THE PALYNOLOGY OF THE PLENMELLER COALFIELD AND ADJACENT AREAS IN NORTHERN ENGLAND

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SUMMARY

The samples collected in the present investigation from Featherstone, Plenmeller and adjacent areas in the North of England, yielded diverse, well preserved miospore assemblages with marked vertical variation, which compare fairly closely with those previously described from strata of the same age elsewhere.

Six major Assemblages are recognised from coal and shale samples collected within Namurian and Westphalian A and B strata which have not previously been dated by miospore evidence. Detailed comparisons are made with miospore assemblages previously described by several authors from similar stratigraphical horizons in Scotland, North England and the Central Province.

Formal taxonomic description is presented for 206 species belonging to 71 genera. 22 new types are described and one new combination is suggested.

Key Words:- Palynology Upper Carboniferous Northern England

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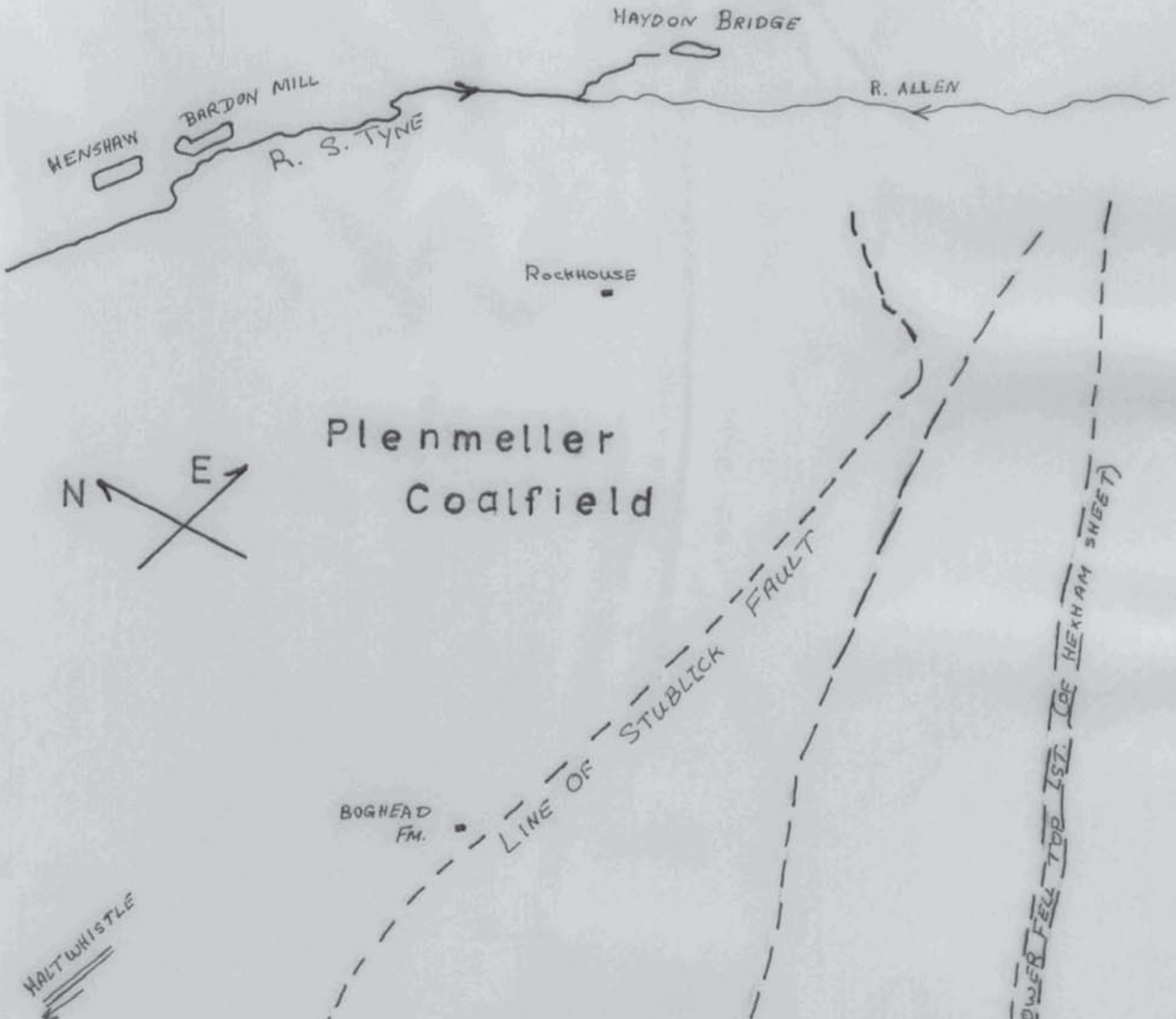

Plenmeller Coalfield

FIG. 1. AERIAL PHOTOGRAPH OF THE PLENMELLER COALFIELD

CHAPTER 1

INTRODUCTION

The present study concerns the palynology of the Plenmeller Coalfield and adjacent areas in the north of England (Fig. 2). Plenmeller is one of three outliers of Upper Carboniferous strata, mainly of Westphalian age, which lie immediately north of the east-west trending Stublick Faults, and on the southern margin of the Northumberland Trough. The outliers are, from west to east, Midgeholme (the largest), Plenmeller (13 miles west of Hexham) and Stublick (the smallest) coalfields. Further to the east, on the border with County Durham, sections from two further sites were studied, Hedley Park and St. Andrew's Opencast Sites; and further west, in Cumbria, samples were also collected from the Low Close Opencast site. All these sites are shown in Fig. 2.

The strata in the Plenmeller Coalfield are largely unexposed as shown in the aerial photograph of the site, Fig. 1; they are being explored at present by the Opencast Executive of the National Coal Board, who kindly provided the samples on which much of the present research is based. Samples from underlying strata of Namurian age were collected at outcrop from the Featherstone area between Midgeholme and Plenmeller (see Fig. 2).

The first detailed description of Carboniferous rocks in the Midgeholme area was published in the Brampton district Memoir by Trotter and Hollingworth (1932). The paucity of macrofossils in the sequence made correlation between this and other areas in Britain difficult. The occasional occurrence of non-marine lamellibranchs and plant fossils in the sequence, however, have

Fig. 2. LOCATION MAP OF THE COALFIELDS STUDIED

made possible the detailed correlations of Hopkins and Bennison (1958), Dr. J. Knight (pers. comm.) and other workers; see Fig. 10.

Details of the geology of the sites and the sections studied are given in Chapter 2. The coals and clastic sediments collected from boreholes and outcrops were treated chemically in different ways in order to obtain satisfactory miospore separations. The techniques used in the present study are described in detail in Chapter 4. Spore recovery was on the whole very good.

The purposes of this project were as follows:-

I. To become familiar with publications dealing with Silesian (Upper Carboniferous) Palynology both in Britain and in the rest of the World. These publications are summarised briefly in Chapter 3.

II. To study the miospore genera and species of the Namurian and Westphalian A and B strata. Detailed systematics of 71 genera including 206 species are given in Chapter 5; two new genera and 11 species are new from the Namurian strata, and 11 species are new from the Westphalian A and B strata.

III. To study the distributions of these taxa in the coals and clastic sediments in sections from Featherstone, Plenmeller and adjacent areas in order to determine their ages. In addition it was aimed to compare and correlate the miospore distributions in these areas with those from other areas in Britain and beyond; these comparisons are presented in Chapter 6.

IV. Correlations between the sites in the present investigation were carried out according to the presence and absence and frequencies of certain species as summarised in Chapter 7.

CHAPTER 2

GEOLOGICAL SETTING AND STRATIGRAPHY

2.1 Geological Setting

The distribution of British Coalfields is shown in Fig. 3, which is based on Calver (1969, Fig. 1). The Midgeholme, Plenmeller and Stublick outliers lie to the south of the River South Tyne, on the northern or downthrow side of the east-west trending Stublick Faults. These have a downthrow of about 500 m to the north and separate the Alston Block to the south from the Northumberland Trough to the north. The sequence of Lower Carboniferous deposition in these two areas was very different. In the Northumberland Trough deposition was continuous from Old Red Sandstone times; George et al. (1976) state that the oldest sediments, the Cementstone Group, are of Courceyan age. These are succeeded by the Fell Sandstone Group (Chadian-Holkerian), deltaic sediments brought in by a large river flowing from the northeast. In Asbian times the Scremerstone Coal Group formed on these silted-up deltas and then the whole area subsided and cyclic marine deposition, responsible for the Yoredale facies of the Lower and Middle Limestone Groups, persisted throughout the rest of the Dinantian. This marine transgression occurred not only in the Northumberland Trough but also on the Alston Block where the higher part of the Asbian is unconformable on Lower Palaeozoic sediments.

Similar conditions persisted throughout the Pendleian and Arnsbergian stages of the Namurian (the Upper Limestone Group). The later stages of the Namurian are represented by a nearshore facies consisting of coarse-grained, cross-bedded sandstones

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Fig. 3. Provinces and Coalfields of Britain (after Calver, 1969).

together with siltstones and occasional thin coals and limestones. These later stages of the Namurian are thin compared with the Pendleian and Arnsbergian stages, and they are also thin compared with equivalent strata further south where the more typical Millstone Grit developed.

Ramsbottom (1969) states that it appears from this that the relative movement of subjacent crustal blocks had ceased by this time in the north-eastern part of England.

According to Calver (1969) there were only slight changes in the conditions of deposition in early Westphalian times. Cyclic deposition continued, but in the Westphalian cyclothems marine limestone are absent, marine shales and coarser sandstones are less common than in the Namurian cyclothems, and non-marine shales, sandstones and coals predominate.

Although similar Westphalian sequences are thought to have been deposited over much of Northern England most of them have been removed by erosion following late Carboniferous earth movements. This erosion was greatest in tectonically positive areas such as the northern Pennines, and the only Coal Measures found here are preserved on the downthrow sides of faults, (Taylor, et al., 1971). The Midgeholme, Plenmeller, and Stublick Coalfields were preserved in this way on the downthrow side of the Stublick Fault.

2.2 Namurian Sections

2.2.1 Previous Work

The focal point of the present study is the valley of the South Tyne and its tributaries in the area between Midgeholme and Plenmeller. It is situated 8½ miles to the northeast of Brampton, 2½ miles south of the small market town of Haltwhistle on a major bend of the South Tyne, and 3 miles south of the village of Greenhead. The area is covered by the Ordnance Survey 2½ inch to one mile maps for Haltwhistle (Sheet NY76) and Greenhead (Sheet NY66). It is covered geologically by the I.G.S. One-inch maps for Brampton (Sheet 18) and Hexham (Sheet 19).

This area lies to the north of the Stublick Fault and between the North Upper Denton and the Blenkinsopp Boundary faults. In general the rocks here are gently folded into the ENE trending Featherstone syncline in the north and Featherstone anticline in the south.

The Geological Survey mapped the area in 1876-78 on the Old Series Geological sheet 106 S.W. (Brampton District), of which a hand-coloured edition on the one-inch scale was published in 1890 without being accompanied by a detailed geological succession or by a descriptive memoir. The only complete account of the area was published by Trotter and Hollingworth (1932), who re-mapped the area (new series sheet 18, one inch Geological Survey Map). Considerable alterations were made as a result of the resurvey and subsequently described in the Brampton Memoir. Some of the younger limestones present could not be traced on to the Alston Block to the south. For instance, the Upper and Lower Fell Top Limestones of the Brampton area are at younger horizons than the limestone with the same name on the Alston Block. They believed the Fell Top Limestone of Alston to be equivalent to the Middle Oakwood Limestone further north.

The Upper Limestone Group was taken by Trotter and Hollingworth (loc. cit.) to include all strata from the base of the Great Limestone to the base of the Upper Carboniferous which they defined as the grit above the Burnfoot Shales; they indicated that this group comprises the greater part of the Carboniferous outcrop in the area to the south of the Stublick Faults.

Subsequently, the base of the Namurian in northern England was placed (Johnson, et al., 1962; Hull, 1968) at the base of the Great Limestone; this is marked by the first occurrence of Cravenoceras leion Bisat in mudstones above the Great Limestone. The top of the Namurian is taken at the base of a marine band containing Gastrioceras subcrenatum Frech.

Ramsbottom et al. (1978) introduced further refinement and more comprehensive correlations and subdivision of the Namurian strata (in the Geological Society's Special Report on the Silesian Subsystem) in the Northern Pennines, based on the goniatites and other key fossils that have been discovered, with additional evidence from palynological studies (Owens in Owens and Burgess 1965, Neves 1969). The stage boundaries of the Namurian Series in this report correspond closely with the boundaries of the major cycles proposed by Ramsbottom (1977).

Ramsbottom et al. (1978), Figs. 9 and 10) draw attention to the fact that the Lower and Upper Fell Top Limestones of the Alston Block correlate with the Corbridge Limestone and the Thornborough Limestone respectively in the Northumberland Trough and Brampton District. The former horizon represents the base of the Arnsbergian (E_2) stage, while the higher horizon lies in the upper part of the E_2a Zone. They correlate the Brampton Lower and Upper Fell Top Limestones with the Newton Limestone and Styford Limestone respectively in the Northumberland Trough. The former horizon lies in the E_2b zone in Ramsbottom's (1977) major cycle N2. The strata immediately above the Brampton Upper Fell Top Limestone lie on the boundary between the Arnsbergian/ Chokierian (E_2/H) stages. The strata representing the H, R and G stages are very thin in the Brampton area and contain the Burnfoot Shales the First Grit and the Second Grit. Ramsbottom et al. (1978) indicate that the E_2c, H_1 and H_2 stages are very thin throughout the region generally as indicated previously by several authors.

No macrofossil evidence of the Chokierian and Alportian (H_1 and H_2) stages have been found in the Stainmore outlier or on the Alston Block (Owens and Burgess 1965). No fossils diagnostic of the Marsdenian (R_2) or Yeadonian (G_1) stages were found in the Woodland borehole (Mills and Hull, 1968). However, Neves (1968) suggests, on palynological evidence from the same borehole, that both stages are present.

Owens in Ramsbottom et al. (1978, Fig. 10) records Kinderscoutian (R_1) spores from the Burnfoot Shales, and the base of the Yeadonian Stage (G_1) is placed by these authors within the Second Grit above the Burnfoot Shales in the Brampton Sequence. All these correlations are shown in Fig. 4.

2.2.2 Samples taken from Namurian and lowermost Westphalian strata of the Featherstone area

The area is covered by a varying thickness of glacial drift and alluvium. A number of samples have been collected in the field from different localities, extending from the Lower Fell Top Limestone to the Upper Kellah Coal Seam. These sections were well exposed

Fig. 4 NAMURIAN SECTIONS IN NORTHERN ENGLAND MODIFIED FROM RAMSBOTTOM ET AL. 1978.

in stream cuttings and their locations are shown in Fig. 5 .

2.2.2.1 Strata associated with the Lower Fell Top Limestone

The Lower Fell Top Limestone crops out in the bed of Park Burn immediately to the west of the road bridge (NY 689609). This locality lies on the northern limb of the Featherstone anticline in the core of which the Thornborough Grit crops out, to the east of Rowfoot. Black shales were sampled in the right bank of the stream (NY 689611) at approximately 1 m and 4 m above the Limestone (Fig. 6). Silty shales from below the limestone and from above the lower of the black shale samples were unproductive.

The outcrop higher in the sequence of the Fell Top Coal, according to Trotter and Hollingworth (1932, p. 91), occurs below the railway bridge 300-400 m downstream. This outcrop however could not be located.

2.2.2.2 Strata associated with the Upper Fell Top Limestone

These were sampled in the left bank of Pinkings Cleugh (NY 676623), referred to by Trotter and Hollingworth (1932, p.91) as "a stream 500 yards west-south-west of Wydon Eals". This locality lies on the southern limb of the Featherstone Syncline, a short distance below the Westphalian A strata which are shown to occupy the core of the syncline on the Brampton 1:50,000 map (sheet 18).

The strata (Fig. 7) include two thin coals and associated black shales which succeed the massive sandstone overlying the Upper Fell Top Limestone. Samples collected from the Burnfoot shales which are exposed in the stream approximately 100 m to

Fig.5. Location map of the Featherstone area.

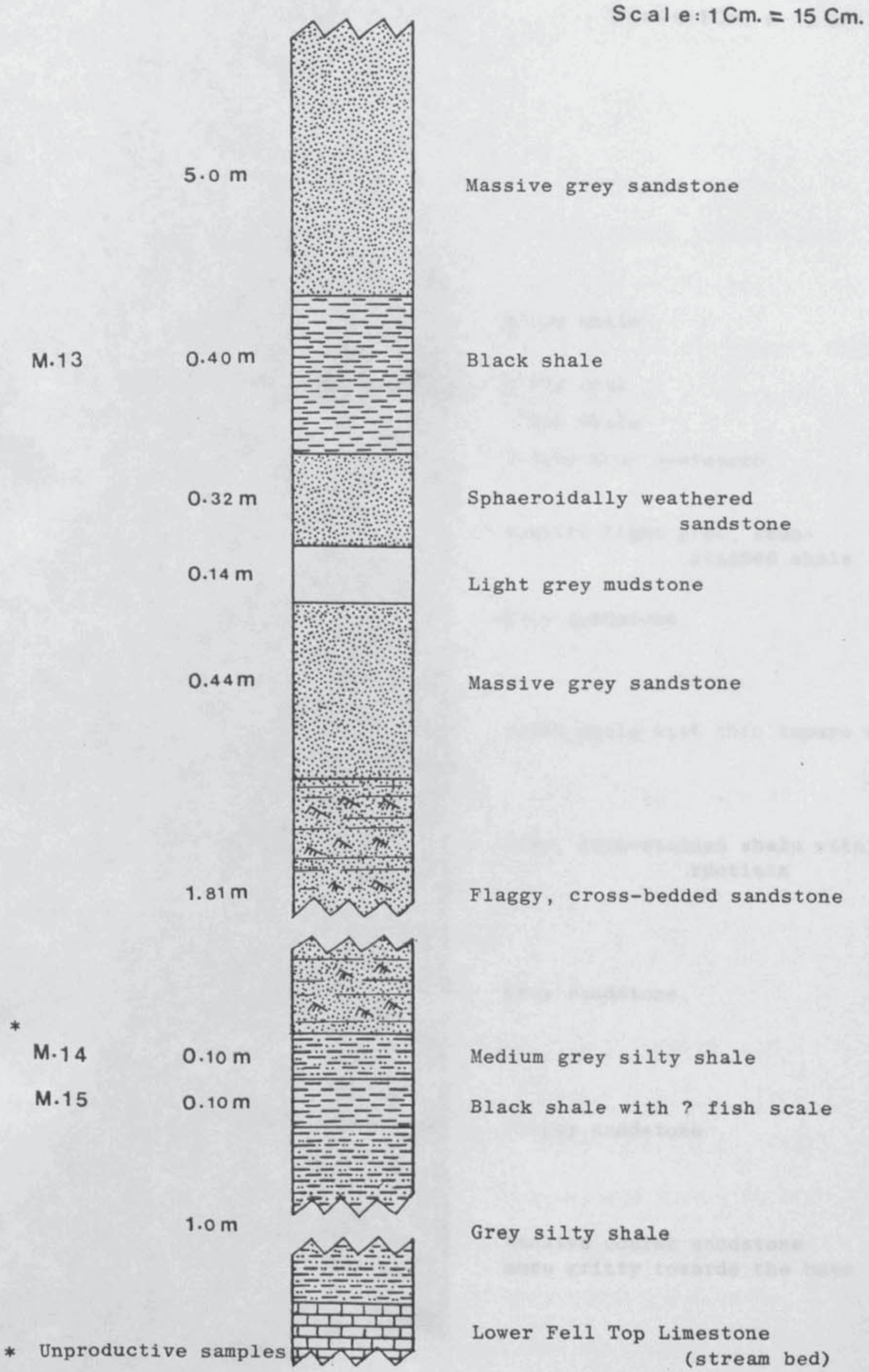


Fig. 6 SEQUENCE OF MEASURES SAMPLED IN PARK BURN.

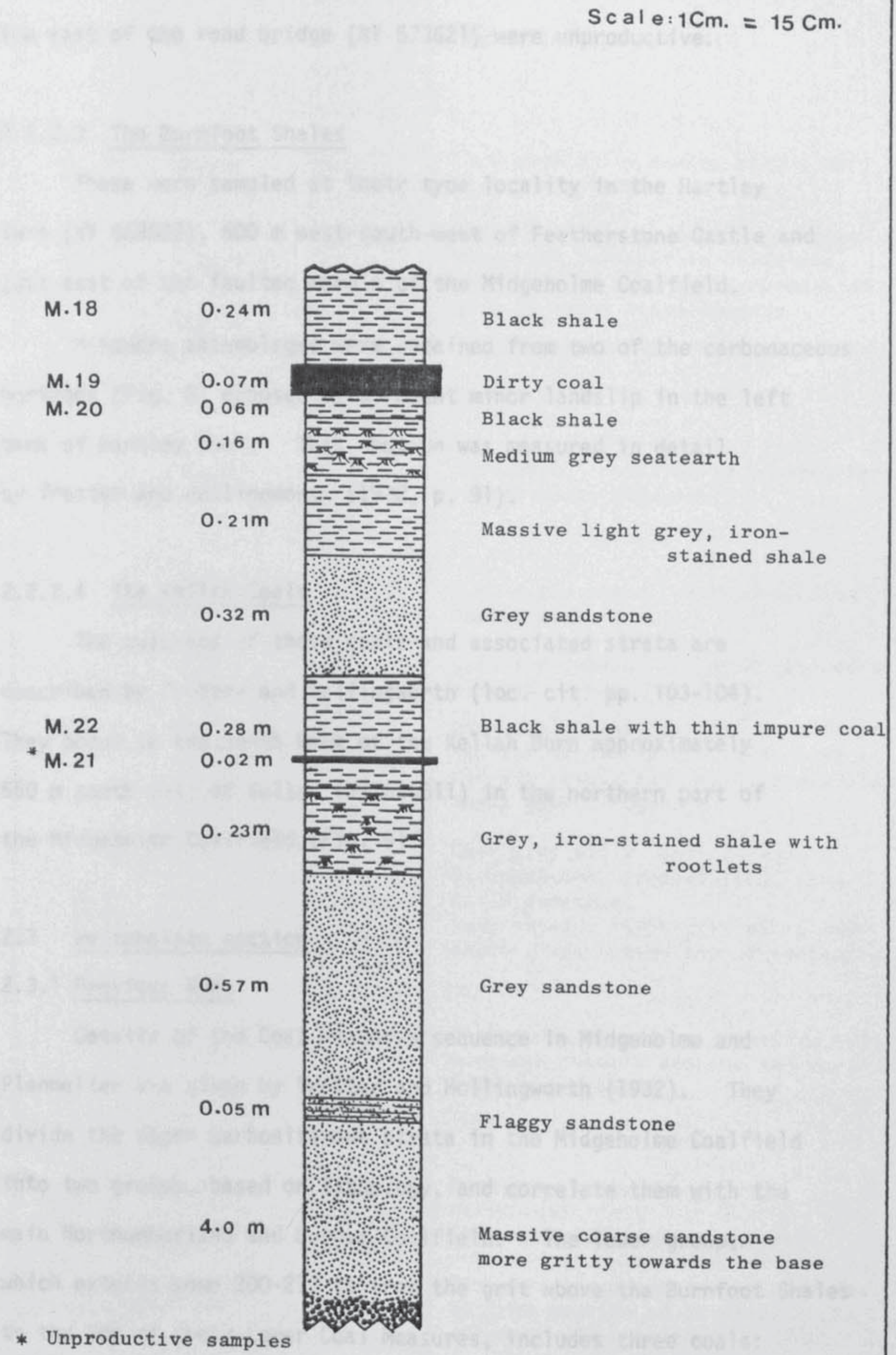


Fig.7 SEQUENCE OF MEASURES SAMPLED IN PINKING CLEUGH.

the east of the road bridge (NY 673621) were unproductive.

2.2.2.3 The Burnfoot Shales

These were sampled at their type locality in the Hartley Burn (NY 668607), 600 m west-south-west of Featherstone Castle and just east of the faulted margin of the Midgeholme Coalfield.

Miospore assemblages were obtained from two of the carbonaceous horizons (Fig. 8) exposed by a recent minor landslip in the left bank of Hartley Burn. This section was measured in detail by Trotter and Hollingworth (1932, p. 91).

2.2.2.4 The Kellah Coals

The outcrops of these coals and associated strata are described by Trotter and Hollingworth (loc. cit. pp. 103-104). They occur in the north bank of the Kellah Burn approximately 650 m south east of Kellah (NY 660611) in the northern part of the Midgeholme Coalfield (Fig. 9).

2.3 Westphalian section

2.3.1 Previous Work

Details of the Coal Measures sequence in Midgeholme and Plenmeller are given by Trotter and Hollingworth (1932). They divide the Upper Carboniferous strata in the Midgeholme Coalfield into two groups, based on lithology, and correlate them with the main Northumberland and Durham Coalfield. The lower group, which extends some 200-270 ft from the grit above the Burnfoot Shales to the top of their Lower Coal Measures, includes three coals: an un-named seam, the Kellah Coals and the Low Main; they

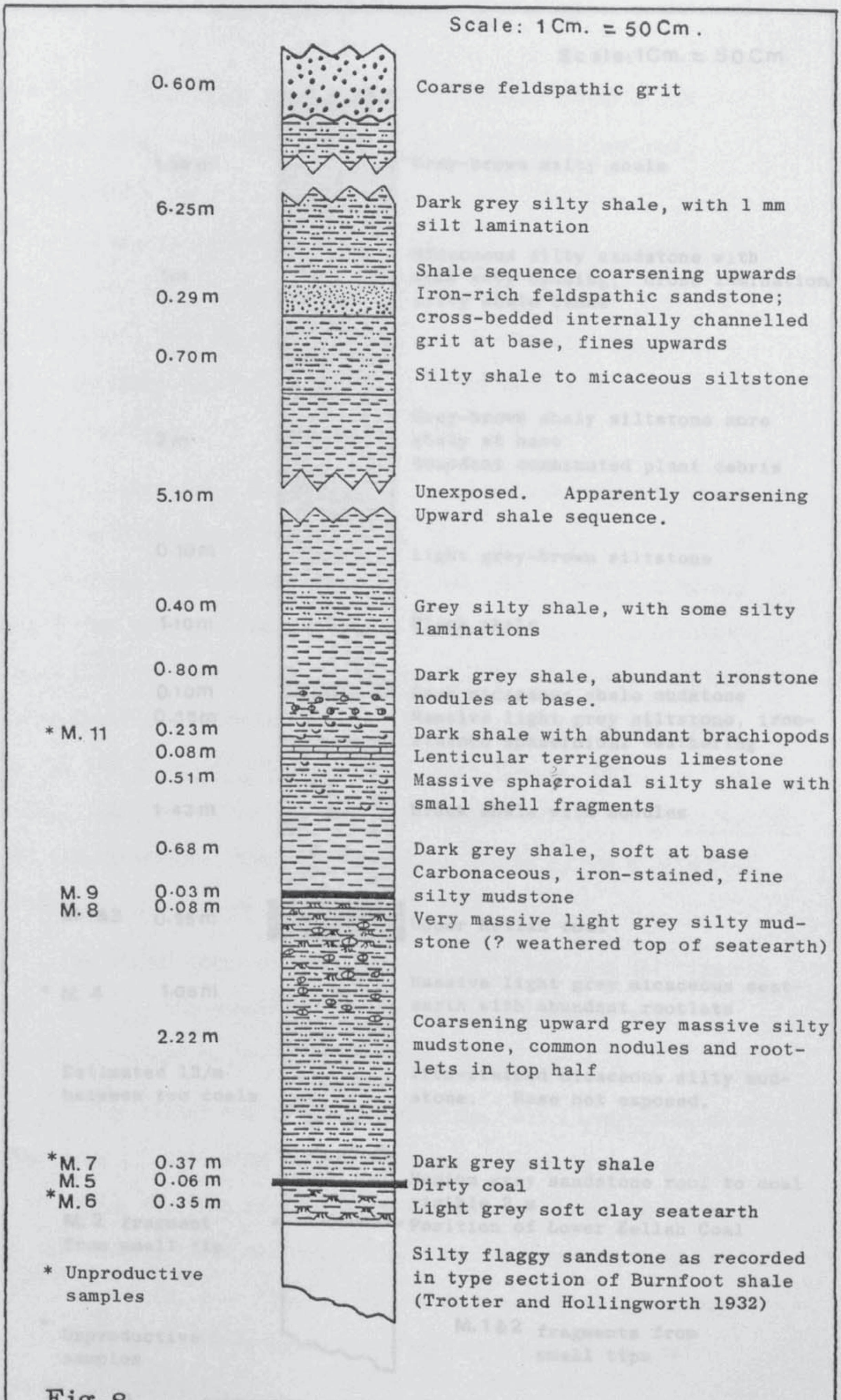


Fig. 8. SECTION OF BURNFOOT SHALE AT HARTLEY BURN

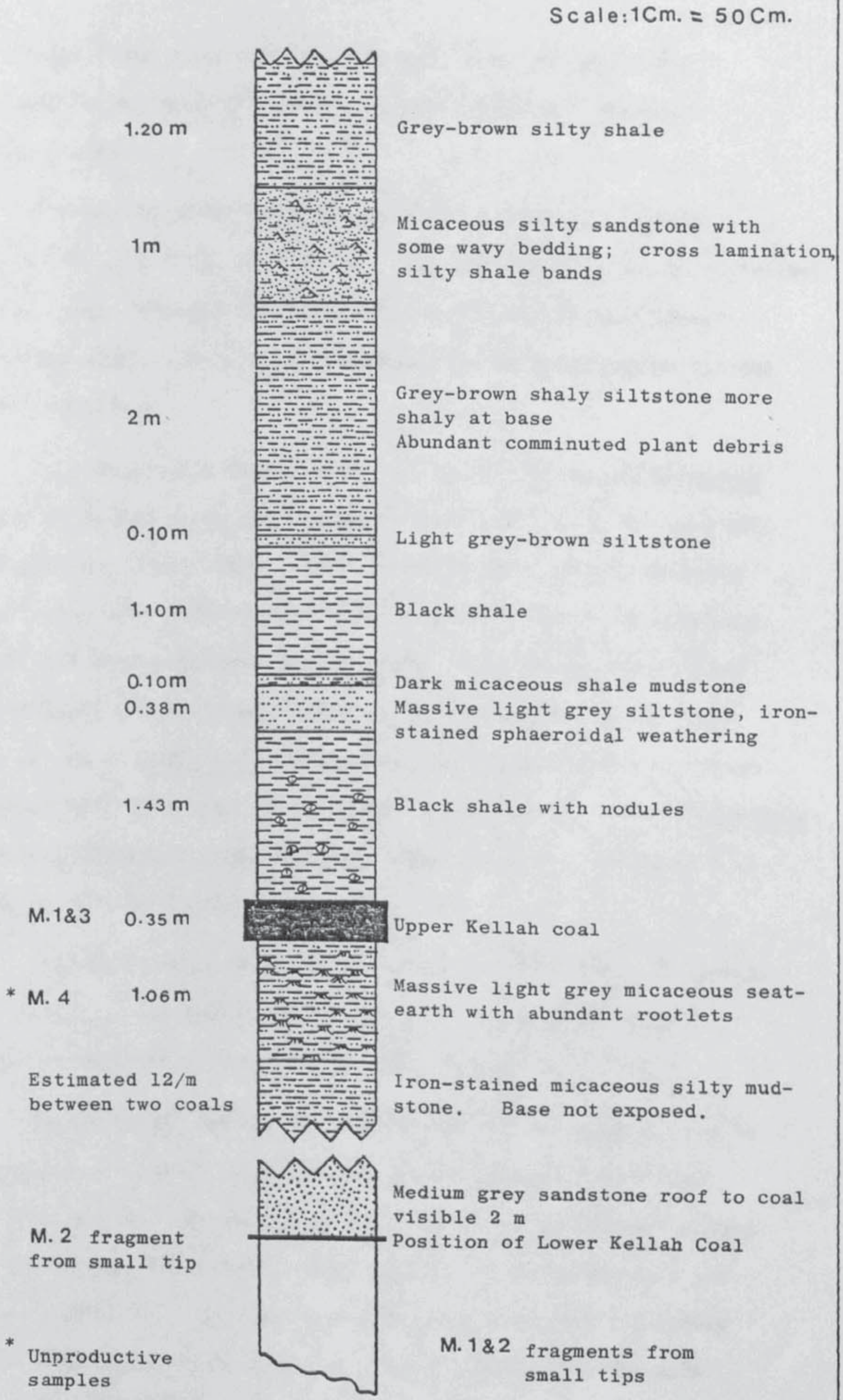


Fig. 9 COMPOSITE SECTION FROM KELLAH BURN

correlated these seams with the Marshall Green, Victoria and Brockwell seams respectively in the main Northumberland and Durham Coalfield.

The second group extends some 470 ft from the Low Main Seam to the Upper Craignook Seam; they considered it to be equivalent to the strata from the Brockwell Seam to the Harvey Seam (known as the Towneley Seam in West Durham) in the main Northumberland and Durham Coalfield.

They observed a mussel band rich in ostracodes and Spirorbis in the shell bed above the Craignook Seam, and they correlated this band with the Hopkins Shell Bed (Ostracode Band) above the Harvey Seam in the main coalfield. This latter shell bed is a prominent mussel and ostracode bed with Spirorbis in the Northumberland and Durham Coalfield which was placed by Hopkins (1930) in the lower part of the A. modiolaris non-marine lamellibranch zone. Trotter and Hollingworth placed the Craignook horizon within the A. modiolaris zone and, therefore, they assigned these strata to the Middle Coal Measures as then defined.

The classification of strata used by Trotter and Hollingworth (loc. cit.) in the Memoir and on the one-inch Brampton sheet 18 (1930) is revised on the 1:50,000 sheet 18 published in 1976.

Taylor (1956) had in the meantime recorded a Lingula band in a borehole at Lambley in Midgeholme and an ostracode band about 60 ft. below it. He correlated these with the Harvey Marine Band and the Hopkins Shell Bed respectively in the Northumberland and Durham Coalfield. He also correlated this band with the Solway Marine Band about 70 ft above the Little Main Coal in the main Cumberland Coalfield.

Later on, Hopkins and Bennison (1958) found considerable faunal assemblages including a *C.pseudorobusta* and *C. cf. pseudorobusta* horizon in the upper part of the *C. communis* zone and, like Trotter and Hollingworth (1932), they correlated it with the Btm. Busty Seam of the main Coalfield. They agreed with the correlations of Trotter and Hollingworth (1932).

Recent evidence from the Midgeholme Coalfield (Taylor *et al.*, 1971) is that the Vanderbeckei Marine Band lies 82 m above the Craignook Seam and is correlated with the Harvey Marine Band to the east and the Solway Marine Band to the West; and the Top Busty Seam is correlated with the Wellsyke Seam, which is the boundary between the *C. communis* zone and the *A. modiolaris* zone, in the Lower Coal Measures. Taylor placed the lowest seam in the sequence at the base of the *C. communis* zone.

In their recent resurvey of the Midgeholme and Plenmeller Coalfields the N.C.B. found that the Vanderbeckei Marine Band lies about 80 m above the Craignook Seam. They correlated the Top Busty and Bottom Busty seams of the main Coalfield with the Upper and Lower Craignook seams respectively of Midgeholme and Plenmeller.

Ramsbottom *et al.*, (1978) agreed with this correlation and moreover they recognised the Craignook Seam as the boundary between the *C. communis* zone and the *A. modiolaris* zone in the Westphalian A stage. They made a queried horizon below the Low Main Seam in Midgeholme equivalent to the Ganister Clay Seam in the main Northumberland and Durham Coalfield; this is the boundary between the *C. lenisulcata* and the *C. communis* zones; they placed a lower queried horizon in the sequence in Midgeholme at the base of the C. lenisulcata zone, i.e. at the horizon of the G. subcrenatum Marine Band.

All of these correlations, together with the one adopted by the N.C.B. Opencast Executive (Dr. J. Knight, Personal communication) are shown in Fig. 10.

2.3.2.Midgeholme, Plenmeller and Stublick Sections

2.3.2.1 Introduction

Three small Westphalian outliers occur along the southern edge of the Northumberland Trough east of Brampton, where some 210 m of strata including the Vanderbeckei (Harvey) Marine Band, about 52 m above a seam recently identified as the Craignook Seam, are preserved on the north side of the Stublick Fault. These outliers are from east to west, Midgeholme, Plenmeller and Stublick; they are situated south of the River South Tyne, on the northern or downthrow side of the east-west tranding Stublick Faults.

The sequence is restricted to the Westphalian A stage and the basal boundary is indefinite (Ramsbottom et al., 1978, Plate 2, AA).

2.3.2.2 Sections examined from the Plenmeller area

In the Plenmeller area (Fig. 11) the Stublick Fault passes across the southern margin and separates the area into Westphalian to the North and older Carboniferous rocks of Namurian age to the south. There are several minor faults in the area lying to the north of the Stublick Fault and trending approximately parallel to it. The strata within the coalfield dip towards the south; they are vertical on the Stublick Fault, dip between 15^0 and 20^0

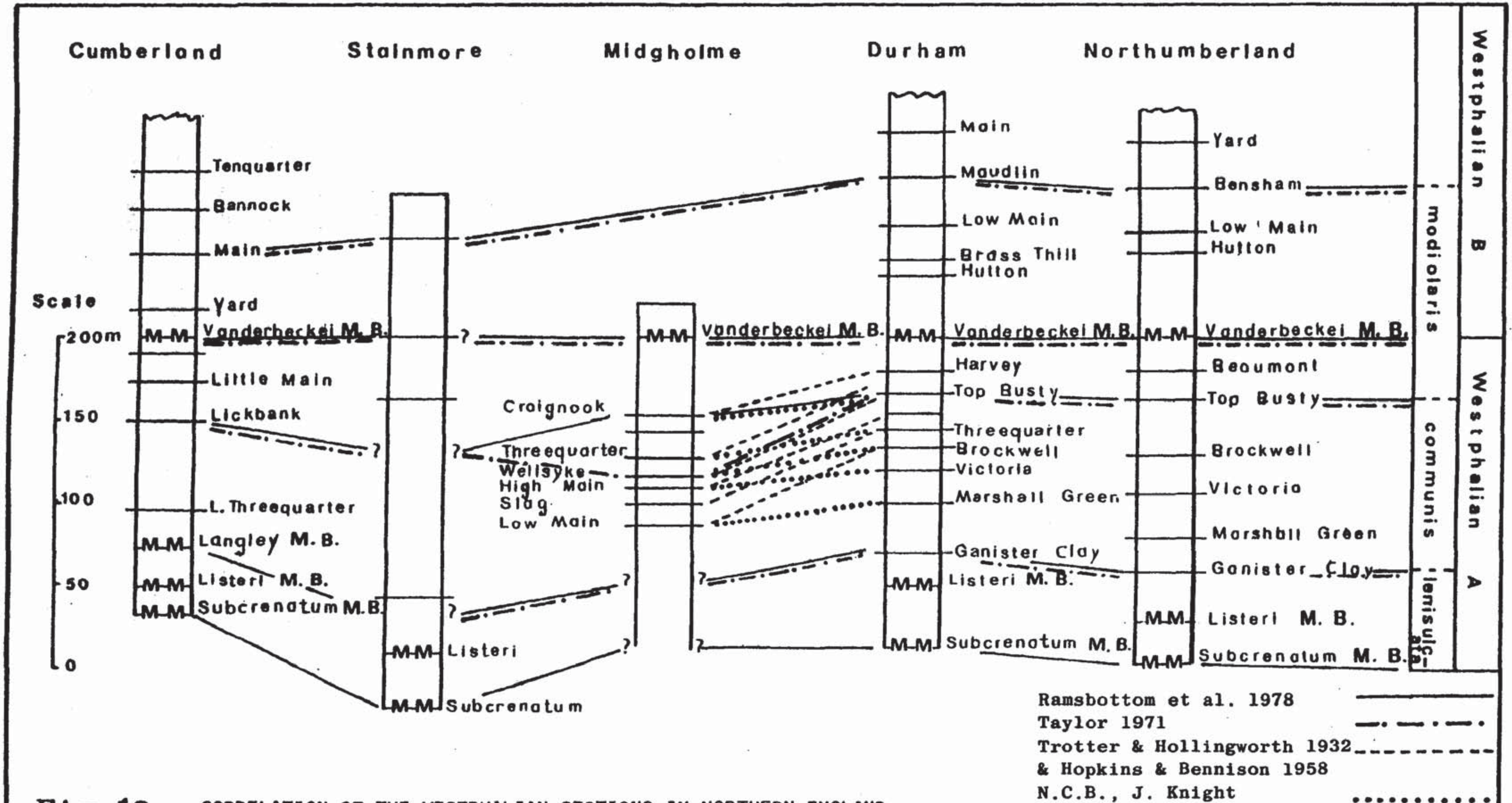


Fig. 10. CORRELATION OF THE WESTPHALIAN SECTIONS IN NORTHERN ENGLAND

in the central area, and dip from 5^{0} to 7^{0} in the north (J. Knight, Personal communication).

The Plenmeller coalfield is situated south of the River South Tyne, 5 kms. south west of the small market town of Haltwhistle. The coalfield is covered by the Ordnance Survey 2½ inch to one mile for Haltwhistle Sheet NY 76.

Outcrops in the Plenmeller Coalfield are few and all the samples were taken from boreholes (Figs. 11 and 13 and Appendix B). Two boreholes (1350 and 1241) were logged in detail, (Appendix A), and a generalised section is shown in Fig. 12.

2.3.2.3 Midgeholme

The Midgeholme Coalfield is the largest of the three small outliers; it lies to the west of the Plenmeller Coalfield, and in the east of the Brampton District (Trotter and Hollingworth 1932). Three samples of the Kellah coals were collected from the type locality in the north bank of the Kellah Burn (see section 2.2.2.4, Fig. 9).

2.3.2.4 Stublick

Stublick is the smallest of the outliers; it is situated 10 kms east of the Plenmeller Coalfield, and 4 kms south of a small market town called Haydon Bridge.

The strata are poorly exposed on account of glacial drift. Therefore the coal samples have been taken from boreholes located in Stublick Opencast Site and only cover restricted portions of the sequence. The location map of the area is shown in Fig. 2, a generalised section in Fig. 14, and details of samples in Appendix B.

Fig. 11. Location map of Plenmeller Coalfield

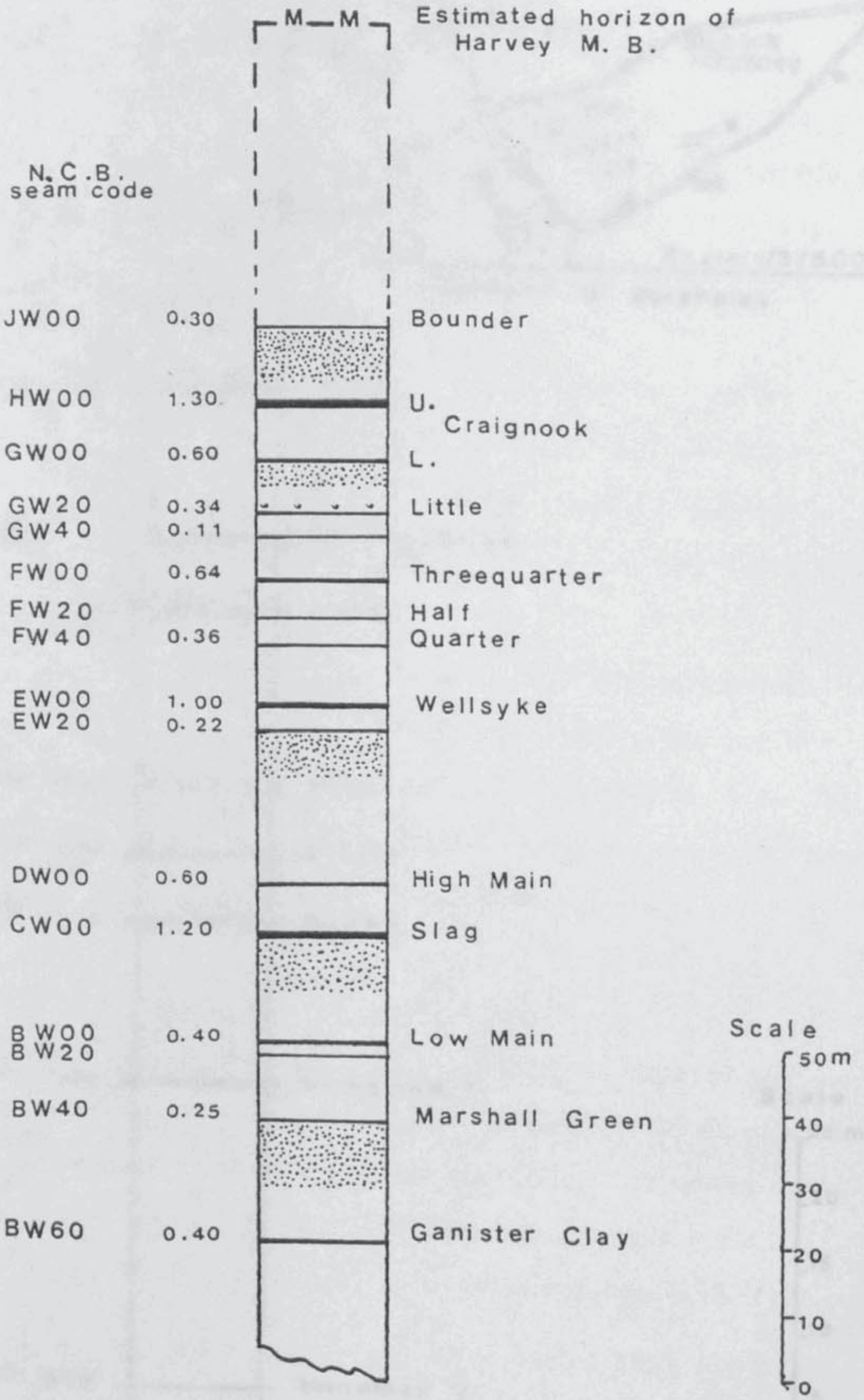


Fig. 12. GENERALISED SECTION OF THE PLENMELLER COALFIELD

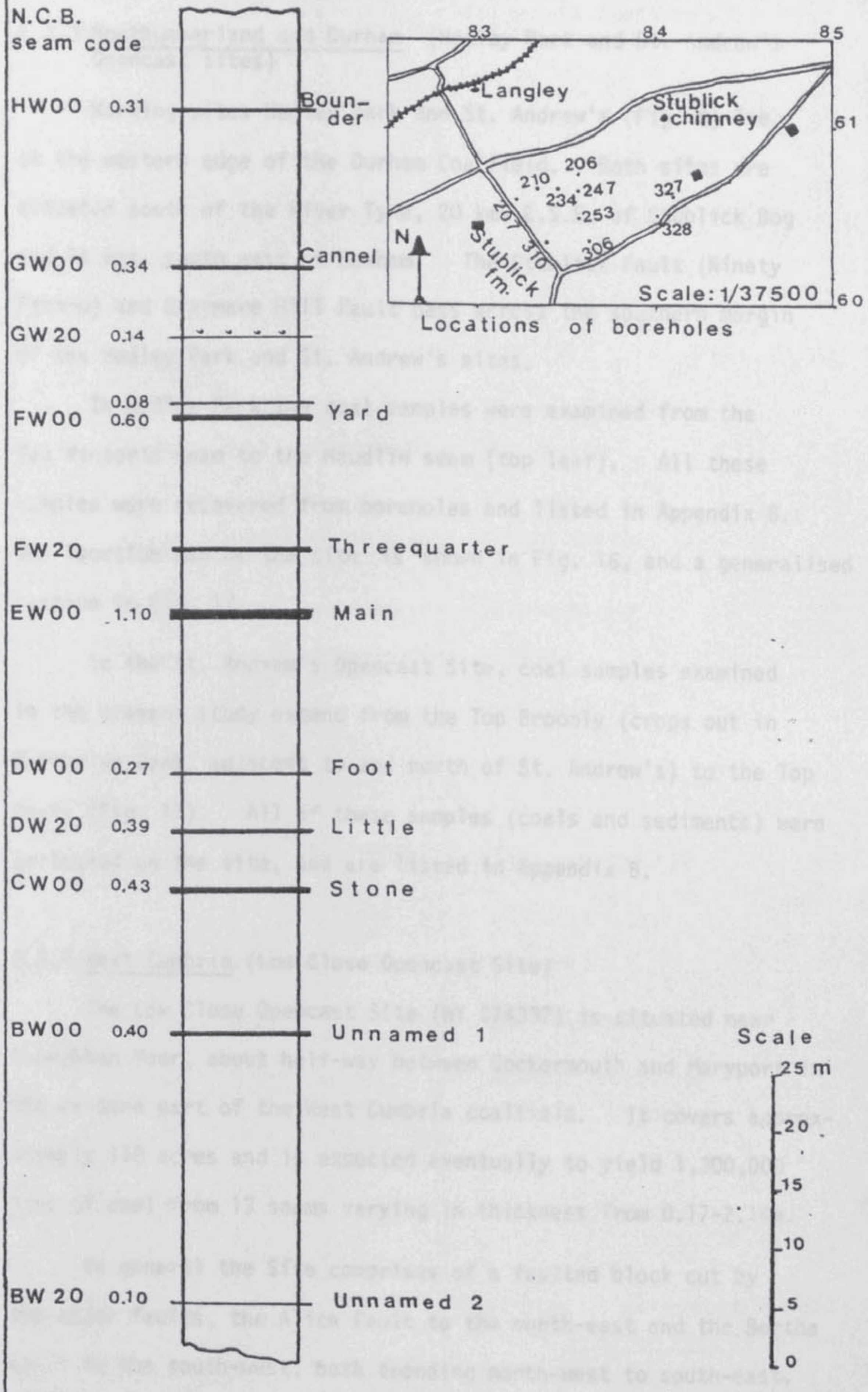


Fig. 14. GENERALISED SECTION OF THE STUBLICK BOG SITE

2.3.3 Northumberland and Durham (Hedley Park and St. Andrew's Opencast sites)

Working sites Hedley Park and St. Andrew's (Fig. 2) lie at the western edge of the Durham Coalfield. Both sites are situated south of the River Tyne, 20 kms E.S.E. of Stublick Bog and 14 kms. south east of Hexham. The Stublick Fault (Ninety Fathom) and Graymare Hill Fault pass across the southern margin of the Hedley Park and St. Andrew's sites.

In Hedley Park the coal samples were examined from the Top Victoria seam to the Maudlin seam (top leaf). All these samples were recovered from boreholes and listed in Appendix B. The location map of the site is shown in Fig. 16, and a generalised section in Fig. 17.

In the St. Andrew's Opencast Site, coal samples examined in the present study extend from the Top Broomly (crops out in Whiteside Bank, adjacent to and north of St. Andrew's) to the Top Busty (Fig. 15). All of these samples (coals and sediments) were collected on the site, and are listed in Appendix B.

2.3.4 West Cumbria (Low Close Opencast Site)

The Low Close Opencast Site (NY 074337) is situated near Broughton Moor, about half-way between Cockermouth and Maryport in the eastern part of the West Cumbria coalfield. It covers approximately 110 acres and is expected eventually to yield 1,300,000 tons of coal from 13 seams varying in thickness from 0.17-2.14m.

In general the Site comprises of a faulted block cut by two major faults, the Alice Fault to the north-east and the Bertha Fault to the south-west, both trending north-west to south-east.

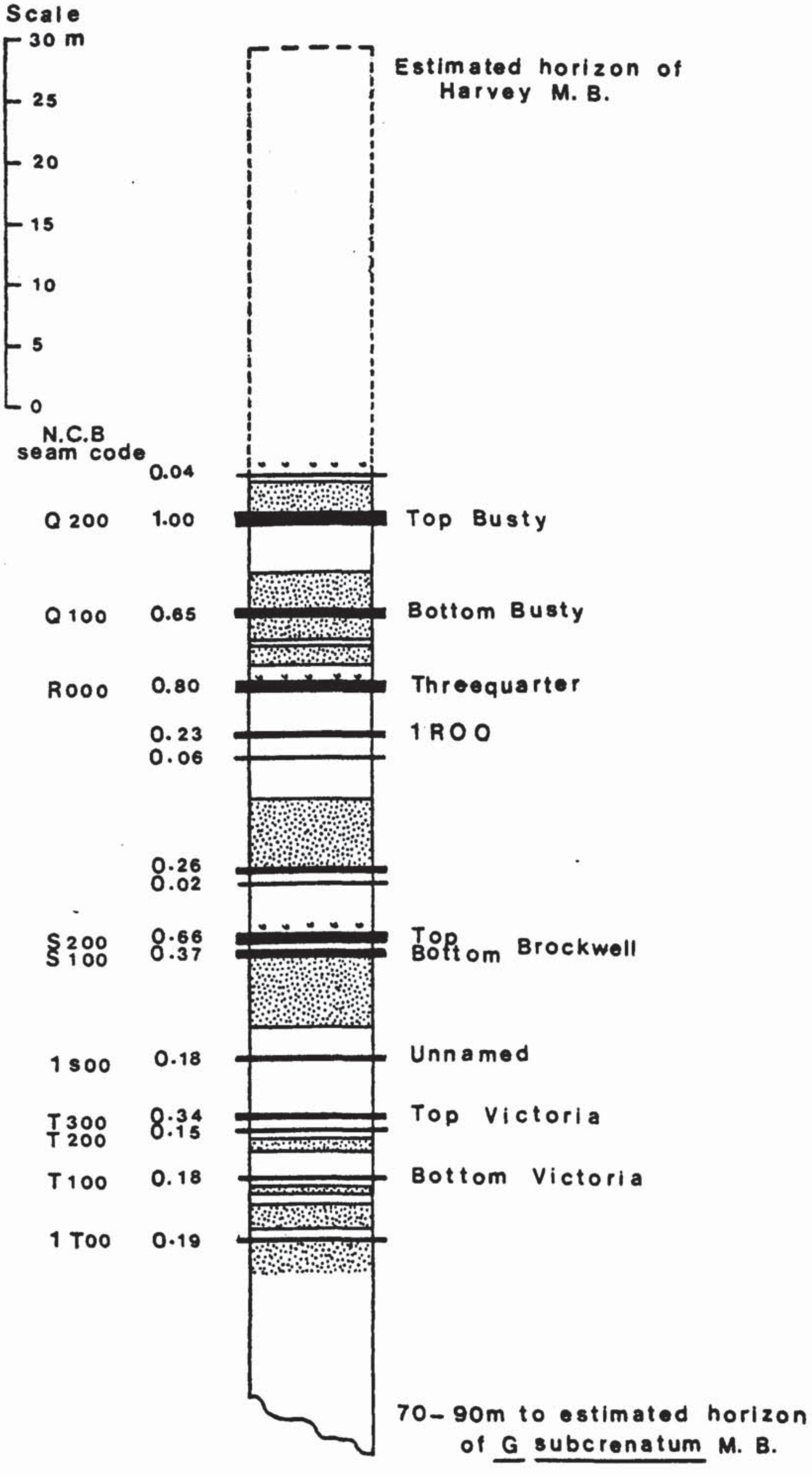


Fig. 15. GENERALISED SECTION OF THE ST. ANDREW'S SITE

Fig. 18: LOCATION MAP OF THE HEDLEY PARK SITE.

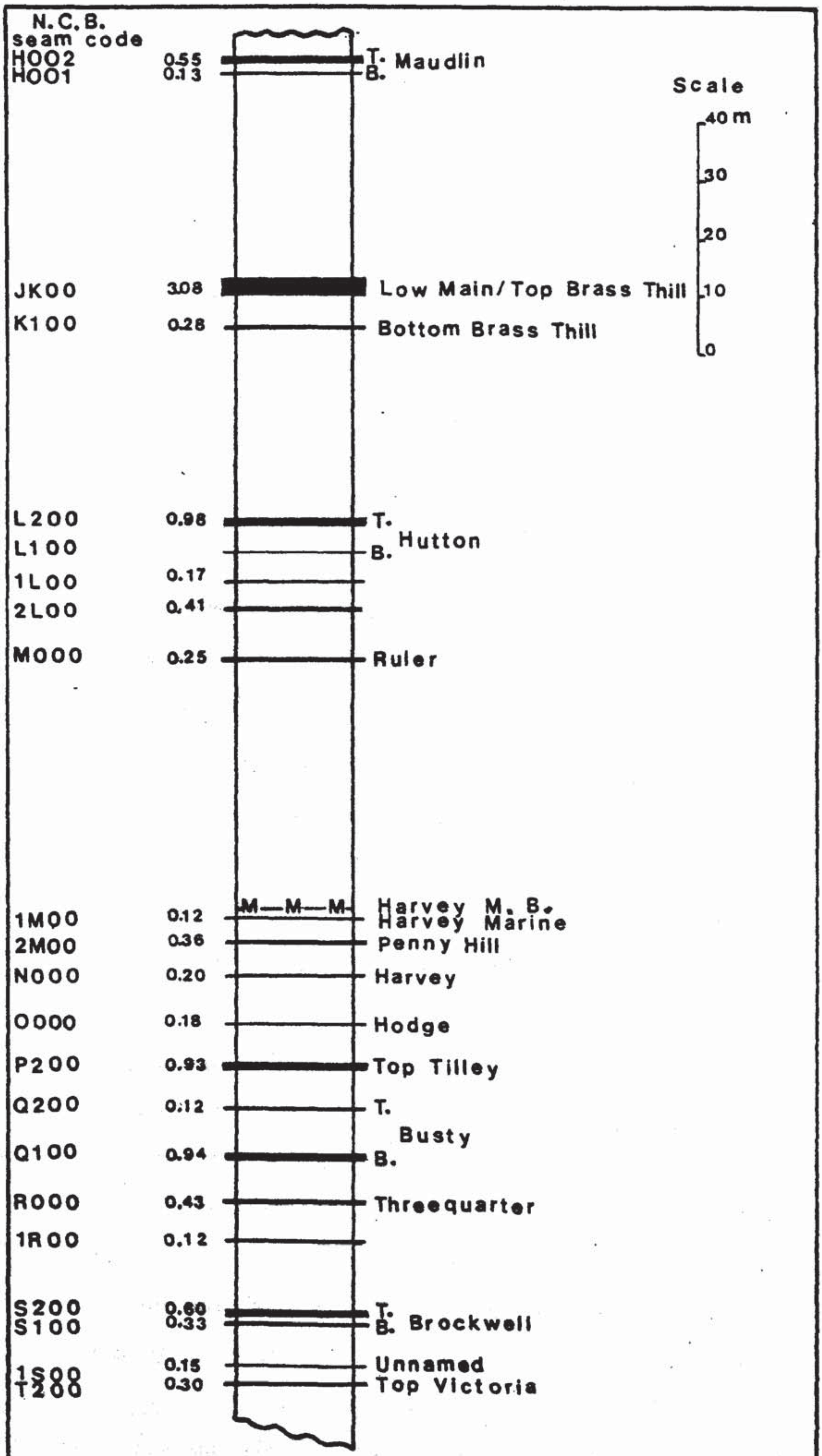


Fig.17. GENERALISED SECTION OF THE HEDLEY PARK SITE

Numerous smaller faults were also proved by drilling and the dislocations caused are, in places, considerable. The regional strike of the strata is north-west to south-east with a corresponding dip to the south-west but this may vary with localised folding and faulting.

The strata apart from the coal seams comprise mainly shales and mudstones, siltstones, sandstones grading into argillaceous sandstones, with softer beds of seatearth and occasional thin clay bands. Impersistent bands of nodular ironstone are common throughout the succession. The site affords a very good section of most of the Lower Coal Measures and the lower part of the Middle Coal Measures with the Vanderbeckei Marine Band (Solway M.B.) containing *Lingula* and fish scales.

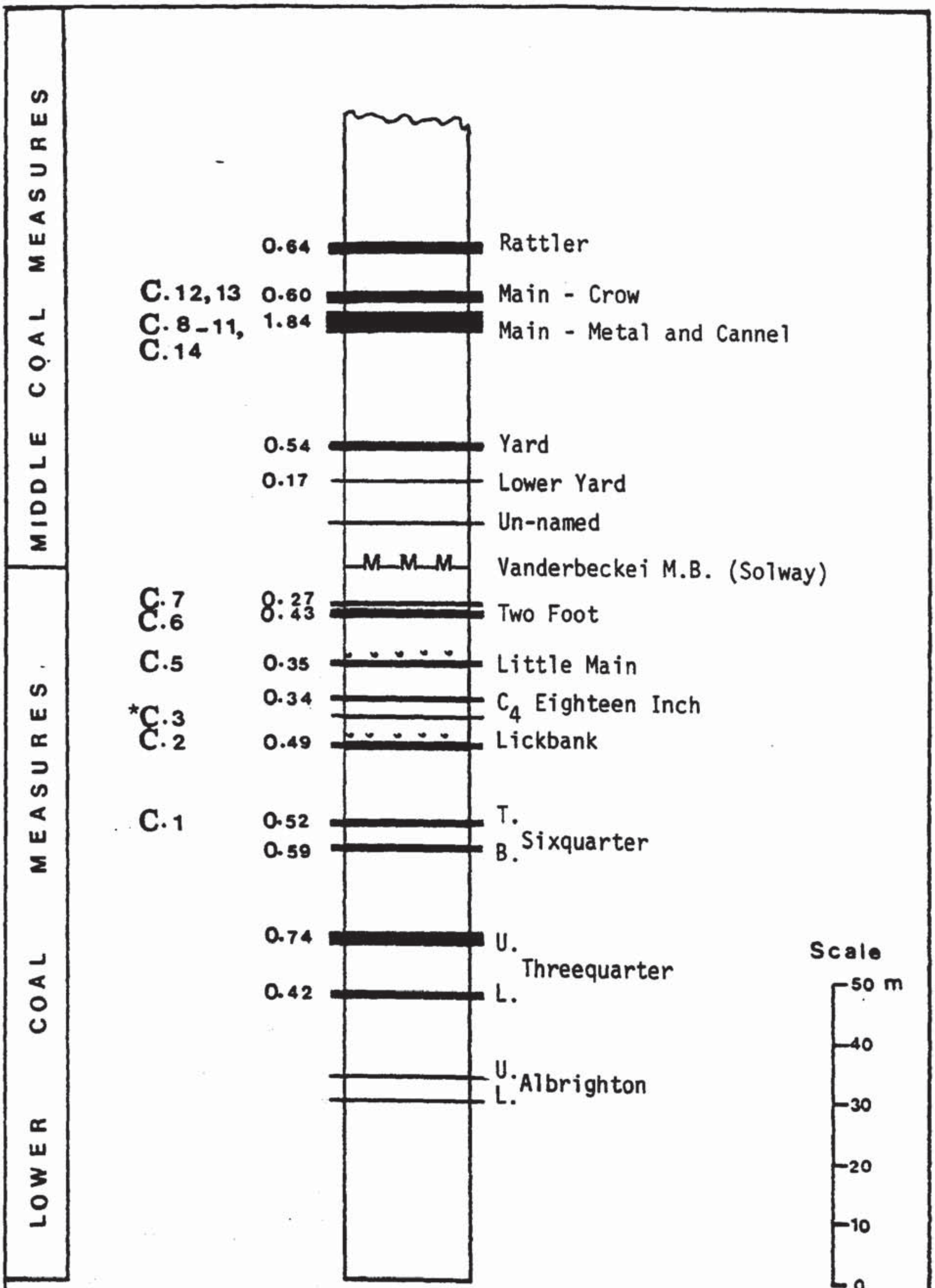
The measures immediately above the *G. subcrenatum* Marine Band at the base of the Lower Coal Measures, contain up to five marine horizons. An horizon a short distance above the uppermost of these horizons, Templeman's Marine Band, but below the Lower Three Quarters Seam, is taken by Taylor (1961), on faunal evidence, as the base of the *C. communis* zone.

There is no marine band between the Upper Three Quarters Seam and the Vanderbeckei M.B. (Solway M.B.). Important seams in the Lower Coal Measures of this coalfield are the Lickbank and Little Main, both containing a non-marine shell assemblage in the immediate roof. Taylor *et al*. (1971, Fig. 23) correlated the Lickbank seam with the Wellsyke Seam in the Midgeholme Coalfield and the Top Busty Seam in Northumberland and Durham Coalfield. Later on, Ramsbottom *et al*. (1978), in their comprehensive Plate 2, placed the Lickbank Seam equivalent to the Craignook Seam at Midgeholme and to the Top Busty Seam in the Northumberland and Durham Coalfield.

The impressive ostracode band above the Top Eighteen Inch Seam (Potash Seam in St. Bees bores No. 3 and 4), indicates the lower part of the *A. modiolaris* ~~Chrono~~zone. Taylor (1961, p. 22) correlated this coal seam on the basis of the abundance of the ostracodes with the (Hopkins Shell Band) Harvey Seam. The Solway Marine Band (Vanderbeckei Marine Band) occurs at about the middle of the *A. modiolaris* zone and is equivalent to the Harvey Marine Band in the Midgeholme and Northumberland and Durham Coalfields. The boundary between the *C. communis* zone and the *A. modiolaris* zone lies near the Lickbank Seam (Taylor 1961, 1971; Ramsbottom *et al*. 1978, Plate 2).

Non-marine shells are usually present associated with fish remains in the roof of the Yard Seam. The fauna as a whole indicates a position roughly in the middle of the Upper *A. modiolaris* zone (Taylor 1961, 1971) and Ramsbottom *et al*. (1978). The shell bands between this horizon and the Main Band are dominated by non-marine faunas typical of the middle and upper part of the *A. modiolaris* zone, therefore, Taylor (loc. cit.) placed the Main Band on the boundary between the *A. modiolaris* zone and the Lower *similis-pulchra* zone in the lower part of the Middle Coal Measures (Westphalian B). Taylor *et al*. (1971, Fig. 23) and Ramsbottom *et al*. (1978, Plate 2), correlated the Main Seam in West Cumberland Coalfield with the Maudlin Seam and Bensham Seam in the Durham and Northumberland Coalfields respectively.

Westphalian A and B seams sampled at Low Close Opencast Site are indicated on the section given in Fig. 18.



*Unproductive samples

Fig. 18. GENERALISED SECTION OF MEASURES IN LOW CLOSE SITE

CHAPTER 3

HISTORY OF SILESIAN PALYNOLOGY

3.1 Silesian Palynology in Britain

3.1.1 Early Workers

The first application of palynology to coal seam identification in Britain was made by Slater, Evans, and Eddy (1930, 1932) from the Fuel Research Division, who examined the megaspores present in thin sections of coal from the Parkgate, Barnsley, and Silkstone coal seams of the Yorkshire Coalfield. They used the distributions of megaspores within seams for correlation purposes.

This work was further advanced by Raistrick and Simpson (1933) and Raistrick (1934, 1937) who investigated the distribution of microspores in seams from Coal Measures deposits in the Northumberland and Durham Coalfield. They recorded the frequencies of various types within each coal seam in terms of general and accessory spores and used them for purposes of correlation. They differentiated seven main groups, lettered from A-G, and figured them. Later, Raistrick (1938) published a paper in which he described the miospores present in some seams from the Lower Carboniferous and Millstone Grit of the Northumberland Coalfield, figuring many spore types which were different from those described from the Coal Measures of the same coalfield.

Millott (1939, 1945) described the vertical distribution of miospore assemblages in seams of Namurian and Westphalian age in the Cheadle and main North Staffordshire Coalfield.

Knox (1942, 1945) examined miospores from coal seams of the productive Coal Measures in Fife and the Central Coalfield of Scotland. She indicated that the occurrence of certain miospore associations within a seam are of value in the correlation of the seams and also she observed that the accessory spores vary in the vertical sequence and therefore have value as zonal fossils. She noticed that there is a similarity between the floral zones proposed by Dix (1933) and the non-marine lamellibranch zones, on the one hand, and the distribution of the accessory spores on the other.

Later on Knox (1948) examined miospore assemblages from the Namurian Limestone Coal Group in Scotland, and she indicated that the miospores recorded from the Limestone Coal Group were greater in number and that most of them differed from those described from the Productive Coal Measures.

3.1.2 Zonations

The first attempt to utilize the miospore assemblages in a zonal scheme was that of Balme and Butterworth (1951-2) who studied the vertical distributions of fossil spores in the coal seams of Central England. They showed that the Coal Measures sequence could be subdivided into three groups characterised by three main assemblages, recognized by the presence and absence of certain spores. This work was extended by Butterworth and Millott (1954) who investigated miospore assemblages in Upper Carboniferous coals of the North Staffordshire, Cannock Chase and North Wales Coalfields. They recognised five assemblages, including those defined by Balme and Butterworth (1951-2), and these assemblages were designated as S0 to S4. In 1960 Butterworth and Millott extended the earlier scheme to nine zones extending from the Upper Visean to the Westphalian D, based on the evidence available from coal seams.

In 1967 Smith and Butterworth introduced further refinement and a more comprehensive zonal scheme, extending the scheme into eleven miospore assemblages ranging from Lower Visean to Westphalian D, all from Great Britain.

In 1961 Neves extended an earlier investigation to the whole of the Southern Pennines Region from where he described Namurian and Lower Westphalian A spore distributions, relating them to the standard sequence of goniatite stages. He indicated the ranges of species recognised but did not establish an independent zonal scheme as he did in 1968 when he examined the vertical distribution of miospore species from some 25 horizons, ranging from Upper Visean to Westphalian A in age, in the Woodland Borehole, Co. Durham. He subdivided the sequence into eight stratigraphical zones which were related to the standard goniatite stages.

Owens, in Owens and Burgess (1965), studied the stratigraphical distribution of spores in the Upper Carboniferous sediments (Namurian and Lower and Middle Coal Measures) of the Stainmore area, Westmoreland, and utilized them to propose an independent zonal scheme, and to support the established goniatite stages and non-marine lamellibranch zones.

Neves _et al_. (1972, 1973), reviewed in detail the distribution of miospore assemblages from Dinantian coals and shales in Northern England and the Midland Valley of Scotland. They devised a significant comprehensive zonal scheme for these Lower Carboniferous strata subdividing them into five concurrent range zones as a substitute for the two assemblages characteristic of the upper part of the Dinantian (Upper Visean) proposed by Smith and

Butterworth (1967), based on the miospore contents of the coal seams only.

Later, in 1977, Owens et al. established a broad scheme of palynological zonation extending from the Upper Visean to the Westphalian A. They recognised in the Namurian deposits five assemblage zones based on data obtained from coal seams and clastic sediments from Northern England and Scotland. These five assemblages replaced the three assemblages proposed by Smith and Butterworth (1967) whose other six Westphalian assemblages were still recognised.

Clayton et al. (1977) in the meantime proposed a broad palynological zonal division for the whole of Western Europe, extending from the Upper Devonian to the Lower Permian System. They substituted the earlier part of the zonal scheme based on coal seams, by an alternative scheme proposed by Loboziak (1974, 1976). In the meantime Owens et al. (1978), during the 1975 C.I.M.P. meeting in Moscow, attempted a comprehensive palynological subdivision of Carboniferous deposits based on a synthesis of different zonal divisions erected by several authors in North-western Europe and the Donetz Basin of the U.S.S.R. This synthesis was read to a later meeting in Halifax, Nova Scotia.

3.1.3 Stratigraphy

Butterworth and Williams (1958) examined the miospore assemblages of coals in the Limestone Coal Group and Upper Limestone Group (Namurian A) in the Midland Valley of Scotland, and found that the spore assemblages were basically the same as assemblages of similar age in North America, Russia, and elsewhere. They pointed out that there was a possibility of using spores of this age for long distance correlations.

Sullivan (1964) isolated miospore assemblages from samples collected from two horizons in the Drybrook Sandstone of the Forest of Dean Coalfield. He established that one horizon was Upper Visean in age and the other was Lower Westphalian A.

Marshall and Williams (1970) examined spore assemblages from 23 horizon of coals and shales in the Yoredale Series of the Roman Wall area in Western Northumberland. Their samples spanned the Visean-Namurian boundary but they found that no significant changes took place in the assemblages at this horizon. This work relates to the area immediately north of the present project and to strata immediately below those described here.

In 1965 Neves et al. studied miospore assemblages from the Passage Group (Namurian-Westphalian) in the Scottish Carboniferous succession; they pointed out that some of the missing stages indicated by previous authors on faunal evidence are in fact present.

In their work, Sabry and Neves (1970) examined and described miospore distributions in the sediments of the Sanquhar Coalfield, Dumfriesshire, Scotland, ranging in age from Upper Visean to Westphalian C. Again Love and Neves (1964) utilized the fossil spore contents of a thin coal (Main Coal), coal lenticles and a seatearth from the most north-westerly of known Carboniferous rocks in Scotland, at Inninmore Bay, to indicate the Mid-Westphalian B age of the lenticles and seatearth, and approximate Westphalian B-C boundary age from the Main Coal.

Recent work has been done in the north eastern part of

Ireland by Whitaker and Butterworth (1978) who studied miospore assemblages from the Visean and Namurian Series of the Ballycastle area Co. Antrim. The same authors (Whitaker and Butterworth, 1979) described miospore assemblages from the Arnsbergian stage of Namurian Series, around the type locality of Slieve Anierin, County Leitrim, Southern Ireland.

Wagner and Spinner (1972) concluded from their study of megaspore and miospore assemblages that the Forest of Dean Upper Coal Measures succession is of Upper Westphalian D age. They compared the assemblages with those from Westphalian D deposits in Saar-Lorrain and with Upper Westphalian D - Lower Stephanian deposits in northwest Spain. They also compared their assemblages with those of the Carbondale and Modesto Formation of Illinois.

Butterworth and Smith (1976) made a broad comparison between the British miospore assemblages of Upper Coal Measures age with those in several countries in Europe, part of Russia and the U.S.A.

3.1.4 Palaeoecological Studies

Neves (1958) recorded spore assemblages from a short sequence of coals, non-marine shales, and marine shales containing the Gastrioceras subcrenatum Marine Band of North Staffordshire. He observed that high percentages of the saccate pollen genus Florinites, which is derived from plants with Cordaitalean (Florin, 1936) and Coniferalean (Potonie and Kremp, 1955, p. 22) affinities, occurred in the marine shale assemblages. He considered that they flourished in the area surrounding the basin of deposition, while Chaloner (1958) concluded from this that the pollen was possibly dispersed from the upland flora, which was relatively

undistrubed during transgression by the sea.
Pfefferkorn (1980) noticed that the term "upland flora" has been used by various workers to describe different habitats. He suggests that the term "upland flora" should be restricted to floras which grow in elevated mountainous terrain.

The first examination of clastic sediments after the earlier work by Neves (1958, 1961) was by Sullivan (1962) who examined fossil plant spores from coals and shales collected at 45 horizons exposed at Wernddu Claypit, near Caerphilly, South Wales.
These assamblages ranged from the upper part of the *Communis* Zone (Upper Westphalian A) to the base of the *Phillipsii* Zone (Upper Westphalian C). He concluded that the assemblages yielded by the coals and shales have similar stratigraphical ranges to those spores which have been used for zoning the coal-bearing strata of Great Britain and his results agreed with the zonal scheme proposed by Butterworth and Millott, 1960. Therefore, he concluded that spore studies can be applied to areas previously neglected due to the rank of the coals which prohibits the isolation of the spores.

He also pointed out that the sediments in close juxtaposition to the coal are more closely related to assemblages isolated from coals; while those assemblages isolated from sediments situated some distance from a coal seam yielded high percentages of the *Florinites* - *Potonieisporites* complex; this feature could serve as "marker-bands" for precise correlation between coalfields.

The most extensive investigations of miospore successions within Carboniferous coal seams are those of Smith (1957, 1962) who discussed the relationship between the sequence of miospore assemblages and the petrographic types in certain seams of the

Lower and Middle Coal Measures in the Yorkshire Coalfield. He noted that certain seams contained horizons of densospore-rich crassidurain and he suggested that the peat-forming crassidurain was deposited above water level (aerobic conditions). Smith (1962) presented a depositional model for the British coal swamps and he recognised several successive spore associations which he termed "phases". The first phase, occurring at the base of the coal, is the _Lycospora_ phase, in which the coal is typically bright. The second, Transition phase, is characterised by various species, in which the coal is intermediate between the bright and dull coal. The third is the _Densosporites_ phase, in which the coal is typically dull. A fourth phase, the Incursion phase, may occur at any point within the _Lycospora_ or Transition phases. This work was followed in 1965 by Marshall and Smith who investigated miospore populations in seatearth, coal and roof measures of Westphalian A, B and C age. They concluded that additional significance to stratigraphic correlation is given by the use of the seatearths and roof measures as well as the coal seams.

3.2 Silesian Palynology in areas outside Britain

3.2.1 Western Europe

In Germany, pioneer work on Westphalian palynology was carried out by Potonie (1932) with the help of Ibrahim and Loose. They studied the spore assemblages of the Westphalian Ägir and Bismarck seams in the Ruhr Coalfield and described for the first time many common Coal Measures species.

Bharadwaj (1957 a, b) described the fossil miospore distributions in coal seams of the Saar and Ruhr Coalfields, which range from Westphalian C to late Stephanian and Lower Westphalian D respectively.

Grebe (1962, 1972) described the vertical distribution of small spore genera and species in the Ruhr area in strata ranging from Upper Westphalian A to uppermost Westphalian C. She compared the Ruhr distributions with those of equivalent age in Britain, North France, and Belgium, and concluded that the miospore assemblages concurred with the zonation proposed by Smith and Butterworth (1967).

Pierart (1958) described the miospores and megaspores of the Upper Westphalian C Neeroeteren zone of the Belgium Campine. In 1962 he described the miospores and megaspores of the Westphalian B and C of the Western part of the Borinage Massif, south-western part of Belgium.

Strata of highest Carboniferous age are particularly well represented in France. They occur in the small scattered basins of the Central Massif and in the Saar-Lorraine basins. Alpern et al. (1966, 1967 and 1969) have worked on the spore assemblages of these sequences, and they made attempts to correlate between the various basins inside, and with areas outside, France.

Loboziak (1971) described the miospores and megaspores isolated from coal seams of Upper Namurian to Upper Westphalian C horizons in the western part of the Nord-Pas-de-Calais Coalfield and proposed six zones subdivided into eighteen subzones.

Loboziak (1974) and Coquel et al. (1976) examined a great number of coal samples from several coal basins of Western Europe and proposed a broad palynological zonation scheme for Westphalian and Stephanian deposits. This was expanded by Loboziak et al. (1976) who proposed a new palynological subdivision for the Westphalian Series of Western Europe and Poland They subdivided it into four zones:

Zone 4	*Thymospora obscura-thiessenii*	Westphalian D
Zone 3	*Torispora securis-laevigata*	Westphalian C
Zone 2	*Florinites junior*	Westphalian B
Zone 1	*Radiizonates aligerens*	Upper Westphalian A

Dijkstra has done much work on the distribution of megaspores in the Dutch Coalfields. In 1952 he studied the vertical distribution of megaspores from Carboniferous coal basins in Turkey and compared it with the Carboniferous coal basins in Poland.

Van Wijhe and Bless (1974) made a useful investigation of the Westphalian miospore assemblages isolated from Dutch coal seams and clastic sediments, and proposed six biostratigraphical miospore zones. This zonal scheme was compared with the one proposed by Smith and Butterworth (1967), and they found a great similarity between the two zonations.

Neves (1964) worked on misopore assemblages from coal seams ranging in age from Upper Namurian A to Lower Westphalian B exposed in the La-Camocha coal mine, Gijon, North Spain. He divided the succession into five zones based on the well-preserved miospores and also indicated that certain spore types have stratigraphic importance with restricted ranges which provide a good comparison with other Namurian-Westphalian sequences reported from Europe and elsewhere. Later on, Neves in Moore *et al*. (1971) described the vertical distribution of miospore assemblages in the Villamanin area of Northern Leon, northwestern Spain, ranging from Namurian B to Westphalian C in age. He recognised four miospore zones. These are:

Zone 4	Triquitrites additus	Lower Westphalian C
Zone 3	Vestispora pseudoreticulatus	Westphalian B
Zone 2	Dictyotriletes bireticulatus	Lower Westphalian A
Zone 1	Raistrickia fulva	Namurian B - C

They compared this sequence with contemporaneous sequences in the United States and the U.S.S.R. and related them to zonations based on plant fossils, Cephalopoda and Foraminifera.

Spinner in Wagner et al. (1970) studied the fossil spore assemblages from a short rhythmic marine section of Upper Cantabrian age in eastern Asturias, Spain. He concluded that the Inguanzo spore assemblages were younger than Westphalian D assemblages, and differed from the Westphalian D Thymospora obscura assemblages described by Smith and Butterworth (1967).

Chateauneuf (1973) studied miospore distributions in strata ranging from the upper part of the Westphalian C to the Lower Stephanian and proposed four palynological zones for Central Asturias, Spain.

3.2.2 Eastern Europe

Much palynological work has been done in Silesia; Horst (1955) described Namurian A spore assemblages from Western Upper Silesia and Mährisch-Ostrau. These strata are overlain in Western Upper Silesia by Westphalian A strata from which he also described assemblages.

This study was followed by a more comprehensive one in 1957 by Dybova and Jachowicz, who isolated miospores from 156 seams occurring within the Silesian Basin and ranging in age from Namurian A to Westphalian D. Later, Dybova and Jachowicz (1970) recognised three miospore phases and eleven subphases in detailed subsection analyses of Upper Silesian Coals, again ranging from Namurian A to Westphalian D in age.

Jachowicz (1971) studied in detail spore assemblages of Namurian and Westphalian A age in North Poland and recognised ten zones in the Namurian and three in the Westphalian A. He compared them with those in Western Europe and Britain; also (1974) he studied miospore distributions in Upper Silesian coal bearing strata of the same age.

Kalibova (1970) studied miospores and megaspores in coal seams from the Lower Grey Formation (Westphalian D) to the Upper Red Formation (Upper Stephanian); these strata underly the Bohemian Cretaceous Basin in the northern and northeastern part of the Bohemian Massif, Czechoslovakia. She also examined megaspores from seams belonging to the Westphalian A to Westphalian B and Lower Westphalian C, and correlated these assemblages with Westphalian A assemblages from Poland.

Kalibova continued her investigations in 1970, when she recorded eight megaspore assemblages from coal seams in the Plzen Basin, Western Bohemia, ranging from the Westphalian B - C boundary to Stephanian C in age.

Beju (1970) examined miospore assemblages from the Moesian Platform of Romania, and proposed three main zones (Cb1, Cb2 and Cb3) ranging from Visean to lowermost Westphalian in age.

3.2.3 Asia

Much palynological work has been done in Turkey, the earliest work on Upper Carboniferous palynology being that of Artuz (1957 and 1959) who described spores from coal seams of Namurian to Lower Westphalian A age from the Zonguldak Coalfield. A later investigation was made by Agrali and Konyali (1969) on miospore distributions from the top of the Visean series to the top of the Westphalian D stage in the Amasra Basin; Konyali examined seven boreholes from the southern part while Agrali examined eleven boreholes from the northern part of the basin. They distinguished ten new genera and listed the stratigraphical ranges of 699 spore species belonging to 109 genera.

Loboziak and Dil (1973) examined fifteen unknown coal seams discovered between the Faille du Midi and the classical Westphalian A Kilits Series in the Caydamar mines, Heraclee Basin, Turkey. They concluded that these unknown coal seams had very similar assemblages to those of the Kilits and Cozlon Series, which had been examined palynologically by several authors, and which they presumed to be Westphalian A in age. Furthermore a comparison has been made between these assamblages and those from the lower part of the Westphalian sequence in the Pas-de-Calais Coalfield, North France, by Loboziak (1971, 1972).

In Russia, Inosova _et al_. (1975) proposed a comprehensive zonal scheme based on miospores and pollen grains in the Donets Basin for strata of Westphalian, Stephanian and Lower Permian age.

Teteriuk (1976) expanded the initial work of Ishchenko (1956 & 1958) in the Donets Basin and examined miospores from strata from Tournaisian to Westphalian D age. He subdivided the Dinantian strata into three zones and the Namurian and Westphalian strata into five zones each. He used Potonie and Kremp's spore classification, and thus linked the various palynological zonations in Europe and Russia.

Owens, Loboziak and Teteriuk (1978) and Clayton et al. (1977) have attempted to link sequences in North Western Europe and the Russian Basins and also to introduce a broad palynological zonal scheme for the Carboniferous System as shown in fig. 19. They based their results on the work of various authors, most of whom have been noted in this section.

3.2.4 North America

The first application of palynology to coal seam correlation was made in the United States by Thiessen and Wilson (1923, 1924) who identified megaspores present in various coals in thin section.

Berry (1937) described 14 spore taxa from coal seams in the Pennington Formation near the Mississippian-Pennsylvanian boundary in Tennessee. Most of his spores were not illustrated and described adequately enough to permit comparison with other spores and the exact source of his samples was not given.

Schopf (1938) made the first major palynological investigation in North America, when he described megaspores and prepollens macerated from the Carbondale Herrin (No. 6) Coal (Upper Westphalian) from Illinois. Later, Schopf, Wilson and Bentall (1944) carried out a broad investigation of the stratigraphical distribution, and especially the classification of the spore genera in Carboniferous coals of the United States.

Kosanke (1950) investigated the stratigraphic distribution of fossil spores isolated from coal seams of Pennsylvanian deposits in Illinois, and attempted to correlate the coal seams by means of spore distributions. Miospores of the same age from Indiana were studied by Guennel (1952, 1958).

Series	Heerlen	Stage	Non-Marine Bivalves	Goniatites	Zonal Index	MIOSPORES Zonal Species
WESTPHALIAN	C		*Phillipsii*		SL	*Torispora securis-laevigata*
			U. Similis - Pulchra			
	B		*L. Similis - Pulchra*		NJ	*Microreticulatisporites nobilis* *Florinites junior*
			Modiolaris			
	A		*Communis*		RA	*Radiizonates aligerens*
			Lenisculcata	G_2	SS	*Triquitrites sinani* *Cirratriradites saturni*
NAMURIAN	C	Yeadonian		G_1	FR	*Raistrickia fulva* *Reticulatisporites reticulatus*
	B	Marsdenian		R_2	KV	*Grassispora kosankei* *Grumosisporites varioreticulatus*
		Kinderscoutian		R_1		
	A	Alportian		H_2	SO	*Lycospora subtriquetra* *Kraeuselisporites ornatus*
		Chokierian		H_1		
		Arnsbergian		E_2	TK	*Stenozonotriletes triang.* *Rotaspora knoxi*
		Pendleian		E_1	NC	*Bellispores nitidus* *Reticulatisporites carnosus*
VISÉAN		Brigantian		P_2 P_1	VF	*Tripartites vetustus* *Rotaspora fracta*
		Asbian		B_2 B_1	NM	*Raistrickia nigra* *Triquitrites marginatus*
		Holkerian		Pe_3	TC	*Perotrilites tesselatus* *Schulzospora campyloptera*
		Arundian			PU	*Lycospora pusilla*
		Chadian		Pe_2		
TOURNASIAN		Courceyan		Pe_1	CM	*Schopfites claviger* *Auroraspora macra*
				Ga	PC	*Spelaeotriletes pretiosus* *Raistrickia clavata*
					NV	*Verrucosisporites nitidus* *Vallatisporites vallatus*

Fig. 19. PALYNOLOGICAL ZONATION OF THE CARBONIFEROUS SYSTEM IN WESTERN EUROPE AFTER CLAYTON ET AL. (1977).

Hoffmeister, Staplin and Malloy (1955a) compared the stratigraphic distribution of miospores ranging from Pre-Devonian to Permian in age, in both North America and Eurasia. Later in the same year (1955b) they published another paper in which they described the vertical distribution of miospores from both coal and clastic sediments in the Hardinsburg Formation of Upper Mississippian age, from Illinois and Kentucky. In these papers they used the system of classification proposed by Potonie and Kremp (1954). They found that the clastic sediments yielded well-preserved spores which would be more representative than those of coals which represent a limited environment.

Wilson and Hoffmeister (1956) studied microfloras isolated from the Croweburg Coal of Pennsylvanian age in the northeastern part of Oklahoma. Wilson (1976) described the distribution of fossil spores and pollen grains and their stratigraphical and paleoecological relations in the Desmoinesian Series (Pennsylvanian) of northeastern Oklahoma. This study was based on several studies and research projects done since the 1950's to the present.

Peppers(1964, 1970) examined and described the vertical variation of miospore assemblages from various lithological types in the late Pennsylvanian cyclothems of the Illinois Basin from the McLeansboro Group and the Carbondale and Spoon Formations respectively.

Felix and Burbridge (1967) studied the spores of the Springer Formation of South Oklahoma, to establish its correct age. The three formations ranged from Lower Mississippian (Tournaisian) to Lower Pennsylvanian (Westphalian B) and they found that some of the spore species were restricted to either the Mississippian or the Pennsylvanian, whereas others were common to both systems. They indicated that the Springer Formation is a final transgressional facies ranging from the Mississippian Goddard Formation to the Pennsylvanian Morrow Formation.

Urban (1971) described miospore distributions in the Independence Shale of eastern Iowa which indicated an Upper Mississippian (Chesterian) age .

An extensive investigation was made by Ettensohn and Peppers(1979), who examined miospore assemblages isolated from shales and thin coals from the Pennington Formation (Chesterian) and Breathitt and Lee Formation (Morrowan) in northeastern Kentucky, to establish its correct age. They concluded on the bases of miospore and conodont distributions, that the samples from the Pennington Formation appear to range in age from middle Chesterian (late Visean) to late Chesterian (Namurian A), and samples from the Breathitt and Lee Formations are early Pennsylvanian (Namurian B - Westphalian A) in age.

Habib (1966) studied miospore associations in the Lower Kittanning Coal Seam (lower Westphalian D) of western Pennsylvania. He recognised five associations starting with a Lycospora assemblage at the bottom and terminating with a Densosporites assemblage. He suggested that the upward increase in abundance of the Densosporites assemblage indicated a change from fresh to brackish-water conditions as marine water encroached upon the swamp during transgression. Where a fresh water facies directly overlies the coal, the assemblage is dominated by Lycospora.

Later on, Ravn (1979) recognised three major miospore associations, termed "intervals" in the CP-19-4 Coal, from the Cherokee Group (Westphalian B) of southern Iowa. The first, occurring at the bottom seam, is the *Florinites* interval which included a high diversity of miospore species dominated by the gymnosperm related taxa, *Florinites*, *Pityosporites* and *Potoniesporites*. He suggests that these miospores were carried from a region outside the peat swamp by fluctuations in water level or by environmental events. The second interval is *Densosporites* - *Crassispora* dominated, spores produced mainly by Herbaceous plants which indicate an open marsh condition. The *Lycospora* interval is dominated by spores produced by arborescent lycopods such as *Lepidodendron* and is characterised by a low diversity of miospores which suggests a stable forest swamp.

In Canada Staplin (1960) studied the frequency distributions of miospores in coals, underclays, and shales from the Mississippian Golata Formation, Alberta. He found that their frequencies differ markedly in the various lithologies.

A comprehensive review was made in 1967 by Barss who illustrated thirteen Carboniferous and Permian miospore assemblages from the Yukon Territory, the Northwest Territories, and the Maritime Provinces of Canada. All of these assemblages were illustrated in plates of photomicrographs.

Neves and Belt (1970) described assemblages of late Visean and Namurian A and B ages from the Antigonish and South West Mabon Basin, Nova Scotia, Canada, and compared them with assemblages of similar ages from Britain and Spain.

Hacquebard and Donaldson (1969) and Hacquebard and Barss (1970) studied fossil spores in order to interpret the environments of deposition of coal measures in different areas of Canada.

They coordinated this study with a variety of geological data. The earlier work was in Sydney, Nova Scotia, on the Morien Series (Westphalian C and D), and in Pictou, on the Stellarton Series (Westphalian C). The second work was in the Minto Coalfield of New Brunswick (Westphalian C and D).

3.3 Previous Literature on Spore Classification

A simple classification scheme was presented by Reinsch (1884) who used the trilete mark as a characteristic feature in his description of megaspores and miospores from Central Russia.

Potonie, Ibrahim and Loose (in Potonie 1932) used a binomial classification for the spores of the Ägir and Bismarck seams of the Ruhr. They allocated all species to one genus <u>Sporonites</u>. In the meantime Ibrahim (1932, 1933), working on the same area under the supervision of Potonie, recognised another two germinal types, Monoletes and Aletes in addition to Reinsch's Triletes; therefore he subdivided the genus <u>Sporonites</u> into groups according to the sutural apertures.

These were used later as a basic feature by Naumova (1939) who proposed a simple and widely accepted classification in Russia, based on the presence and absence of a dehiscence mark and its type.

In Britain the first attempt to classify miospores was introduced by Raistrick (1933, 1934) who separated the miospores arbitrarily depending on certain morphological criteria into seven main groups (Genera) and lettered them from A to G, each group containing more than one type, numbered and corresponding to species. This classification was adequate for correlation purposes, but did not become widely adopted.

Schopf, Wilson and Bentall (1944) recognised 14 genera of megaspores and miospores from Pennsylvanian sediments in the U.S.A. and formulated a binomial system of nomenclature to identify each genus instead of using letters and figures. They did not use suprageneric groups in their classification.

Knox (1950) proposed a slightly different classification depending mainly on morphological criteria, but also based on the examination of the spores of living genera. However the main difference was that she divided Schopf, Wilson and Bentall's genera *Punctatisporites* and *Granulatisporites* into the four separate genera *Spinoso-sporites*, *Plani-sporites*, *Verrucoso-sporites*, and *Microreticulati-sporites*, for spinose, smooth, tuberculate, and microreticulate species respectively.

The morphological classification of fossil dispersed spores presented by Potonie and Kremp (1954, 1955 and 1956) and Potonie (1956, 1958 and 1960) utilized all morphological features of fossil spores and grouped them into artificial suprageneric categories. They incorporated taxa previously proposed by Ibrahim (1933) and Knox (1950) in Europe, Naumova (1939) in the U.S.S.R. and Schopf, Wilson and Bentall (1944) in the U.S.A.

The first subdivision was into the Sporites and Pollenites; they then used the nature of the aperture and equatorial features to divide the Anteturma Sporites into Turmae. These were subdivided into Subturmae according to the form of aperture, wall stratification and equatorial thickening. The fourth rank was Infraturma for which the distinguishing criteria were type of aperture, wall stratification and type of ornamentation.

Dettmann (1963) made some alteration to the classification scheme proposed by Potonie and Kremp (loc. cit.). This was because of their arbitrary and inconsistent use of more than one diagnostic feature for the subdivision of various suprageneric taxa. She subdivided the Anteturma Sporites into Turma, Suprasubturma, Subturma and Infraturma according to aperture, wall stratification, equatorial features and sculptural features respectively, as illustrated in her table 2, p. 15. She proposed the new Turma Hilates for spores with a hilum or operculum.

The Suprasubturma Perinotriletes (Erdtman) was emended by Dettmann to include all 'cavate' spores. This division was questioned by several later authors. Richardson (1965) proposed that it should be used in Erdtman's sense for spores with a third, outer diaphanous layer. He proposed the new taxon Pseudosaccitriletes for spores with a cavity between the two exine layers.

Neves and Owens (1966) also revised part of Dettmann's classification of the Anteturma Sporites. They rejected the use of the term cavate and proposed instead the term camerate. They rejected Dettmann's emenedation of Perinotriletes Erdtman because they thought that it led to confusion and was unnecessary. They also rejected Richardson's taxon Pseudosaccitriletes because it excluded cingulate spores and proposed instead the new Suprasubturma Cameratitriletes. They replaced Dettmann's Acavatitriletes with their Acameratitriletes.

In the meantime Smith and Butterworth (1967) also found some inconsistencies in Dettmann's classification (1963). They used the same classification but with some modifications, they accepted Richardson's Pseudosaccitriletes and proposed a new Suprasubturma Laminatitriletes for spores with the exine layers separated but still more or less in contact, as in Crassispora and and Densosporites.

CHAPTER 4

PRACTICAL TECHNIQUES

4.1 Field Sampling.

Most of the samples of coal and sediments upon which this work is based were kindly provided by the N.C.B. Opencast Executive.

Outcrops in the Plenmeller Coalfield are few and all the rock samples have, therefore, been taken from boreholes in the field: 1338, 1350 and 1331 in the west; 1341, in the middle; and 1241 and 1081 in the east of the coalfield. Channel and subsection samples were taken of coal seams. Some shales were also sampled, with the quantity for a representative coal sample being less than for a representative shale sample. Detailed sections are given in Appendix A for those boreholes which were sampled in detail.

Other coal and sediment samples from the Plenmeller, Stublick Bog, St. Andrew's and Hedley Park Opencast Sites are given in Appendix B.

Samples from St. Andrew's Opencast Site (on the western edge of the Durham Coalfield) and Low Close Opencast Site (west Cumbria) were taken from exposed strata in the site. Outcrop samples utilised in this investigation included coals and sediments from the Featherstone area; all were as fresh as can be collected from stream exposures. Before taking any sample the exposed, weathered surface was cleaned to about 5-10 cm depth; this process helps to avoid contamination, and avoids surfaces which have undergone more oxidation than below.

Channel samples from both outcrops and cores were cut to a convenient width, and the size of cutting kept equal through the whole thickness to ensure full representation of the seam. The subsection samples were first examined in the field, and divided into individual layers wherever possible according to the petrography of the seam. A representative amount of each layer was taken, and later on, in the laboratory, a detailed description of the petrography was made (see Appendix A).

4.2 Sample preparation

After removing any dirt and plant material and washing them if necessary, the samples were left to dry at room temperature. Before crushing the samples, the equipment was washed and cleaned very carefully to avoid any contamination between samples.

The coal samples were crushed to pass through B.S.36 mesh sieve (0.42 mm), while the shale samples were crushed to pass through a B.S.14 mesh sieve (1.20 mm), or slightly coarser, to about 2-3 mm in diameter. The pestle and morter was used several times to crush the individual samples in order to avoid some pieces of the coals and clastic sediments from becoming powdered which causes the destruction of spore exines. Larger shale samples were prepared with the jaw crusher which was cleaned thoroughly between samples.

Representative samples for maceration processes were obtained either by the 'cone and quarter' method as described by Twenhofel and Tyler (1941), or by the manual splitter.

4.3 Maceration

The outer layer (exine) of spores and pollen, called sporopollenin by Zetzsche and Kälin (1932), has a considerable stability and resistance to chemical reaction and to general degradation over millions of years.

The maceration is the oxidation of the organic matter to remove ulmins and humic substances. There are several methods of oxidation but the most important types used in routine maceration are:

(1) Schulze reagent and alkali; Schulze reagent is a mixture of potassium chlorate and concentrated nitric acid:

(a) Wet method: 30 grammes $KClO_3$ dissolved in 300 ml H_2O and 600 ml conc. HNO_3 added.

(b) Dry method: more quickly reacting than the wet method. Described by Raistrick (1934) and Raistrick and Marshall (1939) and used by many later workers; 2 grammes coal, 2 grammes $KClO_3$, mixed with 10 ml conc. HNO_3.

With either method, treatment is followed by washing with distilled water, the addition of a weak alkali solution, and further washing with water.

(2) Fuming nitric acid: Zetzsche and Kälin (1932) recommended the use of fuming nitric acid saturated in bromine, because they thought that this mixture would protect the wall of fossil spores during the process of oxidation, and because they thought that the sporopollenin might be of a polymeric terpenoid nature. The work of Shaw and Yeadon (1964) however, made this hypothesis untenable, and they noted that sporopollenin contains cellulose, a xylan fraction and high percentages of a lipid fraction.

Balme and Butterworth (1952) found that the action of fuming nitric acid was less drastic on thinner exines than the action of Schulze's solution and alkali, and also considered that the use of bromine was not necessary with fuming nitric acid. Later authors agreed with this conclusion.

The length of time and type of oxidation required to macerate individual samples is variable and assessment of this factor is largely a matter of experience. Kosanke (1950), Funkhouser and Evitt (1959), Staplin (1960), and others, all noted that the type of oxidation used, and the time of oxidation, may have varying effects of spore exines; some spores are oxidised more quickly than others and might even disappear.

Procedures used in the present investigation are as follows:

4.3.1 Oxidation of coal:

Representative coal samples (0.5-1 gramme) were treated with varying proportions of fuming and concentrated nitric acid, for periods ranging from 17-72 hours.

(i) 50 ml fuming nitric acid (S.G. 1.5)

(ii) 20 ml conc. HNO_3 with 40 ml fuming HNO_3.

(iii) 25 ml conc. HNO_3 with 25 ml fuming HNO_3.

The strength of oxidation needed, and also the time of oxidation, vary from sample to sample depending on (a) the carbon content of the coal and (b) the degree of weathering. Therefore samples must be checked from time to time to see if they are ready for dilution.

The second and third strengths of oxidation tend to take slightly longer than the first, but give good results. After oxidation the residues were filtered by Buchner funnel with a sintered glass disc, (porosity grade 3), and washed with fuming nitric acid two or three times to ensure that the residue was completely oxidized, and then washed with conc. nitric acid several times (3-4), until the drops from the funnel glass became colourless. Thus the ulmins and humic matter products will pass through the filter plate, leaving the organic residue containing unoxidized plant cuticle and miospores. The residues were then washed with dilute nitric acid four to five times, and then washed very thoroughly with distilled water several times to remove the fine material which tends to become aggregated during oxidation. During the washing the pores of the filter plate become blocked, so blowing air several times from the pressure flask helps to keep the filtration process going (Neves and Dale 1963).

Residual organic compounds may be removed by treatment with a solution of KOH or NaOH. It has been found that treatment with 5% alkali, or prolonged treatment, has a damaging effect on spore exines, and it is well known that this also causes the spore exines to swell. On the rare occasions when alkali was used, therefore, the concentration was reduced to 0.2-0.5% or less and the period of treatment kept very short, for as long as it took the alkali to pass through the filter plate.

4.3.2 Removal of silicates:

The isolation of fossil spores from clastic sediments was done by the treatment of shales with dilute HCl to remove any carbonates present, and then with 40% HF, to dissolve the silicates. 15-20 grammes of a representative shale sample was mixed with 250 ml hydrofluoric acid in a polythene jar. The sample was kept in the acid for a period of 6-7 days, and every day the sample was stirred. The sample was broken down and the products of the reaction are:

$$4HF + SiO_2 \qquad SiF_4 + 2H_2O$$

The residue was then carefully decanted and the jar filled with distilled water, stirred, left to settle for several hours, and then decanted again. This process was repeated five or six times until the residue became neutral. The neutral residue was then transferred into a filter glass funnel and oxidized by the addition of one part conc. HNO_3 with three parts of fuming HNO_3 for 30-90 minutes or the time taken to go through the filter funnel plate, and the same procedure was gone through as described above for coal.

4.3.3 Ultrasonic vibration:

To disperse or to break down any clumps of insoluble organic particles, which may aggregate and obscure spores, the ultrasonic bath was used for 5-8 seconds before and after the clastic sediment was treated with nitric acid, and after the oxidation of coals for a period of between 15-20 seconds.

After ultrasonics it was sometimes necessary to filter the maceration again and wash it with distilled water to remove minute particles.

4.3.4 Mounting of spore residue:

A few drops of the washed residue were taken and mixed with three or four drops of 2% Cellosize (aqueous solution of hydroxyethyl cellulose) which is an excellent dispersing agent recommended by Jeffords and Jones (1959). For each sample a few drops of this mixture were spread evenly and carefully over a coverslip. The moisture on the coverslips must be completely dried very slowly on a low temperature hot plate slightly above room temperature. When the coverslips were dried off they were thinly covered with Canada balsam and left for 15-20 minutes on the hot plate at 120°C before being stuck to a glass slide.

Canada balsam was used instead of the thermo-setting plastic used by Jeffords and Jones (1959).

4.4 Microscopy:

Routine logging of the miospore assemblages was carried out at a magnification of 400 times using a WATSON MICROSYSTEM 70 microscope. Fine details of morphology were observed at higher magnification using a ZEISS PHOTOMICROSCOPE II; all photographs taken were with the Zeiss and the stage co-ordinates for photographed specimens relate to that microscope.

4.5 Scanning Electron Microscopy:

Scanning electron microscopy has provided a new method of investigation into the morphology of fossil spores and pollen along with light microscopy. Brack and Taylor (1972) have used this method to study the structure of Endosporites and the relation of the various spore layers and their type of attachment. Urban (1971), Courvoisier and Phillips (1975), and recent work by Playford and others, has shed additional light on the morphology and the structure of various Carboniferous spores.

In the present study Scanning electron microscopy was also used to obtain more information on the morphology and structure of some of the taxa described. However, in some cases more detailed work is necessary in order to understand more about these features.

The samples prepared for the SEM were made initially by taking a drop of the sample residue and distributing it evenly over a small microscopic slide, and allowing it to dry naturally. During the time when the sample was wet, clean specimens were chosen for the SEM, using a transmitted light microscope. At a later stage in the investigations clean specimens were picked from the sample residue, while slightly wet, using a fine, pointed, hair-like needle, and mounted on a small slightly wet microscopic slide. When the specimen dries completely and naturally it sticks to the slide. (Muir (1970), discussing the use of SEM in palynology, indicated that the use of an adhesive to stick spore and pollen grains to the specimen holder is not satisfactory, because the adhesive might obscure some or all of the spore features).

The slide is then stuck onto an aluminium specimen holder, coated under vacuum with Carbon, and then fixed in the specimen chamber of the microscope where it is evacuated to a working pressure.

The results were not good enough, however, when they were coated with carbon, because of the poor electrical conductivity of the specimens which led to the specimens becoming charged. Gold-palladium coating was, therefore, tried for 3 minutes but the extensive heat used continuously damaged the specimens.

Better results were obtained by subjecting the specimens to short periods of coating during a longer period (5-6 minutes) in the vacuum chamber. This meant that less heat was required, and the specimens kept under a certain temperature. The results were then adequate to good as is shown in the Plates.

CHAPTER 5

Systematic Description of Miospores

This chapter constitutes a systematic account of the miospores recovered from the upper Namurian and Westphalian sediments of Low Close Opencast Site, Featherstone, Plenmeller, Stublick Bog, St. Andrew's Opencast Site and Hedley Park in Northern England.

In this section the descriptive terminology and morphological classification used is that discussed by Grebe (1971) who reviewed and clarified terms employed in spore nomenclature by several workers including Potonié and Kremp (1955), Couper and Grebe (1961) and Kremp (1965).

The classification adopted during the present study is within the framework of Potonié and Kremp's (1954) system. The subturmae Acameratitriletes and Cameratitriletes proposed by Neves and Owens (1966) have been used to accommodate the appropriate genera.

Anteturma SPORONITES (R. Potonié) Ibrahim 1933

Genus CHAETOSPHAERITES Felix 1894

Type species C. bilychnis Felix 1894

Diagnosis in Smith and Butterworth 1967, p. 120 (from description in Felix 1894, p. 272)

Chaetosphaerites pollenisimilis (Horst) Butterworth and Williams 1958

Plate 1, Figures 1 - 3

1907 Karczewski, Plate 1, Figures 5, 6.

1943 Aletes pollenisimilis Horst, (thesis) Figures 84-87.

1955 Sporonites pollenisimilis Horst, p. 150, Plate 24, Figures 84-87.

1957 Sporonites cylindricus (Horst); Dybova and Jachowicz, p.56, Plate 1, Figures 1-34.

1958 Chaetosphaerites pollenisimilis (Horst); Butterworth and Williams, p. 359, Plate 1, Figs. 1-3.

Holotype. Horst 1955, Plate 24, Figure 84. Preparation IV 23, 27.0 77.9.

Type locality. Leopold Seam, Johann-Maria Colliery, Moravska-Ostrava; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 120.

Size in micrometres. (i) Holotype 32; 23-39 (30-35), fum. HNO_3 Horst 1955). (ii) 18 (27) 33 X 14 (18) 24, fum. HNO_3; Northumberland Coalfield, England. Viséan (Smith and Butterworth 1967). (iii) 17 (21) 23 (4 specimens); 40% HF + fum. HNO_3; black shale (M13). (iv) 16-19 X 22 (3 specimens); 40% HF + fum. HNO_3; black shale (M15). (iii) and (iv) from above the Lower Fell Top Limestone, Featherstone.

Description

Spores alete, amb oval to elongate with rounded ends and straight to concave sides, often differentiated into two units each with a central part thicker and darker in colour and an outer part thinner and translucent, unequal in size. The ends of the darker thicker part are concave. The units are generally joined in pairs with thicker parts adjoining, sometimes at an oblique angle.

Previous records. Horst (1955) Moravska-Ostrava, Namurian; Butterworth and Williams (1958) Namurian A, Limestone Coal Group and Upper Limestone Group, Scotland; Staplin (1960) Upper Mississippian, Golata Formation, Alberta, Canada; Playford (1962) Visean and Namurian A, Spitsbergen; Dybova and Jachowicz (1957) Upper Silesia, Poland; Smith and Butterworth (1967) Viséan and Namurian of British Coalfields; Felix and Burbridge (1967) Upper Mississippian, Springer Formation, Oklahoma, U.S.A.; and recorded by several others in

Viséan and Namurian strata.

Occurrence. Rare in black shales, Samples M15 and M13; from above the Lower Fell Top Limestone, Featherstone area.

Sporonites unionus (Horst) Dybova and Jachowicz 1957

Plate 1, Figure 4

1943 Sporonites (?) unionus Horst, (thesis) Figures 88, 89.

1955 Sporonites (?) unionus Horst in Horst; p. 151, Plate 24, Figures 88, 89.

1957 Sporonites unionus (Horst); Dybova and Jachowicz, p. 57, Plate 2, Figures 1-4.

1957 Sporonites aletes Artüz, p. 240, Plate 1, Figure 1.

Holotype. Horst 1955, Plate 24, Figure 88. Preparation I, 70; 29.1, 67.9.

Type locality. Andreas IV Seam, Concordia Mine, Hindenburg; Porubaer Beds, Randgruppe; Namurian A.

Diagnosis. In Horst 1955, p. 151.

Size in Micrometres. (i) Holotype 7, 6-34 (10-20), fum. HNO_3, Horst (1955). (ii) 14 (18) 23, (10 specimens), fum. HNO_3, Little Main Seam, Low Close Opencast Site. (iii) 19 (21) 24, (20 specimens), HF + fum. HNO_3, Black shale (M22) above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular. Exine laevigate, dark brown in colour, 1.5 - 2.5 μm in thickness. Margin smooth. Laesurae (?) indistinct.

Remarks. Staplin (1960, Plate 1, Figures 13-15), illustrated, three photographs of Chaetosphaerites pollenisimilis (Horst) Butterworth and Williams 1958 consisting of one, two and three celled units. But the first photograph, of a single cell, is not characteristic of Chaetospherites pollenisimilis as described by Butterworth and Williams

1958, and is more similar to Sporonites unionus.

Comparison. Distinguished from Chaetosphaerites by its circular amb and uniform thickening of the exine.

Previous records. Horst (1955) Namurian A to Westphalian, Moravska-Ostrava; Dybova and Jachowicz (1957). Upper Silesia, Poland; Artüz (1957) Namurian - Westphalian A, Zonguldak Coalfield, Turkey; Staplin (1960) Upper Mississippian, Golata Formation, Alberta, Canada.

Occurrence. Absent to rare throughout the sequence, common in sample M22 and in the Little Main Seam, Low Close Opencast Site.

Anteturma SPORITES H. Potonié 1893

Turma TRILETES (Reinsch) Dettmann 1963

Suprasubturma ACAMERATITRILETES Neves and Owens 1966

Subturma AZONOTRILETES (Luber) Dettmann 1963

Infraturma LAEVIGATI (Bennie and Kidston) Potonié 1956

Genus LEIOTRILETES (Naumova) Potonié and Kremp 1954

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

Diagnosis. In Smith and Butterworth 1967, p. 121 (from Potonié and Kremp 1954, p. 120).

Comparison. A laevigate exine and triangular shape characterise this genus and differentiate it from Puntatisporites which is characterised by a more or less circular outline.

Leiotriletes inermis (Waltz) Ishchenko 1952

Plate 1, Figures 5, 6 & 12

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

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

1955 Asterocalamotriletes inermis (Waltz); Luber, p. 40, Plate 1, Figures 20, 21.

1955 Leiotriletes inermis (Waltz); Potonié and Kremp, p. 37.

Holotype. Not designated by Waltz.

Diagnosis. In Smith and Butterworth 1967, p. 122 (Waltz 1938, from C.E.D.P. translation No. 1443 in French).

Size in micrometres. (i) 40-50 Schulze (Waltz 1938). (ii) 40-65 (Ishchenko 1958). (iii) 30 (38) 55 fum. HNO_3; Northumberland Coalfield, England; Viséan (Smith and Butterworth 1967).

(iv) 23 (31) 42, (5 specimens), 40% HF + fum. HNO_3, Black shale (M15), above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular with straight to slightly convex sides and rounded angles. Laesurae distinct, straight, simple to occasionally associated with elevated lips up to 1.5 µm; rays open, 2/3 - 3/4 spore radius. Contact area slightly developed. Exine laevigate, relatively thick but less than 2 µm in thickness.

Comparison. L. guennelii Ravn 1979, L. subadnatoides Bhardwaj 1957 and L. subintortus (Waltz) Ishchenko 1952, are all distinguished by their smaller size. L. guennelii has a thinner exine.

Previous records. Ishchenko (1952) Middle Viséan to Lower Namurian of Western Donetz Basin; Ishchenko (1958) Devonian to Bashkirian of the U.S.S.R.; Playford (1962) Middle Viséan, Spitsbergen; Smith and Butterworth (1967) Viséan, British Coalfields.

Occurrence. Rare in samples M15 and M13, Featherstone area.

Leiotriletes guennelii Ravn 1979

Plate 1, Figures 8, 9

1958 Leiotriletes parvus Guennel, p. 57, Plate 2, Figure 8.

1979 Leiotriletes guennelii Ravn, p. 20, Plate 1, Figure 1.

Holotype. Guennel 1958, p. 57; text, Figure 14. Sample 45, Slide 851.

Type locality. Outcrop coal, Upper Block b zone, Owen County, Indiana, U.S.A.: Pottsville Series.

Diagnosis. In Ravn 1979, p. 20 emended from description in Guennel 1958, p. 57.

Size in micrometres. (i) Holotype 22; 16 (20) 28, Schulze (Guennel 1958). (ii) 21 (23) 27, (4 specimens), 1/3 conc. + 2/3 fum. HNO_3, Slag Seam (bottom leaf), at 49.65 m, borehole 1140, Plenmeller Coalfield, England.

Description. Amb triangular with straight to slightly convex sides and rounded to broadly rounded angles. Laesurae distinct, simple, straight, 2/3 - 3/4 of spore radius, rays usually open, with a faint darker area in region of proximal pole. Exine thin, laevigate, less than 1 µm in thickness; usually without compression folds.

Remarks. The specimens described conform to the description in Guennel (1958, p.57), with the exception that the area near the laesurae is slightly darker. Ravn (1979, p.20), emended the diagnosis of the species to clarify the absence of ornamentation which had led some workers, i.e. Loboziak (1971) to consider L. parvus to be synonymous with L. subadnatoides Bhardwaj 1957.

Comparison. L. cf. priddyi (Berry) Potonié and Kremp 1955 is similar in shape but larger in size; L. subadnatoides Bhardwaj 1957 has longer laesurae and an infrapunctate exine.

Previous records. Guennel (1958) Pennsylvanian, Pottsville Series, Indiana, U.S.A. Ravn (1979) Westphalian B, CP-19-4 Coal, Cherokee Group, Southern Iowa, U.S.A.

Occurrence. Rare in the Westphalian sequence.

Leiotriletes levis (Kosanke) Potonié and Kremp 1955

Plate 1, Figures 18, 19

1950 Granulati-sporites levis Kosanke, p. 21, Plate 3, Figure 5.
1955 Leiotriletes levis (Kosanke) Potonié and Kremp, p. 38.
1966 Ahrensisporites vagus Habib, p. 640, Plate 106, Figure 5.

Holotype. Kosanke, 1950, Plate 3, Figure 5. Preparation 500-B, Slide 2.

Type locality. Central Pipe Line - Liddle No. 1 (Friendsville Coal), Wabash County, Illinois, U.S.A., McLeansboro Group.

Size in micrometres. (i) 48 X 50, Schulze and 10% KOH (Kosanke 1950). (ii) 36 and 43 (2 specimens), 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute); Bounder Seam, at 8.44 m, borehole No. 1154, Plenmeller Coalfield, England.

Description. Amb triangular with straight to slightly convex sides and broadly rounded angles. Laesurae distinct, simple, straight, 3/4 of spore radius. Exine laevigate, 1.5 - 2.5 µm in thickness, becoming thicker near the apices and around the laesurae.

Comparison. L. levis is distinguished by its conspicuous thickened areas around the trilete mark.

Previous records. Kosanke (1950) McLeansboro Group, Illinois, U.S.A., Ravn (1979) Westphalian B, CP-19-4 Coal, Cherokee Group, Southern Iowa, U.S.A.

Occurrence. Rare in the Bounder Seam, Sample 796, Plenmeller Coalfield.

Leiotriletes ornatus Ishchenko 1956

Plate 1, Figure 14, 15

1956 *Leiotriletes ornatus* Ishchenko, p. 22, Plate 2, Figures 18-21.

1960 Spore type 1 of Love, p. 122, Plate 2, Figure 9 and text - Figure 12.

1967 *Leiotriletes ornatus* Ishchenko; Felix and Burbridge, p. 354, Plate 53, Figure 3.

Holotype. Information not available.

Type locality. Western extension of the Donetz Basin, Lower Carboniferous, Upper Viséan, U.S.S.R.

Diagnosis. In Ishchenko, 1956, p. 22.

Size in micrometres. (i) 30-45 (Ishchenko 1956). (ii) 28 (37) 45 (10 specimens); 40% HF + fum. HNO_3, black shale (M20) above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular with convex sides and broadly rounded angles. Laesurae distinct, straight, simple to slightly ridged, extend almost to the margin of the spore; lips well developed, dark, bordering the laesurae, 4-6 µm wide. Exine laevigate, 2-3 µm in thickness.

Comparison. *L. tumidus* Butterworth and Williams 1958 differs in having prominent folds. *L. turgidus* Marshall and Smith 1965 is morphologically similar but is larger, 59-104 µm, with a thicker exine and wider lips. Spore type 1 described by Love (1960) is considered by Playford to be *L. ornatus*.

Previous records. Ishchenko (1956), Middle Viséan to Lower Namurian of Western Donetz Basin; Playford (1962) Middle Viséan, Spitsbergen;

Love (1960) Viséan, Pumpherston Shell Bed, Scotland; Felix and Burbridge (1967) Mississippian/Pennsylvanian, Springer Formation, Southern Oklahoma, U.S.A.

Occurrence. Rare in sample M20, shales above the Upper Fell Top Limstone, Featherstone area.

Leiotriletes priddyi (Berry) Potonié and Kremp 1955

1937 Zonales-sporites priddyi Berry, p. 156, text - figure 2.

1944 Granulati-sporites (?) priddyi (Berry); Schopf, Wilson and Bentall, p. 33.

1950 Plani-sporites priddyi (Berry); Knox, p. 316, Plate 17, Figure 220.

1955 Leiotriletes priddyi (Berry); Potonié and Kremp, p. 38.

Holotype. Berry 1937, p. 159; text - Figure 2. Preparation L1, 91 49.4.

Type locality. Pennington Coal, Rhea County, Tennessee, U.S.A. Upper Mississippian.

Diagnosis. In Smith and Butterworth 1967, p. 122 (from Berry 1937, p. 156).

Size in micrometres. Not more than 35 (Berry 1937).

Leiotriletes cf. priddyi (Berry) Potonié and Kremp 1955 in Smith and Butterworth 1967.

Plate 1, Figures 22, 23

1964 Leiotriletes cf. priddyi (Berry) Potonié and Kremp in Sullivan, p. 356, Plate 57, Figure 1.

1967 Leiotriletes cf. priddyi (Berry) Potonié and Kremp in Smith & Butterworth, p. 123, Plate 1, Figures 5, 6.

Size in micrometres. (i) 20 (27) 35 Conc. HNO_3 + 2% KOH, Forest of Dean Coalfield, ? Westphalian A, (Sullivan 1964). (ii) 27 (32) 36, fum. HNO_3; Yorkshire Coalfield, Westphalian B, (Smith and Butterworth 1967). (iii) 24 (28) 31 (6 specimens), fum. HNO_3 Half Seam (top leaf), at 36.79 m, borehole No. 1138; (iv) 22 (26) 31 (5 specimens) 1/3 conc. + 2/3 fum. HNO_3, Ganister Clay, at 24.25 m, borehole No. 1383, (iii) & (iv) Plenmeller Coalfield, England.

Description. Amb triangular with rounded angles and straight to slightly convex sides. Laesurae simple, straight, 2/3 - 3/4 of spore radius, rays open slightly, elevated. Exine laevigate, thin, less than 1.5 µm in thickness, without infrasculpture.

Remarks. The specimens described above conform to the description in Sullivan (1964, p. 356) and Smith and Butterworth (1967, p. 123) with the exception that the apices are not very broadly rounded and "gulaferus" folding is not common; in addition the size of the specimens described above seems to be slightly smaller.

Comparison. L. guennelii Ravn 1979 is distinguished by its smaller size; L. subadnatoides Bhardwaj 1957 has longer laesurae, an infrapunctate exine and also slightly darkened contact area; L. inermis (Waltz) Ishchenko 1952 has the same size range and shape but differs in having a slightly thicker exine and a slight development of the contact area.

Previous records. Sullivan (1964) ? Westphalian A, Forest of Dean Coalfield; Smith and Butterworth (1967) Namurian to Westphalian B, British Coalfields.

Occurrence. Absent to rare throughout the Westphalian sequence, common in the Ganister Clay, Low Main Stringer, Half (top leaf) and Slag (top leaf) seams.

Leiotriletes pyramidatus Sullivan 1964

Plate 1 Figures 7 and 13

1964 Leiotriletes pyramidatus Sullivan, p. 357, Plate 57, Figures 2, 3.

Holotype. Sullivan 1964, Plate 57, Figure 2. Preparation LD1/ 223640.

Type locality. Drybrook Sandstone, Forest of Dean Coalfield, England.

Diagnosis. In Sullivan 1964, p. 357.

Size in micrometres.(i)Holotype 33.5; 25 (31) 38, HF and 2% KOH (Sullivan 1964). (ii) 26 (29.5) 32, (10 specimens), 40% HF + fum. HNO_3; dark shale (M20) above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular with concave to convex sides and rounded apices. Proximal surface pyramidal in shape. Exine laevigate, 1.5-3 µm in thickness. Laesurae distinct, 1/2 -3/4 of spore radius, unequal in length, lips not developed. Three arcuate folds accompany the rays which vary between 3-8 µm in width; occasionally these folds meet near the spore apex.

Comparison. Leiotriletes turgidus Marshall and Smith 1965 has some characters in common but differs in its larger size, 59-104 µm, thicker exine, 5-7 µm and its frequent single fold following the equator. L. ornatus Ishchenko 1956 has a larger size, with broadly rounded angles, well developed dark lips and lack of pyramidal shape on the proximal surface. L. tristchus (Luber) Ishchenko 1958 is larger and the arcuate folds which are 2 µm wide lie at a greater distance from the tecta.

Previous records. Sullivan (1964) Drybrook Sandstone, Forest of Dean Coalfield; Urban (1971) Upper Mississippian of the Independence Shale of Iowa, U.S.A.

Occurrence. Common in M20, black shale, above the Upper Fell Top Limestone, and rare in other Namurian samples, Featherstone area.

Leiotriletes sphaerotriangulus (Loose) Potonié and Kremp 1954.

Plate 1, Figure 16

1932 Sporonites sphaerotriangulus Loose in Potonié, Ibrahim and Loose, p. 451, Plate 18, Figure 45.

1933 Laevigati-sporites sphaerotriangulus (Loose); Ibrahim, p.20.

1944 Punctati-sporites sphaerotriangulus (Loose); Schopf, Wilson, and Bentall, p. 31.

1950 Plani-sporites sphaerotriangulus (Loose); Knox, p.316, Plate 17, Figure 214.

1954 Leiotriletes sphaerotriangulus (Loose); Potonié and Kremp, p. 120.

Holotype. Potonié and Kremp 1955, Plate 11, Figure 107, after Loose. Preparation IV 21, f_2 (m/ol).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 123, (from Potonié and Kremp 1955, p. 41).

Size in micrometers. (i) Holotype 43.5, Schulze. (ii) 40-60, Schulze (Potonié and Kremp 1955). (iii) 30-66, fum. HNO_3 (Horst 1955). (iv) 38 (46) 55, fum. HNO_3; Yorkshire Coalfield, Westphalian B, (Smith and Butterworth 1967). (v) 34 (43) 49 (6 specimens), 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute), Lower Craig nook Seam at 24.93 m, borehole No. 1154. (vi) 37 (44) 51 (5 specimens), 1/3 conc. + 2/3 fum. HNO_3; Low Main Stringer Seam, at 8.50 m, borehole No. 1392; (v) & (vi) Plenmeller Coalfield, England.

Description. Amb triangular, sides straight to convex, with well rounded angles. Laesurae distinct, simple, straight 2/3 - 3/4 of spore radius. Exine laevigate to slightly infrapunctate, relatively thick, 3 μm, brown in colour. Compression folds infrequent.

Comparison. *L. ficilis* Ishchenko 1952 and *L. falsus* Ishchenko 1952 are considered by Dybova and Jachowicz 1957 to be synonymous with *L. sphaerotriangulus*. *L. inermis* (Waltz) Ishchenko and *L. cf. priddyi* have a thinner exine, less sculpture, and are slightly smaller than *L. sphaerotriangulus*.

Previous records. Potonié and Kremp 1955, Middle Westphalian B to Lower Westphalian C of Ruhr Coalfield; Butterworth and Williams 1958, Namurian A of Scotland; Love and Neves 1963, Westphalian B to C, Inninmore, Scotland; Neves 1964, Namurian A to Westphalian A, La Camocha, Spain; Smith and Butterworth, 1967, Westphalian A to Lower Westphalian C of British Coalfields.

Occurrence. Rare throughout the sequence.

Leiotriletes tumidus Butterworth and Williams 1958

Plate 1 Figures 17 and 21

1958 *Leiotriletes tumidus* Butterworth and Williams, p. 359, Plate 1, Figure 11.

Holotype. Butterworth and Williams 1958, Plate 1, Figure 11. Preparation No. T32/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Kilsyth Coking Seam at 1,097 ft. 0 in., Cawder Cuilt borehole, Central Coalfield, Scotland; Namurian A.

Diagnosis. In Smith and Butterworth, 1967, p. 124, from Butterworth and Williams (1958, p. 359).

Size in micrometres. (i) Holotype 46; 34 (42) 52 fum. HNO_3 (Butterworth and Williams 1958). (ii) 28 (36) 42 (4 specimens); 40% HF + fum. HNO_3 dark shale (M20), above the Upper Fell Top Limestone. (iii) 32 (40) 46, (11 specimens). 40% HF + fum. HNO_3 black shale (M15), above the Lower Fell Top Limestone. (ii) and (iii) Featherstone area.

Description. Amb triangular, sides convex, straight to concave, with narrowly rounded angles. Exine laevigate, 1-2 µm in thickness. Laesurae distinct, simple, straight to flexuose, 1/2 - 3/4 of spore radius. Prominent folds of unequal length frequently associated with the rays, vary in width between 2-6 µm.

Comparison. Leiotriletes varioretusus Sabry and Neves 1970, has almost the same size range but the species differs in having well defined contact areas and curvaturae imperfectae. Leiotriletes inermis (Waltz) Ishchenko 1952, L. sphaerotriangulus (Loose) Potonié and Kremp, 1954 and L. subintortus (Waltz) Ishchenko 1952, differ in having broadly rounded angles, thicker exines and absence of the prominent folds which accompany the laesurae; L. ornatus Ishchenko, 1956 differs in having prominent dark raised lips bordering the laesurae.

Previous records. Butterworth and Williams 1958, Namurian A of Scotland, Limestone Coal Group and Upper Limestone Group; Smith and Butterworth 1967, Coals of Great Britain, Viséan and Namurian; Felix and Burbridge 1967, Springer Formation, U.S.A., Miss./Penn.; Sabry and Neves 1970, Sanquhar Coalfield, Scotland; Marshall and Williams 1970, Upper Viséan - Namurian A, Western Northumberland, Northern England. Neves et al. 1973, East Fife, Lothian, Cockburnspath and Berwickshire, Upper Visean.

Occurrence. Common in M15 - M13, dark shales above the Brampton Lower Fell Top Limestone, and rare in other Namurian samples, Featherstone area.

Leiotriletes Sp. A.

Plate 1, Figures 10, 11

Type locality. Dark shale (sample M20), from above the Upper Fell Top Limestone, Pinking Cleugh Section, Featherstone area.

Diagnosis. Amb triangular. Laesurae distinct extend to the margin of the spore, lips well developed and slightly elevated near the extremities. Exine relatively thick, less than 1.5 µm, laevigate.

Size in micrometres. (i) 18 (20) 23 (21 specimens) HF + fum. HNO_3 dark shale (M20), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular with rounded apices and straight to convex sides. Laesurae distinct, straight to flexuous, extending almost to the margin of the spore; lips well developed 1-3 µm in width and up to 1.5µm in height and more elevated near the extremities of the rays. Exine relatively thick, less than 1.5 µm, laevigate to infrapunctate occasionally with small scattered, less than 0.7 µm, grana; margin smooth. Folds occasionally occur, short, less than 4 µm in length, sometimes accompanying the laesurae.

Comparison. This species is distinguished by its small size and long, ridged laesurae. Leiotriletes sp. A. Habib 1966 is more or less similar in shape but differs in its larger size and faint contact area. Leiotriletes adnatoides Potonié and Kremp 1955 has a larger size and simple to straight laesurae. Leiotriletes subintortus (Waltz) Ishchenko 1952 (25-40 µm) has concave sides and simple laesurae.

L. pulvigerus Ishchenko 1956 is larger in size (25-30 μm) and has shorter laesurae.

Occurrence. Rare in black shales (samples, M20 and M22), from above the Upper Fell Top Limestone, Featherstone area.

Leiotriletes sp. B.

Plate 1 Figures 29 - 33

Size in micrometres. 24 (28.5) 31, (6 specimens); 1/3 conc. + 2/3 fum. HNO_3, Slag seam (bottom leaf), at 49.65 m, borehole 1140, Plenmeller Coalfield, England.

Diagnosis. Amb triangular with straight to convex sides and broadly rounded apices. Laesurae distinct, straight to flexuose, extending 1/2 - 2/3 of spore radius, lips well developed, slightly elevated, 1-1.5 μm high; contact area defined by faintly darker area. Exine less than 1.5 μm in thickness. Exine minutely punctate to infrapunctate; ornament more dense near the laesurae. Folds rarely occur.

Comparison. This species is closely similar to L. inflatus (Schemel) Potonié and Kremp 1955 in its size and the convexity of its sides, but differs in its infrapunctate sculpture and ridged laesurae.

L. adnatoides Potonié and Kremp 1955 (30-40 μm) differs from L. subadnatoides Bhardwaj 1957, as Bhardwaj stated, in its size and the shape of its interradial margins. But both species have convex sides and most probably these two species are conspecific. L. adnatoides Potonié and Kremp 1955 differs from L. sp. B. in its laevigate exine and simple, open laesurae.

Occurrence. Rare in the Slag Seam (bottom leaf), Plenmeller.

Leiotriletes sp. C

Plate 1 Figs. **27 & 28**

Type locality Black shale (sample M22), from above the Upper Fell Top Limestone, Featherstone area.

Diagnosis Amb triangular, with rounded apices and convex sides. Laesurae distinct, accompanied by prominent folds. Contact area well defined. Exine thick, laevigate.

Size in micrometres 34, 37 and 37 (3 specimens), HF + fum HNO_3, black shale, above the Upper Fell Top Limestone, Featherstone area.

Description Amb triangular to subtriangular, with rounded apices and straight to slightly convex sides, more convex in the middle of the sides, giving a more or less hexagonal outline. Laesurae simple, straight, 2/3-3/4 of spore radius. Prominent folds frequently accompany the laesurae, 2-4 µm in width, up to 2-5 µm in height and extending to the apices. Contact area well developed, circular to rounded - triangular in shape, occupying 1/2 of the spore diameter. Exine laevigate, moderately thick, less than 2 µm. Secondary folds occasionally occur.

Comparison Leiotriletes sp. C is closely comparable to L. tumidus Butterworth and Williams 1958 (34-52 µm), but differs in having a well-defined contact area, and to L. varioretusus Sabry and Neves 1971 (35-59 µm) in having a contact area but differs in having prominent, broad folds accompanying the laesurae rather than thin lips and curvaturae imperfectae.

Occurrence Rare in black shale (sample M22), from above the Upper Fell Top Limestone, Featherstone area.

Genus PUNCTATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species. P. punctatus Ibrahim 1933

Diagnosis. In Smith and Butterworth 1967, p. 124 (from Potonié and Kremp 1954, p. 120).

Comparison. Differentiated from the genus Leiotriletes (Naumova) Potonié and Kremp 1954 by its more or less circular equatorial outline and thick exine; few compression folds and long laesurae differentiate it from Calamospora Schopf, Wilson and Bentall 1944, which has short laesurae and a thin exine, highly folded.

Punctatisporites aerarius Butterworth and Williams 1958

Plate 1 Figure 34

1958 Punctatisporites aerarius Butterworth and Williams 1958,p.360,pl.1. fig. 17. pl.1. fig.17.

Holotype. Pl. 1, fig. 17. Preparation T33/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Lower Garscadden Ironstone Seam at 1,010 ft. 2 in., Cawder Cuilt borehole, Central Coalfield, Scotland; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 125 (from Butterworth and Williams 1958, p. 360).

Size in micrometres. (i) Holotype 83 X 75; 55 (74) 92, fum. HNO_3, (Butterworth and Williams 1958). (ii) 62 and 67 (2 specimens); 40% HF + fum. HNO_3, black shale (sample M13) above the Lower Fell Top Limestone, Featherstone area.

Description. Amb circular to subcircular. Laesurae distinct, straight, simple to ridged, rays 1/2 to 2/3 of spore radius. Exine laevigate to infragranulate to minutely granulate, grana less than 0.5 µm in basal width; exine 2-3 µm in thickness.

Comparison. P. pseudolevatus Hoffmeister, Staplin and Malloy 1955 is more or less similar but differs in its thinner exine, and its characteristic arcuate fold.

Previous records. Butterworth and Williams 1958, Namurian A of Scotland; Neves 1961, Namurian A to Westphalian A of the Southern Pennines; Love 1960, Upper Viséan of Scotland; Owens and Burgess 1965, Namurian A to Westphalian A, Stainmore area; Sullivan and Marshall 1966, Upper Viséan, Scotland.

Occurrence. Rare in sample M13, black shale above the Lr Fell Top Limestone, Featherstone area.

Punctatisporites giganteus Neves 1961

Plate 2 Figure 9

1961 Punctatisporites giganteus Neves, p. 252, pl. 30, fig. 4.

Holotype. Neves 1961, pl. 30, fig. 4.

Type locality. Marine shale with Eumorphoceras bisulcatum Girty, Bagnall, Staffordshire (Loc. 2). Arnsbergian stage.

Diagnosis. In Neves 1961, p. 252.

Size in micrometres. (i) Holotype 158, 150-170, (10 specimens), Schulze and 10% KOH (Neves 1961). (ii) 90 (106) 120 (6 specimens), 40% HF + fum. HNO_3, black shale, above Lower Fell Top Limestone, Featherstone area.

Description. Amb circular to subcircular. Laesurae distinct, simple, straight, 1/2 - 2/3 of spore radius, rays open slightly elevated up to 1 µm. Exine laevigate to punctate, 2-4 µm in thickness. Margin smooth. Compression folds sometimes occur.

Comparison. Punctatisporites obesus (Loose) Potonié and Kremp 1955 has a thicker exine and smaller size range.

Previous records. Neves 1961, Middle Namurian A, Southern Pennines; Owens and Burgess 1965, Namurian A, Stainmore Outlier; Owens et al. 1977, Middle Namurian A, Northern England and Scotland; Clayton et al. 1977, Middle Namurian A, Western Europe.

Occurrence. Rare in Samples M15 and M13, black shales above Lower Fell Top Limestone, Featherstone area.

Punctatisporites nitidus Hoffmeister, Staplin and Malloy 1955

Plate 1 Figure 35

1955 Punctatisporites nitidus Hoffmeister, Staplin and Malloy, p. 393, pl. 36, fig. 4.

Holotype. Hoffmeister, Staplin and Malloy 1955, pl. 36, fig. 4. Preparation 9, Ser. 18.659.

Type locality. Shale at 2072 ft., Carter No. 3 borehole (TCO-82) Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Smith and Butterworth 1967, p. 127 (from description in Hoffmeister, Staplin and Malloy 1955, p. 393).

Size in micrometres. (i) Holotype 34, 31-43, HF; (Hoffmeister, Staplin and Malloy 1955). (ii) 30 (43) 57, fum. HNO_3; Smith and Butterworth 1967, Central Coalfield, Scotland; Namurian A. (iii) 32 (37) 43, (4 specimens); 40% HF + fum. HNO_3, black shale (M13) above Lower Fell Top Limestone, Featherstone area.

Description. Amb circular. Laesurae distinct, simple, straight 2/3 - 3/4 of spore radius, rays slightly open. Exine laevigate to minutely granulate, 1.5 - 2.5 µm in thickness. Margin smooth, occasional compression folds occur.

Comparison. P. parvipunctatus Kosanke is similar in size range but is more finely punctate. P. globosus (Loose) Schopf, Wilson, and Bentall 1944, has the same size range but appears to be larger and have a coarser ornamentation.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Butterworth and Williams 1958, Namurian A, Scotland; Smith and Butterworth 1967, Namurian, British Coalfields.

Occurrence. Rare in sample M15 and M13, black shales above Lower Fell Top Limestone, Featherstone area.

Punctatisporites nudus Artüz 1957

Plate 2 Figures 1, 2

1957 Punctatisporites nudus, Artüz p. 241, pl. 1, fig. 4.

Holotype. Artüz 1957, pl. 1, fig. 4. Preparation I, 1, 2d.

Type locality. Büyük Seam, Zonguldak Coalfield, Turkey; Westphalian A.

Diagnosis. In Artüz 1957, p. 241.

Size in micrometres. (i) Holotype 53, 47-38, maceration method not stated (Artüz 1957). (ii) 53 & 56, (2 specimens), fum. HNO_3; Little Main Seam, Low Close Opencast Site. (iii) 54 (1 specimen), HF + fum. HNO_3; Black soft coaly shale, immediately underneath the Wellsyke Seam, BH.No. 1350, Plenmeller Coalfield, England.

Description. Amb circular. Laesurae distinct, simple, straight, 1/3 - 2/3 of spore radius; lips well developed 2-3 µm wide and up to 1.5 µm high. Exine laevigate to punctate, 2-3 µm in thickness. Margin smooth, occasional narrow arcuate folds occur.

Comparison. This species is distinguished by its well developed 2-3 µm lips.

Occurrence. Absent to rare in the Little Main Seam, Low Close Opencast Site, and in the seatearth of the Wellsyke Seam in Plenmeller.

Punctatisporites punctatus Ibrahim 1933

Plate 1 Figures 36, 37

1932 *Sporonites punctatus* Ibrahim in Potonié, Ibrahim and Loose, p. 448, pl. 15, fig. 18.

1933 *Punctati-sporites punctatus* Ibrahim, p, 21, pl. 2, fig. 18.

Holotype. Ibrahim 1932, pl. 15, fig. 18. Preparation B29, f1(ul).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 129; (from Ibrahim 1933, p. 21).

Size in micrometres. (i) Holotype 77, Schulze and KOH. (ii) 50-80, Schulze (Potonié and Kremp 1955). (iii) 59 (74) 89, fum.HNO_3, Smith and Butterworth, 1967, Yorkshire Coalfield, England; Westphalian B. (iv) 46 & 53 (2 specimens), fum. HNO_3; Little Main Seam, Low Close Opencast Site, England. (v) 37 (One specimen), 1/3 fum. + 2/3 conc. HNO_3, Slag Seam (bottom leaf); Plenmeller, England.

Description. Amb circular to rounded triangular. Laesurae distinct, ridged, straight, 2/3 -3/4 of spore radius, lips slightly elevated up to 2 μm. Exine laevigate to punctate, not uniformly thickened, 2-3 μm in thickness. Margin smooth.

Remarks. Differs from the original description given by Potonié and Kremp 1955 in its smaller size and the fact that the exine is not uniformly thickened. Sullivan 1964, extends the lower limit from 55 μm to 32 μm.

Comparison. Differs from *P. aerarius* Butterworth and Williams 1958, *P. parvipunctatus* Kosanke 1950 and *P. pseudolevatus* Hoffmeister, Staplin and Malloy 1955, in having a smaller size and coarser ornament.

Previous records. Potonié and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Dybova & Jackowicz 1957, Namurian A to Westphalian A, Upper Silesia; Sullivan 1964, Edgehills Coal, Westphalian A, Forest of Dean Basin, Gloucestershire; Smith and Butterworth 1967, Upper Westphalian A to Lower Westphalian C, British Coalfields.

Occurrence. Rare in Little Seam, Low Close Opencast Site and Slag Seam, Plenmeller.

Punctatisporites sinuatus (Artüz) Neves 1961

Plate 2 Figures 5 & 7, 8

1957 Sinuspores sinuatus Artüz, p. 254, pl. 7, fig. 48.

1958 Punctatisporites densoarcuatus Neves, p. 6, pl. 2, fig. 7.

1958 Punctatisporites coronatus Butterworth and Williams, p.360, pl. 1, fig. 2.

1961 Punctatisporites sinuatus (Artüz) Neves, p. 252.

Holotype. Artüz 1957, pl. 7, fig. 48. Preparation I, 30, 1c.

Type locality. Büyük Seam, Zonguldak Coalfield, Turkey; Westphalian A.

Diagnosis. In Smith and Butterworth 1967, p. 130 (from Artüz 1957, p. 254).

Size in micrometres. (i) Holotype 120; 90-130, maceration method not known (Artüz 1957). (ii) 80 (117) 140, Schulze and KOH (Neves 1958) North Staffordshire Coalfield, Namurian C. (iii) 75 (102) 116 (13 specimens) fum. HNO_3 (Butterworth and Williams 1958) Central Coalfield, Scotland- Namurian A. (iv) 67 (74) 84 (5 specimens), 1/3 conc. + 2/3 fum. HNO_3; Low Main Stringer Seam, at 8.50 m fum. HNO_3; borehole No. 1392, Plenmeller Coalfield, England. (v) 78 (87) 96 (5 specimens) Little Main Seam. (vi) 80 (101) 117 (6 specimens) Eighteen Inch Seam; (v) & (vi) Low Close Opencast Site; Cumbria, England.

Description. Equatorial outline circular to subcircular. Laesurae straight, simple, 1/2 - 3/4 of spore radius. Exine thick, light to dark in colour, and showing a variable thickening in unfolded area, laevigate to infrapunctate; margin smooth, long broad arcuate or peripheral folds present, sometimes joining the radial extremities of the laesurae.

Remarks. The size range recorded during this work in Plenmeller was smaller than the previous sizes recorded by Artüz 1957, Neves 1958 and Butterworth and Williams 1958.

Comparison. P. sinuatus is characterised by its strong peripheral folds and dark brown coloured exine which distinguish it from P. obesus (Loose) Potonié and Kremp 1955, P. giganteus Neves 1961 and P. grandis Hoffmeister, Staplin and Malloy 1955. P. edgarensis Peppers 1970 is most closely similar to P. sinuatus as stated by Pepper "that the former has a more triangular shape and is not as strongly folded, and the broad verrucae are well distinct in P. edgarensis than on P. sinuatus".

Previous records. Artüz 1957, Westphalian A, Zonguldak Coalfield, Turkey; Neves, 1958 Upper Namurian C, North Staffordshire Coalfield; Butterworth and Williams 1958, Namurian A, Scotland; Neves, 1961, Upper Namurian B to Westphalian A, Southern Pennines; Neves 1964 La Camocha, Gijon, Namurian B to Westphalian A, North Spain; Owens and Burgess 1965; Namurian A to Lower Westphalian B, Stainmore outlier; Marshall and Williams 1970; Namurian A, Roman Wall, Northumberland; and also recorded by several workers from Namurian and Westphalian A strata.

Occurrence. Rare throughout the sequence; common in Eighteen Inch (Sample C2), Lickbank (Sample C5), Low Close Opencast Site, Cumbria.

Punctatisporites sabulosus (Ibrahim) comb. nov.

Plate 2 Figs 3-5

1933 Punctata-sporites sabulosus Ibrahim, p. 37, pl. 5, fig. 43.

1955 Punctatasporites sabulosus (Ibrahim) in Potonie and Kremp,
p.45, pl. 11, figs. 126-128.

Holotype Potonie and Kremp 1955, pl. 11, fig. 126 after Ibrahim. Preparation C61, d2(0).

Type locality Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis Amb circular to subcircular. Laesurae distinct, simple, straight, 2/3-3/4 of spore radius. Exine moderately thick, 2-3 µm. Ornamented with minute grana.

Size in micrometres (i) Holotype 67, Schulze and KOH. (ii) 50-70, Schulze (Potonie and Kremp 1955). (iii) 48 (54) 66 (4 specimens), fum. HNO_3, various horizons within the upper part of the Westphalian A sequence.

Description Amb circular to subcircular due to compression folds. Laesurae distinct, simple, straight, 2/3-3/4 of spore radius. Exine moderately thick, less than 3 µm, minutely punctate to granulate, grana 0.5 µm in basal width and height, sometimes these grane fuse at their bases near the contact area to form irregular short ridges, 2-3 µm in length. Compression folds occur frequently.

Remarks The three specimens figured by Potonie and Kremp (pl.11, figs. 126-128) vary, mainly in ornamentation and they show traces of a trilete mark. The specimens described above are similar to the first two photographs of Potonie and Kremp. The species is transferred to Punctatisporites because of the presence of distinct trilete laesurae.

Previous records Ibrahim 1933, top Westphalian B, Ruhr Coalfield, Potonie and Kremp 1955, top Westphalian A to top Westphalian B, Ruhr Coalfield, Germany.

Occurrence Rare in the Upper Craignook Seam (top leaf), Plenmeller Coalfield and the Little Main Seam (sample No. C5), Low Close Opencast Site, Cumbria.

Genus CALAMOSPORA Schopf, Wilson and Bentall 1944

Type species. *C. hartungiana* Schopf in Schopf, Wilson and Bentall 1944 [? synonym of *C. mutabilis* (Loose 1932)].

Diagnosis. (Potonié and Kremp 1955, p. 46) translation in Smith and Butterworth 1967, p. 130.

Remarks. The characteristic features of the genus are the relatively short laesurae which do not usually exceed 2/3 of spore radius; thin laevigate exine; frequent thickened contact area; numerous compression folds due to the weakness of the exine. These are the main features which distinguish this genus from *Punctatisporites*.

Calamospora breviradiata Kosanke 1950

Plate 3 Figures 4 & 7 - 10

1950 *Calamospora breviradiata* Kosanke, p. 41, pl. 9, fig. 4.

Holotype. Kosanke 1950, pl. 9, fig. 4. Maceration 579-B, slide 1.

Type locality. No. 2 Coal, Bureau County, Illinois, U.S.A.; Carbondale Group.

Diagnosis. In Smith and Butterworth, 1967, p. 131 (from Kosanke 1950, p. 41).

Size in micrometres. (i) Holotype 65.1 X 57.7: 52 - 71, Schulze and 10% KOH (Kosanke 1950). (ii) 61 (67) 72, (5 specimens), fum. HNO_3 + 5% KOH, Half Seam top leaf at 12.54 m, borehole No. 264. (iii) 44 (55.5) 69; (10 specimens) fum. HNO_3 + 5% KOH; Three Quarter Seam; at 9.75 m. borehole No. 964. (ii) & (iii) Plenmeller Coalfield, England.

Description. Equatorial outline circular to oval, sometimes *irregular* due to compression folds. Laesurae distinct, simple to slightly ridged and also slightly flexuose, unequal in length -ranging between 7-12, 15-17, 16-28 µm and forming about 1/3 to 1/2 of the spore radius.

Contact area very well marked. The thickness of exine is rather less than 1 μm and it is translucent yellowish in colour. Compression folds tend to be near and parallel to the margin of the spore.

Comparison. *C. saariana* Bhardwaj 1957 has the same size range and morphological features as *C. breviradiata* and is probably a synonym of it. *C. minutus* Bhardwaj 1957 differs in its thick exine and long, elevated laesurae, otherwise it is similar.

Previous records. Kosanke 1950, Middle Group of Tradewater to Upper Group of McLeansboro, Illinois, U.S.A.; Smith and Butterworth 1967; Namurian A to Lower Westphalian C; Owens and Burgess 1965, Namurian A to Westphalian A of Stainmore outlier; and recorded by several workers in Great Britain.

Occurrence. Absent to rare in the lower part of the Westphalian sequence and common in the shale below the Wellsyke Stringer and Upper Craignook in Plenmeller and Maudlin in Hedley Park.

Calamospora laevigata (Ibrahim) Schopf, Wilson and Bentall 1944

1933 *Laevigati-sporites laevigatus* Ibrahim, p. 17, pl. 6, fig. 46.

1944 *Calamospora laevigatus* (Ibrahim); Schopf, Wilson and Bentall p. 52.

Holotype. Ibrahim 1933, pl. 6, fig. 46. Preparation E92, C.

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 132 (from diagnosis and description in Potonié and Kremp 1955, p. 48).

Size in micrometres. (i) Holotype 490, Schulze and KOH. (ii) 250-500, Schulze (Potonié and Kremp 1955).

Calamospora cf. laevigata (Ibrahim) Schopf, Wilson and Bentall 1944 in Smith and Butterworth 1967

Plate 5, Figure 7

1967 Calamospora cf. laevigata (Ibrahim) Schopf, Wilson and Bentall in Smith and Butterworth, p. 132, pl. 2, figs. 10, 11.

Size in micrometres. (i) 150-260, fum. HNO_3; various localities, Great Britain, Westphalian A and B (Smith and Butterworth 1967). (ii) 220-280 (2 specimens); Fum. HNO_3 + 5% KOH; Half Seam (top leaf) at 12.54 m, BH. No. 964. (iii) 151 (194) 265 (4 specimens); Fum. HNO_3 + 5% KOH; Threequarters Seam, at 9.57 m, BH. No. 964. (ii) & (iii) Plenmeller Coalfield, England.

Description. Amb oval, subrounded to irregular in shape due to the compression folds. Exine relatively thin ranging between 1-2 µm. Laesurae distinct, straight to flexuose, simple to ridged, lips up to 2µm, unequal in length, extending 1/3 - 2/3 of spore radius; contact area not very well marked. Compression folds frequently occur over the whole area of the spore and tending to be more or less parallel to the margin of the spore.

Remarks. The smaller size and slightly ridged laesurae, distinguish this form from the type.

Comparison. Distinguished by its larger size range from other types in the genus.

Previous records. Smith and Butterworth 1967, Westphalian A to Lower Westphalian C, British Coalfields.

Occurrence. Absent to rare throughout the Westphalian sequence.

Calamospora liquida Kosanke 1950

Plate 3, Figures 2, 3, 5 and 6

1950 Calamospora liquida Kosanke, p. 41-42, pl. 9, fig. 1.

Holotype. Kosanke 1950, pl. 9, fig. 1. Maceration 574, slide 12.

Type locality. Shoal Creek Coal bed, McLeansboro Group, Bond County, Illinois, U.S.A.

Diagnosis. Kosanke 1950, p. 41.

Size in micrometres. (i) Holotype 81.6 X 84; 76 to 94, Schulze and 10% KOH (Kosanke 1950). (ii) 46 (53) 69, (17 specimens), 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute), Upper Craignook seam (Bottom leaf),at 21-58 m, borehole No. 1154, Plenmeller Coalfield, England.

Description. Amb more or less circular to irregular. Laesurae distinct, simple, straight, two-thirds of spore radius. Exine laevigate, relatively thick, less than 2.5 µm in thickness; numerous compression folds, more or less parallel to the margin of the spore.

Remarks. The specimens described here conform closely with the original diagnosis and description given by Kosanke (1950), excepting that the size range is smaller than that given by him (76-94 µm); this is probably due to the use of KOH in the maceration.

Comparison. Distinguished from forms of similar size by its more or less rounded equatorial outline, relatively thick exine, compression folds which usually occur near the margin of the spore, and absence of contact area. *C. hartungiana* Schopf, Wilson and Bentall 1944 has short, ridged, flexuose laesurae and a darkened contact area. *C. mutabilis* (Loose) Schopf, Wilson and Bentall 1944, has a contact area, bounded by faint curvaturae, as observed by Bhardwaj (1957).

Previous records. Kosanke 1950, infrequent in Westphalian A, Westphalian C to Stephanian, Tradewater Group - McLeansboro Group, Illinois, U.S.A.; Dybova and Jachowicz, 1957, Namurian A - Westphalian A, Upper Silesia: Butterworth and Williams 1958, Namurian A, Scottish Coalfields; Neves 1961, Upper Namurian B to Westphalian A of the Southern Pennines;

Mishell 1966 MS: Namurian A - Westphalian A of Bowland Fells and Ingleton Coalfield; Sabry and Neves 1970, Lower Westphalian A, Sanquhar Coalfield, Scotland.

Occurrence. Rare throughout the sequence; common in the Upper Craignook Seam, Plenmeller Coalfield and in the Lickbank Seam, Low Close Opencast Site.

Calamospora microrugosa (Ibrahim) Schopf, Wilson and Bentall 1944

Plate 2 Figure 10

1932 Sporonites microrugosus Ibrahim in Potonié, Ibrahim and Loose, p. 447, pl. 14, fig. 9.

1933 Laevigati-sporites microrugosus (Ibrahim); Ibrahim, p. 18, pl. 1, fig. 9.

1938 Azonotrilites microrugosus (Ibrahim); Waltz in Luber and Waltz, p. 10, pl. 1, fig. 1, and pl. A, fig. 1.

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

1952 Leiotriletes microrugosus (Ibrahim); Ishchenko, p. 15, pl. 2, fig. 19.

1955 Calamotriletes microrugosus (Ibrahim); Luber, p. 36, pl. 1, figs. 1-3.

Holotype. Ibrahim 1932, pl. 14, fig. 9. Preparation A42, c6 (1).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 133 (from description and diagnosis in Potonié and Kremp 1955, p. 49.).

Size in micrometres. (i) Holotype 77, Schulze and KOH. (ii) 70-100, Schulze (Potonié and Kremp 1955). (iii) British specimens have been recorded up to 110, (Smith and Butterworth 1967). (iv) 70 (89.5) 92, (12 specimens); fum. HNO_3 + 5% KOH, Threequarter Seam, at 9.57 m, borehole No. 964. (v) 72 (77) 89; (10 specimens), 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute) Bounder Seam, at 8.44 m, borehole 1154; (iv) & (v) Plenmeller Coalfield, England.

Description. Equatorial outline subrounded to rounded, shape often irregular due to compression folds. Laesurae distinct, often simple, straight to slightly flexuose, rays equal in length but sometimes some specimens have rays of unequal length and they form 1/3 - 1/2 of spore radius. Exine relatively thin, less than 1.5 µm, translucent and minutely granulate. Large compression folds, tend to be more or less parallel to the margin of the spore.

Comparisons. Calamospora membrana Bharadwaj 1957 (p. 81, pl. 22, fig. 11) shows a dark contact area. C. saariana Bharadwaj 1957 (p.81, pl. 22, figs. 13-15) has smaller size (50-65 µm). C. mutabilis (Loose) Schopf, Wilson and Bentall has the same size range but differs in its longer laesurae and the presence of arcuate ridges. C. liquida Kosanke 1950 (p. 41, pl. 9, fig. 1) has the same size range but is distinguished by its long rays which range between 26 and 31 µm in length.

Previous records. Artüz 1957, Namurian to Westphalian A, Zonguldak, Turkey; Dybova and Jachowicz 1957, Namurian A to Westphalian B, Upper Silesia; Kosanke 1950, Westphalian B Tradewater Group, Illinois, U.S.A.; Grebe 1962, Westphalian B and C, Ruhr Coalfield, Germany; Agrali and Konyali 1969 Amasra Coalfield, Turkey; Smith and Butterworth 1967, Visean to Westphalian C, British Coalfields; Loboziak 1971, Visean to Stephanian of Nord-Pas-de Calais Coalfield, France and others.

Occurrence. Rare to common throughout the sequence; very common in the Marshall Green, Slag, Quarter and Bounder Seams in Plenmeller.

Calamospora pallida (Loose) Schopf, Wilson and Bentall 1944

Plate 3 Figures 11 - 13

1932 Sporonites pallidus Loose in Potonié, Ibrahim and Loose, p. 449, pl. 18, fig. 31.

1934 Punctatisporites pallidus Loose, p. 146.

1944 Calamospora pallida (Loose); Schopf, Wilson and Bentall, p. 52.

Holotype. Loose 1932, pl. 18, fig. 31. Preparation IV26, d4 (ul).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany, Upper Westphalian B.

Diagnosis. In Smith and Butterworth, 1967, p. 135 (from description and diagnosis in Potonié and Kremp 1955, p. 50).

Size in micrometres. (i) Holotype 58.5, Schulze. (ii) 55-70, Schulze (Potonié and Kremp 1955). (iii) 49 (65) 79, fum. HNO_3; Cannel Seam, Bagworth Colliery, Leicestershire Coalfield, England; Lower Westphalian B (Smith and Butterworth 1967). (iv) 58 (66) 75 (12 specimens); fum. HNO_3 + 5% KOH. Threequarter Seam at 9.57 m, borehole No. 964, Plenmeller Coalfield. (v) 56 (67) 74 (10 specimens); 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute) Upper Craig Nook Seam bottom leaf, at 21.58 m, borehole No. 1154,Plenmeller Coalfield, England.

Description. Equatorial outline irregular, rounded to subrounded, shape often distorted by compression folds. Laesurae generally distinct, straight to slightly flexuose, unequal in length 14-20 µm, 11-15 µm, 9-12 µm, and forming 1/3 - 2/3 of spore radius. Exine very thin, less than 1 µm, translucent to yellowish in colour, sculptureless to minutely granulate. Compression folds tend to be more or less parallel to the margin of the spore.

Remarks. Specimens conform with the original diagnosis and description given by Potonié and Kremp 1955, but the laesurae are sometimes indistinct due to the compression folds and also the exine may be ornamented with minute grana.

Comparison. This species differs in size (55-75 µm) from the smaller one *C. parva* (32-52 µm) and from the larger one *C. microrugosa* (70-100 µm). *C. flexilis* Kosanke 1950 (p. 14, pl. 9, fig. 5), has occasional folds running parallel with the rays and has a thick exine 2 µm; Potonié and Kremp (1955) consider these two species as synonyms.

Previous records. Bhardwaj 1957, Westphalian C, Saar Coalfield;Guennel, 1958, Namurian C to Westphalian B of Pottsville Series, Indiana, U.S.A.; Grebe 1962, Westphalian B to C, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Viséan to Westphalian D, British Coalfields; Neves 1968, Viséan to Lower Westphalian A, Woodland Borehole, Co, Durham; Sabry and Neves 1971, Namurian to Westphalian C, Sanquhar Coalfield, Scotland; Loboziak, 1971, Namurian, Nord-Pas-de Calais Coalfield, France.

Occurrence. Rare, common to very common throughout the sequence.

Calamospora parva Guennel 1958

Plate 4 Figure 8

1958 *Calamospora parva* Guennel, p. 71, fig. 16.

Holotype. Guennel 1958, fig. 16, p. 71. Sample 66, slide 4104.

Type locality. Outcrop coal, Upper Block b Zone, Daviess County, Indiana, U.S.A.; Pottsville Series.

Diagnosis. In Smith and Butterworth 1967, p. 136 (from description in Guennel 1958, p. 70).

Size in micrometres. (i) Holotype 38; 32 (37) 45, Schulze (Guennel 1958). (ii) 40 (45) 52; Cannel Seam, Leicestershire Coalfield, England; Lower Westphalian B (Smith and Butterworth 1967). (iii) 32 (38.5) 47, (30 specimens), 1/3 conc. + 2/3 fum. + 2% KOH (one minute) Upper

Craignook Seam (bottom leaf) at 21.58 m, borehole No. 1154, Plenmeller Coalfield, England.

Description. Amb circular to irregular due to compression folds. Laesurae simple and straight, sometimes flexuose, one third to one half of spore radius; in some specimens a slightly darkened contact area visible. Exine laevigate, thin, 0.5 µm, pale yellow in colour; compression folds narrow, more or less parallel to the margin.

Comparison. C. macer Williams 1954 and C. minutus Bhardwaj 1957 have the same size range and are very similar to C. parva but C. minutus has longer (2/3 of spore radius) and elevated ridged laesurae; C. exiguus Staplin 1960 has the same size range but differs in its unequal laesurae.

Previous records. Guennel 1958; Pottsville Coals of Indiana, U.S.A.; Owens and Burgess 1965, Stainmore, Namurian A to Lower Westphalian B; C. cf. parva Felix and Burbridge 1967, Springer Formation, Oklahoma, U.S.A.: Smith and Butterworth 1967, British Coalfields, Viséan to Westphalian B; Sabry and Neves 1971, Sanquhar Coalfield, Scotland; Loboziak 1971, Nord-Pas-de Calais Coalfield, Viséan to Stephanian; Whitaker 1978, Ballycastle, Ireland.

Occurrence. Rare, common to very common throughout the sequence.

Calamospora pedata Kosanke 1950

Plate 4 Figure 9

1950 Calamospora pedata Kosanke, p. 42, pl. 9, fig. 3.

Holotype. Kosanke 1950, pl. 9, fig. 3. Maceration 542-C, slide 3.

Type locality. No. 8 Coal, Peoria County, Illinois, U.S.A.; McLeansboro Group.

Diagnosis. In Smith and Butterworth 1967, p. 136 (from description in Kosanke 1950, p. 42).

Size in micrometres. (i) Holotype 70.3 x 44.1 - 41-75, Schulze and 10% KOH (Kosanke 1950). (ii) 26 (29) 31, (5 specimens) HF + 1/3 conc. + 2/3 fum. HNO_3; Seatearth of Wellsyke Seam, at 20.35 m, borehole No. 1350. (iii) 25 (27) 32, (7 specimens), fum. HNO_3, Slag Seam (bottom leaf) at 49.65 m, borehole 1140; (ii) and (iii) Plenmeller Coalfield, England.

Description. Amb oval to lenticular in shape due to the compression folds. Exine laevigate relatively thick 1-2 μm in thickness. Laesurae distinct, simple, straight to flexuose, 1/3 - 1/2 of spore radius; contact area present. A broad major compression fold occurs extending often parallel to the long axis of the spore and gives the spore two different colours.

Remarks. The size range given in the present study is smaller than the size range given by Kosanke (1950) and that may be due to the use of alkali by Kosanke. The laesurae in the present study seem much shorter than in the original description.

Comparison. The major compression fold distinguishes this species from others in the genus.

Previous records. (1) Kosanke 1950, Middle Tradewater to Middle McLeansboro, Westphalian B to Westphalian D, Illinois , U.S.A.; (2) Potonie and Kremp 1955, Middle Westphalian B, Ruhr Coalfield, Germany; (3) Dybova and Jachowicz 1957, Namurian C to Westphalian D, Upper Silesia; (4) Grebe 1962, Westphalian B to C, Ruhr Coalfield; (5) Owens and Burgess 1965, Upper Namurian A to Lower Westphalian B. Stainmore outlier.

Occurrence. Absent to rare throughout the sequence, common in the Slag, the seatearth below the Wellsyke Seam, and the Wellsyke Seam in Plenmeller.

Calamospora cf. pedata Kosanke 1950 in Ravn 1979

Plate 4 Figures 10, 11

1979 Calamospora cf. pedata Kosanke 1950, in Ravn, p. 24, pl. 3, figs. 6, 7.

Size in micrometres. (i) 49 (56) 63, (4 specimens); 1/3 conc. + 1/2 fum. HNO_3, Bounder Seam, at 8.44 m, BH. No. 1154, Plenmeller Coalfield, England.

Description. Amb oval to lenticular in shape due to the compression folds. Exine laevigate 1-2 µm in thickness. Laesurae distinct, ridged, ends slightly bifurcated,and slightly elevated to 1-5 µm, 2/3 - 3/4 of spore radius; a faint contact area present. A broad long compression fold occurs.

Remarks. These specimens are similar to the specimens described by Ravn 1979, p. 24., which he distinguishes from the type species described by Kosanke (1950) in possessing raised laesurae with distinct lips, as well as the presence of a faint contact area.

Occurrence. Rare in the Bounder Seam, Plenmeller Coalfield.

Calamospora perrugosa (Loose) Schopf, Wilson and Bentall 1944.

Plate 3 Figure 14

1934 Laevigati-sporites perrugosus Loose, p. 145, pl. 7, fig. 13.

1944 Calamospora perrugosus (Loose), Schopf, Wilson and Bentall, p.52.

Holotype. Loose 1934, pl. 7, fig. 13. Preparation IV9, e4 (1/01).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth, 1967, p. 137 (expanded from diagnosis in Potonié and Kremp 1955, p. 51).

Size in micrometres. (i) Holotype 133, Schulze and KOH. (ii) 130-160, Schulze (Potonié and Kremp 1955). (iii) 114 (129.5) 135 (3 specimens) fum. HNO_3 + 5% KOH, Half Seam Top Leaf at 12.54 m, borehole No.964, Plenmeller Coalfield. (iv) 121 (128) 140 (6 specimens), fum. HNO_3 + 5% KOH, Three Quarter Seam at 9.57 m, borehole No.964 Plenmeller Coalfield, England.

Description. Amb irregular, subcircular to oval in shape due to compression folds. Laesurae always distinct but sometimes obscured by the compression folds, slightly ridged, straight to flexuose, unequal in length and forming about 1/3 - 1/2 of the spore radius. Exine relatively thin, less than 1.5 µm; contact area not marked; numerous compression folds distributed over the whole spore and tending to be subparallel to the margin of the spore.

Comparison. Differs from most other species in its large size; but smaller than C. cf. laevigata.

Previous records. Potonie and Kremp, 1955. Upper Westphalian B, Ruhr Coalfield, Germany; Horst 1955, Namurian A to Westphalian A, Moravska-Ostrava; Smith and Butterworth 1967, Namurian A to Westphalian A of British Coalfields; Loboziak 1971, Namurian to Westphalian, Nord-Pas-de-Calais Coalfield, France.

Occurrence. Absent to rare in the Westphalian sequence.

Calamospora straminea Wilson and Kosanke 1944

Plate 4 Figures 6, 7

1944 Calamospora straminea Wilson and Kosanke p.329. pl.1, fig.1.

1958 Punctatisporites straminea (Wilson and Kosanke); Guennel, p.68, pl.4, figs.5-8

Holotype. Wilson and Kosanke 1944, pl. 1, fig. 1. Slide No. 276P, Circle 2.

Type locality. Coal from Angus Coal Company Mine, Iowa, U.S.A.; Des Moines Series.

Diagnosis. In Smith and Butterworth 1967, p. 137 (from description in Wilson and Kosanke 1944, p. 329).

Size in micrometres. (i) 30-45, maceration method not known (Wilson and Kosanke 1944). (ii) 31 (39) 47, fum. HNO_3; Durham Coalfield, England; Upper Westphalian B, (Smith and Butterworth 1967). (iii) 37 (41) 44, (5 specimens) fum. HNO_3; different localities, Low Close Opencast Site, Cumbria.

Description. Amb circular to subcircular. Laesurae distinct, simple to slightly ridged, straight to flexuose, 1/2 - 2/3 of spore radius. Small, short, narrow arcuate compression folds occur parallel to the margin of the spore. Exine laevigate 1-1.5 μm in thickness; contact area faint.

Remarks. The spores described in the present study correspond closely to the original description given by Wilson and Kosanke 1944, p. 329, which stated that the species has a smooth, translucent exine, with frequent tapering and pointed folds. Also the spores described here conform with the description given by Smith and Butterworth 1967 who stated that the specimens photographed by Guennel 1958, pl. 4, figs. 5-8, have a thick wall and should, therefore, by transferred to the genus Phyllothecotriletes Luber which has a wall thicker than in Calamospora, with minor secondary folding and with a darkened contact area.

Comparison. C. straminea is smaller than C. breviradiata, which has a well developed contact area, C. pallida and C. liquida which have long laesurae, and C. mutabilis. C. straminea is distinguished from

C. parva which has the same size range in having a circular to subcircular outline and less arcuate short folds which run parallel to the margin of the spore.

Previous records. Wilson and Kosanke 1944, Des Moines Series, Iowa, U.S.A.; Smith and Butterworth 1967, Westphalian B to D, British Coalfields; Loboziak 1971, Westphalian B, Nord-Pas-de-Calais Coalfield, France.

Occurrence. Rare in the Upper Craignook Seam (Top Leaf), Plenmeller Coalfield, and the Little Main Seam, Low Close Opencast Site, Cumbria.

Calamospora sp. A.

Plate 4 Figures 1 - 5

Type locality. Dark shale (sample M20), above the Upper Fell Top Limestone, Pinking Cleugh section, Featherstone area.

Diagnosis. Amb often circular to subcircular. Laesurae distinct, straight, short 1/3 - 1/2 of spore radius, lips developed, slightly elevated, diverging slightly at ends of suture; contact area well developed. Exine laevigate, less than 2 µm. A single compression fold usually follows the margin of the spore.

Size in micrometres. (i) 28 (44) 56 (10 specimens), 40% HF + fum. HNO_3, dark shale (sample M20). (ii) 48 and 59 (2 specimens). 40% HF + fum. HNO_3, black shale (sample M22). (i) and (ii) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular to subcircular. Laesurae distinct, straight, short 1/3 - 1/2 of spore radius, with slightly elevated lips less than 0.5 µm wide, flexuose, diverging slightly at ends of suture, contact area well developed, more or less circular in shape, 1/2 or slightly more of the length of the trilete rays. Exine laevigate, less than 2 μm. A single narrow compression fold, 1/2 - 2/3 of spore margin.

Comparison. This species is distinguished by its small circular contact area, by the divergence of the folds of the laesurae, and by the single, long compressional fold which tends to follow the spore margin. Calamospora nigrata (Ishchenko) Butterworth and Spinner 1967 is distinguished by its larger size (90 - 110 μm by Ishchenko 1958, and 60 - 77 μm by Butterworth and Spinner 1967), and in its simple open laesurae, with its thinner frequently folded exine.

Occurrence. Rare in black shale (samples M20 and M22) from above the Upper Fell Top Limestone, Featherstone area.

Calamospora sp. B.

Plate 4 Figures 12 & 16

Type locality. Black shale (sample M22) above the Upper Fell Top Limestone, Pinking Cleugh section, Featherstone area.

Size in micrometres. (i) 47 and 53 (2 specimens); HF + fum. HNO_3, black shale (M22), above the Upper Fell Top Limestone, Featherstone area.

Diagnosis. Amb circular to subcircular. Margin smooth. Laesurae distinct, simple, straight, 3/4 or more of spore radius, accompanied by folds 3-7 μm in width. Exine slightly thick up to 1.5 μm, laevigate. Compression folds frequently occur.

Comparison. Distinguished by its slightly thick exine and long laesurae accompanied by 3-7 μm wide folds.

Occurrence. Rare in black shale (sample M22), above the Upper Fell Top Limestone, Featherstone area.

Genus ADELISPORITES Ravn 1979

Type species. A. multiplicatus Ravn 1979

Diagnosis. In Ravn 1979, p. 25.

Comparison. Distinguished by its more or less hexagonal shape and raised laesurae from Calamospora.

Adelisporites multiplicatus Ravn 1979

Plate 1 Figures 20 & 24 - 26

Holotype. Ravn 1979, pl. 4, fig. 2, slide IC2, co-ordinates 136.5 - 60.

Type locality. CP-19-4, Florinites interval, Cherokee Group, Des Moines Series, Middle Pennsylvanian, Iowa, U.S.A.

Diagnosis. In Ravn 1979, p. 25.

Size in micrometres. (i) Holotype 26.8, 21 - 34, (23 specimens); Schulze Solution and KOH (Ravn 1979). (ii) 17 (24) 30 (16 specimens) 40% HF + fum. HNO_3; Dark shale (M20), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb subrounded to irregular or pseudohexagonal in shape due to compression folds. Laesurae distinct, flexuose, dark, ridged, 3-4 μm in width, extend to the margin of the spore, lips elevated, up to 1.5 μm in height. Exine laevigate 1-2 μm in thickness, margin smooth; compression folds frequently occur in the polar area obscuring the laesurae.

Comparison. Differentiated from Calamospora macer Williams 1954 which has the same size, in its pseudohexagonal shape and ridged elevated laesurae. The spore figured by Sullivan and Marshall 1966, as Calamospora exigua Staplin 1960 is quite similar to the description of the above species but differs from their description in its larger size (27-46 μm) and shorter laesurae.

Occurrence. Rare in Sample M20, from above the Upper Fell Top Limestone, Featherstone area.

Infraturma APICULATI (Bennie and Kidston) Potonié 1956

Subinfraturma GRANULATI Dybova and Jachowicz 1957

Genus GRANULATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species. *G. granulatus* Ibrahim 1933.

Diagnosis. In Smith and Butterworth 1967, p. 138 (translation from Potonié and Kremp 1954, p. 126).

Comparison. Distinguished from other genera by its triangular outline and the regular, granulate nature of the ornament.

Granulatisporites minutus Potonié and Kremp 1955

Plate 4 Figures 13 - 15 & 17

1955 *Granulatisporites minutus* Potonié and Kremp, p. 59, pl. 12, figs. 147-148.

Holotype. Potonié and Kremp 1955, pl. 12, fig. 147, Preparation 607/5, KT 14.4.123, 9.

Type locality. Baldur Seam, Brassert Colliery, Ruhr Coalfield, Germany, Lower Westphalian C.

Diagnosis. In Smith and Butterworth 1967, p. 141 (translated and expanded from Potonié and Kremp 1955, p. 59).

Size in micrometres. (i) Holotype 23, approximately 20-25, Schulze (Potonié and Kremp 1955). (ii) 18 (23) 27, fum. HNO_3; Durham Coalfield, England; Westphalian (Smith and Butterworth 1967). (iii) 18 (23) 25, (9 specimens) 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute), Upper Craignook Seam (bottom leaf), at 21.58 m, borehole No. 1154. (iv) 17 (21.5) 24, (4 specimens), fum. HNO_3, Half Seam (bottom leaf), at 37.02 m, borehole No. 1138. (iii) and (iv) from Plenmeller Coalfield, England.

Description. Amb triangular, with concave sides and rounded apices, one of them sometimes more broadly rounded. Laesurae prominent, straight, 2/3 - 3/4 of spore radius, lips open. Exine moderately thick, 0.5 - 1 μm, covered with very small grana less than 1 μm in basal diameter and height, unevenly distributed, bases do not touch, about 40 - 60 elements project at equator. Minor folds occasionally present.

Comparison. Distinguished from other species by its small size.

Previous records. Potonié and Kremp (1955), Westphalian A to C, Ruhr Coalfield; Smith and Butterworth (1967), Lower Westphalian A to Westphalian C, British Coalfields; Loboziak (1971), Namurian to Stephanian, Nord-Pas-de-Calais Basin, France; Grebe (1972), Upper Westphalian A to Westphalian C of Ruhr Coalfield, Germany; and also recorded by several workers from various Carboniferous horizons in Britain.

Occurrence. Rare to infrequent throughout the Westphalian sequence.

Granulatisporites microgranifer Ibrahim 1933

Plate 4 Figures 18 - 19 & 21 - 23

1933 Granulati-sporites microgranifer Ibrahim, p. 22, pl. 5, fig. 32.

1938 Azonotriletes microgranifer (Ibrahim), Luber in Luber and Waltz, pl. 7, fig. 92.

1943 Triletes (Granulati) microgranifer (Ibrahim) Horst, p. 107.

1950 Planisporites microgranifer (Ibrahim) Knox, p. 315, pl. 17, fig. 218.

1955 Granulatisporites microgranifer (Ibrahim) Potonié and Kremp p. 58, pl. 12, figs. 149-151.

Holotype. Ibrahim 1933, pl. 5, fig. 32, Potonié and Kremp 1955, pl. 12, fig. 149, after Ibrahim - Preparation B29, a2(0/1).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 140 (translation from Potonié and Kremp 1955, p. 58).

Size in Micrometres. (i) Holotype 32.5, Schulze and KOH. (ii)(25?) 30-40 Schulze (Potonié and Kremp 1955). (iii) 18 (23) 28 fum. HNO_3; East Fife Coalfield, Scotland, Westphalian B (Smith and Butterworth 1967). (iv) 21 (24) 30, (8 specimens) fum. HNO_3, Slag Seam (top leaf) at 49.56 m, borehole No. 1140. (v) 27 (31) 34, (10 specimens) 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute), Upper Craignook (bottom leaf), at 21.58 m, borehole 1154. (iv) and (v) Plenmeller Coalfield, England.

Description. Amb triangular, angles narrowly rounded with one of them frequently more broadly rounded;interradial margins concave but vary in their degree of concavity. Exine thin, 0.5 - 1 µm, pale in colour, Occasionally minor folds can be observed. Laesurae prominent, simple, straight, 2/3 - 3/4 of spore radius, with one ray sometimes reaching one of the angles, rays slightly open. Ornament of tiny grana less than 1 µm high and 1.5 µm in basal diameter, bases not touching.

Comparison. Granulatisporites piroformis Loose 1934 and G. granulatus Ibrahim 1933 have a coarser grade of ornament. G. parvus (Ibrahim) Potonié and Kremp 1955 is distinguished from G. microgranifer in being slightly larger in size range and in its finer and more closely spaced ornament; G. adnatoides (Potonié and Kremp) Smith and Butterworth 1967, is distinguished by its finer grade of ornament.

Previous records. Ibrahim (1933), Westphalian B, Ruhr Coalfield; Potonié and Kremp (1955), Westphalian B to Lower Westphalian C, Ruhr Coalfield; Dybova and Jachowicz (1957), Namurian A to Westphalian C of Upper Silesia; Smith and Butterworth (1967), Upper Westphalian A to Westphalian C, British Coalfields; Grebe (1972), Upper Westphalian A to Upper Westphalian C, Ruhr Coalfield, Germany; and also recorded by other authors in Britain.

Occurrence. Rare to common throughout the sequence.

Granulatisporites granulatus Ibrahim 1933

Plate 4 Figures 25 - 28

1933 Granulati-sporites granulatus Ibrahim, p. 22, pl. 6, fig. 51.

1955 Granulatisporites granulatus Ibrahim; Potonié and Kremp p. 58, pl. 12, figs. 157-60.

Holotype. Ibrahim 1933, pl. 6, fig. 51. Preparation D57, b7 (U1).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 140; (translation from Potonié and Kremp 1955, p. 58).

Size in micrometres. (i) Holotype 31, Schulze and KOH. (ii) 25-35, Schulze (Potonie and Kremp 1955). (iii) 23 (27) 33, fum. HNO_3; Northumberland Coalfield, England; Namurian B/C. (Smith and Butterworth (1967). (iv) 27 (30.7) 37, (7 specimens), fum. HNO_3 + 5% KOH; Three Quarter Seam at 9.57 m; borehole No. 964. (v) 31 (36) 41 (5 specimens), fum. HNO_3 + 5% KOH, from Low Main Seam at 63.60 m, borehole No. 1057. (vi) 29 (32) 36 (16 specimens) 40% HF + 1/3 conc. + 2/3 fum. HNO_3, Seat earth of Wellsyke Seam, at 20.34 m, borehole No. 1350. (iv), (v) and (vi) Plenmeller Coalfield, England.

Description. Amb triangular with rounded apices and straight to slightly concave, rarely convex interradial margins. Laesurae distinct, simple, straight, unequal in length, 1/2 - 3/4 of spore radius. Exine relatively thick, 0.75 - 1.5 µm, ornamented with grana with slightly pointed apices, 1 µm high, 1.5 - 2 µm basal diameter, evenly distributed; number of grana projecting on the margin range between 30 - 70; minor folds infrequent.

Comparison. Granulatisporites cf. piroformis (Loose) in Smith and Butterworth 1967, is closely similar to G. granulatus but differs in its slightly thicker folded exine and more closely spaced grana. G. jugaligranifer Staplin 1960 is distinguished by its straight to slightly convex sides and coarse uneven size of grana. G. parvus (Ibrahim) Potonié and Kremp 1955 has small and closely packed ornament.

Previous records. Potonié and Kremp (1955), Ruhr Coalfield, Westphalian B - C; Horst (1955), Namurian A and Westphalian A, Silesia; Smith and Butterworth (1967), Viséan to Lower Westphalian C, Coalfields of G.B. Grebe (1972), Ruhr, Germany, Upper Westphalian A to Westphalian C; and this species has been observed by numerous other workers in the Carboniferous.

Occurrence. Rare to common throughout the sequence.

Granulatisporites parvus (Ibrahim) Potonié and Kremp 1955

Plate 4 Figures 20 & 24

1932	Sporonites parvus Ibrahim in Potonié, Ibrahim and Loose, pl. 15, fig. 21.
1933	Punctati-sporites parvus Ibrahim, pl. 2, fig. 21.
1934	Reticulati-sporites parvus Ibrahim; Loose, pl. 7, fig. 18.
1950	Granulati-sporites pallidus Kosanke, p. 21, pl. 3, fig. 3.
1955	Granulatisporites parvus Ibrahim; Potonié and Kremp, p. 59, pl. 12, fig. 161-171.

Holotype. Potonié and Kremp 1955, pl. 12, fig. 161, after Ibrahim 1932. Preparation B35, a, (ol).

Type locality. Ägir Seam, Ruhr Coalfield, Germany, Upper Westphalian B.

Diagnosis. In Potonié and Kremp 1955.

Size in micrometres. (i) Holotype 38.5, Schulze and KOH. (ii) 35-50 (Potonié and Kremp 1955). (iii) 27 (33) 38 (6 specimens), HF + fum. HNO_3, dark shale above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular, angles rounded and with concave to straight sides. Laesurae distinct, straight 2/3 - 3/4 of spore radius, lips very well open and elevated. Exine less than 1.5 μm in thickness, ornamented with tiny grana 0.5 - 1 μm in basal width and height. Minor folds occasionally occur.

Remarks. Potonié and Kremp (1955, p. 59) made G. pallidus Kosanke synonymous with G. parvus.

Comparison. G. granulatus and G. cf.piroformis have a coarser grade of ornamentation. G. parvus is slightly larger and has a finer grade of ornament.

Previous records. Ibrahim (1933), Westphalian B, Ruhr Coalfield; Potonié and Kremp (1955), Westphalian B to Lower Westphalian C, Ruhr Coalfield; Sullivan (1964), ? Westphalian A, Forest of Dean Coalfield, England; Loboziak (1971), Namurian to Stephanian, of Nord-Pas-de-Calais Basin, France; Ravn (1979), Pennsylvanian coals of Iowa, U.S.A.

Occurrence. Rare throughout the Namurian sequence, common in Samples M20 and M5, Featherstone area.

Granulatisporites piroformis Loose 1934

1934 Granulati-sporites piroformis Loose, p. 21, pl. 7, fig. 12.

1950 Granulati-sporites granularis Kosanke, p. 22, pl. 3, fig. 2.

1955 Granulatisporites piroformis Loose; Potonié and Kremp, p. 60, pl. 12, fig. 152.

Holotype. Loose 1934, pl. 7, fig. 19; Potonié and Kremp 1955, pl. 12, fig. 152. after Loose. Preparation IV50, di (m/r).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 141; (translated from Potonié and Kremp 1955, p. 60).

Size in micrometres. (i) Holotype 28.5, Schulze and KOH. (ii) 25-40, Schulze (Potonié and Kremp 1955).

Granulatisporites cf. piroformis Loose 1934 in Smith and Butterworth 1967

Plate 5 Figures 1 - 3

Size in micrometres. (i) 19 (27) 38, fum. HNO_3; Lothians Coalfield, Scotland; Namurian A; (Smith and Butterworth 1967). (ii) 23 (29) 34 (15 specimens); 40% HF + fum. HNO_3, Dark shale (M20), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular, angles broadly rounded with concave sides. Laesurae simple, straight, unequal in length 1/2 - 3/4 of spore radius, rays slightly elevated, 1.5 µm, lips well developed. Exine relatively thick, 1.5 µm in thickness, covered with small closely rounded grana less than 1.5 µm in basal diameter. Compression folds frequently occur.

Remarks. Potonié and Kremp (1955, p. 60) made G. granularis Kosanke 1950 synonymous with G. piroformis.

Previous records. Smith and Butterworth 1967, Namurian A, British Coalfields.

Occurrence. Rare in the Namurian sequence.

Granulatisporites sp. A.

Plate 5 Figure 11

Type locality. Little Main Seam, (sample C5), Low Close Opencast Site, Cumbria.

Size in micrometres. (i) 56 (1 specimen), fum. HNO_3; Little Main Seam, (Sample C5), Low Close Opencast Site, Cumbria.

Diagnosis. Amb triangular to subtriangular, with convex sides and broadly rounded angles. Laesurae prominent, simple to slightly ridged, straight to flexuose, rays slightly open, extend 3/4 or more of spore radius. Exine relatively thin, less than 1.5 µm, covered with closely spaced minute grana, 0.5 µm or less in basal diameter and height and 0.5 - 1 µm apart. Margin smooth to minutely serrate. Minor compression folds occur.

Comparison. Distinguished from other species by its larger size and longer laesurae, otherwise it is closely similar to G. microgranifer.

Genus CYCLOGRANISPORITES Potonié and Kremp 1954

Type species. C. leopoldi (Kremp 1952) Potonié and Kremp 1954.

Diagnosis. In Smith and Butterworth 1967, p. 142 (translation from Potonié and Kremp 1955, p. 60).

Comparison. Granulatisporites (Ibrahim) Potonié and Kremp differs from Cyclogranisporites in having a markedly triangular shape.

Cyclogranisporites aureus (Loose) Potonié and Kremp 1955

Plate 5 Figures 12 - 14

1934 Reticulati-sporites aureus Loose, p. 155, pl. 7, fig. 24.

1944 Punctati-sporites aureus (Loose); Schopf, Wilson and Bentall, p. 30.

1950 Plani-sporites aureus (Loose); Knox, p. 315.

1955 Cyclogranisporites aureus (Loose); Potonié and Kremp, p. 61, pl. 13, figs. 184-6.

Holotype. Potonié and Kremp 1955, pl. 13, fig. 184 after Loose; Preparation IV1, es (ul).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 142 (translation from Potonié and Kremp 1955, p. 61).

Size in micrometres. (i) Holotype 55.5, Schulze and KOH. (ii) 50-80, Schulze (Potonié and Kremp 1955). (iii) 59 (72) 82 (22 specimens) fum. HNO_3, Lancashire Coalfield, England, Westphalian B, (Smith and Butterworth 1967). (iv) 46 (59) 76 (10 specimens) 40% HF + fum. HNO_3, Seatearth of Well Syke Seam at 20.34 m; borehole No. 1350, Plenmeller Coalfield, England.

Description. Equatorial outline more or less circular due to compression folds. Laesurae distinct, straight, simple, more than 2/3 of spore radius, unequal in length. Exine relatively thin, 1-1.5 µm, covered with closely packed grana up to 2 µm in basal diameter and height; exine becomes darker adjacent to laesurae. Compression folds well developed, long, broad or narrow in shape; 70 - 90 grana projecting at the margin.

Comparison. This species is distinguished by its larger size from other species in the same genus; C. lasius (Waltz) Playford 1962 has coarser and more closely spaced grana; C. microgranus Bharadwaj 1957 has a thicker exine than C. aureus (Loose) Potonié and Kremp 1955.

Previous records. Loose (1934), Westphalian B, Ruhr Coalfield; Potonié and Kremp (1955) Upper Westphalian B to Middle Westphalian C, Ruhr Coalfield; Grebe (1962, 1972) Westphalian A-C, Ruhr Coalfield, Germany; Pierart (1958) Nieroeteren Zone, Westphalian C, Campine, Belgium; Owens and Burgess (1965) Namurian A to Lower Westphalian B of Stainmore Outlier; Smith and Butterworth (1967) Westphalian A to D, British Coalfields; Loboziak (1971) Westphalian to Lower Stephanian, Nord-Pas-de-Calais, North France; Ravn 1979; Cherokee Group, CP-19-4 Coal, Iowa, U.S.A.; this species is also recorded by numerous authors inside Britain.

Occurrence. Absent to rare throughout the Westphalian sequence.

Cyclogranisporites multigranus Smith and Butterworth 1967

Plate 5 Figures 20 - 22

1967 Cyclogranisporites multigranus Smith and Butterworth, p. 144 pl. 4, figs. 10-13.

Holotype. Smith & Butterworth 1967. Plate 4, fig.12. Preparation T91/1 in collection of the National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Seam at 491 ft. 10 in. Seafield No. 2 borehole, East Fife Coalfield, Scotland; Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 144.

Size in micrometres. (i) Holotype 53; 38 (47) 55, fum. HNO_3; Smith and Butterworth 1967. (ii) 34 (40) 47 (5 specimens), 1/3 conc. + 2/3 fum. HNO_3, various localities, Plenmeller Coalfield, England.

Description. Amb circular to subcircular due to the compression folds. Laesurae distinct to indistinct, simple, unequal in length, 1/2 - 2/3 of spore radius. Exine relatively thick, 2 µm, covered by closely packed grana less than 0.5 µm in diameter and high, and 1-1.5 µm apart. Compression folds frequently occur.

Comparison. Cyclogranisporites minutus Bharadwaj 1957 and C. densus Bharadwaj 1957 have a comparable size range but they differ in their slightly coarser and less packed sculptural elements. C. parvus Bharadwaj 1957 is distinguished by its thinner exine and a darkening of the exine in the region of the laesurae. C. flexuosus Playford 1962 has well developed sinuous lips with a thick exine which is covered distally by closely spaced fine grana.

Occurrence. Rare throughout the Westphalian sequence.

Cyclogranisporites minutus Bhardwaj 1957

1957 Cyclogranisporites minutus Bhardwaj, p. 83, pl. 22, figs. 22 and 23.

Holotype. Bhardwaj, 1957, pl. 22, figs. 22 and 23. Preparation 7314/2.

Type locality. Wahlschied Seam, Gottelborn Colliery, Saar Coalfield, Germany; Stephanian A.

Diagnosis. In Smith and Butterworth 1967, p. 143 (from Bhardwaj 1957a, p. 83).

Size in micrometres. Holotype 40; 34-43, Schulze (Bhardwaj 1957a).

Cyclogranisporites cf. minutus Bhardwaj 1957 in Smith and Butterworth 1967

Plate 5 Figures 15 - 19

1967 Cyclogranisporites cf. minutus Bhardwaj 1957 in Smith and Butterworth, p. 143, pl. 4, figs. 4-7.

Size in micrometres. (i) 41-52 (6 specimens) fum. HNO_3; various localities, Yorkshire and Durham Coalfields, England; Westphalian

A and B (Smith and Butterworth 1967). (ii) 41 (48) 60 (7 specimens) 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute), Upper Craignook Seam (bottom leaf), at 21.58 m, borehole No. 1154. (iii) 42 (46) 59 (4 specimens) 40% HF + fum. HNO_3, Seatearth of Half Seam, at 6.95 m; borehole No. 1350. (ii) and (iii) Plenmeller Coalfield, England.

Description. Equatorial outline circular to irregular in shape due to to compression folds. Laesurae simple, straight, 2/3 of spore radius. Exine thin, less than 1.5 µm, yellow in colour, arcuate compression folds frequently occur. Exine ornamented distally and proximally with very small grana ranging between 0.5-1 µm in height and basal diameter spaces between grana in some specimens exceed their own diameter.

Remarks. The size of the specimens assigned to this species fall within the size range given by Smith and Butterworth (1967).

Comparison. This species is intermediate in size between C. minutus Bhardwaj 1957 and C. aureus (Loose) Potonié and Kremp 1955, which are similar in the nature of their exinal sculpture. C. multigranus Smith and Butterworth 1967 has a smaller size and finer grana; C. carinatus Artuz 1957 has coarser ornament; C. densus Bhardwaj 1957a and C. parva Bhardwaj 1957a have slightly coarser ornament than C. cf. minutus Bhardwaj 1957.

Previous records. Smith and Butterworth 1967, Namurian A to Westphalian D of British Coalfields.

Occurrence. Rare to infrequent throughout the Westphalian sequence.

Cyclogranisporites aureolus Artüz 1957

Plate 5 Figures 9, 10

1957 Cyclogranisporites aureolus Artüz, p. 242, pl. 1, fig. 6.

Holotype. Artüz 1957, pl. 1, fig. 6. Preparation I, 21 6d.

Type locality. Alimolla Seam, Zonguldak Coalfield, Turkey; Namurian.

Diagnosis. In Artüz 1957, p. 242.

Size in micrometres. (i) Holotype 90, 64-90, maceration method not stated (Artüz 1957). (ii) 49 (63) 75 (6 specimens), HF + fum. HNO_3; black shale, from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular to subcircular to irregular due to the compression folds.. Laesurae indistinct to very faint, 2/3 of spore radius. Exine relatively thin, less than 1 µm in thickness, covered with rounded low grana varying in size between 0.5-1.5 µm in basal width, less than 1 µm in height and 1-3 µm apart. Margin serrate, 50-75 grana project from margin. Compression folds frequently occur.

Comparison. Distinguished by its thinner exine, fine sculptural elements, loosely packed grana and highly folded exine from other species in the genus.

Previous records. Artüz 1957, Namurian, Alimolla Seam, Zonguldak Coalfield, Turkey.

Occurrence. Rare in black shales (sample M22 and M20) from above the Upper Fell Top Limestone, Featherstone area.

Subinfraturma VERRUCATI Dybova and Jachowicz 1957

Genus CONVERRUCOSISPORITES Potonié and Kremp 1954

Type species. C. triquetrus (Ibrahim) Potonié and Kremp 1954

Diagnosis. In Smith and Butterworth 1967, p. 146 (translation from Potonié and Kremp 1954, p. 137).

Comparison. This genus has verrucate ornament similar to the genus Verrucosisporites (Ibrahim) Smith and Butterworth 1967 but the amb tends to be more or less triangular.

Converrucosisporites armatus (Dybova and Jachowicz) Smith and Butterworth 1967

Plate 5 Figures 4 - 6 & 8

1957a Converrucosisporites armatus Dybova and Jachowicz, p. 128, pl. 32, fig. 1.

1967 Converrucosisporites armatus (Dybova and Jachowicz); Smith and Butterworth, p. 146, pl. 4, figs. 19-21.

Holotype. Dybova and Jachowicz 1957a, pl. 32, fig. 1. Preparation Cv I/25.

Type locality. Seam 12, Vaclav Colliery, Czechoslovakia; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 146 (from English summary in Dybova and Jachowicz 1957a, p. 182).

Size in micrometres. (i) Holotype not specified. (ii) Average 30, fum. HNO_3 and 30% NH_4OH (Dybova and Jachowicz 1957a); 45 (Dybova and Jachowicz 1957b). (iii) 26 (36) 43, fum. HNO_3; Durham Coalfield, Westphalian A; (Smith and Butterworth 1967). (iv) 32 (36) 41 (10 specimens); 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH one minute, Bounder Seam at 8.44 m, borehole No. 1154, Plenmeller Coalfield, England.

Description. Amb triangular, with round apices, sides straight to slightly concave. Laesurae very well marked, simple, straight, 3/4 of spore radius. Exine thick, 1.5-3 µm, brown in colour, covered by verrucae which vary in shape and are more or less evenly distributed, the spaces between the verrucae being more than the basal diameter of each verruca; verrucae slightly rounded in shape, 2-4 µm high and 3-7 µm in the basal diameter. Number of projections on the margin varies between 13-23; large verrucae on the apices are bigger than in other areas.

Remarks. Specimens correspond closely to the original diagnosis except that laesurae are longer, and specimens have occasionally larger verrucae on the apices than in any other area of the exine.

Comparison. *Converrucosisporites triquetrus* (Ibrahim) Potonié and Kremp 1954 has a slightly larger size, convex sides and smaller condensed verrucae. *C. tuberoornatus* Artuz 1957 has a comparable size, but straight to slightly convex sides and more condensed verrucae.

Occurrence. Absent to rare throughout the Westphalian sequence.

Genus VERRUCOSISPORITES (Ibrahim) Smith and Butterworth 1967

Type species. *V. verrucosus* (Ibrahim) Ibrahim 1933.

Diagnosis. In Smith and Butterworth 1967, p. 147.

Remarks. Smith and Butterworth 1967, p. 147 and Smith 1971, p. 43, emended the earlier diagnosis of the genus given by several authors (Ibrahim 1933, p. 23, Potonié and Kremp 1954, p. 137, Bhardwaj 1955, p. 123 and Smith *et al*. 1964, p. 1071) suggesting that their emendation meets with the requirement of covering the large number of species with widely different morphographic characters which have been referred to *Verrucosisporites*.

Comparison. Differs from *Apiculatisporis* Potonié and Kremp 1956 in possessing an ornament in which the basal diameter is equal to or greater than the height. *Convolutispora* Hoffmeister, Staplin and Malloy 1955 is differentiated by its anastomosing ornament, *Camptotriletes* (Naumova) Potonié and Kremp 1954 by its narrow ridges and *Grumosisporites* Smith and Butterworth 1967 by the separation of the exine into exoexine and intexine.

Verrucosisporites donarii Potonié and Kremp 1955

Plate 6 Figures 1 - 2

1955 Verrucosisporites donarii Potonié and Kremp, p. 67, pl. 13, fig. 193.

Holotype. Potonié and Kremp 1955, pl. 13, fig. 193. Preparation 31/1.

Type locality. Donar Seam, Brassert Colliery, Ruhr Coalfield, Germany; Lower Westphalian C.

Diagnosis. In Smith 1971, p. 56 (extended from diagnosis in Potonié and Kremp 1955, p. 67).

Size in micrometres. (i) Holotype 71; about 70, Schulze (Potonié and Kremp 1955). (ii) 43 (60) 79, fum. HNO_3; Bristol and Somerset Coalfield, England; Westphalian D, (Smith and Butterworth 1967). (iii) 56 (64) 71 (4 specimens), fum. HNO_3; various localities within the upper part of Westphalian A in the Plenmeller area and Low Close Opencast Site, Cumbria.

Description. Amb circular to subcircular. Laesurae distinct to indistinct, simple, straight, 2/3 - 3/4 of spore radius. Exine moderately thick, less than 2.5 μm in thickness, covered with closely packed verrucae. Verrucae with rounded to low flat apices, 1-2 μm in height, 1.5-3 μm in basal width and less than 1.5 μm apart. Margin crenulate, 50-70 verrucae projecting from margin. Compression folds occasionally occur.

Comparison. V. donarii is very similar to V. verrucosus but differs in its slightly smaller size and the verrucae tend to be more densely packed and regular than in V. verrucosus. V. firmus (Loose) Potonié and Kremp 1955 and V. difficilis Potonié and Kremp 1955 have a smaller size and circular outline with packed large verrucae. V. microtuberosus has slightly smaller and more pointed verrucae as well as frequent compression folds.

Previous records. Potonié and Kremp 1955, Lower Westphalian C, Ruhr Coalfield, Germany; Owens and Burgess 1965, Westphalian B, Stainmore Outlier, Westmorland; Smith and Butterworth, Westphalian B to D, British Coalfields; Grebe 1972, Westphalian B to C, Ruhr Coalfield, Germany; Ravn 1979, Cherokee Group, Pennsylvanian, CP-19-4 Coal, Iowa, U.S.A.

Occurrence. Rare in the Lickbank Seam (C5), Low Close Opencast Site, Cumbria.

Verrucosisporites microtuberosus (Loose) Smith and Butterworth 1967

Plate 6 Figure 6

1932 *Sporonites microtuberosus* Loose in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 33.

1934 *Tuberculati-sporites microtuberosus* Loose, p. 147.

1944 *Punctatisporites microtuberosus* (Loose); Schopf, Wilson and Bentall, p. 31.

1950 *Plani-sporites microtuberosus* (Loose); Knox, p. 316, pl. 17, fig. 211.

1955 *Microreticulatisporites microtuberosus* (Loose); Potonié and Kremp, p. 100, pl. 15, figs. 273-7.

1957a *Planisporites microtuberosus* (Loose) Knox in Bhardwaj, p. 87, pl. 23, figs. 13-14.

1967 *Verrucosisporites microtuberosus* (Loose) Smith and Butterworth, p. 149, pl. 5, figs. 9-11.

Holotype. Potonié and Kremp 1955, pl. 15, fig. 273, after Loose.

Type locality. Bismarck Seam, Ruhr Coalfield, Germany, Upper Westphalian B.

Diagnosis. In Smith 1971, p. 64 (emended from diagnosis in Potonie' and Kremp 1955, p. 100).

Size in micrometres. (i) Holotype 67.5, Schulze. (ii) 55-85 Schulze (Potonie' and Kremp 1955). (iii) 55 (68) 79, fum. HNO_3, Yorkshire Coalfield, England, Westphalian A (Smith and Butterworth 1967). 54 (61.5) 71 (11 specimens) 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute) Upper Craignook Seam (Bottom leaf) at 21.58 m, borehole 1154, Plenmeller Coalfield, England.

Description. Equatorial outline circular, subcircular to oval due to compression folds. Laesurae distinct, straight, rays slightly open, unequal in length extending 1/2 - 3/4 of spore radius; rays accompanied by folds 2-3 µm in width. Exine relatively thin, less than 2 µm, covered distally and proximally with low small closely spaced verrucae varying in shape and size, 0.5-1 µm high, 1-2 µm in basal width and not uniformly distributed; some places less than 1 µm apart and other places up to 3 µm apart; 60-90 elements project at the margin. Margin crenulate, arcuate compression folds frequently occur.

Remarks. The current specimens show a distinct laesurae which is accompanied by folds while the diagnosis of Smith (1971) states that the laesurae are usually obscured.

Comparison. Verrucosisporites donarii Potonie' and Kremp 1955 and V. verrucosus (Ibrahim) Ibrahim 1933 are distinguished by their larger and less closely spaced verrucae.

Previous records. Potonie' and Kremp 1955, Westphalian B to C, Ruhr Coalfield; Grebe (1962, 1972) Westphalian B to C, Ruhr Coalfield, Germany; Artuz 1957, Westphalian A, Zonguldak, Turkey; Smith and Butterworth 1967, Westphalian A to D of British Coalfields; Loboziak 1969-1971, Namurian to Stephanian, France; Ravn 1979, CP-19-4 Coal Cherokee Group, Pennsylvanian, Iowa, U.S.A.; and also recorded by several workers from the Upper Carboniferous of Britain.

Occurrence. Absent to rare throughout the Westphalian sequence.

Verrucosisporites sifati (Ibrahim) Smith and Butterworth 1967

Plate 6 Figure 7

1933 Reticulati-sporites sifati Ibrahim, p. 35, pl. 8, fig. 67.

1955 Microreticulatisporites sifati (Ibrahim) Potonié and Kremp, p. 102, pl. 15, figs. 282-5.

1967 Verrucosisporites sifati (Ibrahim) Smith and Butterworth, p. 152, pl. 6, fig. 1.

Holotype. Pl. 12, fig. 9. Preparation B5, a6 (m) Geol. Inst. Berlin.

Type locality. Ägir Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith 1972, p. 75 (expanded from Smith and Butterworth 1967, p. 152).

Size in micrometres. (i) Holotype 100, Schulze and KOH. (ii) 80-140, Schulze (Potonié and Kremp 1955). (iii) 77 (97) 114, H_2O_2; Kent Coalfield, England; Westphalian B; (Smith and Butterworth 1967). (iv) 60 (75) 92; (5 specimens); 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute); Upper Craignook Seam (bottom leaf), at 21.58 m, borehole No. 1154; Plenmeller Coalfield, England.

Description. Equatorial outline circular to oval in shape, margin smooth to undulating. Laesurae often distinct, straight, slightly elevated, unequal in length, one half of spore radius. Exine thin, covered with verrucae, mostly broader than high, basal width ranges between 2-3 μm and height less than 1 μm, space between verrucae equal or less than basal width; 70-100 verrucae project at the margin. Narrow long compression folds frequent.

Remarks. This specimen generally conforms to the diagnosis of Smith 1972 but the size tends to be slightly smaller than the size previously recorded by several authors.

Comparison. Verrucosisporites sifati differs from V. donarii Potonie´and Kremp 1955 and V. verrucosus (Ibrahim) Ibrahim 1933, in having relatively broad, low, and well rounded verrucae, and from V. microtuberosus (Loose) Smith and Butterworth 1967 in having slightly larger and less tightly packed verrucae. Tuberculatisporites permagnus (Dybova and Jachowicz 1957, pl. 25, figs. 1-4) may be a synonym of V. sifati, but from the photographs the ornament seems slightly coarser and not so well rounded.

Previous records. Potonie´and Kremp (1955) Upper Westphalian B to Lower Westphalian C, Ruhr Coalfield; Grebe (1962) Upper Westphalian B to Westphalian C of Ruhr Coalfield, Germany; Pierart (1962) Westphalian B to C, Borinage Massif, Belgium; Artuz (1957) Namurian A to Westphalian A, Zonguldak basin, Turkey; Smith and Butterworth (1967) Upper Westphalian A to D, in British Coalfields; Ravn 1979, Westphalian B, Cherokee Group, Iowa, U.S.A.

Occurrence. Absent to rare throughout the Westphalian sequence.

Verrucosisporites verrucosus (Ibrahim) Ibrahim 1933

Plate 6 Figures 3 - 5

1932 Sporonites verrucosus Ibrahim in Potonie´, Ibrahim and Loose, p. 448, pl. 15, fig. 17.

1933 Verrucosi-sporites verrucosis Ibrahim, p. 25, pl. 2, fig. 17.

1938 Azonotriletes verrucosus (Ibrahim); Luber in Luber and Waltz, pl. 7, fig. 95.

1944 Punctati-sporites verrucosus (Ibrahim) Schopf, Wilson and Bentall, p. 32.

1950 Verrucoso-sporites verrucosus (Ibrahim); Knox, p. 319, pl. 17, fig. 230.

Holotype. Potonie'and Kremp 1955, pl. 13, fig. 196 and Smith et al. 1964, pl. 3, fig. 7, after Ibrahim. Preparation B29, dl (o).

Type locality. Ägir Seam, Ruhr Coalfield, Germany, Upper Westphalian B.

Diagnosis. In Smith 1972, p. 77 (expanded from diagnosis and description in Potonie'and Kremp 1955, p. 69).

Size in micrometres. (i) Holotype 77, Schulze and KOH. (ii) 70-100, Schulze (Potonie'and Kremp 1955). (iii) 52 (69) 94, H_2O_2; Kent Coalfield, England; Westphalian B, (Smith and Butterworth, 1967). (iv) 51 (65) 80 (12 specimens) 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute) Upper Craignook Seam (bottom leaf), at 21.58 m, borehole No. 1154, Plenmeller Coalfield, England. (v) 56 (64) 77 (7 specimens); HF + 1/3 conc. + 2/3 fum. HNO_3, Seat earth of Slag Seam, at 50.57 m borehole No. 1350; Plenmeller Coalfield, England.

Description. Amb circular to oval. Laesurae distinct, straight, 1/2 - 2/3 of spore radius but vary in length, sometimes obscured by ornament. Exine moderately thick, 2-3 µm, covered with closely spaced verrucae varying in shape and size, 2-3 µm basal width, and 1-3 µm in height. 50-70 elements project at the margin; one or two compression folds more or less parallel to the margin of the spore.

Comparison. V. donarii Potonie'and Kremp 1955 is similar in size but the shape of its verrucae tend to be regular and more densely packed than in V. verrucosus; in V. grandiverrucosus (Kosanke) Smith et al. 1964 the sides of the verrucae taper less than in V. verrucosus and the apices are more rounded than in V. verrucosus, (as indicated by Smith 1972, p. 78). Cyclogranisporites lasius (Waltz) Playford (1962) is differentiated by very densely spaced grana 1-1.5 µm in height and various compression folds. V. microverrucosus Ibrahim is smaller and has more irregular shaped verrucae. Tuberculatisporites gigantonodatus Dybova and Jachowicz 1957 (p. 116, pl. 27, fig. 1-4) is a probable synonym of V. verrucosus.

Previous records. Potonie´and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Grebe (1962), Westphalian B to C, Ruhr Coalfield, Germany; Smith and Butterworth (1967), Westphalian A to D, British Coalfields; Loboziak (1972) Westphalian to Stephanian of Nord-Pas-de-Calais, France; Ravn 1979, CP-19-4 Coal, Cherokee Group, Pennsylvanian Iowa, U.S.A.; and also recorded by several authors from the Upper Carboniferous of Britain.

Occurrence. Rare to common throughout the Westphalian sequence.

Verrucosisporites sp. A.

Plate 6 Figures 8 - 11

Type locality. Eighteen Inch Seam, (sample C4), Low Close Opencast Site, Cumbria.

Size in micrometres. (i) 82 (93) 103 (12 specimens); fum. HNO_3; Little Main Seam. (ii) 89 (98) 123 (18 specimens); fum. HNO_3; Eighteen inch Seam; (i) and (ii) Low Close Opencast Site, Cumbria.

Diagnosis. Amb circular to subcircular. Laesurae distinct, straight, 1/3 to 2/3 of spore radius, rays often open. Exine relatively thick, 2-4 μm in thickness. The sculpture consists of low rounded verrucae, usually approximately 1.5 μm in diameter, although some elements may occasionally reach 2 μm in diameter. Verrucae vary in distribution, from close spacing, where the elements are less than 1 μm apart, and show a short lateral fusion, to loosely spaced, where the elements are 1.5-2 μm apart. Compression folds infrequent.

Comparison. V. sifati (Ibrahim) Smith and Butterworth 1967 shows more or less discrete verrucae reaching 5 μm in diameter, 2.5 μm in diameter and 2.5 μm in height. V. microtuberosus is distinguished by its frequent compression folds, circular shape, thinner exine and shape of verrucae which tend to be irregular and more densely packed.

Remarks. Spores assigned to this species during the present study are characterised by their large size. The species shows a remarkable variation in shape and size of verrucae. The shape of verrucae varies from circular to irregular; and from broadly rounded to flat. The sculptural elements in all specimens observed are densely packed.

Occurrence. Rare in Eighteen Inch (sample C4) and Little Main (sample C5) seams, Low Close Opencast Site, Cumbria.

Subinfraturma NODATI Dybova and Jachowicz 1957

Genus ACANTHOTRILETES (Naumova) Potonié and Kremp 1954

Type species. A. ciliatus (Knox) Potonié and Kremp.

Diagnosis. In Smith and Butterworth 1967, p. 177 (translation from Potonié and Kremp 1954, p. 133).

Comparison. Distinguished from Lophotriletes and Apiculatisporis by the greater length and tapering of the strongly pointed ornamental elements. Anapiculatisporites differs in the distribution of the elements on the exine.

Acanthotriletes castanea Butterworth and Williams 1958

Plate 6 Figures 12, 13 & 17, 18

1948 Knox, p. 158, fig. 18.

1958 Acanthotriletes castanea Butterworth & Williams, p. 365, pl. 1 fig. 35.

Holotype. Smith and Butterworth 1967, pl. 8, fig. 7. Preparation

T42/1 collection of National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Garibaldi Ironstone Seam at 1,058 ft. 3 in., Cawder Cuilt borehold, Central Coalfield, Scotland, Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 177 (from diagnosis and description in Butterworth and Williams, 1958, p. 365).

Size in micrometres. Holotype 46 X 40; 31 - 47 (10 specimens), Schulze and 5% KOH (Butterworth and Williams 1958). (ii) 30 (36) 41 (20 specimens), HF + fum. HNO_3; black shale (M22), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular, irregular to subtriangular with broadly rounded angles. Laesurae indistinct, 1/2 - 2/3 of spore radius. Exine thin, less than 1.5 µm in thickness, covered with long spinae 4-9 µm in length, 2-3 µm in basal width and 2-3 µm apart, tapering uniformly to a sharp point, some of them curved and others straight. 30-40 spinae project at the margin. Folds frequently occur.

Comparison. Distinguished from *A. falcatus* (Knox) Potonié and Kremp 1955 in its narrower and densely packed spines which reach 7 µm in height. *A. microspinosus* (Ibrahim) Potonié and Kremp 1955 has a more triangular shape with shorter and less closely packed spines.

Previous records. Butterworth and Williams 1958, Namurian A, of Scotland; Smith and Butterworth 1967, Viseán and Namurian A, British Coalfields; Beju 1970, Visean and Namurian A, Moesian Platform, Romania; Sullivan and Marshall 1966, Visean, Midland Valley of Scotland; Marshall and Williams 1970, Upper Viseán/Lower Namurian, Western Northumberland, Northern England.

Occurrence. Rare throughout the Namurian sequence, common in black shale (Sample M22), above the Upper Fell Top Limestone, Featherstone area.

Acanthotriletes echinatus (Knox) Potonie and Kremp 1955

Plate 6 Figures 16

1950 Spino-sporites echinatus Knox, p. 313, pl. 17, fig. 208.

1955 Acanthotriletes echinatus (Knox); Potonie and Kremp, p.84.

Neotype. No holotype was cited by Knox (1950) and Smith and Butterworth (1967) therefore selected a neotype (T86/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne).

Type locality. Splint Seam, Cadzow Colliery, Central Coalfield, Scotland, Westphalian B.

Diagnosis. In Smith and Butterworth 1967 (from diagnosis in Knox 1950, p. 313).

Size in micrometres. (i) Neotype 26, fum. HNO_3. (ii) 25, Schulze (Knox 1950). (iii) 12 (20) 28, fum. HNO_3; type locality. (iv) 16 (18.7) 24, (16 specimens); 1/2 conc. + 1/2 fum. HNO_3; from Slag Seam at 49.56 m, borehole No. 1140, Plenmeller Coalfield, England.

Description. Amb circular to triangular with strongly convex sides and broad rounded apices. Laesurae obscured by ornament. Ornament of fine, tapering, long spines 0.5 µm in width, 1.5-3 µm in height with 15-20 elements projecting at the equator. Exine thin, less than 1 µm. Occasional folds occur.

Comparison. Specimens conform with the original diagnosis of Knox 1950. Acanthotriletes castanea Butterworth and Williams 1958 is larger in size, and has longer and broader spines, 8 µm long, 2 µm basal diameter. A. echinatoides Artuz 1957 (p.245, pl. III, fig. 18) has a larger size, circular shape, and denser spines. A. falcatus (Knox) Potonie and Kremp 1955 is larger than the species described above and has denser ornament. A. microspinosus (Ibrahim) Potonie and Kremp 1955 has a more triangular shape, prominent laesurae and spines with wide basal diameter.

Previous records. Knox 1950, Upper Carboniferous, Scotland; Smith and Butterworth 1967, Namurian to Westphalian C, British Coalfields; Sabry and Neves 1971, Viseán to Namurian A, Sanquhar Coalfield, Scotland; and recorded by numerous workers from the Upper Carboniferous.

Occurrence. Rare to absent throughout the sequence.

Acanthotriletes echinatoides Artuz 1957

Plate 6 Figure 14 , 15

1957 Acanthotriletes echinatoides Artüz, p. 245, pl. 3, fig. 18.

Holotype. Artüz 1957, pl. 3, fig. 18. Preparation I, 10, IC.

Type locality. Sülü Seam, Zonguldak Coalfield, Turkey; Westphalian A.

Diagnosis. In Artüz 1957, p. 245.

Size in micrometres. (i) Holotype 23, (22-30), maceration method not stated (Artüz 1957). (ii) 21 (24) 26 (5 specimens); fum. HNO$_3$; different localities within the Westphalian sequence.

Description. Amb circular to oval. Laesurae obscured by heavy ornament. Exine, thin, less than 1 µm in thickness. Ornament of fine spines 0.5-1 µm in basal width, 2-3 µm long and dense, less than 1 µm apart. 20-25 elements project at the margin. Compression folds infrequent.

Comparison. This species is readily distinguished by its dense spinose ornament and small size. A. echinatus (Knox) Potonié and Kremp 1955, which is slightly smaller in size, differs in possessing more loosely set spines and in its triangular shape. A. (Punctatisporites) productus Peppers1964, appears to be identical to this species.

Previous records. Artüz, 1957, Sülü and Büjük Seams (Westphalian A) of the Zonguldak Coalfield, Turkey. Mishell 1966, M.S., Bowland Fells, Namurian to Westphalian A.

Occurrence. Rare in the upper part of the sequence in Plenmeller and Low Close Opencast Site, Cumbria.

Acanthotriletes microspinosus (Ibrahim) Potonie´and Kremp 1955

Plate 7 Figures 2 - 4

1933 Apiculati-sporites microspinosus Ibrahim, p. 24, pl. 6, fig. 52.

1950 Spinoso-sporites microspinosus (Ibrahim); Knox, p. 314, pl. 17, fig. 204.

1955 Acanthotriletes microspinosus (Ibrahim): Potonie´and Kremp, p. 84, pl. 14, fig. 258.

Holotype. Potonie´and Kremp, 1955, pl. 14, fig. 258, after Ibrahim 1933, pl. 6, fig. 52. Preparation A50, e6 (ul).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. Potonie´and Kremp 1955, p. 84..

Size in micrometres. (i) Holotype 39, Schulze and KOH. (ii) 35-45, Schulze, (Potonie´and Kremp 1955). (iii) 31 (36) 42 (7 specimens), 40% HF + fum. HNO_3, black shale (M22), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular to subtriangular, with straight to slightly convex sides and rounded angles. Laesurae distinct, faint, straight, 2/3 - 3/4 of spore radius. Exine thin, less than 1.5 µm, sculptured with short tapering spines 1-1.5 µm in height, 2 µm in basal width and 1.5-2.5 µm apart. Compression folds frequently occur.

Comparison. A. echinatus has longer spines. A. falcatus (Knox) Potonie´and Kremp 1955 and A. castanea Butterworth and Williams 1958 have a larger size, and denser and longer sculptural elements.

Previous records. Potonie´and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Beju 1970, Namurian A, Moesian Platform, Romania.

Occurrence. Rare in black shale (Sample M22), from above the Upper Fell Top Limestone, Featherstone area.

Genus ANAPICULATISPORITES (Potonie´and Kremp) Smith and Butterworth 1967

Type species. A. isselburgensis Potonie´and Kremp 1954.

Diagnosis. In Smith and Butterworth 1967, p. 160 (emended from Potonie´and Kremp 1954, p. 133).

Comparison. Differentiated from several genera like Acanthotriletes, Apiculatisporis, Granulatisporites, Lophotriletes and Anaplanisporites by the restriction of its ornament to the distal surface.

Anapiculatisporites hispidus Butterworth and Williams 1958

Plate 7 Figures 8, 9

Holotype. Butterworth and Williams 1958, pl. 6, fig. 17. Preparation T39/1 in collection of National Coal Board Laboratory. Wath-upon-Dearne.

Type locality. 4 in. Coal at 191 ft. 3 in., Darnley No. 3 borehole, Central Coalfield, Scotland; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 161 (from Butterworth and Williams, 1958, p. 364).

Size in micrometres. (i) Holotype 39; 30 (33) 39, fum. HNO_3 (Butterworth and Williams 1958). (ii) 27 (32) 35 (6 specimens), HF + fum. HNO_3, black shale (M13) above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular with rounded angles and straight to convex sides. Laesurae distinct, simple, straight, open, 2/3 - 3/4 of spore radius, slightly elevated. Exine thin, 1-1.5 μm in thickness, covered distally with sharp pointed, curved or straight spines up to 4 μm long, 2-2.5 μm in basal width and 2-4 μm apart; spinae reduced in size at radial equatorial positions. 15-20 elements project at margin. Occasional folds occur.

Comparison. A. spinosus (Kosanke) Potonié and Kremp 1955 has the same size range and shape as A. hispidus but differs in its closely packed, and greater number of spinae, as well as longer leasurea which extend almost to the equator. A. concinnus Playford 1962 differs in its smaller size and fewer spinae.

Previous records. Butterworth and Williams 1958, Namurian A of Scotland; Owens 1963 M.S.; Lower Namurian A of Stainmore outlier, Westmorland; Smith and Butterworth 1967, Namurian A of Carboniferous Coals of Great Britain; Sabry and Neves, Namurian A, Sanquhar Coalfield, Scotland.

Occurrence. Rare in samples M15 and M13, black shales, above the Lower Fell Top Limestone, Featherstone area.

Anapiculatisporites minor (Butterworth and Williams) Smith and Butterworth 1967

Plate 7 Figures 5 - 7

1958 Anapiculatisporites minor Butterworth and Williams, p.365, pl. 6, fig. 21.

1967 Anapiculatisporites minor (Butterworth and Williams); Smith and Butterworth, p. 161, pl. 6, figs. 21-24.

Holotype. Butt. & Will. 1958, pl. 6, fig. 21. Preparation T40/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Lyoncross Seam at 558 ft. 10 in., Darnley No. 4 borehole, Central Coalfield, Scotland; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 161.

Size in micrometres. (i) Holotype 23; 14 (22) 28, fum. HNO_3 (Butterworth and Williams 1958). (ii) 20 (23) 27, fum. HNO_3; Lancashire Coalfield, England; Westphalian B,(Smith and Butterworth 1967). (iii) 18 (21.5) 25, (10 specimens), 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH one minute, Upper Craignook Seam, at 21.58 m, borehole No. 1154, Plenmeller Coalfield, England. (iv) 16 (22.5) 29 (14 specimens), 1/2 conc. + 1/2 fum. HNO_3, from Slag Seam at 49.56 m, borehole No. 1140, Plenmeller Coalfield, England.

Description. Equatorial outline triangular, with gently concave to convex sides, sometimes straight, and rounded narrow apices. Laesurae distinct, straight, slightly elevated, lips open, 2/3 - 3/4 of spore radius. Ornament of coni and spines, 40-55, restricted to the distal surface, 2-3 μm high, 2-3.5 μm in basal width. Exine pale in colour, thin, more or less 1 μm; short compression folds often present, sometimes parallel to the margin of spore or sometimes parallel to the trilete mark.

Comparison. The Plenmeller specimens differ from Anapiculatisporites concinnus Playford 1962 in their smaller size range and smaller sculptural elements. Anapiculatisporites spinosus Potonié and Kremp 1955 has a larger size and a greater number of distal spinae than A. minor.

Previous records. Butterworth and Williams 1958, Namurian A of Central Coalfield, Scotland; Owens and Burgess 1965, Namurian A to Lower Westphalian B of Stainmore Outlier; Smith and Butterworth 1967, Viséan to Westphalian C of British Coalfields; Sabry and Neves 1971, Upper Viséan to Westphalian C of Sanquhar Coalfield, Scotland; Agrali and Konyali 1969, Namurian and Westphalian A of Amasra Coalfield, Turkey; Marshall and Smith 1970, Yoredale Series (Viséan to Namurian) Western Northumberland; Loboziak 1971, Viséan to Westphalian; Nord-Pas-de-Calais Coalfield, North France.

Occurrence. Rare throughout the sequence; common in Slag seam (Top Leaf), Plenmeller Coalfield; and Bottom Brockwell Seam, Hedley Park area.

Genus ANAPLANISPORITES Jansonius 1962

Type species. A. telephorus Klaus 1960

Diagnosis. In Smith and Butterworth 1967, p. 165 (from the diagnosis in Jansonius 1962).

Comparison. The sculptural elements distributed evenly on the distal surface and around the equator distinguish this genus from other granulate genera.

Anaplanisporites baccatus (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967

Plate 9 Figures 1 - 3

1955 Punctatisporites ? baccatus Hoffmeister, Staplin and Malloy, p. 392, pl. 36, fig. 2.

1958 Apiculatisporis baccatus (Hoffmeister, Staplin and Malloy); Butterworth and Williams, p. 363, pl. 1, fig. 25.

1967 Anaplanisporites baccatus (Hoffmeister, Staplin and Malloy); Smith and Butterworth, p. 166, pl. 7, figs. 1-5.

Holotype. Hoffmeister, Staplin and Malloy 1955, pl. 36, fig. 2. Preparation 8, Ser. 19, 087.

Type locality. Shale at 2,075 ft., Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Smith and Butterworth 1967, p. 166.

Size in micrometres. (i) Holotype 29; 26-46, HF (Hoffmeister, Staplin, and Malloy 1955). (ii) 22 (26) 30, fum. HNO_3; Durham Coalfield, England; Westphalian A (Smith and Butterworth 1967). (iii) 21 (26) 32, (35 specimens), 1/2 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute) from Upper Craignook, borehole No. 1154, at 20.55 m; Plenmeller Coalfield, England.

Description. Equatorial outline circular, oval to irregular due to compression. Exine thin, ranging between 1-2 µm, proximally laevigate, distally ornamented with coni with slightly rounded apices and also small grana, 0.5-2 µm high and 1.5-3 µm in basal diameter; 40-60 project at the equatorial margin. Laesurae indistinct, if seen, straight, simple, 3/4 of the spore radius; short arcuate compression folds occur parallel to the margin of the spore.

Remarks. The density of ornament and the number of projections on the equator vary from specimen to specimen.

Comparison. Lycospora orbicula (Potonié and Kremp) Smith and Butterworth 1967 is quite similar except in its slightly smaller size, fine grana, and narrow flange. Cyclogranisporites leopoldi (Kremp) Potonié and Kremp 1955, differs in being slightly larger and in having indistinct laesurae and coarse packed grana on both proximal and distal surfaces.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Butterworth and Williams, 1958, Namurian A, Scotland; Sullivan and Mishell 1966, Upper Viséan, Western part of the Midland Valley, Scotland; Smith and Butterworth 1967, Viséan to Lower Westphalian C, British Coalfields; Neves and Sabry 1971, Namurian to Westphalian A, Sanquhar Coalfield, Scotland; Ettensohn and Pepper 1979, Viséan to Namurian, Northeastern Kentucky, U.S.A.: Ravn 1979, Cherokee Group (Pennsylvanian) Coals, Iowa, U.S.A.

Occurrence. Rare to infrequent in the Namurian sequence, common to abundant in the Westphalian sequence.

Genus APICULATISPORIS (Ibrahim) Potonié and Kremp 1956

1933 Apiculati-sporites Ibrahim, p. 23, non Bennie and Kidston 1886

1956b Apiculatisporis Potonie and Kremp, p. 94.

Type species. A. aculeatus Ibrahim 1933.

Diagnosis. In Smith and Butterworth 1967, p. 169 (from Potonié and Kremp 1954, p. 130).

Comparison. This genus differs from Planisporites (Knox) Potonié 1960 and Apiculatasporites (Ibrahim) Smith and Butterworth 1967 in its larger coni and also in the considerable variety in shape and size of the sculptural elements.

Remarks. Spores assigned to this genus are characterised in having a conate sculpture and a more or less circular amb.

Apiculatisporis abditus (Loose) Potonié and Kremp 1955

Plate 8 Figure 5

1932 Sporonites abditus Loose in Potonié, Ibrahim and Loose, p. 451, pl. 19, fig. 53.

1934 Verrucosi-sporites abditus Loose, p. 154.

1944 ? Raistrickia abditus (Loose); Schopf, Wilson and Bentall, p. 55.

1950 Verrucoso-sporites abditus (Loose); Knox, p. 317.

1955 Apiculatisporis abditus (Loose); Potonie and Kremp, p. 78, pl. 14, figs, 237-9.

Holotype. Potonié and Kremp 1955, pl. 14, fig. 237, after Loose. Preparation IV 29, e4 (m/or).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 170.

Size in micrometres. (i) Holotype 78 X 55.5, Schulze. (ii) 50-70, fum. HNO_3 from various British Coals, Smith and Butterworth 1967. (iii) 39 (46) 57, (5 specimens), fum. HNO_3, from various seams within Plenmeller Coalfield, England.

Description. Amb rounded triangular. Laesurae obscured by ornament. Exine relatively thick, 2-2.5 μm in thickness. Ornament of fairly closely packed cones, often fused at bases, most have rounded but a few have pointed apices, and a few flat-topped elements may occur; 3-7 μm in basal width, 3-6 μm in height and 1-2 μm apart; 20-30 elements project at margin. On the proximal surface there appears to be a decrease in size and number of ornamental elements.

Comparison. Distinguished by the larger size and closely packed nature of the cones. Apiculatisporis pineatus Hoffmeister, Staplin and Malloy 1955, is quite similar but differs in its smaller size (36-56 μm) and its slightly higher (5-8 μm) elements.

Previous records. Potonié and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Artuz 1957, Westphalian A, Zonguldak Coalfield, Turkey; Smith and Butterworth 1967, Westphalian A to D, of British Coalfields; Grebe (1972), Westphalian A to C, Ruhr Coalfield, Germany; Ravn 1979, Cherokee Group, Pennsylvanian, CP-19-4 Coal, Southern Iowa, U.S.A.

Occurrence. Absent to rare throughout Westphalian sequence.

Apiculatisporis aculeatus (Ibrahim) Smith and Butterworth 1967

Plate 7 Figures 12 - 14

1933 Apiculati-sporites aculeatus Ibrahim, p. 23, pl. 6, fig. 57.

1944 Punctati-sporites aculeatus (Ibrahim); Schopf, Wilson and Bentall, p. 30.

1950 Spinoso-sporites aculeatus (Ibrahim); Knox, p. 313.

1955 Apiculatisporites aculeatus (Ibrahim): Potonié and Kremp, p. 78, pl. 14, figs. 235, 236, 241.

1967 Apiculatisporis aculeatus (Ibrahim); Smith and Butterworth, p. 170, pl. 7, figs. 12, 13.

Holotype. Potonié and Kremp 1955, pl. 14, fig. 235 after Ibrahim. Preparation A27, d6 (or).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 170 (emended from diagnosis and description in Potonié and Kremp 1955, p. 78).

Size in micrometres. (i) Holotype 53; Schulze and KOH. (ii) 50-60, Schulze (Potonié and Kremp 1955). (iii) 32 (42) 50, fum. HNO_3; Yorkshire Coalfield, Westphalian A (Smith and Butterworth 1967). (iv) 42 (49) 59 (6 specimens); fum. HNO_3, Slag seam (top leaf), at 49.56 m, borehole No. 1140, Plenmeller Coalfield, England.

Description. Amb subcircular to oval in shape. Laesurae distinct, simple, straight, 1/2 to 2/3 of spore radius, rays open. Exine moderately thick, less than 2.5 µm, covered with more or less pointed coni, 2 µm high and 2.5 µm in basal width, space between elements more than basal width; number of elements projecting at the margin varies between 30-40. Compression folds occasionally occur, sometimes following the equatorial margin of the spore.

Comparison. *A. punctaornatus* Artuz 1957, (42-60 μm) differs mainly in its oval shape and more developed laesurae. *A. setulosus* (Kos.) Potonié and Kremp is larger in size, and possesses a heavier sculpture of usually rounded cones.

Previous records. Neves 1961, Upper Namurian B to Westphalian A of the Southern Pennines, England. Smith and Butterworth 1967, British Coalfields, Westphalian A to D; Loboziak 1971, Westphalian, Nord-Pas-de-Calais, North France; Ravn 1979, Cherokee Group, Pennsylvanian, CP-19-4 Coal, Southern Iowa, U.S.A.; Grebe 1972, Westphalian A to C, Ruhr Coalfield, Germany; Sabry and Neves 1970, Westphalian A, Sanquhar Coalfield, Scotland.

Occurrence. Absent to rare throughout the Westphalian sequence.

Apiculatisporis irregularis (Alpern) Smith and Butterworth 1967

Plate 7 Figures 15 - 20

1959 *Granasporites irregularis* Alpern, p. 139, pl. 1, figs, 7-9.

non 1955 *Apiculatisporites (Raistrickia) irregularis* (Kosanke); Potonié and Kremp, p. 77.

1967 *Apiculatisporis irregularis* (Alpern) Smith and Butterworth, p. 171, pl. 7, figs. 18, 19.

Holotype. Alpern 1959, pl. 1, fig. 8, slide 509b, 38.5, 113.4.

Type locality. 1st Seam Norsbach, Lorraine Coalfield, France; Lower Stephanian.

Diagnosis. In Smith and Butterworth 1967, p. 171 (from description in Alpern 1959, p. 139).

Size in micrometres. (i) Holotype 52 X 44; 50-75 (Alpern 1959), 45-65 (Alpern) in Smith and Butterworth 1967, Schulze and KOH. (ii) 37 (46) 52, fum. HNO_3; Yorkshire Coalfield, England; Westphalian B

(Smith and Butterworth 1967). (iii) 33 (38.5) 47; (17 specimens); 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH. (one minute) Upper Craignook Seam, at 21.58 m, borehole No. 1154, Plenmeller Coalfield, England.

Description. Equatorial outline circular to subcircular to irregular in shape due to compression folds. Exine very thin, less than 1 μm thick; ornament of small coni and grana of various shapes and sizes, less than 1.5 μm in height and 0.5-1 μm in width, distributed unevenly on the surface of the exine and sometimes grouped into patches leaving other parts of the exine laevigate; number of coni and grana projecting on the margin varying from 35-65. Laesurae faint, very difficult to distinguish, if recognised it is either very faint and its ratio to the spore radius varies between 2/3 - 3/4, or it is torn and represented by a triangular opening in the exine. Short arcuate compression folds frequently present.

Remarks. During the present study a great number of specimens of this species were examined which leave no doubt as to the presence of the trilete rays.

Comparison. This species differs completely from other species of the genus in its small size, thin exine pale in colour, and very fine ornament.

Previous records. Alpern 1959, Lower Stephanian, Lorraine Coalfield, France; Smith and Butterworth 1967, Westphalian A to D, of British Coalfields and recorded by several other authors.

Occurrence. Common, frequent to abundant throughout the Westphalian sequence.

Apiculatisporis latigranifer (Loose) Potonié and Kremp 1955

1932 Sporonites latigranifer Loose in Potonié, Ibrahim and Loose, p. 452, pl. 19, fig. 54.

1934 Granulati-sporites latigranifer Loose, p. 147.

1944 Punctati-sporites latigranifer (Loose); Schopf, Wilson and Bentall, p. 31.

1950 Spinoso-sporites latigranifer (Loose); Knox, p. 314.

1955 Apiculatisporis latigranifer (Loose); Potonié and Kremp, p. 79, pl. 14, figs. 244, 245.

Holotype. Potonié and Kremp 1955, pl. 14, fig. 244 after Loose. Preparation III 36, bl (ul).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 172 (translated from Potonié and Kremp 1955, p. 79).

Size in micrometres. (i) Holotype 78, Schulze. (ii) 55-90, Schulze (Potonié and Kremp 1955).

Apiculatisporis cf. latigranifer (Loose) Potonié and Kremp 1955 in Smith and Butterworth 1967

Plate 8 Figure 1

Size. British specimens fall within the limits given by Potonié and Kremp for A. latigranifer, (Smith and Butterworth 1967). (ii) 46 (50) 71 (9 specimens); fum. HNO_3; Slag Seam (bottom leaf), at 49.65 m, borehole No. 1140, Plenmeller Coalfield, England.

Description. Amb circular. Laesurae simple, straight, unequal in length, 2/3 - 3/4 of spore radius. Exine relatively thick, 2.5-3 µm, covered with small and variably shaped coni, their height ranging between 1.5-2.5 µm and their basal diameter 2-2.5 µm; 15 to 25 elements project at the margin. Folds infrequently occur.

Remarks. Specimens conform with the description of Smith and

Butterworth 1967, and differ in their more prominent ornament from the type.

Comparison. Distinguished from *A. abditus* (Loose) Potonié and Kremp 1955, *A. spinososaetosus* (Loose) Smith and Butterworth 1967, and *A. variocorneus* Sullivan 1964, in its circular shape and more prominent and pointed coni; *A. aculeatus* (Ibrahim) Smith and Butterworth 1967 is smaller in size, and has relatively smaller elements.

Previous records. Ibrahim 1933, Upper Westphalian B, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Westphalian A to D, British Coalfields, and recorded by several other workers in Westphalian sediments.

Occurrence. Rare to common in the Westphalian sequence.

Apiculatisporis spinososaetosus (Loose) Smith and Butterworth 1967

Plate 7 Figure 21

1932 *Sporonites spinososaetosus* Loose in Potonié, Ibrahim and Loose, p. 452, pl. 19, fig. 55.

1933 *Apiculati-sporites spinososaetosus* (Loose); Ibrahim, p.24.

1944 *Raistrickia spinososaetosus* (Loose); Schopf, Wilson and Bentall, p. 56.

1967 *Apiculatisporis spinososaetosus* (Loose); Smith and Butterworth, p. 173, pl. 7, figs. 22, 23.

Holotype. Potonié and Kremp 1955, pl. 14, fig. 249; after Loose. Preparation I2, h.

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 173 (emended from diagnosis in Potonié and Kremp 1955, p. 80).

Size in micrometres. (i) Holotype 74, Schulze. (ii) 50-80, Schulze (Potonié and Kremp 1955). (iii) 38 (50) 60, fum. HNO_3; Yorkshire Coalfield, England; Westphalian B (Smith and Butterworth 1967); (iv) 43 (54) 65, (8 specimens), fum. HNO_3, Half Seam (bottom leaf) at 37.02 m, borehole No. 1138, Plenmeller Coalfield, England.

Description. Amb rounded to rounded triangular. Laesurae distinct, straight, simple, sometimes more than 3/4 of spore radius, apparently unequal in length because the extremities are obscured by ornament. Exine relatively thick, 2.5-4 µm, covered with various shapes and sizes of loosely packed coni and baculae, with their height less than their basal diameter and the spaces between the elements equal to or more than their basal diameter. 25-30 elements project at the margin; compression folds occasionally occur.

Comparison. A. cf. latigranifer (Loose) Potonié and Kremp 1955 in Smith and Butterworth 1967, possesses small pointed coni only, while A. spinososaetosus possesses ornament of coni and baculae; A. variocorneus Sullivan 1964 is distinguished by the variety of its ornamental elements.

Previous records. Loose 1932, Upper Westphalian B, Ruhr Coalfield, Germany; Pierart 1962, Upper Westphalian B to C, Borinage Massif, Belgium; Smith and Butterworth 1967, Westphalian A to C, British Coalfields; Loboziak 1971, Westphalian, Nord-Pas-de-Calais, North France.

Occurrence. Rare throughout the Westphalian sequence.

Apiculatisporis variocorneus Sullivan 1964

Plate 7 Figure 22, 23

Holotype. Sullivan 1964, pl. 58, fig. 4. Preparation SMUD/1.

Type locality. Edgehills Coal, Drybrook Sandstone, Forest of Dean, England, ? Westphalian A.

Diagnosis. In Smith and Butterworth 1967, p. 173 (from Sullivan 1964, p. 363).

Size in micrometres. (i) 40 (60) 78, HF and 2% KOH (Sullivan 1964). (ii) 52 (60) 77 fum. HNO_3; Nottinghamshire Coalfield, England; Westphalian A, Smith and Butterworth 1967. (iii) 49 (63) 75, (7 specimens); 1/3 conc. + 2/3 fum. HNO_3, Ganister Clay Seam, at 19.53 m, borehole No. 1397; (iv) 61 (66) 78, (14 specimens) HF + 1/3 conc. + 2/3 fum. HNO_3; dark grey shale above Quarter Seam, at 7.98 m, borehole No. 1350. (iii) and (iv) from Plenmeller Coalfield, England.

Description. Amb more or less circular. Laesurae distinct, simple. straight, 3/4 of spore radius, sometimes obscured by ornament; exine moderately thick, 3-4 μm, ornamented with coni, spinae, and small verrucae, which vary in shape and size considerably even in one specimen; these elements more strongly developed distally, may reach 3 μm in height and 2.5 μm in their basal diameter, reduced proximally; compression folds frequently developed, more often parallel to the margin of the spore.

Remarks. The specimens described during the present work conform closely to the original diagnosis.

Comparison. The distribution and considerable variation of sculptural elements distinguish this species from others in the genus. As mentioned by Sullivan 1964, the two species described by Artüz 1957, A. punctaornatus and A. subspinosus and the species of A. abditus (Loose) Potonié and Kremp 1955, figured by Artüz 1957, appear to be very similar to this species.

Previous records. Sullivan 1964, ? Westphalian A, Edgehills Coal, Forest of Dean; Smith and Butterworth 1967, Namurian to Westphalian B, British Coalfields; Marshall and Williams 1970, Namurian A, Northumberland; Neves, Read and Wilson 1965, Lower Westphalian A, Scotland; Neves 1968, Namurian C to Lower Westphalian A, Woodland Borehole, Co. Durham. Owens *et al*. 1977, Namurian A to Westphalian A, Northern England and Scotland, Clayton *et al*. 1977, Namurian A to Westphalian A, Western Europe.

Occurrence. Rare throughout the sequence; infrequent in the Ganister Clay, Marshall Green, Slag, Threequarters and Upper Craignook seams, Plenmeller area.

Genus APICULATASPORITES (Ibrahim) Smith and Butterworth 1967

Type species. *A. spinulistratus* (Loose) Ibrahim 1933

Diagnosis. Emendation in Smith and Butterworth 1967, p. 176.

Comparison. Differentiated from *Planisporites* by its circular outline and fine sculptural elements and from *Apiculatisporis* by its fine ornament.

Apiculatasporites spinulistratus (Loose) Ibrahim 1933

Plate 7 Figures 24 - 26

1932 *Sporonites spinulistratus* Loose in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 47.

1933 *Apiculata-sporites spinulistratus* (Loose); Ibrahim, p. 37.

1934 *Apiculati-sporites spinulistratus* Loose, p. 153.

1934 *Apiculati-sporites globosus* Loose, p. 152, pl. 7, fig. 14.

1944 *Punctati-sporites spinulistratus* (Loose); Schopf, Wilson and Bentall, p. 31.

1950 Spinoso-sporites spinulistratus (Loose); Knox, p. 314.

1955 Planisporites spinulistratus (Loose); Potonié and Kremp, p. 71, pl. 14, figs. 214-219.

1960 Apiculatasporites spinulistratus (Loose); Potonié, p. 38.

Holotype. Potonié and Kremp 1955, pl. 14, fig. 214 after Loose 1932. Preparation IV9, d4 (m/or).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 176, (translation from Potonié and Kremp 1955, p. 71).

Size in micrometres. (i) Holotype 53, Schulze. (ii) 45-75, Schulze (Potonié and Kremp 1955). (iii) 38 (57) 87, fum. HNO_3; Yorkshire Coalfield, England; Westphalian B; (Smith and Butterworth 1967). (iv) 47 (67) 86, (7 specimens) 1/3 conc. + 2/3 fum. HNO_3; Marshall Green Seam at 14.60 m, borehole No. 1392; (v) 45 (64) 77, (8 specimens); 1/3 conc. + 2/3 fum. HNO_3, Slag Seam, at 27.57 m, borehole No. 1241. (iv) and (v) Plenmeller Coalfield, England.

Description. Amb circular to subcircular. Laesurae simple, straight, two-thirds of spore radius. Spore coat relatively thin 1-2.5 µm, covered with small grana and low coni, basal diameter ranges between 1-2 µm and height 1-1.5 µm, basal diameter of coni is less than the space between coni; exine with single compression fold.

Comparison. Distinguished from most apiculate species by its fine grade of ornament.

Previous records. Bhardwaj (1957), Westphalian D to Stephanian, Saar Coalfield; Dybova and Jachowicz (1957), Namurian to Westphalian B, Upper Silesia; Pierart (1962), Westphalian B to C, Borinage Massif, Belgium; Grebe (1972), Westphalian A to C, of Ruhr Coalfield, Germany; Smith and Butterworth (1967), Westphalian A to D, British

Coalfields.

Occurrence. Rare to absent throughout the Westphalian sequence.

Genus PLANISPORITES (Knox) Potonié 1960

Type species. *P. granifer* (Ibrahim) Knox 1950.

Diagnosis. In Smith and Butterworth 1967, p. 174 (translation from Potonié 1960, p. 39).

Comparison. *Planisporites* differs from *Apiculatasporites* in its triangular shape and coarse sculptural elements; *Apiculatisporis* differs from *Planisporites* in its greater variety in shape and size of ornament.

Planisporites granifer (Ibrahim) Knox 1950

Plate 8 Figure 2

1933 *Granulati-sporites granifer* Ibrahim, p. 22, pl. 8, fig. 72.

1944 *Punctati-sporites granifer* (Ibrahim); Schopf, Wilson and Bentall, p. 31.

1950 *Planisporites granifer* (Ibrahim); Knox, p. 315.

Holotype. Potonié and Kremp 1955, pl. 13, fig. 207 after Ibrahim. Preparation B29, e5 (0).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 175 (translation from Potonié and Kremp 1955, p. 71).

Size in micrometres. (i) Holotype 96, Schulze and KOH. (ii) 85-100, Schulze (Potonié and Kremp 1955). (iii) 46 (54) 67, (6 specimens); HF + 1/3 conc. + 2/3 fum. HNO_3; Seatearth of Wellsyke Seam, at 20.34 m, borehole No. 1350. (iv) 48 (59) 73, (8 specimens) fum. HNO_3; Low Main Seam, at 63.60 m, borehole No. 1057. (iii) and (iv) from Plenmeller Coalfield, England.

Description. Equatorial outline triangular, with broad rounded apices and straight to slightly convex sides. Laesurae straight, simple, 3/4 of spore radius, sometimes rays unequal in length, and obscured by ornament, lips open. Exine relatively thick, 3-5 μm, covered by grana, small verrucae and coni, 2 μm in height and 2-4 μm in basal diameter, 17-23 elements project at the margin. Compression folds sometimes developed.

Comparison. Apiculatisporis spinososaetosus (Loose) Smith and Butterworth 1967 has a more or less circular shape, with ornament of coarse coni and baculae.

Previous records. Ibrahim (1933) Westphalian B, Bismarck Seam, Ruhr Coalfield; Grebe (1962) Westphalian B to C, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Westphalian A to C, British Coalfields.

Occurrence. Rare throughout the Westphalian sequence, common in Low Main Seam, (sample 752), Plenmeller Coalfield.

Genus LOPHOTRILETES (Naumova) Potonié and Kremp 1954

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

Diagnosis. In Smith and Butterworth 1967, p. 155 (translated from Potonié and Kremp 1954, p. 129).

Comparison. The genus Apiculatisporis Potonié and Kremp 1956 has similar sculptural elements but is distinguished from Lophotriletes by its circular equatorial outline.

Lophotriletes commissuralis (Kosanke) Potonié and Kremp 1955

Plate 8 Figures 8 - 11

1950 Granulatisporites commissuralis Kosanke, p. 20, pl. 3, fig. 1.

1955 Lophotriletes commissuralis (Kosanke); Potonié and Kremp, p. 13, pl. 14, figs. 222-223.

non 1960 Lophotriletes commissuralis (Kosanke); Potonié and Kremp; Imgrund, p. 164, pl. 15, figs. 66-68.

Holotype. Kosanke 1950, pl. 3, fig. 1. Preparation 486-B, slide 22.

Type locality. Friendsville Coal, Wabash County, Illinois, U.S.A.; McLeansboro Group.

Diagnosis. In Smith and Butterworth 1967, p. 156 (from description in Kosanke 1950, p. 20).

Size in micrometres. (i) Holotype, 29.5 X 26; 25-34, Schulze and 10% KOH (Kosanke 1950). (ii) 24 (29) 35 Schulze and 5% KOH, Forest of Wyre Coalfield, England; Westphalian D (Smith and Butterworth 1967). (iii) 22 (31) 37 (5 specimens), 1/3 conc. + 2/3 fum. HNO_3; High Main Seam, at 44.18 m, borehole No. 1350 Plenmeller Coalfield, England.

Description. Amb triangular to subtriangular, sides variable but usually concave, angles broadly rounded. Laesurae simple 2/3 to 3/4 of spore radius, rays open. Exine ranges between 2-3 µm in thickness. Compression folds present, also 'gulaferus' type compression. Ornamented with small elements, mostly coni, between 0.5-1.5 µm in height and 1.5-2.5µm in basal width, evenly distributed with the space between elements more than the basal width; apices of coni sometimes pointed but the majority rounded, bases not fused; 30-40 elements project at the margin.

Comparison. A fine grade of coni distinguish this species from other species within the genus; L. microsaetosus (Loose) Potonié and Kremp 1955, has a similar size range but differs in having coarser ornament. L. tribulosus Sullivan 1964, and L. pseudoaculatus Potonié and Kremp 1955, have a larger size and coarser ornament.

Previous records. Potonié and Kremp 1955, Westphalian C, Ruhr Basin; Bhardwaj 1957, Lower Westphalian D, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Namurian to Westphalian D, of British Coalfields; Loboziak 1971, Namurian to Stephanian, Nord-Pas-de-Calais Coalfield, North France; and also recorded by several other workers in Great Britain.

Occurrence. Absent to rare throughout the Westphalian sequence.

Lophotriletes densus Love 1960

Plate 8 Figure 12

1960 Lophotriletes densus Love, p. 113, pl. 1, fig. 3.

1964 Microreticulatisporites densus (Love); Sullivan, p. 366, pl. 58, fig. 19.

Holotype. Love 1960, pl. 1, fig. 3. Slide PSB 296/m/10.

Type locality. Pumpherston Shell Bed, South Queensferry.

Diagnosis. In Love 1960, p. 113.

Size in micrometres. (i) Holotype 55-58, 40-60, Schulze and KOH, Upper Visean, (Love 1960). (ii) 34 (41) 51 (5 specimens), 40% HF + fum. HNO_3, black shale, (M13), above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular with concave to straight sides and rounded angles. Laesurae distinct, simple, straight, 3/4 of spore radius. Exine 1-2 µm in thickness, covered with coni and some grana and spinae, 1-2 µm in basal width, 1.5-2.5 µm high and 1-2 µm apart; 50-60 elements project at the margin. Occasional folds present.

Comparison. Lophotriletes plicatus Butterworth and Spinner 1967 has straight to convex sides, short folded laesurae, cones and baculae coarser in basal diameter and less closely packed than L. densus, and the exine is thicker.

Remarks. As Love 1960 mentioned, this species is placed in the genus Lophotriletes because of its undoubted apiculate ornament. The cones do not resemble spines even when more finely tapered and only a few are flattened enough to resemble grana. But Sullivan 1964 transferred this species to Microreticulatisporites describing the ornament as circular pits or punctae 0.5 µm in diameter, and the exine between the pits domed 0.5-0.8 µm high at the outline.

Occurrence. Rare in black shale (Sample M13) above the Lower Fell Top Limestone, Featherstone area.

Lophotriletes gibbosus (Ibrahim) Potonié and Kremp 1954

1933 Verrucosi-sporites gibbosus Ibrahim, p. 25, pl. 6, fig. 49.

1938 Azonotriletes gibbosus (Ibrahim); Luber in Luber and Waltz, pl. 7, fig. 91.

1944 Granulati-sporites gibbosus (Ibrahim); Schopf, Wilson and Bentall, p. 33.

1950 Verrucoso-sporites gibbosus (Ibrahim); Knox, p. 317, pl. 7, fig. 232.

1954 Lophotriletes gibbosus (Ibrahim); Potonié and Kremp, p. 129.

non 1958 Lophotriletes gibbosus (Ibrahim); Potonié and Kremp; Guennel, p. 62, pl. 3, fig. 9.

Holotype. Potonié and Kremp 1955, pl. 14, fig. 220, after Ibrahim. Preparation B61, e5 (ul).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 156 (from description and diagnosis in Potonié and Kremp 1955, p. 74).

Size in micrometres. (i) Holotype 46, Schulze and KOH. (ii) 40-50, Schulze (Potonié and Kremp 1955).

Lophotriletes cf. gibbosus (Ibrahim) Potonié and Kremp 1955 in Smith and Butterworth 1967

Plate 8 Figures 6, 7

Size in micrometres. (i) 29 (34) 41, fum. HNO_3; Durham Coalfield, England, Westphalian A (Smith and Butterworth 1967). (ii) 27 (37) 44 (12 specimens); HF + 1/3 conc. + 2/2 fum. HNO_3; dark grey shale, at 7.98 m, borehole 1350, Plenmeller Coalfield, England.

Description. Amb rounded triangular, sides concave, angles broadly rounded. Laesurae simple, straight, 2/3 of spore radius. Exine relatively thick 1.5-2.5 µm, covered with broadly rounded coni, occasionally pointed, 2-3 µm high and 2-4 µm in basal diameter; the spaces between elements are greater than the basal diameter; 25 to 35 elements project at the margin; folds are infrequent.

Comparison. L. commissuralis (Kosanke) Potonié and Kremp 1955 has a smaller size and finer and more closely spaced ornament than L. cf. gibbosus. L. tribulosus Sullivan 1964 has the same size range and shape but differs in its longer laesurae and slightly finer ornament. L. obtusus Felix and Burbridge 1967, has a larger size, longer laesurae, straight sides, with closely spaced and coarser coni, 1.5-7.5 µm high and 1-6 µm in basal diameter.

Previous records. This species has been recorded by several workers from Namurian and Westphalian sediments inside and outside Britain.

Occurrence. Absent to rare throughout the Westphalian sequence.

Lophotriletes granoornatus Artüz 1957

Plate 8 Figures 13, 14

1957 Lophotriletes granoornatus Artüz, p. 244, pl. 2, fig. 13.

Holotype. Artüz 1957, pl. 2, fig. 13. Preparation IIlv, se.

Type locality. Büjük Seam, Zonguldak Coalfield, Turkey; Westphalian A.

Diagnosis. In Smith and Butterworth 1967, p. 157 (translated from Artüz 1957, p. 244).

Size in micrometres. (i) Holotype 37, 35-41, method of maceration not known (Artüz 1957). (ii) 27 (35) 44, fum. HNO_3; Yorkshire Coalfield, England; Westphalian B; (Smith and Butterworth, 1967). (iii) 31 (38) 46; (6 specimens); 1/3 conc. + 2/3 fum. HNO_3; High Main Seam at 44.18 m, borehole No.1350, Plenmeller Coalfield, England.

Description. Amb rounded to sub triangular, with rounded angles, usually straight to convex, sometimes concave. Laesurae simple, straight, 2/3 of spore radius. Exine covered with low coni 2 - 3 µm in basal diameter and 0.5 - 1.5 µm in height, apices sometimes pointed but usually rounded, distributed regularly, bases sometimes touch; margin undulating. 20 - 30 elements project at the margin. Exine pale to dark brown, up to 3 µm in thickness; compression folds frequent and 'gulaferus' type of folding also occurs.

Remarks. The Plenmeller specimens differ from Artüz (1957,1959) diagnosis in that the bases of the coni are sometimes fused, the interradial margins are sometimes convex and they have gulaferus type of folding, which however appears in Artüz's photograph.

Comparison. The straight to concave sides and low coni differentiate this species from L. gibbosus (Ibrahim) Potonié and Kremp, 1954 and L. commissuralis (Kosanke) Potonié and Kremp, 1955. L. labiatus Sullivan 1964 is smaller in size, has fine ornament, 0.5 to 1.5 µm, and laesuraeobscured by thickened bands.

Previous records. Artüz, 1957, Westphalian A, Zonguldak Coalfield, Turkey; Smith and Butterworth, 1967, Westphalian A to B, of British Coalfields; Whitaker 1976 MS (? Namurian B) Ballycastle and Leitrim Coalfields, Ireland.

Occurrence. Absent to rare throughout the Westphalian sequence.

Lophotriletes insignitus (Ibrahim) Potonié and Kremp 1955

Plate 8 Figures 3, 4

1933 Apiculati-sporites insignitus Ibrahim, p. 24, pl. 6, fig. 54.

1955 Lophotriletes insignitus (Ibrahim) Potonié and Kremp, p. 74, pl. 14, figs. 224-226.

Holotype. Potonié and Kremp 1955, pl. 14, fig. 224, after Ibrahim. Preparation A48, b5 (or).

Type locality. Agir Seam, Ruhr Coalfield, Germany; top Westphalian B.

Diagnosis. In Potonié and Kremp 1955, p. 74.

Size in micrometres. (i) Holotype 58, Schulze and KOH. (ii) 45-85, Schulze (Potonié and Kremp 1955). (iii) 43 (56) 67 (5 specimens), various localities within the upper part of the Westphalian sequence.

Description. Amb triangular to subtriangular, with convex sides and broadly rounded angles. Laesurae distinct, simple, straight, 1/2 - 2/3 of spore radius. Exine relatively thick, 2-3 µm in thickness, covered with broadly rounded coni, 2-5 µm in basal width and height. Ornaments vary in shape, size and distribution, even in a single specimen. Sculptural elements vary in shape, from rounded flat to pointed or truncated coni; occasional bacculae, grana, spinae occur. Compression folds occur infrequently.

Comparison. Distinguished by its larger size, thicker exine, and larger size of sculptural elements from other species in the genus. In L. confertus Ravn 1979, which most closely resembles L. insignitus, the coni are of similar size and number, but are fused at their bases as stated by Ravn.

Previous records. Potonié and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Grebe 1972, Upper Westphalian A to Westphalian C, Ruhr Coalfield, Germany.

Occurrence. Absent to rare throughout the Westphalian sequence.

Lophotriletes labiatus Sullivan 1964

Plate 8 Figure 23

1955 Spore type E, Hoffmeister, Staplin and Malloy 1955, p. 39, fig. 8.

1964 Lophotriletes labiatus Sullivan, p. 360, pl. 57, figs. 19-20.

Holotype. Sullivan 1964, pl. 57, figs. 19-20.

Type locality. Edgehills Coal, Forest of Dean Basin, England.

Diagnosis. In Sullivan 1964, p. 360.

Size in micrometres. (i) Holotype 30, HF + 2% NaOH. (ii) 20 (32) 40 (23 specimens) HF + 2% NaOH (Sullivan 1964). (iii) 32 (1 specimen), 1/3 conc. + 2/3 fum. HNO + 2% KOH. Upper Craig Nook (top leaf) Seam, at 20.55 m, borehole No. 1154, Plenmeller Coalfield, England. (iv) 23 (25) 28 (3 specimens); 40% HF + fum. HNO_3, dark shale (M20), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular with convex sides and narrowly rounded angles. Exine relatively thick, 1-2 µm in thickness, dark brown in colour, ornamented with rounded, closely-packed grana and cones 0.5-1.5 µm in diameter; about 20-30 elements project at the margin. Laesurae visible, simple, straight to slightly flexuose, 3/4 of spore radius; thick dark brown band 3-5 µm wide follows the rays and extends to the apices.

Comparison. Differs from other species in its wide prominent lips on either side of laesurae and its closely packed blunt coni.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg Formation (spore type E); Illinois and

Kentucky, U.S.A.; Sullivan 1964, Edgehills Coal; Forest of Dean Basin, England; Felix and Burbridge 1967, Viséan to Wesphalian A, Southern Oklahoma, U.S.A.; Urban 1971, Upper Mississippian, the Independence Shale of Iowa, U.S.A.

Occurrence. Rare in dark shale (Sample M20), above the Upper Fell Top Limestone, Featherstone area, and one specimen found in the Upper Craignook Seam (top leaf), Plenmeller.

Lophotriletes microsaetosus (Loose) Potonié and Kremp 1955

Plate 8 Figures 15 - 18

1932 Sporonites microsaetosus Loose in Potonié, Ibrahim and Loose, p. 450, pl. 18, fig. 40.

1933 Setosi-sporites microsaetosus (Loose); Ibrahim, p. 26.

1934 Setosisporites microsaetosus (Loose); Loose, p. 148.

1944 Granulatisporites microsaetosus (Loose); Schopf, Wilson and Bentall, p. 33.

1950 Spinoso-sporites microsaetosus (Loose); Knox, p. 314, pl. 17, fig. 203.

1955 Lophotriletes microsaetosus (Loose); Potonié and Kremp, p. 74, pl. 14, figs. 229-230.

1958 Lophotriletes gibbosus (Ibrahim); Potonié and Kremp; Guennel, p. 62, pl. 3, fig. 9.

Holotype. Potonié and Kremp, 1955, pl. 14, fig. 229 after Loose. Preparation IV6 f2 (ul).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 158 (from diagnosis and description in Potonié and Kremp, 1955, p. 74).

Size in micrometres. (i) Holotype 39, Schulze. (ii) 25-40, Schulze (Potonié and Kremp 1955). (iii) 21 (30) 39, fum. HNO_3; Cannock Chase Coalfield, England; Westphalian C, (Smith and Butterworth 1967). (iv) 25 (33) 41 (5 specimens), fum. HNO_3, Lickbank Seam (sample C5), Low Close Opencast Site, Cumbria.

Description. Amb triangular with concave sides and rounded angles. Laesurae distinct, simple, straight, 3/4 of spore radius. Exine less than 1.5 µm in thickness, sculptured with rounded flat to moderately pointed coni, 0.5-1.5 µm in height, 1-2.5 µm in basal width, 2-4 µm apart. Compression folds occur infrequently. 25-35 elements project at the margin.

Comparison. L. commissuralis (Kosanke) Potonié and Kremp 1955 has a similar size range but the ornament is of a finer grade and more closely spaced. L. gibbosus (Ibrahim) Potonié and Kremp 1955 has some similarity but is larger and possesses an ornament of round-topped cones.

Previous records. Potonié and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Upper Westphalian B and Westphalian C, British Coalfields; Loboziak 1971, Westphalian A to Westphalian D, Nord-Pas-de-Calais Coalfield, North France; Grebe 1972, Upper Westphalian A to Upper Westphalian C, Ruhr Coalfield, Germany; Ravn 1979, Cherokee Group, CP-19-4 Coal, Iowa, U.S.A.

Occurrence. Rare in the upper part of the Westphalian sequence.

Lophotriletes tuberculatus (Hoffmeister, Staplin and Malloy) Sullivan 1964

Plate 8 Figures 19 - 22

1955 Granulatisporites tuberculatus Hoffmeister, Staplin and Malloy, p. 389, pl. 36, fig. 12.

1964 Lophotriletes tuberculatus (Hoffmeister, Staplin and Malloy) Sullivan, p. 361.

Holotype. Pl. 36, fig. 12. Preparation 6, serial 1,6556.

Type locality. Shale at 2,086 ft., Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Hoffmeister, Staplin and Malloy, 1955, p. 384.

Size in micrometres. (i) Holotype 41.5; 37.5-41.5, HF (Hoffmeister, Staplin and Malloy 1955). (ii) 34 (38.5 (45, (27 specimens); HF + fum. HNO_3; very thin dirty coal (M5) within the Burnfoot shale section, Featherstone area.

Description. Amb triangular with broadly rounded angles and concave to straight sides. Laesurae distinct, simple, straight 1/2 - 3/4 of spore radius; lips well developed, elevated 2 μm in height. Exine thick, 1-2 μm, and even thicker near the contact area, covered with coarse pointed to truncated grana and coni 1-2 μm in basal diameter, sometimes greater, 1-2.5 μm in height and 1-1.5 μm apart. 30-40 elements project at the margin. Folds frequently occur.

Remarks. Sullivan (1964) described a new species, L. tribulosus which is differentiated from L. tuberculatus in shape only. The specimens described here are similar to the descriptions given for both species.

Most of the specimens from Featherstone have shown distinct laesurae while Hoffmeister, Staplin and Malloy, 1955 mentioned the rays are not always distinct. Also the specimens from the Featherstone material show a darker contact area as figured but not mentioned by Felix and Burbridge, 1967 (Pl. 54, fig.14).

Comparison. Difficulty was sometimes encountered in distinguishing between this species and L. pseudoaculatus Pot. and Kr., 1955, which however was recorded from Westphalian strata.

Previous Records. Hoffmeister, Staplin and Malloy, 1955. Upper Mississippian, Hardinsburg Formation, U.S.A.; Sullivan, 1964, Drybrook Sandstone, Forest of Dean Coalfield, England; Felix and Burbridge, 1967, Visean to Westphalian A, Southern Oklahoma, U.S.A.; Loboziak, 1971, Namurian to Stephanian, Nord, Pas de-Calais Coalfield, France; Urban,1971, Upper Mississippian, the Independence shale of Iowa, U.S.A.

Occurrence. Rare throughout the Namurian sequence, common in the dirty thin coal (Sample M5) in Burnfoot section, Featherstone area.

Genus WALTZISPORA Staplin, 1960

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

Diagnosis. In Smith and Butterworth, 1967, p.159. (from diagnosis in Staplin, 1960, p.18.)

Comparison. The characteristic feature of this genus is the angular junction between the radial and the interradial areas.

Waltzispora planiangulata Sullivan 1964.

Plate 8 Figures 26 - 28

1964 Waltzispora planiangulata Sullivan, p.362, pl.51, fig.26.

Holotype. Sullivan 1964, pl.57, fig.26. Preparation LD1/345754.

Type locality. Drybrook Sandstone, Forest of Dean Coalfield, England, Viséan.

Diagnosis. In Sullivan, 1964, p.362.

Size in micrometres. (i) 30 (38) 45, HF and 2% KOH (Sullivan, 1964). (ii) 20 (25) 33 (5 specimens); HF + fum. HNO_3, black shale (M22), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb. triangular with rounded apices, usually having angular junction with the concave sides. Laesurae distinct, simple, straight, 3/4 - 4/5 of spore radius. Exine relatively thick, 1 - 2µm. ornamented distally with grana and coni 0.5 - 1.5 µm high and 1 -

1.5 µm in basal diameter and the space between the elements. Occasionally some low cones reach 2.5 µm in basal width. 20 - 30 elements project at the margin. Occasional compression folds occur.

Remarks. The specimens encountered in this study conform to Sullivan's description, but differ in their smaller size and slightly coarser ornament.

Comparison. The angular junction between the apices and the concave sides is variable but never approaches the distinct angularity of W. lobophora (Waltz) Staplin, 1960. W. prisca (Kosanke) Sullivan, 1964 has a similar size range but has a laevigate exine with some scattered grana.

Previous records. Sullivan, 1964, Viséan, Forest of Dean, Neves et al., 1973, Upper Viscan, Northern England and Scotland.

Occurrence. Rare throughout the Namurian sequence.

Waltzispora polita (Hoffmeister, Staplin and Malloy) Smith and Butterworth, 1967.

Plate 8 Figures 24, 25

1955 Granulati-sporites politus. Hoffmeister, Staplin and Malloy, p.389, pl.36, fig.13.

1960 Leiotriletes politus (Hoffmeister, Staplin and Malloy); Love, p. 111, pl. 1. fig.1.

1967 Waltzispora politus (Hoffmeister, Staplin and Malloy); Smith and Butterworth, p.159, pl.6. fig.14.

Holotype. Hoffmeister, Staplin and Malloy, 1955, pl. 36, fig. 13. Preparation 6, Ser. 15, 718.

Type locality. Shale at 2,077 ft. Carter No.3 borehole (TCO-82), Webster County, Kentucky, U.S.A. Hardinsburg Formation, Chester Series.

Diagnosis. In Smith and Butterworth, 1967, p.159 (from description in Hoffmeister, Staplin and Malloy,1955, p.389).

Size in micrometres. (i) Holotype 37.5; 26-38, HF (Hoffmeister, Staplin and Malloy 1955). (ii) 29 (34) 37; (4 specimens), HF + fum. HNO_3, black shale (M15), above the Lower Fell Top Limestone, Featherstone area. (iii) 29 (30) 33, (5 specimens); 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute), Upper Craignook Seam (bottom leaf), at 21.58 m, borehole No. 1154, Plenmeller Coalfield, England.

Description. Amb triangular with broadly rounded angles and concave sides, junctions of apices and interradial margins slightly angulated. Laesurae distinct, simple, straight, 3/4 or more of spore radius, rays open, sometimes associated with darkening of the exine adjacent to the laesurae region. Exine moderately thick, less than 2 µm in thickness, laevigate to infragranulate, margin smooth. Compression folds sometimes occur.

Comparison. W. lobophora (Waltz) Staplin 1960 is distinguished by its larger size and more granulated exine; W. planiangulata Sullivan 1964 has the same size range but the distal surface is ornamented with grana and coni; W. prisca (Kosanke) Sullivan 1964 has a distinct angular junction between radial and inter-radial margin and occasional scattered grana. Leiotriletes grandiculus Artuz 1957 and W. sagittata Playford 1962 have more prominent angular junctions.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Love 1960, Lower Oil Shale Group, Visean, Scotland; Sullivan and Marshall 1966, Midland Valley, Visean of Scotland.

Occurrence. Rare in black shales sample (M15 and M13), above the Lower Fell Top Limestone, and occasionally occur throughout the sequence.

Genus TRICIDARISPORITES (Sullivan and Marshall) Gueinn, Neville and Williams 1973

Type species. T. serratus (Playford) Sullivan and Marshall 1966.

Diagnosis. Neves et al. 1973, pl. 31.

Remarks. Sullivan and Marshall 1966, p. 268 described the genus Tricidarisporites as having a laevigate proximal surface. Sullivan considered the holotype of Procoronaspora ambigua (Butterworth and Williams) Smith and Butterworth 1967, to possess a cingulum widest in the interradial areas and he suggested that this species should be transferred to the genus Rotaspora.

Tricidarisporites was emended by Gueinn, Neville and Williams (in Neves et al. 1973) to accommodate spores which are ornamented proximally as well as distally.

Comparison. This genus is distinguished from others by its proximal and distal ornament of grana, cones, pila or spines which are reduced or absent at the apices and largest along the interradial margins.

Diatomozonotriletes (Naumova) Playford 1962 differs in possessing equatorial elements of saetae on the interradial portions of the amb which are quite distinct from the ornamentation of the spore body. Rotaspora Schemel possesses an equatorial structure which is widest interradially. The ornament in Anapiculatisporites (Potonié and Kremp) Smith and Butterworth 1967 is of uniform size and shape and shows no reduction at the apices; it does not extend to the interradial margins.

Tricidarisporites balteolus Sullivan and Marshall 1966

Plate 8 Figures 29 - 32

1966 Tricidarisporites balteolus Sullivan and Marshall, p. 268, pl. 1, fig. 13.

Holotype. Sullivan and Marshall 1966, pl. 1, fig. 13.

Type locality. Shales below the Blackbyre Limestone, Renfrewshire, Scotland, Visean.

Diagnosis. In Sullivan and Marshall, 1966, p. 268.

Size in micrometres. (i) Holotype 39, 36-48. (ii) 32 (35) 38, (4 specimens), HF + fum. HNO_3, black shale (M13), above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular in shape with concave to straight sides and rounded angles. Laesurae distinct, simple, straight, 3/4 of spore radius. Exine 1.5-2 µm in thickness and thicker near the rays where it is darker in colour; proximally laevigate and distally covered with cones and spines 2-3 µm high, 1.5-2.5 µm in basal diameter and 0.5-1.5 µm apart. At equator 40-50 elements project.

Comparison. Procoronaspora dumosa (Staplin) Sullivan and Marshall 1966 has the same size range and the same size of ornament but differs in its scattered spines 2-3.5 µm apart. T. serrata (Playford) Marshall and Sullivan 1966 is distinguished by its broadly based, sharply tapering spinae. T. arcuatus Neville 1973 is distinguished in having three arcuate areas near the interradial portions of the proximal hemisphere ornamented with grana and baculae. T. fasciculatus (Love) Gueinn, Neville and Williams 1973 is laevigate proximally, may possess elements up to 3 µm high and 6 µm wide and has strongly developed lips. T. magnificus Neville 1973 and T. elegans (Peppers) Sullivan and Marshall are larger in size and possess verrucae on the distal surface.

Occurrence. Rare in black shale (sample M13), above the Lower Fell Top Limestone, Featherstone area.

Subinfraturma BACULATI Dybova and Jachowicz 1957a

Genus RAISTRICKIA (Schopf, Wilson and Bentall) Potonié and Kremp 1954

Type species. R. grovensis. Schopf, Wilson and Bentall 1944.

Diagnosis. In Smith and Butterworth 1967, p. 179 (translation from Potonié and Kremp 1955, p. 85).

Comparison. Distinguished by its parallel sided baculae and occasionally truncated cones. Neoraistrickia Potonié 1956 differs in having a triangular amb.

Raistrickia digitosa Artüz 1957

Plate 9 Figures 4 - 6

1957 Raistrickia digitosa Artüz, p. 246, pl. 3, fig. 20.

Holotype. Artüz 1957, pl. 4, fig. 20. Preparation I, 32, 2d.

Type locality. Sülü Seam, Zonguldak Coalfield, Turkey; Westphalian A.

Diagnosis. In Artüz 1957, p. 246.

Size in micrometres. (i) Holotype 80, 50-80, maceration method not stated (Artüz 1957). (ii) 44 (54) 68, (9 specimens), fum. HNO_3, High Main Seam (bottom leaf), at 70-46 m; borehole No. 1138. (iii) 46 (55) 68, (6 specimens), fum. HNO_3, Slag Seam (top leaf) at 49.56 m, borehole No. 1140. (ii) and (iii) Plenmeller Coalfield, England.

Description. Amb subcircular to subtriangular. Laesurae indistinct to distinct, straight, simple, 1/2 to 2/3 of spore radius. Exine relatively thick, 2-3.5 µm, covered proximally and distally by coarse baculae, basal diameter more than the height, and verrucae; the ornament tends to fuse at their bases to give short ridge-like processes, 12-19 baculae and verrucae project at the equator.

Comparison. This species is closely similar to R. fulva (Artüz 1957, p. 246) but is differentiated by its larger size, shorter laesurae, circular shape and the fusion of the ornament at their bases. R. grovensis Schopf, Wilson and Bentall 1944, is similar but its baculae have characteristic blunt tips and are of squat pattern.

Previous records. Artüz 1957, Sülü Seam of the Zonguldak Coalfield, Turkey, Westphalian A; Sabry and Neves 1971, Sanquhar Coalfield, Scotland, Westphalian A.

Occurrence. Absent to rare throughout the Westphalian sequence.

Raistrickia fulva Artüz 1957

Plate 9 Figures 7 - 10

1957 Raistrickia fulva Artuz, p. 246, pl. 3, fig. 19.

Holotype. Artüz 1957, pl. 3, fig. 19. Preparation 1 I5, 6d.

Type locality. Sülü Seam, Zonguldak Coalfield, Turkey; Westphalian A.

Diagnosis. In Smith and Butterworth 1967, p. 180 (from description in Artüz 1957, p. 246).

Size in micrometres. (i) Holotype 45, 40-55, maceration method not stated (Artüz 1957). (ii) 39 (51) 66, fum. HNO_3; Durham Coalfield, England- Westphalian A (Smith and Butterworth 1967). (iii) 50 (59) 70 (17 specimens); fum. HNO_3 + 5% KOH, Wellsyke Seam, at 22.62 m, borehole No. 964. (iv) 46 (57) 73 (15 specimens); fum. HNO_3 + 5% KOH, Threequarters Seam, at 9.57 m, borehole No. 964. (v) 42 (52) 63, (20 specimens) fum. HNO_3 High Main Seam (bottom leaf), at 70.46 m, borehole No. 1138. (iii) - (iv) from Plenmeller Coalfield, England.

Description. Equatorial outline subcircular to subtriangular with broadly rounded apices and convex sides. Laesurae distinct, simple straight, 2/3 - 3/4 of spore radius but sometimes obscured by ornament. Thickness of exine ranging between 2-3 µm with minor folds. Ornament of baculae, which predominate, coni, verrucae and grana, varying in shape, size 3-7 µm in height and basal width and distribution; sometimes baculae are truncated at their tips. 10-16 project on the margin.

Comparison. *Raistrickia rubida* Kosanke 1950 is larger and has a thicker exine. *Raistrickia nigra* Love 1960 differs in its regular baculae of equal length and width. *Raistrickia irregularis* Kosanke 1950 is larger in size with short thick blunt spines of irregular width. In *Raistrickia prisca* Kosanke 1950 the proximal surface has got dot-like thickenings adjacent to the rays, which may be a contact area, and also ornament of blunt spines. In *Raistrickia macra* Bharadwaj 1957a the laesurae ends are bifurcated and the baculae dense. *Raistrickia digitosa* Artüz 1957 has a regular distribution of elements which tend to fuse at their bases, otherwise it is quite similar.

Previous records. Recorded by numerous authors from Namurian C and Westphalian A sediments.

Occurrence. Rare to frequent throughout the Westphalian sequence.

Raistrickia microhorrida (Horst) Potonié and Kremp 1955

Plate 9 Figures 14 - 16

1943 *Triletes ? (Apiculati) microhorridus* Horst, p. 171, fig. 356.

1955 *Raistrickia microhorrida* (Horst) Potonié and Kremp, p.36.

1955 *Raistrickia microhorrida* (Horst) Potonie and Kremp in Horst, p. 161, pl. 21, fig. 35.

Holotype. Horst 1943, p. 171.

Type locality. Namurian of Mahrish-Ostrau.

Size in micrometres. (i) 41-66 Schulze solution and KOH. Horst (1934). (ii) 51 (59) 69 (10 specimens); 1/3 conc. + 2/3 fum. HNO_3 +(one minute) 2% KOH; Bounder Seam, at 8.44 m, borehole No. 1154, Plenmeller Coalfield, England.

Diagnosis. In Horst 1955, p. 161.

Description. Equatorial outline circular, oval to irregular. Laesurae distinct to indistinct, obscured by ornament; if seen, faint, simple, straight, 2/3 - 3/4 of spore radius. Exine relatively thick, 1.5-2.5 µm. Ornamented with small grana and long narrow baculae 5-10 µm high and 2-3 µm wide, the tips smooth to dentate; about 14-20 baculae project at the equator.

Comparison. R. saetosa (Loose) Schopf, Wilson and Bentall (1944) is similar but has a larger size and is more densely ornamented with relatively longer baculae. R. fibrata (Loose) Schopf, Wilson and Bentall (1944) has a larger size and longer baculae.

Raistrickia saetosa (Loose) Schopf, Wilson and Bentall 1944

Plate 9 Figures 11 - 13

1932 Sporonites saetosus Loose in Potonie, Ibrahim and Loose, p. 452, pl. 19, fig. 56.

1933 Setosi-sporites saetosus (Loose); Ibrahim, p. 26.

1944 Raistrickia saetosa (Loose) Schopf, Wilson and Bentall, p. 56.

Holotype. Potonié and Kremp 1955, pl. 15, fig. 264 after Loose 1932. Preparation Ill, C.

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 181 (from Potonié and Kremp 1955, p. 87).

Size in micrometres. (i) Holotype 78, Schulze. (ii) 60-90, Schulze (Potonié and Kremp 1955). (iii) 41 (50) 62 (20 specimens) fum. HNO_3; Yorkshire Coalfield, England; Westphalian B. (Smith and Butterworth 1967). (iv) 54 (64) 73 (13 specimens), 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute); Slag Seam, at 49.65m, borehole No. 1140; Plenmeller Coalfield, England.

Description. Amb circular to subcircular. Laesurae not always visible, 1/2 - 2/3 of spore radius. Exine less than 2 µm in thickness, covered with baculae 8-11 µm high and 2-4 µm wide, very thick baculae occur more on the distal surface and on the margin of the spore than on the proximal surface where they are reduced in their number and size; the bases of the baculae are more or less rounded and the crests are truncate, flat or serrate. 15 baculae project at the margin; minor compression folds infrequently occur.

Comparison. Raistrickia crocea Kosanke 1950 is distinguished by its larger size with longer and wider bacula; folds frequent. Raistrickia grandibaculata Venkatachala and Bharadwaj 1964 has a larger size and longer and wider bacula. R. multipertica Hoffmeister, Staplin and Malloy 1955 has a smaller size and small baculae and spinae, more closely packed in the polar region. In R. vulgata Felix and Burbridge 1967 the blunt spines are more closely spaced, approximately the same or slightly larger and as noted by the authors there is no differentiation in the distribution of the elements on the proximal and distal surfaces.

Occurrence. Absent to rare throughout the sequence.

Raistrickia superba (Ibrahim) Schopf, Wilson and Bentall 1944

Plate 9 Figure 17

1933 Setosi-sporites superbus Ibrahim, p. 27, pl. 5, fig. 42.

1944 Raistrickia superbus (Ibrahim) Schopf, Wilson and Bentall p. 56.

Holotype. Potonié and Kremp 1955, pl. 15, fig. 262 after Ibrahim, Preparation B25, a5 (or).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 182 (translation from Potonié and Kremp 1955, p. 88).

Size in micrometres. (i) Holotype 54, Schulze and KOH, 40-60, Schulze (Potonié and Kremp 1955). (ii) 37 (47) 53 (13 specimens) fum. HNO_3; Yorkshire Coalfield, England; Westphalian B (Smith and Butterworth 1967). (iii) 41 (48) 62 (7 specimens); 1/3 conc. + 2/3 fum. HNO_3 + one minute 2% KOH; Bounder Seam, at 8.44 m, borehole No. 1154, Plenmeller Coalfield, England.

Description. Equatorial outline circular to oval to irregular in shape due to compressions. Laesurae straight, two-thirds of spore radius, sometimes obscured by ornament. Exine relatively thick, 1-2 µm, ornamented by baculae 2-9 µm high and 1-3 µm in breadth, tips usually rounded, smooth but may be truncate, unevenly distributed, 8-17 elements project at the margin; major compression folds absent, but narrow marginal folds are sometimes present.

Comparison. This species is differentiated by its smaller size, and smaller and fewer elements projecting at the margin, from R. saetosa (Loose) Schopf, Wilson and Bentall (1944) and R. microhorrida (Horst 1943) Potonié and Kremp 1955, which are both larger, and by the greater number and coarser baculae than R. superba.

Previous records. Bharadwaj (1957b), Westphalian C to Lower Westphalian D, of Saar Coalfield; Grebe (1962), Westphalian B to C of Ruhr Coalfield, Germany; Guennel (1958), Namurian C to Westphalian B, Pottsville Series, Indiana; Smith and Butterworth (1967), Upper Westphalian A to Westphalian C of British Coalfields; Sabry and Neves (1971), Westphalian A, Sanquhar Coalfield, Scotland; Loboziak (1971), Upper Namurian to Westphalian C of Nord-Pas-de-Calais Coalfield.

Occurrence. Absent to rare throughout the Westphalian sequence, infrequent in Bounder Seam.

Infraturma MURONATI Potonié and Kremp 1954

Genus CONVOLUTISPORA Hoffmeister, Staplin and Malloy 1955

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

Diagnosis. In Smith and Butterworth 1967, p. 183 (from description in Hoffmeister, Staplin and Malloy 1955, p. 384).

Comparison. Distinguished from *Camptotriletes* (Naumova) Potonié and Kremp 1954 and *Verrucosisporites* (Ibrahim) Smith and Butterworth 1967 in its dominantly anastomosing ornament; *Camptotriletes* is characterized by the dominance of narrow rugulate ridges. *Secarisporites* Neves 1961 is distinguished by its characteristic discontinuous peripheral rim resulting from lateral fusion and overlapping of the lobate ornament in the region of the equator.

Convolutispora florida Hoffmeister, Staplin and Malloy 1955

Plate 10 Figure 5

1955 *Convolutispora florida* Hoffmeister, Staplin and Malloy, p. 384, pl. 38, fig. 6.

Holotype. Hoffmeister, Staplin and Malloy 1955, pl. 38, fig. 6. Preparation 1, ser 16,551.

Type locality. Shale at 2,086 ft., Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Smith and Butterworth 1967, p. 185 (from description in Hoffmeister, Staplin and Malloy 1955, p. 384).

Size in micrometres. (i) Holotype 49; 39-50, HF (Hoffmeister, Staplin and Malloy 1955). (ii) 36 (47) 56, fum. HNO_3 Central Coalfield, Scotland, Namurian A (Smith and Butterworth 1967). (iii) 30 (38) 49 (10 specimens); HF + fum. HNO_3, dark shale (sample M 20) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular to subcircular. Laesurae distinct to indistinct, simple, straight, extending 1/2 - 2/3 of spore radius. Exine relatively thick, less than 3 µm. Ornamentation of irregularly arranged, closely packed vermiculate ridges of variable shape and size, 2-4 µm in height and 3-5 µm in width. Margin lobate with rounded to flat-topped projecting ridges10-20 elements project at margin.

Comparison. Distinguished from other species of genus by smaller size and relatively coarse ornament. Secarisporites lobatus Neves 1961 is very closely similar to C. florida in size and shape of ornament and sometimes it is didficult to distinguish between those two species in practice; however the pronounced lobation in S. lobatus and the presence of an intexine are the main distinguishing features.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Butterworth and Williams, 1958, Namurian A, Scotland; Love 1960, Lower Oil Shale Group, Upper Viséan, Scotland; Owens and Burgess 1965, Namurian A to B, Stainmore Outlier; Neves 1964, Namurian A to B, La Camocha Mine, Gijon, North Spain; Felix and Burbridge 1967, Upper Mississippian, Springer Formation, Oklahoma, U.S.A.; Smith and Butterworth 1967, Namurian A, British Coalfields; Neves 1968, Namurian A, Woodland Borehole, Co. Durham; Neves and Sabry 1970, Namurian A, Sanquhar Coalfield, Scotland; Beju 1970, Upper Viséan to Namurian, Moesian Platform, Romania; also recorded by several authors from Viséan and Namurian strata in Britain.

Occurrence. Absent to rare in the Namurian sequence.

Convolutispora laminosa Neves 1961

Plate 10 Figures 10, 11

1961 Convolutispora laminosa Neves, p. 259, pl. 32, figs. 4, 5.

Holotype. Neves 1961, pl. 32, fig. 4.

Type locality. Marine shale with Gastrioceras cancellatum, Hipper Sick, Derbyshire (Loc. 12), Yeadonian stage.

Diagnosis. Neves 1961, p. 259.

Size in micrometres. (i) Holotype 72, 50-80, Schulze + 10% KOH, (Neves 1961). (ii) 64 (one specimen), Slag Seam (bottom leaf), 1/2 conc. + 2/3 fum. HNO_3, Plenmeller Coalfield; (iii) 44 and 47 (two specimens), HF + fum. HNO_3, dark shale, (M20), from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular to subcircular. Laesurae indistinct obscured by ornament, if observed faint, simple 2/3 - 3/4 of spore radius. Exine moderately thin, less than 2 μm. Ornamented by low, irregular, flat, meandering ridges, 3-6 μm in width and 1-2 μm in height, enclosing narrow channels 2-5 μm in diameter.

Comparison. C. superficialis Felix and Burbridge 1967, has the same size range but differs in its more or less circular shape and thicker (6 μm) exine. C. cerina Ravn 1979 is closely similar to the species described above but differs as indicated by Ravn 1979, in its smaller size (36-50 μm) and more distinct ornamentation.

Previous records. Neves 1961, Namurian C, Southern Pennines, England.

Occurrence. Two specimens found in dark shale (sample M20), from above the Upper Fell Top Limestone, Featherstone area, and one specimen found in the Slag Seam (bottom leaf), Plenmeller area.

Convolutispora mellita Hoffmeister, Staplin and Malloy 1955

Plate 10 Figure 16

1955 Convolutispora mellita Hoffmeister, Staplin and Malloy,

p. 385, pl. 38, fig. 10.

Holotype. Hoffmeister, Staplin and Malloy, 1955, pl. 38, fig. 10. Preparation 2, Ser. 18,595.

Type locality. Shale at 2,072 ft., Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.: Hardinsburg Formation, Chester Series.

Diagnosis. In Hoffmeister, Staplin and Malloy 1955, p. 385.

Size in micrometres. (i) Holotype 82 X 84; 60-85, HF (Hoffmeister, Staplin and Malloy 1955). (ii) 50 (61) 71 (7 specimens) HF + fum. HNO_3, dark shale (M20) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular to broadly triangular. Laesurae indistinct faint, simple, extend 3/4 of spore radius, frequently obscured by ornamentation. Exine 2-4 µm in thickness. Ornamentation of uniformly closely packed anastomosing ridges varying in width between 2-5 µm, and 2-4 µm in height. Lumina small, less than 2 µm. Margin notched, 35-45 muri project from margin.

Remarks. The specimens conform with the description given by Hoffmeister, Staplin and Malloy 1955, but differ in their smaller size.

Comparison. *C. mellita* is distinguished from *C. jugosa* Smith and Butterworth 1967 by its smaller size and coarser ornament. According to Smith and Butterworth 1967, p. 188 *C. cf. usitata* Playford 1962 in Smith and Butterworth 1967 is similar in size but differs in having a smoother outline with few projections and an ornament of muri which are variable in width and give a distinctly reticulate pattern. *C. ampla* Hoffmeister, Staplin and Malloy 1955 is distinguished by its more closely packed and smaller size ornament. *C. tessellata* has the same size range and sculptural thickenings but differs in having a less anastomosing margin.

Previous records. Hoffmeister, Staplin and Malloy 1955, Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Butterworth and Williams 1958, Namurian A, Scotland; Love 1960, Lower Oil Shale Group, Upper Viséan, Scotland; Neves 1964, Namurian A, La Camocha Mine, Gijon, North Spain; Felix and Burbridge 1967, Upper Mississippian, Springer Formation, Oklahoma, U.S.A.; Sullivan and Marshall 1966, Viséan, Scotland; Beju 1970, Viséan - Namurian A, Moesian Platform, Romania; Sabry and Neves 1970, Namurian A, Sanquhar Coalfield, Scotland.

Occurrence. Absent to rare throughout the Namurian sequence.

Convolutispora tessellata Hoffmeister, Staplin and Malloy 1955

Plate 10 Figures 13 and 14

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

Holotype. Hoffmeister, Staplin and Malloy 1955, pl. 38, fig. 9. Preparation I, Ser. 16,527.

Type locality. Shale at 2,087-8 ft., Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Smith and Butterworth 1967, p. 187 (from description in Hoffmeister, Staplin and Malloy 1955, p. 385).

Size in micrometres. (i) Holotype 86; 48-86, HF (Hoffmeister, Staplin and Malloy 1955). (ii) 55 (64) 73, (5 specimens), HF + fum. HNO_3, dark shale (M20), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular to oval in shape. Laesurae obscured by ornament. Exine thickness varies between 1.5-3 µm, ornamented on both sides with relatively closely packed anastomosing verrucae which vary in width between 2-5 µm and 2-4 µm in height and which are fused at bases to form short ridges less than 9 µm in length; lumina are irregular in shape and vary in width between 1.5-3.5 µm. Margin notched, 30-45 muri project at margin.

Comparison. Convolutispora ampla Hoffmeister, Staplin and Malloy 1955 is distinguished by its finer grade of ornament. C. tuberculata Hoffmeister, Staplin and Malloy 1955, is distinguished by its slightly smaller size and finer grade of ornament, otherwise it is probably synonymous as indicated by Playford 1962.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Butterworth and Williams 1958, Namurian A, Scotland; Love 1960, Lower Oil Shale Group (Upper Viséan), Scotland; Staplin 1960, Upper Mississippian, Golata Formation, Alberta, Canada. Owens and Burgess 1965, Namurian A - B, Stainmore Outlier; Smith and Butterworth 1967, Namurian A, British Coalfields; Beju 1970, Viséan and Namurian A, Moesian Platform, Romania; Neves and Sabry 1971, Namurian A, Sanquhar Coalfield, Scotland.

Occurrence. Absent to rare throughout the Namurian sequence.

Convolutisporites varicosa Butterworth and Williams 1958

Plate 10 Figures 12 and 15

1955 Convolutispora varicosa Butterworth and Williams, p. 372, pl. 10, figs. 4, 5.

Holotype. Butterworth and Williams, 1958, pl. 10, figs. 4, 5. Preparation T51/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Ashfield Coking Seam at 1,717 ft. 5 in., Queenslie Bridge borehole, Central Coalfield, Scotland; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 188 (from diagnosis in Butterworth and Williams 1958, p. 372.

Size in micrometres. (i) Holotype 96; 77 (101) 136, fum. HNO_3 (Butterworth and Williams 1958). (ii) 60 (76) 95 (6 specimens), HF + fum. HNO_3; black shale (M22), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular to subcircular to oval in shape. Laesurae obscured by ornament, rarely distinct, simple, straight, not exceeding 2/3 of spore radius. Exine relatively thin, less than 2.5 µm. Proximal and distal surface ornamented with broad and low discontinuous branching, anastomosing muri; ornament often 4-7 µm in basal width and projecting 1-3 µm from margin. 30-40 elevations project at margin.

Comparison. *C. Jugosa* Smith and Butterworth 1967 is closely similar to *C. varicosa* in size and shape but differs in its more closely spaced ornament. *C. usitata* Playford 1962, *C. cf. usitata* (Playford) in Smith and Butterworth 1967, *C. mellita* Hoffmeister, Staplin and Malloy 1955 differ in having smaller size ranges and finer grades of ornament.

Previous records. Butterworth and Williams 1958 Namurian A, Scotland; Love 1960, Lower Oil Shale Group (Upper Viséan) Scotland; Neves 1964 Namurian A, La Camocha Mine, Gijon, North Spain; Smith and Butterworth 1967, Namurian A, British Coalfield; Beju 1970, Namurian A, Moesian Platform, Romania.

Occurrence. Absent to rare throughout the Namurian samples.

Convolutispora venusta Hoffmeister, Staplin and Malloy 1955

Plate 10 Figures 6 - 9

1955 *Convolutispora venusta* Hoffmeister, Staplin and Malloy, p. 385, pl. 38, fig. 11.

Holotype. Hoffmeister, Staplin and Malloy 1955, pl. 38, fig. 11. Preparation 5, ser. 15,814.

Type locality. Shale at 2072 ft., Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Hoffmeister, Staplin and Malloy 1955, p. 385.

Size in micrometres. (i) Holotype 61.6, 44-66, HF (Hoffmeister, Staplin and Malloy 1955). (ii) 36 (43) 54, (15 specimens); HF + fum. HNO_3; dark shale (M20), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular to subcircular. Laesurae distinct, simple straight, about 2/3 of spore radius and usually obscured by the sculpture. Exine thin, less than 2 µm, covered with irregular, arête-like ridges and verrucae, 2-5 µm in basal width, 1-3 µm in height and 3-6 µm long; lumina irregular in shape, ranging from rounded to elongate. Margin undulate; compression folds often occur.

Remarks. Differs from the original diagnosis in its slightly smaller size.

Comparison. The crowded arête-like ridges distinguish this species. Convolutispora obliqua Neves 1961, is distinguished by its larger size and long (25 µm) anastomosing ridges.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian Hardinsburg Formation, Illinois and Kentucky, U.S.A.: Felix and Burbridge 1967, Upper Mississippian, Springer Formation, Southern Oklahoma, U.S.A.; Clayton et al. 1977, Namurian A, Western Europe.

Occurrence. Common in Sample M20, dark shale from above the Upper Fell Top Limestone, Featherstone area.

Genus MICRORETICULATISPORITES (Knox) Potonié and Kremp 1954 non sensu Bharadwaj

Type species. M. lacunosus (Ibrahim) Knox 1950.

Diagnosis. In Smith and Butterworth 1967, p. 189 (translated from

Potonié and Kremp 1954, p. 143).

Comparison. This genus is distinguished by its extrareticulate exine with small lumina.

Microreticulatisporites lunatus Knox 1950

Plate 9 Figure 18

1948 Type 35K Knox, fig. 41.

1950 Microreticulati-sporites lunatus Knox, p. 320.

Holotype and type locality. Not designated.

Diagnosis. In Knox, 1950, p. 320.

Size in micrometres. (i) 45 μm, Schulze solution & 10% KOH (Knox 1950). (ii) 33, 37 and 41 (3 specimens), various localities within the sequence.

Description. Amb circular, subcircular to subtriangular. Laesurae distinct, straight, simple, 3/4 or more of spore radius, rays open, unequal in length. Exine moderately thick, 1.5-2.5 μm, covered with branched ridges, 2-5 μm broad and 2-3 μm high. Lumina vary in shape, from circular, oval to polygonal, 1-2 μm in diameter. Muri or ridges flat-topped or rounded in shape.

Comparison. This species is distinguished by its flat-topped or rounded muri from other species in the genus.

Previous records. Knox 1948, Lower Carboniferous, Scotland; Butterworth and Williams 1958, Namurian A, Scotland.

Occurrence. Absent to rare throughout the Namurian sequence, and occasional ones occur in the Westphalian sequence.

Microreticulatisporites nobilis (Wicher) Knox 1950

Plate 9 Figures 19, 20

1934 Sporites nobilis Wicher p. 186, pl. 8, fig. 30.

1944 Punctati-sporites nobilis (Wicher); Schopf, Wilson and Bentall, p. 31.

1950 Microreticulatisporites nobilis (Wicher), Knox, p. 321, pl.18, fig. 242.

Holotype. Potonié and Kremp 1955, pl. 15, fig. 279, after Wicher. Preparation IV X5, a_2 (u/r).

Type locality. Seam R_1, Wehofen Colliery, Ruhr Coalfield, Germany; Westphalian C.

Diagnosis. In Smith and Butterworth 1967, p. 192 (translated from Potonié and Kremp 1955, p. 101).

Size in micrometres. (i) Holotype 36, Schulze and KOH. (ii) 30-45, Schulze (Potonié and Kremp 1955). (iii) 32 (37) 43, fum. HNO_3; Yorkshire Coalfield, England; Westphalian C (Smith and Butterworth 1967). (iv) 45 and 48 (2 specimens), fum. HNO_3, Little Main Seam (C5), Low Close Opencast Site, Cumbria.

Description. Amb rounded triangular, with convex sides and broadly rounded angles. Laesurae distinct, simple, straight, extend 3/4 or more of spore radius; lips slightly developed up to 1 µm high. Exine thin, less than 2 µm, ornamented with regular muri 1.5-2 µm in width and height, enclosing rounded, polygonal to longitudinal lumina; lumina 1-2 µm in diameter. Secondary folds infrequently occur. Margin sinuous.

Comparison. M. nobilis closely resembles M. pseudolunatus Sabry and Neves 1970 in size range (35-44 µm) but the latter species is more rounded in shape and has a coarser reticulum. M. sulcatus (Wilson and Kosanke) Smith and Butterworth 1967 has a coarser sculpture. M. novicus Bharadwaj 1957 possesses muri which are pointed in profile.

Previous records. Knox 1950, Upper Carboniferous, Scotland; Potonié and Kremp 1955, Westphalian B, Ruhr Coalfield, Germany; Sullivan 1962, Westphalian B, Wernddu Claypit, Caerphilly, South Wales; Smith and Butterworth 1967, Westphalian B and C, British Coalfields;Van Wijhe and

Bless 1974, Upper Westphalian C, Netherlands.

Occurrence. One specimen found in Little Main Seam (sample C5) Low Close Opencast Site, Cumbria.

Genus CAMPTOTRILETES (Naumova) Potonié and Kremp 1955

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

Diagnosis. In Smith and Butterworth 1967, p. 199 (from Potonié and Kremp 1954, p. 142).

Comparison. Genus Armatisporites Dybova and Jachowicz 1957 differs in having a sculpture of coarse cones which show a tendency toward lateral fusion of their bases.

Camptotriletes bucculentus (Loose) Potonié and Kremp 1955

Plate 10 Figures 3, 4

1934 Verrucosisporites bucculentus Loose, p. 154, pl. 7, fig. 15.

1944 Punctati-sporites bucculentus (Loose); Schopf, Wilson and Bentall, p. 30.

1950 Verrucoso-sporites bucculentus (Loose); Knox, p. 317.

1955 Camptotriletes bucculentus (Loose); Potonié and Kremp, p. 104, pl. 16, figs. 287, 288.

Holotype. Potonié and Kremp 1955, pl. 16, fig. 287, after Loose. Preparation III94, d_2 (m/or).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 199 (from diagnosis and description in Potonié and Kremp 1955, p. 104).

Size in micrometres. (i) Holotype 47.5, Schulze and KOH. (ii) 45-75, Schulze (Potonié and Kremp 1955). (iii) 50 (56) 67, fum. HNO_3; various localities; Westphalian A and B (Smith and Butterworth 1967). (iv) 47 (53) 65 (4 specimens) fum. HNO_3, various localities within the Westphalian sequence.

Description. Amb triangular to subtriangular with convex sides and broadly rounded angles. Laesurae distinct, simple, straight, 1/2 - 2/3 of spore radius. Exine moderately thick, less than 2.5 μm in thickness. Ornament of low ridges and isolated verrucae and large coni, less than 2 μm in height and 4 μm in basal width and 3-5 μm apart.

Comparison. C. corrugatus (Ibrahim) Potonié and Kremp 1955 has a smaller size and the ridges tend to form a reticulate pattern. C. superbus Neves 1961 is distinguished by its circular to subcircular shape, larger size and long irregular ridges.

Previous records. Potonié and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Westphalian A and B, British Coalfields.

Occurrence. Absent to rare in the Upper Westphalian A samples.

Camptotriletes superbus Neves 1961

Plate 10 Figures 1, 2

1961 Camptotriletes superbus Neves, p. 257, pl. 31, fig. 8.

Holotype. Neves 1961, pl. 31, fig. 8.

Type locality. Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13). Yeadonian stage.

Diagnosis. In Neves 1961, p. 257.

Size in micrometres. (i) Holotype 119, 75-125, Schulze solution + 10% KOH. (ii) 61 (70) 80, (5 specimens), 1/3 conc. + 2/3 fum. HNO_3, Low Main Stringer Seam, at 8.50 m, borehole No. 1392. (iii) 58 (67) 81 (9 specimens), 1/3 conc. + 2/3 fum. HNO_3, Bounder Seam, at 8.44 m, borehole No. 1154. (ii) and (iii) Plenmeller Coalfield, England.

Description. Amb circular to subcircular. Laesurae distinct to indistinct due to the ornamentation. Exine relatively thick, 2-3.5 µm. Sculptured with short irregular discontinuous ridges resulting from lateral fusion of verrucae, verrucae 1.5-2.5 µm in height, 2-4 µm in basal diameter and 2-3 µm apart.

Comparison. Distinguished by its irregular discontinuous ridges which result from the lateral fusion of verrucae. *Grumosisporites varioreticulatus* (Neves) Smith and Butterworth 1967 is distinguished by its regular poorly defined reticulate ornament and by its intexine.

Previous records. Neves 1961, Upper Namurian B to Westphalian A, Southern Pennines; Neves 1963, Namurian B and C, La Camocha Mine, Gijon, North Spain; Owens and Burgess 1965, Westphalian A, Stainmore Outlier, Westmorland; Neves, Read, and Wilson 1965, Namurian B and C, Passage Group, Scotland; Neves 1968, Namurian B to Westphalian A, Woodland Borehole, Co. Durham; Neves and Sabry 1970, Namurian B and C, Sanquhar Coalfield, Scotland; Owens *et al.* 1977, Namurian A to Westphalian A, Northern England and Scotland; Clayton *et al.* 1977, Namurian A to Westphalian A, Western Europe.

Occurrence. Absent to rare throughout the sequence.

Genus DICTYOTRILETES (Naumova) Smith and Butterworth 1967

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

Diagnosis. In Smith and Butterworth 1967, p. 194 (emended from Potonié and Kremp 1954, p. 144).

Comparison. The genus *Dictyotriletes* includes azonata forms which differentiates it from the genus *Reticulatisporites* (Ibrahim) Neves 1964 and *Knoxisporites* (Potonié and Kremp) Neves and Playford 1961.

Dictyotriletes bireticulatus (Ibrahim) Smith and Butterworth 1967

Plate 11 Figures 11 - 16

1932 Sporonites bireticulatus Ibrahim in Potonié, Ibrahim and Loose, p. 447, pl. 14, fig. 1.

1933 Reticulati-sporites bireticulatus Ibrahim, p. 35, pl. 1, fig. 1.

1934 Reticulati-sporites bireticulatus Ibrahim; Loose, pl. 7, fig. 28.

1950 Reticulati-sporites mediareticulatus Ibrahim; Knox, p. 323, pl. 18, fig. 253.

1952 Reticulatisporites mediareticulatus Ibrahim; Balme, p. 176, text - fig. 1C.

1952 Reticulati-sporites cf. mediareticulatus Ibrahim; Balme and Butterworth, pl. 48, figs. 4a, b.

1954 Dictyotriletes bireticulatus (Ibrahim); Potonie and Kremp 1954, p. 108.

1954 Reticulati-sporites cf. mediareticulatus Ibrahim; Butterworth and Millott, pl. 21, fig. 8b.

1956 Reticulatisporites mediareticulatus Ibrahim; Butterworth and Millott, text - fig. 3 (8).

1967 Dictyotriletes bireticulatus (Ibrahim); Smith and Butterworth, p. 194, pl. 11, figs. 14, 15.

Holotype. Potonié and Kremp 1955, pl. 16, fig. 296, after Ibrahim. Preparation B33, a4 (r).

Type locality. (i) Holotype 57.5, Schulze and KOH. (ii) 40-60, Schulze (Potonié and Kremp 1955). (iii) 27 (35) 39, fum. HNO_3, Durham Coalfield, England, Westphalian A, (Smith and Butterworth 1967). (iv) 31 (36) 38 (15 specimens), fum. HNO_3, Little Main Seam (C5), Low Close Opencast Site, Cumbria.

Description. Amb triangular to subtriangular, with convex sides and broadly rounded angles. Laesurae faint, simple, straight, 3/4 or more of spore radius. Exine thin, less than 1.5 µm; laevigate proximally, distally ornamented with a reticulum, muri 1-2 µm in width and height. Equatorial margin smooth to lobate due to the intersection of the muri at the margin, number of muri projecting at the margin vary between 12-17. Lumina rounded to polygonal in shape, size varying especially near the equator and ranging between 5-10 µm in diameter, number of lumina varying between 14-23.

Remarks. Smith and Butterworth (1967) emended Potonié and Kremp 1955 diagnosis on the basis that the muri are confined to the distal surface.

Comparison. This species differs from *D. reticulocingulum* (Loose) Smith and Butterworth 1967 and *D. areolatus* (Guennel) Smith and Butterworth 1967 in its triangular shape, thinner muri and more or less regular shaped lumina.

Previous records. Potonié and Kremp 1955, Upper Westphalian A and B, Ruhr Coalfield, Germany; Dybova and Jachowicz 1957, Lower Westphalian A to Westphalian C, Silesia; Butterworth and Millott 1960, Upper Westphalian A to Westphalian B, British Coalfields; Owens and Burgess 1965, Namurian C, Stainmore Outlier, Westmorland; Smith and Butterworth 1967, Westphalian A to Westphalian C, British Coalfields; Owens *et al*. 1977, Namurian C to Westphalian A, Northern England and Scotland; Clayton *et al*. 1977, Namurian C to Westphalian C, Western Europe; Ravn 1979, Cherokee Group, CP-19-4 Coal, Upper Pennsylvanian, Southern Iowa, U.S.A. and also recorded by several workers from the Westphalian A, B and C sequence.

Occurrence. Absent to rare throughout the Upper part of Westphalian sequence; frequent in Little Main Seam (sample C5), Two Foot (Top leaf) (sample C7), Low Close Opencast Site, Cumbria.

Dictyotriletes cf. bireticulatus (Ibrahim) Smith and Butterworth 1967

Plate 11 Figures 7 - 9

Size in micrometres. (i) 33 (41) 48 (25 specimens), 1/3 conc. + 2/3 fum. HNO_3, Low Main Stringer Seam, at 8.50 m borehole No. 1392, Plenmeller Coalfield. (ii) 33 (42.5) 51 (21 specimens), HF and fum. HNO_3, bright coal, Upper Kellah Coal (M3), Kellah Burn, Featherstone area.

Description. Amb triangular to subtriangular with broad rounded angles and convex to straight sides. Laesurae distinct, faint, simple, straight, 3/4 or more of spore radius. Exine thin, less than 1.5 µm, proximal surface laevigate, distal surface covered with reticulum. Lumina rounded to polygonal in shape, number of lumina varying between 20-30. Number of muri projecting at the margin 14-24.

Remarks. Specimens conform with the emended diagnosis given by Smith and Butterworth 1967, excepting in their greater size range, greater number of lumina and greater number of muri projecting at the margin.

Previous records. The population recorded by Smith and Butterworth 1967, p. 195, from the Lower Westphalian A of Northumberland 37 (50) 60 µm may be the same.

Occurrence. Lowest part of the Westphalian A; Common in Upper Kellah Coal (sample M3), Kellah Burn, Featherstone area; and Low Main Stringer (sample 661), at 8.5 m, borehole No. 1392, Plenmeller area.

Dictyotriletes castaneaeformis (Horst) Sullivan 1964

Plate 13 Figures 1, 2

1943 Aletes castaneaeformis Horst (thesis) p. 124, fig. 82.

1955 Reticulatisporites castaneaeformis (Horst) Potonié and Kremp; Horst, p. 169.

1964 Dictyotriletes castaneaeformis (Horst) Sullivan, p.367.

Holotype. Horst 1955, pl. 24, fig. 82. Preparation III91, 16.3, 68.4.

Type locality. Peterswalder Seam, Eugen Colliery, Moravska-Ostrava, Namurian A-

Diagnosis. In Smith and Butterworth 1967, p. 195 (from Horst 1955, p. 169).

Size in micrometres. (i) Holotype 20; 11-29, fum. HNO_3 (Horst 1955). (ii) 21 (26) 32, fum. HNO_3; Yorkshire Coalfield, England; Westphalian B, Smith and Butterworth 1967). (iii) 20 (24) 27 (5 specimens), HF + fum. HNO_3, black shale (M13), from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb subcircular to oval. Laesurae not always visible, 2/3 of spore radius. Exine thin, less than 1 µm , covered with reticulum, muri 0.5-1 µm in width and 1-1.5 µm in height, 15-20 muri projecting at the margin. Lumina irregular in shape, varying between 3-7 µm in diameter.

Comparison. This species differs from other species of the genus in its smaller size and very narrow muri. D. clatriformis (Artuz) Sullivan 1964 is quite similar morphologically but differs in its larger size (30-44 µm).

Previous records. Horst 1955, Namurian A, Eugen Colliery, Moravska-Ostrava; Dybova and Jachowicz 1951, Namurian A, Silesia; Neves, Read and Wilson 1965, Namurian B, Passage Group, Scotland; Owens and Burgess 1965, Namurian A, Stainmore Outlier, Westmorland; Smith and Butterworth 1967, Namurian A to Westphalian B, British Coalfields; Neves 1968, Namurian C to Westphalian A, Woodland Borehole, Co. Durham; Ravn 1979, Cherokee Group, CP-19-4 Coal, Pennsylvanian, Southern Iowa, U.S.A.

Occurrence. Absent to rare throughout the Namurian sequence. Present also in Upper Craignook Seam (bottom leaf), Plenmeller sequence.

Dictyotriletes falsus Potonié and Kremp 1955

Plate 10 Figures 17 - 20

Holotype. Potonié and Kremp 1955, pl. 16, fig. 303. Preparation 485/X.

Type locality. Ägir Seam, Friedrich Thyssen 2/5 (Wehofen) Colliery, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 176 (translated from Potonié and Kremp 1955, p. 109).

Size in micrometres. (i) Holotype 48; 45-55, Schulze (Potonié and Kremp 1955). (ii) 40 (46) 52 (6 specimens) fum. HNO_3; various localities Yorkshire and Nottinghamshire Coalfield, England; Westphalian A and B (Smith and Butterworth 1967). (iii) 46 (49) 57 (7 specimens); 1/3 conc. + 2/3 fum. HNO_3; from various seams within the sequence; Plenmeller Coalfield, England.

Description. Amb circular to subcircular. Laesurae distinct, simple, straight, 2/3 - 3/4 of spore radius, often obscured by ornament. Exine relatively thin, covered with a reticulum of broad muri, 2-4 µm wide and 2-4 µm high, on both distal and proximal surfaces. Lumina vary in shape and size from 2-8 µm in diameter, and vary in number between 15-20. 10-16 muri project at the margin. Secondary folds infrequently occur.

Remarks. The specimens described above conform closely to the previous descriptions of this species.

Comparison. D. densoreticulatus Potonié and Kremp 1955 and D. aredatus Guennel 1958 differs mainly in their larger size, thinner muri and greater numbers of lumina than D. falsus; D. reticulocingulum (Loose)

Smith and Butterworth 1967 has a smaller size range and the muri are restricted to the distal surface. D. densoreticulatus Potonié and Kremp 1955 has the same type of reticulate sculpture but differs in its larger size and high number of lumina. D. mediareticulatus is larger and its muri are regular in form and relatively narrower in diameter.

Previous records. Potonié and Kremp 1955, Middle Westphalian B to Middle Westphalian C, Ruhr Coalfield, Germany; Dybova and Jachowicz 1957, Westphalian B-C, Upper Silesia ; Smith and Butterworth 1967, Westphalian A to C, of British Coalfields; Loboziak 1971, Westphalian A to C, Houiller Basin, North France; Grebe 1972, Lower Westphalian B to Upper Westphalian C, Ruhr Coalfield, Germany.

Occurrence. Absent to rare throughout the Westphalian sequence.

Dictyotriletes insculptus Sullivan and Marshall 1966

Plate 11 Figures 17 - 20

1966 Dictyotriletes insculptus Sullivan and Marshall, p. 271, pl. 2, figs. 5-7.

Holotype. Sullivan and Marshall 1966, pl. 2, fig. 5.

Type locality. Shale below the Blackbyre Limestone, Lower Limestone Group, Upper Visean, Midland Valley of Scotland.

Diagnosis. In Sullivan and Marshall 1966, p. 271.

Size in micrometres. (i) Holotype 43, 38-52, HF + fum. HNO_3; (Sullivan and Marshall 1966). (ii) 34 (40) 47 (10 specimens), fum. HNO_3, Little Main Seam (C5), Low Close Opencast Site, Cumbria.

Description. Amb rounded triangular to circular, with both distal and proximal surface convex. Laesurae distinct, simple, straight, extending 2/3 - 3/4 of spore radius. Exine thin, less than 1.5 µm in thickness, laevigate proximally, reticulum confined to the distal surface with muri 1.5-2.5 µm wide and 2-5 µm in height. Number of muri projecting from margin 8-14; where muri lie along equator they appear in polar compression as a narrow cingulum. Lumina more or less polygonal in shape, varying in size between 4-16 μm; 10-15 lumina on the distal surface.

Remarks. Smith and Butterworth (1967) noticed a great variety in the density of the reticulate ornament of D. reticulocingulum (Loose) Smith and Butterworth (1967). Ravn (1979) observed that the specimens from his horizon CP-19-4 tend to have a consistent fine, dense reticulation. The same consistent reticulation is present in D. insculptus but it is not a dense reticulation. Those two species are very similar morphologically except in the density of the reticulation. Therefore the specimens described above are more closely similar to D. insculptus than to D. reticulocingulum.

Comparison. D. mediareticulatus (Ibrahim) Smith and Butterworth 1967 is distinguished by its greater size, wider muri and greater size of lumina.

Previous records. Sullivan and Marshall 1966, Upper Visean, Midland Valley, Scotland; Felix and Burbridge 1967, Upper Mississippian Springer Formation, Southern Oklahoma, U.S.A.

Occurrence. Absent to rare throughout the Westphalian sequence.

Dictyotriletes karadenizensis (Artüz) Owens 1963 MS

Plate 11 Figure 6

1957 Reticulatisporites karadenizensis Artüz, p. 247, pl. 4, fig. 24.

1963 Dictyotriletes karadenizensis (Artüz); Owens, MS.

Holotype. Artüz 1957, pl. 4, fig. 24. Preparation I, 34, 6f.

Type locality. Alimolla Seam, Zonguldak Coalfield, Turkey, Namurian.

Diagnosis. In Artüz 1957, p. 247.

Size in micrometres. (i) Holotype 68, 60-102, maceration method not stated. (ii) 72 (one specimen), 1/3 conc. + 2/3 fum. HNO_3, Low Main Stringer Seam, at 8.50 m, borehole No. 1392, Plenmeller Coalfield, England.

Description. Amb circular in shape. Laesurae indistinct obscured by ornament. Exine moderately thick less than 2.5 µm. Ornament of closely spaced muri, 4-7 µm wide covering both hemispheres, and enclosing lumina 4-8 µm in diameter. Margin modified by expanded mushroom shaped tops of muri.

Comparison. This species is distinguished by its closely spaced muri. *D. peltatus* is distinguished by its loosely spaced muri.

Previous records. Artüz 1957, Namurian, Alimolla Seam, Zonguldak Coalfield, Turkey; Owens and Burgess 1965, Namurian B and C, Stainmore Outlier, Westmorland; Clayton *et al*. 1977, Namurian B, Western Europe.

Occurrence. One specimen, in Slag Seam (bottom leaf), (sample 138), Plenmeller Coalfield, England.

Dictyotriletes muricatus (Kosanke) Smith and Butterworth 1967

Plate 11 Figure 1 - 5

1950 *Reticulati-sporites muricatus* Kosanke, p. 27, pl. 4, fig. 7.

1967 *Dictyotriletes muricatus* (Kosanke) Smith and Butterworth p. 197, pl. 11, figs. 25, 26.

Holotype. Kosanke 1950, pl. 4, fig. 2. Preparation 600, Slide 2.

Type locality. La Salle Coal, Bureau County, Illinois, U.S.A.;

Upper McLeansboro Group.

Diagnosis. In Smith and Butterworth 1967, p. 197 (from description in Kosanke 1950, p. 27).

Size in micrometres. (i) Holotype 91 X 84; 82-97, Schulze and 10% KOH (Kosanke 1950). (ii) 68 (77) 89, fum. HNO_3; Yorkshire Coalfield, England; Westphalian B. (iii) 53 (60.2) 68, (17 specimens) 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH for one minute, Upper Craignook Seam; borehole No. 1154, at 21.58 m, Plenmeller Coalfield. (iv) 60 (68) 77 (5 specimens), fum. HNO_3, Little Main Seam (C5), Low Close Open Cast Site, Cumbria.

Description. Equatorial outline circular to subcircular. Laesurae distinct, flexuose, partly obscured by muri, 2/3 of spore radius. Muri vary between 4-9 µm in width, 4-7 µm in height, the muri often project 5-10 µm beyond the equator giving a peripheral lighter zone, and giving the outer margin a flange-like appearance. The lumina vary in shape, size and distribution and a larger size is sometimes present in the polar area. Exine laevigate, less than 1-5 µm in thickness.

Remarks. The Plenmeller specimens differ from those described by Smith and Butterworth 1967 in their smaller size, despite the alkali used in maceration.

Comparison. Dictyotriletes vitilis Sullivan and Marshall 1966, p. 270, pl. 2, figs. 1-2; Dictyotriletes pactilis Sullivan and Marshall 1966, p. 270, pl. 2, figs. 3-4, and Dictyotriletes sagenoformis Sullivan (1964b) are similar to the species described above but differ in that the muri tend to be thinner and the lumina more fragmented. Dictyotriletes mediareticulatus (Ibrahim) S 8B, 1967 has got narrower muri and a narrower flange.

Occurrence. Absent to rare throughout the Westphalian sequence.

Dictyotriletes peltatus (Playford) Owens MS

1962 Reticulatisporites peltatus Playford, p. 599, pl. 84, figs. 1-4.

1963 Dictyotriletes peltatus Owens MS.

Holotype. Playford 1962, pl. 84, figs. 1 and 2. Preparation P167B/14, 36.2 102.9. L.1084.

Type locality. Birger Johnsonfjellet (Sample G 1098), Spitsbergen; Lower Carboniferous.

Diagnosis. In Playford 1962, p. 599.

Size in micrometres. (i) Holotype 90, 50-105, Schulze solution and KOH (Playford 1962).

Dictyotriletes cf. peltatus Owens MS

Plate 11 Figure 10

Size in micrometres. (i) 46 (55) 67 (4 specimens), HF + fum. HNO_3, black shale (M15).

Description. Amb circular, subcircular to oval. Leasurae indistinct obscured by ornament. Exine relatively thin, less than 2 µm, covered with long intersecting muri 3-6 µm wide and 3-4 µm long, enclosing polygonal lumina, irregular and up to 12 µm in diameter. Conspicuous peltate (mushroom like) processes originate at junctions of muri in plan view, processes are 5-12 µm long and up to 10 µm wide.

Comparison. D. cf. peltatus differs from the type material in having heavier and more closely spaced muri.

Previous records. Clayton et al. 1977, Namurian A, Western Europe.

Occurrence. Rare in black shales (samples M15 and M13) from above the Lower Fell Top Limestone, Featherstone area.

Dictyotriletes vitilis Sullivan and Marshall 1966

Plate 10 Figure 21

1966 Dictyotriletes vitilis Sullivan and Marshall, p. 270, pl. 2, figs. 1, 2.

Holotype. Sullivan and Marshall 1966, pl. 2, fig. 1.

Type locality. Shale below the Blackbyre Limestone, Lower Limestone Group, Upper Viséan, Midland Valley of Scotland.

Diagnosis. In Sullivan and Marshall 1966, p. 270.

Size in micrometres. (i) Holotype 60, 50-62, HF + fum. HNO_3, (Sullivan and Marshall 1966). (ii) 46, 47 and 52 (3 specimens), HF + fum. HNO_3, black shale (M13) from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb rounded triangular to polygonal. Laesurae distinct to indistinct, obscured by ornament. Exine laevigate, 2-4 µm in thickness. Proximal and distal surfaces bear reticulum, composed of anastomosing muri, 4-7 µm in height and 3-6 µm in width. In profile the muri have parallel sides and broadly rounded crests. Lumina of variable shape, 6-8 in number, with a diameter less than 12 µm. 9-11 muri project at the equator.

Comparison. *D. pactilis* Sullivan and Marshall 1966, has the same size range, but the muri tend to be thin and membranous; *D. sagenoformis* Sullivan 1964 has slightly larger size but differs in its thinner, more dense muri. *Reticulatisporites decoratus* Hoffmeister, Staplin and Malloy 1955, is similar but more or less triangular in shape and the number of muri projecting at the equator are more.

Previous records. Sullivan and Marshall 1966, Upper Viséan, Midland Valley of Scotland; Marshall and Williams 1970, Upper Viséan - Lower Namurian, Roman Wall District, Western Northumberland, Northern England.

Occurrence. Rare in black shale (sample M13), from above the Lower Fell Top Limestone.

Dictyotriletes sp. A

Plate 12 Figures 1 - 11

Diagnosis. Amb circular to subcircular. Laesurae distinct, 1/3 - 2/3 of spore radius. Ornament of closely spaced grana and coni covering both distal and proximal surfaces. Low narrow muri, sometimes well developed, widely curved, extend from margin to margin or from murus to murus, enclosing wide lumina. Exine moderately thick, less than 3 µm. Minor secondary folds often associated with muri.

Size in micrometres. 50 (58) 72 (27 specimens), HF + fum. HNO_3; Lower Kellah Coal, (sample M2), Kellah Burn, Featherstone area.

Description. Amb circular, subcircular to irregular in shape. Laesurae distinct to indistinct, simple, straight, 1/3 - 2/3 of spore radius. Both proximal and distal surface evenly ornamented with closely spaced, low and small grana and coni 1-2 µm in basal width and 0.5-1 µm in height, 40-55 elements projecting at the margin and producing a serrate margin. Exine moderately thick, less than 3 µm thickness, with weak, low, narrow muri, 1-2 µm high and wide, muri sometimes form a reticulate pattern, not always well defined, as short arcuate ridges extending from margin to margin or from murus to murus. Occasionally two muri run parallel to each other to form a wide, long lumen. Folds occur often associated with the muri.

Comparison. Reticulatisporites scrobiculatus Kosanke 1950 is distinguished by its larger size range (102-116 µm), finer grade of ornament which is described by Kosanke as punctate, and also the muri wider reaching 4-5 µm. Dictyotriletes admirabilis Playford 1963, has some similarity with this species, especially the size range (50-75 µm) and broadly curved thread-like muri. But it differs in its very fine open meshed reticulum. The present species is more granulated and has no quadrangular, concave sided lumina on each surface. Tantanisporites granulatus

Ravn 1979 has the same type of ornamentation but is slightly coarser and differs in its smaller size range (36-51μm), triangular shape, absence of thread-like muri, and the presence of ridges along the laesurae up to 8 μm in width.

Occurrence. Common in Lower Kellah Coal (sample M2), from Kellah Burn, Featherstone area.

Subturma ZONOTRILETES Waltz 1935

Infratruma AURICULATI (Schopf) Dettmann 1963

Genus AHRENSISPORITES Potonié and Kremp 1954

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

Diagnosis. In Smith and Butterworth 1967, p. 200 (translated from Potonié and Kremp 1954, p. 155).

Comparison. Characterised by the presence of apical arcuate folds (Kyrtomes) which curve towards the distal pole and distinguish this genus from Triquitrites (Wilson and Coe) Potonié and Kremp 1954.

Ahrensisporites guerickei (Horst) Potonié and Kremp 1954

Plate 13 Figures 7 - 12

1943 Triletes guerickei Horst, (thesis) pl. 7, figs. 58, 59, 61-64.

1954 Ahrensisporites guerickei (Horst); Potonié and Kremp, p. 155.

Holotype. Horst 1955, pl. 23, fig. 63. Preparation I6, 28.7, 71.4.

Type locality. Seam VI, Karsten Central Colliery, Beuthen, Upper Silesia; Westphalian A.

Diagnosis. In Smith and Butterworth 1967, p. 201 (expanded from Horst 1955, p. 178).

Size in micrometres. (i) Holotype 68; 50-84 (50-68), fum. HNO_3

(Horst 1955). (ii) 42 (51) 61, fum. HNO_3; Nottinghamshire Coalfield, England; Westphalian A; (Smith and Butterworth 1967). (iii) 45 (49) 53 (7 specimens); 1/3 conc. + 2/3 fum. HNO_3; Low Main Stringer Seam, at 8.50 m, borehole No. 1392, Plenmeller Coalfield, England.

Description. Amb triangular, sides straight to slightly concave, angles broadly rounded and sometimes truncated. Laesurae straight, simple, 3/4 of spore radius and occasionally extending to the margin of the spore. Exine 2-3.5 µm in thickness, laevigate or ornamented with coni, grana and small verrucae, which vary in shape and distribution. Arcuate kyrtomes prominent, ranging between 5-8.5 µm in basal width and height, continuous and connecting at the apices.

Remarks. The specimens conform very closely with the expanded diagnosis given by Smith and Butterworth (1967).

Comparison. A. angulatus (Kosanke) Potonié and Kremp 1955 is larger and the arcuate thickenings originate from the proximal surface, otherwise it is quite similar morphologically. A. guerickei var. ornatus Neves 1961 is larger and possesses irregular thickenings of a wart-like nature on the distal surface. A. irroratus Felix and Burbridge 1967 has the same size, but is distinguished by the proximal and distal ornament of rounded granules, otherwise it is similar to A. guerickei as noted by Felix and Burbridge.

Previous records. Horst (1955), Namurian A to Westphalian A, Mährisch-Ostrau, Upper Silesia; Dybova and Jachowicz 1957. Namurian A, Upper Silesia; Butterworth and Williams 1958, Namurian A, Scotland; Neves 1961, Upper Namurian B to Westphalian A, Southern Pennines; Sullivan 1962, Westphalian A, Caerphilly, South Wales; Smith and Butterworth 1967, Namurian to Westphalian B, British Coalfields; Sabry and Neves 1971, Namurian to Westphalian A, Sanquhar, Scotland;

Loboziak 1971, Namurian to Westphalian, North France; Grebe (1972), Westphalian A to Middle Westphalian B, Ruhr Coalfield, Germany. .

Occurrence. Absent to rare throughout the Westphalian sequence.

Genus TRIQUITRITES (Wilson and Coe) Potonié and Kremp 1954

Type species. *T. arculatus* Wilson and Coe 1940.

Diagnosis. In Smith and Butterworth 1967, p. 201 (translation from Potonié and Kremp 1954, p. 153).

Comparison. The characteristic feature of *Triquitrites* is the thickened apices in the form of valvae or auriculae, which are restricted to the radial margin only and unconnected by any interradial zone of thickening. The auriculae of *Tripartites* (Schemel) Potonié and Kremp 1954 are more flange-like. *Ahrensisporites* Potonié and Kremp 1954 is distinguished by the presence of a Kyrtome or arcuate muri which unite at the apices and approach the distal pole.

Triquitrites protensus Kosanke 1950

Plate 13 Figure 15

1950 *Triquitrites protensus* Kosanke, p. 40, pl. 8, fig. 2.

Holotype. Kosanke 1950, pl. 8, fig. 2. Preparation 519-B, Slide 1.

Type locality. Dekoven Coal, Williamson County, Illinois, U.S.A.; Tradewater Group.

Diagnosis. In Smith and Butterworth 1967, p. 203 (from description in Kosanke 1950, p. 40.

Size in micrometres. (i) 38 X 36.5; 33.5 - 39. Schulze and 10% KOH (Kosanke 1950). (ii) 32 (36) 39, (7 specimens) 1/3 conc. + 2/3 fum. HNO_3, Low Main Stringer Seam, at 8.50 m, borehole No. 1392, Plenmeller Coalfield, England.

Description. Amb triangular, apices rounded to truncated, interradial margins straight to slightly concave. Laesurae distinct, simple, straight 2/3 - 3/4 of spore radius, rays open. Exine thin, 1.5-3 µm, laevigate; apical thickening varies in shape, even in the individual specimen from rounded to rectangular, and in size, varies between 6-11 µm in width and 4-7 µm in radial length.

Comparison. The specimens conform very closely with the original descriptions given by Kosanke (1950) excepting that the arcuate thickenings were not well developed in these specimens; T. cf. protensus (Kosanke) in Smith and Butterworth (1967) is similar but larger; T. bransonii Wilson and Hoffmeister 1956, T. pulvinatus Kosanke 1950 and T. tribullatus (Ibrahim) Schopf, Wilson and Bentall 1944, have the same size or are slightly larger, but they are distinguished by their rounded and somewhat longer arcuate thickenings.

Previous records. Kosanke 1950, Westphalian B, Tradewater Group, Illinois, U.S.A.; Smith and Butterworth 1967, Lower Westphalian A (uncertain stratigraphic range) British Coalfields.

Occurrence. Absent to rare throughout the Westphalian A.

Triquitrites sinani Artüz 1957

Plate 13 Figure 13

1957 Triquitrites sinani Artüz, p. 248, pl. 4, fig. 27.

Holotype. Artüz 1951, pl. 4, fig. 27. Preparation I, 8, 6c.

Type locality. Sülü Seam, Zonguldak Coalfield, Turkey; Westphalian A.

Diagnosis. In Artüz 1957, p. 248.

Size in micrometres. (i) Holotype 47, 40-68, maceration method not stated (Artüz 1957, Westphalian A). (ii) 53 and 61 (2 specimens), 1/3 conc. + 2/3 fum. HNO_3; Low Main Stringer Seam at 8.50 m, borehole number 1392, Plenmeller Coalfield, England.

Description. Amb triangular, with broad rounded or truncated angles and straight sides. Laesurae distinct, simple, straight, 3/4 or more of spore radius. Exine relatively thick 3-4 µm, covered distally with grana, coni and scattered large, low verrucae, 1-3 µm in basal width and 0.5-1 µm in height. Apical crassitudes vary in shape and size, 4-8 µm in height and 5-12 µm in width. A slight thickening occurs on the distal surface which, with the occasional lateral fusion of large verrucae produces a kyrtome-like sculpture.

Remarks. Sullivan and Neves 1963, p. 1088, suggested the transference of *T. sinani* Artüz 1957 to the genus *Ahrensisporites* Potonié and Kremp 1954, because of the development of an incipient kyrtome. This sculpture occurs in the form of a distal thickening of the exine across the laesurae as well as the lateral fusion of verrucae which follows the line of a kyrtome.

Comparison. The large shovel-shaped auriculae, thick exine and heavily ornamented exine with scattered verrucae distinguish this species from others in the same genus.

Previous records. Artüz 1957, Lower Westphalian A, Zonguldak Coalfield, Turkey; Owens *et al*. 1977, Lower Westphalian A, Northern England and Scotland; Clayton *et al*. 1977, Lower Westphalian A, Western Europe.

Occurrence. Rare in Low Main Stringer Seam, Plenmeller Coalfield, North England.

Triquitrites tribullatus (Ibrahim) Schopf, Wilson and Bentall 1944

Plate 13 Figure 14

1932 *Sporonites tribullatus* Ibrahim in Potonié, Ibrahim, and Loose, p. 448, pl. 15, fig. 13.

1933 *Laevigati-sporites tribullatus* Ibrahim, p. 20, pl. 2, fig. 13.

1934 Valvisi-sporites tribullatus (Ibrahim); Loose, p. 152, pl. 7, fig. 21.

1938 Azonotriletes tribullatus (Ibrahim); Luber in Luber and Waltz, pl. 7, fig. 88.

1944 Triquitrites tribullatus (Ibrahim); Schopf, Wilson and Bentall, p. 47.

Holotype. Potonié and Kremp 1955, pl. 17, fig. 319 after Ibrahim. Preparation B47, c3 (ud).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 205 (translation from Potonié and Kremp 1956, p. 90).

Size in micrometres. (i) Holotype 62, Schulze and KOH. (ii) 40-70, Schulze (Potonié and Kremp 1966). (iii) 37 (43) 52, fuming HNO_3; Nottinghamshire Coalfield, England; Westphalian A (Smith and Butterworth 1967). (iv) 40 (44) 54 (7 specimens); 1/3 conc. + 2/3 fum. HNO_3; Low Main Stringer Seam, at 8.50 m, borehole number 1392, Plenmeller Coalfield, England.

Description. Amb triangular, apices rounded, sides smooth, mostly straight, sometimes concave or convex. Laesurae distinct, simple, straight, 3/4 of spore radius and sometimes extending to the inner margin of the auriculae, rays slightly open. The auriculae (apical crassitudes) vary in shape and size; they are often rounded or truncated and sometimes bilobed, size varied, the radial length of auriculae 6-16 µm and 5-13 µm in width. Exine laevigate, slightly thick, 2-3 µm, covered sometimes with minute grana, and sometimes the exine is thicker around the trilete mark.

Comparison. Triquitrites bransonii Wilson and Hoffmeister 1956, T. novicus Bharadwaj 1957, T. exiguus Wilson and Kosanke 1944, and T. simplex Bharadwaj 1957 all are smaller. T. crassus Kosanke 1950 is larger, 61-73 µm, and it has a thicker exine. T. protensus Kosanke 1950 is smaller with proximal appearance of valvae, and a prominent auricula at one of the apices (Sullivan and Neves 1963, p. 1085). T. pulvinatus Kosanke 1950 has long auriculae with a narrower width.

Previous records. Artüz 1957, Westphalian A, Zonguldak Coalfield, Turkey; Dybova and Jachowicz 1957, Westphalian D, Silesia; Pierart 1958, Westphalian C, Neeroeteren Zone, Belgium Campine; Grebe 1962, Westphalian B - C, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Namurian A to Westphalian C of British Coalfields. Loboziak 1971, Namurian to Stephanian, Nord-Pas-de-Calais, France.

Occurrence. Absent to rare throughout the Westphalian sequence.

Genus MOOREISPORITES Neves 1958

Type species. M. fustis Neves 1958.

Diagnosis. In Smith and Butterworth 1967, p. 210 (from diagnosis in Neves 1958, p. 7).

Comparison. Triquitrites Wilson and Coe 1940 has radial crassitudes (valvae), while Mooreisporites has apical projecting elements.

Mooreisporites sp. A

Plate 13 Figures 16 - 19

Type locality. Upper Kellah Coal Seam (sample M3), Kellah Burn Section, Featherstone area.

Size in micrometres. (i) 39 (45) 53 (5 specimens), 1/3 conc. + 2/3 fum. HNO_3, Low Main Stringer Seam, at 8.50 m, borehole No. 1392, Plenmeller Coalfield. (ii) 45 (47) 50 (4 specimens), HF + fum. HNO_3, Upper Kellah Coal Seam (M3). (iii) 46 and 48 (2 specimens), HF + fum. HNO_3, Lower Kellah Coal Seam (M1). (ii) and (iii) Kellah

Burn, Featherstone area, England.

Description. Amb triangular with rounded angles and straight to slightly convex to concave sides. Laesurae distinct, simple, straight, extend 3/4 or more of spore radius, rays open. Exine relatively thick, 2-3 μm, laevigate, punctate to minutely granulate. Apical thickenings bear baculae varying between 5-11 μm in height and 3-7 μm in width. Baculae fused at their bases and hardly divided at the top. Occasional folds occur.

Remarks. The specimens described from the Low Main Stringer Seam, Plenmeller Coalfield and from the Upper and Lower Kellah Coal Seams, from the Featherstone area, show a great variety of morphological structure, and some appear to be gradational between *Mooreisporites* and *Triquitrites*. *Ahrensisporites guerickei* occurs with these genera in the lowest Westphalian A assemblages.

Comparison. *M. trigallerus* Neves 1961 is distinguished by its larger size (55-80 μm), short laesurae, and overall exine sculpture of scattered coni and larger baculae. *M. fustis* Neves 1958 has a larger size range (60-90 μm), with broadly rounded angles and concave sides, and a more pronounced ornament of longer branching baculae. *M. bellus* Neves 1961 has a much larger size range (95-115 μm) and large baculae on the distal hemisphere. *M. lucidus* (Artüz) Felix and Burbridge 1967 is distinguished by its concave sides and long laesurae which sometimes reach the margin, with open rays. *Triquitrites additus* Wilson and Hoffmeister 1956, which has a size range of (35-45 μm) is distinguished by its ridged laesurae and arcuate thickenings at the angles which are occasionally associated with tubular or lobed elements. *M. inusitatus* (Kosanke) Neves 1958 is distinguished by its baculae, which bifurcate and by the fact that there may be up to 6 bacula.

Occurrence. Rare in Low Main Stringer Seam, Plenmeller Coalfield and Upper and Lower Kellah Coal (samples M1 and M3), Kellah Burn, Featherstone area.

Genus TANTILLUS Felix and Burbridge 1967

Type species. *T. triquetrus* Felix and Burbridge 1967.

Diagnosis. In Felix and Burbridge 1967, p. 383.

Comparison. Distinguished by its triangular thickening on the distal surface which is more concave than the spore body and truncated at the apices.

Tantillus triquetrus Felix and Burbridge 1967

Plate 13 Figures 3 - 6

Holotype. Felix and Burbridge 1967. Slide 03V16-11 (6). Location 40.8 X 110.1 (Ref. 31.7 X 116.9).

Type locality. Springer Formation, Johnson County, Southern Oklahoma, U.S.A.

Diagnosis. In Felix and Burbridge 1967, p. 383.

Size in micrometres. (i) Holotype 18, 16.5-25 (35 specimens), HF, Schulze solution and KOH (Felix and Burbridge 1967). (ii) 18 (22) 26 (6 specimens), HF + fum. HNO_3, black shale (M22) from above the Upper Fell Top Limestone. (iii) 19 (21.5) 26 (6 specimens) HF + fum. HNO_3, dirty coal (M5), from Burnfoot shale section. (ii) and (iii) Featherstone area.

Description. Outline triangular, with concave to straight sides and rounded apices. Laesurae not always visible, simple, straight. Exine relatively thick, 1-1.5 µm; varies from specimen to specimen in its sculptural elements from laevigate to distinctly granulose. A distal Y-shaped thickening, 4-8 µm wide, has sides more concave than the spore margin, and extends from the distal pole of the spore to within 4-6 µm of the apices where the three thickenings expand to form T-shaped apices.

Remarks. Ravn (1979) noticed in his work that there is some variation in the ornamentation of this species from laevigate to distinctly granulose, a feature noticed in the present study. Also in the present study the laevigate exine was much more common than the granulated one.

Previous records. Felix and Burbridge 1967, Upper Mississippian/ Pennsylvanian., Springer Formation, Southern Oklahoma, U.S.A.; Felix and Burbridge 1967, Westphalian B, Subsurface Springer formation of the Anadarko Basin, Kentucky, U.S.A.; Felix and Burbridge 1967, Barnsley Coal, Westphalian B, Southern Pennines, England; provided by Dr. R. Neves; Urban 1971, Upper Mississippian of the independence shale of Iowa, U.S.A.; Ravn 1979, Cherokee Group, CP-19-4 Coal, Pennsylvanian, Southern Iowa, U.S.A.

Occurrence. Absent to rare throughout the Namurian sequence.

Genus TRIPARTITES (Schemel) Potonié and Kremp 1954

Type species. *T. vetustus* Schemel 1950.

Diagnosis. In Smith and Butterworth 1967, p. 207 (translated from Potonié and Kremp 1954, p. 154).

Comparison. The valvae of *Triquitrites* are smaller, are not plicated radially, and are not connected interradially.

Tripartites nonguerickei Potonié and Kremp 1956

Plate 11 Figure 25

1943 *Triletes (Zonales) guerickei* Horst (thesis) pl. 7, fig. 60.

1955 *Ahrensisporites guerickei* Potonié and Kremp; Horst, p.178, pl. 23, fig. 60.

1956 Tripartites nonguerickei Potonié and Kremp, p. 92.

Holotype. Horst 1955, pl. 23, fig. 60. Preparation III41, 14.7 65.3.

Type locality. Hermann Seam, Porubaer Beds. Moravska-Ostrava; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 207 (translated from Potonié and Kremp 1954, p. 154).

Size in micrometres. (i) Holotype (not stated). (ii) 37 (42) 50, fum. HNO_3; Central Coalfield, Scotland; Namurian A (Smith and Butterworth 1967). (iii) 39 (one specimen), HF + fum. HNO_3, black shale (M15) from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular, with concave sides and rounded angles. Laesurae distinct, simple, 2/3 of spore radius. Exine moderately thick, 2.5 µm, ornamented with moderately coarse grana less than 1.5 µm in basal width and 1 µm in height and some scattered coni. Radial crassitudes prominent, 4 µm in height and 5-7 µm in width.

Comparison. T. trilinguis (Horst) Smith and Butterworth is distinguished by its thinner exine and the radial crassitudes occupy a greater portion of the amb. T. vetustus Schemel 1950 has a thinner, laevigate exine.

Previous records. Horst 1955, Namurian A, Moravska-Ostrava; Butterworth and Williams 1958, Namurian A, Scotland; Smith and Butterworth 1967, Upper Visean to Namurian, British Coalfields; Neville 1968, Upper Visean, Scotland; Marshall and Williams 1970, Upper Visean, Lower Namurian, Roman Wall District, Western Northumberland.

Tripartites trilinguis (Horst) Smith and Butterworth 1962

Plate 11 Figures 21 - 23

1943 Triletes (Zonales) trilinguis Horst (thesis), pl. 7, figs. 55, 56.

1955 *Triparitites trilinguis* (Horst) Potonié and Kremp; Horst, p. 176, pl. 23, figs. 55, 56.

1956 *Tripartites trilinguis* (Horst); Potonié and Kremp, p. 92.

1957a *Tripartites cristatus* Dybova and Jachowicz, p. 141, pl. 36, figs. 3, 4.

1957a *Tripartites rugosus* Dybova and Jachowicz, p. 139, pl. 35, figs. 1-4.

1957a *Tripartites trifoliatus* Dybova and Jachowicz, p. 140, pl. 36, figs. 1, 2.

1958 *Tripartites ianthina* Butterworth and Williams, p. 373, pl. 3, figs. 7, 8.

1967 *Tripartites trilinguis* (Horst) Smith and Butterworth, p. 208, pl. 13, figs. 6-9.

Holotype. Horst 1955, pl 23, fig. 56. Preparation IV39, 30.4 68.2.

Type locality. Flora Seam, Michael Colliery, Moravska-Ostrava; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 208.

Size in micrometres. (i) Holotype 51- 41-80, fum. HNO_3 (Horst 1955). (ii) 32 (44) 51, fum. HNO_3 (Butterworth and Williams 1958); Namurian A. (iii) 36 (40) 46 (5 specimens), HF + fum. HNO_3; black shale (M13) from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular with strongly concave and short sides and broadly rounded angles. Laesurae distinct, simple, straight, 2/3 of spore radius. Radial crassitudes prominent, 20-26 µm wide and 6-9 µm high, connected interradially. Exine laevigate proximally and with scattered grana and coni on the distal surface. Occasional folds occur.

Comparison. Sullivan and Neves 1964, p. 1089, considered *T. rugosus*, *T. trifoliatus* and *T. cristatus* Dybova and Jachowicz 1957, within the limit of specific variation of *T. trilinguis*. *T. trilinguis* differs from other species of the genus in its radial crassitudes which are continuous interradially.

Previous records. Horst 1955, Namurian A, Moravska-Ostrava, Germany, Butterworth and Williams 1958, Namurian A, Scotland; Smith and Butterworth 1967, Namurian A, British Coalfields, Sabry and Neves 1970, Namurian A, Sanquhar Coalfield, Scotland. Clayton *et al*. 1977, Upper Viséan and Namurian A, West Europe; Marshall and Williams 1970, Viséan/Namurian Boundary, Roman Wall District, Northumberland, N. England.

Occurrence. Rare in dark shales samples (M15 and M13), from above the Lower Fell Top Limestone, Featherstone area.

Tripartites vetustus Schemel 1950

Plate 11 Figure 24

1950 *Tripartites vetustus* Schemel, p. 242, pl. 40, fig. 11.

Holotype. Schemel 1950, pl. 40, fig. 11. Preparation in collection of Missouri Geological Survey.

Type locality. 24 in. coal about 550 ft. above top of Madison Formation, Daggett County, Utah, U.S.A.; Mississippian.

Diagnosis. In Smith and Butterworth 1967, p. 209 (from description in Schemel 1950, p. 242).

Size in micrometres. (i) 30-40; body 19-25; height of flange 10-15, maceration method not known (Schemel 1950). (ii) 30 (42) 50 equatorial flange, fum. HNO_3; Lothians Coalfield, Scotland; Namurian A, Smith and Butterworth 1967. (iii) 36 (43.5) 56 (5 specimens), HF + fum. HNO_3; black shale (M13) from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular with strongly concave sides and broadly rounded angles. Laesurae distinct, simple, straight, 2/3 of spore radius. Exine less than 2 µm in thickness, laevigate to minutely punctate, margin smooth. Radial crassitudes prominent, variable in width even on the same specimens and may extend beyond the apices, 19-23 µm wide and 8-11 µm high, not connected interradially, margin of crassitudes lobate to crenulate.

Comparison. Tripartites nonguerickei Potonié and Kremp 1955 is distinguished by the presence of ornament on the spore body. T. trilinguis (Horst) Smith and Butterworth 1967 possesses a distinct interradial margin zone.

Previous records. Schemel 1950, Upper Mississippian of Utah, U.S.A.; Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg of Illinois and Kentucky; Butterworth and Williams 1958, Namurian A of Scotland; Owens and Burgess 1965, Lower Namurian A of Stainmore; Sullivan and Marshall 1966, Upper Viséan of the Western part of the Midland Valley of Scotland; Smith and Butterworth 1967, Upper Viséan and Namurian of British Coalfield; Neville 1968, Upper Viséan, Scotland; Beju 1970, Upper Viséan and Namurian A, Moesian Platform, Romania; Sabry and Neves 1971, Viséan and Namurian A, Sanquhar Coalfield, Scotland; Marshall and Williams 1970, Viséan/Namurian Boundary, Roman Wall District, Northumberland, England, and recorded by numerous authors from Viséan and Namurian A.

Occurrence. Rare in black shale (sample M13) from above the Lower Fell Top Limestone, Featherstone area.

Infraturma TRICRASSITI Dettmann 1963

Genus REINSCHOSPORA Schopf, Wilson and Bentall 1944

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

Diagnosis. In Smith and Butterworth 1967, p. 211 (translation from Potonié and Kremp, 1956, p. 131).

Comparison. Diatomozonotriletes (Naumova) Playford, possesses a corona of relatively coarse, strongly developed setae.

Reinschospora speciosa (Loose) Schopf, Wilson and Bentall 1944

Plate 14 Figure 1 - 3

1934 Alati-sporites speciosa Loose, p. 151, pl. 7, fig. 1.

1938 Zonotriletes speciosa (Loose); Waltz in Luber and Waltz, pl. 4, fig. 48 and pl. A, fig. 9.

1944 Reinschospora speciosa (Loose); Schopf, Wilson and Bentall, p. 53, fig. 2.

1958 Diatomozonotriletes speciosa (Loose); Ishchenko, p. 96, pl. 13, figs. 165-167.

Holotype. Potonié and Kremp 1956, pl. 11, fig. 416, after Loose. Preparation IV45, f4 (ul).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 212 (translated from Potonié and Kremp 1956, p. 132).

Size in micrometres. (i) Holotype 81, Schulze and KOH. (ii) 56 (58) 60 (8 specimens) fum. HNO_3; Yorkshire Coalfield, Westphalian B. (Smith and Butterworth 1967). (iii) 55 (59) 62; (5 specimens); 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute), Upper Craignook Seam (bottom leaf) at 21.58 m, borehole No. 1154. (iv) 53 (57) 59 (4 specimens); 1/3 conc. + 2/3 fum. HNO_3; Low Main Stringer Seam, at 8.50 m, borehole No. 1392. (iii) and (iv) Plenmeller Coalfield. (v) 58 (67) 77 (8 specimens), fum. HNO_3, Little Main Seam (sample C5), Low Close Opencast Site, Cumbria.

Description. Equatorial outline rounded to subrounded, amb of spore body triangular with strongly concave sides and well rounded apices.

Laesurae prominent, simple, straight, more than 3/4 of spore radius, rays open, lips narrow, not exceeding 1.5 µm in height and width. Exine moderately thick, 2-3 µm , laevigate to infrapunctate. Corona originates proximally, about 5-6 µm inside the interradial margins, with fine, narrow setae apparently fused at their bases; setae reach maximum length of 14-19 µm in central interradial area. Corona very thin, translucent, hardly preserved.

Comparison. R. punctata Kosanke 1950 (p. 43, pl. 10, fig. 1) is distinguished by its punctate exine, and its corona is more or less coarser and shorter than that of R. speciosa. R. magnifica Kosanke 1950 (p. 42, pl. 10, fig. 2) has shorter setae and broadly rounded apices, otherwise it is similar and may be synonymous. R. bellitas (Bentall) Schopf, Wilson and Bentall 1944 (p. 53, fig. 2), has the same morphological characteristics, but is larger, size 57-76 µm.

Previous records. Smith and Butterworth 1967, Westphalian A to C of British Coalfields; Neves 1964, Namurian C to Lower Westphalian B, La Camocha, Gijon, North Spain; Felix and Burbridge 1967, Upper Mississippian/Lower Pennsylvanian, Springer Formation, Southern Oklahoma, U.S.A,; Ravn 1979, Cherokee Group, Pennsylvanian, Iowa, U.S.A.

Occurrence. Absent to rare throughout the Westphalian sequence.

Reinschospora triangularis (Kosanke) Ravn 1979

Plate 13 Figures 20 - 23

1950 Reinschospora triangularis Kosanke, p. 43, pl. 9, figs. 6, 7.

1957 Reinschospora fimbriata Artüz, p. 255, pl. 7, fig. 50.

1965 Reinschospora triangularis (Kosanke); Laveine, p. 134, pl. 10, fig. 40.

1979 Reinschospora triangularis (Kosanke); Ravn, p. 36, pl. 11, figs. 3-6.

Holotype. Kosanke 1950, pl. 9, figs. 6, 7. Preparation 573, Slide 2.

Type locality. Carlinville Coal, Macoupin County, Illinois, U.S.A. McLeansboro Group.

Diagnosis. Ravn 1979, p. 37 (emended from description of Kosanke 1950, p. 43.).

Size in micrometres. (i) Holotype 74 X 74; 79 X 78 to 66 X 66, Schulze and 10% KOH (Kosanke 1950). (ii) 56, 56 and 60 (3 specimens) fum. HNO_3; Yorkshire Coalfield, Westphalian B (Smith and Butterworth 1967). (iii) 52 (63) 77 (4 specimens), fum. HNO_3, various locality within the Westphalian sequence. (iv) 47 (53) 62, (5 specimens) HF + fum. HNO_3; black shale (sample M22) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb of spore body triangular, sides straight to slightly concave, angles rounded. Laesurae simple to ridged, straight to flexuose, extending more than 3/4 of spore radius, rays open, lips slightly developed. Exine laevigate to infrapunctate, moderately thick, 2-3 µm in thickness. Margin of the spore ornamented with setae, often with rounded tips arranged as a corona; setae near angles are shorter, 2-4 µm in length, reduced compared with their length in the interradial portion 8-15 µm. Setae are in contact at their bases which originate 5-8 µm within the spore wall. A single distal row of short setae, 1.5-3 µm long, radiate from the pole to each angle. Folds frequently occur.

Remarks. Smith and Butterworth 1967 noticed a single row of setae, radiating from the distal pole which were not mentioned by Kosanke 1950. Ravn 1979 emended the diagnosis given by Kosanke because he observed that some of the specimens bear grana and papillae near the angles and coarser cone-shaped distal spinae, but otherwise they are similar to Kosanke's description.

Comparison. Distinguished from other species in the genus by its almost straight sides, coarser setae and distal ornament.

Previous records. Kosanke 1950, McLeansboro Group (Westphalian D), Illinois, U.S.A.; Artüz 1957, Westphalian A, Zonguldak Coalfield, Turkey; Dybova and Jachowicz 1957, Namurian C to Westphalian C, Upper Silesia; Smith and Butterworth 1967, Westphalian B, British Coalfield; Neves 1964, Namurian B to Westphalian A, Gijon, North Spain; Clayton *et al*. 1977, Namurian B, Western Europe; Ravn 1979, Westphalian B, Cherokee Group, CP-19-4 Coal, Iowa, U.S.A.

Occurrence. Rare in black shale (sample M22) from above the Upper Fell Top Limestone, Featherstone area, in Lickbank Seam (sample C2) Low Close Opencast Site, Cumbria, and in Slag Seam (bottom leaf), Plenmeller Coalfield.

Infraturma PSEUDOCINGULATI Neves 1961

Genus SECARISPORITES Neves 1961

Type species. *S. lobatus* Neves 1961.

Diagnosis. In Neves 1961, p. 260.

Comparison. *Secarisporites* is characterised by the lateral overlap and fusion of lobate ornament in the equatorial region which gives rise to a form of discontinuous rim and distinguishes it from the genus *Convolutispora* Hoffmeister, Staplin and Malloy 1955.

Secarisporites remotus Neves 1961

Plate 13 Figures 24 - 26

1961 *Secarisporites lobatus* Neves, p. 261, pl. 32, figs. 6, 7.

Holotype. Neves 1961, pl. 32, fig. 6. Slide ref. 4. 175850. 7, Sheffield University, Micropalaeontology Laboratory.

Type locality. Marine shale with *Gastrioceras cancellatum* Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Diagnosis. In Neves 1961, p. 261.

Size in micrometres. (i) Holotype 81, 55-84 (20 specimens), Schulze and KOH, (Neves 1961). (ii) 34 (41) 47 (11 specimens). 1/3 conc. + 2/3 fum. HNO_3, from various localities within the sequence.

Description. Amb circular to subcircular. Laesurae indistinct, obscured by ornament. Distal surface ornamented with closely spaced, large individual lobate elements, 3-6 µm in height and 4-9 µm in basal width. These elements project more or less radially, 10-18 elements around the pseudo-flange. Compression folds infrequent.

Remarks. The specimens described above closely conform to the original diagnosis given by Neves 1961, except that Neves gave a size range of 55-85 µm and that might be due to the use of the alkali in the maceration. It is difficult to distinguish between S. lobatus and S. remotus Neves 1961, in the present study.

Comparison. S. lobatus is closely similar to Convolutispora florida Hoffmeister, Staplin and Malloy 1955, but differs in its peripheral rim formed by the lobes which is quite distinct from the convolute ornament in the latter species.

Previous records. Neves 1961, Upper Namurian B to Westphalian A, Southern Pennines, England; Owens and Burgess 1965, Namurian B to Lower Westphalian A, Stainmore Outlier, Westmorland; Marshall and Williams 1970, Upper Viséan-Namurian A, Roman Wall District, West Northumberland; Sabry and Neves 1970, Namurian A to Westphalian C, Sanquhar Coalfield, Scotland; Owens et al. 1977, Namurian A to Westphalian A, northern England and Scotland.

Occurrence. Absent to rare throughout the sequence.

Infraturma CRASSITI (Bharadwaj and Venkatachala) Smith and Butterworth 1967

Genus CRASSISPORA (Bharadwaj) Sullivan 1964

Type species. C. kosankei (syn. C. ovalis) (Potonié and Kremp) Bharadwaj 1957.

Diagnosis. In Smith and Butterworth 1967, p. 233 (from generic description in Sullivan 1964, p. 375).

Remark. Potonié and Kremp (1955) placed this genus in the Infraturma Apiculati (Bennie and Kidston) Potonié 1956. Sullivan (1964) indicated the presence of an intexine in Crassispora which frequently shows apical papillae. Smith and Butterworth (1967) following Sullivan's suggestion of the presence of an intexine, emended the Infraturma Crassiti (Bharadwaj and Venkatachala 1961) to accommodate trilete (cavate) camerate miospores with a crassitudinous margin.

Comparison. Cadiospora Kosanke (1950) possesses curvaturae and well marked, thickened lips. Apiculatisporis (Ibrahim) Potonié and Kremp 1955 lacks curvaturae and an intexine.

Crassispora kosankei (Potonié and Kremp) Smith and Butterworth 1967

Plate 17 Figures 4 - 11

1955 Planisporites kosankei Potonié and Kremp, p. 71, pl. 13, figs. 208-213.

1957a Planisporites ovalis Bharadwaj, p. 86, pl. 23, figs. 9, 10.

1957 Apiculatisporites apiculatus (Ibrahim); Dybova and Jachowicz (non sensu Ibrahim), p. 87, pl. 15, figs. 1-4.

1957b Crassispora ovalis Bharadwaj, p. 126, pl. 25, figs. 73-76.

1957b Crassispora kosankei (Potonié and Kremp); Bharadwaj, p.127.

1967 Crassispora kosankei (Potonié and Kremp); Smith and Butterworth, p. 234, pl. 19, figs. 2-4.

Holotype. Potonié and Kremp 1955, pl. 13, fig. 208. Preparation 565/V, KT 20.9 126.1.

Type locality. Seam R. Friedrich Thyssen 2/5 (Wehofen) Colliery, Ruhr Coalfield, Germany, Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 234 (emended from Potonié and Kremp 1955, p. 71).

Size in micrometres. (i) Holotype 79.8; 68-85, Schulze (Potonié and Kremp 1955). (ii) 40 (56) 69, fum. HNO_3, South Wales Coalfield, Westphalian D, (Smith and Butterworth 1967). (iii) 46 (57) 69 (14 specimens), 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute), Bounder Seam at 8.44 m, borehole No. 1154. (iv) 40 (53) 65 (32 specimens), 1/2 conc. + 1/2 fum. HNO_3, Upper Craignook Seam (bottom leaf) at 21.58 m, borehole No. 1154. (v) 60 (79) 95 (18 specimens), fum. HNO_3 + 5% KOH. Threequarters Seam at 9.59 m, borehole No. 964. (iii), (iv) and (v) Plenmeller Coalfield, England.

Description. Equatorial outline circular, oval to irregular in shape due to secondary folds. In equatorial view the proximal surface is slightly convex to pyramidal, with laevigate to minutely granulate ornament, the distal and equatorial surfaces covered with coni, grana and small spines varying in shape, distribution and size, 0.5-2 µm in basal diameter and reaching sometimes 2.5 µm in height and becoming gradually condensed toward the margin of the spore. The equatorial thickening ranges in width between 7-13 µm. Small circular verrucae, varying in number between 4-10 are distributed unevenly, and more in the polar area. Laesurae indistinct in some specimens and in others very clearly developed as a triangular opening in the proximal polar area along the triradite line of weakness of the exine, varying in length between 1/2 - 2/3 of spore radius. Apical papillae present occasionally.

Remarks. As indicated by several workers, the size range of this species is very closely related to the use of alkali in macerations; this causes the exine to swell. Therefore the size range is not an important diagnostic feature in the recognition of this species.

Comparison. *Crassispora maculosa* (Knox) Sullivan 1964, has a larger size range, ridged laesurae, laevigate proximal surface and a narrow, weakly developed equatorial crassitude. *C. annulatus* Ravn 1979 has a thin, uniform in width, crassitude.

Previous records. Potonié and Kremp 1955, Upper Westphalian A to Lower Westphalian C, Ruhr Coalfield, Germany; Neves 1961, Namurian B to Westphalian A, Southern Pennines, England; Love and Neves 1963, Upper Westphalian B, Inninmore, Scotland; Sullivan 1964, Lower Westphalian A, Forest of Dean Basin, Wales; Neves 1964, Namurian A to Upper Westphalian A, La Camocha, Gijon, North Spain; Owens and Burgess 1965, Upper Namurian A to Lower Westphalian B, Stainmore Outlier, Westmorland; Neves 1968, Namurian A to Westphalian A, Woodland borehole, Co. Durham; Owens *et al*. 1977, Namurian A to Westphalian A, Northern England and Scotland; Clayton *et al*. 1978, Namurian A to Stephanian B, Western Europe.

Occurrence. Rare, common to abundant throughout the sequence.

Crassispora sp. A.

Plate 17 Figures 1 - 3

Type locality. Black shale (sample M22) from above the Upper Fell Top Limestone, Pinking Cleugh Section, Featherstone area.

Diagnosis. Amb triangular to subtriangular. Laesurae distinct, ridged, extend to the inner margin of the equatorial crassitude. Apical papillae present. Equatorial crassitude thick, uniform in width.

Exine in polar area thin, covered distally and equatorially with galeae and coni. Compression folds infrequent.

Size in micrometres. (i) 47 (55) 59, (5 specimens), black shale (sample M18). (ii) 57 and 62 (2 specimens), black shale (sample M22). (iii) 48 (1 specimen), dark shale (sample M20). (i) - (iii) 40% HF + fum. HNO_3, from above the Upper Fell Top Limestone, Featherstone area, England.

Description. Amb triangular, subtriangular to subcircular. Laesurae distinct, flexuose, slightly ridged, lips 1-2 μm in width and less than 2 μm in height, extending to the inner margin of the crassitude. Apical papillae occasionally discernible. Equatorial crassitude distinct, 6-10 μm wide. Exine in polar area thin, less than 2 μm, covered distally and equatorially with galeae and low coni, 1-3 μm in basal width, 1-2 μm in height and 2-5 μm apart. Proximal exo-exine punctate. Occasional compression folds occur.

Comparison. Distinguished from C. kosankei (Potonié and Kremp) Smith and Butterworth 1967 by its more or less triangular shape, prominent ridged laesurae, well defined equatorial crassitude and coarser sculptural elements. C. annulatus Ravn 1979 (36-55 μm) differs in its faint laesurae, narrow crassitude of uniform width and frequent compression folds in the polar area of the spore, C. maculosa (Knox) Sullivan 1964 has a greater size range (76-111 μm), and narrow, weakly developed equatorial crassitude.

Occurrence. Rare in sample M22, M20 and M18 from above the Upper Fell Top Limestone, Pinking Cleugh Section, Featherstone area, England.

Infraturma CINGULATI (Potonié and Klaus)
Dettmann 1963

Genus BELLISPORES (Artüz) Sullivan 1964

Type species. Bellispores bellus Artüz 1957.

Diagnosis. Smith and Butterworth 1967, p. 225 (from description in Sullivan 1964, p. 374).

Comparison. Distinguished by radially oriented bands of thickening variously ornamented, on the distal surface.

Bellispores nitidus (Horst) Sullivan 1964

Plate 14 Figures 13 - 15

1943 Triletes nitidus Horst (thesis), pl. 8, fig. 81.

1948 D11 Knox, p. 157, fig. 8.

1955 Lycospora nitida (Horst); Potonié and Kremp in Horst, p. 181, pl. 24, fig. 81.

1957 Bellispores bellus Artüz, p. 255, pl. 7, fig. 49.

1957 Simozonotriletes trilinearis Artüz, p. 251, pl. 5, fig. 36.

1964 Bellispores nitidus (Horst)- Sullivan, p. 375.

Holotype. Horst 1955, pl. 24, fig. 81. Preparation IV53, 23.4 73.8.

Type locality. Justa Seam, Michael Colliery, Moravska-Ostrava; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 225 (expanded from Horst 1955, p. 181 and Artüz 1957, p. 255).

Size in micrometres. (i) Holotype 42; 33-34; fum. HNO_3 (Horst 1955). (ii) 31 (34) 36, fum. HNO_3; Northumberland Coalfield, England; Namurian (Smith and Butterworth 1967). (iii) 37 (39) 40 (4 specimens); 40% HF + fum. HNO_3, black shale (sample M13). (iv) 35 (39) 43, (6 specimens); 40% HF + fum. HNO_3 black shale (sample M15). (iii) and (iv) from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular with concave sides and rounded apices. Laesurae distinct, simple, extending to the margin of the spore cavity. Spore margin crenulate due to the sculpturing of the cingulum, 4-7 μm in width. Three distal thickenings radiate from the pole to the equator, and have margins 4-6 µm in width. These consist of muri, 0.5-1 µm in width and circular to rectangular luminae which do not exceed 2.5 µm in diameter and form a foveolate sculpture.

Remarks. Different authors differentiated between *B. nitida* and *B. bellus* (Artüz) Sullivan 1964 by the degree of concavity of the inter-radial margins and the variable width of the distal thickened zone; but this distinction is not easy to make. Butterworth and Williams 1958 and Felix and Burbridge 1967 expressed their doubts as to whether this spore should be accommodated in *Lycospora*. Smith and Butterworth 1967 placed both species in *B. nitidus*.

Previous records. Knox 1948, Limestone Coal Group. Fifeshire; Horst 1955, Namurian A, Mahrisch-Ostrava, Germany; Artüz 1957, Westphalian A, Zonguldak Coalfield, Turkey; Butterworth and Williams 1958, Namurian A Scotland; Sullivan 1964, ? Westphalian A, Edgehills coal, Forest of Dean Basin; Owens and Burgess 1965, Namurian A - Lower Namurian B, Stainmore Outlier; Felix and Burbridge 1967, Upper Mississippian/Lower Pennsylvanian, Springer Formation, Southern Oklahoma, U.S.A.; Smith and Butterworth 1967, Namurian, British Coalfields, Beju 1970, Upper Viséan - Namurian, Moesian Platform, Romania; Neves and Sabry 1971, Lower Westphalian A, Sanquhar Coalfield, Scotland; Clayton *et al*., 1977, Upper Visean to Westphalian A, Western Europe.

Occurrence. Absent to rare throughout the Namurian sequence.

Genus SAVITRISPORITES Bharadwaj 1955

1958 *Callisporites* Butterworth and Williams, p. 276.

Type species. *S. triangulus* Bharadwaj 1955.

Diagnosis. In Smith and Butterworth, 1967, p. 223 (from Bharadwaj 1955, p. 127).

Remarks. Sullivan (1964, p. 373) considered Callisporites to be congeneric with Savitrisporites following his re-examination of the type species of C. nux Butterworth and Williams 1958.

Savitrisporites nux (Butterworth and Williams) Smith and Butterworth 1967

Plate 14 Figures 4 - 7

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

1964 Savitrisporites nux (Butterworth and Williams); Sullivan, p. 373, pl. 60, figs. 1-5.

1967 Savitrisporites nux (Butterworth and Williams); Smith and Butterworth, p. 223, pl. 15, figs. 1-3.

Lectotype. Plate 15, figs. 1, 2. Preparation 155/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne. The holotype could not be located on the type slide, so another specimen from this slide was designated as the lectotype by Smith and Butterworth 1967.

Type locality. Upper Hirst Seam at 2,310 ft. 4 in., Brucefield borehole, West Fife Coalfield, Scotland; Namurian A.

Diagnosis. Smith and Butterworth 1967, p. 224 (from diagnosis in Butterworth and Williams 1958, p. 377).

Size in micrometres. (i) Lectotype 58; 45 (56) 64 Schulze and 5% KOH (Butterworth and Williams 1958). (ii) 30 (47) 60, fum. HNO_3 (Sullivan 1964); Edgehills Coal, Forest of Dean Coalfield, England; ? Westphalian A.

(iii) 35 (45.5) 53 (16 specimens), fum. HNO_3; Slag Seam, borehole No. 1140; at 49.65 m, Plenmeller Coalfield, England.

Description. Amb triangular with straight to slightly convex sides and rounded angles. Laesurae distinct, simple, straight, extending to the inner margin of the cingulum. Exine relatively thin, less than 2 µm, ornamented distally with linear, short, concentric ridges, 2-8 µm long and 2-4 µm wide, of fused bases of coni and verrucae, which run parallel to the margin of the spore or more or less parallel to the laesurae. Cingulum uniform in width, 2-3 µm wide and occasionally not continuous. Margin of the cingulum smooth to slightly undulating.

Remarks. Specimens examined, black shale (sample M22), above the Upper Fell Top Limestone and those described from the Plenmeller area are similar to the original diagnosis excepting that the latter specimens do not show a perfectly developed and continuous cingulum like those in the Namurian specimens.

Comparison. S. triangulus Bharadwaj 1955, has the same size, shape, and distal sculptural elements but differs in its more or less continuous cingulum, and lack of proximal thickening associated with the laesurae. S. asperatus Sullivan 1964 differs in being smaller in size, and having disorganised distal ornament, otherwise it may be an immature form of S. nux as stated by Sullivan (1964, p. 374). The spore figured as Converrucosisporites triquetrus (Ibrahim) Potonié and Kremp by Artüz (1959, pl. ii, fig. 16) is probably S. nux. The holotype of Lycospora percusa (Horst) Potonié and Kremp (in Horst 1955, pl. 24, fig. 74) has similar organisation of S. nux. S. major Bharadwaj 1957 is larger and has a more rounded amb. S. concavus Marshall and Smith 1965 is smaller, with concave sides, and a well-defined continuous cingulum.

Previous records. Butterworth and Williams 1958, Namurian A, Scotland;

Love and Neves 1963, Westphalian B, Inninmore, Scotland; Owens and Burgess 1965, Namurian A to Lower Westphalian B, Stainmore Outlier; Sullivan 1964, Lower Westphalian A, Edgehill Coal; Forest of Dean, Wales; Smith and Butterworth 1967, Namurian A to Westphalian B of British Coalfields; Neves 1964, Namurian A to Lower Westphalian B of La Camocha, Gijon, North Spain; Beju 1970, Upper Viséan - Namurian, Moesian Platform, Romania; Clayton _et_ _al_. 1977, Upper Viséan to Westphalian C, Western Europe; Ravn 1979, Pennsylvanian, Cherokee Group, CP-19-4 Coal, Iowa, U.S.A.

Occurrence. Absent, rare to common throughout the sequence.

Savitrisporites _sp. A_.

Plate 14 Figures 8 - 12

Type locality. Black shale (sample M22) from above the Upper Fell Top Limestone, Pinking Cleugh section, Featherstone area.

Diagnosis. Amb rounded triangular. Laesurae distinct to indistinct. Exine relatively thin, less than 2 µm, covered distally with irregular large coni and verrucae, sometimes fused at their bases to form long ridges. Cingulum simple, narrow, less than 2 µm in width. Compression almost invariably oblique.

Size in micrometres. (i) 32 (36) 42 (20 specimens), 40% HF + fum. HNO_3, black shale (sample M22) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb rounded triangular. Laesurae indistinct, obscured by ornament; if seen, simple, straight, 1/2 - 2/3 of spore radius. Exine thin, less than 2 µm, covered distally by large verrucae and coni which vary in shape, 2-6 µm in basal diameter and 3-7 µm in height. These elements may occur discretely or may be fused at their bases to form a series of random, sinuous ridges which run over the distal surface and project at the margin. Cingulum narrow, less than 2 µm in width. Margin undulate. Proximal ornament not clear because of compression, in some specimens there is an indication of crassitudes following the laesurae and the equatorial margin.

Comparison. Distinguished by its irregular distribution of large verrucae and coni, sometimes fused at their bases, on the distal surface.

Occurrence. Rare in black shale (sample M22) from above the Upper Fell Top Limestone, Featherstone area.

Genus KNOXISPORITES (Potonié and Kremp) Neves and Playford 1961

Type species. K. hageni Potonié and Kremp 1954.

Diagnosis. In Smith and Butterworth 1967, p. 218 (from Neves and Playford 1961).

Comparison. This genus is characterised by a cingulum of more or less uniform thickness throughout its width. Reticulatisporites (Ibrahim) Neves 1964 is distinguished by its differentiated cingulum. Bascaudaspora Owens 1963 MS, possesses an undifferentiated cingulum but differs in that it bears prominent distal reticulate sculpture.

Knoxisporites dissidius Neves 1961

Plate 15 Figure 10

1961 Knoxisporites dissidius Neves, p. 266, pl. 33, figs. 4, 6; text - fig. 4.

Holotype. Neves 1961, pl. 33, fig. 4.

Type locality. Non-marine roof shales of the Pot Clay, Holymoorside, Derbyshire (Loc. 13) Yeadonian stage.

Diagnosis. In Neves 1961, p. 266.

Size in micrometres. (i) Holotype 70; 50-80, Schulze solution and alkali (Neves 1961). (ii) 36 (40) 42 (4 specimens), HF + fum. HNO_3 dark shale (Sample M20) from above the Upper Fell Top Limestone. (iii) 37 (40) 42 (3 specimens) HF + fum. HNO_3, black shale (sample M13) from above the Lower Fell Top Limestone. (ii) and (iii) Featherstone area.

Description. Amb rounded hexagonal. Laesurae distinct, simple, extending to the inner margin of the cingulum. Exine laevigate. Distal surface with three radial bars (4-6 µm) bisecting the angles of the trilete rays and uniting to enlcose a circular to triangular area. Cingulum 7-10 µm wide, not uniform, differentiated into inner thickened zone and an outer thinner irregular surface zone more or less equal in width.

Comparison. Distinguished from other species by its rounded hexagonal shape, pattern of distal thickenings and the differentiation of the cingulum.

Remarks. The specimens described above confirm with the diagnosis given by Neves 1961 excepting that their size is smaller than the size range given by Neves, and they were badly preserved.

Previous records. Neves 1961, Namurian, Southern Pennines; Owens and Burgess 1965, Middle Namurian A - Namurian B, Stainmore Outlier; Felix and Burbridge 1967, Springer Formation, Oklahoma, U.S.A.; Sabry and Neves 1970, Namurian to Westphalian A, Sanquhar Coalfield, Scotland; Marshall and Williams 1970, Visean to Namurian, Western Northumberland, England; and recorded by other workers inside Britain; Owens et al. 1977, Upper Namurian A to Namurian C, Northern England and Scotland; Clayton et al. 1978, Upper Namurian A to Namurian C, Western Europe.

Occurrence. Absent to rare throughout the Namurian sequence.

Knoxisporites rotatus Hoffmeister, Staplin and Malloy 1955

Plate 14 Figures 16 - 18

1955 Knoxisporites rotatus Hoffmeister, Staplin and Malloy, p. 390. pl. 37, fig. 13.

Holotype. Hoffmeister, Staplin and Malloy 1955, pl. 37, fig. 13. Preparation 5, Ser. 18, 672.

Type locality. Shale at 2,077 ft., Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Hoffmeister, Staplin and Malloy 1955, p. 390.

Size in micrometres. (i) 52-65, HF (Hoffmeister, Staplin and Malloy 1955). (ii) 52 (65) 73, (12 specimens); HF + fum. HNO_3 dark shale (sample M20), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular to subcircular. Laesurae distinct, straight, extending to the inner margin of the cingulum, rays often open. Cingulum varies in width between 9-14 µm and sometimes varies in thickness and width in a single specimen. Exine laevigate, less than 2.5 µm in thickness; margin smooth to slightly lobate. Occasional folds occur. An annular distal thickening varies in width between 3-7 µm and is connected interradially by short thickened bars to the cingulum.

Remarks. The species figured by Beju 1970, (pl. 4, fig. 11) as K. rotatus is more likely to be K. stephanephorus Love 1960, because of the distinct distal boss.

Comparison. K. rotatus differs in its annular distal thickening from K. triradiatus Hoffmeister, Staplin and Malloy 1955, K. hageni Potonie and Kremp 1954 and K. seniradiatus Neves 1961. K. stephanephorus Love 1960 differs in having a distal boss.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Clayton et al., Namurian C, Western Europe.

Occurrence. Rare in dark shale (sample M20) above the Upper Fell Top Limestone, Featherstone area.

Knoxisporites stephanephorus Love 1960

Plate 15 Figures 11 - 14

1960 Knoxisporites stephanephorus Love, p. 118, pl. II, figs. 1, 2.

Holotype. Love 1960, pl. II, fig. 1.

Type locality. Pumpherstone Shell Bed, South Queensferry, Visean, Scotland.

Diagnosis. In Love 1960, p. 118.

Size in micrometres. (i) Holotype 70, 40-90 (61 specimens). (ii) 30 (35) 42 (4 specimens), 40% HF + fum. HNO_3, black shale (sample M18) from above the Upper Fell Top Limestone. (iii) 40 (45) 59 (4 specimens); HF + fum. HNO_3, black shale (sample M13) above the Lower Fell Top Limestone (ii) and (iii) Featherstone area, England.

Description. Amb circular to subcircular. Laesurae distinct, simple, straight, extending to the margin, and accompanied by folds 2-4 µm in width and up to 2 µm in height. Exine laevigate, 2-3 µm in thickness with an equatorial ring 4-9 µm in width on the proximal surface and a distal ring 4-7 µm, in width, with weakly developed interradial thickenings which join the equatorial thickening, and a distal polar boss 4-12 µm in diameter.

Comparison. Distinguished from other species and especially from K. rotatus Hoffmeister, Staplin and Malloy 1955 by the presence of the distal polar boss and the thickening joining the two rings in the interradial position which are less strongly developed in the above species, as stated by Love 1960 (p. 119).

? Rotaspora disjuncta Neville 1973 has the same features but differs in its smaller size, 21-29 μm, and in possessing an equatorial extension which is widest interradially.

Previous records. Love 1960, Visean, Lower Oil Shale Group of Scotland; Sullivan 1962, Westphalian A - C, Caerphilly, South Wales; Owens and Burgess 1965, Namurian A - B of Stainmore; Sullivan and Marshall 1966, Visean of Midland Valley, Scotland; Felix and Burbridge 1967, Springer Formation, Oklahoma, U.S.A.; Sabry and Neves 1970, Namurian to Westphalian A, Sanquhar Coalfield, Scotland; Marshall and Williams 1970, Visean to Namurian, Western Northumberland, Northern England; Urban 1971, Upper Mississippian of the independence shale of Iowa, U.S.A.; Ravn 1979, Middle Pennsylvanian, CP-19-4 Coal, Cherokee Group, Southern Iowa, U.S.A.

Occurrence. Absent to rare throughout the Namurian sequence. Occasional ones occur in the Westphalian samples.

Knoxisporites triradiatus Hoffmeister, Staplin and Malloy 1955

Plate 15 Figures 15, 16

1955 Knoxisporites triradiatus Hoffmeister, Staplin and Malloy, p. 391, pl. 37, figs. 11, 12.

Holotype. Hoffmeister, Staplin and Malloy 1955, pl. 37, fig. 12. Preparation 6, Serial 18, 939.

Type locality. Shale at 2087 ft., Carter No. 3 Borehole (TCO-82) Webster County, Kentucky, U.S.A. Hardinsburg Formation, Chester Series, Mississippian.

Diagnosis. In Hoffmeister, Staplin and Malloy, 1955, p. 391.

Size in micrometres. (i) Holotype 80 X 86; 50-88, HF (Hoffmeister, Staplin and Malloy, 1955). (ii) 59, 64 and 78 (3 specimens), HF + fuming HNO_3, different localities within the Westphalian sequences;

Plenmeller area.

Description. Amb circular, sometimes folded into a roughly rectangular shape. Laesurae distinct, straight, extending into the cingulum, usually accompanied by lips 1-3.5 μm in width. Cingulum or equatorial girdle smooth, uniform in width (6-11 μm), shorter thickened lobes sometimes projecting inward at the radial positions from the cingulum to enclose the ends of the trilete rays. Three distal bands of thickening (4-10 μm in width) radiate from the centre of the spore to the equatorial thickening and bifurcate into two bands 2-4 μm in width, 3-5 μm from the cingulum and bisecting the angles between the trilete rays. Exine laevigate to slightly punctate, 2.5-4 μm in thickness.

Comparison. K. seniradiatus Neves 1961 is very similar but it differs in the lack of the prominent thickening associated with the trilete rays. K. hageni Potonie and Kremp 1954 differs in having the three distal thickenings arranged triangularly.

Previous records. Hoffmeister, Staplin and Malloy 1955, Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Love 1960, Upper Visean, Lower Oil Shale Group, Scotland; Felix and Burbridge, Mississippian/Pennsylvanian Springer Formation, Oklahoma, U.S.A.; Sullivan and Marshall 1966, Upper Visean, Midland Valley, Scotland; Loboziak 1971, Namurian to Westpahlain, Nord-Pas-de-Calais, North France, Urban 1971, Upper Mississippian of the Independence Shale of Iowa, U.S.A.; Ravn 1979, Pennsylvanian, Cherokee Group, CP-19-4 Coal, Southern Iowa, U.S.A.

Occurrence. Occasional ones occur in the Westphalian samples.

Knoxisporites sp.A

Plate 15 Figures 1 - 9

Type locality. Black soft coaly shale with rootlets (sample P.8) from below the Wellsyke Seam, borehole No. 1350, Plenmeller Coalfield, England.

Size in micrometres. (i) 36 (45) 55 (25 specimens), HF + fum. HNO_3, black soft coaly shale with rootlets (sample P.8) from below the Wellsyke Seam, borehole No. 1350, Plenmeller Coalfield.

Diagnosis. Amb circular, subcircular to polygonal in shape due to the distal thickening. Laesurae distinct, simple, extending to the margin of the cingulum, terminating in curvaturae perfectae and associated with folds 2-4 µm in width. Exine moderately thick, laevigate to infrapunctate. Cingulum, 2-5 µm in width, more or less uniform in width and thickness. Distal Y-shaped thickening, 5-7 µm in width and 1-2 µm in height, with one bar apparently shorter than the others, intersecting the angles between the rays. Compression slightly oblique.

Comparison. This species is distinguished from K. triradiatus Hoffmeister, Staplin and Malloy 1955 (50-88 µm) in its smaller size range, narrower cingulum, its more or less polygonal outline, and in the laesurae which are associated with folds 2-4 µm in width and terminate in curvaturae. K. seniradiatus Neves 1961 has a larger size range (60-105 µm), shorter laesurae, 3/4 of spore radius accompanied by prominent, wider 5-7 µm in width, thickened tecta and no curvaturae.

Occurrence. Rare in black soft coaly shale with rootlets (sample P.8), from below the Wellsyke Seam, Plenmeller Coalfield, England.

Genus RETICULATISPORITES (Ibrahim) Neves 1964

Type species. R. reticulatus Ibrahim 1932.

Diagnosis. In Smith and Butterworth 1967, p. 220 (from emendation in Neves 1964, p. 1066).

Remark. This genus was emended by Neves 1964 to include only spores with a differentially thickened cingulum.

Comparison. The genus Reticulatisporites is distinguished from the genus

Knoxisporites (Potonie and Kremp) Neves and Playford 1961 by the cingulum which is differentiated into three zones.

Dictyotriletes (Naumova) Smith and Butterworth 1967, has the same reticulate sculpture but is without a cingulum.

Reticulatisporites polygonalis (Ibrahim) Smith and Butterworth 1967

Plate 16 Figures 3 - 6

1932 Sporonites polygonalis Ibrahim in Potonie, Ibrahim and Loose, p. 447, pl. 14, fig. 8.

1933 Laevigati-sporites polygonalis Ibrahim, p. 19, pl. 1, fig. 8.

1934 Reticulati-sporites polygonalis Ibrahim; Loose, p. 155, pl. 7, fig. 16.

1955 Knoxisporites polygonalis (Ibrahim); Potonie and Kremp, p. 117, pl. 16, fig. 318, text fig. 33.

1964 Reticulatisporites polygonalis (Ibrahim); Neves, p. 1066.

1967 Reticulatisporites polygonalis (Ibrahim); Smith and Butterworth, p. 221, pl. 14, fig. 13.

Holotype. Potonie and Kremp 1955, pl. 16, fig. 318 after Ibrahim. Preparation A40, b5 (or).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 221.

Size in micrometres. (i) Holotype 108, Schulze and KOH. (ii) 80-100, Schulze (Potonie and Kremp 1955). (iii) 79 (91) 102 (11 specimens) fum. HNO_3; Nottinghamshire Coalfield, England, Westphalian A (Smith and Butterworth 1967). (iv) 63 (76) 87 (7 specimens) fum. HNO_3; High Main Seam (bottom leaf) at 70.46 m borehole No. 1138, Plenmeller Coalfield, England.

Description. Amb more or less circular to polygonal in shape, outline smooth. Laesurae simple, straight, 1/2 - 2/3 of spore radius, often reaching the inner thickened margin of the spore; exine laevigate to infrapunctate, covered distally by muri enclosing a triangular to polygonal lumen; width of muri varies even in one specimen and ranges between 3-5.5 μm; muri intersect at the margin to form prominent, more or less circular nodes; cingulum differentiated into three zones, the outer wider (2-3 μm), the middle narrow (1-2 μm in width), and the inner wider zone, broader than the other two, 2-5 μm.

Remarks. The specimens examined during this study tend to be slightly smaller in size than those previously recorded by earlier authors.

Comparison. R. carnosus (Knox) Neves 1964, has a circular shape, and the inner area is wider than in R. polygonalis. R. reticulatus (Ibrahim) Ibrahim 1933 has a distal ornament which forms a reticulate pattern.

Previous records. Potonie and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Neves 1961, Namurian A - Westphalian A, Southern Pennines; Owens and Burgess (1965) Namurian A to Westphalian A, Stainmore Outlier; Smith and Butterworth (1967), Westphalian A to Lower Westphalian C of British Coalfields; Neves (1968) Namurian B to Westphalian A, Woodland Borehole, Co. Durham; Marshall and Williams (1970) Namurian A, Roman Wall District, Western Northumberland, England. Loboziak (1971) Namurian to Westphalian, North France; Van Wijhe and Bless (1974) Westphalian C, Netherlands.

Occurrence. Absent to rare throughout the Westphalian sequence.

Reticulatisporites reticulatus (Ibrahim); Ibrahim 1933

Plate 16 Figures 1, 2

1932 Sporonites reticulatus Ibrahim in Potonie, Ibrahim and Loose, p. 447, pl. 14, fig. 3.

1933 Reticulatisporites reticulatus Ibrahim, p. 33, pl. 1, fig. 3.

1938 Azonotriletes reticulatus (Ibrahim); Luber in Luber and Waltz, pl. 7, fig. 99.

1955 Reticulatisporites reticulatus Ibrahim in Potonie and Kremp, p. 112, pl. 16, figs. 310-312.

Holotype. Plate 14, fig. 16 after Ibrahim. Preparation B5, b2 (or).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 222 (expanded from Potonie and Kremp 1955, p. 112).

Size in micrometres. (i) Holotype 81, Schulze and KOH. (ii) 75-90, Schulze (Potonie and Kremp 1955). (iii) 59 (73) 89, fum. HNO_3, Yorkshire Coalfield, England; Upper Westphalian B (Smith and Butterworth 1967). (iv) 70 (80) 96 (16 specimens); fum. HNO_3 + 5% KOH, Low Main Seam, at 63.60 m, borehole No. 1057; Plenmeller area, England.

Description. Amb subrounded to subangular, with smooth margin. Laesurae simple, straight to flexuose, 1/2 - 2/3 of spore radius. The broad cingulum is differentiated into three prominent zones, an outer thickened zone, 2-4 µm in width and darker brown in colour, an inner, slightly thickened zone 3-7 µm in width and also brown in colour. and an intermediate zone ranging between 1-3 µm which appears lighter in colour than the others. Distal surface ornamented with variable thickened muri, forming a reticulum, muri wider than high, width of muri 4-7 µm and height 1-3 µm; the distal muri define polygonal lumina, rounded or angular in shape in the polar area and surrounded by a 5-8 µm wide marginal area; muri sometimes branch before reaching the equator; the diameter of the polygonal lumina is about 24-30 µm and there are 71-2 distal muri reaching the equator.

Comparison. Spores assigned to this species are characterised by their differentiated cingulum. Reticulati-sporites annulatus Guennel 1958 (pl. 6, figs. 1, 2) appears to be cingulate and comparable to R. reticulatus. Potonie and Kremp 1955 consider Dictyotriletes muricatus (Kosanke) Smith and Butterworth 1967 synonymous with R. reticulatus, however, both have similar ornament but differ in that the former species lack a cingulum.

Previous records. Potonie and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Westphalian A to D of British Coalfields; Pierart 1958, Westphalian C, Neeroeteren zone, Campine, Belgium; Grebe (1962) Upper Westphalian C, Ruhr Coalfield, Germany; Loboziak (1971) Namurian to Westphalian, N. France; Clayton et al. 1977, Namurian C to Westphalian D, Western Europe.

Occurrence. Absent to rare throughout the Westphalian sequence.

Genus ROTASPORA Schemel 1950 Smith and Butterworth 1967

1956 Camarozonotriletes (Naumova) Potonie

Type species. R. fracta Schemel 1950.

Diagnosis. In Smith and Butterworth 1967, p. 266 (emended from description in Schemel 1950, p. 241).

Remarks. Smith and Butterworth 1967, p. 226, in their emendation of the genus, considered that the equatorial extension of the exine is more in the nature of a zona rather than a cingulum as suggested by Potonie and Kremp 1954.

Rotaspora fracta (Schemel) Smith and Butterworth 1967

Plate 17 Figure 12

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

1956 Camarozonotriletes auritus Ishchenko, p. 96.

1967 Rotaspora fracta (Schemel); Smith and Butterworth, p.227, pl. 15, figs. 8-11.

Holotype. Schemel 1950, pl. 40, fig. 8. In collection of Missouri Geological Survey.

Type locality. 24 in. coal about 550 ft. above top of Madison Formation, Daggett County, Utah, U.S.A.; Mississippian.

Diagnosis. In Smith and Butterworth 1967, p. 227 (emended from description in Schemel 1950, p. 242).

Size in micrometres. (i) 28-35, body 17-24; maceration method not known (Schemel 1950). (ii) 24-40, fum. HNO_3 (Butterworth and Williams, 1958). (iii) 29 and 31 (2 specimens) HF + fum. HNO_3, black shale (sample M13) from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb subcircular to subtriangular. Spore body triangular with concave sides and rounded angles. Laesurae distinct, simple, straight 3/4 or more of spore radius, rays slightly open. Zona is wider in the interradial region than at angles. Zona folded over the distal surface of the body in the radial positions. Margin smooth.

Comparison. R. knoxi Butterworth and Williams 1958, is distinguished by its slightly thicker exine, and the body outline is convex or slightly concave. In R. fracta the zona is folded distally at the apices.

Previous records. Schemel 1950, Mississippian, Daggett County, Utah, U.S.A.; Hoffmeister, Staplin and Malloy 1955, Hardinsburg Formation, Upper Mississippi, Illinois and Kentucky, U.S.A; Butterworth and Williams 1958, Namurian A, Scotland, Owens and Burgess 1965, Lower Namurian, Stainmore Outlier ; Smith and Butterworth 1967, Visean and Namurian A, British Coalfields; Felix and Burgess 1967, Upper Mississippian, Springer Formation, Southern Olkahoma, U.S.A.; Neville 1968, Upper Visean, Scotland; Beju 1970, Upper Visean to Namurian A, Moesian Platform, Romania;

Sabry and Neves 1970, Namurian A, Sanquhar Coalfield, Scotland; Owens et al. 1977, Upper Visean to Namurian A, northern England and Scotland; Clayton 1977, Upper Visean to Namurian A, Western Europe.

Occurrence..Rare in (sample M15 and M13) black shales from above the Lower Fell Top Limestone, Featherstone area.

Rotaspora knoxi Butterworth and Williams 1958

Plate 17 Figure 13

1948 Knox, p.157, text fig.5

1958 Rotaspora knoxi Butterworth and Williams, p.378, pl.3,figs.21-23

Holotype. Butterworth and Williams 1958. Plate 15, fig.15. Preparation T56/1 in collection of National Coal Board , Laboratory, Wath-upon-Dearne.

Diagnosis. In Smith and Butterworth 1967, p.228 (from Butterworth and Williams, 1958, p.378.

Size in micrometres. (i) Holotype 40; 26 (32) 44, fum. HNO_3, Namurian A (Butterworth and Williams, 1958). (ii) 32 (1 specimen), 40% H F + fum.HNO_3, black shale (sample M13) from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular with straight to convex sides and broadly rounded angles; body more triangular, less rounded. Laesurae simple, straight, extending 3/4 of spore radius. Exine laevigate, thick, less than 2 µm. Zona broader in interradial areas, narrow at angles, up to 3 µm in width. Margin smooth.

Previous records. Butterworth and Williams, 1958, Namurian A, Scotland; Owens and Burgess, Lower Namurian A and basal Upper Namurian A, Stainmore Outlier, Westmorland; Sullivan and Marshall, 1966, Upper Visean, Midland Valley of Scotland, Smith and Butterworth, 1967, Visean and Namurian A, British Coalfield; Neville 1968, Upper Visean, Scotland; Neves, 1968, Upper Visean, Naumrian A, Woodland borehole, Co. Durham; Sabry and Neves, 1970, Naumrian A, Sanquhar Coalfield, Scotland; Owens et al.1977, Visean to Namurian A, Northern England and Scotland; Clayton et al., 1977, Visean to Namurian A, Western Europe.

Occurrence. Rare in (sample M13) black shale from above the Lower Fell Top Limestone, Featherstone area.

Genus STENOZONOTRILETES (Naumova) Potonié 1958

Type species. S. conformis Naumova 1953.

Diagnosis. In Smith and Butterworth 1967, p.216 (from Hacquebard, 1957, p.313).

Comparison. Simozonotriletes Potonié and Kr. 1954 is distinguished by the presence of a well-defined central area, and the cingulum is often expanded and thickened into a smooth triangular shape with valvae at the apices; the cingulum in Lycospora and Densosporites is differentiated into thinner and thicker parts, while in Stenozonotriles the cingulum is more or less uniform in thickness and does not show any flange development.

Stenozonotriletes Sp.A.

Plate 18 Figures 7 - 19

Locality. Black shale with plant fragments (sample p.71) from above the Quarter Seam, borehole No.1350, Plenmeller Coalfield, England.

Size in micrometres. (i) 26 (31) 39 (26 specimens);40% H.F. + 1/3 conc. + 2/3 fum. HNO_3, black shale with plant fragments (sample p.71) from above the Quarter Seam, borehole No.1350, Plenmeller Coalfield.

Diagnosis. Amb circular to subcircular. Laesurae distinct, straight, ridged with broad raised lips, extend to equatorial margin of cingulum. Cingulum uniform in thickness. Exine including cingulum laevigate to faintly punctate distally.

Description. Amb circular to subtriangular with convex sides and broadly rounded angles. Laesurae distinct ridged, straight to flexuose, extending to inner margin of the cingulum, prominent lips often unequal in length and varying (2 - 6 μm) in width. Exine laevigate proximally and minutely punctate distally, relatively thick, 2 - 3 μm, brown in colour. Cingulum uniform in thickness and width and ranging between 4 - 8 μm.

Margin smooth to slightly undulating. Both proximal and distal hemispheres are slightly convex.

Comparison. *Stenozonotriletes triangulus* Neves 1961 (p.268) is distinguished by its larger size (60 - 80 µm), laesurae associated with small folds not reaching the cingulum, and it has a triangular shape. *Leiotriletes turgidus* Marshall and Smith 1965 (p.658), is differentiated by its larger size, 59 - 104 m, simple laesurae accompanied by 3.5 µm folds and with its single distal compression fold following the margin. *Stenozonotriletes lycosporoides* (Butterworth and Williams) Smith and Butterworth 1967, has the same shape, size and laevigate exine, but is distinguished by its thinner exine, narrower cingulum and relatively simple laesurae.

Lycospora ?verrucosus Staplin 1960 has short, simple laesurae, a narrow cingulum and thin exine; excepting in size (30 - 32 µm) it is similar to Neves' species noted above. Neves 1961 compared his species with *S. conspersus* Naumova 1953 and he mentioned that it has a similar shape but is smaller. *S. simplex* Naumova 1953 is distinguished by its larger size, thinner exine and simple laesurae.

Occurrence. Common in black shale with plant fragments from above the Quarter seam, borehole No.1350, Plenmeller Coalfield, England.

Stenozonotriletes sp.B.

Plate 18 Figures 20 - 28

Type locality. Little seam (bottom leaf), at 33.46 m. borehole No. 1154. Plenmeller Coalfield, England.

Size in micrometres. (i) 21 (25) 30 (15 specimens), 1/3 conc. + 2/3 fum. HNO_3. Little Seam (bottom leaf), at 33 - 46 m. borehole No.1154 Plenmeller Coalfield.

Diagnosis. Amb circular to subcircular. Laesurae distinct, simple, rays open. Exine covered distally with broad based coni.

Description. Amb circular to subcircular. Laesurae distinct, simple, straight, extending 3/4 of spore radius and sometimes extending to the inner margin of the cingulum, rays open. Exine thin, less than 1.5 μm, yellowish to brown in colour, covered distally with moderately broad based coni, 1 - 2 μm wide and 1 - 2 μm high, tips of the coni low flat or rounded, and the spaces between elements equal to or more than their basal diameter. Proximal surface laevigate to minutely punctate. Cingulum more or less uniform in width 2 - 4 μm. Ornamentation extending onto the cingulum, 30 - 40 elements project at the margin. Margin denticulate.

Comparison. Stenozonotriletes coronatus Sullivan and Marshall 1966 is distinguished by its larger size (37 - 55 μm), more or less triangular shape, well developed laesurae and distal covering of closely packed small (0.5 - 1.5 μm high and wide) coni, tubercles or spines. S. bracteolus (Butterworth and Williams) Smith and Butterworth, 1967 is distinguished by its larger size (36 - 54 μm), wider and more defined cingulum, and the ornamentation appears to be relatively of a finer grade, closely packed and not so well marked at the margin as that of S. sp.B.

S. utilis Ishchenko is closely related to S. coronatus as mentioned by Sullivan and Marshall (1966, p. 273).

Occurrence. Rare in Little Seam (bottom leaf), Plenmeller Coalfield, England.

Stenozonotriletes lycosporoides (Butterworth and Williams) Smith and Butterworth 1967

Plate 17 Figures 14 - 16

1958 Anulatisporites lycosporoides Butterworth and Williams, p. 278, Plate 3, Figs. 28, 29.

1967 Stenozonotriletes lycosporoides (Butterworth and Williams), Smith and Butterworth, p. 218, pl. 14, Figs. 5, 6.

Holotype. Butterworth and Williams 1958. Plate 14, Fig. 5. Preparation

T 58/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Chapelgreen Seam at 314 ft. 2 in. Cawder Cuilt boreholes. Central Coalfield, Scotland. Namurian A.

Diagnosis. In Smith and Butterworth, 1967. p.218 (from Butterworth and Williams 1958, p. 378).

Size in micrometres. (i) Holotype 33; 26 (34) 42 fum. HNO_3; (Butterworth and Williams 1958). (ii) 18 (24) 33 spore diameter, 2 (3) 4 cingulum width (30 specimens); 40% HF + fuming HNO_3, dark shale (sample M20) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb subcircular to subtriangular, with broad angles, occasionally one apex more pointed than the others. Laesurae generally distinct, straight to flexuose, simple, sometimes one or two rays are slightly ridged up to 1 µm in width, extending to the margin of the cingulum, rays frequently open. Cingulum uniform in width, 2-4 µm. Exine laevigate to infrapunctate.

Comparison. S. grandiculus Ishchenko 1952 and S. clarus Ishchenko 1958 have a greater size and shorter laesurae. S. perforatus Playford 1962 has a greater size, but otherwise is similar.

Previous records. Butterworth and Williams 1958, Namurian A, Scotland. Love 1960, Visean of Lower Oil Shale Group of Scotland; Smith and Butterworth, Namurian of British Coalfields; Urban 1971, Upper Mississippian, (Independence shale) of Iowa, U.S.A.

Occurrence. Absent to rare throughout the Namurian sequence; common in dark shale (sample M20) from above the Upper Fell Top Limestone, Featherstone area.

Genus SIMOZONOTRILETES (Naumova) Potonie and Kremp 1954

Type species. S. intortus. (Waltz) Potonie and Kremp 1954.

Diagnosis. In Smith and Butterworth 1967, p. 236 (from the diagnosis in Sullivan 1958, p. 126).

Comparison. Differs from *Tripartites* in not possessing radial crassitudes and from *Triquitrites* in the presence of a continuous equatorial structure.

Simozonotriletes dupla Ishchenko 1956

1956 *Simozonotriletes dupla* Ishchenko, p. 93, pl. 17, fig. 216.

1962 *Murospora dupla* (Ishchenko); Playford, p. 614, pl. 86, fig. 22, text fig. 8a.

Holotype. Not stated.

Type locality. Western extension of the Donetz Basin, U.S.S.R., Visean.

Diagnosis. In Ishchenko 1956, p. 93.

Size in micrometres. (i) 35-45 (Ishchenko 1956). (ii) 72 (75) 82, Schulze and NH_4OH (Playford 1962); Spitsbergen; Lower Carboniferous.

Simozonotriletes cf. dupla Ishchenko 1956

Plate 18 Figures 1 - 6

Size in micrometres. (i) 50 (56) 65, body 33 (37) 43, (11 specimens), fum. HNO_3; Eighteen Inch Seam (sample C4) Low Close Opencast site, Cumbria.

Description. Amb triangular with concave sides and rounded to truncated angles. Laesurae distinct, simple, straight, extending 3/4 to almost the inner margin of the cingulum,, rays slightly open. Exine relatively thick, laevigate to infragranulate. Cingulum more or less uniform in width, 6 (10.5) 14 μm, and divided into two parts by a thinner, continuous, narrow, less than 1 µm groove. The outer darker part sometimes becomes more closely defined, thicker, and wider at the apices.

Remarks. The specimens described above show a considerable amount of variation in the width and the structure of the cingulum. The description given by Playford 1962 (p. 514, pl. 86, fig. 22) indicates more sharply concave sides of the spore body (intexine), than the specimens described above, which have a straight to slightly concave sides; and also in the present specimens the cingulum becomes well defined, thicker, and wider at the apices. The latter feature is not mentioned by either Ishchenko 1956, or Playford 1962, otherwise the specimens conform to the descriptions given by those authors.

Comparison. This species is closely comparable to S. intortus (Waltz) Potonie and Kremp 1954, in size range, shape and in the thickening at the apices, but differs mainly in the lack of the groove-like structure in the middle of the cingulum. This groove-like structure also distinguishes S. cf. dupla from other species in the genus. S. strigata (Waltz) Ishchenko 1958, and S. trigonalis Ishchenko 1956 differ in that their cingulum is differentiated into three concentric zones equal in width, and the middle zone is thinner; the latter also has ridged laesurae.

Occurrence. Rare in the Eighteen Inch Seam (sample C4) and in the Little Main Seam (sample C5); Low Close Opencast Site, Cumbria.

Suprasubturma CAMERATITRILETES Neves and Owens 1966

This suprasubturma was proposed by Neves and Owens 1966 to accommodate those trilete, camerate miospores in which the intexine is completely enveloped by an exoexine of uniform or differentiated thickness. Separation of the two wall layers may be partial or more or less complete when attachment is restricted to the proximity of the trilete rays.

Subturma MEMBRANATITRILETES Neves and Owen 1966

Trilete , partially camerate miospores in which the sculptured or sculptureless exoexine shows only partial separation from the intexine. In addition to proximal attachment, the two wall layers are in close contact over the whole, or polar region only, of the distal surface and/or along linear attachments which may be randomly or regularly orientated.

Infraturma CINGULICAMERATI Neves and Owens 1966

Trilete , cingulate miospores with a variable degree of chamber formation adjacent to the inner margin of the cingulum.

Genus LYCOSPORA (Schopf, Wilson and Bentall) Somers 1972

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

Diagnosis. Emended in Somers 1972, p. 55.

Remarks. This genus has a considerable number of species with small differences between them which makes identification difficult; several authors have tried to reduce the number of species by using different characters. The latest of these (Somers, 1972) re-examined a large number of types and other specimens. She grouped many published species into four broadly defined form species using type of ornament and the development of the cingulum as basic criteria; these species are:

1) L. orbicula (Potonie and Kremp) Smith and Butterworth 1967, with a very narrow cingulum.

2) *L. pusilla* (Ibrahim) Somers 1972, with clearly visible cingulum; she divided *L. pusilla* into two tendencies :- tendency A, with the zona reduced, (Cingulum + Zona)/Radius low, and tendency B, with the zona well developed, (Cingulum + Zona)/Radius high; the tendency B she then divided into two groups according to the type of ornament. These are: tendency B_1, smooth to punctate ornament and tendency B_2, granulate.

3) *L. rotunda* (Bharadwaj) Somers 1972, with verrucate ornament covering the whole exine including the flange.

4) *L. noctuina* var. *noctuina* Butterworth and Williams 1958, with verrucate and rugulate ornament arranged irregularly, zona smooth; and *L. noctuina var. reticulata* Kruszewska with rugulae arranged in a pseudoreticulum.

This revision has been employed variously by subsequent authors, and the utility of certain synonyms has been questioned. Of the specimens described in the present study, some conformed with Somer's diagnosis, while others did not conform due to some variations, generally in the type of ornament. This means that some species can be distinguished easily and there is no need to group them together. These are *L. ? rugosa*, *L. pellucida*, *L. punctata*, *L. triangulata* and *L. uber*, the first of which Somers grouped with *L. orbicula* and and the remainder with *L. pusilla*. Another reason for recognising these separately is not to reduce the possibility of using them for correlation and to a lesser extent for zonation.

Lycospora noctuina var. noctuina (Butterworth and Williams) Somers 1972

Plate 19 Figures 11, 12

1958 *Lycospora noctuina* Butterworth and Williams, p. 376, pl. III, figs. 14, 15.

1972 Lycospora noctuina var. noctuina (Butterworth and Williams) Somers, p. 70, pl. I, figs. 1-3, pl. II, fig. I, pl. XIII, fig. 1-17.

Holotype. Butterworth and Williams 1958, Plate 20, fig. 4. Preparation T54/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. 9 in. coal at 256 ft. 11 in. Darnley No. 3 borehole, Central Coalfield, Scotland; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 248 (expanded from diagnosis in Butterworth and Williams 1958, p. 376).

Size in micrometres. (i) Holotype 36; 30-45, Schulze and 5% KOH (Butterworth and Williams 1958). (ii) 31 (35) 38, fum. HNO_3; Durham Coalfield, England, Westphalian A; (Smith and Butterworth 1967). (iii) 33 (37) 41, (15 specimens); 1/3 conc. + 2/3 fum. HNO_3, Little Seam (bottom leaf) at 33.46 m, borehole No. 1154. (iv) 31 (36) 41 (12 specimens); HF + 1/3 conc. + 2/3 fum. HNO_3, dark seatearth of Quarter Seam, at 8.93 m, borehole No. 1350. (iii) and (iv) Plenmeller Coalfield, England.

Description. Amb triangular to rounded triangular. Laesurae distinct, ridged, straight to flexuose, slightly elevated and extending to inner margin of cingulum. Flange broad, 5-7 μm, and consisting of a narrower cingulum and a broader zona but sometimes the two parts are equal in width. Exine in the distal polar area ornamented with irregularly shaped verrucae, uneven in distribution, varying in size between 2-5 μm,

Remarks. The specimens described above conform closely with the original diagnosis given by Butterworth and Williams 1958.

Comparison. As stated by Somers 1972, L. noctuina var. noctuina is characterized by verrucae on the distal surface, ridged laesurae, smooth margin, and unornamented zona, which distinguish it from other species in the genus.

Synonym L. nitida Artüz 1957, (p.250, pl. v, fig. 34) is probably the same species described above; L. paulula Artüz 1957 (p.250, pl. v, fig. 35) is probably synonymous with L. noctuina.

Previous records. Butterworth and Williams 1958, Namurian A, Scottish Coalfields; Love 1960, Upper Visean, Lower Oil-shale Group, Scotland; Owens and Burgess 1965, Namurian A to Lower Namurian B, Stainmore Outlier, Westmorland; Smith and Butterworth 1967, Visean to Westphalian B, British Coalfield; Felix and Burbridge 1967, Upper Mississippian/Lower Pennsylvanian, Southern Oklahoma, U.S.A.; and recorded inside Britain by several authors.

Occurrence. Absent, rare to common throughout the sequence.

Lycospora orbicula (Potonie and Kremp) Smith and Butterworth 1967

Plate 19 Figures 15, 16 & 21

1955 Cyclogranisporites orbiculus Potonie and Kremp, p. 63, pl. 13, figs. 179-183.

1967 Lycospora orbicula (Potonie and Kremp), Smith and Butterworth, p. 249, pl. 20, figs. 16-19.

1972 Lycospora orbicula (Potonie and Kremp) Smith and Butterworth; In Somers, p. 71, pl. I, fig. 4; pl. II, fig. 2; pl. XIV.

Holotype. Potonie and Kremp, 1955, In Somers 1972, pl. I, fig. 4; pl. II, fig. 2. Preparation 607/2, KT18, 6 110,0; Geologisches Landesamt für Nordrhein-Westfalen, Krefeld.

Type locality. Baldur Seam, Brassert Colliery, Ruhr Coalfield, Germany; Lower Westphalian C.

Diagnosis. In Smith and Butterworth 1967, p. 249 (emended from Potonie and Kremp 1955, p. 63).

Size in micrometres. (i) Holotype 27; 25-35, Schulze (Potonie and Kremp, 1955). (ii) 20 (25) 30, fum. HNO_3; Yorkshire Coalfield, England; Westphalian A (Smith and Butterworth 1967). (iii) 21 (24) 27 (8 specimens) 1/3 conc. + 2/3 fum. HNO_3; High Main Seam, at 44.18 m, borehole No. 1350. (iv) 19 (24.5) 31 (9 specimens); HF + 1/3 conc. + 2/3 fum. HNO_3, dark seatearth of Quarter Seam, at 8.93 m, borehole No. 1350. (iii) and (iv) Plenmeller Coalfield, England.

Description. Amb circular. Laesurae simple, straight to slightly flexuose, very faint to indistinct, extending to the inner margin of the cingulum. Flange very narrow, not exceeding 2 µm in width. Exine very thin, pale in colour; covered distally with very small grana and spinae, often less than 1.5 µm in height and basal diameter, and the ornament reduced proximally. Narrow, short arcuate compression folds occur very often near the margin. Margin denticulate to crenulate.

Remarks. Smith and Butterworth 1967, p. 249 and Somers 1972, p. 72, mentioned that the weakly developed flange of this species is not a characteristic feature of the genus Lycospora, but Chaloner (1953, pl. 3, figs. 187-190 and 179-183) found in the cones of Lepidostrobus olryi Zeiller, a spore with a size range (19 (26) 34 µm) resembling L. orbicula, which justifies the classification of the species in the genus Lycospora.

Comparison. Anaplanisporites baccatus (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967, has a similar size and shape, but differs in its coarser, more prominent distal ornament and lack of zona.

Synonymy. Bharadwaj (1957b) transferred Lycospora (Cyclogranisporites) pressoides (Potonie and Kremp) Bharadwaj (p. 127, pl. 25, fig. 89-92) to Lycospora on one criterion, which is the length of laesurae; Smith and Butterworth 1967 re-examined the holotype and other specimens of L. (C.) pressoides and L. (C.) orbicula and concluded that there are some differences between them and that British specimens are closer to orbicula than to pressoides; they concluded that L. (C.) pressoides does not belong to the genus Lycospora. Lycospora ? rugosa Schemel 1951 in Smith and Butterworth 1967, (p.252, pl. 20, figs. 13-15) differs from L. orbicula in its more or less smaller size, smooth margin, and its laevigate and robust exine.

Previous records. Potonie and Kremp 1956, Lower Westphalian B and Middle Westphalian C, Ruhr Coalfield, Germany; Owens and Burgess 1965, Namurian A to Lower Westphalian A, Stainmore Outlier, Westmorland; Smith and Butterworth 1967, Westphalian A to D of British Coalfields; Loboziak 1971, Namurian to Westphalian, Coal Basin of North France; Somers 1972, Westphalian C, Ruhr Coalfield; Germany.

Occurrence. Absent to common throughout the Westphalian sequence.

Lycospora pellucida (Wicher) Schopf, Wilson and Bentall 1944

Plate 19 Figures 17 - 19

1934 Sporites pellucidus Wicher, p. 186, pl. 8, fig. 29.

1944 Lycospora pellucidus (Wicher); Schopf, Wilson and Bentall, p. 54.

1972 Lycospora pusilla "tendence B_2" (Ibrahim) Somers, p. 66, pl. I, figs. 5-33; pl. II, figs. 3-20; pl. IX & IIX.

Holotype. Potonie and Kremp 1955, pl. 17, fig. 341 after Wicher. Preparation IIIB5, dl(dr).

Type locality. Seam R_1, Wehofen Colliery, Ruhr Coalfield, Germany; Westphalian C.

Diagnosis. In Smith and Butterworth 1967, p. 250 (expanded from Potonie and Kremp, 1956, p. 102).

Size in micrometres. (i) Holotype 46, Schulze and KOH. (ii) 30 (38) 44, fum. HNO_3; Yorkshire Coalfield, England, Westphalian B; (Smith and Butterworth 1967). (iii) CIMP type 35 Somers 1972. (iv) 36 (42) 50 (16 specimens), Wellsyke Seam at 22.62 m, borehole No. 964. (v) 30 (39) 49 (25 specimens), fum. HNO_3 + 5% KOH, Half Seam (top leaf) at 12.54 m, borehole No. 964. (vi) 30 (38) 44 (60 specimens), fum. HNO_3 + 5% KOH. Three quarter Seam at 9.57 borehole No.964. (iv, v & vi) Plenmeller Coalfield, England.

Description. Equatorial outline subtriangular to subcircular. Laesurae prominent, straight to flexuose, simple to ridged, extending to the inner margin of the cingulum and sometimes extending to the outer margin of the spore, lips elevated, 1.5 to 2.5 µm. Flange differentiated into two parts, the inner darker cingulum (which overlaps the spore body) 2 - 4 µm wide and outer thinner translucent zone 3 - 7 µm wide. Distal surface ornamented with minute grana not exceeding 3 µm in basal width, more prominent on the proximal surface. The margin of the spore is generally undulating but sometimes smooth.

Remarks. Somers 1972 included this species in the L. pusilla tendency B_2 because of its punctate and granulate ornament and the high ratio of (C + Z)/R. The specimen above conforms closely to L. pusilla tendency B_2 in their distal ornament of grana.

Comparison. The broad flange, especially the zona, differentiate Lycospora pellucida from other species of Lycospora. L. noctuina var. noctuina (Butterworth & Williams) Somers 1972, has the same size and nearly the same width of flange but differs in the presence of small irregular grana and verrucae in the polar area.

Previous records. Recorded by numerous authors in Carboniferous sediments.

Occurrence. Frequent to abundant throughout the sequence.

Lycospora pusilla (Ibrahim) Somers 1972

Plate 19 Figures 22 - 28

1932 Sporonites pusillus Ibrahim in Potonie, Ibrahim and Loose, p.448, pl.15, fig.19.

1933 Zonales sporites pusillus Ibrahim, p.32, pl.2. fig.20.

1938 Zonotriletes pusillus (Ibrahim); Waltz in Luber and Waltz, pl.3. fig.33 and pl.8. fig.105.

1944 Lycospora pusilla (Ibrahim); Schopf, Wilson and Bentall, p.54.

1972 Lycospora pusilla "tendency B" (Ibrahim); Somers, p.66, Pl.I. Fig.5-33; Pl.II, Fig.3-20; Pl.IX & VII.

Holotype. Ibrahim 1932 in Somers 1972. Pl.I, Fig.13- Pl.II, Figs.6-8 after Ibrahim. Preparation B27, a1 (0); Staatl, Geologische Kommission, Berlin.

Type CIMP. Somers 1972; Pl.XII, Fig.17. Preparation EDS5 $(I)_2$; Iniex, Liege.

Type locality. Ägir Seam, Ruhr Coalfield, Germany; Upper Horster Beds, Upper Westphalian B.

Type locality CIMP. Reynoldsburg coal bed, Johnson County, Illinois, U.S.A. Abbott Formation, McCormick Group, Pennsylvanian.

Diagnosis. In Somers 1972 p.67.

Size in micrometres.(i) Holotype 38, Schulze and KOH, (ii) 22 (27) 35, fum. HNO_3, Yorkshire Coalfield, Westphalian A, (Smith and Butterworth, 1967). (iii) CIMP type (28) (Somers 1972) (iv) 30 (40) 45 (43 specimens); fum. HNO_3 + 5% KOH, Wellsyke Seam, at 22.62 m, borehole No.964. (v) 30 (35) 44, (37 specimens), fum. HNO_3 + 5% KOH; Half Seam (top leaf) at 12.54 m, borehole No.964. (vi) 26 (33.5)-40, (40 specimens) fum. HNO_3 + 5% KOH, Threequarters Seam at 9.57 m, borehole No.964. (vii) 21 (26) 34 (30 specimens) HF + 1/3 con. + 2/3 fum. HNO_3. Seatearth of Quarter Seam at 8.93 m, borehole No.1350 (iv, v, vi & vii). Plenmeller Coalfield, England.

Description. Equatorial outline subcircular to rounded triangular with broadly rounded angles. Laesurae distinct, straight to slightly flexuose, simple to ridged, lips elevated up to 2 µm, and extending to the inner margin of the cingulum. Flange narrow and differentiated into an inner thicker, 2 - 4 µm cingulum and an outer thinner, 1 - 3 µm zona, the zona occasionally folded. Exine including flange thin and ornamented distally with small grana and coni not exceeding 1.5 µm in basal diameter and height; in equatorial view proximal surface slightly convex and broadly convex distally.

Remarks. This species has been extended by Somers 1972 to include all lycospores firstly with punctate to granulate ornament and secondly with a clearly visible cingulum. The specimens described above conform with L. pusilla tendency B; zona clear to well developed and smooth to punctate ornament. This species formed in some seams between 70 - 85% of the spore assemblage.

Synonomies. Somers (1972, p.66, 67) incorporated many species into this one.

Previous records. This species has been reported by Somers to have an almost world wide distribution in Carboniferous sediments younger than Tournaisian age.

Occurrence. Abundant throughout the sequence.

Lycospora punctata Kosanke 1950

Plate 19 Figures 1 - 6

1950 Lycospora punctata Kosanke, p.45, Pl.10 Fig.3.

Pars 1972 Lycospora pusilla tendency B_2 (Ibrahim) Somers, p.66. Pl.I. Figs.5 - 33; Pl.II, Figs. 3 - 20; Pl.IX and IIX.

Holotype. Kosanke 1950, Pl.10, fig.3. Maceration 474 - A, Slide 4.

Type locality. No.6 Coal Bed, Franklin County,Illinois, U.S.A.

Diagnosis. In Kosanke 1950, p.45.

Size in micrometres. (i) 36.7 x 38; 30 to 42, Schulze and 10% KOH (Kosanke 1950) (ii) 31 (36) 44 (20 specimens); HF + 1/3 conc. + 2/3 fum. HON_3; dark seatearth of Quarter Seam at 8.93 m. borehole No.1350; (iii) 34 (37) 43 (20 specimens) HF + 1/3 conc. + 2/3 fum. HNO_3; Seatearth of Wellsyke Seam at 24.74m, borehole No.1350, (ii and iii) Plenmeller Coalfield, England.

Description. Amb triangular to subtriangular, with rounded apices and convex sides. Laesurae prominent, simple to ridged, slightly elevated, 1 - 2 μm in height and extending very often to the margin of the spore. Flange differentiated into an outer broad translucent zona and an inner narrow, thick cingulum. Exine ornamented distally by small grana, equal in size and well distributed especially inthe polar area.

Remarks. Somers 1972 placed this species in the L. pusilla tendency B_2 because of its punctate and granulate ornament and the high (C + Z)/R ratio. This species conforms generally with the diagnosis and description given by Kosanke 1950, which differs in its relatively larger size and broader zona, due to the use of alkali in his maceration.

Comparison. This species is distinguished from other types described here by its broad zona and by its punctate to granulate exine, especially in the polar area. Lycospora rotunda (Bharadwaj) Somers 1972, is distinguished by its coarser grana, which extend to the margin of the spore. L. noctuina var. noctuina (Butterworth and Williams,1958) Somers 1972 has the same width of zona but is distinguished by the irregular distribution and various shape and size of verrucae in the polar area. L. pellucida (Wicher) Schopf, Wilson and Bentall 1944 is distinguished by its more or less triangular shape, wider zona and less punctate to granulate exine.

Occurrence. Abundant in the dark grey mudstone seatearth (sample P.20) of the Wellsyke Stringer and in a medium grey mudstone at 12.5 m below the Wellsyke Stringer, borehole No.1350, Plenmeller Coalfield, England.

Lycospora rotunda (Bhardwaj) Somers 1972

Plate 19 Figures 7 - 10

1956 Lycospora granulata Kosanke in Potonie and Kremp, p.102, Pl.17. Figs. 339 - 340.

1957a Lycospora rotunda Bahardwaj, p.103, Pl.27, Figs.10 - 12.

1967 Lycospora granulata Kosanke in Smith and Butterworth, p.247, Pl.20. Figs.1 - 3.

1972 Lycospora rotunda (Bhardwaj) Somers, p.73, Pl.I, Figs.34-38 & Pl.XV.

Holotype. Bhardwaj 1957a. Pl.27, Fig.10; Preparation, Sl.No.7325. 11 Geologisches Landesamt fur Nordrhein Westfalen, Krefeld; and the same holotype in Somers 1972, Pl.I, fig.36.

CIMP type. Somers 1972, Pl.XV, Fig.4. Preparation 125 (3) 2; Iniex, Liege.

Type locality. Constanze Seam, mine Gottelborn, Saar Basin, Westphalian D.

CIMP locality. Couche 16, siege de Houthalen, bassin de Campine, Belgique; Zone de Genk, Westphalian A.

Diagnosis. Emendation in Somers 1972, p.73.

Size in micrometres. (i) Holotype ?; 29-37 (Bhardwaj 1957a); (ii) CIMP type 33; 24 - 37 (Somers 1972) (iii) 27 - 37 fum. HNO_3 Yorkshire Coalfield; Westphalian B (Smith and Butterworth 1967). (iv) 29 (36) 42 (17 specimens), fum. HNO_3 + 5% KOH; Wellsyke Seam at 22.62m, borehole No. 964, Plenmeller Coalfield, England.

Description. Amb subtriangular to subcircular, margin undulating to crenulate. Laesurae distinct, sometimes not well developed, simple to ridged, straight, lips slightly elevated, nearly 1.5 μm high, rays extending to the inner margin of the cingulum, sometimes extending to the margin of the spore; length ranges between 13 - 17 μm. Flange differentiated into two parts, the width of the outer thinner translucent zone 3 - 5 μm, broader than the inner thicker cingulum, 2 - 4 μm. Exine covered distally by closely spaced relatively coarse grana and coni and small verrucae 2 - 3 μm in their basal diameter and 1 - 2.5 μm in height. Grana extend to the margin of the flange and are reduced slightly proximally. Compression folds infrequent.

Remarks. Somers 1972 placed L. granulata Kosanke 1950 in synonomy with L. pusilla tendency B_2 (Ibrahim) Somers 1972, because the holotype is only finely granulated; L. granulata Kosanke in Potonie and Kremp 1956 and in Smith and Butterworth 1967 has coarser ornament which covers the polar area and equatorial structure. Therefore, Somers placed this species with verrucae and coarse grana in L. rotunda; she did not use L. torquifer in her regrouping of this type of Lycospora because the holotype is very badly preserved. The diagnosis of Bhardwaj 1957 has been amended by her to include all verrucate forms with circular and triangular outlines.

Comparison. The small verrucae as well as coni and grana covering the distal surface and extending on to the cingulum and zona and the clearly lobed margin differentiate this species from others.

Previous records. Recorded by numerous workers and reported by Somers to have a wide distribution from (Visean?) Namurian A to Stephanian B(?C)

Occurrence. Absent, rare to frequent throughout the sequence.

Lycospora ?rugosa Schemel 1951 in Smith and Butterworth, 1967.

Plate 19 Figures 29, 30

1951 Lycospora rugosa Schemel. P.747 text Fig.4

1967 Lycospora ?rugosa Schèmel in Smith and Butterworth, p.252, Pl.20. Figs. 13 - 15.

Pars 1972 Lycospora orbicula (Schemel); Somers. P.71, Pl.I. Fig.4; Pl.II, Fig.2; and Pl.XIv.

Lectotype. Schemel did not publish details of a holotype, but the specimen figured by Schemel (1951, P.748, text. Fig.4) is stated to be in the author's collection at the West Virginia Geological Survey and this specimen has been chosen as a lectotype by Smith and Butterworth 1967, p.252.

Type locality. Mystic Coal of Southern Iowa, U.S.A.; Des Moines Series.

Diagnosis. In Smith and Butterworth 1967, p.252 (from description in Schemel 1951, p.747).

Size in micrometres. (i) 20 (24) 26, maceration method not known (Schemel 1951) (ii) 17 (22) 30, fum. HNO_3; Yorkshire Coalfield, England. Upper Westphalian B. (iii) 16 (23) 27; (20 specimens); 1/3 conc. + 2/3 fum. HNO_3 from various seams in the Plenmeller Coalfield, England.

Description. Amb circular to subcircular. Laesurae distinct, simple, straight, extending to inner margin of the cingulum, rays open. Cingulum not exceeding 2 µm in width. Zona not present. Exine laevigate, pale to light brown in colour. Margin smooth. Folds infrequent.

Remarks. Somers 1972 put this species as a probable synonym of L. orbicula (Potonie and Kremp) Smith and Butterworth 1967 because of its very narrow flange while, in the meantime, she put L.rugosa Schemel 1951 as a probable synonym of L. pusilla tendency A (Ibrahim) Somers 1972 because Schemel's species has a slightly broader flange, 2- 2.5 µm as mentioned by Smith and Butterworth 1967.

Comparison. L. ? rugosa is differentiated from L. orbicula (Potonie and Kremp, 1955) Smith and Butterworth 1967 by its smooth, slightly thicker exine, smooth margin and well developed cingulum; the size range and lack of zona differentiate this species from other species in the genus.

Occurrence. Absent to rare throughout the sequence.

Lycospora triangulata Bhardwaj 1957

Plate 19 Figures 13, 14

1957a Lycospora triangulata Bhardwaj. P.103,Pl.27, Figs.13 & 14.

Pars 1972 Lycospora pusilla"tendency B_2" (Ibrahim) Somers, p.66, Pl.I, figs. 5 - 33; Pl.II, figs. 3 - 20; Pl.IX and IIX

Holotype. Bhardwaj 1957a. Pl.27, figs.13; Preparation Sl. No.10705/1a;

Type Locality. Grenzkohlen Seam, mine Labach, Saar Basin, Westphalian D.

Diagnosis. In Bhardwaj 1957a. P.103.

Size in micrometres. (i) Holotype ? 24 - 29 (Bhardwaj 1957a) (ii) CIMP type 35, Somers 1972. (iii) 25 (32) 37, (15 specimens); from various seams within the sequence, Plenmeller Coalfield, England.

Description. Amb triangular to subtriangular with one apex frequently more pointed than the others. Laesurae prominent, ridged, straight to flexuose, lips elevated 1.5 - 2 μm high, rays extending to the inner margin of the cingulum, sometimes to the margin of the spore; 12 - 20 μm in length. Flange differentiated into inner thicker cingulum 0.5 - 2 μm wide, and outer, lighter zona 3.5 μm wide. Exine relatively thick, uniformly dense, brown in colour, covered distally and less proximally by small grana 2 μm in basal diameter, more prominent in the polar area.

Remarks. Somers 1972 placed this species in the L. pusilla tendency B_2 because of its punctate and granulate ornament, and high ratio of (C + Z)/R.

Comparison. The small size and densely granulate ornament differentiate this species from L. pellucida and L. noctuina var noctuina (Butterworth & Williams) Somers 1972 which have a larger size and a smaller number of irregular grana and verrucae; L. pusilla has the same size range but differs in its less granulated and not very well developed zona; the grana of L. rotunda are coarser and distributed over the whole area of the spore, while the grana in this species are smaller and restricted to the polar area.

Occurrence. Absent to rare throughout the Westphalian sequence.

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

Plate 19 Figure 20

1955 Cirratriradites uber Hoffmeister, Staplin & Malloy,1955 P.383, Pl.36, Fig.24.

1960 Lycospora uber (Hoffmeister, Staplin & Malloy) Staplin, P.20, Pl.4, Figs..13, 17 - 18 and 20.

pars 1972 Lycospora pusilla tendency B_2 (Ibrahim) Somers, P.66, Pl.I Figs. 5 - 33; Pl.II, Figs. 3 - 20; Pl.IX and IIX.

Holotype. Hoffmeister, Staplin & Malloy, 1955. Pl.36, Fig.24. Preparation 3, Ser. 18,608.

Type locality. Shale at 2072 ft., Carter No.3 borehole (TCO-82) Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Hoffmeister, Staplin & Malloy, 1955. P.383.

Size in Micrometres. (i) Holotype 31.5 x 35, 28 - 42, HF (Hoffmeister, Staplin & Malloy, 1955). (ii) 32 (37) 42 (10 specimens), dark shale (sample M.20) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular to subtriangular with convex sides and broadly rounded angles. Laesurae prominent extending almost to the margin of the spore accompanied by folds 2 - 5 µm wide andup to 3 µm in height. Flange 6 - 11 µm in width, differentiated into an inner thicker cingulum and an outer thicker zona, equal in width. Exoexine ornamented distally in the polar area with grana, coni and with some scattered verrucae.

Remarks. Somers 1972 placed this species in L. pusilla tendency B_2 because of its punctate to granulate ornament and the high (C + Z)/R ratio. The specimens described above conform to the description given by

Hoffmeister, Staplin & Malloy, 1955, but differ slightly in some specimens having occasional scattered verrucae on the distal polar surface.

Comparison. This species is closely similar to *L. pellucida* and *L. noctuina* but it differs in having characteristic prominent elevated folds accompanying the rays.

Previous records. Hoffmeister, Staplin & Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Hacquebard and Brass 1957, Visean, Canada; Staplin 1960, Upper Visean to Namurian, Golata Formation, Alberta, Canada; Sullivan 1964, Visean, Drybrook Sandstone, Forest of Dean Basin, Gloucestershire; Sullivan and Marshall 1966, Upper Visean, Scotland; Felix and Burbridge 1967; Upper Mississippian/Lower Pennsylvanian, Springer Formation, Southern Oklahoma, U.S.A; Beju 1970, Visean to Lower Westphalian A, Moesian Platform, Romania.

Occurrence. Absent to rare throughout the sequence; and common in black shales(samples M20 and M22) from above the Upper Fell Top Limestone, Featherstone area.

Genus DENSOSPORITES (Berry) Butterworth, Jansonius, Smith and Staplin 1964.

Type species. *D. covensis* Berry 1937

Diagnosis. In Smith and Butterworth 1967, p.238 (From Staplin and Jansonius, 1964, p.101).

Comparison. *Cingulizonates* (Dybova and Jachowicz) Butterworth et al. 1964 is distinguished by possession of a cuesta. *Radiizonates* Staplin and Jansonius 1964 is distinguished by the presence of radial plications on the outer part of the cingulum. *Cristatisporites* (Potonie and Kremp) Butterworth et al. 1964 is distinguished by its prominent distal sculpture and the arrangement of its ornament in cristae.

Densosporites anulatus (Loose) Smith & Butterworth 1967

Plate 20 Figures 1 - 3 & 6, 7

1932 Sporonites anulatus Loose in Potonie, Ibrahim and Loose, p.451, Pl.18, Fig.44.

1934 Zonales-sporites (Anulati-sporites) anulatus, Loose P.151.

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

1950 Denso-sporites reynoldsburgensis Kosanke P.33, Pl.6, Figs.9-11.

1956 Anulatisporites anulatus (Loose); Potonie and Kremp P.112-Pl.17, Figs. 365 - 72.

1967 Densosporites anulatus (Loose) Smith and Butterworth, P.239, Pl.19, Fig.5-6.

Holotype. Potonie and Kremp 1956, Pl.17, Fig.365 after Loose. Preparation III 31, b5 (m/or).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, P.239 (translation from Potonie and Kremp 1956, P.112)

Size in micrometres.(i) Holotype 37.5; 35-60; Schulze (Potonie and Kremp 1956); (ii) 33 (40) 43 spore diameter; fum. HNO_3; Northumberland Coalfield, England; Lower Westphalian A (Smith and Butterworth 1967) (iii) 27 (33) 39 spore diameter, 12 (17.5) 21, central body (22 specimens) 1/3 conc. + 2/3 fum. HNO_3, Ganister Clay Seam at 24.25 m. borehole No.1383. (iv)27(34) 38 spore diameter, 14 (19) 23 central body, (35 specimens), fum. HNO_3, Slag Seam (top leaf) at 49.56 m. borehole No.1140. (iii and iv) Plenmeller Coalfield, England.

Description. Amb subcircular to subtriangular with broadly rounded angles and convex sides. Laesurae distinct to indistinct, faint, extending to the inner margin of the cingulum. Cingulum uniform in width 4 - 8 μm darker than the polar area and occupying approximately 40% of the spore radius. Central area or intexine pale in colour, laevigate to slightly infrapunctate. Margin smooth.

Comparison. Densosporites dentatus (Waltz) Potonie and Kremp 1956 and Densosporites parva, Hoffmeister, Staplin and Malloy 1944 (p.386, pl. 36, fig. 21) have the same size range, but the cingulum is differentiated into two zones, an inner thick and an outer thin zone. D. pseudoannulatus Butterworth and Williams 1958 (p.379, pl.III, figs. 42, 43) has a broader cingulum. D. simplex Staplin 1960 (p. 24, pl. 5, fig. 6) has well developed sutural ridges. D. tripapillatus Staplin 1960 (p. 24, pl. 5, figs. 4-5) is quite similar to the species described above but it has apical papillae.

Previous records. Recorded by several authors in the Carboniferous.

Occurrence. Abundant in the lower part of the Westphalian sequence, infrequent to frequent throughout the Westphalian sequence.

Densosporites duriti Potonie and Kremp 1956

Plate 20 Figures 4, 5 & 8 - 11

1956 Densosporites duriti Potonie and Kremp, p. 117, pl. 18, figs. 383-384.

Holotype. Potonie and Kremp, 1956, pl. 18, fig. 383. Preparation 524/1, KT 14,8: 114,5.

Type locality. Zollverein Seam, Friedrich Heinrich Mine, Ruhr Coalfield, Germany; Lower Westphalian B.

Diagnosis. In Potonie and Kremp, 1956, p. 117.

Size in micrometres. (i) 68, 45-70, Schulze (Potonie and Kremp 1956). (ii) 47 (52) 60 (15 specimens), fum. HNO_3, Little Main Seam (sample C5), Low Close Opencast Site, Cumbria.

Description. Amb triangular to rounded triangular with convex sides and broadly rounded angles. Laesurae distinct, simple, straight, extending into the inner margin of the cingulum. Intexine thin, laevigate. Proximal exoexine minutely granulate. Distal exoexine verrucate, verrucae 1.5-3 µm in basal diameter, and up to 2 µm in height, and with spines which are more prominent towards the inner margin of the cingulum than at the equator. Cingulum 12-15 µm in width (40-50% of total diameter) and differentiated into an inner darker wider zone and an outer thinner, narrower zone. Margin denticulate.

Remarks. Smith and Butterworth 1967, p. 243, differentiated *D. sphaerotriangularis* from *D. duriti* on the basis of heavier ornament in the latter species, but they noted a gradation between these two species, and they decided to use only the former species. In the present study both species have been recognised and the differentiation based on the heavier ornamentation and coarser verrucate element in *D. duriti* which is well represented in the Little Main Seam (sample C5) from the Low Close Opencast Site.

Comparison. It is closely similar to *D. sphaerotriangularis* Kosanke 1950 in size range, shape and type of ornamentation, but differs in having distinct laesurae and coarser and heavier verrucate ornament.

Previous records. Potonie and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Westphalian A and B, British Coalfields.

Occurrence. Frequent in the Eighteen Inch Seam (sample C4) and the Little Main Seam (sample C5), Low Close Opencast Site, Cumbria.

Densosporites intermedius Butterworth and Williams 1958

Plate 21 Figures 8, 9

1958 *Densosporites intermedius* Butterworth and Williams, p. 379, pl. 3, figs. 38, 39.

1955 *Densosporites tenuis* Hoffmeister, Staplin and Malloy, p. 387, pl. 36, figs. 18, 19 and 23.

1960 *D. cuneicinctus* Staplin, p. 26 (non pl. 5, fig. 15).

Holotype. Plate 19, fig. 10. Preparation T61/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Righead borehole, West Fife Coalfield, Scotland, Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 240 (from Butterworth and Williams 1958, p. 379).

Size in micrometres. (i) Holotype 56; 35-36, Schulze and 5% KOH (Butterworth and Williams 1958). (ii) 37 (43) 51, fum. HNO_3; upper bed of Marshall Green Seam, Northumberland Coalfield, England. Lower Westphalian A. (iii) 34 (39) 46 (23 specimens); 40% HF + fum. HNO_3, carbonaceous silty mudstone (sample M9), Burnfoot shale section, Featherstone area.

Description. Amb rounded triangular. Laesurae distinct to indistinct, simple, faint, straight to flexuose extending to inner margin of the cingulum; central area thin, slightly granulated. Proximal polar surface of exoexine rarely with scattered granules, distal surface ornamented with minute grana. Cingulum 8-13 μm in width, sometimes reaches half of spore radius, differentiated into darker inner zone and outer thinner zone, margin smooth to slightly notched.

Comparison. *Densosporites annulatus* and *D. pseudoannulatus* differ in having a uniform cingulum. *D. triangularis* and *D. sphaerotriangularis* differ in having an ornamentation on the distal polar area. *D. rotatus* Staplin 1960 differs in having faint apical papillae, with large granules or apiculae on the distal polar area. *D. formosus* and *D. microponticus* ArtÜz 1957, have some slight similarity in size and outline but differ in having a granulate polar area and serrate margin.

Remarks. Staplin and Jansonius 1964 and Smith and Butterworth 1967 stated that the species D. intermedius which was described by Butterworth and Williams 1958 is conspecific with D. tenuis Hoffmeister, Staplin and Malloy 1955. D. tenuis is invalid, being previously occupied by the well established species D. tenuis (Loose) Potonie and Kremp 1956, which was later transferred to genus Radiizonates tenuis by Butterworth et al. 1964. Therefore the species D. tenuis is no longer invalid. Staplin 1960 proposed a new name, D. cuneicinctus for the species of Hoffmeister, Staplin and Malloy 1955.

Occurrence. Rare to common throughout the Namurian sequence.

Densosporites glandulosus Kosanke 1950

Plate 20 Figures 16, 17

1950 Densosporites glandulosus Kosanke, p. 32, pl. 6, fig. 3.

Holotype. Kosanke 1950, pl. 6, fig. 3. Maceration 144. Slide 5.

Type locality. "Sub-Babylon" coal bed, Fulton County, Illinois, U.S.A.; lower part of Tradewater Group.

Diagnosis. In Kosanke 1950, p. 32.

Size in micrometres. (i) Holotype 27.3 X 35.7; 25-38, Schulze and 10% KOH (Kosanke 1950). (ii) 34 (38) 49, (4 specimens); 2/3 conc. HNO_3 + 1/3 fum. HNO_3, Slag Seam (top leaf), at 49.56 m, borehole No. 1140, Plenmeller Coalfield, England.

Description. Amb subcircular, subtriangular to irregular in shape. Laesurae very faint to indistinct. Central area covered proximally and distally with minute grana and ornamented distally with glandulose elements, spinae with swollen tips, which vary in shape and size and project into the cingulum, 3-8 μm in height, 2-5 μm in basal width and 2-3.5 μm at apices which are rounded; 30-45 elements project at the margin.

Remarks. The specimens described above conform very closely with the diagnosis given by Kosanke 1950. The ornament is slightly coarser than that recorded by the above author and the size range is slightly larger than that recorded previously.

Occurrence. Rare in the Slag Seam (top leaf), at 49.56 m, borehole No. 1140, Plenmeller Coalfield; and in the Little Main Seam (sample C5), Low Close Opencast Site, Cumbria.

Densosporites microponticus Artüz 1957

Plate 20 Figures 18, 19

1957 Densosporites microponticus Artüz, p. 253, pl. 6, fig. 45.

Holotype. Artüz 1957, pl. 6, fig. 45. Preparation I142d.

Type locality. Büyük Seam, Zonguldak Coalfield, Turkey; Westphalian A.

Diagnosis. In Artüz 1957, p. 253.

Size in micrometres. (i) Holotype 45, 42-50, maceration method not stated (Artüz 1957). (ii) 36 (40) 44, Cingulum 8 (9.5) 11 (12 specimens), HF + fum. HNO_3, dark shale (sample M20) from above the Upper Fell Top Limestone, Featherstone area. (iii) 40 (43.5) 50, Cingulum 8 (9.7) 11 (8 specimens), fum. HNO_3, Slag Seam (top leaf), at 49.56 m, borehole No. 1140, Plenmeller Coalfield, England.

Description. Amb triangular to subtrangular with rounded angles. Laesurae seldom visible. Proximal central area laevigate to punctate, distal surface covered with closely packed minute grana and scattered coarse grana, 1-1.5 µm in height and 1-2 µm in basal width, fused at their bases to give a reticulate pattern. Cingulum 8-11 µm in width, differentiated into two zones, the inner is thicker and wider and the outer is thinner and frequently indented.

Comparison. This species differs from D. intermedius Butterworth and Williams 1958, in having minute grana which form a reticulate pattern.

D. formosus Artüz 1957, has some similarity with the above described species, but differs in the lack of granulation in the polar area and in having a reticulate pattern on the thicker inner zone of the cingulum which extends into the outer thinner zone. D. hispidus Felix and Burbridge 1967 has prominent laesurae, a wider, more uniform cingulum, and has the same type of ornamentation on the distal surface but without the scattered coarse grana.

Occurrence. Absent, rare throughout the sequence; common in samples M22 and M20 from above the Upper Fell Top Limestone, Featherstone area.

Densosporites pseudoannulatus Butterworth and Williams 1958

Plate 20 Figures 12 - 15

1958 Densosporites pseudoannulatus Butterworth and Williams, p. 379, pl. 19, fig. 11.

Holotype. Butterworth and Williams, 1958. Plate 19, fig. 11. Preparation T59/1 in collection of National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Seam at 2,082 ft. 2 in. Righead borehole, West Fife Coalfield, Scotland; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 241 (from Butterworth and Williams 1958, p. 379).

Size in micrometres. (i) Holotype 45; 35 (44) 51, Schulze and 5% KOH (Butterworth and Williams 1958). (ii) Spore diameter 31 (35) 40, Cingulum 7 (9.5) 10 (22 specimens) HF + fum. HNO_3 carbonaceous silty mudstone (sample M9), Burnfoot shale section; Featherstone area.

Description. Amb subcircular to subtriangular with broad angles. Laesurae not always visible, simple, straight, extending to the inner margin of the cingulum. Intexine thin, laevigate; exoexine of the polar area slightly granulated with small low grana less than 1 µm in basal width. Cingulum 7-10 µm wide, uniform in width just slightly thinner at the edge (0.5-1 µm in width). Margin occasionally serrate.

Comparison. D. anulatus (Loose) Smith and Butterworth 1967, and D. tripapillatus Staplin 1960, are distinguished from the described species in their cingulum being proportionally less than 40% of spore radius and the possession by the latter species of apical papillae. This species is distinguished from D. intermedius Butterworth and Williams 1958 in having a uniform broad cingulum.

Remarks. D. pseudoannulatus is difficult to distinguish from D. intermedius especially as it is frequently corroded, which often leads to the spore margin appearing tapered, because they have more or less the same cingulum width.

Previous records. Butterworth and Williams, 1958, Namurian A, Scotland; Smith and Butterworth 1967, Visean to Namurian, British Coalfield.

Occurrence. Rare to common throughout the Namurian sequence.

Densosporites sphaerotriangularis Kosanke 1950

Plate 20 Figures 20 - 22

Holotype. Kosanke 1950, pl. 6, fig. 7. Preparation 520-A, Slide 2.

Type locality. Bald Hill Coal, Williamson County, Illinois, U.S.A.; Trade Water Group.

Diagnosis. In Smith and Butterworth 1967, p. 242 (from description in Kosanke 1950, p. 33).

Size in micrometres. (i) Holotype 50.4 X 48.4, 46 - 59; Schulze and 10% KOH (Kosanke 1950) (ii) 38 (47) 59, fum. HNO_3. Warwickshire Coalfield, England; Upper Westphalian A (Smith & Butterworth 1967) (iii) 36 (48.7) 60 spore diameter, 7 (17) 24 cingulum width, 16 (18) 21

central body (8 specimens) fum. HNO_3 + 5% KOH; Half Seam (top leaf) at 12.54 m; borehole No.964; Plenmeller Coalfield, England.
(iv) 34 (42) 46, spore diameter, 7 (11) 15 cingulum with 14 (18) 24, central body (25 specimens), fum. HNO_3, Slag Seam (top leaf) at 49.56 m, borehole No.1140, Plenmeller Coalfield, England.

Description. Amb triangular to subtriangular with convex sides and broadly rounded angles. Laesurae distinct, sometimes obscured by ornament. Central polar area ornamented proximally with fine to coarse grana, and with coni and verrucae distally. Cingulum occupies more or less 50% of spore diameter differentiated into inner darker thicker zona, widerthan the outer lighter, slightly translucent thinner part. Margin of the spore undulating.with projecting spinae. Compression folds infrequent.

Comparisons. *Densosporites granulosus* Kosanke 1950 is distinguished in its undifferentiated cingulum, as well as the granulate proximal and distal surface. In *Cingulizonates cf. capistratus* (Hoffmeister, Staplin and Malloy) Butterworth et al. 1964 the cingulum is differentiated into three zones, the middle zone being characterised by variable radiating ribs. *D. lobatus* Kosanke 1950 has the outer margin of the dark inner part of the cingulum sharply lobed. *D. duriti* Potonie and Kremp 1956 is closely similar but differs in having coarser verrucae on the distal surface.

Previous records. Kosanke 1950, Westphalian A and B Tradewater Group, Illinois, U.S.A.; Potonie and Kremp, 1956, Upper Westphalian A to Middle Westphalian B, Ruhr Coalfield, Germany; Bharadwaj 1957, Upper Westphalian B, Saar Coalfield; Love and Neves 1963, Westphalian B, Inninmore, Scotland; Neves 1964, Namurian B to Middle Westphalian A, La Camocha, Gijon, N. Spain; Smith and Butterworth, 1967, Westphalian A to D, British Coalfield; Ravn 1979, Pennsylvanian, Cherokee Group, CP-19-4 Coal, Southern Iowa, U.S.A.

Occurrence. Absent, rare to common throughout the Westphalian sequence.

Densosporites spinifer Hoffmeister, Staplin and Malloy 1955

Plate 21 Figures 1 - 7

1955 Densosporites spinifer Hoffmeister, Staplin and Malloy, p. 386, pl. 36, fig. 17.

Holotype. Hoffmeister, Staplin and Malloy 1955, pl. 36, fig. 17, TCO-82. Preparation 3, ser. 19,066.

Type locality. Shale at 2,075 ft. Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Smith and Butterworth 1967, p. 243, (from description in Hoffmeister, Staplin and Malloy 1955, p. 386).

Size in micrometres. (i) Holotype 46 X 42; 32 - 48; HF. Hoffmeister, Staplin and Malloy 1955). (ii) 33 (40) 53; fum. HNO_3; Northumberland Coalfield; Namurian A; (Smith and Butterworth 1967). (iii) 35 (41.5) 47, Cingulum 6 (9) 10.5 (35 specimens) 40% HF + fum. HNO_3, dark shale (sample M20) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb subtriangular, sides straight to slightly convex, angles rounded. Laesurae not always distinct, extending into thickened zone. Cingulum differentiated into darker zone 3 (5) 7 µm in width, and outer thinner zone 2 (2.5) 4 µm. Distal polar area with coarse grana, 1.5-2.5 µm in basal diameter, some of the grana fused at their bases to form a vermiculate pattern. Equatorial region of both zones of cingulum are undulating with dense spinae projecting from the thicker zone and scattered spinae from outer zone, spinae 2-5 µm in height.

Comparison. Cristatisporites pannosus Knox 1950 and D. spinosus Dybova and Jachowicz 1957 have longer, more closely packed spinae and well-marked laesurae associated with spinose ridges. D. microponticus Artüz 1957, has a similar size and shape but differs in its larger and less granulate central area and lack of spinose elements projecting from the distal polar area to the cingulum. D. glandulosus Kosanke 1950 differs in having glandulose elements which project at the margin. D. aculeatus Playford 1963 is distinguished in having coarser, rounded at the base spines, and distinct laesurae with well developed lips up to 2 µm in height.

Previous records. Hoffmeister, Staplin and Malloy 1955, Hardinsburg Formation, Upper Mississippian, Kentucky and Illinois, U.S.A.; Butterworth and Williams 1958, Namurian A, Scotland; Staplin 1960, Golata Formation, Upper Mississippian, Alberta, Canada; Smith and Butterworth 1967, Visean to Namurian, British Coalfields.

Occurrence. Absent to rare throghout the Namurian sequence and frequent in sample M22 from above the Upper Fell Top Limestone, Featherstone area.

Densosporites spinosus Dybova and Jachowicz 1957

Plate 21 Figures 10 - 13

1950 Denso-sporites indignabundus (?) (Loose) Schopf, Wilson and Bentall in Kosanke 1950, pl. 7, fig. 2.

1956 Densosporites spinosus (Kosanke); Dybova and Jachowicz, p.5, pl. 4, fig. 12.

1957 Densosporites spinosus Dybova and Jachowicz, pl. XLIX, fig. 4.

Holotype. Dybova and Jachowicz 1957, pl. XLIX, fig. 1. Preparation Del/39.

Type locality. Seam 17, Silesia, Polska; Westphalian B.

Diagnosis. In Dybova and Jachowicz, p. 165.

Size in micrometres. (i) Holotype not specified. (ii) 38 (48) 54, fum. HNO_3 and 30% NH_4OH (Dybova and Jachowicz 1957). (iii) 39 (43)

46, Cingulum 8 (10.5) 14; 40% HF + fuming HNO_3, black shale (sample M22) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular, sides straight to convex, with two apices broadly rounded. Laesurae distinct, simple, very faint to ridged, 2-4 µm in width, slightly elevated, and extending almost to the margin of the intexine. Cingulum differentiated into an inner thicker zone 3-5 µm in width and an outer thinner, wider zone 4-8 µm, both zones covered with grana and spinae closely packed, 3-9 µm long and 2-4 µm wide, projecting radially from the polar areas, which are also covered, distally with spines and proximally with minute grana and small coni.

Comparison. D. spinosus is transitional between D. spinifer and Cristatisporites pannosus (Knox), Butterworth et al. 1964, D. spinifer is smaller in size and has shorter spines, and C. pannosus is larger in size and has longer spines and prominent ridged laesurae. Also, D. rarispinosus Playford 1963 and D. belliatus Artüz 1957, have more prominent laesurae.

Previous records. Dybova and Jachowicz 1957, Namurian A to Westphalian B, Silesian, Poland; Neves 1961, Namurian A-B, Southern Pennines; Owens and Burgess 1965, Namurian A to Westphalian A, Stainmore Outlier, Westmorland, Neves 1964, Namurian A, La Camocha, Gijon, North Spain; Neves 1968, Namurian A and B, Woodland Borehole, Co. Durham; Beju 1970, Namurian A to C, Moesian Platform, Romania; Ravn 1979, Pennsylvanian Cherokee Group, CP-19-4 Coal, Southern Iowa, U.S.A.

Occurrence. Absent to rare throughout the Namurian sequence, frequent in sample M22, from above the Upper Fell Top Limestone, Featherstone area.

Genus CINGULIZONATES (Dybova and Jachowicz) Butterworth, Jansonius, Smith and Staplin 1964

Type species. *C. bialatus* (Waltz), Smith and Butterworth 1967.

Diagnosis. In Smith and Butterworth 1967, p. 259 (from diagnosis of Butterworth, Jansonius, Smith and Staplin 1964, p. 105).

Comparison. This genus is distinguished by the presence of a cuesta.

Cingulizonates bialatus (Waltz) Smith and Butterworth 1967

Plate 23 Figures 1 - 4

1938 *Zonotriletes bialatus* Waltz in Luber and Waltz, p. 22, pl. 4, fig. 51.

1941 *Zonotriletes bialatus var. undulatus* Waltz in Luber and Waltz, p. 28, pl. 5, figs. 71a, b.

1941 *Zonotriletes bialatus var. costatus* Waltz in Luber and Waltz, p. 29, pl. 5, fig. 72.

1956 *Densosporites bialatus* (Waltz); Potonie and Kremp, p. 114.

1956 *Hymenozonotriletes bialatus var. undulatus* (Waltz); Ishchenko, pp. 63, 64, pl. 12, figs. 135-7.

1957 *Cingulizonates tuberosus* Dybova and Jachowicz, p. 171, pl. 53, figs. 1-4.

1958 *Densosporites striatus* (Knox); Butterworth and Williams, p. 380, pl. 3, fig. 36.

1967 *Cingulizonates bialatus* (Waltz); Smith and Butterworth, p. 260, pl. 21, figs. 3, 4.

Holotype. Not designated.

Type locality. Bed 6, Verkhni-Goubakhin Colliery, U.S.S.R.; Lower Carboniferous.

Diagnosis. In Smith and Butterworth 1967, p. 260 (from Waltz, in Luber and Waltz 1941).

Size in micrometres. (i) 70-80, Schulze (Luber and Waltz 1938). (ii) 36 (41) 48; thickened area of cingulum 2 (6) 9, thin part 2 (5) 8, fum. HNO_3; Northumberland Coalfield, England; Namurian A. (iii) 27 (35) 40, Cuesta 3 (4.5) 7, outer zone 2 (3.7) 7, (25 specimens); HF + fum. HNO_3, dark shale (sample M20) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular to subrounded with straight to concave sides. Laesurae distinct to indistinct, simple, straight extend into inner margin of the cuesta. Polar area laevigate to slightly punctate. Cingulum differentiated into inner thicker cuesta which is usually associated with tubercles 2.5 μm in height and 3.5 μm in basal width projecting into the thinner outer zone.

Comparison. C. bialatus is closely similar to C. loricatus in size range and morphological structure, but C. bialatus differs in having larger and more prominent tubercles projecting into the outer thinner zone of the cingulum. Radiizonates striatus (Knox) Staplin and Jansonius 1964 has the same size range but differs in having plications radiating from the thicker inner zone of the cingulum, whereas in the case of C. bialatus the cuesta may be ornamented with fine radial striations but is never plicated or ribbed and lacking a cuesta. Densosporites intermedius Butterworth and Williams 1958 has much in common with C. bialatus, and a certain amount of gradation may exist espcially with the effects of corrosion; this causes difficulty in distinguishing between the species D. intermedius, C. loricatus and C. bialatus.

Previous records. Luber and Waltz 1941, Lower Carboniferous, Kizelovsky District, U.S.S.R.; Potonie and Kremp 1956, Tournaisian to Visean, Karaganda Basin; Dybova and Jachowicz 1957, Namurian A to Westphalian B, Silesian Coalfield; Butterworth and Williams 1958, Namurian A, Scotland; Smith and Butterworth 1967, Visean and Namurian, British Coalfields; Beju 1970, Visean to Namurian C, Moesian Platform, Romania.

Occurrence. Absent, rare to frequent throughout the Namurian sequence.

Cingulizonates loricatus (Loose) Butterworth and Smith (in Butterworth et al. 1964)

Plate 23 Figures 5 - 7

1932 Sporonites loricatus Loose in Potonie, Ibrahim and Loose, p. 450, pl. 18, fig. 42.

1934 Zonales-sporites loricatus Loose, p. 151.

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

1964 Cingulizonates loricatus (Loose); Butterworth and Smith; Butterworth et al., p. 1053, pl. 2, fig. 4.

Holotype. Potonie and Kremp 1956, pl. 18, fig. 400 after Loose. Preparation III2, a_3 (ur).

Type locality. Bismark Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 262 (translation from Potonie and Kremp 1956, p. 119).

Size in micrometres. (i) Holotype 41.5; 35-50; Schulze (Potonie and Kremp 1956). (ii) 32 (41) 48, spore diameter 3 (4.5) 7, cuesta; 1 (4.2) 6, outer zone fum. HNO_3; Coalbrookdale Coalfield, England; Lower Westphalian B (Smith and Butterworth 1967). (iii) Spore diameter 32 (36) 44, Central area 16 (18.6) 22, outer part of cingulum

2 (4) 5, cuesta 3 (4.7) 8, (14 specimens), 1/3 conc. HNO_3 + 2/3 fum. HNO_3; Ganister Clay Seam, at 24.25 m depth, from borehole No. 1383, Plenmeller Coalfield, England.

Description. Amb triangular to subtriangular. Laesurae simple, flexuose, reaching to inner margin of cingulum. Intexine (central body) thin, laevigate, central distal area granulose. Cingulum differentiated into inner dark thickening (cuesta) which is slightly broader than the outer thinner zone, or sometimes they are equal in width; outer edge of cuesta crenulate, the distal surface of cuesta occasionally plicated with a few plications extending to the outer part of cingulum; margin of spore slightly modified by grana and by these few plications.

Comparison. Cingulizonates loricatus is similar to Radiizonates striatus (Knox) Staplin and Jansonius 1964, but the former lacks the positive radial plication and the second lacks the inner ridge elevation of the cingulum above the surface of the central proximal area; i.e. cuesta. In Densosporites annulatus (Loose) Smith and Butterworth 1967, the cingulum is smooth and is not differentiated into two parts. The inner thicker part of the cingulum (cuesta) in C. bialatus (Waltz) Smith and Butterworth 1967 has large tubercles projecting into the thinner outer part of the cingulum.

Previous records. Potonie and Kremp 1956, Upper Westphalian B to Westphalian C of Ruhr Coalfield and recorded by several authors in and outside Britain.

Occurrence. Absent to infrequent throughout the sequence.

Genus KRAEUSELISPORITES (Leschik) Scheuring 1974

Type species. K. dentatus (Leschik) Scheuring 1974

Diagnosis. In Owens, Mishell and Marshall 1976, p.146 (from Scheuring, 1974)

Comparison. Vallatisporites (Hacquebard) Sullivan 1964 is distinguished by possessing an internal vacuolation adjacent to the margin of the spore body. Cirratriradites Wilson and Coe 1940 has some similarity to Kraeuselisporites, but differs in having foveae on the distal surface.

Kraeuselisporites ornatus (Neves) Owens, Mishell and Marshall, 1976

Plate 21 Figures 18, 19

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

1976 Kraeuselisporites ornatus (Neves) Owens, Mishell and Marshall, p.153, Pl.2, figs. 2 - 4.

Holotype. Neves 1961, pl.33, fig.3.

Type locality. Non-marine shale, Hipper Sick, Derbyshire (Loc. 12) Yeadonian stage.

Diagnosis. In Neves 1961, p.269.

Size in micrometres. (i) Holotype 92, 80-110, Schulze and 10% KOH (Neves, 1961) (ii) 76 - 86, maceration method not stated;(Owens, Mishell and Marshall 1976) (iii) 54 (58.5) 67 (10 specimens) ; HF + fum. HNO_3; black shale (sample M18) from above the Upper Fell Top Limestone, (iv) 70 (74) 85 (5 specimens); HF + fum. HNO_3, black shale (sample M13), from above the Lower Fell Top limestone, (iii and iv) Featherstone area.

Description. Amb triangular to rounded triangular. Laesurae distinct, flexuose, ridged, extend to the margin of the central body, accompanied by 2 - 4 µm wide folds which sometimes continue onto the flange. Exoexine infrapunctate proximally, distally with coarse grana and coni, and small spines 2 - 4µm high and 1.5 - 2.5 µm wide. The spines vary in shape and size on individual specimens. Flange thin, more or less uniform in width, ranging between 8 - 13 µm, and sometimes possessing a few relatively short thin spines. Flange is differentiated into an inner, thicker, narrower zone, and an outer, thinner, wider zone. Margin of the flange cirrate.

Remarks. The specimens described above conform closely to the description given by Owens et al. 1976, excepting that the size range of the specimens from black shale (sample M18) is smaller.

Comparison. K. echinatus Owens, Mishell and Marshall 1976, is distinguished in its larger size range (74 - 147 m), and larger and more distinct spines. Cirratriradites rarus (Ibrahim) Schopf, Wilson and Bentall 1944 is similar but differs in the presence of foveae and lack of the distal spines.

Previous records. Neves 1961, Naumrian C, Southern Pennines; Neves 1964, Namurian B to lower Westphalian A, La Camocha mine, Gijon, N. Spain; Neves 1965, Namurian B - C, Passage Group, Scotland; Neves 1968, Namurian B - C, Woodland borehole, Co. Durham; Sabry and Neves 1970, Namurian C, lower Westphalian A, Sanquhar Coalfield, Scotland; Owens, Mishell and Marshall, 1976 recorded from Namurian B (R_1) - lower Namurian C (G1), Stainmore Outlier, Westmorland, and from Upper Namurian A - Namurian B (E_2b - R_2), Bowland Forest, Ingelton; Owens et al., 1977, Upper Namurian A (E_2b) to Lower Westphalian A, Northern England and Scotland; Clayton et al., 1978, Upper Namurian A to lower Westphalian A, Western Europe.

Occurrence. Absent to rare throughout the Namurian sequence.

Genus CIRRATRIRADITES Wilson and Coe 1940

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

Diagnosis. In Smith and Butterworth 1967, p.256 (from diagnosis and description in Schopf, Wilson and Bentall 1944, p.43).

Comparison. Lycospora, Densosporites, Cingulizonates, and Radiizonates are distinguished by their cuneiform cingulum which overlaps the intexine proximally and distally. Vallatisporites (Hacquebard) Sullivan 1964 is distinguished from this genus, which has some similarity, by the internal vacuolation adjacent to the margin of spore body. Kraeuselisporites (Leschik) Scheuring 1974 has a great similarity with Cirratriradites but is distinguished in possessing strong spinose sculpture on the distal surface and in the lack of foveae.

Cirratriradites saturni (Ibrahim) Schopf, Wilson and Bentall, 1944

Plate 21 Figures 14 - 16

1932 Sporonites saturni Ibrahim in Potonie, Ibrahim and Loose, p.448, Pl.15, fig.14.

1933 Zonales - sporites saturni Ibrahim, p.30, Pl.2, fig.14.

? 1938 Zonotriletis saturni (Ibrahim); Luber in Luber and Waltz, Pl.8, fig.102.

1944 Cirratriradites saturni (Ibrahim); Schopf, Wilson and Bentall, p.44.

Holotype. Ibrahim 1932, Pl.15, fig.14. Potonie and Kremp, 1956, Pl.18, fig.412 after Ibrahim Preparation B26, d2 (ul).

Type locality. Agir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p.258 (translation from Potonie and Kremp 1956, p.128.)

Size in micrometres. (i) Holotype 69.5, Schulze and KOH (ii) 70-100 Schulze (Potonie and Kremp 1956) (iii) 46 (57) 68, fum. + HNO_3, St. Helens No.3 Colliery, Cumberland Coalfield, England. Westphalian A (Smith and Butterworth 1967) (iv 54 (66) 86 spore diameter, 50 (56) 62 Central area, 6 (7) 9 flange, (16 specimens) 1/3 conc. + 2/3 fum. HNO_3 + one minute KOH, Bounder Seam at 8.44m, Borehole No.1154, Plenmeller Coalfield, England.

Description. Amb of spore and spore body triangular to sub triangular with convex sides and broadly rounded angles, margin serrate. Laesurae distinct, simple to ridged, straight to flexuose and accompanied by a wide fold 1.5 - 2 μm extending to the spore margin. Flange with very fine radial striations; the outer part of the flange very thin, pale in colour, and the inner part thicker and darker in colour. Exine ornamented distally with coarse and fine grana and occasionally with small verrucae. One central, or sometimes three, circular foveae present on the distal surface ranging between 7 - 11 μm in diameter. One specimen contained a distal circular fovea not in the centre of the spore.

Remarks. The specimens recovered during the present study correspond closely to the diagnosis and descriptions of previous workers.

Comparison. C. annulatus (Kosanke 1950, p.35) has got four or more distal foveae and a minutely punctate exine. C. annuliformis (Kosanke 1950, p.35) is differentiated from C. saturni by its narrower flange which has not got radial striations and also the minutely punctate exine. C. foveatus Guennel 1958 is similar morphologically to C. saturni but smaller (48 - 68 μm).

Previous records. Potonie and Kremp 1955, Upper Westphalian B to Middle Westphalian C, Ruhr Coalfield, Germany; Sullivan 1962, Westphalian A and B, Wernddu, South Wales; Love and Neves 1963, Upper Westphalian B, Inninmore, Scotland; Neves 1964, Middle Westphalian A, La Camocha mine, Gijon, North Spain; Sullivan 1964, Lower Westphalian A, Edgehills Coals, Forest of Dean Basin, Wales; Owens and Burgess, 1965; Westphalian A and B, Stainmore Outlier, Westmorland; Smith and Butterworth 1967, Upper Namurian to Westphalian C, British Carboniferous; Neves 1968, Westphalian A, Woodland Borehole, Co. Durham; Van Wijke and Bless 1974, Westphalian A to C, Netherlands; Owen et al. 1977, Westphalian A, Northern England and Scotland; Clayton et al., 1978, Namurian A to Westphalian A, Western Europe; Ravn 1979, Cherokee Group, Pennsylvania, CP-19-4 Coal Southern Iowa, U.S.A.

Occurrence. Two specimens found in black shale (sample M13), from above the Lower Fell Top Limestone, Featherstone area. Absent to rare throughout the Westphalian sequence.

Cirratriradites rarus (Ibrahim) Schopf, Wilson and Bentall, 1944

Plate 21 Figure 17

1933 Zonales-sporites rarus Ibrahim, p.29, Pl.6, fig.33.

1944 Cirratriradites rarus (Ibrahim); Schopf, Wilson and Bentall, p.44

1956 Cirratriradites rarus (Ibrahim); Schopf, Wilson and Bentall; in Potonie and Kremp, p.127, Pl.19, figs. 416 - 419.

Holotype. Potonie and Kremp 1956, Pl.19, fig.416 after Ibrahim, Pl.6 fig.53. Preparation B54 db (r).

Type Locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Potonie and Kremp 1956, p.127.

Size in micrometres. (i) Holotype 60, Schulze and KOH. (ii) 60 - 100, Schulze (Potonie and Kremp 1956) (iii) 57, 62, 67; (3 specimens), HF + fum. HNO_3; black shale (sample M18), above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular to subtriangular with rounded to rounded triangular central body. Laesurae distinct to indistinct, straight, simple to ridged, lips elevated up to 1.5 µm, extending to the margin of the central body. Intexine not clearly discernible. Exoexine infragranulose proximally and ornamented distally with coarse grana and coni, up to 2 µm in height and 1.5 - 2.5 µm in basal diameter. Flange wide, translucent with radial striations and concentric thickening. Distal foveae not present.

Remarks. Very few specimens were encountered of C. rarus in this work. There is some doubt about the presence of distal foveae. If these are not present the species should be assigned to the genus Kraeuselisporites.

Comparison. Distinguished from other species of *Cirratriradites* by its wide flange, which lacks prominent concentric thickening, and by its apparent lack of distal foveae.

Previous records. Potonie and Kremp 1956, Upper Westphalian B, Ruhr Coalfield, Germany; Owens et al. 1977, Upper Namurian A to Namurian C, northern England and Scotland, Clayton et al., 1978, Upper Namurian to Namurian C, Western Europe.

Occurrence. Rare in black shale (sample M18) above the Upper Fell Top Limestone, Featherstone area.

Genus CRISTATISPORITES (Potonie and Kremp) Butterworth, Jansonius, Smith and Staplin, 1964.

Type species. *C. indignabundus* (Loose) Potonie and Kremp 1954.

Diagnosis. In Smith and Butterworth 1967, p.253 (from diagnosis by Butterworth, Jansonius, Smith and Staplin, in Staplin and Jansonius, 1964, p.108.

Comparison. Distinguished from other genera by its prominent distal sculpture and the arrangement of cristae or concentric discontinuous ridges.

Cristatisporites connexus Potonie and Kremp 1955

Plate 22 Figures 1 - 4

Holotype. Potonie and Kremp 1955, Pl.16, fig.291. Preparation 77e.

Type locality. Gas boring KM 1, Ascheburg, Germany, Lower Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p.253 (translated from Potonie and Kremp 1955, p.106).

Size in micrometres. (i) Holotype 46, 45 - 70, Schulze (Potonie & Kremp, 1955). (ii) 51 (58) 67 spore diameter, Schulze and 5% KOH Lancashire Coalfield, England; Lower Westphalian B, (Smith and Butterworth 1967) (iii) 55 (65.5) 78 spore diameter; 20 (25) 32 polar area; 15 (20) 26 cingulum width; (11 specimens) fum. HNO_3 + 5% KOH; Half Seam (top leaf) at 12.54 m, borehole No.964, Plenmeller Coalfield, England.

Description. Amb triangular to rounded triangular. Laesurae indistinct obscured by ornament. The proximal surface of the central body is finely punctate. Both cingulum and distal surface are heavily ornamented with mainly verrucose elements 2 - 7 μm in basal diameter and 2 - 6 μm in height, as well as wide based cones, spines and galeae. These elements become more closely packed on the cingulum and are arranged into two or three concentric continuous ridges or cristae. Cingulum more or less occupies half of the spore radius. Margin deeply serrated by different shape and size of ornament. 25 - 35 elements project from the margin.

Remarks. In addition to the verrucate elements which mainly cover the cingulum and distal surface, the specimens described above show a remarkable variation in type of ornament. They vary from grana, coni to baculae with wart-like projections or setose tips to galeae and spines.

Comparison. C. connexus is distinguished from other species in the genus in its ornament consisting mainly of verrucate sculpture. Densosporites spackmanii Habib 1966 closely resembles C. connexus.

Previous records. Potonie and Kremp 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Love and Neves 1965, Westphalian B, Inninmore, Scotland; Smith and Butterworth 1967, Upper Westphalian A to B, British Coalfield.

Occurrence. Absent to rare throughout the Westphalian sequence.

Cristalisporites indignabundus (Loose) Staplin and Jansonius, 1964.

Plate 22 Figures 5, 6

1932 Sporonites indignabundus Loose in Potonie, Ibrahim and Loose, p.451. Pl.19, fig.51.

1934 Apiculati-sporites indignabundus Loose, p.153.

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

1954 Cristatisporites indignabundus (Loose); Potonie and Kremp, p.142.

1964 Cristatisporites indignabundus (Loose); Staplin and Jansonius, p.108, Pl.19, figs. 7 - 9, 12, 14, 20.

Holotype. Potonie and Kremp 1955, Pl.16, Fig.294 after Loose. Preparation IV 24, d4 (oI)

Type locality. Bismarck Seam, Ruhr Coalfield, Germany, Upper Westphalian B.

Diagnosis. In Smith and Butterworth, 1967, P.254 (from emendation in Staplin and Jansonius 1964, p.108).

Size in Micrometres. (i) Holotype 52.5, 50-80; Schulze (Potonie & Kremp, 1955) (ii) 44 (52) 61; fum. HNO_3; Yorkshire Coalfield, England; Westphalian B; (Smith and Butterworth 1967) (iii) 47 (56) 71 (8 specimens), 1/3 conc. + 2/3 fum. HNO_3.from various seams throughout the Westphalian sequence, Plenmeller Coalfield, England.

Description. Amb subtriangular to subcircular. Laesurae indistinct, due to the heavy ornament. Central body not well defined, minutely granulate proximally. Distal surface with prominent warts, frequently fused at their bases, 5 - 9 µm in basal diameter and 3 - 7 µm in height, often with setose apices, smaller and widely separated towards the outer margin. Cingulum differentiated into an inner darker zone and an outer lighter zone, ornamented with cristae as above.

Remarks. C. splendidus Artüz 1957 (45 - 63 µm) is very similar in shape and type of ornament to C. indignabundus. This similarity leads one to suggest that the species are conspecific.

Comparison. C. indignabundus has the same size range and more or less the same type of ornament as C. connexus Potonie and Kremp 1955, but it differs in having more closely packed distal verrucae and less definite central body due to the crowding of verrucae near the margin of the central body.

Previous records. *Artuz 1957, Westphalian A, Zonguldak Coalfield, Turkey; *Owens and Burgess 1965, Westphalian A and B, Stainmore Outlier, Westmorland, for *C. splendidus Artuz 1957. Kosanke 1950, Tradewater Group, Illinois, U.S.A.; Potonie and Kremp, 1955, Upper Westphalian B, Ruhr Coalfield, Germany; Smith and Butterworth, Westphalian B, British Coalfield; Felix and Burbridge 1967, Upper Mississippi/Lower Pennsylvania, Springer Formation, Southern Oklahoma, U.S.A.; Beju 1970, Visean to Namurian, Moesian Platform, Romania; Owens et al. 1977, Upper Namurian B to Westphalian A, Northern England and Scotland; Clayton et al. 1978, Westphalian B, Western Europe; Ravn 1979, Pennsylvania, Cherokee Group, CP-19-4, Iowa, U.S.A.

Occurrence. Absent to rare throughout the Westphalian sequence.

Cristatisporites pannosus (Knox) Butterworth and Smith (in Butterworth et al. 1964)

Plate 22 Figures 17 - 19 & 21

1948 Densosporitis pannosus Knox, pl. 1, fig.9K.

1950 Densosporites pannosus Knox, p.17, pl.18, fig.267.

1964 Cristatisporites pannosus (Knox) Butterworth and Smith; Butterworth et al., P.1053, Pl.1. fig.20.

Holotype. Not designated.

Type locality.Fifeshire Coalfield, Scotland; Limestone Coal Group.

Diagnosis. Knox 1950, p.325.

Size in micrometres. (i) 50 - 75, Schulze and KOH (Knox, 1950). (ii) 44 (50) 53, Cingulum 10 (12.5) 16, (12 specimens); HF + fum HNO_3, black shale (sample N22) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular with straight to concave sides and broadly rounded angles. Laesurae distinct, straight, ridged, 2 - 7 µm wide and up to 3 µm in height, covered with grana, large coni and spinae which extend almost to the equatorial margin. Cingulum differentiated into inner darker zone 3 - 5 µm in width and outer, thinner, wider zone, 6 - 9 µm. Cingulum and distal polar area often densely covered with grana and cristae reduced proximally and rising to spines at the cingulum; 1 - 2 µm in basal diameter, 1 - 2 µm apart and projecting, 3 - 11 m at the margin.

Comparison. C. pannosus differs from C. connexus Potonie and Kremp 1955, C. indignabundus (Loose) Staplin and Jansonius 1964 and C. sp. A. in its prominent ridged laesurae and its sharply long spines rather than verrucate or saetose sculpture. D. spinosus Dybova and Jachowicz 1957 is very similar morphologically. It differs from C. pannosus in having a smaller size, simple laesurae, a narrow cingulum and shorter spinae. C. echinatus Playford 1963 (58 - 96 µm) is very similar but larger.

Previous records. Knox 1950, Limestone Coal Group, Scotland; Butterworth and Williams 1958, Namurian A, Scotland; Neves 1961, Namurian B - C, Southern Pennines; Owens and Burgess 1965, Namurian B - C. Stainmore Outlier, Westmorland; Neves and Sabry 1970, Namurian A, Sanquhar Coalfied, Scotland.

Occurrence. Absent to rare in Park Burn and Pinking Cleugh sections.

Cristatisporites sp.A

Plate 22 Figures 7, 8

Type locality. Half seam (top leaf) at 12.59 m, borehole No.964, Plenmeller Coalfield.

Size in micrometres. (i) 44 (54) 66, spore diameter, 16 (20) 26, cingulum width and 9 (18.5) 26, polar area diameter; Fum. HNO_3 + 2% KOH (4 specimens); Half Seam top leaf) at 12.54 m, borehole No.964, Plenmeller Coalfield.

Description. Equatorial outline sub circular to subtriangular. Laesurae often indistinct. Central polar area ornamented distally with baculae, capillae and verrucae of variable shape and size, basal diameter varies between 3 - 7 µm; these verrucae are more predominant than the baculae; the proximal surface punctate to minutely granulate, grana not exceeding 5 µm in height and width; these elements extend to the cingulum. Cingulum forms 55 - 65% of spore diameter and is differentiated into an inner darker zone, 7 - 10 µm wide and an outer thinner zone, 4 - 6 µm wide, modified by projecting verrucae and baculae, which are arranged as ridges and not closely packed, varying in height between 10 - 14 µm and 3 - 5 µm in width, the tips of verrucae sometimes branched, pointed, blunt or rounded in shape. 25 - 35 verrucae, baculae and capillae project at the margin.

Comparison. C. connexus Potonie and Kremp 1955 has closely packed, short verrucae and the distal surface is covered with verrucae only. C. indignabundus (Loose) Staplin and Jansonius 1964 is distinguished in its distal sculptural elements, which consist of short prominent verrucae sometimes connected at their bases, and also the zona is not well defined.

Occurrence. Rare in black shale with plant fragments (sample P.71). Bore hole No.1350 and in Half Seam (top leaf) at 12.54 m, Borehole No.964 Plenmeller Coalfield; and in Little Main Seam (Sample

C5), Low Close Opencast Site, Cumbria.

Genus RADIIZONATES Staplin and Jansonius 1964

Type species. R. aligerens (Knox) Staplin and Jansonius 1964.

Diagnosis. In Smith and Butterworth 1967, p.263 (from diagnosis in Staplin and Jansonius 1964, p.106)

Comparison. The strong radial plications of the outer part of the cingulum, and lack of a cuesta, distinguish this genus from Cingulizonates.

Radiizonates aligerens (Knox) Staplin and Jansonius 1964.

Plate 22 Figures 20 & 22

1950 Cirratriradites aligerens Knox, p.329, Pl.19. Fig.288.

1964 Radiizonates aligerens (Knox); Staplin and Jansonius, P. 106, Pl.18, Figs. 23 - 28, text fig. 2r.

Neotype. Smith and Butterworth 1967, (pl.21, figs.9, 10). Knox did not designate a holotype. A neotype was selected by Staplin from Scottish materials T80/1 in collection of the National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Glass Seam at 819 ft. 8 in. Monkton House borehole, Lothians Coalfield, Scotland; Westphalian A.

Diagnosis. In Smith and Butterworth 1967, p.263 (from Staplin and Jansonius 1964, p.106).

Size in micrometres. (i) 70 - 90, Schulze and 10% KOH (Knox 1950). (ii) Neotype 59, 47 (59) 76, Schulze and 5% KOH; type locality. (iii) 48 (60) 76, fum. HNO_3 Durham Coalfield, England. Westphalian A: (Smith and Butterworth, 1967) (iv) 40 (49) 60, spore diameter, 3 (4) 6 inner thickness, 10 (11.5) 16, outer thin zone, (22 specimens); 1/3 conc. + 2/3 fum. HNO_3; Bounder Seam at 8.44 m, Borehole No.1154, Plenmeller Coalfield, England.

Description. Equatorial outline subtriangular to subcircular. Laesurae faint, simple, straight to flexuose, extending to the inner margin of the proximal polar area. Exoexine ornamented distally in the polar area with small grana and coni. Equatorial part of exoexine is differentiated into an inner thicker narrower zone and an outer thinner wider zone. Zones extremely variable in width with irregular radial ribs which extend to the equatorial margin proximally as well as distally.

Comparison. R. aligerens is distinguished from other species of the same genus by its large size and by its broad zona and prominent radial ribs.

Previous records. Knox 1950, Westphalian A, Scotland; Owens and Burgess 1965, Upper Westphalian A, Stainmore Outlier, Westmorland; Smith and Butterworth 1967, Upper Westphalian A, British Coalfields; Neves 1968, Upper Westphalian A, Woodland borehole, Co. Durham; Sabry and Neves 1970, Upper Westphalian A, Sanquhar Coalfield, Scotland; Grebe 1972, Westphalian A, Ruhr Coalfield, Germany; Van Wijhe and Bless 1974, Upper Westphalian A, Netherlands; Clayton et al. 1977, Upper Westphalian A, Western Europe.

Occurrence. Absent to rare throughout the Westphalian sequence. Common in Bounder Seam, Plenmeller Coalfield; Cannel Seam, Stublick Bog; and frequent in Top Tilley Seam, Hedley Park. Absent throughout the Westphalian sequence in Low Close Opencast Site, Cumbria.

Radiizonates difformis (Kosanke) Staplin and Jansonius,1964.

1950 Cirratriradites difformis Kosanke, P.35, Pl.7 Fig.3.

1964 Radiizonates difformis (Kosanke); Staplin and Jansonius, p.106.

Holotype. Kosanke 1950, Pl.7, fig.3. Preparation 625 - B, slide 7.

Type locality. Willis Coal, Gallatin County, Illinois, U.S.A.; Tradewater Group.

Diagnosis. In Smith and Butterworth 1967, p.264 (from description in Kosanke 1950, p.35).

Size in micrometres. (i) Holotype 63 x 53.3, body 31.5; 52-68, Schulze and 10% KOH (Kosanke) 1950.

Radiizonates cf. difformis (Kosanke) Staplin and Jansonius 1964 in Smith and Butterworth 1967.

Plate 22 Figures 15, 16

1967 Radiizonates cf. difformis (Kosanke) Staplin and Jansonius in Smith and Butterworth, p.264, Pl.21, Figs. 14 - 16.

Size in micrometres. (i) 42 (47) 54, thickened inner area of cingulum 3 (6) 8, thin outer area of cingulum 7 (9) 12 fum. HNO_3, Lothians Coalfield, Scotland; Westphalian A, (Smith and Butterworth 1967). (ii) 41 (52) 62, thickened inner area of cingulum 5 (6) 10, thin outer area of cingulum 7 (8) 11, (14 specimens); fum. HNO_3 + 5% KOH, Wellsyke Seam at 22.62 m. Borehole No.964. (iii) 32 (37) 44, thickened inner area of cingulum 3 (5) 6, thin outer area of cingulum 4 (7) 8, (10 specimens) fum. HNO_3, Slag Seam (top leaf) at 49.56 m, borehole No.1140. (iv) 37 (42) 50, thickened inner area of cingulum 3 (5.5) 7, thin outer area of cingulum 6 (7) 9 (20 specimens); 1/2 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute); Upper Craignook Seam (bottom leaf) at 21.58m, borehole No.1154, (ii, iii & iv) Plenmeller Coalfield, England.

Description. Amb. triangular to subtriangular. Laesurae distinct to indistinct, simple, straight to flexuose, extending to the inner margin of the cingulum. Exoexine laevigate to minutely punctate proximally and minutely granulate with some scattered verrucae and coarse coni distally. Cingulum differentiated into more or less equal in width parts, but often the inner thicker part narrower and composed of ridges and ribs radiating from the margin of the polar area and extending into the outer membraneous part. The membraneous part of the cingulum occasionally folded or slightly twisted.

Remarks. As stated by Smith and Butterworth 1967, R.cf. difformis differs from the type species in its wider inner thickened area of the cingulum. In the present study the specimens examined have shown the same feature, therefore the species is assigned to R. cf. difformis.

Comparison. This species is distinguished from R. aligerens (Knox) Staplin and Jansonius 1964 by its smaller size, narrower outer part of the cingulum and slightly wider inner part of the cingulum. R. striatus (Knox) Staplin and Jansonius 1964 differs in its thinner outer part of the cingulum and less developed radial ribs. R. faunus (Ibrahim) Smith and Butterworth 1967 and R. tenuis (Loose) Butterworth and Smith 1964 are smaller in size and have a narrower cingulum.

Previous records. Smith and Butterworth 1967, Westphalian A, British Coalfields.

Occurrence. Absent to infrequent throughout the Westphalian sequence. Absent throughout the Westphalian sequence in the Low Close Opencase Site, Cumbria. Common in Upper Kellah Coal Seam (sample M3), Kellah Burn Section, Featherstone area.

Radiizonates striatus (Knox) Staplin and Jansonius 1964.

Plate 22 Figures 9 - 14

1950 Cirratriradites striatus Knox, P.330, Pl.19, fig.289.

1957 Densosporites marginata Artüz, p.252, Pl.6. Fig.42

non 1958 Densosporites striatus (Knox) Butterworth and Williams, p.380, Pl.3. Fig.36.

1964 Radiizonates striatus (Knox); Staplin and Jansonius, p.106.

Neotype. Butterworth and Williams 1954, Pl.18. Fig.1. Specimens number PF 3009 (formerly 76486), Geological Museum, London. This specimen was one of two designated as hypo~~to~~types by Butterworth and Williams.

Type locality. Ruabon Yard Seam, 388's Drift, Llay Main Colliery, North Wales Coalfield; Upper Westphalian A.

Diagnosis. In Smith and Butterworth 1967, p.265 (from description in Butterworth and Williams 1954, p.757).

Size in micrometres. (i) 36 (46) 58, Schulze and 5% KOH. (ii) 35 (44) 53 fum. HNO_3, (i & ii Type locality Butterworth and Williams 1954). (iii) 41 (54) 64, inner thickened zone 4 (7.5) 11, outer thin zone 2 (4) 6 (40 specimens); fum. HNO_3 + 5% KOH: Wellsyke Seam at 22.62 m, borehole No.964; Plenmeller Coalfield, England. (iv) 32 (36) 42, inner thickened zone 2 (3) 4, outer thin zone 3.5 (5) 8, (11 specimens) HF + fum. HNO_3, black shale (sample M18), from above the Upper Fell Top Limestone, Featherstone area.

Description. Equatorial outline triangular to subtriangular with rounded angles and convex sides. Laesurae distinct to indistinct. Cingulum is differentiated into two zones, an inner thicker zone, which is uniform in width and an outer thinner zone, not uniform and varying between 2 - 10 μm. The thicker zone sometimes possesses bands of radial thickening which extend and support the thinner zone. Margin undulate and occasionally folded. Scattered verrucae 3-5 in number and small grana cover the exine distally and to a lesser extent proximally.

Remarks. The specimens examined from the Namurian sequence show some differences from those specimens examined from the Westphalian strata in shape, width of the two zones and number of striations. The Namurian specimens show a thinner and less sculptured exoexine and wider cingulum, especially the outer thinner zone, with more long radial plications. The Namurian specimens more resemble *Cingulizonates radiatus* Dybova and Jachowicz 1957, which is mentioned by Smith and Butterworth 1967, p. 266, as probably conspecific with *R. striatus*.

Comparison. *Cingulizonates loricatus* (Loose) Butterworth *et al*. 1964 and *Cingulizonates bialatus* (Waltz) Butterworth *et al*. 1964 differ in their inner thickened raised part of the cingulum (cuesta) which lacks the radial plications.

Previous records. Butterworth and Williams 1958, Namurian A, Scotland; Artüz 1957, Westphalian A, Zonguldak Coalfield, Turkey; Sullivan 1962, Westphalian A, South Wales; Smith and Butterworth 1967, Westphalian A, British Coalfields; Van Wijh and Bless 1974, Westphalian A, Netherlands.

Occurrence. Absent to common throughout the Namurian sequence, common in black shale (sample M18) from above the Upper Fell Top Limestone, Featherstone area. Rare to common throughout the Westphalian sequence. Absent throughout the Westphalian sequence in Low Close Opencast Site, Cumbria.

Genus VALLATISPORITES Hacquebard 1957

Type species. *V. vallatus* Hacquebard 1957.

Diagnosis. In Sullivan 1964, p. 370 (restatement from Hacquebard 1957, p. 312).

Remarks. Sullivan 1964 and Owens in Neves and Owens 1966 observed that some species in the genus "have a thinner transulucent intexine, which is folded independently of the exoexine and frequently withdrawn from the margin of the spore cavity" as stated by Sullivan in his description of V. ciliaris (Luber) Sullivan 1964. This cavity development feature led Neves and Owens 1966 to place this genus in the Subturma Membranatitriletes.

Comparison. The development of a narrow cavity "cuniculus" adjacent to the equatorial margin of the spore body as well as the presence of vacuoles within the equatorial extension of the exoexine distinguish this genus from others which are closely similar, such as Kraeuselisporites (Leschik) Owens, Mishell, and Marshall 1976; Cirratriradites Wilson and Coe 1940; Spinozonotriletes (Hacquebard) Neves and Owens 1957.

Vallatisporites ciliaris (Luber) Sullivan 1964

Plate 24 Figure 9

1938 Zonotriletes ciliaris Luber, in Luber and Waltz, p. 25, pl. 6, fig. 82.

1964 Vallatisporites ciliaris (Luber); Sullivan, p.370, pl. 59, figs. 14, 15.

Holotype. Not designated in the literature.

Diagnosis. Luber in Luber and Waltz 1938, p. 25, and the description in Sullivan 1964, p. 370.

Size in micrometres. (i)

(ii) 50 (62) 70, HF + 2% KOH (Sullivan 1964). (iii) 50, 54 and 57

(3 specimens) HF + fum. HNO_3, black shale (sample M18) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular to subcircular with broadly rounded angles, and convex sides. Laesurae distinct, ridged, flexuose, extending to the margin of spore body; laesurae accompanied by folds, up to 2-3 µm high and 2 µm wide. Exoexine laevigate proximally and infrapunctate distally. Distal surface bears coni, grana and small spines 1-2.5 µm in height and 0.5-1.5 µm in basal diameter. The central body is well defined and separated from the cingulum by a structure of small vacuoles within the flange; therefore the cingulum shows a bizonate structure with an inner lighter, narrower zone with vacuoles and an outer, slightly thicker, wider zone.

Comparison. V. ciliaris is distinguished from V. communis Sullivan 1964 and V. galearis Sullivan 1964 in its smaller grade of ornament on the distal surface.

Previous records. Luber and Waltz 1938, Lower Carboniferous, Karaganda Basin, U.S.S.R.; Sullivan 1964, Drybrook Sandstone, (Visean), Forest of Dean Basin, Gloucestershire; Butterworth and Spinner 1967, Lower Carboniferous, N.W. England.

Occurrence. Rare in black shale (sample M18) from above the Upper Fell Top Limestone, Featherstone area.

Vallatisporites vallatus Hacquebard 1957

Plate 24 Figures 7, 8

Holotype. Hacquebard 1957, p. 312, M 101, Slide 5, at 39.6 by 106.3.

Type locality. West Core and Blue Beach samples, Horton Group, Nova Scotia.

Diagnosis. In Hacquebard 1957, p. 312.

Size in micrometres. (i) 60-70, body 35-41, Schulze (Hacquebard 1957). (ii) 42 (61) 75 (4 specimens), HF + fum. HNO_3, black shale (sample M18) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb triangular with convex sides and broadly rounded angles. Laesurae distinct, simple, straight to slightly flexuose, accompanied by folds 2-3 µm wide and up to 2 µm high extending to the margin of the intexine. Exoexine laevigate to infrapunctate proximally and ornamented distally with grana and coni 1-3 µm in basal diameter, 1-2 µm in height and 2-3 µm apart. Central body well defined and separated from the flange by small, distinct vacuole structure. Flange 5-8 µm wide. Margin of both central body and flange are serrated.

Comparison. *V. verrucosus* Hacquebard 1957 is distinguished in having a verrucate sculpture on the distal surface.

Previous records. Hacquebard 1957, and Playford 1963, Lower Carboniferous, Horton Group, Nova Scotia; Neves 1961, Upper Namurian B and C, Southern Pennines; Owens and Burgess 1965, Namurian A to lower Namurian C, Stainmore Outlier, Westmorland; Clayton *et al*., Namurian A and B, Western Europe.

Occurrence. Absent to rare in samples from Park Burn and Pinking Cleugh section.

Spore Type A1

Plate 23 Figures 8 - 15

Type locality. Dark shale (sample M20) above the Upper Fell Top Limestone, Featherstone area.

Diagnosis. Spore radial, trilete. Amb triangular to rounded triangular. Laesurae distinct, faint, narrowly tectate, flexuose, terminating in curvaturae imperfectae. Intexine ? laevigate, indistinct. Exoexine with prominent proximal cuesta, dark brown in colour, 3 - 5 µm in width and a thin, translucent outer zone, 4 - 7 µm in width. Margin of cuesta undulating, sometimes with arcuate depressions at the spore apices. The distal exoexine has narrow, 1 - 2 µm in width, radial bands of thickening and forming an irregular reticulum. Polar areas of exoexine thin, laevigate to minutely punctate. Interradial papillae sometimes discernible.

Size in micrometres. (i) 29 (35) 40, width of cingulum 6 - 12, (30 specimens), HF + fum. HNO_3, Dark shale (sample M20), above the Upper Fell Top Limestone.

Comparison. Cingulizonates loricatus (Loose) Butterworth et al.,1964 and C. bialatus (Waltz) Smith and Butterworth 1967 have a prominent high proximal cuesta with radial projections into the thin outer flange, and ornament of the distal polar area of the exoexine. Radiizonates spp. have a radially plicate cingulum, the plications or thickenings of which project into the much thinner, outer flange.

Occurrence. Frequent in dark shale (sample M20) from above the Upper Fell Top Limestone, and rare in shaley coal (sample M19) from Burnfoot shale section, Featherstone area.

Spore Type A 2

Plate 23 Figures 16 - 25

Type locality. Dark shale (sample M20), above the Upper Fell Top Limestone, Featherstone area.

Diagnosis. Spore radial, trilete. Amb subcircular to rounded triangular. Laesurae distinct, simple, straight to flexuose. Intexine ? laevigate, indistinct. Exoexine, thin, laevigate to punctate. Cingulum 6 - 11 μm in width differentiated into a prominent proximal cuesta, 3 - 6 μm in width and lying 4 - 7 μm from the equatorial margin. Margin undulating, and two less prominent distal zones of thickening, an inner thinner, narrower zone 2 - 4 μm in width, and an outer slightly thicker zone 2.5 - 4 μm in width. The distal exoexine sometimes has narrow 1 - 2 μm radial bands of thickening connecting the two concentric zones. Interradial papillae sometimes discernible.

Size in micrometres. 32 (36) 41 (20 specimens); HF + fum HNO_3, dark shale (sample M20) from above the Upper Fell Top Limestone, Featherstone area.

Comparison. Spore type A1 closely resembles the specimens described above apart from the absence of the outermost distal thickened zone and the presence of more radial bands of thickening. Potoniespores delicatus Playford 1963 (p.643, Pl.91, figs. 12,13) is distinguished in its well defined triangular shape with markedly concave to slightly convex sides, and the lack of radial thickenings. As mentioned by Playford the cingulum is differentiated into an inner, thicker, wider (1/2 - 2/3 of total width of the cingulum) zone, and an outer thinner zone. But from his photographs it seems that the outer thinner part is differentiated into an outer thicker zone and an inner thinner zone. Monilospora dignata Playford 1963 (p.642, Pl.92, figs. 4,5) is distinguished by its larger size range (48 -

64 µm), lack of radial thickenings, wider cingulum (12 - 17 µm in width), absence of distal cuesta, and elevated, marginal thickenings (5 - 9 µm) in width.

Occurrence. Frequent in black shale (sample M20) from above the Upper Fell Top Limestone, Featherstone area.

Infraturma CONTINUATI Neves and Owens 1966

Trilete, camerate miospores distinguished by a single, continuous equatorial chamber concentric with the amb of the intexine.

Remarks. Separation of the intexine and exoexine occurs essentially in the sub-equatorial region of the intexine on both the proximal and distal surfaces. This feature provides a more or less rigid relationship between the two exine layers.

Genus DISCERNISPORITES (Neves) Neves and Owens 1966

Type species. *D. irregularis* Neves 1958.

Diagnosis. In Neves and Owens 1966, p.357.

Comparison. Distinguished by the equatorial extension of the exoexine containing a single, continuous chamber peripheral to the intexine.

Discernisporites irregularis Neves 1968

Plate 24 Figure 6

1958 *Discernisporites irregularis* Neves, p.4, Pl.3. figs.5-6, Text fig.1.

Holotype. Neves 1958, Pl.3, fig.5, slide F.745, ref.244639.

Type locality. *Gastrioceras subcrenatum* marine shale, North Staffordshire Coalfield, England; Namurian C.

Diagnosis. In Neves 1958, p.4.

Size in micrometres (i) Holotype 80, 50 - 100, Schulze and KOH (Neves 1958) (ii) Spore diameter 73, 78; Intexine 53, 56 (2 specimens), HF + fum. HNO_3; black shale (sample M13, from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular, with convex sides and rounded apices. Intexine circular to rounded triangular in shape. Laesurae distinct, straight, flexuose, extending to the inner margin of the intexine; lips well developed, 2 - 5 µm in width and flexuose folds up to 3 µm in height, extending almost to the margin of the exoexine. Exoexine thin, ornamented proximally with coarse coni and verrucae 2 - 3 µm in basal diameter and up to 2 µm in height, which fuse at their bases to form irregular ridges 2 - 3 µm in width and height, and only 3 - 7 µm long, these become more dense in the polar area. Slight thickening developed at the equatorial margin, 1 - 2 µm in width. Secondary folds infrequently occur.

Comparison. Distinguished by the development of irregular ridges in the proximal polar area.

Previous records. Neves 1958, Namurian/Westphalian boundary, North Staffordshire; Marshall and Williams, 1970, Visean/Namurian A boundary, Roman Wall District, Northern England.

Occurrence. Rare in black shale (sample M13) from above the Lower Fell Top Limestone, Featherstone area.

Discernisporites micromanifestus (Hacquebard) Sabry and Neves 1970

Plate 24 Figure 5

1957	Endosporites micromanifestus Hacquebard, p.317, Pl.3. fig.16
1958	Discernisporites concentricus Neves, p.5, Pl.3, fig.7.
1960	Auroraspora micromanifestus (Hacquebard); Richardson, p.51, Pl.14, figs.1, 2.
1960	Endosporites micromanifestus Hacquebard in Love, p.121, Pl.2, Fig.6.
1963	Endosporites micromanifestus Hacquebard in Playford, p.652, Pl.93, Figs, 17, 19.

1966 Endosporites micromanifestus Hacquebard in Neves and Owens, P.357.

1970 Discernisporites micromanifestus (Hacquebard) Sabry and Neves, P.1445, Pl.3. Fig.2.

Holotype. Hacquebard 1957, p.317, Pl.3, fig.16. M.101, Slide 10.

Type locality. Horton Group, Nova Scotia, Canada.

Diagnosis. In Hacquebard 1957, p.317.

Size in micrometres. (i) 57 - 100, body 37 - 67, Schulze (Hacquebard 1957). (ii) 75, 79, intexine 51 - 56, (2 specimens); HF + fum. HNO_3, black shale (sample M13) above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular, with convex sides and rounded to broadly rounded angles. Intexine conformable to more or less rounded triangular. Laesurae distinct, flexuose, extending to the outer margin of the intexine, accompanied by well developed lips 4 - 7 µm in width and up to 4 µm high. Intexine slightly thicker and darker than the exoexine; both show an infrapunctate to infragranulate ornament. Limbus not present. Margin of the intexine distinct.

Comparison. Distinguished from Endosporites zonalis (Loose) Knox 1950 by its well developed lips which extend almost to the outer margin of the spore.

Previous records. Hacquebard 1957, Lower Mississippian, Horton Group, Canada; Neves 1958, Namurian C/Westphalian A boundary north Staffordshire, Southern Pennines; Love 1960, Lower Oil Shale Group (Upper Visean), Scotland; Playford 1963, Lower Carboniferous Spitsbergen; Playford 1964, Lower Mississippian, Horton Group, Canada; Sullivan and Marshall 1966, Upper Visean, Middle Valley of Scotland; Butterworth and Spinner 1967, Lower Carboniferous, northern England; Felix and Burbridge 1967, Springer Formation, Oklahoma, U.S.A; Beju 1970, Visean, Moesian Platform, Romania; Sabry and

Neves 1970, Upper Visean and Namurian, Sanquhar Coalfield, Scotland; Marshall and Williams 1970, Visean/Namurian boundary, Roman Wall District, Northern England, and also recorded by several workers in the Visean-Namurian rocks.

Occurrence. Rare in black shale (sample M13) from above the Lower Fell Top Limestone, Featherstone area.

Genus SPINOZONOTRILETES (Hacquebard) Neves and Owens 1966.

Type species. S. uncatus Hacquebard 1957.

Diagnosis. In Neves and Owens 1966, p.355 (emended from Hacquebard 1957, p.316.

Remarks. Neves and Owens 1966, emended the diagnosis of the genus to clarify its structure as a camerate spore. They indicated that the exoexine is attached to the intexine on both proximal and distal surfaces, with a variable separation between the two layers.

Comparison. Grandispora Hoffmeister, Staplin and Malloy, 1955 is distinguished by possessing a thin exoexine which is attached to the intexine only in the region of the trilete rays. Vallatisporites Hacquebard 1957 is distinguished by its smaller size and the development of numerous vacuoles within the equatorial extension of the exoexine.

Spinozonotriletes uncatus Hacquebard 1957

Plate 27 Figure 13

1957 Spinozonotriletes uncatus Hacquebard, p.316, Pl.3,figs. 8 - 10.

Holotype. Hacquebard 1957, Pl.3, fig.8, M.101, Slide 1, at 40.8 by 97.5

Type locality. Horton Group, Nova Scotia, West Gore and Blue Beach samples.

Diagnosis. In Hacquebard 1957, p.316.

Size in micrometres. (i) Holotype 144 x 148, 82 - 148, body 62 - 103, Schulze (Hacquebard 1957). (ii) 78 and 81 (2 specimens): HF + fum. HNO_3, black shale (sample M13), above the Lower Fell Top Limestone, Featherstone area.

Description. Amb circular to rounded triangular. Laesurae distinct, extending to the margin of intexine. Intexine indistinct. Exoexine thick, 2 - 4 µm in thickness, ornamented with broad based spines, 2 - 7 µm in basal diameter, and up to 5 µm high.

Remarks. specimens described above confirm to the original diagnosis and description given by Hacquebard 1957.

Comparison. S. tuberculatus Neves and Owens 1966 is distinguished by the larger size of the sculptural elements and their uniformly dense distribution.

Previous records. Hacquebard 1957, Lower Mississippian (Tournasian), Horton Group, Nova Scotia, Canada; Owens and Burgess, 1965, Upper Visean to lower Namurian A, Stainmore Outlier, Westmorland; Beju 1970, Visean, Moesian Platform, Romania; Owens et al. 1977, Upper Visean to lower Namurian A, Northern England and Scotland, Clayton et al. 1978, Upper Visean to lower Namurian A, Western Europe.

Occurrence. Rare in black shale (sample M13) above the Lower Fell Top Limestone, Featherstone area.

Genus SPENCERISPORITES Chaloner 1951

Type species. S. radiatus (Ibrhaim) Felix and Parks 1959.

Diagnosis.In Smith and Butterworth 1967, p.268 (from diagnosis in Chaloner 1951, p.861).

Comparison. Differs from Endosporites in shape and mode of attachment of pseudosaccus (wing) to body. (In Smith and Butterworth, 1967).

Spencerisporites radiatus (Ibrahim) Felix and Parks 1959.

Plate 24 Figures 11, 12

1932 Sporonites radiatus Ibrahim in Potonie, Ibrahim and Loose, p.442, Pl.16. Fig.25.

1933 Zonales-sporites radiatus Ibrahim, p.28, Pl.3. fig.25.

1934 Triletes karczewskii Zerndt, p.27. Pl.31, fig.3.

1944 Triletes radiatus (Ibrahim); Schopf, Wilson and Bentall,p.45.

1946 Microsporites karczewskii (Zerndt); Dijkstra and van Vierssen Trip, p.64, pl.4, fig.40.

1951 Spencerisporites karczewskii (Zerndt); Chaloner, p.862, text. figs. 1,2 and 6,7.

1955 Endosporites ? radiatus (Ibrahim); Dijkstra, p.342, Pl.45, Fig.54.

1956 Microsporites radiatus (Ibrahim); Dijkstra; Potonie and Kremp, p.156, Pl.20, figs.449, 450.

1959 Spencerisporites radiatus (Ibrahim) Chaloner; Felix and Parks p.362, Pl.1, figs.1 - 4 and Pl.2, figs. 1 - 4.

Holotype. Potonie and Kremp 1955, Pl.20, fig.400 after Ibrahim 1932, Preparation B43, C6 (ul).

Type locality. Agir Seam, Ruhr Coalfield, Germany, Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p.269 (abbreviated from Chaloner 1951 for S. karczewskii).

Size in Micrometres. (i) Holotype 330, Schulze and KOH. (ii) 270 - 440, Schulze (Potonie and Kremp 1956). 252 (288) 343, Schulze and NaOH (Chaloner 1951) Lancashire Coalfield, England; Westphalian A. (iv) 240 - 260 (10 specimens) Schulze or fum. HNO_3, various localities, England; Westphalian A and B (Smith and Butterworth 1967) (v) 208 - 246 (10 specimens) 1/3 conc. + 2/3 fum. HNO_3, from various localities, within the sequence, Plenmeller Coalfield, England.

Description. Amb triangular with rounded angles and straight to convex sides, amb of spore body circular to subcircular, 130 - 170 µm in diameter, and occupying about 40% of overall spore diameter. Laesurae simple, straight to flexuose, accompanied by ridged, flexuose folds, 5 - 10 µm in width and up to 5 µm in height, extending beyond the central body a short distance. Contact area characterised by heavy, 1 - 2 µm wide, muri forming an irregular network radiating from three centres, one on each of the three contact faces and extending to the exoexine. Exoexine thin, translucent, broad, ornamented with very low, narrow, less than 0.5 µm in width and height, intersecting muri. Both exine layers frequently folded. Margin more or less crenulate.

Previous records. Numerous workers have recorded this species from Carboniferous rocks including Smith and Butterworth (1967), Visean to Westphalian D of British Coalfields; Marshall and Williams (1970), Namurian A, Roman Wall, Northumberland, England.

Occurrence. Absent to rare throughout the sequence.

Infraturma MEMBRANATI (Neves) Neves and Owens 1966.

Trilete, camerate miospores in which the exoexine has partially separated from the intexine, and projects at the spore margin as a clear, thin membrane. The two exine layers may be attached to one another only in the region of the trilete mark, or the exoexine can be arranged as a series of folds which run over the surface of the spore body membrane.

Genus PROPRISPORITES Neves 1958

Type species. P. rugosus Neves 1958

Diagnosis. In Neves 1958, p.10.

Comparison. The lobate and linear folding of the perisporal membrane is characteristic of this genus.

Proprisporites laevigatus Neves 1961

1961 Proprisporites laevigatus, Neves, p. 269, pl. 33, fig. 9.

Holotype. Neves 1961, Pl.33, fig.9. Slide ref. 5. 304770.

Type locality. Marine shales with Hudsonoceras proteum, Congleton Edge ganister quarry, Staffordshire (Loc.4) Sabdenian stage (H).

Diagnosis. In Neves 1961, p.269.

Size in micrometres. (i) Holotype 77, 70-115, Schulze and KOH (Neves 1961). (ii) 43 (52) 64 (5 specimens), HF + fum. HNO_3, dark shale (sample M20) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb rounded to rounded triangular. Laesurae simple, straight, extending 2/3 of spore radius. Perisporal membrane covering intexine, laevigate and folded into ridges, 2 - 4 μm in height and 1 - 2.5 μm in width, with 5 - 7 μm ridges traversing the spore. The sinuous folds end abruptly at the poles.

Remarks. The size range given above differs from that given by Neves 1961. The specimens described above were restricted to one sample, and they were badly preserved.

Comparison. Differs from P. rugosa Neves 1958 in its laevigate exine.

Previous records. Neves 1961 Namurian A and B, Southern Pennines; Owens and Burgess 1965, Upper Namurian A, Stainmore Outlier, Westmorland; Felix and Burbridge, 1967, Upper Mississippian, Springer Formation, Oklahoma, U.S.A.; Clayton et al. 1977, Namurian A and B Western Europe.

Occurrence. Rare in dark shale (sample M22) above the Upper Fell Top Limestone, Featherstone area.

Genus HYMENOSPORA Neves 1961

Type species. H. palliolata Neves 1961

Diagnosis. In Neves 1961, p.270.

Remarks and comparison. Peppers 1970 and Ravn 1979 discussed a number of morphologically similar genera such as Perotrilites (Erdtman) Couper 1953; Hughes and Playford 1961 and Peppers 1970 used this Mesozoic genus for taxa from Carboniferous sediments as well as some from Palaeozoic rocks such as Hymenospora Neves 1961 and Diaphanospora Balme and Hassell 1962. Evans 1970 emended the diagnoses of Perotrilites and Diaphanospora, restricting the former to zonate rather than perisporate miospores. While he did not discuss the relationship of Hymenospora with the others, he indicated that in the genus Diaphanospora the attachment of the perispore is of a tenuous nature, and this genus appears to have some similarity with Hymenospora, which has a perispore thick enough to obscure details of the central body. Hymenspora also differs in the manner of attachment of perispore to central body (Neves 1961). The new genus erected by Ravn 1979, Thysanites, seems to have some similarity with Hymenospora excepting that it has a zonate structure.

Hymenospora multirugosa Peppers 1970

Plate 27 Figures 10 - 12

1970 Hymenospora multirugosa Peppers p.129, Pl.13, figs. 8 - 9.

Holotype. Peppers 1970, Pl.13, fig.8. Maceration 1384 - U, slide 12, coordinates, 125.6 x 43.1.

Type locality. Danville (No.7) Coal; Illinois, U.S.A; Carbondale formation.

Diagnosis. In Peppers 1970, p.129.

Size in micrometres. (i) Holotype 39, body 32.5; 35.8 - 45.8; body 29.3 - 39; Schulze + 10% KOH (Peppers 1970). (ii) 32 (36.5)

41 (9 specimens), Fum. HNO_3, Eighteen Inch Seam (Sample C2), Low Close Opencast Site, Cumbria.

Description. Amb circular to rounded triangular. Laesurae distinct, simple, straight to slightly flexuose, extending 3/4 or more of spore body (intexine), rays slightly open. Intexine relatively thick, dark brown in colour, with finely granulose (0.5 - 1 μm in basal diameter) to punctate sculpture. Perispore (exoexine) thin, translucent, with a series of narrow linear furrows, along which lines it is attached to the intexine, which forms a zonate-like margin about the body 2.5 - 4 μm in width, (1/6 - 1/8 of the diameter of the spore body.)

Comparison. H. paucirugosa Peppers 1970 is distinguished by its larger size range (55 - 82 μm); H. palliolata Neves 1961 is larger, and possesses a laevigate body; H. caperata Felix and Burbridge 1967 is distinguished by its punctate body and a broad zonate-like exoexine. The exoexine of Diaphanospora vicinata Balme and Hassell 1962 is unornamented and that of D. perplexa Balme and Hassell 1962 is infragranulate, D. cingulata Guennel 1963 has a body ornamented with grana of two different sizes, D. reticulata Guennel 1963 is more triangular and its exoexine is more coarsely punctate. Thysanites densus Ravn 1979 has a zonate structure which usually is folded and widened at apices.

Previous records. Peppers 1970, Carbondale Formation (Pennsylvanian), northeastern part of the Illinois Basin; Ravn 1979, Cherokee Group (Pennsylvanian) CP-19-4 Coal, Iowa, U.S.A.

Occurrence. Rare in Eighteen Inch Seam (Sample C2) and Little Main Seam (sample C5), Low Close Opencast Site, Cumbria.

Infraturma POLYCAMERATI Neves and Owens 1966

Genus ALATISPORITES (Ibrahim) Smith and Butterworth,1967.

Type species. *A. pustulatus* Ibrahim 1932.

Diagnosis. In Smith and Butterworth 1967, p.279 (emended from diagnosis in Potonie and Kremp, 1956. p.154).

Remarks and comparison. This genus is clearly distinguished from all other Carboniferous genera by the presence of three or multiples of three exoexine pseudosacci.

Alatisporites pustulatus Ibrahim 1932

Plate 24 Figures 1 - 4

1932 *Sporonites pustulatus* Ibrahim in Potonie, Ibrahim and Loose, p.448. Pl.14, fig.12.

1933 *Alati-sporites pustulatus* Ibrahim p.32, Pl.1. fig.12.

Holotype.Potonie and Kremp 1956, Pl.19, fig.445 after Ibrahim. Preparation B36, b4 (u).

Type locality. Agir Seam, Friedrich Thyssen 2/5 (Wehofen) Colliery, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p.280 (from Potonie and Kremp 1956, p.155).

Size in micrometres. (i) Holotype 73; 70 - 90, Schulze and KOH (Potonie and Kremp 1956). (ii) 74 (81) 89,(8 specimens) fum. HNO_3; various localities. Westphalian A to C (Smith and Butterworth 1967) (iii) 69 (74) 81, (7 specimens), 1/3 conc. + 2/3 fum. HNO_3; from various seams within the sequence, Plenmeller Coalfield, England.

Description. Amb of body triangular with broadly rounded apices, and straight to slightly convex sides. Laesurae distinct, simple, straight, extending almost to the inner margin of the body. Body moderately thick, ornamented with coarse grana and small verrucae, becoming more packed and coarser near the equator. Margin of the body crenulate. These pseudosacci very thin, translucent, finely punctate or infragranulate, often accompanied by long minor secondary folds.

Comparison. *A. trialatus* Kosanke 1950 is differentiated by its laevigate body and punctate pseudosacci. *A. punctatus* Kosanke 1950 is similar morphologically but has a larger body and highly folded pseudosacci. *A. hoffmeisterii* Morgan 1955, and *A. tessellatus* Staplin 1960 differ in having more than three pseudosacci.

Previous records. Grebe 1962 Upper Westphalian A to C, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Upper Westphalian A to lower Westphalian C, British Coalfields; Loboziak 1971, Westphalian to Stephanian, Houiller Basin, North France; Van Wijhe and Bless 1974, Westphalian C, Netherlands;Ravn 1979, Upper Pennsylvania, Cherokee Group, Iowa, U.S.A.

Occurrence. Absent to rare throughout the Westphalian sequence.

Subturma SOLUTITRILETES Neves and Owens 1966

This subturma includes all trilete, camerate spores in which the intexine is attached to the exoexine only in the proximity of the trilete mark, i.e. there is complete separation equatorially and distally producing a single cavity or camera.

Infraturma DECORATI Neves and Owens 1966

Trilete, camerate miospores; exoexine ornamented with a variety of sculptural elements, i.e. baculae, spines, cones, grana, verrucae.

Genus SPELAEOTRILETES Neves and Owens 1966

Type species *Spelaeotriletes triangulus*. Neves and Owens 1966.

Diagnosis. In Neves and Owens 1966, p.342.

Comparison. *Aculeispores* Artüz 1957 is distinguished by a subcircular amb and the lack of a distinct contact area. Endosporites (Wilson and Coe) Bharadwaj 1965 is closely similar to the above genus morphologically but it differs in lacking ornament. Kraeuselisporites (Leschik) Scheuring 1974 and Vallatisporites (Hacquebard) Sullivan 1964 differ in the thinner distal exoexine and in the presence of numerous vacuoles within the equatorial extension of the exoexine of the latter genus.

Spelaeotriletes arenaceus Neves and Owen 1966

Plate 25 Figures 7 - 10

1966 Spelaeotriletes arenaceus Neves and Owens, p.345 Pl.2, figs. 1 - 3.

Holotype. Neves and Owens 1966, Pl.2, fig.1. Preparation LBG/SG/D.

Type locality. Lower Bentham Grit Coal, Greta River (G.R. SD. 34633718) Lancashire. Sabdenian Stage. Namurian A.

Diagnosis. In Neves and Owens 1966. p.345.

Size in micrometres. (i) 82 - 144; Intexine 44 - 90, maceration method not stated (Neves and Owens 1966). (ii) 70 (83) 105, intexine 37 (47) 63; (11 specimens), HF + fum. HNO_3, black shale (sample M18). (iii) 74 (85) 102 , intexine 36 (42) 49, (5 specimens), HF + fum. HNO_3 , black shale (sample M22). (ii and iii) from above The Upper Fell Top Limestone, Featherstone area. (iv) 74 (86) 93, intexine 50 (53) 60, (4 specimens), HF + fum. HNO_3 black shale (sample M13), from above the Lower Fell Top Limestone, Featherstone area.

Description Amb subcircular to rounded triangular. Laesurae often distinct, straight to flexuose, unequal in length, extending beyond the intexine margin and accompanied by elevated flexuose exoexinal folds up to 3 µm in height and 2 - 5 µm in width. Exoexine relatively thin, 1 - 2 µm, sculptured distally with a mixture of grana, rounded cones and some verrucae, varying in density and size

0.5 - 3.5 μm in basal diameter, 0.5 - 3 μm in height and 1.5 - 4 μm apart; bases sometimes fused to form short irregular ridges. Margin of the spore slightly thicker and defined by 1.3 - 3 μm in width "limbus". Intexine subcircular to subtriangular in shape, not sharply distinct as a darker area. Compression folds frequently occur.

Remarks: S. arenaceus Neves and Owens 1966 (82 - 144 μm) and S. triangulus Neves and Owens 1966 (101 - 175 μm) are differentiated from each other by the fact that the latter has a larger size range and coarser, more densely set and uniformly distributed sculptural elements. This distinction was not always easy to make in practice in the present study and for this reason those two species are placed in S. arenaceus. From photomicrographs of both species in Clayton et.al. 1977. Playford and Powis (1979, p.391) suggested that the species are conspecific with each other.

Comparison. Lophotriletes coniferus Hughes and Playford 1961 identified by Felix and Burbridge 1967, appears to be similar morphologically; Spelaeotriletes ybertii (Marques-Toigo) Playford and Powis 1979 seems to be similar to the species described above but it differs in its indistinct intexinal body; S. obtusus Higgs 1975 is distinguished by its smaller size range (54 - 94 μm) and its larger sculptural elements which are not fused at their bases; S. balteatus (Playford) Higgs 1975 differs in possessing a sculpture of spinae.

Previous records. This species has been recorded by several workers from Namurian sediments.

Occurrence. Absent, rare to common throughout the Namurian sequence.

Spelaeotriletes sp.A

Plate 26 Figures 1 - 5

Type locality. Black shale (sample M13), above the Lower Fell Top Limestone, Featherstone area.

Diagnosis. Spore radial, trilete, camerate. Amb triangular to rounded triangular. Laesurae distinct to indistinct, tecta extend to the margin of the spore. Margin of the spore defined by a limbus. Intexine well defined, rounded to rounded triangular in outline, occasionally eccentric. Distal exoexine covered with coarse grana and some scattered coni and spinae. Elements forming the ornament are normally discrete.

Size in micrometres. (i) 63 (77) 90 (25 specimens), 40% H.F. + fum. HNO_3, black shale (sample M13), from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb triangular to rounded triangular with convex sides and rounded apices. Laesurae distinct, straight to flexuose, narrowly tectate, less than 2 µm in width, extending to margin of the spore. Margin of the spore finely undulating, defined by thickening of exoexine ranging in width between 2 - 5 µm (limbus). Intexine well defined, dark brown in colour, occupying 50 - 60% of the spore diameter, amb rounded to rounded triangular, sometimes eccentrically placed relative to the exoexine, laevigate to faintly punctate. Proximal exoexine laevigate to minutely granulate. Distal exoexine covered with coarse grana, 0.5 - 1.5 µm in basal diameter and 0.5 µm in height and some scattered coni and spinae present.

Comparison. *Spelaeotriletes* *sp.A.* is distinguished from other species of the genus by its well developed intexine, and the presence of a limbus. *S.* *balteatus* (Playford) Higgs 1975 differs by its indistinct intexinal body and exoexine sculpture of spinae.

Occurrence. Rare in black shale (sample M13) above the Lower Fell Top Limestone, Featherstone area.

Spelaeotriletes sp.B

Plate 26 Figures 8 - 14

Type locality. Black shale (sample M13) above the Lower Fell Top Limestone, Featherstone area.

Diagnosis. Spore radial, trilete, camerate. Amb circular to rounded triangular. Laesurae distinct, simple. Curvaturae imperfectae and apical papillae sometimes discernible. Intexine well defined, laevigate, conformable with the amb, diameter approximately 4/5 of overall diameter. Exoexine ornamented with closely spaced grana and small coni and spinae also present.

Size in micrometres. (i) 24 (27) 31, (35 speciments), 40% H.F. + fum. HNO_3, black shale (sample M13), from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb circular, sub circular to rounded triangular. Laesurae distinct, simple, straight, accompanied sometimes by narrow, low folds which extend slightly beyond intexine. Curvature imperfectae and apical papillae sometimes discernible. Intexine more or less defined, occupying 75 - 85% of overall diameter, laevigate to infrapunctate. Exoexine with some scattered short, hair-like elements radially arranged, 1 μm in height and less than 0.5 μm in basal diameter, in the proximal polar area. Distal exoxine covered with grana, coni and small spines 0.5 - 1 μm in basal width and height. Equator of spore with well developed thickened margin, 1.5 - 2.5 μm in width, i.e. limbate.

Remarks. This species is placed in the genus Spelaeotriletes because of the proximal attachment of the intexine and exoexine, the distal ornamentation and the presence of a limbus.

Comparison. Discernisporites crenulatus (Playford) Clayton 1970 is distinguished by its morphological structure, the absence of a limbus and by its larger size range (30-45 m). Grandispora gracilis (Kedo) Streel differs in the absence of a limbus and of curvaturae imperfectae.

Occurrence. Common in black shale (sample M13) above the Lower Fell Top Limestone, Featherstone area.

Genus RUGOSPORA Neves and Owens 1966

Type species. R. corporata Neves and Owens 1966

Diagnosis. In Neves and Owens 1966, p.350.

Remarks and Comparison. Exoexine is attached to intexine in the region of the trilete rays. Intexine thin, laevigate. Exoexine bears a characteristic ornament of microverrucae. Zonalasporites ulughbeki (Ibrahim) in Potonie and Kremp, 1956 is distinguished by the absence of a trilete mark and verrucose ornament. The genus Velamisporites Bharadwaj and Venkatachala 1962 has a wrinkled exoexine which appears to be more comprehensively attached to the intexine.

Rugospora corporata Neves and Owens 1966

Plate 25 Figure 3

1966 Rugospora corporata Neves and Owens, p.353, pl.2. fig.4 - 5 text - fig.2.

Holotype. Neves and Owens 1966, pl.2., fig.4; S.G.No.6.8.19.

Type locality. Marine shales with Gastrioceras cancellatum, Crowborough Wood (G.R. SJ 902556), Nr. Biddulph, Staffordshire.

Diagnosis. In Neves and Owens 1966, p.353.

Size in micrometres. (i) 105-175, diameter of intexine sac 66 - 102, maceration method not stated (Neves and Owens 1966). (ii) 131 (154) 180, diameter of intexine 76 (81) 93, (4 specimens) dark shale (sample M15) from the Lower Fell Top Limestone, Featherstone area.

Description. Amb subcircular to oval. Laesurae distinct to indistinct, faint, straight, extending to the margin of the intexine. Sac-like intexine thin, distinct, slightly darker than the exoexine, circular to subcircular in outline. Exoexine thin, covered with small verrucae up to 3 µm in basal diameter and 2 µm in height; these elements are superimposed on a series of narrow, flat-topped exinous folds, which are irregular and randomly oriented. Margin irregular due to minor secondary folds.

Remarks. Neville 1968 noticed a variation in the sculptural elements of the species. The first type, with a laevigate exoexine between the ridges, he called R. corporata var. laevigata and the second type with a verrucose exoexine between the ridges he called R. corporata var. verrucosus. He indicated that the former species is present in the Namurian C, while the latter species occurs in lower Namurian sediments. In the present study, due to the rare occurrence of the species, it was difficult to differentiate between them.

Occurrence. Rare in dark shale (sample M15) above the Lower Fell Top Limestone, Featherstone area.

Genus GRUMOSISPORITES Smith and Butterworth 1967

Type species. G. verrucosus (Butterworth and Williams) Smith and Butterworth 1967.

Diagnosis. In Smith and Butterworth 1967, p. 228.

Comparison. As stated by Smith and Butterworth 1967, p. 229, this genus is distinguished from Dictyotriletes (Naumova) Smith and Butterworth 1967, Camptotriletes (Naumova) Potonie and Kremp 1955, Verrucosisporites (Ibrhaim) Smith and Butterworth 1967, and Convolutispora Hoffmeister, Staplin and Malloy 1955 in that the exine has two layers which are separated except in the contact area.

Grumosisporites papillosus (Ibrahim) Smith and Butterworth 1967

Plate 27 Figures 5 - 6

1933 Verrucosi-sporites papillosus Ibrahim, p. 25, pl. 5, fig, 44,

1944 Punctati-sporites papillosus (Ibrahim); Schopf, Wilson and Bentall, p. 31.

1950 Verrucoso-sporites papillosus (Ibrahim); Knox, p. 318, p. 17, fig. 229.

1967 Grumosisporites papillosus (Ibrahim); Smith and Butterworth, p. 230, pl. 16, figs. 9-13.

Holotype. Potonie and Kremp 1955, pl. 13, fig. 206, after Ibrahim. Preparation C28, h4(or).

Type locality. Ägir Seam, Ruhr Coalfield, Germany, Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 230 (emended from Ibrahim 1933, p. 25).

Size in micrometres. (i) Holotype 77 X 74; 77-98, Schulze and KOH (Ibrahim). (ii) 68-86 (6 specimens) fum. HNO_3; various localities; Yorkshire and Leicestershire Coalfield, England; Westphalian A and Lower Westphalian B; Smith and Butterworth 1967. (iii) 65 (70) 75 (4 specimens); 1/3 conc. + 2/3 fum. HNO_3, Low Main Stringer Seam, at 27.60 m; borehole No. 1278. (iv) 65 (72) 80 (4 specimens) HF + 1/3 conc. + 2/3 fum. HNO_3; dark grey Seatearth of Wellsyke Stringer Seam, at 23.74 m, borehole No. 1350. (v) 60 (70) 77 (4 specimens); 1/3 conc. + 2/3 fum. HNO_3; from various localities within the sequence. (iii), (iv) and (v) Plenmeller Coalfield, England.

Description. Amb circular to subcircular. Laesurae simple, straight, 2/3 - 3/4 of spore radius, extend to the inner margin of the intexine.

Intexine thin, more or less triangular in shape, thickly folded so that it seems darker than the exoexine. Exoexine thick, 3-4 µm, covered with broad based verrucae with rounded apices, which sometimes fuse to form an irregular and weakly defined reticulum. Infrequent compression folds occur on the exoexine.

Comparison. The large size of the species and the relatively large, broad based verrucae with rounded apices and moderate height distinguish this species from others of the genus.

Occurrence. Absent to rare throughout Westphalian sequence.

Grumosisporites *varioreticulatus* (Neves)
Smith and Butterworth 1967
Plate 27 Figures 7 - 9

1958 *Dictyotriletes* *varioreticulatus* Neves, p. 8, pl. 2, figs. 3a, b.

1967 *Grumosisporites* *varioreticulatus* (Neves); Smith and Butterworth, p. 232, pl. 17, figs. 8-10.

5

Holotype. Neves 1958, pl. 2, fig. 1. Preparation F7S1, reference 056550 in collection of Geological Department, Sheffield University.

Type locality. Roof shales of Six Inch Seam, Quarnford, North Staffordshire, England; Namurian C.

Diagnosis. In Smith and Butterworth 1967, p. 232 (emended from Neves 1958, p. 8).

Size in micrometres. (i) Holotype 106; 70-110, Schulze and 10% KOH Neves (1958). (ii) 67 (78) 89 (16 specimens) fum. HNO_3; various localities; Westphalian A and B, Smith and Butterworth 1967. (iii) 70 (75) 83 (5 specimens) 1/3 conc. + 2/3 fum. HNO_3; Low Main Stringer Seam, at 27.60 m; borehole No. 1278. (iv) 66 (73) 82 (6 specimens) 1/3 conc. + 2/3 fum. HNO_3; from various seams within the sequence.

(iii) and (iv) Plenmeller Coalfield, England.

Description. Equatorial outline circular to subcircular. Laesurae distinct, straight, simple, three-quarters of spore radius. Intexine more or less triangular in shape, thin and highly folded, and appears darker than the exoexine, which ranges in thickness between 2.5-4 µm. Ornamented with very low, weakly defined muri, 35 to 40 elements projecting at the margin, which appear under oil immersion as coni, broad based and with low height; long compression folds sometimes developed parallel to the margin of the spore.

Comparison. *G. varioreticulatus* is distinguished from other species in the genus by its low, irregular and weakly defined muri. Also differs from *Camptotriletes superbus* Neves 1961 and *Dictyotriletes maculatus* (Ibrahim) Potonie and Kremp 1955 in possessing a folded intexine and poorly defined reticulate ornament.

Previous records. Neves 1958, Lower Westphalian A, Six Inch Mine Coal Seam, North Staffordshire; Neves 1961, Namurian B and C, Southern Pennines; Owens and Burgess 1965, Namurian B to Westphalian A, Stainmore Outlier, Westmorland; Smith and Butterworth 1967, Namurian B to Westphalian B, of British Coalfields; Owens *et al*. 1977; Namurian B to Westphalian A, Northern England and Scotland; and also recorded by numerous workers inside and outside Great Britain.

Occurrence. Absent to rare throughout the sequence and infrequent Low Main Stringer, grey mudstone below Wellsyke and dark grey mudstone below Slag Seam.

Genus GRANDISPORA (Hoffmeister, Staplin and Malloy 1955) Neves and Owens 1966

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

Diagnosis. In Neves and Owens 1966, p. 346 (emended from diagnosis in Hoffmeister, Staplin and Malloy 1955, p. 388).

Remarks. Neves and Owens 1966 emended the diagnosis of the genus in order to clarify the nature of attachment of the intexine and the exoexine.

Comparison. Spinozonotriletes (Hacquebard) Neves and Owens 1966 is distinguished from Grandispora by the presence of a solid equatorial flange and also by the thicker development of the exoexine over the distal surface relative to the proximal surface. The exoexine of Spinozonotriletes is attached to the intexine on both the proximal and distal surface, but separated from it to variable degrees in the more equatorial portions.

Grandispora spinosa Hoffmeister, Staplin and Malloy 1955

Plate 27 Figure 14

1955 Grandispora spinosa Hoffmeister, Staplin and Malloy, p. 388, pl. 39, figs. 10, 14.

Holotype. Hoffmeister, Staplin and Malloy 1955, p. 388, pl 39, fig. 10, Slide 6, ser. 19, 311.

Type locality. Shale at 2077 ft., CarterNo.3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Hoffmeister, Staplin and Malloy 1955, p. 388.

Size in micrometres. (i) Holotype 118, 100-143, body 84-100, HF (Hoffmeister, Staplin and Malloy 1955). (ii) 67, intexine 55 (one specimen) HF + fum. HNO_3, black shale (sample M13) from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb of both exoexine and intexine (central body) circular. Laesurae distinct but faint, extending to the margin of the intexine. Intexine thin, laevigate to punctate. Exoexine thin, punctate to minutely granulose with a prominent ornament of scattered spines and cones on the distal surface, 2-6 µm in height, 2-4 µm in basal width and 5-12 µm apart.

Comparison. G. echinatus Hacquebard 1957 differs in its smaller size range (62-93 µm) and in possessing a finer grade of sculptural elements.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Neves 1961, Namurian A, Southern Pennines; Owens and Burgess 1965, Namurian A, Stainmore Outlier, Westmorland; Sullivan and Marshall 1966, Upper Visean, Midland Valley of Scotland; Neville 1968, Upper Visean, East Fife Coast, Scotland; Neves 1968, Upper Visean to Namurian A, Woodland Borehole, Co. Durham; Marshall and Williams 1970, Visean/Namurian boundary, Roman Wall District, Western Northumberland, England; Neves et al. 1973, Visean, Northern England and Scotland; Owens et al. 1977 Upper Visean to Namurian A, Northern England and Scotland; Clayton et al. 1978, Upper Visean to Middle Namurian A, Western Europe.

Occurrence. Very rare in black shale (sample M13) from above the Lower Fell Top Limestone, Featherstone area.

Infraturma PLANATI Neves and Owens 1966

Trilete, camerate miospores in which the sculptureless exoexine is attached to the intexine only on the proximal surface, commonly in the region of the trilete rays.

Genus AURORASPORA Hoffmeister, Staplin and Malloy 1955

Type species. A. solisortus Hoffmeister, Staplin and Malloy 1955.

Diagnosis. In Hoffmeister, Staplin and Malloy 1955, p. 380.

Comparison. Auroraspora is distinguished from Endosporites Wilson and Coe 1940 by the absence of a 'limbus'.

Auroraspora solisortus Hoffmeister, Staplin and Malloy 1955

Plate 25 Figure 4, 5

1955 Auroraspora solisortus Hoffmeister, Staplin and Malloy, p. 381, pl. 31, fig. 3.

Holotype. Hoffmeister, Staplin and Malloy 1955, pl. 38, fig. 2. Preparation 5, ser. 19, 471.

Type locality. Shale at 2071 ft. Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis. In Hoffmeister, Staplin and Malloy 1955, p. 381.

Size in micrometres. (i) Holotype 61 X 67, 61-78, HF (Hoffmeister, Staplin and Malloy 1955). (ii) 54-69 (5 specimens) various localities, within the Westphalian sequence, Northern England.

Description. Amb subcircular to rounded triangular. Laesurae distinct to indistinct, simple, straight, extend more than 3/4 of intexine radius. Intexine thick, laevigate to infragranulate, occupying about 1/2 or less of the radius of spore body. Exoexine thin, translucent, finely infragranulose to infrareticulate. Occasional peripheral folds infrequently occur.

Comparison. A. kerimi Artüz 1957 is distinguished from A. solisortus in having a larger size range, 70-120 μm, otherwise they appear to be conspecific. A. balteola Sullivan 1964 differs in the fact that the proportion of intexine to exoexine is greater than in A. solisortus.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Butterworth and Williams 1958, Namurian A, Scotland; Neves 1961, Namurian A to Lower Westphalian B, Southern Pennines; Owens and Burgess 1965, Namurian A to Lower Westphalian A, Stainmore Outlier, Westmorland; Neves 1968, Westphalian A, Woodland Borehole, Co. Durham; and recorded by several workers in Namurian and Westphalian sediments.

Occurrence. Absent to rare throughout the Westphalian sequence.

Genus ENDOSPORITES (Wilson and Coe) Bharadwaj 1964

Type species. E. ornatus Wilson and Coe 1940.

Diagnosis. In Bharadwaj 1964, p. 88.

Comparison. Enodsporites differs from Florinites in the proximal attachment of the central body to the pseudosaccus and in having a granulate to infragranulate sculpture, rather than an infrareticulate exoexine. According to Hoffmeister, Staplin and Malloy (1955, p. 381) Auroraspora differs from Endosporites in possessing a thick-walled central body enclosed by a transparent and very thin pseudosaccus, and in the lack of a limbus. Wilsonites Kosanke 1959 has a circular shape, with slightly coarse reticulate ornament rather than granulate to infragranulate ornament.

Endosporites globiformis (Ibrahim) Schopf, Wilson and Bentall 1944

Plate 25 Figure 1

1932 Sporonites globiformis Ibrahim in Potonie, Ibrahim and Loose, p. 447, pl. 14, fig. 5.

1933 Zonales-sporites globiformis Ibrahim, p. 28, pl. 1, fig. 5.

1938 Zonotriletes globiformis (Ibrahim); Luber in Luber and

Waltz, pl. 8, fig. 103, and pl. B, fig. 30.

1944 Endosporites globiformis (Ibrahim); Schopf, Wilson and Bentall, p. 45.

Holotype. Potonie and Kremp 1956, pl. 20, fig. 459 after Ibrahim. Preparation B33, dl(or).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 271 (translated from Potonie and Kremp 1956, p. 161).

Size in micrometres. (i) Holotype 131, Schulze and KOH. (ii) 110-60, Schulze (Potonie and Kremp 1956). (iii) 62 (87) 102, pseudosaccus; 30 (40) 54 body; fum. HNO_3; Yorkshire Coalfield, England; Westphalian B; Smith and Butterworth 1967. (iv) 67 (78) 96, pseudosaccus; 31 (36) 46 body, (5 specimens), 1/3 conc. + 2/3 fum. HNO_3; from various localities within the Westphalian sequence, Plenmeller Coalfield, England.

Description. Equatorial outline of pseudosaccus and body triangular, subtriangular to subrounded with broad rounded angles. Laesurae simple to slightly ridged, straight to flexuose, lips slightly elevated, extending to the margin of intexine. Intexine and exoexine (pseudosaccus) often folded. Intexine darker and thicker than the thinner translucent pseudosaccus. Ornamented with fine grana which appear clearly sometimes at the margin. Limbus very well developed at the margin, 4-7 µm wide.

Comparison. E. vesicatus Kosanke 1950 has a wider pseudosaccus than E. globiformis; otherwise it is difficult to distinguish them from the original diagnosis and description. E. ornatus Wilson and Coe 1940 differs in having proportionally greater intexine to exoexine diameter.

Previous records. Ibrahim 1932, Upper Westphalian B, Ägir Seam, Ruhr Basin, Germany; Pierart 1958 Westphalian C, Neeroeteren Zone, Belgium Campine; Sullivan 1962, Westphalian B to Westphalian C, South Wales Coalfield; Love and Neves 1963, Upper Westphalian B to C, Inninmore, Scotland; Neves 1964, Namurian B to Westphalian A, La Camocha, Gijon, North Spain; Owens and Burgess 1965, Upper Westphalian A, Stainmore Outlier, England; Smith and Butterworth 1967, Upper Westphalian A to Westphalian D, British Coalfields; Grebe 1972, Westphalian A to C, Ruhr Coalfield, Germany; Ravn 1979, Pennsylvanian, Cherokee Group, CP-19-4 Coals, Iowa, U.S.A.

Occurrence. Absent to rare throughout the Westphalian sequence; common in Lower Westphalian B, Hedley Park, England.

Endosporites zonalis (Loose) Knox 1950

Plate 25 Figures 2 & 6

1934 Zonales-sporites zonalis Loose, p. 148, pl. 7, fig. 5.

1944 Cirratriradites zonalis (Loose); Schopf, Wilson and Bentall, p. 44.

1950 Endosporites zonalis (Loose); Knox, p. 332.

Holotype. Potonie and Kremp 1956, pl. 20, fig. 455 after Loose. Preparation IV27, f5(mlol).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany, Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 273 (translated from Potonie and Kremp 1956, p. 163).

Size in micrometres. (i) Holotype 95, Schulze and KOH. 90-100 Schulze (Potonie and Kremp 1956). (ii) Pseudosaccus 61 (78) 100; fum. HNO_3; Silkstone Seam, various localities, Yorkshire Coalfield, England (Smith and Williams 1957) Westphalian A. (iii) 59 (77) 88

Pseudosaccus, 24 (46) 60 Central body, (14 specimens) 1/3 conc. + 2/2 fum. HNO_3 + one minute 2% KOH; Bounder Seam; at 8.44 m depth, borehole No. 1154, Plenmeller Coalfield, England.

Description. Equatorial outline of pseudosaccus and body subrounded to subtriangular. Laesurae simple to slightly ridged, straight, extending to the margin of the intexine (central body). Pseudosaccus thin, often folded, and finely punctate; body laevigate and shows peripheral compression folds which give a distinct darker peripheral zone; a proximal marginal thickening or "limbus" frequently appears, 4-7 μm wide.

Comparison. E. globiformis (Ibrahim) Schopf, Wilson and Bentall 1944, has similar size, shape and morphological characters, excepting that the ratio of body to pseudosaccus is less than 50% or equal, and the pseudosaccus appears more granulate than in E. zonalis which has more than 50% the ratio of body to pseudosaccus, and the pseudosaccus appears infrapunctate. E. rotundus (Ibrahim) Schopf, Wilson and Bentall 1944 and E. plicatus Kosanke 1950 appear to be similar. Wilsonia punctata Dybova and Jachowicz 1957a (p.215, pl. 75, figs. 1-3) is quite similar, and may be a synonym of E. zonalis.

Previous records. Pierart 1958, Westphalian C, Neeroeteren Zone, Belgium Campine; Smith and Butterworth 1967, Upper Westphalian A to Westphalian D, British Coalfields; Ravn 1979, Cherokee Group, (Pennsylvanian), Southern Iowa, U.S.A.; and recorded by several workers in Upper Carboniferous sediments.

Occurrence. Absent to rare in the lower part of the sequence and rare in Threequarters, Lower and Upper Craignook and Bounder Seams, Plenmeller Coalfield; rare in Little Main Seam (sample C5), Low Close Opencast Site, Cumbria, and rare in Lower Westphalian B, Hedley Park, England.

Genus SCHULZOSPORA Kosanke 1950

Type species. S. rara Kosanke 1950.

Diagnosis. In Smith and Butterworth 1967, p. 273 (expanded from Kosanke 1950, p. 53).

Comparison. Schulzospora is distinguished from Endosporites by the elliptical shape of its pseudosaccus, and from Florinites and Wilsonites by its clearly defined body and laesurae and lack of infrareticulation.

Schulzospora plicata Butterworth and Williams 1958

Plate 24 Figure 10

Holotype. (Butterworth and Williams 1958) Plate 23, fig. 4. Preparation T67/1 in collection of the National Coal Board Laboratory, Wath-upon-Dearn.

Type locality. Seam at 1,555 ft. 4 in., Righead borehole, West Fife Coalfield, Scotland; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 276 (from diagnosis in Butterworth and Williams 1958, p. 388).

Size in micrometres. (i) Holotype 43 X 26; 44-64 X 25-40 at type locality, (40-100 (10 specimens) various horizons). Schulze and 5% KOH (Butterworth and Williams 1958). (ii) 53, 63 (2 specimens), HF + fum. HNO_3, black shale (sample M13) from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb elongate to elliptical, constricted in the region of the body. Body elongate, distinct, peripheral zone varies in width between 4-12 μm, often plicate. Laesurae indistinct. Pseudosaccus thin, finely granulate to infragranulate; body granulate and bears some scattered cones and verrucae which are occasionally fused. Compression folds frequently occur radiating from the peripheral zone of the body. The constriction of the pseudosaccus gives the appearance of a bi-saccate spore.

Comparison. Distinguished from other species of the genus by its small size, and the prominent plicated zone peripheral to the intexine.

Previous records. Butterworth and Williams 1958, Namurian A, Limestone Coal Group and Upper Limestone Group, Scotland; Smith and Butterworth 1967, Visean to Westphalian A, British Coalfields.

Occurrence. Rare in black shale (sample M13) from above the Lower Fell Top Limestone, Featherstone area.

Schulzospora ocellata (Horst) Potonie and Kremp 1956

1943 Triletes (Zonales) ocellatus Horst, (thesis) figs. 40, 41.

1955 Schulzospora ocellata (Horst); Potonie and Kremp in Horst, p. 195, pl. 21, figs. 40a, b.

1956 Schulzospora ocellata (Horst); Potonie and Kremp, p. 166.

non 1958 Schulzospora ocellata (Horst); Potonie and Kremp; Butterworth and Williams, pl. 4, fig. 15.

Holotype. Horst 1955, pl. 21, figs. 40a, b. Preparation IV68, 20.5, 75.8.

Type locality. Osmana Seam, Michael Colliery, Moravska-Ostrava; Namurian A.

Diagnosis. In Smith and Butterworth 1967, p. 275 (from Horst 1955, p. 195).

Size in micrometres. (i) Holotype 90; 61-130 (80-100) body 25-59, fum. HNO_3 (Horst 1955). (ii) 76 (92) 110 X 60 (69) 88, body 56 (66) 77 X 52 (61) 74, fum. HNO_3; Northumberland Coalfield, England; Namurian A.

(Smith and Butterworth 1967). (iii) 64 (68) 75, body 49 (53) 61, (7 specimens) HF + fum. HNO_3, black shale (sample M13), from above the Lower Fell Top Limestone, Featherstone area.

Description. Amb rounded to oval. Pseudosaccus infrapunctate to minutely punctate thickened at the boundary with the body. Body thin, circular to oval in shape. Laesurae distinct to indistinct, faint, straight, extend 1/2 - 2/3 of spore radius.

Remarks. The specimens described above are very poorly preserved; it was difficult to distinguish them from *S. rara* excepting by the thickened area at the margin of the body.

Comparison. Differs from *S. campyloptera* (Walts) Hoffmeister, Staplin and Malloy 1955 in having a more rounded shape.

Previous records. Hoffmeister, Staplin and Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Butterworth and Williams 1958, Namurian A, Scotland; Love 1960, Upper Visean, Oil-Shale Group, Scotland; Neves 1964, Namurian B to Westphalian A, La Camocha Mine, Gijon, Northern Spain; Sullivan 1964, Visean, Drybrook Sandstone, Forest of Dean, Gloucestershire; Owens and Burgess 1965, Namurian A to C, Stainmore Outlier, Westmorland; Smith and Butterworth 1967, Visean and Namurian, British Coalfields; Felix and Burbridge 1967, Mississippian to Pennsylvanian Springer Formation, Oklahoma; Owens *et al*. 1977, Visean to Namurian A, Northern England and Scotland; Clayton *et al*. 1978, Visean to Namurian, Western Europe; and also recorded by numerous authors from Carboniferous sediments.

Occurrence. Rare in black shales (samples M15 and M13) above the Lower Fell Top Limestone, Featherstone area.

Schulzospora rara Kosanke 1950

Plate 27 Figures 1 - 4

1950 Schulzospora rara Kosanke, p. 53, pl. 13, figs. 5-8.

non 1950 Planisporites ovatus Knox, p. 316, pl. 17, fig. 222.

1952 Endosporites ovatus (Knox); Balme, P.180, text - fig.1e

1958 Schulzospora ocellata (Horst) Potonie and Kremp;
Butterworth and Williams, Pl.4, Fig.15.

Holotype. Kosanke 1950, Pl.13, fig.8. Preparation 587, Slide 8.

Type locality. Battery Rock Coal, Hardin County, Illinois, U.S.A.; Caseyville Group.

Diagnosis. In Smith and Butterworth 1967, p.277 (from description in Kosanke 1950, p.53).

Size in micrometres. (i) Holotype 109.2 x 81.9, body 73.3 x 73.5, Schulze and 10% KOH (Kosanke 1950) (ii) 54 (67) 83 x 38 (50) 60, body 40 (51) 62 x 32 (42) 56, fum. HNO_3; Lancashire Coalfield, England, Upper Westphalian A, (Smith and Butterworth 1967). (iii) 58 (65) 75 x 40 (46) 55; body 40 (45) 50 x 37 (41) 47 (12 specimens), 1/3 Conc. + 2/3 fum. HNO_3 + 2% KOH. Upper Craignook Seam (top leaf) at 20.55 m, borehole 1154, Plenmeller Coalfield, England.

Description. Equatorial outline oval to circular, intexine (central body) circular. Laesurae distinct to indistinct, simple, straight to flexuose, extending 3/4 of spore body radius. Intexine moderately thin, saccus and body ornamented with minute punctae to infrapunctate. Central body (intexine) tends to be slightly oblique.

Comparison. Distinguished from other species of the genus in its oval shape (not elongate) and relatively small saccus compared with central body. It is similar to S. occellata (Horst) Potonie and Kremp, 1955, but has a smaller size range and thinner exine.

Previous records. Kosanke 1950, Upper Westphalian A, Battery Rock Coal, of Illinois; Hoffmeister, Staplin and Malloy 1956; Upper Mississippian, Hardinsburg Formation, U.S.A.; Neves 1958, Upper Namurian C to Lower Westphalian A, Six Inch Mine coal seam, North Staffordshire; Love 1960, Upper Visean, Scotland, Neves 1964, Namurian B to Westphalian A, La Camocha, Gijon, North Spain; Felix and Burbridge, 1967, Miss/Penn., Oklahoma, U.S.A.; Smith and Butterworth 1967, Visean to Westphalian A, British Coalfields; Clayton et al. 1977, Namurian to Westphalian A, Western Europe; and also recorded by several workers from Namurian and Westphalian A sediments in Britain.

Occurrence. Absent to rare throughout the sequence, common in High Main (bottom leaf), borehole No.1138, Wellsyke, borehole No.964, and in Upper Craignook (Top Leaf), borehole No.1145, Plenmeller Coalfield, England.

Infraturma VARIOCAMERATI Mishell 1966 M.S.

Diagnosis. From Mishell 1966 M.S. p. 370. "Trilete, camerate, non-cingulate, miospore, distinguished by the markedly variable and gradational separation of intexine and exoexine from specimen to specimen within individual species."

Mishell 1966 M.S., proposed a new infraturma to accommodate genera which cannot be accommodated within any infraturma proposed by Neves and Owens 1966.

Genus CORRUGITRILETES Mishell 1966 M.S.

Type species. C. ruginosus Mishell M.S. 1966.

Diagnosis. From Mishell 1966 M.S., p. 371. "Trilete miospores, amb rounded triangular to circular. Spores variably camerate from complete and clear equatorial cameration to cases where the exoexine is separated from the intexine only along portions of the equatorial surface of the intexine, occasionally the separation may only be determined with difficulty. Intexine and exoexine laevigate or with infrastructure. Exoexine where separated and non-separated intexine and exoexine thrown into folds or wrinkles, more or less radially arranged on sub-equatorial surface of smaller dimensions and more randomly orientated towards the poles. Laesurae may be sinuous on account of exinal folding, half radius or more in extent."

Comparison. Radialetes Playford 1963 is alete, and non-camerate with regular and radially arranged muroid thickenings. Rhabdosporites Richardson 1960 is distinguished by its sculpture of rod-like projections on the exoexine, and also lacks the entangled pattern of more or less radially disposed folds of Corrugitriletes. Mishell 1966 M.S. (p.372) transferred Rhabdosporites cymatilus Allen 1965 to Corrugitriletes.

Corrugitriletes ruginosus Mishell 1966 M.S.

Plate 27 Figures 15 - 17

1963 Radialetes sp. A. Owens M.S., p. 169, pl. 29, fig. 8.

1966 Corrugitriletes ruginosus Mishell M.S., p. 373.

Holotype and type locality. Mishell 1966 M.S.; unpublished manuscript.

Diagnosis. In Mishell 1966, M.S. p. 373.

Size in micrometres. (i) 40-61, fum. HNO_3; Mishell M.S. 1966. (ii) 36 (45) 50 (5 specimens), HF + fum. HNO_3; black shale (sample M22) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb circular, subcircular to rounded triangular. Laesurae distinct to indistinct extending to the margin of the intexine, rays open. Intexine very thin, laevigate. Exoexine moderately thick, 1-2 µm, ornamented with minute grana less than 0.5 µm in width and height, and a rugulate sculpture, 1-2 µm in basal width and height,more or less in a radial pattern; these are less frequent in the polar area, and also more randomly distributed. Cluster of minute pila occur towards the pole on the distal exoexinal surface. Margin sinuous - secondary folds frequently occur.

Comparison. Perotrilites perinatus Hughes and Playford 1961 is distinguished in having a thin, hyaline, laevigate, loosely-fitting exoexine (perine), which projects 4-10 µm beyond the equatorial margin of intexine and does not have narrow, radial folds or distal pila.

Previous records. Owens M.S. 1963, Namurian A to C, Stainmore Outlier, Westmorland; Mishell M.S. 1966, Namurian A and B, Bowland Fells, Lancashire; Sabry M.S. 1969, Upper Visean to Lower Westphalian A, Sanquhar Coalfield, Scotland; Clayton et al.1978, Namurian C, Western Europe.

Occurrence. Rare in black shale (sample M13) from above the Lower Fell Top Limestone, and in black shale (sample M22) from above the Upper Fell Top Limestone, Featherstone area.

Turma MONOLETES Ibrahim 1933

Suprasubturma ACAMERATOMONOLETES Neves & Owens 1966

Subturma AZONOMONOLETES Luber 1935

Infraturma LAEVIGATOMONOLETES Dybova and Jachowicz 1957

Genus LAEVIGATOSPORITES Ibrahim 1933

Type species. L. vulgaris Ibrahim 1933.

Diagnosis. In Smith and Butterworth 1967, p. 281 (translated from Potonie and Kremp 1955, p. 165).

Remarks. Smith and Butterworth 1967, subdivided the species of Laevigatosporites on overall size into four species having a maximum length less than 100 µm. Spores between 16-35 µm were assigned to L. minimus (Wilson and Coe) Schopf, Wilson and Bentall 1944; spores between 35-65 µm were assigned to L. minor Loose 1934; and spores between 65-85 µm were assigned to L. vulgaris Ibrahim 1933, while those spores greater than 85 µm were assigned to L. maximus (Loose) Potonie and Kremp 1956. However several later authors have continued to use additional taxa.

Laevigatosporites minor Loose 1934

Plate 28 Figures 9 - 14

1932	Sporonites vulgaris Ibrahim in Potonié, Ibrahim and Loose, in part.
1933	Laevigato-sporites vulgaris Ibrahim, in part.
1934	Laevigato-sporites vulgaris minor Loose, p. 158, pl. 7, fig. 12.
1957a	Laevigato-sporites minor (Loose) Potonié and Kremp; Bharadwaj, p. 109, pl. 29, figs. 8, 9.

Holotype. Loose 1934, pl. 7, fig. 12. Preparation V29, a.

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 284 from Ibrahim 1933, p. 39.

Size in micrometres. (i) Holotype 58.5, 40-70, Schulze solution and KOH (Loose 1934). (ii) Schulze (Bharadwaj 1957a). (iii) 37 (40) 50, fum. HNO_3, Warwickshire Coalfield, England, Westphalian D. (iv) 40 (54.8) 62 (15 specimens) fum. HNO_3 + 2% KOH Threequarters Seam, borehole 964, at 9.57 m. (v) 33 (53.5) 61 (35 specimens) 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH, (one minute) Upper Craignook Seam; borehole 1154, at 21.58 m. (vi) 46 (51) 62 (15 specimens) fum. HNO_3 + 2% KOH, Half Seam, borehole 964, at 12.54 m. (vii) 32 (54) 64 (25 specimens), 1/3 conc. + 2/3 fum. HNO_3, BounderSeam, at 8.44 m, borehole No. 1154. (iv) to (vii) Plenmeller Coalfield, England.

Description. Amb in proximal view oval, and in equatorial view reniform. Laesurae distinct, simple, straight, 2/3 - 3/4 of spore length, and most often open. Exine laevigate, pale in colour ranging in thickness between 1.5-2.5 µm. Minor secondary folds infrequently occur. Margin smooth.

Remarks. This species differs in size from the two species L. minimus Schopf, Wilson and Bentall 1944, and L. vulgaris Ibrahim 1933, while other species such as L. globosus Schemel 1951, L. medius Kosanke 1950, and L. ovalis Kosanke 1950 fall within the above size range.

Previous records. Numerous authors have recorded this species from throughout the Upper Carboniferous.

Occurrence. Absent to rare throughout the Namurian sequence; absent in the Namurian/Westphalian boundary and rare, frequent to abundant throughout the Westphalian sequence.

Laevigatosporites vulgaris Ibrahim 1933

Plate 28 Figures 6 - 8

1932 Sporonites vulgaris Ibrahim in Potonie, Ibrahim and Loose, p. 448, pl. 15, fig. 16.

1933 *Laevigato-sporites vulgaris* Ibrahim, p. 39, pl. 2, fig. 16.

1940 *Phaseolites desmoinesensis* Wilson and Coe, p. 182, pl. 1, fig. 4.

1944 *Laevigato-sporites desmoinesensis* (Wilson and Coe); Schopf, Wilson and Bentall, p. 37.

1967 *Laevigato-sporites vulgaris* Ibrahim; In Smith and Butterworth, p. 285, pl. 24, fig. 4.

Holotype. Potonie and Kremp 1956, pl. 19, fig. 429 after Ibrahim. Preparation B31, C6 (or).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 285 (from Ibrahim 1933, p. 39).

Size in micrometres. (i) Holotype 69.5; 56-77, Schulze and KOH (Ibrahim 1933). (ii) 56 (72) 83, fum. HNO_3; Northumberland Coalfield, England; Westphalian B (Smith and Butterworth 1967). (iii) 64 (69) 80 (16 specimens), fum. HNO_3 + 5% KOH, Wellsyke Seam, borehole No. 964, at 22.62 m, Plenmeller Coalfield, England. (iv) 65 (69.7) 78 (7 specimens) fum. HNO_3 + 5% KOH, Threequarters Seam, borehole No. 964, at 9.57 m, Plenmeller Coalfield, England.

Description. Amb oval in proximal view and reniform in equatorial view. Laesurae distinct simple, straight, 2/3 - 3/4 of the spore length, suture slightly elevated, and often open. Exine laevigate, 1.5-2.5 μm in thickness, average width 40 μm. Secondary folds infrequently occur, parallel to the margin of the spore.

Remarks. Smith and Butterworth 1967 incorporated *L. desmoinesis* (60-75 μm) (Wilson and Coe) Schopf, Wilson and Bentall 1944, with *L. vulgaris* in one species. Sullivan and Marshall 1966 recorded

L. desmoinesis from the Upper Visean of Scotland with a size range (53-60 µm).

Previous records. Potonie and Kremp 1954, Upper Westphalian B, Ruhr Coalfield, Germany; Bharadwaj 1957, Westphalian C, Saar Coalfield, Germany; Smith and Butterworth 1967, Westphalian B, British Coalfields; Clayton *et al*. 1978, Westphalian A to C, Western Europe; Ravn 1979, Pennsylvanian, Cherokee Group, CP-19-4 Coal, Southern Iowa, U.S.A.; and also recorded by several workers inside Britain.

Occurrence. Absent in the Namurian and the lower part of the Westphalian sequence, and rare to common in the upper part of the Westphalian sequence.

Infratruma SCULPTATOMONOLETES Dybova and Jachowicz 1957

Genus PUNCTATOSPORITES Ibrahim 1933

Type species. *P. minutus* Ibrahim 1933

Diagnosis. In Smith and Butterworth 1967, p. 287 (translated from Potonie and Kremp 1954, p. 165).

Comparison. Distinguished from other monolete genera such as *Laevigatosporites* Ibrahim 1933 and *Latosporites* Potonie and Kremp 1954 by its ornament of fine grana.

Punctatosporites minutus Ibrahim 1933

Plate 28 Figures 1, 2

1933 *Punctato-sporites minutus* Ibrahim, p. 40, pl. 5, fig. 33.

1938 *Azonomonoletes minutus* (Ibrahim); Luber in Luber and Waltz, pl. 8, fig. 112.

1957 *Granulatosporites minutus* (Ibrahim); Dybova and Jachowicz, p. 191.

Holotype. Ibrahim 1933, pl. 19, fig. 439. Preparation A45, al.(o).

Type locality. Ägir Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 288 (from Potonie and Kremp 1956, p. 143).

Size in micrometres. (i) Holotype (25.5), Schulze and KOH. (ii) 21-28, Schulze (Potonie and Kremp 1956). (iii) 18 (22) 27, Schulze and KOH; North Staffordshire Coalfield, England; Westphalian D (Smith and Butterworth 1967). (iv) 18 (23) 29 (30 specimens); 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH; Upper Craignook Seam (bottom leaf) at 21.58 m, borehole No. 1154, Plenmeller Coalfield, England.

Description. Amb oval. Laesurae distinct to indistinct, simple, straight 1/2 - 2/3 of spore length. Exine thin, ornamented with small grana less than 0.5 µm in basal width and height. Secondary folds infrequently occur.

Comparison. *P. granifer* Potonie and Kremp 1956, (25-35 µm), and *P. oculus* Smith and Butterworth 1967, (17-32 µm) differ in their larger size, thicker exine and coarser ornament; *P. rotunda* Bharadwaj 1957 (20-24 µm) has the same size range and shape but differs in its thicker exine and slightly coarser ornament.

Previous records. Recorded by numerous workers from the Westphalian sequence.

Occurrence. Infrequent to frequent to abundant throughout the Westphalian sequence.

Spore type B

Plate 29 Figures 1 - 7 & 10, 11

Type locality. Black shale (sample M22) from above the Upper

Fell Top Limestone, Pinking Cleugh, Featherstone area.

Diagnosis. Monolete miospore. Amb oval to reniform. Monolete suture distinct to indistinct; if observed, faint, 1/2 - 2/3 of long diameter of spore. Exine 1-1.5 µm in thickness covered with reticulate sculpture. Lumina rounded to polygonal in shape. Margin finely crenulate.

Size in micrometres. (i) 16 (22) 28 (35 specimens), 40% HF + fum. HNO_3, black shale (sample M22) from above the Upper Fell Top Limestone, Featherstone area.

Description. Amb oval to reniform. Monolete suture distinct to indistinct, if observed, faint, straight to slightly curved ranging between 1/2 - 2/3 of spore length. Exine yellow in colour, less than 1.5 µm in thickness, covered with closely packed reticulate sculpture, muri 0.5-1 µm in height, enclosing more or less regular pattern of polygonal to rounded lumina, 1-1.5 µm and occasionally reaching 2 µm in diameter. Margin finely crenulate, 45-60 muri project at the margin. Short arcuate secondary folds infrequently occur.

Comparison. Distinguished by its monolete suture and very distinct reticulate sculpture from several species such as the trilete species Microreticulatisporites microreticulatus Knox 1950 and M. punctatus Knox 1950 and from the monolete species Thymospora obscura (Kosanke) Wilson and Venkatachala 1963 in its sculptural elements. Thymospora pseudothessenii (Kosanke) Wilson and Venkatachala 1963, T. theiesseni (Kosanke) Wilson and Venkatachala 1963 and T. pseudogranulata (Bharadwaj) Wilson and Venkatachala 1963 also differ in their sculptural elements.

Occurrence. Common in black shale (sample M22) above the Upper Fell Top Limestone, Featherstone area.

Turma HILATES Dettmann 1963

Suprasubturma CAMERATIHILATES Sabry M.S. 1969

Subturma AZONOCAMERATIHILATES Sabry M.S. 1969

Infraturma EPITYGMATI (Spode M.S.) in Smith and Butterworth 1967

Genus VESTISPORA (Wilson and Hoffmeister) Wilson and Venkatachala 1963

Type species. Vestispora profunda Wilson and Hoffmeister 1956.

Diagnosis. In Smith and Butterworth 1967, p. 294 (from diagnosis in Wilson and Venkatachala 1963, p. 96).

Remarks. Potonie 1960 and Wilson and Venkatachala 1963 transferred Cancellatisporites Dybova and Jachowicz 1957 and Glomospora Butterworth and Williams 1958 (by the former author) and Foveolatisporites Bharadwaj 1955 and Novisporites Bharadwaj 1957 (by the latter authors) to Vestispora.

Comparison. Vestispora is distinguished from other genera by the presence of an operculum on the proximal surface.

Vestispora costata (Balme) Spode in Smith and Butterworth 1967

Plate 29 Figures 8, 9

1952 Endosporites costatus Balme, p. 178, text-fig. 1f.

1957b Vestispora costata (Balme); Bharadwaj, p. 118, pl. 24, figs. 36-40.

1958 Glomospora costata (Balme); Butterworth and Williams, p. 385.

1967 Vestispora costata (Balme); Spode in Smith and Butterworth, p. 295, pl. 25, figs. 1, 2.

Lectotype. Balme did not designate a holotype but a lectotype (T71/1) was chosen by Spode from the material deposited by Balme in the collection of the National Coal Board Laboratory, Wath-upon-Dearne.

Type locality. Seam at 719 ft. 3 in., Manton Colliery, No. 4 Shaft Sinking, Yorkshire Coalfield, England; Westphalian C.

Diagnosis. In Smith and Butterworth 1967, p. 295 (from diagnosis in Spode, unpublished manuscript).

Size in micrometres. (i) Lectotype 74 X 64; 60 (79) 104, Schulze (Balme). (ii) 52-88, Schulze and 5% KOH (Spode). (iii) 48 (68) 82, Schulze and 10% KOH, North Staffordshire Coalfield, England; Westphalian C. (iii) 55 (63) 71 (5 specimens), various samples within Low Close Opencast Site, Cumbria.

Description. Amb circular to subcircular. Operculum circular covering the area of the trilete mark. Laesurae distinct to indistinct, simple, straight, extending 1/3 - 1/2 of spore radius. Inner body (intexine) as well as exoexine laevigate. Exoexine moderately thin less than 2 µm in thickness, sculptured with widely spaced spiral costae and rarely branched muri, less than 3-5 µm wide and less than 2 µm in height, enclosing more or less polygonal shaped lumina, 6-14 µm in diameter. Secondary folds occasionally occur.

Comparison. This species is closely similar to *V. tortuosa*; the latter can be distinguished by its more frequently branching muri.

Previous records. Balme 1952, Westphalian C, Yorkshire Coalfield, England; Bharadwaj 1957, Westphalian C, RuhrCoalfield, Germany; Pierart 1958, Westphalian C, Belgium; Smith and Butterworth 1967, Westphalian B and C;Van Wijhe and Bless 1974, Upper Westphalian C, Netherlands; Clayton *et al*. 1977, Westphalian A, Western Europe.

Occurrence. Absent to rare in Upper Westphalian A and lower Westphalian B, of Low Close Opencast Site, Cumbria, and Hedley Park.

Vestispora pseudoreticulata (Spode) in Smith and Butterworth 1967

Plate 28 Figures 24, 25

1952 Reticulatisporites tortuosus Balme (in part), p. 179.

1967 Vestispora pseudoreticulata Spode, in Smith and Butterworth, p. 298.

Holotype. Spode (unpublished manuscript). Plate 1, fig. 3.

Type locality. Barnsley Seam, Yorkshire Coalfield, England; Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 299 (from diagnosis in Spode, unpublished manuscript).

Size in micrometres. (i) Holotype 122.6 X 101; 50-80, various localities, Yorkshire Coalfield, England, Schulze and 5% KOH (Spode, unpublished manuscript). (ii) 58 (73) 90, fum. HNO_3, North Wales Coalfield, Lower Westphalian B, (Smith and Butterworth 1967). (iii) 53 (66) 74, fum. HNO_3, Bottom Brass Thill (sample No. 492), Hedley Park, England.

Description. Amb circular to oval, margin crenulate. Laesurae simple, clearly seen only when proximal operculum is detached, simple, straight, short, 1/3 of spore radius. Exoexine moderately thick, 3 µm, ornamented with primary muri, 3-5 µm in width, and up to 3 µm in height and enclosing circular to polygonal shaped lumina 1.5-3 µm in diameter; these primary muri form a coarse reticulation. Weak secondary muri are also present, lighter in colour and forming a slightly finer reticulation.

Comparison. V. pseudoreticulata is distinguished from other species in the genus in having a secondary, light reticulum. V. magna (Butterworth and Williams) in Spode, is distinguished by its much coarser primary muri.

Previous records. Spode (unpublished manuscript), Westphalian B, Yorkshire Coalfield; Neves 1964, Middle Westphalian A to B, La Camocha, N. Spain; Smith and Butterworth 1967, Westphalian A to C, Yorkshire Coalfield; Clayton et al. 1978, Westphalian B and C, Western Europe; Ravn 1979, Cherokee Group (Pennsylvanian), CP-19-4 Coal, Iowa, U.S.A.

Occurrence. Common in the Bottom Brass Thill Seam, sample No. H.492, and rare in the Maudlin Seam (bottom leaf), sample No. H.543, Hedley Park, England.

Vestispora tortuosa (Balme) Spode in Smith and Butterworth 1967

Plate 28 Figures 21 - 23

1952 Reticulatisporites tortuosa Balme, text-fig. 1d.

1957b Vestispora tortuosa (Balme); Bharadwaj, p. 119.

1957a Cancellatisporites cancellatus Dybova and Jachowicz, p. 111, pl. 24, figs. 1-4.

1967 Vestispora tortuosa (Balme); Spode in Smith and Butterworth, p. 299, pl. 26, figs. 1, 2.

Lectotype. No holotype was designated by Balme but a lectotype (T72/1) was chosen by Smith and Butterworth 1967 from material deposited by him in the collection of the National Coal Board, Wath-upon-Dearne.

Type locality. Wheatworth Seam at 907 ft. 11 in., Wentbridge No. 2 borehole, Yorkshire Coalfield, England; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 299 (from diagnosis in Spode, unpublished manuscript).

Size in micrometres. (i) Lectotype 77; 65 (86) 100 Schulze (Balme 1952). (ii) 56 (67) 78, fum. HNO_3, Lothians Coalfield, Scotland;

Lower Westphalian A (Smith and Butterworth 1967). (iii) 58 (65) 72 (5 specimens); 1/3 conc. + 2/3 fum. HNO_3 + 2% KOH (one minute); Upper Craignook Seam (top leaf) at 20.55 m, borehole No. 1154, Plenmeller Coalfield, England. (iv) 54 (65) 72 (11 specimens), fum. HNO_3, Little Main Seam, sample C5, Low Close Opencast Site, Cumbria.

Description. Amb circular to subcircular. Laesurae distinct to indistinct, simple, straight, extending 1/3 - 2/3 of spore radius. Exine laevigate, moderately thick, ornamented with muri 1.5-3 µm in width, 1-2 µm in height; muri often branched and forming polygonal to oval shaped lumina, not exceeding 10 µm in diameter. Margin smooth to crenulate, due to the intersection of muri at margin. Operculum occasionally observed and tends to be somewhat rounded in outline. Compression folds sometimes occur.

Comparison. V. costata (Balme) Spode in Smith and Butterworth 1967 is distinguished by its unmodified muri; V. pseudoreticulata Spode in Smith and Butterworth 1967 has a well-developed secondary reticulum.

Previous records. Balme 1952, Westphalian C, Yorkshire Coalfield, England; Bharadwaj 1957a, Westphalian C, Ruhr Coalfield, Germany; Dybova and Jachowicz 1957, Upper Westphalian A to B, Upper Silesia, Poland; Smith and Butterworth 1967, Upper Westphalian A to Lower Westphalian C, British Coalfields; Van Wijhe and Bless 1974, Upper Westphalian C, Netherlands.

Occurrence. Rare in the Upper Craignook Seam, Plenmeller Coalfield, England; common in the Little Main Seam (sample C5), Low Close Opencast Site, Cumbria; rare to common in the upper part of the Westphalian A and in the Westphalian B of Hedley Park.

Vestispora sp. A

Plate 28 Figures 15 - 20

Type locality. Little Main Seam, Sample No. C5, Low Close Opencast Site, Cumbria, England.

Size in micrometres. 56 (63) 72 (20 specimens), fum. HNO_3; Little Main Seam, Low Close Opencast Site, Cumbria.

Diagnosis. Spore radial, trilete, outline circular to oval in shape, operculum distinct, thick, dark brown in colour, occupying about 35-45% of spore diameter. Laesurae indistinct due to the thick operculum. Exoexine moderately thick, laevigate, infragranulate to minutely punctate or granulate, grana less than 0.5 µm in basal width and height. Faint, low reticulate sculpture of muri less than 0.5 µm in width and height also occur. Compression folds occasionally occur.

Comparison. The specimens described above may be compared to *V. laevigata* Wilson and Venkatachala 1963, but differ from the latter in possessing a distinct, thick, dark-brown operculum, with slightly thinner exoexine, and indistinct laesurae; differentiated from other species in the genus by its distinct, darker operculum and laevigate to minutely granulate exoexine.

Occurrence. Rare in Little Main Seam, sample No. C5, Low Close Opencast Site, Cumbria.

Turma ALETES Ibrahim 1933

Subturma AZONALETES (Luber) Potonie and Kremp 1954

Infraturma PSILONAPITI Erdtman 1947

Genus FABASPORITES Sullivan 1964

Type species. *F. pallidus* Sullivan 1964

Diagnosis. In Smith and Butterworth 1967, p. 300 (from Sullivan 1964, p. 378).

Comparison. This genus is distinguished from *Aletes* Sommers 1953 and *Inaperturopollenites* (Thomson and Pflug) Potonié 1958 by the presence of the single longitudinal fold.

Fabasporites pallidus Sullivan 1964

Plate 28 Figure 3

1964 *Fabasporites pallidus* Sullivan, p. 379, pl. 61, figs. 9-11.

1967 *Fabasporites pallidus* Sullivan, in Smith and Butterworth, p. 300, pl. 24, figs.34-38.

Holotype. Sullivan 1964, pl. 61, fig. 11.

Type locality. Edgehills Coal, Forest of Dean Coalfield, England; ? Westphalian A.

Diagnosis. In Smith and Butterworth 1967, p. 301 (from Sullivan, 1964, p. 379).

Size in micrometres. (i) 13 (17) 23, HF and 2% KOH (Sullivan 1964). (ii) 16 (21) 27, fum. HNO_3 Durham Coalfield, England; Westphalian A; (Smith and Butterworth 1967). (iii) 12 (18) 24 (12 specimens), fum. HNO_3, Quarter Seam, at 39.45 m, borehole No. 1138, Plenmeller Coalfield, England.

Description. Amb oval, circular to irregular in shape due to the secondary folds. Exine thin, less than 1 µm in thickness, covered with small grana less than 1 µm in basal width and height. Secondary folds frequent, usually along the major axis of the spore.

Comparison. *F. pallidus* superficially resembles *Latosporites minutus* Bharadwaj 1957 and small specimens of *P. minutus* Ibrahim 1933 but does not possess a recognizable monolete suture.

Previous records. Sullivan 1964, ? Westphalian A, Edgehills Coal, Forest of Dean Basin, Gloucestershire; Smith and Butterworth 1967, Westphalian A to D, British Coalfields.

Occurrence. Absent, rare to common throughout the Westphalian sequence.

Fabasporites sp. A

Plate 28 Figure 4, 5

Type locality. High Main Seam, borehole No. 1350, Plenmeller Coalfield, England.

Diagnosis. Amb oval; exine thin, minutely granulate. A single major fold frequently occurs.

Size in micrometres. (i) 28 (34) 39 (30 specimens), fum. HNO_3, High Main Seam, borehole No. 1350, Plenmeller Coalfield, England.

Description. Amb oval, subcircular to irregular in shape due to the compression folds. Exine pale and translucent, relatively thin, less than 1.5 μm in thickness, covered with very small grana less than 0.5 μm in basal diameter and height. A single major compression fold is often present, accompanied by narrow, short, arcuate folds. Margin smooth.

Comparison. Distinguished from F. pallidus Sullivan 1964 by its larger size range and the smaller grade of its sculptural elements. Apiculatisporis irregularis (Alpern) Smith and Butterworth 1967 is distinguished by its faint laesurae and by its irregularly distributed patches of coni, 1.5 μm in height and diameter.

Occurrence. Common in the High Main Seam (top leaf and bottom leaf) borehole No. 1138 and in borehole No. 1350, Plenmeller Coalfield, England.

Anteturma POLLENITES R Potonie 1931

Turma SACCITES Erdtman 1947

Subturma MONOSACCITES (Chitaley) Potonie and Kremp 1954

Infraturma ARADIATES Bharadwaj 1957a

Genus FLORINITES Schopf, Wilson and Bentall 1944

Type species. *F. mediapudens* (Loose) Potonie and Kremp 1956.

Diagnosis. In Smith and Butterworth 1967, p. 301 (from Schopf, Wilson and Bentall 1944, p. 56).

Remarks and comparison. The genus *Guthoerlisporites* Bharadwaj 1954 theoretically is distinguished from *Florinites* by possession of a central body free from the saccus on the proximal surface. Peppers 1970 expressed his doubt of this interpretation, which is difficult to apply in practice. Most species assigned to *Guthoerlisporites* are circular in outline, rather than elliptical.

Florinites diversiformis Kosanke 1950

Plate 30 Figure 5, 6

1950 *Florinites diversiformis* Kosanke, p. 49, pl. 12, fig. 5.

Holotype. Kosanke 1950, pl. 12, fig. 5. Preparation 618, slide 2.

Type locality. Reynoldsburg coal bed, Johnson County, Illinois, U.S.A.; Caseyville Group.

Diagnosis. In Kosanke 1950, p. 49.

Size in micrometres. (i) Holotype 94.5 X 134.4; Saccus, length 129-139 and 91-98 in width; Schulze and 10% KOH (Kosanke 1950). (ii) Saccus 48 (52) 65, body 22 (31) 39 (13 specimens); fum. HNO_3, Little Main Seam, (sample C5) Low Close Opencast Site Cumbria.

Description. Amb elliptical to circular. Body elongated at right angles to the long axis of the grain due to three or more prominent folds which control the shape of the body. Body laevigate to infrapunctate. Saccus laevigate, thin, minutely infrareticulate, muri 0.5-1 μm in width and lumina 1-1.5 μm in diameter. The saccus encloses the body on the distal surface.

Remarks. The specimens correspond to the original diagnosis given by Kosanke (1950), but the size range given here is much smaller than that recorded by Kosanke. The difference in size may be attributed to the method of maceration (Kosanke used Schulze and 10% KOH). Ravn (1979) transferred this species to a new genus *Pseudoillinites*. This genus was erected by Ravn to accommodate monosaccate prepollen or pollen grains in which the central body apparently bisects the saccus into two separate lateral sacci. In the species as described by Kosanke (1950), as well as in the specimens described above, the body does not occupy the full width of the saccus and so bisect it.

Comparison. Differs from other species of the genus by a distinct body which has major folds at right angles to the long axis of the grain which gives the body a polygonal shape.

Occurrence. Rare in Little Main Seam (sample C5) Low Close Opencast Site, Cumbria.

Florinites junior Potonie and Kremp 1956

Plate 31 Figure 12

1956 *Florinites junior* Potonie and Kremp, p. 168, pl. 21, figs. 466-467.

Holotype. Potonie and Kremp, 1956, pl. 21, fig. 466. Preparation 607/2.

Type locality. Flöz Baldur, Seche Brassert, Ruhr Coalfield, Germany; Upper Westphalian B, Lower Westphalian C.

Diagnosis. In Potonie and Kremp 1956, p. 168.

Size in micrometres. (i) Holotype 87, 70-90, Schulze + KOH (Potonie and Kremp 1956). (ii) Saccus 56-59 and 63, body 32, 33 and 36; (3 specimens); HF + fum. HNO_3; black shale with plant fragment, above the Quarter Seam, borehole No. 1350, Plenmeller Coalfield.

Description. Amb oval. Margin smooth or minutely indented. Body usually distinct circular to oval, often distorted by folds. Laesurae indistinct. Body laevigate to infragranulate, darker and thicker than the saccus. Saccus laevigate, thin with infrareticulation, muri 1-2 µm in width, lumina 1.5-3 µm. Folds rarely occur in the saccus.

Comparison. The proportion of the diameter of the body to the diameter of the saccus is smaller in F. junior than in F. mediapudens; in addition the body in F. mediapudens is thin and infrapunctate and folds occur peripheral to the margin. F. similis is distinguished by its larger size range with coarser infrareticulate exoexine and folds occur peripheral to the body. F. triletes Kosanke 1950 is smaller with distinct trilete rays.

Previous records. Kosanke 1950, Middle McLeansboro, Illinois, U.S.A.; Sullivan 1962, Upper Westphalian A and B, Wernddu Claypit, South Wales; Clayton et al. Westphalian A to C, Western Europe.

Occurrence. Rare in the upper part of the Westphalian A and Westphalian B sequence.

Florinites triletus Kosanke 1950

Plate 30 Figures 7 - 9

1950 Florinites triletus Kosanke; p. 50, pl. 12, figs. 3 - 4.

Holotype. Kosanke 1950, pl. 12, fig. 3. Preparation 574, Slide 3.

Type locality. Shoal Creek coal bed, Bond County, Illinois, U.S.A.; McLeansboro Group.

Diagnosis. In Kosanke 1950, p. 50.

Size in micrometres. (i) Holotype 52.9 x 65.1 (Kosanke 1950). (ii) saccus 49-69; body 25-36; Schulze and 10% KOH (Kosanke 1950). (iii) saccus 46-76; body 31-39; fum. HNO_3 (5 specimens); various localities within upper part of Westphalian A sequence.

Description. Amb oval to subcircular. Saccus laevigate, thin with faint infrareticulate sculpture, muri less than 1.5 μm in width, lumina polygonal in shape sometimes reach 3 μm in diameter. Central body distinct, occupies 50-65% of saccus, circular to irregular in shape due to peripheral folds. Laesurae distinct, simple, straight, extend almost to the margin of the body, lips sometimes present. Margin of the saccus smooth and rarely folded.

Comparison. This species is distinguished by the presence of the trilete rays. F. volans (Loose) Potonie and Kremp 1956 is larger.

Previous records. Clayton et al., 1977, Upper Westphalian A, Western Europe.

Occurrence. Absent to rare in the upper part of the Westphalian A sequence.

Florinites mediapudens (Loose) Potonie and Kremp 1956.

Plate 31 Figure 13

1934 *Reticulati-sporites* *mediapudens* Loose, P.158, Pl.7, fig.8.

1956 *Florinites mediapudens* (Loose); Potonie and Kremp, p.169, Pl.21, figs. 468 - 471.

1957a *Endosporites mediapudens* (Loose);Dybova and Jachowicz, p.207, Pl.71, fig.4.

Holotype. Potonie and Kremp 1956, Pl.21, fig.468 after Loose. Preparation III4, b4 (O).

Type locality. Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p.303 (from Potonie and Kremp, 1956, p.169).

Size in micrometres. (i) Holotype 60, Schulze and KOH. (ii) 50-65, Schulze (Potonie and Kremp 1956). (iii) 50 (58) 72, fum. HNO_3; Yorkshire Coalfield, England; Westphalian B, (Smith and Butterworth, 1967). (iv) Saccus 48 (57) 68; body 21 (34) 40); (11 specimens); HF and 1/3 conc. + 2/3 fum. HNO_3; black shale above Quarter Seam at 8.35 m, $\overset{b}{\text{b}}$orehole No. 1350, Plenmeller Coalfield, England.

Description. Amb oval to subcircular; margin smooth or minutely indented. Saccus laevigate, yellow in colour, thin, with faint infrareticulate sculpture, muri less than 1.5 µm in width and maximum diameter of lumina less than 3 µm. Saccus not often folded. Central body well developed, circular to oval in shape, brown in colour, darker than saccus, frequently folded mainly in peripheral region. Body occupying about 50% of overall diameter.

Remarks. *F. antiquus* Schopf,Wilson and Bentall 1944 was previously considered a junior synonym of *F. pellucidus* by Wilson 1963. Smith and Butterworth 1967, p.304 noted that there is considerable overlap in the size ranges of *F. pellucidus* and *F. mediapudens* and because there is no characteristic for separating these two species in practice, they considered F. pellucidus as a junior synonym of F. mediapudens. Furthermore the same authors included F. parvus Wilson and Hoffmeiester 1956 and F. ovalis Bharadwaj 1957 in F. mediapudens for the same reason even though they are smaller. Forms similar to these species were observed occasionally during the present study and they were included in F. mediapudens.

Comparison. F. junior Potonie and Kremp 1956 is distinguished by its larger size as well as the smaller ratio of the diameter of the body to the diameter of the saccus. F. triletus Kosanke 1950 has the same size and a distinct body but differs in having a distinct trilete mark. F. volans (Loose) Potonie and Kremp 1956 resembles F. triletus.

Previous records. Potonie and Kremp 1956 Upper Westphalian B, Ruhr Coalfield, Germany; Dybova and Jachowicz 1957, Upper Silesia, Poland; Sullivan 1962, Westphalian B, Wernddu Claypit, South Wales; Love and Neves 1963, Upper Westphalian B, Inninmore, Scotland; Neves 1964, Westphalian A, La Camocha Mine, Gijon, N. Spain; Smith and Butterworth 1967, Upper Westphalian A to Westphalian D, British Coalfields; Sabry and Neves 1970, Westphalian A, Sanquhar Coalfield, Scotland; Ravn 1979, Cherokee Group, Pennsylvania, CP-19-4 Coal, Southern Iowa, U.S.A.

Occurrence. Absent to rare throughout the Westphalian sequence.

Florinites millotti Butterworth and Williams 1954.

Plate 30 Figures 3, 4

Holotype. Butterworth and Williams 1954, in Smith and Butterworth 1967, Pl.26, fig.9. Specimen No.PF 3013 (formerly 76490), Geological Survey Museum, London.

Type locality. Bottom 1 ft. 4 in. coal at 3,388 ft. 2 in., Upton borehole, Oxfordshire, England; Westphalian D.

Diagnosis. In Smith and Butterworth 1967, p.305, (abbreviated from Butterworth and Williams, 1954, p.760).

Size in micrometres.(i) Holotype, saccus 37 x 29, body 19 x 19, maceration method not known; saccus, max. 30 (39) 49, min. 23 (30) 37, Schulze (Butterworth & Williams 1954) (iii) saccus 26 (31) 35 Body 18 (20) 22, (6 specimens); fum. HNO_3, different samples within the upper part of the Westphalian sequence, England.

Description. Amb elliptical to subcircular. Body oval to elliptical, not well developed, with long axis at right angle to length of the grain. Saccus thin, laevigate, infrareticulate, slightly thicker than the central body due to relatively coarse infrareticulation. Margin smooth to crenulate.

Comparison.Distinguished by its smaller size. F. minutus Bharadwaj 1957 is distinguished by its distinct, well developed body.

Previous records. Butterworth and Williams 1954, Westphalian D. Oxfordshire; Smith and Butterworth 1967, Westphalian B to D, British Coalfields; Ravn 1979, Cherokee Group (Pennsylvanian), CP-19-4 Coal, Southern Iowa, U.S.A.

Occurrence. Absent to rare throughout the Westphalian sequence.

Florinites occultus Habib 1966

Plate 29 Figure 12

1966 Florinites occultus Habib, p.649, Pl.108, figs. 4 - 5.

Holotype. Habib 1966, pl.108, fig.5a, b; Slide LKC-12 (51-52), mount 21.

Type locality. Lower Kittanning Coal, Western Pennsylvanian (Allegheny Series), Lower Westphalian D.

Diagnosis. In Habib 1966, p.649.

Size in micrometres. (i) 60 --106- central body 35 - 80; Schulze and 8% KOH (Habib 1966) (ii) Saccus 77; body 41 (one specimen); HF + fum. HNO_3, black coaly shale with rootlets, (Sample P8) from below the Wellsyke Seam, Borehole No.1350, Plenmeller Coalfield. (iii) 130, 117; body 63, 52 (2 specimens); Fum. HNO_3, Little Main Seam (Sample C5), Low Close Opencast Site,Cumbria.

Description. Amb elliptical. Central body (intexine), circular, dark, thick and uniform in thickness, margin well-defined. Laesurae indistinct. Central body occupying about 35 - 40% of overall diameter. Saccus thin, laevigate and with a coarse infrareticulate ornament, with muri less than 1 μm in width and lumina less than 1.5 μm in diameter; reticulation pattern radiating out from the central body. Saccus attached distally to (intexine) central body, proximal side free. Folds occur occasionally; margin smooth to weakly crenulate.

Comparison.Distinguished from other species in the genus by its dark thick central body and the radiating pattern of its infrareticulation.

Previous records. Habib, Lower Westphalian D, Lower Kittanning Coal, Western Pennsylvania, U.S.A.; Ravn 1979, Westphalian B, Cherokee Group, Iowa, U.S.A.

Occurrence. Rare in black coaly shale (sample P8) below the Wellsyke, Plenmeller Coalfield; and in the Little Main Seam (sample C5), Low Close Opencast Site, Cumbria.

Florinites pumicosus (Ibrahim) Schopf, Wilson and Bentall, 1944.

Plate 30 Figures 1, 2

1932 Sporonites pumicosus. Ibrahim in Potonie, Ibrahim and Loose, p.447. Pl.14, fig.6.

1933 Reticulata-sporites pumicosus Ibrahim, P.38, Pl.1.fig.6.

1938 Zonaletes pumicosus (Ibrahim); Luber in Luber and Waltz, Pl.8, fig.110.

1944 Florinites ? pumicosus (Ibrahim); Schopf, Wilson and Bentall, p.59.

Holotype. Potonie and Kremp 1955, Pl.21, fig.472 after Ibrahim. Preparation B34, d4 (u).

Type locality. Agir Seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p.305 (from Potonie and Kremp 1956, p.169).

Size in micrometres. (i) Holotype 92.5, Schulze and KOH. (ii) Saccus, 80 - 100, Schulze (Potonie and Kremp 1956) (iii) Saccus 77 (93) 117, fum. HNO_3; Yorkshire Coalfield, England, Westphalian B, (Smith and Butterworth 1967). (iv) 85 (97) 106, (15 specimens), HF and 1/3 conc. + 2/3 fum. HNO_3; black shale below Wellsyke Seam at 20.21 m. Borehole No.1350, Plenmeller Coalfield, England.

Description. Amb circular to oval. Central body indistinct. Saccus laevigate to infrapunctate, thin, ornamented with infrareticulate sculpture, muri less than 1.5 µm in width, lumina less than 2 µm; the sculpture is less well developed in the central area. Compression folds usually occur obliquely across the saccus. Margin smooth to weakly crenulate.

Comparison. The size range and apparent lack of a central body distinguish this species from others. Florinites antiquus Schopf, Wilson and Bentall, 1944, has a similar size range and shape but differs in having a well developed central body. F. visendus (Ibrahim) Schopf, Wilson and Bentall 1944 is larger and has coarser infrareticulate sculpture. F. cf. florini (Imgurund) in Smith and Butterworth 1967 has a smaller size otherwise it is similar.

Previous records. Grebe 1962, Upper Westphalian B to C, Ruhr Coalfield, Germany; Sullivan 1962, Westphalian A to B, South Wales; Love and Neves 1963, Westphalian B, Inninmore, Scotland; Owens and Burgess 1965, Westphalian A, Stainmore Outlier, Westmorland; Sabry and Neves 1971, Namurian C to Westphalian B, Sanquhar Coalfield, Scotland.

Occurrence. Absent to rare throughout the sequence; infrequent in the Upper Craignook and Slag Seams, in the dark grey and black shales above the Quarter Seam and in the dark grey shale below it, and in the dark grey shale beneath the Wellsyke stringer.

Florinites similis Kosanke 1950

Plate 29 Figures 13 - 15

1950 Florinites similis Kosanke p.49, Pl.12, fig.2.

Holotype. Kosanke 1950, pl.12, fig.2. Preparation 524-C, Slide 2.

Type locality. No.8 Coal, Peoria County, Illinois, U.S.A. McLeansboro Group.

Diagnosis. In Smith and Butterworth 1967, p.306 (from description in Kosanke 1950, p.49).

Size in micrometres. (i) Holotype 133 x 92; saccus, max. 124 x 42, min. 88 - 97; Schulze and 10% KOH (Kosanke 1950) (ii) Saccus, max. 112 - 61, min. 99 - 127; body, max. 65 - 92, min. 55 - 72. fum. HNO_3; Yorkshire Coalfield, England; Lower Westphalian C (Smith and Butterworth 1967). (iii) Saccus 87 (107) 127, body 46 (58) 67, (9 specimens) different macerations; different seams within the sequence, Plenmeller Coalfield, England.

Description. Amb oval to circular. Central body distinct, dark, minutely granulate, irregular in shape, due to compression folds; several compression folds occur parallel to the margin of the body. Saccus thin, translucent, laevigate, infrareticulate, with muri less than 1.5 µm in width and lumina less than 2 µm in diameter. Saccus overlaps the body distally.

Comparison. F. similis is distinguished from F. mediapudens (Loose) Potonie and Kremp 1956 by its larger size, and from F. visendus (Loose); Schopf, Wilson and Bentall 1944, and F. pumicosus (Ibrahim) Schopf, Wilson and Bentall 1944 by the clearly discernible central body.

Previous records.Sullivan 1962, Westphalian A - B, Wernddu Claypit, South Wales; Love and Neves 1963, Upper Westphalian B, Inninmore, Scotland; Neves 1964, Namurian B to Upper Westphalian A, La Camocha, North Spain; Owens and Burgess 1965, Upper Namurian A to Lower Westphalian B, Stainmore outlier, Westmorland; Smith and Butterworth 1967, Westphalian A to D, British Coalfields.

Occurrence: Absent to rare throughout the sequence.

Florinites visendus (Ibrahim) Schopf, Wilson and
Bentall, 1944.
Plate 30 Figures 10, 11

1933 Reticulata-sporites visendus Ibrahim, p.39, pl.3, fig.66.

1944 Florinites (?) visendus (Ibrahim) Schopf, Wilson and Bentall, 1944

1956 Florinites visendus (Ibrahim) Schopf, Wilson and Bentall; Potonie and Kremp, p.170, pl.21, figs. 476-7.

Holotype. Potonie and Kremp 1956, pl.21, fig.477 after Ibrahim, Preparation B29, cb (ur).

Type locality. Agir Seam, Ruhr Coalfield, Germany; Top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p.306 (from description and diagnosis in Potonie and Kremp 1956, p.170)

Size in micrometres. (i) Holotype 165, Schulze and KOH. (ii) 150 - 175, Schulze (Potonie and Kremp, 1956). (iii) 122 (151) 186, fum. HNO_3; Yorkshire Coalfield, England, Westphalian C; (Smith and Butterworth 1967). (iv) Saccus 127 and 151 (2 specimens); Fum. HNO_3, different localities, Plenmeller Coalfield.

Description. Amb circular to elliptical. Laesurae indistinct. Central body thin, not well developed. Saccus coarsely reticulate, with muri less than 2.5 μm in width and less than 1 μm in height and lumina less than 3 μm in diameter; reticulation in the polar area is less pronounced. Compression folds occur in the peripheral region of the polar area as well as across it.

Comparison. Distinguished from other species in the genus by its larger size. Potonieisporites elegans (Wilson and Kosanke) Habib 1966 is distinguished by its well defined central body as well as the longitudinal suture.

Previous records. Potonie and Kremp 1956, Upper Westphalian B to Lower Westphalian C, Ruhr Coalfield, Germany; Smith and Butterworth 1967, Upper Westphalian A to Lower Westphalian D, British Coalfields; Habib 1966, Lower Westphalian D, Lower Kittanning Coal, U.S.A.; Sabry and Neves 1970, Westphalian A, Sanquhar Coalfield, Scotland; Felix and Burbridge 1967, Pennsylvanian, Springer Formation, Southern Oklahoma, U.S.A.

Occurrence. One specimen found in Low Main Stringer, and another in Upper Craignook seam, Plenmeller Coalfield.

Infraturma VESICULOMONORADITI (Pant) Bharadwaj 1957

Genus PALEOSPORA Habib 1966

Type species. P. fragila Habib 1966.

Diagnosis. In Habib 1966, p.647.

Remarks. This genus is characterised by an elliptical to subcircular amb, central body enveloped by saccus and very wide equatorial flange. A longitudinal slit occupies the complete length of the saccus.

Comparison. This genus is distinguished from Potoniesporites Bharadwaj 1954 by its wide flange with more elliptical well developed central body and finer, less distinct infrareticulation.

Paleospora fragila Habib 1966

Plate 31 Figures 1 - 4

1966 Paleospora fragila Habib, p.647, pl.108, figs, 1, 2.

Holotype. Habib 1966, Pl.108, fig.1. Slide LKC - 2 (21-22) 2, 36.5, 115.2.

Type locality. Lower Kittanning Coal, Western Pennsylvanian, (Allegheny Series), lower Westphalian D.

Diagnosis. In Habib 1966, p.647.

Size in micrometres. (i) Holotype 161 x 93, 150 - 195, saccus 105 - 140, flange width 15 - 25, Schulze + 8% KOH. (ii) 119 (139) 157 (16 specimens), HNO_3, Little Main Seam, Low Close Opencast Site, Cumbria.

Description. Monosaccate grains, oval to elliptical in equatorial outline. Central body distinct, elliptical in shape, with long, frequently marginal folds. The longitudinal slit is bordered by folds through the whole length. Saccus encloses the central body, sometimes showing a differentiation in thickness, with an inner slightly darker thicker area and an outer slightly wider, lighter and thinner area (flange of Habib). Saccus including flange, 12 - 18 µm wide, ornamented with very low corrugation to infrapunctate.

Previous records. Habib 1966, lower Westphalian D, Lower Kittanning Coal, western Pennsylvania, U.S.A.; Peppers 1970, Spoon Formation (Pennsylvanian), northeastern part of the Illinois Basin, U.S.A.

Occurrence. Rare in Little Main (sample C5), Low Close Opencast Site, Cumbria.

Genus POTONIEISPORITES Bharadwaj 1954

Type species. P. novicus Bharadwaj 1954.

Diagnosis. (from Bharadwaj 1954, p.520) "Monosaccate miospores with an elliptical or oval equatorial outline and longitudinal suture. Central body oval to circular. In the compressed state it shows two annular folds. The suture lies parallel to the longest axis. Surface of saccus smooth but inner surface with infrareticulate ornament".

Potonieisporites elegans (Wilson & Kosanke) Habib,1966.

Plate 32 Figures 1, 2

1944 Florinites elegans Wilson and Kosanke, p.330, fig.3

1964 Potonieisporites elegans (Wilson and Kosanke); Wilson and Venkatachala, P.67, Pl.1, figs. 1, 2.

1966 Potonieisporites elegans (Wilson and Kosanke); Habib, p.648, Pl.108, fig.3.

Holotype.Wilson and Kosanke 1944, fig.3.

Type locality. Angus Coal Company Mine, Oskaloosa, Iowa, Des Moines Series, Slide 279 P, Circle 1.

Diagnosis.In Habib 1966, P.648.

Size in micrometres. (i) Holotype 197 x 135; 180 - 210 x 130 - 145, Schulze and KOH (Wilson and Kosanke 1944). (ii) 217, 18; body 71, 89 (2 specimens), HF + fum. HNO_3, black shale (sample M20) above the Upper Fell Top Limestone Featherstone area. (iii) 197 (173) 152 (5 specimens), various localities, in the Westphalian sequence.

Description.Amb oval to roundly elliptical. Body distinct, elliptical to subrounded in outline, often distorted by long, lenticular folds which occur peripheral to the margin on both distal and proximal surfaces. Suture distinct to indistinct, simple straight to  shaped, usually open. Intexine thin with infrareticulate to infragranulate ornament. Saccus laevigate, slightly thicker than the central body, ornamented with coarse infrareticulation, muri 0.5 - 1.5 µm in width, lumina 1.5 - 2.5 µm in diameter. Margin smooth to undulating.

Remarks. Bharadwaj (1954) defined *Potonieisporites* as a monolete monosaccate genus. Wilson and Venkatachala (1964) transferred *Florinites elegans* Wilson and Kosanke (1944) to this genus and their photograph of the holotype is clearly monolete. In his emendation of the diagnosis of this species, Habib (1966) described the suture as "essentially straight, longitudinal, but occasionally T-shaped with a much reduced third suture or even symmetrically (Y-shape) trilete". In the present specimens the sutures were not clearly discernible.

Previous records. Wilson and Kosanke 1944, Des Moines Series, Iowa, U.S.A.; Kosanke 1950, Upper Tradewater Group, Illinois and Kentucky, U.S.A.; Neves 1961, Upper Namurian A - Namurian C, Southern Pennines; Owens and Burgess 1965, Namurian B to Westphalian A, Stainmore Outlier, Westmorland; Habib 1966, Lower Westphalian D, Lower Kittanning Coal, Western Pennsylvania, U.S.A; Felix and Burbridge 1967, Lower Pennsylvanian, Springer Formation, Southern Oklahoma, U.S.A.: Neves 1968, Namurian A to C, Woodland Borehole, Co. Durham; Sabry and Neves 1970, Namurian C/Westphalian A boundary, Sanquhar Coalfield, Scotland; Ravn 1979, Cherokee Group, CP-19-4 Coal, Southern Iowa, U.S.A.

Occurrence. Absent to rare throughout the sequence.

Subturma DISACCITES Cookson 1947

Genus PITYOSPORITES (Seward) Manum 1960

Type species. P. antarticus Seward 1914.

Diagnosis. In Smith and Butterworth 1967, p.308 (from Manum, 1960, p.14).

Comparison. Schopf, Wilson and Bentall 1944, p.49 compared the genus Alisporites Daugherty 1943 with Pityosporites; it differs in that the bladders are attached symmetrically opposite each other and are not distally inclined. Pityosporites differs from other Carboniferous bisaccate forms in that the bladders are distinctly offset from the body and are entirely separate.

Pityosporites westphalensis Williams 1955

Plate 31 Figures 6 - 11

1955 Pityosporites westphalensis Williams, p.467, Pl.6, Fig.1.

Holotype. Williams 1955, Pl.6, fig.1. Preparation No.V 31900 in collection of British Museum (Natural History), London.

Type locality. No.12 Seam, Nantgarw Colliery, South Wales Coalfield, Westphalian C.

Diagnosis. In Smith and Butterworth 1967, p.309 (from diagnosis in Williams 1955, p.467).

Size in micrometres. (i) Holotype: dimensions have no significance due to oblique compression, body partly concealed by sacci. Length of grain 39 (47) 51; fum. HNO_3 (Williams 1955). (ii) Length of grain 36 (44.5), 47 (6 grains); width of grain 21 (26) 31 (6 grains); fum. HNO_3, Maudlin Seam (top leaf) at 14.53 m, Borehole No.5058, Hedley Park, England.

Description. Amb of grain oval, amb of body circular to slightly elongated in direction of long axis. Length of body less than full length of grain owing to the lateral displacement of the sacci;

the width of the body is the full width of the grain. Body wall laevigate, less than 1.5 µm in thickness. Sacci laevigate and thin, with reticulate infrasculpture. Lumina less than 2 µm in maximum dimension, muri less than 1 µm in width. Margin smooth or minutely indented.

Previous records. Williams 1955, Westphalian C, South Wales Coalfield; Smith and Butterworth 1967, Upper Westphalian A to Westphalian D; Ravn 1979, Cherokee Group (Pennsylvanian), CP-19-4 Coal, Iowa, U.S.A.

Occurrence. Rare in the Harvey Seam, sample No.H.235, Pennyhill Seam, sample No.H.236, Bottom Brass Thill Seam, sample No.H.492, Low Main/Top Brass Thill Seam, sample No.H.30, and in the Maudlin Seam (top leaf) sample No.H.541, all from Hedley Park; one specimen in the Lower Craignook, sample No.800, Plenmeller Coalfield.

Turma PLICATES (PLICATA Naumova 1937, 1939) Potonie 1960

Subturma PRAECOLPATES Potonie and Kremp 1954

Genus SCHOPFIPOLLENITES Potonie and Kremp 1954

Type species. S. ellipsoides (Ibrahim) Potonie and Kremp 1954.

Diagnosis. In Smith and Butterworth 1967, p.309 (translated from Potonie and Kremp 1954, p.180)

Schopfipollenites ellipsoides (Ibrahim) Potonie and Kremp, 1954.

Plate 31 Figure 5

1932 Sporonites ellipsoides Ibrahim in Potonie, Ibrahim and Loose, p.449, Pl.17, fig.29.

1933 Laevigato-sporites ellipsoides Ibrahim p.40, Pl.4. fig.24.

1934 Punctato-sporites ellipsoides (Ibrahim); Loose, p.158, Pl.7, fig.35.

1934 Sporites ellipsoides (Ibrahim); Wicher, p. 185.

1938 Monoletes ellipsoides (Ibrahim); Schopf, p. 45, pl. 1, fig. 14, and pl. 6, figs. 5-6.

1954 Schopfipollenites ellipsoides (Ibrahim); Potonie and Kremp, p. 180.

Holotype. Potonie and Kremp 1956, pl. 22, fig. 478 after Ibrahim. Preparation E55, a.

Type locality. Ägir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis. In Smith and Butterworth 1967, p. 310 (from translation in Potonie and Kremp 1956, p. 184).

Size in micrometres. (i) Holotype 350; 200-500. Schulze (Potonie and Kremp 1956). (ii) 137, 142 and 166 (3 specimens), various localities within the sequence.

Description. Amb oval. Suture distinct, simple, moderately bent near the middle, extending 3/4 of length of the spore body. Two major, distal, longitudinal folds usually run parallel to the suture. Intexine (central body) indistinct. Exoexine minutely granulate to punctate.

Comparison. S. ellipsoides var. corporeus Neves 1961 is distinguished by its well-defined central body (intexine).

Previous records. Potonie and Kremp 1956, Westphalian B, Ruhr Coalfield, Germany; Neves 1958, Namurian C/Westphalian A boundary, North Staffordshire; Neves 1961, Namurian A to Westphalian A, Southern Pennines; Neves 1964, Namurian B and C, La Camocha Mine, North Spain; Smith and Butterworth 1967, Namurian B to Westphalian D, British Coalfields; Ravn 1979, Cherokee Group, Pennsylvanian), CP-19-4 Coal, Southern Iowa, U.S.A.

Occurrence. One specimen occurs in the black shale above the Lower Fell Top Limestone (sample M15), Park Burn; absent to rare throughout the Westphalian sequence.

Schopfipollenites ellipsoides var. corporeus Neves 1961

Plate 32 Figures 3 - 6

1961 Schopfipollenites ellipsoides var. corporeus Neves, p. 274, pl. 34, fig. 5.

Holotype. Neves 1961, pl. 34, fig. 5. Preparation 4.23680o.

Type locality. Pot Clay Coal, Consall, North Staffordshire, England; Namurian C.

Diagnosis. In Smith and Butterworth 1967, p. 311 (from diagnosis in Neves 1961, p. 274).

Size in micrometres. (i) Holotype 168; 145-210, Schulze and KOH (Neves 1961). (ii) 124 (167) 223, fum. HNO_3, Yorkshire Coalfield, England; Westphalian B (Smith and Butterworth 1967). (iii) 126 (153) 187 (5 specimens); 1/3 conc. + 2/3 fum. HNO_3, Upper Craignook Seam (top leaf), at 20.55, borehole No. 1154, Plenmeller Coalfield, England.

Discription. Equatorial outline oval. Suture longitudinal, straight to slightly flexuose, extending 2/3 length of spore body, suture slightly open. Distal surface bears two major longitudinal folds, usually confined to the margin. Intexine (central body) distinct. Exoexine faintly granulate.

Comparison. This variety is distinguished from S. ellipsoides (Ibrahim) Potonie and Kremp 1954 by its well-defined inner body.

Previous records. Neves 1961, Namurian C to Westphalian A, Southern Pennines; Owens and Burgess 1965, Westphalian A to B, Stainmore Outlier, Westmorland; Smith and Butterworth 1967, Namurian B to Westphalian D, British Coalfields; Neves 1968, Namurian C to Westphalian A, Woodland Borehole, Co. Durham.

Occurrence. Absent to rare throughout the Westphalian sequence.

CHAPTER 6

MIOSPORE DISTRIBUTIONS

6.1 Introduction

The main aim of the present study is the use of miospores for stratigraphical subdivision and correlation of strata.

The miospores isolated from coals and sediments, from Featherstone, Plenmeller and other areas, were adequately and often well preserved, and the majority of the spores observed in them could be assigned to previously described Upper Carboniferous species.

The miospores isolated from fifteen carbonaceous shale samples from Plenmeller, borehole No. 1241, were badly preserved and accompanied by numerous wood fragments. On the other hand, of the thirty coals, carbonaceous shales, seatearth, and roof shales collected from Plenmeller, borehole No. 1350, fifteen yielded moderately to well-preserved miospore assemblages and some of them yielded a high variety of species. Among these are two new species of the genus Stenozonotriletes, one new species of the genus Knoxisporites, and one new species belonging to the genus Cristatisporites, all of which have been described in Chapter 5.

Similarly, of the eighteen coals, carbonaceous sediments, seatearth and roof measures collected in the field from the Featherstone area, twelve yielded satisfactory miospore assemblages. Among these are two new genera and twelve new species, all of which have been described in the previous chapter.

In St. Andrew's opencast Site, of the twenty eight samples collected on the site, fifteen samples yielded moderately preserved assemblages, while in Low Close Opencast Site, of the fourteen coal samples collected on the site, ten yielded well-preserved assemblages. Among these are two new species belonging to the genera Verrucosisporites and Vestispora.

In general the assemblages are dominated throughout the sequence by spores of the genera Lycospora, Densosporites (mainly L. pusilla and D. anulatus respectively) and Calamospora; and also high percentages of Apiculatisporis, Radiizonates, Cingulizonates, and Crassispora. The distribution of all species are shown in charts Nos. 1, 2 and 3.

Quite a few of the miospore species recorded from the Featherstone, Plenmeller and other successions studied in the present investigation, are common to both Namurian and Westphalian strata. Others have stratigraphically significant distributions and are relatively common in certain parts of the sequence and uncommon in others as shown in Chart 4. These variations in distributions make possible the subdivision of the sequence into six distinctive Assemblages. They are similar to the concurrent range zones of other authors but because the sequences from which the samples were taken are not always continuous they are referred more loosely to Assemblages. Their limits are shown in Fig. 20.

In the following section the Assemblages are first described and then compared with the concurrent range zones defined by Owens et al. (1977) and Clayton et al. (1977), and with assemblages from strata of comparable age in Northern England described by earlier workers.

6.2 Assemblage I

The oldest spore assemblages examined in the succession were obtained from two samples (M15 and M13) of black shales which overlie the Brampton Lower Fell Top Limestone, exposed in Park Burn, 300 yards east of the railway (Section 2.2.2).

The samples were productive and the spores well preserved. The Assemblage was dominated by *Lycospora spp.*, *Densosporites intermedius* Butterworth and Williams 1958, *Cingulizonates bialatus* (Waltz) Smith and Butterworth 1967, and by *Spelaeotriletes spB*. (12.5% in sample M13).

The assemblages recorded from these two samples were distinguished by the presence of many typical Namurian A species, and these are: *Leiotriletes inermis* (Waltz) Ishchenko 1952, *L. tumidus* Butterworth and Williams 1958, *Punctatisporites giganteus* Neves 1961, *Granulatisporites spp.* *Waltzispora planiangulata* Sullivan 1964, *Tricidarisporites balteolus* Sullivan and Marshall 1966, *Acanthotriletes castanea* Butterworth and Williams 1958, *Convolutispora spp.*, *Knoxisporites spp.*, *Tantillus triquetrus* Felix and Burbridge 1967, *Savitrisporites nux* (Butt. & Will.) Smith and Butterworth 1967, *Stenozonotriletes lycosporoides* (Butt. & Will.) Smith and Butterworth 1967, *Densosporites pseudoannulatus*, Butterworth and Williams 1958, *D. spinifer* Hoffmeister, Staplin and Malloy 1955, *D. microponticus* Artuz 1957, *Lycospora noctuina* Butterworth and Williams 1958, *Cristatisporites pannosus* (Knox) Butterworth *et al*. 1964, *Radiizonates striatus* (Knox) Staplin and Jansonius 1964, *Spelaeotriletes arenaceus* Neves and Owens 1966, *Discernisporites irregularis* (Neves) Neves and Owens 1966, *D. micromanifestus* (Hacquebard) Sabry and Neves 1970, *Vallatisporites vallatus* Hacquebard 1957, *Rugospora corporata* Neves and Owens 1966, and others. In addition, species of zonal significance include *Dictyotriletes castanaeformis* (Horst) Sullivan 1964, *Crassispora kosankei* (Potonie and Kremp) Smith and Butterworth 1967, *Kraeuselisporites ornatus* (Neves) Owens, Mishell, and Marshall 1976, Schulzospora rara Kosanke 1950, and Bellispores nitidus (Horst) Sullivan 1964. The newly described species Spelaeotriletes spA. and S. spB. are present in both samples, and may be of stratigraphical significance; they are more common in sample M13 (1-2% and 12.5% respectively).

The presence of the following species, which are not found higher in the present sequence, have also stratigraphical significance; these are: Chaetosphaerites pollenisimilis (Horst) Butterworth and Williams 1958, Schulzospora elongata Hoffmeister, Staplin and Malloy 1955, S. ocellata (Horst) Potonie and Kremp 1955, Laevigatosporites minor Loose 1934 (which occurs in younger, Westphalian strata) and occasional specimens of the following significant species: Tripartites spp., Rotaspora spp. and Spinozonotriletes uncatus Hacquebard 1957. Crassispora maculosa (Knox) Sullivan 1964, Kraeuselisporites echinatus Owens, Mishell, and Marshall 1976, Remysporites magnificus (Horst) Butterworth and Williams 1958, Grandispora echinata Hoffmeister, Staplin and Malloy 1958, and Schulzospora campylotpera (Luber and Waltz) Potonie and Kremp 1955 have not been recorded.

6.2.1 Stratigraphical comparison and conclusions

Neves (1968) examined miospore assemblages from the Woodland Borehole, Co. Durham and indicated a significant change in the microflora representing his Group 5. The lowest horizon in Neves' Group 5, which includes samples at 812 ft, 828 ft and 871 ft contain Chaetosphaerites pollenisimilis, Bellispores nitidus, Spelaeotriletes arenaceus, Remysporites magnificus, Potoniesporites elegans (Wilson and Kosanke) Habib 1966, and occasional specimens of Laevigatosporites spp. and Crassispora kosankei. Tripartites spp.

and *Rotaspora spp*. are present at these horizons but do not occur any higher in the sequence. *Crassispora maculosa* disappears below Group 5 (in the E_1 stage) and *Grandispora spinosa* Hoffmeister, Staplin and Malloy 1955 disappears a little higher, in low E_2 strata. Therefore, the assemblage described by Neves from 812 ft. and 871 ft. compares closely with Assemblage I, excepting in the absence of *Remysporites magnificus*, and *Potoniesporites elegans*, and the presence of *Kraeuselisporites ornatus* in the latter.

Owens *et al*. 1977, and Clayton *et al*. (1977) in their comprehensive treatment of the stratigraphical distribution of miospores from the Upper Devonian to the Lower Permian in Western Europe, describe the *Stenozonotriletes triangulus* - *Rotaspora knoxi* (TK) Zone, and *Lycospora subtriquetra* - *Kraeuselisporites ornatus* (SO) Zone, which include the E_{2a} and lower E_{2b}, and E_{2b} - H goniatite stages respectively. The composition of Assemblage I compares to some extent with the uppermost part of the TK zone and the lower part of the SO Zone, which is equivalent to the middle or upper part of the E_{2b} Zone. They indicate the disappearance of *Tripartites spp*. *Cingulizonates cf. capistratus* (Hoffmeister, Staplin and Malloy) Staplin and Jansonius 1964, and *Rotaspora spp*., however at the top of the TK Zone, while *Crassispora maculosa* and *Grandispora spinosa*, which are not present in Assemblage I, disappear about halfway up the SO Zone. The base of the SO Zone is marked by the first appearance of *Kraeuselisporites ornatus*, *Lycospora subtriquetra* (Luber) Potonie and Kremp 1956, *Camptotriletes superbus* Neves 1958 and *Apiculatisporis variocorneus* Sullivan 1964. The latter two species occur higher in the present assemblages. Other significant species which are common in both zones are: *Punctatisporites giganteus*, *Savitrisporites nux*, *Bellispores nitidus*, *Crassispora kosankei* *Secarisporites remotus*, *Rugospora corporata*, *Spelaeotriletes arenaceus* and *Schulzospora ocellata*. On the other hand, the following species are not recorded in the present assemblages, but they were recorded by them, and these are: *Punctatisporites pseudopunctata* Neves 1961, *Moorisporites trigallerus* Neves 1961, *Kraeuselisporites echinatus*, and *Remysporites magnificus*. *Laevigatosporites minor* was recorded in the present study, but did not occur in their assemblages until the top of SO Zone (Clayton *et al*., loc. cit.).

However, the misopore assemblages described by Whitaker and Butterworth (1978) from near to the limit of the E_{2a} zone and the E_{2b} zone, around the type locality of Slieve Anierin, County Leitrim, have much in common with the present Assemblage I.

Significant species present in both assemblages are: *Tripartites vetustus* Schemel 1951, *Rotaspora knoxi* Butterworth and Williams 1958, *Bellispores nitidus*, *Crassispora kosankei*, *Schulzospora ocellata* and *Laevigatosporites minor*; while *Chaetosphaerites pollenisimillis*, *Punctatisporites giganteus*, *Secarisporites remotus*, *Spelaeotriletes arenaceus* and *Rugospora corporata* were present in Assemblage I, but absent in the Leitrim assemblage. The absence of *Kraeuselisporites ornatus*, and the presence of *Camptotriletes cristatus* Sullivan and Marshall 1966, and *Cingulizonates cf. capistratus* in the Leitrim assemblage, indicates a horizon older than Assemblage I.

It is concluded, from the presence of *Tripartites spp*., *Rotaspora spp*., and *Kraeuselisporites ornatus*, that Assemblage I lies at an horizon between the TK and SO zones of Owens *et al*. (1977) and Clayton *et al*. (1977), at an horizon near the middle or upper part of the E_{2b} goniatite stage.

6.3 Assemblage II

The assemblages were obtained from samples M22, M20, M19 and M18, from strata above the Brampton Upper Fell Top Limestone, which crop out in Pinking Cleugh, 500 yards west-south-west of Wydon Eals (section 2.2.2). The samples were productive and well-preserved.

The assemblages were dominated by *Lycospora pusilla*, *Densosporites spp.*, *Cingulizonatus spp.* and by the presence of three newly described species, Spore type A_1 and A_2 (5.2% in sample M20) and a reticulate monolete spore, Spore type B (1.8% in sample M22).

Several of the newly described species occur in this assemblage; these species are *Leiotriletes sp.A*, *L. spC*. *Calamospora spA.*, *C. sp.B.*, *Savitrisporites sp.A.*, *Crassispora sp.A.*, Spore type A_1 and Spore type A_2. A Pennsylvanian species recorded for the first time in the Namurian of Europe is *Adelisporites multiplicatus* Ravn 1979, which occurs in sample M20 (0.5%).

The assemblage also includes: *Leiotriletes tumidus*, *L. pyramidatus* Sullivan 1964, *Calamospora spp.*, *Granulatisporites spp.* *Waltzispora planiangulata*, *Acanthotriletes castanea*, *Apiculatisporis variocorneus* Sullivan 1964, *Dictyotriletes castaneaformis*, *Convolutispora florida* Hoffmeister, Staplin and Malloy 1955, *C. mellita* Hoff., Stap. and Mall., *C. tessellata*Hoff., Stap. and Mall., *C. varicosa* Butterworth and Williams 1958, *Savitrisporites nux*, *Bellispores nitidus*, *Camptotriletes superbus* Neves 1961, *Crassispora kosankei*, *Reinschospora triangularis* (Kosanke) Ravn 1979, *Knoxisporites spp.*, *Cristatisporites pannosus*, *Radiizonates striatus*, *Cirratriradites rarus* (Ibrahim) Schopf, Wilson and Bentall 1944, *Spelaeotriletes arenaceus*, *Kraeuselisporites ornatus*, *Proprisporites laevigatus* Neves 1961, *Florinites similis* Kosanke 1950, and

Potoniesporites elegans

6.3.1 Stratigraphical comparison and conclusions

A number of significant elements present in Assemblage I are no longer present in this Assemblage, and these are: Chaetosphaerites pollenisimilis, Rotaspora spp., Tripartites spp., Schulzospora elongata, S. ocellata, and Laevigatosporites minor. In the meantime the continued presence of several characteristic Namurian A species, the absence of Raistrickia fulva Artuz 1957, Grumosisporites varioreticulatus (Neves) Smith and Butterworth 1967, and abundant C. kosankei, and the first appearance of Apiculatisporis varicorneus, Camptotriletes superbus and Cirratriradites rarus, together with the newly described species indicate horizone in the higher part of the SO Zone (below the R. goniatite stage), Clayton et al. 1977, and Owens et al. 1977.

The assemblages described by Neves (1961) from two samples of marine shales from the Arnsbergian (E_2) stage and from marine and non-marine shales and a coal from the H_2a zone of the South Pennines differ from both the assemblages described above. This difference may be due to the fact the Neves' assemblages were isolated from the Southern Pennines, so that the assemblages have different floral affinities from those in the Northern Pennines.

Owens, in Owens and Burgess (1965), indicates that the 270 ft which extend from the High Wood Marine Beds to the Mousegill Marine Bed (Stainmore, E_{2b} - H_2), yielded miospore assemblages which were rather impoverished. The miospores isolated from the lower part of this section, from marine shales at 57 ft. above the High Wood Marine Bed and from shales about 25 ft higher in the succession did not yield very significant assemblages; the strata are marked by the absence of *Rotaspora spp.*, *Tripartites spp.* *Stenozonotriletes lycosporoides* and *Grandispora spinosa* and the persistence from older horizons of *Schulzospora elongata*, *S. ocellata*, *Leiotriletes tumidus*, *Bellispores nitidus* and *Remyspora magnificus* and *Crassispora kosankei* which becomes much more common above these horizons. Owens suggests that the H goniatite stage is characterised by the absence of many diagnostic E_2 miospores and by the presence of *Crassispora kosankei* in small numbers.

Neves, Read and Wilson (1965) examined miospore assemblages from coal samples from the Passage Group of Scotland. Neves indicates that the lowest two coal samples (13 and 14) are of Upper Namurian A age and are distinguished from older horizons by the absence of *Rotaspora spp.* and *Tripartites spp.*

Neves (1969) examined 7 samples from the Woodland Borehole, Co. Durham from his Group 5 assemblages which extend from the base of E_2 to the base of the R_1 goniatite stage. The genera *Rotaspora* and *Tripartites* do not occur above 812 ft., in the middle of the group. The higher three samples (Neves loc. cit., plate III) are characterised by the persistence of *Spelaeotriletes arenaceus*, *Crassispora kosankei*, *Bellispores nitidus*, *Potoniesporites elegans*, *Chaetosphaerites pollenisimilis* and *Remysporites magnificus*. The higher part of Group 5 compares closely with Assemblage II, excepting in the absence of the latter two species.

Owens *et al.* (1977) and Clayton *et al.* (1977) described the composition of the higher assemblages in their *Lycospora subtriquetra - Kraeuselisporites ornatus* (SO) Zone which compares closely with Assemblage II described above in the absence of *Punctatisporites giganteus*, *Rotaspora spp.*, *Tripartites spp.*, *Remysporites magnificus* and Grandispora spinosa and in the presence of occasional specimens of Apiculatisporis variocorneus, Camptotriletes superbus and Cirratriradites rarus.

Bellispores nitidus shows an occasional occurrence above the SO Zone, while it disappears above Assemblage II in the present study.

Owens et al. (1977) and Clayton et al. (1977) indicated that the upper part of the SO zone is equivalent to the H goniatite stage, and they pointed out that the upper limit is equivalent to the boundary between the H_2/R_1 goniatite zones. This limit is marked by the gradual disappearance of most of the species which are characteristic of the late Visean and early Namurian and which are progressively replaced by species which become more characteristic of the late Namurian. Moreover, they suggested that this horizon is comparable with the boundary between the Mississippian and Pennsylvanian systems in North America.

Therefore it is concluded that Assemblage II is from the highest part of the E_2 Zone (E_{2c}) or from the H goniatite stage.

6.4 Assemblage III

The assemblages were recorded from three samples (M5, M8 and M9) from the type locality of the Burnfoot Shale which is well exposed in Hartley Burn (See Section 2.2.2).

The spores were adequately preserved and identifiable; the assemblage is characterised by its transitional nature between those of the Namurian A below and the Westphalian above. It is characterised by the disappearance of Acanthotriletes castanea, Waltzispora planiangulata, Dictyotriletes castanaeformis, Bellispores nitidus, Densosporites spinosus Dybova and Jachowicz

1957, Cristatisporites pannosus, and Laevigatosporites minor; and the incoming of Westphalian species for the first time, i.e. Raistrickia fulva Artüz 1957, Grumosisporites varioreticulatus (Neves) Smith and Butterworth 1967, Camptotriletes superbus, Apiculatisporis varicorneus, A. irregularis (Alpern) Smith and Butterworth 1967 and Densosporites anulatus (Loose) Smith and Butterworth 1967.

The assemblage is dominated by Lycospora pusilla, Densosporites spp. and Cingulizonates loricatus; the other characteristic miospores which are present in Assemblage III are: Lycospora noctuina, Densosporites pseudoannulatus, D. spinifer, D. microponticus, D. intermedius, D. anulatus, Leiotriletes tumidus, Savitrisporites nux, Granulatisporites spp. Calamospora spp. Spelaeotriletes arenaceus, Radiizonates striatus, Knoxisporites dissidius K. stephanephorus, Secarisporites remotus, Crassispora kosankei, Cingulizonates loricatus, Stenozonotriletes lycosporoides and Kraeuselisporites ornatus.

6.4.1 Stratigraphical comparison and conclusions

The assemblage described above compares closely to the miospore assemblages described by Neves (1961) from the Marsdenian (R_2) stage of the Southern Pennines. As he stated, many spores make their first appearance in the Marsdenian stage and persist through into the Westphalian assemblages.

Neves in Neves, Read and Wilson (1965) described similar assemblages from the Scottish Passage Group (coal samples 4 to 7) and he indicated that the assemblages show a progressive increase of Westphalian species like Grumosisporites varioreticulatus, Camptotriletes superbus, Spelaeotriletes arenaceus, Apiculatisporis variocorneus, and Raistrickia fulva.

The lowest part of the Group 3 assemblage recorded by Neves (1968) from the Woodland Borehole also comapres closely with Assemblage III. The miospore assemblages isolated from samples at 466-479 ft. were poorly preserved and characterised by the presence of Densosporites anulatus and Cingulizonates loricatus with occasional specimens of Apiculatisporis variocorneus, Florinites similis Kosanke 1950 and Grumosisporites varioreticulatus. However, the succeeding 7 samples from 425 ft to 464 ft produced poorly preserved and unidentifiable miospore assemblages.

Owens (in Owens and Burgess 1965) described assemblages from the 420 ft. section between the Mousegill Marine Beds and the Swinstone Top Marine Band in Stainmore. Owens could not isolate any spores from a large number of samples of various lithologies from the sediments between the Swinstone Bottom and Top Marine Bands which Ramsbottom et al. (1978) indicate to be equivalent to the R_2 and G_1 goniatite stages. He described a significant association of Grumosisporites varioreticulatus, Secarisporites remotus, Crassispora kosankei and Kraeuselisporites ornatus, with the absence of Ibrahimispores brevispinosus Neves 1961 and Cirratriradites rarus, in a sample at 60 ft below the Swinstone Bottom Marine Band, which compares closely to the present Assemblage III. Owens and Burgess placed this assemblage in the upper part of the R_2 or the lower G_1 stage. (Ramsbottom et al. (1978), however, placed the horizon in the upper part of the R_1 stage.)

Owens et al. (1977) stated that the base of the Crassispora kosankei, Grumosisporites varioreticulatus (KV) Zone is marked by high numbers of C. kosankei and the appearance of Ibrahimispores magnificus.

Slightly higher (middle R_1) in the sequence Raistrickia fulva, and Grumosisporites varioreticulatus appear for the first time. Assemblage III, therefore, corresponds closely to the higher part of this zone.

Clayton et al. (1977) in their comprehensive chart also show that the upper part of the KV Zone is characterised by the first appearance of occasional specimens of Grumosisporites varioreticulatus and Raistrickia fulva, which as stated above compares closely with Assemblage III. However, Clayton et al.(loc. cit.) also noted that the base of the KV Zone (base of R_1 stage) is marked by a significant increase in Crassispora kosankei; this feature has been utilised by several workers (Neves 1961, Southern Pennines; Owens 1965, Stainmore area; Mishell 1966, Bowland Fells; Owens et al. 1977, Northern England and Scotland) and is associated with the first appearance of Ibrahimispores magnificus, which is restricted to the R_1 stage (Owens et al. 1977). This species does not occur in the present assemblage.

It is, therefore, concluded that Assemblage III is most probably of lower R_2 age.

6.5 Assemblage IV

Miospore species from Assemblage IV were characterised by the first appearance of several Westphalian species, and by the disappearance of some Namurian species. The appearance of the monolete species Laevigatosporites minor and Punctatosporites minutus together with other species in the Ganister Clay and Marshall Green seams allow Assemblage IV to be subdivided into Assemblages IVa and IVb.

6.5.1 Assemblage IVa

The highest assemblage examined in the Featherstone area was obtained from three coal samples; M1 and M3 are of the Upper Kellah Coal and M2 of the Lower Kellah Coal, both exposed in the Kellah Burn section (section 2.2.2).

The assemblages were well preserved and characterised by the absence of Namurian elements including *Leiotriletes tumidus*, *Bellispores nitidus*, *Stenozonotriletes lycosporoides*, *Densosporites spinifer*, *D. spinosus*, *Cristatisporites pannosus*, *Spelaeotriletes arenaceus*, and *Kraeuselisporites ornatus*, and by the presence of many Westphalian species. The three samples contain little variety of spore species (15-20) and are dominated by *Lycospora* spp., *Apiculatisporis* spp. and *Densosporites anulatus*. They also contain *Calamospora* spp., *Granulatisporites* spp., *Leiotriletes* spp., *Raistrickia fulva*, *Crassispora kosankei*, and *Triquitrites tribullatus*.

Dictyotriletes cf. *bireticulatus* (Ibrahim) Smith and Butterworth 1967, which first appears in the uppermost Namurian strata, is present for the first time in this assemblage, in Upper Kellah Coal samples only. Amongst other species which are present together with *D.* cf. *bireticulatus* in the Upper Kellah Coal samples, and which characterise this assemblage are *Apiculatisporis irregularis*, *Planisporites granifer* (Ibrahim) Knox 1950, *Moorisporites* spA., *Radiizonates striatus*, *R.* cf. *difformis* (Kosanke) Staplin and Jansonius, *Spencerisporites radiatus* Felix and Parks (1959) and *Fabasporites pallidus* Sullivan 1964. On the other hand the newly described species *Dictyotriletes* spA. occurs in the Lower Kellah Coal (0.7%) only; other species which are present only in the Lower Kellah Coal are *Anaplanisporites baccatus* (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967, (1.4%), *Lycospora orbicula* (Potonie and Kremp) Smith and Butterworth 1967, (10%) and *Florinites mediapudens* (Loose) Potonie and Kremp 1956. Although the miospore assemblages differ in the Upper and Lower Kellah Coal samples, they are similar in the absence of most of the Namurian species listed before and also in the absence of the characteristic Assemblage IVb species, as shown in Table I.

6.5.2 Assemblage IVb

This assemblage includes the following seams:- Ganister Clay (2 samples), Marshall Green (one sample), Low Main Stringer (2 samples) and Low Main (2 samples) from the Plenmeller Coalfield; the Unnamed 2, Unnamed 1 and Stone seams, from Stublick Bog and the Top Broomly, Middle Victoria and Top Victoria seams from St. Andrew's. The miospores obtained from these samples were all well preserved.

All these seams have assemblages dominated by *Lycospora spp.* (mainly *L. pusilla*) and *Densosporites anulatus*; they contain 37 genera comprising 71 species which vary considerably in their frequencies. Some of the following species have been recorded from some or all of these seams and are characteristic of this assemblage: *Leiotriletes spp.*, *Punctatisporites sinuatus*, *Calamospora spp.*, *Granulatisporites spp.*, *Cyclogranisporites spp.*, *Verrucosisporites spp.*, *Raistrickia spp.*, *Camptotriletes superbus*, *Grumosisporites varioreticulatus*, *Radiizonates striatus*, *Schulzospora rara*, *Spencerisporites radiatus*, *Alatisporites pustulatus* Ibrahim 1932, *Fabasporites pallidus*, *Florinites pumicosus*, *F. mediapudens* and others.

In fact the two assemblages IVa and IVb have much in common, but the main difference between them is the first appearance, in Assemblage IVb of *Densosporites sphaerotriangularis* Kosanke 1950 and the monolete miospore *Punctatosporites minutus* Ibrahim 1932, (0.1% and 0.5% respectively in the Ganister Clay) and *Laevigatosporites*

Table 1. The distribution of selected miospore species in Assemblage IVa and b.

MIO-SPORE SPECIES / SAMPLE NUMBERS	Featherstone			Plenmeller							Stublick			St. Andrew's		
	L.K.C	U.K.C	U.K.C	G.C	G.C	M.G	L.M.S	L.M.S	L.M	L.M	Un. 2	S	Un.1	T.B.	M.V.	T.V.
	M2	M1	M3	658	663	662	661	1	752	139	342	338	343	S.7	S.8	110
Dictyotriletes spp.	0.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Densosporites intermedius		0.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apiculatissporis cf. latigranifer	0.35	-	-	0.2	0.09	0.8	0.4	0.2	-	-	0.3	0.5	-	-	-	0.1
A. variocorneus	0.17	-	0.4	0.1	0.3	1	-	-	0.4	-	-	-	-	0.5	-	-
Triquitrites tribullatus	0.7			0.3	0.09	-	0.3	-	-	0.3	-	-	-	-	-	-
Crassispora kosankei	0.35	0.94	0.42	4	3.5	0.3	1	0.2	7.6	5.5	0.7	6.1	1.5	6.9	0.66	4.4
Densosporites anulatus	2.12	14.9	21.4	47	33	1.2	17	11	9.9	7.5	3.4	2.9	1.7	7.6	2	2.2
Florinites mediapudens	0.17	-	-	-	-	-	-	0.09	0.1	-	-	-	-	-	-	-
Apiculalisporis irregularis	-	25.5	24.7	2.3	1.6	2	8	8.7	12.7	6.5	7.8	8.2	7.5	8.3	5.6	19.3
Radiizonates striatus	-	2	2.3	-	-	0.2	1	0.1	0.2	-	0.6	-	-	0.35	0.5	-
Radiizonates cf. difformis	-	0.75	5	-	-	-	2.9	0.2	-	-	1.1	-	-	0.88	3	-
Dictyotrilates cf. bireticulatus	-	0.2		-	-	-	1	-	-	0.1	0.1	-	-	-	-	-
Moorisporites spp.	-	0.94	1.25	-	-	-		-	-	-	-	-	-	-	-	-
Planisporites granifer	-			-	0.1	-	0.1	-	0.1	0.7	-	-	-	-	-	-
Densosporites sphaero-triangularis	-	-	-	0.1	-	-	-	0.2	1.4	0.6	-	1.8	0.2	-	-	-
Punctatosporites minutus	-	-	-	0.5	-	12	6	2.8	2.7	5	1.8	4.7	8.5	3	6.96	2.8
Cingulizonates loricatus	-	-	-	3.5	2.7	-	0.8	0.8	0.7	0.9	0.6	0.6	-	1	-	0.1
Lophotriletes cf.gibbosus	-	-	-	0.2	0.1	-	0.1	0.1	-	-	-	-	-	0.35	-	-
Schulzospora rara	-	-	-	0.1	0.1	0.5	0.3	0.2	-	0.1	-	-	-	0.17	0.5	-
Cyclogranisporites cf. minutus	-	-	-	0.3	0.1	1	0.2	-	-	0.1	-	-	-	-	-	-
Cyclogranisporites aureus	-	-	-	0.1	0.1	-	-	0.1	0.1	-	-	-	-	-	-	-
Reticulatisporites reticulatus	-	-	-	0.2	-	-	-	0.1	0.1	-	-	-	-	-	-	-
Apiculatasporites spinulistratus	-	-	-	-	0.1	0.9	-	-	-	-	-	-	0.19		-	-
Laevigatosporites minor	-	-	-	-	-	0.2	-	2.6	0.4	2.7	0.9	1.1	2.9	-	0.5	1
Ahrensisporites guerickei	-	-	-	-	-	-	0.2	-	0.1	0.1	-	-	-	-	-	-
Punctatisporites sinuatus	-	-	-	-	-	-	0.1	-	-	-	-	-	-	0.35	-	-
Cirratriradites saturni	-	-	-	-	-	-	-	0.1	-	-	-	-	-		-	-
Cristatisporites connexus	-	-	-	-	-	-	-	-	1	1.1	-	0.6	0.3	0.38	-	0.1
Reinschospora speciosa	-	-	-	-	-	-	-	-	0.1	0.1	-	-	-	-	-	-
Verrucosisporites verrucosus	-	-	-	-	-	-	-	0.1	--	-	0.1	0.8	-	0.17	-	-
Cristatisporites spA.	-	-	-	-	-	-	-	-	-	0.4	-	-	-	0.17	-	-

G.C.	Ganister Clay	L.M.	Low Main	**M.V.**	**Middle Victoria**	**U.K.C.**	**Upper Kellah Coal**
L.K.C.	Lower Kellah Coal	L.M.S.	Low Main Stringer	**S.**	**Stone**	**Un.2.**	**Unnamed 2**
		M.G.	Marshall Green	**T.B.**	**Top Broomly**	**Un.1**	**Unnamed 1**
				T.V.	**Top Victoria**		

minor (after an apparent absence in Assemblages II, III and IVa, it becomes more common in the Low Main seam and shows a further increase in frequency in the succeeding assemblages). The other significant species recorded for the first time in Assemblage IVb are: Lophotriletes cf. gibbosus (Ibrahim) Smith and Butterworth 1967, Cyclogranisporites aureus (Loose) Potonie and Kremp 1954, C. cf. minutus Bhardwaj 1957, Apiculatasporites spinulistratus (Loose) Ibrahim 1933, Reticulatisporites polygonalis (Ibrahim) Smith and Butterworth 1967, R. reticulatus (Ibrahim) Ibrahim 1933, Cristatisporites connexus Potonie and Kremp 1955 and Cirratriradites saturni (Ibrahim) Schopf, Wilson and Bentall 1944, as shown in Table 1.

The miospore assemblage obtained from the Low Main Stringer, sample No. 661, BH No. 1392, Plenmeller, shows a great similarity to the assemblages obtained from the Upper Kellah Coal samples, as shown in Table 1, especially in the occurrence of Dictyotriletes cf. bireticulatus, Moorisporites spA., Planisporites granifer, Radiizonates striatus, R. cf. difformis and Triquitrites tribullatus. On the other hand Densosporites sphaerotriangularis, Laevigatosporites minor and Punctatosporites minutus (6%) are present only in the Low Main Stringer assemblage, together with several other species which did not occur in Upper Kellah Coal samples.

6.5.2.1 The Plenmeller Coalfield. The significant features of miospore distribution in the indivdual seams are as follows:

Ganister Clay (2 samples) and Marshall Green (1 sample)

This horizon is dominated by Lycospora pusilla, Densosporites anulatus (especially in Ganister Clay samples), Calamospora spp., and *Apiculatisporis spp*. Ganister Clay samples contain moderate percentages of *Crassispora kosankei*, and *Cingulizonates loricatus*, together with low frequencies of *Triquitrites tribullatus*, *D. sphaerotriangularis*, *Schulzospora rara*, and *Punctatosporites minutus*. On the other hand the Marshall Green sample contains 5.2% *Lycospora orbicula*, 0.2% *Laevigatosporites minor*, high percentages of *Punctatosporites minutus*, and no *Densosporites sphaerotriangularis*. At this horizon *Lophotriletes cf. gibbosus*, *Cyclogranisporites cf. minutus*, *C. aureus*, *Densosporites sphaerotriangularis*, *Laevigatosporites minor*, and *Punctatosporites minutus* appear for the first time, together with high frequencies of *Densosporites anulatus*.

Low Main Stringer (2 samples):

This horizon is characterised by a great diversity of species which is dominated by *Lycospora spp*., *Densosporites anulatus*, *Apiculatisporis irregularis*, *Calamospora spp*., *Raistrickia fulva* and *Punctatosporites minutus*.

This assemblage compares with the assemblage obtained from the Upper Kellah Coal samples except in the differences in percentages of species present and in the absence of *Punctatosporites minutus*.

Low Main (2 samples)

This horizon is dominated, as the other horizons, by *Lycospora spp*. (mainly *L. pusilla* and *L. pellucida*), *Densosporites anulatus* and *Punctatosporites minutus*, and by moderate percentages of *Leiotriletes spp*., *Calamospora spp*., *Apiculatisporis spp*. (*A. irregularis*), *Raistrickia fulva*, *Triquitrites tribullatus*, *Reticulatisporites reticulatus*, *R. polygonalis*, *Crassispora* kosankei, Cristatisporites connexus. While Dictyotriletes cf. bireticulatus, Densosporites sphaerotriangularis, Radiizonates cf. difformis and Laevigatisporites minor are very rare.

6.5.2.2 Stublick Bog Site

The miospores obtained from the Unnamed 2, Unnamed 1 and Stone samples are almost the same as those recorded in Assemblage IVb seams from Plenmeller (Table 1). They are characterised by high percentages of Lycospora pusilla, Densosporites anulatus, Apiculatisporis irregularis and Punctatosporites minutus; and by moderate frequencies of Crassispora kosankei, Lycospora orbicula, Cingulizonates loricatus and Laevigatosporites minor.

The assemblage obtained from the Marshall Green Seam differs slightly from the latter two samples in the absence of Densosporites sphaerotriangularis and in the presence of Dictyotriletes cf. bireticulatus,Radiizonates striatus, R. cf. difformis, Laevigatosporites minor, and Punctatosporites minutus. Therefore, the miospore assemblage obtained from the Marshall Green is more similar to those obtained from the Low Main Stringer samples in Plenmeller.

6.5.2.3 St. Andrew's Site

The miospore assemblages obtained from the Top Broomly, Middle Victoria and Top Victoria coals contain almost all the elements recorded in Plenmeller and Stublick Bog. The miospores isolated from the Victoria seam were badly preserved while those from the Top Broomly were moderately good. The assemblage obtained from the Top Broomly is distinguished by moderate frequencies of Apiculatisporis irregularis, Crassispora kosankei, and Densosporites anulatus and a low frequency of Radiizonates striatus and R. cf. difformis, together with 3% of Punctatosporites minutus, and by the absence of Densosporites sphaerotriangularis and Laevigatosporites minor.

On the other hand, the miospore assemblages obtained from the Middle Victoria compare more closely with the assemblages obtained from the Marshall Green in Stublick Bog and the Low Main Stringer in Plenmeller.

6.5.3 Stratigraphical comparison and conclusions

The species recorded from Assemblage IV are most likely of Lower Westphalian A age. They compare closely with assemblages of this age from well dated stratigraphic successions recorded by Neves (1958, 1961), Sullivan (1964), Owens in Owens and Burgess (1965), Neves, Read and Wilson (1965), Smith and Butterworth (1967), Neves (1968) and Owens et al. (1977) as well as Clayton et al. (1977).

Assemblage IVb differs from the older Assemblage IVa in the first appearance of Densosporites sphaerotriangularis and the monolete miospore Punctatosporites minutus together with the reappearance of Laevigatosporites minor.

Neves (1958, 1961) recorded several species from a short sequence associated with the Gastrioceras subcrenatum Horizon in the North Staffordshire Coalfield and from a Namurian to Lower Westphalian A sequence in the Southern Pennines. The Lower Westphalian A species recorded by him have much in common with those recorded in Assemblage IV.

Sullivan (1964) recorded several species from the ? Lower Westphalian A Edgehills coal in the Forest of Dean basin, and most of these are also similar, in particular, Cyclogranisporites cf. minutus, Reticulatisporites polygonalis, Cirratriradites saturni, occasional specimens of *Laevigatosporites spp*., and *Fabasporites pallidus*. Sullivan indicates that this horizon is probably from the Lower to middle part of the *A. lenisulcata* zone.

Smith and Butterworth (1967) established the *Densosporites anulatus* assemblage to include the uppermost Namurian and the lowermost Westphalian A (*lenisulcata* zone); they recorded in this assemblage a number of species which are closely comparable with those of the lower part of Assemblage IVb (Ganister Clay and Marshall Green, Plenmeller); the significant features are the high frequencies of *Densosporites anulatus*, *Radiizonates striatus*, and *Crassispora kosankei*, and low frequencies of *Densosporites sphaerotriangularis*, *Cingulizonates loricatus*, *Cristatisporites spp*., and occasional specimens of *Laevigatosporites spp*., recorded in the Northumberland Coalfield from the Marshall Green Seam which lies in the *communis* chronozone, (Ramsbottom *et al*. 1978).

Also they showed that the appearance of *Dictyotriletes bireticulatus* varied from area to area within the British Coalfields; its first appearance was in the highest Namurian of Scotland but to the south in the Midlands its appearance was in the higher part of the Westphalian A. In the Cumberland and Durham Coalfields occasional specimens of *D. bireticulatus* appeared in the Albrighton Seam (Top Leaf) and the Ganister Clay Seam respectively, which lie at the bottom of the *communis* chronozone (Ramsbottom *et al*., 1978).

Similar assemblages containing quite a few of the characteristic species of this Assemblage have been recorded from coals and sediments (three samples) by Neves (1968), from the Woodland Borehold, Co. Durham. His Group Two is more closely comparable to Assemblage IV than the younger Group One, which contains *Radiizonates aligerens*

(Knox) Staplin and Jansonius 1964, and *Laevigatosporites minimus* (Wilson and Coe) Schopf, Wilson and Bentall 1944, or the older Group Three which has *Ahrensisporites beeleyensis* Neves 1961, *Kraeuselisporites ornatus*, and *Discernisporites irregularis*. Neves referred his Group Two to the lowermost Westphalian A (*A. lenisulcata* Zone).

Sabry and Neves (1971) recorded assemblages from the Sanquhar Coalfield in Southern Scotland, from the upper part of the Passage Group. Samples were taken from coals and sediments in Polneul Burn and the Cat Cleuch area. The species recorded from Assemblage IV can be closely compared with those recorded by these authors from strata which they referred to the Lower Westphalian A. They placed their assemblages, in terms of the non-marine lamellibranch scheme of classification, to the middle or upper part of the *A. lenisulcata* zone

The most significant feature in Assemblage IVa, and in particular in the two samples from the Upper Kellah Coal, is the presence of *Moorisporites spA.* which differs from other described species of the genus and shows some morphological intergradation with species of the genus *Triquitrites*. This feature is indicated by Neves *et al*. (1965) from their lowest (sample No. 3) of three samples, in the lowest part of the Westphalian sequence, in the Upper Passage Group, Scotland; and Neves (1968) in the Woodland Borehole, Co. Durham, from the lowest sample at 336 ft of three samples in his Group 2. These are characterised by a wide range of morphological variation in the genus *Ahrensisporites*. Sabry and Neves (1970) noticed the same significant complexity in species attributed to the genus *Triquitrites*, in both Polneul Burn and the Cat Cleuch area, Sanquhar Coalfield, Scotland. Owens *et al*.

(1977) from northern England and Scotland, and Clayton et al. (1977) also indicate that this wide morphological intergradation between the genera Triquitrites and Ahrensisporites lies in their SS zone. All these authors indicate that such a complexity is a characteristic feature of the A. lenisulcata zone. Therefore, the Assemblage IVa is most likely to be from the lowest part of Westphalian A, and in the Anthraconian lenisulcata non-marine lamellibranch zone.

Clayton et al. (1977) indicate that the lower limit of their RA zone (base of the communis chronozone) is marked by the first appearance of Radiizonates aligerens and Punctatosporites minutus.

The former species is more constantly present in the middle of their zone. The latter species makes its first appearance in the Ganister Clay seam in Plenmeller, and in the Marshall Green Seam in Stublick. Therefore this horizon indicates the boundary between the SS/RA zones, and the boundary between the lenisulcata/communis chronozones.

Comparison with other palynological studies in Britain indicates therefore that the present Assemblage IVa and b are most likely of Lower Westphalian A age, from within the lenisulcata and lower part of the communis non-marine lamillibranch zones respectively. It is probably equivalent to the Triquitrites sinani - Cirratriradites saturni (SS) and lower part of Radiizonates aligerens (RA) zones respectively.

6.6 Assemblage V

This Assemblage is dominated by high percentages of Lycospora spp. (mainly L. pusilla), and Densosporites spp.; and moderate percentages of Calamospora spp., Apiculatisporis spp. (mainly A. irregularis), Granulatisporites spp., Raistrickia fulva, Crassispora kosankei, Punctatosporites minutus and Laevigatosporites spp.

Most of the species recorded in Assemblage IV persist into Assemblage V; these include Punctatisporites sinuatus, Reinschospora speciosa, Radiizonates striatus, R. cf. difformis, Florinites spp., Schopfipollenites spp., etc.

However, there are some variations in the characteristics of the miospore contents in the middle part of this Assemblage, from the Lower and Upper Craignook and Bounder Seams of Plenmeller. Because of these variations, and others in the highest Westphalian A coals, this assemblage can be divided into Assemblages Va, Vb and Vc.

6.6.1 Assemblage Va

This Assemblage is characterised by the first appearance of Verrucosisporites microtuberosus (Loose) Smith and Butterworth 1967, Dictyotriletes bireticulatus, D. muricatus (Kosanke) Smith and Butterworth 1967, Triquitrites protensus Kosanke 1950, Radiizonates aligerens (Knox) Staplin and Jansonius 1964, and Endosporites globiformis (Ibrahim) Schopf, Wilson and Bentall 1944. Stenozonotriletes spA., S. spB. and Knoxisporites spA. appear higher in this Assemblage.

6.6.1.1 The Plenmeller Coalfield: this assemblage occurs in the Slag, High Main, Wellsyke Stringer, Wellsyke, Quarter, Half, Threequarter and Little Seams.

The significant features of miospore distributions in the individual coals and associated sediments are as follows:

Slag Seam, top and bottom leaf, and seatearth

These horizons contain moderate frequencies of Granulatisporites microgranifer, Raistrickia fulva, Crassispora kosankei, Radiizonates cf. difformis, and R. striatus; low frequencies of Verrucosisporites microtuberosus, Dictyotriletes bireticulatus, D. muricatus and Triquitrites protensus; the first appearance of Radiizonates aligerens and Endosporites globiformis in the sequence (but not common) and high numbers of Densosporites sphaerotriangularis and Laevigatosporites spp.

The Slag Seam, top leaf, is distinguished from the bottom leaf and associated seatearth by a great variety in the densospore group of species; this includes a high frequency of Densosporites spp., especially D. anulatus and D. sphaerotriangularis, Radiizonates cf. difformis, R. striatus, and Cristatisporites connexus; this most probably represents a period of crassidurain formation.

High Main, top and bottom leaf, and composite seam with associated seatearth and shale at 5.14 m above the seam

The assemblages are dominated by Lycospora pusilla which reaches over 34%, Apiculatisporis irregularis, Punctatosporites minutus, and Calamospora spp.

The significant features in this assemblage are the presence of Densosporites sphaerotriangularis and Lycospora orbicula in relatively high numbers, with a few specimens of Cristatisporites connexus and Radiizonates aligerens. However, Radiizonates striatus and R. cf. difformis are still found in large numbers. Laevigatosporites minor and a few specimens of L. vulgaris frequently occur in these assemblages, Dictyotriletes bireticulatus is recorded only, and at a high frequency (1.8%), from the shale at 5.14 m, above the High Main Seam.

Wellsyke Stringer, seatearth, and the shale at 12.5 m below the Wellsyke Stringer Seam; Wellsyke Seam (3 samples) and seatearth.

The misopore assemblages recorded from these horizons were the same as those recorded from the previous horizons, excepting in the presence of Lycospora noctuina var.noctuina (2.9 and 0.9%), L. punctata Kosanke 1950 (12 and 25%) and Florinites pumicosus (0.5 and 1.3%) in the seatearth and shale at 12.5 m below the Wellsyke Stringer. Knoxisporites spA. makes its first, and might be a significant, appearance in the sequence with a relatively high frequency (1.6%); this species occurs in the seatearth of the Wellsyke Seam, which also contains large numbers of F. mediapudens (1.6%), F. pumicosus (1.9%), and a few specimens of F. junior, F. similis, and Schopfipollenites ellipsoides var. corporeus Neves 1961 (0.6%).

Quarter Seam (2 samples) and associated roof shale and seatearth

This horizon is distinguished by an increase in frequency of Radiizonates aligerens. A considerable number of Florinites spp. and Lycospora orbicula again occurs in the seatearth and roof shale; again the newly described Stenozonotriletes spA. has been recorded from the roof shale with a frequency of 1.3%.

Half Seam (3 samples) and associated roof shale, seatearth and shale at 0.95 m below the Half Seam.

This horizon is characterised by an increase in frequency of Radiizonates aligerens and Cristatisporites connexus; Cristatisporites spA. occurs occasionally in low numbers. Again Florinites spp. are recorded in large numbers from the shale at 0.95 m; while Schopfipollenites ellipsoides var. corporeus is recorded with a frequency of 0.6% from the roof shale.

Threequarters Seam (3 samples)

A low frequency of Endosporites zonalis, together with a moderate frequency of Cristatisporites connexus and Laevigatosporites vulgaris characterise this horizon.

Little Seam (2 samples)

A low frequency (0.9%) of Stenozonotriletes spB., together with Lycospora orbicula (1.4 and 1.8%) characterise this horizon.

6.6.1.2 Stublick Bog Site

The miospore assemblages obtained from the Little, Foot, Main and Threequarters top and bottom leaves are in general similar to Assemblage Va from Plenmeller. In this section, Verrucosisporites microtuberosus, Dictyotriletes muricatus, Cristatisporites spA., Radiizonates aligerens, and Laevigatosporites vulgaris made their first appearance, together with moderately high percentages of Densosporites anulatus, D. sphaerotriangularis and Laevigatosporites minor.

6.6.1.3 St. Andrew's Site

The miospore assemblages obtained from St. Andrew's were not well preserved and the identification of spores sometimes was difficult. The assemblages from the Unnamed, Bottom Brockwell, Top Brockwell, 1 ROO, 2 ROO, and Threequarters Seams, contain high percentages of Anaplanisporites baccatus, Apiculatisporis irregularis, Crassispora kosankei, Densosporites anulatus, Lycospora orbicula, Laevigatosporites minor, and Punctatosporites minutus. On the other hand, quite a few of the characteristic species which are present in Assemblage Va in Plenmeller, Stublick Bog and Hedley Park are missing at these horizons, and these are: Dictyotriletes bireticulatus Endosporites globiformis and E. zonalis; Verrucosisporites microtuberosus, Dictyotriletes muricatus and Radiizonates aligerens occur higher in the sequence.

6.6.1.4 Hedley Park Site

The miospores recovered from samples from the Hedley Park Site were adequately to well preserved and sufficiently diversified to enable the sequence to be clearly subdivided into two Assemblages. The species obtained from the first Assemblage have many elements in common with Assemblage Va from Plenmeller.

Miospore assemblages were obtained from the Top Victoria, Unnamed Seam (2 samples), Bottom Brockwell, Top Brockwell (2 samples), Threequarter and Bottom Busty Seams. These samples are characterised by the presence of *Crassispora kosankei*, *Densosporites anulatus*, *Laevigatosporites minor*, and *Punctatosporites minutus*, which occur in relatively high percentages throughout the sequence; *Densosporites sphaerotriangularis*, *Radiizonates striatus*, and *R. cf. difformis* occur at low frequencies except the former species, which occurs in high percentages (9 and 4.2%) in the two samples of the Top Brockwell. The other significant species which occur in this sub assemblage are *Dictyotriletes bireticulatus* and *Radiizonates aligerens*.

6.6.2 *Assemblage Vb*

Assemblage Vb differs from Assemblage Va in changes in the frequencies of the following characteristic species: a high frequency of *Densosporites sphaerotriangularis*, *Laevigatosporites minor* and *Punctatosporites minutus* and lower frequencies of *D. anulatus* and *Radiizonates striatus* than those recorded in Assemblage Va. The significant feature which distinguishes this Assemblage is the occurrence of *Radiizonates aligerens* at high frequencies. *Dictyotriletes bireticulatus*, *Schulzospora rara*, *Florinites spp.* and *Schopfipollenites ellipsoides var. corporeus* occur frequently in this Assemblage but in low numbers. Vestispora tortuosa (Balme) Spode in Smith and Butterworth (1967) appears for the first time but in low numbers - Anaplanisporites baccatus, Apiculatisporis irregularis, Crassispora kosankei, and Lycospora orbicula maintain their relatively high frequencies from older horizons.

6.6.2.1 The Plenmeller Coalfield

This Assemblage was obtained from the following samples: the Lower Craignook (2 samples), Upper Craignook (top and bottom leaves) and Bounder Seams, and the Bounder Seam from Halton Lea.

This Assemblage is characterised by low frequencies of Densosporites anulatus, D. microponticus and Radiizonates striatus. Radiizonates aligerens and R. cf. difformis occur frequently in this assemblage and reach an even higher frequency in the Bounder Seam from Plenmeller and Halton Lea (1.6, 2.6% and 3.3, 4.6% respectively). Schulzospora rara occurs at a relatively high frequency (1.7% in the Upper Craignook Seam). Other significant species present at these horizons are shown in Chart 2.

6.6.2.2 Stublick Bog Site

The miospore assemblage Vb was obtained from the following samples: the Cannel (5 samples) and Bounder seams. This assemblage shows little variation from the older Assemblage Va as in the Plenmeller Assemblages. Crassispora kosankei, Densosporites anulatus, D. sphaerotriangularis and Radiizonates striatus are persistently present in this assemblage. Radiizonates aligerens occurs at a relatively high frequency in the Cannel Seam (1.5%); Radiizonates cf. difformis and Laevigatosporites vulgaris occur at relatively higher frequencies than in the older Assemblage Va.

Also *Schulzospora rara*, *Florinites spp*. and *Schopfipollenites ellipsoides var. corporeus* occur occasionally in low numbers, while *Endosporites spp*. and *Vestispora tortuosa* are missing.

6.6.2.3 St. Andrew's Site

The miospore assemblage Vb occurs in the Bottom Busty (top and bottom leaves) and Top Busty (top and bottom leaves).

This assemblage is characterised by the first appearance of *Verrucosisporites sifati* (Ibrahim) Smith and Butterworth 1967, and the frequent occurrence of *Laevigatosporites vulgaris*. *Densosporites sphaerotrianularis* and *Laevigatosporites minor* reach higher frequencies in this assemblage, and to a lesser extent *Cingulizonates loricatus* and *Cirratriradites saturni*. *Radiizonates aligerens* occurs in relatively high percentages (0.6 and 0.7% in the Bottom Busty - top leaf - and Top Busty Seams respectively). *Dictyotriletes bireticulatus*, *Endosporites spp*., and *Vestispora tortuosa* are missing.

6.6.2.4 Hedley Park Site

This Assemblage was obtained only from the Top Tilley Seam. This horizon is characterised by the significant occurrence at a relatively high percentage of *Radiizonates aligerens* (4.8%). Other significant elements are low frequencies of *Densosporites anulatus* and *D. sphaerotriangularis* and the first appearance of *Laevigatosporites vulgaris* and *Florinites cf. florini* Imgrund 1960.

6.6.2.5 Low Close Site

This Assemblage occurs in the following samples: the Six-quarter (top leaf), Lick Bank, and Eighteen Inch Seams. This Assemblage is characterised by high frequencies of *Apiculatisporis* *irregularis*, *Densosporites sphaerotriangularis* (22.7% in the Eighteen Inch Seam), *Laevigatosporites minor* and *Punctatosporites minutus*. Other significant species which occur in this Assemblage are *Verrucosisporites donarii*, *V. sifati*, *Schulzospora rara* and *Florinites spp*. together with the newly described *Verrucosisporites spA*. in the Eighteen Inch Seam. *Radiizonates aligerens* is not present in this Assemblage, and in fact no species of *Radiizonates* is present in the Low Close Opencast Site Assemblages.

6.6.3 Assemblage Vc

Assemblage Vc differs from Assemblage Vb in the absence of *Radiizonates aligerens* and in changes in the frequencies of the following characteristic species; high frequencies of *Dictyotriletes bireticulatus* and *Vestispora tortuosa* and frequent occurence of *Endosporites globiformis*, *Florinites spp*. (mainly *F. mediapudens*), *Vestispora costata* and *Pityosporites westphalensis*.

6.6.3.1 Hedley Park Site

Assemblage Vc occurs in the following seams: Harvey, Penny Hill and Harvey Marine (top and bottom leaves); these horizons are characterised by the significant occurrence at relatively high percentages of *Dictyotriletes bireticulatus* (1% in the Harvey Seam) and *Vestispora tortuosa* (2, 1.6 and 1.18% in the Penny Hill and Harvey Marine, top and bottom leaves, seams respectively), together with the disappearance of *Radiizonates aligerens*.

Other significant features present at these horizons are a gradual decrease in the percentages of *Densosporites anulatus* together with a gradual increase in the percentages of *Laevigatosporites minor*. Other elements which occur in this Assemblage are

Endosporites globiformis (0.14% in the Harvey Marine Seam, bottom leaf), Vestispora costata (0.7 and 0.35% in the Harvey and Penny Hill Seams respectively), and Pityosporites westphalensis (0.17% in the Penny Hill Seam).

6.6.3.2 Low Close Site

Satisfactory miospore preparations were obtained from all of the samples from this site with a characteristic Vc assemblage. The miospore assemblages recorded from the Little Main and Two Foot (top and bottom leaves) seams are characterised by the occurrence of Dictyotriletes bireticulatus at high frequencies (4.2 and 2% in the Little Main and Two Foot (top leaf) seams respectively). Other species which characterise this assemblages are Endosporites globiformis, E. zonalis, Vestispora tortuosa, v. costata, Densosporites duriti (1.6% in the Little Main Seam) and Florinites spp., together with the newly described Vestispora spA. which occurs in the Little Main Seam.

6.6.4 Stratigraphical comparison and conclusions

The miospore assemblages obtained from these horizons include many species recorded in Assemblage IV and persisting into this Assemblage but there are enough significant features which made it possible to define the base and to divide the whole sequence into three sub assemblages. The most useful marker horizon is the first appearance, at the base, of Radiizonates aligerens which occurs along with relatively high percentages of Laevigatisporites spp. This horizon is the Slag Seam of Plenmeller, Unnamed seam of St. Andrew's, Top Victoria of Hedley Park and the Little Seam of Stublick. These characteristics were used by Butterworth and

Millott (1960) and Smith and Butterworth (1967) to define the lower limit of their *Radiizonates aligerens* Assemblage and were also used by several later authors as an important marker.

There is a noticeable increase in the frequencies of *Densosporites sphaerotriangularis*, *Radiizonates* cf. *difformis*, and *Laevigatosporites minor* and to a lesser extent *Cristatisporites connexus* and *Cingulizonates loricatus* at the base of Assemblage V together with continuing and increased high frequencies of *Densosporites anulatus* and *Radiizonates striatus*. The latter two species are reduced in numbers in the higher part of the Assemblage. This feature was also recorded by Smith and Butterworth (1967) in the Northumberland and Durham Coalfield and in the North Staffordshire Coalfield.

There are minor changes in the middle horizons of Assemblage V, at the base of Vb, which include increases in the frequencies of *R. aligerens* and *Laevigatosporites minor* and *L. vulgaris* and the first appearance of *Vestispora tortuosa*, *V. costata* and *Endosporites globiformis* and relatively low numbers of *Endosporites zonalis*, *Schulzospora rara* and *Pityosporites westphalensis*.

The higher part of this Assemblage, Vc, which includes the Harvey, Penny Hill, and Harvey Marine seams of Hedley Park and the Little Main and Two Foot seams of Low Close, Cumbria, shows a noticeable increase in the frequencies of *Dictyotriletes bireticulatus*, *Vestispora tortuosa*, *V. costata* and *Endosporites globiformis* together with the disappearance of *Radiizonates aligerens* in Hedley Park.

The Assemblage V miospores compare in detail with assemblages recorded by Owens and Burgess (1965) from the Stainmore outlier to the south of the present investigated areas, and by Smith and Butterworth (1967) from the main Northumberland and Durham Coalfield to the east of the Plenmeller area (see fig. 2). The assemblages recorded in the present study also compare with assemblages recorded by Neves (1968) from the Woodland Borehole, Co. Durham.

Owens and Burgess (1965) assigned the section from the Swinstone Top Marine Band up to 175 ft. of unproductive strata, to the lower Westphalian A, in particular to the *A. lenisulcata* zone. They also indicated that the sequence from the 6 in. coal to the *C. pseudorobusta* mussel band represents the lower half of the *C. communis* zone.

The assemblages obtained by Owens from the coal immediately below the *C. pseudorobusta* horizon conforms closely with the assemblages obtained from the Slag and High Main Seams. The significant features are the first appearance of *Radiizonates aligerens* with an increase in the frequency of *Laevigatosporites spp*. The upper half of the *C. communis* chronozone includes the sequence from the *C. pseudorobusta* mussel band to an horizon about 50 ft. below the Argill Shell Bed. He recorded a list of species from the shale approximately 10 ft. above the *C. pseudorobusta* horizon which includes *Cirratriradites saturni* and *Schopfipollenites ellipsoides var. corporeus* and he indicated that the latter species is recorded for the first time in the sequence together with *Radiizonates aligerens*. *S. ellipsoides var. corporeus* is also recorded for the first time in Assemblage Va from the Wellsyke Seam. Owens also noticed a high frequency of *R. striatus* from horizons above the *C. pseudorobusta* subzone. All of these are significant features of Assemblage Va.

The miospore assemblage obtained by him from the three seams 30-40 ft. below the Argill Shell Bed are closely comparable with the miospore components recorded in the lower part of Assemblage Vb.

The significant species are a high frequency of Laevigatosporites spp. together with the highest occurrence of Radiizonates aligerens in the sequence, and a low frequency of R. cf. difformis, Cirratriradites saturni, Endosporites zonalis and Florinites spp. and occasional specimens of Dictyotriletes bireticulatus and Vestispora tortuosa.

This assemblage was placed by Owens and Burgess (1965) in the lowest part of the Anthraconaia modiolaris chronozone.

The miospore assemblage obtained by Owens from the Argill Shell Bed compares closely to the present Assemblage Vc, which is characterised by a relatively high frequency of Florinites spp. together with the presence of the characteristic species Dictyotriletes bireticulatus, Vestispora tortuosa and Cirratriradites saturni, and by the disappearance of Radiizonates aligerens. Owens and Burgess (1965) placed this horizon in the lower to middle part of the A. modiolaris chronozone.

The species recorded in Assemblage V are also comparable with the Radiizonates aligerens and Schulzospora rara assemblages described by Smith and Butterworth (1967) in the Northumberland and Durham and Cumberland Coalfields from near the base of C. communis zone to the middle of the A. modiolaris chronozone.

The significant occurrences listed by Smith and Butterworth (Loc. cit.) in the Radiizonates aligerens and Schulzospora rara assemblages are: Laevigatosporites spp:- They recorded this genus from the Durham Coalfield as becoming common in the Victoria Seam and showing a further increase in frequency in the Busty Seam from near the base of the A. modiolaris zone. This genus becomes common in Assemblage Va and abundant in both Assemblages Vb and c.

Densosporites anulatus and *Radiizonates striatus*:- These species are common in the Victoria, Threequarter and Bottom Busty Seams in Northumberland and the Brockwell, Threequarter and Busty Seams in Durham and become less common higher in the sequence. These species were also recorded by Sullivan (1962) in the Hard Vein Coal in the Wernddu Claypit, South Wales, and by Owens and Burgess (1965) from coals and sediments above the *C. pseudorobusta* horizon in the Stainmore Outlier.

In the present investigation these species are common in Assemblage Va and less common in Assemblages Vb and c.

Densosporites sphaerotriangularis:- Smith and Butterworth (1967) also noted that this species increases in numbers gradually towards the top of their *R. aligerens* assemblages and persists in the *Schulzospora rara* assemblage (in the Little Main Seam of Cumberland and the Beaumont and Harvey Seams in the Northumberland and Durham Coalfield respectively).

Assemblage Vc is closely comparable to the *Schulzospora rara* assemblage recorded by Smith and Butterworth (loc. cit.) by the absence of *Radiizonates aligerens* and by the frequent occurrence of *Dictyotriletes bireticulatus* together with *Vestispora tortuosa* and *Pityosporites westphalensis*.

Neves (1969) examined coals and sediments from the Woodland Borehold, Co. Durham and recorded several species in his Group One which are closely comparable with those of Assemblage V. These species include *R. aligerens* which he obtained from the lower 110 ft. sample of Group One with other species such as *Laevigatosporites* spp., *Florinites junior* and *F. antiquus* (junior synonym of *F. mediapudens*).

In the sample at 53 ft. he recorded occasional specimens of *D. bireticulatus*, *R. striatus*, *Laevigatosporites spp*., *R. aligerens*, *Florinites similis* and *F. antiquus* and also *Knoxisporites hageni* Potonie and Kremp. *Knoxisporites spA*. which is close to *K. hageni* was recorded from the seatearth of the Wellsyke Seam at a low frequency (0.9%). Neves concluded that his Group One belongs to the *C. communis* zone.

Clayton *et al*. (1977) define the lower limit of their *Radiizonates aligerens* (RA) Zone by the first appearance of this characteristic species, which does not extend to the top of the zone, together with the first appearance of *Punctatosporites minutus*. The latter species first appears in Assemblage IVb in the present study.

The appearance and disappearance of *Radiizonates aligerens* before it reaches the top together with other significant features compare to Assemblage V.

Clayton *et al*. (loc. cit.) note the top limit of *Spelaeotriletes triangulus* and *S. arenaceus* at the base of their RA Zone, and *Kraeuselisporites ornatus* in the middle of the zone; these species disappear in the present study in Assemblage III.

Clayton *et al*. (1977) placed the RA Zone in the middle and upper part of the Westphalian A, from near the base of the *C. communis* zone to the middle part of *A. modiolaris* zone.

It is concluded, therefore, that the present Assemblage V, by comparison with other palynological studies, is most likely of middle and upper Westpahlian A age. Assemblage Va should be referred to the *C. communis* zone, Vb near the base of the *A. modiolaris* zone and Vc should be referred to the lower part of the *A. modiolaris* zone. They are probably equivalent to the

Radiizonates aligerens (RA) Zone of Clayton *et al*. (1977), that is *Radiizonates aligerens* and *Schulzospora rara* assemblages of Smith and Butterworth (1967).

6.7 Assemblage VI

The youngest spore assemblages examined in the present study were obtained from coal samples from the Hedley Park and Low Close Opencast Sites.

The assemblages contain a well preserved and diversified microflora containing many species which persist from the preceeding Assemblage V, but are distinguished by the frequent occurrence and high percentages of *Apiculatisporis irregularis*, *Laevigatosporites minor* and *Punctatosporites minutus*. *Anaplanisporites baccatus*, *Crassispora kosankei*, *Densosporites sphaerotriangularis*, and *Cingulizonates loricatus* are generally common. The significant features of this Assemblage are the presence of *Endosporites globiformis*, *Vestispora tortuosa*, *Dictyotriletes bireticulatus*, *Florinites spp*. and *Pityosporites westphalensis* as persistent members.

6.7.1 Hedley Park Site:

This Assemblage occurs in the following samples:-
Ruler, Top Hutton, Bottom Brass Thill, Low Main/Top Brass Thill, and Maudlin (bottom and top leaves).

This Assemblage is dominated by *Lycospora pusilla*, *Apiculatisporis irregularis*, *Calamospora spp*. and moderate to high percentages of *Anaplanisporites baccatus*, *Crassispora kosankei*, *Lycospora orbicula*, *Laevigatosporites minor* and *Punctatosporites minutus*.

The significant features which characterise this Assemblage are the changes in the frequencies of certain species, such as *Anaplanisporites baccatus*, *Crassispora kosankei*, *Lycospora orbicula*, *Endosporites globiformis* and *Pityosporites westphalensis* which show a more frequent occurrence or increases in their percentages. *Raistrickia fulva* and *Densosporites anulatus* are only occasionally present and at low frequencies. *Dictyotriletes bireticulatus* occurs in relatively high percentages (1.6% in the Top Hutton). *Vestispora pseudoreticulata* (Spode) Smith and Butterworth 1967 makes its first appearance in the Bottom Brass Thill with a frequency of 1.2%. *Palaeospora fragilla* Habib 1966 occurs in the Maudlin seam (bottom leaf).

6.7.2 Low Close Opencast Site.

This Assemblage occurs in the following samples:- Metal (top 2 samples, middle and bottom leaves). It is characterised by the following features: high frequencies of *Anaplanisporites baccatus*, *Apiculatisporis irregularis*, *Laevigatosporites minor* and *Punctatosporites minutus* and the frequent occurrence of *Calamospora spp.* and *Granulatisporites spp.* In the meantime *Densosporites anulatus*, *D. sphaerotriangularis*, *Cingulizonates loricatus*, *Florinites mediapudens* and *Laevigatosporites vulgaris* show moderate percentages and frequent occurrence. *Schulzospora rara* and *Radiizonates aligerens* are not present in this Assemblage.

6.7.3 Stratigraphical comparison and conclusions.

The miospore assemblages obtained from the coal samples in Assemblage VI include many elements recorded in Assemblage V. The significant difference between this Assemblage and the preceeding Assemblage V is the first appearance of *Verrucosisporites donarii*, *Vestispora pseudoreticulata* and *Palaeospora fragilla* together with the persistent occurrence of *Endosporites globiformis* and the disappearance of the characteristic Assemblage V elements *Radiizonates aligerens* and *Schulzospora rara*. These were used by Butterworth and Millott (1960) and Smith and Butterworth (1967) to define the upper limit of their *Radiizonates aligerens* and *Schulzospora rara* assemblages respectively and were also used by several later authors as an important marker.

Other factors which characterise this Assemblage are increases in the percentages of *Anaplanisporites baccatus* and *Apiculatisporis irregularis*, which reach their maximum percentages in this Assemblage, together with the frequent occurrence of *Crassispora kosankei*, *Densosporites sphaerotriangularis*, *Cingulizonates loricatus*, *Florinites mediapudens*, *F. pumicosus* and *Laevigatosporites vulgaris*.

Owens in Owens and Burgess (1965) assigned the miospore assemblages obtained from the section above the Argill Shell Bed to the middle to upper part of the *A. modiolaris* chronozone. This assemblage compares closely to Assemblage VI.

Owens indicates that the spores of this section differ from the miospore assemblages obtained from the section below in the absence of *Radiizonates aligerens* and the presence of *Dictyotriletes bireticulatus* and *Endosporites globiformis*.

The miospores obtained by Owens from the 2½ in. coal 30 ft. above the Argill Shell Bed were well preserved and compare closely to Assemblage VI. These species are: *Raistrickia fulva*, *Knoxisporites polygonalis*, *Endosporites globiformis*, *Schopfipollenites ellipsoides* and *S. ellipsoides var. corporeus*.

The miospore assemblages obtained higher in the section, from a bed about 195 ft. above the Argill Shell Bed, and from other coal samples, yielded misopores similar to the present Assemblage VI.

Among these are Laevigatosporites vulgaris, Densosporites anulatus, D. sphaerotriangularis, Verrucosisporites donarii, Dictyotriletes bireticulatus, Cingulizonates loricatus and Cirratriradites saturni.

The miospore assemblages listed in Assemblage VI compare closely to the Dictyotriletes bireticulatus assemblage described by Smith and Butterworth (1967) in the Northumberland and Durham Coalfield extending from the Hutton Seam to Seam D in the Durham Coalfield.

The significant species recognised by them and characterising their D. bireticulatus assemblage include Endosporites globiformis as a persistent element, which appears in the Hutton Seam of Durham. Crassispora kosankei, Cingulizonates loricatus, Densosporites sphaerotriangularis, Florinites mediapudens and Laevigatosporites spp. are generally common to abundant throughout the Assemblage. These elements are also common in Assemblage VI, some of them in Hedley Park and others in Low Close.

Radiizonates tenuis (Loose) Butterworth and Smith 1967, a characteristic member of the D. bireticulatus assemblage was not significant and generally scarce in the Northumberland and Durham Coalfield. This species is absent in Assemblage VI. (In fact all species of this genus are not present throughout the sequence in Low Close, and only occasionally occur in Hedley Park in Assemblage VI).

Smith and Butterworth (1967) examined the miospore assemblages in the Cumberland Coalfield and they indicate the first appearance of Endosporites globiformis in the seam above the Solway Marine Band, which marks the base of their D. bireticulatus assemblage. This species is absent in the present Assemblage from Low Close but

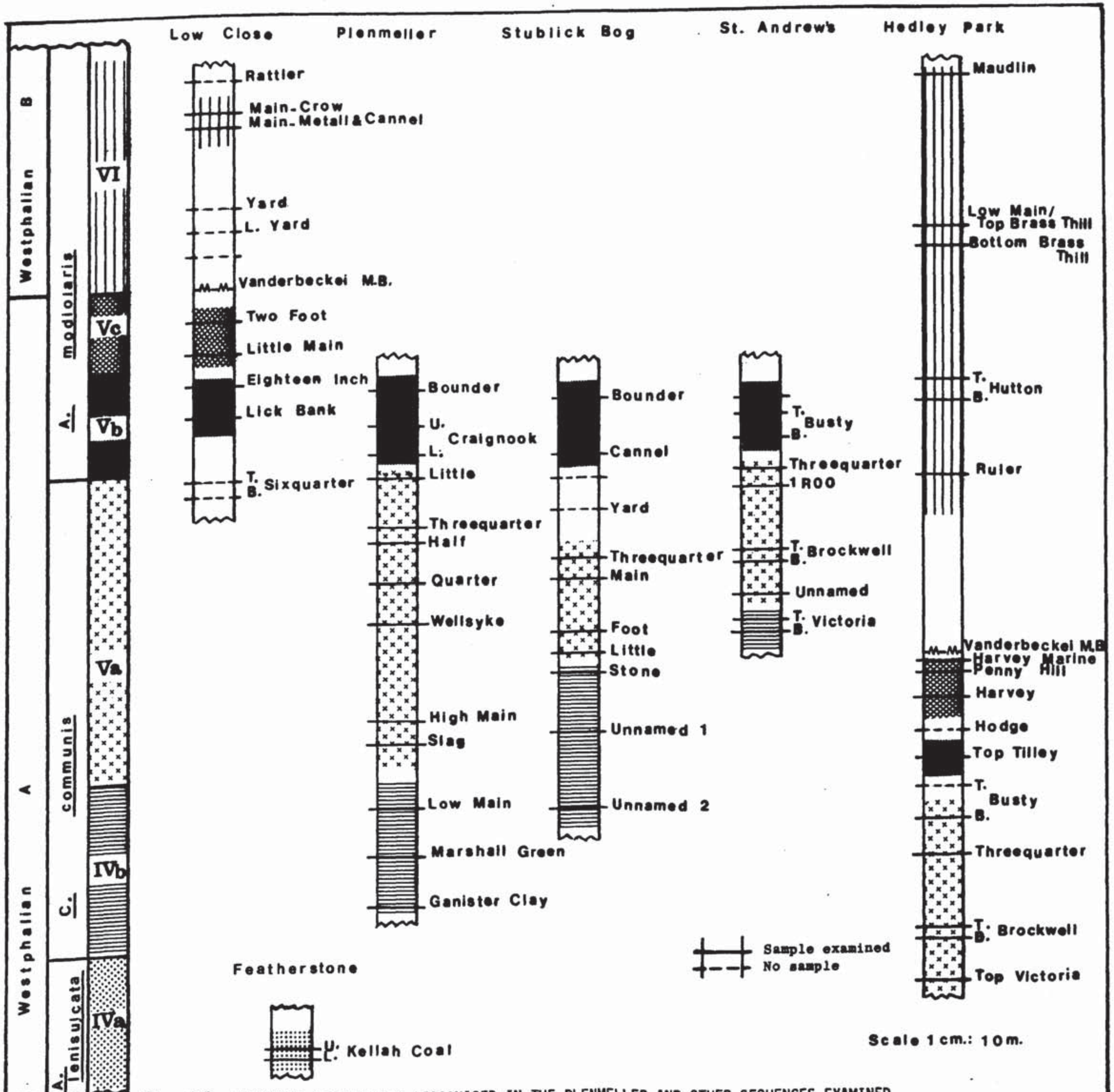


Fig. 20. MIOSPORE ASSEMBLAGES RECOGNISED IN THE PLENMELLER AND OTHER SEQUENCES EXAMINED

occurs frequently in the Hedley Park Assemblages. Also they noticed that *Crassispora kosankei* is present in minimum numbers in the Main Band and increases upward in the sequence; this feature also occurs in the present Assemblage from Low Close. In the meantime the other significant elements which occur in both assemblages are *Dictyotriletes bireticulatus*, *Densosporites anulatus*, *Cingulizonates loricatus*, *Laevigatosporites spp*. and *Florinites mediapudens*.

The significant features listed by Clayton *et al*. (1977) in their *Microreticulatisporites nobilis* - *Florinites junior* (NJ) Zone are also comparable to Assemblage VI. These features are the frequent occurrence of *Dictyotriletes bireticulatus* together with the disappearance of *Radiizonates aligerens* and *Schulzospora rara*. *Microreticulatisporites nobilis* and *Florinites junior* make their first appearance in their assemblage; the former species is missing in the present assemblage, while the latter species occurs only occasionally.

The stratigraphical age of the present Assemblage VI by comparison with other palynological studies in Britain by several workers, is most likely lower Westphalian B and can be referred to the middle and upper part of the *A. modiolaris* chronozone.

6.8 Comparison with areas other than Britain

6.8.1 Western Europe:

Loboziak (1971) recorded from the Westphalian A of the Nord-Pas-de-Calais basin, North France, an assemblage which is closely comparable with both the present Assemblages IVb and V. He recorded *Lycospora spp*., and *Densosporites spp*. (mainly *D. anulatus* and *D. sphaerotriangularis*) as dominant species throughout the sequence. Assemblage IVb can be compared with assemblages slightly above the base of the Westphalian A which are characterised by the first appearance of *Laevigatosporites spp.*, *Verrucosisporites verrucosus*, *V. microtuberosus*, *Cyclogranisporites minutus*, *Planisporites granifer*, *Dictyotriletes bireticulatus*, *Cirratriradites saturni*, *Cristatisporites connexus*, *C. indignabundus*, *Lophotriletes gibbosus*, *Triquitrites tribullatus* and *Ahrensisporites guerickei*, together with several other Westphalian A species. Most of these species were recorded in the present Assemblage IVa.

The Westphalian B assemblages recorded by Loboziak (loc. cit.) are characterised by the first appearance of *Densosporites duriti* and *Florinites junior* together with several other species which occur in the present Assemblage IV.

Raistrikia fulva and *Radiizonates aligerens* were not recorded in the Nord-Pas-de-Calais basin and another two species did not appear until later; the first one was *Punctatosporites minutus* which appeared at the base of the Westphalian B, and the second one was *Radiizonates striatus* which appeared in the middle of the Westphalian B.

Grebe (1972) recognised seven zonal assemblages from the Westphalian A to C of the Ruhr Coalfield, Germany. She subdivided the Westphalian A assemblages into Zones I and IIa and b; these two zones were dominated by high frequencies of *Densosporites anulatus*, *D. sphaerotriangularis* and *Cingulizonates loricatus*. Moreover, other significant species which also occur in the present Assemblages IVb and Va are *Radiizonates striatus*, *Schulzospora rara*, *Triquitrites spp.*, *Ahrensisporites guerickei*, *Dictyotriletes bireticulatus* and *Florinites spp.* She recorded the frequent occurrence of *Radiizonates aligerens* in her Zone I and its disappearance at the top of her Zone IIa.

Grebe (loc. cit.) divided the Westphalian B into zones IIIa, b and c and IVa and b; the present Assemblage VI compares to some extent with the lower part of her Zone IIIa and b which are characterised by the disappearance of Schulzospora rara and Bellispores nitidus and the first appearance in Zone IIIb of several species, most of which were not recorded in the present study.

The assemblages reported by Van Wijhe and Bless (1974) from the Netherlands compare fairly closely with those recorded in the present investigation. They divided the Westphalian strata into six zones or assemblages. The first zone was Apiculatisporis I, which is comparable more or less with the present Assemblage IVb in the occurrence of Densosporites sphaerotriangularis and Laevigatosporites minor (which are not present in Assemblage IVa). Other species present in both assemblages are Apiculatisporis spp., Dictyotriletes bireticulatus, Crassispora kosankei, Densosporites anulatus, Cirratriradites saturni, Radiizonates difformis, and Florinites spp. This zone was referred by them to the Lower Westphalian A of the Netherlands.

The second zone, Radiizonates aligerens II assemblage, is recorded by them from the middle and upper part of the Westphalian A, excepting the uppermost beds of Westphalian A. This zone is closely comparable to the miospore assemblages of similar age in Great Britain and in Germany. Their R. aligerens zone is distinguished by the first appearance and last appearance of Radiizonates aligerens. Again this assemblage can be compared with the present Assemblage Va & b, by the low frequency of R. aligerens in the lower part of the sequence and high frequency in the upper part. They recorded the following genera and species as occurring regularly to sometimes at high frequencies: Densosporites *sphaerotriangularis*, *Raistrickia spp*. (mainly *R. saetosa*), *Apiculatisporis spp*., *Florinites spp*., and *Laevigatosporites minor*. They recorded three significant species in the higher part of the zone which are also recorded from the present Assemblage Vb, and these are *Vestispora costata*, *V. tortuosa* and *Endosporites* globiformis. They also recorded *Schulzospora rara* as an extremely rare element in this assemblage, as in the present Assemblage Va and b.

The third zone (*Dictyotriletes bireticulatus* III assemblage), which extends from the uppermost Westphalian A to the upper part of the Westphalian B, is closely comparable to the present Assemblage VI. This assemblage is characterised by the frequent occurrence in moderate numbers of *Dictyotriletes bireticulatus* and the frequent occurrence of *Vestispora costata*, *V. tortuosa*, *V. pseudoreticulatus* and *Endosporites globiformis* together with the disappearance of *Radiizonates aligerens* which is also absent in the present Assemblage VI. Other species recorded in their zone and also present in Assemblage VI are, *Raistrickia fulva*, *Punctatisporites sinuatus*, *Radiizonates striatus*, *R. difformis*, *Densosporites anulatus* and *Cingulizonates loricatus*.

Neves (1964) examined miospore assemblages from Upper Carboniferous coals and shales from the La-Camocha Mine in North west Spain. He allocated the lowest assemblages to the *Remysporites magnificus* Zone, which is characterised by the absence of *Rotaspora spp*. *Tripartites spp*., and *Chaetosphaerites pollenisimilis*. This feature compares to the present Assemblage II from Pinking Cleugh. Moreover, other species which are present in both assemblages are *Convolutispora spp*., *Savitrisporites nux*, *Crassispora kosankei*, *Camptotriletes superbus*, *Densosporites spinosus*, *D. anulatus*, *Lycospora spp.*, *Radiizonates striatus*, *Laevigatosporites spp.*, *Florinites similis*, *Schopfipollenites ellipsoides* and *Schulzospora rara*. Other species recorded by Neves and not recorded in Assemblage II are *Schulzospora campyloptera* (Waltz) Potonie and Kremp, *Hymenospora palliolata* Neves and *Remysporites magnificus*. On the other hand species recorded in Assemblage II and not recorded from the *R. magnificus* Zone are *Apiculatisporis variocorneus*, *Dictyotriletes castanaeformis*, *Bellispores nitidus*, *Proprisporites laevigatus*, *Grumosisporites varioreticulatus*, *Cingulizonates bialatus*, *C. loricatus*, *Cristatisporites pannosus* and *Kraeuselisporites ornatus*. From a consideration of this *R. magnificus* Zone assemblage Neves deduced that it coincides with the Upper Namurian A.

The succeeding *Dictyotrilete bireticulatus* Zone at La Camocha is characterised by increased numbers of *Crassispora* and *Laevigatosporites* together with *Moorisporites fustis* Neves (which does not occur in the Featherstone assemblages), *Secarisporites remotus*, *Savitrisporites nux*, *Reinschospora speciosa*, *Dictyotriletes bireticulatus*, *D. castanaeformis*, *Densosporites anulatus*, *D. sphaerotriangularis* *Radiizonates striatus*, *Grumosisporites varioreticulatus*, *Camptotriletes superbus*, *Convolutispora florida*, *Schulzospora rara*, *Florinites spp.* and many other Westphalian species. This assemblage was considered to span the Namurian B, C and the lower part of the Westphalian A. Most of these elements occur in the present Assemblages III and IVa from the Burnfoot shales and Kellah Burn and Assemblage IVb from Plenmeller and other sites.

The overlying *Vestispora tortuosa* Zone was marked by the first appearance of *Vestispora tortuosa*, *Endosporites zonalis*, and *Florinites mediapudens* and by an increase in the abundance of *Densosporites* *anulatus*, *Radiizonates striatus* and *Laevigatosporites spp*. Other species present in this zone are *Punctatisporites sinuatus*, *Calamospora spp*., *Dictyotriletes bireticulatus*, *Verrucosisporites spp*., *Apiculatisporis spp*., *Densosporites sphaerotriangularis*, *Schulzospora rara*, *Florinites spp*. and several other characteristic Westphalian species. This zone, which was determined by Neves to be of Lower Westphalian A age, has much in common with the present Assemblage IVb excepting in the occurrence at high frequency of *Vestispora tortuosa* in his assemblage. The succeeding *Vestispora pseudoreticulata* Zone is characterised by the incoming of *Vestispora pseudoreticulata* (which first appears in the present Assemblage VI) and *Cirratriradites saturni*. The species listed by Neves in this assemblage compare closely to the present Assemblages Va and b especially in the presence of *Dictyotriletes bireticulatus*, *Schulzospora rara*, and *Laevigatosporites vulgaris*. The significant species which was not recorded by Neves is *Radiizonates aligerens*. Neves placed this zone in the middle-upper Westphalian A.

Moore *et al*. (1971) studied stratigraphically and palaeontologically the strata from the Villamanin area of northern Leon, N.W. Spain. The palynology was carried out by R. Neves who divided the strata, which extends from Upper Namurian B to lower Westphalian C in age, into five assemblages. The *Raistrickia fulva* assemblage is the oldest assemblage recognised by him, and he determined the age to be Upper Namurian B, because of the absence of characteristic Namurian A species and the absence of *Dictyotriletes bireticulatus* and *Florinites mediapudens*. He suggested, more specifically, Marsdenian (R_2) age rather than a Kinderscoutian (R_1) age, because of the absence of *Spelaeotriletes* and *Kraeuselisporites* from this assemblage.

The overlying *Dictyotriletes bireticulatus* and *Florinites mediapudens* assemblages have many species in common with those recorded in Assemblage IVa and b; some of these species are *Densosporites anulatus*, *Radiizonates striatus*, *Raistrickia fulva*, *Crassispora kosankei*, *Florinites spp*., *Schulzospora rara* and other Westphalian species. These two assemblages were recorded by Neves to be of Namurian C age and lower and middle Westphalian A age respectively.

The succeeding *Vestispora pseudoreticulata* assemblage compares closely with the present Assemblage VI from Hedley Park and Low Close. These two assemblages are characterised by the presence of *Densosporites anulatus*, *D. sphaerotriangularis*, *Cingulizonates loricatus*, *Cirratriradites saturni*, *Dictyotriletes bireticulatus*, *Endosporites globiformis*, *E. zonalis*, *Florinites spp*., *Vestispora pseudoreticulata*, *V. costata*, *Laevigatosporites spp*. and others. This assemblage was indicated by Neves to be of Westphalian B age.

6.8.2 Eastern Europe

The number of papers covering the distribution of miospore assemblages in Namurian strata is small in comparison with those dealing with Dinantian and Westphalian strata.

Significant contributions have been made in Poland by Horst (1955) and Dybova and Jachowicz (1957) in Upper Silesia and by Jachowicz (1964, 1974) in the Bug Basin, eastern Poland and in Upper Silesia respectively.

The common species recorded by Horst (1955), who described miospore assemblages from strata of mainly Namurian A age in the West-Oberschlesischen and Mährisch-Ostrauer regions were also recorded in the present Assemblages I and II. The closest comparison can be made with the Jaklowetzer and Porubaer Groups; these horizons are characterised by the absence of the older species Chaetosphaerites pollenisimilis, Rotaspora annellita (Horst) Potonie and Kremp and Tripartites trilinguis.

Jachowicz (1974) introduced a refinement of the earlier description of miospore distributions of the Namurian and Lower Westphalian A strata of the Upper Silesia section in Poland. From his distribution chart there appears to be a remarkable similarity between his misopore assemblages (Zone N7, upper part of the Namurian A) and Assemblage I in the occurrence of Tripartites spp. Rotaspora fracta, R. knoxi, which disappear at the top of his N7 Zone, Chaetosphaerites pollenisimilis, Crassispora kosankei, Cingulizonates bialatus, Schulzospora rara, and Cirratriradites saturni.

His younger assemblages, N8 and N9 from the Namurian B and the assemblages from the Westphalian A, are difficult to compare with the assemblages from the Featherstone area and from Plenmeller and other sites, due to the presence of younger species in N8 and N9; these are Planisporites granifer, Reinschospora speciosa, Dictyotriletes bireticulatus, Radiizonates difformis and R. aligerens. The range of the latter species differs from most British records of this species. Moreover Endosporites zonalis appears in his Zone N10 (Middle Namurian C) and E. globiformis and Punctatosporites minutus appear slightly above the base of Westphalian A. Some of Jachowicz's species, i.e. Planisporites granifer, Dictyotriletes bireticulatus and Radiizonates difformis together with other significant species like Moorisporites spA. and Triquitrites spp., occur with other Westphalian A species in Assemblage IVa in the Upper Kellah Coal samples.

Beju (1970) recognised three miospore assemblages (Cb_1, Cb_2 and Cb_3 zones) from the Romanian Carboniferous of the Moesian Platform. He described two assemblages (Cb_2 and Cb_3) from Namurian and Lower Westphalian A strata. In his zone Cb_2 he encountered many species which were recorded in the present study, e.g. *Leiotriletes tumidus*, *Acanthotriletes castanea*, *Convolutispora spp*., *Crassispora (ovalis) kosankei*, *Bellispores nitidus*, *Savitrisporites laevigatus*, *Kraeuselisporites ornatus*, *Densosporites spinosus*, *Spinozonotriletes uncatus*, and *Laevigatosporites* (ovalis) *minor*. However his assemblage is characterised by the frequent occurrence of *Crassispora maculosa*, *Triquitrites vetustus*, *T*. *(ianthina) trilinguis*, *Rotaspora fracta*, *R*. *knoxi* and *Grandispora echinatus*. This suggests that the present Assemblage I from Park Burn is younger, because it is characterised by the absence of *C*. *maculosa* and *G*. *echinatus* and by the occasional occurrence only of *Chaetosphaerites pollenisimilis*, *Tripartites spp*., *Rotaspora spp*., and *Schulzospora spp*. The younger assemblage (Cb_3Zone) recognised by Beju to be Upper Namurian and Lower Westphalian A in age, is characterised by the disappearance of those species which form significant elements of Namurian A assemblages, i.e. the *Tripartites spp*., *Rotaspora spp*. and *Schulzospora spp*. group.

6.8.3 Turkey

Artüz (1957, 1959) described an assemblage of spores from the Upper Namurian and Lower Westphalian A from the Sülü and Büyük seams of the Zonguldak Basin, Turkey. It includes several species recorded in Assemblage IVa and others in IVb, these are *Raistrickia fulva*, *R*. *digitosa*, *Laevigatosporites spp*., *Bellispores nitidus* (not recorded in Assemblage IV), *Punctatisporites sinuatus*, *Cirratriradites saturni*, *Verrucosisporites sifati*, *V. microtuberosus* *Triquitrites tribullatus*, *T. sinani*, *Moorisporites lucidus* (Artüz) Felix and Burbridge 1967 (not recorded in Assemblage IV), *Densosporites crassigranifer* Artüz 1957, and *Radiizonates striatus* Other species present in Assemblage IV but not recorded by Artüz include *Florinites spp.*, *Endosporites spp.*, *Schulzospora rara*, and *Radiizonates aligerens*.

Assemblage IV and V in general compare with those described by Loboziak and Dil (1973) from fifteen coal seams in the Caydamar mines, Heraclee Basin, Turkey. These assemblages were dominated by *Lycospora spp.* and *Densosporites spp.* They also recorded high frequencies of *Crassispora kosankei*, *Calamospora spp.*, *Cingulizonates loricatus* and to a lesser extent *Granulatisporites spp.* and *Raistrickia spp.* (especially *R. fulva*). All these elements are found in both Assemblage IV and V in large numbers; however among the spores noted only occasionally are *Triquitrites*, *Ahrensisporites* and *Punctatisporites sinuatus*, which also occurred occasionally in Assemblages IV and V.

6.8.4 North America

Fifty-nine spore taxa have been described by Hoffmeister, Staplin and Malloy (1955) from the Hardinsburg Formation, just below the middle of the Chesterian Series, of the Illinois and Kentucky basins in the U.S.A. The age of the Hardinsburg Formation was considered by Felix and Burbridge (1967) to be equivalent to the late Visean in European time stratigraphy. However, Sullivan and Mishell (1971) regard the Hardinsburg assemblages to be similar or slightly older in age than the Goddard Formation assemblages in Oklahoma, because of the absence in the former assemblage of *Savitrisporites* nux and Bellispores nitidus.

Felix and Burbridge (1967) described miospore assemblages from the Goddard, Springer and Morrow formations (Mississippian/ Pennsylvanian systems) in Southern Oklahoma. Sullivan and Mishell (1971) placed the base of the Goddard Formation at the Namurian/ Visean boundary according to the first appearance of the seven significant species at that horizon. However Neves (1967) considered that four of those species are known to occur in the Visean of Britain (see his table 3) and therefore, Neves placed the base of Goddard formation within the late Visean.

Felix and Burbridge's range chart (table 2) and spore distribution chart for the Springer Formation (table 3), reveal significant elements on which comparisons can be made with the spores encountered in Assemblages I and II from Park Burn and Pinking Cleugh respectively. Assemblage I is comparable to the lower part of the Springer Formation assemblage which includes all the samples from 03V16-1 to 03V17-2 and is illustrated in their table 3. It is characterised by the presence of the following genera: Ibrahimispores Artüz 1957, Moorisporites Neves 1958, Grandispora Hoffmeister, Staplin and Malloy 1955, Nexuosisporites Felix and Burbridge 1967, and Cincturasporites (Hacquebard and Barss) Bharadwaj and Venkatachala 1962, which are not recorded in the present assemblages. Also present are the following characteristic species: Chaetosphaerites pollenisimilis, Rotaspora fracta, Tripartites spp., Discernisporites micromanifestus and Laevigatosporites spp. On the other hand, Assemblage II is comparable to the upper part of the Springer Formation, which is characterised by the absence of the previous Assemblage I species. However, the other elements which are significant in both assemblages are: Leiotriletes tumidus, Convolutispora spp., Secarisporites remotus, Bellispores nitidus, Savitrisporites nux, Tantillus triquetrus, Knoxisporites spp., Crassispora kosankei, (which increases in abundance in the upper part of the Springer Formation) Proprisporites laevigatus, Shulzospora rara and Potoniesporites elegans.

Ettensohn and Peppers (1979) examined four samples from the Pennington Formation in northeast Kentucky and their miospore distributions are shown in their table 1. However their assemblages are difficult to compare with the Assemblage I from Park Burn, because some of their species are characteristic of the lower Namurian A (E_1 stage); these include Retusotriletes golatensis Staplin 1960, Crassispora maculosa, Grandispora echinatus and several other characteristic Visean and Namurian species which are not recorded in the present Assemblage I. They indicate that the assemblages recorded from these four samples are of late Chesterian (Namurian A) age.

Ettensohn and Peppers (loc. cit.) also examined three samples from the younger Breathitt and Lee Formations, which are indicated by them to be of early Pennsylvanian (Namurian B to Westphalian A) age. Several species present in these samples are also recorded in the present Assemblages IVa and b and Va and b.

Kosanke (1950) described the spore assemblages of coals of the Caseyville Formation, lowermost Pennsylvanian of Illinois and probably corresponding to the upper part of Namurian B and lower part of Namurian C of Europe, and the lower part of the Tradewater Group which probably corresponds to the upper half of the Namurian C and the Westphalian A. The Caseyville Formation contains a restricted microflora dominated by Lycospora spp. and Densosporites *anulatus* (*D. reynoldsburgensis* Kosanke 1950). *Schulzospora rara* is restricted to the middle coal and species of *Laevigatosporites* and *Florinites* (F. *antiquus*) appears for the first time and persists into the Tradewater Group. Species recorded in the present study which were not present in the Caseyville Formation but do occur in the Tradewater Group are *D. sphaerotriangularis*,*Radiizonates difformis* (*Cirratriradites difformis* Kosanke 1950), *Calamospora pedata*, *C. liquida*, *Reinschospora spp*. and *Lycospora punctata* Kosanke 1950.

Barss (1967) has figured a wide variety of spores from the Westphalian A Riversdale Group of the Maritime Provinces of Canada. These include, *Calamospora spp*., *Apiculatisporis spp*., *Laevigatosporites spp*., *Florinites spp*., *Schulzospora rara* and *Schopfipollenites ellipsoides var. corporeus*, but he did not record *Densosporites anulatus*, *D. sphaerotriangularis*, *Radiizonates spp*., *Cingulizonates loricatus*, *Cirratriradites saturni* and *Dictyotriletes bireticulatus*.

CHAPTER 7

Correlation of coals at Plenmeller with those in adjacent areas

In the present study an attempt has been made to correlate individual coal seams of the Plenmeller Coalfield with the coal seams of the adjacent sites at Stublick Bog, St. Andrew's and Hedley Park.

Detailed correlations are shown in Fig. 21, which agree with Dr. J. Knight's correlations based on lithology (per. comm., see Fig. 10).

7.1 Correlations within Assemblage IVb seams

Four seams were recognised with Assemblage IVb from Plenmeller; these are, from bottom to top, the Ganister Clay, Marshall Green, Low Main Stringer and Low Main seams.

Based on evidence given in Chapter 6 and in Table 1, good correlations can be made between the Ganister Clay seam of Plenmeller and the Top Broomly further east, and between the Low Main of Plenmeller, the Stone of Stublick Bog and the Top Victoria of St. Andrew's. A good correlation can also be made between one of the samples of the Low Main Stringer (below the Low Main) of Plenmeller and the lower of the two unnamed seams at Stublick Bog.

The two samples of the Low Main Stringer yielded rather different spore assemblages as discussed in Chapter 6.

7.2 Correlations within Assemblage Va seams:

Seven seams were recognised with this Assemblage from Plenmeller and these are, from bottom to top, the Slag, High Main, Wellsyke, Quarter, Half, Threequarter and Little Seams.

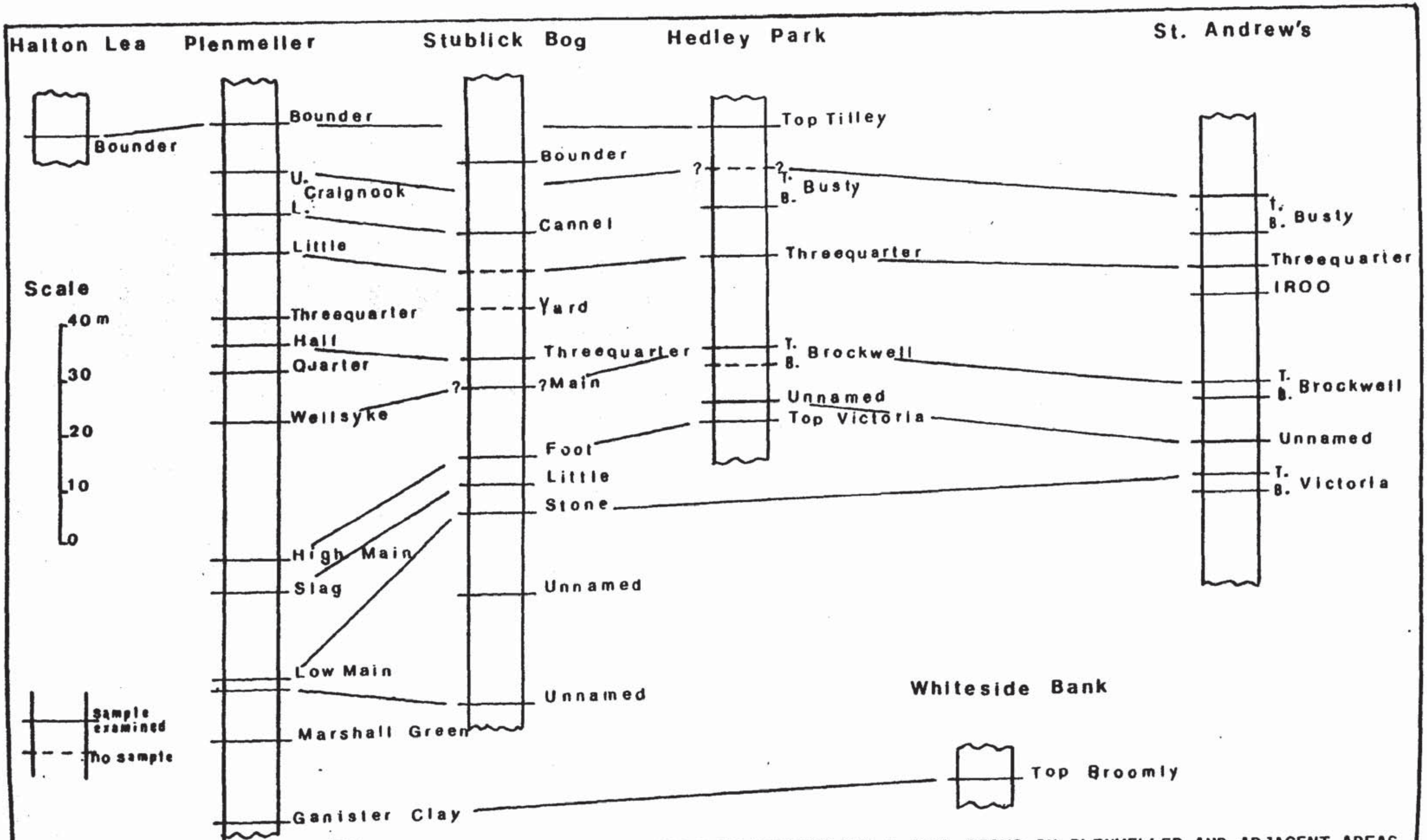


Fig. 21. SUGGESTED CORRELATION OF WESTPHALIAN A COAL SEAMS IN PLENMELLER AND ADJACENT AREAS

A good correlation has been made between the Slag and High Main seams from Plenmeller and the Little and Foot seams from Stublick Bog respectively.

The Top Victoria seam from Hedley Park correlates closely with the Foot and High Main seams from Stublick Bog and Plenmeller respectively.

The Wellsyke seam from Plenmeller correlates with both Top Brockwell seams from St. Andrew's and Hedley Park. The Threequarter seams in both St. Andrew's and Hedley Park correlate with the Little Seam from Plenmeller.

The Bottom Busty in Hedley Park did not correlate with the Bottom Busty in St. Andrew's (which does not agree with Dr. J. Knight's correlation) because of the differences in the frequencies of certain species; for instance Densosporites sphaerotriangularis and Radiizonates aligerens are absent from the Bottom Busty of Hedley Park, whereas the former species has a high frequency and the latter species has a relatively high frequency in the Bottom Busty of St. Andrew's. Radiizonates striatus and R. cf. difformis are present in low numbers in Hedley Park, but they are present in relatively high numbers in the St. Andrew's seam. Bottom Busty seam from St. Andrew's correlates closely with the Lower Craignook and Cannel seams from Plenmeller and Stublick Bog respectively.

7.3 Correlations within Assemblage Vb seams

Three seams were recognised with this Assemblage from Plenmeller and these are the Lower Craignook, Upper Craignook and Bounder seams. The suggested correlations of these seams are in close agreement with Dr. J. Knight's correlation.

The Lower Craignook seam from Plenmeller correlates with the Cannel from Stublick Bog. The Upper Craignook seam correlates with the Top Busty seam in St. Andrew's, and the Bounder seam in both Halton Lea and Plenmeller correlates with the Top Tilley seam from Hedley Park.

CHAPTER 8

CONCLUSIONS

The miospore assemblages recorded during the present study confirm that the Namurian sequence of the Featherstone area and the Coal Measures of the Plenmeller Coalfield and adjacent areas, which have not previously been dated by miospore evidence, are of Upper Namurian A to B and Westphalian A to Lower Westphalian B age respectively.

206 species belonging to 71 genera are described in detail in Chapter 5. 11 types are new from the Namurian strata and 11 types are new from the Westphalian A and B strata; most of the new taxa are provided with formal diagnoses. Comparisons and discussion of individual species are given when needed.

Six miospore assemblages have been recognised in the present investigation. These are based mainly on the first appearances of new taxa and also to some extent on variations in abundance.

Detailed comparisons with miospore assemblages previously described by several authors from similar stratigraphical horizons in Scotland, North England, the Central Province of England and the Forest of Dean Coalfield indicate that the present first three Assemblages from the Featherstone area are probably equivalent to the middle of E_2b, uppermost E_2c or H and lower R_2 goniatite chronozones respectively; the other three Assemblages from the Featherstone area, Plenmeller Coalfield, and the adjacent areas are probably equivalent to the A. lenisulcata, C. communis and lower A. modiolaris non-marine bivalve chronozones.

The present assemblages also compare closely with those further afield published from Western and Eastern Europe and North America.

The assemblages described in the present study correlated most closely with the assemblages in the Stainmore Outlier described by Owens in Owens and Burgess (1965), in the Northumberland and Durham and the Cumberland Coalfields described by Smith and Butterworth (1967) and in the Woodland Borehole, Co. Durham, by Neves (1968). The assemblages also compared fairly closely with the concurrent range zones defined by Owens *et al*., (1977) and Clayton *et al*. (1977). All these have been discussed in detail in Chapter 6.

Assemblages I and II from the Featherstone area include some notable new taxa; they correspond approximately to the limit of the TR and SO concurrent range zones of Clayton *et al*. (1977) which lies towards the top of the Arnsbergian stage. This accords with the correlations of Ramsbottom *et al*. (1978) who place the Brampton Lower Fell Top Limestone (lying below strata with Assemblage I) in the E_2b goniatite chronozone and the Brampton Upper Fell Top Limestone (lying below strata with Assemblage II) near to the base of the Chokierian (H) stage.

Assemblage III from the Burnfoot Shales of the Featherstone area corresponds to the higher part of the KV concurrent range zone of Clayton *et al*. (1977) which occurs in the lower part of the Marsdenian (R2) stage. Ramsbottom *et al*. (1978) place the Burnfoot Shales in the upper part of the Kinderscoutian (R1) stage, on the evidence of high numbers of *Crassispora kosankei*.

Assemblage IV is from the highest part of the Featherstone sequence and the lowest part of the Plenmeller sequence. Assemblage IVa includes a lower diversity of typical Westphalian species, the presence of *Moorisporites sp. A.*(which shows some morphological intergradation with species of the genus *Triquitrites*) and the absence of monolete spores. Assemblage IVb is characterised by the first appearance of *Densosporites sphaerotriangularis* and the monolete spores *Laevigatosporites minor* and *Punctatosporites minutus*. Assemblage IVa corresponds to the SS, and IVb to the highest SS and basal RA concurrent range zones of Clayton *et al*. and occur in strata which Ramsbottom *et al*. place in the *C. lenisulcata* and basal *C. communis* non-marine bivalve zones of the Westphalian A stage.

Assemblage V occurs at higher horizons in the Westphalian A. Assemblage Va is characterised by the first appearance of *Radiizonates aligerence* and high numbers of *R. difformis*, *R. striatus* and *Densosporites anulatus*. Assemblage Vb contains fewer of these latter two species and more *D. sphaerotriangularis*, *Radiizonates aligerens*, *Schulzospora rara*, *Vestispora spp*. and *Cristatisporites spp*. *R. aligerens* and *R. difformis* are absent from Assemblage Vc which is characterised by high frequencies of *Dictyotriletes bireticulatus* and *Endosporites globiformis*. These correspond to the RA concurrent range zone of Clayton *et al*.

Assemblages Va and b correspond to the *R. aligerens* assemblage of Smith and Butterworth (1967) and Vc corresponds to their *Schulzospora rara* assemblage. Ramsbottom *et al*. (1978) place the Assemblage Va horizons in the *C. communis* zone and the Assemblage Vb and c horizons in the lower part of the *A. modiolaris* zone.

Assemblage VI, with no *S. rara* and with *E. globiformis* and *Vestispora spp*. constantly present, corresponds to the NJ concurrent range zone of Clayton *et al*. and occurs in Westphalian B strata which was examined from West Cumbria and the Main Northumberland Coalfield only.

Selected correlations of the Westphalian A seams of the

Plenmeller Coalfield are considered in Chapter 7 and shown in Fig. 21. They have been discussed in detail with Dr. J. Knight and compare fairly closely with his correlations based on lithological and faunal evidence. The major differences in the correlation are those between the two samples of the Low Main Stringer from Plenmeller and the Bottom Busty Seam from Hedley Park and St. Andrew's; neither of these corresponds, perhaps because of sampling differences or of differences in the petrology of the coals.

APPENDICES

APPENDIX A

Sections of Boreholes from Plenmeller Opencast Site sampled on the site

Plenmeller Borehole 1350

Box 1

From 5.50 m	42 cm dark grey micaceous siltstone with plant fragments and occasional lighter grey bands.
+P90	40 cm laminated dark grey shale.
	57 cm coal - HALF SEAM:-
P1	1.5 cm coal
P2	7 cm very bright coal
P3	8 cm interbanded coal
P13	4 cm dull coal
P72	10 cm interbanded coal
P4	4.5 cm dull coal
P75	16 cm bright and banded coal
P10	3 cm dull coal
+P7	3.5 cm medium grey clay with rootlets
To 7.50 m	43 cm similar to above but siltier towards the base and slightly banded, light and dark grey.
From 7.50 m *P11	26 cm light grey, irregularly banded silty mudstone with darker rounded inclusions, 2 cm diameter, very black and shiny when split - fish?
+P73	22 cm dark grey shale with plant fragments
	13 cm light grey and buff banded siltstone, banding more irregular and with washout in upper part.
+P71	24 cm black shale with plant fragments
	25.5 cm coal - QUARTER SEAM:-
P12	4 cm top - bright banded coal
P74	17 cm middle
P6	5 cm bottom - bright banded coal
+P5	6 cm dark grey clay with rootlets
	36 cm as above
To 10.10 m	83 cm dark grey shale with ironstone nodules up to 5 cm in diameter.

Box 2

From 10.10 m	51 cm medium grey mudstone with plant fragments including Lepidodendron.
	19 cm dark grey shale with abundant plant remains and and occasional ironstone nodules.
	5 cm medium grey siltstone, ?feldspathic, with plant fragments.

+ Productive samples

* Unproductive samples

2 cm dark grey shale with plant fragments and occasional ironstone nodules.

7 cm medium grey siltstone

2 cm black shale with plant fragments

8 cm medium grey siltstone

8 cm dark grey shale with plant fragments and interbanded silty layers

8 cm medium grey siltstone

2 cm black shale

12 cm banded shale and silt - bands 1 cm thick

7 cm dark grey shale

8 cm medium grey siltstone

13.5 cm dark grey shale

14 cm siltstone interbanded with shale, bands 1 cm thick

8 cm shale

8 cm siltstone

*P14 13 cm interbanded black shale and buff siltstone

10 cm light grey siltstone with darker bands 1 mm to 1 cm thick

5 cm light grey siltstone

2.5 cm shale

305 cm light grey siltstone with dark bands and ochre ironstone bands:-

P51 37 - 51 cm
P52 94 - 104 cm
P53 110-125 cm
125-133 cm dark grey shale with plant fragments
133-165 cm banded siltstone/shale
165-178 cm dark grey shale
178-186 cm banded siltstone
186-206 cm dark grey shale with thin silty layers
206-312 cm pale siltstone with thin discontinuous
To 15.50 m bands of dark shale.

Box 3

From 15.50 m 157 cm light grey siltstone with very thin laminae of dark grey shale; some cross-lamination.

11 cm interbanded black shale/light grey siltstone, bands up to 2 cm thick

*P70 88 cm as 157 cm above. Sample from bottom 32 cm

2 cm black carbonaceous shale

109 cm light grey siltstone with thin laminae of dark grey shale; some slight cross-lamination. 2-3 cm dark grey shale 23 cm from base.

+P84-channel	99 cm coal - WELLSYKE SEAM
P15	4 cm dull coal 32 cm below the roof
+P8	3 cm black soft coaly shale with rootlets
	21 cm medium grey clay with rootlets and slickensides
	4 cm disturbed grey clay
	41 cm medium grey silty mudstone with plants and occasional nodules
	14 cm light grey very hard siltstone with plants and large nodules, up to 4 cm long.
*P83	44 cm hard medium grey banded siltstone with lighter iron-stained bands. Calcite on joint plane.

Box 4

From 21.50 m	94 cm as above, also with calcite joints
*P69	31 - 76 cm of above
	21 cm medium grey fine siltstone with plant fragments (Lepidodendron).
	Fine irregular banding, medium/light grey siltstone. Calcite joints.
*P85	24 cm medium grey siltstone with Calamites. Calcite joints.
	13 cm medium grey shale
	11 cm dark grey mudstone with plants
+P86	33 cm coaly shale
	21 cm coal - WELLSYKE STRINGER
P50	7.5 cm top bright coal
+P19	6 cm middle interbanded coal
P9	7.5 cm bottom bright coal
+P20	7 cm very dark grey soft muddy clay
+P22	5.5 cm medium grey mudstone
	18 cm dark grey more consolidated mudstone with rootlets
	9 cm similar but not consolidated
	12 cm dark grey silty mudstone with plants
	90 cm light grey siltstone with thin irregular dark grey shale bands, indistinctly cross-laminated.
	18 cm pale grey sandstone with very thin small lenses of similar sandstone with iron-rich matrix or with buff or black coarser sand. Medium grained. Indistinctly cross bedded.
	slightly gradational boundary
	5 cm dark grey shale
	sharp boundary

12 cm pale grey sandstone as above; medium grained

gradational boundary

3 cm dark grey shale

sharp boundary

50 cm pale grey sandstone, medium-grained

gradational boundary

10 cm dark grey shale with fine silty partings: sharp base

*P88 8.5 cm pale grey sandstone
3.0 cm sandstone/shale gradation
3.0 cm dark grey shale

To 27.05 m 94 cm pale grey sandstone

N.B. All sandstone below the Wellsyke Stringer similar in lithology apart from the first metre which was more finely banded. Below that are coarsening-up cycles as in P88 and the sandstones are less carbonaceous with paler laminations, sometimes cross-laminated

<u>Box 5</u>

From 27.05 m 31 cm pale sandstone - continuation of 94 cm above.

sharp contact

2 cm dark grey shale

*P87 2cm gradational change
4.5 cm pale sandstone
2 cm gradational change

5.0 cm shale

sharp contact

78 cm pale sandstone, cross-laminated, as above

3 cm gradation

3.5 cm dark shale

sharp contact

N.B. Not much dark shale below this level - gradations paler.

38 cm pale sandstone as above but slightly paler

4 cm dark shale/pale siltstone alternation

3 cm dark shale with very thin pale silty partings

sharp contact

31 cm pale sandstone as above

8.5 cm medium grey silty shale and pale grey siltatone alternations, well cross-laminated.

89 cm pale grey sandstone, steeply dipping, some cross-laminations, with irregular bands of slightly coarser darker sandstone, ironstained.

146 cm as above

*P54	97 cm as above but bands more prominent
To 33.10 m	59 cm pale grey gritstone with parallel laminations
<u>Box 6</u>	
From 33.10 m	176 cm pale grey feldspathic grit, continuation of above, with carbonaceous partings and plant fragments. Ironstained parallel banding in lower part.
	Sharp gradation to
	55 cm dark grey shale with occasional ironstained silty lenses in the lower part.
	9 cm similar but pale ironstained silt more dominant
	19 cm dark grey shale with very occasional pale silty laminations
To 36.10 m	42 cm medium grey slightly silty shale with occasional pale silty bands
From 36.10 m	84 cm as above
*P24	Sample from 16 cm above the base of 84 cm above
	64 cm black carbonaceous mudstone
+P23	92 cm similar to above but slightly fissile
To 38.50 m	
<u>Box 7</u>	
From 38.50 m	131 cm as above
To 40.40 m	66 cm friable dark grey shale
	49 cm as above
To 42.45 cm	157 cm as above but paler and harder - because drier?
<u>Box 8</u>	
From 42.45 m	17 cm black carbonaceous shale as above
	10 cm very hard carbonaceous siltstone
	84 cm black carbonaceous shale
*P25	Bottom 14 cm of above
+P76	62 cm coal - HIGH MAIN
	117 cm black very slightly fissile mudstone with numerous plant remains, rootlets; lystric surfaces; occasional ironstone nodules, up to 3 cm, in lower part.
+P77	Sample of above from immediately below the coal 47 cm similar to above
	49 cm dark grey shale with fine buff silty bands and lenses, more or less parallel
	55 cm black shale, only slightly fissile, plant fragments
	sharp contact
	15 cm dark grey carbonaceous siltstone, nearly parallel laminations

	29 cm dark grey shale/thin layers of buff silt
*P21	56 cm dark grey shale
To 48 m *P78	22 cm banded siltstone/shale
Box 9	
From 48.0 m	31 cm as above
	72 cm black carbonaceous slightly fissile mudstone with occasional silty laminations; more fissile towards base
*P26	10 cm black shale
	120 cm coal - SLAG SEAM
P27	Top 18 cm
P36	24 cm
P35	8 cm
P37	27 cm
P28	15 cm
P29	9 cm - with tonstein?
P48	22 cm
+P80 To 50.50 m	24 cm dark grey mudstone with plants, rootlets and lystric surfaces. Sharp oblique contact between seatearth material and -
	61 cm pale grey coarse plant-rich sandstone/grit, micaceous, with rootlets. Thin irregular ironstone stained laminations.
	75 cm pale grey siltstone, cross-laminated and with fine carbonaceous partings.
	103 cm pale siltstone, banded
To 53 m *P67	19 - 42 cm from the top
Box 10	
	50 cm pale siltstone as above
	1 cm dark grey shale
	4 cm siltstone
	3 cm gradation, siltstone/shale
	1 cm dark grey shale
	215 cm pale grey silty sandstone with darker grey bands, steeply dipping at the top, cross-laminated at the base.
56.00 m	18 cm pale grey silty sandstone with carbonaceous laminae and lenses
	Gap?
	10 cm as above
	30 cm light grey breccia, clasts up to 2 cm
	16 cm dark grey broken silty mudstone
To 58.30 m	30 cm medium grey broken clay and mudstone

Box 11

From 58.30 m	17 cm grey siltstone
	23 cm medium grey mudstone, loose
	29 cm finely banded light grey silty sandstone with carbonaceous patches and streaks
	15 cm medium grey mudstone, loose
	16 cm as above
	55 cm steeply dipping medium grey mudstone, slightly fissile
To 61.30 m	42 cm medium grey silty mudstone
To 62.30 m	82 cm medium grey silty mudstone
To 63.20 m	80 cm broken dark grey mudstone

Plenmeller Borehole 1241

Box 1/7

From 11.30 m	medium-grained pale orange/brown sandstone with iron-rich cement
From 13.04 m	
From 14.54 m	
	47 cm as above
To 15.99 m	62 cm soft earthy grey silty clay
From 15.99 m	96 cm dark grey slightly fissile mudstone/shale
To 17.13 m	

Box 2/7

From 17.13 m	119 cm as above, with fish remains
To 18.43 m	
From 18.43 m	10 cm medium grey fine-grained silty mudstone with iron
	126 cm black shale with occasional ironstone nodules and one horizon of ?carbonaceous seatearth
To 31.43 cm	5 cm, near to the top.

Box 3/7

From 21.43 m	8 cm orange/brown sandstone, probably not in situ
	15 cm black shale
	8 cm dark grey silty mudstone with iron
P107	36 cm dark grey shale
*P106	roof - soft black laminated clay
*P104	coal - 53 cm
P105	?tonstein 2 cm, 23 cm from base of seam
*P103	22 cm dark grey plant rich fissile mudstone with *Stigmaria*. (Sample from immediately below the coal)

To 23.43 m, but this should probably be at the end of -

	72 cm the same as above and still very plant rich
*P102	12 cm sample, taken 13 cm from top of above
From 23.43 m	57 cm slightly coarser and more fissile medium grey silty mudstone with plant fragments
	6 cm medium grey silty ironstone
	82 cm as above
	17 cm dark grey shale interbedded with light grey siltstone
	13 cm dark grey slightly silty shale
*P101	39 cm banded dark grey shale/pale grey or buff siltstone, more or less parallel laminations
	53 cm slightly silty medium grey shale and lenses of silty ?ironstone
To 26.33 m	34 cm as above but more faintly banded
<u>Box 4/7</u>	
From 26.33 m	48 cm medium grey silty shale with lenses of buff, iron-stained siltstone, ranging up to 1 cm thick
	26 cm similar to above but with thin lenses of pale grey siltstone
	34 cm as above
*P148	3.5 cm coal
	3 cm shale
+P147	9.5 cm coal
*P150	5 cm dark seatearth
*P145	9 cm light seatearth
To 29.33 m	84 cm irregularly bedded medium grey plant-rich silty mudstone with rootlets. Occasional ironstone nodules.
From 29.33 m	51 cm muddy siltstone, still plant-rich, with lenses of iron-rich buff siltstone and occasional ironstone nodules.
*P133	119 cm dark grey shale interbedded with pale grey siltstone
	sharp contact with
	35 cm very pale sandstone with thin buff lenses and slight cross-laminations; medium grained
	1.5 cm gradation
	2.0 cm medium grey micaceous siltstone
	63 cm sandstone, as above
	2 cm alternation of medium grey silty shale with micaceous partings

8 cm darker shale, with plants

To 32.33 m P134 19 m coarse pale sandstone, massive, thin brown lenses.

Black shale with sharp contact on end of sandstone.

Box 5/7

From 32.33 m 23 cm broken dark grey shaley mudstone, slightly silty, with *Stigmaria* and plant fragments.

sharp contact with

34 cm pale sandstone with thin buff lenses and some cross lamination. cf. P134.

19 cm finely alternating pale sandstone and black carbonaceous layers

15 cm pale sandstone with buff micaceous layers again. Cross-laminated

*P144 8cm pale grey silty sandstone with black carbonaceous lenses

19 cm similar but more carbonaceous lenses, with plant fragments and marked cross-laminations

2 cm pale silt lense

127 cm as 19 cm above and with one thicker silty band (4 cm) in top half.

sharp contact with

34 cm pale sandstone with thin buff lenses as in P134

4 cm gradation pale silt/dark shale

15 cm dark silty mudstone, slightly fissile

sharp contact

P146 7 cm pale sandstone with buff thin lenses, with thin gradational layer at base

9 cm gradation continued

11 cm dark silty mudstone, slightly fissile and micaceous, with plant fragments

6 cm dark/light gradation

12 cm very finely banded pale grey/buff siltstone, very micaceous, roughly parallel laminations

*P137 10 cm as above but with more patches of carbonaceous material

22 cm alternations of white siltstone/black carbonaceous material, micaceous, plant fragments, parallel laminations

not very sharp contact to

7 cm similar to P137

wavy contact with black mudstone and plants to

*P136	16 cm regularly banded pale grey siltstone with buff bands
	18 cm similar to above but buff predominating. Very micaceous partings
	26 cm similar to above but white predominating, some cross lamination
	4 cm buff siltstone
	43 cm pale grey sandstone, buff bands but not well-defined
To 37.23 m	Coarsely cross laminated
<u>Box 6/7</u>	
From 37.23 m	100 cm almost white massive sandstone
To 39.67 m	132 cm very pale sandstone with ill-defined buff micaceous partings. Cross-stratified.
From 39.67 m	28 cm as above
	4 cm dirty brown sandstone with a layer less than 1 cm thick of pure white sandstone
	33 cm slightly coarser dirty brown sandstone coarsening to a grit at the base. Top 11 cm lighter and less coarse.
	106 cm coarse pale sandy grit becoming slightly coarser towards base and with carbonaceous partings in the lower 20 cm or so - patches or lenses rather than partings - drifted plant fragments. All fairly massive otherwise.
	Very sharp contact with -
	7 cm dark grey shale with micaceous partings
	6 cm alternations of pale siltstone/dark grey shale with plants predominant. Almost parallel laminations.
To 41.73 m	14 cm very finely banded pale grey siltstone with fine partings of carbonaceous material and mica; cross laminations.
<u>Box 7/7</u>	
From 41.73 m	109 cm as above but paler because more siltstone and fewer carbonaceous/buff mica partings. More micaceous to base and cross laminations more prominent.
	undulating contact with
	6 cm banded siltstone
	10 cm medium grey shale
	10 cm alternating medium grey shale and buff siltstone.
	5 cm medium grey shale
	4 cm shale interbedded with fine parallel silty laminations, micaceous

	17 cm as above
	128 cm black shales
*P135	bottom 9 cm of above
*P131 in P172	7 cm black shaley mudstone - roof
	37 cm coal - LOW MAIN SEAM
P170	Top 9 cm
P138	8 cm
P132	4 cm
P171	17 cm
To 45.05 m	
From 45.05 m	48 cm medium grey silty mudstone with rootlets. With wavy laminae, sometimes paler, especially towards the base.
*P173	top 10.5 cm of above
	10 cm as above but with ?pyritic nodules and bands of ironstone
	85 cm as above
	2 cm ironstone band
	7 cm as 85 cm
	1.5 cm ironstone band
	7.5 cm as 85 cm
	1.5 cm ironstone band
	47 cm medium grey silty mudstone with fine parallel laminae
To 47.05 m	becoming iron-stained towards base

Plenmeller Borehole 1084

Box 4

N.B. Very prominent ironstone nodules noted about 1 m below Slag washout

P177 and P178 - from about 164 cm below the Low Main Seam.

P179 - continuous 38 cm from 21 cm above P177 and P178.

Plenmeller Borehole 1338

Box 2/11

Three Quarter Seam

*P79	roof
+P82	channel section of coal - 65 cm (1441 cm - 1506 cm).
*P49	seatearth

Box 4/11

Quarter Seam

+P17	channel section of coal - 25 cm (1937 cm - 1962 cm)
*P18	seatearth

Plenmeller Borehole 1331

Box 8/8

Low Main Seam

+P47	roof
	coal 82 cm (3825 cm - 3907 cm)
P40	Top 2 cm - channel-like
P38	18 cm
P81	30 cm
P30	15 cm
P31	13 cm
*P41	seatearth

Plenmeller Borehole 1341

Box 2/8

High Main Seam

*P44	roof
	coal - 62 cm (1836 cm - 1898 cm)
P66	Top 27 cm - top at top of bag
P65	Middle 21 cm - top at top of bag
Special bag	Bottom 11 cm
*P43	seatearth

APPENDIX B

Details of samples provided by the NCB Opencast Executive from Plenmeller, Stublick Bog, Hedley Park and St. Andrew's Sites

PLENMELLER

Sample No.	NCB Seam Code	BH. No.	Seam Name	Depth in metres	Thickness in metres
796	JW00	1154	Bounder	8.44	0.25
797	HW02	1154	Up. Craignook, T.L.	20.55	0.15
797	HW01	1154	Up. Craignook, B.L.	21.58	1.00
800	GW00	1154	Lower Craignook	24.93	0.58
801	GW21	1154	Little, B.L.	33.46	0.10
127	GW00	1138	Lower Craignook	15.28	0.65
128	GW20	1138	Little comp.	23.12	0.24
129	FW00	1138	Threequarter	31.96	0.65
130	FW22	1138	Half, T.L.	36.79	0.35
131	FW21	1138	Half, B.L.	37.02	0.10
132	FW40	1138	Quarter	39.45	0.21
133	EW00	1138	Wellsyke	49.46	0.89
134	DW02	1138	High Main, T.L.	70.19	0.28
136	DW01	1138	High Main, B.L.	70.46	0.23
137	CW02	1140	Slag, T.L.	49.56	1.04
138	CW01	1140	Slag, B.L. + band	49.65	0.09
139	BW00	1140	Low Main	67.08	0.38
752		1057	Low Main	63.60	0.58
749		964	Wellsyke	22.62	1.00
750		964	Half, T.L.	12.54	0.37
751		964	Threequarter comp.	9.57	0.68
* 3		1186	Millstone Grit Coal	13.75	0.15
1	BW20	1278	Low Main Stringer	27.60	0.14
* 2	BW40	1278	Marshall Green	32.55	0.44
* 4	GW40	1343	2 CN	9.84	0.17
* C1		1345	Un-named (Coal 1)	17.14	0.23
* C2		1345	Un-named (Coal 2)	20.35	0.23
658	BW60	1383	Ganister Clay	24.25	0.32
661	BW20	1392	Low Main Stringer	8.50	0.10
662	BW40	1392	Marshall Green	14.60	0.39
663	BW60	1397	Ganister Clay	19.53	0.13

* Unproductive samples

comp - composite section

STUBLICK BOG SITE

Sample No.	NCB Seam Code	BH. No.	Seam Name	Depth in metres	Thickness in metres
366	HW00	328	Bounder	16.01	0.61
367	GW00	328	Cannel	29.44	0.28
362	FW22	327	Three Quarter T.L.	21.00	0.37
364	FW21	327	Three Quarter B.L.	21.42	0.38
365	EW00	327	Main	28.45	1.17
234	GW00	310	Cannel (comp.)	18.86	0.51
233	GW00	306	Cannel	33.17	0.36
768	GW00	253	Cannel	17.52	0.42
767	GW00	253	Cannel	17.40	0.05
763	DW20	247	Little (Residual coal)	14.80	0.38
760	DW00	234	Foot	14.92	0.52
343	CW00	210	Stone (incl. band)	13.49	0.76
342	BW20	207	Un-named 2	45.01	0.10
338	BW00	206	Un-named 1	24.44	0.43

HEDLEY PARK SITE

Sample No.	NCB Seam Code	BH. No.	Seam Name	Depth in metres	Depth in metres
H541	H002	5058	Maudlin T.L.	16.91	0.56
H543	H001	5058	Maudlin B.L.	15.85	0.13
H30	JK00	5058	Low Main/Top Brass Thill	50.51	3.12
H492	K100	5056	Bottom Brass Thill	56.80	0.29
H10	L200	4964	Top Hutton	16.91	0.98
H496	M000	4990	Ruler	10.61	0.25
H370	IM00	5018	Harvey Marine T.L.	11.43	0.14
H372	IM00	5018	Harvey Marine B.L.	11.68	0.23
H236	2M00	5004	Penny Hill	11.08	0.25
H235	N000	5001	Harvey	16.97	0.18
H60	P200	7072	Top Tilley (incl. Icm band, probable F.C.R.*)	57.92	0.65
H119	Q100	6022	Bottom Busty + band	18.31	0.94
H120	R000	6024	Threequarter	16.91	0.58
H20	S200	4913	Top Brockwell	23.38	0.83
H50	S200	8011	Top Brockwell (incl. bottom shaley leaf 0.13 m)	31.22	0.71
H129	S100	4913	Bottom Brockwell	23.82	0.30
H124	1S00	6028	Un-named	24.08	0.23
H40	1S00	7230	Un-named	28.73	0.16
H118	T200	6020	Top Victoria	33.45	0.36

H - maceration numbers

* - Fragmental clay rock

ST. ANDREW'S SITE

Sample No.	NCB Seam Code	Sample Description	Thickness in metres
+ ‡ P7	W000	Top Broomley	0.43
* P6	T100	Bottom Victoria	0.23
+ P8	T200	Middle Victoria	0.13
* P4		Middle Victoria + Band (probably F.C.R.)	0.04
* P2		Black carbonaceous shale in roof of Middle Victoria	0.05
* P1	T300	Top Victoria	0.32
+ P110	T000	Victoria	0.31
* P111		Roof of Victoria Seam	0.13
+ P108	1S00	Un-named	0.24
P46		Orange-brown siltstone with rootlets	
+ P61	S100	Bottom Brockwell	0.33
+ P32		Bright Coal	0.05
+ P64		Massive dark silty mudstone	0.13
+ P34		Basal 10 cm (dull coal) of above (Top Brockwell)	0.10
+ P60	S200	Top Brockwell	0.67
* P55		Very dark grey mudstone	0.13
* P33		Black shale with bivalves	
+ P45	2R00 ?	Thin bright coal directly below sandstone about 6 m above Brockwell seam	0.11
+ P68	1R00 ?	This could be 2R00 and the previous sample (P45) a thin coal lying between the Brockwell and the 2R00.	
* P56		Floor	0.09
* P112		Seatearth	0.02
+ P113		1R00 from above previous 1R00	0.23
* P109		Roof	0.04
+ P118	R000	Threequarter	0.32
* P57		Roof-fragmental clay rock	0.08
* P115		Floor	
+ P114	Q101	Bottom Busty B.L.	0.43
* P42	Q102	Bottom Busty M.L.	0.12
+ P120	Q103	Bottom Busty T.L.	0.42
+ P116	Q200	Top Busty	0.81
* P58		Dark grey mudstone, immediately above coal	0.09
* P59		Roof measures with bivalves	
+ P117	Q200	Top Busty	0.83
* P39		Roof measures	

\+ Productive samples
* Unproductive samples
‡ Outcrop at Whiteside Bank, adjacent and north of St. Andrew's Site
P Maceration numbers

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PLATES

All photographs x 500 unless otherwise stated.

R. - Reverse slide.

PLATE 1

Fig. 1 Chaetosphaerites pollenisimilis (Horst) Butterworth and Williams; M13/7, 67.0/21.3
Fig. 2 C. pollenisimilis; M13/6, 67.3/8.0
Fig. 3 C. pollenisimilis; M13/6, 69.6/28.7
Fig. 4 Sporonites unionus (Horst) Dybova and Jachowicz; M22/1, 75.5/10.6
Fig. 5 Leiotriletes inermis (Waltz) Ishchenko; M15/4, 70/20.0
Fig. 6 L. inermis; M13/1, -/-
Fig. 7 L. pyradmidatus Sullivan; M20/3, 77.3/18.9
Fig. 8 L. guennelii (Guennel) Ravn; 137/6, 72.8/26.1
Fig. 9 L. guennelii; 137/7, 68.5/16.6
Fig. 10 Leiotriletes spA; M20/3, (R.) 72/7.8
Fig. 11 L. spA; M20/6, 78.1/17.9
Fig. 12 L. inermis (Waltz) Ishchenko; M20/2, 79.0/11.6
Fig. 13 L. pyramidatus Sullivan; M20/3, (R.) 68.3/6.2
Fig. 14 L. ornatus Ishchenko; M22/1, 78.4/7.3
Fig. 15 L. ornatus Ishchenko; 796/6, 65.6/16.8
Fig. 16 L. sphaerotriangulus (Loose) Potonie and Kremp; 137/1, 67.7/25.3
Fig. 17 L. tumidus Butterworth and Williams; M13/4, 58.1/16.5
Fig. 18 L. levis (Kosanke) Potonie and Kremp; 796/9, 75.5/20
Fig. 19 As Fig. 18 x 1000
Fig. 21 L. tumidus Butterworth and Williams; M13/4, 66.4/10
Fig. 22/ L. cf. priddyi (Berry) Potonie and Kremp; C5/28, 77.5/19
23 Fig. 23 - x 1000
Fig. 20/ Adelisporites multiplicatus Ravn; M20/5, 72.8/19.3;
24 Fig. 24 - x 1000
Fig. 25 A. multiplicatus; M20/2, 67.2/14.8
Fig. 26 A. multiplicatus; M20/8, 71.3/24.1
Fig. 27 Leiotriletes spC; M22/1, 73.9/24.8
Fig. 28 L. spC; M13/1, 58.6/11.6
Fig. 29 Leiotriletes spB; 137/1, 61.1/7.8
Fig. 30 L. spB; 137/1, 71.5/2.2
Fig. 31 L. spB; C5/4, 74.5/19.1
Fig. 32 L. spB; 1/1, 60/10.7
Fig. 33 L. spB; C5/24, 78.8/16.3
Fig. 34 Punctatisporites aerarius Butterworth and Williams; M13/4 69.7/25.8
Fig. 35 P. nitidus Hoffmeister, Staplin and Malloy; M13/6, 70/7/20.3
Fig. 36 P. punctatus Ibrahim; C5/10, 79.5/16.5
Fig. 37 P. punctatus; C5/14, 76.6/21.7

PLATE 1

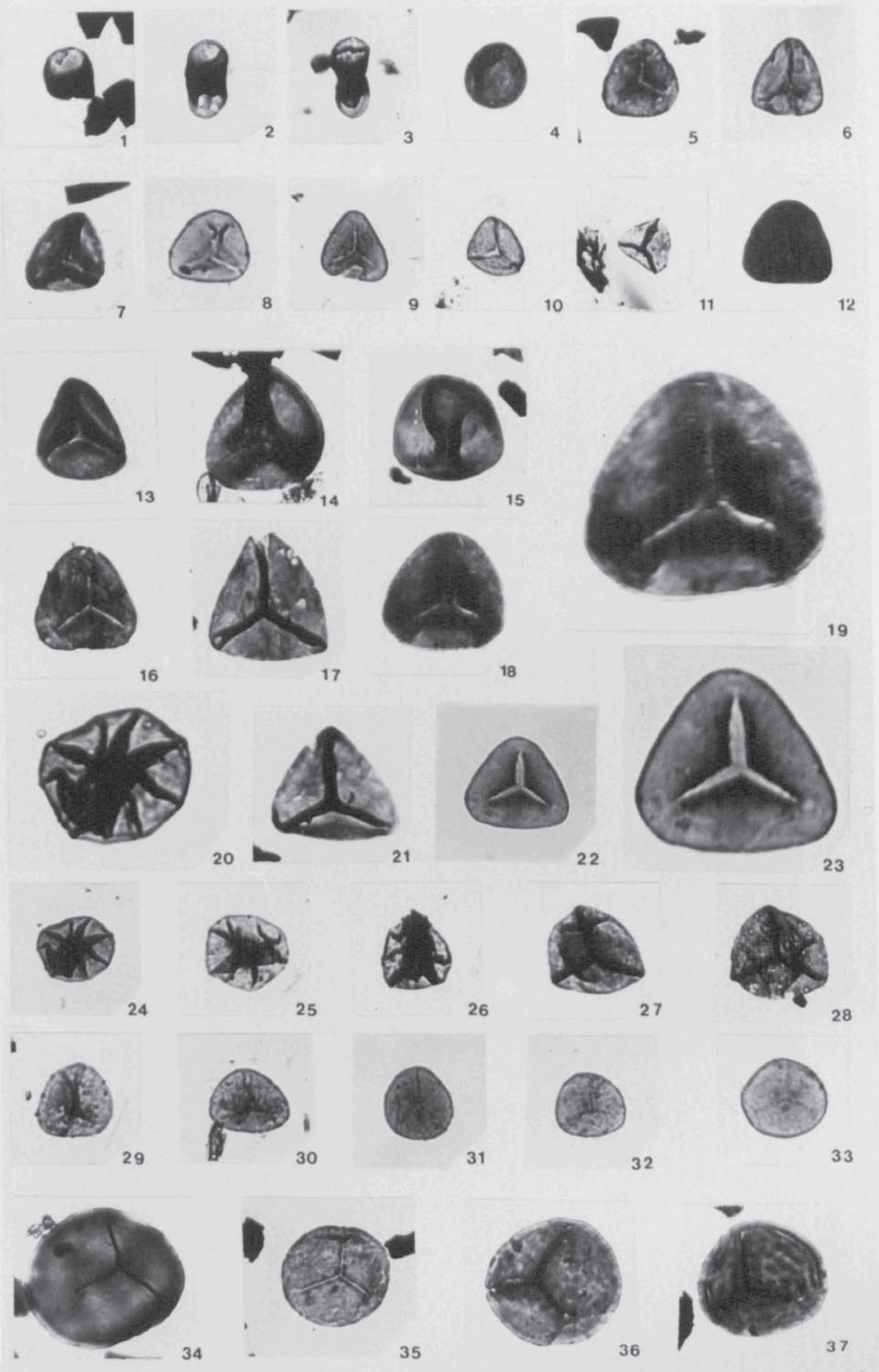
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PLATE 2

Fig. 1 *Punctatisporites nudus* Artüz; C5/6, 68.8/1.7

Fig. 2 *P. nudus*; 8/1, 62.6/1.7

Fig. 3 *P. sabulosus* (Ibrahim) Comb. Nov.; 797/6, 71.4/16.6

Fig. 4/6 *P. sabulosus* (Ibrahim) Comb. Nov.; C5/24, 73.4/12.2; Fig. 6 - x 1000

Fig. 5 *P. sinuatus* (Artüz) Neves; C4/6, 65.5/14.2

Fig. 7 *P. sinuatus*; C5/8, 81.7/6.2

Fig. 8 *P. sinuatus*; C5/13, 67.5/10.6

Fig. 9 *P. giganteus* Neves; M13/3, 70.4/1.4

Fig. 10 *Calamospora microrugosa* (Ibrahim) Schopf, Wilson and Bentall; 797/2, 73.4/18.4

PLATE 2


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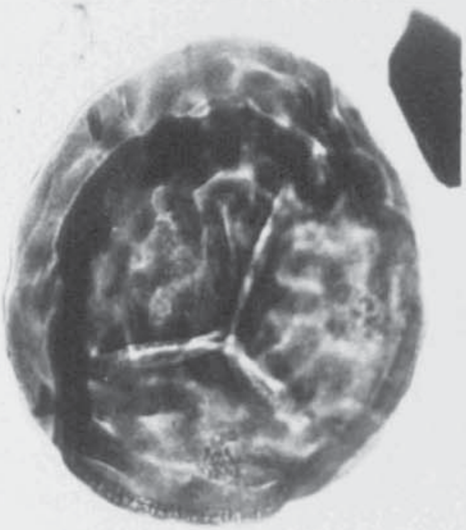
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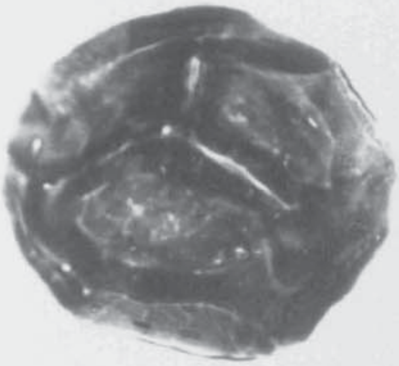
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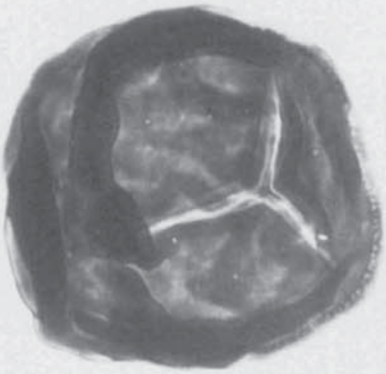
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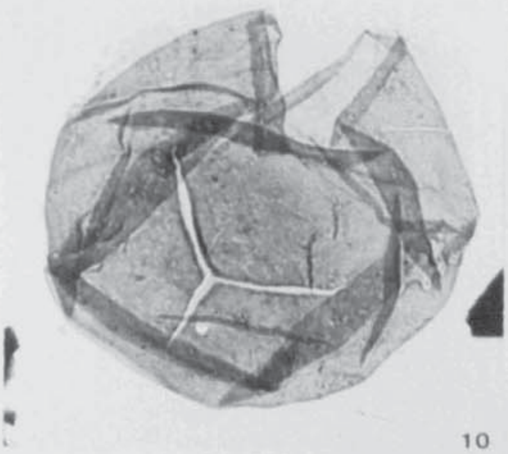
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PLATE 3

Fig. 1 *Calamospora microrugosa* (Ibrahim) Schopf, Wilson, and Bentall; 799/2, 58.2/5.6

Fig. 2 *C. liquida* Kosanke; 797/8, 67.7/10.5

Fig. 3 *C. liquida*; C5/16, 68.7/16.3

Fig. 4 *C. breviradiata* Kosanke; 797/8, 78.9/2.7

Fig. 5 *C. liquida* Kosanka; C5/22, 83.4/15

Fig. 6 *C. liquida*; 76/5, 65.3/16.6

Fig. 7 *C. breviradiata* Kosanke; 796/5, 65.5/12

Fig. 8 *C. breviradiata*: 797/2, (R.) 76.2/2.3

Fig. 9 *C. breviradiata*; 797/2, (R.) 75.5/7.2

Fig. 10 *C. breviradiata*; C5/8, 70/7.0

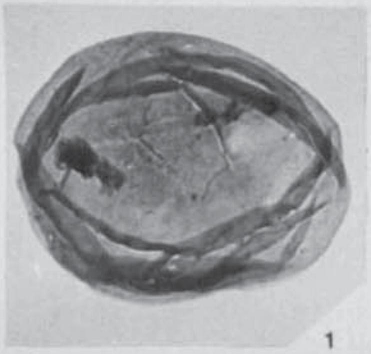
Fig. 11 *C. pallida* (Loose) Schopf, Wilson, and Bentall; C5/15 79.6/8.7

Fig. 12 *C. pallida*; H.541/1, 71.2/6.2

Fig. 13 *C. pallida*; SEM. Preparation 797.

Fig. 14 *C. perrugosa* (Loose) Schopf, Wilson, and Bentall; 796/9, 66.9/21

PLATE 3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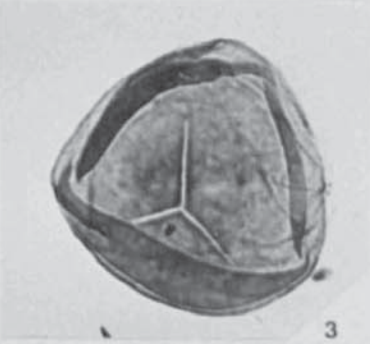
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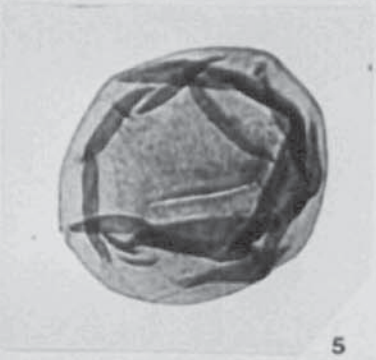
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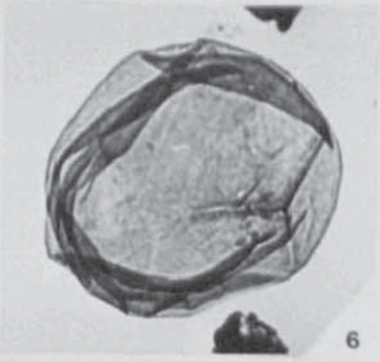
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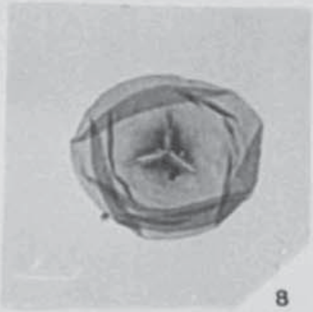
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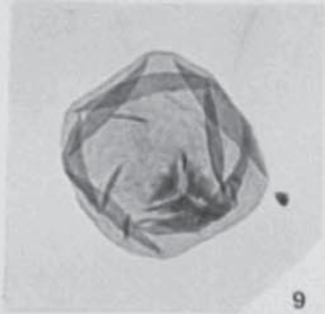
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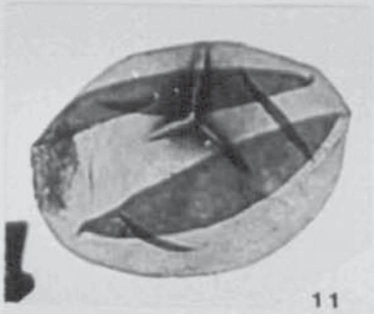
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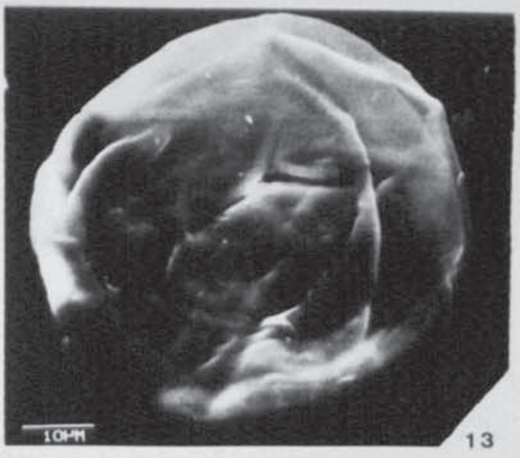

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PLATE 4

Fig. 1 *Calamospora spA*; M22/1, 56.8/24.8

Fig. 2 *C. spA*; M22/1, 59.1/25

Fig. 3 *C. spA*; M20/2, 61.7/28.7

Fig. 4 *C. spA*; M20/2, 69.5/9.1

Fig. 5 *C. spA*; M20/2, 73.7/9.5

Fig. 6 *C. straminea* Wilson and Kosanke; C5/29, 81.4/14.5

Fig. 7 *C. straminea*; 797/1, 65.2/21.8

Fig. 8 *C. parva* Guennel; 797/2, 70.2/5.9

Fig. 9 *C. pedata* Kosanke; C2/1, 70.7/11.8

Fig. 10 *C. cf. pedata* Kosanke in Ravn; 799/1, (R.) 58.2/12.7

Fig. 11 *C. cf. pedata*; 797/4, 73.1/20.9

Fig. 12 *Calamospora spB*; M22/2, 73.6/0.3

Fig. 13 *Granulatisporites minutus* Potonie and Kremp; 1/1, 59.3/8.1

Fig. 14 *G. minutus*; C4/1, 70.2/12.2

Fig. 15 *G. minutus*; C4/1, 70.1/12.2

Fig. 16 *Calamospora spB*; M22/2, 74.5/2.3

Fig. 17 *Granulatisporites minutus* Potonie and Kremp; 799/1, 75.8/9.9

Fig. 18 *G. micrognanifer* Ibrahim; 136/6, 68.5/18.1

Fig. 19 *G. micrognanifer* 136/6, 644./11.8

Fig. 20 *G. parvus* (Ibrahim) Potonie and Kremp; M20/7, 65.1/14.1

Fig. 21 *G. micrognanifer* Ibrahim; M22/4, 70/13.3

Fig. 22 *G. micrognanifer*; M22/1, 67.1/17.8

Fig. 23 *G. micrognanifer*; M22/1, 68.3/22.5

Fig. 24 *G. parvus* (Ibrahim) Potonie and Kremp; M20/4, 80.9/2.8

Fig. 25 *G. granulatus* Ibrahim; 797/1, 71.3/15.1

Fig. 26 *G. granulatus*; 796/6, 71.7/21.1

Fig. 27 *G. granulatus*; M20/6, 78.4/13.1

Fig. 28 *G. granulatus*; M22/4, -/1

PLATE 4


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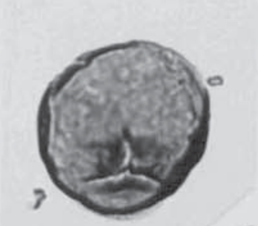
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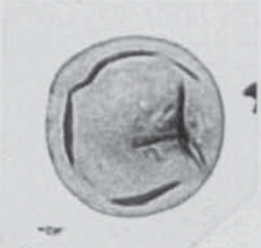
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PLATE 5

Fig. 1	Granulatisporites piroformis Loose; M22/3, -/-
Fig. 2	G. piroformis; M22/3, 70.7/15
Fig. 3	G. piroformis; M20/6, 76.1/5.8
Fig. 4	Converrucosisporites armatus (Dybova and Jachowicz) Smith and Butterworth; 796/10, 64.3/23.9
Fig. 5	C. armatus; 796/9, 69.5/27.2
Fig. 6	C. armatus; 796/12, 64.3/24.6
Fig. 7	Calamospora cf. laevigata (Ibrahim) Schopf, Wilson and Bentall; 4/1, 64.3/10.3
Fig. 8	Converrucosisporites armatus (Dybova and Jachowicz) Smith and Butt.; C5/15, 81.3/29.4
Fig. 9	Cyclogranisporites aureolus Artüz; M20/6; 77.5/18
Fig. 10	C. aureolus; M20/5, 64.9/4.2
Fig. 11	Granulatisporites spA; C2/1, 71.3/6.7
Fig. 12	Cyclogranisporites aureus (Loose) Potonie and Kremp; 797/8 -/-
Fig. 13	C. aureus; P8/2, 72.6/16.8
Fig. 14	C. aureus; 796/9, 65.5/25.5
Fig. 15	C. cf. minutus Bhardwaj in Smith and Butterworth; C5/7, -/-
Fig. 16	C. cf. minutus; C5/16, (R.) 78.8/4.2
Fig. 17	C. cf. minutus; C5/14, (R.) 70.7/7.1
Fig. 18	C. cf. minutus; C5/12, 66.2/25.4
Fig. 19	C. cf. minutus; C5/7, -/-
Fig. 20	C. multigranus Smith and Butterworth; 796/10, -/1
Fig. 21	C. multigranus; P76/2, 72.3/23.2
Fig. 22	C. multigranus; 796/7, 62.3/18.7

PLATE 5


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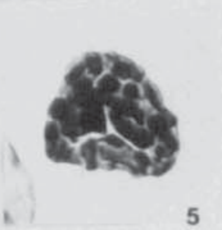
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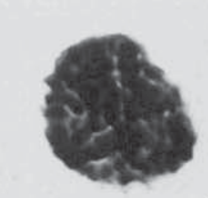
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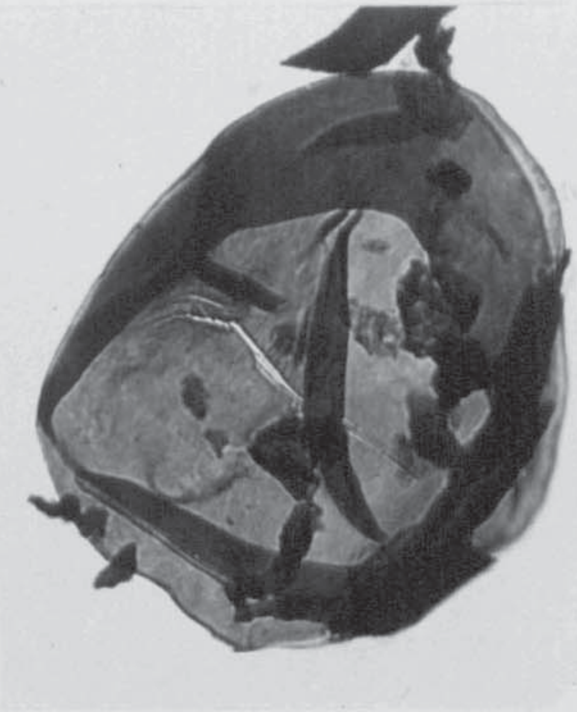
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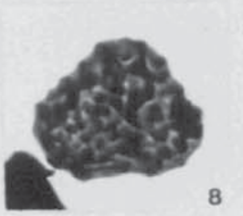
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PLATE 6

Fig. 1 *Verrucosisporites donarii* Potonie and Kremp; C5/18, 81.1/15.7

Fig. 2 *V. donarii*; P76/2, 73.7/5.1

Fig. 3 *V. verrucosus* (Ibrahim) Ibrahim; 796/9, 70.2/21.1

Fig. 4 *V. verrucosus*; 796/9, 59.6/29.6

Fig. 5 *V. verrucosus*; C5/14, (R.) 74.1/4.6

Fig. 6 *V. microtuberosus* (Loose) Smith and Butterworth; C5/6,

Fig. 7 *V. sifati* (Ibrahim) Smith and Butterworth; C5/9, 74.5/10.6

Fig. 8 *Verrucosisporites spA*; C4/6, 81.4/20.4

Fig. 9 *V. spA*; C5/18, 78.3/19.3

Fig. 10 *V. spA*; C4/4, 69.5/24.8

Fig. 11 *V. spA*; C4/4, (R.) 84.2/8.4

Fig. 12 *Acanthotriletes castanea*; Butterworth and Williams; M22/1 67.4/13.8

Fig. 13 *A. castanea*; M22/2, -/-

Fig. 14 *A. echinatoides* Artüz; C5/26, 76.7/22.4

Fig. 15 *A. echinatoides*; C4/4, 77.6/19.2

Fig. 16 *A. echinatus* (Knox) Potonie and Kremp, 138/1, -/-

Fig. 17 *A. castanea* Butterworth and Williams; M22/1, 73.4/18.2

Fig. 18 *A. castanea*, M22/3, 73.3/27.1

PLATE 6


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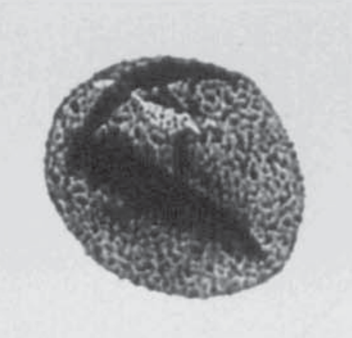
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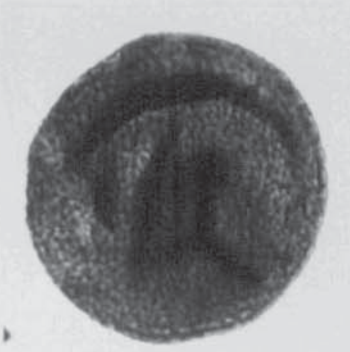
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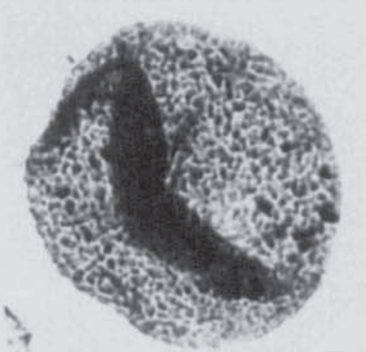
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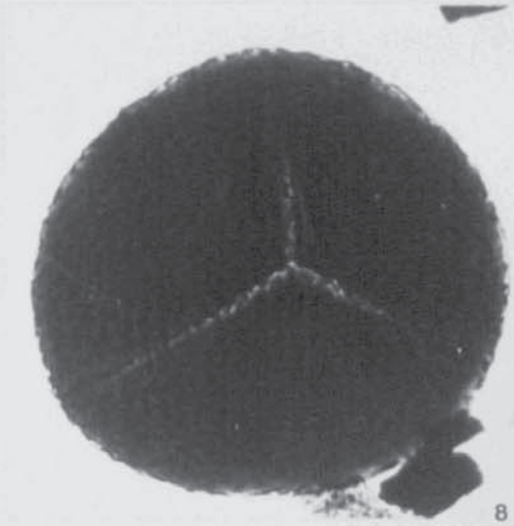
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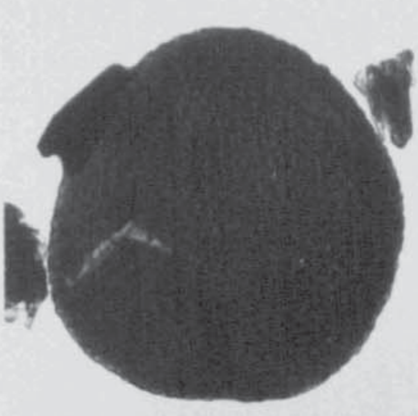
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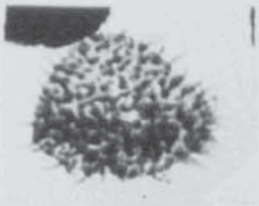
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PLATE 7

Fig. 1	*Verrucosisporites spA*; C5/17, (R.) 80/6.1
Fig. 2	*Acanthotriletes microspinosus* Potonie and Kremp; M22/1, 65.8/26.1
Fig. 3	*A. microspinosus*; M22/1, 68/26.8
Fig. 4	*A. microspinosus*; M22/2, -/-
Fig. 5	*Anapiculatisporites minor* (Butterworth and Williams) Smith and Butterworth; 137/6, 73.3/5.8
Fig. 6	*A. minor*; C5/23, 68.4/26.7
Fig. 7	*A. minor*; C5/25, 69.7/15.7
Fig. 8	*A. hispidus* Butterworth and Williams; M13/2, 61.5/12.8
Fig. 9	*A. hispidus*; M13/4, 59.6/15.7
Fig. 10	*Acanthotriletes triquetrus* Smith and Butt.; H541/2, 65.3/8.1
Fig. 11	*A. triquetrus*; 797/4, 72.2/12.5
Fig. 12	*Apiculatisporis aculeatus* (Ibrahim) Smith and Butterworth; 137/3, 72/11.5
Fig. 13	*A. aculeatus*; C5/14, 78.8/9.3
Fig. 14	*A. aculeatus*; 137/6, 64.4/5.6
Fig. 15	*A. irregularis* (Alpern) Smith and Butterworth; C2/11, 64.1/22.6
Fig. 16	*A. irregularis*; 137/6, 57.8/16.8
Fig. 17	*A. irregularis*; C2/1, 72.4/11.3
Fig. 18	*A. irregularis*; C2/9, 70.3/13.2
Fig. 19	*A. irregularis*; Tetrad, H541/3
Fig. 20	*A. irregularis*; Tetrad, H541/2, 71.8/18.2
Fig. 21	*A. spinososaetosus* (Loose) Smith and Butterworth; 138/1, -/-
Fig. 22	*A. variocorneus* Sullivan; 234/1, 70.8/9.7
Fig. 23	*A. variocorneus*; M22/3, 68.5/25.7
Fig. 24	*A. spinulistratus* (Loose) Ibrahim; 4/1, 59.7/5.8
Fig. 25	*A. spinulistratus*; 799/2, 65.1/2.0
Fig. 26	*A. spinulistratus*; 796/9, 74.2/31.1

PLATE 7


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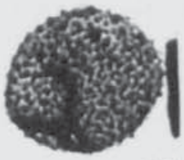
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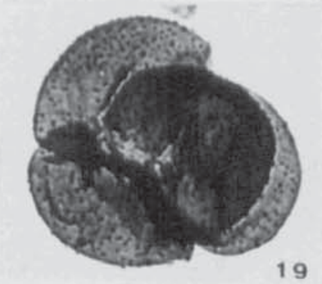
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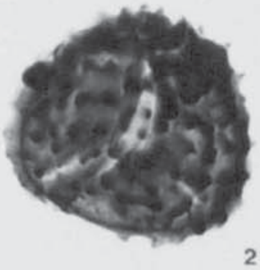
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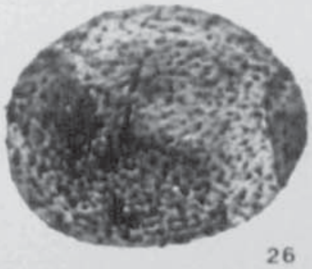
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PLATE 8

Fig. 1	*Apiculatisporis* cf. *latigranifer* (Loose) Potonie and Kremp; M1/3, 68.8/12.2
Fig. 2	*Planisporites granifer* (Ibrahim) Knox; 661/3, 60/26.1
Fig. 3	*Lophotriletes insignitus* (Ibrahim) Potonie and Kremp; 797/1, 65.6/24.8
Fig. 4	*L. insignitus*; P8/2, 62.7/25.1
Fig. 5	*Apiculatisporis abditus* (Loose) Potonie and Kremp; 137/2, -/-
Fig. 6	*Lophotriletes* cf. *gibbosus* (Ibrahim) Potonie and Kremp; 797/5, 66.5/1.4
Fig. 7	*L.* cf. *gibbosus*; 797/1, (R.) 62.1/5.1
Fig. 8	*L. commissuralis* (Kosanke) Potonie and Kremp; P76/2, 60.9/23.3
Fig. 9	*L. commissuralis*; 138/3, 71.1/22.9
Fig. 10	*L. commissuralis*; 137/2, 82.1/1.5
Fig. 11	*L. commissuralis*; 138/5, 62.3/12.7
Fig. 12	*L. densus* Love; M18/2, 73.4/23.1
Fig. 13	*L. granoornatus* Artüz; C5/6, 80.1/19.2
Fig. 14	*L. granoornatus*; C5/5, 75.3/7.3
Fig. 15	*L. microsaetosus* (Loose) Potonie and Kremp; C5/23, 73.3/23.1
Fig. 16	*L. microsaetosus*; P81/2, -/-
Fig. 17	*L. microsaetosus*; 234/2, 74.5/13.2
Fig. 18	*L. microsaetosus*; H541/1, 64.2/1.2
Fig. 19	*L. tuberculatus* (Hoffmeister, Staplin and Malloy) Sullivan; 797/6, 67.6/24.4
Fig. 20	*L. tuberculatus*; M5/1, 64/18.1
Fig. 21	*L. tuberculatus*; M13/3, 68.2/9.8
Fig. 22	*L. tuberculatus*; M13/7, 65.8/10.9
Fig. 23	*L. labiatus* Sullivan; 797/3, 67.4/23.3
Fig. 24	*Waltzispora polita* (Hoffmeister, Staplin and Malloy) Smith and Butterworth; M20/9, 84.2/4.9
Fig. 25	*W. polita*; P8/1, 62.5/18.2
Fig. 26	*W. planiangulata* Sullivan; M13/3, 60.1/1.0
Fig. 27	*W. planiangulata*; M13/4, 58.2/18.7
Fig. 28	*W. planiangulata*; M20/5, 69.9/29.6
Fig. 29	*Tricidarisporites balteolus* Sullivan and Marshall; M13/4, (R.) 57.4/5.2
Fig. 30	*T. balteolus* Sullivan and Marshall; M13/6, 70.7/20.3
Fig. 31	*T. balteolus*; M13/4, 74.1/27.3
Fig. 32	*T. balteolus*; M15/3, 64.4/18.4

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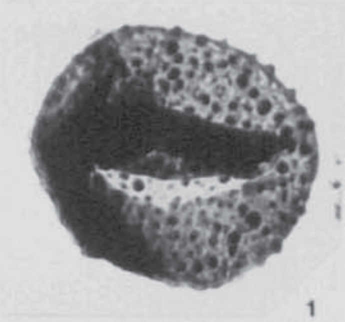
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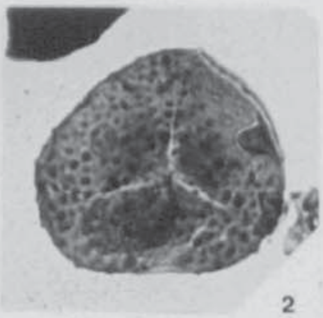
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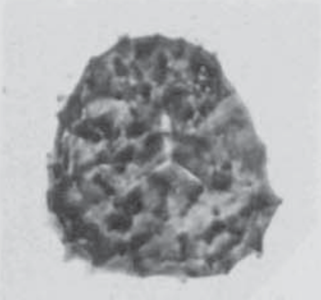
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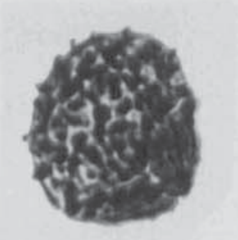
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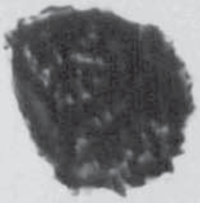
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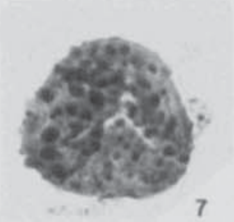
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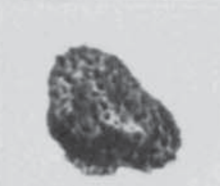
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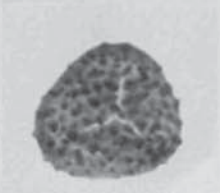
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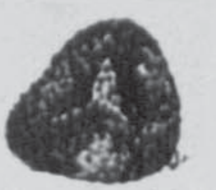
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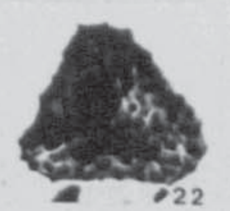
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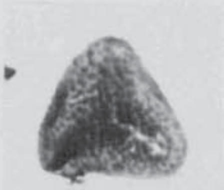
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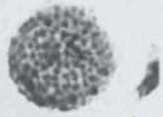
PLATE 9

Fig. 1	*Anaplanisporites baccatus* (Hoffmeister, Staplin and Malloy) Smith and Butterworth; C5/21, 71.5/23.3
Fig. 2	*A. baccatus*; 797/1, 58.5/10.9
Fig. 3	*A. baccatus*; Tetrad, 797/1, 61.5/11.1
Fig. 4	*Raistrickia digitosa* Artüz,; SEM. Preparation C5.
Fig. 5	*R. digitosa*; 661/4, 65.6/24.1
Fig. 6	*R. digitosa*; C5/20, 75.7/23.2
Fig. 7	*R. fulva* Artüz; C2/4, 74.5/25
Fig. 8	*R. fulva*; 235/1, 75.7/2.7
Fig. 9	*R. fulva*; 661/1, 60.6/26.3
Fig. 10	*R. fulva*; 138/1, -/-
Fig. 11	*R. saetosa* (Loose) Schopf, Wilson and Bentall; C2/9, 70/3/13.2
Fig. 12	*R. saetosa*; C5/15, 79.4/2.6
Fig. 13	*R. saetosa*; C5/5, 74.1/8.3
Fig. 14	*R. microhorida* (Horst) Potonie and Kremp; 796/4, 62.5/19.8
Fig. 15	*R. microhorida*; 796/4, 58.6/-
Fig. 16	*R. microhorida*; C5/6, 84.6/4
Fig. 17	*R. cf. superba* (Ibrahim) Schopf, Wilson and Bentall; 136/2 71.3/0.9
Fig. 18	*Microreticulatisporites lunatus* Knox; C2/5, 67.8/3.8
Fig. 19	*M. nobilis* (Wicher) Knox; C5/7, -/-
Fig. 20	*M. nobilis*; 362/1, 75.8, 22.6

PLATE 9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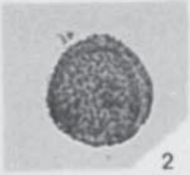
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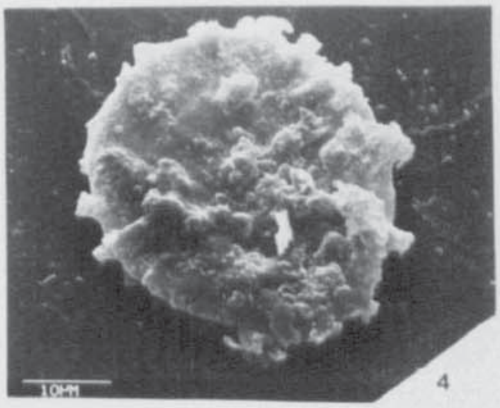

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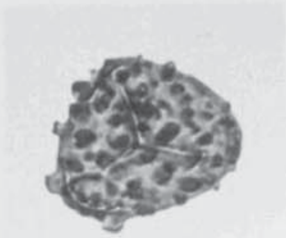
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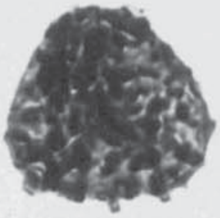
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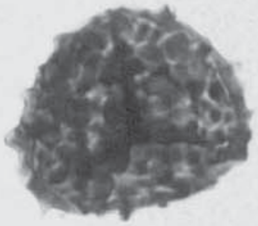
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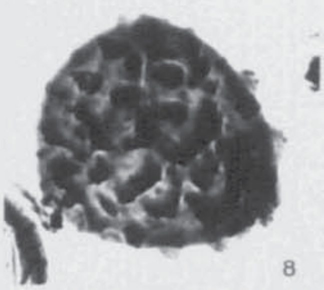
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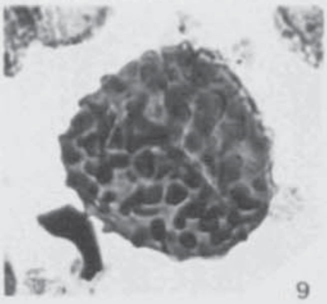
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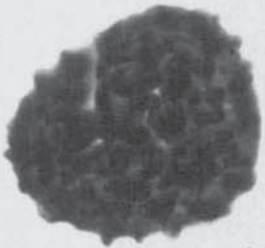
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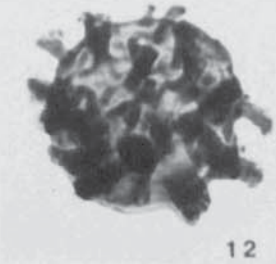
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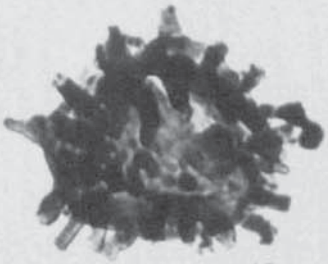
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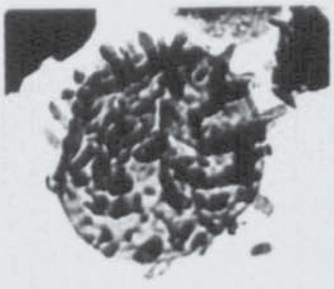
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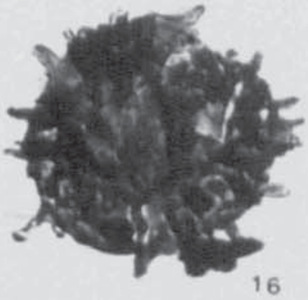
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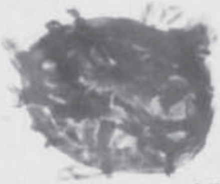
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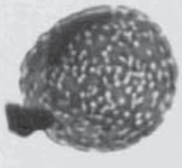
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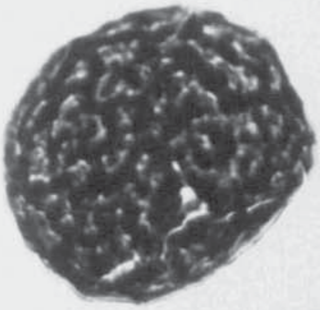
PLATE 10

Fig. 1	*Camptotriletes superbus* Neves; C4/6, 81.3/26.8
Fig. 2	*C. superbus*; 138/2, 74.1/2.3
Fig. 3	*C. bucculentus* (Loose) Potonie and Kremp; C2/9, 73.1/28
Fig. 4	*C. bucculentus*; C2/6, 73.7/2.8
Fig. 5	*Convolutispora florida* Hoffmeister, Staplin and Malloy; M22/3, 79.2/14.8
Fig. 6	*C. venusta* Hoffmeister, Staplin and Malloy; M20/2, 79/26.2.
Fig. 7	*C. venusta*; M20/8, 68.6/23.3
Fig. 8	*C. venusta*; M20/7, 81.5/28.3
Fig. 9	*C. venusta*; M20/4, 70.5/28.9
Fig. 10	*C. laminosa* Neves; M20/2, 81.1/25.1
Fig. 11	*C. laminosa*; 138/4, -/-
Fig. 12	*C. varicosa* Butterworth and Williams; M22/4, 74/15.1
Fig. 13	*C. tessellata* Hoffmeister, Staplin and Malloy; M20/6, 83.2/18.8
Fig. 14	*C. tessellata*; M22/1, 74.5/8.2
Fig. 15	*C. varicosa* Butterworth and Williams; M22/2, 69.6/37.1
Fig. 16	*C. mellita* Hoffmeister, Staplin and Malloy; M20/3, 68.2/5.4
Fig. 17	*Dictyotriletes falsus* Potonie and Kremp; C4/5, 83/12.7
Fig. 18	*D. falsus*; C5/13, -/-
Fig. 19	*D. falsus*; C2/1, 70.4/21.7
Fig. 20	*D. falsus*; C2/4, 82.4/18.5
Fig. 21	*D. vitilis* Sullivan and Marshall, M13/4, 58.2/20.1

PLATE 10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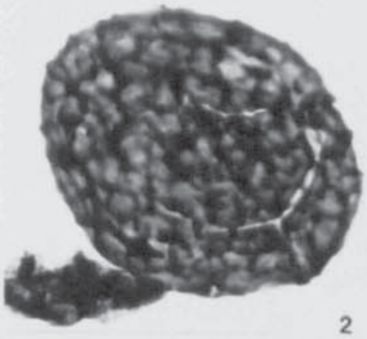
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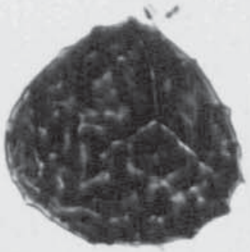
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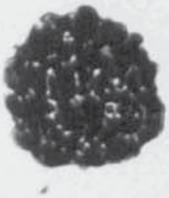
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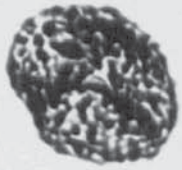
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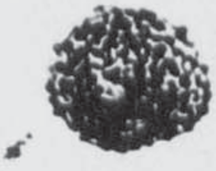
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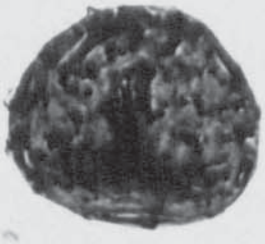
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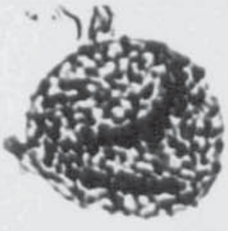
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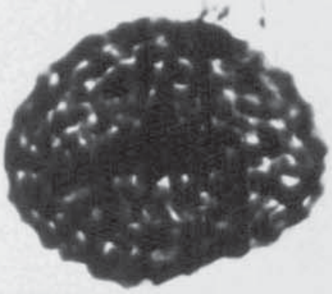
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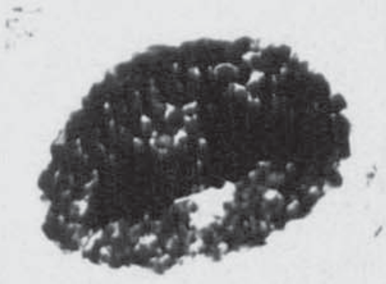
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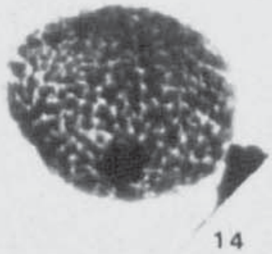
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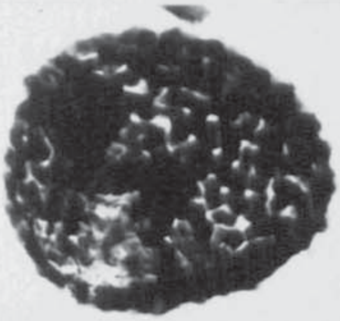
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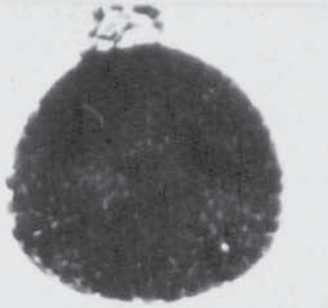
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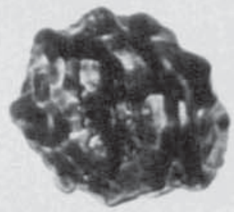
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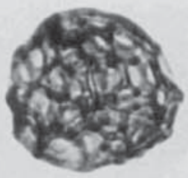
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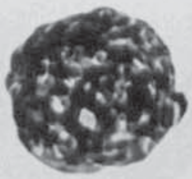
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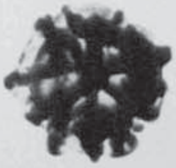
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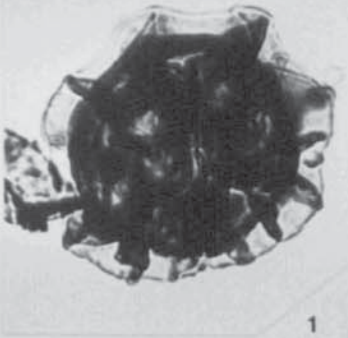
PLATE 11

Fig. 1 *Dictyotriletes muricatus* (Kosanke) Smith and Butterworth; C2/10, 78.9/10.7
Fig. 2 *D. muricatus*; C2/1, 83.7/7.1
Fig. 3 *D. muricatus*; C5/15, 82.8/17.7
Fig. 4 *D. muricatus*; C5/12, 81.2/21.2
Fig. 5 *D. muricatus*; C2/7, 77/16.8
Fig. 6 *D. karadenizensis* (Artuz) Owens MS; 138/6, -/-
Fig. 7 *D. cf. bireticulatus* (Ibrahim) Smith and Butterworth; P22/5, 65.3/6.4
Fig. 8/9 *D. cf. bireticulatus*; 661/4, 73.7/10.6
Fig. 10 *D. cf. peltatus* Owens MS; M13/5, 81.8/8.7
Fig. 11 *D. bireticulatus* (Ibrahim) Smith and Butterworth; C5/21, -/-
Fig. 12 *D. bireticulatus*; C5/17, (R.) 80.5/8
Fig. 13 *D. bireticulatus*; C5/8, 78.8/13.3
Fig. 14 *D. bireticulatus*; C5/7, 66.3/18
Fig. 15 *D. bireticulatus*; C5/9, 72.3/21.3
Fig. 16 *D. bireticulatus*; C5/14, (R.) 70.3/7.3
Fig. 17 *D. insculptus* Sullivan and Marshall; C5/6, 76.8/11.5
Fig. 18 *D. insculptus*; C5/8, 70.3/25.4
Fig. 19 *D. insculptus*; M1/1, 68.3/4.4
Fig. 20 *D. insculptus*; C5/5, 74/7.8
Fig. 21 *Tripartites trilinguis* (Horst) Smith and Butterworth; M13/4, 63.2/25
Fig. 22 *T. trilinguis*; M13/2, (R.) 61.5/3.4
Fig. 23 *T. trilinguis*; M13/6, 62.8/14
Fig. 24 *T. vetustus* Schemel; M13/4, 66/17.6
Fig. 25 *T. nonguerickei* Potonie and Kremp; M13/7, 65.7/14.7

PLATE 11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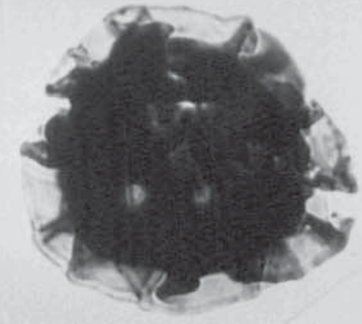
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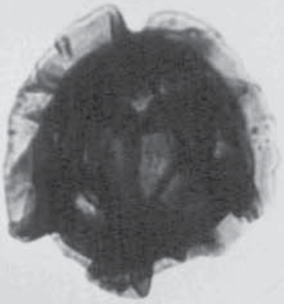
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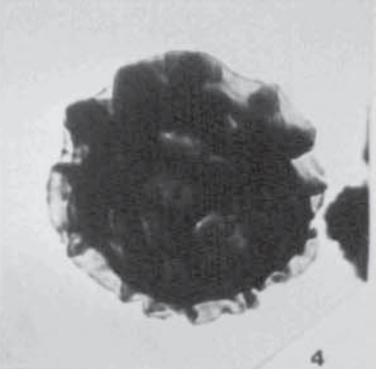
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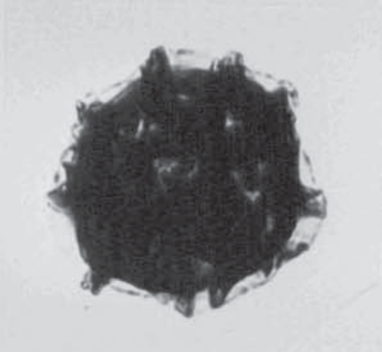
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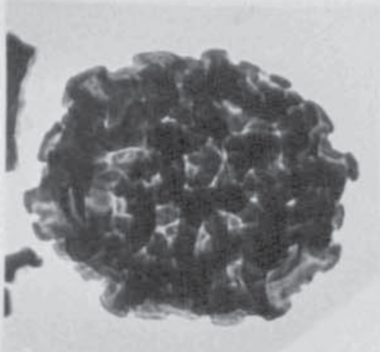
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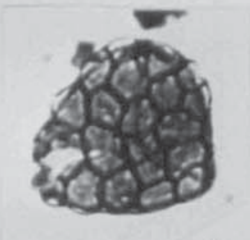
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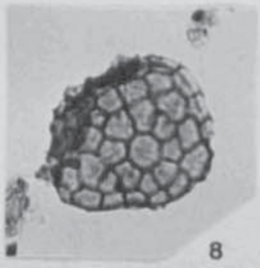
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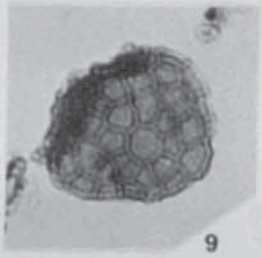
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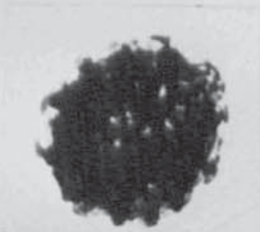
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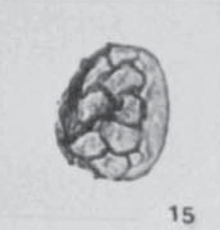
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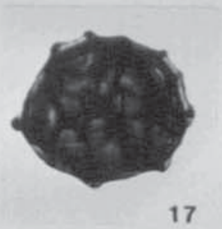
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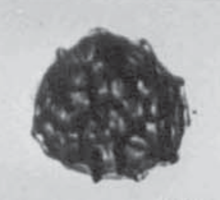
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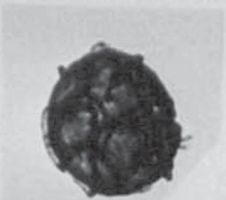
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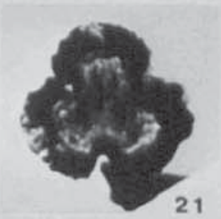
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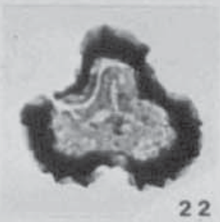
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PLATE 12

Fig. 1. *Dictyotriletes* *spA*.; M2/3, -/-.

Fig. 2. *D*. *spA*.; M2/1, -/-.

Fig. 3. *D*. *spA*.; M2/1, 63.4/26.3

Fig. 4/5. *D*. *spA*.; M2/2, 70.9/20.8, Fig. 5 - proximal surface.

Fig. 6. *D*. *spA*.; M2/4, 66.1/7.3.

Fig. 7/8. *D*. *spA*.; M2/2, 63.7/23, Fig. 8 - proximal surface.

Fig. 9. *D*. *spA*.; M2/1, 73.7/17.6; Tetrad.

Fig. 10. *D*. *spA*.; SEM. Preparation M2.

Fig. 11. *D*. *spA*.; SEM. Preparation M2.

PLATE 12


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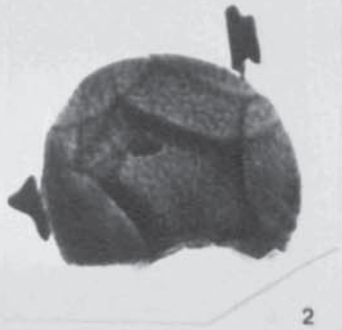
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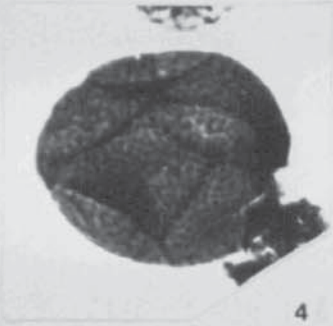
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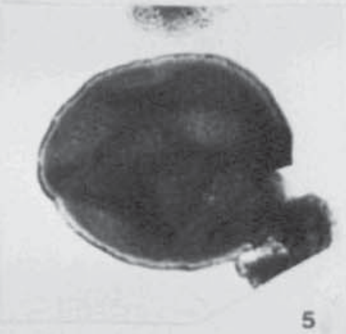
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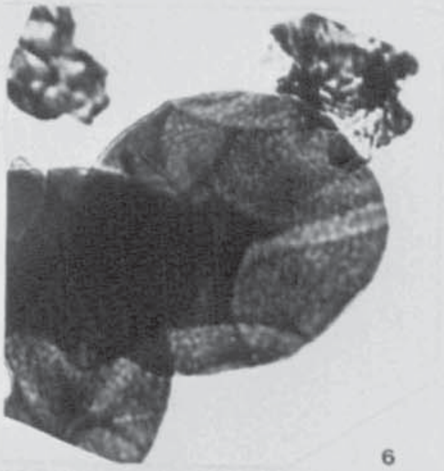
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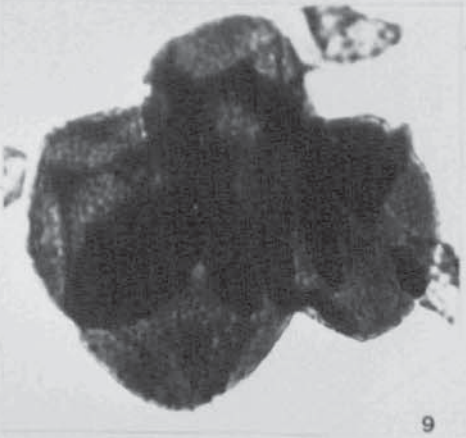
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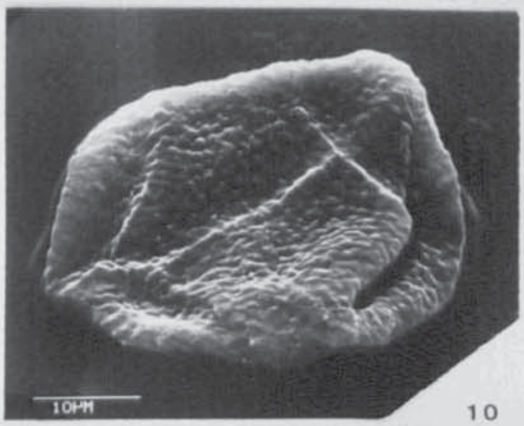

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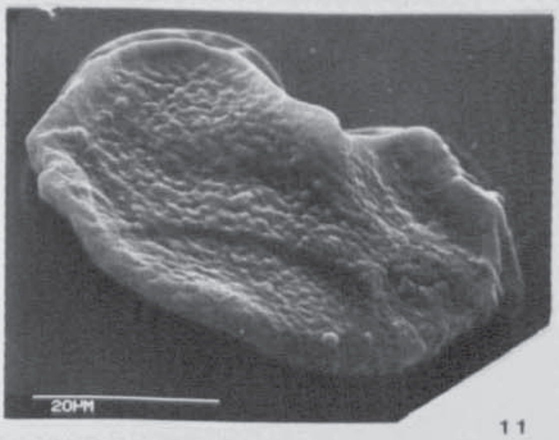

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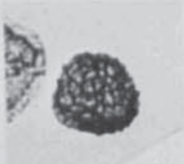
PLATE 13

Fig. 1.	*Dictyotriletes castaneaeformis* (Horst) Sullivan; M5/1, 62/19.2.
Fig. 2.	*D. castaneaeformis*; M20/6, 78.5/4.9.
Fig. 3.	*Tantillus triquetrus* Felix and Burbridge; M20/9, 78.7/2.1.
Fig. 4.	*T. triquetrus*; M22/2, -/-.
Fig. 5/6	*T. triquetrus*; M22/1, 74.6/11; Fig. 6 - X 1000
Fig. 7	*Ahrensisporites guerickei* (Horst) Potonie and Kremp; P8/1, (R.) 59.8/2.1.
Fig. 8.	*A. guerickei* (Horst) Potonie and Kremp; 138/4, -/-.
Fig. 9.	*A. guerickei*; C5/24, 79/0.3.
Fig. 10/11	*A. guerickei*; C5/23, 76/27.7; Fig. 11 - X 1000
Fig. 12.	*A. guerickei*; C5/23, (R.) 77.5/5.3.
Fig. 13.	*Triquitrites sinani* Artüz; 661/1, 62.1/16.
Fig. 14.	*T. tribullatus* (Ibrahim) Schopf, Wilson and Bentall; P80/1, -/-.
Fig. 15.	*T. protensus* Kosanke; 136/4, 67.3/21.1.
Fig. 16	*Mooreisporites spA*. 661/2, 66.6/16.2.
Fig. 17.	*M. spA.*; 661/1, 72.7/8.2.
Fig. 18.	*M. spA.*; M1/3, 63.4/9.2.
Fig. 19.	*M. spA.*; M1/1, -/-.
Fig. 20.	*Reinschospora triangularis* Kosanke; C4/4, 78.8/26.6.
Fig. 21.	*R. triangularis*; M22/1, 57.2/7.4
Fig. 22.	*R. triangularis*; M22/1, 71.6/19.8.
Fig. 23.	*R. triangularis*; M22/4, 69.8/13.5.
Fig. 24.	*Secarisporites lobatus* Neves; 138/3, 72.1/21.2.
Fig. 25.	*S. lobatus*; 796/6, 67.1/21.6.
Fig. 26.	*S. lobatus*; 137/6, 68.3/13.4.

PLATE 13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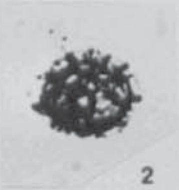
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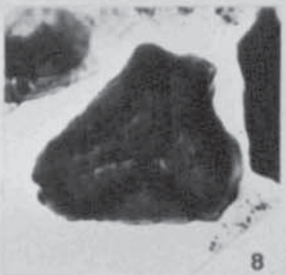
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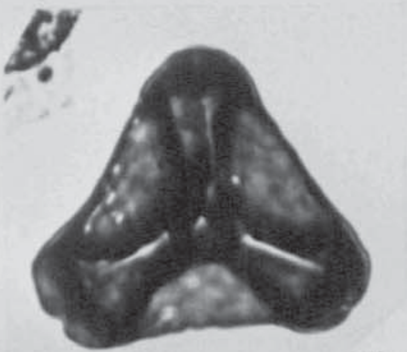
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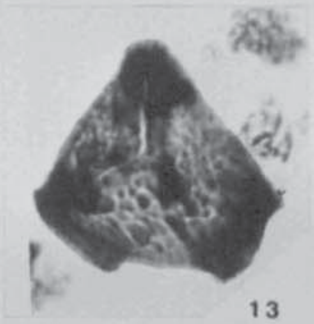
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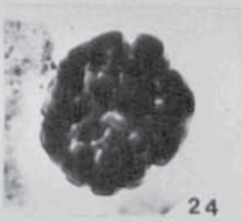
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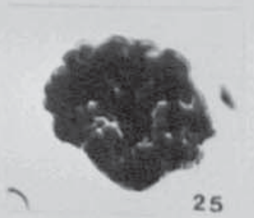
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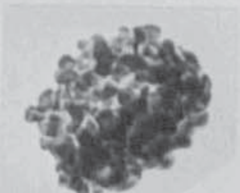
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PLATE 14

Fig. 1, 2.	Reinschospora speciosa (Loose) Schopf, Wilson and Bentall; C5/21, 69.8/20.5; Fig. 2 - X 1000
Fig. 3.	R. speciosa; C5/16, 72.8/25.4.
Fig. 4.	Savitrisporites nux (Butterworth and Williams) Smith and Butterworth; 362/2, 81.3/0.6.
Fig. 5.	S. nux; M22/1, 66.//10.6.
Fig. 6, 7.	S. nux; M22/1, 62.7/20.2.
Fig. 8.	Savitrisporites spA.: M22/1, 62.6/1.4.
Fig. 9.	S. spA.; M22/1, 65.3/15.5.
Fig. 10.	S. spA.; M22/3, 83.5/22.
Fig. 11.	S. spA.; M22/1, 71.7/20.1.
Fig. 12.	S. spA.; M22/1, 66.3/10.6.
Fig. 13.	Bellispores nitidus (Horst) Sullivan; M15/4, 62.5/11.3.
Fig. 14.	B. nitidus; M13/4, 63.4/4.6.
Fig. 15.	B. nitidus; M13/1, 68/20.5.
Fig. 16.	Knoxisporites rotatus Hoffmeister, Staplin and Malloy; M20/3, (R.) - 80.4/7.6.
Fig. 17.	K. rotatus; M20/2, 66.5/12.1.
Fig. 18.	K. rotatus; M20/8, 84.1/18.3.

PLATE 14


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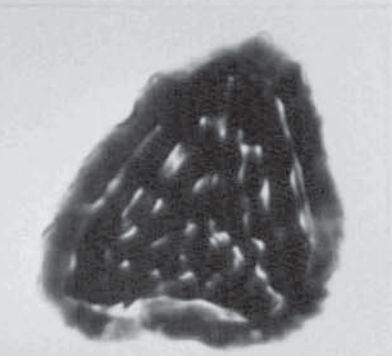
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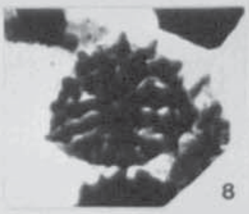
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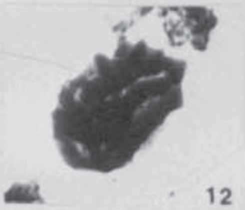
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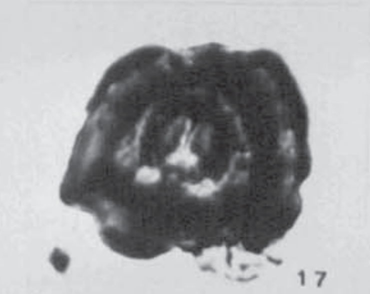
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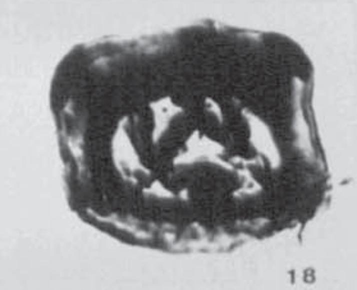
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PLATE 15

Fig. 1, 4. *Knoxisporites* *spA*.; P8/2, 62.9/16.1; Fig. 4 - X 1000.

Fig. 2. *K*. *spA*.; P8/1, 59.5/1.4.

Fig. 3, 5. *K*. *spA*.; P8/2, 67.7/16.3; Fig. 5 - X 1000.

Fig. 6, 7. *K*. *spA*.; P8/1, 71.3/3.7; Fig. 6 - proximal surface, Fig. 7 - distal surface.

Fig. 8. *K*. *spA*.; P8/1, 66.8/17.7.

Fig. 9. *K*. *spA*.; P8/1, 67.2/0.8.

Fig. 10. *K*. *dissidus* Neves; M20/3, 69.5/2.6.

Fig. 11. *K*. *stephanopherus* Love; 661/3, 68/3.6.

Fig. 12. *K*. *stephanopherus*; M13/6, 71.5/28.

Fig. 13. *K*. *stephanopherus*; M20/1, 76.5/21.7.

Fig. 14. *K*. *stephanopherus*; M13/6, 73/15.7.

Fig. 15. *K*. *triradiatus* Hoffmeister, Staplin and Malloy; P22/3, -/-.

Fig. 16. *K*. *triradiatus*; P8/1, (R.) 66.7/4.5.

PLATE 15


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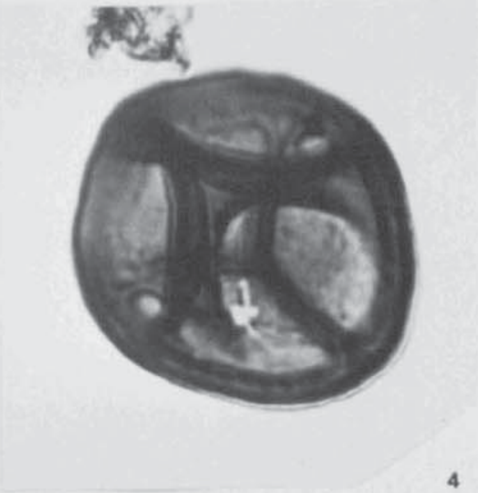
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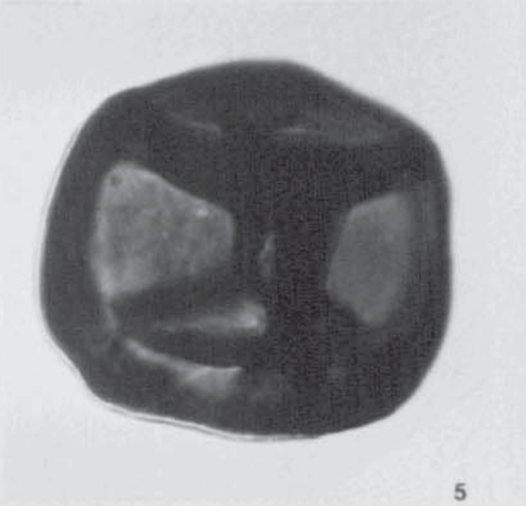
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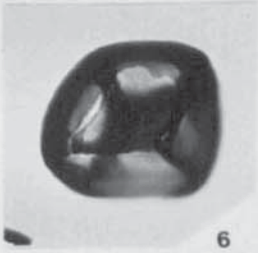
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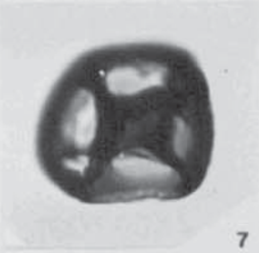
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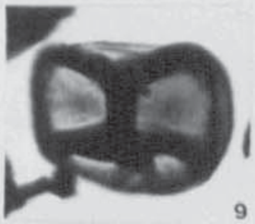
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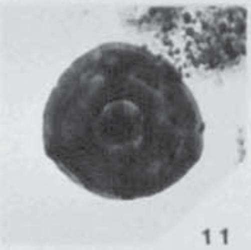
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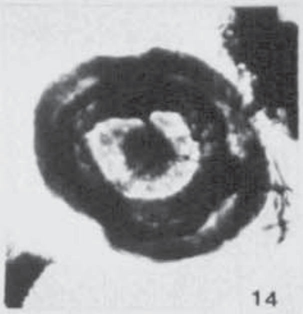
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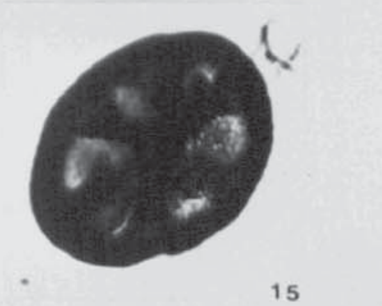
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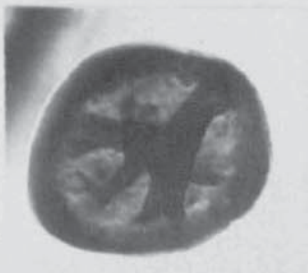
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PLATE 16

Fig. 1, 2. Reticulatisporites reticulatus Ibrahim; 796/9, 61.3/0.1; Fig. 2 - X 1000.

Fig. 3, 4. R. polygonalis (Ibrahim) Smith and Butterworth; 137/1, 69.3/23; Fig. 4 - X 1000.

Fig. 5, 6. R. polygonalis; C8/1, 77.2/13.6, Fig. 5 - proximal surface, Fig. 6 - distal surface.

PLATE 16


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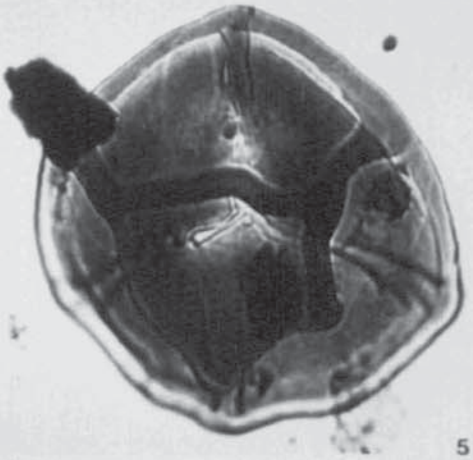
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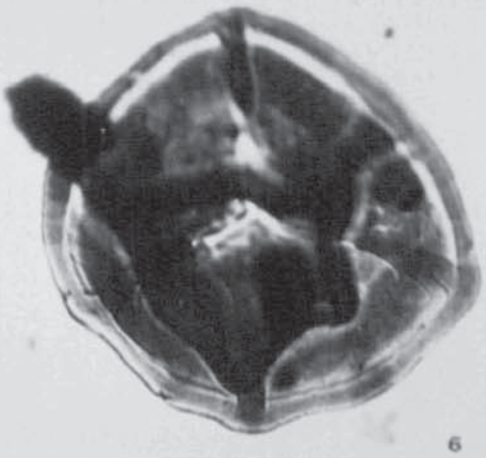
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PLATE 17

Fig. 1. *Crassispora spA.*; M22/1, 64.6/18.8.

Fig. 2. *C. spA.*; M18/2, 65.8/21.

Fig. 3. *C. spA.*; M18/1, 83.3/23.

Fig. 4. *C. kosankei* (Potonie and Kremp) Bhardwaj; C2/4, 73.5/30.

Fig. 5. *C. kosankei*; C2/7, (R.) -84.8/7.1.

Fig. 6. *C. kosankei*; C2/11, 67.6/28.

Fig. 7. *C. kosankei*; C2/10, (R.) -71/6.5.

Fig. 8. *C. kosankei*; C5/8, 67/23.4.

Fig. 9. *C. kosankei*; 137/3, 64.5/16.6.

Fig. 10. *C. kosankei*; C2/10, 74.9/11.8.

Fig. 11. *C. kosankei*; C2/1, 80.5/1.4; Tetrad.

Fig. 12. *Rotaspora fracta* (Schemel) Smith and Butterworth; M13/3, 62.3/19.1.

Fig. 13. *R. knoxi* Butterworth and Williams; M13/5, 66.1/3.6.

Fig. 14. *Stenozonotriletes lycosporoides* (Butterworth and Williams) Smith and Butterworth; M20/5, 60.4/26.6.

Fig. 15. *S. lycosporoides*; M20/5, 61.5/28.8.

Fig. 16. *S. lycosporoides*; M22/4, 66.4/28.

PLATE 17


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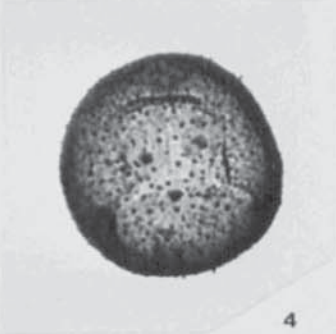
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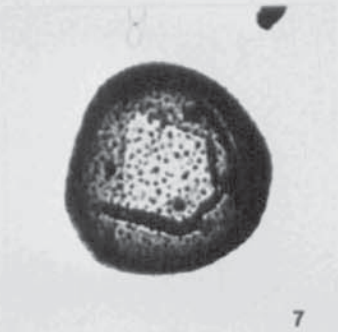
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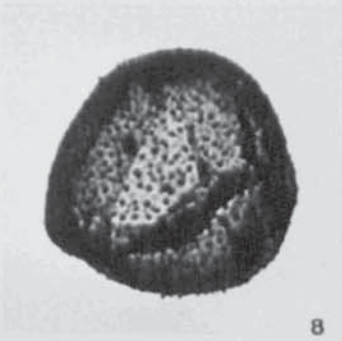
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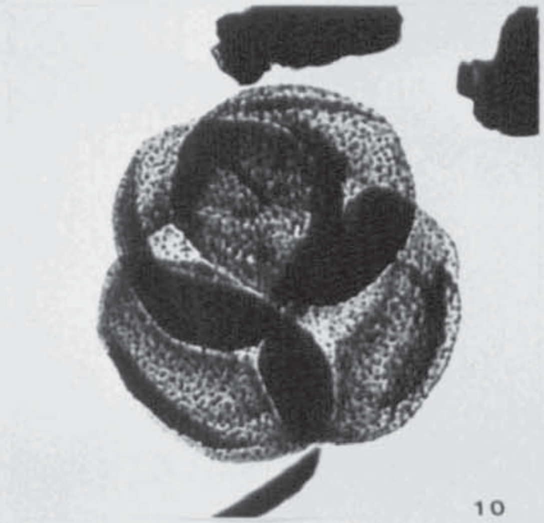
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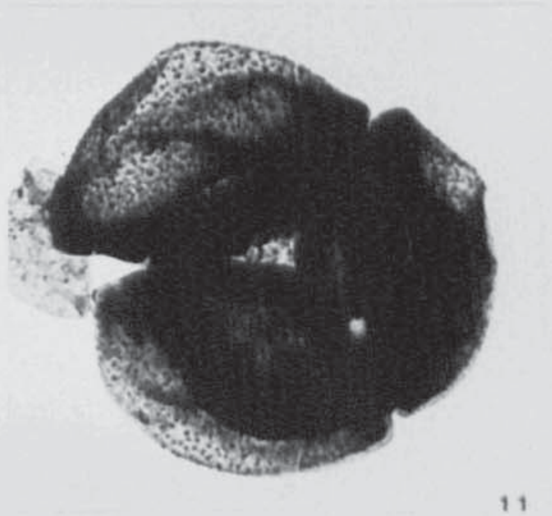
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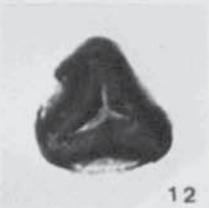
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PLATE 18

Fig. 1.	*Simozonotriletes cf. dupla* Ishchenko; C4/6, 83.6/23.9.
Fig. 2.	*S. cf. dupla*; C4/6, 72.1/5.8.
Fig. 3.	*S. cf. dupla*; C5/23, 68.2/25.3.
Fig. 4.	*S. cf. dupla*; C4/6, 79/19.8.
Fig. 5.	*S. cf. dupla*; C4/4, 77.9/13.8.
Fig. 6.	*S. cf. dupla*; C4/5, 65.4/25.4.
Fig. 7.	*Stenozonotriletes spA*.; P71/4, 68.4/5.7.
Fig. 8.	*S. spA*.; P71/2, 69/6.5.
Fig. 9.	*S. spA*.; P71/2, 68/6.6.
Fig. 10.	*S. spA*.; P90/1, 67.5/13.2.
Fig. 11/15.	*S. spA*.; P71/1, 69/17.2; Fig. 15 - X 1000.
Fig. 12/16.	*S. spA*.; P71/1, 67.5/1.6; Fig. 16 - X 1000.
Fig. 13/17.	*S. spA*.; P71/4, 68.5/6; Fig. 17 - X 1000.
Fig. 14/18.	*S. spA*.; P90/1, 67.3/12.8; Fig. 18 - X 1000.
Fig. 19.	*S. spA*.; P71/1, 65.8/10.8.
Fig. 20.	*Stenozonotriletes spB*.; 801/1, (R.) -71.2/4.2.
Fig. 21.	*S. spB*.; 797/8, 78/15.
Fig. 22.	*S. spB*.; 801/1, 68.5/9.8.
Fig. 23.	*S. spB*.; 801/1, 62.6/14.5.
Fig. 24.	*S. spB*.; P90/2, 64.5/24.2.
Fig. 25/27.	*S. spB*.; P90/2 69/18.9.; Fig. 27 - X 1000.
Fig. 26/28.	*S. spB*.; 801/1, (R.) -67/7.7.

PLATE 18


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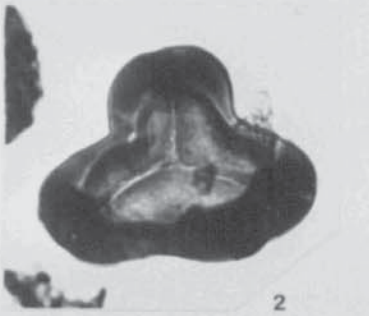
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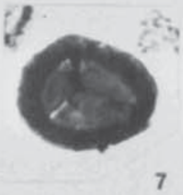
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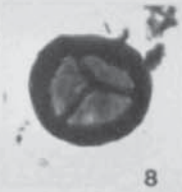
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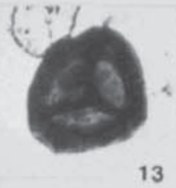
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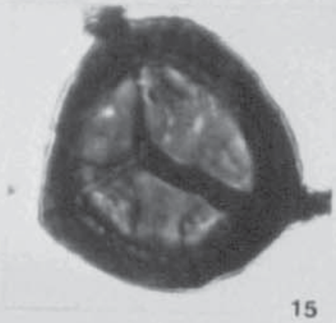
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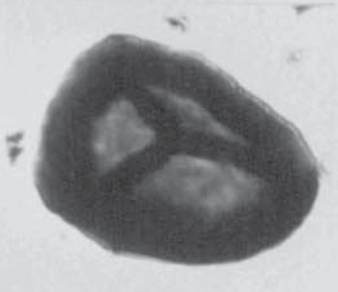
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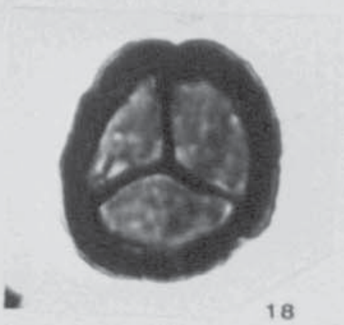
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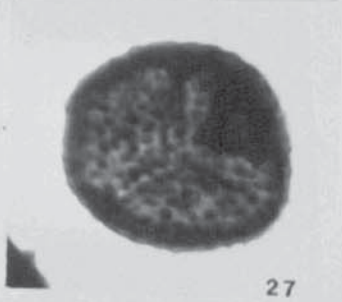
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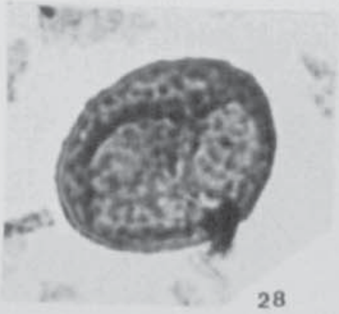
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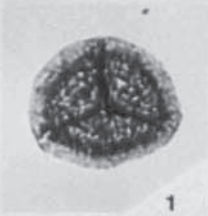
PLATE 19

Fig. 1.	*Lycospora punctata* Kosanke; P20/2, 68.7/14.5
Fig. 2.	*L. punctata*; C5/16, 69.3/17.8.
Fig. 3/4.	*L. punctata*; P20/2, (R.) - 63.7/8.
Fig. 5.	*L. punctata*; P20/2, -/-.
Fig. 6.	*L. punctata*; P20/2, 74.1/18.7.
Fig. 7.	*L. rotunda* (Bhardwaj) Somers; equatorial view, M1/1, 66.8/11.4.
Fig. 8.	*L. rotunda*; C5/18, 70/5.3.
Fig. 9.	*L. rotunda*; C5/1, 71.5/22.1.
Fig. 10.	*L. rotunda*; P5/1, 72/15.1.
Fig. 11.	*L. noctuina var. noctuina* Butterworth and Williams; P8/2, -/-.
Fig. 12.	*L. noctuina var. noctuina*; P1/2, 74.6/7.8.
Fig. 13.	*L. triangulata* Bhardwaj; 658/1, 69.4/23.4.
Fig. 14.	*L. triangulata*; P5/1, (R.) -65.3/5.3.
Fig. 15/16.	*L. orbicula* (Potonie and Kremp) Smith and Butterworth; P20/2, -/-; Fig. 16 - X 1000.
Fig. 17.	*L. pellucida* (Wicher) Schopf, Wilson and Bentall; 132/1, 68.5/20.3.
Fig. 18.	*L. pellucida*; 796/10, 72.8/24.8.
Fig. 19.	*L. pellucida*; C5/1, 78.2/8.7.
Fig. 20.	*L. uber* (Hoffmeister, Staplin and Malloy) Staplin; M20/9, 77/22.1.
Fig. 21.	*L. orbicula*; Tetrad, 797/5, 62.7/23.8.
Fig. 22.	*L. pusilla* (Ibrahim) Schopf, Wilson and Bentall; P5/1, 64.8/6.
Fig. 23.	*L. pusilla*; P5/1, 65.4/29.2.
Fig. 24.	*L. pusilla*; 797/2, 62/25.6.
Fig. 25.	*L. pusilla*; 797/2, 70.2/6.1.
Fig. 26.	*L. pusilla*; Tetrad, 797/1, 73/11.1.
Fig. 27.	*L. pusilla*; SEM. Preparation 797.
Fig. 28.	*L. pusilla*; Tetrad, SEM. Preparation 797.
Fig. 29.	*L. ? rugosa* Schemel; P8/3, 67.4/8.7.
Fig. 30.	*L. ? rugosa* P5/2, 66.8/20.6.

PLATE 19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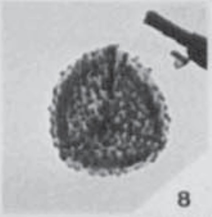
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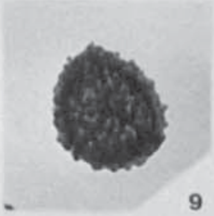
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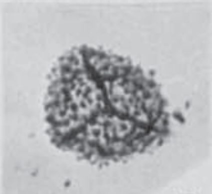
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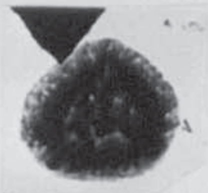
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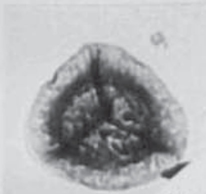
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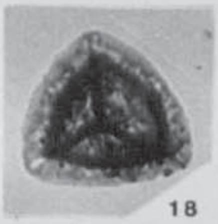
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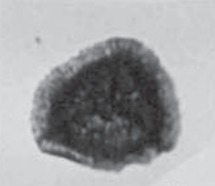
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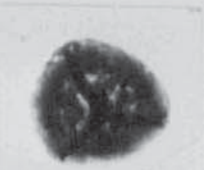
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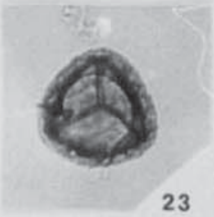
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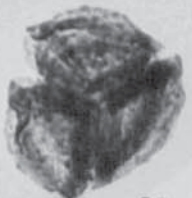
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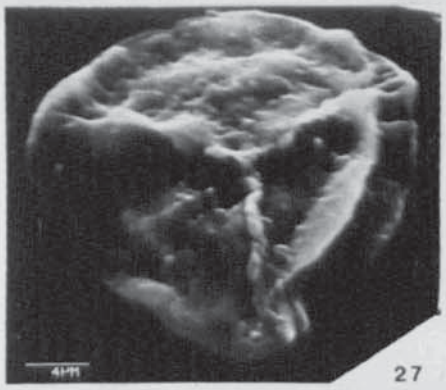

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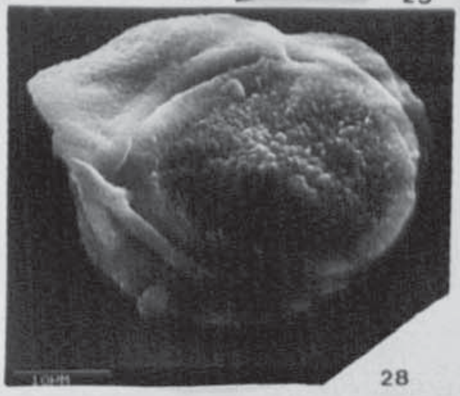

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PLATE 20

Fig. 1. *Densosporites anulatus* (Loose) Smith and Butterworth; M3/2, 70/10.5.

Fig. 2. *D. anulatus*; Tetrad, M3/2, 57.4/8.9.

Fig. 3. *D. anulatus*; SEM. Preparation C5.

Fig. 4. *D. duriti* Potonie and Kremp; C5/9, 70.2/14.2.

Fig. 5. *D. duriti*; C5/15, 80.1/16.4.

Fig. 6. *D. anulatus*; 137/1, 63.5/17.6.

Fig. 7. *D. anulatus*; 137/1, 71.6/26.4.

Fig. 8. *D. duriti*; C5/12, 82.1/26.8.

Fig. 9. *D. duriti*; C5/15, 80.5/16.4.

Fig. 10. *D. duriti*; C5/20, 75.3/12.5.

Fig. 11. *D. duriti*; C5/9, -/-.

Fig. 12. *D. pseudoannulatus* Butterworth and Williams; M9/2, 80.2/25.1.

Fig. 13. *D. pseudoannulatus*; M9/1, 69.5/2.8.

Fig. 14. *D. pseudoannulatus*; M1/2, 62.3/27.8.

Fig. 15. *D. pseudoannulatus*; M1/2, 60.6/23.3.

Fig. 16. *D. glandulosus* Kosanke; C5/1, 76.4/13.5.

Fig. 17. *D. glandulosus*; 137/1, 72.2/15.4.

Fig. 18. *D. microponticus* Artüz; M20/1, 66.2/11.2.

Fig. 19. *D. microponticus*; 137/1, 63/1.3.

Fig. 20. *D. sphaerotriangularis* Kosanke; 137/1, 61.5/21.

Fig. 21. *D. sphaerotriangularis*; 661/1, 63.8/18.3.

Fig. 22. *D. sphaerotriangularis*; SEM. Preparation C5.

PLATE 20


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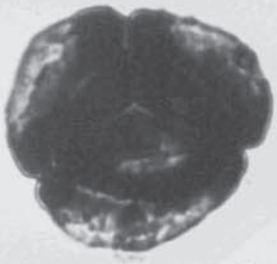
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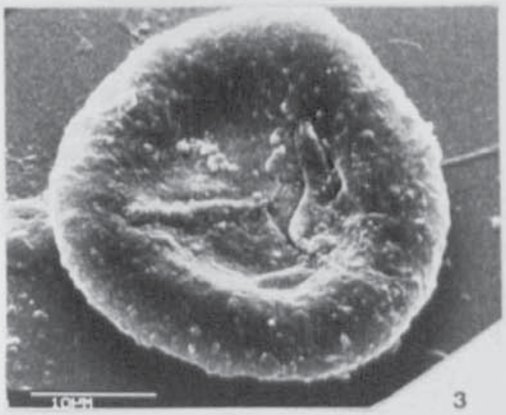

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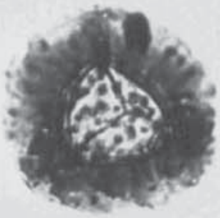
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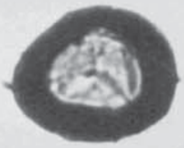
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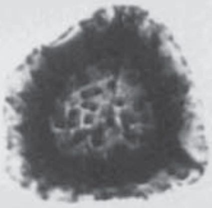
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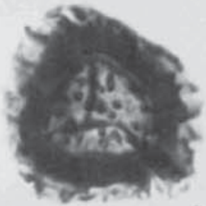
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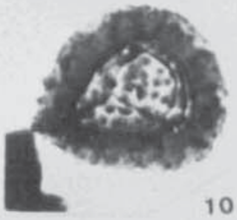
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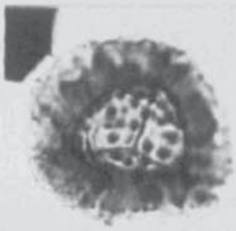
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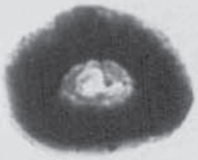
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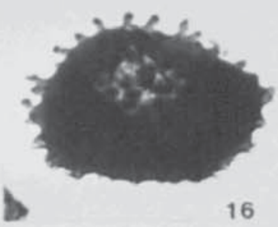
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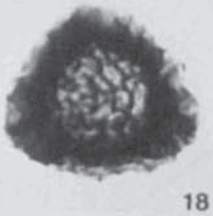
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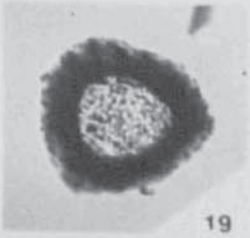
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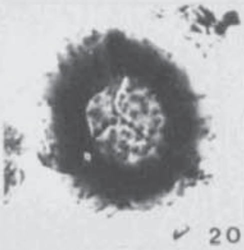
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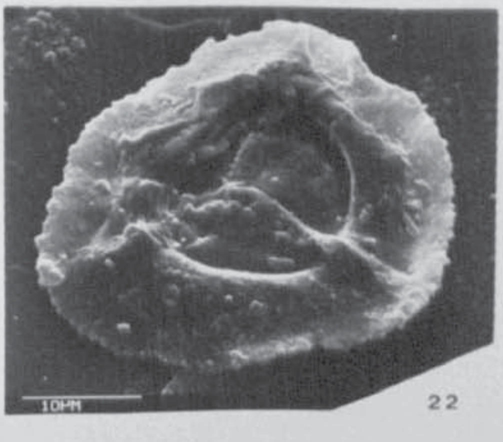

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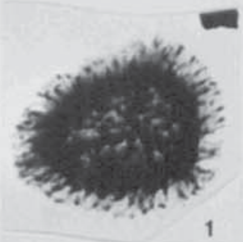
PLATE 21

Fig. 1.	*Densosporites spinosus* Dybova and Jachowicz; M22/3, 74.3/5.5.
Fig. 2.	*D. spinosus*; M22/1, 70/26.6.
Fig. 3.	*D. spinosus*; M22/1, 75.6/11.2.
Fig. 4.	*D. spinosus*; M22/1, 70.6/8.
Fig. 5.	*D. spinosus*; SEM. Preparation M22.
Fig. 6.	*D. spinosus*; M22/1, 63.3/26.2.
Fig. 7.	*D. spinosus*; M22/3, 81.7/2.3.
Fig. 8.	*D. intermedius* Butterworth and Williams; M9/3, 75.6/25.7.
Fig. 9.	*D. intermedius*; 661/3, 63.5/20.7.
Fig. 10.	*D. spinifer* Hoffmeister, Staplin and Malloy; M22/1, 67.3/13.8.
Fig. 11.	*D. spinifer*; M22/1, -/-.
Fig. 12.	*D. spinifer*; M20/8, 71.4/23.9
Fig. 13.	*D. spinifer*; M20/8, 75.2/22.4.
Fig. 14.	*Cirratriradites saturni* (Ibrahim) Schopf, Wilson and Bentall; H541/1, 67/9.7.
Fig. 15.	*C. saturni*; H541/1, 75.3/5.
Fig. 16.	*C. saturni*; C5/22, 79.8/5.1.
Fig. 17.	*C. rarus* (Ibrahim) Schopf, Wilson and Bentall; M13/1, 70/4/29.
Fig. 18.	*Kraeuselisporites ornatus* (Neves) Owens, Mishell and Marshall; M181, 77.8/23.2.
Fig. 19.	*K. ornatus*; M18/4, 71.4/20.

PLATE 21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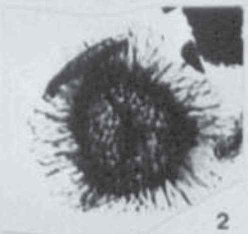
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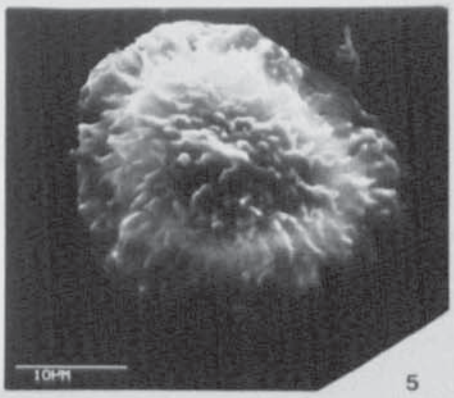

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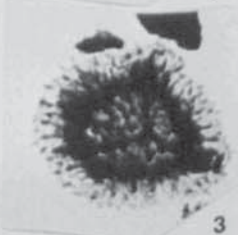
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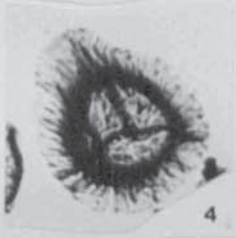
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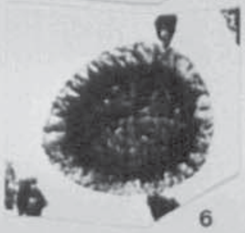
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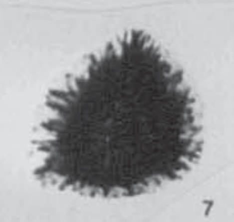
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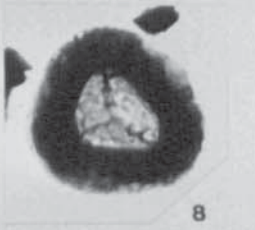
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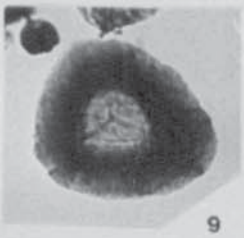
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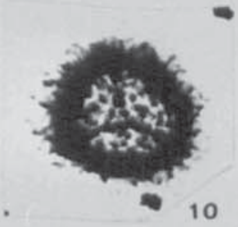
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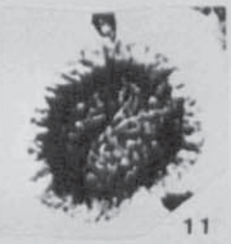
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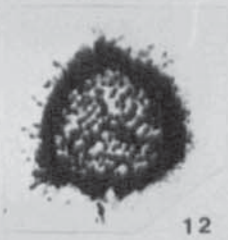
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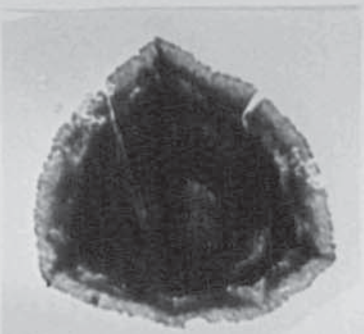
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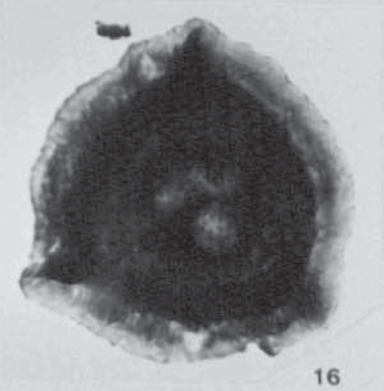
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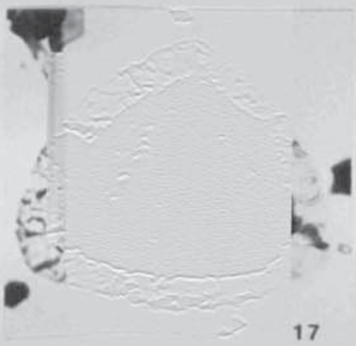
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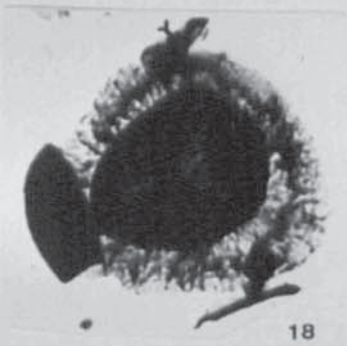
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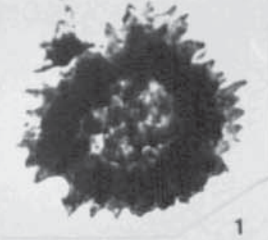
PLATE 22

Fig. 1.	*Cristatisporites connexus* Potonie and Kremp; 137/1 70.6/21.9.
Fig. 2.	*C. connexus*; C5/12, 80.2/23.
Fig. 3.	*C. connexus*; C5/17, 81.3/11.2.
Fig. 4.	*C. connexus*; 137/1, -/-.
Fig. 5.	*C. indignabundus* (Loose) Staplin and Jansonius; 137/3, 63/12.8.
Fig. 6.	*C. indignabundus*; 234/4, 73.3/20.2.
Fig. 7.	*Cristatisporites spA.*; P71/1, 66/21.9.
Fig. 8.	*C. spA.*; C5/17, 73.4/28.2.
Fig. 9.	*Radiizonates striatus* (Knox) Staplin and Jansonius; 362/1, 66.7/16.
Fig. 10.	*R. striatus*; 137/1, 2/1.7.
Fig. 11.	*R. striatus*; M18/2, 75.6/27.3.
Fig. 12.	*R. striatus*; M18/1, 78.8/12.8.
Fig. 13.	*R. striatus*; M18/6, 71.6/6.2.
Fig. 14.	*R. striatus*; M18/2, 79/27.2.
Fig. 15.	*R. cf. difformis* (Kosanke) Staplin and Jansonius;
Fig. 16.	*R. cf. difformis*; M1/3, 62.5/26.5
Fig. 17.	*Cristatisporites pannosus* (Knox) Butterworth *et al.*; M13/7, 71.2/26.
Fig. 18.	*C. pannosus*; M13/6, 62.4/27.8.
Fig. 19.	*C. pannosus*; M13/2, 65.6/21.9.
Fig. 20.	*Radiizonates aligerens* (Knox) Staplin and Jansonius; 797/3, 74.1/2.7.
Fig. 21.	*Cristatisporites pannosus*; SEM. Preparation M13.
Fig. 22.	*Radiizonates aligerens* (Knox) Staplin and Jansonius; SEM. Preparation 797.

PLATE 22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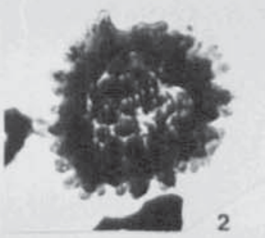
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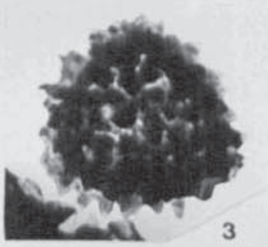
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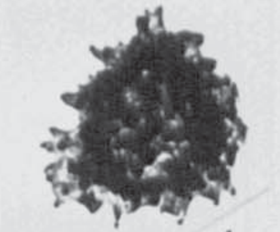
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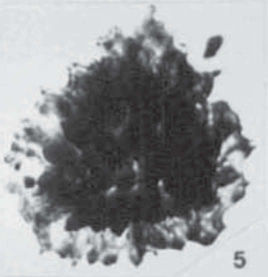
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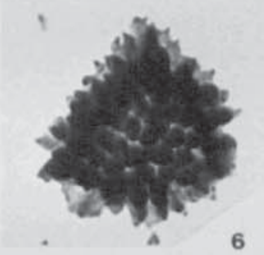
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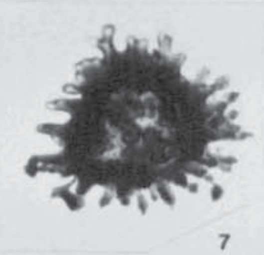
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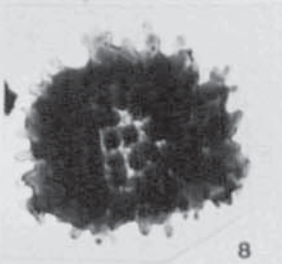
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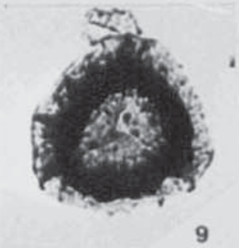
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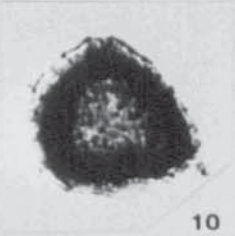
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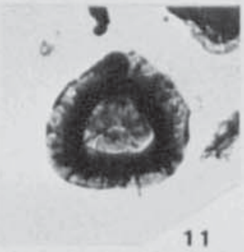
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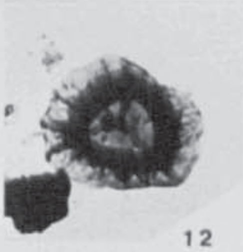
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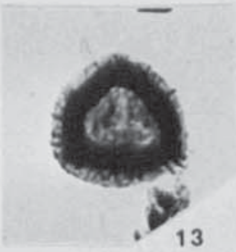
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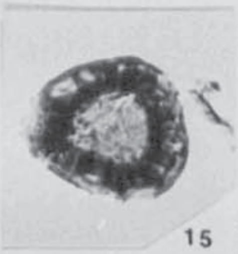
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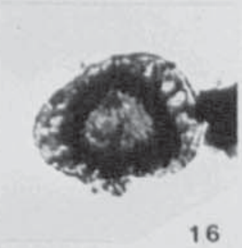
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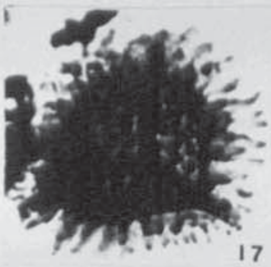
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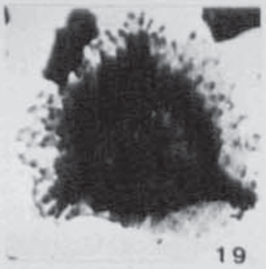
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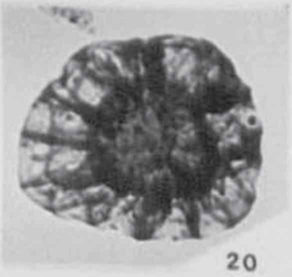
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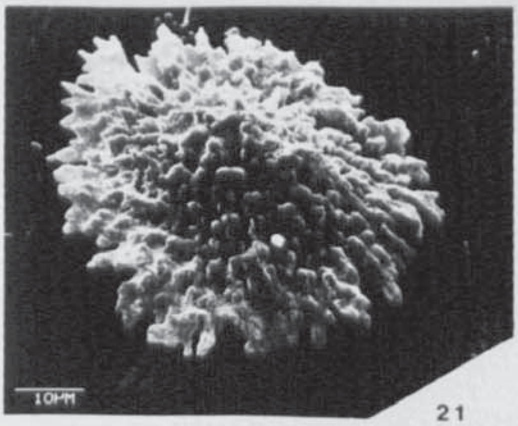

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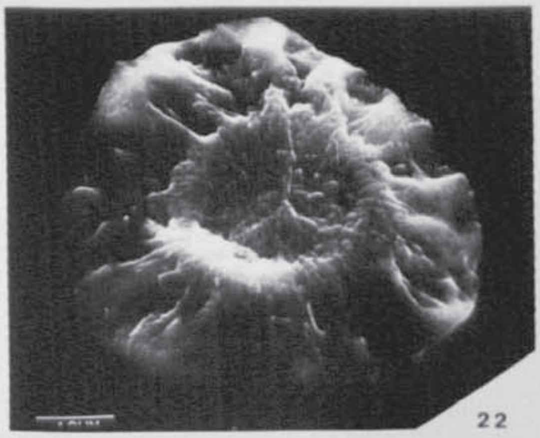
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PLATE 23

Fig. 1.	*Cingulizonates bialatus* (Waltz) Smith and Butterworth; M20/2, 75.2/13.
Fig. 2.	*C. bialatus*; M20/1, 77.8/20.2.
Fig. 3/4.	*C. bialatus*; M20/2, 78.6, 28.2, Fig. 4 - X 1000.
Fig. 5.	*C. loricatus* (Loose) Butterworth *et al.*; M9/1, 75.2/16.
Fig. 6.	*C. loricatus*; M9/2, 64/8.6.
Fig. 7.	*C. loricatus*; M9/3, 80.5/2.2.
Fig. 8.	*Spore Type A1*; M20/9, 79.8/25.3.
Fig. 9.	" " " M20/1, 69.7/25.
Fig. 10/11	" " " M20/2, 77.5/17.5; Fig. 11 - X 1000.
Fig. 12.	" " " M20/9, 66.8/24.5
Fig. 13.	" " " M20/9, 76.6/19.7.
Fig. 14.	" " " M20/1, 73.4/13.3.
Fig. 15.	" " " SEM. Preparation M20.
Fig. 16.	Spore Type A2; M20/8, -/-.
Fig. 17.	" " " M20/4, 79.6/6.9.
Fig. 18.	" " " M20/3, 78.3/7.3.
Fig. 19.	" " " M20/8, 76.2/29.4.
Fig. 20.	" " " M20/4, -/-.
Fig. 21.	" " " M20/3, 71.3/23.2.
Fig. 22.	" " " M20/3, 69/15.3.
Fig. 23.	" " " M20/2, 68.5/22.8.
Fig. 24.	" " " M20/2, 79/5.1.
Fig. 25.	" " " SEM; distal surface; Preparation M20.

PLATE 23


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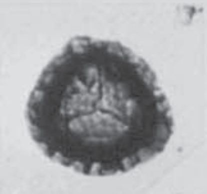
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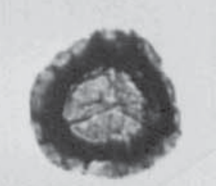
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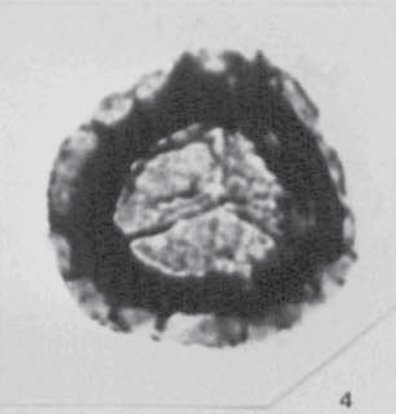
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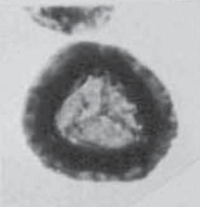
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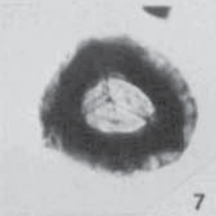
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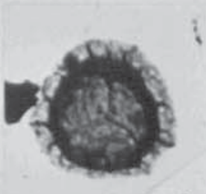
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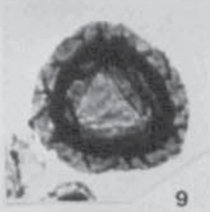
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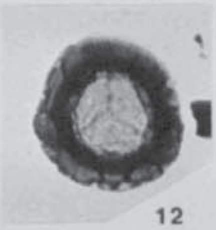
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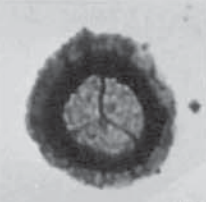
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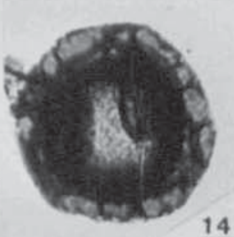
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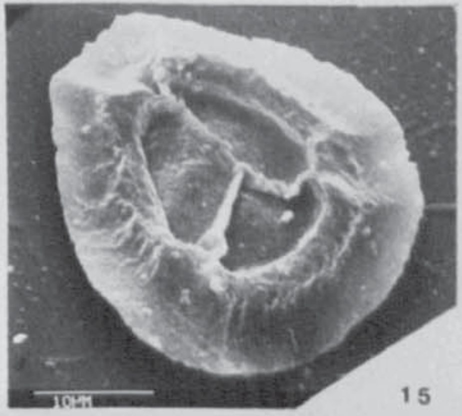

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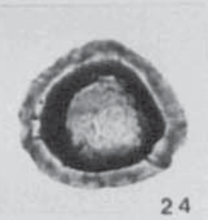
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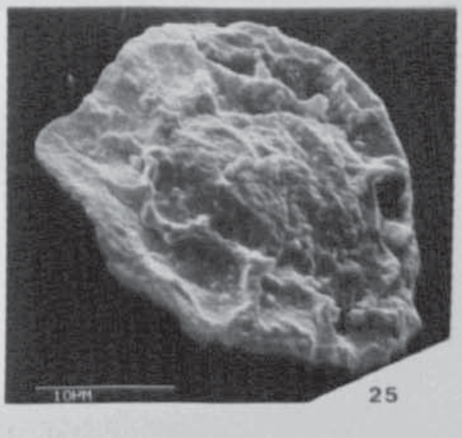

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PLATE 24

Fig. 1. *Altisporites pustulatus* Ibrahim 1932; C5/14, 80.4/7.2.

Fig. 2. *A. pustulatus*; C5/21, 74.2/26.3.

Fig. 3. *A. pustulatus*; C5/22, 77.3/15.6.

Fig. 4. *A. pustulatus*; C5/13, 67.5/10.6.

Fig. 5. *Discernisporites micromanifestus* (Hacquebard) Sabry and Neves; M13/2, 73.2/16.8.

Fig. 6. *D. irregularis* (Neves) Neves and Owens; M13/4, (R.) - 62/10.

Fig. 7. *Vallatisporites vallatus* Hacquebard; M20/5, 67/18.7.

Fig. 8. *V. vallatus*; M1/2, 67/24.

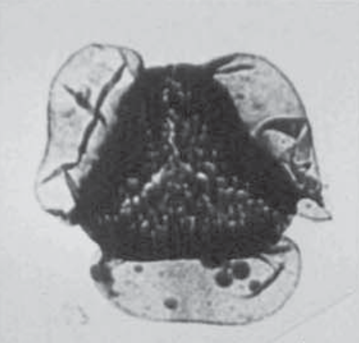
Fig. 9. *V. ciliaris* (Luber) Sullivan; M18/2, 78.3/23.8.

Fig. 10. *Schulzospora plicata* Butterworth and Williams; M13/3, 60.2/1.4.

Fig. 11. *Spencerisporites radiatus* (Ibrahim) Felix and Parks; 234/3, 81.7/10.4 - X 250.

Fig. 12. *S. radiatus*; C5/21, 78.1/17. X 250.

PLATE 24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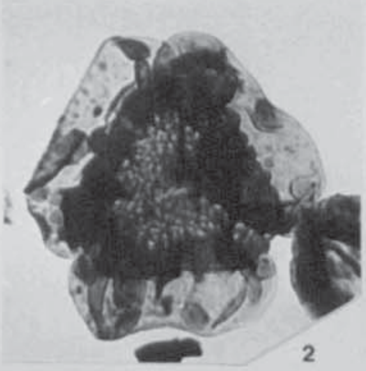
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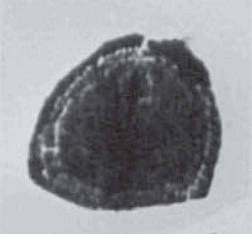
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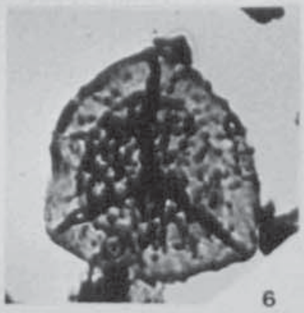
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PLATE 25

Fig. 1. *Endosporites globiformis* (Ibrahim) Schopf, Wilson and Bentall; H541/1, 67.3/1.4.

Fig. 2. *E. zonalis* (Loose) Knox; C5/21, 69.3/19.2.

Fig. 3. *Rugospora corporata* Neves and Owens; M15/4, 84.1/10.7.

Fig. 4. *Auroraspora solisortus* Hoffmeister, Staplin and Malloy; C5/14, 81.4/12.3.

Fig. 5. *A. solisortus*; C4/1, 74/27.3.

Fig. 6. *Endosporites zonalis*; 796/1, -/-.

Fig. 7. *Spelaeotriletes arenaceus* Neves and Owens; M22/1,

Fig. 8. *S. arenaceus*; M13/5, 66.1/4.1.

Fig. 9. *S. arenaceus*; M22/3, 73/7.6.

Fig. 10. *S. arenaceus*; M18/2, 70.2/16.

PLATE 25


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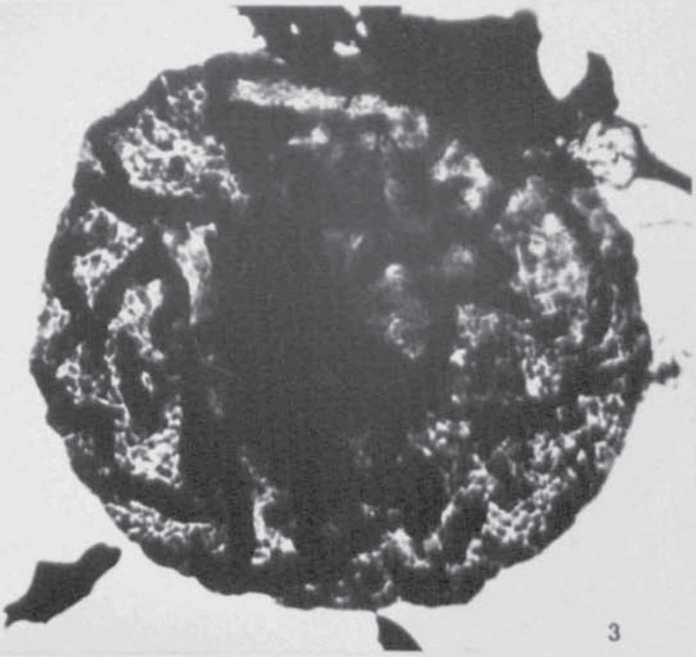
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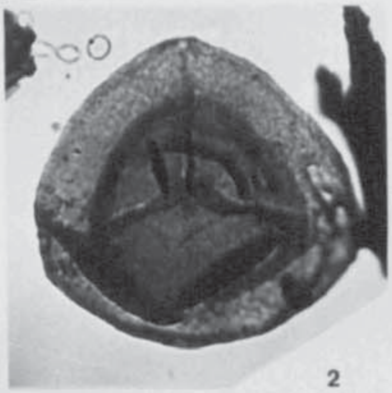
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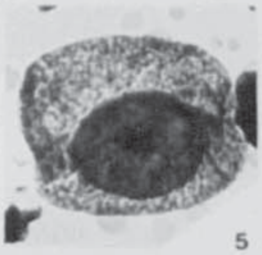
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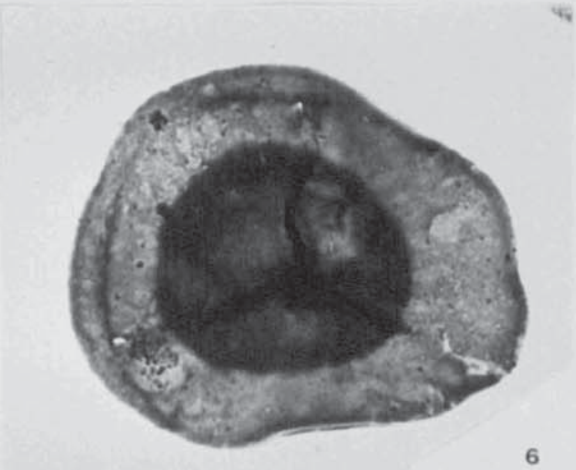
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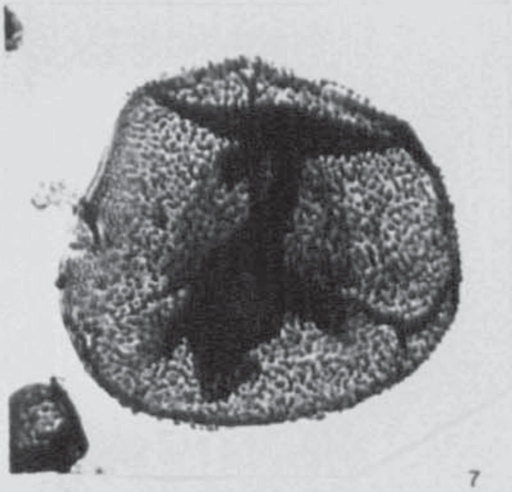
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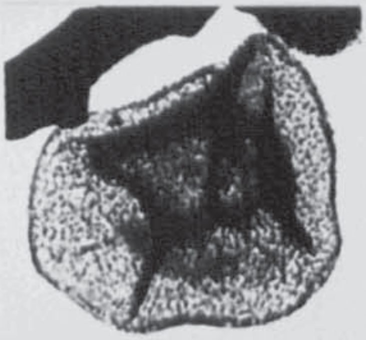
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PLATE 26

Fig. 1. *Spelaeotriletes* *spA*.; M13/1, (R.) -67.4/3.

Fig. 2. *S*. *spA*.; M13/7, 67.8/23.4.

Fig. 3. *S*. *spA*.; M13/2, 73.4/20.7.

Fig. 4. *S*. *spA*.; M13/3, 64.7/5.6.

Fig. 5. *S*. *spA*.; M13/2, 68.5/10.4.

Fig. 6. *S*. *spA*.; SEM. Proximal surface. Preparation M13.

Fig. 7. *S*. *spA*.; SEM. Proximal surface. Preparation M13.

Fig. 8. *S*. *spA*.; SEM. Distal surface. Preparation M13.

Fig. 9. *Spelaeotriletes* *spB*.; SEM, Distal surface.

Fig. 10. *S*. *spB*.; SEM, Proximal surface. Preparation M13.

Fig. 11. *S*. *spB*.; M13/3, 67.5/7.8.

Fig. 12/13 *S*. *spB*.; M13/6, 66/2.3. Fig. 13 - X 1000.

Fig. 14. *S*. *spB*.; M13/4, 72.3/19.6.

Fig. 15. *S*. *spB*.; M13/3, 71.5/23.4.

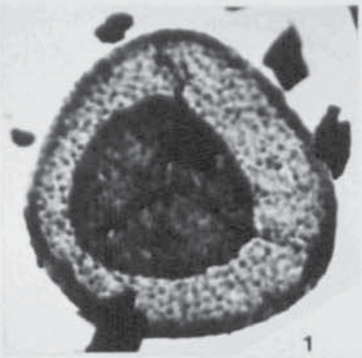
Fig. 16. *S*. *spB*.; M13/1, 69.2/24.

Fig. 17. *S*. *spB*.; M13/4, 58.2/20.

Fig. 18. *S*. *spB*.; M13/1, 72.4/9.8.

Fig. 19. *S*. *spB*.; M13/2, 72.5/1.4.

PLATE 26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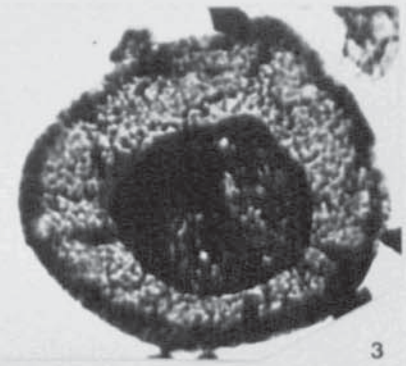
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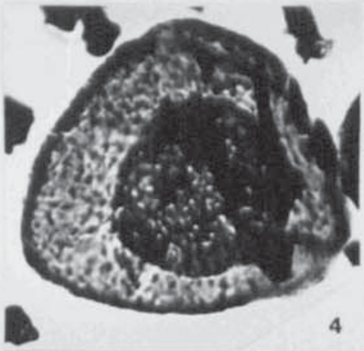
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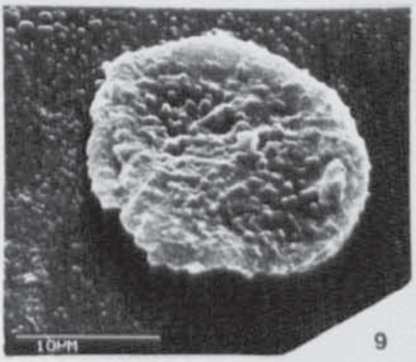

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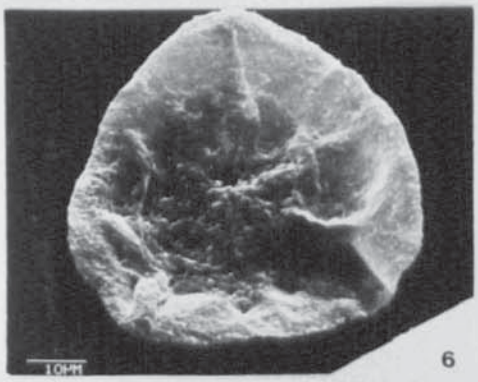

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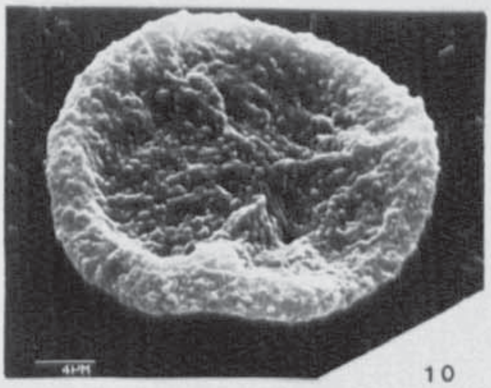

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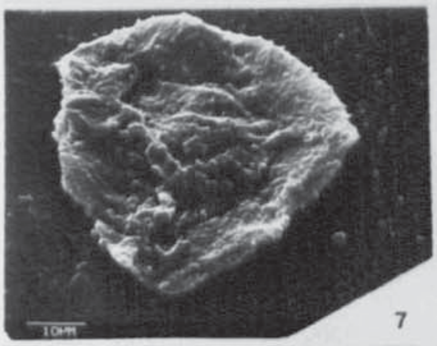

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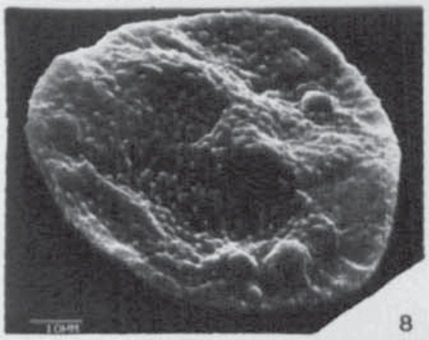

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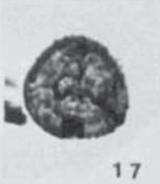
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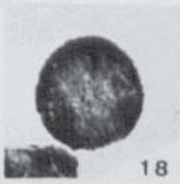
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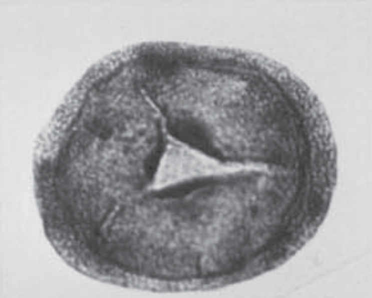
PLATE 27

Fig. 1. Schulzospora rara Kosanke; C5/10, 68.7/23.1.
Fig. 2. S. rara; C5/12, 76/24.1.
Fig. 3. S. rara;
Fig. 4. S. rara; C2/1, 70.7/9.9.
Fig. 5. Grumosisporites papillosus (Ibrahim) Smith and Butterworth; P76/2, 69.7/27.4.
Fig. 6. G. papillosus; P76/4, 68.4/3.
Fig. 7/8. G. varioreticulatus (Neves) Smith and Butterworth; P76/2, 75.6/20.7. Fig. 7 - X 1000.
Fig. 9. G. varioreticulatus; 796/5, 72/5.3.
Fig. 10. Hymenospora multirugosa Peppers; C2/9, (R.) - 75.4/5.
Fig. 11. H. multirugosa; C2/4, 71/1.
Fig. 12. H. multirugosa; C2/7, 81.8/19.3.
Fig. 13. Spinozonotriletes uncatus Hacquebard; Tetrad, M13/4, 71/26.
Fig. 14. Grandispora spinosa Hoffmeister, Staplin and Malloy; M20/4, 79.8/14.6.
Fig. 15. Corrugitriletes ruginosus Mishell 1966 MS.; M22/3, 70.8/15.
Fig. 16. C. ruginosus; M13/1, 67.7/24.3.
Fig. 17. C. ruginosus; M22/1, 63.7/26.7.

PLATE 27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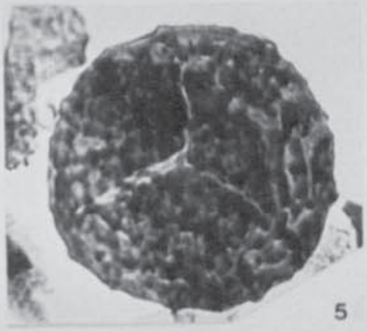
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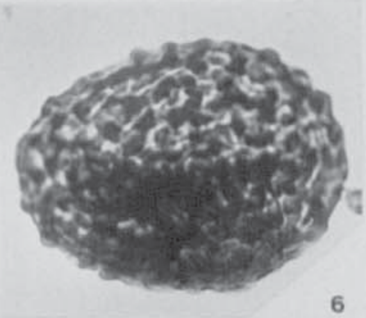
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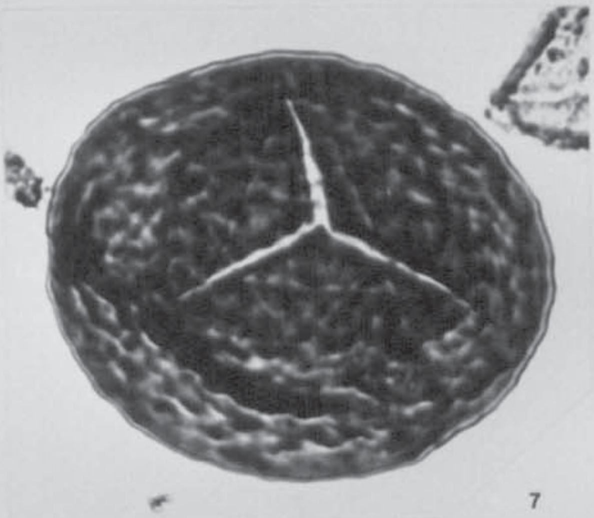
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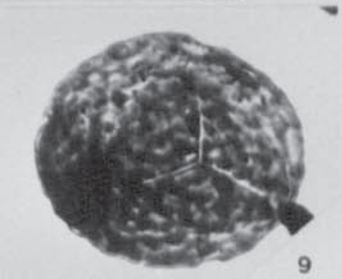
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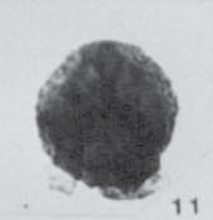
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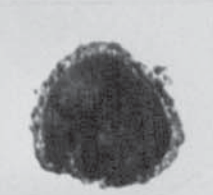
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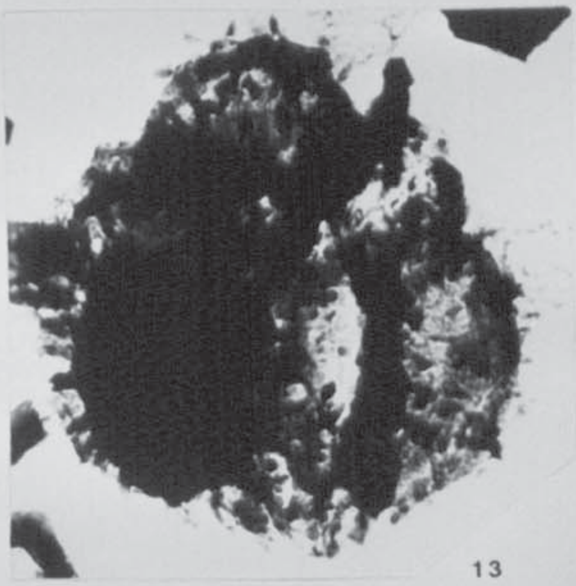
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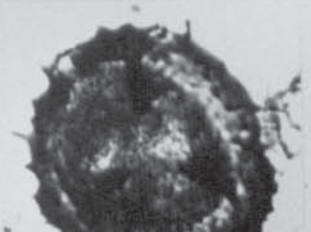
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PLATE 28

Fig. 1. *Punctatosporites minutus* Ibrahim; C2/5, 77.1/30.2.
Fig. 2. *P. minutus*; C5/15, 79.5/2.
Fig. 3. *Fabasporites pallidus* Sullivan; 797/2, 73/10.4.
Fig. 4. *F. spA.*; P76/1, 67/19.2.
Fig. 5. *F. spA.*; P76/1, 67.8/22.2.
Fig. 6. *Laevigatosporites vulgaris* Ibrahim; C5/11, 80.3/26.2.
Fig. 7. *L. vulgaris*; C5/12, 73.5/12.5.
Fig. 8. *L. vulgaris*; C5/15, 71.5/13.4.
Fig. 9. *L. minor* Loose; 797/6, 70.7/5.
Fig. 10. *L. minor*; C2/6, 83.2/4.9.
Fig. 11. *L. minor*; 797/2, 61.2/25.1.
Fig. 12. *L. minor*; 797/2, (R.) -61.6/6.7.
Fig. 13. *L. minor*; 797/1, 65/22.1.
Fig. 14. *L. minor*; C5/11, 72.2/3.5.
Fig. 15. *Vestispora spA.*; C5/9, 75.5/19.9.
Fig. 16. *V. spA.*; C5/19, 79.5/16.4.
Fig. 17. *V. spA.*; C2/6, 76/1.6.
Fig. 18. *V. spA.*; C5/12, 74.6/8.2.
Fig. 19. *V. spA.*; C2/8, 78.3/5.4
Fig. 20. *V. spA.*; C5/14, 72.3/20.6.
Fig. 21. *V. tortuosa*; (Balme) Spode in Smith and Butterworth; C5/14, 77.8/3.8.
Fig. 22. *V. tortuosa*; C5/16, 73/27.
Fig. 23. *V. tortuosa*; detached operculum; C5/14, 67/4.6.
Fig. 24. *V. pseudoreticulata* Spode in Smith and Butterworth; H.541/2, 65.3/5.6.
Fig. 25. *V. pseudoreticulata* ; H.543/1, 77.6/14.

PLATE 28


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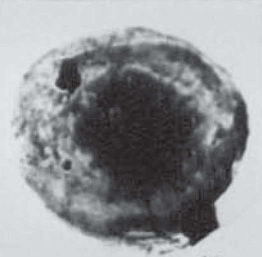
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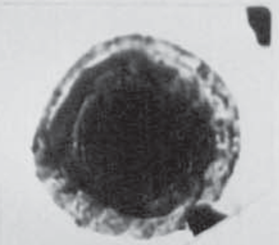
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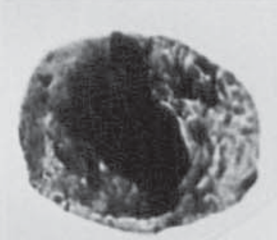
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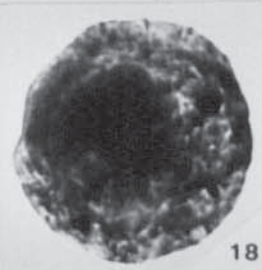
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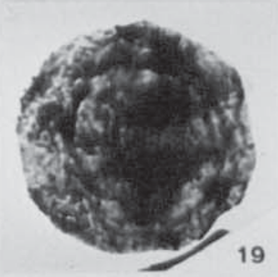
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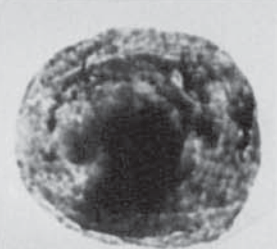
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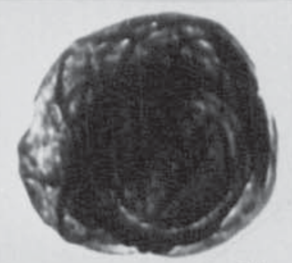
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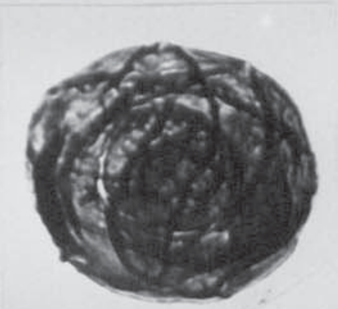
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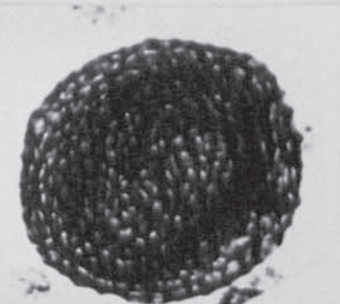
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PLATE 29

Fig. 1/2. *Spore type B*; M22/2, 75/2.7, Fig. 2 - X 1000.

Fig. 3. *Spore type B*; M22/2, -/-.

Fig. 4/5. *Spore type B*; M22/3, 75.2/21.8, Fig. 5 - X 1000.

Fig. 6. *Spore type B*; M22/2, -/-.

Fig. 7. *Spore type B*; M22/1, 68.3/22.5.

Fig. 8. *Vestispora costata* (Balme) Spode in Smith and Butterworth; C5/12, 75.8/21.4.

Fig. 9. *V. costata*; C5/22, 84.2/10.7.

Fig. 10. *Spore type B*; SEM. Preparation M22.

Fig. 11. *Spore type B*; SEM. Preparation M22.

Fig. 12. *Florinites occultus* Habib; C5/9, 70.2/14.2.

Fig. 13. *F. similis* Kosanke; C2/7, 77.4/18.2.

Fig. 14. *F. similis*; C5/15, 77.8/7.

Fig. 15. *F. similis*; C2/6, 70/10.

PLATE 29


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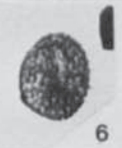
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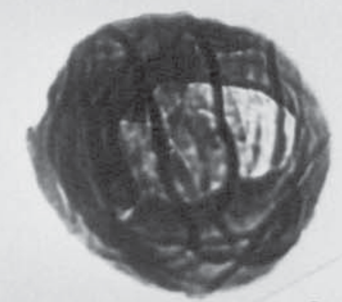
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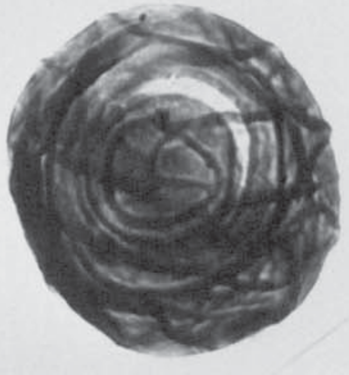
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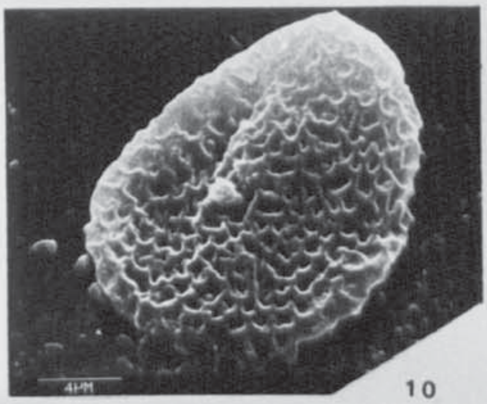

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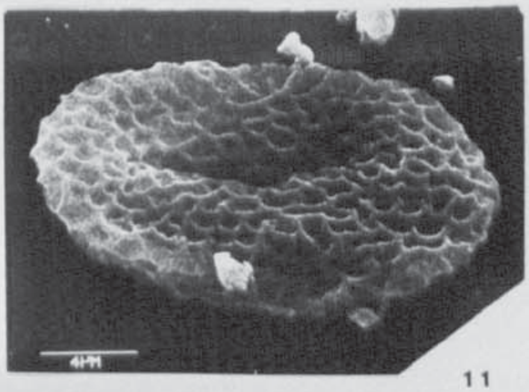

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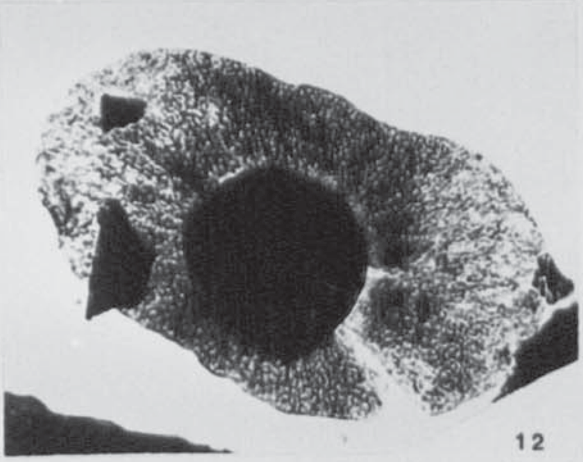
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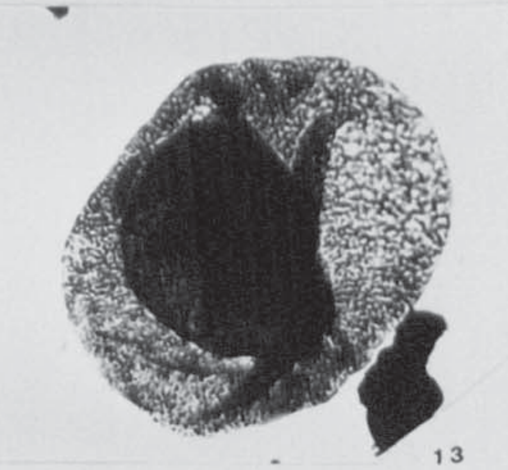
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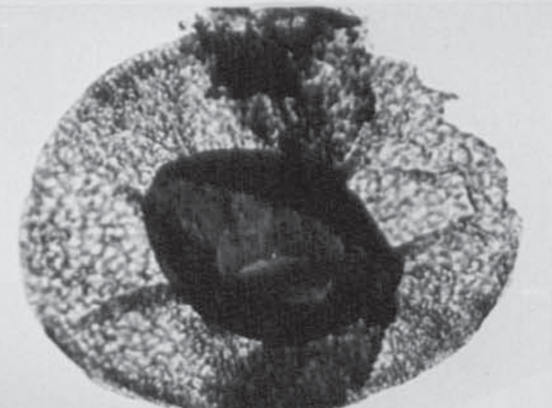
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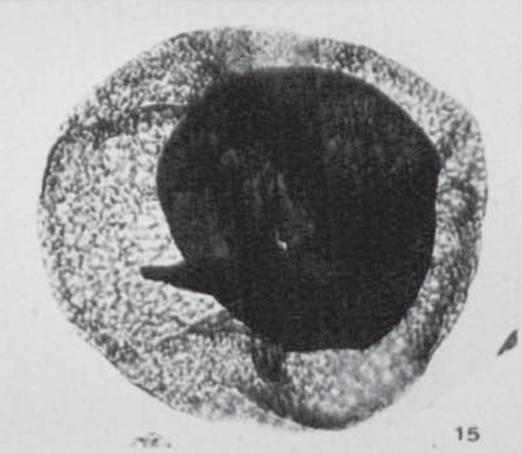
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PLATE 30

Fig. 1. *Florinites pumicosus* (Ibrahim) Schopf, Wilson and Bentall; 797/5, 68.1/16.

Fig. 2. *F. pumicosus*; M20/6; 65.5/7.3

Fig. 3. *F. millotti* Butterworth and Williams; C5/16, 82.5/26.5.

Fig. 4. *F. millotti*; 138/2, -/-.

Fig. 5. *F. diversiformis* Kosanke; C5/5, 69.4/4.7.

Fig. 6. *F. diversiformis*; C5/5, 79.5/3.8.

Fig. 7. *F. triletus* Kosanke; C2/9, (R.) -75.9/7.9.

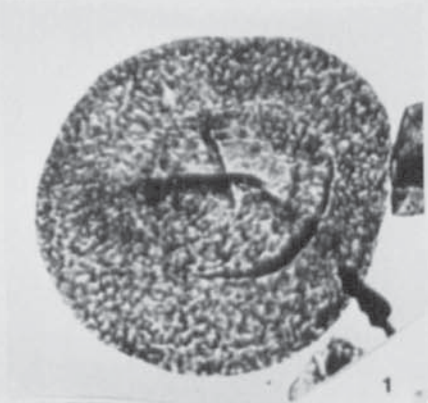
Fig. 8. *F. triletus*; C2/5, 70.4/25.8.

Fig. 9. *F. triletus*; 797/6, 66.8/7.1.

Fig. 10. *F. visendus* (Ibrahim) Schopf, Wilson and Bentall; 797/8, 80.6/24.

Fig. 11. *F. visendus*; 661/5, 71.5/17.5.

PLATE 30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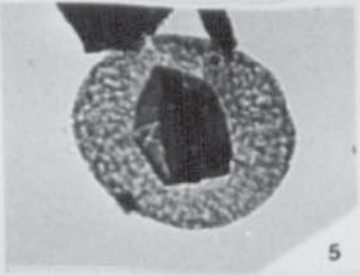
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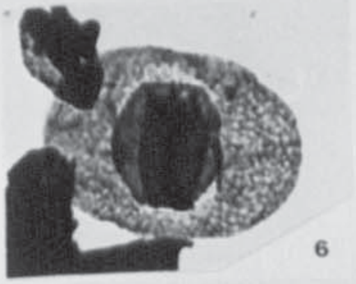
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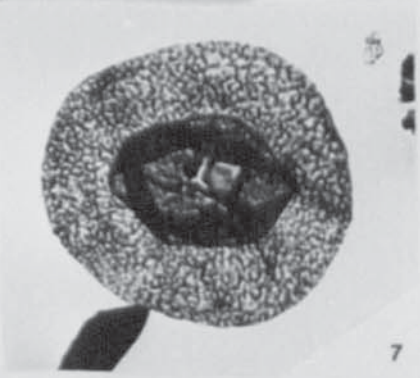
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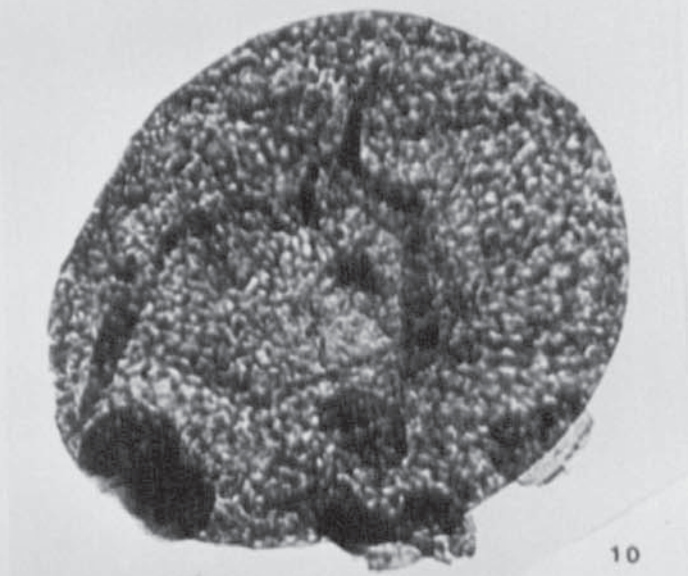
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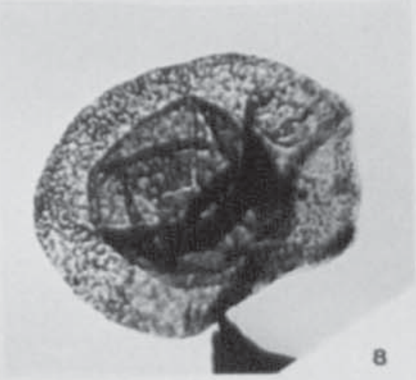
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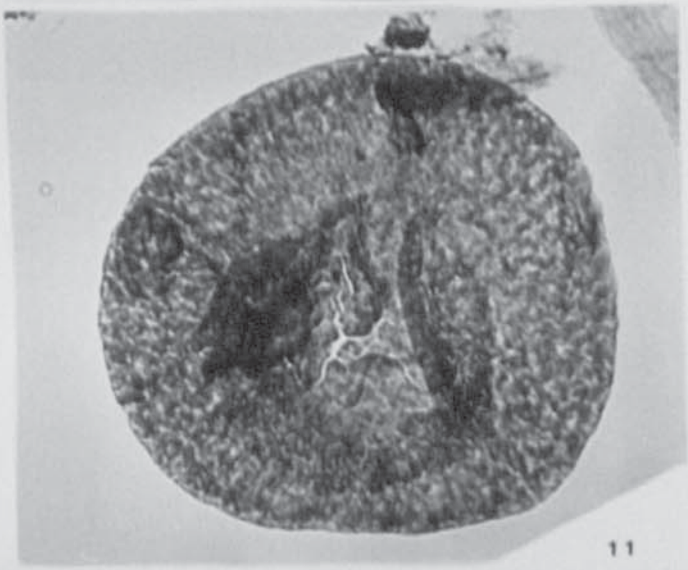
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PLATE 31

Fig. 1. *Paleospora fragila* Habib; C5/21, 70/3.5.

Fig. 2. *P. fragila*; C5/27, 68.8/10.9.

Fig. 3. *P. fragila*; C5/14, 77.4/24.4.

Fig. 4. *P. fragila*; C5/10, 75.5/11.1.

Fig. 5. *Schopfipollenites ellipsoides* (Ibrahim) Potonie and Kremp; 797/5, 65.5/9.4.

Fig. 6. *Pityosporites westphalensis* Williams; 800/1, 59.8/10.5.

Fig. 7/8. *P. westphalensis*; 234/2, 71.9/4.4, Fig. 8 - X 1000.

Fig. 9. *P. westphalensis*; H.541/2, -/-.

Fig. 10. *P. westphalensis*; H.541/1, 66.4/7.4.

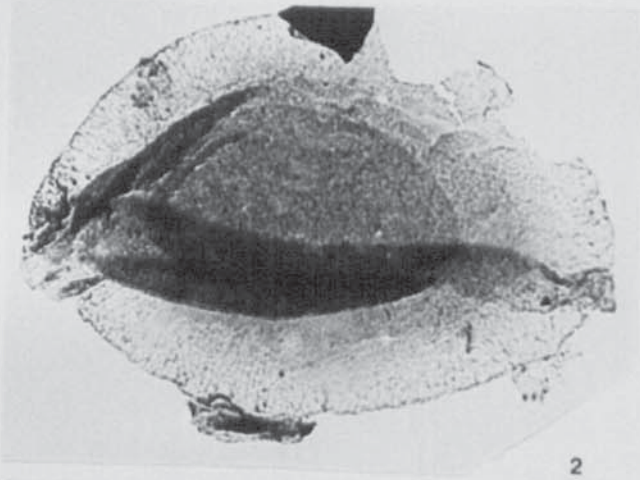
Fig. 11. *P. westphalensis*; H.541/2, -/-.

Fig. 12. *Florinites junior* Potonie and Kremp; P71/2, 77.4/12.3.

Fig. 13. *F. mediapudens* (Loose) Potonie and Kremp; 797/2, 73/10.4.

PLATE 31


1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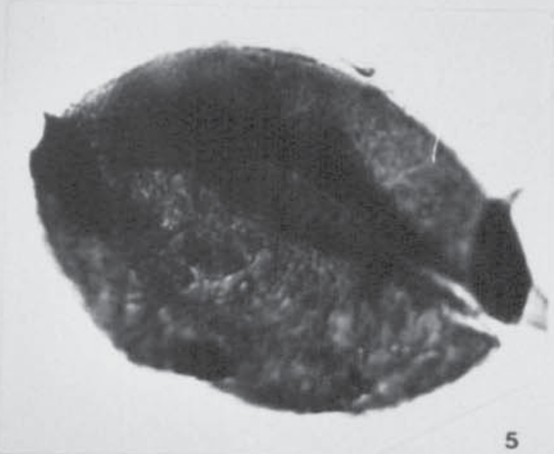
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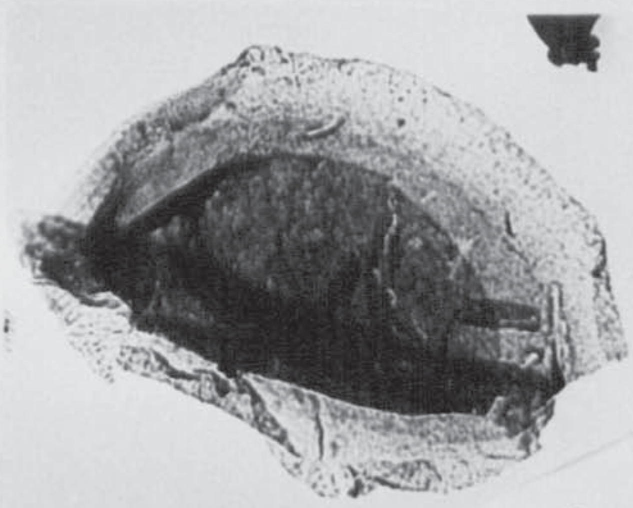
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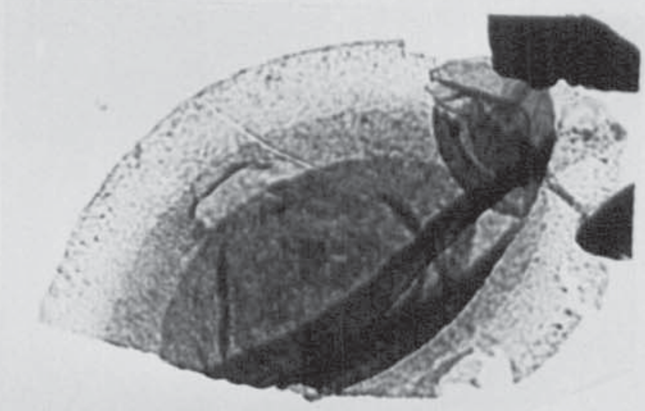
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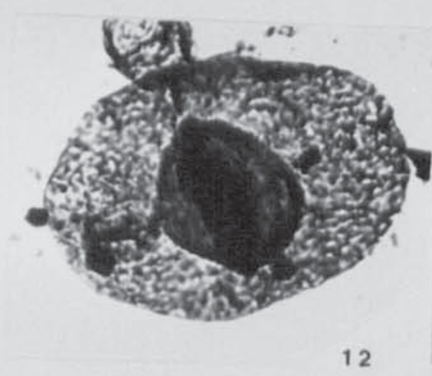
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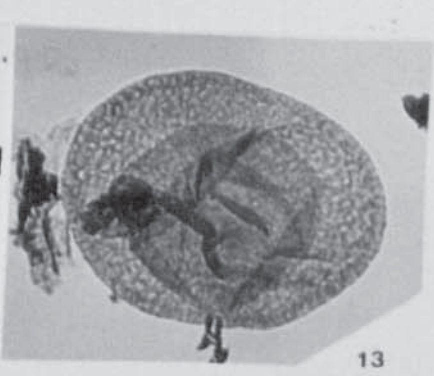
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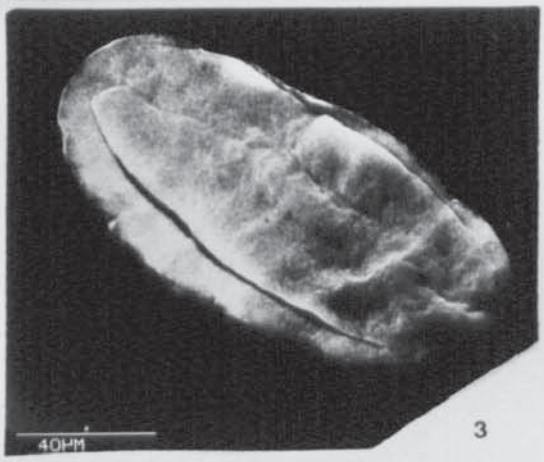
PLATE 32

Fig. 1.	*Potonieisporites elegans* (Wilson and Kosanke) Habib; 797/8, 76.2/23.
Fig. 2.	*P. elegans*; C5/17, 74.6/15.6.
Fig. 3.	*Schopfipollenites ellipsoides var.corporeus* Neves; SEM. Preparation 797.
Fig. 4.	*S. ellipsoides var. corporeus*; 132/2, 60/5.8.
Fig. 5.	*S. ellipsoides var. corporeus*; equatorial view, 797/6, 71.8/17.8.
Fig. 6.	*S. ellipsoides var. corporeus*; H.543/2, 76.7/21.7.

PLATE 32


1


2



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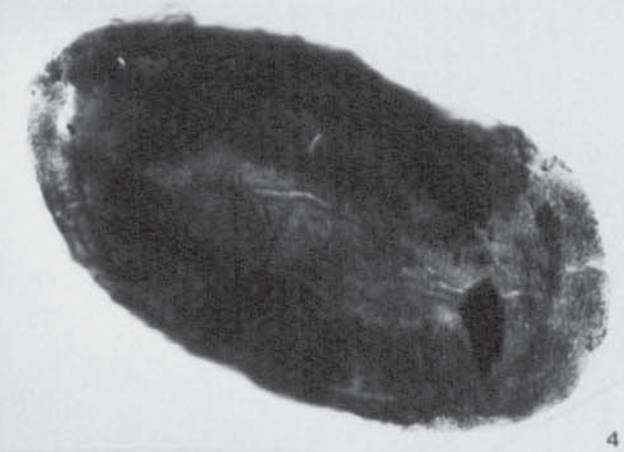
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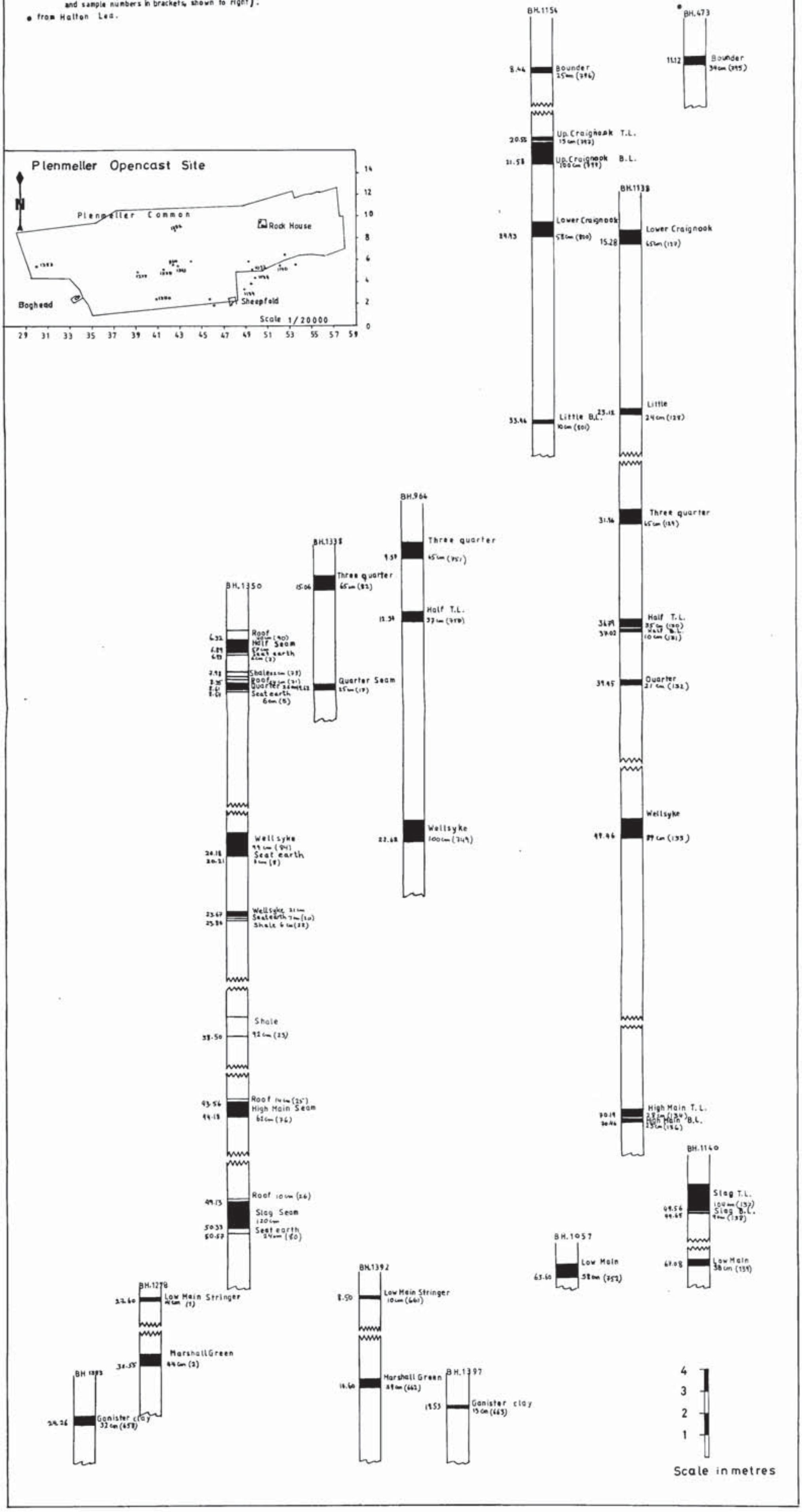
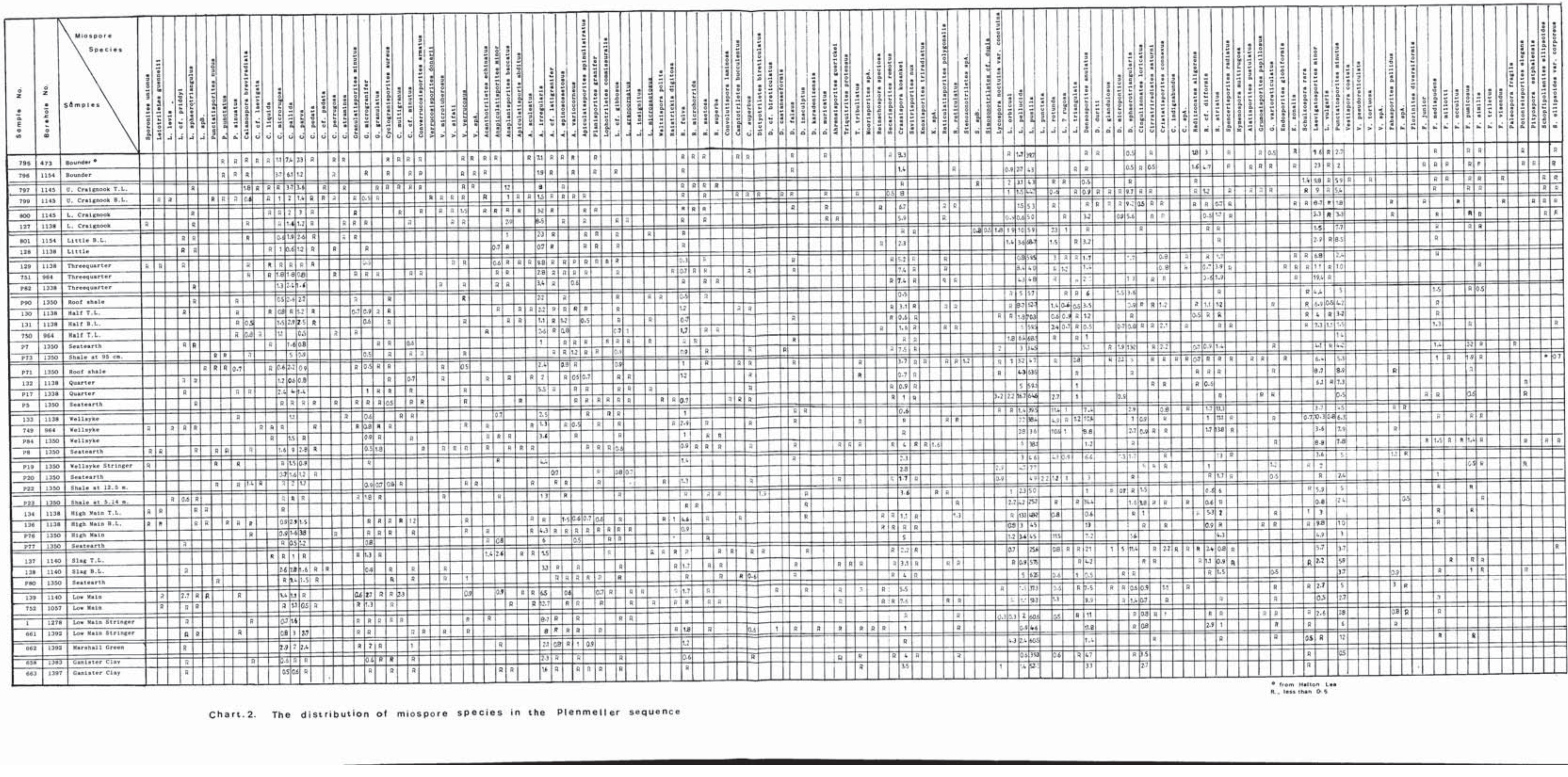
Fig. 13. PLENMELLER BOREHOLES

(Sample depth shown to left in metres; sample thicknesses in centimetres, and sample numbers in brackets, shown to right).

• from Halton Lea.





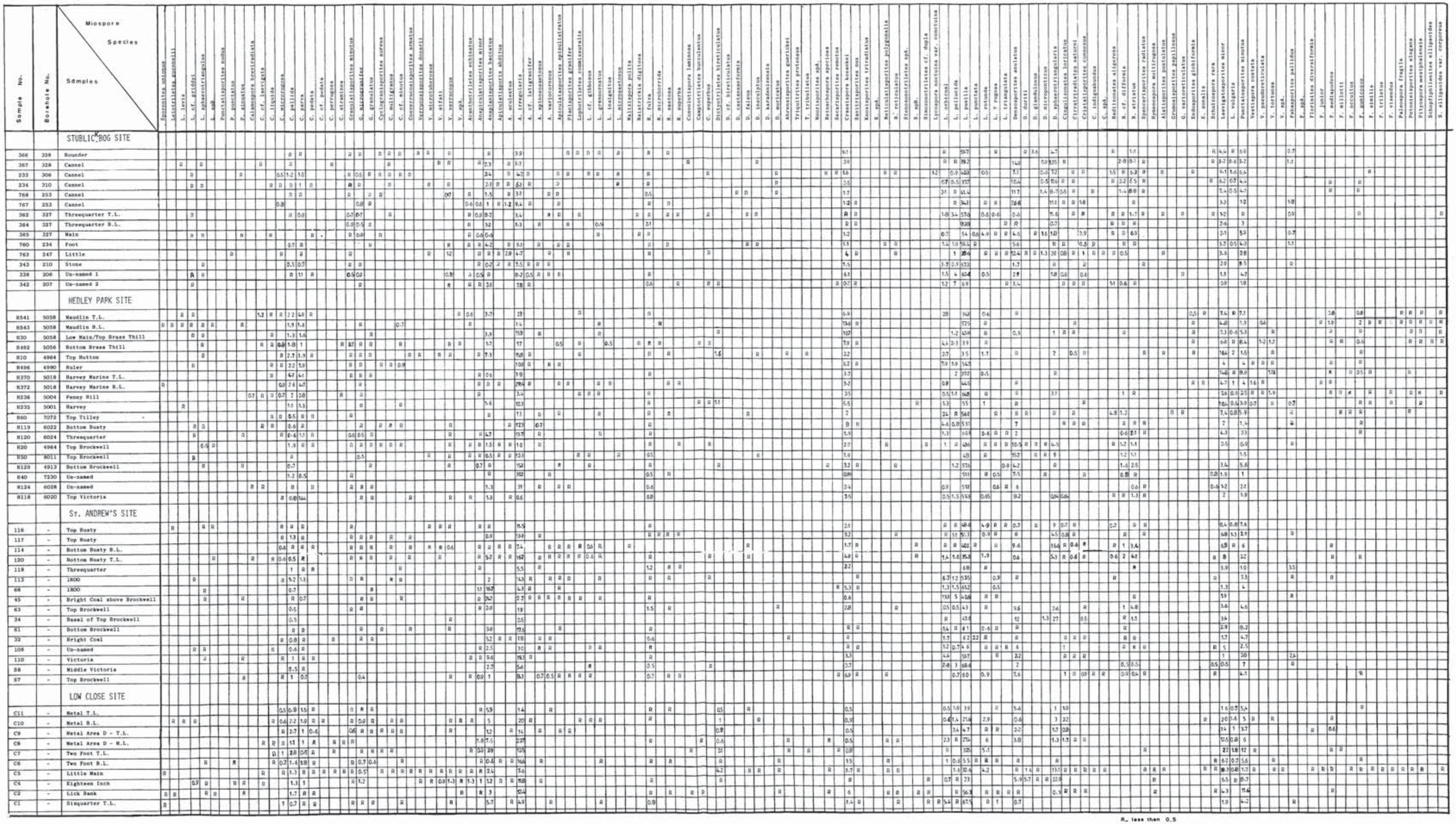
Sample No.	Borehole No.	Samples
795	473	Bounder *
796	1154	Bounder
797	1145	U. Craignook T.L.
799	1145	U. Craignook B.L.
800	1145	L. Craignook
127	1138	L. Craignook
801	1154	Little B.L.
128	1138	Little
129	1138	Threequarter
751	964	Threequarter
P82	1338	Threequarter
P90	1350	Roof shale
130	1138	Half T.L.
131	1138	Half B.L.
750	964	Half T.L.
P7	1350	Seatearth
P73	1350	Shale at 95 cm.
P71	1350	Roof shale
132	1138	Quarter
P17	1338	Quarter
P5	1350	Seatearth
133	1138	Wellsyke
749	964	Wellsyke
P84	1350	Wellsyke
P8	1350	Seatearth
P19	1350	Wellsyke Stringer
P20	1350	Seatearth
P22	1350	Shale at 12.5 m.
P23	1350	Shale at 5.14 m.
134	1138	High Main T.L.
136	1138	High Main B.L.
P76	1350	High Main
P77	1350	Seatearth
137	1140	Slag T.L.
138	1140	Slag B.L.
P80	1350	Seatearth
139	1140	Low Main
752	1057	Low Main
1	1278	Low Main Stringer
661	1392	Low Main Stringer
662	1392	Marshall Green
658	1383	Ganister Clay
663	1397	Ganister Clay

Miospore Species

Sporonites unionus
Leiotriletes guennelii
L. levis
L. cf. priddyi
L. sphaerotriangulus
L. spB.
Punctatisporites nudus
P. punctatus
P. sinuatus
Calamospora breviradiata
C. cf. laevigata
C. liquida
C. microrugosa
C. pallida
C. parva
C. pedata
C. cf. pedata
C. perrugosa
C. straminea
Granulatisporites minutus
G. microgranifer
G. granulatus
Cyclogranisporites aureus
C. multigranus
C. cf. minutus
Converrucosisporites armatus
Verrucosisporites donarii
V. microtuberosus
V. sifati
V. verrucosus
V. spA.
Acanthotriletes echinatus
Anapiculatisporites minor
Anaplanisporites baccatus
Apiculatisporis abditus
A. aculeatus
A. irregularis
A. cf. latigranifer
A. spinososaetosus
A. variocorneus
Apiculatasporites spinulistratus
Planisporites granifer
Lophotriletes commissuralis
L. cf. gibbosus
L. granoornatus
L. insignitus
L. microsaetosus
Waltzispora polita
Raistrickia digitosa
R. fulva
R. microhorrida
R. saetosa
R. superba
Convolutispora laminosa
Camptotriletes bucculentus
C. superbus
Dictyotriletes bireticulatus
D. cf. bireticulatus
D. castaneaeformis
D. falsus
D. inaculptus
D. karadenizensis
D. muricatus
Ahrensisporites guerickei
Triquitrites protensus
T. tribullatus
Mooreisporites spA.
Reinschospora speciosa
Secarisporites remotus
Crassispora kosankei
Savitrisporites nux
Knoxisporites triradiatus
K. spA.
Reticulatisporites polygonalis
R. reticulatus
Stenozonotriletes spA.
S. spB.
Simozonotriletes cf. dupla
Lycospora noctuina var. conctuina
L. orbicual
L. pellucida
L. pusilla
L. punctata
L. rotunda
L. ? rugosa
L. triangulata
Densosporites anulatus
D. duritii
D. glandulosus
D. micropunticus
D. sphaerotriangularis
Cingulizonates loricatus
Cirratriradiates saturni
Cristatisporites connexus
C. indignabundus
C. spA.
Radiizonates aligerens
R. cf. difformis
R. striatus
Spencerisporites radiatus
Hymenospora multirugosa
Alatisporites pustulatus
Grumosisporites papillosus
G. varioreticulatus
Endosporites globiformis
E. zonalis
Schulzospora rara
Laevigatosporites minor
L. vulgaris
Punctatosporites minutus
Vestispora costata
V. pseudoreticulata
V. tortuosa
V. spA.
Fabasporites pallidus
F. spA.
Florinites diversiformis
F. junior
F. mediapudens
F. millotti
F. occultus
F. pumicosus
F. similis
F. triletus
F. visendus
Paleospora fragila
Potonieisporites elegans
Pityosporites westphalensis
Schopfipollenites ellipsoides
S. ellipsoides var. corporeus

* from Hatton Lee
R., less than 0.5

Chart.2. The distribution of miospore species in the Plenmeller sequence



Sample No.	Borehole No.	Samples
		STUBLIC BOG SITE
366	328	Bounder
367	328	Cannel
233	306	Cannel
234	310	Cannel
768	253	Cannel
767	253	Cannel
362	327	Threequarter T.L.
364	327	Threequarter B.L.
365	327	Main
760	234	Foot
763	247	Little
343	210	Stone
338	206	Un-named 1
342	207	Un-named 2
		HEDLEY PARK SITE
H541	5058	Maudlin T.L.
H543	5058	Maudlin B.L.
H30	5058	Low Main/Top Brass Thill
H492	5056	Bottom Brass Thill
H10	4964	Top Hutton
H496	4990	Ruler
H370	5018	Harvey Marine T.L.
H372	5018	Harvey Marine B.L.
H236	5004	Penny Hill
H235	5001	Harvey
H60	7072	Top Tilley
H119	6022	Bottom Busty
H120	6024	Threequarter
H20	4964	Top Brockwell
H50	8011	Top Brockwell
H129	4913	Bottom Brockwell
H40	7230	Un-named
H124	6028	Un-named
H118	6020	Top Victoria
		ST. ANDREW'S SITE
116	-	Top Busty
117	-	Top Busty
114	-	Bottom Busty B.L.
120	-	Bottom Busty T.L.
118	-	Threequarter
113	-	1800
68	-	1800
45	-	Bright Coal above Brockwell
63	-	Top Brockwell
34	-	Basal of Top Brockwell
61	-	Bottom Brockwell
32	-	Bright Coal
108	-	Un-named
110	-	Victoria
58	-	Middle Victoria
57	-	Top Brockwell
		LOW CLOSE SITE
C11	-	Metal T.L.
C10	-	Metal B.L.
C9	-	Metal Area D - T.L.
C8	-	Metal Area D - M.L.
C7	-	Two Foot T.L.
C6	-	Two Foot B.L.
C5	-	Little Main
C4	-	Eighteen Inch
C2	-	Lick Bank
C1	-	Sixquarter T.L.

R_ less than 0.5

Chart.3. The distribution of miospore species in the Stublick, St. Andrew's, Hedley Park and Low Close Sites