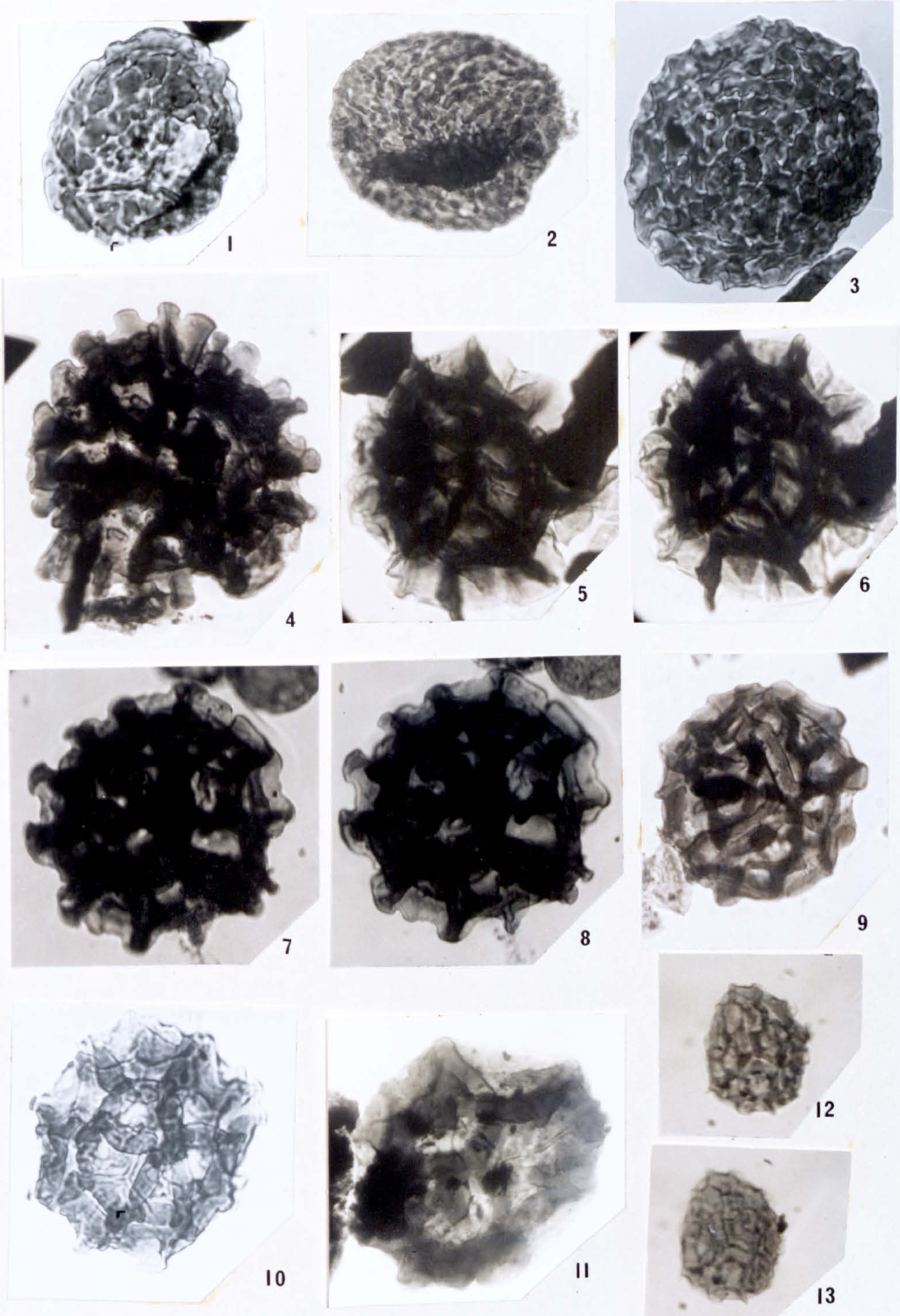
Fig. 9. Dictyotriletes cancellatus (Waltz) Potonié and Kremp 1955. Preparation L.C. 10c, 37·4 110·8.

Fig.10. Dictyotriletes piliformis sp. nov. Preparation A.M. 16d, 27·0 107·9 (x500).

Fig. 11. Dictyotriletes tuberosus Neves 1961. Distal surface,; preparation U.C. 9a, 53.3 96.4

Figs. 12, 13. Dictyotriletes vagus sp. nov. Holotype; 12, distal surface; 13, proximal surface; preparation U.C. 9b 25·3 103·0.

PLATE 5



Explanation of Plate 6.

All figures × 450

Figs. 1, 2, *Perotriletes reticulatus* sp. nov. 1, Holotype, distal surface; preparation L.C. 2e, 43·4 99·1. 2, proximal surface; preparation L.C.2b, 21·6 113·2.

Fig. 3. *Perotriletes punctatus* sp. nov. Holotype, distal surface; preparation L.C.2e, 29·1 94·6

Fig. 4. *Perotriletes magnus* Hughes and Playford 1961. Preparation L.C. 2e, 41·8 102·2.

Fig. 5. *Ahrensisporites guerickei* (Horst) Potonié and Kremp 1955. Preparation U.C. 7d, 45·3 103·1.

Figs, 6,7. *Knoxisporites concentricus* sp. nov. Holotype; 6, proximal surface; 7, distal surface; preparation U.C. 6c, 45·4 97·3.

Figs. 8, 9. *Knoxisporites convolutus* sp. nov. Holotype; 8, proximal surface; 9, distal surface; preparation L.C.5c, 24·2 100·8.

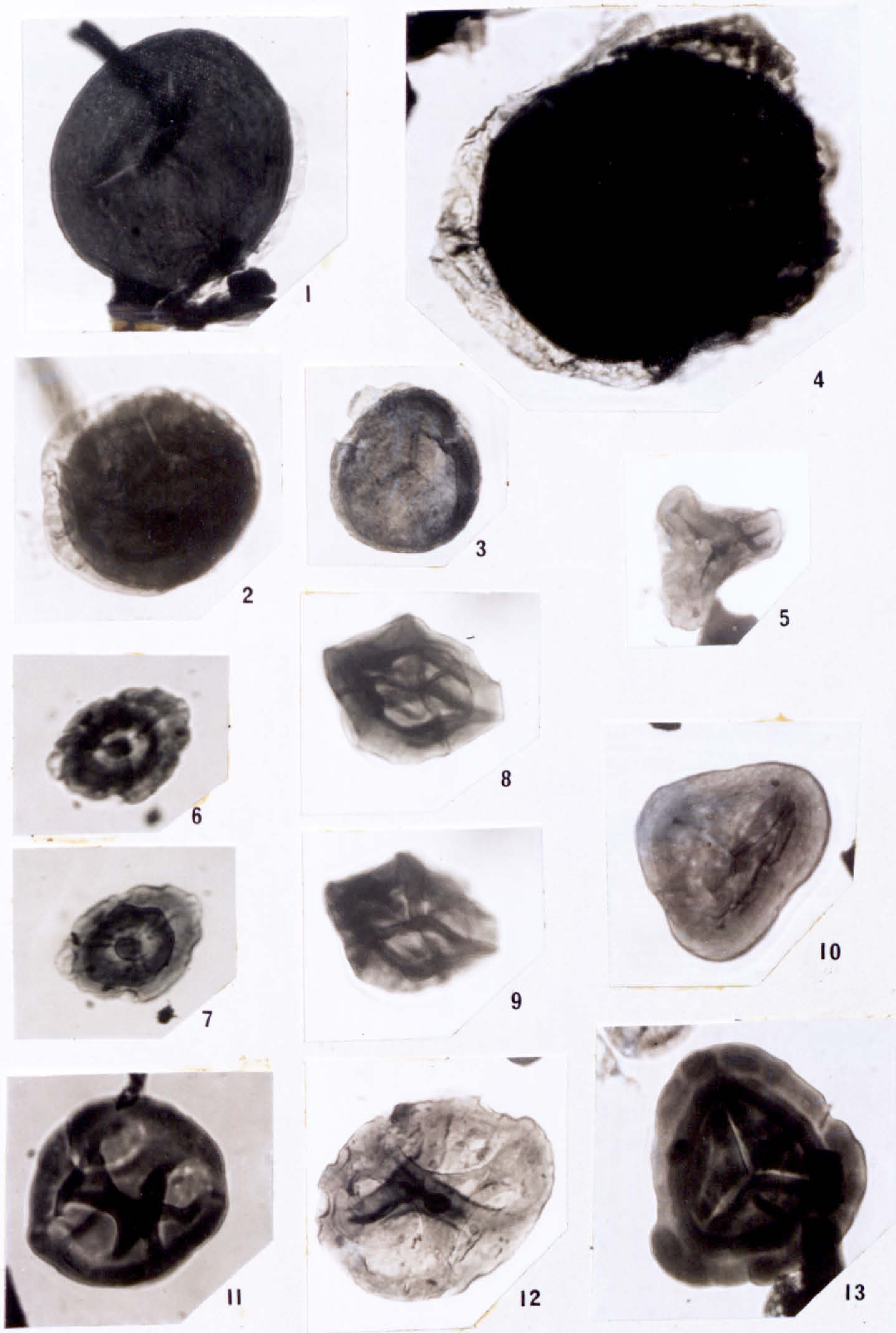
Fig. 10. *Murospora intorta* (Waltz) Playford 1962. Preparation U.C. 5/2a 43·6 97·1.

Fig. 11. *Knoxisporites triradiatus* Hoffmeister, Staplin and Malloy 1955, Preparation U.C.3c, 19·4 97·5.

Fig. 12. *Knoxisporites seniradiatus* Neves 1961. Preparation U.C.5b, 50·5 105·4.

Fig. 13. *Murospora aurita* (Waltz) Playford 1962. Preparation L.C.7b, 33·4 101·6.

PLATE 6



Explanation of Plate 7.

All figures ×450, unless otherwise stated.

Fig. 1. Knoxisporites cf. rotatus. Hoffmeister, Staplin and Malloy. 1955
Preparation A.M. 22a, 45·1 104·3 (×500).

Fig. 2. Anulatisporites anulatus (Loose) Potonié and Kremp 155.
Preparation A.M.6a, 39.6 103·4 (×500).

Fig. 3. Densosporites intermedius Butterworth and Williams 1958
Preparation U.C. 9a, 37·9 101·6.

Fig. 4. Densosporites spinosus Dybova and Jachowicz 1957. Preparation
U.C. 1a, 22·8 98·0

Fig. 5. Densosporites striatus (Knox) Butterworth and Williams, 1958.
Preparation A.M.7f, 53·4 97·8.

Figs. 6, 7 Lophozonotriletes muricatus sp. nov. Holotype; 6, proximal
surface; 7, distal surface; preparation L.C.6b, 46·7 101·4.

Fig. 8. Cristatisporites indignabundus (Loose) Potonié and Kremp 1955.
Preparation U.C. 3c, 35·6 109·9.

Fig. 9. Densosporites cuneiformis Hacquebard and Barss 1957
Preparation U.C. 1b, 52·5 98·2.

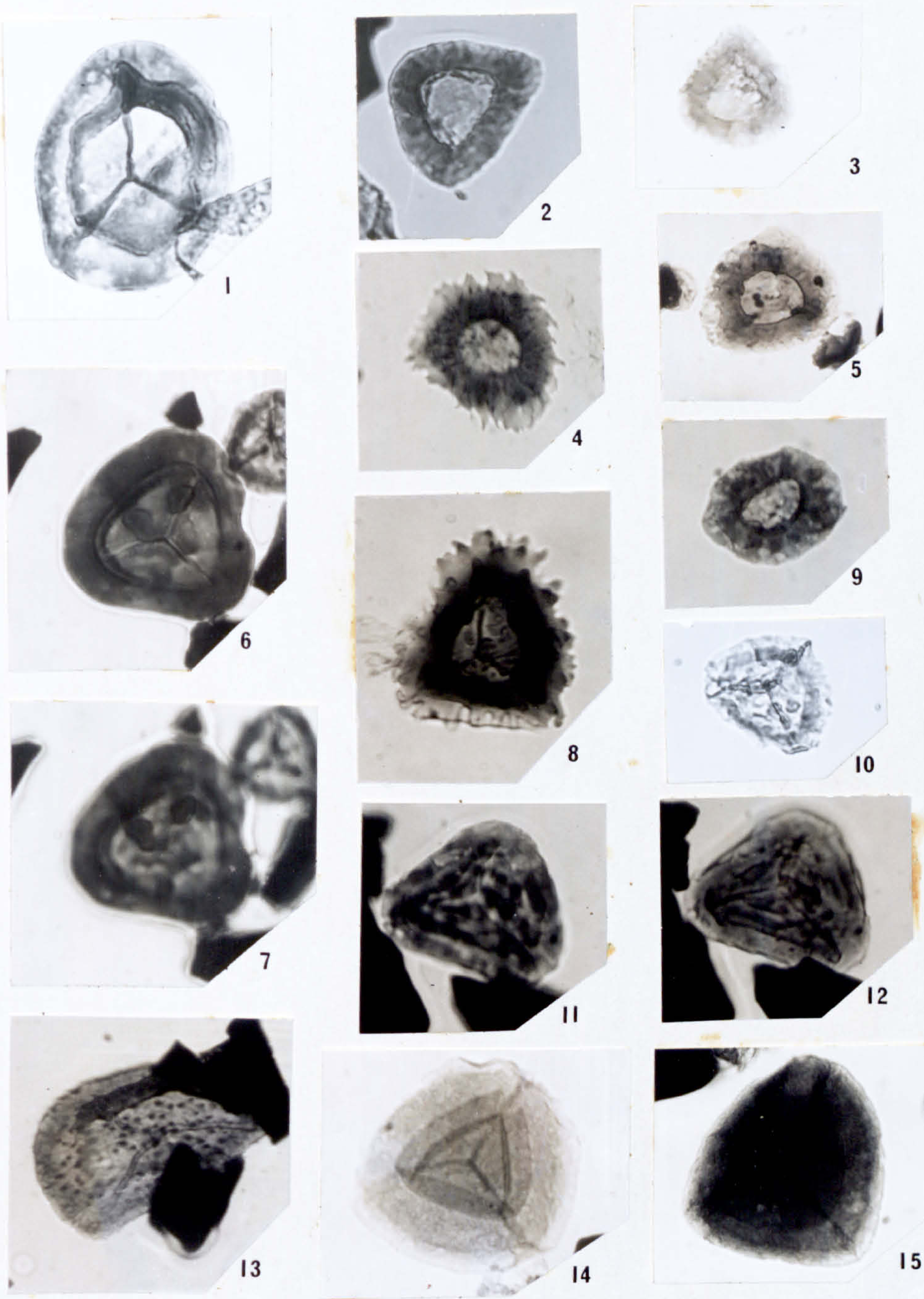
Fig.10. Lycospora uber (Hoffmeister, Staplin and Malloy) Staplin 1960.
Preparation A.M. 16a, 36·5 107·2. (×500)

Figs.11, 12. Savitrisporites nux. (Butterworth and Williams) Sullivan 1965
11, distal surface; 12, proximal surface; preparation U.C.1b,
46·9 109·1

Fig.13. Cirratriradites ornatus Neves 1961. Preparation U.C.1a,
22·3 93·4.

Figs.14, 15. Cirratriradites elegans. (Waltz) Potonié and Kremp 1955.
14, preparation L.C. 2b, 31·4; 15, preparation L.C.2b 33·8
104. 3.

PLATE 7



Explanation of Plate 8.

All figures x450, unless otherwise stated.

Figs 1, 2. *Vallatisporites ciliaris* (Luber) Sullivan 1964
1, distal surface; 2, proximal surface; preparation L.C. 2e, 45·1 99·6.

Figs. 3,4. *Vallatisporites microgalearis* sp. nov. Holotype; 3, distal surface; 4, proximal surface; preparation L.C. 10c, 24·5 101.9.

Figs. 5, 6. *Vallatisporites spinosus* sp. nov. Holotype; 5, proximal surface; 6, distal surface; preparation L.C.2c, 28·9 95·5.

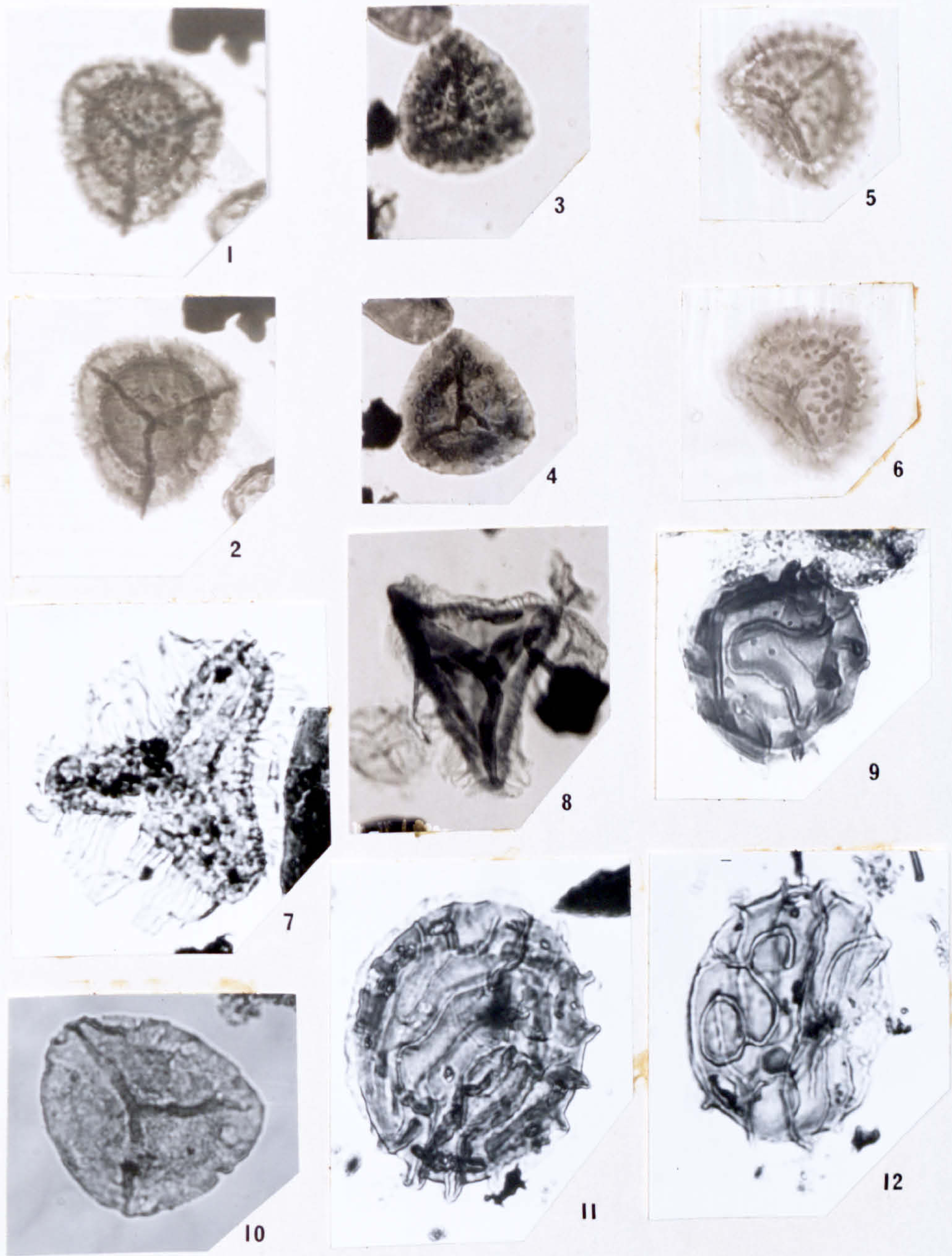
Fig. 7. *Reinschospora speciosa* (Loose) Schopf, Wilson and Bentall, 1944. Preparation A.M. 1a, 43·1 99·6 (x500).

Fig. 8. *Reinschospora* cf. *triangularis* Kosanke. Preparation U.C.1c, 44·0 108·6.

Figs. 9,11, 12. *Proprisporites glaber* sp. nov. 9, holotype, proximal surface; preparation U.C.3c, 30·3 101·5;11, distal surface; preparation A.M.19a, 24·0 97·9 (x500); 12, preparation A.M.19a, 46·4 101·4 (x500).

Fig.10. *Endosporites micromanifestus* Hacquebard 1957. Preparation A.M. 6e, 53·2 107·1. (x500).

PLATE 8



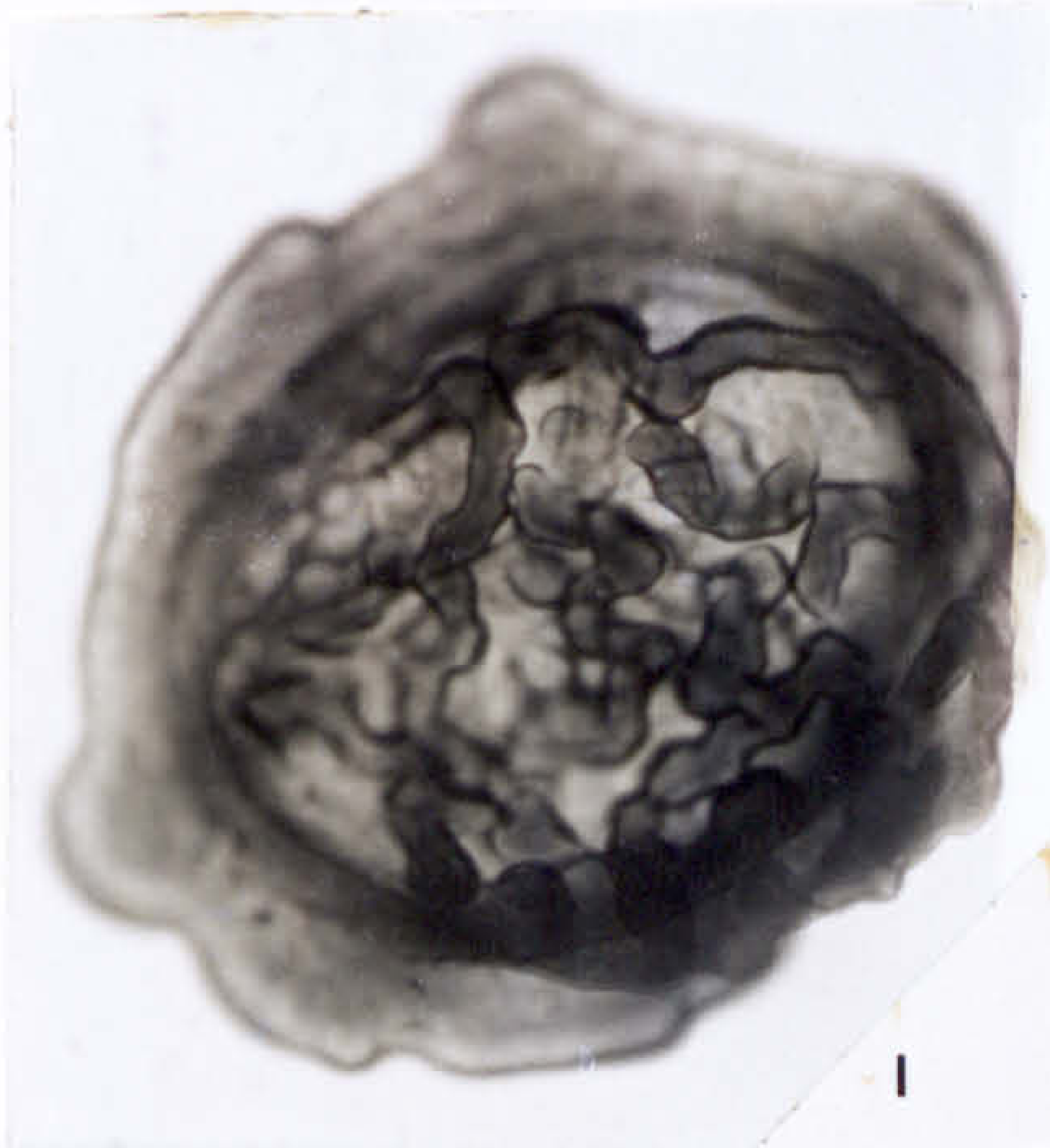
Explanation of Plate 9.

Figs. 1, 2. Diversizonotriletes intestinalis gen. et sp. nov. 1, distal surface; 2, proximal surface; preparation M.S. 132. (x450).

Fig. 3. Remysporites magnificus Butterworth and Williams 1958 Preparation M.S. 238 (x450).

Figs. 4,5,6. Florinites elegans. Wilson and Kosanke 1944. 4, preparation A.6a, 52·2 104·4; 5, showing the central body about to become detached from the saccus; preparation A.M.6c, 39·2 98·4; 6, preparation A.M.1d, 26·2 96·3 (x500).

PLATE 9



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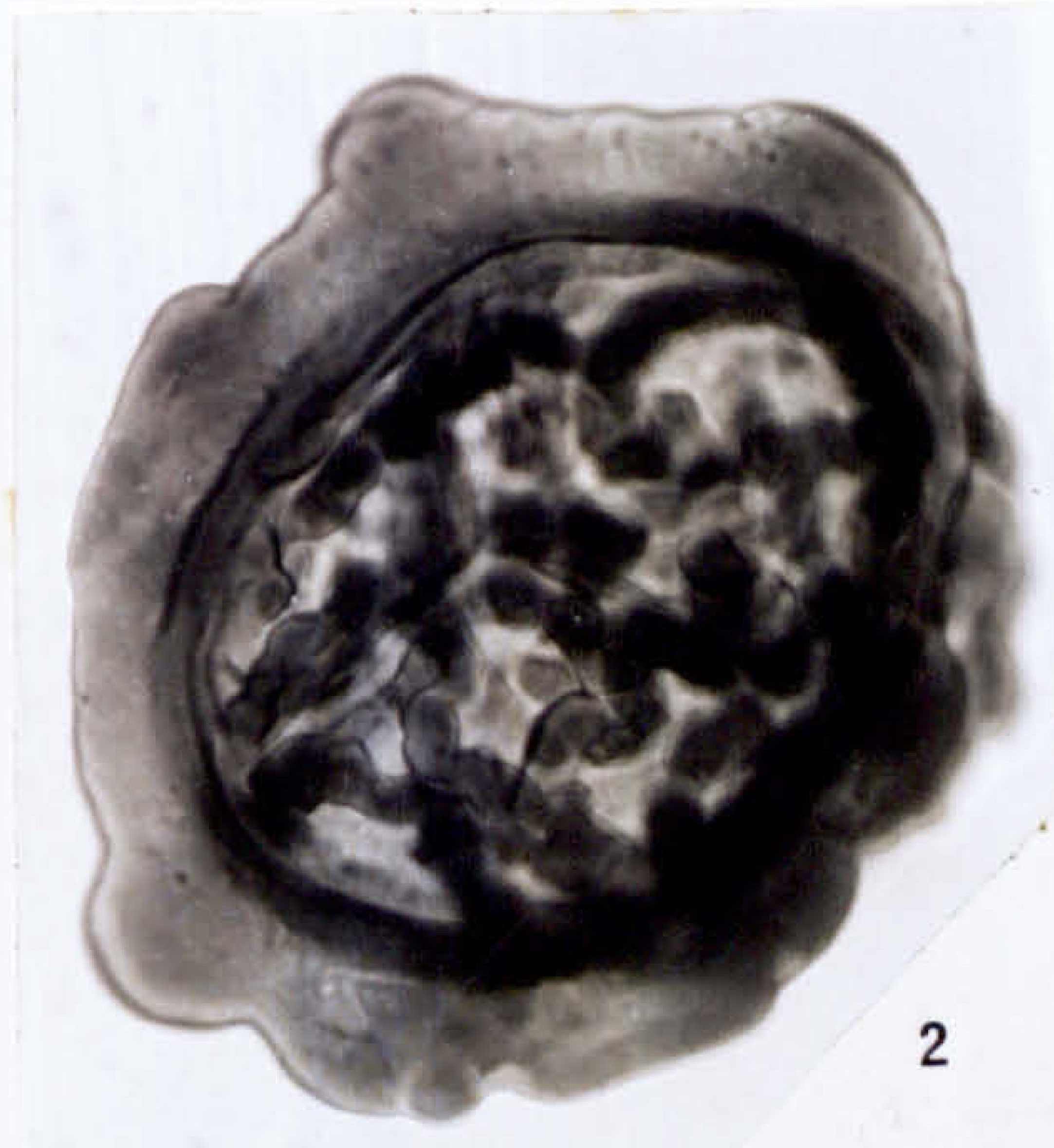

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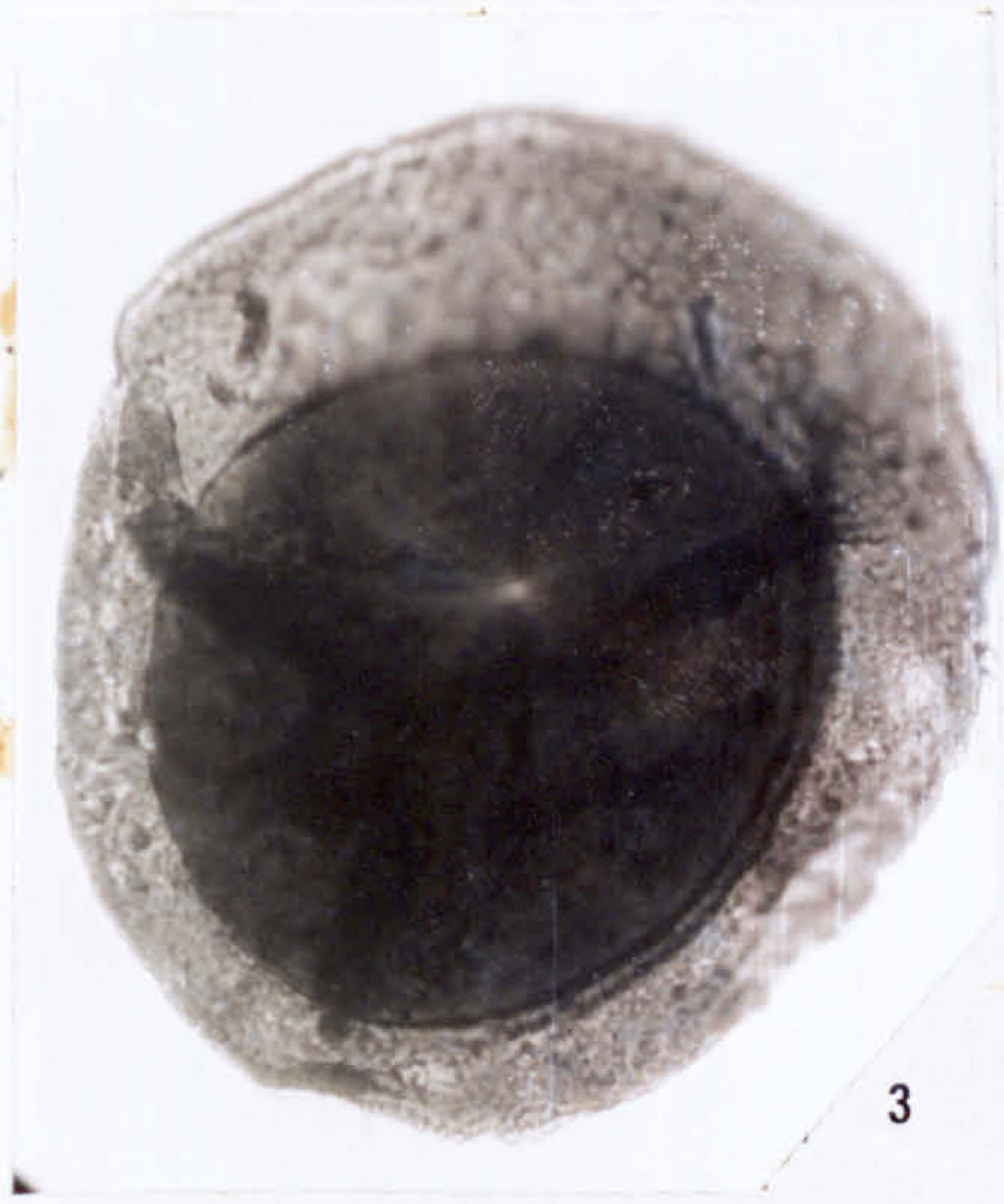

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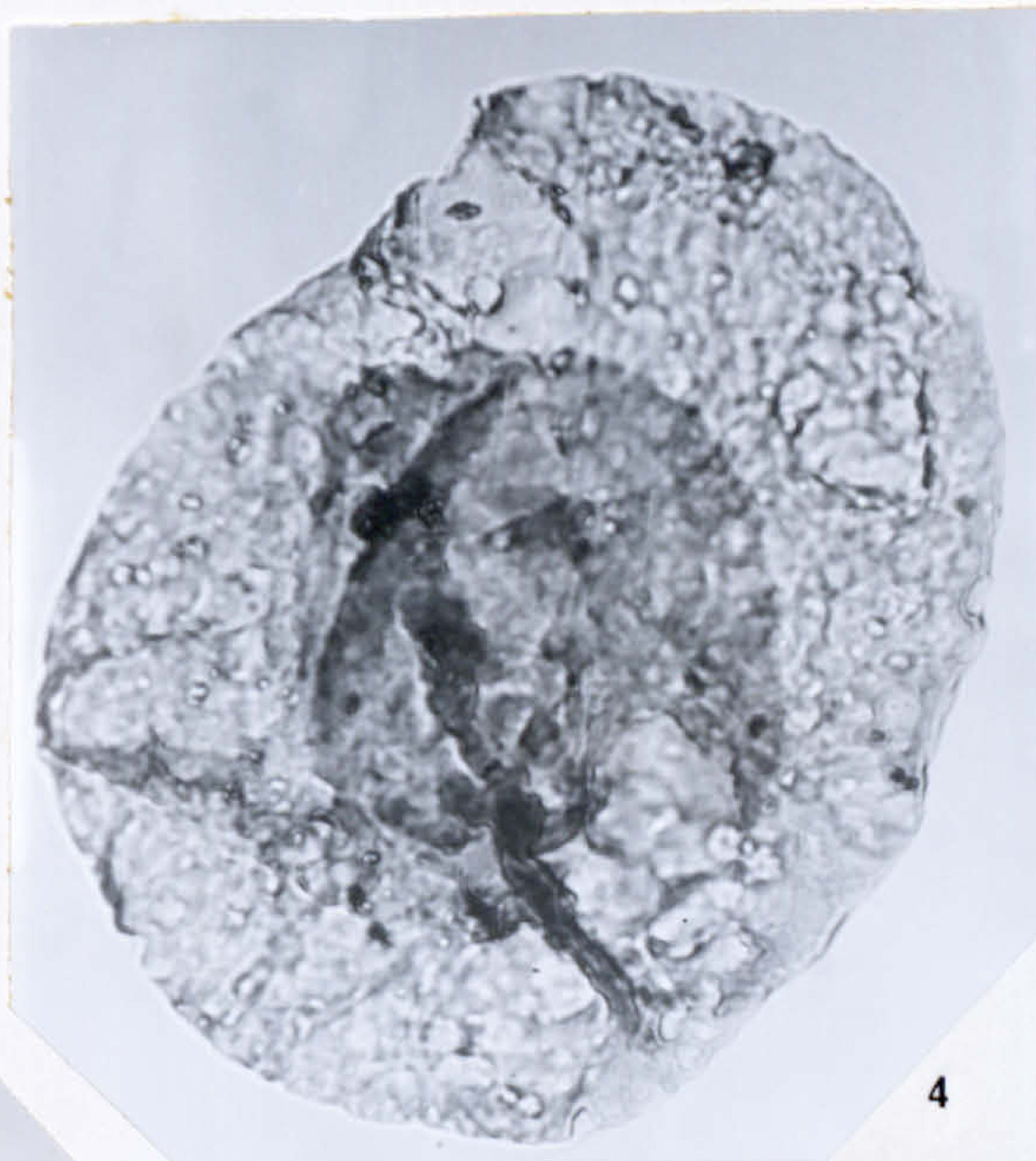

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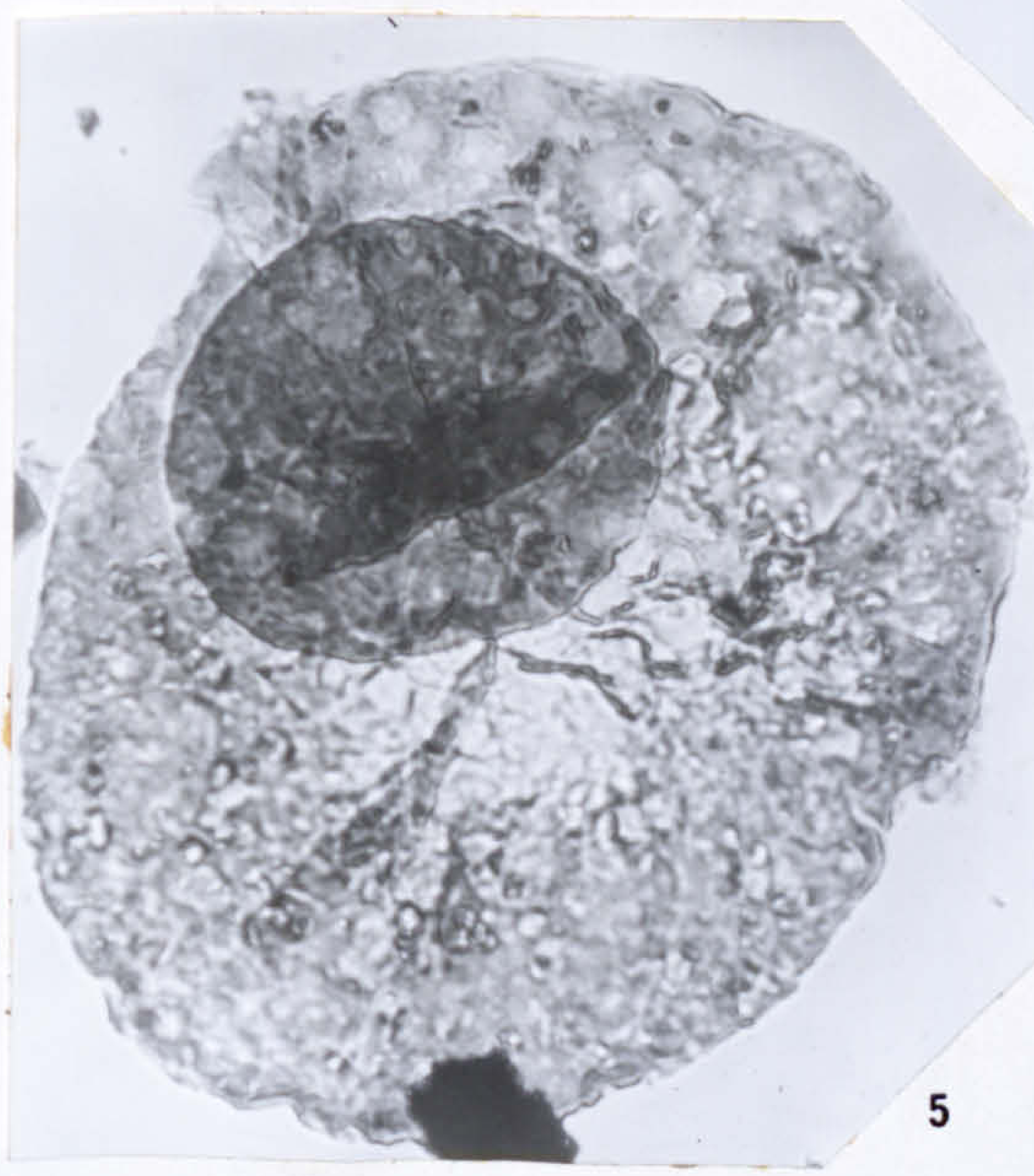

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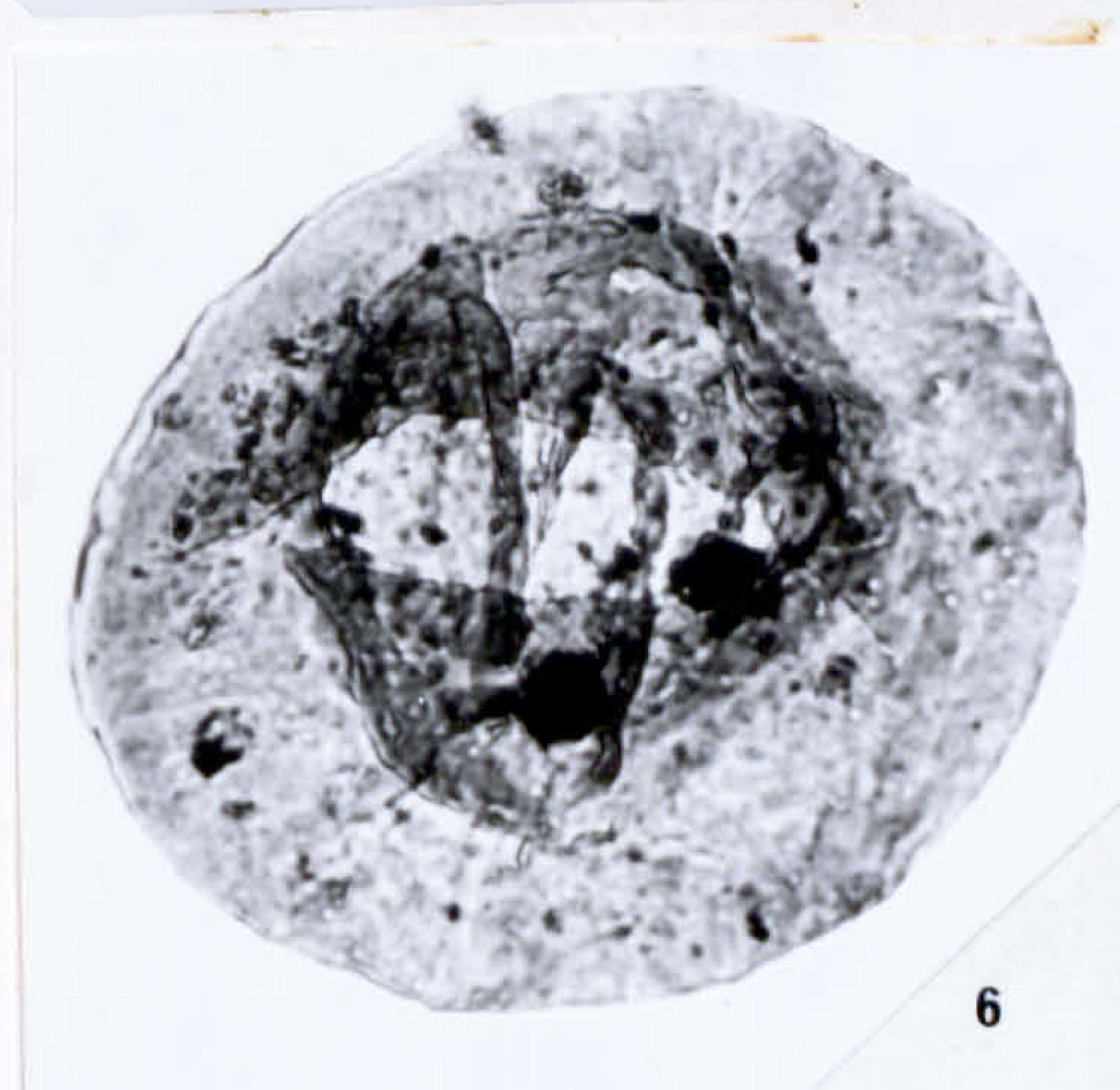


6

Explanation of Plate 10.

All figures ×450, unless otherwise stated.

Figs. 1, 2. Spinozonotriletes reticulatus sp. nov. Holotype; 1, distal surface; 2, proximal surface; preparation L.C.2e, 45·5 107·6.

Figs. 3,4, 5. Spinozonotriletes marginatus. sp. nov. 3, distal surface; 4, proximal surface; preparation M.S. 6. 5, holotype; proximal surface; preparation L.C.2e, 55·6, 110·9.

Fig. 6. Schulzospora ocellata (Horst) Potonie and Kremp 1955. Preparation A.M. 7f, 45·0 96·1

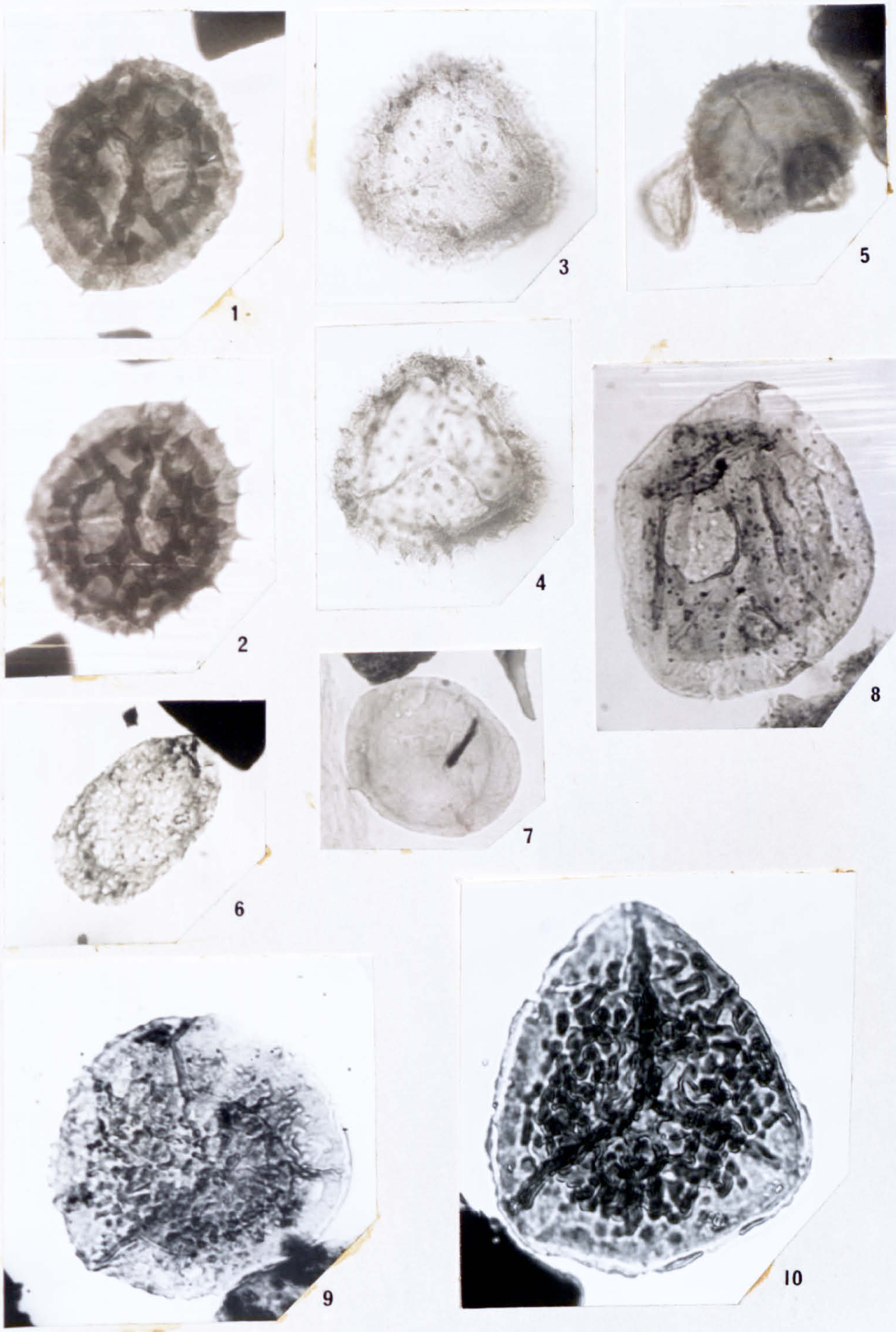
Fig. 7. Schulzospora rara Kosanke. Preparation U.C. 21d, 31·8 100·0

Fig. 8. Grandispora spinosa Hoffmeister, Staplin and Malloy 1955. Preparation A.M. 19g, 34·8 107·3.

Fig. 9. Discernisporites dentatus sp. nov. Holotype, distal surface; preparation U.C.5b, 47·2 110·7.

Fig.10 Discernisporites vermiformis sp. nov. Holotype, distal surface; preparation A.M. 22d, 56·2 106·2. (x 500)

PLATE 10



Explanation of Plate 11.

Figs. 1 - 4. Tetrapterites visensis Sullivan and Hibbert 1964.

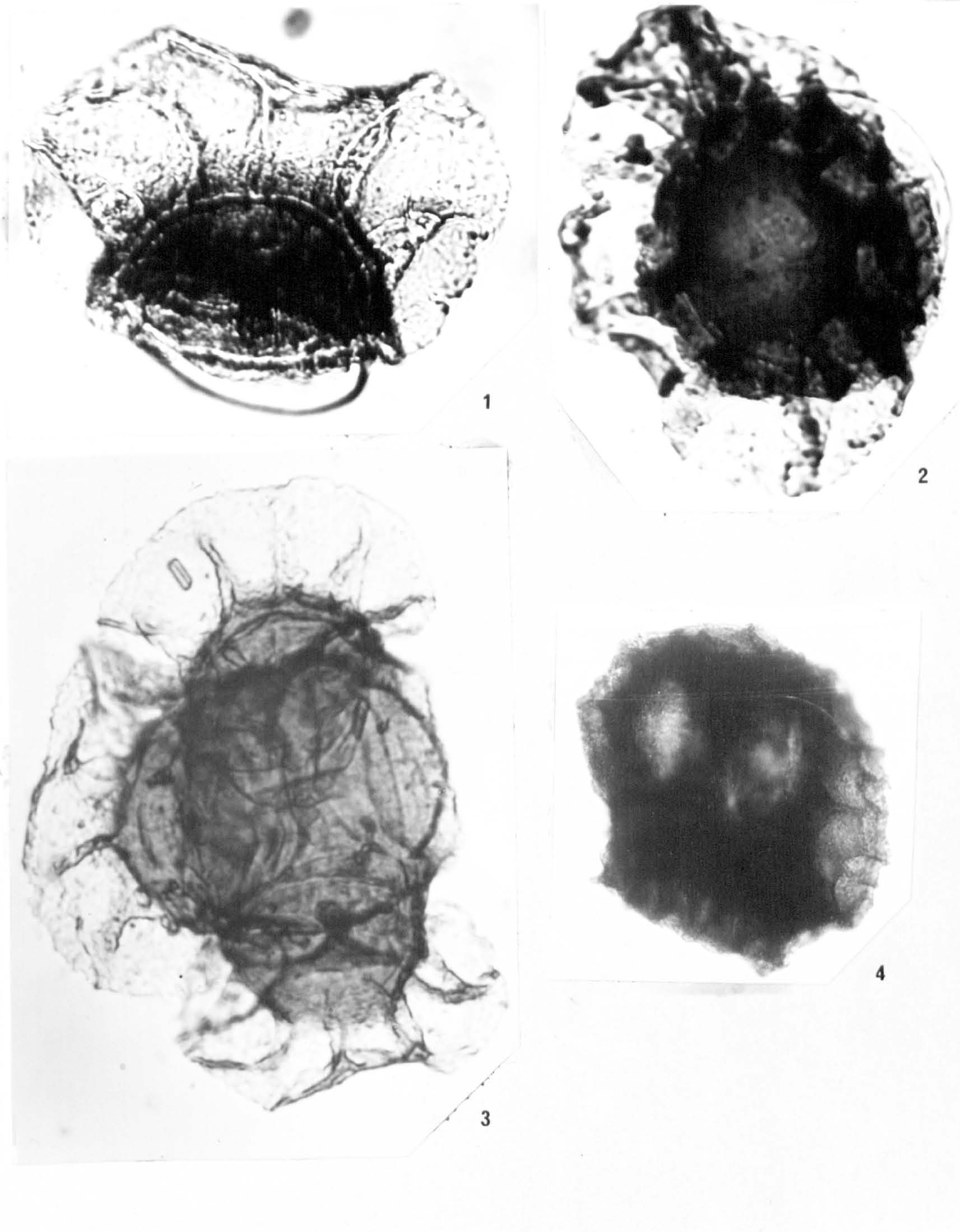
1. Skiadion, containing spore, which separated from the base of the specimen illustrated in fig. 3, preparation M.S.1. (x500);

2. Skiadion with its associated spore; preparation M.S.2. (x500).

3. Capsule with three skiadions attached, photographed before the separation of the skiadion shown in fig. 1, preparation M.S. 1a (x500).

4. Wall membrane without skiadions or spores, preparation M.S. 251 (x450).

PLATE 11



APPENDIX.

SOURCE OF SAMPLES EXAMINED WITH DETAILS OF LOCALITIES AND HORIZONS.

Lower Carboniferous.

Vaynol Park, Menai Straits, Caernarvonshire.
Series of exposures on the shore (Grid reference 541709); all are from the Basement Series.

L.C. 1. Exposure on the foreshore, seen at low tide; grey, siliceous shale.

" 2. Exposure one foot above 1.; grey siliceous shale.

" 3. Plant bed exposed at the foot of the cliff; grey-black, hard, siliceous shale.

" 4. Exposure at the base of the cliff, two feet above 3.; grey siliceous shale.

" 5. Friable black siliceous shale, two feet above 4.

" 6. Thick band of friable black, siliceous shale running up the cliff from some three feet above 5; channel sample of the lower three feet.

" 7. As number 6.; channel sample of the upper three feet.

" 8. Thick band of siliceous, friable, black shales two feet above 7, reaching to the top of the cliff, channel sample of the lower four feet.

" 9. As 8.; channel sample of the top five feet.

" 10. Grey, siliceous shale; containing macroscopic "seed" remains.

Quarry exposures in Denbighshire; all are from the D1 sub-zone.

L.C. 11. Carboniferous Limestone quarry at Llanddulas (Grid Reference 892782), calcareous grey-brown in colour and with plant remains.

" 12. Llanddulas quarry; calcareous grey-brown shales above sample 11.

" 13. Llanddulas quarry; thick band of calcareous, black, friable shale three feet above 12.

" 14. Graig quarry, Denbigh (Grid reference 054668); calcareous grey shale with plant remains.

" 15. Graig quarry; calcareous, black, friable shales some twelve feet above 14.

Quarry exposures in Flintshire.

L.C. 16. Lady McLaren quarry, Prestatyn (Grid reference 075821); calcareous, grey shale from the foot of the disused quarry face. In the D2 sub-zone.

" 17. Lady McLaren quarry; calcareous grey-black shale six feet above sample 16. In the D2 sub-zone.

" 18. Telia quarry, Gwaenysgor (Grid reference 081814); calcareous, grey shale, with fragmentary plant remains. In the D3 sub-zone.

Exposures from Anglesey.

L.C. 19. Lligwy quarry (Grid reference 489860) slightly calcareous grey shale from the floor of the disused quarry. Basal conglomerate.

" 20. Lligwy quarry; calcareous, somewhat harder grey shale, three feet above 19.

" 21. Lligwy Bay (Grid Reference 500872); shore exposures, calcareous, grey shale at the foot of the cliff on the south east end of the bay. In the D1 - D2 sub-zone.

" 22. Lligwy Bay; cliff exposures six feet above 21; calcareous, grey shale.

" 23. Bwrdd Arthur, quarry on the shore (Grid reference 583820) thick band of calcareous, black, friable shale. In the D2 sub-zone.

" 24. Bwrdd Arthur quarry; calcareous grey-black shale two feet above 23.

" 25. Bwrdd Arthur quarry, calcareous, grey shale above 24.

Upper Carboniferous

U.C. 1. Stream exposure in Panton Hall Dingle, Holywell (Grid reference 201751) siliceous grey-black shales; Gastrioceras cancellatum horizon.

" 2. Panton Hall Dingle, stream exposure, siliceous, grey shale without marine fossils three feet below 1.

" 3. Panton Hall Dingle, stream exposure, silicous grey shale, without marine fossils three feet below 2.

" 4. Coed Pen-y-Maes, Holywell (Grid reference 194765) stream exposure, siliceous grey shale; Reticuloceras gracile horizon.

U.C. 5. Coed Pen-y-Maes, stream exposure, siliceous grey shale, one foot below 4.

" 6. Coed Pen-y-Maes, stream exposure siliceous grey shale fifty yards downstream from 4; Reticuloceras reticulatum horizon.

" 7. Coed Pen-y-Maes, stream exposure one foot below 6. siliceous, grey shale.

" 8. Coed Pen-y-Maes, stream exposure, siliceous grey shale one hundred yards upstream from 6., no marine fossils in evidence.

" 9. Coed Pen-y-Maes, stream exposure three feet above the marine band of sample 10; siliceous grey shale.

" 10. Coed Pen-y-Maes, stream exposure, siliceous grey shale Reticuloceras eoreticulatum zone.

" 11. Coed Pen-y-Maes, stream exposure, siliceous, grey shale, three feet below 10.

" 12. Coed Pen-y-Maes, Stream exposure, siliceous, grey shale, six feet below 10.

" 13. Victoria Cottages, Holywell (Grid reference 197758), stream exposure below the cottages, siliceous, grey shale; Homoceras smithii horizon.

" 14. Hawarden Park (Grid Reference 318654) stream exposure by waterfall, siliceous black shale; Reticuloceras reticulatum horizon

" 15. Hawarden Park, exposure in the bank above the waterfall some nine feet above sample 14. siliceous, friable, black shale.

" 16. Warren Dingle (Grid Reference 318623) stream exposure north of Bank Farm, close to road bridge, siliceous, black shales; Reticuloceras superbilingue horizon.

" 17. Warren Dingle, stream exposure one-hundred yards downstream from 16, siliceous, light grey shales.

" 18. Terrig Valley, Cae gwydd (Grid Reference 234578) stream exposure siliceous, grey shales; Gastrioceras cancellatum horizon.

" 19. Terrig Valley, Rhyd Ceirw (Grid Reference 234566) exposure in the river bank; Eumorphoceras bisulcatum horizon.

" 20. Terrig Valley, exposure in the bank above sample 19. siliceous, grey-brown shales.

" 21. Ruby Brick Works, Rhydymwyn (Grid Reference 205678) coal sample above the Gastrioceras cancellatum horizon.

Samples from the Abbey Mills, Greenfield No. 4 Borehole (Grid Reference 193777).

A.M.1 to 23. Details of the faunal horizons can be seen from the Text-Text-figure 3.

SUPPORTING PUBLICATIONS.

1. SULLIVAN, H. J. and HIBBERT, A. F. 1964. *Tetrapterites visensis* - a new spore-bearing structure from the Lower Carboniferous. Palaeontology, 7, 64 - 71

2. HIBBERT, F. A. and EGGERT, D. A. 1965. A new calamitalean cone from the Middle Pennsylvanian of southern Illinois. ibid., 8, 681 - 686.

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