Carboniferous miospore distributions in Cumberland with special reference to those in the Hensingham Group

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SUMMARY

Miospore assemblages are described from the Basement Beds, the Chief Limestone Group, the Hensingham Group, and the lower part of the Lower Coal Measures in the area around Cockermouth, north-west Cumberland. The Basement Beds are considered to be of Upper Tournaisian age. Strata in the Hensingham Group consist of alternating shales and sandstones, ten sandstones being recognised. The lower and upper parts of the Hensingham Group are considered to be comparable in age to Lower and Upper Eumorphoceras stage (E_1 and E_2) respectively elsewhere. Evidence is considered to exist in support of a non-sequence at the top of the Hensingham Group probably excluding the Homoceras, Reticuloceras and Lower Gastrioceras stages (H, R_1 and G_1). The Lower Carboniferous assemblages are compared with the spore Concurrent Range Zones of Neves et al. (1972), and comparisons are made with the spore distributions described by other workers in Britain and elsewhere.

One new species, *Densosporites horridus*, is proposed, and eleven new types are described:- *Punctatisporites* sp.A, *Calamospora* sp.A, *Muraspora* sp.A, *Lophozonotriletes* sp.A, *Stenozonotriletes* sp.A, *Colatisporites* sp.A, *C*. cf. *decorus*, *Discernisporites* cf. *micromanifestus*, *D*. cf. *irregularis*, *Schopfites* cf. *claviger*, and Species type A.

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CHAPTER ONE

1.0.0. Introduction

The area studied lies on the northern flanks of the English Lake District, between Aspatria and Cockermouth in the west and Hesket Newmarket in the east. It is almost covered by the Cockermouth (23) Geological Survey one-inch map.

The area generally consists of three major groups of strata, each having an approximate east-west strike. Northerly dipping Ordovician strata in the south form the northern limb of the Lake District dome and are succeeded unconformably by Lower and then Upper Carboniferous sediments, also dipping to the north and forming the southern margin of the Cumberland Coalfield. The Upper Coal Measures are succeeded unconformably by the Permo-Trias red beds in the northern part of the area (see map 1).

The aim of this study was to investigate the palynology of the Carboniferous sediments in the area. They crop out in an east-west tract of gently rolling country separating the more rugged terrain of the Lower Palaeozoics to the south from the Permo-Trias plain of the Solway Firth to the north. The strata dip generally to the north and are only gently folded but much disturbed by faulting. A series of north-westerly trending faults is truncated against several large east-west faults. Drift cover is more or less continuous on the low-lying ground occupied by younger strata. Outcrop material however is adequate and is confined for the most part to quarries and stream sections. Most of the streams flow northwards to the River Ellen which flows westwards across the northern part of the area, or eastwards to the River Caldew which flows in a north-easterly direction.

The basal beds of the Carboniferous are macroclastic and are overlain by about a hundred metres of the Cockermouth lavas. The Chief Limestone Group (Eastwood et al. 1968) above this horizon is divided into seven limestones with intervening strata, the limestones being numbered from one to seven in descending order. The Fourth Limestone consists of seven limestone bands separated by shales. The Hensingham Group, the local representative of the Millstone Grit Series, lies above the horizon of the First Limestone. These strata consist of alternating shales and thin sandstones over a basal grit. The Group also contains two thin limestones and two thin coals. Coals are more prominent in the succeeding Lower Coal Measures which also has a grit as its base. Details of this succession and its various subdivisions are shown in Table 1.

The first detailed description of the Carboniferous rocks of the area was published in the Cockermouth Memoir (Eastwood et al. loc cit). Earlier work in the West Cumberland iron ore field to the west and the lead, zinc and copper field to the east led to the establishment of the lithological subdivisions noted above. Macrofossils are fairly abundant in the sequence but diagnostic forms tend to be absent so that correlation with other regions in Britain is not always easy. Correlation of the lower part of the sequence was accomplished by comparisons with Vaughan's classical studies on coral-brachiopod faunas in the South-West Province, and, more particularly, with Garwood's (1913) work with similar faunas in the north-west of England. Goniatites are particularly scarce in the Hensingham Group but the presence of two or three diagnostic species has enabled correlations to be made with Bisat's zonal sequence further south. The presence of non-marine bivalves and plants in the Coal Measures have made detailed correlations possible, following the schemes of Trueman and Kidston respectively. Conclusions drawn by earlier workers from the distribution of various macrofaunas are included in Table 1. More detailed references are given in chapter 2.

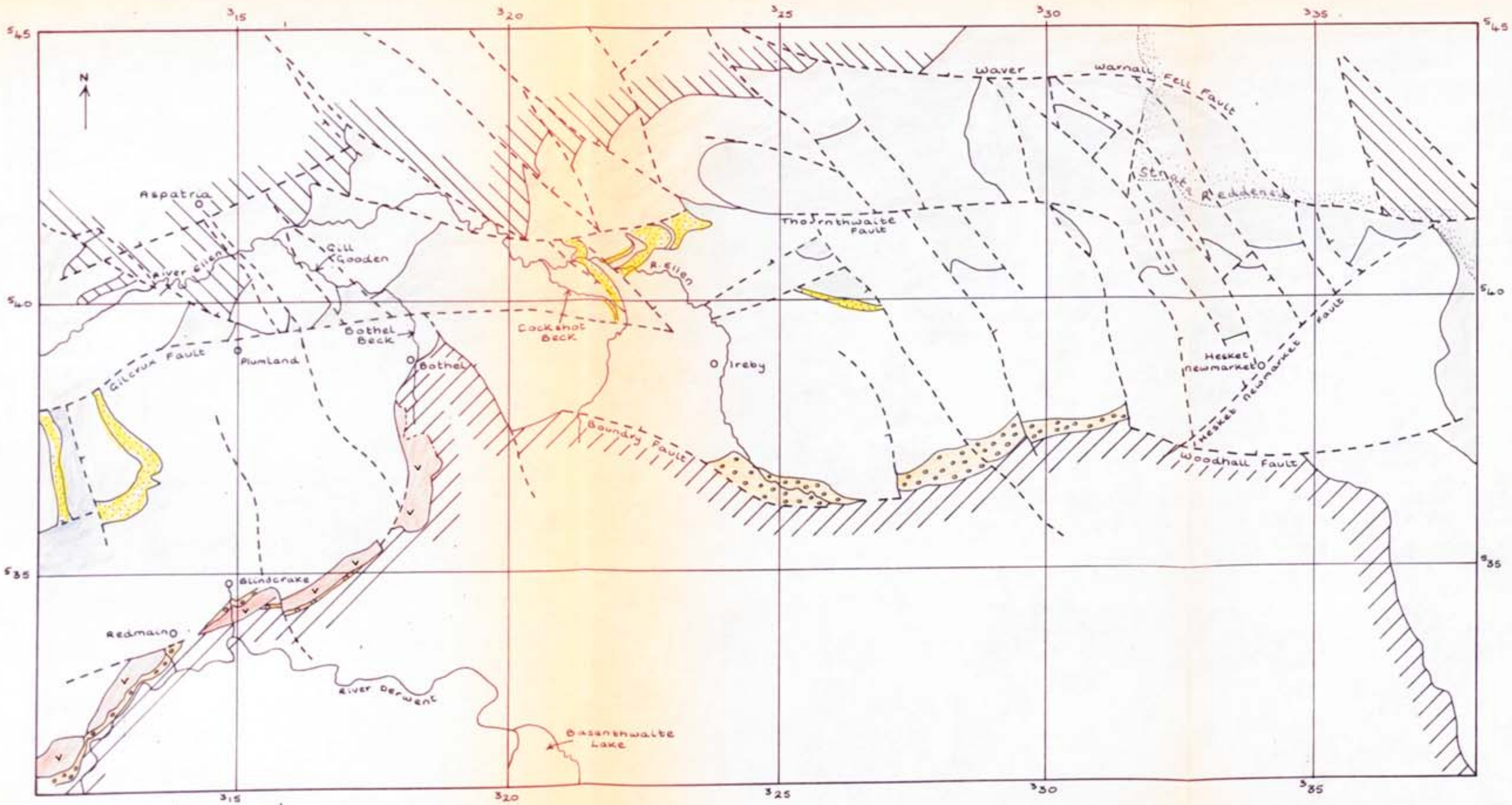
The major aims of the present study are as follows:-

1) To determine the distributions of fossil palynomorphs throughout the Carboniferous sequence with the exception of the Middle Coal Measures which were covered by Smith and Butterworth (1967).

2) More particularly, to obtain palynological evidence of the age of the Hensingham Group and its upward passage into the Lower Coal Measures. At present this part of the sequence is only loosely correlated on the evidence of scanty macrofossils.

3) To determine, palynologically, the age of the Basement Beds.

4) To compare the assembled information with that of similar horizons elsewhere which have been investigated by other workers.



Map of Basic Carboniferous geology in the area around Cockermouth.
Based on 1" = 1 mile Geological Survey of Great Britain map Sheet. 23

Legend

- Post Lower and middle Coal Measure strata
- Lower and middle Coal Measure strata
- Hensingham Group strata
- Hensingham Grit
- Chief Limestone Group
- Basement beds
- Cockermouth volcanics
- Pre Carboniferous strata
- Lithological boundaries
- Faults, tick on downthrow side

Scale

1" = 1 mile

N.B.

Much of the detail has been omitted for clarity.

TABLE 1 Carboniferous succession in the Cockermouth area according to Eastwood et al. 1968.
See text for full explanation.

Westphalian	Upper Coal Measures	NB	Red and purple sandstones and Shales
	Lower Coal Measures	WA	Shales and sandstones with workable coals and fire clays, reddened in places
		?	A. lenisulcata and C. communis zones missing to the East
non sequence			
Namurian			H, R, + G_1 stages missing
	Millstone Grit Series (Hensingham group)	E_2	Sandstones and grits with subordinate Limestone bands and occasional thin coals, reddened in places
		?	
	non sequence		E_1 stage probably missing
Visean	Lower Carboniferous (Upper Chief Limestone Group)	D_2	Limestones with subordinate sandstones and shales and a few thin coals
		D_1	
	(Lower Chief Limestone Group)	S_2	
	(Cockermouth Lavas)		Basaltic Lavas
?	(Basement beds)	?	Conglomerates with bands of shale

CHAPTER TWO

2.0.0. Details of the Carboniferous sequence in the area

2.1.0. Structure (See Map 1)

The dips are generally shallow, varying from 10 to 15 degrees and from a north-west direction in the west to a north-east direction in the east. The sediments are gently folded but only three of the folds are relevant to the present study:-
the Carboniferous Limestone around Plumbland in the western part of the area forms the eastern part of a faulted, westerly plunging syncline; the shallow Fauld's Brow syncline in the central part of the area trends east-west and plunges at about 12 degrees to the west, disappearing into gently dipping strata; and a very shallow syncline, trending north-south, occurs to the east of Hesket Newmarket, in the extreme eastern part of the area.

Two main sets of faults occur in the area, trending east and north-west. A third minor set of faults have a north-north-west component and some of the east trending faults have east-south-east and east-north-east components. To the north-west of the Hesket Newmarket Fault the north-north-west faults are generally dip faults and the east-north-east faults are strike faults, whereas south east of the Hesket Newmarket fault the north-west faults are strike faults and the easterly faults are dip faults (See Map 1). The resulting structure is a complex arrangement of blocks of Carboniferous strata. However the continuity of the relevant strata is not seriously disrupted. Wherever possible the sections sampled were sited in blocks where a continuous succession occurred across major rock boundaries.

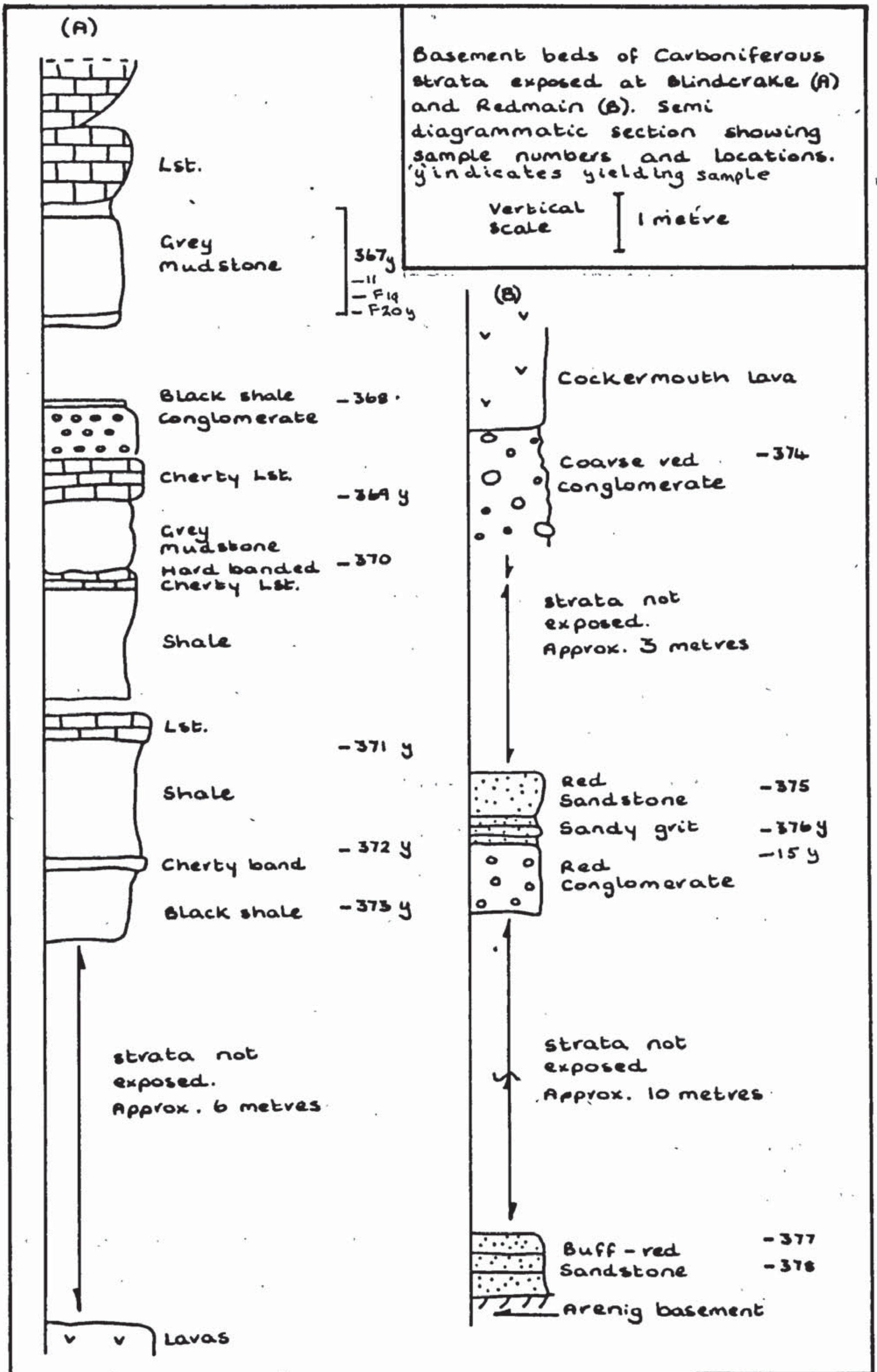
2.2.0. Basement beds.

The basal strata lie with marked unconformity on Ordovician rocks, on the Skiddaw slates in the Cockermouth area and on the Borrowdale Volcanic series further east. If Silurian and Devonian sediments were deposited on the Ordovician basement they must have been eroded prior to the Carboniferous transgressions (Eastwood et al. 1968). Carboniferous sedimentation began earlier in the Northumberland trough to the north, and in that area and further east of the Cockermouth area the basal Carboniferous strata (Tournaisian) reaches considerable thickness. The conglomerates, termed Polygenetic Conglomerates of Mell Fell are much thicker and may be considerably older, even Devonian in age (Eastwood et al. 1968).

The Basement beds reach a thickness of about 35 metres in the area. The strata consist of macro-clastic conglomeratic layers with large pebbles, less coarse conglomerates, shale partings, and towards the upper part interbedded cherts and thin limestones. The Cockermouth lavas occur above the lower, more conglomeratic layers. The lavas are variable in thickness reaching a maximum of 100 metres (Taylor et al. 1971). Above the lavas occur the thin sequence of cherty limestones, which are exposed at Blindcrake as described below.

Two sections provided an almost complete succession at Redmain (137337) in Tommy gill and at Blindcrake in Gill Yeat (14943456). The Cockermouth lavas form the base of the latter stream section and the top of the former. At Redmain the unconformable base of the beds is clearly seen, and at Blindcrake the passage into the overlying Seventh Limestone is exposed. The Basement beds have been taken here to include those strata passing into the base of the Seventh Limestone and not only the conglomeratic layers below the Cockermouth lavas.

To date no fossil evidence for the relative age of these rocks has been found. Their age has been assumed to be Visean, by association with



Basement beds of Carboniferous strata exposed at Blindcrake (A) and Redmain (B). Semi diagrammatic section showing sample numbers and locations. 'y' indicates yielding sample

FIG. 1

the overlying Seventh Limestone, which has been placed in the Nematophyllum minus zone (S2) (Eastwood et al. 1968). Fig. 1 shows the succession of these rocks together with sampling details.

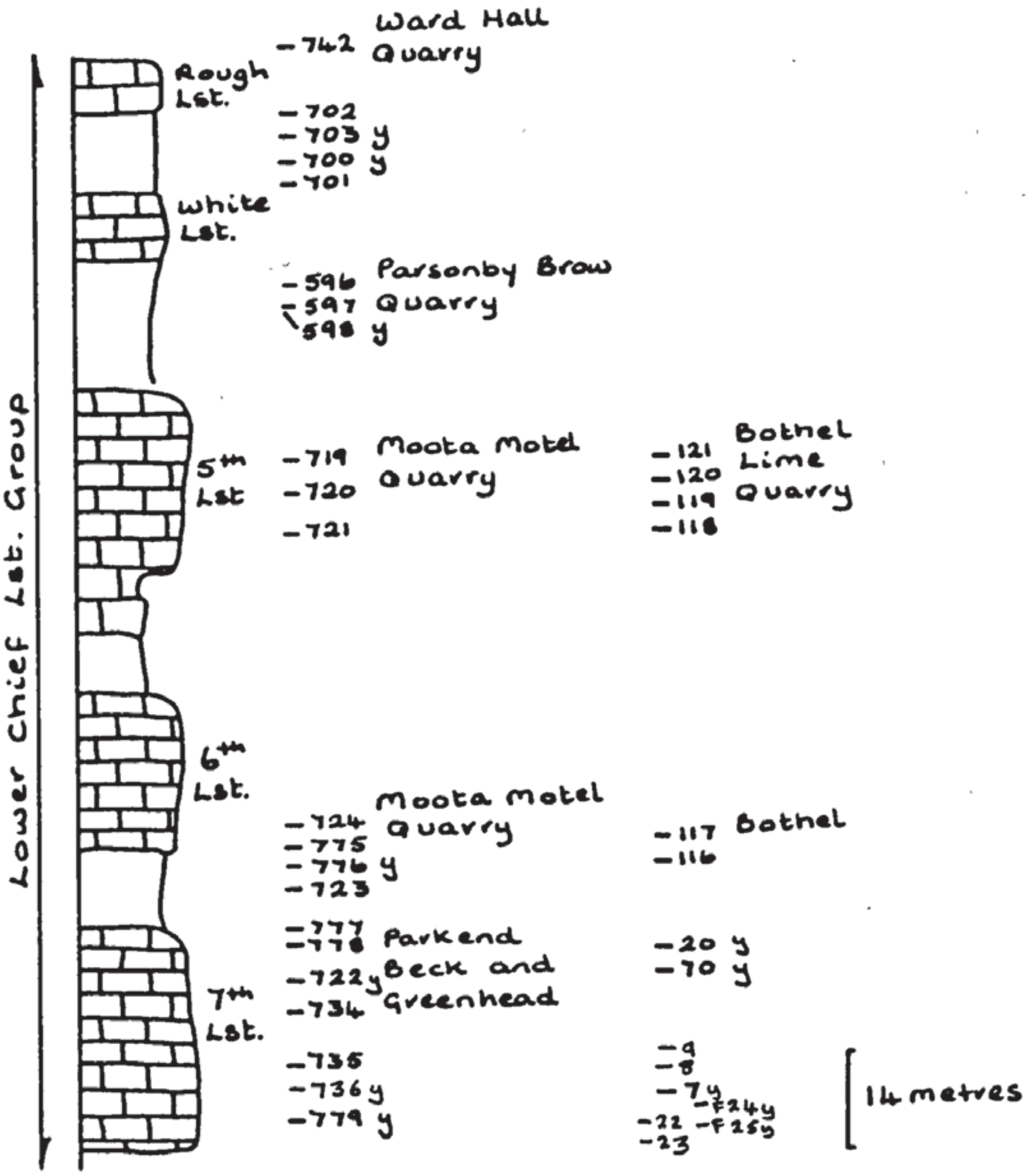
As mentioned above these strata are not regarded as being as old as the basement conglomerates in surrounding regions. The basement conglomerates in the Ravenstonedale area including the Pinksey Gill Beds are considered to be Tournaisian in age. Taylor et al. (1971). No definite age for the Basement conglomerates at Roman Fell both north and south of the Swindale Beck fault was given by Burgess and Harrison (1970) excepting that they must be older than the overlying Roman Fell sandstones given as C1 in age.

According to Taylor et al. (1971) the basal conglomerates of the Isle of Man are of C2,S1 age. The Mell Fell conglomerates to the south east of the present area underlie much older Carboniferous rocks and are much thicker deposits (Eastwood et al. loc cit.). The lower beds of north Cumberland are Tournaisian in age. They attain 500 to 700 metres in thickness and include the Main Algal Beds, Bewcastle Beds and the Lynebank Beds which together constitute part of the Lower Border Group (Taylor et al. 1971). The Cementstone Group represents the lowest Carboniferous rocks further to the north east and this group is considered to be Tournaisian in age and has conglomerates at its base. (Taylor et al. loc cit.)

2.3.0. The Chief Limestone group

In the western part of the area the whole of this group, from the Seventh to the First Limestone, is dominated by massive limestones. In the central and eastern parts however the upper section of the group is composed of alternating limestones, shales and a noteable sandstone.

2.3.1. Lower chief Limestone group



Diagrammatic lithostratigraphic column of the Lower Chief Limestone Group, indicating sample locations and horizons. For full explanation see text.
'y' indicates yielding sample.

FIG. 2a

The Lower Chief Limestone group includes the Seventh, Sixth, Fifth, and the basal two limestone bands of the Fourth limestone.

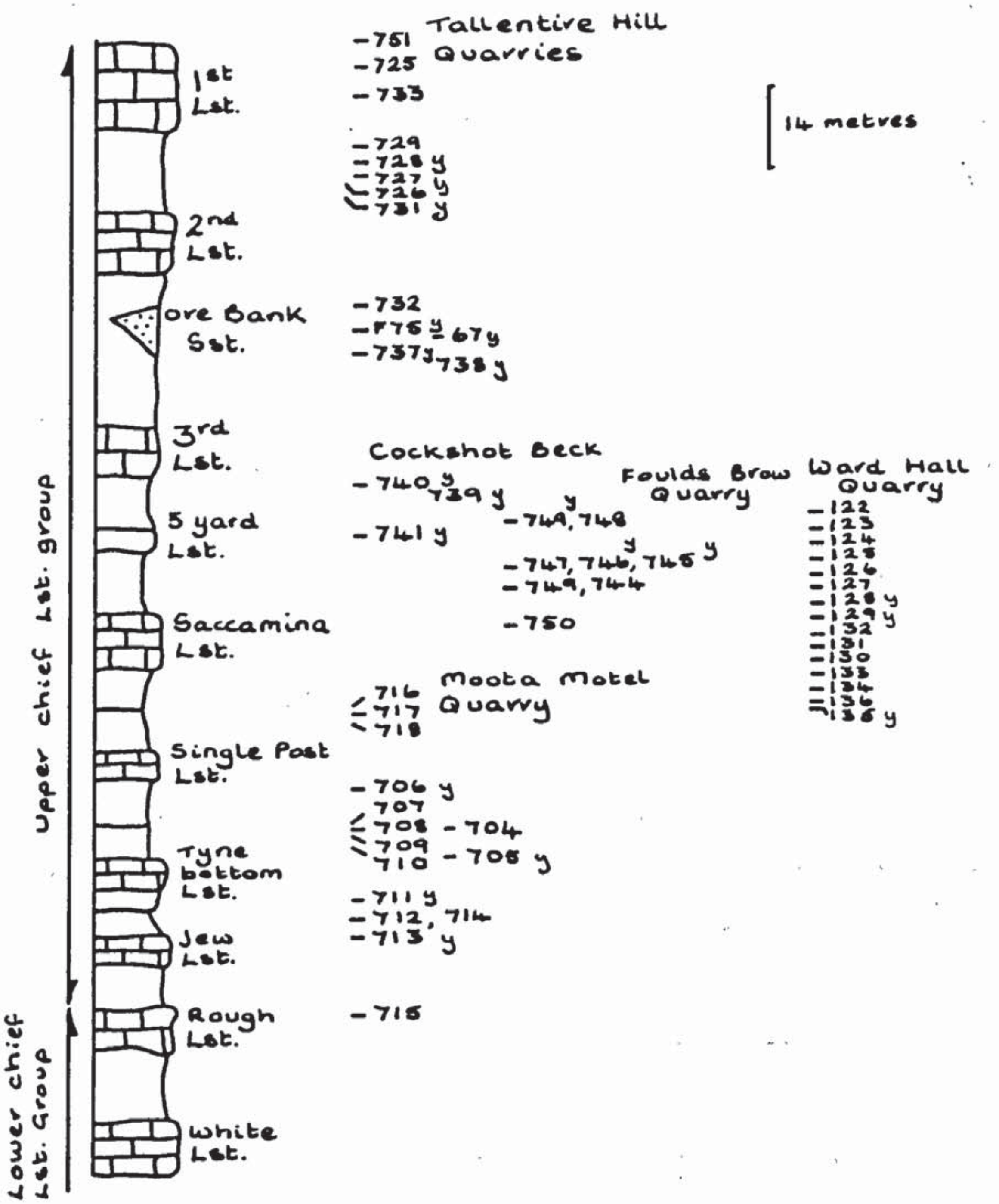
The Seventh Limestone contains conglomeratic bands at its base, representing a continuation of the coarse sedimentation of the Basement beds. In the region of Blindcrake the passage into the Seventh Limestone is less clearly marked than further west where there is a more sudden occurence of massive limestone. Taken generally the Seventh Limestone is a massive shallow water deposit which includes crinoidal limestones, and attains a total thickness of between 55 and 100 metres.

Above this there occurs a thin band of shales only a few metres in thickness and reportedly containing a coal seam (Eastwood et al. loc cit.) The Sixth Limestone is thinner, approximately 30 metres generally. It is a massive rock but like the Seventh does contain some thin calcareous shale partings.

Shales in these strata were sampled at Setra Hill Quarry (170365) in the Seventh Limestone; at a small exposure at Greenhead (283373) and in nearby Parkend Beck in the Seventh Limestone and overlying shales, and at a small quarry near Bothel (17803840) at the base of the Sixth Limestone.

The Sixth and Fifth Limestones are separated by shales no exposure of which was found. The Fifth Limestone consists of a lower minor limestone and an upper, massive, thicker one, separated by shale partings according to Eastwood et al. loc cit., totalling an approximate thickness of 20 to 35 metres.

Shales in the latter limestone were sampled at Limestone Kiln Quarry Bothel (175390) and in one of a series of new quarries near Moota Motel (157365).



Diagrammatic lithostratigraphic column of the Upper Chief Limestone Group indicating sample locations and horizons. For full explanation see text. 'y' indicates yielding sample.

FIG. 2b

Above the Fifth Limestone a series of shales occurs followed by the White and Rough Limestones also separated by shales; these two thin limestones form the base of the Fourth Limestone. Above the Rough Limestone the sequence is recognised as being in the Upper Chief Limestone Group.

The upper part of the Lower Chief Limestone Group was sampled at various localities including old limestone quarries at Parsonby Brow (142382) Quarries near Moota Motel (157365) and the East Quarry of Ward Hall Quarries (14003815).

2.3.2. Upper Chief Limestone Group

To the east of the area the Fourth Limestone marks the commencement of a rhythmic sequence of alternating shales and limestones. There is lateral variation of the separate limestone bands within the Fourth Limestone. However the most useful way to approach this sequence is to use the local names of each limestone band (Eastwood et.al.loc.cit.)

Following the Rough Limestone are the Spotted Beds, a mixture of shales and sandstones up to 17 metres thick. At Cockermouth these beds are very much reduced in thickness to approximately 3.5 metres and include cherts and limestones. The succeeding Jew Limestone is not evident at Cockermouth but occurs as a 10 metre limestone in surrounding areas.

The succeeding beds are together called the Saccamina Beds at Cockermouth. However, further east they are more typically separated into individual limestone horizons, the Tyne Bottom and Single Post Limestones 15 and 5 metres thick respectively.

Thin coals are mentioned in the Cockermouth memoir above the Saccamina Beds at Cockermouth and above the Single Post Limestone at Gilcrux. A thin coal was sampled in the present study in the Moota Motel Quarry and has been placed between the Jew Limestone and the Tyne Bottom Limestone. In the shales between the latter and the Single Post Limestone a second coal seam was also sampled in the rocks exposed in the series of quarries near Moota Motel. Here above the Single Post Limestone a sequence of shales occurs in which a third thin coal was recorded. The overlying Scar or Junceum Limestone varies in thickness over the area and is considered in some places by Eastwood et al. (loc. cit.) to be equivalent to the Five Yard Limestone. This is a thinner bed usually separated from the top of the Scar Limestone by shales. For the purpose of the present study the Scar and Five Yard Limestones are considered as being separate.

The Fourth Limestone was sampled at various places including the series of Quarries near the Moota Motel (157365); Parsonby Brow Quarry (142382); Faulds Brow Hill Quarry (305408) and Ward Hall Quarries (135385).

There then follows a series of shales and sandstones usually not greater than 5 metres thick over which the Third or Three Yard Limestone lies. According to Eastwood et al. this Limestone is of local importance only, particularly around Gilcrux. The Third Limestone would generally appear to be about 10 metres thick. Above this occurs a series of shales with a thick sandstone. The Orebank Sandstone Group; this reaches a maximum thickness of 65 metres, again in the Gilcrux region, elsewhere it is thinner but retains its essential characteristics of shales and yellow iron rich sandstones and grits.

The Second or Four Fathom Limestone which overlies the Orebank Sandstone is a dark Limestone of about 10 metres thickness and is followed by the First or Great Limestone separated by about 10 metres of shales.

The Third Limestone and overlying strata in the Upper Chief Limestone Group were sampled at Bothel (17103810), Tallentire Hill Quarries (357120) and the immediately surrounding area, at Snittlegarth in Cockshot Beck (220393). The shales immediately over the First Limestone were sampled at a large new Quarry at Warnell Fell (342408).

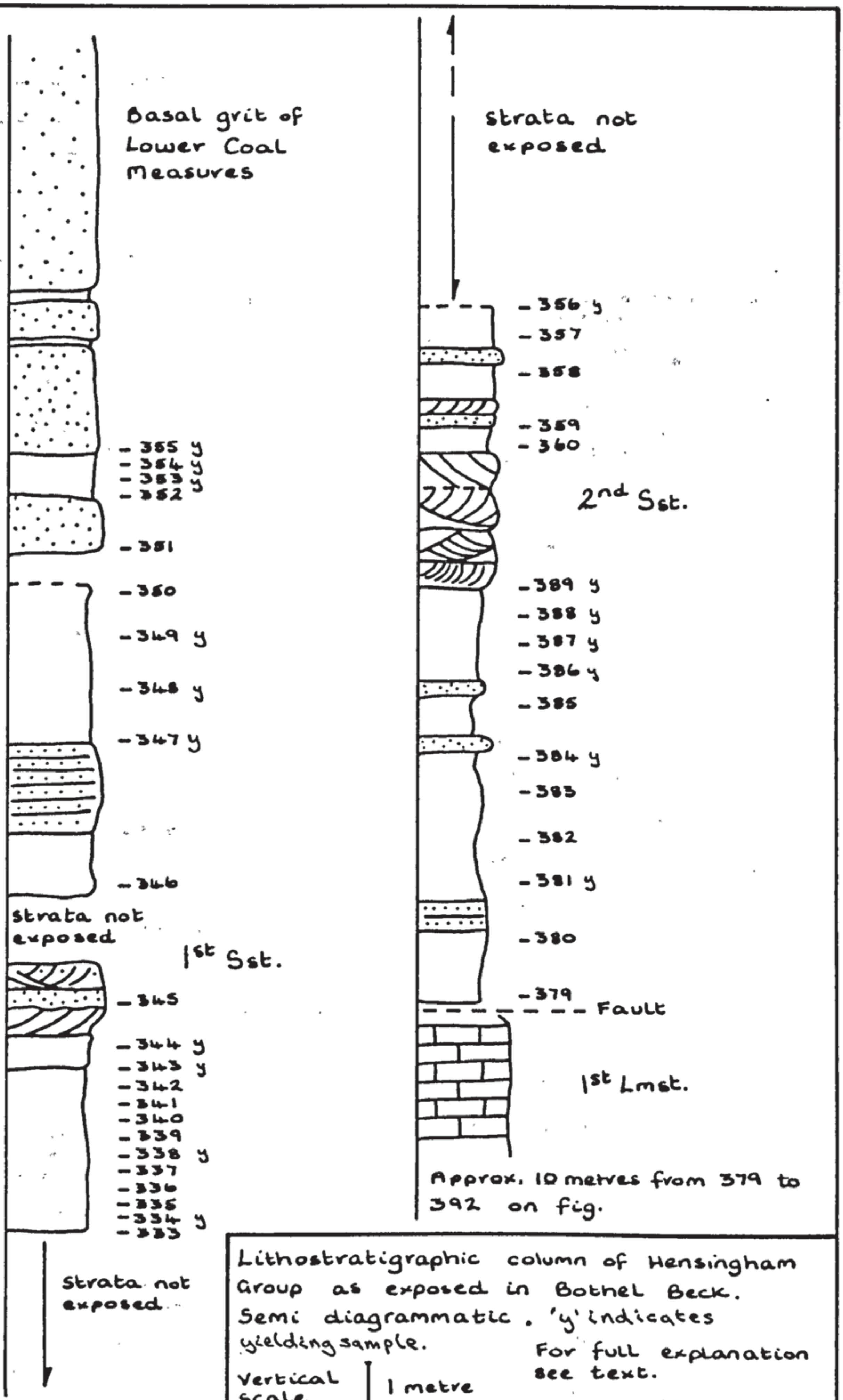
The whole of the Chief Limestone Group is illustrated in fig. 2 which provides a schematic picture of the succession and includes sampling details. As can be seen from fig. 2 seventy eight samples were collected from the group as a whole.

As stated above, the base of the Seventh Limestone is placed in the S2 coral brachiopod zone which furthermore is restricted to this limestone. From the top of the Seventh Limestone to the base of the Rough Limestone the strata are placed in the lower Dibunophyllum zone (D1), and strata above this up to the First Limestone are placed in the Upper Dibunophyllum zone (D2). The base of the Namurian strata as defined at the Carboniferous Congress at Heerlen in 1935 is taken as the point where Cravenoceras first appears. Although the diagnostic fossil Cravenoceras leion has not been found in this area (see below) evidence elsewhere has shown that the shales above the Great or First Limestone are Namurian. The modern convention is to take the base of the First Limestone as the base of the Namuvian strata, mainly for practical reasons (Ramsbottom 1969, Taylor et al. 1971). Eastwood et al. (1968, p.161), follow the older classification of placing the First Limestone in the Visean whereas Taylor et al. (1971) use the more modern classification and place the First Limestone in the Namurian.

Lower Carboniferous rocks of equivalent age in the surrounding regions are summarised in fig. 15, which shows their relative thicknesses and stratigraphical horizons. As can be seen from this diagram and fig.17 p.47 in Taylor et al. 1971, which shows the Visaen isopachytes, the rate of sedimentation in the Northumberland trough was very varied at this time. The result of this variation is that in north Northumberland, across the Northumberland trough Lower Carboniferous sedimentation reached approximately five times the proportions of that in the Cockermouth area. Correlations of the Fourth Limestone are possible over a wide area, and some horizons of this limestone form useful datum lines.

In north Cumberland the Lower, Middle and most of the Upper Border Group are believed to represent C2, S1, age strata although the S2 boundary has not been clearly delineated (Taylor et al. loc cit). It is considered to be at the horizon of the Naworth Limestone and the base of the D2 zone thought to be at the Low Tipalt Limestone, the base of the Upper Liddesdale Group. Further afield in Northumberland the Fell Sandstone Group and the lower part of the Scremerston Coal Group is believed to lie in the C2, S1, coral-brachiopod zone. Above the Duddo limestone in this area D1 zone fossils are found and the lower boundary of the D2 zone is placed at the Watchlaw limestone. However lithologies in this region are diachronous, which has led to an inconsistancy in the nomenclature (Taylor et al. 1971). Recently Taylor et al. (loc.cit.) have summarised the probable correlations of this area. This information appears on fig.15.

In the Midland Valley of Scotland, for example near Edinburgh, the Dinantian strata are thick and show some relationship with those in the Northumberland trough. The Cementstone Group at the base is Tournaisian in age. Above this a thick series of lavas occur, the Arthurs Seat Volcanics which are included in the Lower Oil Shale Group. This is thought to be from C2 S1 to Lowest D1 zone in age. This is followed by the Upper Oil Shale Group which is thought to be D1 and lower D2 in age. Above the Hurlet Limestone the strata up to the Top Hosie Limestone are placed in the Lower Limestone Group and is of upper D2 age and equivalent to the P2 goniatite stage (Francis, in Craig, 1965)

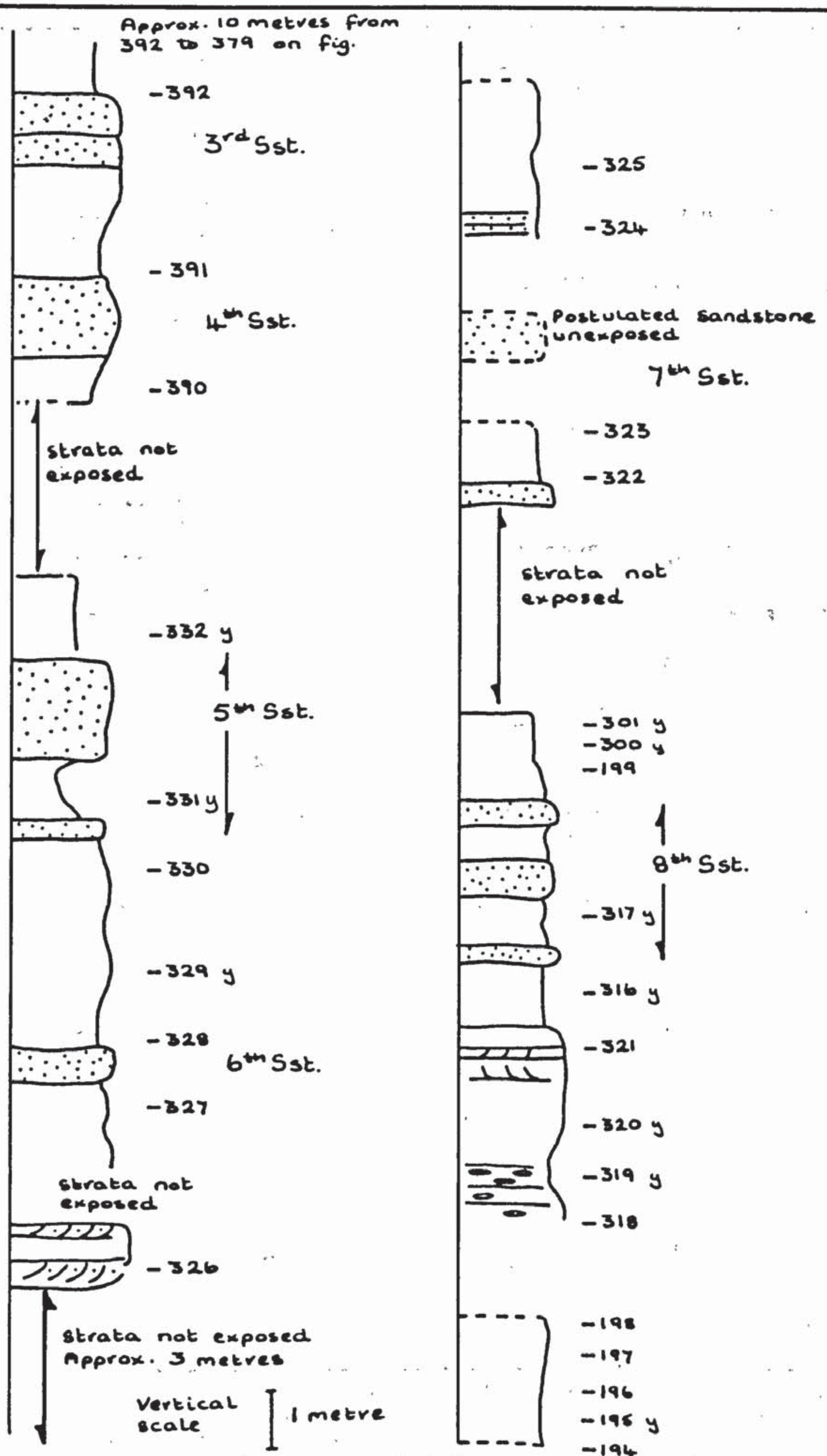


Lithostratigraphic column of Hensingham Group as exposed in Bothel Beck. Semi diagrammatic. 'y' indicates yielding sample.

Vertical scale | 1 metre

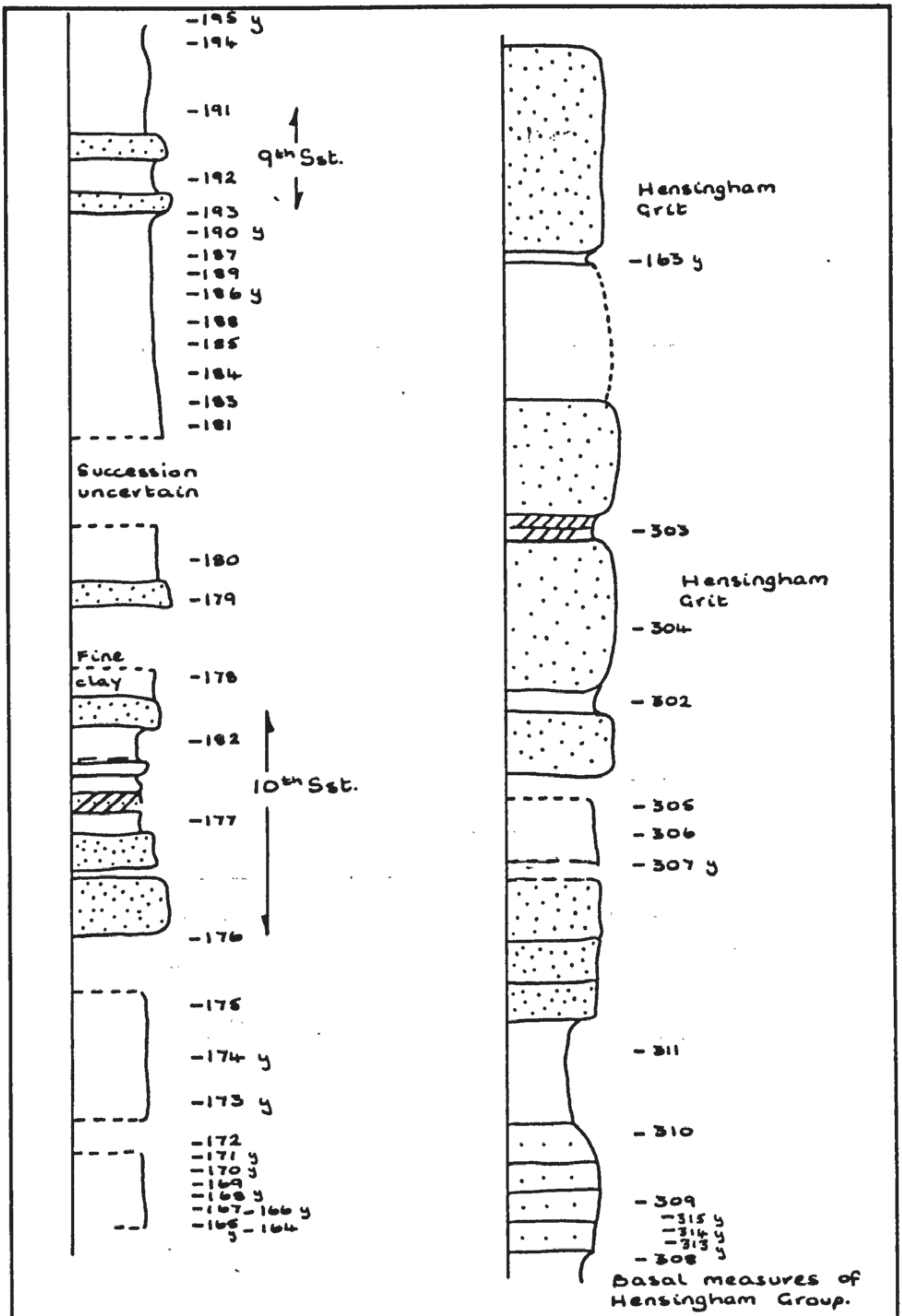
For full explanation see text.

FIG. 3a



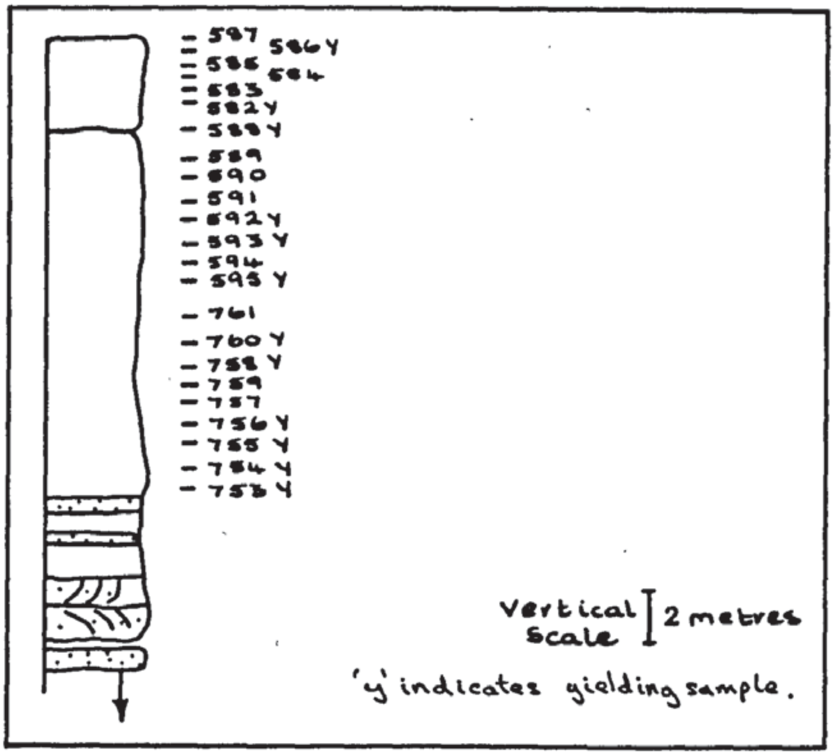
For explanation see Fig. 3a, overleaf.

FIG. 3b



Lithostratigraphic column of Hensingham group as exposed in River Ellen and Cockshot Beck. Semi diagrammatic showing sample numbers + locations. For full explanation see text. Vertical scale: 1 metre

FIG. 3c



Lithostratigraphic column of the Lower part of the Lower Coal measures in Gill Gooden. Showing sample locations. See text for full explanation.

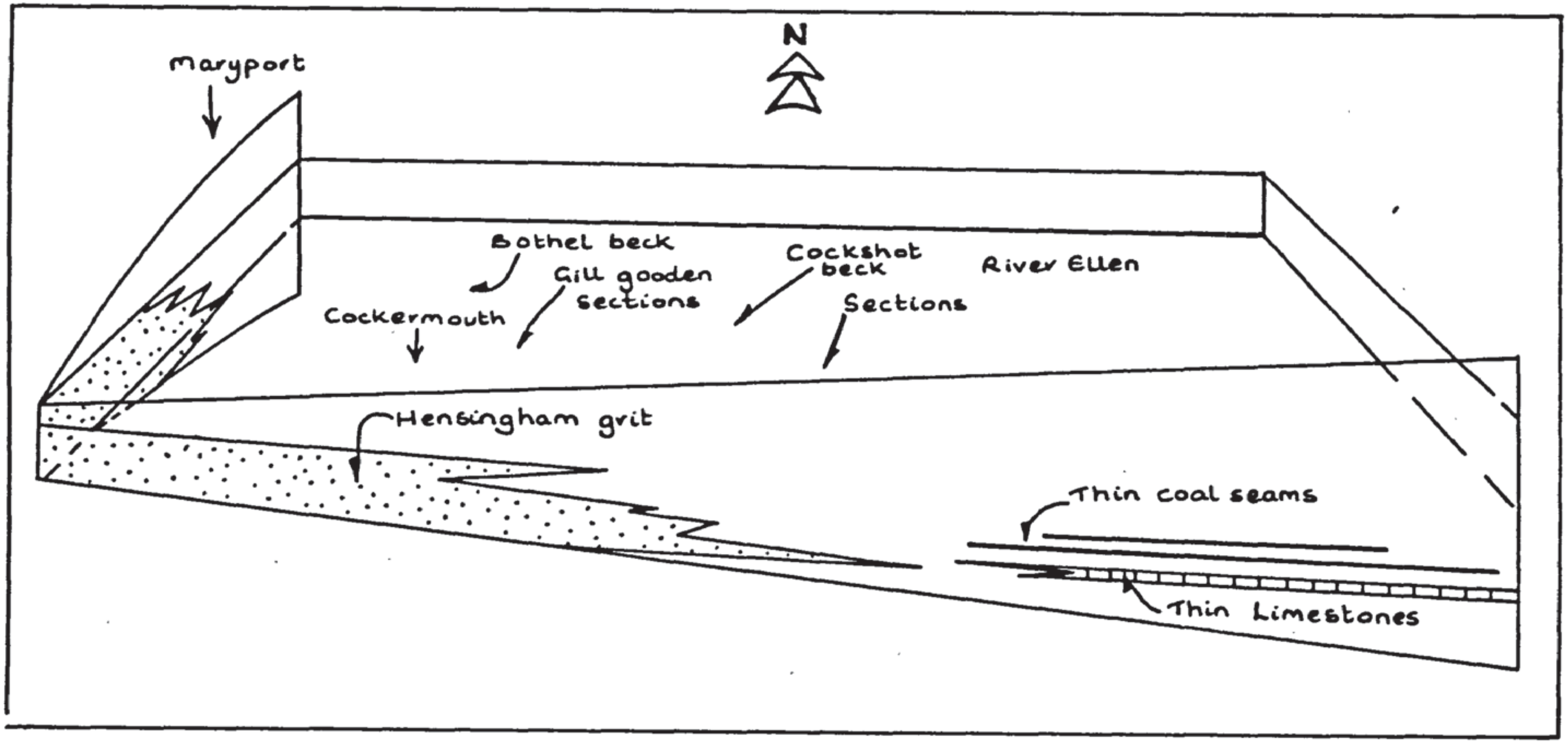
Fig. 3d.

2.4.0. The Hensingham Group

The sequence continues with the Hensingham Group which includes the strata immediately above the First or Great Limestone. The sequence begins with a series of shales, then a prominent grit, called the Hensingham Grit. The group taken as a whole varies greatly in thickness from its type locality, Hensingham off the west of the area, where it is 50 metres thick, and where there is a relatively thick basal grit. In the area around Maryport, to the north, the group attains 500 metres in thickness. In the area of the present study its thickness varies but is less than this, but the trend of northward thickening is conspicuous. Furthermore there is a trend for the group to thicken eastwards, towards the Caldbeck area, where it is in excess of 340 metres thick compared with 135 metres at Aspatria in the west. The thickness of the group as seen in the sections sampled in the present study is taken as approximately 250 metres.

The Hensingham grit thins from the west to the east, splitting into two or three layers in the central part of the area. East of the Snowhill f fault the grit is not apparent. Above the grit, in the central and eastern parts of the area, is a thin limestone band - the Little Limestone, which is followed by the Little Limestone Coal, locally split into three seams. The relationship of these rocks to each other over the area is shown in schematic form in fig. 4.

The Cockermouth memoir (Eastwood et al. 1968) states that the group consists of sandstones, medium to coarse grits, shales with marine fossils, sporadic thin bands of marine limestones and a few thin coals. However a detailed succession for the group has not been published. From the work carried out in the present study an almost complete succession has been compiled from the localities sampled. As indicated on fig. 3. most of the sequence is taken from two areas, the Cockshot beck and River Ellen



Schematic block diagram of the Hensingham group strata in the area of the present study. For full explanation see text.

Fig. 4.

section and the Bothel beck and Gill Gooden section (see map 1). The succession begins with dark shales, nodular in parts with nodules reaching 30 centimetres in length, laminated and often containing marine fossils. These strata lie above the First Limestone and below the Hensingham grit, and may reach 5 metres in thickness. They are well exposed in Cockshot beck (213402) upstream from Cockshot bridge where the Hensingham grit is also seen. The grit here is massive and coarse grained with intervening slightly laminated, finer grained grits totalling 10 to 12 metres.

The sandstones in the overlying sequence have been numbered by the present author, in descending order from one to ten. This follows the practice used for the limestones in the Chief Limestone Group. Further downstream from Cockshot bridge the shales above the Hensingham Grit occur, being mostly dark grey to black, fine grained, finely laminated rocks. However, occasionally more colcaeous, light grey shales are found. In these a series of sandstone bands about 2 - 3 metres thick forms the Tenth Sandstone. As can be seen from fig. 3, the Ninth, Eighth, Fifth and Second Sandstones similarly consist of separate bands, grouped together for convenience.

Above the Tenth Sandstone, shales approximately 4 to 5 metres thick occur followed by the two Sandstone bands of the Ninth Sandstone which is approximately 1.5 to 2 metres thick. Above this again dark, laminated shales about 8 to 10 metres thick occur followed by the three bands of sandstone forming the Eighth Sandstone totalling 2 metres. The exposure is then very poor in this section but the Seventh Sandstone lies approximately 6 to 10 metres above the Eighth. Above the Seventh Sandstone exposure is again poor and only 4 to 5 metres of shale are exposed of the 12 to 15 metres of strata between the Seventh and Sixth Sandstones.

4 metres above the Sixth Sandstone lies the Fifth, which consists

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Palaeogeography of British Dinantian
adapted from George 1969

Fig. 5.

of two bands, an upper massive 2 metre band and a lower, minor 40 centimetre one. Approximately 4 metres of shale follow up to the Fourth Sandstone which is a massive 2 metre band. Above this the final 4 metres of shales exposed in the Cockshot beck and River Ellen section crop out and include the Third Sandstone.

The sequence above the Third Sandstone continues in Bothel beck and Gill Gooden. Here the Hensingham Group is faulted against the First Limestone. In Bothel beck (180400) the shales contain some subsidiary sandy beds. The sequence is not continuous from the previous section, however it is estimated that not more than 15% of the Hensingham Group as a whole is missing. The group of three sandstone bands in Bothel beck have been termed the Second Sandstone, which consists of one lower, cross bedded, laminated 4 metre band, and two very minor upper bands. Poor exposure further down stream prevents approximately 6 metres of succeeding strata from being sampled. The final 10 to 13 metres up to the basal Coal Measure sandstone contains a 1.5 metre sandstone which has been termed the First Sandstone.

Towards the top of the Hensingham sequence the shales become sandy, micaceous, light buff to grey in colour with only rare thin black laminae. These rocks are exposed in Gill Gooden (167403) where the junction between the basal Coal Measure sandstone and the Hensingham Group is seen.

The two stream sections described above provide the basis for almost all the sequence of strata in the Hensingham Group used in the present study with the exception of the strata in the immediate vicinity of the Little Limestone Coal, below the Tenth Sandstone. These were sampled in Townthwaite beck (275435) where the thin coal seam is exposed in the stream bed. This coal was also sampled from small tips near to broken ground at various locations (417315 and 434315) where the coal had been

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Local Dinantian Palaeogeography adapted from Taylor (1971)

Fig. 6

worked from shallow bell pits in the past.

According to Eastwood et.al. (1968) and Taylor et.al. (1971) correlation of this sequence is not straight forward. It is stated that no Pendleian (E1) fossils have been found in the lower part of the sequence. It is considered by these authors that in some areas there may be a non sequence at the base of the Hensingham Group. Diagnostic fossils which have been found in the Hensingham Group include _Tylonautilus nodiferous_ Armstrong, which has been found at several localities including Gill Gooden just below the basal Westphalian sandstone. _Anthracoceras glabrum_ Bisat has been found at one location only, at Pow Gill (25384232) (Eastwood et.al.loc.cit.). According to these authors there is evidence for a non sequence at the top of the Group, in Chalk beck where typical Hensingham Group fossils are found up to within 3 metres of a mussel band yielding _Anthraconaia modiolaris_. This appears to cut out the Chokierian (H1) Alportian (H2) Kinderscoutian (R1) Marsdenian (R2) and Yeadonian (G1) stages of the Namurian and some or all of the two basal zones of the Westphalian. Therefore the majority of the Hensingham Group is currently placed in the Arnsbergian (E2) stage.

Eastwood et.al. (1968) state that the non sequence at the base of the Hensingham Group may not be as important in the east of the area, where the Little Limestone coal occurs, as in the west, where the Hensingham Grit becomes important. Thus the non sequence is probably not a strong feature in the succession sampled for the present study. Broadly the grit fails in areas where the coal becomes important (see fig. 4). The sequence sampled for the present study lies in the west-central region where the grit is wedging out and the coal is still persisting.

In the region around Chalk Beck, about 2 miles north of Caldbeck,

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Diagrammatic Section across Cumbrian Block showing approximate dates of transgressions According to George (1966)

Fig. 7

the upper strata in the Hensingham Group and Lower Coal Measures have suffered oxidation causing the rocks to become reddened. Cockley beck stream section (385405) was traversed and sampled but the rocks,which are more arenaceous, have been reddened here also. Whilst macro fossils are usually unaltered by this oxidation process, miospores are destroyed. Therefore palynological evidence relating to the upper part of the Hensingham Group and the transition into the Lower Coal Measures was only obtained from the Gill Gooden section.

No unconformity is detectable in the field between the Hensingham Group and the Westphalian strata (Ramsbottom 1969 Eastwood et.al. 1968). In the northern part of England the upperstages of the Namurian are much reduced compared with other regions. However the likelihood of this being due to a condensing of the sequence rather than a non sequence is not favoured by Ramsbottom (1969). Features characteristic of condensed sequences such as abundance of phosphatic nodules, fish remains, conodents, and increased radioactivity are not present.

In the present area the passage into Lower Coal Measure strata is marked by a sandstone approximately 13 metres thick. This is well exposed in the Gill Gooden stream section at (165405). The sandstone consists of a light buff to grey grit with rootlets at the base and yellow, medium grained sandstone showing some cross bedding towards the top. The rock consists of several sandstone bands narrowly separated by shale partings.

Above this occurs a series of flaggy shales and dark finely laminated shales for approximately 10 metres at which point a 40 centimetre coal which was sampled crops out in Gill Gooden at 1661 4051. Above this the exposure in Gill Gooden is very poor indeed. The coal seam is probably equivalent to the Harrington 4 feet or the Albrighton coal seams of the Cumberland coal field. These two seams are the lowest seams in the Lower

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British Namurian Palaeogeography, after Ramsbottom 1969

Fig. 8

Remains of Cumbrian-Manx block suggested from present study.

Coal Measures in this area and have been placed in the Densosporites anulatus spore zone which elsewhere occurs in the Anthraconaia lenisulcata non marine bivalve zone (Smith and Butterworth 1967). The Harrington 4 feet seam was investigated by means of a sample from the Solway Colliery (by courtesy of the N.C.B.).

Namurian strata in surrounding areas are summarised in fig. As can be seen, the local sequence is much reduced compared with areas to the north and east in the Northumberland trough. At Langholm the boundaries of the E1 and E2 stages are not certain (Lumsden et.al. 1967). In the area around Stainmore all the stages seem to be present (Taylor et.al.) although the correlation with Cockermouth area is not clear.

Hull (1968) has described the Namurian strata from the Throckley bore hole and Broom hill bore hole in Northumberland. Here the stages are all present although some condensing of the upper stages appears to occur. In the Midland valley of Scotland Hull has described the Namurian sequence from Falkirk. The sequence is very well developed, the Scottish Limestone Coal Group covers the E1 stage, the Scottish Upper Limestone Group is E2, and the Passage Group encompasses the four upper stages. From the latter area Neves et.al. (1965) have described the micro flora from the Passage Group but results could not confirm the prescence of H1 or H2 stages.

Hull also describes the facies changes in the Northumberland trough showing that the E1, E2, H and part of the R1 stages consist of an Upper Limestone Group facies except in the extreme east where a Limestone Coal Group facies element appears in E1 as in Scotland. Hull places the R1, R2 and G1 stages in the Northumberland trough in a Millstone grit facies. Clearly there was not so much variation in the controls of sedimentation during the Namurian in the Northumberland trough as in Visaen times. Only

Isopachytes of Namurian strata in N. Britain, after Ramsbottom 1969. At 1000 ft. intervals.

Fig. 9

to the south west was there sufficient uplift to cause disconformities of recognisable proportions.

2.5.0. Palaeogeographical aspects

The North of England was an area of blocks and basins during the early Carboniferous times. During the Dinantian epoch the area in the present study was situated on the Southern margin of the Northumberland trough and the northern margin of the Manx - Cumbrian - Alston ridge. Sedimentation commenced earlier in the trough than on the block and the trough was probably submerged by the end of the Tournaisian times whereas the ridge was probably not submerged until C2 S1 times. (Taylor et.al. 1971) (see fig. 5).

Thus deposition in the present area was controlled by the rate of subsidence of the block and trough relative to each other. In the Chief Limestone Group some periodicity can be detected in alternating shallow and deeper water limestones (Eastwood et.al. 1968). This indicates that the subsidence was sporadic. During the periods when subsidence was rapid clear water, marine limestones built up but during the slower subsidence the rate of deposition caused a shallowing of the sea even to the point where deltas with plant growth built up briefly. The latter accounts for the development of thin coal seams in the Chief Limestone Group.

Several transgressive phases have been tabulated for the whole of Britain during the Dinantian by Ramsbottom(1974). According to him the area of West Cumberland first became properly inundated in the D1 coral-brachiopod zone times, which represents Ramsbottoms Fourth transgression.

Figures 5 and 6 illustrate the salient features of the paleogeography during these times.

Palaeogeographical relationship between Britain and East Canada during Carboniferous times adapted from a diagram in Haquebard (1971).

Fig. 10

During Upper Chief Limestone times a better developed rhythmic type of deposition is evident (see above). However the area seems to have been beyond the influence of the factors causing formation of coal swamps which became so well developed in the Pennines and North Cumberland.

The area may have suffered elevation and contemporary erosion at these times which could account for the marked lateral variations of some of the limestone bands including the Pothole Limestone near Cockermouth (Eastwood et.al. 1968).

By Namurian times the Cumbrian massif had become submerged (see fig. 8). The influence of the Northumberland trough had become negligable but it is probable that land still existed further north. As can be seen from fig. 9 the area around the old Manx - Cumbrian - Alston block was still influencing deposition, so that the Namurian strata in this vicinity are much reduced compared with other areas (see also above).

The early Namurian rocks in the Cockermouth area are characterised by grits in the western part but by shales in the eastern part. As has been explained above there is evidence that deposition was possibly held up during E1 times in the west. The present author interprets the significance of Namurian deposits in the area as follows (see fig. 4).

In the west a low land area existed while to the east sedimentation continued after the end of clear marine conditions which produced the First Limestone. In this shallowing sea the shales in the east are at first marine in nature, containing corals and brachipods. Evidence for this was found in Cockshot Beck at 22033932. However the shales rapidly lose their marine nature, becoming less calcareous upwards, until the horizon of the Little Limestone coals. The thickness of shales beneath the Hensingham Grit becomes less towards the west, with virtually no shales

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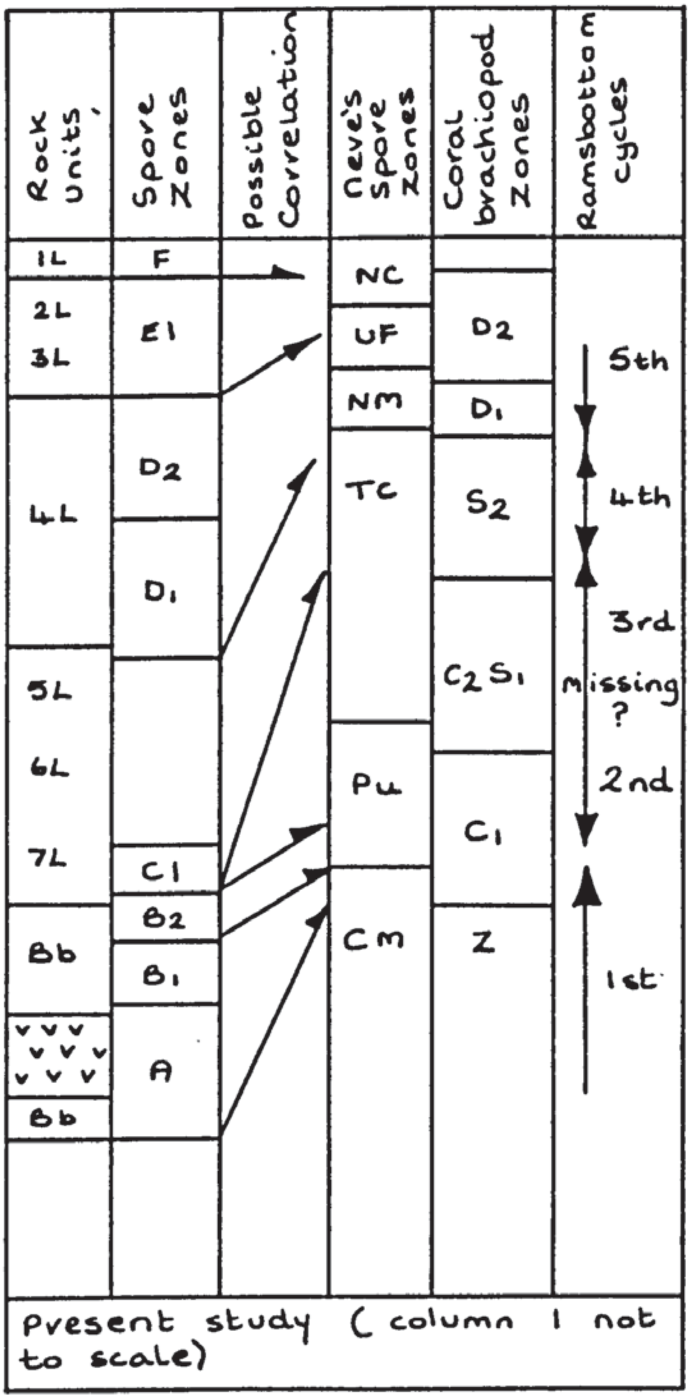
Possible lateral equivalents of Carboniferous strata adapted from Neves (1971).

Fig. 11a.



Possible correlations from the present study. See also text and Chart 1 and Table 2.

Fig. 11b.

at all in the Hensingham area.

The coals probably represent the most westerly extension of the coal swamps to the north and east. At this time the Hensingham Grit was still being deposited to the west possibly near a land area which may represent the last remnant of the Manx - Cumbrian ridge. The effect of this positive area was to allow a much reduced thickness of sediment to accumulate in the west of the area. This effect was less marked to the north and east where shales and sandstones accumulated to a much greater thickness. (Fig. 4).

There are ten recognisable sandstone horizons in the Namurian sequence above the Hensingham grit, which alternate with shales. These may be a result of the sporadic subsidence characteristic of these times elsewhere. Elevation towards the end of the E2 times may represent the final recognisable movement of the block which resulted in a cessation of deposition in the area. This would account for the non sequence described above, at the top of the Hensingham Group.

By early Westphalian times sedimentation was resumed with the deposition of the basal sandstone. The influence of the positive area previously called the Manx - Cumbrian - Alston block had become very limited, however it may account for deposits in the Cumberland coalfield being much thinner than elsewhere, especially in the Pennine Province (Calver 1969). The S. Uplands massif was also much reduced.

The world setting is illustrated in fig. 10. The continental positions have been based on the Smith and Briden interpretations (1971). The relative position of the paleoequator throughout the period of time relevant to the present study is interesting. From extensive palaeomagnetic and other data the paleoequator is believed to have

Continental positions during Lower Carboniferous times after Smith Briden and Drewry 1973. (Mercator projection)

FIG. 12

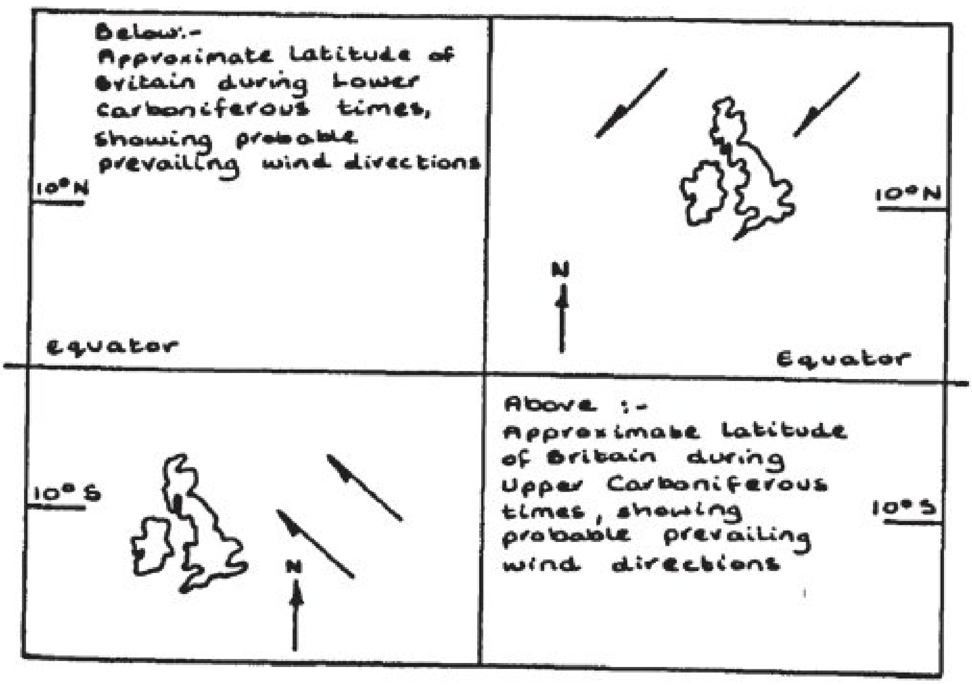
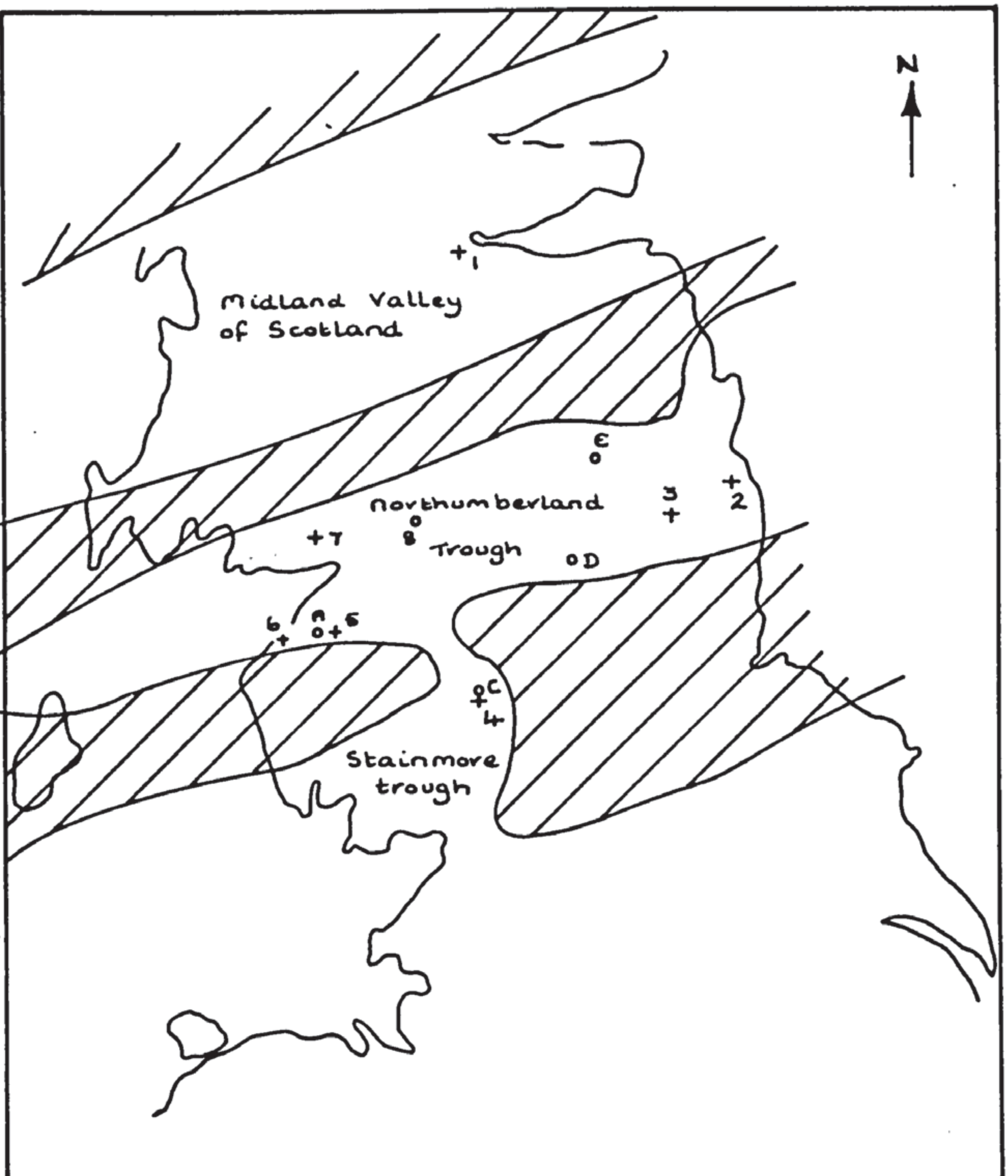


FIG. 13

progressed from a position 10 degrees to the north of the area in Lower Carboniferous times to 10 degrees south of the area in early Westphalian times. The paleoequator is believed to have been approximately coincident with the area during Namurian times. (Smith and Breidden 1971).

There may be some significance in the resulting wind directions. Spore distributions may not be as much influenced by wind as by currents in the basin of sedimentation or by drainage catchment provinces. However the distribution of anemophilous grains may be influenced by changing prevailing wind directions. From fig. 13 it can be seen that global wind patterns predict that there would be a significant change of direction of prevailing winds from south east in Lower Carboniferous timesto north east in Lower Coal Measure times. (see chapter 6 for further discussion).



Map of N. England and Scotland showing approximate paleogeography in Visean and Namurian times, with locations of stratigraphic columns in figs 15 and 16

FIG. 14

Comparison of local Visean stratigraphy of various locations in N. England, indicating probable correlation of Coral - brachiopod zones. After Taylor 1971, Lumsden et al. 1967. See also Fig. 14.

Fig. 15.

Comparison of local Namurian stratigraphy at various locations in North England and Scotland, indicating probable correlation of goniatite stages. Adapted from Hull 1968, Taylor 1971, Eastwood et. al. 1968 and Lumsden et al. 1967. See also Fig. 14.

Fig. 16

CHAPTER THREE

3.0.0. Practical Techniques

The problem of poor exposure in the area especially with the shale sequences has already been outlined in Chapter One. Most of the samples from the Basement beds were taken from the two stream sections at Redmain and Blindcrake as described above. Most of the samples from the Limestone series were obtained from isolated quarries in the limestone. Most of the samples from the Hensingham group and the Lower Coal Measures were obtained in stream sections. Detailed information on locations of samples are given in the text in Chapter 2 and figs. 1, 2a, 2b, 3a, 3b, 3c and 3d.

In the shales, samples were taken at intervals of between 1.5 metres to 0.3 metres depending upon exposure and accessability. Coals were sampled at 2 centimetres intervals where possible. Sandstones were not generally sampled in detail, usually one sample of each sandstone band was taken. Within the limestone only the shale partings were sampled, or the shaly intercalations where present in the same manner as the shale sequences. If the partings were less than 1 centimetre thick then lateral samples were also taken so as to make up the bulk of the sample.

Representative samples were occasionally taken where a monotonous sequence occured or where detailed sampling was impossible due to physical difficulaties. Details of sampling are shown on the litho-stratigraphic figures 1, 2 and 3.

Sample size varied from 50g to 200g. Coal samples generally being less than shales or other rock types. All samples were taken with extreme care so as to prevent contamination by other rock debris. Samples were as far as possible chosen from the least weathered rock available and usually the surface few centimetres were scraped away. However in many case, especially when sampling the Hensingham group weathered rock was unavoidable, often forming the stream bed exposed due to low summer water levels.

The samples were collected in self-seal plastic bags and labelled, the exact position and other details being recorded in the field note book.

The rock samples were washed and thoroughly scraped to remove any trace of contaminating material such as recent growth or soil particles. The samples were then dried.

The preliminary step in processing rock samples for palynological studies is to crush the sample prior to demineralizing. Crushing of the samples was achieved with a mortar and pestle. The rock was reduced to an average particle size of 5 - 10mms. Further size reduction would probably increase the speed of the subsequent reaction with HF but may damage the spore exines. The risk of contamination was reduced to a minimum by vigorous scouring of the mortar and pestle and air blast drying after each sample was crushed. There is a further risk of contamination due to airborne fragments of the more brittle rocks during crushing. To avoid this such samples were crushed inside plastic bags which were then discarded.

Tests were carried out using a mechanical air crusher. The conclusions from this test were as follows:- the method involves much more stringent cleaning and decontamination than mortar and pestle; the metal jaws and other surfaces are rough and one cannot be absolutely certain of their cleanliness, and it was found that no time was saved using this method compared with the pestle and mortar. For these reasons the method was not used.

The procedure involved in demineralization, oxidation and slide making is outlined in flow diagram form in figs. 17, 18 and 19. After crushing the samples need to be demineralized. Carbonates must be removed before application of HF because fluorides are created particularly calcium fluoride which causes unsatisfactory preparations. Approximately 20 - 40g of the crushed sample in each case was placed in 250 c.c. plastic bottles with holes drilled in the lid to prevent build up of pressure during the reaction with acids. Hydrochloric acid was used to rid the samples of carbonates. With very calcareous samples the acid was renewed periodically in order to ensure a complete reaction. When the reaction is complete the liquid was decanted to neutrality.

Desilicification was achieved using 40% Hydrofluoric Acid. This is an established method and has been described by numerous authors (J. Grey in Kummel and Raup 1965). The polyethylene bottles used were found to be satisfactory and the reaction was never exothemic enough to cause damage to the bottles.

It was found that if the time that HF treatment was continued for was extended to six days at room temperature there were practically no mineral matter remaining. This avoided the step of heavy liquid centrifugal density separation. It was concluded that any step which can be eliminated from the whole process should be so eliminated as each change of container will increase the chances of contamination and error. Furthermore the present author believes that the standardization of procedure so that all samples can be similarly processed is important so as to ensure as constant a source of error as possible. Therefore heavily mineralized samples were allowed more time in HF rather than using the alternative heavy liquid density separation method.

40% HF was used as a safer alternative to the 70% HF which requires the use of an aspiratior. When digestion of mineral matter was complete the liquid was decanted to neutrality using distilled water.

Spore exines are composed of a complex of chemicals referred to generally as Sporopollenin. This is a very resistant substance to chemical and microbiological decay. Broadly, the components of exines are Ulmins and Polymerbitumens including sporins, cutins and resins. The removal of the dark coloured ulmins is required so as to render the exines transparent to light. This can be achieved by the use of an oxidant followed by washing in alkali as in the Schulze method, or more simply by oxidation with Nitric acid. By using the Nitric acid method the break down products are dissolved and washed away by the acid. For this reason the Nitric Acid technique has become a standard method, in many cases preferable to the Schulze solution method, (Kummel and Raup 1965). Many other oxidants have been advocated in the literature but need not be used with normal material.

The nitric acid method was chosen for the above reasons and also because it involves the use of as few chemicals and procedural steps as possible. The oxidation was carried out in a sintered glass filter funnel of No. 3 porosity attached to a Buchner flask. Nitric acid was applied in increasing strength up to Fuming nitric acid. Different samples require different degrees of oxidation. The most satisfactory method for establishing the required duration was to subject each sample to vigorous microscopic observation prior to the Fuming H N 03 step. This enabled a subjective estimation of the degree of oxidation required. The use of a subjective method is not thought desirable but the alternative employment of a fixed objective protocol is considered less desirable and unnecessarily time consuming. Times in H N 03 varied from 0mns to 20mns. Usually about 10mns. was found to be sufficient. Those shales which were particularly badly weathered had already suffered oxidation to such an extent that the use of Fuming HNO_3 was not required.

The oxidized residue was then washed with at least 2 litres of distilled water to rid the sample of fine material which tends to become disaggregated during oxidation. If this is left in the residue the resulting slide is poor, the spores being partially obscured. Periodical use was made of a blow back pump to free the filter pores.

Coal samples were processed by oxidation only as mineral matter is not usually present. These samples were crushed to a finer grain size than shales, usually approximately 1 to 2mm. diameter.

An alternative to washing by filtration was found. The oxidised sample is stored in water in sealed tubes. The settling rate of the organic particles was found to be such that after 30 minutes the water contained no detectable particles of spore size, only particles of less than 5 μ remained. If this water is decanted and the operation repeated, it has been found that a large proportion of the fines can be eliminated.

It is though that this method may be more desirable due to its speed, ease and use of smaller volumes of water than the filter method. Also, this method avoids repeated blow-back action which is thought could easily damage the more delicate spores.

The final residue was stored in 10c.c. glass vials in distilled water. Strew slides of this residue were made using cellosize as a dispersal agent and Canada Balsam as a mounting medium (see fig. 12). With samples in which the material became clumped, ultra sonics were used to disaggregate them, a maximum time of 1 minute was used in a Bundept ultra sonic cleaner no. 91 785. Many of the coal samples were particularly susceptible to clumping and it was found that application of 10% KOH partly overcame this. However the use of KOH was not thought desirable as this chemical tends to cause a marked swelling of many spores (Mishell 1966). Logging of the slides was carried out on a Zeiss binocular microscope serial no. 4752386.

Several problems presented themselves in the processing of samples. Many were found to be unsatisfactory due to heavy pyritization. If the conditions in which the shales were deposited were euxinic iron sulphide becomes prominent in the environment and is extracted by bacterial action (Love 1964). The quality of the spores extracted from these samples is invariably poor as the exines are often damaged by pyrite crystal growth. Occasionally the hollow spore body was found to have been almost completely filled with pyrite cubes. During the processing the pyrite is dissolved usually in such a way as to destroy the spore. Neves and Sullivan (1965) have described this phenominon in detail.

In other samples the effect on spore exines of bacterial decay were often evident. Bacterial rosettes were frequently observed as have been described by Elsik (1971). This phenominon was not found to affect the quality of the spores greatly. However, close attention was required at all times when observing the morphological details of exines because of the possible confusion between original and secondary ornament. Usually this distinction was reasonably easily made.

Many samples contained mush clumps which bore a close resemblance to spores in general outline and size. In these cases it is possible that the environmental conditions of deposition were such that sapropelic action of micro organisms destroyed the spores, (Elsik 1971). The appearance of such samples under the microscope was distinctive there being no evidence of fresh looking wood or other organic fragments. Other samples which were barren of spores often contained much organic and wood debris

Maceration techniques flow diagrams

1. Demineralization

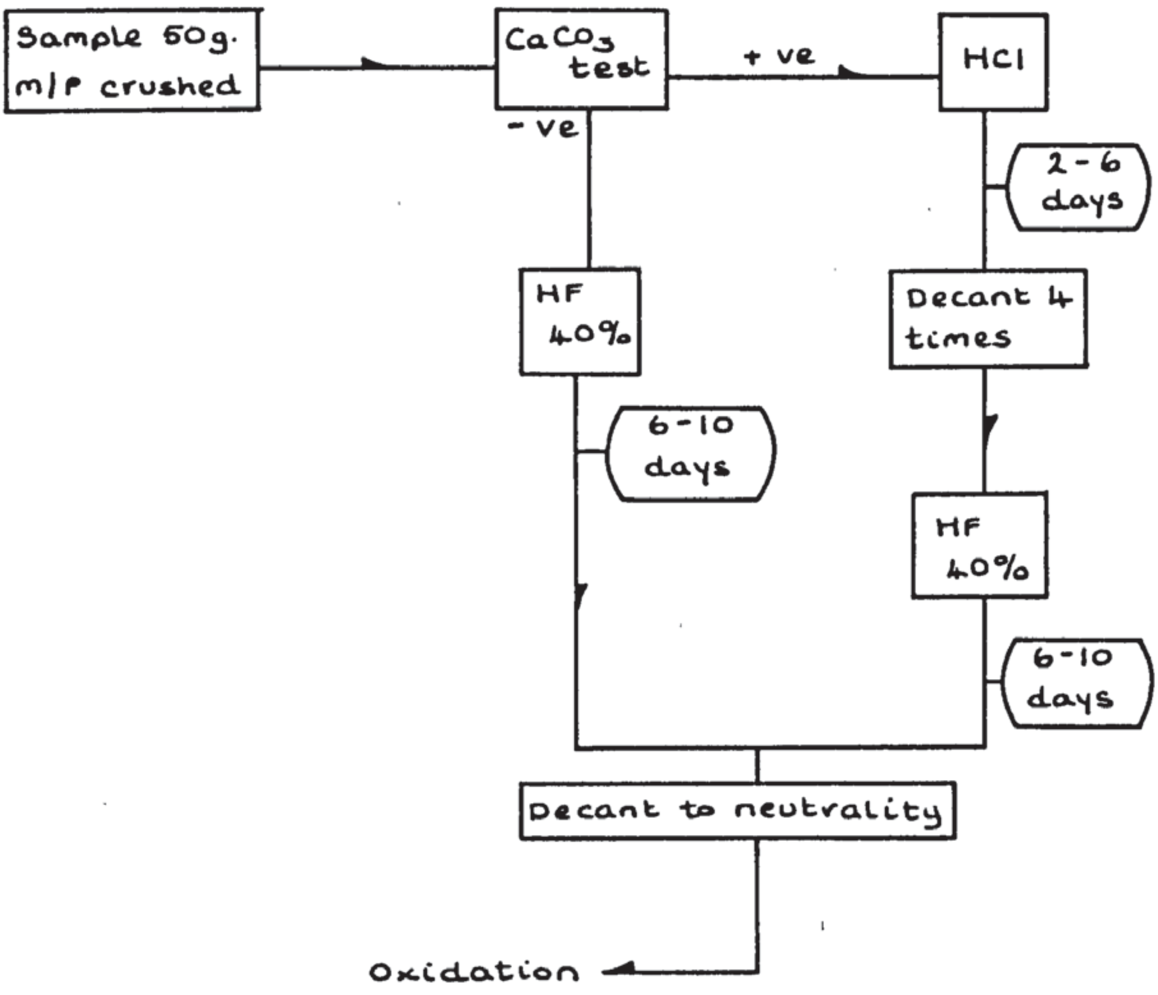


FIG. 17

of a fresh nature, In those samples presumably the lack of spores is a primary phenomenon. Still other samples contained a very low proportion of spores. With these a limited degree of success was achieved in concentrating the residue. This was achieved by extra washing or decanting to remove as much of the fine fraction as possible. Removal of the coarse fraction was achieved by pipetting off the residue suspension in the 10c.c. vials 30 seconds after agitation. During the 30 seconds particles larger than 200 μ.had settled and the overlying suspension contained a high concentration of spore sized particles.

The use of a scanning electron microscope for observation of the miospores was investigated. The microscope consists of an electron gun emitting electrons which are accelerated towards the anode. The beam is focussed by several magnetic, electron lenses, and impinges on the specimen. The beam is deflected so as to scan across the field of the specimen stub normally on a linear raster basis. The primary electrons in the beam produce secondary electrons when impinging on the coated surface of the specimen. The secondary electron scatter is collected by an electron collector, amplified and the signal is displayed on a cathode ray tube.

The scanning of the beam in the display tube is linked to the scanning generator for the main beam thus producing an image of the reflected beam. The magnification of the image is achieved by reducing the area of the specimen being scanned by the main beam, the resulting display, which remains constant in size, will show an increased magnification. Magnifications from 10 to 20,000 can be obtained. The depth of field which is obtainable from the scanning electron microscope is much greater than with optical instruments. This is due to the very small angular apperture of the electron beam. When an optical microscope is used to resolve an angular distance of 1μ a depth of field of

Maceration techniques flow diagrams

2. Oxidation

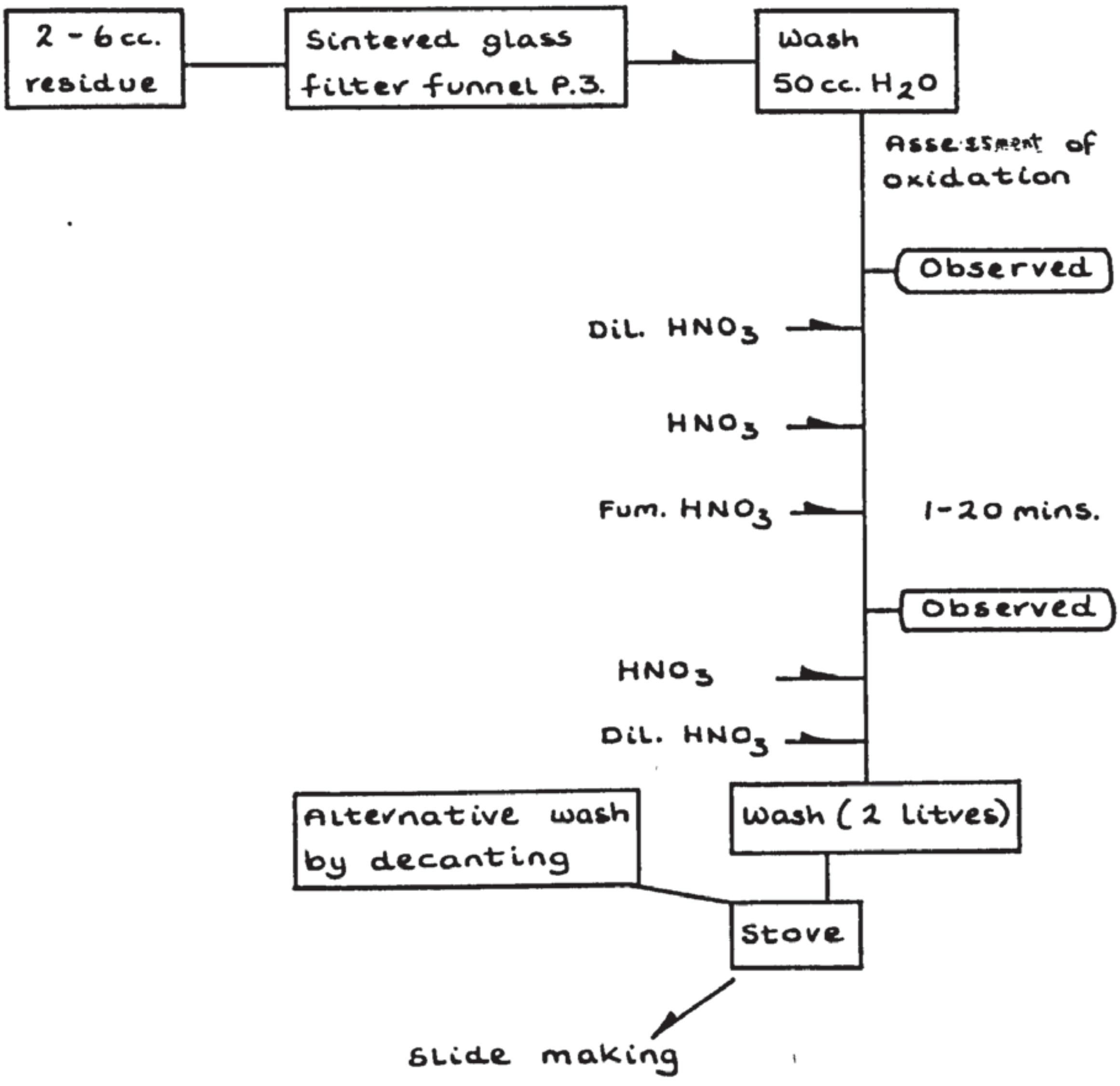


FIG. 18

approximately 1μ is common. However with a scanning electron microscope, at this level of resolution a depth of field of 7000μ is common (Nixon 1971). Therefore small specimens such as spores or pollen grains may be observed at high magnifications with the whole specimen in focus.

Many workers have described the use of various mounting media and techniques. Larger microfossils for example, Foraminifera, were used at first in the present study, whilst becoming familiar with the use of the scanning electron microscope. For these specimens double sided sellotape was found to be a good mounting medium. This has been described by Leffingwell and Hodgkin (1971), who also tested a range of adhesives for use with scanning electron microscopy of palynomorphs. The tape method is unsuitable for small spores because the specimens sink into the adhesive and become obscured. Bartlesan (1972) has described the "nose fat" method for adhering spores to glass slips for S E M work. It was found in the present study that the simple, dry mounting method was satisfactory. The specimen is isolated from a water strew on a glass cover slip under an optical microscope and is left to dry in an open area of the glass slip. The specimens must then be coated with a reflecting film such as gold-platinum, in a vacuum chamber.

The operation of isolating single specimens, particularly small ones was found difficult. Another difficulty was the charging up effect of the specimens under the electron beam. This occured usually if poor conducting contact was made between the glass slip and the specimen stub, which was facilitated by silver paint.

Unfortunately time did not allow the incorporation into the present report of this technique. One reason for this was that the instrument, a Cambridge Mk.II Electron scan, in the department of Metallurgy in the University of Aston in Birmingham, was out of commission for a time.

Maceration techniques flow diagrams

3. Slide making

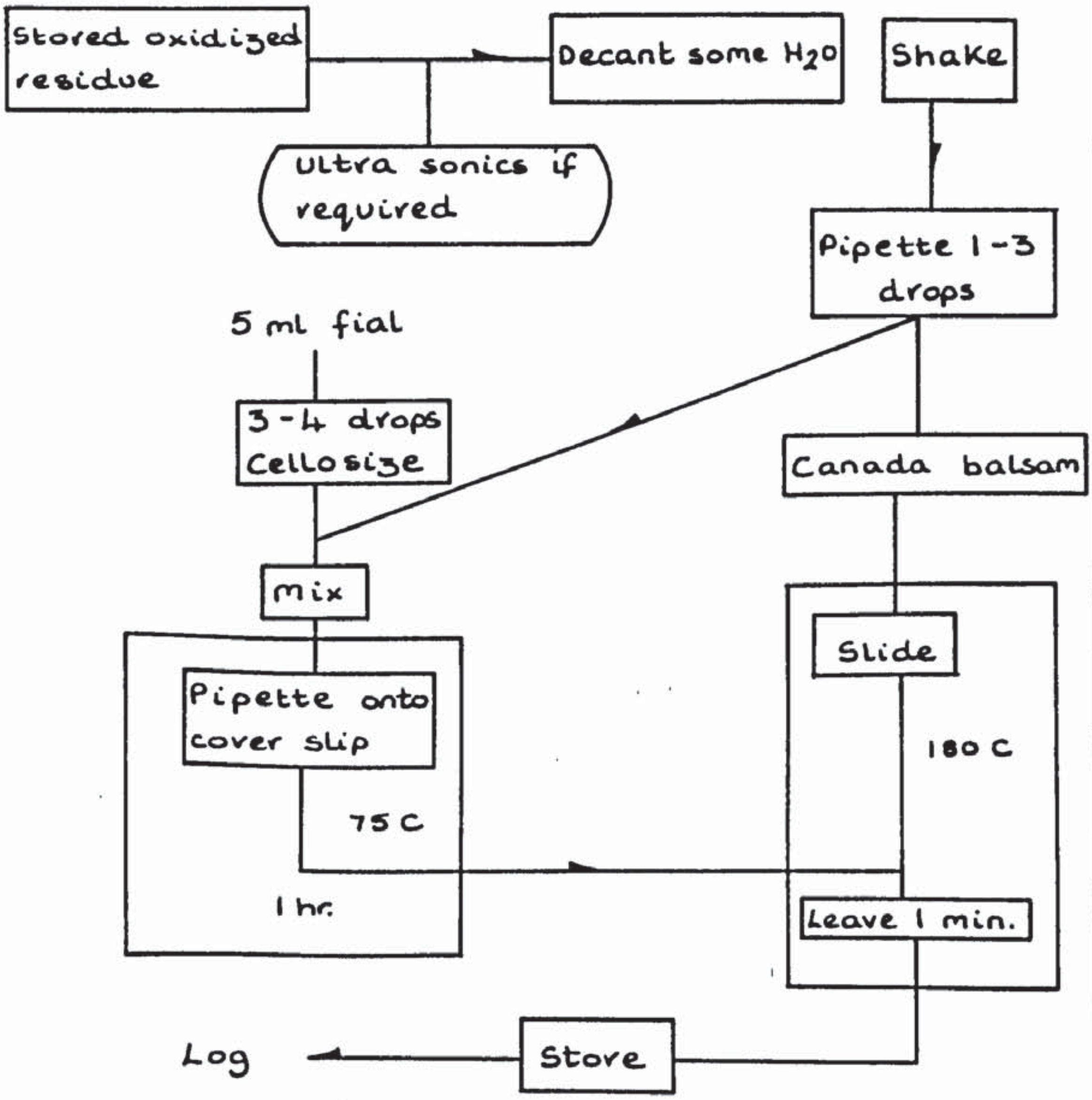


FIG. 19

However numerous workers have demonstrated the value of the S E M in palynology. Clayton (1971) Bertlesen (1972) and Neves et al. (1973) have all recently used scanning electron microscopy in Carboniferous palynology. Transmission electron microscopy in palynology was pioneered by Hughes, Playford and Dettman (1962) who observed Carboniferous spores in thin section.

CHAPTER FOUR

4.0.0. History of Carboniferous Palynology

The early history of palynology has been amply described by numerous authors, notably Playford (1962), Smith and Butterworth (1967) and Kosanke in Tschudy and Scott (1969). In this section therefore earlier works will be summarised and emphasis placed on more recent works.

Reinsch (1884) was a pioneer in the field of coal palynology and described megaspores and microspores from Central Russia and Saxony, although the precise ages and locations of his material are not known. In 1866 Bennie and Kidston showed that megaspores and microspores could be found in the cannel coals of Lancashire. These spores had been observed earlier by Whitham (1883) but had not been identified as such.

The first application of palynology to coal seam correlation has been attributed to Thiessen (1923, 1924) in America, who identified spores in thin sections of coals. In Britain Slater, Eddy and Evans (1930, 1932) attempted to follow the ideas of Thiessen. Correlation of coals by means of palynology was carried a stage further by Raistrick and Simpson (1933) and Raistrick (1934, 1937, 1938) who extracted miospores from coal seams in the Northumberland and Durham coalfields. They used a numerical system of miospore classification. Their work was extended by Millott (1939, 1946) to the coalfields of North Staffordshire, and by Knox (1942, 1940, 1946 and 1948) to the Upper Carboniferous of Scotland.

In the meantime the Westphalian coals of the Ruhr were being investigated by Ibrahim (1932, 1934) and Loose (1932, 1933) who, under the supervision of Potonie, formulated the first binomial classification of spores. Work on classification was extended by Schopf, Wilson and Bentall (1944) in the course of their studies of spores of Pennsylvanian age in

America. They were the first to diagnose many of the genera currently in use. Knowledge of North American Upper Carboniferous microfloras was greatly extended by the work of Kosanke (1950) on Pennsylvanian spores of Illinois and of Guennell (1952, 1958) on the Pottsville coals of Indiana.

In 1950 Knox published a scheme of miospore classification based on analogies with spores of living representatives of lower plants which she had studied extensively. This scheme was superseded in 1954 when Potonie and Kremp published the generic diagnoses of thir classification; this was expanded to include diagnoses and photographs of a large number of Westphalian species (Potonie and Kremp 1955, 1956). This has been subsequently amended and greatly expanded, but it is the classification most generally used at the present day.

One area of the world in which the Potonie and Kremp classification has not been used is Russia. Early studies were published by Luber and Waltz (1938, 1941), Naumova (1939) and Luber (1955). Many of the taxa used in these works were later incorporated in Potonie and Kremp's classification. One of the interesting aspects of the early Russian work was the recognition of separate floral provinces in European and Asiatic Russia (the Karaganda Basin). Ishchenko (1952, 1956 and 1958) published detailed stratigraphical studies of spore distributions in the Dnieper and Donetz Basins in the Ukraine, and the pioneer work of Luber and Waltz has been extended to other parts of the Soviet Union by a number of other Russian palynologists.

Detailed studies of British Westphalian coal sequences were made by Balme and Butterworth (1951), and later, Butterworth and Millott (1960). In these papers a broad zonal sequence for the Westphalian and part of the Namurian was established. Butterworth and Williams (1958) amplified earlier work by Knox (1948) and established the stratigraphic palynology of coals in the Limestone Coal Group and Upper Limestone Group of Scotland. Many of the spores described in these works compare with those observed from Namurian A coals of Upper Silesia by Horst (1955) and Silesian seams up to lower Westphalian D age by Dybova and Jachowicz (1957). A systematic account of the miospores in all British Namurian and Westphalian coals was published by Smith and Butterworth in 1967. They established 11 miospore zones as a result of their work.

During the late 1950's miospores from rocks other than coals began to be investigated. In America Hoffmeister, Staplin and Malloy (1955) contributed a major work on Upper Mississippian spores from Illinois and Kentucky. They described assemblages from shales and coals of the Hardinsburg Formation and made the important point that a more complete idea of spore assemblages is obtained if intervening clastics are examined as well as coal seams. In Britain, Neves (1958) was the first to describe spores from clastics and coals when he worked on strata associated with the Gastrioceras subcrenatum marine band in North Staffordshire. He found a much greater variety of taxa in the clastics compared with the coal and discovered a totally different assemblage in the marine shales, compared with the coal and the non-marine shales. These findings were substantiated by Staplin (1960) when he published details of 110 species of miospores from a coal and adjacent shales in the Upper Mississippian of Alberta. Later, in 1961, Neves extended his earlier work to cover the whole of the Namurian and the basal part of the Westphalian Series in the Southern Pennine area. The ages of the samples used were controlled by their contained goniatite faunas and the paper remains the most extensive treatment of miospores in the Namurian Series. Similar horizons in Stainmore were covered by Owens and Burgess (1966). Data from the Southern Pennine area were used by Neves (1964) in his correlation of Namurian and Westphalian strata in Northern Spain. In this work he formulated five concurrent range zones based on spores and extending from the Namurian A into Westphalian. In this part of the sequence, Jachowicz (1971) described spores from boreholes in Northern Poland and compared their distributions with those of Britain and N.W. Europe. Loboziak (1971) has described megaspores and miospores from Namurian C to Westphalian C strata of the western part of the Nord-Pas de Calais coalfield. He proposed six assemblage zones and 18 subdivisions and again made comparisons with British and German coalfields. Further afield, in the U.S.A., Felix and Burbridge (1967) have described miospore assemblages from the Springer Formation in Oklahoma which probably spans the Mississippian-Pennsylvanian boundary. Their difficulties in detecting changes in the spore assemblages were due partly to recycling within the sediments concerned. The most recent publication on Namurian and Westphalian spores is an account by Jachowicz (1974) on miospore distributions in the Upper Silesian coal-bearing strata.

Much of the work so far described was concentrated on the economically important coal-bearing strata, mainly of Upper Carboniferous age. However, by the 1960's more attention was focussed by palynologists on Lower Carboniferous strata. The spores described by Staplin (1960) from Canada and those described much earlier by Luber and Waltz (1938, 1941) and Ishchenko (1956, 1958) from Russia were found to be common in the Lower Carboniferous strata of Spitzbergen. Miospores from these rocks were first described by Hughes and Playford (1961) who carried out a preliminary study, and in detail by Playford (1962, 1963). Bharadwaj and Venkatachala (1961) also published descriptions from this area.

Sullivan (1964a) was the first worker to publish descriptions of Tournaisian spores from Europe. He isolated these from the Lower Limestone Shales of the Forest of Dean, and in 1968 he described spores of a definite Tournaisian aspect from the Cementstone Group in Ayrshire, the first proof of Tournaisian strata from north of St. George's land. In a separate paper, Sullivan (1964b) described Visean spores from the Drybrook Sandstone of the Forest of Dean.

As a result of his studies of Lower Carboniferous spore distributions Sullivan (1965, 1968) was able to recognise two provinces, represented in the Tournaisian by his Lophozonotriletes and Vallatisporites Suites, and in the Visean by his Monilspora and Grandispora Suite. Spores of the latter were recognised in the Midland Valley of Scotland (Sullivan and Marshall, 1966), in Poland by Jachowicz (1962) and Kruszewska (1963), in Roumania by Beju (1970) and Venkatachala (1962) and in Turkey by Agrali (1963). Spores of the Monilspora Suite included those described by Hacquebard and Barss (1957) and Staplin (1960) from Canada as well as the various assemblages described from Russia and Spitzbergen. Sullivan (1968) noted the similarity in geographical extent of the younger Grandispora and Monilspora Suites with the older Vallatisporites and Lophozonotriltes Suites respectively.

Neville (1968) outlined the ranges of some spores from the upper Visean of the East Fife coast in the Midland Valley of Scotland. He found that his assemblage compared well with Sullivan's Grandispora Suite, but with some Monilspora Suite influence, probably due to its proximity to the boundary between the two provinces.

Work on the palynology of the Devonian - Carboniferous boundary produced a number of reports including those by Streel (1966, 1968, 1969 and 1970) and Paproth and Streel (1970) on the Ardennes-Rhine Basin and Combaz and Streel (1970) in north west France. Lanzoni and Magloire (1969) examined Upper Devonian and Lower Carboniferous strata from the Grand Erg Occidental region in Algeria. This work covered not only the Devonian-Carboniferous transition beds but also Visean strata. Neves and Dolby (1971) studied the transition microfloras in S.W. England and Dolby (1970) summarised progress in this work and outlined three spore assemblages from the West of England, South Wales and southern Ireland. Further work on these Devonian-Carboniferous miospores was carried out by Utting and Neves (1970) in the Avon Gorge area, by Dolby and Neves (1971) in S.W. England and by Clayton et al. (1974) in S. Ireland.

Miospore assemblages from the Central Province Lower Carboniferous of England and Wales were studied by Hibbert and Lacey (1969), Llewellyn, Backhouse and Hoskin (1970) and Mortimer, Chaloner and Llewellyn (1970). Hibbert and Lacey worked on the basal beds of the Carboniferous in North Wales. They considered that the spores found indicated a Visean age for these beds with reworking accounting for a Tournaisian component. Llewellyn, Backhouse and Hoskin reported an assemblage of Tournaisian spores from Leicestershire, as did Mortimer, Chaloner and Llewellyn.

Lower Carboniferous sequences in the Scottish and Northumberland Provinces provide many sediments which are suitable for palynological work. Brackish and fluviatile deposits predominate and marine deposits are relatively scarce. Many workers have described assemblages from the Lower Carboniferous of the Scottish Province. Love (1960) described spores from a variety of rock types in the Lower Oil Shales Group, and noted little or no difference in assemblages in the marine and non-marine shales. The work of Sullivan and Marshall (1966) and Neville (1968) has already been noted. In the Northumberland Trough Butterworth and Spinner (1967) studied megaspores and microspores from coals and shales of C1 to S2 age in the coral brachiopod zonation. Marshall and Williams (1970) published an account of the palynology of the Yoredale Series (Upper Visean and Lower Namurian) in western Northumberland. This account is of an area closest geographically to the area studied in the present work. Many similarities were found between the spore assemblages described and those from comparable horizons in the Cockermouth area. Further information on the Northumberland Trough miospore assemblages has been published by Neves and Williams in Day (1970).

All previous data on the palynology of the Scottish and Northumberland Trough was considered in a paper published in 1973 by Neves et al. This paper also included much new data from that author and from the work of Clayton, Gueinn, Ioannides, Kruszewska and Neville. The results are of special value to the present study because of their close proximity both geographically and stratigraphically. Five miospora concurrent range zones were described which had been previously outlined by Neves et al. (1972) and which cover Lower Carboniferous strata from the Tournaisian up to the base of the Namurian. The sequence of zones with their complete names is given here and will be referred to subsequently only by their initial letters -

<u>Tripartites vetustus</u> - <u>Rotaspora fracta</u> zone VF

<u>Raistrickia nigra</u> - <u>Triquitrites marginatus</u> zone NM

<u>Perotriletes tesselatus</u> - <u>Schulzospora campyloptera</u> zone TC

<u>Lycospora pusilla</u> zone Pu

<u>Schopfites claviger</u> - <u>Auroraspora macra</u> zone CM

The Tournaisian - Visean boundary is considered to lie towards the middle of the <u>Lycospora pusilla</u> zone.

Two of the locations considered in detail in the above paper were of special interest with respect to the present work as they lie on the opposite side of the Northumberland Trough (viz. the Archerbeck borehole and Brampton).

Relatively few accounts have been published of Lower Carboniferous miospore distributions in the rest of Europe. Doubinger and Rausher (1966) described an upper Visean assemblage of miospores from the Vosges area of eastern France. Kalibova (1971), working in Czschoslovakia, has described a Lower Carboniferous assemblage and Jachowicz (1967, 1970) published an account of spores from the Lower Carboniferous Zareby Beds of south east Poland, and in 1970 also published details of upper Visean assemblages from southern Poland. Rumanian assemblages ranging from Visean to Westphalian A age have been described by Beju (1970). The most recent contribution from Europe has been the account by Bertelsen (1972) of findings from a borehole in Denmark. The miospore assemblages found were assigned to the Pu zone of Neves et al. (loc. cit.) and comparisons were drawn with assemblages from eastern Canada, Scotland, northern England and the Donetz Basin of Russia. Bertelsen concluded that the spore producing plants on the southern margin of the Old Red Sandstone continent must have been uniform over long distances.

Lower Carboniferous microfloras of Eastern Canada have been described from the Visean Windsor Group by Barss (1967), Playford (1963b) and Neves and Belt (1970). The latter authors worked on the upper part of the Windsor Group and drew comparisons with late Visean assemblages from Scotland. The Horton Group, which underlies the Windsor Group, has been investigated by Hacquebard (1957), Playford 1963b) and Varma (1969). The lower part of the Horton Group has been compared with the Lower Limestone Shales of Burrington Combe (Dolby and Neves, 1970) and of the Forest of Dean (Sullivan 1964b). Assemblages from the upper part of the group are comparable with those from Scotland which fall into the CM zone of Neves et al. (1973) and part of the material described by Bertelsen (1972) from Denmark.

Lower Carboniferous assemblages from further afield have been described by Hacquebard and Barss (1957) and Playford and Barss (1963) from north-west Canada. These seem to represent part of a northern floral province which along with the Spitzbergen material has been placed in the Monilospora Suite of Sullivan (1965). In Australia Carboniferous miospore assemblages have been described by Balme (1960) Venkatachala (1964), De Jersey (1966), Evans (1968), Playford and Helby (1968) and Playford (1971). The Australian assemblages do not appear to show affinities to either of the suites described by Sullivan. Apart from Australia no assemblages of definite Lower Carboniferous age have been described from the Southern Hemisphere.

Figure 1a shows an attempt to correlate Northern Hemisphere spore sequences (after Neves, 1971).

CHAPTER FIVE

5.0.0. The Miospore Assemblages

In the following section the assemblages obtained from different horizons in the present study are described in stratigraphical order, commencing with the oldest and proceeding to the youngest. The definition of assemblage used here may differ slightly from that of some previous workers. An assemblage is considered to be the collective group of miospores showing distinctive characteristics and recovered from one horizon or from a group of horizons; it is considered to be approximately equivalent to 'assemblage biozone' of Harland et al. (1972). Some workers have used the term assemblage to describe the group of miospores recovered from one sample only, and others have used it to cover what Harland et al. (loc. cit.) would call a concurrent range biozone.

In the present study the assemblages have been grouped into larger units conforming to concurrent range biozones (Harland et al. loc. cit.). These have been identified by capital letters starting with A at the base of the succession and proceeding to H at the top. The assemblages have been numbered in similar order within each biozone. Table 2 shows the arrangement of assemblages and biozones in relation to the succession. It is to be noted that the strata in the Basement Group and Hensingham Group particularly have not been accurately dated by macrofossils.

In the following descriptions the first and last occurrences of the more important species are noted. Reference is made to lithological subdivisions, macrofossil zones and to the zonations of other palynologists where possible. Any stratigraphical or palaeogeographical conclusions are drawn in the discussion at the end of the section on each concurrent range biozone.

Lithological Units		Concurrent range biozones	Assemblages
L.C.M	Lower coal measures; Basal Coal Measure Sst.	H	H1
Hensingham group	1st. Sst.; 2nd. Sst.	G	G3
	3rd Sst.		G2
	4th sst.; 5th sst.; 6th sst.		G1
	7th Sst.; 8th Sst.; 9th sst.	F	F3
	10th sst.; Little Limestone Coal		F2
	Hensingham Grit; 1st Lst.		F1
Upper chief Limestone group	2nd. Lst.; ove bank sst.; 3rd Lst.	E	E1
	5 yard Lst.; Saccamina Lst; Single Post Lst.; Tynebottom Lst. (4th Lst.)	D	D2
Lower chief Limestone group	Jew Lst.; Rough Lst.; White Lst. (4th Lst.)		D1
	5th Lst; 6th Lst.	Gap	Gap
	7th Lst.	C	C1
Basement Beds	Basement beds	B	B2
	Cherty Lst.		B1
	Cockermouth lavas		
	Basement beds	A	A1
	Ordovician		

Relationship of Assemblages to local Stratigraphy

Table 2.

Chart 1 displays the ranges of all miospore species observed in this study, arranged in systematic groups. Chart 2 shows the ranges of selected species only, in order of their first appearances. The Limits of the assemblages and of the concurrent range biozones are included in both charts.

5.1.0. Concurrent range biozone A.

That part of the Basement Group lying below the Cockermouth Lavas is assigned to one concurrent range biozone within which one assemblage (A1) only has been delimited. The relevant strata are exposed at Redmain (fig. 1). Of the nine samples collected from this section only two yielded miospores.

Twenty two species were observed in the two samples. Three of these are restricted to this assemblage alone - Apiculiretusispora multiseta, Muraspora sp.A and Hymenozonotriletes fammenensis. Seven species are particularly common - Auroraspora macra, Schopfites claviger, Colatisporites decorus and Retusotriletes incohatus form between 60% and 70% of the populations, and Verrucosisporites nitidus, Colatisporites denticulatus and Punctatisporites sp.A together make up about 20% in roughly equal proportions.

Other important species present include Perotrilates perinatus, Baculatisporites fusticulatus, Spore type A, Corbulispora cancellata, Calamospora sp., Punctatisporites irrasus, Knoxisporites pristinus, Schopfites cf. claviger and Discernisporites cf. irregularis. Lycospora spp. are absent.

Discussion

Similar assemblages to this have been recorded from the Spilmersford borehole, East Lothian, the Birnieknowes borehole, Cove - Peasebay, and the lower part of the Cementstone Group near Edinburgh (in Neves et al. 1973). These were all assigned by these authors to their CM concurrent range zone. Assemblage A1 differs from the foregoing in the absence of Raistrickia corynoges and Umbonatisporites distinctus.

Many of the species present in assemblage A1 were recorded by Sullivan (1964a) from the Lower Limestone Shales of the Forest of Dean, although Neves et al. (loc. cit.) considered this assemblage to be slightly older than those recovered from the CM zone in Scotland. Sullivan records Discernisporites sp., which is probably equivalent to the present author's D. cf. irregularis. Some dissimilarities between the assemblages could be accounted for by their geographical separation. However, the high percentages of R. incohatus and Verrucosisporites grumosus (a species similar to V. nitidus) are common to both assemblages.

In 1968 Sullivan described a spore assemblage from the Cementstone Group of Ayrshire, and like Neves et al. from elsewhere in Scotland recorded a typical CM zone assemblage. However he did not find Colatisporites decorus and C. denticulatus to be so dominant as in the assemblage A1. Grandispora echinata was not observed by the present author until the next biozone.

A close comparison can be made with Clayton's (1971) assemblage, especially with Schopfites claviger. Many individuals were found with a central body in both of these assemblages. The present author has followed Neves and Ionnides (1974) in assigning these to a separate type, unlike Clayton (loc. cit.). Clayton also records Anaplanisporites baccatus in his assemblage. He infers a late Tournaisian age, but many of the species recorded by him do not occur until higher in the present sequence, e.g. Discernisporites micromanifestus.

Mortimer et al. (1970) and Llewellyn et al. (1969) recorded assemblages of similar age and miospore content from the Central Province of England. Further afield, the assemblages recorded from Spitzbergen (Hughes and Playford, 1961, Playford, 1962) have many species in abundance which do not occur in the present assemblage. The Russian Tournaisian assemblages have affinities with those of Spitzbergen.

It is concluded from the palynological evidence that this assemblage lies within the CM concurrent range zone of Neves et al. (loc. cit.). It follows from this that the strata concerned are Tournaisian in age, probably approximating to the Z coral-brachiopod zone. Although as yet no macrofossil evidence has been found to date these beds (see above) they have been assumed to be of Visean age. The overlying limestones have been placed in the S2 coral-brachiopod zone by Eastwood et al. (1968) (see above)

The possibility of reworking in these sediments must be considered. However the present author is of the opinion that if reworking has occurred then some younger microfloral elements would be present with the older, reworked material. This does not seem to be so. The overlying assemblage B1 contains species additional to those in A1, but this too lacks the *Lycospora*-content to be expected in sediments of C1 coral-brachiopod zone age or younger.

For a discussion of the ages of basal Carboniferous rocks in surrounding areas see Chapter 2 above.

5.2.0. Concurrent Range Biozone B.

That part of the Basement Group lying above the Cockermouth Lavas and passing into the base of the Seventh Limestone is assigned to concurrent range biozone B within which two assemblages are recognised (B1 and B2). The relevant strata are exposed in the Gill Yeat at Blindcrake (Fig. 1).

Seven of the 11 samples collected from these strata yielded miospores, but in samples 369 and 371 the preservation of the exines was very poor; they appear to have suffered much corrosion which may be the effect of reworking. Assemblage B1 covers strata from the top of the lavas to the Cherty Limestone at Blindcrake, and assemblage B2 includes strata above the cherty limestone up to the base of the Seventh Limestone.

Assemblage B1.

16 species from assemblage A1 continue up into B1, but Knoxisporites pristinus, and Calamospora sp. disappear a short distance above the lavas and Verrucosisporites nitidus, Punctatisporites sp. A and Discernisporites cf. irregularis disappear about half way up the strata concerned.

Important incoming species are Verrucosisporites nodosus, V. variotuberculatus, Colatisporites cf. decorus, C. type A, Anaplanisporites baccatus, Retusotriletes avonensis, Pulvinispora scolecophora, Spelaeotriletes microspinosus, Crassispora trychera, Grandispora echinata and Discernisporites micromanifestus. Rare but notable species also in this assemblage are Calamospora minuta, two species of Convolutispora, Stenozonotriletes clarus, Spinozonotriletes uncatus and Discernisporites crenulatus.

Notable species present throughout the range of this assemblage are Schopfites claviger, Colatisporites decorus, C. denticulatus and Aurora-spora macra. The lower part of the assemblage particularly has strong affinities with assemblage A1 occurring below the lavas.

Assemblage B2

This assemblage sees the first appearance of species of the genus Lycospora including L. noctuina var. noctuina, L. pusilla and L. rugulosa. Also making their first appearance are Lophotriletes microsaetosus, Lophozonotriletes bellus, Knoxisporites stephanophorus and Vallatisporites ciliaris. Other less significant incoming species are shown on Chart 1.

L. rugulosa is abundant, especially in sample F 20 where it constitutes 80% of the population. L. pusilla is rare at first but becomes abundant above the base of the Seventh Limestone. K. stephanophorus is spasmodic in occurrence but generally more frequent than L. bellus and V. ciliaris which are rare. Punctatisporites minutus, one of the longest ranging species found in this study, makes its first appearance in this assemblage and then occurs right through the sequence into Westphalian strata.

Species still present in this assemblage include Verrucosisporites nodosus, Pulvinispora scolecophora, Grandispora echinata, Perotrilites perinatus, Auroraspora macra, Crassispora trychera and rare specimens of Retusotriletes avonensis and Discernisporites micromanifestus. Baculatisporites fusticulatus makes its last appearance just below the Seventh Limestone, and Schopfites claviger disappears at the base of this assemblage.

5.2.1. Discussion

Essentially assemblages A1 and B1 are very similar although 18 additional species occur in the latter. The effect is to amplify the characteristics of the lower assemblage. Assemblage B1 compares very closely with those assigned by Neves et al. (loc. cit.) to their CM concurrent range zone and with those described by others which are mentioned in the discussion of assemblage A 1. The absence of the species Raistrickia corynoges, Umbonatisporites distinctus and very rare occurrence of Spinozonotriletes uncatus suggests that the assemblage is from a horizon towards the top of the CM concurrent range zone. According to Neves et al. (1973) this could include the strata just at the base of the C 1 coral-brachiopod zone.

The stratigraphical significance of these data is notable. As mentioned above, the Basement Group is currently placed in the Visean Series. At Blindcrake, where the strata containing the B zone assemblages are located, previous workers have found a fauna in the shale below the Seventh Limestone which includes Archaeocidaris sp., cf. Gigantoproductus sp., Productus cf. redesdalensis, Aviculopecten cf. eskdalensis, Limipecten cf. dissimilis, Edmondia senilis, Sanguinolites cf. plicatus, S. cf. variabilis, Sulcatopinna mutica, cf. Wilkingia elliptica and Aphelaeceras discum., but apparently no diagnostic zonal fossils (Eastwood et al., 1968). The fossils listed above are usually associated with strata of the S2 coral-brachiopod zone. The present evidence seems to suggest that the strata from immediately above the Cockermouth Lavas up to the cherty limestone in this section are in fact equivalent in age to the C1 coral-brachiopod zone or older. The present evidence also suggests that the strata between the Cherty Limestone and the base of the Seventh Limestone is more definitely equivalent to C1 age.

However, within a few metres the miospore assemblage changes. Assemblage B 2 is typical of those usually found in the Pu concurrent range zone of Neves et al. The first appearance of the species Knoxisporites stephanephorus and Vallatisporites ciliaris along with the first specimens of Lycospora spp. suggests that these strata are from an horizon towards the top of the Pu zone, ie. from near to the base of the C2 - S1 coral-brachiopod zone (Neves et al., loc. cit.). The rare occurrence of Crassispora aculeata implies the same because this species has only been recorded from the overlying TC concurrent range zone.

Within the space of a further few metres there is macrofossil evidence (Eastwood et al., loc. cit.) indicative of the S2 coral-brachiopod zone. Thus it is clear that this section of the sequence is very much reduced either by condensing or by disconformities.

Assemblage B2 can be compared with some of those described by Butterworth and Spinner (1967) from the Bewcastle area, particularly as regards the abundance of <u>Lycospora rugulosa</u> which those authors found especially in sediments of C2 - S1 coral-brachiopod zone age.

Bertelsen (1972) recorded assemblages from a borehole in Denmark which bear a close resemblance to assemblage B2. However, he found a much greater variety of species. <u>L. rugulosa</u> attained up to 83% in some of his samples. He also recorded <u>Raistrickia nigra</u> which is usually associated with strata of Upper Visean age in Britain.

East Canadian assemblages studied by Hacquebard, Playford and Varma all show some similarities with assemblages A1, B1 and B2. This is not surprising considering the close proximity of Canada to England during Lower Carboniferous times. (Fig.10.)

5.3.0. <u>Concurrent Range Biozone C.</u>

Strata in this biozone, which comprises only one assemblage, C1, include the lower part of the Lower Chief Limestone Group. 14 samples were collected from the Seventh Limestone and associated shales of which six yielded spores. The barren samples were mostly characterised by a very high percentage of fine grained material with no evidence of spores. Presumably this is indicative of a lack of spore input in the sediment rather than of subsequent degradation. Ten samples were collected from the strata between the Seventh and Sixth Limestones and of these three yielded spores. Eleven samples from horizons of the Sixth and Fifth Limestones and the intervening shales were all barren. The residues were characterised by mushy clots of material which often had the size and shape of miospores. This material may be the product of sapropelic decay of the spores as described by Elsik (1971). Whatever the cause, the environmental conditions prevailing during the deposition of these strata clearly did not favour the preservation of miospores.

26 species make their first appearance at the base of assemblage Cl. Three of these are very rare in occurrence and are restricted to this assemblage - Convolutispora cerebra, C. cf. finis and Perotriletes magnus. The more significant of the remaining first appearances are P. tessellatus. Waltzispora planiangulata, Schulzospora rara, S. sp. and S. elongata, marking the first appearance of this genus. This assemblage is also marked by the first appearance of species of the genus Densosporites including D. annulatus, D. triangularis, D. spinifer, and a very rare occurrence of D. cf. regalis. Dictyotriletes sagenoformis, D. fragmentimurus and Laevigatosporites desmoinensis all appear for the first time in the assemblage. Other incoming species in this assemblage are Punctatisporites minutus, Calamospora spp., Verrucosisporites nodosus, Anaplanisporites baccatus, Lophotriletes microsaetosus, Stenozonotriletes clarus, Knoxisporites stephanophorus, Pulvinispora scolecophora, Lycospora noctuina, L. pusilla, Spinozonotriletes uncatus, Crassispora aculeata, Vallatisporites ciliaris and Perotrilètes perinatus.

Densospores and lycospores, especially D. annulatus and L. pusilla, make up 80% or 90% of the populations for the first time in the present study. D. annulatus becomes more abundant in the higher part of the biozone, reaching 40% in some samples.

Eleven species die out within this zone, notably Retusotriletes incohatus, Lycospora rugulosa, Colatisporites decorus, C. denticulatus and Auroraspora macra. The apparent extinction of so many important species is undoubtedly a result of the lack of data from above the shales between the Seventh and Sixth Limestones, samples from which were barren, and exposure of which was very poor. (see chapter 2).

5.3.1. Discussion

This assemblage has several characteristics which seem typical of the TC concurrent range zone of Neves et al. (loc. cit.). It sees the first appearances of the genera Densosporites and Schulzospora, and Crassispora aculeata becomes more common. On the other hand many of the typically Tournaisian species present in lower assemblages die out.

The present author is of the opinion that this assemblage lies towards the top of the TC zone. It differs in certain respects from assemblages described from this zone in Scotland and the North of England. Potoniespores delicatus is not recorded in this sequence at all and Triquitrites marginatus is not found until higher in the sequence, and is then rare. The bulk of the evidence therefore suggests the placing of this assemblage in the upper part of the TC zone, which, according to Neves et al. (loc. cit.) signifies an horizon in the S2 coral-brachiopod zone. The lack of obvious discordance between the strata concerned and those below in which assemblage B2, characteristic of the Pu concurrent range zone (equivalent to the lower part of the C2 - S1 coral-brachiopod zone), occurs must mean that the sequence is condensed, or that most of the C2 - S1 zone is missing.

Smith and Butterworth (1967) record assemblages from coals of this age in Northumberland, but detailed comparison is not necessary owing to the fact that coals were not sampled in the present sequence. However, this assemblage can probably be related to their Grumosisporites verrucosus assemblage 1.

Sullivan (1964b) recorded an assemblage from the Drybrook Sandstone of the Forest of Dean which shows many similarities to the present one. There are differences however in that several species described by Sullivan are not present; these include several species of Leiotriletes, and Neoraistrickia drybrookensis and Lycospora uber which do not occur until much higher in the present sequence. Sullivan did not record Perotriletes tessellatus.

5.4.0. Concurrent range biozone D

Strata in this zone represent that of the upper part of the Lower Chief Limestone Group, including the White Limestone up to the base of the Third Limestone. Out of 48 samples collected from these horizons, 16 yielded spore populations. The barren samples were mostly of the variety which were characterised by mush clumps as described above, especially below the Tyne bottom limestone.

Twenty seven species appear near the base of the White Limestone and a further twelve in the region of the Rough Limestone. This large influx of new species is not the result of a sudden burst of evolution but is rather the effect of the lack of data for the Fifth and Sixth Limestones. The sudden mass incomings simply represents the backlog of new species. These populations have been grouped into the lower of two assemblages in this zone (D1).

The second assemblage (D2) is marked by an incoming of five new species at the horizon of the Jew Limestone, and encompasses the strata up to the shales below the Third Limestone.

Many of the newly appearing species in assemblage D1 are of significant stratigraphic importance and include Raistrickia peltatus, Muraspora intorta, Camptotriletes cristatus, M. sublobata, Tripartites distinctus, T. vetustus, Triquitrites batillatus, T. bransoni, T. comptus, T. marginatus, Tricidarisporites magnificus, Rotaspora crenulata, Tholisporites decoratus, Crassispora maculosa, Spelaeotriletes arenaceus, and Grandispora spinosa.

T. vetustus is rare at first but gains in importance a little higher in the sequence. All the species mentioned above only ever occupy very low percentages of the populations, between 1% and 2%. C. maculosa is the least rare of these spores. However their diagnostic value cannot be over-emphasised. Towards the upper part of the assemblage Rotaspora ergonulei and R. knoxi are important incoming species.

Important species also occuring in this varied assemblage are Waltzispora planiangulata, W. polita, Verrucosisporites nodosus, Lophotriletes microsaetosus, Dictyotriletes fragmentimurus, Dictyotriletes sagenoformis, Lycospora noctuina, L. pusilla, Vallatisporites ciliaris, Discernisporites micromanifestus, Perotrilites perinatus, Schulzospora rara, Laevigato sporites and Bianulatisphaerites simplex. The latter species first appears in assemblage C1 although only one specimen was recorded from that assemblage.

Dictyotriletes submarginatus, Crassispora aculeata, and Pulvinispora scolecophora are important species to make their last appearance in this assemblage. This low percentage of outgoings seems to be a characteristic feature of these horizons, and contrasts with higher horizons. Many of the species of this assemblage can be compared with those of surrounding areas, these are discussed below.

Assemblage D2

The second assemblage has clear affinities with the first assemblage but with the additions of Punctatisporites obesus, Knoxisporites triradiatus, K. dissidius, Ahrensisporites guerickei, Raistrickia nigra and Convolutispora cf. varicosa. Of these, K. triradiatus, R. nigra and A. guerickei are stratigraphically significant and are the basis for distinguishing this assemblage. However A. guerickei is very rare indeed. These are no important species which die out in these horizons, which cover the Jew, Tyne bottom and Five Fathom limestones.

The species which attain greater numerical importance in this assemblage and which first made their appearance in the preceeding assemblage are Crassispora maculosa, Rotaspora crenulata and Tripartites vetustus.

5.4.1. Discussion

The first assemblage represents a very much changed microflora from that of the earlier assemblages. This is due to the large gap which separates them. Macrofossil evidence puts the strata in this concurrent range zone in upper D1 and D2 coral-brachiopod zones (Eastwood et al. 1968). The aspect of the assemblages is entirely consistant with this dating. The dominant features of the first assemblage indicate a placing within the uppermost part of the NM concurrent range zone and lower part of the VF zone of Neves et al. 1973.

Rotaspora is present as is Triquitrites marginatus, and although very rare at first, Tripartites vetustus gradually gains in importance. Crassispora maculosa does not appear until the upper part of the first assemblage, with Grandispora spinosa, and this supports the view that the boundary between the NM and VF zones is being spanned. If this is so the boundary must be close to the D1, D2 coral-brachibpod zonal boundary which occurs at the base of the Rough Limestone. This appears to be a little lower in the Carboniferous sequence than is suggested by Neves et al. (1973). Alternatively the lower part of the D2 sequence in this area could be condensed or missing.

Lele and Provan (1962) described an assemblage from horizons in the Lower Oil Shale Group of Ayrshire which is placed lower in the NM zone. The assemblage described by Love (1960) from similar horizons shows general similarities but again probably lies lower in the zone towards the base of the D1 coral-brachiopod zone as described by Neves et al. 1973.

Marshall and Williams (1971) have described assemblages from similar horizons in Northumberland which represent the closest geographical comparison. From their samples 1 and 2 many similar species were obtained. These workers did not record Tripartites vetustus until the Green Gate Well Limestone, (sample 3), higher in the sequence than the first occurence of Triquitrites marginatus, which is in accordance with the present study.

Further evidence for this assemblage being representative of the lowest part of the VF zone is the lack of Rotaspora fracta. Marshall and Williams did not record this species until higher in their sequence and this compares exactly with the findings in the present study. Raistrickia nigra is lacking in the first assemblage but a few specimens have been recorded in the second assemblage. This occurence probably represents the upper part of the range of this species. This would be expected if the assemblage is at the top of the NM zone.

Lycospora uber and Rugospora corporata var. verrucosa are both common in the assemblage of Marshall and Williams but both are not recorded until higher in the present sequence. Hibbert and Lacey (1969) described an assemblage from N. Wales which in some respects resembles this one, although it is more definitely placed in the NM zone. They record several species not seen in the present study such as Umbonatisporites variabilis, various species of Dictyotriletes, and Remysporites magnificus, also various Tournaisian components were recorded which were considered to be due to reworking. In many ways the Menai Strait assemblage of Hibbert and Lacey is similar to the assemblage from the Drybrook Sandstone of Sullivan (1964b) and the comparisons with the present assemblages are of a similar nature.

As has been stated above the second of the two assemblages is largely similar to the first. Although R. nigra is present it is rare. The increased importance of Tripartites vetustus and Crassispora maculosa in the assemblage seems to suggest a more definite VF zone aspect for this assemblage. Rotaspora fracta which is used by Neves et al. (1973) to delimit the base of the VF zone in the Spilmersford borehole does not occur until slightly higher in the present sequence. The Diatomozonotriletes assemblage (VII) of Smith and Butterworth (1967) probably represents similar age strata.

5.5.0. Concurrent range biozone E

The strata encompassed by this zone include those above the Five Fathom Limestone to the base of the First Limestone, within the Upper Chief Limestone Group. Populations of miospores were recovered from twelve samples out of twenty five collected. At the horizon of the Third Limestone a change in the miospore populations occurs but this is not considered to be sufficiently significant to warrant the recognition of more than one assemblage (E1) in this biozone.

Assemblage E1

Twenty four species make their first appearance and eight other species die out in this assemblage. Therefore in this part of the sequence a distinct assemblage is recognised. Many very important species with a Namurian aspect occur in this assemblage for the first time, notably Waltzispora prisca, W. sagittata, Microreticulatisporites concavus, Rotaspora fracta, Tricidarisporites fasciculatus, Tholisporites scoticus, Bellispores nitidus, Cingulizonates cf. capistratus, Vallatisporites vallatus, Spencerisporites radiatus, Auroraspora solisortus and Rugospora corporata var. verrucosus.

C. cf. capistratus, which is especially important is very rare indeed early in this assemblage. This specis only becomes a significantly important member of the populations above the Second Limestone.

Early in this assemblage it only attains a maximum frequency of less than 1% of the populations compared with 20% or more above the Second Limestone.

T. scoticus was found to be rare, only a few specimens were recorded which is interesting in the light of previous work which is discussed below. Other species which appear in this assemblage are Punctatisporites minutus, Granulatisporites minutus, Lophotriletes commisuralis, Dictyotriletes clatriformis, Muraspora aurita, Tholisporites biannulatus, Stenozonotriletes bracteolus, Grumosisporites rufus, G. inaequalis, Kraeuselisporites ~~clatriformis~~ echinatus, and Corrugitriletes ruginosus.

The drastic change in the microflora compared with that of the preceeding assemblage is further emphasised by the last appearance of several notable species between the Five Fathom and Third Limestones. These species are Triquitrites batillatus, Dictyotriletes fragmentimurus, Reticulatisporites peltatus, Perotrilètes tessellatus, Spelaeotriletes arenace us, and a little earlier than these Vallatisporites cìliaris.

Important species occurring in this assemblage which also occur in the preceeding one are Rotaspora knoxi, R. ergonulii, Triquitrites comptus, (although very rare), Grandispora spinosa, Crassispora maculosa, Tholisporites decoratus, Triparitites vetustus, which attains frequencies of up to 15% of the populations and Biannulatisphaerites simplex. The significance of this very distinctive assemblage is discussed below.

5.5.1. Discussion

This assemblage is comparable with those in the VF concurrent range zone of Neves et al. 1972. Although very rare, the occurence of Cingulizonates cf. capistratus here would seem to correspond with previous records, for example in E. Fife, Neves et al. 1973. However the species is rare in this assemblage at first and does not become important until the upper part. The use of this species as an indicator for the base of the Namurian would seem loosly valid.

Vestispora was not recorded in the present study but is distinctive in the Scottish Province. Species of this genus were recorded by Sullivan and Marshall (1966) in the assemblages obtained from Scotland along with Tripartites vetustus, Grandispora spinosa, Rotaspora fracta, R. knoxi and Crassispora maculosa.

Assemblages recorded by Marshall and Williams (1971) in Northumberland, are the closest to the present study. Here Raistrickia nigra becomes important and Savitrisporites nux appears earlier than in the present study where it appears at the base of the Second Limestone. C. cf. capistratus first appears in their sample 11, below the Three Yard Limestone which is equivalent to the Third Limestone. However the sampling of the Yoredale Limestones in this part of the sequence is very scanty in Marshall and Williams' study. Only one sample was taken from strata between the Scar Limestone and the shales between the Four Fathom Limestone and Great Limestone, i.e. the whole of P 2 B and P 2 C in the goniatite zonal scheme.

Spencerisporites radiatus first appears in their sample 8, just below the Single Post Limestone, whereas in the present study it first appears higher up the sequence at the Third Limestone. T. vetustus makes its first appearance at a lower horizon and is scarce in the corresponding sequence by Marshall and Williams. Auroraspora solisortus was much more important numerically in the present study than in theirs.

One important point is their recorded occurrence of Bellispores nitidus. This species first occurs in strata above the Great Limestone, well into the Namurian E1 goniatite stage in Marshall and Williams sample 16. This seems to be a late occurrence, according to the data in Neves et al. (1973) the first occurrence has elsewhere been recorded in mid P2 strata as is the case in the present study.

At the top of the present assemblage, just above the Ore Bank Sandstone B. nitidus becomes an important recognisable component. This would appear to suggest that the Third Limestone is of similar age to strata which lie in the P2 goniatite zone. This is consistent with the macrofossil evidence in similar strata in the region to the East. Tholisporites scoticus was first recorded in the present study in this assemblage whereas Marshall and Williams found that it did not appear until the base of the Namurian.

As described above Sullivan and Marshall's assemblage from Ayrshire shows numerous similarities with the present one, and in the upper part the VF - NC zonal boundary is crossed. The present assemblage is probably a result of a very similar parent flora, which can be assigned to the Grandispora suite of Sullivan (1968).A discussion of this is given above.

The strata in this concurrent range zone represents the top of the Visean Series in the area. Changes of significance across the boundary to the Namurian Series are of particular interest. As can be seen from chart 2 the significant changes are the dying out of five species, none of which is of great stratigraphic significance. This lack of a fundemental change is consistant with previous work, particularly Marshall and Williams (1971).

5.6.0. Concurrent Range Biozone F.

This biozone extends from the shales above the Second Limestone in the Upper Chief Limestone Group up to the Sixth Sandstone in the

Hensingham Group. The top of the Second Limestone is taken as the base of the Namurian Series according to contemporary convention (see above). From the strata in this zone 82 samples were collected and processed and 40 of these yielded reasonably good spore populations (See fig. 3). The coverage of the strata is better than may be indicated by these figures because many of the samples were closely spaced. Three assemblages are recognised in this biozone (F1, F2 and F3).

Assemblage F1.

The lowest assemblage includes strata from the shales above the Second Limestone to the top of the Hensingham Grit. Its base is marked by the first appearance of Calamospora liquida, Stenozonotriletes coronatus, Bascaudaspora canipa, Lophozonotriletes sp. A, and Savitrisporites nux. The base of the assemblage is also marked by the disappearance of the species Camptotriletes cristatus, Dictyotriletes insculptus, Perotrilites perinatus and, a little higher in the succession, Laevigatosporites desmoinesensis. This latter species, which has also been recorded from the Westphalian Series, was not recorded higher in the sequence in the present study.

This very varied assemblage includes the following important species:- Punctatisporites obesus, P. nitidus, Calamospora microrugosa, Leiotriletes inermis, L. parvus, Granulatisporites microgranifer, G. minutus, G. granulatus, Waltzispora polita, W. prisca, Anaplanisporites baccatus, Lophotriletes commisuralis, L. gibbosus, Acanthotriletes echinata, Raistrickia nigra, Camptotriletes superbus, Microreticulatisporites concavus, Knoxisporites stephanephorus, Stenozonotriletes cf. clarus, Bellispores nitidus, Rotaspora cremulata, R. ergonulei, R. fracta, R. knoxi, Triquitrites comptus (rare), Tripartites vetustus, Lycospora noctuina var. noctuina, L. pusilla (very abundant) Cingulizonates cf. capistratus, Densosporites brevispinosus, D. spinifer (very abundant), D. pseudoannulatus, Tholisporites decoratus, T. ?bianulatus, Vallatisporites vallatus (very rare), Kraeuselisporites echinatus, Crassispora maculosa, Corrugitriletes ruginosus, Rugospora corporata var. verrucosa (rare), Grandispora echinata, G. spinosa, Auroraspora solisortus and Schulzospora spp.

Assemblage F2.

Strata with this assemblage extend from the Hensingham Grit to the Ninth Sandstone in the Hensingham Group. They were among the most productive in the present study and they contained spores were among the best preserved. However the Little Limestone Coal did not yield a useful preparation as it consisted mainly of the mush clumps which elsewhere in this study have been thought to be associated with sapropelic activity in the depositional environment.

The assemblage is again a very varied one and the following species first appear at or near to its base:- Anapiculatisporites minor, Acanthotriletes falcatus, Pustulatisporites papillosus, Neoraistrickia drybrookensis (rare), Murospora friendii and Discernisporites cf. micromanifestus which dies out at the top of this assemblage.

Stenozonotriletes bracteolus and Rotaspora fracta make their last appearance at the base of the assemblage. Murospora sublobata, Rotaspora ergonulii and Densosporites brevispinosus are important members of this assemblage, but make their last appearances in it, disappearing in the strata above the Hensingham Grit.

Important species also occurring in this assemblage are as follows:- Calamospora liquida, Leiotriletes inermis, L. cf. priddyi, L. tumidus, Granulatisporites minutus, Anaplanisporites baccatus, Lophotriletes commisuralis, Acanthotriletes echinatus, Waltzispora prisca, Tricidarisporites magnificus, Savitrisporites nux, Convolutispora laminosa, Micro-

-reticulatisporites concavus, Bellispores nitidus, Rotaspora knoxi, Triquitrites marginata, Tripartites vetustus, Corrugitriletes ruginosus, Lycospora noctuina, L. pusilla, Cingulizonztes cf. capistratus (very abundant), Densosporites annulatus, D. spinifer, D. triangularis, Tholisporites ?bianulatus, T. decoratus, Auroraspora solisortus and Crassispora maculosa.

The top of the assemblage is marked by the disappearance of Punctatisporites sinuatus, Tricidarisporites fasciculatus, Raistrickia nigra, Microreticulatisporites nobilis, Dictyotriletes sagenoformis, Murospora intorta, Rotaspora crenulata, Biannulatisporites simplex, Grumosisporites inaequalis and G. rufus. Waltzispora sagittata becomes very rare above this horizon.

Assemblage F 3

Strata with this assemblage extend from between the Ninth and Tenth Sandstones to the Sixth Sandstone of the Hensingham Group. The base is marked by the disappearance of the species listed at the end of the preceeding section. The only species to make its first appearance at the base of this assemblage is Microreticulatisporites microreticulatus, which has been recorded from lower horizons by other workers.

The species which characterise this assemblage are as follows:- Calamospora microrugosa, Anapiculatisporites minor, Acanthotriletes falcatus, Lophotriletes commisuralis, Pustulatisporites papillosus, Verrucosisporites morulatus, Convolutispora cf. usitata, Savitrisporites nux, Microreticulatisporites concavus, Corrugitriletes ruginosus, Lycospora pusilla (dominating the assemblage numerically), Cingulizonates bialatus, C. cf. capistratus, Densosporites annulatus, D. pseudoannulatus, D. spinifer, Kraeuselisporites echinatus, Bascaudospora canipa, Vallatisporites vallatus, Crassispora maculosa and Schulzospora spp.

The following species disappear at the top of the strata concerned:- Tricidarisporites magnificus, Convolutispora laminosa, Neoraistrickia drybrookensis, Bellispores nitidus, Triquitrites comptus, Muraspora friendii, Rotaspora knoxi, Grandispora spinosa (this is the final appearance of this spore after it became extremely rare above the horizon of the Sixth Limestone), and Discernisporites micromanifestus.

This marked extinction of species seems to be a characteristic of the Namurian assemblages generally. Most of the above species are important stratigraphically, as will be discussed below.

5.6.1. Discussion

The three assemblages making up this biozone have many species in common which occur in most of the samples examined. F1 and F3 are distinguished by the disappearance of species present in earlier assemblages, and the same applies to F2 but in this case there are also some new appearances to mark its base.

The assemblages compare well with those of previous workers in strata of Namurian A age. These include Butterworth and Williams (1958) in the Midland Valley of Scotland, Neves (1961) in the Southern Pennines, Mishell (1966) in the Bowland Fells, Owens and Burgess (1966) in Stainmore, Smith and Butterworth (1967) in Scotland and Northumberland and Marshall and Williams (1971) in Northumberland.

None of these authors has recorded marked changes in spore distributions at the boundary between the lower and upper parts of the Eumorphoceras goniatite stage (E1 and E2 respectively). However, there is some evidence to indicate that strata of E1 age are present in the Cockermouth area, and this is detailed in the following paragraphs.

Rotaspora fracta is the only species which all of the authors listed above recorded from the El goniatite stage only (with the exception of Neves, 1961, who did not find this genus in the Southern Pennines). R. fracta has been found in the present study in the Fl assemblage and in the lower part of the F2 assemblage. On present evidence therefore it seems certain that the Fl and lower F2 assemblages correlate with the El goniatite stage. The presence of Tholisporites scoticus in the Fl assemblage substantiates this conclusion as it was recorded by Butterworth and Williams (1958) only from the Scottish Limestone Coal Group, and by Mishell (1966) only from similar El horizons in Bowland.

The presence of Bellispores nitidus throughout the F biozone could suggest that the lower part of the El goniatite stage is missing from the section under study, as none of the previous authors already listed have recorded it from the lowest part of the stage. However, in the present section this species occurred lower in the sequence, in the Visean Series.

Species which have been recorded only from the El and lower part of the E2 stages of the Namurian Series include Rotaspora knoxi, Tripartites vetustus, Crassispora maculosa and Grandispora spinosa. C. maculosa and T. vetustus range higher in the present sequence than biozone F and will be referred to later; the other two species on the other hand are restricted to assemblages Fl-3. This rather scanty evidence seems to suggest that F3 is no younger than the lower part of the E2 goniatite stage. The presence in assemblage F3 of Acanthotriletes falcatus, Waltzispora polita, Pustulatisporites papillosus and Verrucosisporites morulatus could be used to argue an El goniatite age as all were found to be restricted to the Scottish Limestone Coal Group (Butterworth and Williams, 1958). All, however, have been recorded subsequently from higher horizons, notably by Mishell (1966) in the Bowland area.

On the whole there seems to be little change in the microfloras across the Visean - Namurian Boundary, which is in agreement with the findings of earlier workers. Bascaudaspora canipa is a species which could perhaps be added to the list of those marking the onset of Namurian sedimentation.

It has been demonstrated in the present author's opinion that evidence exists to suggest that strata equivalent to E1 age is present in the lower part of the Hensingham Group. This evidence comes from one section only of the strata, the Cockshot Beck - River Ellen and the Bothel Beck and Gill Godden stream sections, which lie in the west of the area. As described in Chapter 2, the geographical extent of the postulated non-sequence described by Eastwood et al. (1968) at the base of the Hensingham Group may be confined to the east of the present area.

Comparisons with work on Namurian strata from further afield is made at the end of the following section.

5.7.0. Concurrent Range Biozones G and H

The strata in these zones comprise the horizons in the Hensingham Group above the Sixth Sandstone up to and including the lower part of the Lower Coal Measures. Concurrent range biozone G has been divided into three assemblages (G1, G2 and G3) which encompass the upper part of the Hensingham Group. Concurrent range biozone H includes one assemblage (H1) which occurs in the Lower Coal Measures. The description and discussion of the four assemblages are treated in one section in order that the important horizons at the boundary between the Hensingham Group and the Lower Coal Measures (Namurian and Westphalian Series respectively) may be considered. 80 samples were collected from these strata and 45 yielded satisfactory miospore preparations.

Assemblage G1

This assemblage is found in strata between the Sixth Sandstone and the Third Sandstone in the Hensingham Group. Its base is marked by the disappearance of the important species listed at the end of the last section. As a result of this the assemblage shows a lack of variety compared with earlier ones.

The species Leiotriletes densus, Schopfipollenites ellipsoides and Florinites similis make their first appearance at the base of the assemblage. Other important constituent species include Calamospora microrugosa, Lophotriletes commisuralis, Microreticulatisporites concavus, Savitrisporites nux, Cingulizonates cf. capistratus (still abundant), Lycospora pusilla, various species of Densosporites, with D. annulatus and D. spinifer being the most common, forming usually about 20% of the populations excluding Lycospora spp., Kraeuselisporites echinatus (becoming rare), Crassispora maculosa and Auroraspora solisortus.

Assemblage G2

The strata in which this assemblage occurs lie between the Third and Second Sandstones of the Hensingham Group. It occupies only a few metres of strata and has as its distiguishing characteristic the reduced nature of its microfloras. The base is marked only by the disappearance of seven species present in the underlying assemblage. These are Calamospora breviradiata, Anapiculatisporites concinnus, Waltzispora prisca, Acanthotriletes echinatus, A. falcatus, Microreticulatisporites concavus, and Schulzospora elongata.

Notable species still present in the assemblage include Calamospora microrugosa, Anapiculatisporites globulus (very rare), Corrugitriletes ruginosus, Tripartites vetustus, Lycospora pusilla, L. noctuina var. noctuina, Densosporites annulatus, D. triangularis, Cingulizonates bialatus, C. cf. capistratus, Aurorospora solisortus, Schulzospora rara, Spencerisporites radiatus (very rare), and Schopfipollenites ellipsoides.

The following species are present in the assemblage but were not found any higher in the present sequence:- Granulatisporites microgranifer, Pustulatisporites papillosus, Anapiculatisporites minor, Microreticulatisporites microreticulatus, Triquitrites marginatus, Stenozonotriletes lycosporoides, Densosporites spinifer, Kraeuselisporites echinatus Vallatisporites vallatus (already very rare) and Crassispora maculosa.

Assemblage G 3

The strata containing this assemblage extend from the Second Sandstone of the Hensingham Group to the basal grit of the Lower Coal Measures. The many disappearances of species noted in the two previous assemblages continue in this one, at various levels within the section.

The base of the assemblage is marked by the first appearances of the following species:- Apiculatisporis variocorneus, Diatomozonotriletes rarus, D. ubertus (both of these latter two species very rare), Secarisporites lobatus and Crassispora kosankei.

Species which feature in this assemblage and which persist into the overlying strata are Calamospora liquida, C. microrugosa, Leiotriletes densus, Punctatisporites minutus, Granulatisporites granulatus, G. minutus, Knoxisporites stephanephorus, Lycospora noctuina, L. pusilla, Densosporites annulatus (although this species is very rare in the overlying strata), Aurorspora solisortus, Schulzospora rara, Florinites mediapudens and F. similis.

It has been noted above that many species disappear at a number of horizons in these strata. This may be in part due to the very poor spore recovery from many of the samples taken from towards the top of the Hensingham Group. These spores include Punctatisporites minutus, Calamospora minuta, Granulatisporites minutus, Anaplanisporites baccatus, Lophotriletes microsaetosus, Bascaudaspora canipa, Acanthotriletes castanea, A. microspinosus, Densosporites pseudoannulatus, D. triangularis, Tripartites vetustus, Tholisporites ?bianulatus, Murospora sublobata, Cingulizonates cf. capistratus, Grumosisporites inaequalis, Rugospora corporata var. verrucosa and Spencerisporites radiatus.

Assemblage H 1

The fourth assemblage for consideration in this section has been assigned to a separate concurrent range biozone (H) because of the large influx of new species appearing at its base. It is separated from assemblage G 3 by the basal Westphalian Grit which yielded no miospores. The gap between samples 355 and 753 represents approximately 20 metres of basal Westphalian strata. The assemblage is derived from eleven samples which yielded good miospore preparations. The Harrington Four Feet coal seam was also investigated but produced very poor results, as was found by Smith and Butterworth (1967).

The species making their first appearance in this assemblage include the following:- Apiculatisporis spinulistratus, Verrucosisporites microtuberosus, Raistrickia fulva, R. microhorrida, R. saetosa, Knoxisporites rotatus (very rare), Triquitrites trivalvis (in the Harrington Four Feet coal), Cirratriradites saturni, ~~?Lycospora granulata, L. rotunda~~, L. uber Densosporites horridus, Secarisporites remotus, Grumosisporites varioreticulatus, Florinites grandis, F. junior, F. pumicosus and F. visendus.

5.7.1. Discussion

Assemblage G1 covers strata from the Sixth to just above the Third Sandstone. It is closely associated with earlier assemblages in that it contains Tripartites vetustus and Crassispora maculosa, typical E1 goniatite stage spores. It is an unusual assemblage compared with those from surrounding areas in that it also contains Florinites similis. However, Smith and Butterworth (1967) record T. vetustus and C. maculosa from E2 strata up to the horizon of the Orchard Limestone in the Scottish Upper Limestone Group, and Mishell (1966) records the first appearance of F. similis at the base of the E2 goniatite stage in the Bowland area. So it seems possible that assemblage G1 is from the lower half of the E2 goniatite stage. The first appearance in this assemblage of Schopfipollenites ellipsoides would correspond with Owens and Burgess's (1966) first record of the species at the base of the E2 stage in Stainmore. Neves (1961) however recorded the species from throughout the Namurian of the Southern Pennines. The presence of Microreticulatisporites concavus, Kraeuselisporites echinatus and Bellispores nitidus is also suggestive of an horizon in the Eumorphoceras Stage, although Mishell (1966) recorded all of them from higher horizons in the Bowland Fells.

Many of the characteristic lower Namurian miospores disappear in assemblage G2, found in the shales between the Third and Second Sandstones, and the next significant event is the first appearance of the species Apiculatisporis variocorneus, Secarisporites lobatus and Crassispora kosanke in assemblage G3 from the Second Sandstone and higher strata at the top of the Hensingham Group. Apiculatisporis variocorneus is a more typically Westphalian A species but Mishell (1966) recorded it from the Homoceras stage in Bowland. S. lobatus was first recorded by Neves (1961) from the Homoceras stage and higher in the South Pennines, from the Reticuloceras stage and higher in Stainmore (Owens and Burgess, 1966), and from the E2b stage and higher in Bowland by Mishell (1966). Owens and Burgess (loc. cit.) and Smith and Butterworth (1967) recorded the first appearance of Crassispora kosanke in the middle of the Eumorphoceras stage in Stainmore and the Midland Valley of Scotland respectively.

Neves (loc. cit.) and Mishell (loc. cit.) recorded much later and earlier first appearances respectively for this species in the South Pennines and Bowland.

Thus evidence appears to be present to substantiate the macrofossil evidence that E2 age strata occurs in Gill Godden. Furthermore there is some tentative suggestion that part of the Homoceras stage may also be present.

The low percentage of F. similis and other saccate grains is similar to the findings of Mishell in Bowland. This contrasts with the south Pennines and Stainmore where such spores and pre pollen are more prominent. This probably reflects the palaeogeographical situation especially with regard to wind direction. As described above the prevailing wind direction must have been from the north east during the Upper Carboniferous. Florinites and Schopfipollenites, presumably anemophilious grains, could not have been carried into the area by air currents from their source flora. Furthermore the catchment area of the terrestrial drainage systems may not have collected such grains so that they would not have been incorporated in these sediments. Or alternatively the sea currents may have been such as to cause the outfall plume of the drainage system to be deflected away from this area. The lack of Tripartites and Rotaspora in the south Pennine area must also be accounted for by similar phenomena. These grains from their construction may not be wind borne; therefore terrestrial drainage patterns and ocean currents must be involved rather than wind direction. One solution would be for there to have been a land mass to the south of the present area, possibly a remnant of the Cumbrian positive block. This would have provided source material for the Hensingham Grit and succeeding deposits from North flowing rivers containing Tripartites and Rotaspora. A more or less south flowing drainage system from this relict block presumably would not have carried these spores if their parent flora was confined to the northern flanks of the block.

With the predominant wind direction being north easterly the northern side of the land mass would be expected to be an area of greater precipitation than the southern side. Therefore the parent flora for Tripartites and Rotaspora may have been less xerophytic, or the precipitation mass may simply not have been sufficient to supply a southerly flowing drainage system.

Thus the greater percentage of saccates in the Pennines and Stainmore and lack of Tripartites and Rotaspora in the Pennines may be due to a combination of wind direction, consequent precipitation and relative position of the land.

Toward the top of the Hensingham Group poor recovery and preservation of spores prohibits comprehensive comparisons. There is a similar problem in the early Westphalian samples, and this probably helps to account for the apparent massive dying out of many species.

The assemblage in concurrent range biozone H is clearly very different due to two major reasons. The large non-sequence postulated by previous workers, (see above), would allow the parent plants of many species to become extinct. This seems to be the case as can be seen from the large number of species dying out at the top of the Hensingham Group. The presence of the basal Lower Coal Measure grit would also tend to accentuate this, as no effective samples were found in it.

All the species which persist into these strata from those below are typical Westphalian A species as recorded by numerous workers in the past. For example, Mishell (1966), Owens and Burgess (1966), Neves(1958, 1961) and Smith and Butterworth (1967) all record similar species from Westphalian A sediments in surrounding areas. One interesting feature is the rarity of Densosporites anulatus. This is not a feature noted by other workers. Another interesting feature is the occurrence of Florinites mediapudens at the top of the Hensingham Group. Mishell does not record this species until Westphalian A strata at Bowland.

In Biozone H the incoming species are all very characteristic Westphalian A species. They are typical of assembalges recorded by many previous workers. Especially notable are the species of Florinites and Raistrickia fulva. The latter has been recorded from R2 strata at Bowland which may be further evidence for a non sequence as is the occurrence of Raistrickia microhorrida which Mishell records from R1 up to Lower Westphalian A. The occurrence of Secarisporites remotus is similar and also tends to indicate the loss of the upper stages of the Namurian at the top of the Hensingham Group.

Coals in the strata above the Harrington four foot coal seam have been palynologically analysed in this region by Smith and Butterworth (1967). The Harrington four foot seam provided a very poor spore recovery as did all the coals in the succession below this in the present study. Coals above this yielded good spore preparations (samples loaned from N.C.B.) therefore regional effects to explain the poor yields at lower horizons can probably be ruled out. The conclusions drawn are that the spore assemblages from the lower strata of the Lower Coal Measures in Gill Godden appear to be consistent with those obtained from strata in the Anthraconaia lenisulcata zone by other workers. Dictyotriletes bireticulatus was not recorded in the present study and Radiizonates aligerens does not occur until much higher in the sequence (information based on a rapid investigation of coals from higher up the sequence which conforms with published data (Smith and Butterworth) 1967).

If this is so then there is a slight inconsistency with the evidence presented in Eastwood et al. loc. cit. from Chalk Beck. In that region the A. lenisulcata and Carbonicola communis zones appear to be missing. However that region is in the east of the area where as Gill Godden is in the west where the extent of the break appears to be less (see Chapter 2).

A brief comparison of the Namurian and Lower Westphalian assemblages with those from further afield follows.

Loboziak (1969) recorded the distribution of spores from the Upper Namurian and Westphalian of the north of France. Loboziak found twenty species which traversed the Namurian Westphalian boundary including Punctatisporites punctatus, Granulatisporites granulatus, Raistrickia saetosa, Lycospora pusilla, Savitrisporites nux, Densosporites anulatus, D. sphaerotriangulus, Cingulizonates loricatus, Crassispora kosankei and Florinites pumicosus, which are consistant with the findings from the present study.

The assemblages described by Jachowicz (1974) from the Namurian and lower Westphalian of Oberschlesischen show some interesting points for comparison. Jachowicz recorded rare Punctatasporites minutus in early Westphalian.A rocks as did the present author. However Radiizonates aligrens is recorded as early as Namurian B which conflicts with most British records of this species. The same is true of the occurrence of Cirratriradites saturni which Jachowicz records as early as top Namurian A. Rotaspora knoxi and Rotaspora fracta are recorded up to top Namurian A by Jachowicz.

The spore assemblages described by Beju (1970) from Rumania included strata of Namurian A, B and C, and Lower Westphalian age.(Dinantian strata were also covered in the lower part of the sequence). In Beju's work the

Cb2 and Cb3 palynological zones cover the Namurian and transition into Westphalian strata. Grumosisporites rufus, Raistrickia microhorrida, Microreticulatisporites concavus, Crassispora maculosa, Murospora sublobata, M. intorta, Tholisporites ?biannulatus, Bellispores nitidus and Rotaspora fracta are all species whcih occur in the Cb2 zone but do not continue into the Cb3 zone. This is consistant with the present study, and most British records. However, Cirratriradites saturni is recorded in Cb2 (Namurian A) which is much lower than in the present study and most British records but is comparable to the findings of Jachowicz (1974). In the transation strata from Namurian to Westphalian (in the Cb zone) the following species are recorded by Beju, Raistrickia saetosa, Lycospora uber and Florinites visendus which is in common with the present study. However Beju also records several species which have not been recorded by the present author, including Vestispora spp.. The broad study by Beju can therefore be compared quite clearly with the present work for the Namurian and Westphalian strata.

Further afield in the U. S. A. the Springer Formation investigated by Felix and Burbridge (1967) yielded many species whcih could be compared with the present study, however the age of the formation is not absolutely clear due to recycling and detailed comparison is unwarranted.

CHAPTER SIX

6.0.0. Spore Systematics

As has been described in chapter 4 the classification of miospores has received much attention by past workers. Potonie and Kremp (1954-5) produced an important system which has been the basis for most subsequent systems. In this section the miospores are arranged in systematic order following the systems currently in general use including those of Dettmann(1963), Neves and Owens (1966) and Smith and Butterworth (1967). The origins of the suprageneric categories are indicated in the text.

Anteturma SPORITES Potonie 1893

Turma TRILETES (Reinsch) Dettmann1963

Suprasubturma ACAMERATITRILETES Neves and Owens 1966

Subturma AZONOTRILETES (Luber) Dettmann1963

Infraturma LAEVIGATI (Bennie and Kidston) Potonie 1956

Genus LEIOTRILETES (Naumova) Potonie and Kremp 1954

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

Diagnosis Potonie and Kremp, 1954, p.120; translation in Smith and Butterworth, 1967.

Leiotriletes densus Neves 1961
Pl. 1, fig. 6

1961 Leiotriletes densus Neves p. 251, pl.30, figs.1,2

Holotype Neves, 1961, slide ref. S.Z.1 Size 96 microns.

Type locality Non-marine roof shales of the Pot Clay Coal, Langsett, Yorks. (Locality 16) Yeadonian Stage.

Diagnosis Neves 1961, p.251

Description Spores trilete, amb triangular, sides straight to convex with rounded apices. Laesurae straight, simple, 3/4 spore radius. Exine thick, typically dark. Size 50 - 62 microns (10 specimens).

Remarks The specimens conform to the original diagnosis but fall below the size range of the type. This is almost certainly due to the maceration process. Spores are larger and thicker than other species of the genus.

Occurrence Second Sandstone into the Lower Coal Measures.

Previous records Neves, 1961, Nam.C - West.A; Mishell, 1966, Nam.-West., Bowland.

Leiotriletes inermis (Waltz) Ishchenko 1952
Pl. 1, fig. 1

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

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

1955 Asterocalamotriletes inermis (Waltz); Luber, p.40, pl.1, figs 20, 21

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

Holotype Not given. Size range of type material 40 - 50 microns

Diagnosis Waltz, 1938; C.E.D.P. translation no. 1443, in French.

Description Trilete spores, amb rounded triangular, sides slightly convex or slightly concave, rarely straight. Laesurae simple, straight, 3/4 to 9/10 spore radius. Exine unfolded, average thickness 1.5 microns, proximal polar region slightly darker. Size 30(39)50 microns (20 specimens)

Remarks Spores conform more or less to diagnosis. Size range similar to those of other workers using fuming nitric acid, eg. Smith and Butterworth 1967, 30(38)55 microns. Distinguished from other species by longer laesurae and proximal polar thickening.

Occurrence Base of the White Limestone up to the Lower Coal Measures.

Previous records Many previous workers have recorded this species from both Lower and Upper Carboniferous strata.

Leiotriletes parvus Guennel 1958
Pl. 1, fig. 7

1958 Leiotriletes parvus Guennel, p.57

Holotype Guennel (1958) p.57, text-fig.14; sample 45, slide 851. Size

22 microns.

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

Diagnosis In Guennel, 1958, p.57.

Description Spores triletes, amb rounded triangular, sides concave, apices broadly rounded. Laesurae straight, simple, 1/2 spore radius, Size 24 microns.

Remarks The spores conform to the original diagnosis but appear thicker, They also appear darker than those illustrated by Smith and Butterworth (1967), but this is probably due to underoxidation. This species is usually associated with Upper Carboniferous strata. Deltoidospora implumis Staplin 1960 occurs in Lower Carboniferous strata but it has a thicker exine. Distinguished from other species in this study by its small size.

Occurrence White Limestone to Sixth Sandstone, rare.

Previous records Guennel, 1958, Pottsville Series, Indiana, U.S.A. Smith and Butterworth 1967, Westphalian, British Coalfields.

Leiotriletes cf. priddyi (Berry) Potonie and Kremp 1955
Pl.1. figs 4.5.

1955 Leiotriletes cf. priddyi Potonie and Kremp, p.120

Description Spores trilete. Amb subtriangular with well rounded apices; interradial margins generally straight to convex. Laesurae simple, straight, 2/3 to 3/4 of radius. Exine laevigate, occasionally darker in area of proximal pole.

Remarks Specimens assigned to L. cf. priddyi conform to the description in Smith and Butterworth 1967, with the exception that 'gulaferus' folding was not seen to be common. Size range 27 μ to 36 μ from 20 specimens, conforms almost exactly with Smith and Butterworth 1967, p.123. However the amb shape was found to be more variable than described previously, but this may well be a result of preservation and other factors on spores with such a thin exine.

Occurrence Seventh Limestone to Second Sandstone.

Previous records This species has been recorded by many previous workers from the Lower and Upper Carboniferous.

Leiotriletes tumidus Butterworth and Williams 1958

Pl. 1, fig. 2,3

1958 Leiotriletes tumidus Butterworth and Williams, p.359

Holotype Butterworth and Williams, 1958, pl. 1, fig.11; preparation no. T32/1, in the collection of the National Coal Board Laboratories, Wath-upon-Dearne. Size 46 microns, in range 54 - 53 microns.

Diagnosis Butterworth and Williams 1958, p. 359

Description Trilete spores, amb triangular with straight or slightly convex sides, apices rounded. Laesurae straight, simple, extending 2/3 to 3/4 spore radius, with folds adjacent to laesurae up to 2.5 microns wide, tapering very gently towards apices. Exine 1.5 - 2 microns thick. Size 25(38)44 (20 specimens).

Remarks The specimens conform well to the original diagnosis but the size range is less than that given by Butterworth and Williams, especially with respect to the lower part of the range.

Leiotriletes ornatus Ishchenko differs in having broadly rounded apices and labrate laesurae which may superficially resemble the folded laesurae of L. tumidus; these serve to distinguish the species from others of the genus.

Occurrence Seventh Limestone to Sixth Sandstone.

Previous records Butterworth and Williams, 1958, Namurian A, Scotland; Owens and Burgess, 1965, Namurian A, Stainmore; Smith and Butterworth, 1967, Visean and Namurian, British Coalfields; Spinner and Clayton, 1973, Visean, Scotland; Neves et al. 1973, Lower Carboniferous, Scotland.

Genus Punctatisporites (Ibrahim) Potonie and Kremp 1954

Type species P. punctatus Ibrahim 1933

Diagnosis Potonie and Kremp 1954, p.120.

Punctatisporites aerarius Butterworth and Williams 1958
Pl. 1, fig. 8

1958 Punctatisporites aerarius Butterworth and Williams p. 360
Pl. 1, figs 10,11

1967 P. aerarius Butterworth and Williams; Smith and Butterworth
Pl. 1, fig. 17

Holotype Preparation no. T33/1 in collection of National Coal Board Laboratories, Wath-upon-Dearne. Size 83 µ x 75 µ.

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

Diagnosis In Smith and Butterworth, 1967, p. 125.

Description Spores trilete. Amb circular. Laesurae simple, straight, 1/2 spore radius. Exine thick, 3.5 µ, cisably ornamented giving roughened appearance. Size range 55 µ to 70 µ. 10 specimens.

Remarks Smith and Butterworth compare eight species with the present one. In the present study smaller spores with thinner exine were included in P. nitidus Hoffmeister, Staplin and Malloy. P. obesus differs by having thicker exine and longer laesurae.

Occurrence Limestone group and Hensingham group.

Previous records Numerous authors have recorded this species from Visean, Namurian and Westphalian strata.

Punctatisporites glaber (Naumova) playford 1962
Pl. 1, fig. 9

1938 Azontriletes glaber (Naumova) Waltz in Luber and Waltz, p.11, Pl. 1, fig. 2 and Pl. A, fig. 3.

1956 Leiotriletes glaber Naumova - Ishchenko, P. 18, Pl. 1, figs. 7,8

1958 Leiotriletes glaber Naumova - Ishchenko P. 34, Pl. 1, fig 4.

1962 Punctatisporites glaber (Naumova) Playford p. 576, Pl. 78, figs 15, 16.

Holotype W in L & W. Pl. 1, fig. 2 (size in range 32 µ to 70 µ Playford 1962).

Diagnosis Description in Playford 1962.

Description Amb circular, exine approximately 2 μ thick, laevigate. Laesurae straight, simple, relatively distinct 1/2 spore radius. Size range 40 μ to 62 μ.

Remarks This species is very similar to P. nitidus but has a less ornamented exine, and is longer.

Occurrence Rough Lst.

Previous records Numerous previous records from widely separated areas, the closest is Marshall and Williams 1971 Northumberland, from the Upper Visean and Lower Namurian.

Punctatisporites irrasus Hacquebard 1957
Pl. 1, fig. 10

1957 Punctatisporites irrasus Hacquebard p. 308, Pl. 1, fig. 7-8

Holotype M 101, Slide 4, 32.2 96. Size in range 67 - 83 μ

Type location Horton Group, Nova Scotia. West Gore sample.

Diagnosis Description in H. 1957, p. 308.

Description Spores trilete. Amb subcircular, laevigate or infra granulate. Laesurae 1/2 to 3/4 spore radius, straight, narrow labra sometimes present. Exine occasionally folded. Size range 48 μ to 69 μ (18 specimens)

Remarks The species was distinguished by its size, folded infragranulate exine and slightly thickened laesurae.

Occurrence Basement beds.

Previous records First recorded in Lower Carboniferous of Nova Scotia where it was very common, this species has also been recorded by Sullivan 1964a Tourn. Forest of Dean.

Punctatisporites minutus Kosanke 1950
Pl. 1., fig. 11

1950 Punctatisporites minutus Kosanke, p. 15

Holotype K. 1950, Pl. 16, fig. 3, maceration no. 584, slide 7. Size 29 μ in range 27-33 μ

Type location Woodbury cove, Jasper County, Illinois, U.S.A. McLeansboro Gp. Size 29 μ

Diagnosis Description in Kosanke 1950, p.15

Description Small trilete spores, amb circular, laesurae straight, simple, approximately 1/2 spore radius. Exine laevigate, but may be infragranulate. Size range 23 μ to 32 μ, (20 specimens)

Remarks This very long ranging spcies was recognised by its small size. Smith and Butterworth (1967) point out that some small species of Calamospora may be identical.

Occurrence Base of Seventh Limestone to Lower Coal Measures.

Previous records Numerous authors have recorded this species, the closest being Marshall and Williams 1971, Northumberland.

Punctatisporites nitidus Hoffmeister, Staplin and Malloy 1955. Pl. 1, fig. 12

1955 Punctatisporites nitidus Hoffmeister, Staplin & Malloy p. 393, Pl. 36, fig. 4

Holotype H. S. & M, 1955. Pl. 36, fig. 4, Preparation 9, ser. 18,659. Size 34 μ

Type locality Shale at 2,072 ft. Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A; Hardinsburg Formation, Chester Series.

Diagnosis Description in H. S. & M, 1955, p.393.

Description Spores trilete. Amb subcircular, laesurae fairly distinct approximately 1/2 spore radius, straight, simple. Exine typically appears roughened or very finely ornamented. Size range 29 μ to 40 μ, (12 specimens)

Remarks Playford (1962) and Bertdsen (1972) point out the similarity between P. nitidus and P. glaber (Naumova) Playford, a possible difference being the more evident exinal ornament of the former.

Occurrence Base of Fourth Limestone to First Sandstone.

Previous records Recorded by many workers from Carboniferous rocks from widely separated areas. Marshall and Williams (1971) Northumberland represents the closest.

Punctatisporites obesus (Loose) Potonie and Kremp 1955.
Pl. 1, fig. 13

1932 Sporites obesus Loose in Potonie, Ibrahim and Loose p. 451, pl. 19, fig. 49.

1934 Laevigatisporites obesus Loose, p.145

1944 ?Calamospora obesus (Loose); Schopf Wilson & Bentall p.52

1955 Punctatisporites obesus (Loose); Potonie and Kremp p. 43, Pl. 11, fig. 124.

Holotype Loose 1932 Pl. 19, fig. 49. Preparation 1116,e4 (m). Size 117 μ.

Type location Bismark seam, Ruhr, Coalfield, Germany; Up. West B.

Diagnosis From description in Loose 1932, in Smith and Butterworth 1967 p. 127.

Description Large trilete spores, amb subcircular, exine thick about 4.5 μ. Laesurae distinct, straight, simple, extending 1/2 to 3/4 radius. Exine smooth, possibly infragranulate. Size range 57 μ to 80 μ, (11 specimens)

Remarks This species was distinguised from P. aerauis Butterworth and Williams by its thicker exine and longer laesurae.

Occurrence Tyne Bottom Lst. to Sixth Sst.

Previous records This species has been recorded by numerous authors from widely separated horizons and areas.

Punctatisporites sinuatus (Artuz) Neves 1961
Pl. 1, fig. 14

1957 Sinuspores sinuatus Artuz, 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. 12

1961 Punctatisporites sinuatus (Artuz); Neves p. 252

Holotype Artuz 1957, Pl. 7, fig. 48. Preparation 1,30,1c. Size 120 μ.

Type locality Buyuk Seam, Zonguldak Coalfield, Turkey, Westphalian A.

Diagnosis Artuz 1957 p. 254 (in Smith and Butterworth (1967) p.130).

Description Large trilete spore. Amb circular to irregular, laesurae simple, straight 3/4 spore radius. Exine characteristically folded sub-parallel with equator causing undulating dark areas. Exine in contact area also darkened in uneven patches. Size range 55 μ to 80 μ.

Remarks This species of Punctatisporites is easily distinguished by the characteristic appearance of the folded exine.

Occurrence Hensingham Group.

Previous records Numerous authors have recorded this from Namurian and Westphalian strata, the closest record being that of Marshall and Williams (1970), Northumberland (Namurian).

Punctatisporites sp. A
Pl. 1, fig. 15.

Description Large trilete spores. Amb sub-circular to oval, exine scabrate in appearance. Laesurae short, approximately 1/4 spore radius. Exine thick, probably more than 5 μ. Size range 30(62)75 microns.

Remarks This species was common in the Basement beds. The scabrate appearance may be due to corrosion effects. The size is too large for P. minutus and the laesurae too short for P. obesus and P. aerarius.

Occurrence

Basement beds.

Genus Calamospora Schopf, Wilson & Bentall 1944

Type species Chartungiana Schopf in Schopf Wilson and Bentall 1944 (?syhonym of C. mutabilis (Loose 1932)).

Diagnosis Potonie and Kremp 1955, p.46.

Calamospora breviradiata Kosanke 1950
Pl. 2, fig. 1

1950 Calamospora breviradiata Kosanke p. 41, Pl. 9, fig. 4

Holotype K. 1950, p.9, fig. 4. Maceration 579 - B, slide 1. Size 65.1 μ.

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

Diagnosis In Kosanke 1950, p.9

Description Spores trilete. Amb more or less circular. Exine often folded. Laesurae 1/3 spore radius, straight. Contact areas frequently darkened. Size range 37 μ to 64 μ, 8 specimens.

Remarks This species was distinguished by its short laesurae. The smaller size range compared with that of the type is a result of the processing technique used.

Occurrence Sixth sandstone to Third sandstone.

Previous records K. 1950 W.C./Steph Illinois; Schemel 1951 West D. Iowa; Imgrund 1960 West D. Kaiping; Dybova and Jachowicz 1957 West D. Silesia; Bharadwaj and Venkatachala, Germany; Sullivan 1962 West B. S. Wales; Smith & Butterworth 1967 Nam. A to West B. Britain.

Calamospora liquida Kosanke 1950
Pl. 2, fig. 2

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

Holotype K. 1950 Pl. 9, fig. 1. Size in range 76 - 94 μ

Type location Pennsylvanian of Illinois, U.S.A.

Diagnosis K. 1950 p. 41-42.

Description Spores trilete. Amb oval to sub-circular, irregular. Exine thin, frequent folding evident. Laesurae 3/4 spore radius, simple, straight. Contact areas sometimes darkened. Size range 40 μ - 64 μ (10 specimens).

Remarks This species is very similar to C. microrugosa except that the laesurae are longer. The smaller size range obscured during the present study probably results from processing techniques.

Occurrence Upper part of Hensingham Group into Lower Coal Measures.

Previous records Many previous authors have recorded this species from Carboniferous sediments of widely separated horizons and locations.

Calamospora microrugosa (Ibrahim) Schopf, Wilson and Bentall 1944. Pl. 2, fig. 3.

1932 Sporonites microrugosus Ibrahim in Potonie, Ibrahim and Loose p. 447, Pl. 14, fig. 9.

1933 Laevigate - sporites microrugosus (Ibrahim); Ibrahim p. 18, Pl. 1, fig. 9.

1938 Azonotriletes 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. 9.

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

Holotype Ibrahim 1932, Pl. 14, fig. 9. Preparation A42 C6(1). Size 77 microns in range 70 - 100 microns (P & K 1955).

Type location "Ayr" Seam, Ruhr Coalfield, Germany; top of West. B.

Diagnosis P & K 1955, p.49 in Smith and Butterworth p.133.

Description Spores trilete. Amb irregular, sub-circular. Exine folded in long folds sometimes sub-parallel to margin. Laesurae distinct, straight, simple 1/2 spore radius. Size range 37 µ - 67 µ (20 specimens).

Remarks Specimens of this description were common in many of the samples taken in the present study. C.liquida Kosanke is distinguished by longer laesurae.

Occurrence Fourth Limestone into Lower Coal Measures.

Previous records Many authors record this species - see list in Playford (1962).

Calamospora sp. A
Pl. 2, fig. 5.

Description A large trilete spore, amb oval, exine rough in appearance but probably laevigate, Laesurae indistinct. Exine folded and gives the characteristic appearance of Calamospora. Size range 85 µ to 90 µ. (5 specimens).

Occurrence Basement beds.

Remarks These specimens were all poorly preserved but bear a close resemblance to C. perrugosa (Loose) Schopf, Wilson and Bentall.

Genus Retusotriletes Naumova 1953

Type species R. simplex Naumova 1953.

Diagnosis Naumova 1953.

Retusotriletes avonensis Playford 1963
Pl. 2, fig. 7,8.

1963 Retusotriletes avonensis Playford p. 9, Pl. 1, figs.15 & 16.
Pl. 2, figs.1 & 2

Holotype Playford 1963. G.S.C. No. 13068.

Type location Horton Group (Cheverie Formation), Nova Scotia, G.S.C. loc. 6408.

Diagnosis P. 1963, p. 9.

Description Spores trilete. Amb sub-circular, occasionally sub-triangular. Laesurae indistinct to distinct with slight labra, straight, extending 3/4 spore radius, accompanied by Curvaturae which are clearly evident and often merge into equatorially thickened exine. Width of ?cingulum approximately 6 µ. Exine infrapunctate, outline smooth. Delimitation between central area and ?cingulum not clear, obscured by darkened exine. Size range 55 µ - 63 µ. (8 specimens).

Remarks This species was distinguished from R. incohatus Sullivan by its larger size, darkened exine and wider ?cingulum.

Occurrence Basal beds above Cockermouth lavas to Seventh Limestone.

Previous records Playford 1963 Horton Gp. Canada, Varma 1969 H. group Canada;.

Retusotriletes incohatus Sullivan 1964a
Pl. 2, fig. 6,9.

1964a Retusotriletes incohatus Sullivan p. 1251, Pl. 1, figs.5-7.

Holotype Specimen in Pl. 1, fig. 7. Sullivan 1964.

Type location Lower Limestone Shales of Puddlebrook Forest of Dean.

Diagnosis In Sullivan 1964, p. 1251.

Description Trilete spores, amb circular to sub-circular, laesurae indistinct to distinct, 3/4 of spore radius, straight and simple with curvaturae. Equatorial region of exine is thickened to produce a darker peripheral band from 2 - 10 μ wide. Laesurae extent to inner margin of this band. Exine laenigate. Size range 27 μ to 51 μ (47 u) (15 specimens) Holotype 56.5 μ.

Remarks Specimens of this species were easily distinguished by their general appearance and conformed to the original diagnosis but were somewhat smaller. This species is distinguished from R. avonensis Playford 1963 by its smaller size.

Occurrence Basement beds up to Seventh Limestone. Infrequent.

Previous records Sullivan 1964a, Tourn. Forest of Dean; Sullivan 1968, L. Carb. Scotland; Butterworth and Spinner 1967, L. Carb. N.W. England; Clayton 1971 L. Carb Scotland; Neves et al. 1973 L. Carb Scotland and N. England.

Infraturma Apiculati (Bennie and Kidston) Potonie 1956.

Genus Granulatisporites (Ibrahim) Potonie and Kremp 1954

Type species G. granulatus Ibrahim 1933.

Diagnosis Potonie and Kremp 1954, p. 126 translation in Smith and Butterworth 1967.

Granulati/sporites micrografer Ibrahim 1933
Pl. 2, fig. 16.

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

1938 Azmotriletes microgranifer (Ibrahim); Luber in Luber and Waltz, Pl. 7, fig. 92.

1955 Granulatisporites microgranifer Ibrahim; Potonie & Kremp, p. 58, Pl. 12, figs. 149-151.

Holotype Ibrahim 1933, Pl. 5, fig. 32. Potonie and Kremp 1955, Pl. 12 fig. 149 after Ibrahim. Preparation B29, a2 (0/1). Size 32.5 μ in range (?25)30-40 μ (P & K, 1955).

Type locality Agir seam, Ruhr coalfield, Germany; Top West. B.

Diagnosis Potonie and Kremp 1955, p. 58. Translation in S&B. 1967, p.140.

Description Amb triangular with broadly rounded apices, laesurae simple, approximately 1/2 radius of spore often (split open) gaping. Sides of spore usually concave. Ornament consisting of very small grana approximately 0.5 μ diameter more or less evenly distributed over exine with between 83 and 103 on the margin. Size range 27 μ - 36 μ. (18 specimens).

Remarks This species generally conforms to diagnosis although ornamentation tends to be slightly coarser than the type species, thus reducing slightly the number of grana at the amb. One specimen appears to have denser packing of the grana and the appearance of very slight thickening around the laesurae. More densly ornamented than G. granulatus.

Occurrence Rough 1st. to just below Second Sst.

Previous records This species was first recorded by Ibrahim in 1933 and has since been recorded by numerous workers in the Carboniferous.

Granulatisporites minutus Potonie and Kremp 1955
Pl. 2, fig. 17.

Holotype Potonie and Kremp 1955, Pl. 12, fig. 147. Preparation 607/5 KT 14.4 123,9

Type locality Baldur Seam, Brassent colliery, Ruhr Coalfield, Germany; Lower Westphalian C. Size 23 μ (20-25 μ).

Diagnosis Expanded version in Smith and Butterworth 1967 from Potonie and Kremp 1955, p.59.

Description Spores conform more or less to diagnosis being rounded triangular with broad apices. Laesurae mostly gaping, of 1/2 spore radius. Ornament of low grana of approximately 1 μ diameter. Size range 21 μ to 26 μ (17 specimens).

Remarks The spores conform to the original authors diagnosis in all respects except that folding of the exine was not observed to be frequent, this may be due to the use of the fuming HNO technique for oxidizing rather than schulze solution. Distinguished from other species by its small size.

Occurrence Infrequent, Third Lst. to Second Sst.

Previous records This common species has been recorded by numerous workers from various Carboniferous horizons.

Granulatisporites granulatus Ibrahim 1933
Pl. 2, fig. 14, 15.

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

1955 Granulatisporites granulatus Ibrahim, Potonie & Kremp, p. 58, Pl. 12, figs. 157-60

Holotype Ibrahim 1933, Pl. 6, fig. 51. Prep. D57.b7(ul) 25-35 u (P&K 1955) Size 21 μ.~~in large.~~

Type locality Bismarck seam, Ruhr Coalfield. Upper Westphalian B.

Diagnosis Spores trilete. Amb triangular, rounded apices, sides mostly concave often with one side straight or much less concave; between 45 and 56 grana at equator, grana between 1 μ and 1.7 μ diameter approximately evenly distributed. Size range 23 μ - 31 μ (20 specimens)

Remarks This common species appears to conform generally with previous recorded descriptions.

Occurrence Seventh Lst. to Lower Coal Measures.

Previous records Recorded first in 1933 by Ibrahim this species has since been observed by numerous workers in the Carboniferous.

Genus Cyclogranisporites Potonie and Kremp 1955

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

Diagnosis Potonie and Kremp 1955, p.60, translation in Smith and Butterworth 1967.

Cyclogranisporites aureus (Loose)
Pl. 3, fig. 1.
Potonie and Kremp 1955.

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); Potonie and Kremp, p.61, Pl. 13, figs 184-6.

Holotype P & K 1955 Preparation 1V1E5 (UL) (Loose) Size 55.5 µ.

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

Diagnosis P & K 1955, p.61 Translation in S & B 1967, p.142.

Description Spores trilete. Amb uneven, approximately circular. Laesurae distinct straight, simple, 1/2 spore radius. Exine frequently folded ornamented with closely set grana approximately 1 µ diameter. Size range 45 µ - 64 µ. (20 specimens).

Remarks This species was distinguished by its large size from other members of the genus recovered in the present study. The specimens conformed closely to diagnosis.

Occurrence Fourth limestone into Hensingham Group.

Previous records First recorded by Loose 1934 W.C. Germany. This species has been recorded by numerous workers including a recent record from the Visean of Scotland by Spinner and Clayton (1973).

Cyclogranisporites minutus Bharadwaj 1957
Pl. 3, fig. 2

1957 Cyclogranisporites minutus Bharadwaj p.83, Pl. 22, figs 22,23

Holotype Bharadwaj 1957, sl. number 7314/2. Size 40 µ.

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

Description Small trilete spores. Amb circular, Laesurae straight, simple, 1/2 spore radius in length. Exine thin, ornamented with small grana 1 µ diameter closely set. Size range 33 µ to 47 µ. (20 specimens)

Remarks Specimens were assigned to this species on account of their size; some may have fallen within the range of C. cf. minutus in S & B 1967, however, it was felt unnecessary to split this species.

Previous records First recorded from the Stephanian of Germany by Bharadwaj 1957, this species has been recorded by numerous workers since from a variety of stratigraphic horizons.

Genus Waltzispora Staplin 1960

Type species W. lobophora Staplin 1960

Diagnosis Staplin 1960, p.18.

Waltzispora planiangulata Sullivan 1964b
Pl. 2, fig. 10

1964b Waltzispora planiangulata Sullivan
p. 362, Pl. 57, figs. 25 to 30.

Holotype Specimen illustrated as Pl. 57, fig. 26 in Sullivan 1964b.

Size range 30 µ to 45 µ.

Type locality Drybrook Sandstone Forest of Dean.

Diagnosis S. 1964b, p. 362.

Description Spores trilete. Amb triangular, sides markedly concave, apices broad with sharp angle between radial and inter-radial region. Outline extended radially. Laesurae straight, simple, 3/4 spore radius. Exine ornamented with grana closely spaced not modifying margin. Size range 25 µ (32) 40 µ.

Remarks Specimens recovered during present study conform closely to original diagnosis particularly fig. 26, Pl. 57 in Sullivan 1964b. This species was distinguished from W. prisca (Kosanke) sullivan, by the more elongate radial parts and coarser ornamentation.

Occurrence Seventh Limestone to Sixth Sandstone.

Previous records Sullivan 1964, Visean, Forest of Dean; Jachowicz 1970 Upper Visean, Poland, Neves et al. 1973 Visean, Scotland.

Waltzispora prisca (Kosanke) Sullivan 1964
Pl. 2, fig. 11

1950 Triquitrites prisca Kosanke

1964b Waltzispora prisca (Kosanke) Sullivan p.362, Pl.57, fig.24

Holotype In Kosanke 1950, pl. 2 fig. 4.

Type locality In Kosanke 1950.

Diagnosis In Kosanke 1950.

Description Spores trilete. Amb triangular, sides concave, apices broad, sharp angle between radial and interradial region. Exine ornamented with small grana widely spaced and tending to a radial arrangement, mostly on distal surface. Laesurae straight, simple, often gaping extending almost to spore margin. Size range 24 μ to 35 μ (9 specimens).

Remarks Sullivan (loc. cit.) distinguished this species from *W. planiangulata* by its more widely spaced grana. The present author distinguishes it also by its less elongate apices and by the radial arrangement of the grana.

Occurrence Top of Fourth Limestone to Fifth Sandstone.

Previous records Kosanke 1950 Penn. Illinois; Sullivan 1964b Drybrook sst., Forest of Dean.

Waltzispora polita (Hoffmeister, Staplin and Malloy) Smith and Butterworth 1967. Pl. 2, fig. 12.

1955 *Granulatisporites politus* Hoffmeister, Staplin and Malloy p. 389, Pl. 36, fig. 13.

1958 *Granulatisporites politus* (Hoffmeister, Staplin and Malloy 1955) Butterworth and Williams p.361, Pl. 1, fig. 15.

1960 *Leiotriletes politus* (Hoffmeister, Staplin and Malloy) Love, p.111, Pl. 1, fig. 1.

Holotype Hoffmeister, Staplin and Malloy 1955 Pl. 36, fig. 13. Preparation 6 sev 15, 718. Size 37.5 μ.

Type Locality Shale at 2,077 ft. Carter No. 3. borehole (TCO-82) Webster County, Kentucky, U.S.A.; Hardingsburg Formation, Chester series.

Diagnosis H.S.M. 1955, p. 389.

Description Spores trilete. Amb subtriangular, interradial margins concave, radial margins broad, slightly rounded, angled outline between the two regions. Exine laevigate, laesurae distinct, extend 3/4 of radius. Size range 30 μ(34μ) to 41 μ. (12 specimens.)

Remarks The specimens recovered in the present study conform well to the original diagnosis.

Occurrence White Lst. to Second Sst.

Previous records This species has been recorded from Carboniferous strata by numerous workers.

Waltzispora sagittata Playford 1962
Pl. 2, fig. 13.

1960 Leiotriletes politus (Hoffmeister, Staplin & Malloy 1955) p. 389, Pl. 36, fig. 13.) Love Pl. 1, fig. 1.

1962 Waltzispora sagittata Playford 1962 p.582,Pl.74, fig.12 Text fig. 50.

Holotype Preparation P180B/1, 54.4 105.8. L.975. Size in range 24-35 µ.

Type location Birger Johnson (sample G1102) Spitzbergen; Lower Carb.

Diagnosis In Playford 1962 p.582.

Description Spores trilete. Amb subtriangular, sides concave or straight, apices expanded to greater or lesser extent. Laesurae simple, straight, 8/10 of spore radius. Exine 1-2 µ thick ornamented often with very low small grana 0.25 µ approx. diameter. Size 24 to 28 µ. (10 specimens).

Remarks Spores resemble those described and illustrated by Playford 1962. Fine granulate ornament is occasionally present as described by Playford 1962, therefore the suggestion by Sullivan 1964b, p.362, with regard to erecting a new genus for laevigate Waltzispora to include W. sagittata, would not be strictly correct.

Occurrence Top of the Fourth Lst. to Sixth Sst.

Previous records Love 1960. Lower Oil Shale Group Visean, Scotland. Playford 1962 Lower Carboniferous, Spitzbergen.

Genus Pulvinispora Balme and Hassell 1962

Type species P. depressa Balme and Hassell

Pulvinispora scolecophora Neves and Ioannides 1974
Pl. 14 fig. 3. 4.

1974 Pulvinispora scolecophora Neves and Ioannides p. 74, Pl. 5, fig. 9 and 10.

Holotype M.P.K. 689, Pl. 9 Neves and Ioannides 1974.

Type location 2504' 9" (763.45 m) Spilmersford borehole, E. Lothian; L. Carboniferous.

Diagnosis Neves and Ioannides, p.74.

Description Spores trilete, amb triangular with rounded apices. Laesurae usually distinct, straight, extending almost to equator, curvaturae clearly evident. Apices often indented. Exine appears infraornamented, distal fold developed, being confined to central area. Size range 35 µ (41 µ) 48 µ from 8 specimens.

Remarks The few specimens recovered during the present study appear to conform with the diagnosis. The preservation of the spores was not always good thus the nature of the exine may have been affected giving the appearance of infrapunctation.

Occurrence Rare. Basement beds.

Genus Baculatisporites Thomson and Pflug 1958

Type species B. primarius (Wolf) Thomson and Pflug 1953.

Diagnosis Thomson and Pflug 1953.

Baculatisporites fusticulus Sullivan 1968
Pl. 3, fig. 3, 4.

1968 Baculatisporites fusticulus Sullivan p. 117, Pl.25, figs 1-2

Holotype Slide P. 26381 - A - 04. 115.0 53.0 Size 86 µ.

Type locality 100 feet above base of Cementstone Group, Ayrshire, Scotland

Description Spores trilete. Amb subcircular, exine frequently folded in large cresentic folds more or less following periphery. Exine ornamented with pila and small bacula rarely more that 2 u in height and closely spaced. Laesurae often indistinct, usually straight, simple, extending 2/3 of spore radius. Diameter 49 µ to 65 µ (59 µ) (15 specimens).

Remarks The species was recognised by the nature of the ornament and the large folds in the exine. The size range of the specimens recovered in the present study falls below that recorded by Sullivan (73 µ to 100 µ) and Clayton (54 µ to 93 µ). Bertlesen (1972) remarks on a lower ornament on the specimens from the Ørslev No. 1 borehole in Denmark probably being due to a corrosion effect.

Occurrence Basement Beds up to Seventh Limestone.

Previous records Sullivan 1968 Cementstone Group, Tournaisian Scotland; Llewellyn, Backhouse and Hoslin 1969 Tournaisian, Central Province, Leicestershire, Johnson and Marshall 1971 Visean, Ravenstonedale, England. Clayton 1971 Calciferous Sandstone, Scotland, Streel 1970 Tournaisian, Belgium - Germany, Bertlesen 1972, Denmark, Neves et al. 1973 Visean, S. Scotland.

Genus Acanthotriletes (Naumova) Potonie and Kremp 1954

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

Diagnosis Potonie and Kremp 1954, p. 133, translation Smith and Butterworth 1967.

Acanthotriletes castanea Butterworth and Williams 1958
Pl. 3, fig. 17.

1948 Knox p.158, fig. 18.

1958 Acanthotriletes castanea Butterworth and Williams
p. 365, Pl. 1, fig. 35.

Holotype Pl. 8, fig. 7. Preparation T42/1 in collection of N.C.B. labs,
Size 46x40 µ.

Type locality Garibaldi Ironstone seam at 1058 ft. 3 ins. Cawder Cuilt borehole, Central Coalfield Scotland. Namurian A.

Description Rounded triangular to sub circular, trilete spores. Laesurae not very distinct, except when gaping, approximately 1/2 to 2/3 spore radius. Exine covered with spinae up to 9 µ long and about 3 µ wide, gently tapering to a point, distributed evenly over surface. Size 27 µ to 40 µ (15 specimens).

Remarks The spores assigned to this species conform to the diagnosis with the exception of the size range, which extends slightly below that of the type material.

A. microspinosus (Ibrahim) Potonie and Kremp, has shorter spines, and A. ciliatus (Knox) Potonie and Kremp, has finer grade of spinae.

Occurrence Orebank Sst. to First Sst.

Previous records Butterworth and Williams 1958, Namurian A, Scotland; Owens (MS) 1963 Namurian A-B Stainmore. Mishell 1966 (MS) Namurian A - B Bowland. Smith and Butterworth 1967, Visean - Namurian A, British Coalfields; Marshall and Williams 1970, Nam. Northumberland.

Acanthotriletes echinatus (Knox) Potonie & Kremp 1955
Pl. 3, fig. 18.

1950 Spinoso-sporites echinatus Knox, p.313, Pl. 17, fig. 208

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

Neotype designated by Smith and Butterworth 1967, p. 178. T86/1 in National Coal Board laboratories, Wath-upon-Dearn. Size 26 µ.

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

Diagnosis In P & K 1955, p.84.

Description Amb generally circular to subcircular. Laesurae indistinct, approximately 1/2 spore radius. Exine ornamented with long thin spinae up to 4 µ long and 1.5 µ wide, gently tapered and sit about 4 µ apart. Size 21 - 27 µ (8 specimens).

Remarks The spores generally conform to the diagnosis. This species is recognised by its small size.

Occurrence Rough Lst. to just below Second Sst.

Previous records Recorded by numerous authors from Upper Carb. including Knox 1950 Upper Carb., Scotland; Smith and Butterworth 1967, Namurian to Westphalian C, British Coalfields.

Acanthotriletes falcatus (Knox) Potonie & Kremp 1955.
Pl. 3, fig. 19.

1948 18K, Knox, p. 157, fig. 15.

1950 Spinoso-sporites falcatus Knox, p.313, Pl.17, fig.205

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

1958 Acanthotriletes falcatus (Knox), Potonie and Kremp Butterworth and Williams, p.366, Pl. 1, fig. 37-38

Neotype Plate 8, fig. 11. Preparation T41/1 in collection of National Coal Board laboritories, Wath-upon-Dearne. Size 42 µ.

Type locality Possil main seam 600 ft. 2 ins. Cawder Cuilt borehole, Central Coalfield, Scotland. Namurian A.

Diagnosis P & K translation in Smith and Butterworth 1967.

Description Triangular trilete spores with rounded apices, sides concave. Laesurae indistinct about 2/3 spore radius. Exine covered with spinae up to 6 µ long and 3.5 µ wide fairly rapidly tapering to point. Spinae are curved throughout 25 degrees. Size 25 µ to 40 µ (5 specimens).

Remarks Only 5 specimens of this species were recovered in the present study. They were distinguished from other species of Acanthotriletes principally by their curved spinae.

Occurrence Just above Hensingham Grit to Third Sst.

Previous records Knox 1948 and Butterworth and Williams 1958. Lst. Coal Group, Namurian A, Scotland. Neves 1959 (MS) (in Mishell 1966 MS) Namurian A - C. Owens 1963 (MS) Namurian A Stainmore. Mishell 1966 (MS) Namurian A - B Bowland. Smith and Butterworth 1967 Visean-Namurian, British Coalfields; Marshall and Williams 1970, Visean and Namurian, Northumberland.

Genus Lophotriletes (Naumova) Potonie & Kremp 1954

Type species L. gibbosus (Ibrahim) Potonie & Kremp.

Diagnosis Potonie and Kremp 1954, p. 129. Translation in Smith and Butterworth 1967.

Lophotriletes commisuralis (Kosanke) Potonie & Kremp 1955
Pl. 3, fig. 5.

1950 Granulatisporites commisuralis Kosanke p.20, Pl. 3, fig. 1

1955 Lophotriletes commisuralis (Kosanke) Potonie & Kremp p. 73, Pl. 14, figs 222, 223.

non 1960 Lophtriletes commisuralis (Kosanke) Potonie & Kremp in Imgrund, p.164, Pl.15, figs 66-68.

Holotype Kosanke 1950, Pl. 3, fig. 1. Preparation 486-B. Slide 22, size 29.5 x 26 µ.

Type locality Friendsmille coal, Wabash County, Illinois, U.S.A.; McLeansboro Gp.

Diagnosis Kosanke 1950 p.20.

Description Rounded triangular trilete spores. Sides concave. Laesurae distinct 3/4 radius, usually straight, rarely slightly bent. Ornament of coni of varying size up to a maximum of 2 µ in height, spaced more or less evenly over surface. Size 23µ (26) 35µ. (20 specimens)

Remarks Specimens assigned to this well established species were distinguished from L. microsaetosus (Loose) Potonie and Kremp 1955 by their size (maximum of 35 µ) and size of the ornament (2u maximum). L. microsaetosus is larger, up to 40µ and has coarser coni, up to 2.5 µ. Furthermore the cori on L. commisuralis are less closely spaced.

Occurrence Top of Fourth Lst. to Lower Coal Measures.

Previous records First described in 1950 by Kosanke this species has since been described by numerous workers from Namurian to Westphalian horizons.

Lophotriletes gibbosus (Ibrahim) Potonie & Kremp 1954
Pl. 3, fig. 6.

1933 Verrocosi-sporites gibbosus Ibrahim p.25, Pl.6, fig. 49.

1938 Azonotriletes gibbosus (Ibrahim); Luber in Luber & Waltz Pl.7, fig. 91.

1944 Granulati-sporites gibbosus (Ibrahim); Schopf Wilson and Bentall p. 33.

1950 Verrocoso-sporites gibbosus (Ibrahim) Knox p.317, Pl.17, fig.232

1954 Lophotriletes gibbosus (Ibrahim) Potonie & Kremp p. 129

non 1958 Lophotriletes gibbosus (Ibrahim) Potonie & Kremp; Guennel, p.62 Pl.3, fig.9 (in Smith and Butterworth 1967).

Holotype Potonie and Kremp 1955, Pl.14, fig.220 after Ibrahim. Preparation B61 e5(ul).

Type locality Agir seam, Ruhr coalfield, Germany. Top Westphalian B.

Diagnosis From description and diagnosis Potonie and Kremp 1955, p.74. in Smith and Butterworth 1967, p.156.

Description Rounded triangular, trilete spores with concave sides. Trilete mark more or less distinct, straight, simple 2/3 radius. Ornament of coni 3 µ to 3.7 µ high, 2.5 - 3 µ wide. Some of the coni are blunt, generally the large ones. Size range 23 µ to 48 µ (34µ) (20 specimens).

Remarks The specimens observed during the present study would fall in the size range of L. cf. gibbosus (Ibrahim) P & K in Smith and Butterworth 1967, which has a size range 29 - 41 µ. The oxidizing procedure is probably the cause for the size discrepancy and the present author has for this reason placed all specimens, some of which would have been classified as L. cf. gibbosus, in L. gibbosus. Also the coni shape of L. cf. gibbosus appears to be fairly spinose from the description in Smith and Butterworth, p. 157, whereas the coni on the specimens observed here are generally much less spinose, and indeed blunt in some cases.

Occurrence White Lst. to Sixth Sst.

Previous records This species was first recorded by Ibrahim in 1938 but has since been recorded by numerous workers from Namurian and Westphalian and Permian rocks.

Lophotriletes microsaetosus (Loose) Potonie & Kremp 1955
Pl. 3, fig. 7.

1932 Sporonites microsaetosus Loose in Potonie & Kremp, Ibrahim and Loose p. 450, Pl.8, fig. 40.

1933 Setosi sporites microsaetosus (Loose) Ibrahim p.26.

1934 Setosi sporites microsaetosus (Loose) Loose p. 148

1944 Granulati-sporites microsaetosus (Loose); Schopf Wilson and Bentall p.33.

1950 Spinoso-sporites microsaetosus (Loose); Knox p.314, Pl.17, fig. 203

1955 Lophotriletes microsaetosus (Loose) Potonie & Kremp p.74, Pl.14, figs. 229-30.

1958 Lophotriletes gibbosus (Ibrahim); Potonie & Kremp; Guennel p.62, Pl. 3, fig. 9.

Holotype Potonie and Kremp 1955, pl. 14, fig.229 after Loose. Preparation 1V 6 f (UL) Size 39 μ.

Type locality Bismarck seam, Ruhr coalfield, Germany.

Diagnosis From Potonie and Kremp in Smith and Butterworth 1967, p.158.

Description Rounded triangular trilete spores. Sides straight or more often concave. Trilete mark distinct usually straight 4/5 of spore radius. Ornament consists of coni more or less evenly spread, variable in size up to 2.5 μ approximately. Size 35 μ to 41 μ (37μ) (20 specimens).

Remarks Spores assigned to this species were distinguished from L. gibbosus (Ibrahim) Potonie and Kremp 1954 and L. cf. gibbosus Smith and Butterworth, by their size ie: less than 40 μ approximately, and the nature of the ornament, ie. less than 3.5 μ coni. L. gibbosus has larger blunt coni and an overall size in excess of 40 μ.

The effect of a false, negative reticulum produced by close packing of the coni, referred to in the diagnosis was not observed.

Occurrence Below Seventh Lst. to Second Sst.

Previous records First recorded by Loose in 1932 this species has since been recorded by numerous workers from Namurian to Westphalian horizons.

Lophotriletes tribulosus Sullivan 1964b
Pl. 3, fig. 8

1964b Lophotriletes tribulosus Sullivan p.361, Pl.57, fig. 21-3.

Holotype Pl. 57, fig.22 Sullivan. Size in range 30-45 μ.

Type location Drybrook Sst. Forest of Dean.

Description In Sullivan 1964 p.361. Two specimens were recovered during the present work which conform to the original diagnosis, being very rounded triangular, trilete with large rounded coni of variable size up to 3 μ. The spores closely resemble that illustrated by Sullivan 1964b, Pl.57 fig. 23.

Occurrence Lower part of Hensingham Gp.

Previous records 1964 Sullivan, Drybrook sst. Forest of Dean. 1964 Hibbert and Lacey, Menai straits, Lower Carb. N Wales.

Genus Apiculatisporis Potonie & Kremp 1956

Type species A. aculeatus Ibrahim 1933

Diagnosis Potonie and Kremp 1954, p.130, translation in Smith and Butterworth 1967.

Apiculatisporis variocorneus Sullivan 1964
Pl. 4, fig. 3.

1964 Apiculatisporis variocarneus Sullivan p.363,Pl.58,figs.4-8.

Holotype Sullivan 1964, Pl. 58, fig. 4. Preparation S M U D/1. Size in range 40 μ to 78 μ.

Type locality Edgehills Coal, Drybrook Sandstone, Forest of Dean Coalfield, England; ?,Westphalian A.

Diagnosis S. 1964 p. 363.

Description Spores trilete. Amb more or less circular. Laesurae indistinct. Exine thick, ornamented with coni and verrucae. Elements attain variable proportions over each specimen, more strongly developed distally where may reach 5 μ, whereas proximally the ornament is reduced to small verrucae and grana. Size range 33 μ to 55 μ.

Remarks The specimens recovered during the present study conform closely to the original diagnosis. The distribution and variation in ornament distinguishes the species.

Occurrence Second sandstone to Lower Coal Measures. Very rare below basal Coal Measure grit.

Previous records Sullivan 1964 Edgehills Coal. Forest of Dean; Smith and Butterworth British Coalfields 1967 Namurian - WestB; Mishell 1966 Nam. A - West. A. Marshall and Williams 1970 Nam. Northumberland.

Genus Apiculatasporites (Ibrahim) Smith & Butterworth 1967.

Type species A. spinulistratus (Loose) Ibrahim 1933

Diagnosis Smith and Butterworth 1967, p.176.

Apiculatasporites spinulistratus (Loose) Ibrahim 1933
Pl.3, fig. 11, 12.

1932 Sporonites spinulistratus Loose in Potonie, Ibrahim & 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); Potonie & Kremp p. 71, Pl. 14, figs. 214-19.

1960 Apiculisporites spinulistratus (Loose) Ibrahim; Potonie,p.38

Holotype Potonie and Kremp 1955, P. 14, fig. 214 after Loose 1932.

Preparation 1V9 (m/or)

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

Diagnosis P & K 1955 p. 71, Translation in S & B p. 176.

Description Spores trilete. Amb circular. Laesurae distinct, 1/2 spore radius, simple, straight. Exine ornamented with low coni, widely spaced and with broad bases.

Remarks These spores were recovered from the Lower Coal Measures and were distinguished from A. globulus by the finer ornament and bore a close resemblance to fig. 5, Pl. 8, S & B 1967.

Occurrence Lower Coal Measures.

Previous records Recorded by numerous authors from Upper Carboniferous sediments.

Genus Anaplanisporites Jansonius 1962

Type species A. telephorus Klaus 1960

Diagnosis Jansonius 1962.

Anaplanisporites baccatus (Hoffmeister, Staplin & Malloy) Smith & Butterworth 1967. Pl. 3, fig. 9.

1955 Punctatisporites ?baccatus Hoffmeister, Staplin and Malloy. p. 393, Pl. 36, fif. 2.

1958 Apiculatisporis baccatus (H. S & M); Butterworth & Williams p. 363, Pl. 1, fig. 25.

1967 Anaplainsporites baccatus (H. S. & M.) Smith & Butterworth 1967. p. 166, Pl. 7, fig. 1-5.

Holotype Hoffmeister, Staplin and Malloy 1955, Pl. 36, fig. 2. Preparation 8, ser. 19,087 - Size 39 μ (26-46 μ).

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

Diagnosis Smith and Butterworth 1967, p. 166.

Description Spores trilete. Amb circular to subcircular. Laesurae indistinct. Exine thin, ornamented distally with small coni, less than 0.5 μ high and in basal width. Size range 20-32 μ (20 specimens).

Remarks In the present study this species was present in varying proportions almost throughout the succession examined. The size range falls below that of Smith and Butterworth with an average at 23-24 μ diameter. Also the prominence of the ornament was less than appears to be the case in other workers' specimens especially Bertelsen 1971.

Occurrence Basement beds above Cockermouth lavas to First Sst.

Previous records This is a very common species throughout the Carboniferous & has been recorded by many workers.

Anaplanisporites globulus (Butterworth and Williams) Smith and Butterworth 1967. Pl. 3, fig. 10.

1948 Knox, p. 158, fig. 19.

1950 Apiculatisporis globulus Butterworth & Williams, p. 363, Pl. 1, figs. 26, 27.

1967 Anaplanisporites globulus B & W

Holotype Plate 7, fig. 6. Preparation T38/1 in collection of N.C.B. laboritories, Wath-upon-Dearne. Size 38 µ in range 32-46 µ.

Type locality Cloven Seam at 1,764 ft. 2 ins. Queenslie Bridge borehole, Central Coalfield, Scotland; Namurian A.

Diagnosis S & B., 1967, p. 167.

Description Spores trilete. Amb circular to subcircular. Laesurae indistinct, approximately 3/4 spore radius. Exine ornamented distally with blunt coni. Approx. 2.5 µ in diameter, widely spaced. Size 25 µ to 48 µ (8 specimens).

Remarks Species conformed to diagnosis. Amb was rarely triangular. Ornament occasionally slightly spinose.

Occurrence Sixth sandstone to top of Hensingham Group.

Previous records Knox 1948, Butterworth and Williams 1958, Nam. Scotland; Sullivan 1964 Drybrook sst. Forest of Dean; Smith and Butterworth 1967 Nam. A, British Coalfields; Marshall and Williams 1970 Nam. Northumberland.

Genus Anapiculatisporites (Potonie & Kremp)
Smith and Butterworth 1967.

Type species A. isselburgensis Potonie and Kremp 1954

Diagnosis Smith and Butterworth 1967, p.160.

Anapiculatisporites concinnus Playford 1962.
Pl. 3, fig. 14.

1962 Anapiculatisporites concinnus Playford p.587,Pl.80, figs.9-12

Holotype Playford's Preparation P145C/1,23.6 100.9 L.994. Size 35 µ in range 23-44 µ.

Type location Truingen (sample G1466), Spitsbergen; L. Carb.

Diagnosis In P. 1962, p.587.

Description Spores trilete. Amb triangular, rounded apices, straight sides. Laesurae straight, simple, 2/3 spore radius. Exine thin ornamented with coni approx. 2 µ long set 3 µ apart mostly in polar region of distal surface. Proximal surface laevigate. Size range 22 µ to 30 µ.

Remarks This species conformed closely to diagnosis and was distinguished by its size and grade of ornament from A. hispidus Butterworth and Williams and from A. minor (B & W) Smith and Butterworth by its more rounded shape.
Occurrence Sixth Sandstone to between Second and Third Sandstone.
Previous records Recorded by numerous authors from Carboniferous sediments. The closest record is Marshall and Williams 1970 L. Nam., Northumberland.

Anapiculatisporites hispidus Butterworth & Williams 1958
Pl. 3, fig. 15, 16.

1958 Anapiculatisporites hispidus B & W, p. 364, Pl. 6, fig. 17
Holotype Plate 6, fig. 17. Preparation T39/1 in collection of National Coal Board laboritories, Wath-upon-Dearne. Size 39 µ in range 30-39 µ.
Type locality 4 in. coal at 191 ft. 3 ins. Darnley No. 3 borehole, Central Coalfield, Scotland; Namurian A.
Diagnosis B & W p. 364.
Description Spores trilete. Amb triangular rounded apices, sides more or less straight. Laesurae straight, simple, 3/4 spore radius. Exine thin, ornamented with coni 3.5 µ high with ovate bases up to 3 µ long, bases not touching. Ornament concentrated in polar region of distal surface mostly. Size range 33 µ to 38 µ.
Remarks Few specimens were recovered in present study. These were distinguished from A. concinnus Playford, by the broader based ornament which tends to be slightly curved.
Occurrence First Sandstone to base of basal Coal Measure Grit.
Previous records Butterworth and Williams Nam. Scotland; Owens 1963 L. Nam. A. Stainmore; Mishell 1966 Nam. Bowland; Smith and Butterworth Nam. British Coalfields.

Anapiculatisporites minor (Butterworth & Williams)
Smith and Butterworth 1967. Pl. 3, fig. 13.

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, fig. 21-24.

Holotype Preparation T40/1 in collection of N.C.B. laboritories, Wath-upon- Dearne. Size 23 μ.

Type locality Lyncross seam at 558 ft. 10 ins., Darnley No. 4 borehole, Central Coalfield, Scotland; Nam. A.

Diagnosis S & B p. 161.

Description Spores trilete. Amb triangular, sides straight. Laesurae straight, simple, extending 3/4 spore radius. Exine ornamented with coni about 2 μ long concentrated on distal surface. Size range 20 μ to 32 μ. (10 specimens).

Remarks This more common species of Anapiculatisporites was distinguished from other members by its small size and grade of ornament.

Occurrence Little Limestone to Second Sandstone.

Previous records Recorded by numerous authors from the Upper Carboniferous. The closest record Marshall and Williams 1970 Nam. Northumberland.

Genus Apiculiretusispora Streel 1964

Type species A. brandtii Streel 1964.

Diagnosis Streel 1964, p. 138.

Apiculiretusispora multiseta (Luber) Butterworth and Spinner 1967. Pl. 4. fig. 1,2.

1938 Azonotriletes multisetus Luber in Luber and Waltz p. 23, Pl. 5, fig. 61.

1962 Acanthotriletes multisetus (Luber) Potonie and Kremp - Playford, p. 590, Pl. 80, figs. 14-15.

1963 Acanthotriletes multisetus (Luber) Kedo, p.43,Pl.2,figs.51-52

1966 Acanthotriletes multisetus (Luber) Kedo - Kedo p. 56, Pl. 1, figs. 36-38.

1967 Apiculiretusispora multiseta (Luber) Butterworth and Spinner, p. 5, Pl. 2, figs. 13, 18.

Holotype L in L and W. Pl. 5, fig. 61. Size range in B & S 1967 35μ to 62μ.

Diagnosis L & W p. 32 and Description in B & S 1967 p. 5.

Description Amb circular. Laesurae indistinct ending in darkened curvatural. Exine ornamented with very small spiral approximately 1 u. Size range 29 μ to 49 μ.

Remarks The few specimens observed during the present study conform closely to description in B & S. The ornament was only clearly visible under oil immersion. Preservation of the specimens was poor.

Occurrence Basement Beds.

Previous records Luber L. Carb. Karaganda Basin; Love 1960 Visean Scotland; Playford 1962 L. Carb. Spitsbergen. Butterworth and Spinner, 1967, Bewcastle Beds.

Genus *Pustulatisporites* Potonie and Kremp 1954

Type species *P. pustulatus* Potonie and Kremp 1954.

Diagnosis In Potonie and Kremp 1954, p. 134.

Pustulatisporites papillosus (Knox) Potonie & Kremp 1955
Pl. 3, fig. 20, 21.

1948 Type 16K Knox text figure 13.

1950 *Triquitrites papillosus* Knox p. 327, Pl. 17, fig. 234.

1955 *Pustulatisporites papillosus* (Knox) Potonie and Kremp p.82

Holotype Not chosen by Knox.

Lectotype Designated by Smith and Butterworth, T84/1 in N.C.B. laboratories, Wath-upon-Dearne, Knox preparation 360A., Pl. 7, fig. 9., S & B 1967. Size 45 μ.

Diagnosis In Butterworth and Williams 1958, p. 365.

Description Amb triangular to subtriangular, sides straight or slightly concave, or rarely convex. Laesurae sometimes difficult to observe but simple, straight, extending to margin of spore. Exine ornamented with irregular, large verrucae, about 6 μ high, oval in basal outline about 4 μ in diameter, irregularly placed, mostly over distal surface. Size range 34 μ to 48 μ. (5 specimens).

Remarks The species is distinguished from P. subornatus by the tendency for oval bases to the elements which the latter species has. Smith and Butterworth 1967 observed that larger elements concentrate towards the pole, leaving the amb often little modified; this tendency was not observed in the present study.

Occurrence Top Hensingham Grit to Second Sandstone.

Previous records Knox 1948 and 1950 Nam. A, Scotland; Butterworth and Williams 1950, Nam. A Scotland; Sullivan 1964 Drybrook Sst., Forest of Dean ? figs. from Edgehill coal; Mishell 1966 Nam A - B Bowland; Marshall and Williams 1970, Yoredales Northumberland; Smith and Butterworth 1967, Nam. A, British Coalfields; Loboziak 1969, Nam. France.

Genus Schopfites Kosanke 1950

Type species S. dimorphus Kosanke 1950

Diagnosis From description in Kosanke 1950, p. 52.

Schopfites claviger Sullivan 1968
Pl. 5, fig. 8, 9, 10.

1968 Schopfites claviger Sullivan p.121, Pl.25, figs. 9-10

Holotype Slide P.26381 - A-03, 125.0 26.5. Size 50 µ.

Type location 100 feet above base of Cementstone Group, Ayrshire, Scotland. Tournaisian.

Diagnosis In Sullivan 1968, p.121.

Description Spores trilete. Amb circular to subcircular, trilete. Exine ornamented with elongate pila and bacula and strongly infrapunctate. Pila often 3 - 4.5 µ in height, with rounded bases 1 - 2 µ in diameter and expanded heads of 2 - 3 µ in diameter. Strength of ornament reduces gradually from distal to proximal surface. The latter is devoid of ornament. Pila not of equal height over distal surface. Trilete rays usually indistinct but straight, simple. Size range 28µ (39) 50µ (20 specimens).

Remarks These spores are easily distinguished by their ornament and overall shape. Clayton (1971) observed many specimens with an intexine, and he incorporated this additional feature into the description of the species. Clayton (1971) also described S. cf. clavıger which displayed strong laesura, clear cameration and larger ornament relative to size of spore. The present author found specimens of S. claviger to be either as described above or with a clearly defined intexine and with stronger infrapunctate exoexine. For this reason a two fold classification has been adhered to with S. claviger on the one hand conforming to the pre-Clayton description and S. cf. claviger on the other hand conforming to the camarate version.

Occurrence Basement Beds to base of Seventh Limestone. Frequent to abundant.

Previous records Su. 1968 Cementstone Group Scotland; Cl. 1971, L. Carb. Scotland; L. B. and H. 1969 Tourn., Leicestershire; Ne. et al. 1973 S. Scotland. Tourn.; Be. 1972 L. Carb. Denmark.

Schopfites cf. claviger Sullivan 1968

Non Schopfites cf. claviger (Sullivan) Clayton 1971 sensu stricto.
Pl. 5, fig. 11, 12.

Holotype Slide 373D. 88.1/7.5

Type location Basement beds below the Cockermouth lavas, Redmain, Cumberland.

Description Trilete, camerate spores. Exoexine infrapunctate, ornamented with bacula up to 4 µ in height with rounded bases, with expanded spherical heads. Ornament confined mostly to distal surface. Intexine more or less distinct, cameration usually between 4 u and 8 u but may be variable in any one specimen. Size range 29µ(36)48µ. (10 specimens).

Remarks This species is clearly very similar to S. claviger, with the exception that an intexine is clearly visible. Clayton (1971) records S. cf. claviger which is distinguished from S. claviger by the presence of an intexine and stronger laesurae. However, his unamended description of S. claviger also contains specimens with an intexine.

Genus Verrucosisporites (Ibrahim) Smith and Butterworth 1967

Type species V. verrocosus (Ibrahim) Ibrahim 1933

Diagnosis Smith and Butterworth 1967 p. 147.

Verrucosisporites microtuberosus (Loose) Smith & Butterworth 1967. Pl. 4, fig. 4

1932 Sporonites microtuberosus Loose in Potonie, 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); Potonie & Kremp p. 100, Pl. 15, figs. 273 - 7.

1957a Planisporites microtuberosus (Loose) Knox in Bharadwaj p. 87, Pl. 23, figs. 13, 14.

1967 Verrucosisporites microtuberosus Smith and Butterworth p. 149, Pl. 5, fig. 9,11.

Holotype P & K 1955, Pl. 15, fig. 2/3. Preparation 11150 C6 (OR) Size 67.5 μ in range 55 - 85 microns.

Type location Bismarck seam, Ruhr Coalfield, Germany; Upper Westphalian B.

Diagnosis S.& B. p. 150.

Description Spores trilete. Amb circular to subcircular. Laesurae often split open, 1/2 spore radius simple. Exine ornamented with snall irregularly shaped, closely set low verrucae up to 2 μ wide 1.5 μ high. Size range 50 μ to 75 μ (9 specimens).

Remarks The ornament of this species distinguishes it from V. donarii being more irregularly elongated in outline and more variable in size. Several specimens were observed which had been split open enabling the inner surface of the exine to be observed. This surface was irregular rather than smooth, following the verrucate ornament.

Occurrence Lower Coal Measures.

Previous records Recorded by numerous authors from the Upper Carboniferous more recently including Mishell 1966, Westphalian A. Bowland and Loboziak 1969, Westphalian A., France.

Verrucosisporites microverrucosus Ibrahim 1933
Pl. 4, fig. 5.

1933 Verrucosi-sporites microverrucosus Ibrahim, p. 25, Pl. 7, fig. 60.

1944 Punctati-sporites microverrucosus (Ibrahim); Schopf, Wilson and Bentall p. 31.

1950 Verrucososporites microverrucosus (Ibrahim) Knox; p. 318, Pl. 17, fig. 228.

Holotype Potonie and Kremp 1955, Pl. 13, fig. 200 after Ibrahim. Preparation B26, C2 (ur) Size 56.5 µ.

Type locality Agir seam, Ruhr coalfield, Germany; Top Westphalian B.

Diagnosis Smith and Butterworth p. 151.

Description Spores trilete. Amb circular to oval, laesurae simple, straight, 2/3 radius. Exine ornamented with verrucae of about 3 µ in diameter, low in profile and irregular in outline, with approximately 30 projecting at equator. Size range 50 µ to 65 µ. (8 specimens).

Remarks The few specimens observed during the present study conform to the diagnosis.

Occurrence Top of Fourth Lst.

Previous records Numerous authors have recorded this species from Upper Carboniferous sediments mostly.

Verrucosisporites morulatus (Knox) Smith and Butterworth 1967, Pl. 4, fig. 6.

1948 Type 20K Knox, text fig. 23

1950 Verrucoso-sporites morulatus Knox, p.318, Pl. 17, fig. 235.

1955 Verrucosisporites morulatus (Knox) Potonie & Kremp, p.65

1967 Verrucocisporites morulatus (Knox) Smith & Butterworth p. 152, Pl. 5, fig. 15, 16.

Lectotype Pl. 5, fig. 15, after Knox. Preparation 369A (T85/1 in collection of N.C.B. laboritories, Wath-upon-Dearne) Size 58 μ.

Type locality Sulphur seam, Lindsay Colliery, East Fife Coalfield, Scotland; Namurian A.

Diagnosis Smith and Butterworth 1967, p. 152.

Description Spores trilete, Amb oval, subcircular or circular. Laesurae simple, straight, often indistinct. Exine ornamented with discrete verrucae with circular bases and domed apices up to 3 μ high and 3 μ wide. Apices occasionally slightly expanded. Size range 47 μ to 58 μ.

Remarks The specimens observed during the present study conform to the diagnosis. This species was distinguished from V. nodosus by its smaller grade of ornament and larger size.

Occurrence Sixth Lst. to Seventh Sst.

Previous records Butterworth and Williams 1958, Nam. A, Scotland; Neves 1961, Nam. A, S. Pennines; Smith and Butterworth 1967, Visean and Nam., British Coalfields; Marshall and Williams 1970, Visean and Nam., Northumberland.

Verrucosisporites nitidus (Naumova) Playford 1963
Pl. 4, fig. 7, 8.

1953 Lophotriletes grumosus Naumova p. 57, Pl. 7, figs. 14-15

1956 Lophotriletes cff. grumosus Naumova - Ischenko p.40,Pl.6, fig. 74.

1963 Verrucosisporites nitidus Playford nom.nar. pp.13-14 Pl. 3, figs 3 - 6.

1964 Verrucosisporites grunnosus (Naumova) Sullivan pp. 1252-3 Pl. 1, figs 9 - 15.

1971 Verrucosisporites nitidus (Naumova) Playford - Clayton, p. 592, Pl. 4, figs. 7.

Holotype (In Playford 1963 p. 14) As designated by Naumova p. 57 for Lophotriletes grumosus (IGN NO. 3450/3612). (either fig. 14 or 15 Pl. 7)

Hypotypes GSC Nos. 13084, 13085, 13086, 13087. Size range 25 μ to 55 μ.

Type location Petino Beds (Upper Frasnian); Petino, Voronezh region U.S.S.R.

Diagnosis Playford 1963, p. 592.

Description More or less circular, trilete spores. Laesurae straight, simple, 2/3 of spore radius. Exine ornamented with smooth, large, individual verrucae of low profile, measuring 3 μ to 8 μ in diameter and 2 μ to 3.5 μ high. The verrucae are more or less evenly distributed over the surface. Size 30 μ to 48 μ diameter (15 specimens).

Remarks Spores assigned to this species conform to the diagnosis - The distribution of verrucae was not generally observed to be so closely spaced as to produce a polygonal pattern as described by Playford. The amb was more often circular than subtriangular.

The spores were distinguished from Pustulatisporites gibberosus Playford 1963, which has more widely separated verrucae than V. nitidus, by the fact that the former possesses elements relatively much higher than V. nitidus and also longer laesurae.

This species was distinguished from V. scoticus Sullivan 1968 by the fact that the latter has ornament principally distributed over the distal and equatorial surfaces.

Occurrence Basement beds.

Previous records Upper Devonian and Lower Carboniferous U.S.S.R. by Naumova 1953 and Ishchenko 1956. 1963 Playford, Mississippian Horton Gp., Canada. 1964 Sullivan, Tournaisian, Forest of Dean. 1970 Combaz and Streel, Tournaisian, France. 1970 Paproth and Streel, Devonian/Carb. Belgium and Germany. 1970 Dolby and Dolby and Neves, Devonian/Carb. Ireland. 1971 Johnson and Marshall, Ravenstonedale, Gt. Britain. 1971 Playford, Lower Carboniferous, Borepart Gulf Basin, Australia. 1972 Bertlesen, Lower Carboniferous, Denmark. 1973 Neves et al., Lower Carboniferous, Scotland and N. England.

Verrucosisporites nodosus Sullivan & Marshall 1966
Pl. 4, fig. 9.

1966 Verrucosisporites nodosus Sullivan and Marshall
p. 269, Pl. 1, figs. 20-21.

Holotype Pl. 1, fig. 20 (S. & M.). Size in range 34 u - 48 μ.

Type locality Shale below Blackbyre Limestone.

Diagnosis In S. & M. 1966, p. 269.

Description Circular to subcircular, trilete spores. Laesurae extend to 1/2 of spore radius. Exine ornamented with distinct verrucae. The verrucae vary in size from 2 μ to 4 μ wide and about 2.5 μ high. In profile the elements are bulbous, often with expanded ends (see diagram)

An average of about 40-50 elements project at the equator. Size range from 30 u to 40 u (15 specimens).

Remarks This species was distinguished from V. monulatus (Knox) Smith and Butterworth, by its size range, ie. 30-40 μ, which is smaller than V. monulatus which is 50-80 μ (Butterworth and Williams 1958). Also the ornamental elements in the specimens observed in the present work were more often expanded than those observed in specimens assigned to V. monulatus, furthermore in the latter species more elements were found to project at the equator. (50 to 60).

Occurrence Basement beds above the Cockermouth lavas to Sixth Sst.

Previous records Sullivan and Marshall 1966, Visean, Scotland. Neves et al. 1973, Lower Carboniferous, Scotland.

Verrucosisporites papulosus Hacquebard 1957.
Pl. 4, fig. 10.

1957 Verrucosisporites papulosus Hacquebard, p.311, Pl.2, figs.4-5.

Holotype M101, slide 1, 47.2 108.4.

Type location Horton Gp., Nova Scotia.

Diagnosis Description in H. 1957, p. 311.

Description Spores trilete. Amb circular. Laesurae indistinct. Exine ornamented with papulate verrucae up to 2 µ high, irregularly spaced. Size 40 µ.

Remarks One specimen was found which broadly corresponds to the diagnosis.

Occurrence Basement beds.

Previous records Hacquebard 1957, Playford 1963, Vorma 1969, Horton Group, Nova Scotia.

Verrucosisporites variotuberculatus Sullivan 1968
Pl. 4, fig. 11.

1968 Verrucosisporites variotuberculatus Sullivan p.121,Pl.26,fig. 1 - 4.

Holotype Slide P26381-A-01, 114.7, 38.3. Size 64 µ.

Type locality Cementstone Gp., Ayrshire, Scotland.

Diagnosis Sullivan 1968, p.121.

Description Spores more or less circular in shape, trilete; laesurae usually obscure but occasionally very distinct. Ornament of variously sized verrucae, between 2 - 3.5 µ high and 3 - 7 µ wide. Verrucae rather closely spaced so as to form a polygonal pattern at their bases. The size of the verrucae often reduced on the proximal surface although not in every case, and never to the extent shown by Sullivan 1968 Pl. 26, fig. 2. Size 50 µ to 58 µ (5 specimens).

Remarks The few specimens recovered in the present work conform to the diagnosis with the exception of the features mentioned in the description above. V. grumosus Sullivan 1964a would appear to be very similar to these spores.

Occurrence basement beds.

Previous records Sullivan 1968, Tournaisian, Scotland.

Genus Raistrickia (Schopf, Wilson & Bentall) Potonie and Kremp 1954.

Type species R. grovensis Schopf in Schopf, Wilson and Bentall 1944

Diagnosis Potonie and Kremp 1955, p.85, translation in Smith and Butterworth 1967.

Raistrickia fulva Artuz 1957
Pl. 4, fig. 13.

1957 Raistrickia fulva Artuz, p. 246, Pl. 3, fig. 19

Holotype A. 1957, Pl. 3, fig. 19. Preparation 1115, 6d. Size 45 μ.

Type location Sulu seam, Zonguldak Coalfield, Turkey.

Diagnosis Description in A. 1957, p. 246, in Smith and Butterworth 1967, p. 180.

Description Spores trilete. Amb rounded triangular. Laesurae indistinct. Exine ornamented with rounded irregular sized coni, from 2.5 μ to 5 μ long, about 12 project at equator. Elements are extremely irregular in shape both in plan view and profile. Size range from 35 μ to 48 μ for 15 specimens.

Remarks The specimens recovered during the present study conform closely to diagnosis. However, the specimens described by some authors which have blunt bacula as ornament did not appear to be present in the present study. The specimens bore a close resemblance to those illustrated by Mishell 1966, as Armatisporites fulvus and S & B 1967 as R. fulva, Pl. 8, fig. 18.

Occurrence Lower Coal Measures.

Previous records Numerous records of this species exist from the Upper Carboniferous, including Owens and Burgess 1965, Westphalian A. Stainmore; Mishell 1966, Westphalian A, Bowland; Smith and Butterworth 1967, Westphalian A - C, Britain.

Raistrickia microhorrida (Horst) Potonie & Kremp 1955
Pl. 4, fig. 12.

1943 Triletes ?(Apiculati) microhorridus Horst, p.171, fig. 356.

1955 Raistrickia microhorrida Potonie & Kremp, p.278, p.86.

Holotype Horst 1943, p.171. Size range 51 μ to 66 μ.

Type location Namurian of Mahrisch-Ostrau.

Diagnosis Horst 1943.

Description Spores trilete. Amb approximately circular. Laesurae not clearly visible. Exine ornamented with elongate bacula about 7 μ high and 2.5 μ wide with approximately circular bases and with apices which are often expanded and slightly ragged. Size range 36 μ to 58 μ (44μ) from 15 specimens.

Remarks This species was distinguished from R. saetosa (Loose) S. W. & B. by its smaller size and the slightly more slender ornament and from R. bacculatus by the fact that the latter species has ornament which is stouter and more variable. The present specimens conform closely to the original description.

Occurrence Rare to abundant Lower Coal Measures.

Previous records Horst 1943, Namurian; Dyborn and Jachowicz 1957 Namurian A to C Upper Silesia; Horst 1955 Namurian A Mahrisch Ostrava; Owens and Burgess 1966 Namurian A - B Stainmore; Mishell 1966 Namurian and Westphalian, Bowland; Sabry and Neves 1971, Westphalian Sanquhar Coalfield, Scotland.

Raistrickia nigra Love 1960
Pl. 4, fig. 15.

1960 Raistrickia nigra, Love p. 114, Pl. 1, fig. 5, text fig. 4.

Holotype Love 1960, Pl. 1, fig. 5, Slide PSB 296 m/8. Size 73 μ.

Type location Pumpherston Shell band, South Queensferry.

Diagnosis Love 1960, p. 114.

Description Spores trilete. Amb circular to oval. Laesurae distinct, straight, simple, extending 3/4 of spore radius, gaping often. Exine relatively thick, ornamented with blunt bacula or rounded coni, approximately 5 μ long and 3μ to 4μ in basal diameter. About 15 elements project at equator. Size range 40 μ to 59 μ (6 specimens).

Remarks This distinctive species was recognised by the size and distribution of its ornament and thick exine. The size range recorded here falls below the type material which was 60 μ to 75 μ, however several authors have recorded smaller size ranges for the species i.e. Sullivan and Marshall 1966 46 μ to 70 μ, Bertelsen (1972) 45 μ to 58 μ. Ornament did not seem to be much reduced on proximal surface.

Occurrence Rare, Fourth Limestone to Ninth Sandstone.

Previous records Love 1960, Upper Visean, Scotland; Owens 1963 Lower Namurian A, Stainmore; Sullivan and Marshall 1966, Upper Visean, Scotland; Mishell 1966 Lower Namurian A, Bowland; Neville 1968 Visean, Scotland; Hibbert and Lacey 1969 Visean, N. Wales; Marshall and Williams 1970 Upper Visean, Lower Namurian, Northumberland; Bertlesen 1972, Visean, Denmark; Neves et al. 1973, Lower Carboniferous, N. England and Scotland.

Raistrickia saetosa (Loose) Schopf, Wilson & Bentall 1944.
Pl. 4, fig. 14.

1932 *SporonitesBsaetosus* Loose in Potonie, Ibrahim and Loose p. 452, Pl. 19, fig. 56.

1933 *Setosi-sporites saetosus* (Loose); Ibrahim, p. 26.

1944 *Raistrickia saetosus* (Loose); Schopf, Wilson and Bentall p.56

Holotype Potonie and Kremp 1955, Pl. 15, fig. 264 after Loose 1932. Preparation 111, c. Size 78 μ in range 60 - 90 μ.

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

Diagnosis P and K. 1955, p. 87 translation in S. and B. 1967 p. 181.

Description Spores trilete. Amb circular to subcircular. Laesurae simple, straight, extending 1/2 spore radius distinct. Exine ornamented with bacula up to 10 μ high 2 μ wide with circular bases not much expanded but slightly ragged at distal end. Spaced 10 μ to 15 μ apart, approximately 15 at equator. Exine otherwise laevigate and thick. Size range 35(50)54μ (20 specimens).

Remarks This species became abundant in Westphalian strata. Smith and Butterworth (1967) remark on expansion of the bacula at base and tip, this was not observed in the present study. The present author observed some intergradation with this species and R. microhorrida (Horst)P. & K. , which was however distinguished by its smaller ornament.

Occurrence Lower Coal Measures.

Previous records Numerous authors have recorded this species including Love and Neves 1964, Westphalian B. Scotland; Kalibova 1964 Steph. Checzlovakia; Artuz 1957 Namurian - Westphalian A., Turkey; Mishell 1966 Namurian - West Bowland.

Genus Neoraistrickia Potonie 1956

Type species N. truncatus (Cookson) Potonie 1956

Diagnosis Potonie 1956.

Neoraistrickia drybrookensis Sullivan 1964b
Pl. 5, fig. 1.

1964b Neoraistrickia drybrookensis Sullivan p.364,Pl.58, figs.11,12

Holotype Sullivan 1964b. Specimen illustrated as Pl. 58, fig. 11 from the Drybrook Sandstone. Size 46.5 µ.

Type location Brybrook Sandstone, Forest of Dean, Visean.

Diagnosis S. 1964b p. 365.

Description Spores trilete. Amb triangular, apices slightly rounded, sides straight to concave. Outline greatly affected by elongate bacula. Laesurae 2/3 spore radius, invariably gaping. Exine ornamented with elongate bacula up to 6 µ high to 2.5 µ wide, attaining their greatest length at apices, much reduced over polar region to blunt coni. Size range 42 µ to 47 µ (4 specimens).

Remarks The ornament on the specimens recovered during the present study occasionally resembled that on N. inconstans, Neves, which however is much larger, with broader apices.

Occurrence Little Limestone up to Sixth Sandstone.

Previous records Sullivan 1964b, Visean, Forest of Dean.

Genus Tricidarisporites (Sullivan & Marshall 1966) Gueinn, Neville and Williams 1973.

Type species T. serratus (Playford) Sullivan and Marshall 1966.

Diagnosis In Neves et al. 1973, p. 31

Tricidarisporites dumosus (Staplin) Sullivan and Marshall 1966. Pl. 5, fig. 2.

1960 Granulatisporites ?dumosus (Staplin) p.16,Pl.3, figs.15-17

1967 Procoronaspora dumosa (Staplin) Smith and Butterworth p. 164, P. 6, figs. 28-30.

1966 Tricidarisporites dumosus (Staplin) Sullivan and Marshall p. 268.

Holotype Staplin 1960, Pl. 3, fig. 16. Imp.1707,5-40.3, 118.2

Type locality Shale at 4,385 ft. Imperial Belloy borehole 12-14, Alberta, Canada; Golata formation.

Diagnosis In Staplin 1960, p.16.

Description Small trilete spores, amb triangular, sides straight to slightly convex, apices slightly rounded. Distal surface ornamented with long spinae which project at interradial equatorial regions but become reduced to absent at the apices. Laesurae straight, simple, extending almost to margin of spore. Size 25 μ, 27 μ and 30 μ.

Remarks The three specimens found in the present study conform very well to the diagnosis of this distinctive species.

Occurrence Third Lst. to Hensingham Grit. Rare.

Previous records Staplin 1960, Golata formation, Canada; Smith and Butterworth 1967, Visean-Namurian A., British Coalfields.

Tricidarisporites fasciculatus (Love) Gueinn, Neville and Williams 1973. Pl. 5, fig. 3, 4.

1960 Procoronaspora fasciculata Love, p.112-113,Pl.1,fig.2 text. fig. 2

non 1966 Tricidarisporites fasciculatus (Love) Sullivan & Marshall pp.268-269, Pl. 1, fig. 16.

non 1967 Procoronaspora fasciculata Love in Smith & Butterworth p. 164, Pl. 6, fig. 31.

non 1971 Tricidarisporites fasciculatus (Love) Sullivan and Marshall in Marshall and Williams Pl. 1, fig. 6.

1973 Tricidarisporites fasciculatus (Love) Gueinn, Neville and Williams, p. 32.

Holotype Love 1960, Pl. 1, fig. 2. Slide PSB 296m/6. Size 50 µ.

Type locality Pumpherston Shell Bed, S. Queensferry, Scotland.

Diagnosis Love 1960, p. 112.

Description Amb triangular with rounded apices and straight or slightly concave sides. Laesurae distinct, straight, slightly thickened, extending almost to margin. Exine ornamented with grana or coni over distal surface where the size of the elements is smaller than on the interradial equatorial regions where approximately 18 elements project. The apices are devoid of ornament. Size range 43 µ to 47 µ. (6 specimens).

Remarks The few species recovered in the present study conform to the emmended description in Neves et al. 1973. The species is distinguished from T. arcuatus Neville, by its ornament over distal surface only, from T. magnificus, Neville, by the latter's larger blunt ornament and from T. serratus (Playford) Sullivan and Marshall, by the ornament which is of long pointed spinae.

Occurrence Third Limestone to Tenth Sandstone. Very rare.

Previous records Love 1960 Visean Scotland; Felix and Burbridge 1967 Springer formation, Oklahoma.

Tricidarisporites magnificus Neville 1973
Pl. 5, fig. 5, 6, 7.

1973 Tricidarisporites magnificus Neville in Neves et al. p. 33, Pl. 1, fig. 9-11.

Holotype In Neves et al. Pl. 1. fig. 9. ML 885, F66. Size in range 50µ to 62µ.

Type locality Sample A4 - Coal at a depth of 118 ft. 2 ins. in the Anstruther borehole.

Diagnosis In Neves et al. 1973, p.33.

Description Amb triangular with rounded apices and straight or slightly convex sides. Laesurae fairly distinct, extending 2/3 to 3/4 spore radius, straight, simple. Exine ornamented with verrucae on distal surface. Size of the elements varies on any one specimen being larger towards the distal pole in basal diameter but probably becoming more elongate towards the equator in interradial regions. Towards the apices the ornament becomes reduced or absent. Size range 40µ(53)56µ (15 specimens). Size of tubercules at equatorial interradii 3.5 µ to 4 µ increasing to a maximum of 7 µ high.

Remarks This species was distinguished by its ornament of blunt tubercules and verrucae. One specimen was observed on which the ornament was very varied in diameter, varying from 1.5 µ to 6 µ in adjacent locations, however this specimen conformed well to the description of the species in all other respects.

Occurrence Infrequent, Rough Limestone up to Seventh Sandstone.

Previous records Neves et al. 1973, Lower Carboniferous, Scotland.

Infraturma Murornati Potonie & Kremp 1954

Genus Camptotriletes (Naumova) Potonie & Kremp 1954

Type species C. corrugatus (Ibrahim) Potonie and Kremp 1954

Diagnosis Potonie and Kremp 1954, p. 142 translation in Smith and Butterworth 1967.

Camptotriletes cristatus Sullivan and Marshall 1966
Pl. 5, fig. 13.

1966 Camptotriletes cristatus S. and M. p. 270

Holotype S. and M. 1966, Pl. 1, fig. 25. Lady Ann coal. Size in range 32 µ to 45 µ.

Type location Upper Sed. Group, Scotland.

Diagnosis S. and M. p. 270

Description Spores trilete. Amb circular to subcircular. Laesurae indistinct. Exine ornamented with rugulose, conical, cristae, about 2 µ high. Ornament joined at bases into very irregular ridges about 2 µ wide. Occasionally elements may be more spinose in cross section, when they may reach 3.5 µ in height. Size range 30 µ to 47 µ for 8 specimens.

Remarks Specimens recovered during the present study conform to original diagnosis. Species distinguished from C. superbus, Neves, by its smaller size and smaller grade of ornament.

Occurrence Base of Fourth Limestone to Second Limestone.

Previous records Sullivan and Marshall 1966, Upper Visean, Scotland; Neville 1968, Visean Scotland; Marshall and Williams Visean and Namurian, Northumberland.

Camptotriletes superbus Neves 1961
Pl. 5, fig. 14.

1961 Camptotriletes superbus Neves p. 257

Holotype Pl. 31, fig. 8 sl. ref. 3.240769 Size 119 µ.

Type locality Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13). Yeadonian stage.

Diagnosis Neves 1961, p. 257.

Description Spores trilete. Amb circular, laesurae indistinct to distinct. Exine ornamented with irregular discontinuous ridges up to 3 µ high, 5 µ to 1 µ wide, relatively widely separated, approximately 20 project at equatorial outline. Size range 50 µ to 69 µ.

Remarks Specimens recovered during the present study compare closely to original diagnosis excepting that the size range falls well below that of the type. This is certainly due to the processing technique. The species was distinguished from C. cristatus Sullivan and Marshall, by its larger size and coarser grade of ornament.

Occurrence Fourth Limestone to lower part of Hensingham Group also Lower Coal Measures.

Previous records Neves 1961 Upper Namurian B. - Westphalian A. South Pennines; Neves 1964, Namurian B. Namurian C. La Camocha Spain; Owens and Burgess Westphalian A., Stainmore; Neves, Read and Wilson 1965, Upper Namurian B - C., Passage Group, Scotland; Mishell 1966 Namurian B - Westphalian A., Bowland.

Camptotriletes verrucosus Butterworth & Williams 1958
Pl. 5, fig. 15.

1958 Camptotriletes verrucosus B. & W. p. 368-369

Holotype B. & W. 1958, Pl. 2, fig. 2. Size in range 40-65 µ.

Type location Seam at 2851 ft. 3 in. (Upper Blackbird) Monkton House Bore. Limestone Coal Group, Scotland.

Diagnosis B. and W. 1958, p. 368.

Description Spores trilete. Amb irregular subcircular. Laesurae indistinct. Exine ornamented with very irregular, low ridges up to 3 µ high, 5 µ in width mostly isolated but some partially anastomosing. Size range 37 µ to 58 µ. (5 specimens).

Remarks This species is distinguished from C. superbus, Neves, by the larger more irregular form of ornament.

Occurrence Lower part Hensingham Group.

Previous records Butterworth and Williams 1958. Lower Namurian A., Scotland; Neves 1961 Lower Namurian A., S.Pennines; Playford 1964 Horton Group, Canada; Mishell 1966 Lower Namurian A., Bowland.

Genus Microreticulatisporites (Knox) Potonie and Kremp 1954 non sensu Bharadwaj.

Type species M. lacunosus (Ibrahim) Knox 1950

Diagnosis Potonie and Kremp 1954, p. 143. translation in Smith and Butterworth 1967.

Microreticulatisporites concavus Butterworth and Williams 1958. Pl. 5, fig. 16, 17, 18.

1958 Microreticulati sporites concavus Butterworth & Williams p. 367, Pl. 1, fig. 56.

Holotype S. and B. 1967, Pl. 11, fig. 1, after Butterworth and Williams, Pl. 1, fig. 56. Preparation T45/1 in collection of N.C.B. Laboratory, Wath-upon- Dearne. Size 44 µ.

Type locality Seam at 1,872 ft. 7 ins., Righead borehole, West Fife Coalfield, Scotland; Namurian A.

Diagnosis (in Butterworth and Williams 1958, p. 367.)

Description Spores trilete. Amb rounded triangular with concave sides. Laesurae indistinct, 2/3 spore radius, straight, simple. Exine ornamented with muri approximately 2 µ wide, forming small luminae about 2.5 µ wide. Size range 30 to 45 µ. (14 specimens).

Remarks The muri frequently attain greater width at the apices, a feature recorded by S. and B. 1967.

Occurrence Orebank sandstone to Third Sandstone.

Previous records Butterworth and Williams 1958 Namurian A., Scotland; Love 1960, Visean, Scotland; Neves 1961 mid. Namurian A., S. Pennines; Owens and Burgess 1965, L. Namurian A., Stainmore. Mishell 1966, Namurian A. to Namurian B., Bowland; Sullivan and Marshall 1966, Visean, Scotland; Smith and Butterworth 1967, Namurian British Coalfields; Marshall and Williams 1971, Yoredales, Northumberland.

Microreticulatisporites microreticulatus Knox 1950
Pl. 5, fig. 19.

1948 36K Knox, p. 159, text,fig 42.

1950 Microreticulati-sporites microreticulatus Knox,p.321.

Neotype Plate 11, fig. 5, after Butterworth and Williams 1958. Preparation T43/1 in collection of N.C.B. Laboratory, Wath-upon-Dearne. (in Smith and Butterworth 1967).

Type locality A bed of Milton Main Seam at 1,735 ft. 3 ins. Righead borehole, West Fife Coalfield, Scotland; Namurian A.

Diagnosis Smith and Butterworth 1967, p. 191.

Description Amb subcircular to circular. Laesurae indistinct. Muri approximately 1.5 µ wide, 1 µ high, forming reticulate pattern over both hemispheres forming luminae approximately 4 µ diameter. Size range 25 µ, 30 µ, 33 µ.

Remarks The few specimens recovered in the present study closely resemble the description in S. and B. 1967.

Occurrence Ninth Sandstone to Second Sandstone.

Previous records Knox 1950, Namurian A., Scotland; Butterworth and Williams 1958 Namurian A., Scotland; Bharadwaj and Veukatachala 1961, Lower Carboniferous, Spitzbergen; Owens 1963 Upper Namurian A., Stainmore; Mishell 1966, Lower Namurian A., Bowland; Smith and Butterworth 1967, Namurian British Coalfields, ; Marshall and Williams, Yoredales, Northumberland.

Microreticulatisporites nobilis (Wicher) Knox 1950.
Pl. 5, fig. 20.

1934 Sporites nobilis, Wicher, p. 186, Pl. 8, fig. 30.

1944 Punctati- sporites nobilis (Wicher); Knox,p.321,Pl.18,fig.242

1950 Microreticulatisporites nobilis (Wicher); Knox,p.321,Pl.18, fig. 242.

Holotype Potonie and Kremp 1955, Pl. 15, fig. 279 after Wicher. Preparation lV X5, a (u/r). Size 36 µ.

Type locality Seam R , Wehofen Colliery, Ruhr Coalfield, Germany; Westphalian C. (Seam R in Wicher 1934 is a thin coal between the seams Kobold and Loki and is not the authentic R of the Ruhr Coalfield.

Diagnosis Potonie and Kremp 1955, p. 101, translation in Smith and Butterworth, p. 192.

Description Spores trilete. Amb rounded triangular, sides straight to slightly convex. Laesurae straight, simple, extending almost to margin. Exine ornamented with broad muri very closely set forming small luminae approximately 1.5 µ in diameter. Muri approximately 2 to 2.5 µ wide. Size range 23 to 39 µ (36 µ) (20 specimens).

Remarks The specimens recovered during the present study conform well to the diagnosis. This species was distinguished from M. concavus, Butterworth and Williams, by the straight or convex sides and broader muri and fewer, more prominent luminae. M. triangularis, Neves and Belt, is similar but slightly larger with straighter sides.

Occurrence Rough limestone to Ninth Sandstone.

Previous records Recorded by numerous workers, including Laboziak 1969, Westphalian of France.

Genus Convolutispora, Hoffmeister, Staplin and Malloy 1955.

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

Diagnosis Description in Hoffmeister, Staplin and Malloy 1955, p. 384.

Convolutispora ampla Hoffmeister, Staplin and Malloy 1955
Pl. 6, fig. 4.

1955 Convolutispora ampla H. S. and M. 1955, p. 384

Holotype H. S. and M. 1955, Pl. 38, fig. 12. Preparation 3, ser.19, 280. Size 64x62 μ in range 40-75 microns.

Type locality Outcrop area (TCO-143), Christian County, Kentucky, U.S.A., Hardinsburg Formation, Chester Series.

Diagnosis Description in H. S. and M., p. 384.

Description Trilete spores. Amb circular, laesurae indistinct, exine ornamented with very closely set small corrugated convolute verrucae approximately 1.5 μ high, 2 μ to 3 μ wide set 1 μ apart. In excess of 50 elements project at equator. Size range 40 μ to 61 μ, 6 specimens, holotype 64 μ x 62 μ.

Remarks The specimens conform to diagnosis they were distinguished by their closely set, fine ornament. V. donari and V. sifati were distinguished by their discreet verrucae.

Occurrence Seventh Limestone.

Previous records Recorded by many authors including Neves 1959, Namurian A, Pennines; Love 1960 Visean, Scotland; Owens 1963 Namurian A., Stainmore;

Mishell 1966, Namurian, Bowland.

Convolutispora cerebra Butterworth and Williams 1958.
Pl. 5, fig. 21.

1958 Convolutispora cerebra Butterworth & Williams, p.371

Lectotype Plate 9, fig. 5. Preparation T48/3 in collection of N.C.B. Laboratory, Wath-upon-Dearne (the holotype is missing). Size 82 µ.

Type locality Shale Seam at 663 ft. 6 ins., Cawder Cuilt borehole, Central Coalfield, Scotland; Namurian A.

Diagnosis Smith and Butterworth 1967, p. 184.

Description Amb circular, laesurae indistinct, long. Exine ornamented with closely set anastamosing muri, circular in section, about 3 µ wide 2 µ high, enclosing irregular shaped luminae. Peripherally elements appear enlarged and radially arranged. Size range 45 µ to 60 µ.

Remarks The characteristic features of this species are the thick ornamanet and peripheral zone which however probably result from compression of the thick exine as described by Smith and Butterworth 1967, p.185.

Occurrence Seventh Lst.

Previous records Butterworth and Williams 1958, Smith and Butterworth 1967, Namurian Scotland; Love 1960 Visean Scotland; Owens 1963 Namurian Stainmore; Mishell 1966 Namurian, Bowland.

Convolutispora circumvallata Clayton 1971
Pl. 6, fig. 5.

1971 Convolutispora circumvallata Clayton p. 582, Pl.1, figs.5,6,7.

Holotype Specimen ML 809, sample 5.

Type location Birnieknowes borehole, depth 1259 ft. 3 ins.

Diagnosis Clayton 1971, p. 582.

Description Spores trilete. Amb circular, laesurae indistinct but with wide labra. Exine ornamented with rounded, convolute, uneven ridges or muri. The muri are widely separated being about 6 µ apart and 5 µ wide. Size range 51 µ to 70 µ. (4 specimens).

Remarks The specimens seem to conform to the more "Convolutispora" like of the two extremes described by Clayton 1971. The nuri are rounded and do not enclose very regular luminae like the more "Dictyotriletes" like end member.

Occurrence Basement beds above Cockermouth lavas.

Previous records Clayton 1971 and Neves et al. 1973, Lower Carboniferous Scotland; Bertlesen 1972 Lower Carboniferous, Denmark.

Convolutispora florida Hoffmeister, Staplin and Malloy 1955. Pl. 5, fig. 22.

1955 Convolutispora florida Hoffmeister, Staplin and Malloy p. 384, Pl. 38.

Holotype H. S. and M. 1955, Pl. 38, fig. 6. Preparation 1, ser. 16,551. Size 49 μ.

Type location Shale at 2,086 ft., Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis Description in H. S. and M. 1955, p. 384.

Description Spores trilete. Amb irregular, subcircular, laesurae indistinct. Exine ornamented with closely set convolute lobate verrucae, approximately 4 μ high by 5 μ wide but variable on any one specimen. Size range 30 μ to 47 μ (7 specimens).

Remarks Specimens recovered during the present study conform closely to diagnosis. The species is distinguished by its small size and relatively large ornament.

Occurrence Below Fourth Lst. to First Sst.

Previous records This species has been recorded by numerous workers mainly from Upper Visean, Namurian and Lower Westphalian strata.

Convolutispora jugosa Smith and Butterworth 1967 Pl. 6, fig. 3.

1958 Convolutispora cf. mellita Hoffmeister, Staplin and Malloy; Butterworth and Williams, p. 372, Pl. 2, figs. 20, 21.

Holotype Plate 10, figs. 1,2. Preparation T49/1 in collection of N.C.B. Laboratory Wath-upon-Dearne. Size 112μ in range 84(102)119 microns.

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

Diagnosis S. and B. 1967, p. 186.

Description Amb circular, laesurae indistinct. Exine ornamented with closely spaced thick, convolute, rounded ridges, approximately 6 µ wide 3 µ high, 1 µ apart. Size range 72 µ to 91 µ. (4 specimens).

Remarks This species was recognised by the large closely set ornament. *C. mellita* is smaller.

Occurrence Rare in strata below horizon of Seventh Lst. also in Lower part of Hensingham Gp.

Previous records Smith and Butterworth, Namurian Scotland.

Convolutispora laminosa Neves 1961
Pl. 5, fig. 23

1961 *Convolutispora laminosa* Neves p. 259 Pl.32, fig. 4,5

Holotype Pl. 32, fig. 4. Slide ref. 7.221665.5. Size 69 µ.

Type locality Marine shale with Gastrioceras cancellatum, Hipper Sick, Derbyshire (loc.12) Yeadonian stage.

Diagnosis Neves 1961, p. 259.

Description Trilete spores. Amb oval, laesurae rarely seen, exine ornamented with wide, flat, convolute thickenings, enclosing long, narrow, luminae. Thickened bars about 10 µ to 14 µ wide; luminae, 2 µ wide. Occasionally the thickened bars touch and merge at their edges. Size range 34 µ to 55 µ. (6 specimens)

Remarks The specimens were characterised by their wide, low ornament. The present author considers that *C. planimuricatus*, Butterworth and Spinner (1967) and *C. laminosa* may be conspecific.

Occurrence Top of Fourth Lst. to Sixth Sst.

Previous records Neves 1961, Nam. Pennines.

Convolutispora tessellata Hoffmeister, Staplin and Malloy 1955. Pl. 6, fig. 1

1955 Convolutispora tessellata Hoffmeister, Staplin & Malloy p. 385.

Holotype H. S. and M. 1955 Pl. 38, fig. 9. Preparation 1, ser. 16527. Size 86 μ in range 45-86 microns.

Type Location Shale at 2087 - 8 ft. Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

Diagnosis Description in H. S. and M. p. 385.

Description Triletes spores. Amb circular, laesurae straight, simple, 1/2 spore radius. Exine ornamented with convolute low verrucae closely set joined at bases up to 3 μ high and 4 times the height in length. Approximately 40 project at equator. Size range 47 μ to 63 μ. (8 specimens).

Remarks This species resembles several species of Convolutispora but is distinguished on the bases of ornament size and distribution being coarser than that of C. ampla Hoffmeister Staplin and Malloy.

Occurrence Seventh Lst. to White Lst.

Previous records This species has been recorded by many authors from widely distributed areas, mainly from Namurian age strata.

Convolutispora vermiformis Hughes and Playford 1961 Pl. 6, fig. 2.

1957 Convolutispora flexuosa forma minor Hacquebard, p.312, Pl.2 fig. 10.

1961 Convolutispora vermiformis Hughes and Playford

Holotype H. 1957 p. 312 Pl. 2, fig. 11. M 101 sl. 9. 32.5 x 94.9

Diagnosis Description in H 1957 p. 312.

Description Amb oval laesurae not visible. Exine ornamented with thick convolute bars about 6 μ wide 3 μ high enclosing irregular luminae. Size range 41 μ to 57 μ. (4 specimens).

Remarks Although smaller than the type, the specimens had the characteristic appearance.

Occurrence Seventh Lst. to White Lst.

Previous records Recorded by numerous authors from Lower Carboniferous localities including the Horton Group, Nova Scotia, Spitsbergen and Scotland.

Genus Dictyotriletes (Naumova) Smith and Butterworth 1967.

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

Diagnosis Smith and Butterworth 1967, p. 194.

Dictyotriletes castaneaeformis (Horst) Sullivan 1964
Pl. 6, fig. 6,7.

1943 Aletes castaneaeformis Horst (thesis) p. 124, fig. 82

1955 Reticulatisporites castaneaeformis (Horst) Potonie and Kremp; Horst, p. 169.

1964 Dictyotriletes castaneaeformis (Horst); Sullivan, p. 367.

Holotype Horst 1955, Pl. 24, fig. 82. Preparation 11191, 16.3, 68.4.

Size 20 µ in range 11 µ to 29 µ.

Type locality Peterswalder Seam, Eugen Colliery, Moravska Ostrava; Namurian A.

Diagnosis In Horst 1955, p. 169.

Description Small, circular, occasionally oval. Laesurae not clearly visible, probably short, straight and simple. Reticulate ornament of very low muri, approximately i µ or less in height, forming wide luminae approximately 5 µ to 8 µ wide. About ten muri visible at equator. Size range 18 µ to 28 µ from eight specimens.

Remarks This species was recognised by its small dimensions and characteristic oval shape. D. barbatus Mishell 1966 is also a small species but is characterised by spines at the junction of the muri. Sullivan points out that R. crassireticulatus is probably conspecific with D. clatriformis (Artuz) Sullivan, both of which are larger than D. castaneaeformis.

Occurrence Rare.

Previous records Horst 1955, Namurian A; Sullivan 1964a, Forest of Dean, Edgehill coal (West A.), Smith and Butterworth 1967, Nam. A to West. B. British Coalfields.

Dictyotriletes clatriformis (Artuz) Sullivan 1964
Pl. 6, fig. 8.

1957 Reticulatisporites clatriformis Artuz p. 248, Pl. 4, fig.25

1964 Dictyotriletes clatriformis (Artuz) Sullivan p. 367.

Holotype Artuz Pl. 4, fig. 25. 1957

Type locality Sulu and Bujuk seams, Westphalian A; Zonguldak Coalfield, Turkey.

Diagnosis In Artuz 1957, p. 248.

Description Small reticulate circular spores. Laesurae not clearly visible. Muri low, approximately 1.5 μ high, about 8 at equator. Luminae polygonal in shape about 5 μ across. Size 22 μ to 37 μ (3 specimens).

Remarks The few specimens observed in the present study conform to the diagnosis. The species was distinguished from D. castaneaeformis (Horst) Sullivan, by the circular outline and more regular luminae.

Occurrence Very rare. Orebank Sst. to Second Sst.

Previous records Artuz 1957, Turkey W. A.; Sullivan 1964 D. cf. c, Forest of Dean, Edgehill coal (West. A.); Neves 1959 Nam. C. South Pennines; Mishell 1966, Nam., Bowland.

Dictyotriletes falsus Potonie and Kremp 1955
Pl. 6, fig. 9.10.

1955 Dictyotriletes falsus Potonie and Kremp p.109,Pl.16,fig.303

Holotype Pl. 16, fig. 303. Preparation 485/X Size 48 u.

Type location Agir seam, Freidrich Thyssen 2/5 (Wehofen) Colliery, Ruhr Coalfield, Germany; Top Westphalian B.

Diagnosis In Potonie and Kremp 1955, p. 109.

Description Amb circular, laesurae not clearly visible muri, 2 μ to 3 μ in width and height. Relatively thick bars extending over whole surface. Approximately 30 rounded luminae are produced on each hemisphere. Size range 36 μ to 51 μ. (4 specimens only).

Remarks The four specimens closely conform to previous descriptions of D. falsus.

Occurrence Rare. Hensingham Gp.

Previous records Potonie and Kremp 1955, Nid. West. B to Mid. West. C; Dybova and Jachowicz 1957 West. B - C, Upper Silesia; Love 1960, Lower oil shale group, Scotland; Owens 1963, Upper Nam. A. to Nam. B. Stainmore; Mishell 1966, Nam. Bowland; Smith and Butterworth 1967 West. A - C, British coalfields; Beju 1970 Nam. Rumania.

Dictyotriletes fragmentimurus Neville 1973
Pl. 6, fig. 11.

1973 Dictyotriletes fragmentimurus Neville in Neves et al. p. 33, Pl. 1 figs. 12 and 13.

Holotype Plate 1, fig. 12. Size in range 22 µ to 48 µ.

Type locality Sample F61, grey shales just below 1' 2" irony limestone at 400' in section between fault in West Bay, Pittenwean and fairway to Pittenween Harbour.

Diagnosis In Neves et al. 1973, p. 33

Description Amb oval or more usually circular. Laesurae not visible. Muri form reticulate pattern with luminae of irregular rectangular or polygonal shape, approximately 8 µ across. Muri irregular approximately 1.5 µ wide and 3.5 µ to 4.5 µ high, often discontinuous and sinuous; approximately 20 project at equator. Size range 25 µ to 45 µ(eight specimens).

Remarks These specimens were distinguished from other species of the genus by the fragmented appearance of the muri. This effect could be produced also by corrosion of the exine, however the size range and general height of muri were both consistent with the type material.

Occurrence Rare, base of Seventh Limestone to Third Limestone.

Previous records Neves et al. 1973, L. Carb. Scotland and N. England.

Dictyotriletes insculptus Sullivan and Marshall 1966
Pl. 6, fig. 12.

1966 Dictyotriletes insculptus, Sullivan and Marshall p.271,Pl.2. fig. 5-7.

Holotype In Sullivan and Marshall Pl. 2, fig. 5.

Type locality Shale below the Blackbyre Limestone, Upper Visean, Scotland.

Diagnosis In S. & M. , p. 271

Description Trilete spores. Amb circular to subcircular. Laesurae distinct, straight, simple, extending to margin of spore. Muri approximately 2.5 μ high and 2 μ wide, rounded in profile, more or less continuous, forming luminae which are relatively large but irregular in shape, about 8 μ across. Exine thine. Size range 40 μ to 55 μ. (10 specimens).

Remarks The thin exine, prominent laesurae and widely separated muri give these spores a characteristic appearance. Sullivan and Marshall describe the reticulum as being confined to the distal surface but this was difficult to assess in the present study. The muri appeared to cover at least the equatorial portions of the proximal surface.

Occurrence Base of Seventh Limestone to First Limestone.

Previous records Sullivan and Marshall 1966, Up. Visean, Scotland.

Dictyotriletes sagenoformis Sullivan 1964b
Pl. 6, fig. 13. 14.

1964b Dictyotriletes sagenoformis Sullivan p.367,Pl.56,figs.5,6.

Holotype Specimen on Pl. 56, fig. 5, Sullivan 1964. Size 67 μ in range 58 μ to 73 μ.

Type location Edgehill Coal, Forest of Dean.

Diagnosis Sullivan 1964b, p. 367.

Description Spores trilete. Amb circular or occasionally oval. Trilete rays not observed clearly, obscured by the muri. Muri prominent 5 μ to 7μ high, 1.5 μ wide, sometimes folded over at crests; approximately 10 at equator, joining a peripheral murus which intermittently follows equator. Luminae irregular, polygonal in shape approximately 10 μ across. Overall size range from 45 μ to 60 μ (20 specimens).

Remarks This species of Dictyotriletes was fairly abundant and distinguished from other species of the genus by the nature of the muri. The specimens closely resemble the photographs of the type material. The size range falls below that recorded by Sullivan but this may be due to the application of caustic potash by that author.

<u>Occurrence</u> Base of Seventh Limestone to Tenth Sandstone.

<u>Previous records</u> Sullivan 1964b, Edgehill Coal (West. A) Forest of Dean; Clayton 1970 L. Carb. Scotland; Neves et al. 1973, L. Carb. Scotland and N. England.

<u>Dictyotriletes</u> <u>submarginatus</u> Playford 1963
Pl. 6, fig. 15

1963 <u>Dictyotriletes</u> <u>submarginatus</u> Playford p.29,Pl.VIII,figs.9-13

<u>Holotype</u> GSC No. 13156. Size in range 53-70 μ. Size 68 μ.

<u>Type location</u> Horton Gp. (Cheverie Formation), Nova Scotia, GSC loc.6407.

<u>Diagnosis</u> In Playford 1963, p. 29.

<u>Description</u> Spores trilete. Amb circular or occasionally oval. Laesurae usually indistinct but straight, extending to equator, probably slightly thickened. Muri long, flexuose, approximately 2 μ high and 25 projecting at equator. Luminae trapezoid or irregular polygonal in shape. Size range 40 μ to 58 μ.

<u>Remarks</u> The few specimens recovered in the present study conform to the diagnosis in most respects. The size range is a little below that of the type. The laesurae were not so clearly visible as described by Playford but this could be due to under oxidation of some of the samples. This species was distinguished from <u>D</u>. <u>fragmentimurus</u> Neville, by the continuous nature of the muri, and from other species of the genus by the high number of muri projecting at the equator.

<u>Occurrence</u> Rare from base of Seventh Limestone to Jew Limestone.

<u>Previous records</u> Playford 1963 Va. 1969, Horton Gp. Nova Scotia; Hibbert and Lacey 1969, Menai Straits, L. Carb. N. Wales; Mortimer Chalenor and Llew. 1970 L. Carb. Tournaisian England; Neves et al. 1973 L. Carb. Scotland and N. England.

Genus Corbulispora

Corbulispora subalveolaris (Luber 1938) Sullivan 1964
Pl. 9, fig. 19.

1938 Azonotriletes subalveolaris Luber in Luber and Waltz
Pl. 5. fig. 72.

1955 Dictyotriletes subalveolaris (Luber) Potonie and Kremp

1960 Dictyotriletes subalveolaris (Luber) Potonie and Kremp; Love, Pl. 1, fig. 9, p. 116.

1964 Corbulispora subalveolaris Sullivan p.1253, Pl. 1, figs.16-20

Holotype In L. and W. Pl. 5, fig. 72.

Diagnosis Description in S. 1964 p. 1253.

Description Amb circular to sub circular. Laesurae indistinct. Exine ornamented with knobbly reticulate muri, about 2.5 µ wide and from 2.5 µ to 5.5 µ high, often discontinuous forming irregular subpolygonal luminae. Size 50 µ and 55 µ.

Remarks Only two specimens were recovered, these were rather poorly preserved and bore some resemblance to Dictyotriletes sp.

Occurrence Basal beds.

Previous records Sullivan 1964a and 1964b, L. Carb. (Tournaisian)

Subturma Zonotriletes Waltz 1935

Infraturma Auriculati (Schopf) Dettmann 1963

Genus Triquitrites (Wilson and Coe) Potonie and Kremp 1954.

Type species T. arculatus Wilson and Coe 1940

Diagnosis Potonie and Kremp 1954, p. 153, translation in Smith and Butterworth 1967.

Triquitrites batillatus Hughes and Playford 1951
Pl. 6, fig. 17.

1961 Triquitrites batillatus Hughes and Playford, p.33, Pl.2, figs 11-14

Holotype Preparation P150/3, 19.3 101.0 Dialux 1.

Type location Sample S 59a, Lower Carboniferous Spitzbergen; abundant.
Size 67 μ in range 45 μ - 73 μ.

Diagnosis H. and P. 1961, p. 33.

Description Trilete spores with subtriangular amb. Auriculae prominent dark, smooth, cap shaped with sides often inflated giving sides of spore a concave appearance. Suturae often slightly gaping, extend almost to inner margin of auriculae. Size range 47 μ - 60 μ (5 specimens).

Remarks From the few specimens the spores appear to conform to the diagnosis. The equatorial outline was seen to be slightly lengthened interradially giving a more slended appearance to the spores. T. Bransonii was distinguished by its smaller size and less well developed auriculae and T. trivalvis was distinguished by its much more strongly developed auriculae and slightly larger suturae.

Occurrence

Previous records 1961 Hughes and Playford, Lower Carboniferous of Spitzbergen. 1962 Playford, L. Carb. Spitzbergen. 1970 Beju, Dinantian of Rumania.

Triquitrites bransonii Wilson and Hoffmeister 1956
Pl. 6, fig. 18.

1956 Triquitrites bransonii Wilson and Hoffmeister p.24,Pl.5,fig.1

Holotype In W. and H. Preparation No. 12A, WH6. Size 33μ x 37.5μ.

Type locality Croweburg Coal, Stewart Mine, Oklahoma, U.S.A.; Des Moines Series.

Diagnosis Description in Wilson and Hoffmeister Pl. 5, p. 24.

Description Small trilete spores. Amb triangular, apices truncated sides, straight. Laesurae straight, simple, extending to internal margin of apical thickening. Exine thin, laevigate apical thickenings slightly irregular, rectangular 4 μ by 6 μ approximately. Size range 26 μ to 37 μ.

Remarks These spores were distinguished by their small size and rectangular thickening which does not modify amb much. The size range falls below that of the type material which as S. and B. 1967 point out is due to the macerating agent. The size range corresponds to that of Peppers 1970. The occurence of this species in Upper Visean strata is unusual. T. pulvinatus Kosanke 1950 has a longer range than T. bransonii but is larger according to Kosanke. This size range may be a result of processing techniques. With these reservations in mind the present author has classified these specimens in T. bransonii as Mishell (1966) has done for very similar specimens from Namurian strata in Bowland.

Occurrence Rough Limestone to Third Limestone.

Previous records Wilson and Hoffmeister 1956, W.D. Oklahoma; Bharadwaj 1957, W.C. Saar; Guennel 1958 Pottsville series Indiana; Neves 1959, W.A. Pennines; Owens 1963 L. W. B. Stainmore; Mishell 1966 Nam. B - W.A.; Smith and Butterworth 1967 W.C. - W.D.; Peppers 1970 Penn. Illinois.

Triquitrites comptus Williams 1973
Pl. 6, fig. 19.

1973 Triquitrites comptus Williams in Neves et al. p.34,Pl.1,fig.18

Holotype Pl. 1, fig. 18, in Neves et al. 1973. ML 894, BR 23, Size in range 38 μ to 60 μ.

Type location Roof shales of Little Limestone Coal, New Angerton Colliery, half a mile south of Greenhead, Cumberland (NY660645) Namurian A.

Diagnosis Neves et al. 1973, p. 35.

Description Spores trilete. Amb triangular with concave sides. Laesurae straight, simple, extending 3/4 spore radius. Apices broadly rounded, thickened, thickening slightly uneven merging into interradial equatorial crossitude about 3 μ wide. Exine ornamented with small irregular elements up to 4 μ wide. Size 41 μ to 53 μ.

Remarks Specimens conformed closely to diagnosis. This species was distinguished from T. marginatus*by virtue of its irregular ornamentation which the latter species lacks. * Hoffmeister Staplin and Malloy.

Occurrence Rough Limestone to Seventh Sandstone.

Previous records Neves et al. 1973 L. Carb. Scotland. N. England.

Triquitrites marginatus Hoffmeister Staplin & Malloy 1955
Pl. 6, fig. 21.

1955 Triquitrites marginatus H.S. & M. p.397,Pl.39,fig. 12

Holotype TCO-82 ft., slide 1, ser. 15,789, Hardinsburg formation. Size 45.8 x 49.3 μ.

Type location Hardinsburg formation, Chester Series, Webster County, Kentucky, U.S.A.

Diagnosis Description in H. S. and M. 1955, p. 397.

Description Spores trilete. Amb triangular, sides concave. Laesurae distinct, gaping, extending 2/3 spore radius, straight, simple. Exine essentially laevigate may have occasional patchy darker areas. Apical crassitudes approximately 3 μ to 4 μ wide, elongate, merging into interradial areas, but becoming thinner. Outer margin of apices crassitude uneven, inner margin even. Size range 30 μ to 45 μ. (12 specimens).

Remarks This species was distinguished from T. camptus, Williams 1973 by its essentially laevigate spore body. T. type A H. S. and M. bears close resemblance to the present species and may be conspecific in the present authors opinion.

Occurrence Rough Limestone to Second Sandstone.

Previous records Hoffmeister, Staplin and Malloy 1955 Miss. Illinois; Marshall and Williams 1970 Yoredale, Northumberland; Spinner and Clayton Visean, E. Lothian; Neves et al., L. Carb., Scotland, N. England.

Triquitrites trivalvis (Waltz) Potonie & Kremp 1956
Pl. 6, fig. 20.

1938 Zonotriletes trivalvis Waltz in Luber and Waltz, Pl. 4,fig.41

1956 Triquitrites trivalvis (Waltz); Potonie and Kremp p. 88

1956 Trilobozonotriletes trivalvis (Waltz); Ischenko p.97,Pl.19, figs. 231-3

1958 Tripartites incisotrilobus (Naumova) Potonie and Kremp; Butterworth and Williams p. 373, Pl. 3, figs. 2, ?3, ?4.

Holotype not designated. Size range of type material 45 μ - 65 μ.

Diagnosis Waltz in Luber and Waltz 1938; C.E.D.P. French translation No. 1443.

Description Spores triangular in shape, trilete, suturae reaching to inner margin of auriculae, which are well developed at apices. Exine laevigate auriculae inflated into low mushroom shapes with slightly roughened, split or corroded surface. Size 56 μ (3 specimens).

Remarks Only 3 specimens were recovered in the present study, all of which conformed to type. T. batillatus, Hughes and Playford, was distinguished by its less well developed, smooth auriculae and T. bransonii, Wilson and Hoffmeister, by its smaller size.

Occurrence Rare, Lower Coal Measures.

Previous records 1938 Luber and Waltz Carboniferous, U.S.S.R.; 1956 Potonie and Kremp, Upper Carboniferous of Ruhr; 1956 Ischenko, Donetz basin, Lower Carboniferous, U.S.S.R.; 1958 Butterworth and Williams, Lower Carb. Scotland; 1962 & 63 Playford, Lower Carboniferous, Spitzbergen; 1966 Sullivan and Marshall, Upper Visean W. part of the Midland Valley of Scotland; 1967 Smith and Butterworth, Up. Visean and Namurian British Coalfields; 1968 Neville, Visean, Scotland.

Genus Ahrensisporites Potonie and Kremp 1954

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

Diagnosis In Potonie and Kremp 1954, p. 155.

Ahrensisporites guerickei (Horst) Potonie & Kremp 1954
Pl. 6, fig. 16.

1943 Triletes guerickei Horst, (thesis) Pl. 7, figs.58,59,61-4

1954 Ahrensisporites guerickei (Horst); Potonie & Kremp, p. 155

Holotype H. 1955, Pl. 23, fig. 63. Preparation 16, 28.7,71.4. Size 68μ.

Type location Seam VI, Karsten Central Colliery, Berthen, Up. Silesia; West. A.

Diagnosis H. 1955, p. 178 expanded in Smith and Butterworth 1967, p.201

Description Amb triangular, sides straight, apices broadly rounded.

Laesurae straight, simple, extend to inner margin of kyrtome. Kyrtome, very distinct, forming an undulating ridge midway between pole and margin interradially about 4 μ wide, and curving out to margin at apices where it is wider, about 5 μ. Apices often uneven in outline. Exine otherwise laevigate. Size range 30 μ to 41 μ (5 specimens).

Remarks This species may possess either ornamented or laevigate exine according to S and B 1967, p. 201. The species recovered during the present study conform to this description.

Occurrence Jew Lst. to Third Lst.

Previous records Numerous authors have recorded this species from Upper Carboniferous strata, including:- Bybova and Jachowicz 1957, Nam. A, Silesia; Neves 1961, U. Nam. B. South Pennines; Neves 1964 La Camocha, Spain, West. A; Mishell 1966, U. Nam. A - West. A. Bowland.

Genus Tripartites (Schemel) Potonie and Kremp 1954

Type species T. vetustus Schemel 1950

Diagnosis from Potonie and Kremp 1954, p. 154, translation in Smith and Butterworth 1967.

Tripartites distinctus Williams 1973
Pl. 6, fig. 24.

1973 Tripartites distinctus Williams in Neves et al. p.35, Pl. 1, fig. 16,17.

Holotype Pl. 1, fig. 16, ML 892 BR46. Size 65 μ.

Type location Sandy shales below Naworth Limestone. Small stream exposure 130 yards upstream from junction with River Irthing, north of Low Broom Hill (NY 583641), Cumberland. Birdoswald Limestone Group. Visean.

Diagnosis Neves et al. 1973, p. 35.

Description Spores trilete with equatorial crassitude. Amb triangular, markedly concave sides, apices bifurcate and truncated. Laesurae indistinct to distinct, straight, simple, appear to extend to inner margin of crassitude. Central area truncated triangular, concave sides, thin. Equatorial crassitude approximately 3 μ to 4 μ wide. At apices larger bifurcate thickening which range into equatorial crassitude interradially. Size range 30 μ to 45 μ.

Remarks Specimens recovered in the present study conformed closely to the original diagnosis. This species was easily recognised by its appearance which more closely approximated to Pl. 1, fig. 17 (Neves et al.) than Pl. 1, fig. 16.

Occurrence Rough Limestone to First Limestone.

Previous records Neves et al. 1973. L. Carb. Scotland, N. England.

Tripartites vetustus Schemel 1950
Pl. 6, fig. 22, 23, 25.

1950 Tripartites vetustus, Schemel, p. 242.

Holotype Schemel 1950, Pl. 40, fig. 11, Preparation in collection of Missouri Formation, Daggett County, Utah, U.S.A. Mississippian.

Diagnosis Description in Schemel 1950, p. 242.

Description Spores trilete. Amb broadly subtriangular, interradial margins concave. Laesurae usually distinct, straight, simple, extending almost to inner margin of apical auriculae. Exine laevigate. Apical auriculae thick, variable in extent from being restricted to apices, to tapering in width and extending interradially. Auriculae show radial striations or bands of thickening. Size 27 μ - 45 μ diameter. (30 specimens).

Remarks The specimens recovered during the present study conform to the diagnosis. Much variation in shape was observed. The extremes of the variation of the auriculae are illustrated on plate 6 . T. trilinguis (Hurst) Smith and Butterworth, differs by possessing distinct granulate ornament in the central area and a thickened flange extending interradially. Mishell (1966) includes specimens with granulate ornament at the inner edge of the auriculae in T. vetustus. The present author observed many specimens which resemble T. trilinguis but without the granulate ornament. These are placed in T. vetustus.

Occurrence Base of Fourth Lst. to top of Hensingham Gp.

Previous records Schemel 1950, Utah, U.S.A., Upper Mississippian;

Hoffmeister, Staplin and Malloy 1955, Hardinsburg Formation of Illinois, Mississippian; Butterworth and Williams 1958, Namurian A., Scotland; Owens, 1963 Lower Nam. A, Stainmore; Sullivan and Marshall 1966, Upper Visean, Scotland; Mishell 1966, Lower Nam. A, Bowland; Smith and Butterworth 1967, Upper Visean and Namurian, British Coalfields; Marshall and Williams 1970, Upper Visean and Namurian, Northumberland; Loboziak 1969, Namurian France; Neves et al. 1973, Visean, Scotland; Jachowicz 1974, Namurian, Poland.

Infraturma Crassiti (Bharadwaj and Venkatachala) Smith and Butterworth 1967

Genus Crassispora (Bharadwaj) Sullivan 1964

Type species C. kosankei (syn. C. ovalis)(Potonie and Kremp) Bharadwaj 1957

Diagnosis generic description in Sullivan 1964, p.375.

Crassispora acculeata Neville 1968
Pl. 7, fig. 1, 2.

1968 Crassispora acculeata Pl. 2, fig. 5, 6, p. 443

Holotype Plate 2, fig. 5. Sample F75. Size 76.8 µ.

Diagnosis Neville 1968, p. 443.

Description Spores generally circular in outline, trilete with prominent thickened laesurae 9/10 to whole of spore radius. 4.5 µ wide flexuose in some instances. Spines on distal surface spreading on to proximal surface over area of equatorial crassitude. Exine infrapunctate to infra reticulate Size 60 µ to 78 µ. (17 specimens).

Remarks Spores assigned to C. acculeata are distinguished by their spinose ornament and laesurae from other members of the genus. The spinae very from slender, gently tapering to rapidly tapering sharp elements, to bulbous based sharp pointed elements up to 12 µ long. Many have their tips bent as observed by Neville 1968. Approximately 30 spines appear at equator Crassitude variable in width from 5 µ to 8 µ.

The thickened laesurae were frequently observed as being slightly flexuose, a feature not previously commented upon.

The exine was observed as being infra punctate, in some specimens so strongly developed as to be infra reticulate. Neves et. al. 1973 state that the apical papillae indicate a double exinal structure but no separation was observed in the specimens in the present study.

Neves et al. 1973 also state that the equatorial crassitude is in fact a slight thickening of the proximal exoexine equatorially. The present author finds the distinction too fine to be of significance and from the specimens observed is of the opinion that "crassitude" is an adequate term.

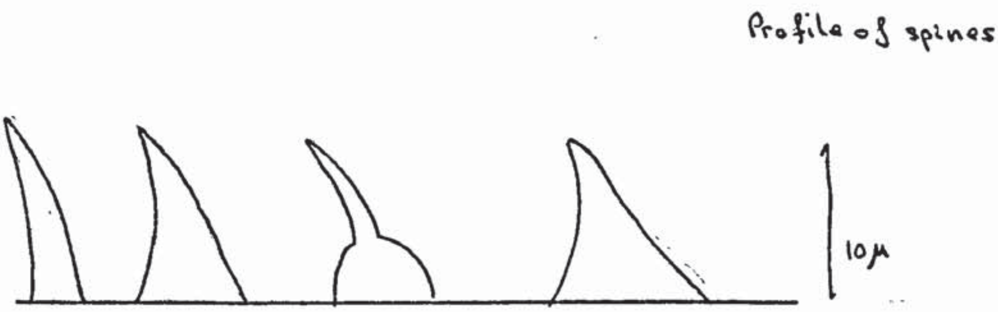
Crassitude: (Potonie and Kremp 1955, p. 15, Tr. in G. Kremp 1968) "......In the simplest case the exine may be a little thicker here (equatorially) than in the remaining area.."

Crassitude: (Smith and Butterworth 1967, p. 116) "Localized thickening of the exine. It may occur as a slight thickening encircling the spore at the equator...."

See Pl. 7, fig. 2 of tetrad of C. acculeata

Occurrence Lower Chief Limestone.

Previous records Neville 1968, Visean, Scotland; Neves et al. 1973 Lower Carb. Scotland and N. England.



Crassispora kosankei (Potonie & Kremp) Smith and Butterworth 1967. Pl. 7, fig. 3, 4.

1955 Planisporites kosankei Potonie & Kremp p.71,Pl.13,figs.208-13

1957 Planisporites ovalis Bharadwaj p.86,Pl.23,figs. 9,10

1957 Crassispora ovalis Bharadwaj p.126,Pl.25,figs.73-6

1957 Apiculatisporites apiculatus (Ibrahim) Dybova & Jachowicz (non sensu Ibrahim) p.87

1967 Crassispora kosankei (Potonie and Kremp) Smith and Butterworth p. 234, Pl. 19, figs. 2 - 4.

Holotype Potonie and Kremp 1955 Pl. 13, fig. 208. Preparation 565/V, KT20.9 126.1. Size 79.8 µ.

Type locality S.R., Friedrich Thyssen 2/5 (Wehofen) Colliery, Ruhr Coalfield, Germany. Westphalian B.

Diagnosis S. and B. 1967, p. 234.

Description Semi oval trilete spores with clearly visible equatorial crassitude, approximately 5 - 7 µ wide. Distal ornament of coni, blunt coni, small coni and grana irregularly distributed over both proximal and distal surfaces. Size range 37 µ to 53 µ (15 specimens).

Remarks The spores assigned to this species conform to the diagnosis as emended by Smith and Butterworth in most respects. The size range however falls below theirs ie. 37 µ - 53 µ as compared with 47 µ to 84 µ (max.). This is the only major difference of the spores recovered in this study from the diagnostic circumscription and does not warrant their placing in another taxon in the author's opinion. (Many of the species recovered in the present work appear to fall within the lower end of the size ranges of the type and other material and as stated elsewhere in this work, this phenomenon may be due to the processing technique.

Occurrence Second Sst. into Lower Coal Measures.

Previous records Potonie and Kremp 1955, Upper Westphalian A- Lower Westphalian C, Ruhr; Neves (M.S.) 1959 Namurian B - Westphalian A; Owens and Burgess 1965, Upper Namurian A - Lower Westphalian B Stainmore; Love and Neves 1963, Upper Wewtphalian B. Iminmore, Scotland; Sullivan 1964, Lower Westphalian A., Forest of Dean; Neves 1964, Namurian A. - Upper Westphalian A. La Camocha mine, Gijou, N. Spain; Neves, Read and Wilson 1965, Lower Namurian B. passage Gp. Scotland; Mishell 1966, Namurian A - Westphalian A, Bowland; Smith and Butterworth 1967, Namurian to Westphalian D; Loboziak 1969, Nam. and West. A-B., France; Sabry and Neves 1970, West. A. Sanquhar Coalfield, Scotland.

<u>Crassispora</u> <u>maculosa</u> (Knox) Sullivan 1964
Pl. 7, fig. 8.

1948 23K Knox p. 158, fig. 26.

1950 <u>Verrucoso-sporites</u> <u>maculosus</u> Knox p. 318

1955 <u>Apiculatisporites</u> <u>maculosus</u> (Knox); Potonie and Kremp p.78

1964 <u>Crassispora</u> <u>maculosa</u> (Knox) Sullivan p. 376.

<u>Holotype</u> No holotype was designated by Knox. Lecotype (in Smith and Butterworth p. 235) Pl. 18, fig. 8, Smith and Butterworth 1967 preparation 360A (T 83/1) Knox, held at N.C.B. laboratory, Wath-upon-Dearne. Size 121 x 113 microns.

<u>Type locality</u> Dunfermline Splint Seam, Lumphinnans No. 1 Colliery, West Fife Coalfield, Scotland. Namurian A.

<u>Diagnosis</u> S. 1964, p. 376.

<u>Description</u> Circular to sub-circular trilete spores with marked equatorial crassitude varying between 6 - 13 μ in width. Ornament variable on any one specimen from grana 1 μ diameter to imstate verrucae up to 4 μ diameter and 4.5 μ high with intermediate sized ornament of blunt and sharp coni. Ornament mainly on distal surface. Exine thich approximately 2-3 μ in polar regions, and infra granulate. Size 59(70)90 μ. (20 specimens).

<u>Remarks</u> The spores were assigned to this species on account of their equatorial crassitude, size, variable ornament and overall shape. The laesurae were not always found to be prominently ridged but were within the 1/2 - 3/4 spore radius limits. Whilst the size range is slightly below that of the material examined by Smith and Butterworth it does not preclude the placing of the spores in this taxon. The laesurae were very

frequently found to be gaping as described in Smith and Butterworth 1967.

The ornament observed by the author exceeds in coarseness and variety that described by Smith and Butterworth, Most of the coarser elements are concentrated some distance away from the equator and therefore the modification of the amb is as described by them.

Much variety in coarseness of the larger elements was observed, some specimens seeming to be almost devoid of ornament larger than small coni 2.5 μ in diameter. The author resisted the use of a separate taxon for these specimens because an intergradation was found between the two extremes.

Most other species of Crassispora are easily distinguished from C. maculosa by the larger size and ornament of the latter.

Occurrence Rough Lst. to Lower part of Hensingham group.

Previous records

Knox 1948, Lst. Coal Group. Namurian A. Scotland; Butterworth and Williams 1958, Namurian A. Scotland; Neves 1961, Lower Namurian A. S. Pennines; Bharadwaj and Venkatachala 1961, Lower Carb. Spitzbergen; Owens (M.S.) 1963, Lower Namurian A. Stainmore; Sullivan 1964, Forest of Dean; Sullivan and Marshall 1966, Upper Visean, Scotland (P); Smith and Butterworth 1967, Visean and Namurian; Neville 1968, Visean, Scotland; Marshall and Williams 1970, Namurian, Northumberland; Loboziak 1969, Nam. - West. France; Neves et al. 1973, L. Carb., Scotland.

Crassispora trychera Neves & Ioannides 1974
Pl. 7, fig. 5, 6, 7.

1974 Crassispora trychera Neves & Ioannides
p. 78, Pl. 7, figs. 6-8

Holotype No. I 1974 Ref. MPK 720. Size 63.2 μ.

Type locality At 2563 ft. (781.2m) in the Spilmersford Borehole, East Lothian; Lower Carboniferous.

Diagnosis N and I, p. 78.

Description Trilete spores. Amb circular to sub-triangular, laesurae occasionally visible, straight, extending almost to spore margin. Exoexine ornamented probably distally with grana/+ minute coni irregularly dispersed. Inner region lighter margin folded. Outline of spore often slightly extended radially. Size range 40µ(55)58 µ. (20 specimens).

Remarks Specimens conform to diagnosis distinguished from other species of Crassispora by its fine ornament and exinal folds. The specimens were distinguished from Colatisporites decorus, (B & V) Williams, by the cameration of the latter species. The laesurae were often found separated uniformly along their length.

Occurrence Basal beds.

Previous records Neves et al. 1973 and Neves and Ioannides 1974, Lower Carboniferous, East Lothian, Scotland.

Infraturma Tricrassiti (Dettmann 1963)

Genus Diatomozonotriletes (Naumova) Playford 1963

Type species D. saetosus (Hacquebard & Barss) Hughes & Playford 1961

Diagnosis Playford 1963, p. 646.

Diatomozontriletes ubertus Ishchenko 1956

Pl.7. fig.10

1956 Diatomozontriletes ubertus Ishchenko p. 96

Holotype Not specified. Size in range 35-40 microns.

Type location Western extension of Donetz Basin, U.S.S.R; Visean.

Diagnosis I. 1956. Translation in Smith and Butterworth 1967, p. 215.

Description Amb triangular, sides straight, apices narrow. Laesurae straight, simple, extend to margin of spore. Exine thin, interradially corona of narrow saetae 1.5 µ wide at base, 5 µ to 14 µ long reduced or absent at apices. Size range 40µ, 45µ and 47 µ.

Remarks The few specimens observed in the present study conform reasonably well to diagnosis. R. triangularis is distinguished by its larger size, longer saetae and thickened laesurae.

Occurrence Very rare, Fourth Lst.

Previous records Ishchenko 1956 Visean U.S.S.R; Smith and Butterworth 1967 Visean Northumberland.

Infraturma Pseudocingulati Neves 1961

Genus Secarisporites Neves 1961

Type species S. lobatus Neves 1961

Diagnosis Neves 1961 p. 260-261.

Secarisporites lobatus Neves 1961
Pl. 7, fig. 11.

1961 Secarisporites lobatus Neves, p. 261, Pl. 32, fig. 6, 7

Holotype Slide ref. 4.175850. Sheffield University, Micropalaeontology laboratory. Size 81 μ.

Type locality Marine shales with Gastrioceras cancellatum, Hipper Sick Derbyshire (Loc.12) Yeadonian stage.

Diagnosis Neves, p. 261, 1961.

Description Spores trilete. Amb subtriangular to circular, outline uneven. Laesurae indistinct. Exine lobate, lobes up to 7 μ high, 10 μ wide, variable in size on any one specimen. Spores tend to display characteristic dark red - brown colour. Size range 42 μ to 57 μ.

Remarks The size range of the specimens recovered during the present study falls below that of the type. S. remotus, Neves, has a comparable size range, however, it differs in the nature of exinal lobes which are relatively smaller and more isolated.

Occurrence Second Sandstone to basal Coal Measure Grit.

Previous records Neves 1961, Nam,, S.Pennines; Owens 1963, Nam. B - W.A. Stainmore; Neves 1964 Nam. B - L.W.A., La Camocha, Spain; Neves, Read and Wilsom 1965, U. Nam. B - Nam. C, Pausage Gp. Scotland; Mishell 1966, Nam. B. Bowland; Owens & Burgess 1966;Stainmore; Marshall & Williams Nam. Northumberland.

Secarisporites remotus Neves 1961
Pl. 7, fig. 12.

1961 Secarisporites remotus Neves 1961, p.262,Pl.32,figs. 8,9.

Holotype Slide ref. 8. 343708. Sheffield University micropaloemtology Laboratory. Size 46 µ.

Type location Non marine roof shales of the Pot Clay Coal, Holymoorside, Derbyshire (Loc.13) Yeadonian stage.

Diagnosis N. 1961 p. 262.

Description Spores trilete. Amb uneven,very approx. circular, outline lobate. Laesurae indistinct. Exine lobate, lobes 3 µ to 6 µ high, up to 8 µ wide, relatively discreet. Size range 30 µ to 38 µ.

Remarks This species was distinguished from S. lobatus, Neves, by its smaller size and more discreet lobes.

Occurrence Lower Coal Measures.

Previous records Neves 1961, Nam. S. Pennines; Mishell 1966 Nam - W. Bowland; Owens and Burgess 1966 U. Nam. Stainmore; Marshall and Williams 1971, Nam. Northumberland.

Genus Bellispores (Artuz) Sullivan 1964

Type species B. nitidus (Horst) Sullivan 1964.

Diagnosis Generic description in Sullivan 1964, p. 374.

Bellispores nitidus (Horst) Sullivan 1964 (Pl. 7. fig.14)

1943 Triletes nitidus Horst (thesis) Pl. 8, fig. 81

1948 D11 Knox p. 157, fig. 8

1955 Lycospora nitidus (Horst); Potonie and Kremp in Horst p. 181, Pl. 24, fig. 81.

1957 Bellispores bellus Artuz, p. 255, Pl. 7, fig. 49

1957 Simozonotriletes trilinearis Artuz, p.251, Pl. 5, fig. 36.

1964 Bellispores nitidus (Horst) Sullivan p. 375.

Holotype Horst 1955, Pl. 24, fig. 81 Preparation IV 53, 23.4 73.8. Size 42µ

Type locality Justa seam, Michael Colliery, Moravska-Ostrava; Namurian A.

Diagnosis Horst 1955, p. 181 (Expanded in Smith and Butterworth 1967 p. 255.

Description Spores trilete. Amb rounded triangular with concave sides with markedly sculpted margin. Laesurae straight and extending to margin, accompanied by thickening of irregular outline. Distal surface foveolate. Size 28 μ (26μ) 39.5 μ.

Remarks The forms recovered in the present study conform to the expanded diagnosis in Smith and Butterworth (1967) however, the number and distribution of Foveolae is very slightly at variance, they are generally smaller and more closely spaced. From the few specimens observed, it would appear that the equatorial thickened flange(which may not be a true cingulum sensu, Couper and Grebe 1961 in Kremp 1965) is somewhat more uniform in width than recorded in other works.

Sullivan and Marshall 1966 state that the pores, or fovea, are probably a secondary feature resulting from corrosion. This would not seem to be so and in the present author's opinion they are a primary structure.

Occurrence Third Lst. to Sixth Sst.

Previous records Horst 1955 Namurian A of Moravska Ostrava, Czechoslovakia; Butterworthh and williams 1958 Up. Lst. Gp. and possibly Lst. Coal Gp. Scotland; Venkatachala and Beju 1962 (in Sullivan and Marshall 1966 p.273) carboniferous of Rumania; Owens 1963 MS. Namurian A Stainmore; Sullivan 1964 (B.bellus), Edgehill Coals, Forest of Dean, England, probably Westphalian A; Smith and Butterworth 1967, Namurian to Lower Westphalian A, British Coalfields; Sullivan and Marshall 1966, Visean, Scotland; Marshall and Williams 1970, Nam. Northumberland; Jachowicz 1970 Upper Vis. Poland.

Genus Savitrisporites Bharadwaj 1955

Type species S. triangulasi Bharadwaj 1955

Diagnosis Bharadwaj 1955, p. 127.

Savitrisporites nux (Butterworth and Williams) Smith and Butterworth 1967 Pl. 7, fig. 15, 16.

1958 Callisporites nux Butterworth and Williams
p. 377, Pl. 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 S. and B. Preparation T55/1 in Collection of N.C.B. Laboratory, Wath-upon-Dearne. Size 58µ in range 45(56)64 µ.

Type locality Upper Hirst Seam at 2,310 ft. 4 ins., Brucefield borehole, West Fife Coalfield, Scotland; Namurian A.

Diagnosis S. and B. p. 224.

Description Spores trilete, cingulate. Amb triangular, sides straight to convex, apices rounded. Laesurae simple, straight, extend to inner margin of equatorial thickening. Exine characteristically thickened with undulating low mounds or verrucae distally. The elements frequently linked in the form of ridges sub-parallel to the equator. Equatorial thickening of similar nature forming a cingulum approx. 3 µ to 4 µ wide. Size range 34 µ (47) 55 µ. (20 specimens).

Remarks The specimens recovered during this study conform closely to original diagnosis. S. asperatus, Sullivan, differs in being smaller and more coarsely ornamented. This species displayed a characteristic glossy lustre.

Occurrence First Limestone to Lower Coal Measures.

Previous records Butterworth and Williams (1958) Nam. Scotland; Sullivan (1964) West. Forest of Dean; Smith and Butterworth Nam. A Scotland; Sullivan (1962) West. A-B Wernddu Clay Pit S. Wales; Love and Neves (1963) West. B. Scotland; Neves (1964) U. Nam. A. - West. A. La Comocha; Owens and Burgess (1966) Nam. A. Stainmore; Mishell (1966) Nam. A. - West. A. Bowland; Marshall and Williams Nam. Northumberland; Jachowicz (1970) Upper Visean Poland; Sabry and Neves (1971) Sanquhar West. Scotland.

Infraturma Cingulati (Potonie & Klaus) Dettmann 1963

Genus Stenozontriletes (Naumova) Potonie 1958

Type species S. conformis Naumova 1953

Diagnosis Hacquebard 1957, p. 313

Stenozonotriletes sp. A

Pl. , fig.

Holotype 373 88.3/7.5

Type location Carboniferous Basement beds, Redmain, Cumberland.

Description Amb more or less circular, to subtriangular, band of thickening around equator about 5 µ wide, dense, smooth. Laesurae not very distinct, extend to inner margin of equatorial thickening. Central area exine ornamented with small grana, and it is also infra ornamented. Size range 35 µ to 40 µ. (Six specimens).

Remarks The species is distinguished by its fine ornament in the central area. This appears to be of fine grana but may possibly be an effect of differential corrosion, as these spores were often poorly preserved.

?Stenozonotriletes bracteolus (Butterworth and Williams) Smith and Butterworth 1967. Pl. 8, fig. 10.

1958 Lycospora bracteola Butterworth and Williams p. 375, Pl. 3 figs. 26,27.

1967 ?Stenozonotriletes bracteolus (Butterworth and Williams) Smith and Butterworth p. 217, Pl. 14, figs. 1-4.

Holotype Pl. 14, fig. 1. Preparation T57/1 in collection of N.C.B. Laboratory, Wath-upon-Dearne. Size 45 µ.

Type locality Lower Hirst seam at 1,854 ft. 2 ins. Kincardine borehole, West Fife Coalfield, Scotland. Namurian A.

Diagnosis Butterworth and Williams 1958, p. 373.

Description Spores usually rounded triangular in shape. Laesurae thickened up to 3.5 µ wide, extending to inner margin of cingulum, curaturae weakly developed. Exine ornamented with grana, approximately 1 µ diameter, unevenly distributed over surface of both central area and cingulum, with about 45 at the equator. Size, overall diameter 27 µ to 39 µ, cingulum 3 - 8 µ. (10 specimens).

Remarks Generally the spores conform to the diagnosis. The size range, which falls below the type range, is almost certainly a result of the oxidation technique (B. and W. 1958 used schulze solution). One specimen exceeded the range considerably, being 56 µ diameter yet in all other respects conformed to the diagnosis and has therefore been placed in the same species.

The thickening of the laesurae appears to be slightly more prominent in the specimens recovered in this study compared with the type.

Occurrence Third Lst. to Tenth Sst.

Previous records 1958 Butterworth and Williams, Namurian A, Scotland; 1960 Love, Visean, Lower Oil Shale Group, Scotland; 1967 Smith and Butterworth, Namurian, British Coalfields.

Stenozonotriletes clavus Ishchenko 1958
Pl. 8, fig. 4.

1958 Stenozonotriletes clavus Ishchenko p. 86, Pl. XI, fig. 136

Holotype Ishchenko, p. 86, Pl. XI, fig. 136. Tournaisian - Visean, Dinieper-Donetz basin U.S.S.R. Size 45 µ - 50 µ.

Diagnosis Ishchenko 1958, p. 86 in Russian.

Description Rounded, subtriangular trilete spores, laesurae extend to inner margin of cingulum. Cingulum of constant width, usually 5 µ, ranging from 4-6 µ. Exine laevigate. Overall diameter 39 µ to 48 µ. (10 specimens).

Remarks The features of this species are the uniform cingulum, straight simple laesurae reaching almost to inner margin of cingulum. The smooth appearance of the exine and the overall size. All these features were used to distinguish this species from others of the genus in the present study.

Hughes and Playford 1961, quote a size range of 47 µ to 80 µ thus extending the upper limit considerably from Ishchenko 1958. Mishell 1966 used a lower limit of 31 μ. S. triangulus, Neves 1961, is more triangular, has lips on the comisures and has a size range of 60 μ to 80 μ.

Occurrence Upper part of Basement beds to Upper part of Hensingham Gp.

Previous records 1958 Ishchenko, Lower Carb., Dinieper-Donetz Basin, USSR; 1961 Hughes and Playford, Lower Carb., Spitzbergen; 1962 Playford, Lower Carb. Spitzbergen; 1963 Owens (MS) Namurian A, Stainmore; 1966 Mishell (MS) Nam. A to Middle Namurian B. Bowland.

Stenozonotriletes coronatus Sullivan & Marshall 1966
Pl. 8, fig. 9.

1966 Stenozonotriletes coronatus Sullivan & Marshall
p. 273, Pl. 3, figs 1-5.

Holotype Pl. 3, fig. 2. Size range 37 μ to 55 μ.

Type locality Shale below the Blackbyre Limestone - Scotland.

Diagnosis Description in Sullivan & Marshall p. 273.

Description Spores usually sub-triangular in shape having a narrow cingulum, from 2 μ to 4 μ. Exine ornamented with coni of 2 μ approximate diameter on distal surface. Coni 2 μ to 2.5 μ high, unevenly distributed, about 40 projecting at equator. Laesurae simple, very slightly tapering and wavy. Size 26 μ to 38 μ. (5 specimens).

Remarks Specimens referred to this species were distinguished from ?S. bracteolus (B & W) Smith and Butterworth 1967, by their relatively narrower cingulum, more prominent ornament, simple laesurae and often sub triangular amb.

Occurrence Top of First Lst. to below Tenth Sst.

Previous records 1966 Sullivan and Marshall, Visean, Scotland; 1968 Neville, Visean, Scotland; Neves et al. 1973 L. Carb., Scotland.

Stenozonotriletes lycosporides (Butterworth & Williams)
Smith and Butterworth 1967. Pl. 8, fig. 7, 8.

1958 Annulatisporites lycosporites Butterworth & Williams
p. 378, Pl. 3, fig. 28, 29.

1967 Stenozonotriletes lycosporoides (Butterworth & Williams) Smith and Butterworth p. 218, Pl. 14, fig. 5, 6.

Holotype Pl. 14, fig. 5. Preparation T58/1 in collection of N.C.B. laboratory, Wth-upon-Dearne. Size 33 μ in range 26(34)42 μ.

Type locality Chaplegreen seam at 314 ft. 2 ins., Cawder Cuilt borehole Central Coalfield, Scotland. Namurian A.

Diagnosis Butterworth and Williams 1958, O. 378.

Description Sub-circular to circular spores, laesurae usually simple, straight, extending to inner margin of cingulum, occasionally slightly flexuose. Cingulum usually 1/3 to 1/2 spore radius. Exine is generally thin approximately 1.5 μ and laevigate but often giving appearance of being roughened. Size range 21 μ to 37 μ. (17 specimens).

Remarks The spores assigned to this species generally conform to the original diagnosis. The size range falls below that given for the type material however does not conform to S. granianellatus, Staplin 1960. (22 - 28 μ).

Ornamentation of the exine is occasionally present as either very small grana, unevenly distributed on the distal surface, or a general roughening of the whole exine. The latter effect is probably due to corrosion.

Flexuose laesurae were observed on 3 specimens but this is consistent with remarks by Smith and Butterworth 1967, p. 218 regarding the type material. The flexuosity of laesurae was only observed on the smaller of the specimens.

Occurrence Seventh Lst. to Second Sst.

Previous records 1958 Butterworth and Williams, Scotland Namurian A; 1960 Love, Lower Oil Shale Group, Scotland, Visean; 1967 Smith and Butterworth, Gt. Britain Namurian.

Genus Muraspora Sommers 1952

Type species M. kosankei Sommers 1952

Diagnosis Sommers 1952. Discussions on the validity of this genus appear in Playford 1962 and Smith and Butterworth 1967. Simozonotriletes is probably congeneric. Muraspora is retained by Neves and Ioannides (1974).

Muraspora sp. A.
Pl. 8, fig. 6.

Description Trilete spores. Amb subtriangular, muras (equatorial thickened flange) uneven at outer margin, even at inner margin about 8-10 µ wide. Laesurae straight, labrate, extend to inner margin of 'cingulum'. Central area exine thin, ornamented with irregular thickened patches. Size 47 µ to 50 µ. (4 specimens).

Remarks The few species observed in the present study were distinguished from other species of this genus by the combination of irregularly ornamented central area and labrate laesurae.

Occurrence Basement beds.

Muraspora aurita (Waltz) Playford 1962
Pl. 8, fig. 1.

1938 Zonotriletes auritus Waltz in Luber & Waltz, p.17,Pl.2,fig.23

1956 Simozonotriletes auritus (Waltz) Potonie & Kremp, p. 109

1957 Cincturasporites auritus (Waltz) Hacquebard & Barss p. 23, Pl. 3, fig. 1.

1957 Cincturasporites irregularis Hacquebard & Barss pp.25-26, Pl. 3, fig. 9.

1960 Muraspora varia Staplin,p.30,Pl.6,figs. 16-18

1960 Muraspora sp. cf. M. varia Staplin,p.30,Pl.6,fig.19

1962 Muraspora aurita (Waltz) Playford p.609-610 Pl. 87, figs. 1-6; text figs. 6a - q, 7.

Holotype (designated by Playford 1962, p. 610) Plate 2, fig. 23 of Luber and Waltz (1938) Size in range 45 - 95 µ.

Type location U.S.S.R. - Kizel region. New Kizel mines, oblique shaft 24, bed 4. (Luber and Waltz)(p.17)

Diagnosis Playford 1962, p. 609.

Description Trilete spores, amb uneven but generally subtriangular. Cingulum width approximately 1/2 or less of spore radius. Cingulum of variable thickness and may be concentrically thickened into a thicker inner ring and thinner outer ring. Spore body generally convexly triangular to uneven, and lighter. Laesurae extend almost or completely to inner margin of cingulum. Laesurae straight with low lips up to 5 μ wide. Size overall 46 μ - 60 μ body 28-37 μ. (6 specimens).

Remarks The few specimens recovered in the present study appear to conform to the emended diagnosis of Playford 1962. The outline of both the body and the amb tend to be less regular than illustrated by Playford.

The laesurae in 2 specimens did not quite extend to the inner margin of the cingulum but in all other respects conform to this species.

The species was distinguished from M. friendii Playford 1962 by the wide low lips on the laesurae.

Occurrence Third Lst. to Second Sst.

Previous records 1884 Reinsch, Carboniferous U.S.S.R. (in Playford); 1938 and 1941 Luber and Waltz, Lower Carb. U.S.S.R.; 1957 Hacquebard and Barss, Upper Mississippian, Canada; 1960 Staplin Upper Mississippian, Canada; 1961 Hughes and Playford, Lower Carb. Spitzbergen; 1962 Playford, Lower Carb. Spitzbergen.

Muraspora friendii Playford 1962
Pl. 8, fig. 2.

1962 Muraspora friendii Playford, p.617,Pl. 87, figs. 10-12

Holotype Preparation P188/3, 36.3 95.2 L.1117. Size in range 46μ-70μ.

Type location Birger Johnson fjellet (sample G1102), Spitzbergen Lower Carboniferous.

Diagnosis In Playford 1962, p. 617.

Description Subcircular trilete spores with clearly defined central spore body. Outline uneven due to bulbous thickenings of cingulum. The thickenings may be radial or interradial. Outline of body convexly triangular. Laesurae more or less straight, slightly thickened extending to inner margin of cingulum. Exine laeingte. Size overall 45-55 μ, body 23 - 27 μ. (5 specimens).

Remarks From the few specimens observed this species appears fairly clearly defined. The specimens conform to the original diagnosis.

Occurrence Lower part of Hensingham Gp.

Previous records 1962 Playford, Lower Carb., Spitzbergen

Muraspora intorta (Waltz) Playford 1962

1938 Zonotriletes intortus Waltz in Luber and Waltz, p. 22 (no description); Pl. 2, fig. 24.

1954 Simozonotriletes intortus (Waltz) Potonie & Kremp, p. 159.

1956 Simozonotriletes intortus (Waltz) Ishchenko, pp.88-89,Pl.17 Fig. 204.

1962 Muraspora intorta (Waltz) comb. nov. Playford p.609,Pl.86, fig. 12, 13.

Lectotype Luber and Waltz 1938, Pl. 2, fig. 24 (designated by Horst 1955)

Size range of Playford's material 50 - 82 μ.

Type locality Moscow brown coal; Tournaisian or Visean. Neotype of Horst 1955 Upper Silesia, Westphalian A. Holotype of Hacquebard and Barss 1957, Canada, Lower Carboniferous.

Description Trilete spores with concave sides and a broad cingulate structure. Width of cingulum more or less uniform. Shape of central region consistent with amb, with broadly rounded apices. Laesurae 1/2 to 2/3 radius of central region. Exine laevigate. Size overall diameter 40 μ to 57 μ, central region 21 μ to 28 μ. (10 specimens).

Remarks Much has been written about this species by previous workers. Sullivan 1958 described the variation of shape of the amb of these spores, thereby enabling varieties to be set up. The present author has followed Playford 1962 and placed this species in Muraspora. The specimens recovered in the present study conform to the diagnosis and earlier descriptions.

Occurrence Base of Fourth Lst. to Ninth Sst.

Previous records 1938 Waltz, Visean & Tournaisian, Karaganda basin, USSR; 1955 Horst Namurian A - Westphalian Upper Silesia; 1956 Ishchenko Lower Carboniferous Donetz Basin, USSR; 1957 Hacquebard and Barss Upper Mississippian N.W. Territories, Alberta, Canada; 1958 Sullivan Westphalian A - B Gt. Britain; 1958 Butterworth and Williams Namurian A Scotland; 1959 Neves (M.S.) Namurian A - C S. Pennines; 1961 Bharadaj and Venkatachala Lower Carb. Spitzbergen; 1961 Hughes and playford, Lower Carb. Spitzbergen; 1962 Playford, Lower Carb. Spitzbergen; 1963, Owens (M.S.) Namurain - Lower Westphalian B; 1963 Playford and Barss Upper Mississippian Axel Heiberg IIIs Canada Arctic archipeligo; 1964 Neves Namurian B - C La Camocha mine, Gijou, N. Spain; 1966 Mishell Upper Nam. A - B Bowland; 1967 Smith and Butterworth Visean - Westphalian B. Gt. Britain; 1970 Marshall and Williams Visean Namurian Northumberland.

Muraspora sublobata (Waltz) Playford 1962
Pl. 8, fig. 4.5

1938 Zonotriletes sublobatus Waltz in Luber & Waltz p.17, Pl. 2, fig. 22

1956 Simozonotriletes sublobatus (Waltz) Potonie & Kremp p.110

1957 Triquitrites tendoris Hacquebard & Barss p.18, Pl.2, figs 18,19

1960 Muraspora laeingata Staplin pp.29-30, Pl.6, fig. 21

1962 Muraspora sublobata (Waltz) Playford p.613, p.86, figs 17-19

Holotype Luber and Waltz p. 17, Pl. 2, fig. 22. Karaganda basin U.S.S.R. Size range of Playford's material 34 µ - 58 µ.

Diagnosis Description in Playford 1962, p. 614.

Description Trilete spores with generally sub-triangular amb, sides generally concave, outline usually very uneven due to irregular thickening of cingulum. Spore body, lighter in colour than cingulum, markedly concave sides with rounded apices, straight simple laesurae extending almost to inner margin of cingulum. Cingulum width approximately 1/2 or less of spore radius. Size 42(50)57µ. (10 specimens).

Remarks Playford (loc.cit.) carried out an exhaustive study of 150 specimens from Spitzbergen and came to the conclusion that a gradation between Zonotriletes sublobatus, Waltz, Triquitrites tendoris, Hacquebard and Barss and Murospora laevigata, Staplin, exists within the realm of M. sublobata. The range observed in specimens from the present work conform to Playford's description.

The cingulum thickening and width is more uneven than described by Playford but valvae are hot present. This fact was used to distinguish these spores from Simozonotriletes intortus var. sublobatus, Sullivan 1958.

Occurrence Base of Fourth Lst. to Ninth Sst.

Previous records 1938 and 41, Luber & Waltz, Lower Carb. U.S.S.R; 1957 Hacquebard and Barss, Upper Mississippian, Canada; 1960 Staplin, Upper Mississippian, Canada; 1962 Playford, Lower Carb. Spitzbergen.

Genus Rotaspora (Schemel) Smith & Butterworth 1967

Type species R. fracta Schemel 1950.

Diagnosis In Smith and Butterworth 1967, p. 226.

Rotaspora arenulata Smith & Butterworth1967
Pl. 8, fig. 15,16.

1967 Rotaspora arenulata Smith & Butterworth p.227,Pl.15,figs 12-14

Holotype Pl. 15, fig. 12; T93/1 in collection of Coal Survey Laboratory, Sheffield. Size 34 µ.

Type locality Greenes seam at 147 ft. 8 ins., Stamford borehole, Northumberland Coalfield, England. Visean.

Diagnosis S. & B. p. 227.

Description Trilete spores. Amb sub-triangular to circular. Zona of very variable width, very narrow at apices and of compund structure similar to that of R. knoxi but with verrucae interradially. Size, overall 27 µ to 38 µ, body 22 µ to 26 µ. (9 specimens).

Remarks The 9 specimens conformed to the diagnosis with the exception that they appeared to be slightly thicker, the exine being 2 - 2.5 µ thick.

Occurrence Base of Fourth Lst. to Tenth Sst.

Previous records Smith and Butterworth, 1967, Visean, British Coalfields.

Rotaspora ergonulii (Agrali) Sullivan & Marshall 1966
Pl. 8, fig. 17, 18.19.

1963 Rotisporites ergonulii Agrali, p.150,Pl.22,fig.11

1966 Rotaspora ergonulii (Agrali) Sullivan & Marshall p.272,Pl.2 figs 20-24.

Holotype In Agrali Pl. 22, fig. 11. Size range of S. & M. is material 30 - 42 μ.

Diagnosis In Agrali p. 150 and description in Sullivan & Marshall 1966 p.272

Description Trilete spores. Amb rounded triangular with convex sides. Spore cavity triangular, also with convex sides. Laesurae distinct, straight, simple, extending to margin of spore cavity. Exine ornamented on distal surface with low coni or grana irregularly dispersed covering cingulum as well as central region. Size of elements from 1.5 μ to 3 μ diameter from 5 μ to 8 μ apart approximately 10 elements project from equator interradially with approximately 20 occurring in each sector. Size range 23.7μ (35)41 μ, width of cingulum interradially 4 μ to 6.3 μ and 2 μ to 3 μ radially. (20 specimens).

Remarks This distinctive species was easily distinguished from other species of Rotaspora by its ornament. The species was particularly common in some samples (see text) but usually rare. Sullivan and Marshall record some specimens with a concave sided cavity, this was nver observed in the present study.

Occurrence Rare to abundant, Fourth Limestone to top of Hensingham Grit.

Previous records Agrali 1963 Namurian, Turkey; Sullivan and Marshall 1966, Visean, Scotland; Marshall and Williams 1970, Yoredales, Northumberland; Neves et al. 1973 L. Carb. Scotland and N. England; Neville 1968 L. Carb. Scotland.

Rotaspora fracta (Schemel) Smith & Butterworth 1967
Pl. 8, fig. 21, 23.

1950 Rotaspora fracta Schemel p. 242

1967 Rotaspora fracta (Schemel) Smith & Butterworth p.227,Pl.15 fig. 8 - 11.

Holotype Schemel 1950 Pl. 40, fig. 8 in collection of Missauri Geological Survey. Size 28 μ to 35 μ.

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.

Description Rounded triangular trilete spores conforming closely to diagnosis. Size 25 μ to 37 μ. (15 specimens).

Remarks The spores assigned to this species are very distinctive, being very similar to the diagnosis. The inner body has concave sides. From the specimens observed a darker rim around the laesurae occurs frequently, in the contact area. Laesurae are straight, simple, reaching almost to margin of inner body.

Occurrence Top of Fourth Lst. to below Tenth Sst.

Previous records Schemel 1950 Mississippian, Daggett Co. U.S.A; Hoffmeister Staplin and Malloy 1955, Upper Mississippian (Lower Namurian) Hardinsburg Formation, Illinois, Kentucky, U.S.A; Butterworth and Williams 1958, Lower Namurian A, Scotland; Owens and Burgess 1965, Lower Namurian A., Stainmore; Sullivan and Marshall 1966, Upper Visean (P) Scotland; Mishell (M.S.) 1966, Lower Namurian A; Smith and Butterworth 1967, Visean and Namurian A, Britain; Marshall and Williams 1970, Visean and Nam. A., Northumberland; Neves et al. 1973. Lower Carb. Scotland.

Rotaspora knoxi Butterworth & Williams 1958
Pl. 8, fig. , 20.21

1948 Knox p. 157. text fig. 5.

1958 Rotaspora knoxi Butterworth & Williams p.378,Pl.3,fig.21-23

Holotype Pl. 15, fig. 15. Preparation T56/1 in collection of N.C.B. Laboratory, Wath-upon-Dearne. Size 40 μ.

Type locality Lower Garscadden Ironstone seam at 1010 ft. 2 ins., Cawder Cuilt borehole, Central Coalfield, Scotland, Namurian A.

Diagnosis Butterworth and Williams p. 378.

Description Rounded triangular trilete spores. Inner body sub-triangular often with slightly concave sides. Laesurae 3/4 of radius of inner body. Darkened contact area, in region of proximal pole only. Zona variable in width from 4.5 µ - 5 µ interradially to 1.5 µ - 2.5 µ radially. Size 25µ to 43µ. (15 specimens).

Remarks The spores assigned to this species conform closely to diagnosis. The exine is laenigate. The zona was frequently observed to be of a double nature in structure, the inner region thicker than the outer region, both of approximately equal width. Smith and Butterworth 1967 describe a "thickened peripheral rim" being often linked to the body by "thin very closely spaced radial thickenings". The present author considers this effect to be due to corrosion of the thinner, outer region of the zona described above.

This species was distinguished from R. fracta by the shape of the inner body, the structure of the zona and the fact that it very rarely appears folded over the apices, (probably due to its structure and width), the darkened contact areas, and overall slightly larger size.

R. crenulata, Smith and Butterworth 1967, was distinguished by the presence of interradial ornament.

Occurrence Rough Lst. to Sixth Sst.

Previous records Butterworth and Williams 1958, Lst. Coal Gp. and Upper Lst. Gp. Scotland; Venkatachala and Beju 1962, Namurian of Rumania; Kruszewska (in Sullivan and Marshall 1966) 1963, Namurian of Upper-Silesian Basin; Owens and Burgess 1966, Namurian A. Stainmore; Sullivan and Marshall 1966, Upper Visean, Scotland; Mishell (MS) 1966, Lower Namurian A; Smith and Butterworth 1967, Visean and Namurian A, British Coalfields; Marshall and Williams 1970, Visean and Namurian, Northumberland; Neves et al. 1973 and Neves and Ioannides 1974, L. Carb. Scotland.

Genus Reticulatisporites (Ibrahim) Neves 1964

Type species R. reticulatus Ibrahim 1932.

Diagnosis Neves 1964, p. 1066.

Reticulatisporites peltatus Playford 1962
Pl. 9, fig. 1.

1962 Reticulatisporites peltatus Playford, p. 599, Pl. 84, figs 1-4

Holotype P. 1962, Pl. 84, fig. 1-2. Preparation P167B/14, 36.2 102.9
Size 90 u. L. 1048

Type location Birger Johnson fjellet (sample G1098), Spitzbergen; L.Carb.

Diagnosis P. 1962, p. 599.

Description Amb more or less circular. Laesurae indistinct. Exine ornamented with thick bars or muri forming a reticulate pattern, enclosing luminae approximately 10 µ wide, bars about 3.5 µ wide. At junctions of muri, projections approximately 4 µ to 6 µ high, peltate in shape with expanded heads. Size range 47 µ to 64 µ. (8 specimens).

Remarks The specimens recovered during the present study conform to the diagnosis with the exception that the peltate projections do not reach the height recorded by Playford (1962). A similar ornament is recorded on D. tornatilis Mishell 1966.

Occurrence Base of Fourth Lst. to Third Lst.

Previous records Playford 1962, L. Carb., Spitzbergen.

Genus Lycospora (Schopf, Wilson & Bentall) Sommers 1972

Type species L. micropapillata (Wilson and Lee) Schopf, Wilson & Bentall 1944.

Diagnosis Sommers 1972.

Lycospora noctuina var. noctaina (Butterworth & Williams)
Pl. 9. fig. 8, 9. Sommers 1972.

1958 Lycospora noctuina Butterworth & Williams,p.376, Pl.

1972 Lycospora noctuina var. noctuina Sommers Pl.VIII, Pl.XIII

Holotype S. and B. Pl. 20, fig. 4. Preparation T/54/1 in collection of Coal Survey Laboratory, Sheffield. Size 36 µ.

Type locality 9 in. coal at 256 ft. 11 ins. Darnley No. 3 borehole, Central Coalfield, Scotland; Namurian A.

Diagnosis Sommers 1972, p. 62.

Description Spores trilete, cingulate. Amb sub-triangular, sides convex. Laesurae distinct straight, slightly thickened extending over cingulum almost to spore margin. Cingulum consists of relatively wide equatorial extension of exine with narrow thickened inner zone and broad thinner flange, the proportions of which vary around 1/3 to 2/3 respectively. Exine in central area ornamented with irregular shaped verrucae and elongate low patches placed randomly. Size range 28 µ to 40 µ. (20 specimens)

Remarks Sommers included several species in the synohomy of this species, however the present spores conformed most closely with those from Scotland (Butterworth and Williams) and Golata Formation, Alberta (Staplin 1960).

Occurrence Seventh limestone to Lower Coal Measures.

Previous records This species recorded by numerous authors, the closest of which is Marshall and Williams 1970, Visean, Namurian, Northumberland.

Lycospora pusilla (Ibrahim) Sommers 1972
Pl. 9, fig. 12, 13, 14.

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 & Waltz Pl. 3, fig. 33 and Pl. 8, fig. 105.

1944 Lycospora pusilla (Ibrahim); Schopf, Wilson & Bentall p.54

1972 Lycospora pusilla (Ibrahim) Sommers Pl. X, XI & XII

Holotype Potonie and Kremp 1956, Pl. 17, fig. 351 after Ibrahim.

Preparation B27, al 0 .

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

Diagnosis Sommers 1972, p. 82.

Description Spores trilete, cingulate. Amb circular to triangular. Laesurae distinct, simple, slightly open, occasionally with very slight labra, straight, extending to margin. Cingulum distinct, narrow, width approximately 4 u maximum, frequently shows light outer flange occupying up to 50% cingulum width. Exine including cingulum, ornamented with small grana, particularly on distal surface. Size range 21 µ to 35 µ. (25 spec.) Holotype 38 µ.

Remarks Sommers has incorporated many species into this species. The specimens recovered during the present study almost invariably conform to the original L. pusilla diagnosis (sensu strictu). This species formed in some cases over 90% of the spore assemblage but remarkably little obvious variation was observed. A computer statistical analysis of this species was carried out by Whittaker which failed to resolve several hundred specimens into significantly separate groups (personal communication).

Occurrence Below Seventh Limestone to Westphalian, Lower Coal Measures.

Previous records This species has been reported by Sommers to have an almost world wide distribution in Carboniferous sediments younger than Tournaisian age.

Lycospora rugulosa Butterworth and Spinner 1967
Pl. 9, fig. 22

1967 Lycospora rugulosa Butterworth and Spinner, p.10, Pl.2, fig.1,2

Holotype Specimen on Pl. 2, fig. 1. Size in range 20-38 u.

Type locality Half inch coal, Lewis Burn Group; Lewis Burn, Northumberland sample 5.

Diagnosis In Butterworth and Spinner 1967, p.10.

Description Amb subcircular to rounded triangular with convex sides. Laesurae fairly distinct, simple extending to inner margin of very narrow cingulum. Exine very thin and crenulate. Crenulations formed by granulate rugulae clearly visible at margin where they are 1 u in height. The reugulae are visible over the distal surface, less easily visible on proximal surface. Three apical papillae usually prominent. Cingulum is indistinct and narrow, approximately 3.5 µ wide. Size range 22 µ to 35 µ (20 specimens).

Remarks These specimens conform closely to the original diagnosis. There is some debate regarding the placing of this species in Lycospora by Sommers, however the evidence suggests retaining this classification. The original authors remark on the close similarity of Cyclogranisporites tripapillatus Staplin 1960, however the specimens recovered in the present study conform exactly to the diagnosis of L. rugulosa except for their narrow size range. Bertlesen (1972) has recorded a wider range from Denmark. C. tripapillatus was recorded by Neves and Williams in Day et al. (1968) however the illustration of their specimens on Plate I shows a marked similarity to L. rugulosa.

Lycospora uber (Hoffmeister, Staplin & Malloy)
Staplin 1960 Pl. 9, fig. 11.

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

1960 Lycospora uber (Hoffmeister Staplin and Malloy)
p. 20, Pl. 4, fig. 13,17,18,20.

Holotype H. S. and M. 1955 Pl. 36, fig. 24.

Type locality Hardinsburg formation, Illinois, U.S.A. Mississippian.

Diagnosis H. S. and M. 1955, p. 383.

Description Spores trilete, cingulate, amb sub-triangular. Flange or cingulum wide, often striated. Laesurae distinct, extending to cingulum. Exine over central area granulate, proximal and distal surfaces of the cingulum very finely granulate. Size range 33 μ (41μ) 52 μ for 15 specimens.

Remarks The specimens referred to this species were distinguished from other species of Lycospora by their relatively wider cingulum which was also often striated, by their larger size, and by the generally coarser nature of the ornament. Staplin (1960) lists several species in his synonomy which are in fact distinct species, notably L. noctuina Butterworth and Williams. As Sommers (1972) points out L. uber may well be synonomous with L. pusilla, however the species as described in the present study appears to be stratigraphically confined and for this reason has been retained.

Occurrence Upper Hensingham Gp.

Previous records This species has been recorded by numerous previous authors usually from Upper Visean strata.

Genus Knoxisporites (Potonie & Kremp) Neves & Playford 1961

Type species K. hageni Potonie & Kremp 1954

Diagnosis Neves and Playford 1961, Report Commission. Internationale de Microflore du Paleozoique.

Knoxisporites dissidus Neves 1961
Pl. 9, fig. 6.

1961 Knoxisporites dissidus Neves p. 266, Pl. 33, fig. 4, 6 text fig. 4

Holotype Plate 33, fig. 4. Size 70 μ in range 50-80 microns

Type locality Non marine roof shales of the Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13) Yeadonian stage.

Diagnosis Neves p. 266.

Description Trilete spores with irregular equatorial outline. Suturae simple, slightly flexuose, indistinct. Distal surface with irregular bars of thickening, three in number joining at pole, proximal surface has three thickened, short bars extending radially over the cingulum polewards. Cingulum 1/3 to 1/2 spore radius not clearly delimited at the inner margin, and irregular at equator resembling corrosive effects.

Remarks The spores were assigned to this species on account of these distinctive cingulum, and bars of thickening.

Occurrence

Previous records Neves (1961) Namurian A - West. A., S. Pennines, England; Owens and Burgess (1965) mid. Namurian A. to Nam. B. Stainmore; Mishell (1966) M.S. Nam. A to mid. Nam. B., Bowland fells.

Knoxisporites pristinus Sullivan 1968
Pl. 9, fig. 3.

1968 Knoxisporites pristinus Sullivan p.123,Pl.7, fig.1-5

Holotype Slide P26381-A-08, 123.1 48.9 Size 66 μ.

Diagnosis Sullivan 1968, p. 123.

Description Spores of irregular shaped outline, but generally polygonal. Trilete mark straight reaching to inner margin of cingulum, each vary accompanied by darker possibly low lips. Size range 57 - 64 μ. (8 specimens)

Remarks Some difficulty was found with the eight specimens placed in this species owing to certain broad similarities of K. pristinus with K. lederatus and K. triradiatus. Fig. 3, Pl. 27 in Sullivan (1968) Pl. 27, fig. 3 appears to resemble K. triradiatus . Poor preservation of the present material also contributed to some uncertainty. The size range falls very slightly below that given by Sullivan (1968) for K. pristinus.

Occurrence Basement beds.

Previous records Sullivan 1968 Scotland, Cementstone Group, Tournaisian; Hibbert and Lacey 1969 Lower Carb. basement beds, N. Wales; Llewellyn Backhouse and Hoskin 1969, Lower-Mid. Tournaisian, Leicestershire; Johnson and Marshall 1971, Tournaisian Ravenstonedale, Westmorland.

Knoxisporites stephanephorous Love 1960
Pl. 9, fig. 2.

1960 Knoxisporites stephanephorous Love, p. 118, Pl.11, fig. 1-2.

Holotype Love 1960, Pl. 11, fig. 1. Slide S/29. Size 70 u.

Type locality Pumpherston Shell bed, South Queensferry, Visean, Scotland.

Diagnosis Love 1960, p. 118.

Description Spores trilete amb circular to oval with straight laesurae, 3/4 spore radius or, more often extending to margin. Two anulae of thickened exine equatorially, which have interradial connecting bars. There is also a thickened region on the distal pole. Size range 39 μ to 61 μ (15 specimens).

Remarks The specimens recovered in the present study more or less conform to the original diagnosis with the exception that the central, distal boss is occasionally of a double nature. In some specimens the distinction between K. stephanephorous and ?Tholisporites bianulatus, Neves, was difficult to determine. This has been observed by previous authors e.g. Mishell (1966). However the distinction was based on the fact that ?T. bianulatus is generally larger, up to 90 μ, (in Neves 1961) and does not possess thickened, or apparently thickened, laesurae as does K. stephanephorous.

Occurrence Seventh Lst. to top of Hensingham Group and into Lower part of Lower Coal Measures.

Previous records Love, 1960, Lower Oil Shale (upper Visean) Scotland; Sullivan 1962, Coal Measures, West. A-C, Wernddu, S. Wales; Love and Neves 1963, Inninmore Bay, Scotland, Visean; Halbertsma and Staplin 1960, Tyler Formation, Alberta and Oklahoma; Owens and Burgess 1966, Nam. A-B, Stainmore; Mishell 1966, Nam. A - West A, Bowland; Marshall and Williams 1970, Visean and Nam., Northumberland; Neves et al. 1973, L. Carb. Scotland.

Knoxisporites triradiatus Hoffmeister, Staplin and Malloy 1955. Pl. 9, fig. 4, 5.

1955 Knoxisporites triradiatus H. S. and M. p.391, Pl. 37,figs.11,12.

Holotype TCO-82 2087 ft., slide 6, ser. 18,939.

Type location Hardinsburg formation, Mississippian, Illinois, U.S.A.

Diagnosis Description in H. S. and M. p. 391.

Description Spores trilete, cingulate. Amb subtriangular. Laesurae indistinct. Cingulum dark occupies 20% spore radius; distal surface with 3 radiating bars joining the cingulum interradially. Exine laevigate. Size range 39 μ to 60 μ. (9 specimens).

Remarks The specimens conform to diagnosis and descriptions of previous workers. The species is characterised by the triradiate thickening and is distinguished from K. seniradiatus by the possession of unthickened laesurae.

Occurrence Fourth Limestone to Tenth Sandstone.

Previous records Numerous authors including Neves and Belt 1971, Canada; Sullivan and Marshall Visean Scotland; Mishell 1966, Nam. Bowland; Laboziak 1969, Nam. France; Marshall and Williams 1971, Vis. and Nam. Northumberland; Felix and Burbridge 1967 Miss./Penn, U.S.A.

Genus Lophozonotriletes (Naumova) Potonie 1958

Type species L. Lebedianensis Naumova 1953

Diagnosis Potonie and Kremp 1958, p. 28.

Lophozonotriletes sp. A
Pl. 9, fig. 16.17.

Description Trilete, cingulate, sub-circular miospores. Amb sub-circular to rounded triangular. Laesurae distinct to indistinct, straight, often wide or gaping, extending to inner margin of cingulum. Cingulum thick, much darker in colour than central region, from 8 µ to 15 µ wide, inner margin follows outline of outer margin. Exine ornamented with large, rounded verrucae; cingulum laevigate, dimensions of ornament may be variable on one specimen. Usually approximately 5 µ diameter and 4 u high but ranging from 2 µ to 9 µ in diameter. Ornament appears to be mostly restricted to the distal polar region. Size range from 30 µ to 52 µ diameter. (7 specimens).

Remarks These specimens are not Clayton's 1970 L. sp. A which has more verrucae of more equal size, furthermore, they differ from L. rarituburculatus Kedo in having some ornament on the proximal surface and in the variable size of the verrucae.

Occurrence Rare.

Lophozonotriletes bellus Kedo 1963
Pl. 9, fig. 15.

1963 Lophozonotriletes bellus, Kedo 1963

1970 Lophozonotriletes bellus (Kedo) Clayton, Pl. 2, fig. 6

Holotype In Kedo 1963.

Diagnosis In Kedo 1963 (in Russian).

Description Amb rounded triangular, sides convex. Laesurae distinct, straight, simple, extending almost to periphery. Exine ornamented with large, smooth coni with rounded apices, approximately 5 µ in height with irregularly sub-circular bases approximately 4 µ to 5 µ in diameter. Ornament mainly on distal surface. Approximately 10 elements project at equator, with 3 to 5 in each sector of distal surface. Size 30 µ and 42 µ on three specimens.

Remarks The few specimens observed conformed to the description in Clayton 1970. The cingulate nature of the spores could not be definitly determined. The species may be placed in Pustulatisporites if the cingulum cannot be proved.

Occurrence Very rare, Basement beds, below the Cockermouth lavas.

Previous records Kedo 1963, Tournaisian, U.S.S.R; Clayton 1970, L. Carb Scotland.

Genus Bascaudaspora Owens 1963 p.201 (unpublished thesis)

Type species B. canipa Owens 1963 Pl. 19, fig.6-14.

Holotype N.B. Mousegill beck, Stainmore.

Bascaudaspora canipa Owens 1963
Pl. 8, fig. ,12,13.14

1963 Bascaudaspora canipa Owens, M.S. Sheffield (unpublished thesis)

Diagnosis Owens 1963, p. 201.

Description Spores trilete. Amb subtriangular, distal surface ornamented with irregular reticulate pattern of thickened muri, about 2 µ wide, enclosing irregular luminae about 7 µ wide. Cingulum or equatorial flange narrow and thin, gently tapering. Laesurae, flexuose, with labra, extending to cingulum, distinct. Size range 39 µ to 49 µ. (Six specimens).

Remarks These specimens closely resemble those described and illustrated by both Owens 1963 and Mishell 1966, also the range of the species in the present study corresponds to the stratagraphic range quoted by these two authors.

Occurrence Second Lst. to First Sandstone.

Infraturma. Patinati (Butterworth & Williams) Smith and Butterworth 1967.

Genus Tholisporites Butterworth & Williams 1958

Type species T. scoticus Butterworth and Williams 1958

Diagnosis Butterworth and Williams 1958, p. 381.

Tholisporites ? bianulatus Neves 1961
Pl. 9, fig. 20.

1961 Tholisporites bianulatus Neves p.271,Pl.34,fig.2,text fig. 6

Holotype Neves Pl. 34, fig. 2. Slide ref. 18,263816. Size 80 µ.

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

Diagnosis N. 1961, p. 271.

Description Spores trilete. Amb circular. Laesurae indistinct to distinct 2/3 spore radius. Distal pole bears circular thickening. Proximal surface laevigate. Two circular bands of thickening around the equator up to 5 µ wide separated by thin band of exine, intermediate areas of exine laevigate. Size range 38 µ to 57 µ.

Remarks The specimens conform to diagnosis. The smaller size range observed in the present study probably results from maceration technique, the present author did not use alkali. The species was distinguished from T.? decoratus by its laevigate exine, and from K. stephanephorus by the lack of radial, interconnecting bars, and from B. simplex by the presence of a trilete dehiscence mark and larger size.

Occurrence Third Limestone to First Sandstone.

Previous records Neves 1961, Nam. S. Pennines; Mishell 1966, (cf.) Nam. Bowland.

Tholisporites ? decoratus Gueinn 1973
Pl. 9, fig. 21.

1966 Knoxisporites stephanephorus Love in Sullivan & Marshall Pl. 3, fig. 7.

1973 Tholisporites ? decoratus Gueinn in Neves et al. p.39,Pl.2, fig. 8.

Holotype Pl. 2, fig. 8. ML 906. Size in range 35 µ to 48 µ.

Type location Cousland No. 1 borehole of 2409', Midlothian, Scotland.

Diagnosis Neves et al. 1973, p. 39.

Description Spores trilete. Amb circular. Laesurae straight, simple, gaping. Exine has two circular bands of thickening approximately 5 µ wide sub equatorially and a small circular polar thickening distally with irregular small low grana occasionally. Size range 32 µ to 47 µ.

Remarks This species bears a superficial resemblance to T? bianulatus however was distinguished from it by the ornamented proximal area. Gueinn remarks that K, stephanephorus has labra but does not state directly that T.? decoratus does not.

Occurrence Rough Limestone to Seventh Sandstone.

Previous records Neves et al. 1973 L. Carb, N. England, Scotland; Sullivan and Marshall, 1966 L. Carb. Scotland.

Tholisporites scoticus Butterworth and Williams 1958
Pl. 9, fig. 19.

1958 Tholisporites scoticus Butterworth and Williams Pl. 3, fig. 48

Holotype Pl. 3, fig. 48. Preparation T63/1 in collection of Coal Survey laboratory, Sheffield. Size 52 µ.

Type locality Seam at 1872 ft. 7 ins. Righead borehole, West Fife Coalfield, Scotland; Namurian A.

Diagnosis B. and W. 1958, p. 84.

Description Spores with irregular undulose outline and indistinct trilete suture. Proximal surface laevigate or very finely granulate. The spores generally conform to diagnosis. Size 38-50 µ. (6 specimens).

Remarks The trilete suture was found to be very indistinct not 'distinct' as in the diagnosis.

Occurrence Third Lst. only. rare.

Previous records Butterworth and Williams 1958 Lst. Coal Gp. Lower Namurian A., Scotland; Bharadwaj and Venkatatchala 1961, Lower Carboniferous, Spitzbergen; Owens 1963 M.S. Lower Namurian A., Stainmore; Misheall 1966, M,S, Namurian A., Bowland; Smith and Butterworth 1967, Visean and Namurian A., British Coalfields; Marshall and Williams, 1970, Namurian, Northumberland.

Suprasubturma Cameratitriletes Neves & Owens 1966.

Subturma Solititriletes Neves & Owens 1966

Infraturma Planati Neves & Owens 1966

Genus Auroraspora Hoffmeister Staplin & Malloy 1955

Auroraspora macra Sullivan 1968
Pl. 10, fig. 1, 2.

1968 Auroraspora macra Sullivan p.124,Pl.27,figs.6-10

Holotype Slide P26381-A-04, 120.2, 34.6. Size 49 μ.

Type locality 100 feet above Cementstone Group base, Ayrshire.

Description Spores trilete, camerate. Amb sub-circular to sub-triangular often uneven. Intexine and exoexine both clearly visible. Trilete rays distinct, usually straight but occasionally slightly flexuose, reaching almost to margin of central body. Intexine considerably darker in colour than exoexine. Intexine sub-circular, strongly to weakly punctate or infra punctate, to scabrate, diameter 20 μ to 28 μ. Exoexine thin, infra punctate and characteristically darker around periphery, often folded into uneven shape approximate diameter 46 μ to 57 μ at maximum.

Remarks Sullivan recorded a size range from 48 μ to 68 μ with a mean of 58 u. Clayton (1971) recorded a smaller size range from 51 μ to 61 μ and Bertlesen (1972) recorded a size range from 50 μ to 70 μ. In the present study a size range is smaller, corresponding most closely with that of Clayton, which represents the closest geographically. The darkening around the periphery of the intexine noted by Clayton was not commonly observed. The species was easily distinguished by its overall appearance from most other species and from Species A by its more variable size, larger outer body compared with the central body and the unthickened laesurae.

Occurrence Basement beds up to the Seventh Limestone.

Previous records Sullivan 1968, Cementstone Group, Scotland;Llewellyn Backhouse and Hoskin 1969, Tournaisian, Central Province England;

Johnson and Marshall 1971, Tournaisian, Ravenstonedale England; Clayton 1971, Calciferous Sandstone Measures, E. Scotland; Neves et al. 1973, L. Carb. S. Scotland.

<u>Auroraspora</u> <u>solisortus</u> Hoffneister, Staplin & Malloy 1955
Pl. 10, fig. 3. 4

1955 <u>Auroraspora</u> <u>solisortus</u> Hoffmeister, Staplin & Malloy p.381,Pl.37 fig. 3.

<u>Holotype</u> H. S. and M. p. 381, Pl. 37, fig. 3.

<u>Type location</u> Hardinsburg formation, Illinois.

<u>Diagnosis</u> H. S. and M. p. 381.

<u>Description</u> Spores trilete camerate. Amb sub-circular often folded and therefore irregular. Laesurae indistinct to distinct extending to and beyond margin of central body. Intexine dark forming more or less circular central body. Exoexine very thin flimsy often folded in radiating folds and folded over upon itself at the equator. Exoexine punctate to coarsely granulate but often corroded. Size range 38 µ (62) 71 µ. (15 specimens).

<u>Remarks</u> Spores closely conform to original diagnosis. These specimens often suffered from corrosive effects which ,may have enhanced the granulate-punctate nature of the exoexine.

<u>Occurrence</u> Third Sandstone to Westphalian.

<u>Previous records</u> Hoffmeister, Staplin and Malloy, U. Miss'n. U.S.A; Butterworth and Williams 1958 Scotland Nam. A; Sullivan 1964 Visean, England; Felix and Burbridge L. upper Carb. U.S.A; Sabry and Neves 1970 West. A Scotland; Marshall and Williams Yoredales Northumberland; Playford 1971 Lower Carb. West Australia.

Genus <u>Spencerisporites</u> Chaloner 1951

<u>Type species</u> <u>S.</u> <u>radiatus</u> (Ibrahim) Felix & Parks 1959

<u>Diagnosis</u> Chaloner 1951, p. 861.

<u>Spencerisporites</u> <u>radiatus</u> (Ibrahim) Felix & Parks 1959
Pl. 11, fig. 8. 9.

1932 Sporonites radiatus Ibrahim in Potonie, Ibrahim & Loose, p. 449, 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 & Bentall p.24

1944 Endosporites ? karczewskii (Zerndt); Schopf, Wilson & Bentall p.45

1946 Microsporites karczewskii (Zerndt); Dijkstra & 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 & Kremp p. 156, Pl. 20, figs, 449, 450.

1959 Spencerisporites radiatus (Ibrahim) Chaloner, Felix & Parks p. 362, Pl. 1, figs 1-4 & Pl. 2, figs 1-4

Holotype Potonie and Kremp 1955, Pl. 20, fig. 400, after Ibrahim 1932. Preparation B43, cl (ul). Size 330 microns.

Type location Agir Seam, Ruhr Coalfield, Germany; top of Westphalian B.

Diagnosis Felix and Parks 1959.

Description Large rounded spore. Amb sub-triangular to irregular, exoexine thin, saccate, characteristically ornamented with anastomosing ridges radiating from central region in a similar fashion to blood capilliaries. Central region occupied by dark central body which is 40% diameter of spore or less. Intexine shows darker band around margin. Central area shows characteristic infra ornament of lines radiating from several points. Size 170 µ to 200 µ.

Occurrence Very rare, Third Lst. to Second Sst.

Previous records Numerous authors have recorded this species from Upper Carboniferous rocks including Neves 1959, Nam. A. Pennines; Owens 1963 Nam. A to West. B., Stainmore; Mishell 1966 Nam. A to Nam. B Bowland; Marshall and Williams 1971 Nam. A., Northumberland.

Infraturma Decorati Neves and Owens 1966

Genus Rugospora Neves & Owens 1966

Type species R. corporata Neves and Owens 1966

Diagnosis Neves & Owens p. 350.

Rugospora corporata Neves & Owens var. verrucosa Neville 1968. Pl. 10, fig. 11.

1966 Velamisporites rugosus Bharadwaj and Venkatachala

1966 Rugospora corporata Neves & Owens

1968 Rugospora corporata var. verrucosa Neville p.450,Pl.3,fig.2-3

Holotype N. 1968, Pl. 3, fig. 2, 147.2 r from sample F100 lower of the two coals 3' below the Mid Kinniny Limestone. Size range 59 μ to 192 μ.

Diagnosis N. 1968 p. 450.

Description Large trilete, camerate spores. Amb sub-circular, irregular. Exoexine folded, pleated, ornamented with rugulae and small verrucae arranged in rows, thin. Intexine dark irregular in shape may or may not follow exoexine outline. Laesurae indistinct. Size range 100 μ - 160 μ.. (10 specimens).

Remarks Following the original description by Neves and Owens 1966, the rugulose and laevigate varieties of this species have been split. The specimens recovered in the present study conform to the diagnosis.

Occurrence Third Limestone to First Sandstone.

Previous records Neves and Owens 1966, Nam. Penn.; Sullivan and Marshall 1966, U. Visean, Scotland; Neville 1968, Visean, Scotland; Clayton 1971, Visean Scotland; Neves et al. 1973, L. Carb., N. England, Scotland.

Rugospora minuta Neves & Ioannides 1974 Pl. 11, fig. 1,

1974 Rugospora minuta Neves & Ioannides p. 79, Pl. 8, fig. 7,8

Holotype MPK 732. Size 46 u.

Type locality At 2563 ft. (781.2m) in the Spilmersford Borehole, East Lothian; Lower Carboniferous.

Description Trilete spores. Amb circular, laesurae not usually visible, exoexine crinkled by numerous folds radiating more or less from the polar region, up to 3 µ high and 1 µ to 2 µ wide. Intexine sometimes visible degree of cameration slight up to 6 µ, size range 27 µ to 52 µ.

Remarks The specimens were not so coarsely ornamented as those illustrated by Neves and Ioannides 1974, but fit the diagnosis. However, Mishell 1966 recorded an unpublished species Corrugisporites ruginosus which appears very similar to the specimens observed during the present study with the exception that an intexine is not detectable.

Occurrence Basement beds and Seventh Limestone.

Previous records Neves et al. 1973 and Neves and Ioannides 1974, Lower Carboniferous, East Lothian, Scotland.

Genus Grandispora (Hoffmeister, Staplin & Malloy 1955)
Neves and Owens 1966.

Type species G. spinosa Hoffmeister, Staplin and Malloy 1955

Diagnosis Emended diagnosis in Neves and Owens 1966, p. 346.

Grandispora echinata Hacquebard 1957
Pl. 10, fig. 13.

1957 Grandispora echinata Hacquebard p.317, Pl.3, fig. 17

Holotype M101, Slide 2, at 21 103.9.

Type locality Horton Group, Nova Scotia, West Gore sample.

Diagnosis Description in Hacquebard 1957, p. 317.

Description The spores are trilete, camerate with a sub-triangular amb. Laesurae are straight sometimes flexuose, and appear simple. Exoexine ornamented with coni and low spinae not more than 3 µ long and 3 µ in basal diameter, set irregularly apart at from 2 µ to 9 or 10 µ, mainly on distal surface. Intexine reasonably distinct, thin, follows outline of exoexine with a cameration of approximately 10 µ. Intexine is laevigate. Overall diameter from 59(70)75 µ. (12 specimens).

Remarks The spores conform to the original diagnosis. Bertlesen (1972) remarks on the labiate nature of the laesurae which became obvious under

S.E.M. This feature is not readily visible under transmitted light. The species was distinguished from G. spinosa by its smaller size and smaller ornament and from S. microspinosus by its larger size and coarser ornament.

Occurrence Basement Beds above Cockermouth lavas. Common.

Previous records Nacquebard 1957, Playford 1963, Varma 1969, Horton Group, Nova Scotia; Sullivan and Marshall 1966, Visean, Scotland; Sullivan 1968 L. Carb. Scotland; Neves 1968, L. Carb. Scotland; Neves and Owens 1966, Namurian, Central England; Llewelyn, Backhouse and Hoskin 1969, Leicestershire Tournaisian; Marshall and Williams 1971, Northumberland, Visean; Uttings and Neves 1970, Dev/Carb. boundary, Avon gorge England; Johnson and Marshall, Ravenstonedale, Tourn; Dolby 1970, Eire, Tourn; Streel 1970, Tourn., Belgium and Germany; Neves et al. 1973, Scotland and N. England; Owens 1963 Namurian C., Stainmore.

Grandispora spinosa Hoffmeister Staplin & Malloy
Pl. 10, fig. 12.

1955 Grandispora spinosa Hoffmeister Staplin and Malloy
Pl. 3a, figs 10, 14.

Holotype TCO 82, 2077 ft. slide 6, ser.19311 (Pl. 3a, fig. 10) Hardinsburg formation. Size 118 μ.

Diagnosis Description in H. S. and M. 1955, p. 388.

Description Trilete camerate spores. Amb roughly circular in outline. Trilete mark usually indistinct, laesurae extend to approximately 3/4 spore diameter. Exoexine occasionally infra punctate and ornamented with with spinae 2 - 4 μ diameter and 3 - 8 μ long, spaced up to 15 μ apart. Intexine distinct, occupying approximately 1/2 to 2/3 diameter of spore. Size 70 - 95 μ overall diameter. (6 specimens).

Remarks The specimens recovered in the present study conform to the original diagnosis except for the following points. The overall diameters fall below that of those in the type material, the oxidizing technique and the small number of specimens observed may account for this.

The region of attachment of the intexine appears to be in the region of the trilete mark only. Also, two specimens were observed which had a more triangular amb, longer and more prominent suturae and slightly smaller central body, which were ornamented with spines of up to 12-14μ long. These specimens were nevertheless referred to G. spinosa because of their overall structure.

Occurrence Base of Fourth Lst,. to Sixth Sst. then very rare to Second Sst.

Previous records Hoffmeister Staplin and Malloy 1955, Hardinsburg Formation, (Up. Mississippian) Illinois, Kentucky, U.S.A.; Staplin and Halbertsma 1960, Up. Chainman Formation, Nevada, U.S.A; Bharadwaj and Ventkatachala 1961, Lower Carboniferous of Spitzbergen; Neves 1961, Namurian A, Southern Pennines, England; Owens and Burgess 1965, Namurian A, of Stainmore, England; Sullivan and Marshall 1966, Upper Visean of West part of Mid. Valley, Scotland; Mishell 1966, Lower Namurian A., Bowland; Neville 1968 Visean, Scotland; Marshall and Williams 1970, Visean and Namurian, Northumberland; Neves et al. 1973, L. Carb. Scotland.

Genus Spelaeotriletes Neves & Owens 1966

Type species S. triangulus

Diagnosis Neves and Owens p. 342 - 344.

Spelaeotriletes arenaceus Neves and Owens 1966

Pl.10. fig. 9

1966 Spelaeotriletes arenaceus Neves & Owens Pl. 3, fig. 4

Holotype N. & O. Pl. 3, fig. 4.

Type locality Namurian, Stainmore, Lower Bentham Grit Coal, Greta River. SD 34633718.

Diagnosis N. & O. 1966.

Description Spores trilete camerate. Amb sub-triangular, irregular. Exoexine folded. Ornamented distally and partly proximally with mixed verrucae and grana, sometimes fused at bases. Intexine convexly triangular about 40% of exoexine diameter, sometimes folded. Laesurae indistinct extend to margin of intexine with curvaturae sometimes visible. Size range 75 μ to 120 μ. (10 specimens).

Remarks Specimens correspond closely to original description, distinguished from R. corporata var. verrucosa by the more isolated ornament, lack of rugulae and triangular shape, and from S. triangularis, Neves and Owens 1966 by its finer ornament.

Occurrence Base to top of Fourth Limestone.

Previous records Neves and Owens 1966, Nam. A - Nam. C, Penn; Mishell 1966, Nam. A - Nam. B. Bowland; Neville 1968, Visean, Scotland.

Spelaeotriletes microspinosus Neves and Ioannides 1974
Pl. 10, fig. 10.

1974 Spelaeotriletes microspinosus Neves and Ioannides
p. 81, Pl. 8, figs. 1, 3.

Holotype MPK 726 Size 39.9 µ.

Type locality At 2504 ft. 9 ins. (763.45m) in the Spilmersford Borehole, East Lothian; Lower Carboniferous.

Diagnosis N. and I. p. 81.

Description Spores trilete, camerate. Amb sub-triangular to circular. Laesurae indistinct. Intexine just discernible approximately 60% of spore diameter. Exoexine ornamented with closely set, slightly irregular coni about 1.5 µ in height, size range 29 µ to 43 µ.

Remarks Few specimens were recovered in the present study and these were relatively poorly preserved but appear to conform to the diagnosis.

Occurrence Basement beds.

Previous records Neves and Ioannides 1974 Lower Carboniferous, East Lothian, Scotland.

Genus Grumosisporites Smith and Butterworth 1967

Type species G. verrocosus (Butterworth & Williams) Smith & Butterworth 1967

Diagnosis Smith and Butterworth 1967, p. 228.

Grumosisporites inaequalis (Butterworth and Williams)
Smith and Butterworth 1967. Pl. 10, fig. 7.

1948 39K Knox text-fig. 47.

1958 Verrucosisporites inaequalis Butterworth & Williams, p.363, Pl.1 figs. 46,47

1967 <u>Grumosisporites inaequalis</u> (Butterworth & Williams) Smith and Butterworth p. 229, Pl. 16, fig. 1 to 8.

<u>Holotype</u> S. and B. 1967 Plate 16, fig. 1 after Butterworth and Williams. Preparation T37/1 in collection of N.C.B. Laboratory, Wath-upon-Dearne. Size 40 μ in range 25 - 47 μ.

<u>Type locality</u> Seam at 1,336 ft. 3 ins. Righead borehole, West Fife Coalfield, Scotland; Namurian A.

<u>Diagnosis</u> Smith and Butterworth p. 229.

<u>Description</u> Spores trilete, camerate. Amb sub-circular. Laesurae straight, indistinct. Intexine barely discernible. Exoexine ornamented with very irregular protrubrances, approximately 3 μ in height., bases joining in some cases appromimately 10 at equator. Size range 30 to 40 μ.

<u>Remarks</u> The few specimens observed conform well to diagnosis.

<u>Occurrence</u> Orebank sandstone to Little Sandstone.

<u>Previous records</u> Knox 1948, Butterworth and Williams 1958 Scotland, Namurian; Smith and Butterworth, Namurian Britain.

<u>Grumosisporites rufus</u> (Butterworth & Williams) Smith & Butterworth 1967. Pl. 10, fig. 5.

1948 Knox fig. 20

1958 <u>Verrucosisporites rufus</u> Butterworth and Williams, p.363, Pl.1 figs 44, 45.

1967 <u>Grumosisporites rufus</u>, Smith and Butterworth p.231, Pl.17 fig. 1 to 7.

<u>Holotype</u> S. & B. 1967. Plate 17, figs 1 - 4. Preparation T36/1 in collection of N.C.B. Laboratory, Wath-upon-Dearne. Size 54 μ.

<u>Type locality</u> Cadell's Parrot Seam at 1,110 ft. 9 ins. Righead borehole, West Fife Coalfield, Scotland, Namurian A.

<u>Diagnosis</u> S. and B. p. 231.

<u>Description</u> Spores trilete camerate. Amb circular irregular. Laesurae obscure, simple, at least 2/3 of spore radius. Intexine indistinct more or less follows outline of exoexine. Exoexine ornamented with low rounded irregular verrucae partially anastamosing at base. Separation of exines

narrow approximately 5 μ. Size range 37 μ to 45 μ.

Remarks Intexine visible under oil immersion. This species was distinguished from G. inaequalis (Butterworth & Williams) Smith & Butterworth by its wider, lower ornament and thinner exine.

Occurrence Orebank Sandstone to Ninth Sandstone.

Previous records Butterworth and Williams 1958, Nam. A. Scotland; Smith and Butterworth 1967, Visean, Britain; Love 1960, Visean, Scotland; Peppers 1970, Pennsylvanian, Illinois (cf).

Grumosisporites varioreticulatus (Neves) Smith & Butterworth 1967. Pl. 10, fig. 8.

1958 Dictyotriletes varioreticulatus Neves p. 8, Pl. 2, figs 1a,b

1967 Grumosisporites varioreticulatus (Neves) Smith & Butterworth p. 232, Pl. 17, figs 8 to 10.

Holotype Neves 1958, Pl. 2, fig. 1. Preparation F 7S1, reference 056550 in collection of Geological Department, Sheffield University. Size 106 μ in range 70-110 μ.

Type locality Roof shales of Six Inch Seam, Quarnford, North Staffordshire Coalfields, England; Namurian C.

Diagnosis Smith and Butterworth p. 232, 1967.

Description Spores trilete camerate. Amb sub-circular. Laesurae straight simple 2/3 of spore radius. Intexine distinct triangular convexly folded sides widely separated from exoexine. Exoexine ornamented with low irregular muri forming crude roticulation. Size range 46 to 62 μ.

Range. Lower Coal Measures

Genus Perotrilites Couper 1953

Type species. P. perinatus

Perotrilites perinatus Hughes and Playford 1961 Pl. 10, fig. 15.

1961 Perotrilites perinatus Hughes & Playford p.33, Pl.2, figs.7-10

Holotype Preparation P 003/4, 42.8 95.1 Size 62 μ.

Type location Sample B685, Lower Carboniferous, Spitzbergen.

Dıagnosis In H. and P. 1961, p. 33.

Description Spores trilete camerate. Amb circular to sub-triangular, outer perine very thin, often torn, laevigate almost always folded. Body dark in colour, sub-triangular to circular, laesurae often very indistinct, but straight simple. Diameter of whole spore from 38µ(49)57 µ.(12 specimens)

Remarks These spores were often poorly preserved and sometimes presented problems of identification. The exoexine or perine was usually closely fitting to the central body with a 5 µ gap. Bertlesen (1972) observed that the outer layer was often torn and partly destroyed as was the case in some specimens recovered in the present study.

Occurrence Basement Beds up to the base of the First Limestone. Rare.

Previous records Hughes and Playford 1961, Spitzbergen Lower Carb; Playford 1962 Spitzbergen; Kaiser 1970, Bear Ils. L. Carb; Sullivan and Marshall 1966, Visean of Scotland; Butterworth and Smith 1967, Lower Carb. N. W. England; Hibbert and Lacey 1969, N. Wales, Visean; Marshall and Williams 1970, Northumberland Visean; Utting and Neves 1970, Dev./Carb. Avon Gorge, England; Johnson and Marshall 1971, Ravenstonedale Tourn.. Neves et al. 1973 S. Scotland,L.Carb. Felix and Burbridge 1967 U.S.A. L. Carb; Playford 1963 Canada,L. Carb; Balm 1967 and Varma 1969 Canada, L. Carb.

Perotriletes tessellatus (Staplin) Neville 1973
Pl. 10, fig. 16.

1960 Alatisporites tessellatus Staplin,p.31,Pl.7,fig.10

1973 Perotriletes tessellatus (Staplin) Neville in Neves et al. 1973. p. 39, Pl.2, figs. 9,10,17.

Diagnosis Staplin p. 31.

Holotype Imp. 1707 ns 7/34.6 x 117.7 Size in range 62-83 µ.

Type location Golata formation Canada.

Description Spores trilete,camerate. Amb sub-circular,often irregular due to folds. Laesurae rarely seen. Exoexine laevigate, thin, frequently folded and creased, crumpled over intexiene. Dark margin of intexine not always distinct owing to folded exoexine. Size range 62 μ to 79 μ.

Remarks Separation of exines variable in any one specimen but generally appears less than illustrated in Neves et al. Pl. 2, figs 9 and 10. The rarity of this species may be associated with poor influx of anemophilous grains.

Occurrence Seventh Limestone to Third Limestone.

Previous records Staplin 1960 Canada U. Miss; Neves et al. 1973 L. Carb. Scotland and N. England.

Subturma Membranatitriletes Neves & Owens 1966

Infraturma Continuati Neves & Owens 1966

Genus Spinozonotriletes (Hacquebard 1957)
Neves and Owens 1966.

Type species S. uncatus Hacquebard 1957

Diagnosis Emended diagnosis in Neves and Owens 1966 p. 355.

Spinozonotriletes uncatus Hacquebard 1957
Pl. 11, fig. 7.

1957 Spinozonotriletes uncatus Hacquebard, p.316, Pl. 3, figs 8-10

Holotype M.101, Slide 1 at 40.8 97.3. Size in range 82 μ - 148 μ.

Type locality Horton Gp. Nova Scotia.

Diagnosis In Hacquebard 1957, p. 316.

Description Trilete, camarate spores. Amb sub-triangular, laesurae thickened and extending to margin of spore, thickening uneven and occasionally sinuous. Exoexine ornamented with large spinae up to 8 μ long and 2.5 μ diameter at base, about 25 project at equator. Intexine very indistinct. Size 65 μ to 80 μ. (4 specimens).

Remarks The specimens observed in the present study displayed characteristics conformable with the original diagnosis. Preservation was poor in samples in which this species occurred therefore detailed comparisons are unwarranted. The smaller size noted is probably due to the maceration process used in the present work.

Occurrence Very rare, Basement beds up to base of Hensingham Group.

Previous records Hacquebard 1957, L. Carb. Nova Scotia; Playford 1963, L. Carb. Nova Scotia; Varma 1969, L. Carb. Nova Scotia; Clayton 1971, L. Carb. Scotland; Clayton and Spinner 1973, L. Carb. Scotland; Neves et al. 1973 L. Carb.Scotland and N. England.

Genus Discernisporites (Neves 1958)

Neves and Owens 1966.

Type species D. irregularis Neves 1958

Diagnosis Emended diagnosis in Neves and Owens p. 357.

Discernisporites crenulatus (Playford) Clayton 1971

1963 Granulatisporites crenulatus Playford,p.11,Pl.2, figs 8,9,10

1971 Discernisporites crenulatus (Playford) Clayton p.583,Pl.2,figs 2,3,4.

Holotype Playford 1963, Pl. 2, fig. 10 GSC no. 13076. Size in range 36 μ to 54 μ.

Type location Horton Gp. (Craigmaish Fm.), Nova Scotia, GSC,Loc. 6405.

Diagnosis Emended in Clayton 1971, p. 583.

Description Rounded triangular, trilete, camerate spores. Laesurae extend to margin of intexine. Camaration 1.5 μ to 3 μ. Exoexine ornamented with grana mostly on distal side. Intexine laevigate although indistinct. Size 28 μ and 30 μ.

Remarks Only two specimens were recovered in the present study, these appear to conform to the original diagnosis.

Occurrence Sample 373. Basement beds.

Previous records Playford 1963, Horton Gp. Canada; Clayton 1971, L. Carb. Scotland; Neves et al. 1973, L. Carb. Scotland and N. England.

Discernisporites micromanifestus (Hacquebard) Sabry and Neves. Pl. 11, fig. 2,3.

1957 Endosporites micromanifestus Hacquebard p.317,Pl.3,fig.16.

1960 Auroraspora micromanifestus (Hacquebard) Richardson,p.51,Pl.14 figs, 1&2.

1971 Discernisporites micromanifestus (Hacquebard) Sabry & Neves p. 1445, Pl. 3, fig. 11.

Holotype M101, Slide 10 at 36.1 101.6.

Type location West Gore and Blue Beach samples, Horton Group, Nova Scotia.

Diagnosis Description in Hacquebard 1957, p.317.

Description Trilete, camerate spores. Amb triangular to rounded triangular, sides convex. Trilete rays distinct extending almost to equator, straight to very slightly flexuose, with raised labra. Exoexine laenigate to infra granulose, thin, separated from central body by wide cameration, probably minutely infra ornamented, attached to exoexine proximally. Overall diameter 50 µ to 78 µ, intexine from 42µ to 60µ diameter. (20 specimens)

Remarks The spores conform to the original diagnosis. Several specimens were recovered in which the ratio of the intexine to exoexine diameters was higher than that recorded in the type material. However the specimens all bore such a very close resemblance to the descriptions that all were placed in this species.

Occurrence Basement Beds above Cockermouth lavas to Sixth Sandstone of Hensingham Group.

Previous records Many authors record this species, including:- Hacquebard 1957, Playford 1963, Varma 1969 all in Horton Gp. L. Carb. Canada; Playford 1964, Spitzbergen L. Carb; Sullivan and Marshall 1966, L. Carb. Scotland; Neves 1959, Nam. A - Nam. C, Pennines (in Mishell 1966); Richmond 1960 M.D.R.S., U.S.A.; Owens 1963, N. A. - L. Nam. B, Stainmore; Mishell 1966, N.A. - L. Nam. B. Bowland; Doubinger and Rauscher 1966 L. Carb. France; Smith and Butterworth 1967, Visean and Nam. of Britain; Felix and Burbridge 1967, Oklahoma L. Carb; Clayton 1971, L. Carb. Scotland; Playford 1971, W. Australia, L. Carb; Neves et al. 1973, L. Carb, S. Scotland.

Discernisporites cf. irregularis

Pl. 11, fig. 5, 4.

Holotype 373B82/5 57 µ

Type locality Carboniferous Basement beds, Redmain, Cumberland.

Description Amb convexly subtriangular, laesurae, flexuose, labrate, extend3/4 spore radius. Exoexine infra ornamented thin, intexine indistinct, occupies about 50% of spore diameter. Exoexine ornamented in central area, probably distally, with irregular elongate rougulae and verrucae. Size 55μ 57μ and 60μ.

Occurrance Basement beds.

Remarks These specimens, although imperfectly preserved bear a close resemblance to D. irregularis, Neves, which however is only recorded in Upper Carboniferous strata and has ornament on the proximal side. A similar specimen has been recorded in Lower Carboniferous strata by Butterworth (pers. communication). Also Neves and Belt (1971), figure a similar spore.

Infraturma Cingulicamerati Neves and Owens 1966

Diagnosis Neves and Owens 1966, p. 358.

Genus Cirratriradites Wilson and Coe 1940

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

Diagnosis From Schopf, Wilson and Bentall 1944, p. 43.

Cirratriradites saturni (Ibrahim) Schopf, Wilson & Bentall 1944. Pl. 12, fig. 5.

1932 Sporonites saturni Ibrahim, Potonie & Loose p.448,Pl.15 fig.14

1933 Zonalesporites saturni Ibrahim p.30, Pl. 2, fig. 14

1938 Zonotriletes saturni (Ibrahim) Luber in Luber & Waltz P.8 fig. 102.

1944 Cirratriradites saturni (Ibrahim); Schopf, Wilson & Bentall p.44

Holotype Ibrahim 1932, Pl. 15, fig. 14. Potonie and Kremp 1956, Pl. 18, fig. 412 after Ib.. Preparation B26, d2(ul) Size 69.5μ.

Type location Agir Seam, Ruhr Coalfield, Germany; top of West.B.

Diagnosis P & K 1956, p. 128, translation in Smith & Butterworth 1967.

Description Amb sub-triangular, Laesurae distinct, straight to slightly flexuose, with labra, extending to spore margin. Exine of outer zona is thin but over body thicker, darker and ornamented with minute grana, darker band of thickening around margin of central area. Zona narrow, approximately 15% to 20% of spore radius. Centrally one or more fovea present. Spore outline characteristically slightly extended radially. Size range 42 μ to 61 μ.

Remarks The specimens recovered during the present study conformed well with the diagnosis, and descriptions of previous workers.

Occurrence Lower Coal Measures.

Previous records Numerous authors have recorded this species from Upper Carboniferous rocks, including Owens and Burgess 1965, West. A, Stainmore; Mishell 1966, West. A.Bowland.

Genus Vallatisporites Hacquebard 1957

Type speciesB V. vallatus Hacquebard 1957

Diagnosis Hacquebard 1957, p. 312.

Vallatisporites ciliaris (Luber) Sullivan 1964
Pl. 14, fig, 20

1938 Zonotriletes ciliaris Luber, in Luber & Waltz, p.25,Pl.6,fig 82

1964 Vallatisporites ciliaris (Luber) Sullivan,p.370,Pl.59,figs 14,15

Holotype In Luber and Waltz. Sullivan's range 50 μ to 70 μ.

Diagnosis Luber and Waltz and Sullivan description p.370,371.

Description Spores trilete, camerate. Exoexine extended equatorially to form a zona. Amb rounded triangular with convex sides. Laesurae prominent straight to flexuose, with narrow tecta. Central region dark and distal surface ornamented with spinae, proximal side unornamented. Outer zone with radiating light and dark lines formed probably by corrosion or expanded vacuoles. Spinae up to 2.5 to 3.5 μ long. Overall size 59 μ to 68 μ. (10 specimens). Sullivan recorded range from 50 μ to 70 μ.

Remarks These spores were frequently poorly preserved but generally conformed to the description in Sullivan 1964. The zona occupied between 1/3 and 1/2 of the spore radius. The sinose ornament was not observed to be so coarse at the base as described by Sullivan, but this could be a result of corrosion. The species was distinguished from V. vallatus, Hacquebard, by the broader zona and more distinct ornament of the former species.

Occurrence Rare, from Basement beds below Seventh Limestone

Previous records Luber and Waltz 1938, L. Carb. Karaganda Basin; Sullivan 1964, Visean, Forest of Dean; Butterworth and Spinner 1967, L. Carb. N.W. England; Marshall and Williams 1970, Upper Visean, Northumberland, Yoredales; Neves and Belt, Hastings beds, Visean, Nova Scotia; Sullivan and Marshall 1966, Visean of Scotland; Neves et al. 1973, L. Carb. of Scotland and N. England.

Vallatisporites vallatus Hacquebard 1957

1957 Vallatisporites vallatus Hacquebard p.312,Pl.2, fig. 12.

Holotype M101, Slide 5, at 39.6 106.3 Size 60μ-70μ.

Type locality West Gore and Blue Beach samples, Horton Gp., Nova Scotia.

Diagnosis In Hacquebard 1957, p. 312.

Description Trilete, camerate spores with equatorial zona. Amb rounded sub-triangular with convex sides. Laesurae indistinct, straight, extending to equator. Central area of exine ornamented with grana distally. The narrow zona also is ornamented with small grana giving the equatorial outline an uneven or ragged appearance. Size range from 47 μ to 60 μ (7 specimens)

Remarks The specimens appear to conform to the original diagnosis although preservation of the material was often poor. The species was distinguished from V. cillaris (Luber) Sullivan, by the nature of the ornament.

Occurrence Rare from Third Limestone of the Upper Chief Lst. Gp. to Second Sst. of Hensingham Gp.

Previous records Hacquebard 1957, Playford 1963, Varma 1969, Horton Gp. Nova Scotia; Neves 1959, Upper Nam. B to Nam. C Pennines; Owens 1963 Nam. A to Lower Nam. C, Stainmore; (in Mishell 1966) Mishell 1966, Nam. Bowland; Sullivan, 1968, Tournaisian, Scotland.

Genus Cingulizonates (Dybova and Jachowicz)
Butterworth, Jansonius, Smith and Staplin 1964

Type species C. bialatus (Waltz) Smith and Butterworth 1967

Diagnosis Butterworth, Jansonius, Smith and Staplin 1964, p. 105

Cingulizonates bialatus (Waltz) Smith & Butterworth 1967
Pl. 12, fig. 5.

1938 Zonotriletes bialatus Waltz in Luber & Waltz p.22,Pl.4,fig.51

1941 Zonotriletes bialatus var. costatus Waltz in Luber & Waltz p. 28, Pl. 5, figs 71a, b.

1956 Densosporites bialatus (Waltz) Potonie & Kremp p. 114

1956 Hymenozonotriletes bialatus var. undulatus (Waltz) Ishchenko pp.63-4, Pl. 12, figs. 135-7

1957 Cingulisonates tuberosus Dybova & Jachowicz p.171,Pl.53 figs. 1-4.

1958 Densosporites striatus (Knox), Butterworth & Williams p. 380, Pl. 3, fig. 36.

1967 Cingulizonates bialatus (Waltz) Smith & Butterworth p. 260, Pl. 21, figs. 3-4.

Holotype Not designated.

Type locality Bed 6, Verkhin-Gonbakhin Colliery, U.S.S.R; L. Carboniferous.

Diagnosis Waltz in Luber and Waltz 1941.

Description Trilete, cingulate spores. Amb circular to sub-circular or sub-tiangular. Laesurae indistinct. Simple, straight, extending to inner margin of cingulum. Cingulum with marked cuesta forming light outer flange and dark inner region, both of equal width. Darker region occasionally appears wider interradially. Outer, lighter flange often has a striated appearance. Central region light in colour.

Remarks The specimens recovered during the present study conform to the original diagnosis. Staplin remarks that the laesurae are somewhat shorter than the radius of the spore body. In the present study it was found that they extended to the inner margin of the cingulum. (As in Smith and Butterworth Pl. 21, figs 3 and 4)

Occurrence Base of Seventh Lst. to First Sst.

<u>Previous records</u> Recorded by numerous workers from Carboniferous sediments.

<u>Cingulizonates</u> cf. <u>capistratus</u> (Hoffmeister, Staplin and Malloy) Staplin and Jansonius 1964.
Pl. 12, fig. 9,10,11,12,13.

1958 <u>Densosporites capistratus</u> Hoffmeister, Staplin & Malloy; Butterworth and Williams, Pl. 3, figs 44, 45.

1958 <u>Densosporites variablis</u> (Waltz) Potonie & Kremp; Butterworth and Williams, Pl. 3, figs. 32-34.

1967 <u>Cingulizonates</u> cf. <u>capistratus</u>, Smith & Butterworth p. 261, Pl. 21, figs. 5, 6.

<u>Holotype</u> Staplin & Jansonius 1964

<u>Diagnosis</u> See description in S. and B. p. 261.

<u>Description</u> Spores trilete, cingulate with cuesta. Amb irregular but roughly circular to sub-circular, occasionally sub-triangular. Laesurae indistinct usually extending to inner margin of cingulum. Central area weakly to strongly foveolate. Cingulum occupies approximately 30% to 50% of spore diameter. Outer margin of cuesta very irregular, thin bars of thickening radiating in an irregular fashion over outer flange. Inner thickened part of cingulum with radiating bars also. Outer flange frequently appears to contain vacuoles which may be irregularly enlarged by corrosion. Size range 42 μ to 57 μ overall diameter.

<u>Remarks</u> This species is distinguished from the type species by its foveolate central area. It was found to be extemely common and its possible importance in recognising the onset of Namurian sedimentation is detailed in ~~warranted the separate study below.~~ chapter 5. Briefly, the present author feels that this species may be a polygenetically derived type from corrosion effects on different original species.

<u>Occurrence</u> Below Orebank Sandstone to First Sandstone.

<u>Previous records</u> Numerous authors have recorded this species since Smith and Butterworth, 1967, the closest geographically being Marshall and Williams 1971, Yoredales, Northumberland; Neves et al. 1973 Scotland and N. England.

Cingulizonates loricatus (Loose) Butterworth and Smith (in Butterworth et al. 1964) Pl. 12, fig. 7.

1932 Sporonites loricatus Loose in Potonie, Ibrahim & Loose, p. 450, Pl. 18, fig. 42.

1934 Zonales - sporites loricatus Loose, p.151

1944 Denosporites 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 112, a (ur). Size in range 70-80 μ, S. and B., 36 μ-48 μ.

Type Locality Bismarck Seam, Ruhr Coalfield, Germany; Upper Westphalian A.

Diagnosis In Potonie and Kremp 1956, p. 119, translation in S. and B. p.262

Description Spores trilete, cingulate. Amb rounded triangular to circular. Laesurae indistinct to distinct occasionally flexuose extended to inner margin of cingulum. Central body thin, light, unornamented. Cingulum with marked cuesta which is eneven in outline and appears striated. Size range 32(43)49 μ. (15 specimens) Holotype in range of 70 to 80μ S.& B. range 36 to 48.

Remarks This species is very similar to C. bialatus but was distinguished from it by the nature of the cingulum which in the present study was observed to be rather more striate than C. bialatus. This feature is not regarded as diagnostic by S. and B. who remark that the two species may overlap. C. loricatus was also found to occur higher in the sequence than C. bialatus in the present study.

Occurrence Second Sst. to Westphalian L. Coal Measures (rare at first).

Previous records This species has been recorded by numerous authors from Carboniferous sediments.

Genus Kraeuselisporites (Leschik 1955) Jansonius 1962

Type species K.

Diagnosis Jansonius 1962.

Kraeuselisporites echinatus Owens 1963
Pl. 12, fig. 14, 15.

1963 Kraeuselisporites echinatus, Owens, p. 226

Holotype Owens 1963

Type location Argill beck, Stainmore. Namurian A (E).

Diagnosis Owens 1963 p. 226.

Description Trilete spores. Amb sub-triangular. Laesurae, labrate, distinct to indistinct, extend to margin of central body. Exine punctate or infra punctate over central area. Distal surface ornamented with elongate spinae from 4 µ to 15 µ long and 2 µ to 5 µ wide at base. Flange thin, membranous with radially arranged fibrous ribs. Size range 67 µ to 100µ (20 specimens)

Remarks The present specimens correspond very well with the description of Owens 1963 (unpublished thesis). Neville 1968 has also described a very similar species, K. sp. A., which may be conspecific, with the present species. However the present species resembles that of Owens rather more closely than that of Neville, for example, the spinae are wider at their bases on the latter species. K. sp. A., Neville has yet to be described formally, according to Neville 1968, p. 452, in a future publication by Owens.

Genus Densosporites (Berry) Butterworth, Jansonius, Smith and Staplin 1964.

Type species D. covensis Berry 1937

Diagnosis Butterworth, Jansonius, Smith and Staplin 1964, p. 101.

Densosporites anulatus (Loose) Smith & Butterworth 1967
Pl. 11, fig. 1D, 1E.

1932 Sporonites anulatus Loose in Potonie, Ibrahim & Loose p. 451, Pl. 18, fig. 44.

1934 Zonales-sporites (anulati-sporites)anulatus Loose p. 151

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

1950 Denso-sporites reynoldsburgensis Kosanke p.33,Pl.6,figs 9-11

1956 Anulatisporites anulatus (Loose);Potonie & Kremp p.112,Pl.17 figs 365-72.

1967 Densosporites anulatus (Loose)Smith & Butterworth p.239,Pl.19 figs 5,6

Holotype Potonie and Kremp 1956, Pl. 17, fig. 365, after Loose.
Preparation 111 31, b (M/or). Size 37.5 μ.

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

Diagnosis Potonie and Kremp 1956, p. 112.

Description Trilete, cingulate spores circular in outline very indistinct suturae. Central area thin usually laenigate but occasionally showing fine sculpture, or infra sculpture, sometimes folded in a single fold adjacent to the inner margin of cingulum. Cingulum dense, thick, unornamented generally, although small spinae have been observed at the margin. Cingulum 50% diameter of spore, very gently tapered to margin.

Remarks Spores generally conform to diagnosis. Exoexine in proximal central region occasionally possessed infra sculpture not mentioned by Smith and Butterworth, also this thin exoexine sometimes becomes folded as described above. This feature is characteristic in D. vulgaris, Neves (1961), however the present specimens do not appear to possess a proximal thickening in the contact areas so have been retained in D. anulatus.

No apical papillae were observed in the present study as described in Smith and Butterworth 1967, p. 239.

The species was distinguished from D. pseudoangulatus, Butterworth and Williams, by the entire nature of the cingulum as opposed to the fractured nature of the cingulum in the latter species, and slightly smaller overall size.

Occurrence Seventh Lst. to Lower Coal Measures.

Previous records Loose 1932 and 34 Ruhr Coalfield; Potonie and Kremp 1956, Mid. West. B. to Mid. C. Ruhr; Dybova and Jachowicz 1957, Namurian A. to Westphalian D upper Silesia; Jachowicz 1958, Namurian B Upper Silesia; Neves 1959 M.S. Namurian B. to Westphalian A. S. Pennines (in Mishell 1966); Smith 1960 Lower Coal Measures Durham; Bharadwaj and Venkatachala 1961 Lower Carboniferous Spitzbergen; Hughes and Playford 1961 Lower Carboniferous; Sullivan 1962, Westphalian A - B,S.Wales; Playford 1962, Lower Carb. Spitzbergen;

Owens 1963 M.S. Namurian A - Lower Westphalian B, Stainmore; Love and Neves 1963, Upper Westphalian B, Inninmore, Scotland; Neves 1964, Namurian A - Mid. Westphalian A, La Comocha, Gijou, Spain; Mishell 1966, Namurian A - Westphalian A; Bowland; Smith and Butterworth 1967, Visean to Lower Westphalian C, British Coalfields; Marshall and Williams 1970, Visean and Namurian Northumberland; Loboziak 1969, Namurian - Westphalian, France.

Densosporites horridus sp.nov.
Pl. 12, fig. 1,2,3,4.

Holotype Sample 755 97.5/11

Type locality Lower Coal Measures, Gill Gooden, Cumberland.

Diagnosis Subtriangular, trilete, cingulate miospores. Cingulum slightly tapered, margin serrerated with large cones. Central area thin, laesurae not clearly evident.

Description Amb approximately sub-triangular, but very irregular due to ornament. Cingulum very thick, not tapering much, outer margin deeply serrated by large short spines or cones, up to 6 μ long and 4 μ wide at the base, about 10 large elements project at amb. Cingulum approximately 15 μ wide. Central area thin, sometimes ornamented with verrucae, about 2.5 μ in diameter, also in this region the exine is (densly) foveolate or punctate. Size range 46 μ to 51 μ. (17 specimens).

Occurrence Lower Coal Measures. Gill Gooden, N.W. Cumberland.

Remarks This species does not readily fit into described species of Densospores. The ornament is too coarse for D. spinifer. The marked cingulum present on the observed specimens allows the placing in this genus. Cristatisporites differ in having cristate ornament over the cingulum and central area.

Densosporites pseudoannulatus Butterworth & Williams 1958

1958 Butterworth and Williams Pl. 19, fig. 11.

Holotype Pl. 19, fig. 11. Preparation T59/1 collection of N.C.B. Laboratory Wath-upon-Dearne. Size 45 μ.

Type locality Seam at 2082 ft. 2 ins. Righead borehole, West Fife Coalfield, Scotland; Namurian A.

Diagnosis In Smith and Butterworth 1967.

Description Trilete spores, circular to irregular in outline, cingulum approximately 1/2 spore diameter margin interrupted by small fractures extending up to 2/3 into cingulum. Central area very thin, ornament not observed. Size 36 µ to 43 µ. (15 specimens).

Occurrence Base of Fourth Lst. to Second Sst.

Remarks The spores were assigned to this species due to

the presence of small marginal fractures in the cingulum. Spinose ornament was not generally observed, as found by Butterworth and Williams 1958.

Previous records Butterworth and Williams 1958, Namurian A Scotland; Smith and Butterworth 1967, Visean and Namurian.

Densosporites triangularis Kosanke 1950
Pl. 12, fig. 8.

1950 Densosporites triangularis Kosanke p.34,Pl.7,fig. 1

1958 Densosporites spongeosus Butterworth and Williams p. 380, Pl. 3, figs. 40,41.

Holotype Kosanke 1950, Pl. 7, fig. 1. Preparation 144, slide 3. Size 58.8u.

Type locality 'Sub-Babylon' Coal, Fulton County, Illinois, U.S.A.

Diagnosis Kosanke 1950, description.

Description Trilete spores with subtriangular amb. Laesurae indistinct, central area thin, light in colour, the distal central area often slightly foveolate or granulate. Cingulum large often 60% or more of spore diameter, smooth margin proximal and distal surfaces often have small spinae or cristae. Inner margin of the cingulum contains sub-triangular arrangement of vacuoles approximately 2/3 of cingulum width from equatorial margin. Size range 42 µ to 56 µ (20 specimens).

Remarks Generally spores assigned to this species conform to original diagnosis. The vacuoles are variable in size and shape in different specimens, from small and almost circular to very elongate, and sometimes multiple and complex cavities can be formed by adjacent vacuoles impinging on each other. The degree of corrosion of the spores seems to affect the degree of vacuolization in the present author's opinion. (see also Cingulizonates cf. capistratus).

Occurrence Seventh Lst. to Second Sst.

Previous records Kosanke 1950, Pennsylvanian; Butterworth and Williams, 1958, Scotland Lst. Coal Gp. Lower Carboniferous; Smith and Butterworth 1967, Visean and Namurian; Peppers 1970, Pennsylvanian, Illinois, U.S.A.

Densosporites spinifer Hoffmeister, Staplin & Malloy 1955. Pl. 11, fig. 12,13.

1955 Densosporites spinifer H. S. and M. p. 386.

Holotype Hoffmeister, Staplin and Malloy 1955, Pl. 36, fig. 17, TCO-82 Preparation 3, ser. 19,066.

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

Diagnosis Description in H. S. and M. 1955, p. 386.

Description Cingulate, trilete spores. Amb sub-triangular to sub-circular, very irregular. Laesurae usually indistinct, extend almost to inner margin of cingulum. Cingulum very broad, 50% of spore radius, inner margin clearly defined, outer margin deeply spinose, oftem more exaggerated on 1/2 of equatorial outline perhaps due to compression. Spinae up to 5 μ high but broad based and merging with adjacent elements forming a generally ragged appearance. Size range 38 μ to 47 μ. (20 specimens).

Remarks Many specimens of this species were observed during the present study most of which conform to the extreme end of the ornamental range described by H. S. and M. and as illustrated by these authors, Pl. 37, fig. 17. H. S. and M. also illustrate D. type A. which to some extent resembles the present species.

Occurrence Seventh Limestone to Second Sandstone.

Previous records Numerous authors have recorded this species from Lower and Upper Carboniferous, sediments.

Incertae sedis

Species A

Plate 14. fig. 12 13 14.

Holotype 373 D 87.4 - 7.9

Location Basement beds, Carboniferous, Redmain, Cumberland.

Description Trilete camerate spores. Amb sub-circular to sub-triangular. Exoexine thin coarsely infra punctate occasionally apparently granulate often uneven in shape with periphery tending to fold over giving a dark halo. Cameration 1 to 2.3 μ more or less regular. Laesurae distinct with labra dark, 2/3 to 3/4 spore radius, slightly flexuose. Intexine outline conform to amb approximately thin. Often a lighter region adjacent to periphery of central body. Size range 32 μ to 42 μ overall diameter (36μ) Intexine diameter 30 μ to 38 μ. (15 specimens).

Remarks This species superficially resembles Aurorospora macra in its infra punctate exoexine and camerate structure but has much more prominent laesurae. Lycospora tenebricosa, Staplin, is similar to this species but apparently differs in possession of a flange or cingulum and thick central body. The present author has distinguished species A from lycospora by its camerate nature, however it maybe synonomous with L. tenebricosa.

Occurrence Upper part of Basement beds.

Genus Colatisporites Williams 1973

Type species C. decorus (Bharadwaj & Venkatachala) Williams.

Diagnosis In Neves et al. 1973, p. 40.

Colatisporites sp. A.

Pl. 13, fig. 12.

Description Spores trilete, camerate. Amb circular to sub-circular, laesurae indistinct, approximately 3/4 spore radius, simple, straight. Exoexine strongly infra punctate. Intexine indistinct, follows equatorial outline, cameration 1 μ to 3 μ. Size range 22 μ to 30 μ. (4 specimens).

Remarks These spores conform to the diagnosis of C. decorus with the exception of their size which falls well below the minimum quoted in Neves et al. 1973.

Occurrence Basement beds.

Colatisporites decorus (Bharadwaj & Venkatachala) Williams 1973. Pl. 14, fig. 5, 6.

1961 Tholisporites decorus Bharadwaj & Venkatachala p.39, Pl.10 fig.142 to 146.
1973 Colatisporites decorus (B & V) Williams.

Holotype Bharadwaj and Venkatachala 1961, pl. 10, fig. 142. Size 52 μ.

Type locality Pyramidenberg Spitzbergen, Lower Carboniferous.

Diagnosis Williams in Neves et al. 1973, p. 41.

Description Trilete spores, circular to sub-circular in outline, trilete mark not very prominent, usually straight, simple, 3/4 spore radius approximately. Amb often flattened at radial positions. Cameration variabble in any one specimen, mostly indistinct. Infra punctation variable in strength among specimens. Size 40 to 52 μ.

Remarks The spores generally conform to the original diagnosis. Flattening of the amb at radial positions was not observed by Neves et al. 1973. Several specimens were observed in which the double nature of the exinal structure was clearly seen due to splitting of the exoexine. The intexine was often of slightly darker colour. The infra punctation varied from weak to very strong and some specimens have the appearance of the genus Schulzospora.

Occurrence Basement beds up to Sixth Limestone.

Previous records Bharadawaj and Venkatachala 1961, Lower Carboniferous, Spitzbergen; Neves et al. 1973 Lower Carboniferous CM to VF zones.

Colatisporites cf. decorus (Bharadwaj & Venkatachala) Williams 1973.

Description Trilete camerate spores. Amb circular to sub-circular, laesurae straight, often indistinct 3/4 radius of spore. Intexine indistinct cameration narrow but conformable with amb. Exoexine infra punctate and folded, and ornamented with widely separated narrow verrucae or baccula.

Size range 39 µ to 49 µ.

Remarks The specimens conform to the diagnosis of C. decorus with the exception of the dispersed ornament. The ornament may be blobs of resin adhering to the exoexine, although this was not verifiable. The significance of the type is not condidered to be of importance by the present author owing to the small number of specimens observed.

Occurrence Basement beds. Very rare.

Colatisporites denticulatus Neville 1973
Pl. 14, fig. 7.

1961 Tholisporites cf. decorus Bharadwaj & Venkatachala p. 39, Pl. 10, fig. 142-6.

1973 Colatisporites denticulatus Neville, in Neves et al. p. 41, Pl. 2, figs. 14-16.

Holotype ML912,A3 Pl. 14 in Neves et al. 1973. Size in range 43(59)72µ.

Type location Sample A3. 1½" coal at a depth of 11' 7" in the Anstruther borehole, Scotland.

Diagnosis P. 41 in Neves et al. 1973.

Description Spores trilete, camerate. Amb circular to sub-circular. Trilete rays indistinct but straight, simple, extending approximately 3/4 of spore radius. Degree of cameration occasionally indistinct. Exoexine ornamented with very closely set spinae, bacula, and possibly coni all of very low dimension, up to 2 u. Exoexine infra punctate, ornament less developed over the proximal surface. Intexine indistinct, appears to follow the shape of the exoexine with a camaration of up to 8 u. Overall size range of spores 37 µ(54)61 µ. (15 specimens).

Remarks Spores conform well to original diagnosis. The nature of the ornament was often difficult to observe, as was the limits of the intexine. Clayton (1971) distinguished Apiculiretusospora multiseta (Luber) Butterworth and Spinner 1967 by its acamerate nature and the presence of curvaturae. However some specimens observed in the present study displayed indistinct curvaturae, and this feature is remarked on in Neves et al. 1973.

Also the cameration was frequently very indistinct in specimens observed in the present study, therefore the two species may need to be closely compared if found in juxtaposition.

Occurrence Basement beds up to between Seventh and Sixth Limestones. Infrequent to frequent.

Previous records Bharadwaj and Venkatachala 1961, L. Carb. Spitzbergen; Neves and Ioannides (in press), Spilmersford, Scotland. L. Carb; Clayton 1971, Scotland, L. Carb; Neves et al. 1973, S.Scotland, L. Carb.

Turma Monoletes Ibrahim 1933

Suprasubturma Acavatomonoletes Dettmann 1963

Subturma Azonomonoletes Luber 1935

Infraturma Laevigatomonoletes Dybova and Jachowicz 1957

Genus Laevigatosporites Ibrahim 1933

Type species L. vulgaris Ibrahim 1933

Diagnosis Potonie and Kremp 1954, p. 165 translation in Smith and Butterworth 1967, p. 281.

Laevigatosporites desmoinesensis (Wilson and Coe) Schopf, Wilson & Bentall 1944. Pl. 14 fig. 1

1940 Phaseolites desmoinesensis Wilson & Coe. p. 182, Pl. 1, fig. 4.

1944 Laevigatosporites desmoinesensis (Wilson & Coe) Schopf, Wilson and Bentall, p. 37.

Holotype W. and C. 1940. Pl. 1, fig. 4. Size range 60 μ to 75 μ.

Type location Des Moines Series of Iowa

Diagnosis W. and C. 1940 p. 182.

Description Monolete spore with oval to reniform outline. Exine laevigate, laesurae 2/3 length of spore, simple, straight. Size range 60 μ to 80 μ. (8 specimens) Holotype in range 60 to 75 μ.

Remarks Smith and Butterworth 1967 incorporate L. vulgaris, Ibrahim, and

L. desmoinensis in one species. However several authors have since continued to use the separate taxa e.g. Peppers (1970). Whilst there is probably little difference between the two species the size range given for L. vulgaris was greater than that of L. desmoinensis, and L. medius Kosanke, is smaller.

Occurrence Seventh Limestone to First Limestone.

Previous records Many authors have recorded this species. Butterworth and Williams found it rare in Nam. A. Scotland, Sullivan and Marshall 1966 recorded it from U. Visean, Scotland and Peppers 1970 from Penn. Illinois.

Laevigatosporites minimus (Wilson & Coe)
Schopf, Wilson and Bentall 1944. Pl. 14, fig. 2.

1940 Phaseolites minimus Wilson & Coe, p. 183, Pl.1, text-fig. 5

1944 Laevigate-sporites minimus (Wilson & Coe); Schopf, Wilson and Bentall, p. 37.

Holotype Wilson 1958, Pl. 1, fig. 5 after Wilson and Coe (1940) Preparation 121P. Size 25 µ.

Type locality What Cheer Clay Products Company Mine, What Cheer, Keokuk County, Iowa, U.S.A., Des Moines Series.

Diagnosis In Schopf, Wilson and Bentall 1944, p. 37.

Description Monolete spore, amb oval, outline smooth, laesurae straight, simple 1/2 spore length. Size range 27 µ to 36 µ.

Remarks L. minor, Loose, is similar but larger (40µ to 70µ, Loose); however several specimens recovered during the present study could have been placed in that group on account of their more elongate outline. Punctatosporites minutus, Ibrahim, has fine grained sculpture as has Fabasporites pallidus, Sullivan, which also lacks a monolete suture.

Occurrence Second sandstone to first sandstone.

Previous records Schopf, Wilson and Bentall 1944, Wilson and Coe 1940, Upper Carb. U.S.A; Smith and Butterworth 1967 West. Britain; Mishell Nam.A to West. A Bowland.

Infraturma Sculptatomonoletes Dybova & Jachowicz 1957

Genus Punctatosporites Ibrahim 1933

Type species P. minutus Ibrahim 1933

Diagnosis Potonie and Kremp 1954, p. 165, translation in Smith and Butterworth, p. 287.

Punctatosporites minutus Ibrahim 1933

1933 Punctatosporites minutus Ibrahim p.40,Pl.5,fig.33.

Holotype Ib. 1933, Pl. 19, fig. 439, Preparation A45,al(o) Size 25.5 u.

Type location Agir Seam, Ruhr Coalfield, Germany, Top West. B.

Diagnosis P. and K. 1956, p. 143 translation in Smith & Butterworth 1967 p. 288.

Description Small monolete spores, amb oval, laesurae short, straight, simple, 1/2 spore length. Exine ornamented with small grana. Size 23μ & 25μ.

Remarks Only two specimens of this species were observed in the present work.

Occurrence Lower Coal Measures.

Previous records Numerous authors have recorded this species from Upper Coal Measures.

Turma Plicates (Plicata Naumova 1937,1939)
Potonie 1960.

Subturma Praecolpates Potonie and Kremp 1954

Genus Schopfipollinites Potonie & Kremp 1954

Type species S. ellipsoides (Ibrahim) Potonie & Kremp 1954

Diagnosis Potonie and Kremp 1954, p. 180, translation in Smith and Butterworth 1967 p. 309.

Schopfipollinites ellipsoides (Ibrahim) Potonie & Kremp 1954
Pl. 13, fig. 10.

1932 Sporonites ellipsoides Ibrahim in Potonie, Ibrahim & Loose
p. 449, Pl. 17, fig. 29.

1933 Laevigato-sporites ellipsoides Ibrahim p.40,Pl.4,fig.39

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 & Kremp p.180

Holotype Potonie and Kremp 1956, Pl. 27, fig. 478 after Ibrahim. Preparation E55 a. Size 350 µ.

Type locality Agir Seam, Ruhr Coalfield, Germany; top of Westphalian A.

Diagnosis P & K 1956, p. 184 translation in S. & B. p. 310.

Description Spores monolete. Amb oval, suture 3/4 length of long axis, curved prominent. Surface of exine laevigate but patchy in appearance. Size 170µ to 210 µ long. (11 specimens).

Remarks This species was distinguished from S. ellipsoides var. corporeus by its lack of a visible inner body.

Occurrence Upper part of Hensingham group

Previous records Love and Neves 1964, West. B. Inninmore, Scotland; Neves 1964 Nam. A to West. A, La Camocha, Spain; Mishell 1966 Upper Nam.A West,A Bowland; Owens and Burgess 1966, Nam. and West. Stainmore; Marshall and Williams 1971, Nam. Northumberland; Neves and Belt 1971 Nova Scotia; Sabry and Neves Westpahalian Scotland.

Anteturma Pollenites Potonie 1931

Turma Saccites Erdtman 1947

Subturma Monosaccites (Chitaley)Potonie & Kremp 1954

Infraturma Aradiates Bharadwaj 1957 a

Genus Florinites Schopf, Wilson & Bentall 1944

Type species F. pellucidus (Wilson & Coe 1940) Wilson 1958 (?synonym of F. mediapudens (Loose) Potonie and Kremp).

Diagnosis abbreviated from Schopf, Wilson & Bentall 1944,p.56.

Florinities mediapudens (Loose) Potonie & Kremp 1956
Pl. 13, fig. 2.

1934 Reticulata-sporites mediapudens Loose, p.158, Pl. 7, fig. 8

1956 Florinites mediapudens (Loose); Potonie & Kremp, p.169, Pl.21 figs 468-71.

1957 Endosporites mediapudens (Loose); Dybova & Jachowicz, p. 207, Pl. 71, fig. 4.

Holotype P. and K. 1956. Preparation 1114, b4 (o), (Loose) Size 60 μ.

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

Diagnosis From P. and K. 1956, p. 169, in Smith and Butterworth 1967 p.303.

Description Pollen monosaccate. Amb approximately oval to sub-circular. Exoexine thin, infra granulate and infra reticulate, not often folded. Central body frequently shows folding of its central part, darker than saccus, relatively small, approximately circular, occupying about 30% to 40% of overall dimension. Separation between central body and saccus less on short axis than long axis, often imparting a pseudo-bisaccate appearance. Size range 37 μ to 60 μ long and 30 μ to 50 μ wide overall dimension, central body 15 μ to 34 μ diameter. (20 specimens).

Remarks Specimens recovered during the present study conform to previous descriptions. The species was distinguished from F. similis by its smaller size, feinter central body and relatively coarser infra reticulation of the saccus.

Occurrence Top Hensingham Group into Coal Measures.

Previous records Loose 1934, Potonie and Kremp 1956, West. Germany, Sullivan 1962, West. B. S. Wales; Love and Neves 1964 West. B. Scotland; Owens 1963, Nam. A - L. West. B, Stainmore; Neves 1964, La Camocha, Spain; Mishell 1966 West A. Bowland; Peppers 1970, Penn., U.S.A.; Smith and Butterworth 1967, West. Britain.

Florinites millotti Butterworth & Williams 1954
Pl. 13, fig. 3.

1954 Florinites millotti, B and W, p. 760, Pl. 26, fig. 9.

Holotype Pl. 26, fig. 9. Specimen no. PF3013 (formerly 76490), Geological

Survey Museum, London. Size 37 µ x 29 µ.

Type location Bottom 1 ft. 4 ins. coal at 3,388 ft. 2 ins., Upton borehole, Oxfordshire, England; West. D.

Diagnosis B. and W. 1954, p. 760.

Description Pollen, monosaccate. Amb oval to sub-circular. Exoexine infra reticulate, thin, sometimes folded; central body indistinct but oval, long axis parallel to short axis of saccus. Size 25 µ 30 µ 34 µ.

Remarks The three specimens recovered in the present study were distinguished by their small size and indistinct central body. Loboziak 1969 observes that F. minutus, Bharadwaj, differs in having a more obvious central body.

Occurrence Lower Coal Measures.

Previous records Love and Neves 1964, West. B; Spinner 1966, West. D. England; Sullivan 1962 West. C. S. Wales; Loboziak 1969, U. Nam. - West., France.

Florinites pumicosus (Ibrahim) Schopf, Wilson & Bentall 1944
Pl. 13, fig. 6.

1932 Sporonites pumicosus Ibrahim in Potonie, Ibrahim & 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 & Waltz, Pl. 8, fig. 110.

1944 Florinites ?pumicosus (Ibrahim); Schopf, Wilson & Bentall p.59

Holotype P. and K. 1955, Pl. 21, fig. 472. Preparation B34 d 4(U). (Ibrahim). Size 92.5 µ.

Type location Agir Seam, Ruhr Coalfield, Germany; top of West. B.

Diagnosis P. and K. 1956, p. 169, in S. and B. p. 305.

Description Pollen monosaccate. Amb oval. Exoexine coarsely infrareticulate occasionally folded. Central body apparently lacking but lighter area visible centrally. Size range 57 µ to 74 µ long.

Remarks This species was distinguished by its coarse infrasculpture and by its apparent lack of a central body. F. visendus (Ibrahim) Schopf Wilson and Bentall is larger.

Occurrence Lower Coal Measures.

Previous records Numerous authors have recorded this species from the Upper Carbonfierous, notably Spinner 1966, Woodbury Hill, West. D?; Sullivan 1962, West. B - C. South Wales; Kalibova 1964 Steph. A. Pilzen Basin; Jachowicz 1966 West A. Lublen Basin; Mishell 1966, West. A. Bowland; Loboziak 1969, U. Nam. - W.C. France.

Florinites similis Kosanke 1950

Pl. 13, fig. 1

1950 Florinites similis Kosanke p. 49, Pl. 12, fig. 2.

Holotype Kosanke 1950, Preparation 524-C, slide 2.

Type locality No. 8, Coal, Peonia County, Illinois, U.S.A; McLeansboro Gp.

Diagnosis Description in K. 1950, p. 49.

Description Pollen, monsaccate. Amb oval, rounded, outline slightly rough. Exoexine often folded, thin, strongly infrapunctate and infra reticulate. Central body dark, circular to oval, sometimes folded, occupies more or less central position usually and about 35% to 50% of diameter of exoexine. Size range 95 μ to 120 μ long, overall dimension, body 45 μ to 70 μ (20 specimens).

Remarks The specimens recovered during the present study conform closely to the diagnosis and descriptions. The species was distinguished from L. mediapudens, (Loose) Potonie and Kremp, by its larger size and from from F. visendus (Loose) Schopf, Wilson & Bentall, and F. pumicosus (Ibrahim) Schopf, Wilson and Bentall, by the obvious presence of a central body. This species only becomes abundant in Lower Coal Measure rocks.

Occurrence Upper part of Hensingham Group into Lower Coal Measures.

Previous records Many previous workers have recorded this species, notably:- Sullivan 1962, West. A - B, Wernddu Claypit, S. Wales; Owens 1963, Upper Nam. A - L. West. B. Stainmore; Love and Neves 1964, U. West. B, Scotland; Neves 1964 Nam. B - U. West A., La Camocha, Spain; Mishell 1966,

U. Nam. - West., France; Peppers 1970, Penn. U.S.A.

Florinites visendus (Ibrahim) Schopf, Wilson & Bentall 1944

1933 Reticulata-sporites visendus, Ibrahim p.39,Pl.8 fig.66

1944 Florinites ? visendus (Ibrahim); Schopf, Wilson & Bentall p.60

Holotype P. and K. 1956, Pl. 21, fig. 477. Preparation E29.06 (ur) (Ibrahim) Size 165 µ.

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

Diagnosis P. and K. 1956 p. 170. In S and B 1967, p. 306.

Description Pollen monosaccate. Amb oval. Exoexine infrareticulate sometimes folded. Central body not apparent although frequently a lighter area is visible centrally. Size range 100 µ to 110 µ. Holotype 165 µ.

Remarks The larger size and apparent lack of central body distinguish this species.

Occurrence Lower Coal Measures.

Previous records Numerous authors recorded this species notably, Mishell 1966, Nam. - W.A.; Spinner 1966 Woodbury Hill West. D., Jachowicz 1966, W.A. - D., Basin of Lublim.

Incertae sedis

Genus Biannulatisphaerites Neville 1973

Type species B. simplex Neville 1973

Diagnosis In Neves et al. 1973, p. 40.

Biannulatisphaerites simplex Neville 1973

Pl.14. fig.11.

1973 Biannulatisphaerites simplex Pl.14,fig.3, Neville, in Neves et al. 1973 p.40,Pl.1,figs 1&2.

Holotype Neves et al. (loc. cit.) Pl. 1, fig. 1.

Type locality Sample F59. Upper of two seat-earths 50' below 1'2" ferruginous limestone exposed in the coast section between the fault in West Bay, Pittenweem and the fairway into Pittenweem Harbour, East Fife Coast.

Diagnosis In Neves et al. p. 40.

Description Spores alete. Amb circular, outline smooth. Exine laevigate two rings of thickening clearly defined one on each surface following equatorial outline approximately 4 µ wide. One small circular polar thickening approximately 3 µ to 5 µ diameter. Size range 20 µ to 35 µ.

Remarks This species is very easily recognised by its appearance, disinguished from *T. bianulatus* by being alete and having narrower bands of thickening.

Occurrence Sixth Limestone to Ninth Limestone.

Previous records Neves et al. 1973, L. Carb. Scotland, N. England.

Genus *Schulzospora* Kosanke 1950

Type species *S. rara* Kosanke 1950

Diagnosis Expanded from Kosanke 1950, p. 53.

Schulzospora campyloptera (Waltz) Hoffmeister, Staplin and Malloy, 1955. Pl. 13, fig. 10.

1884 No. 619 Reinsh, p.60, Pl. 22, fig. 231D

1938 *Zonotriletes campylopterus* Waltz in Luber & Waltz, p. 16, Pl.3 fig. 39 and Pl. A, fig. 15.

1955 *Schulzospora campylopterus* (Waltz); Ishchenko,p.94,Pl.12, figs. 160, 161.

Holotype Not given

Type locality Seam 46, Skakulin Colliery, Selizharovo, Moscow Basin.

Diagnosis In C.E.D.P. French translation number 14 43.

Description Spores trilete, monosaccate. Amb oval rounded and occasionally elongate. Laesurae indistinct. Exine of saccus infrapunctate often dark at borders of central body. Central body usually circular. Size range 47 u x 64u - 63 µ x 101µ. Overall diameter, 40 µ x 43 µ - 58 µ x 60 µ, central body. (10 specimens).

Remarks This species was distinguished by the dark region surrounding central body particularly on long axis edge. It is larger than *S.elongata*. Mishell (1966) suggested the size limit for the latter species should be 70 µ long. Present author does not feel this to be a reliable criterion owing to different processing techniques.

Occurrence Fourth Limestone into Hensingham Group.

Previous records Luber and Waltz 1938, Vis. Tourn. U.S.S.R; Hoffmeister Staplin and Malloy, 1955, U. Miss. U.S.A; Love 1960 U. Vis. Scotland; Owens 1963, Nam. A., Stainmore; Neves 1964, Nam. A, La Camocha; Sullivan and Marshall, U. Vis. Scotland; Mishell 1966, Nam. A - Nam. B.

Schulzospora elongata Hoffmeister, Staplin and Malloy 1955. Pl. 13, fig. 7.

1955 Schulzospora elongata H. S. and M. p. 396, Pl. 39, fig. 2

Holotype H. S. and M. 1955. Preparation 1, Ser. 15,800. Size 35 μ x 25 μ

Type locality 2, 072 ft., Carter No. 3 borehole (TCO-82), Webster County, Kentucky, U.S.A., Hardinsburg Formation, Chester Series.

Diagnosis Description in H. S. and M. 1955. p. 396.

Description Spores trilete monosaccate. Amb elongate oval. Intexine circular to oval, long axis parallel to long axis of saccus. Laesurae usually distinct, extend almost to margin of intexine, often gaping. Saccus infrapunctate, separated from intexine narrowly on short axis widely on long axis. Size range 40 μ x 74 μ 55 μ x 89 μ overall, holotype 60.8 μ x 30.5 μ; central body 36 μ x 37 μ - 45 μ x 50 μ.

Remarks This species was distinguished from other species of Schulzospora by its elongate shape.

Occurrence Sixth limestone to Third Sandstone.

Previous records Hoffmeister, Staplin and Malloy 1955, U. Miss. USA; Butterworth, Williams 1958, Nam. A., Scotland; Sullivan and Marshall 1966 U. Visean, Scotland; Mishell 1966, Nam. A. Bowland; Smith and Butterworth 1967 Vis. and Nam.

Schulzospora rara Kosanke 1950
Pl. 13, fig. 9.

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. 6

1958 Schulzospora ocellata (Horst) Potonie and Kremp; Butterworth and Williams Pl. 4, fig. 15. (1... ...

Holotype Kosanke 1950. Preparation 587, slide 8. Size 73.5 μ.

Type locality Battery Rock Coal, Hardin County, Illinois, U.S.A; Caseyville Group.

Diagnosis In Kosanke 1950, p. 53.

Description Spores trilete, monosaccate. Amb oval, often not symmetrical. Outline of saccus does not deviate greatly from that of body. Laesurae reasonably distinct, 2/3 of central body radius, appears to be attached proximally and distally. Saccus infrapunctate. Size range 47 μ x 53 μ - 60 μ x 89 μ. (20 specimens) holotype ,09.2 μ x 81.9 μ. Overall dimension 40 μ x 41 μ - 45 μ x 47 μ. Central body diameter.

Remarks This species of Schulzospora was recognised by its asymmetical ovoid outline and relatively small saccus compared with central body. The small size range compared with that of the type probably reflects the species sensitivity to alkali.

Occurrence Seventh Limestone to Lower Coal Measures.

Previous records Recorded by numerous authors including Kosanke 1950, Nam. - W.C. Illinois; Hoffmeister Staplin and Malloy 1955, U. Miss; Love 1960, U. Visean; Neves 1964 Nam. B - West. A; Felix and Burbridge, 1968, Miss. - Penn. Oklahoma.

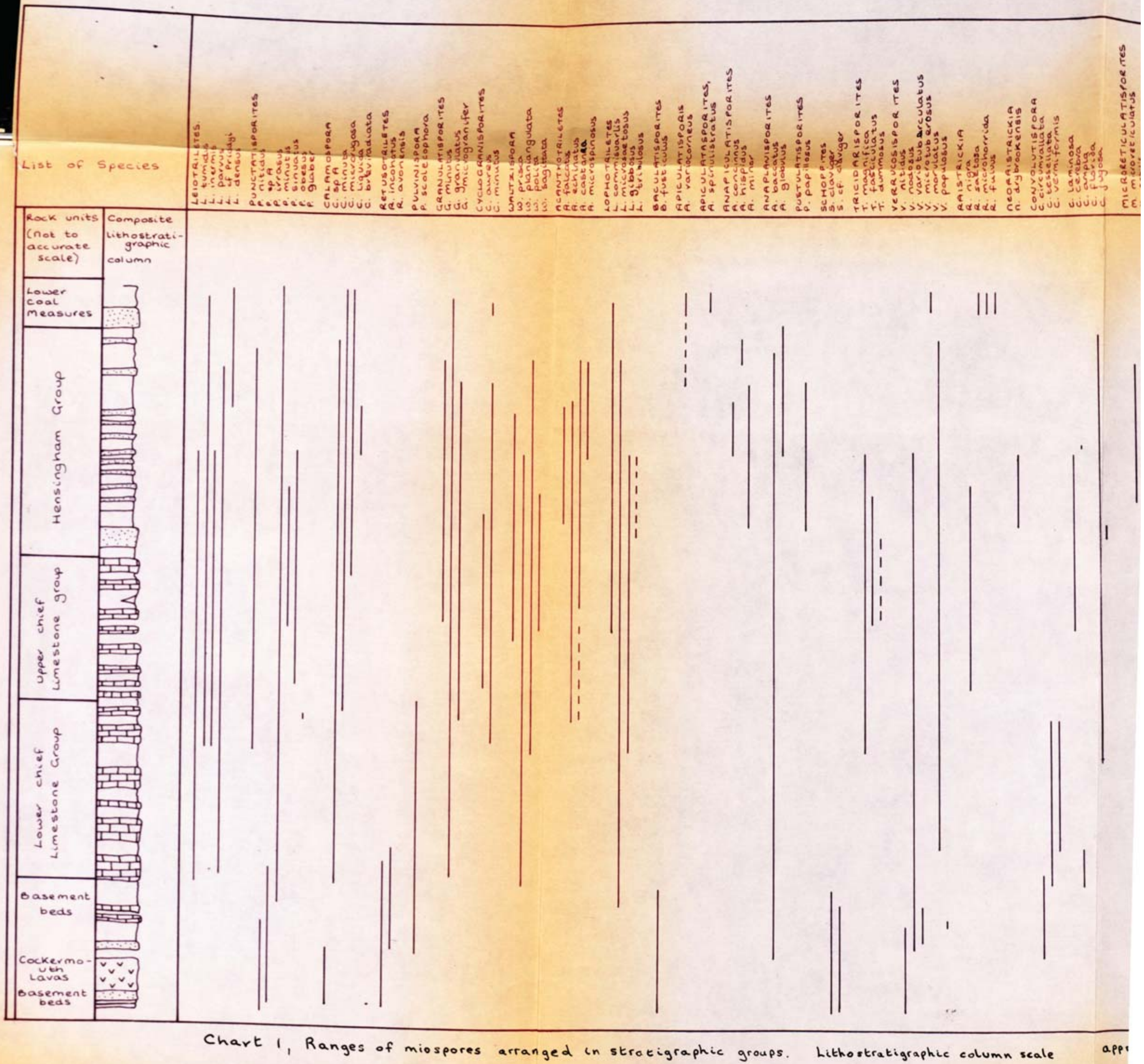
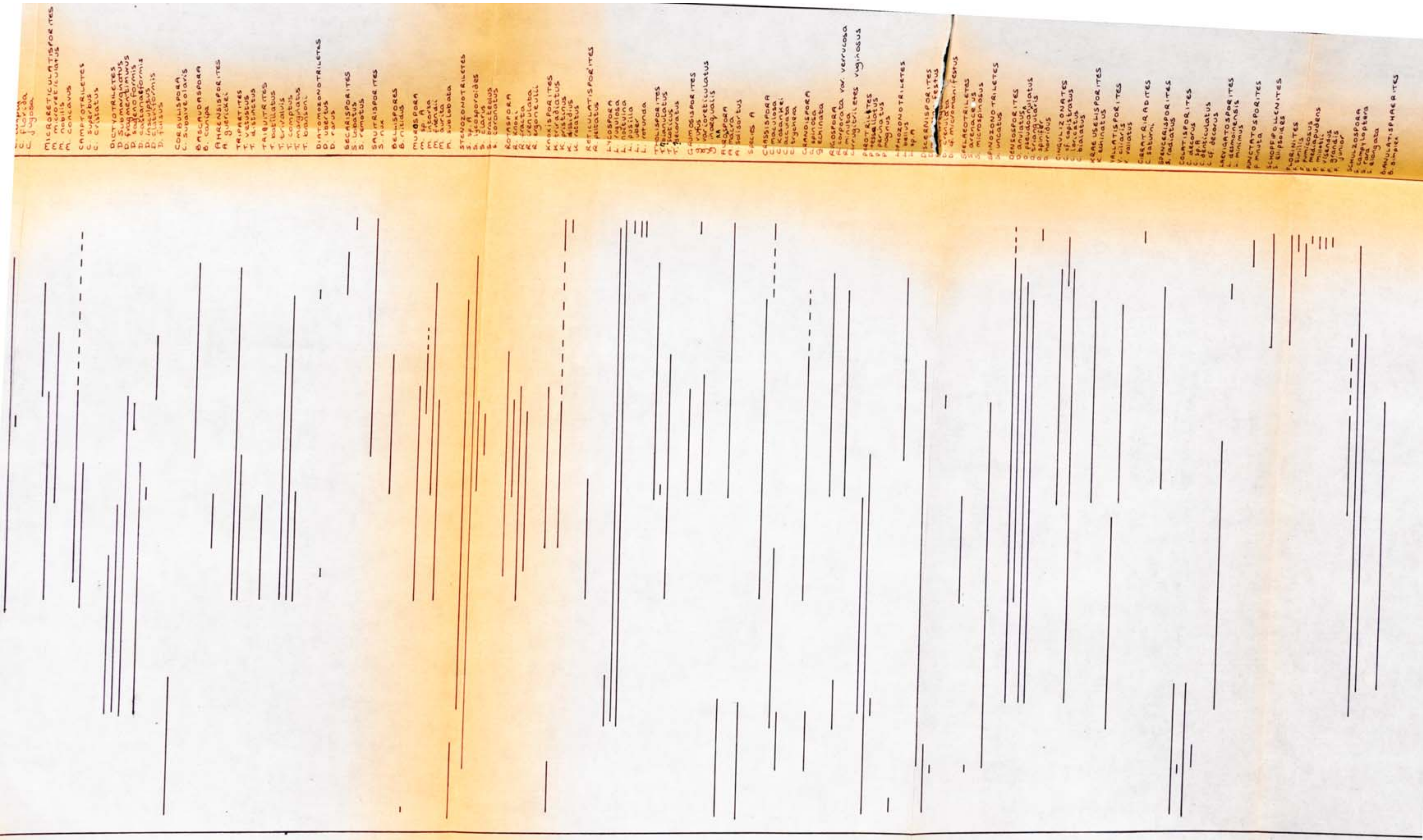


Chart 1, Ranges of miospores arranged in stratigraphic groups. Lithostratigraphic column scale appr



Approximate only (1 cm. = 15 m)

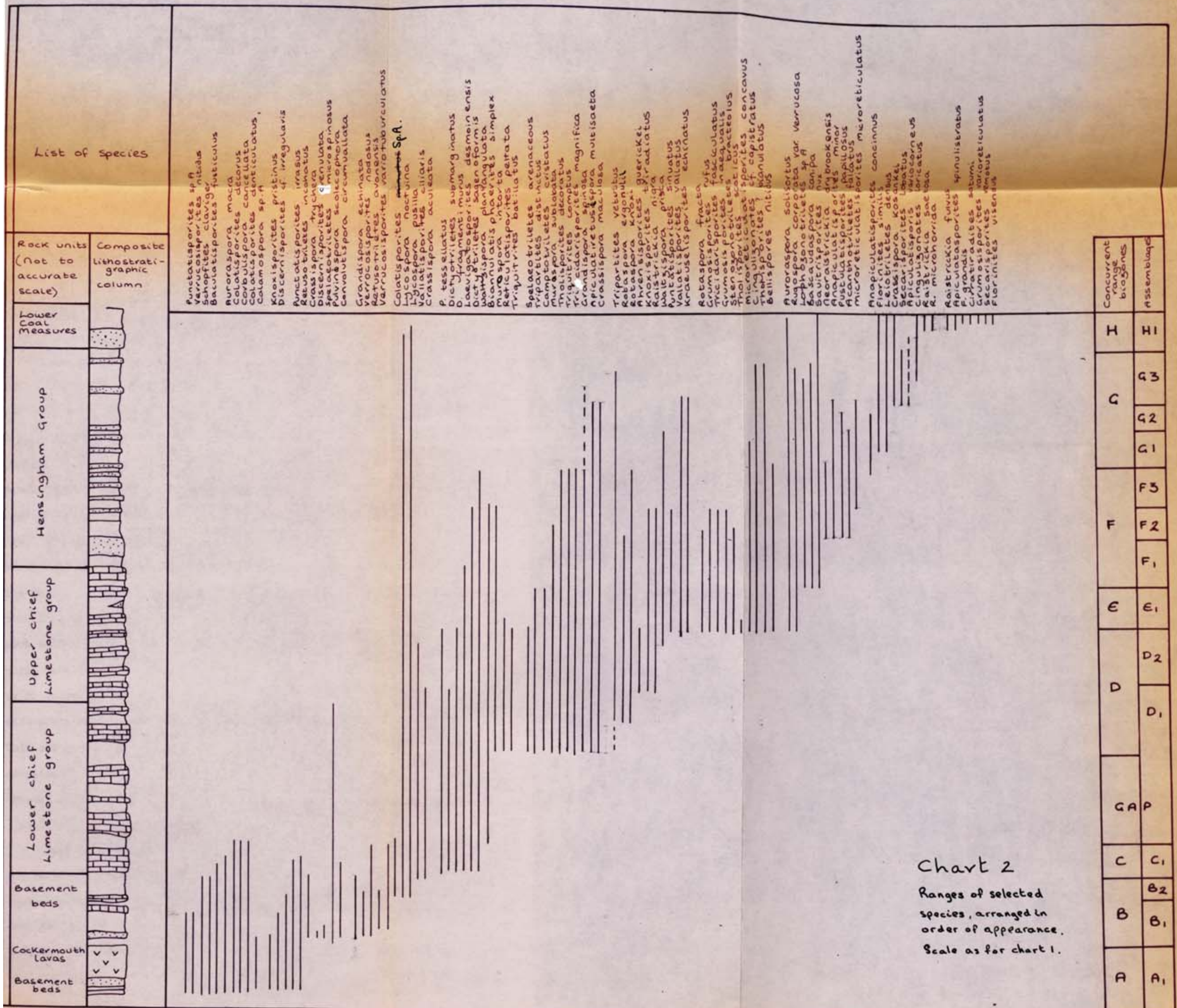


Chart 2

Ranges of selected species, arranged in order of appearance. Scale as for chart 1.

CHAPTER SEVEN

CONCLUSIONS

Preservation of miospores

Preservation of the miospore exines was generally poor in much of the strata investigated. In the Basement Group there are two main reasons for this, the high energy environment in which the macroclastic sediments formed, and the oxidation process which was responsible for the predominantly red colouration of the strata. The precise method of formation of the reddened beds here, and those higher in the sequence in Namurian and Lower Westphalian strata in the east of the area, is not clearly understood. However the effect is probably produced by an oxidising process either penecontemporaneously or during subsequent diagenesis. Whatever the cause, the effect on miospore exines is drastic. The exines cannot withstand oxidation and satisfactory preparations cannot be obtained from such sediments. This was found to be the case in reddened samples from the north eastern part of the area by the present author as well as previously by Butterworth (personal communication). As has been described above, this fact prevented palynological investigation of the Chalk Beck stream section. This section is quoted by Eastwood et al. (1968) as the location for the macrofossil evidence for the non-sequence at the top of the Hensingham Group.

Poor preservation of miospores within the Chief Limestone Group may possibly be accounted for by the presence of mineralisation. This occurs extensively to the west of the area (the West Cumberland iron-orefield) and it has been shown by previous workers (eg. Neves and Sullivan 1965, Wilson 1961 and 1971) that mineralisation precludes satisfactory palynological preparations.

In those samples which when processed provided 'mush clumps' the action of sapropeles is considered by the present author to have destroyed the spores. Those samples which provided a higher proportion of wood fragments, leaf cuticle and other undecayed organic matter, and no 'mush clumps', are presumed to represent strata deposited under conditions in which there was a paucity of palynomorphs.

In the preparation of rock samples for palynological analysis the present author concluded that it was preferable to use a basic, standard procedure for all samples. This procedure, which was described in Chapter 3, utilized the least number of steps and chemical reagents.

Stratigraphical conclusions

The miospores recorded during the present study have been grouped into assemblages. These conform to assemblage biozones of Harland et al. (1972) and consist of groups of species showing distinctive characteristics, and recovered from one or more horizons. (This use of the term 'assemblage' differs from that of some previous authors). The present assemblages have been arranged in eight concurrent range biozones, lettered from A to H. These are not intended to be equivalent to the concurrent range zones of Neves et al. (1972, 1973). (See figs. 11a, b and Table 2).

The Basement Group The basal beds of the Carboniferous in the area around Cockermouth have not previously been dated by fossil evidence. The results of the present study appear to indicate that these strata, both below the Cockermouth Lavas and above them, up to the horizon of the Cherty Limestone at Blindcrake, lie in the CM concurrent range zone of Neves et al. (loc. cit.). The assemblages in these strata have been compared with those from Scotland, Northern England, the Central Province of England, the Forest of Dean and, further afield, with those described from Spitzbergen.

It follows from this conclusion that the strata concerned are Tournaisian in age, probably approximating to the Z coral-brachiopod zone. It was assumed previously that these strata were of Visean age. The Cockermouth Lavas consist of about 100 metres of olivine basalts representing 'a somewhat coarse variety of Dalmeny type'. (Eastwood 1928 in Eastwood et al. 1968). They have approximately the same thickness and composition as the Birrenswark lavas of Dumfriesshire (Francis in Craig, 1965) with which, from the evidence of the present studies, they may be contemporaneous.

It follows from the above that the northern flank of the Cumbrian Massif was submerged earlier than was previously considered. The approximate dating of this event (Z coral-brachiopod zone times) would be consistent with Ramsbottom's (1974) first cycle. The vertical, and probably lateral extent of these deposits is limited, indicating that the transgression was of only minor, and possibly local, significance. The necessary adjustment to the limit of the Tournaisian transgression in the area of the southern part of the Northumberland Trough is therefore not great. On the northern side of the Trough at this time much greater thicknesses of sediment accumulated.

The shales below the Seventh Limestone, above the horizon of the Cherty Limestone at Blindcrake, yielded assemblage B 2 containing abundant lycospores. These strata have been assigned by the present author to the Pu concurrent range zone of Neves et al. (1973) and would appear to be equivalent to strata of the C 1 coral-brachiopod zone. The assemblages have been compared with those obtained from the Northumberland Trough by Butterworth and Spinner (1967), from Scotland and Northern England by Neves et al. (loc. cit.) and from Denmark by Bertlesen (1972).

The Chief Limestone Group The Seventh Limestone has been dated by previous workers (Eastwood et al. loc. cit.), on macrofossil evidence, as S 2 coral-brachiopod zone age. The present author has placed the spore assemblages from the strata in the upper part of the TC concurrent range zone of Neves et al. (loc.cit.), which would approximate to the upper C 2 - S 1 and S 2 coral-brachiopod zones, and thus be in accord with the macrofossil evidence. Caomparisons have been made with the assemblages recorded by Sullivan (1964a) from the Forest of Dean, by Smith and Butterworth (1967) from Northumberland and by Neves et al. (loc.cit.) from Northern England and Scotland.

This dating means that some of the C 1 and most of the C 2 - S 1 coral-brachiopod zones must be missing from, or condensed in this area. This period of partial or complete re-emergence of the Cumbrian Massif would correspond with Ramsbottom's (loc.cit.) second and third cycles. The transgression which brought about the deposition of the Seventh Limestone in S 2 times corresponds with Ramsbottom's fourth cycle.

The strata between the Sixth Limestone and the base of the Fourth Limestone are very poorly exposed. Furthermore, the samples obtained from these strata yielded no satisfactory spore preparations. This gap in the data is responsible for the changed nature of the assemblage found in the upper part of the Lower Chief Limestone Group.

The first assemblage in concurrent range biozone D in these strata compares well with the assemblages of the NM - VF concurrent range zones of Neves et al. (1973) as found in Northern England and Scotland. Comparisons have also been made with the findings of Love (1960) and Lele and Provan (1962) in Scotland, Marshall and Williams (1971) from the Yoredales of Northumberland, Hibbert and Lacey (1969) from North Wales, and Sullivan (1964a) from the Forest of Dean.

Spore assemblage D2 from the lower part of the Upper Chief Limestone Group, although similar to the underlying assemblage D1, compares well with those of the VF zone as described by Neves et al. (loc. cit.) Comparisons have been made with results from the Spilmersford borehole, and from other localities.

In the present study the boundary between the NM and VF concurrent range zones seems to lie slightly lower in the coral-brachiopod succession than is suggested by Neves et al. The boundary seems to lie close to the boundary between the D1 and D2 coral-brachiopod zones. Alternatively, the lower part of the D2 coral-brachiopod zone strata may be missing or condensed in this area. These possibilities are fully discussed in Chapter 5. The dating of the strata is consistent with the macrofossil evidence in the area (Eastwood et al. 1968.)

The assemblages recorded from the strata between the horizons of the Third Limestone and the First Limestone compare well with those of Marshall and Williams (1971) from Northumberland, and Neves et al. (1973) from Northern England and Scotland, and also with those of many previous workers. The assemblages are typical of their Visean-Namurian transitional nature. Cingulizonates cf. capistratus becomes prominent and may be used as an indicator of the onset of Namurian sedimentation, as may also be Bascaudaspora canipa.

The Hensingham Group. These strata have not previously been described in detail. The present author has described the succession as exposed in the Cockshot Beck - River Ellen and the Bothel Beck - Gillgooden stream sections. Ten sandstones have been delimited and have been numbered in descending order, following the practice for the limestones in the Chief Limestone Group. Previous workers have found no diagnostic macrofossils to indicate the presence of the E 1 goniatite stage in this area, but they have found evidence to suggest the presence of E 2 stage strata up to within a few metres of the Lower Coal Measures in Gillgooden (Eastwood et al. 1968.)

Palynological evidence from concurrent range biozone F in the present study indicates the possible presence of strata of the E 1 goniatite stage in the sequence examined. The relevant assemblages have been compared with those from Namurian strata described by Neves (1961) from the Southern Pennines, Butterworth and Williams (1958) from Scotland, Owens and Burgess (1964) from Stainmore, by Mishell (1966) from Bowland, and by Marshall and Williams (1971) from Northumberland. This present evidence is not at variance with Eastwood et al.'s postulated non-sequence at the base of the Hensingham Group as they state that the non-sequence is probably restricted to the eastern part of the present area, whereas the sequence examined palynologically lies in the western part of the area.

Above the Sixth Sandstone in the Hensingham Group the present author considers that the miospore evidence indicates E 2 goniatite stage horizons. This conclusion is based on comparisons of the concurrent range biozone G in the present work with assemblages recorded by the authors listed above. This is consistent with the macrofossil evidence recorded in Eastwood et al. (loc. cit.). The uppermost part of the Hensingham Group yielded poor results, but there is some evidence to indicate that part of the Homoceras goniatite stage may be present.

Previous workers have postulated a large non-sequence at the top of the Hensingham Group which excludes the Homoceras, Reticuloceras and lower Gastrioceras goniatite stages of the Namurian and the lenisulcata and communis non-marine lamellibranch zones of the Westphalian Series. (Eastwood et al. 1968). The macrofossil evidence for this non-sequence comes from Chalk Beck in the eastern part of the area. As described above, no positive results were obtained from this region in the present study because of the reddening of the strata. The palynological evidence from Gillgooden in the western part of the area suggests that the non-sequence exposed there is of shorter duration. As noted above, there is a possibility that strata of the Homoceras stage are present at this locality. There is also evidence that the succeeding Coal Measures in this section are of Lower Westphalian A age. The evidence suggests that the strata are older than those equivalent to the Radiizonates aligerens zone of Smith and Butterworth (1967), and probably lie in the Lenisulcata zone. However, Eastwood et al. (loc. cit.) state that the non-sequence may be greater in the east of the area than in the west. This reduction or loss of the upper stages of the Namurian series is a common feature in the north of England, in contrast to the Southern Pennines area. Comparisons with Namurian successions in adjacent area have been made in Chapter 2 and in fig. 16.

Palaeocological conclusions

Sullivan (1965) described suites of miospores which occurred in broad latitudinal bands parallel with the palaeoequator, and which were probably climatically controlled. The assemblages from the Upper Visean and Namurian in the present study can be compared with his Grandispora Suite. This was equatorial and, as has been described above, is consistent with the palaeoclimatic conditions during these times.

Low percentages of saccate grains were recorded from Namurian strata in the present study. This accords with Mishell's (1966) findings in the Namurian of the Bowland Fells, but not with Neves' (1961) findings in the Namurian of the Southern Pennines where saccates were fairly abundant. It has been suggested by the present author in Chapter 5 that the palaeowind directions, and the relative positions of nearby land masses may account for this difference. Furthermore, the absence of the genera

Rotaspora and Tripartites in the Southern Pennines Namurian (Neves, loc. cit.) has also been tentatively explained by the drainage of the land mass with respect to catchment area, outfall position and ocean currents. The general conclusion made was that land existed to the south and probably the west of the present area during Namurian times. This was probably the remains of the Cumbrian Massif, and the climatic implications are discussed at the end of Chapter 5.

Systematics

Of the 230 species described in the present study one new species is proposed - Densosporites horridus, and ~~twelve~~ eleven new types are described - Punctatisporites sp.A, Calamospora sp.A, Schopfites cf. claviger, Stenozonotriletes sp.A, Lophozonotriletes sp.A, Colatisporites sp.A, C. cf. decorus, Murospora sp.A, Discernisporites cf. micromanifestus, D. cf. irregularis and Spore type A.

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PLATE 1

All x500 unless otherwise stated.

Fig. 1 *Leiotriletes inermis* (Waltz) Ishchenko 1952.
170 B 190/345

Fig. 2 *L. tumidus* Butterworth and Williams 1958
740 A 93/1.2

Fig. 3 740 A 84/4.9

Fig. 4 *L.* cf. *pryddii* (Berry) Potonie and Kremp 1955
716 A 81.7/33

Fig. 5 740 C 104.5/1.2

Fig. 6 *L. densus* Neves 1961 334 32/84.3

Fig. 7 *L. parvus* Guennel 1958 356 A 88/7.9

Fig. 8 *Punctatisporites aerarius* Butterworth and Williams
58 166A 11.3/104

Fig. 9 *P. glaber* (N) Pl. 62

Fig. 10 *P. irrasus* Hacquebard 1957. 371 87.5/22

Fig. 11 *P. minutus* Kosanke 1950. 73 B90/11

Fig. 12 *P. nitidus* Hoffmeister, Staplin & Malloy 1955. 65A 103.5/31

Fig. 13 *P. obesus* (Loose) Potonie & Kremp 1955. 728 9.8/110.8

Fig. 14 *P. sinuatus* (Artuz) Neves 1961. 728 30/117.5

Fig. 15 P. sp. A. 373A 9/100

In all plates reference is made to sample numbers which are the same as slide numbers. Slide numbers also have A, B, C or D, suffix. Coordinates refer to Zeiss microscope No. 4752386.

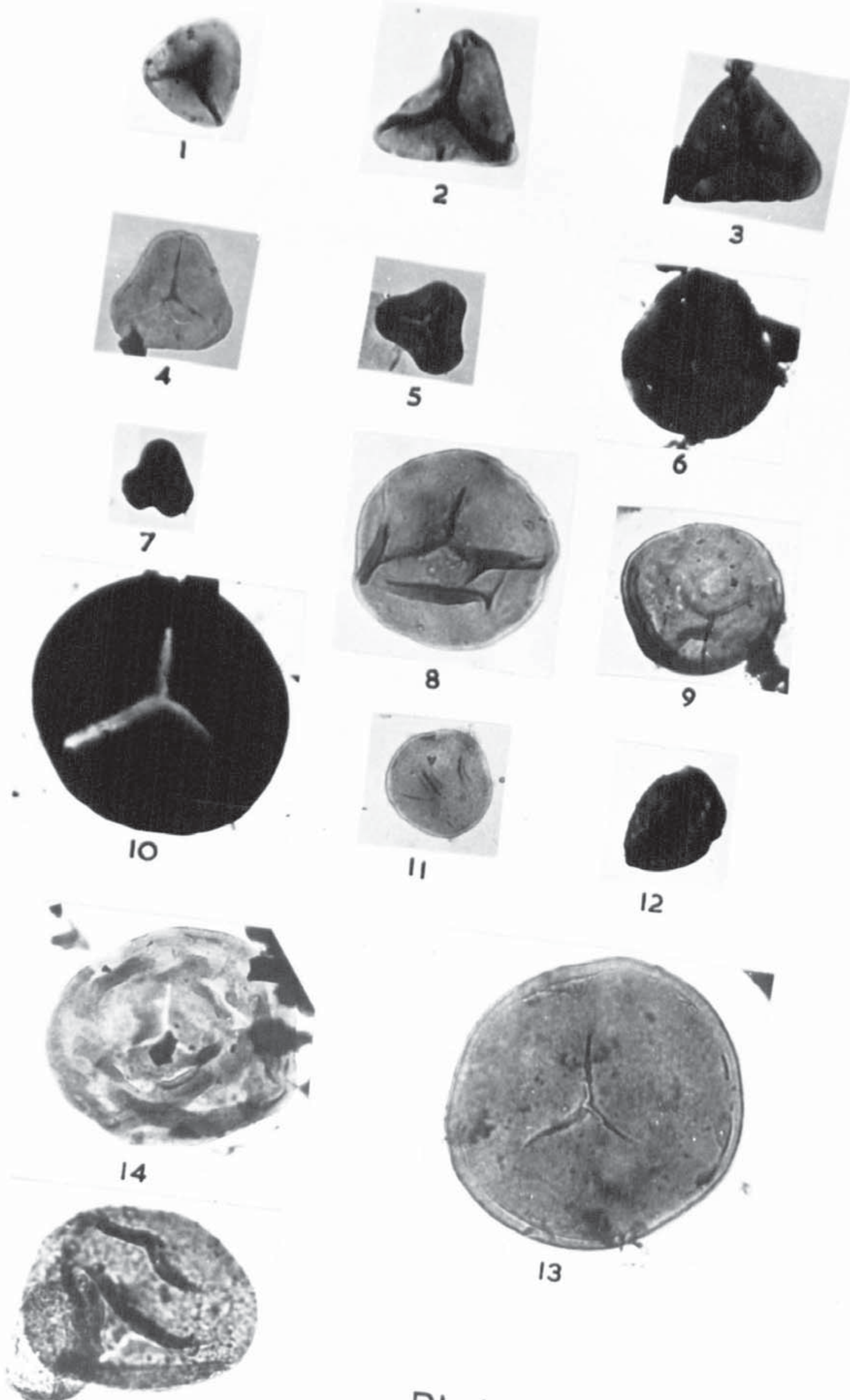


Plate I

PLATE 2

All x 500 unless otherwise stated.

Fig. 1 *Calamospora breviradiata* Kosanke 1950. 348 8.8/88

Fig. 2 *C. liquida* Kosanke 1950. 389A 23/115

Fig. 3 *C. microrugosa* Schopf, Wilson and Bentall 1964 165A 17/6

Fig. 4 *C. minuta* 108/30 65A

Fig. 5 C. sp. A. 373 107.9/85

Fig. 6 *Retusotriletes incohatus* Sullivan 1964. a155A 97/6

Fig. 7 *R. avonensis* Playford 1963. 371A 11/94.8

Fig. 8 *R. avonensis* 371A 15.5/100

Fig. 9 *R. incohatus* 376A 108.1/27

Fig. 10 *Waltzispora planiangulata* Sullivan 1964b 5a 8 F 94.3/5.5

Fig. 11 *W. prisca* (Kosanke) Sullivan 1964. 317A 112/30

Fig. 12 *W. polita* (Hoffmeister, Staplin & Malloy) Smith & Butterworth 1967. 598F 90.8/6

Fig. 13 *W. sagittata* Playford 1962 711 D 110/12.9

Fig. 14 *Granulatisporites granulatus* Ibrahim 1933. 728 D 87/7

Fig. 15 195A 105/8.5

Fig. 16 *G. microgranifer* Ibrahim 1933. 598F 111/5.5

Fig. 17 *G. minutus* Potonie & Kremp 1955. 361A 111/11.5

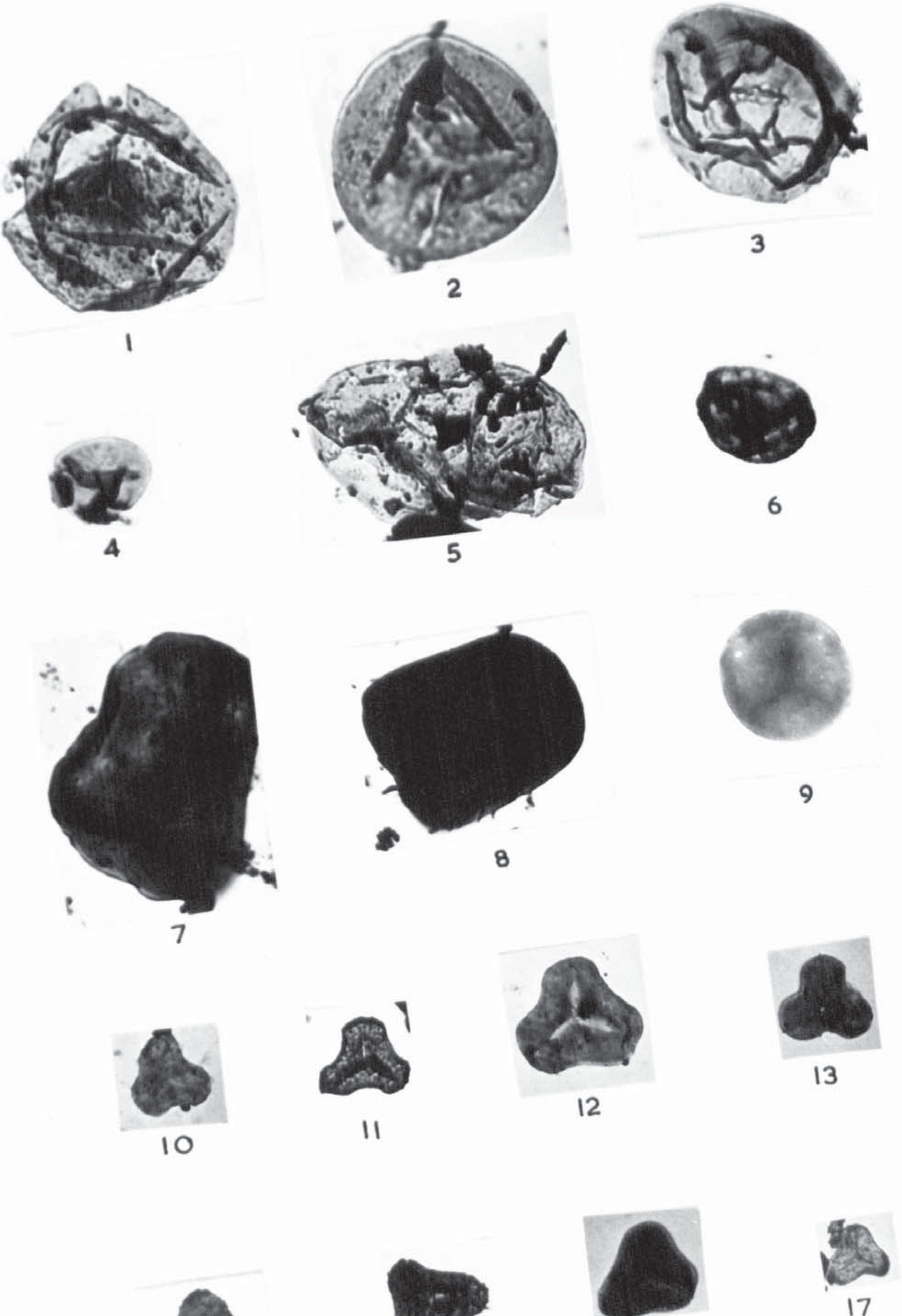


Plate 2

PLATE 3

All x 500 unless otherwise stated.

Fig. 1 Cyclogranisporites aureus (Loose) Potonie & Kremp 1955
316 A 105.7/1.4

Fig. 2 C. minutus Bharadwaj 1957. 166A 93.4/6

Fig. 3 Baculatisporites fusticulus Sullivan 1968. 373A 105/5.4

Fig. 4 As for Fig. 3 x 900

Fig. 5 Lophotriletes commisuralis (Kosanke) Potonie & Kremp. 316A 102/3.9

Fig. 6 L. gibbosus (Ibrahim) Potonie & Kremp 1954. 166A 90/11.7

Fig. 7 L. microsaetosus (Loose) Potonie & Kremp 1955 65A 101/2

Fig. 8 L. tribulosus Sullivan 1964b. 65A 97.5/37

Fig. 9 Anaplanisporites baccatus (Hoffmeister, Staplin & Malloy)
Smith and Butterworth 1967 316A 94.5/5.8

Fig. 10 A. globosus (Butterworth & Williams) Smith & Butterworth 1967
125.5/31

Fig. 11 Apiculatisporites spinulistratus (Loose) Ibrahim 1933
755A 90.5/8.8

Fig. 12 A. spinulistratus 755A 110/30

Fig. 13 Anapiculatisporites minor (Butterworth & Williams) Smith
and Butterworth 1967. 316A 89.9/4.5

Fig. 14 A. concinnus Playford 1962. 316A 98/3.0

Fig. 15 A. hispidus Butterworth and Williams 1958

Fig. 16 A. hispidus 195A 93/7

Fig. 17 Acanthotriletes castanae Butterworth & Williams 1958
174B 89.5/7.5

Fig. 18 A. echinatus (Kremp) Potonie and Kremp 1955. 187A 100/3.4

Fig. 19 A. falcatus (Knox) Potonie & Kremp 1955. 316A 101/30.3

Fig. 20 Pustulatisporites papillosus (Knox) Potonié & Kremp 166B 102/9.1

Fig. 21 As for Fig. 20. 389A 88.1/6.5

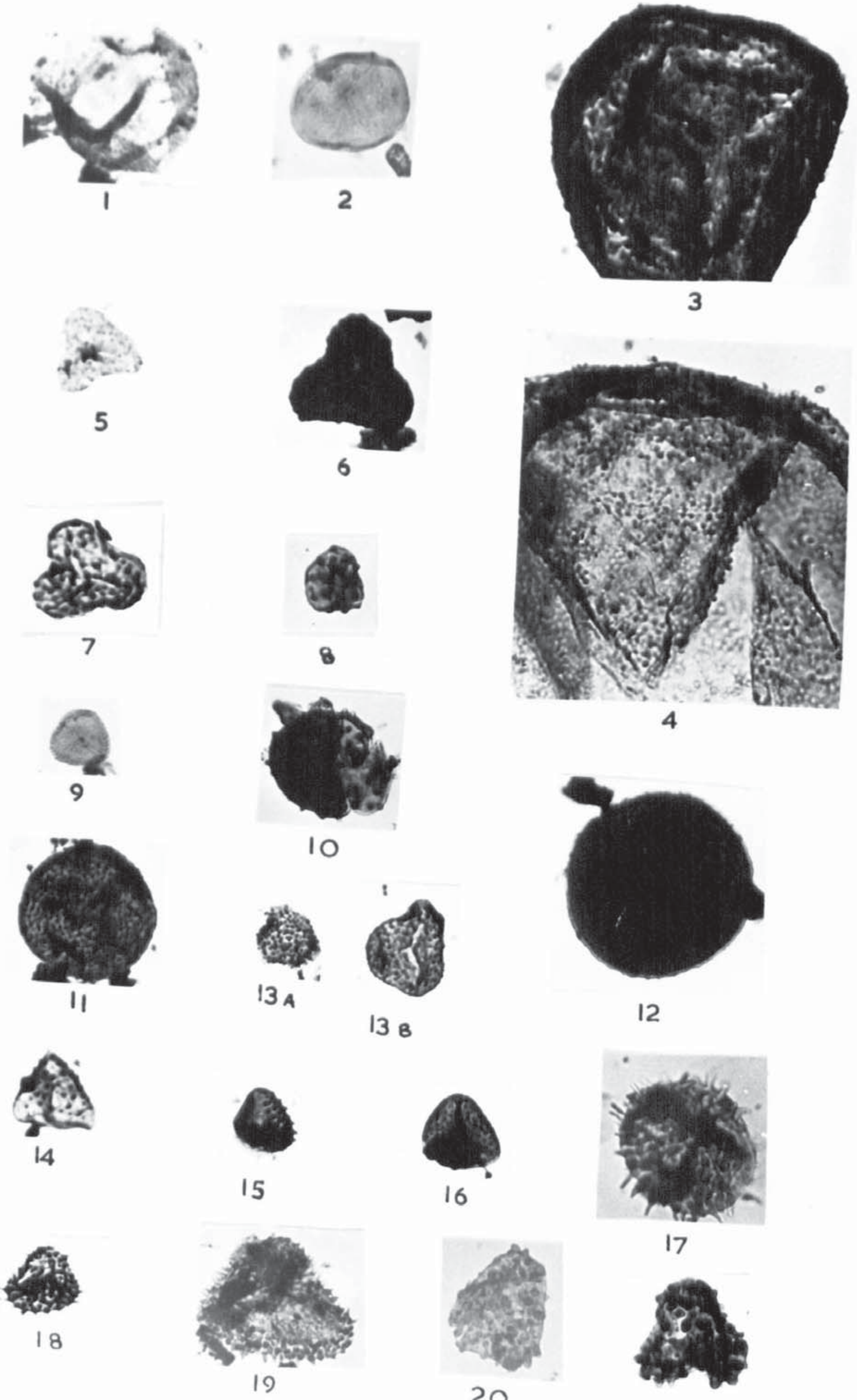


Plate 3

PLATE 4

All x 500 unless otherwise stated.

Fig. 1 Apiculiretusispora multisaetus (Luber) Butterworth & Spinner 1967.

Fig. 2 A. multisaetus x 1000

Fig. 3 Apiculatisporis variocorneus Sullivan 1964

Fig. 4 Verrucosisporites microtuberculatus (Loose) Smith and Butterworth 1967. 371 86/3.5

Fig. 5 V. microverrucosus Ibrahim 1933. 162A 88/1.8

Fig. 6 V. morulatus (Knox) Smith & Butterworth 1967. 353A 83/10

Fig. 7 V. nitidus (Naumova) Playford 1963. 155a 100 2/8.5

Fig. 8 As for Fig. 7 x 900

Fig. 9 V. nodosus Sullivan & Marshall 1966. 332A 855/5.3

Fig. 10 V. papullosus Hacquebard 1957. 120B 105/0.6

Fig. 11 V. variotuberculatus Sullivan 1968. 371 86/3.5

Fig. 12 Raistrickia microhorrida (Hacquebard) Potonie & Kremp 1955 593A 80.5/8.0

Fig. 13 R. fulva Artuz 1957 754A 161/6.6

Fig. 14 R. saetosa (Loose) Schopf, Wilson and Bentall 1944. 760A 89/24.5

Fig. 15 R. nigra Love 1960 65A 110/4.2

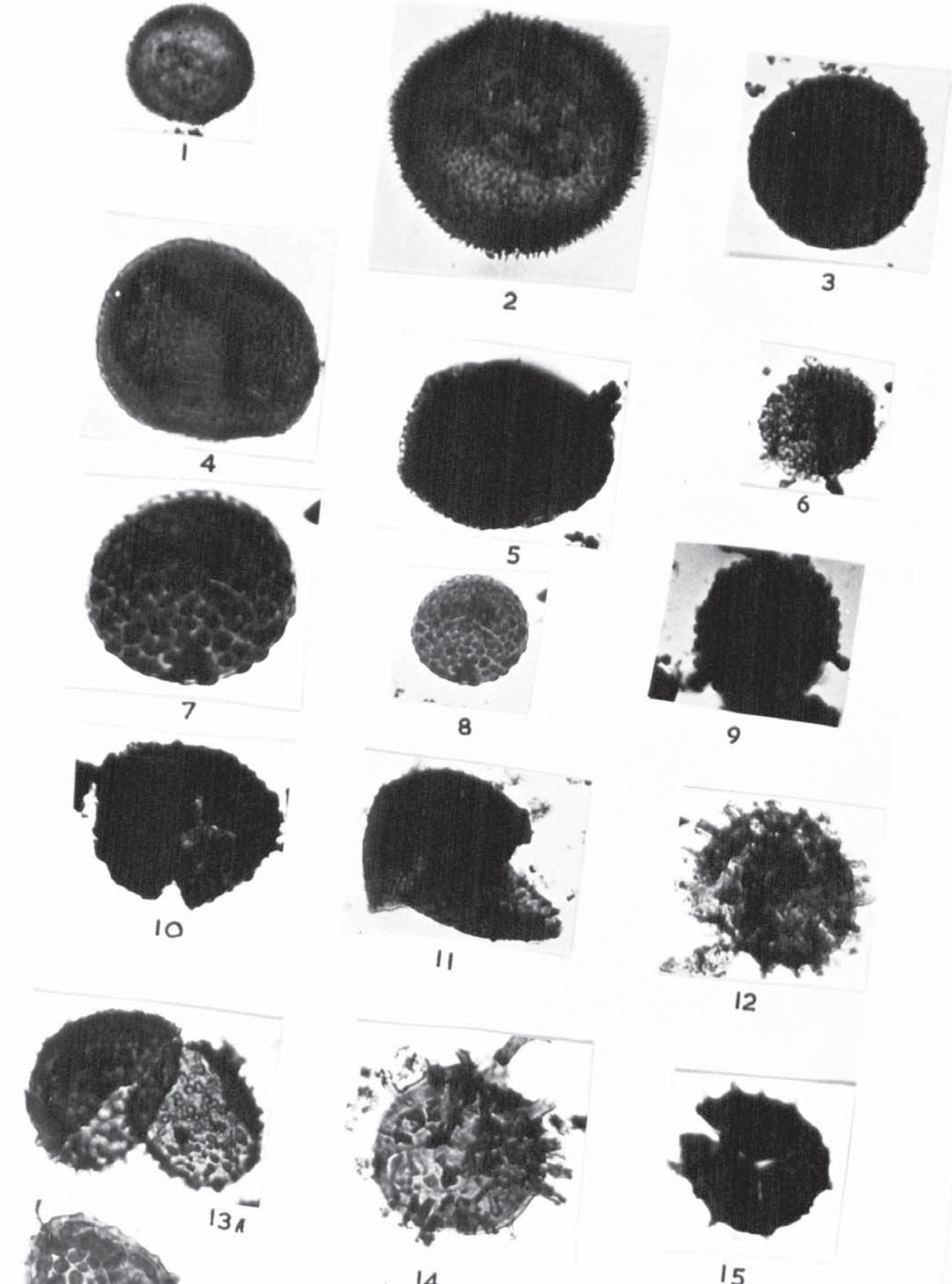


Plate 4

PLATE 5

All x 500 unless otherwise stated.

Fig. 1	*Neoraistrickia drybrookensis* Sullivan 1964b. 65A 105.5/36
Fig. 2	*Tricidarisporites dummosus* (Staplin) Sullivan and Marshall 1966 356A 93/32.3
Fig. 3	*T. fasciculatus* (Love) Gueinn ,Neville, proximal side, high focus. 174A 93.3/28
Fig. 4	" " " (low focus)
Fig. 5	*T. magnificus* Neville 1973 739B 86.514
Fig. 6	" 740A 100/74.5
Fig. 7	" 728D 87/35.8
Fig. 8	*Schopfites claviger* Sullivan 1968. 373 102.2/145
Fig. 9	" " " 37397.5/11
Fig. 10	" " " 371 104/7
Fig. 11	*S.* cf. *claviger* 371 80/9.2
Fig. 12	" 373 D 106/33. Sullivan & Marshall 1966.
Fig. 13	*Camptotriletes cristatus* 316 A 101.8/10.2
Fig. 14	*C. superbus* Neves 1961 384A 88/12
Fig. 15	*C. verrucosus* Butterworth and Williams 1958. 711C 100.5/6
Fig. 16	*Microreticulatisporites concavus* 740C 84/8.2 equatorial view
Fig. 17	*M. concavus* Butterworth & Williams 1958. 740C 95.8/1.5
Fig. 18	*M. concavus* 159C 102/21 equatorial view.
Fig. 19	*M. microreticulatus* Knox 1950 186A 98/2.9
Fig. 20	*M, nobilis* (Wicher) Knox 1950 711A 104/21
Fig. 21	*Convolutispora cerebra* Butterworth & Williams 1958
Fig. 22	*C. florida* Hoffmeister, Staplin & Malloy 1955 740 C 82.3/3.4
Fig. 23	*C. laminosa* Neves 1961 316A 100.9/7.8

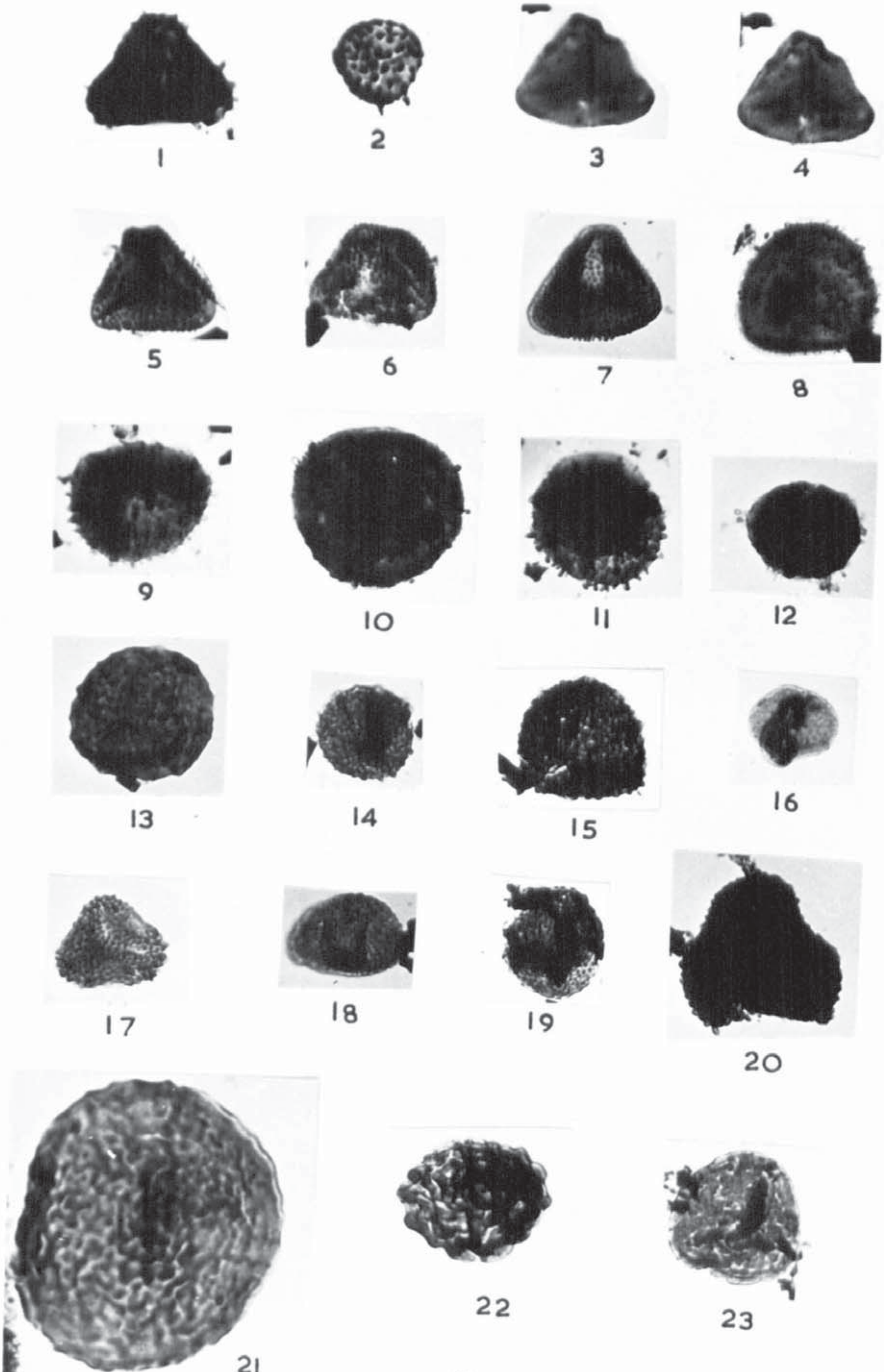


Plate 5

PLATE 6

All x 500 unless otherwise stated.

Fig. 1. Convolutispora tosellata, Hoffmeister, Staplin & Malloy 1955 165A 7.1/85.5.

Fig. 2 C. vermiformis Hughes and Playford 1961.

Fig. 3 C. jugosa Smith and Butterworth 1967.

Fig. 4. C. ampla Hoffmeister, Staplin & Malloy 1954

Fig. 5. C. circumvallata c/71 77a 30/98.5.

Fig. 6. Dictyotriletes castanaeformis (Horst) Sullivan 1964 316A 29?

Fig. 7. D. castanaeformis 64A 17/13

Fig. 8. D, clatriformis (Artuz) Sullivan 1964. 356 82/9

Fig. 9. D. falsus Potonie and Kremp 1955. 186A 91.5/106.

Fig. 10. D. falsus 174B 102/4

Fig. 11. D. fragmentimurus Neville 1973 740B 90/34.5

Fig. 12. D, insculptus Staplin and Malloy 1966 39A 94/2

Fig. 13. D. sagenoformis Sullivan 1964b 740C 99/12.5

Fig. 14. " " 778 101/8 oblique compression

Fig. 15. D. submarginatus Playford 1963 F24B 92.3/32.5

Fig. 16. Ahrensisporites guerickei (Horst) Potonie and Kremp 1954 384A 111/3.8

Fig. 17. Triquitrites batillatus Hughes and Playford 1961. 518 101.5/3.5

Fig. 18. T. bransonii Wilson and Hoffmeister 1956

Fig. 19. T. comptus Williams 1973. 320A 7.3/102.5

Fig. 20. T. trivalvis (Waltz) Potonie and Kremp 1950

Fig. 21. T. marginatus Hoffmeister, Staplin & Malloy 1955. 186A 104/108.

Fig. 22. T. vetustus Schemel 1950. 314A 111/32.5

Fig. 23. " 734A 85/8.3

Fig. 24. T. distinctus Williams 1973 598F 705.5/6.2

Fig. 25. T. vetustus 166A 105 3/10

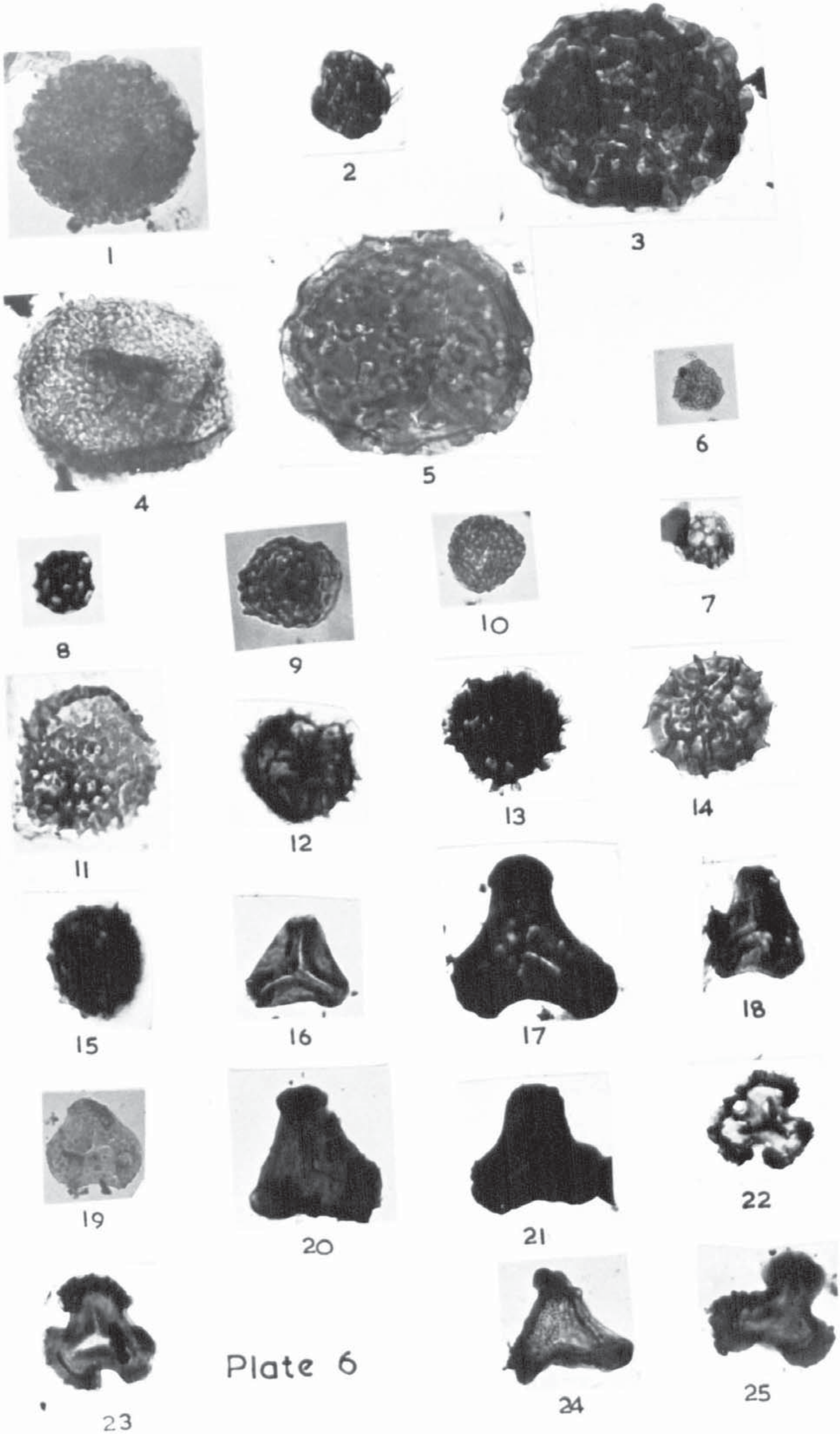


Plate 6

PLATE 7

All x 500 unless otherwise stated.

Fig. 1. Crassispora acculeata Neville 1968 711A 88.8/8

Fig. 2. " " tetrad 711D 99/8.8

Fig. 3. C. kosankei (Potonie & Kremp) Smith & Butterworth 1967 389A 85.5/11

Fig. 4. " " 343A 100.3/4.3

Fig. 5. C. trychera Neves & Ioannides 1974 371 89/10.1

Fig. 6. " " 373 82/7.2

Fig. 7. " " 373D 104/6.4

Fig. 8. C. maculosa (Knox) Sullivan 1964 186A 112.5/4

Fig. 9a. Diatomozonotriletes rarus Playford 1962 73a A 110/7.5 proximal side, high focus

Fig. 9b. D. rarus, Playford 1962 " " low focus

Fig. 10. D. ubertus Ishchenko 1956

Fig. 11. Secarisporites lobatus Neves 1961

Fig. 12. S. remotus Neves 1961

Fig. 13. S. lobatus x 750

Fig. 14. Bellispores nitidus (1.6) S 64 740689.5/8.6

Fig. 15. Savitrisporites nux (Butterworth & Williams) Smith & Butterworth 1967. 166A85/5.8

Fig. 16 " " 347A 103.7/36.4

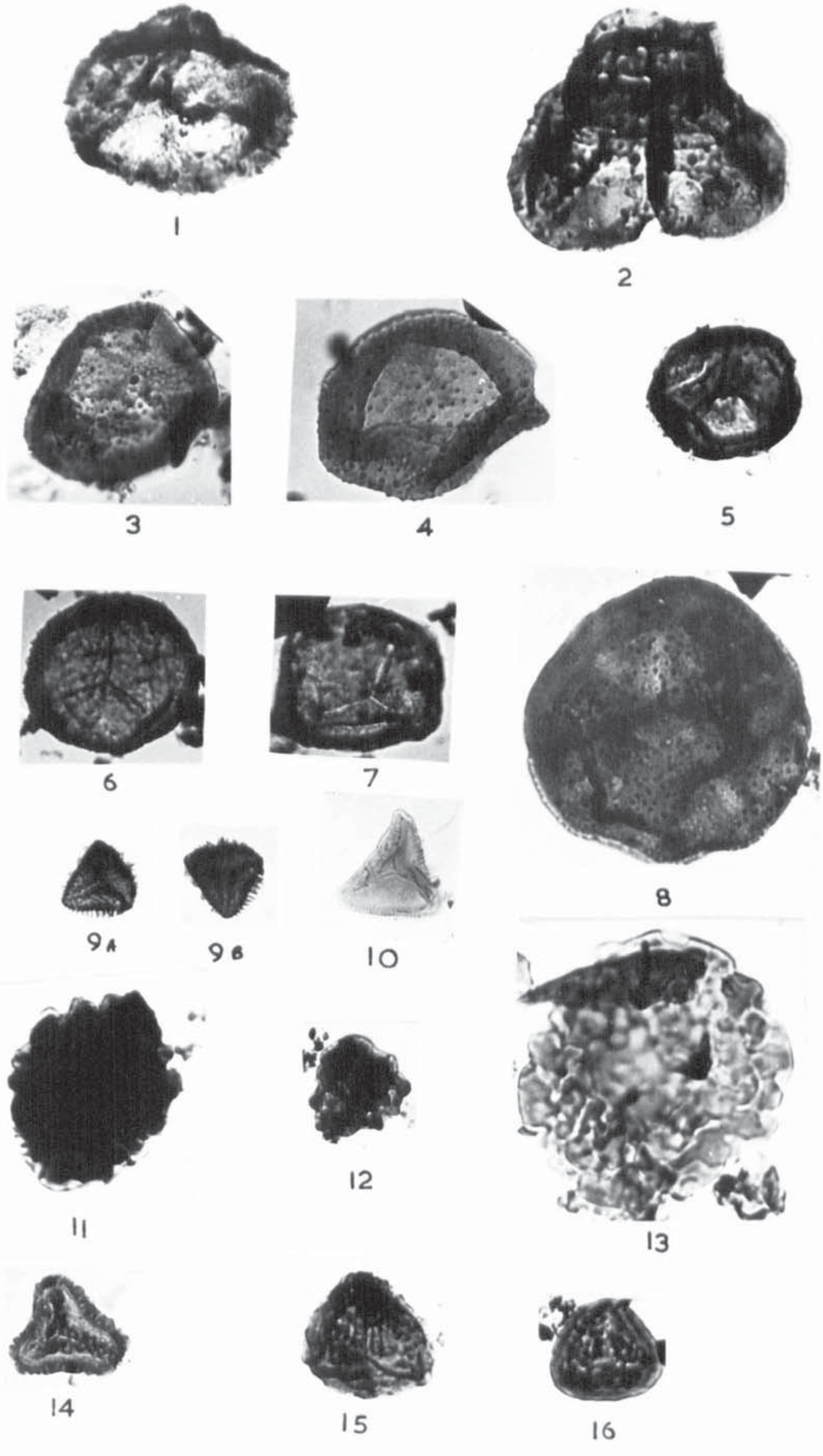


Plate 7

PLATE 8 .

All x 500 unless otherwise stated.

Fig. 1. Murospora aurita 186A 100/0

Fig. 2. M. frendii P16295.2/1.8

Fig. 3. M. aurita (Waltz) Playford 1962 329A 34.5/90

Fig. 4. M. sublobata (Waltz) Playford 1962 703B 113/5

Fig. 5. " 739 89/1

Fig. 6. M. sp. A. 82.3/8.3

Fig. 7. Stenozonotriletes lycosporides (Butterworth & Williams) Smith and Butterworth 1967. 356A 91/51.5

Fig. 8. " " 356A 81/11.5

Fig. 9. S. clarus (Ishchenko) 1158 320A 9.4/104.1

Fig. 10. S. coronatus Sullivan & Marshall 1966 356A 111.9/4.1

Fig. 11. S. bracteolus (Butterworth & Williams) Smith & Butterworth 1967 316A 82/1.7 x 600

Fig. 12. Bascaudaspora campa Owens 1963 166A 42/31

Fig. 13. " " 316 28.3/31.2

Fig. 14. " " 166B 98/1.5

Fig. 15. Rotaspora crenulata Smith & Butterworth 1967 598 90/7.8

Fig. 16. " " 703A 88.8/16

Fig. 17. R. ergonulei (Artuz) Sullivan & Marshall 1966 320A 8.4/90.5

Fig. 18. " " 703A 105/3.5

Fig. 19. " " tetrad 703A 89.8/3.3

Fig. 20. R. knoxi Butterworth & Williams 1958 740A 110/7.2

Fig. 21. R. knoxi 166B94 /8

Fig. 22. R. fracta (Schemmel) Smith & Butterworth 1967 737 A 84.5/6

Fig. 23. " 193A 92/4.3

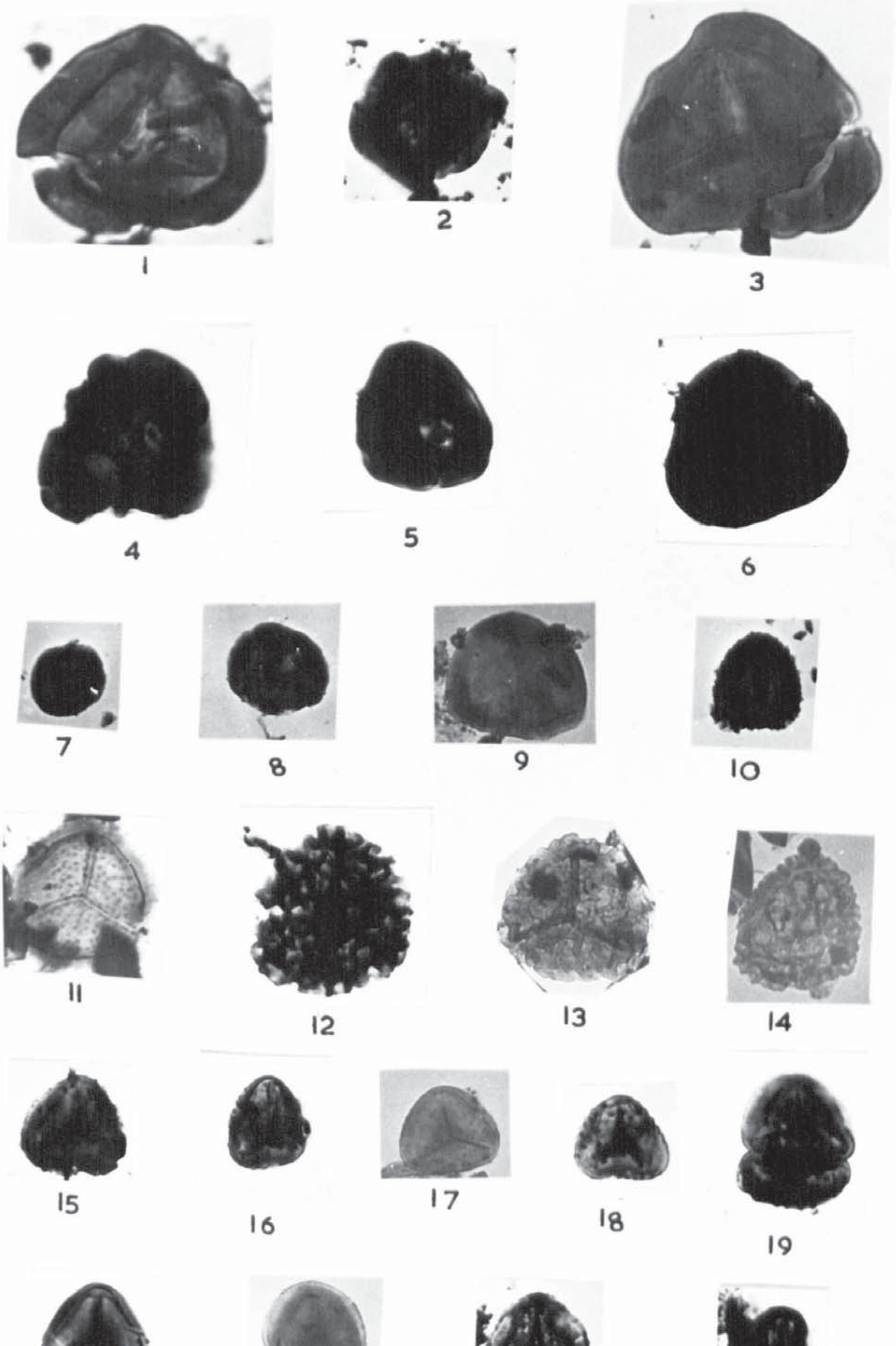


Plate 8

PLATE 9

All x 500 unless otherwise stated.

Fig. 1. Reticulatisporites peltatus Playford 1962

Fig. 2. Knoxisporites stephanephorous Love 1960 168,91/9

Fig. 3. K. pristinus Sullivan 1968 373A 86/7.2

Fig. 4. K. triradiatus Hoffmeister Staplin & Malloy 166A 108.9/30.3

Fig. 5. " 173 109/23.8

Fig. 6. K. dissidius Neves 1961 334A 88/8

Fig. 7. K. rotatus 389A7.1/100.8

Fig. 8. Lycospora noctuina var. noctuina (Butterworth & Williams) Somers 1972 343A89.4/3.3

Fig. 9. " " " " 316A 86/0

Fig. 10. " " " " 196A 95.6/7

Fig. 11. L. uber (Hoffmeister Staplin & Malloy) Staplin 1960. 354A 98/4

Fig. 12. L. pusilla (Schopf Wilson & Bentall) Somers 1972. 740C 89/8.4

Fig. 13. " 376 A101/8

Fig. 14. " tetrad 165A 118/7.5

Fig. 15. Lophozonotriletes bellus Kedo 1963 oblique view, 120C 93/34.5

Fig. 16. L. sp. A 728 97/5.5

Fig. 17. " 356 102/27

Fig. 18. Corbulispora subalveolaris (Luber) Sullivan 1964.373D 95/3.5

Fig. 19. Tholisporites scoticus Butterworth & Williams 1958 174B107.5/3.5

Fig. 20. T. ? bianulatus Neves 1961 166A 100/14 x 600

Fig. 21. T. ? decorus Gueinne 1973. 65A 98/40

Fig. 22. Lycospora rugulosa Butterworth & Spinner 1967 F24 84/4.

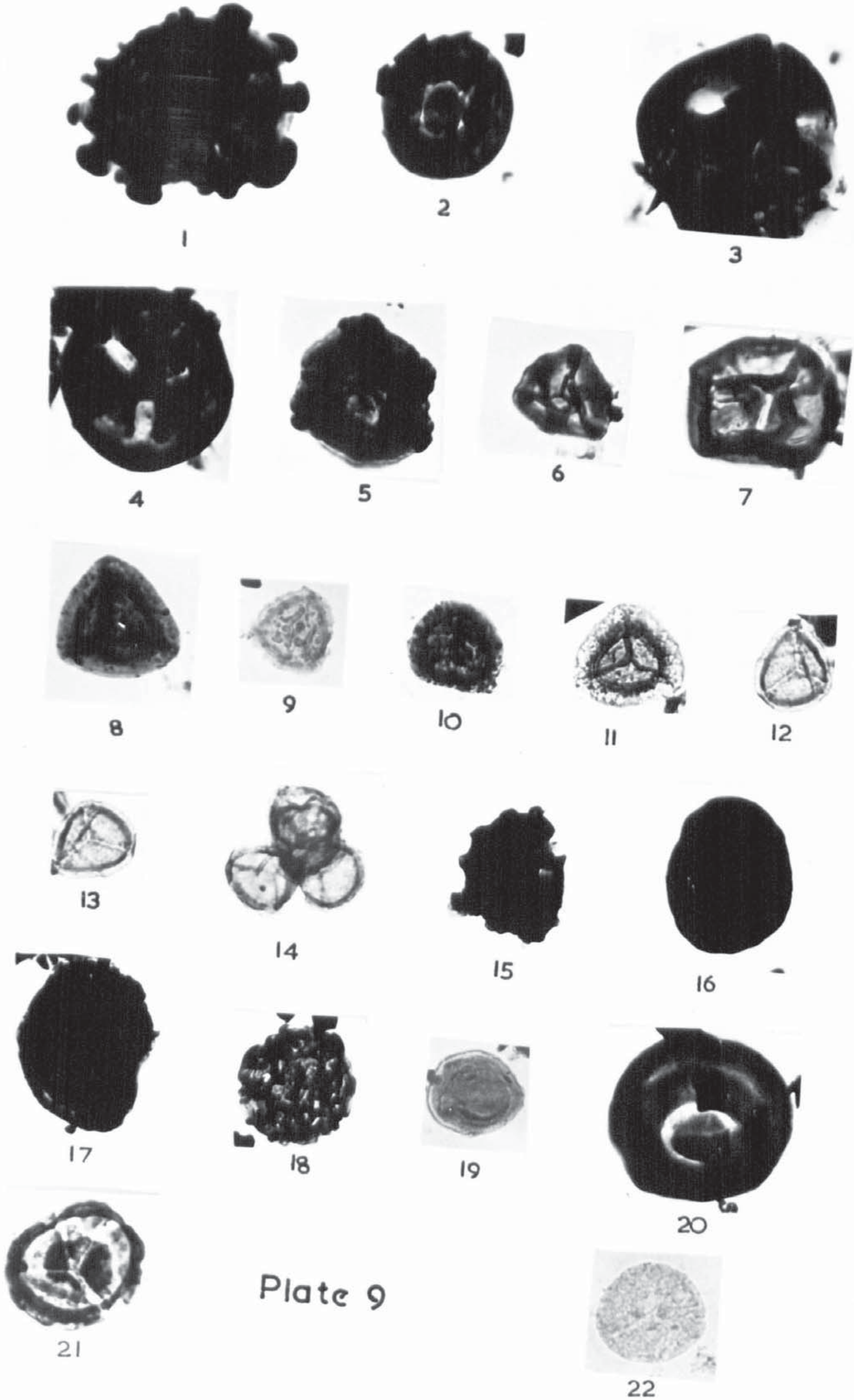


Plate 9

PLATE 10

All x 500 unless otherwise stated.

Fig. 1. Auroraspora macra Sullivan 1968 174B 105.5/34.8

Fig. 2. " " 166B 93.5/0.3

Fig. 3. A. solisortus Hoffmeister Staplin & Malloy 1955 .343A 95.5/6.1

Fig. 4. " 166A 103/8.3

Fig. 5. Grumosisporites rufus(Butterworth & Williams) Smith & Butterworth 1967 320A 6.2/84.1

Fig. 6. " 316A 10.2/84

Fig. 7. G. inaequalis (Butterworth & Williams) Smith & Butterworth 1967 740C 99/6.3

Fig. 8. G. varioreticularis (Neves) Smith & Butterworth 1967, focussed on intexine, 589 A99/3.5

Fig. 9. Spelaeotriletes arenaceous Neves & Owens 1966 740C 88/2.5

Fig. 10. S. microspinosus Neves & Ioannides 1974 373 A104/30.8

Fig. 11. Rugospora corporata var. verrucosus Neville 1968. 343A109/83

Fig. 12. Grandispora spinosa Hoffmeister Staplin & Malloy 1955 316A 88/3.2

Fig. 13. G. echinata Hacquebard 1957 120A 86/8.9

Fig. 14. Perotriletes magnus F24 101/6.2

Fig. 15. P. perinatus Hughes and Playford 1961 728D 85/11

Fig. 16. P. tessellatus (Staplin) Neville 1973 740B. 94.5/2.8

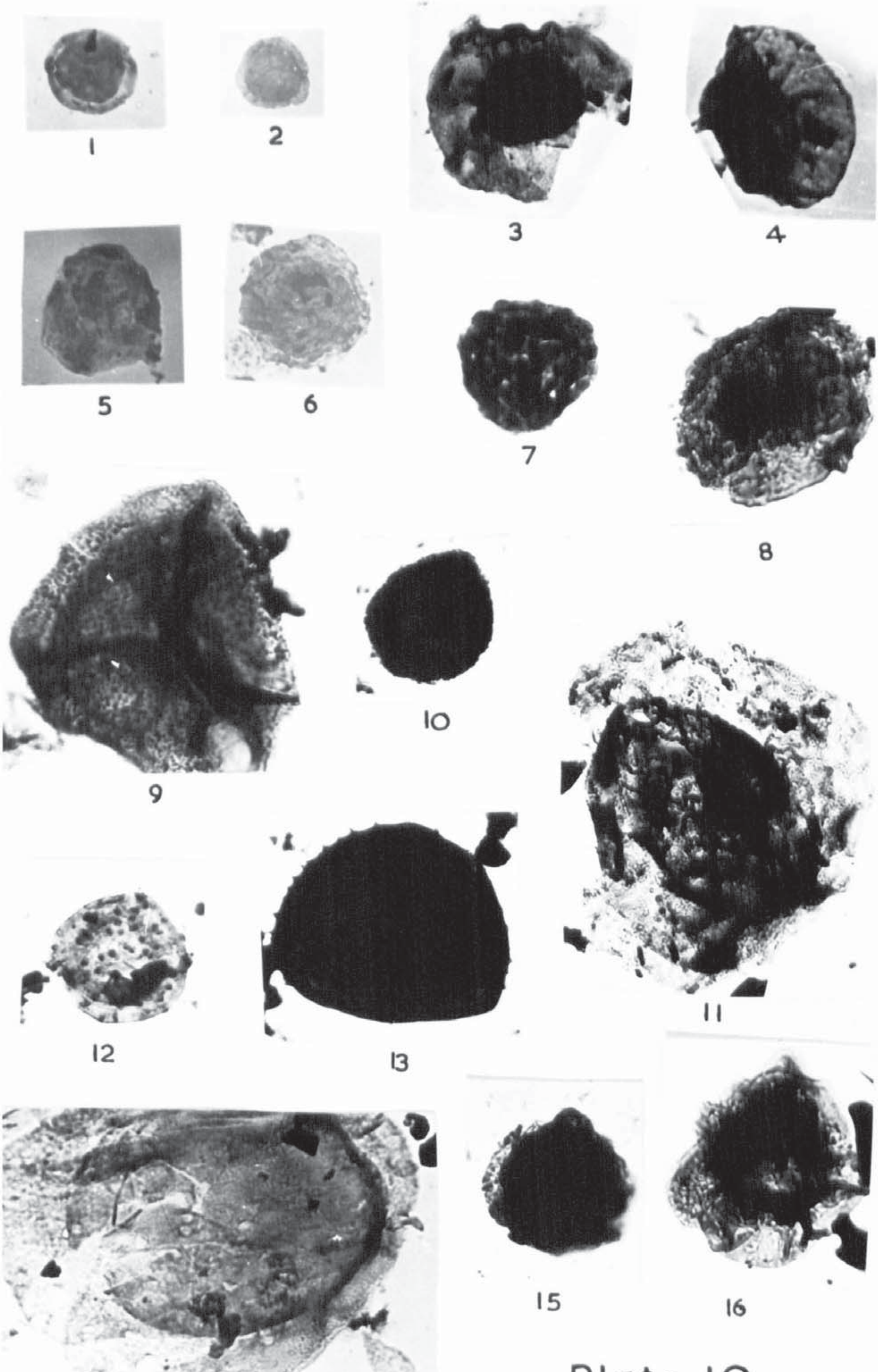


Plate 10

PLATE 11

All x 500 unless otherwise stated.

Fig. 1. Rugospora minuta Neves & Ioannides 1974 376A 86/4.4

Fig. 2. Discernisporites micromanifestus (Hacquebard) Sabry & Neves 1971. 162A 88/32.5

Fig. 3. " " 740C 98.5/2.5

Fig. 4. D, cf. irregularis 373D95.5/2.5

Fig. 5. " 373B 92/5

Fig. 6. Grandispora spinosa 598F104/33.9 Hoffmeister Staplin & Malloy.

Fig. 7. Spinozonotriletes uncatus Ibrahim 1957 739 B 97/1.7

Fig. 8. Spencerisporites radiatus (Ibrahim) Felix & Parks 1959. 703B 113/5

Fig. 9. " " x 800 central area, 159B87.5/9.4

Fig. 10. Densosporites anulatus (Loose) Smith and Butterworth 1967 317A 7.4/88

Fig, 11. " " 165A 14.6/88.0

Fig. 12. D. spinifer Hoffmeister Staplin & Malloy 1955 316A 101/32.5

Fig. 13. " 316A 100/10.3

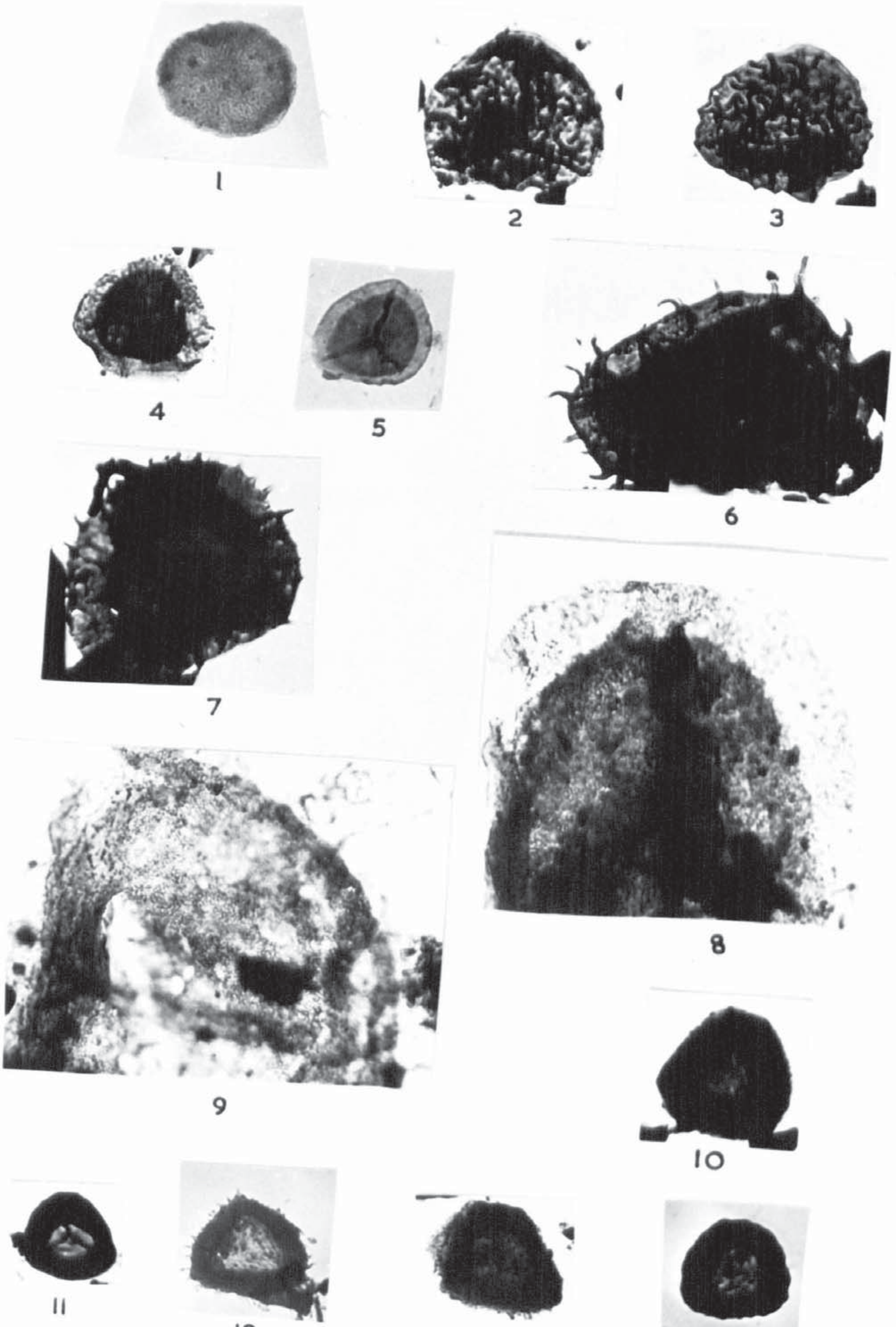


Plate 11

PLATE 12

All x 500 unless otherwise stated.

Fig. 1. *Densosporites horridus* sp.nov. 755A 110.3/7.3

Fig. 2. " 755 A 112/11.2

Fig. 3. " 755 A 104/1.1

Fig. 4. " 755 A 100/5

Fig. 5. *Cirratriradites saturni* (Ibrahim) Schopf Wilson & Bentall 1944

Fig. 6. *Cingulizonates bialatus* (Waltz) Smith & Butterworth 1967

Fig. 7. *C. loricatus* (Loose) Butterworth & Smith (in Butterworth et al.) 1954. 753 100/4

Fig. 8. *Densosporites triangularis* Kosanke 1950. 347 A 98/20

Fig. 9. *Cingulizonates* cf. *capistratus* (Hoffmeister Staplin & Malloy) Staplin and Jansonius 1964. 302 A 95.5/4

Fig. 10. " 301 A 95/12.3

Fig. 11. " 347 A 102/8.5

Fig. 12 " 343 A 99/10.5

Fig. 13. " 728 A 97/12.4

Fig, 14. *Kraeuselisporites echinatus* Owens 1966. 166 B 91.5/4.8

Fig. 15. " 166 B 85.2/10

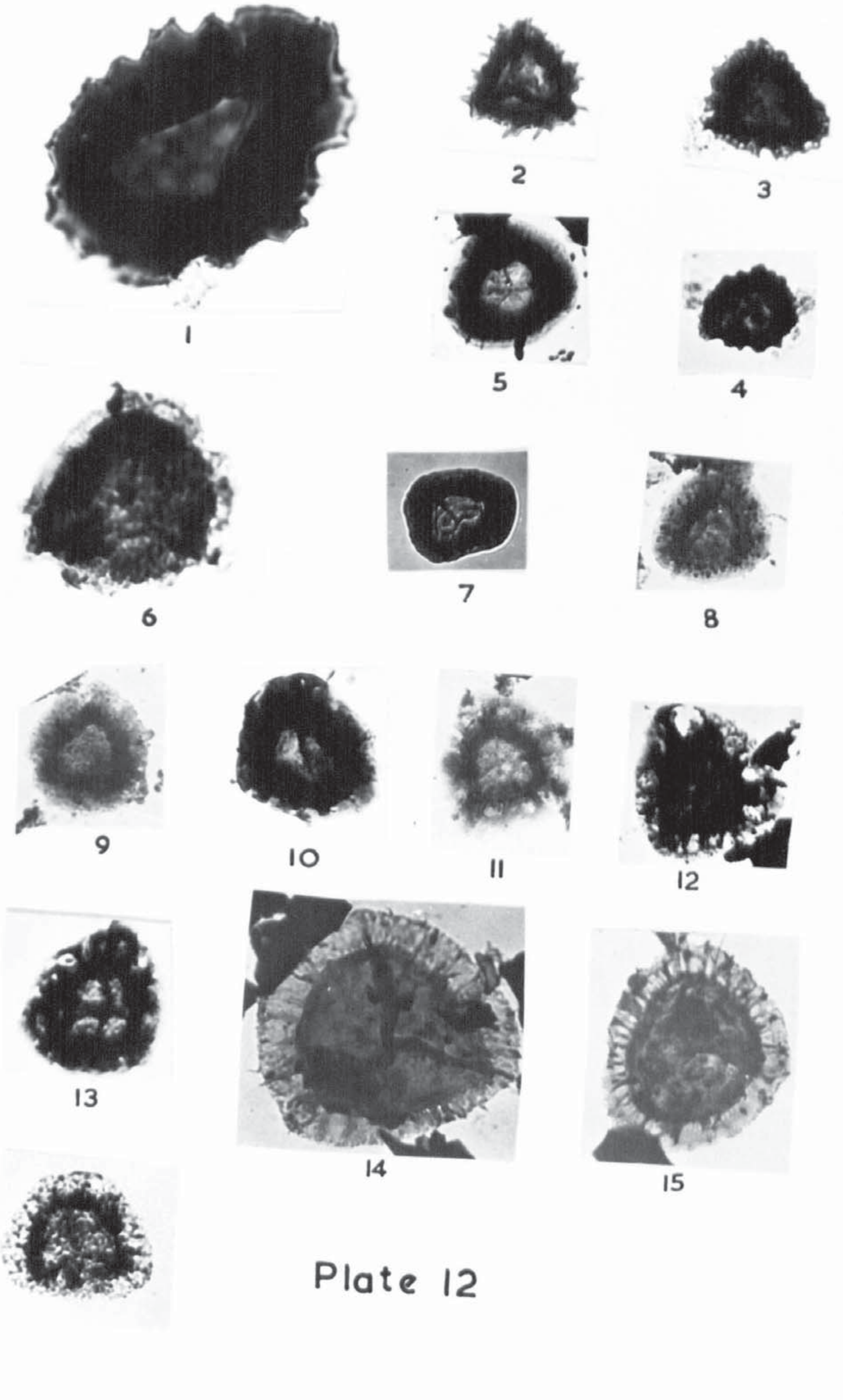


Plate 12

PLATE 13

All x 500 unless otherwise stated.

Fig. 1. Florinites similis Kosanke 1950. 354 A 96/11.3

Fig. 2. F. mediapudens (Loose) Potonie & Kremp 1956. 755 A 94/8.5

Fig. 3. F. milotti Butterworth & Willisms 1954. 589 105.5/3.2

Fig. 4. F. junior Peppers 760 A 98.1/4.1

Fig. 5. F. grandis 760 A 84/35.0

Fig. 6. F. pumicosus (Ibrahim) Schopf Wilson & Bentall 1944. 597 A 85.4/24

Fig. 7. Schulzospora elongata Hoffmeister Staplin & Malloy 1955. 165 A 5 106/20

Fig. 8. " central body distorted by pyrite crystals 166 A 99.5/1.4

Fig. 9. S. rara Kosanke 1950. 740 C 85/6

Fig. 10. S. campyloptera (Waltz) Hoffmeister Staplin & Malloy 1955 198 A 33/88.5

Fig. 11. Schopfipollenites ellipsoides (Ibrahim) Potonie & Kremp 1954 316 A 6.2/77

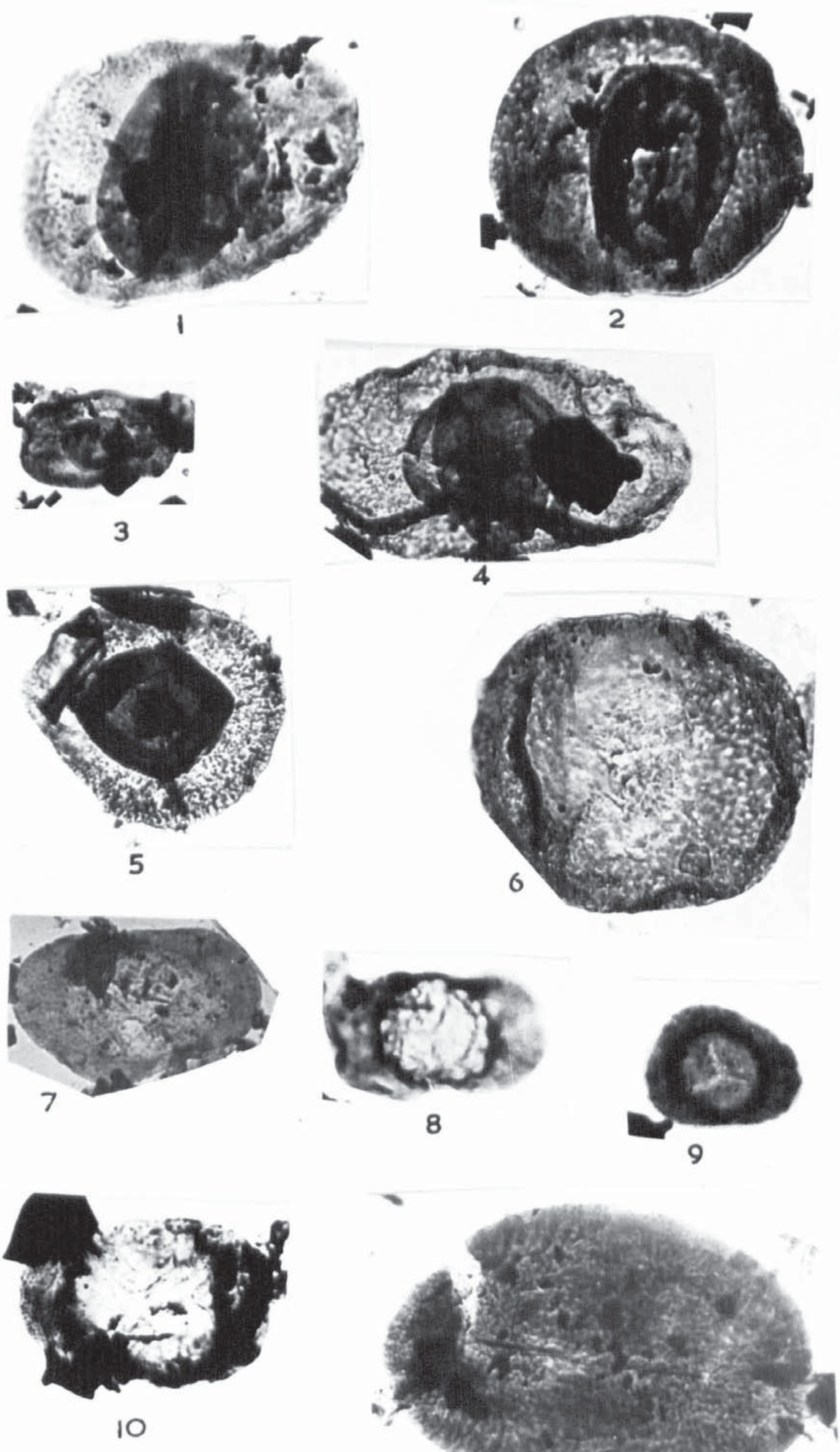


Plate 13

PLATE 14

All x 500 unless otherwise atated.

Fig. 1. Laevigatosporites desmoinensis (Wilson and Coe) Schopf Wilson & Bentall 1944. 728 D 87/4.

Fig. 2. L. minimus (Wilson & Coe) Schopf Wilson & Bentall 1944 345 A 79/10.5

Fig. 3. Pulvinispora scolecophora Neves & Ioannides 1974 373 A 89.3/.8

Fig. 4. " 713 A 112/1.1

Fig. 5. Colatisporites decorus (Bharadwaj & Venkatachala) Williams 1973 371 A 104.1/3.5

Fig. 6. " 371 A 94.3/6.7

Fig. 7. C. denticulatus Neville 1973 373 88/4.5

Fig. 8. C. sp. A 373 99/10

Fig. 9. C. cf. decorus 373 106/11

Fig. 10. " 373 108/10

Fig. 11. Biamulatisphaerites simplex Neville 1973 781 A 100/4.7

Fig. 12. Species A 375 D 97.1/8.8

Fig. 13. " 728 A 94/6.8

Fig. 14. " 728 A 95.6/10.4

Fig. 15. Corrugitriletes ruginosus Mishell 1966 319 A 88.7/12.5

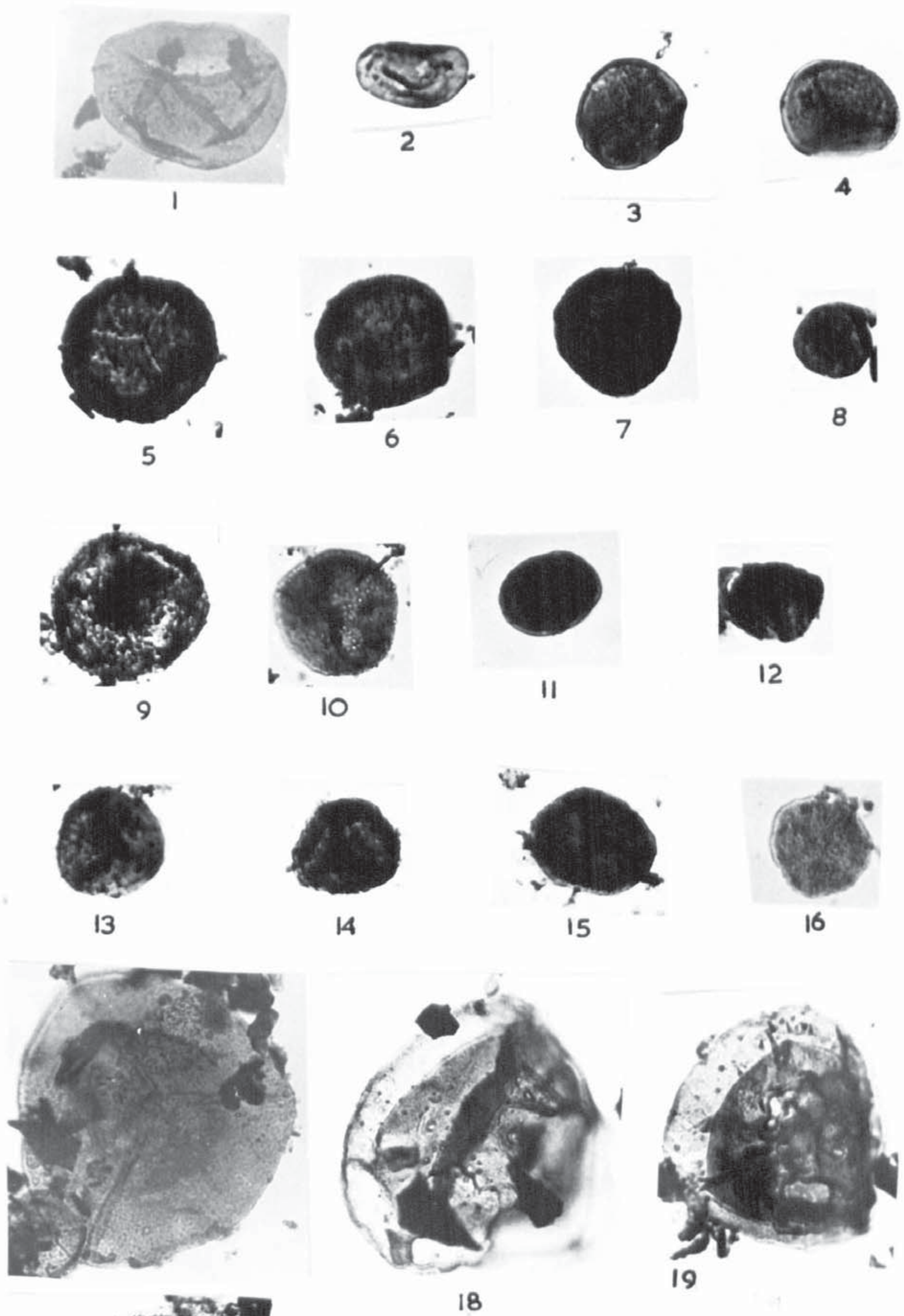
Fig. 16. " 319 A 101/4.3

Fig. 17. Discernisporites cf. micromanifestus 376 A 97.4/4.4

Fig. 18. " 740 C 21/101

Fig, 19. " 740 C 18/108

Fig. 20 Vallatisporites ciliaris (Luber) Sullivan 1964. 737 A 90/14



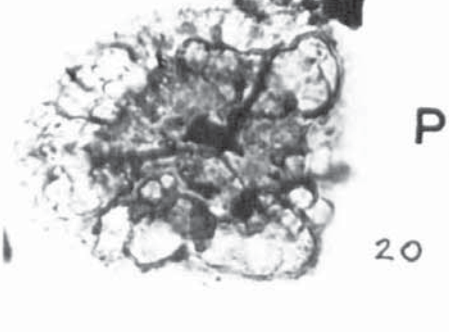


Plate 14

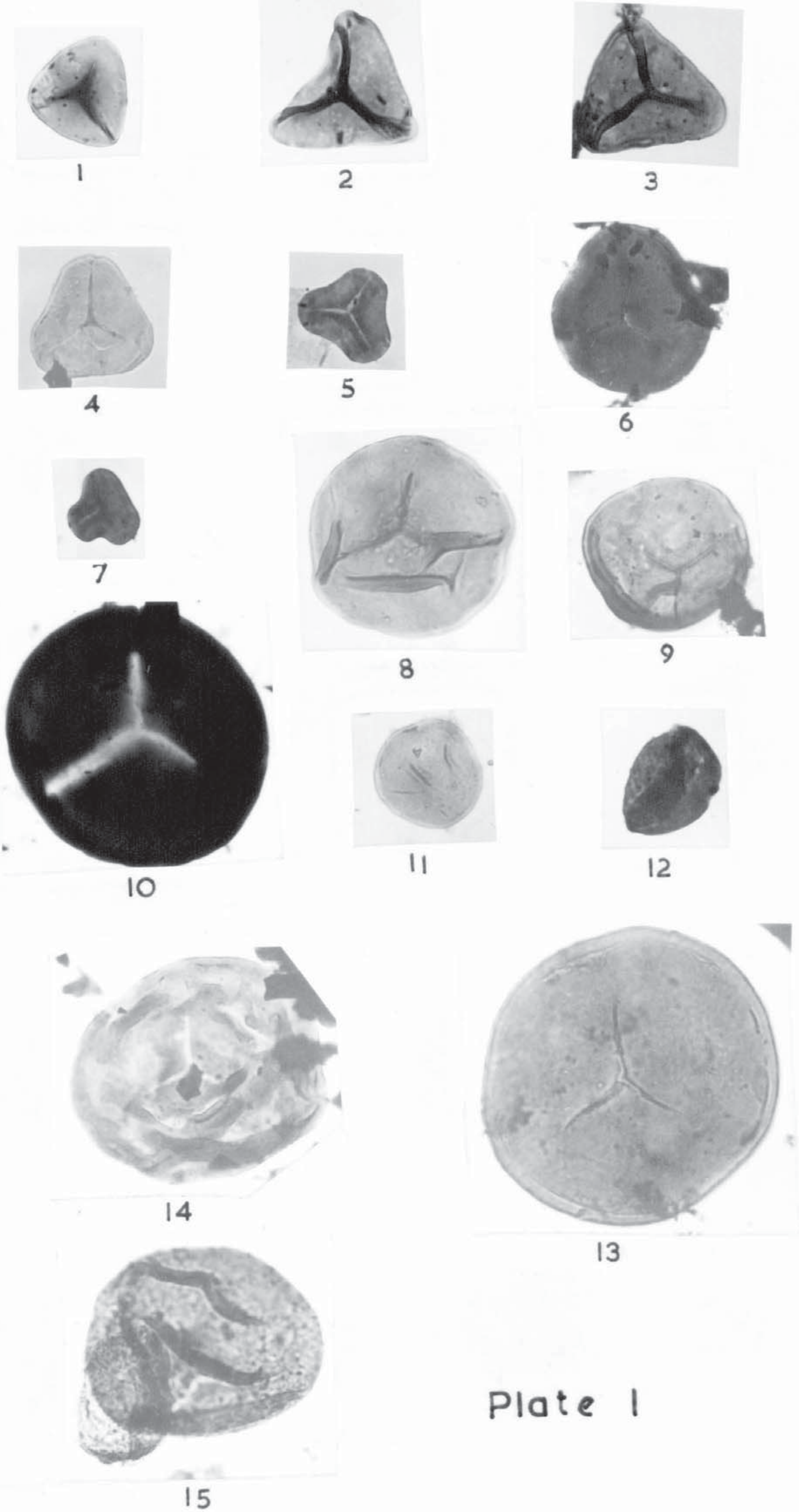
Original photographic material is included in the pocket on the rear of the thesis. I4 photographic plates bound together, are included.

C.E.BUTCHER, PhD. 1974.

Original photographic material for thesis "Carboniferous miospore distributions in Cumberland with special reference to those in the Hensingham group "

University of Aston in Birmingham
Gosta Green
Birmingham B4 7ET.

I4 Plates are included.



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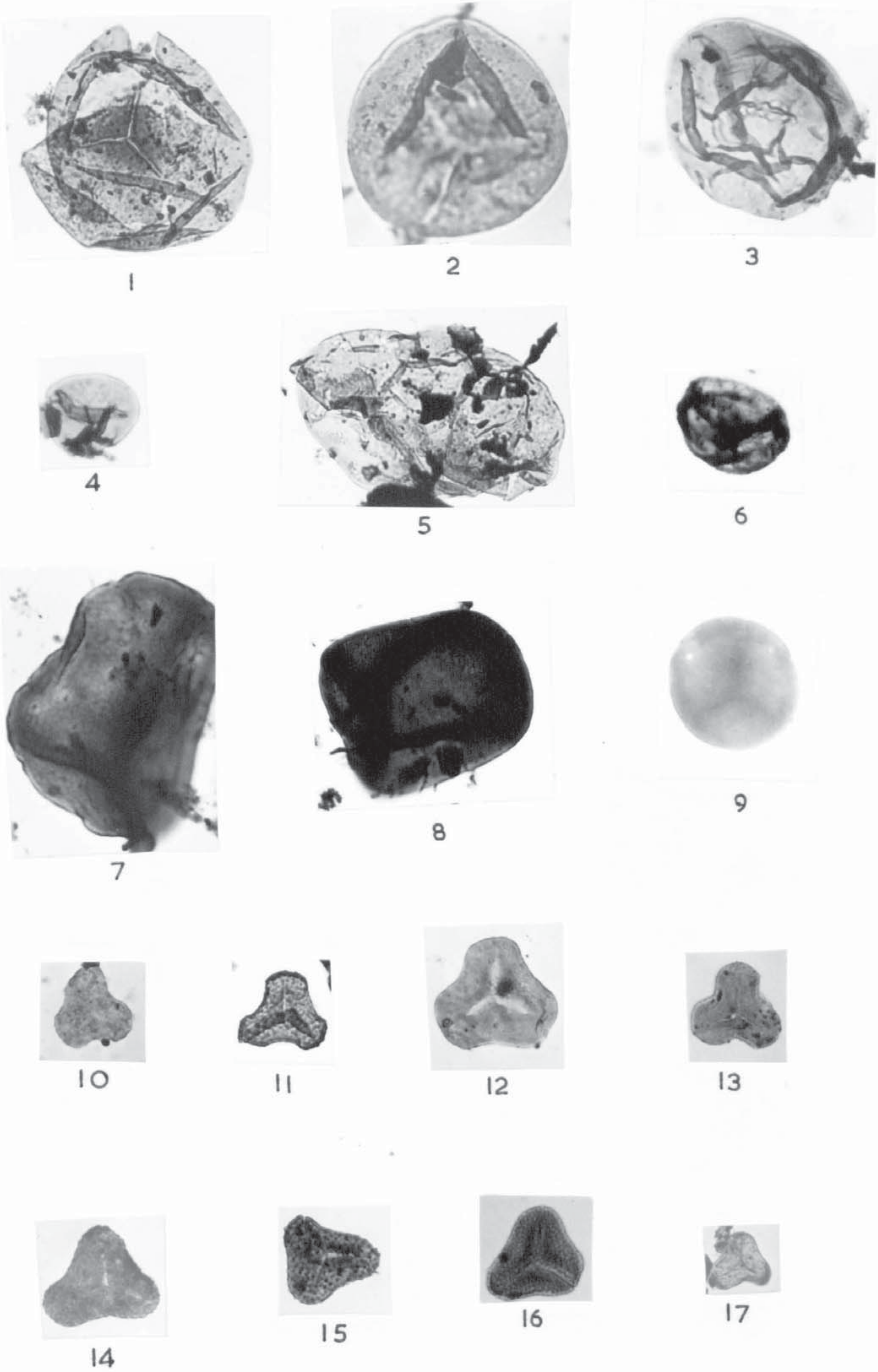

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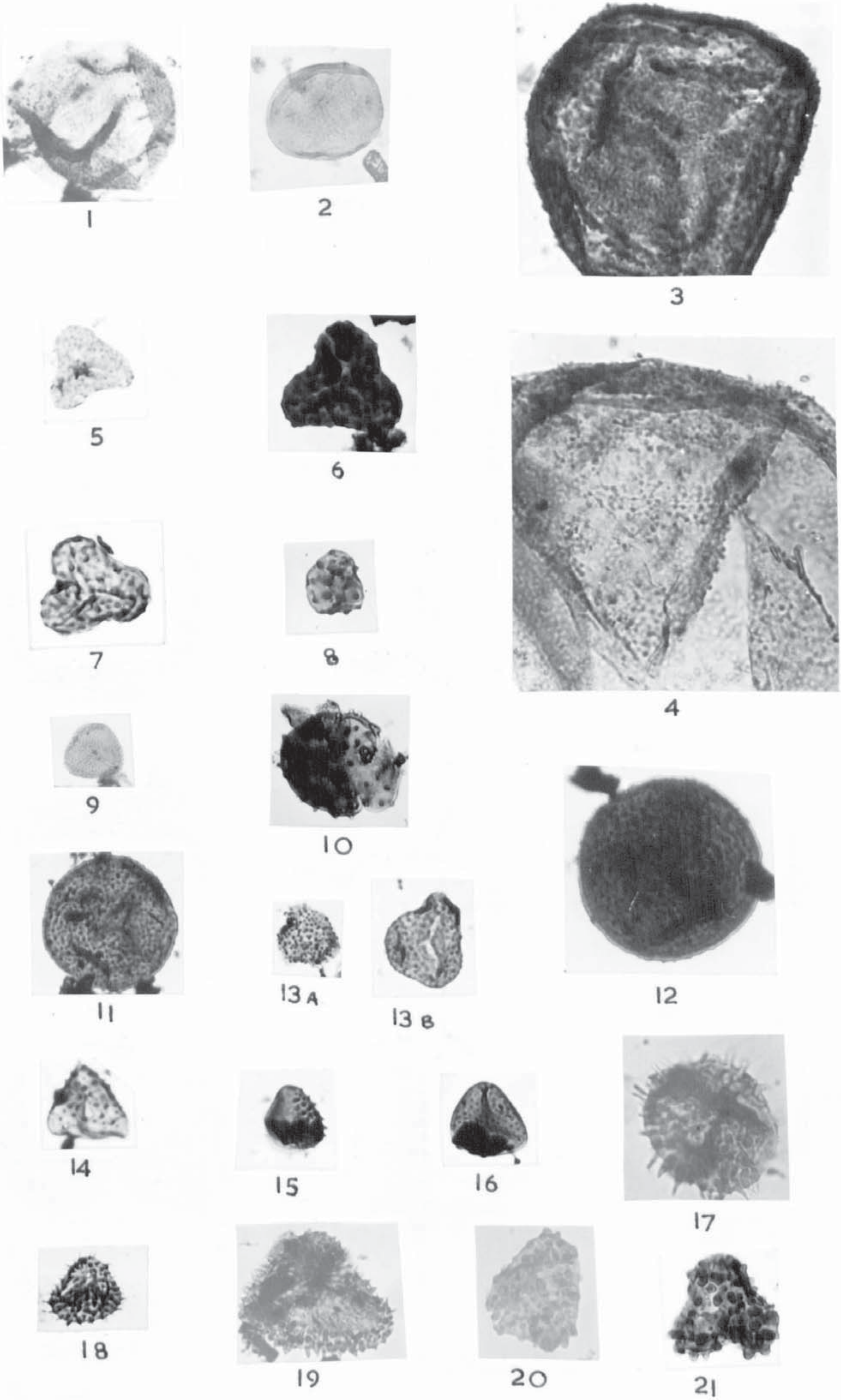

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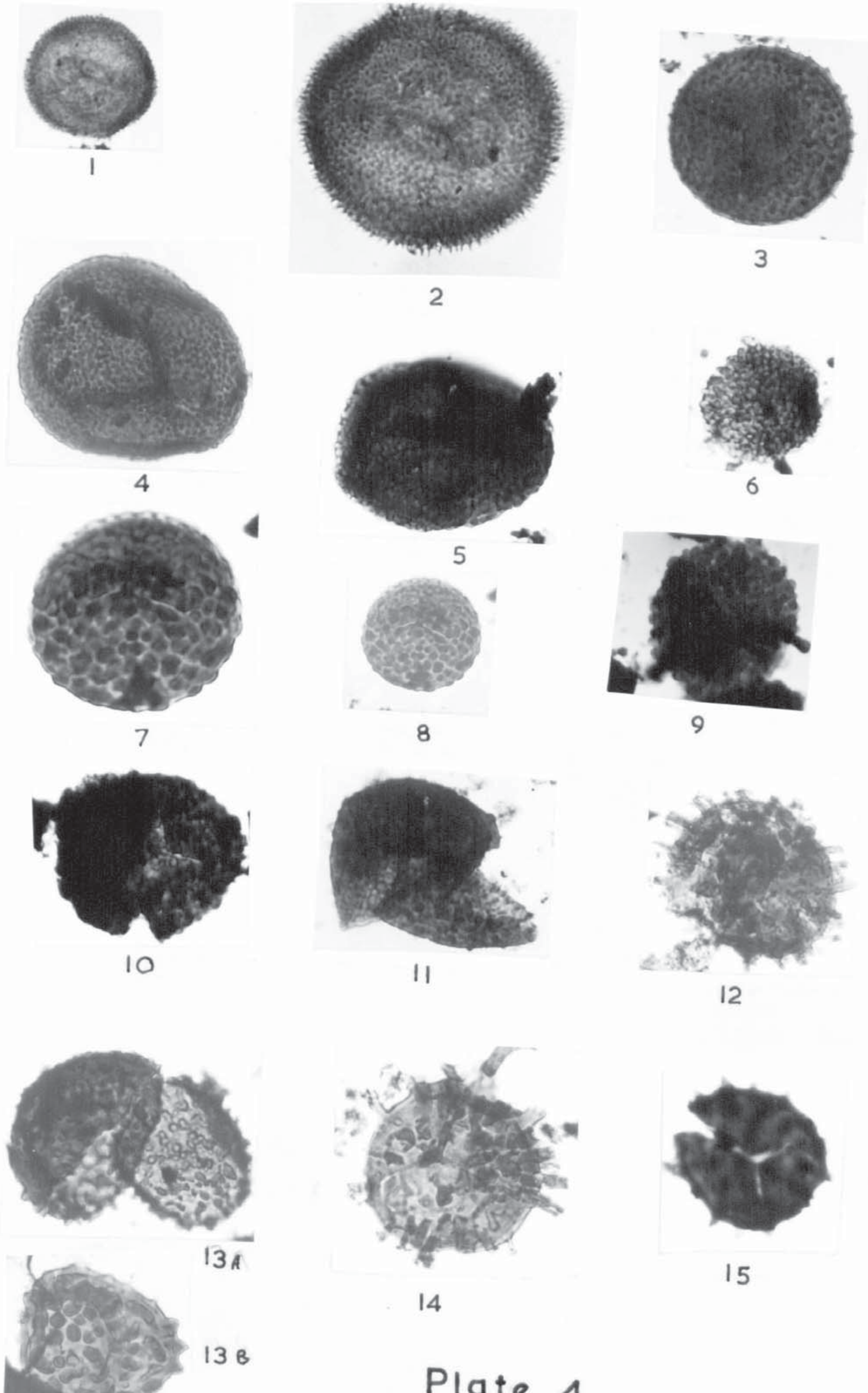

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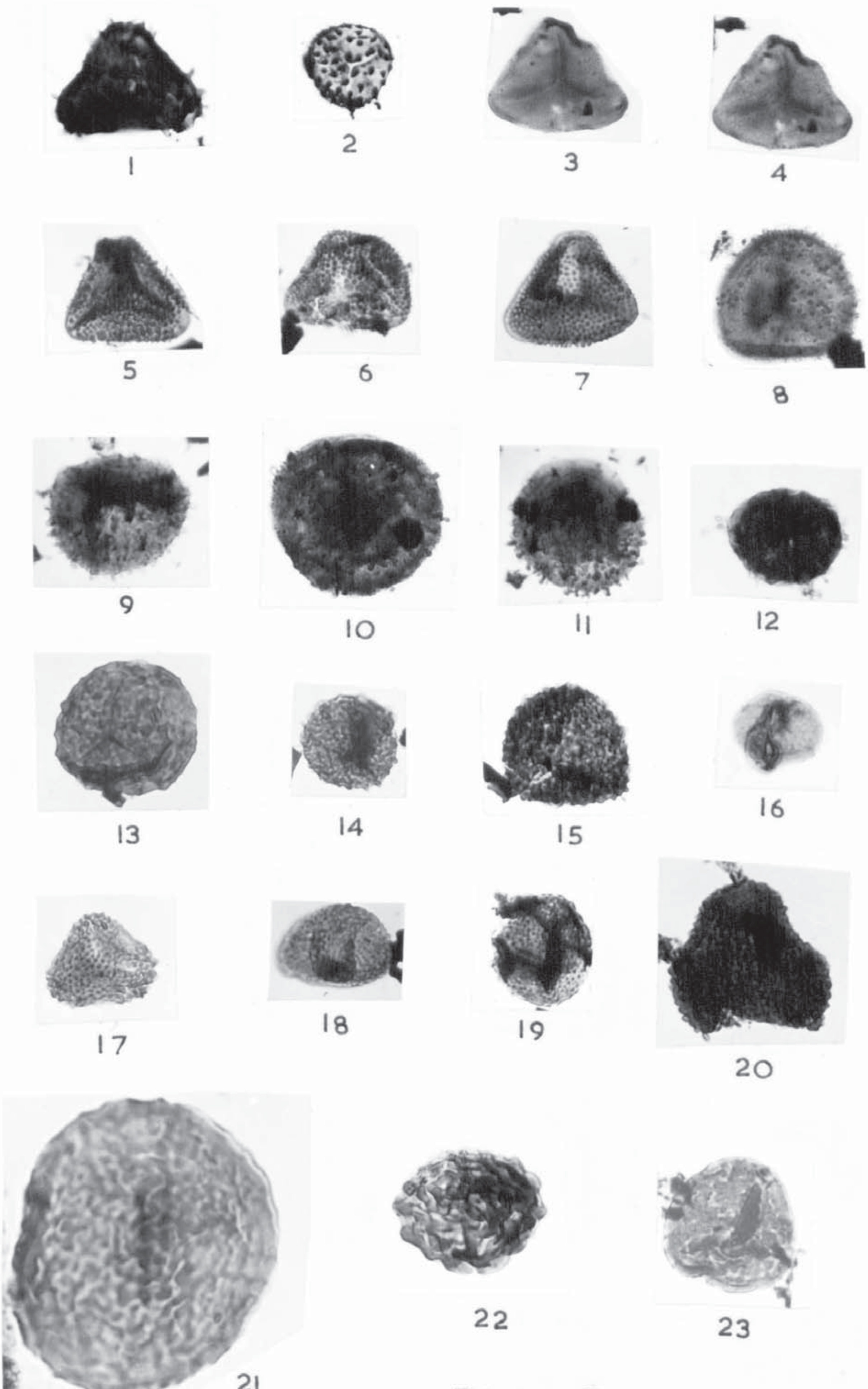

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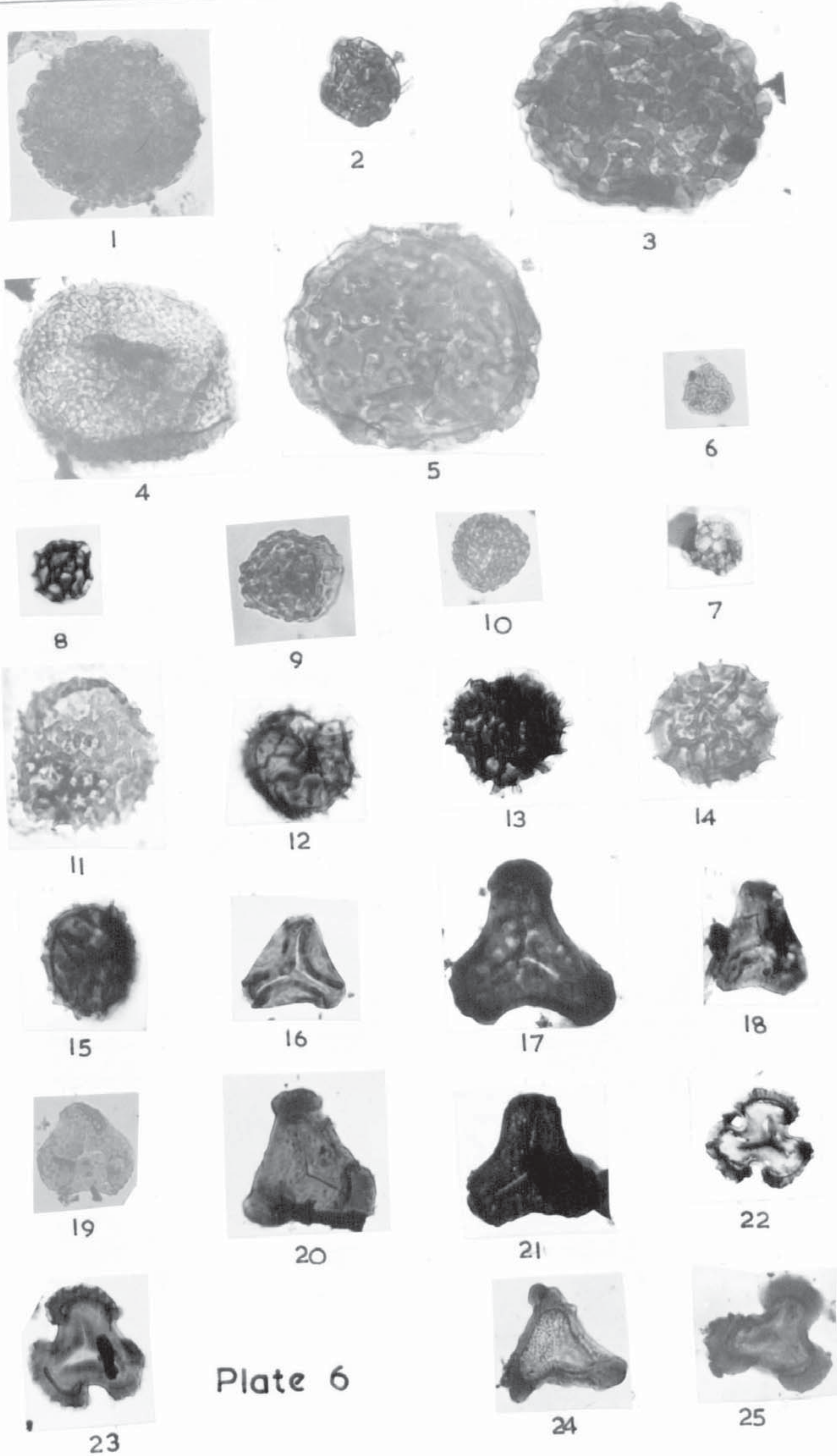

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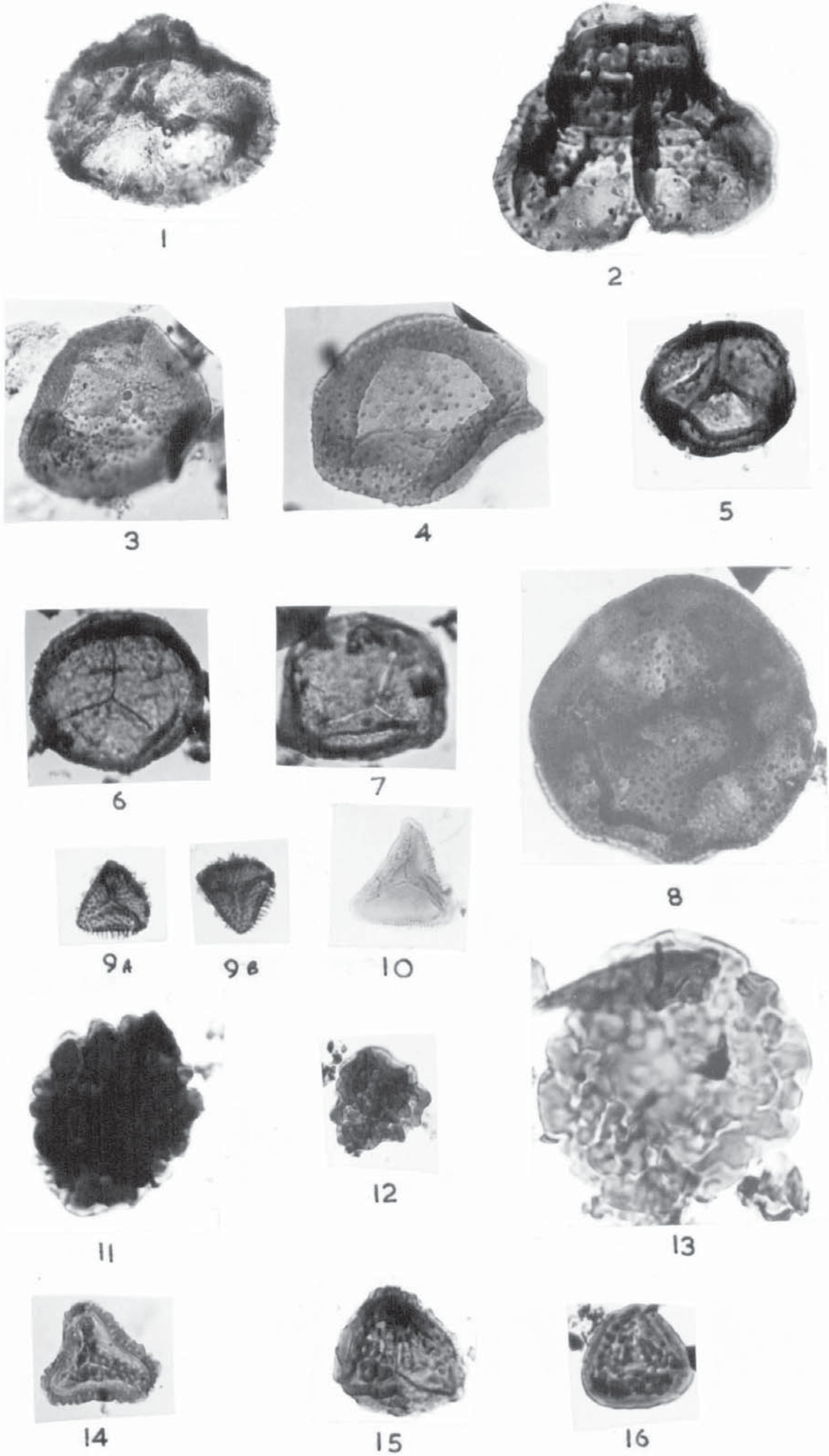
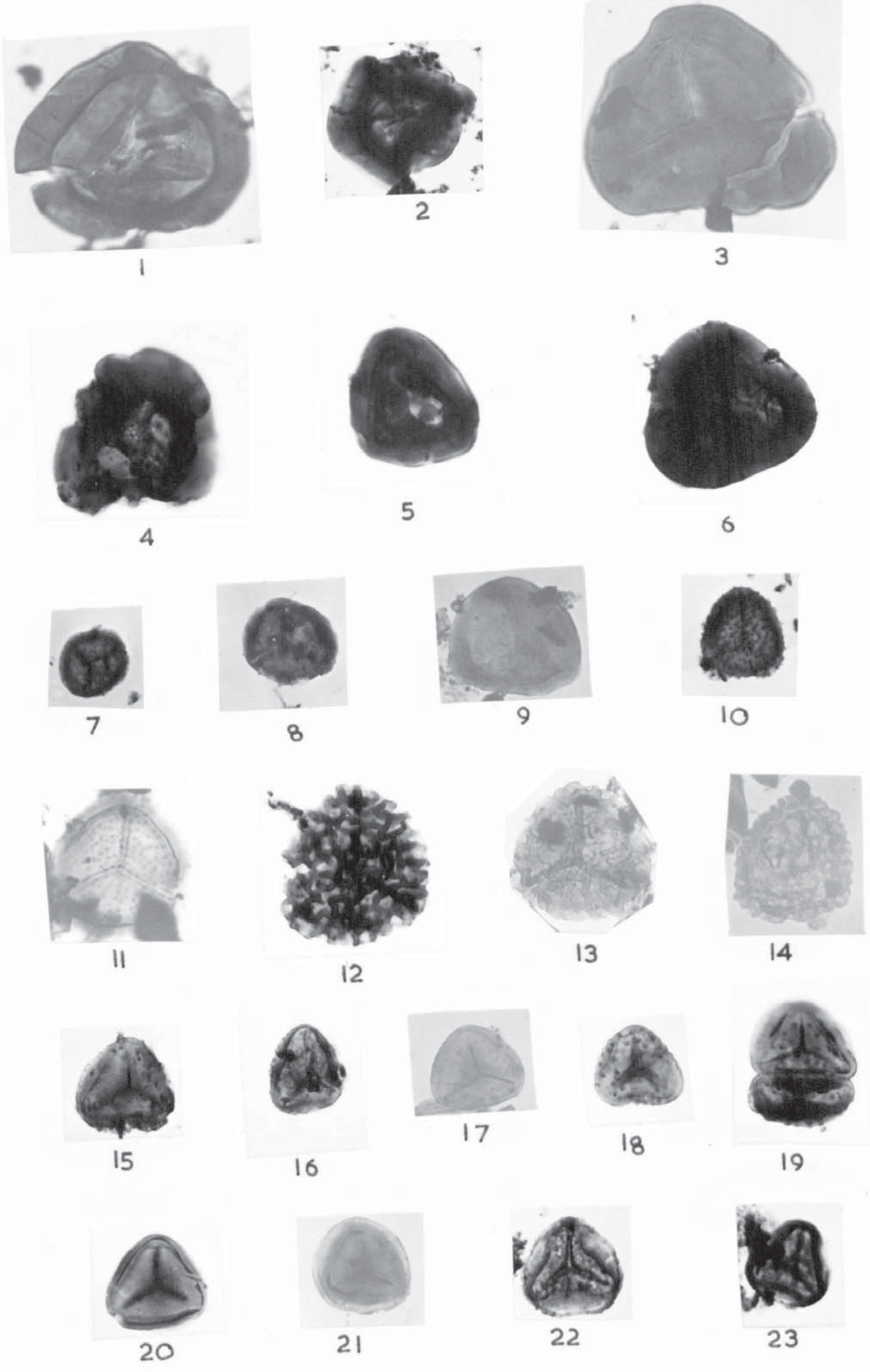


Plate 7



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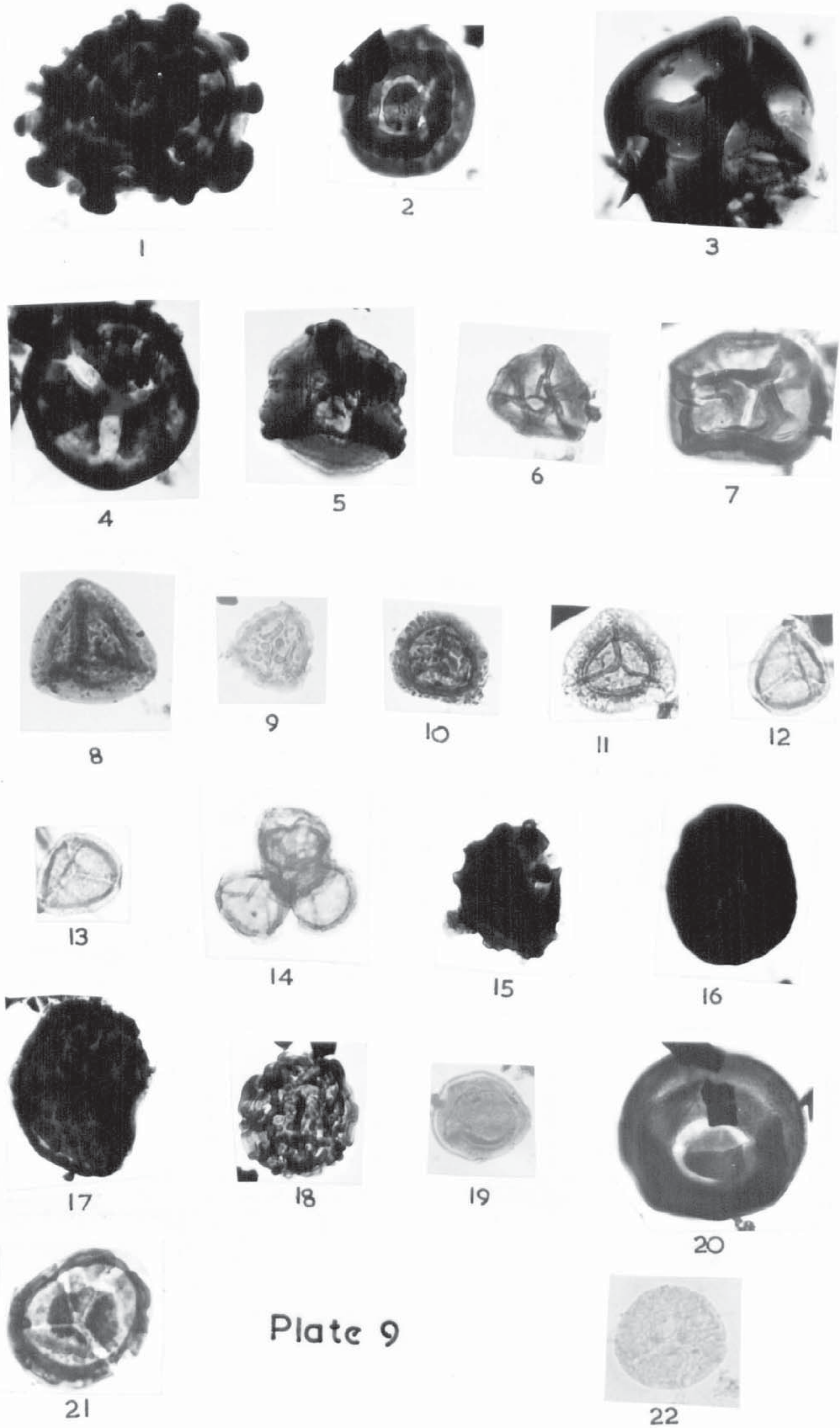


Plate 9

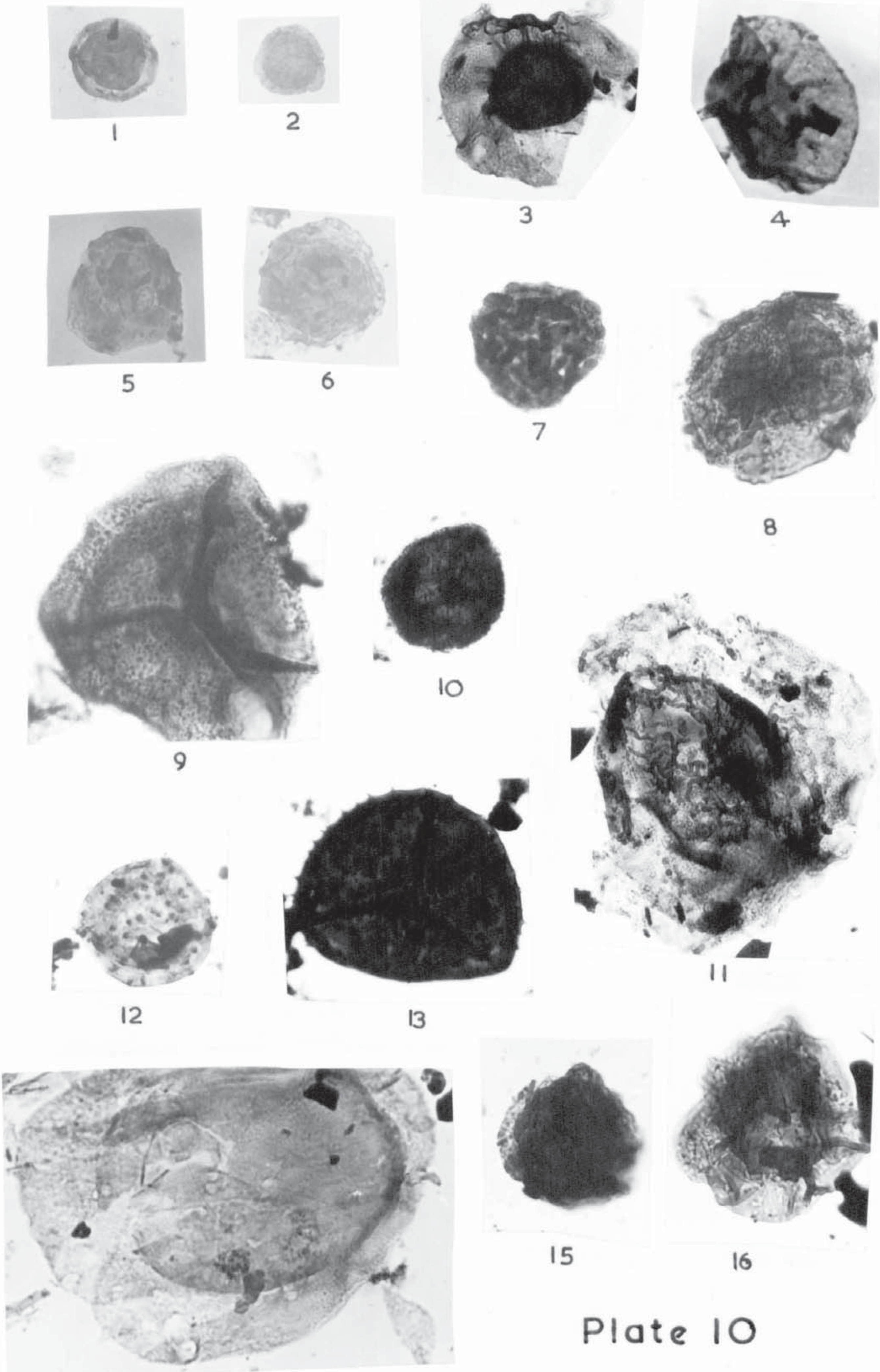


Plate 10

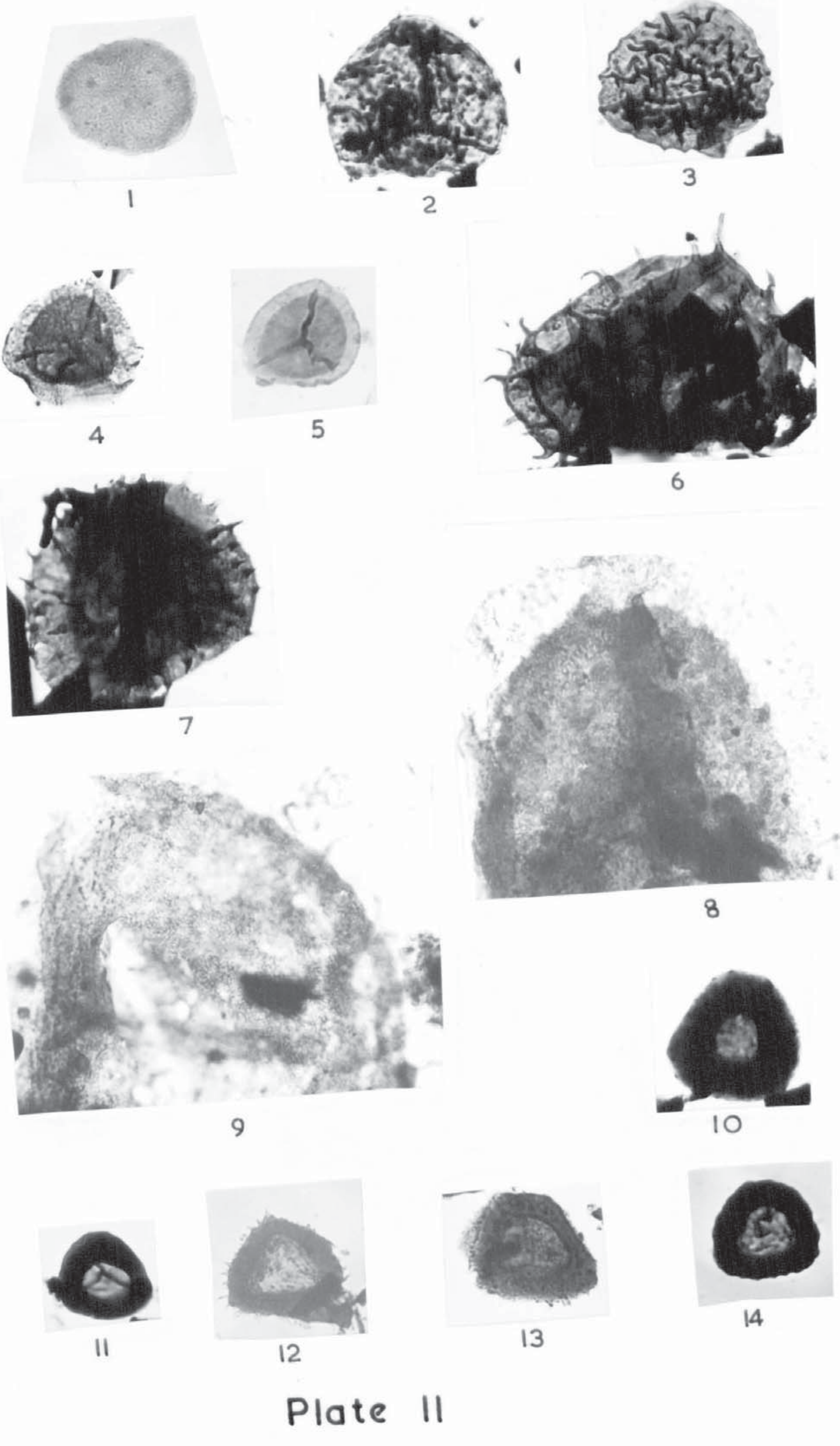
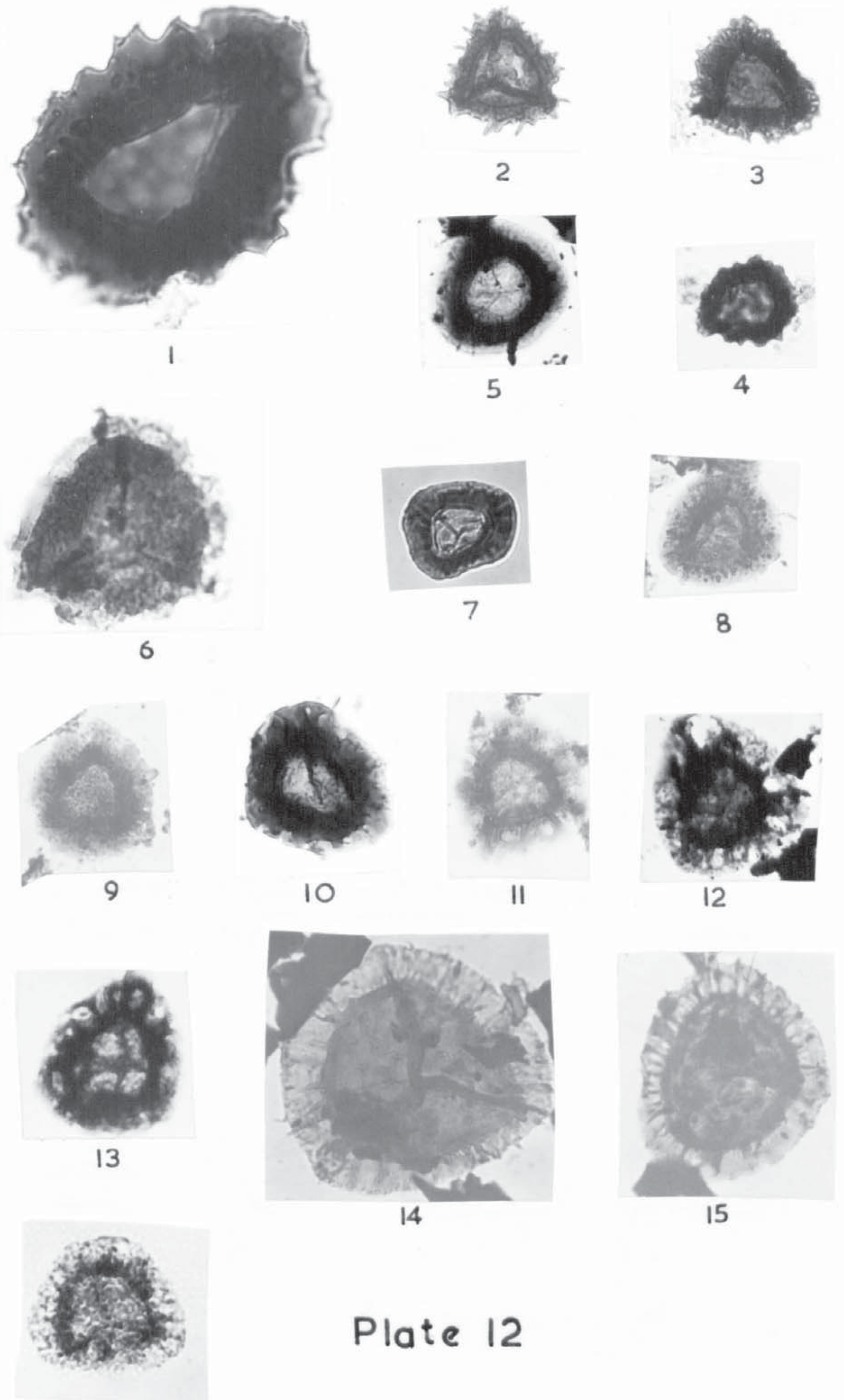


Plate 11



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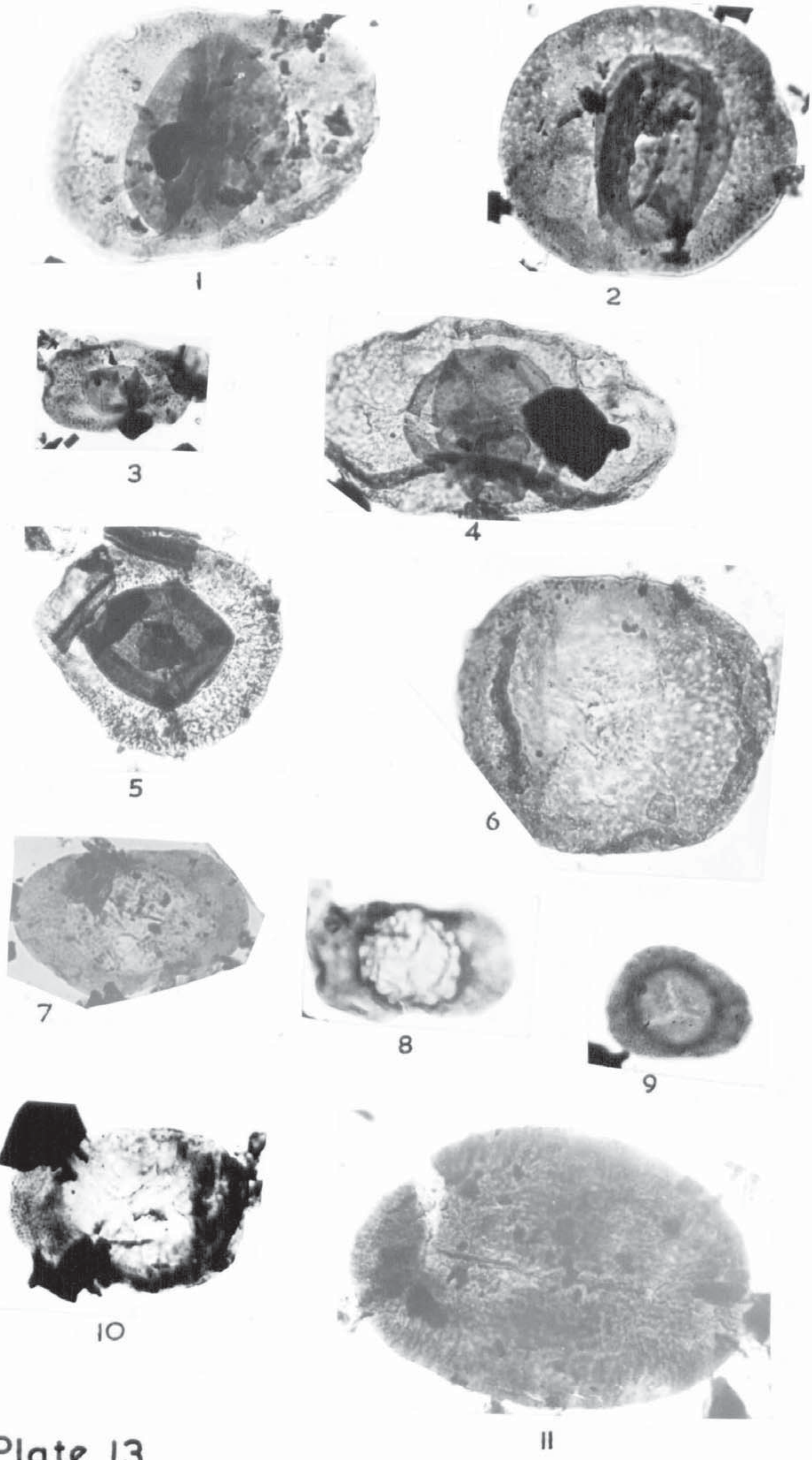

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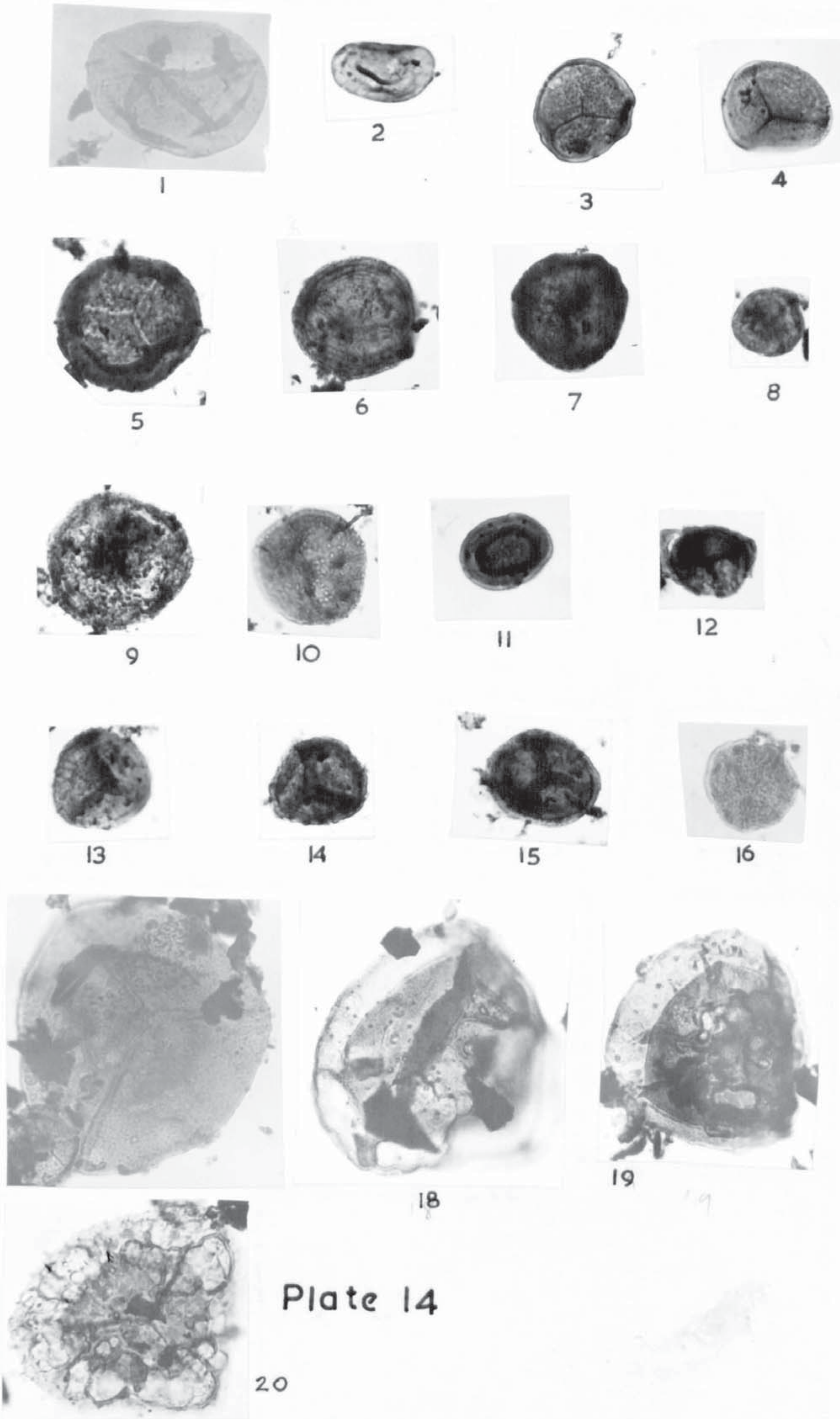

Plate 14