THE PALYNOLOGY OF CARBONIFEROUS SEDIMENTS IN IRELAND, WITH SPECIAL REFERENCE TO THE BALLYCASTLE AND LEITRIM AREAS.

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SUMMARY

Approximately four hundred samples were collected from the Carboniferous sediments of Ireland. Few of these proved to be productive. Twenty-seven assemblages were obtained from the type locality of Slieve Anierin in County Leitrim, which includes goniatite dated strata of the late Pendleian and early Arnsbergian stages. Seventy-seven assemblages were obtained from Ballycastle in County Antrim, which includes poorly dated strata of B_2 to possibly E_2 zone age. Seven assemblages were also obtained from strata of various ages within the lower Carboniferous (K – S zone).

Two Concurrent Range Biozones are described from Leitrim which are considered to be composed of three main elements, (i) Pendleian autochthonous species, (ii) Younger species at the earlier part of their stratigraphic range and (iii) a contemporary upland flora.

Two C.R. Biozones are described from Ballycastle. Their assemblages support the earlier recognition of the Main Coal horizon as the possible Namurian/Viséan boundary, but suggest the oldest sediments belong to the Posidonia zone, and that the youngest assemblages are more consistent with those described from previous Pendleian (E_1) age.

Lower Carboniferous assemblages from North Western Ireland appear older in aspect than the macrofaunal evidence indicates and that they also show some affinities with assemblages described from Canada.

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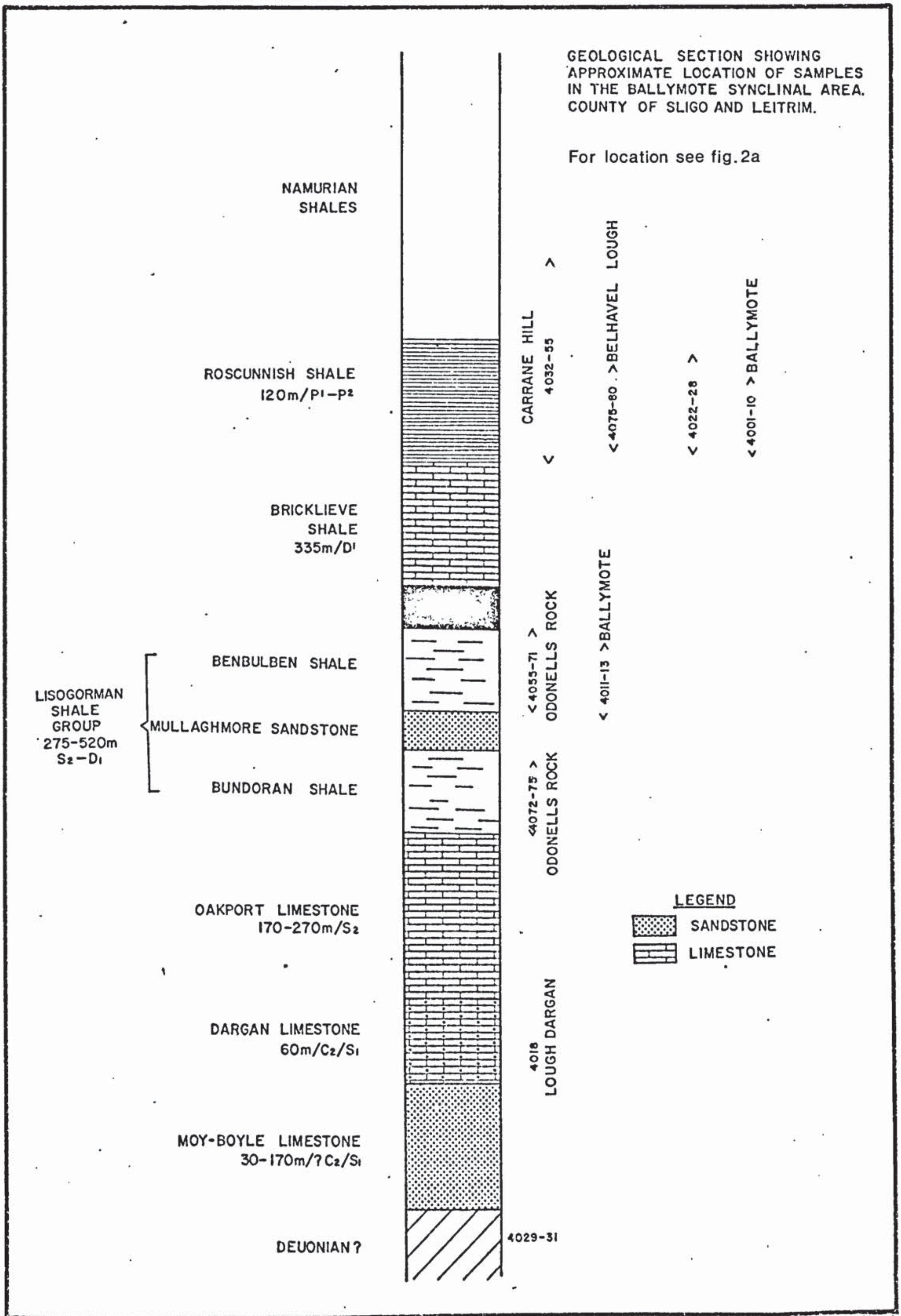
CHAPTER I

INTRODUCTION

The original purpose of this thesis was to study a series of borehole cores of Carboniferous ages provided by the Geological Survey of Ireland from the Leitrim area and to supplement this information with further field work in that area. It was known that from previous accounts by Brandon (1968) and Yates (1967) that a goniatite dated section of Viséan P_1/P_2 to Namurian E_2 zone age was present. Also Ramsbottom (1969) had suggested that this area become the type section for the Pendleian and Arnsbergian stages. Subsequent preparation of the material, however, produced only a few good spore assemblages which were mainly from the area to the north of Lough Allen. (See text figs.: 1, 2a, 13.)

On a second collecting trip to Ireland particular attention was given to Outcrops around Lough Allen and increased the area sampled to include the districts around Carrick-on-Shannon, Lough Arrow, Boyle and the counties of Mayo and Sligo (text figs. 1, 2, 3 & 4). The Carboniferous succession here, described in a recent paper by Dixon (1972) begins with a coarse grit and sandstone of questionable C_2/S_1 age followed by the Dargon and Oakport Limestones. A few samples were collected from these horizons but there were few shaly intervals. The overlying Lisogorman Shale Group (S_1 - D_1) was reasonably exposed in stream sections and a number of samples through this sequence were taken, particularly near the Odonells Rock locality. The Bricklieve Limestone which lay above proved similarly poor in shaly intervals. Well exposed sections of the Roscunnish Shales (P_1/P_2) and Namurian shales can be found both north and south of Leitrim, and were sampled in several areas particularly Ballymote, Carrane Hill, Belhavel Lough and Odonells Rock. (Fig. 2a.)



Drawing No. 15885 3·VIII·76 Figure No. 4

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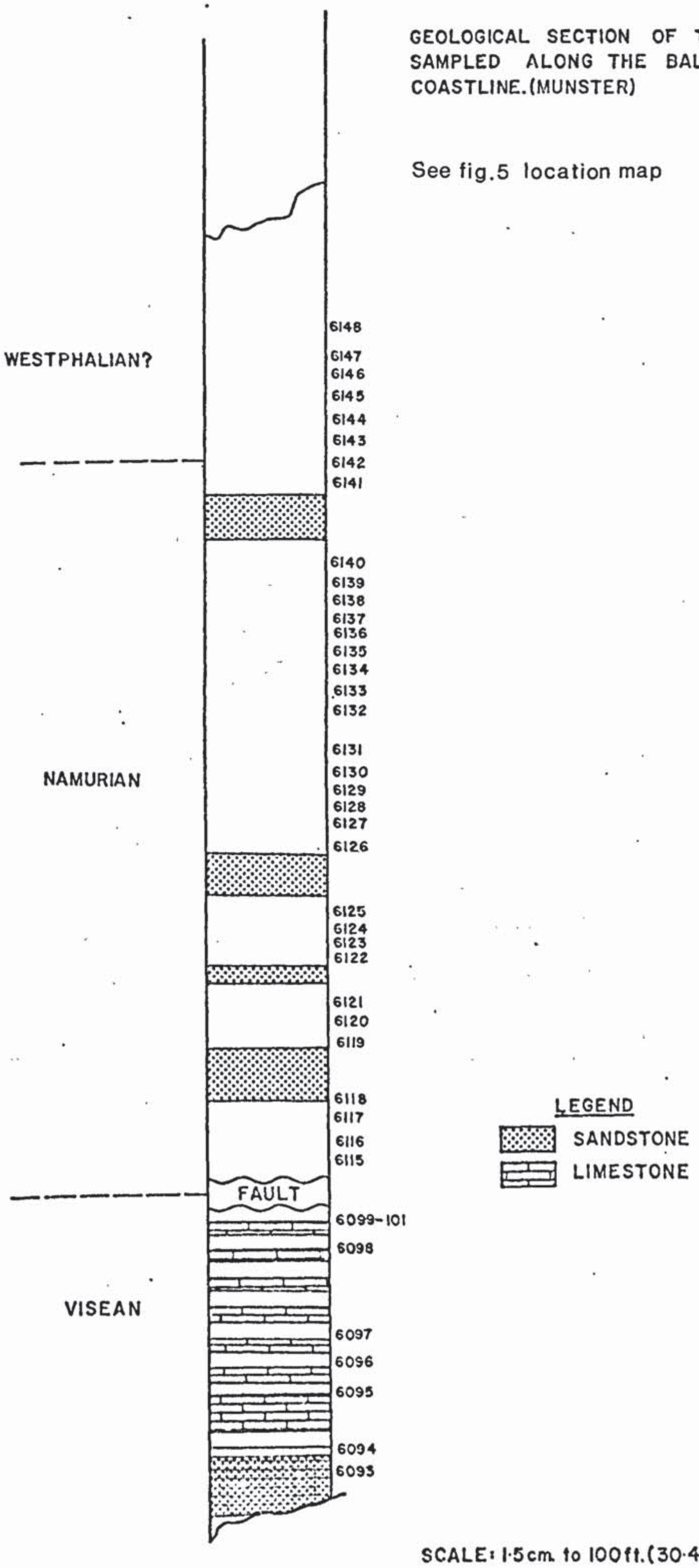
GEOLOGICAL SECTION OF THE AREA SAMPLED ALONG THE BALLYBUNION COASTLINE. (MUNSTER)

See fig.5 location map

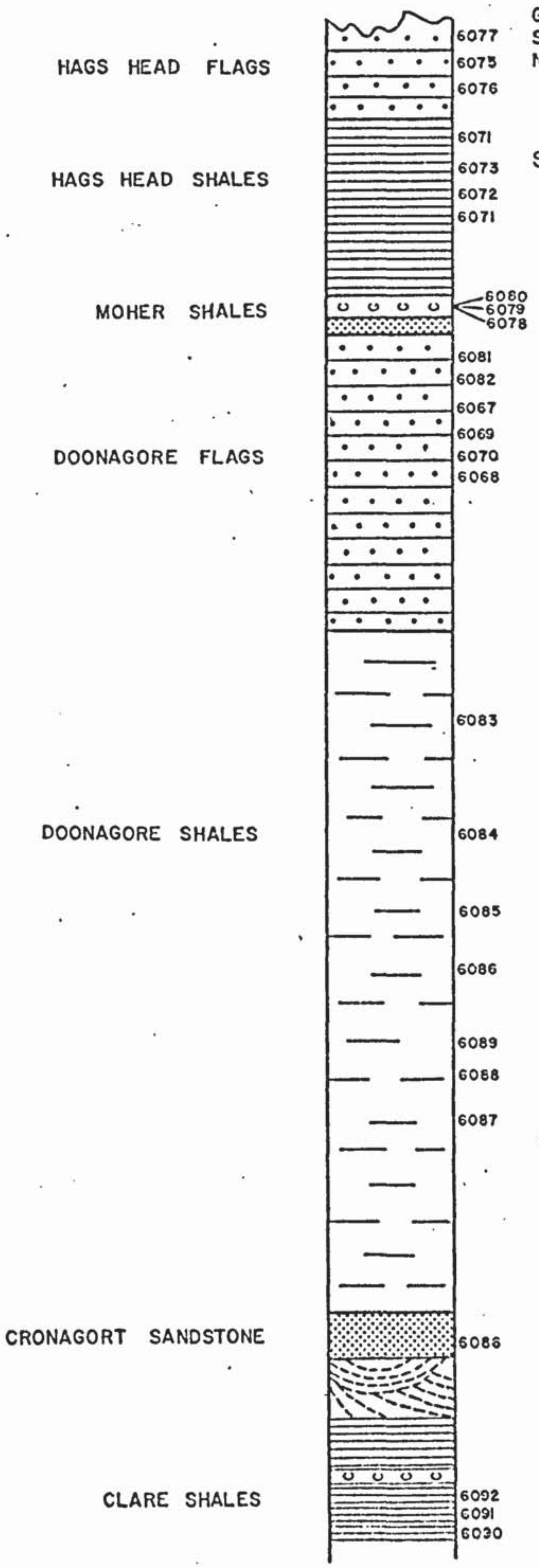


SCALE: 1·5 cm. to 100 ft. (30·48 m.)

Drawing No. 15880 22·VII·76 Figure No.6

GEOLOGICAL SECTION OF THE AREA SAMPLED AROUND WESTERN AND NORTHERN CLARE.

See fig.7 location map



LEGEND

SANDSTONE

MUSSLE BAND

SCALE: 1·5cm. to 100ft. (30·48m.)

Drawing No. 15883 26·VII·76 Figure No.(

GEOLOGICAL SECTION OF THE AREA SAMPLED AROUND THE SLIEVEARDAGH COALFIELD.

Productive _ sample underlined

Location - FIG.10a

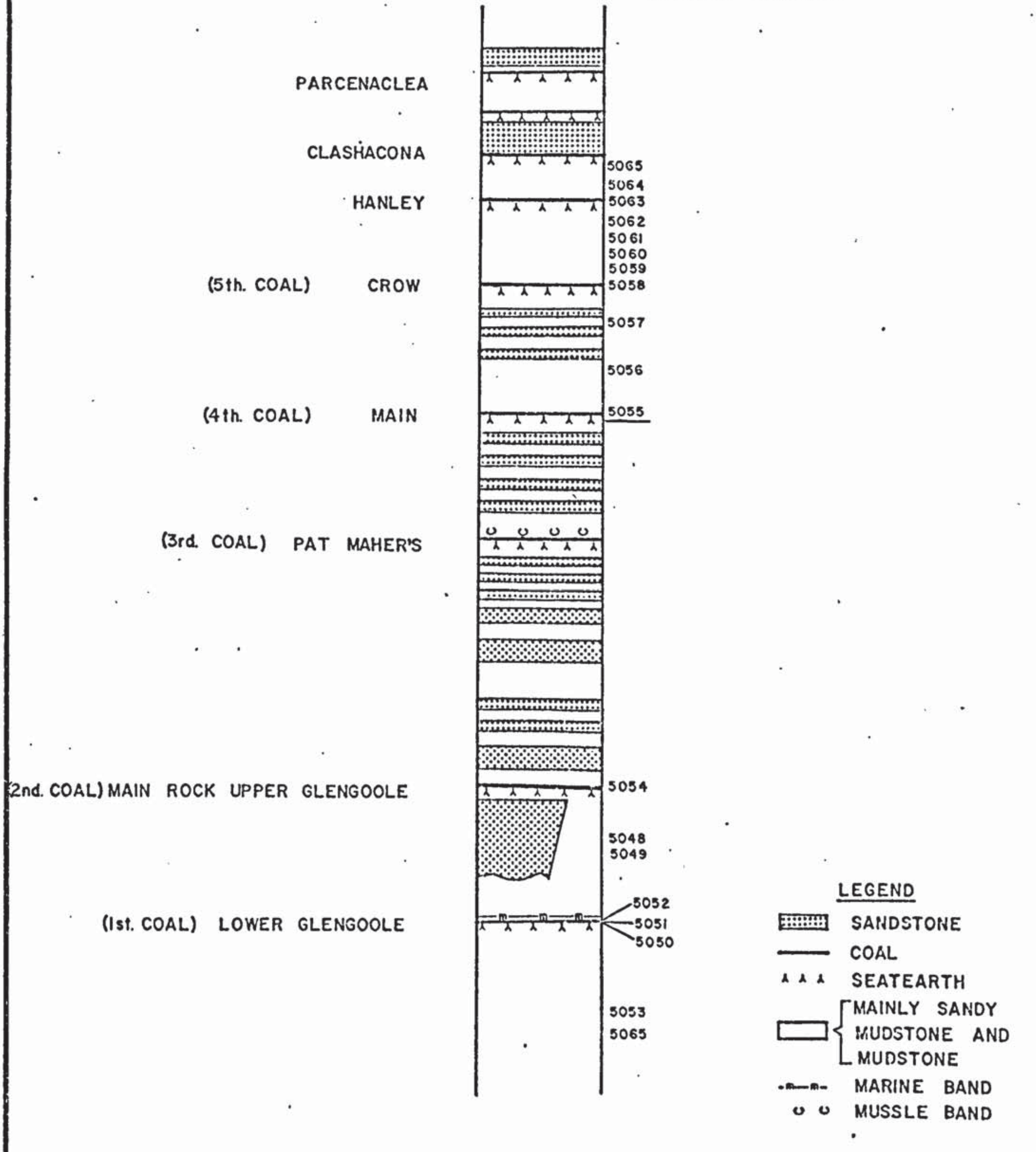


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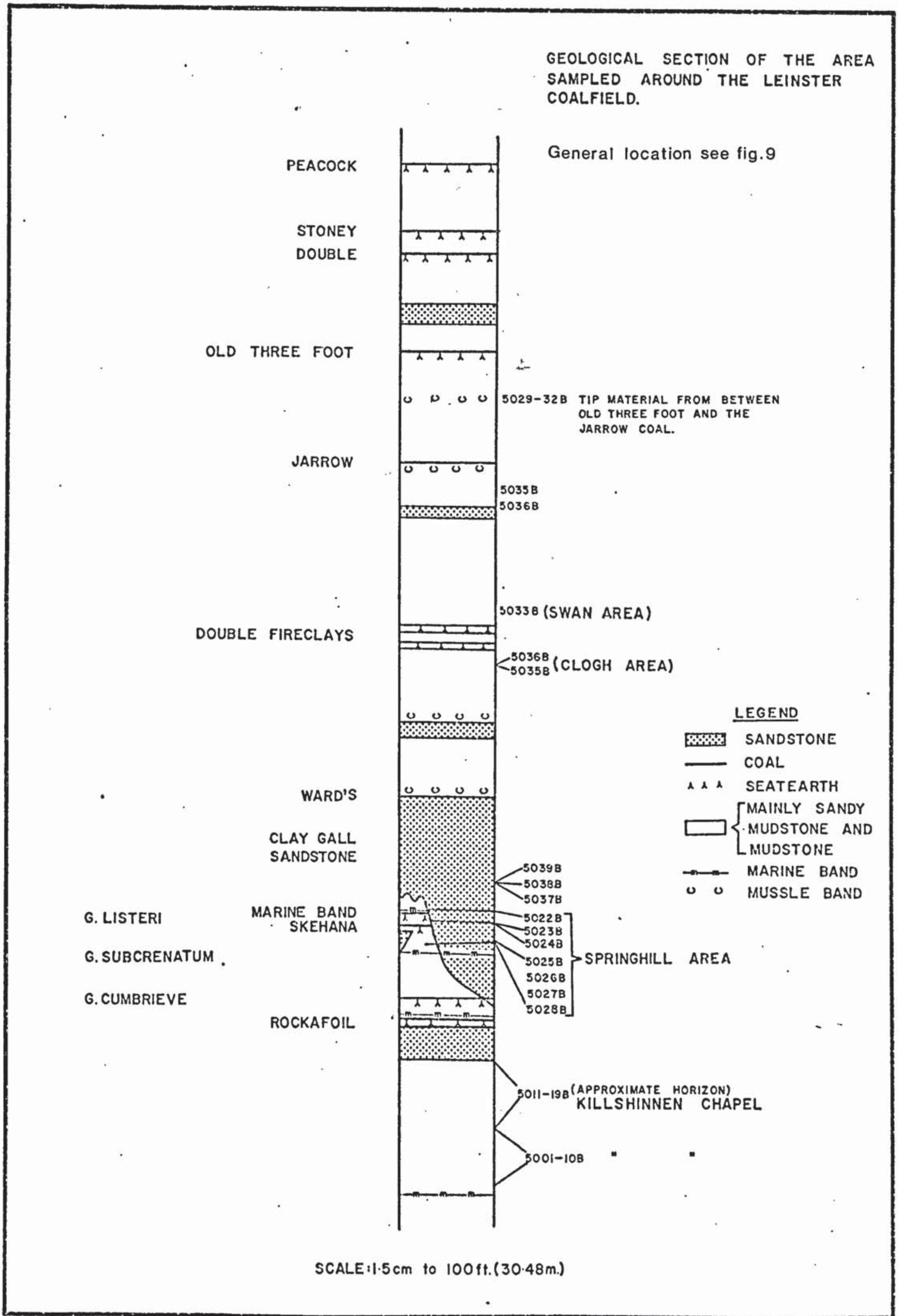
Figure No. 10



Drawing No. 15882 26·VII·76 Figure No.11

Despite numerous experimental maceration methods the results were disappointing, with only two more productive samples obtained, both of which were obtained from the Namurian E_1 shales of the Odonells Rock area.

Strata of approximate Viséan age were also sampled along the northern coast of County Mayo (text figs. 1 & 2), which proved equally unproductive. This latter area had been previously sampled by C. Butcher (Aston University, personal communication) who gained one reasonable assemblage from Killala Bay, which is included as a part of this study.

On a third collecting trip to Ireland, Carboniferous outcrops in a wider area were sampled and these included some of the southern counties, Carlow, Kilkenny, Tipperary, Limmerick, Clare and Kerry (text figs. 1, 5, 6, 7, 8, 9, 10 & 11). Here the Lower and Upper Carboniferous are well developed, particulalry the latter, where the E, R, H and G zones of the Namurian can be found together with the Ammanian and Morganian of the Westphalian, as described by Charlesworth (1953, 1963). In the Munster Basin there are approximately 4,500' (1473 m) of shales, coals and siltstones with only rare sandstones. The P_2 and E_1 zones are missing but the E_2 - R_2 zones are recognised. In the Slieve Ardagh and Castle Comer areas the E_2 and R_1 zones are probably absent, but the Westphalian sequence is present.

The above areas are well exposed and one hundred and fifty-five samples were taken from strata of both Lower and Upper Carboniferous age. Only five good assemblages were obtained. Two were from Goresbridge described as K zone age; one of Westphalian age from Castlecomer; and two of approximately Namurian age from Ballybunian. The latter three were not included in a stratigraphical study as their quality was considered poor.

It was decided now to consider Northern Ireland which had until then been avoided because of the political situation. Dr. M.A. Butterworth had already made a preliminary study of the Ballycastle area for the Geological Survey in Northern Ireland and had a small number of samples in her possession stored at the N.C.B., Wath-on-Dearne (text figs. 1, 18 & 19). These were kindly loaned to us by A.H.V. Smith and the results proved to be very good. A field excursion to the area resulted in a detailed section being obtained from above the lava sequence, a section which on macrofaunal evidence has been poorly dated as including strata from B to E_2 zone age. Further samples were also kindly provided by the Northern Ireland Geological Survey.

C. Butcher, Aston University provided a small number of Lower Carboniferous assemblages he collected from Donegal (text fig. 30). The author is also grateful for two productive samples provided by Dr. Dhoran of the Irish Geological Survey, which he collected from the Tournaisian/Viséan of Southern County Mayo. Fig. 30.

The present study now consists of a stratigraphic and environmental interpretation of assemblages taken from the Ballycastle, Leitrim and Goresbridge areas, which range from Tournaisian to Lower Namurian in age. A statistical study of the genera Lycospora and Schulzospora is included, from a series of samples taken essentially from a Leitrim coal of E_2 age.

CHAPTER II

CARBONIFEROUS PALYNOLOGY AND CLASSIFICATION

Classification Summary

Work on Carboniferous palynology began with Reinsch (1884), when he described megaspores and microspores from Central Russia and Saxony. The first classification of spores was proposed also by Reinsch, who recognised the trilete suture as an important feature and erected his Tribe - Triletes, dividing these into sub-tribes, in which were several 'types' described with excellent drawings.

The next work of importance concerning classification was by Potonie, Ibrahim & Loose (1933), who initiated the binomial system of nomenclature, placing morphographical groups into genera which had names based on their exine features. They provided a type species for each genus and proposed two more groups to supplement Triletes of Reinsch i.e.: Monoletes and Aletes.

The first classification used in Britain was by Raistrick and Simpson (1933) who first classified spores into morphographic groups A - G. Each group was further divided, also by morphographic means, into types A_1 A_2 A_3 A_4, B_1 B_2 etc. Raistrick considered that his types were equivalent to Potonié and Ibrahim species. It was a successful scheme for coal seam correlation purposes enabling a series of assemblages from the Upper and Lower Carboniferous of Northumberland to be recognised. His rarer spores he called 'accessory', noticing that many of these had restricted ranges with a potential for correlation purposes.

Many authors subsequently published work based on seams from other coalfields; Tomlinson - Productive Measures of the Cumberland Coalfield; Millot - North Staffordshire Coal Seams; Paget - North Derbyshire and Warwickshire Coalfields and Knox - Scottish Coalfields. Many of Raistrick's types were identified in these areas, particularly C_1 Endosporites globiformis and A_7 Radiizonates aligerens, and thus a basis for correlation within the coal sequences was becoming more practical. Limitations to this scheme came from the morphographic types not being adequately defined and their detailed structure not taken into account.

Naumova (1939) proposed a classification which became widely accepted in Russia. She divided the taxonomic groups in more detail. Triletes and Monoletes were sub-divided into Azonotriletes and Zonotriletes. Her classification has the important feature of using only one diagnostic factor for subdivision at any taxonomic level. Since 1939 her classification has been altered by Ischenko (1952) and Luber & Waltz (1939). Schopf, Wilson & Bentall, studying the Pennsylvanian in America extended Ibrahim's classification but did not use any supra-generic groups at all in their classification of 1944. They grouped morphographically similar species into genera providing genotypes and holotypes. Knox (1950) proposed a classification without supra-generic terms but no types were named, and the classification has not been widely adopted.

Potonié & Kremp (1954) were the first to recognise wall stratification as a feature for classification. They sub-divided their anteturma Sporites into Turma, Subturma and Infraturma levels by considering aperture, lip stratification, sculpture and equatorial features.

Dettmann (1963) revised the above scheme but her use of the word 'cavate' in the scheme is misleading and regarded by many authors as incorrect. She also introduced supra subturma Perinotriletes to include spores with a similar outer membrane to that of Perotrilites. Richardson (1965) criticised this term as it had been used elsewhere with a different sense, and also thought it undesirable to use Cavati to describe the

STRATIGRAPHICAL DISTRIBUTION OF PALYNOLOGICALLY DESCRIBED SEQUENCES IN THE BRITISH LOWER CARBONIFEROUS

(BASED ON A DIAGRAM FROM NEVES ET. AL. 1972)

Drawing No. 15894 12·VIII·76 Figure No. 12

structure of Perotrilites. Neves and Owens (1966) agreed with Richardson and based the importance in their classification on the presence or absence of cameration at subturma level. They thus set up Acameratitriletes of Dettman and devised Cameratitriletes for camerate spores in which the outer membrane could not be demonstrated as a true perine. Their third supra subturma within Triletes was Perinotriletes after Erdtman. Subdivision of Cameratitriletes was based on the nature of attachment. Smith & Butterworth 1967 also modified Dettman's classification, however they continued to use cavate in the same way, but change the name to Laminatitriletes. They also introduce a new suprasubturma Pseudsaccitriletes for spores with a well developed cavate structure. Neville (1968 thesis) points out that there is no fixed definition of where the division of two groups occurs: and also that it allows widely different morphographic types e.g.: Schulzospora and Spencerisporites to be placed in the same group.

Neves & Owens (1966) is considered to be the most suitable classification ( ) since it clarifies the use of the term cavate, gives a close morphographic grouping of the spores, and makes use of Palaeobotanical evidence.

Grebe (1974) in her recent paper, reviewed and clarified terms used in spore nomenclature. In the present study the terminology used is essentially that suggested by Grebe (loc. cit.).

Summary of Stratigraphical Application of Spores in the Carboniferous

Some of the earliest stratigraphical work was the result of practical attempts at seam correlation. Slater, Evans & Eddy (1930,1932) used megaspores and recognised the necessity of studying the distribution of spore assemblages rather than the absence or presence of a single spore.

Raistrick(1924 - 1928) described a series of assemblages from the upper and lower Carboniferous of Northumberland, recognising many differences in content. Many authors subsequently published work based on seams from other coalfields Tomlinson (1940) - Productive Measures of the Cumberland Coalfield; Millot (1938-39) - North Staffordshire Coalfield; Paget (1936-37) - North Derbyshire and Warwickshire Coalfields; and Knox - Scottish Coalfields.

Two important works by Balme and Butterworth (1952) and Butterworth & Millot (1955) helped increase the knowledge of microfloras in the Productive Measures of the central group of British Coalfields, sufficiently to enable a number of zonal assemblages to be put forward for this part of the Carboniferous. Later work by Williams (1956) in the southern group of coalfields helped refine the scheme even more..

One of the earliest studies of the Namurian Series was by Butterworth & Williams (1958) in the Limestone Coal Group and Upper Limestone Group of Scotland. This work enabled Butterworth and Millot 1960 to establish a series of zones covering much of the British Carboniferous coal-bearing strata. Work by Neves (1958, 1961) in the southern Pennines was the first of its kind in Britain to study spore assemblages from rocks other than coals. This work also describes assemblages from well dated (goniatites) Namurian and Lower Westphalian horizons. Owens (1965) in his study of Westmoreland Namurian microfloras added more knowledge to the changes in flora.

Smith & Butterworth (1967) refined the zonation scheme of B. & M (1960) even further in their monograph, a study which includes most of the coals in G. Britain. Eleven 'assemblage zones' were described, many of which, particularly in the Namurian and Westphalian, are still very useful.

Little information was available so far, from rocks of Tournaisian and Viséan age.. The only published work at this time was from the Forest of Dean (K zone, Sullivan). The next three to four years produced many papers of probable Tournaisian and Viséan assemblages, which helped to complete a more comprehensive picture of Carboniferous Palynology.

Particularly useful was Dolby and Neves (1967) Burrington Coombe assemblage which indicated the potential of Spelaeotriletes (Hymenozonotriletes) lepidophytus and associated spores as useful stratigraphical 'markers' at the Tournaisian/Famennian boundary. Other work includes: Johnson & Marshall (1971) Ravenstonedale (Z age); Llewellyn & Mortimer (1969, 1970) Leicestershire (Z age) Butterworth & Spinner (1967) Bewcastle (C_1 to S_2 age).

During the early 1970s, much thesis work supervised by Neves at Sheffield University was coordinated, which included lower Carboniferous sections from many parts of northern England and Scotland. A zonal scheme with particular reference to the Spilmersford borehole, Scotland (Ioannides) was proposed for the British Dinantian in Neves et al. (text fig.12). These have largely replaced the Viséan 'assemblage zones' of Smith & Butterworth for this part of the Carboniferous. In 1973 they published a series of correlations based on these microspore assemblages, between sections in Northern England and the Midland Valley of Scotland. Additional work by Neves et al. in Southern Ireland has enabled a detailed examination of the Devonian/Carboniferous boundary. Here has been discovered a highly characteristic assemblage which includes Hymenozonotriletes lepidophytus proving very useful for correlation.

On the American continent Hoffmeister, Staplin & Malloy (1955) studied the Upper Mississippian of Illinois and Kentucky in the Hardinsburg Formation. This was a major work of its time, since it was the first study of assemblages derived from rocks other than coals. Further work on the Upper Mississippian was carried out by Staplin (1960) in Alberta. The Lower Carboniferous has been studied by Barss (1967), Playford (1963b) and Neves and Belt (1970) who all studied the upper part of the Windsor Group, suggesting a late Viséan age. The Horton Group below, has been described by Hacquebard (1957), Playford (1963b(and Varma (1969). Felix & Burbridge (1967) proposed a new type of transitional assemblage for the Springer Group which lay between rocks of Mississippian and Pennsylvanian age. This work is also useful for comparison with the European early Namurian microfloras.

From Russia, information has not been abundantly forthcoming, but a few early works have enabled some comparison to take place. Ischenko (1952, 1956 & 1958) made a detailed study of the Donetz and Dnieper Basins. This together with Luber & Waltz (1938, 1941) describe assemblages which have a lower Carboniferous aspect, and also display a different microfloral suite to those from Europe.

Work in Europe on the Upper Carboniferous includes papers by Jachowicz (1971), who studied spores from Northern Poland, comparing them with north west Europe and Britain; also 1974 studying microspore distributions in Upper Silesian coal bearing strata. Loboziak (1971) in the Nord Pas de Calais coalfield proposed several assemblage zones, comparing them with British and German work.

In the Lower Carboniferous Doubinger and Rauster(1966)described Upper Viséan assemblages from the Vosges of eastern France. Kalibova (1971) described some lower Carboniferous spores from Czechoslovakia: and Jachowicz (1967, 1970) from the Zoreby Beds of S.E. Poland. Bertlesen described a very comperhensive assemblage from Denmark, which had many characteristics of the (Pu) Lycospora pusilla zone of Neves et al.

An importantconclusion reached by Sullivan on the spore distribution (1965) within the Carboniferous of the northern hemisphere was the existence of microfloral suites. By a study of existing literature, he was able to recognise two 'suites' in the Tournasian i.e.: Lophozonotriletes and Vallatisporites Suites; and in the Viséan, the Monilospora Suite recognised from Canada, Spitzbergen and Russia and the Grandispora Suite recognised in assemblages from the Midland Valley of Scotland, Poland, Roumania and Turkey. The Grandispora Suite was detected by Neville (1968) in East Fife, Scotland, but there were some Monilospora Suite influences, which suggested that the boundary of these two Suites lay nearby.

In Australia a couple of authors have described assemblages, Balme (1960), Playford & Helby (1968) and Playford (1971), which display affinities to neither suite.

CHAPTER III

MACERATION AND MOUNTING TECHNIQUES

The standard oxidation method employed was to use approximately 10 ml. conc. HNO_3 adding fuming HNO_3 a little at a time. The oxidation time varied from 2 - 60 minutes. The volume of fuming HNO_3 and the time of oxidation were judged from the colour of the supernascent liquid and the visible effect on the residue. Once the required oxidation was complete the residue was washed in decreasing concentrations of acid and finally distilled water. In some instances fine debris was removed by washing in a 2% solution of KOH.

The samples that could be seen to contain spores in their unoxidised state responded adequately to the standard technique.

However, a tremendous number of samples from areas other than Ballycastle seemed totally devoid of spores, and did not appear to respond adequately to the fuming HNO_3 treatment. The author found that within the barren samples three groups could be recognised.

1) From all the areas other than Ballycastle black, sharply defined, angular, woody fragments dominated, with very little else. Sometimes their appearnce was similar to the outline of spores (whether coincidental or real). However, increasing the oxidation time of fuming HNO_3 had little effect, and only served to remove any further fractions that may have been present. Even a little potassium dichromate was added to fuming HNO_3 with no improved results. Treatment with 10% KOH had similarly little effect. A hydrogen peroxide method was tried where 1 gm of coal was boiled gently with 50 ml. 100 volume H_2O_2 for 4 - 6 hours or longer, more H_2O_2 added as required. Once again there was no improvement. A slightly more successful approach involved treatment with Schulze solution (conc. HNO_3 and

$KClO_3$) for periods of up to two days. The black carbonaceous residues were oxidised to more translucent browns and yellows, but all these samples were either barren, or the spores were poor in number and preservation.

2) In the Leitrim area, particularly Arigna, the standard technique produced very fine carbonaceous material, with normal yellow and brown colouring which flocculated, creating clumps of various sizes. Sometimes these had the vague shape of spores. Intensive sieving concentrated only a few wood fragments. The above described alternative oxidation methods were tried, with similarly poor results.

3) Samples from North and South Mayo, the Slieve Ardargh Coalfield and Goresbridge produced this type of residue which is similar in many respects to 2) since these were often dominated by fine carbonaceous material, but the colour was grey or black. There was no brown, yellow or other colour. The standard technique did very little to change the residue from its unoxidised state. All the above mentioned techniques were tried, and it was found that prolonged treatment with Schulze solution (up to several days) was the only moderately successful method and gave the material a little brown colour (which may have been staining), and removed most of the black from the wood fragments.

The different oxidation methods were tried on samples known to contain well preserved spores to observe the severity of the treatment. It was found that they produced as good results as the standard techniques.

In view of the barren nature of many of the samples from Mayo, Donegal and Southern Ireland, a close watch was kept on the residues throughout the oxidation to ensure that the spores were not disintigrating at any stage. As there were no traces of spores at any stage in the oxidation it is assumed that the barren nature of the samples was the result of the mode of preservation of the spores, and not of the laboratory techniques used.

When spores were found, they were generally obvious in their unoxidised state in many of the samples, especially in areas away from Ballycastle. Their preservation also seemed to fall into three categories. The first is the better form of preservation giving the rich brown and yellow colours, as in those from 4201 - 4209, 4236 and most of the Ballycastle samples. The second type of preservation contains more brown and often black coloured material, as in the 4249 sample and those from the Lackagh Hills. There appeared to be no yellow tints in the colour, and no amount of increase in oxidation using all the methods mentioned above would bring the samples up to the appearance of the Ballycastle type of preservation. The third type of preservation is that illustrated by the samples of North Mayo, Goresbridge and the Westphalian samples from the Slieve Ardargh Coalfield. This type of preservation (as mentioned before in the treatment of barren samples)was characterized by its grey and black colour, and a complete absence of any other colour such as brown or yellow. Continuing fuming HNO_3 treatment had no effect, and similarly with KOH. Continued treatment with Schulze over a period of 2 days, produced a brown colour, which may possibly have been staining, rather than oxidation. The spores were thin and very delicate relative to their former state, and were not improved to any practical extent for study.

For the purpose of biometric analysis, constant maceration techniques were used in the preparation of samples containing species of Lycospora and Schulzospora, the results of which are discussed in a later chapter. The treatment consisted of 5 minutes in conc. HNO_3 and 40 minutes in fuming HNO_3. No alkali was used in the preparation of these samples.

Slides were prepared using two layer multiple mounts (Jefford & Jones, 1959). The aqueous residue, when thoroughly washed and neutralised, was mixed with 1% solution of Cellosize and spread evenly on cover slips. (The recommended 2% solution of Cellosize tended to flocculate the residue). The cover slips were cemented to slides by means of Canada balsam, heated on a hot plate to 110 - 120°C to drive-off solvent xylene.

A complete tabulation of the times and chemicals used in preparing the samples is given in Appendix B.

CHAPTER IV

DISCUSSION OF PRESERVATION CHARACTERISTICS

Havinga (1967) describes a number of factors which can affect the original spore assemblage. These include micro-organism attack, chemical oxidation, mechanical forces and high temperature.

Some of these factors may have contributed to the poor preservation of samples in this study.

A common cause of corrosion is micro-organism attack, where pressure and pH are high. Thus, fertile soils with high biological activity are unsuitable environments for preservation. Dimbleby showed three mineral soils with pH 6.5, 6.5 - 7, and 7.9 - 8.1, that were quite spore and pollen free. An exception however to the general rule of high Ph causing corrosion is illustrated by Gehu and Planchais (1966) who found abundant pollen in highly alkaline pH (surface material in a dried lake). Environments such as these may have existed for short periods in the margins of a coal swamp, and therefore be possibly contributory.

Elsik (1966) gives an account of the biological degradation of fossil pollen grains and spores. He quotes Goldstein (1960) who found that "Phycomycetes, particularly chytrids were prominent among those organisms responsible for the weakening of the spore walls. These fungi appeared to be involved primarily with the contents of the grains rather than with the wall material itself, although occasionally they were observed to germinate and penetrate the air sacs of coniferous spores. The smoothness of the pollen wall in the region immediately surrounding the penetrating rhizoids and discharge tubes of these organisms suggests that they digest rather than puncture the wall".

Multiple injections would not probably weaken the spore exine sufficient for other physico-chemical activities to destroy the spore shape. Some laevigate spore walls are reduced to small remnants leaving only enough wall material for the spore to retain its original shape. In extreme cases the spore is reduced to fragments of degraded material, Elsik suggests in fossil assemblages certain spore and pollen types may be selectively removed or altered beyond recognition because of the destructive activity of bacteria and fungi. Features of this kind were recognised in the present study suggesting destruction by biological attack, and may explain why certain forms are well preserved, whereas others are poorly preserved in the same assemblage, particularly from Leitrim.

It is believed that the presence of pyrite within the spore exine is due to the action of anaerobic bacteria, which attacked the spore wall and so provided centres for crystallization. Certainly this pyritic feature was common in some of the Irish samples. Particularly good examples were from Goresbridge and Northern Mayo, which also coincides with the third type of preservation noted in the previous section. Both compound faviform and simple polygonal cavities were common, as described by Neves and Sullivan (1964). Thus the combination of micro-organism attack and the formation of pyritic structures may have had much to do with the rarity of well preserved assemblages from these areas in particular.

Another external factor which may affect preservation, noted by Havinga, is oxidation, as in well aerated soil conditions. This would seem an unlikely cause, since in this study the environment is that of a coal-producing swamp. Fire may cause oxidation of a kind, reducing the spore, but such events are most likely to occur only on a small scale, and not be widespread in area and time.

A third and more likely cause for the destruction of the assemblages is mechanical, caused by high pressure and temperature. This includes secondary events such as tectonism and igneous activity. Volcanic rocks of Lower Carboniferous age are found in the Ballycastle area, and possible deep seated plutons occur around Sligo and further south in the Golden Vale of Limmerick and County Tipperary.

A great sill of olivine-dolerite in the "Yoredale Series" which occurs east of Lough Melvin in Fermanagh is probably Tertiary.

Metamorphism in the Carboniferous is most noticeable south of County Clare. The Old Red Sandstone and Carboniferous of Kerry and Cork have many examples of cleavage and jointing. Further north, the effects are much weaker, though in Clare thin coal seams have been converted to anthracite (5.8% volatile) and the sand and silt members of the Namurian have been indurated by secondary silification (Brindley & Gill 1958, 246).

To study to what extent the spores from Leitrim had reacted to post depositional changes, the rank of the Leitrim coals have been studied by A.H.V. Smith at the N.C.B. Laboratories, Wath-on-Dearne. It was found that except for sample 4257 the rank of the coals was too high to enable spores to be extracted and in addition seemed to be fusainic and dirty. Spores were just visible in sample 4223, but absent in 4227 which was a heavily pyritized vitrain. Sample 4243 was fusain impregnated with mineral matter so one would not expect to find spores in such a sample whatever its rank. Similarly a block of coal from 4242 proved to be a mixture of fusain and carbonaceous shale. Thus post depositional changes and movements would appear to be major factors in causing the absence of good spore assemblages.

Although the American movements are stated in Charlesworth to be unaccompanied by igneous activity, the movements nevertheless were associated with the generation of mineral deposits, with magmatic solutions from deep-seated sources. This is especially a feature in Co. Kerry, Sligo, Clare and Tipperary and the southern aureole of the Main Donegal Granite. Heat generated from deep-seated plutons has been suggested by Neves (personal communication 1970) as possibly producing sufficiently high temperatures for carbonization and destruction of spore exines. When a suitable lithology is present for conducting heat e.g.: limestone, it may be transferred through large thicknesses from the pluton. Such a conductor is commonly present in the Visean to facilitate this process over a wide area.

In common with Western Scotland, North East Ireland was subject to an extensive outburst of Tertiary igneous activity. Plugs, dykes, sills and plutonic complexes were intruded and vast floods of lava "flood basalts inundated the land". The present outcrop of lavas probably only represents a remnant of a vast lava region extending to Greenland. However, it would appear that their effect on the rocks below is minimal, and thus the possibility of damaging the spores in any great volume of rock is unlikely. An example of the depth to which the lavas affect the rock is given by the 20' (6.1m) thick Portrush Coal, east of Portrush in which only the upper 6" have been charred, the remainder still producing fossil pollen grains as described by Simpson (1952). This fact was confirmed in Ballycastle where samples taken from immediately below the large Tertiary sill proved charred and barren, but in samples taken from a few feet below, preservation proved good.

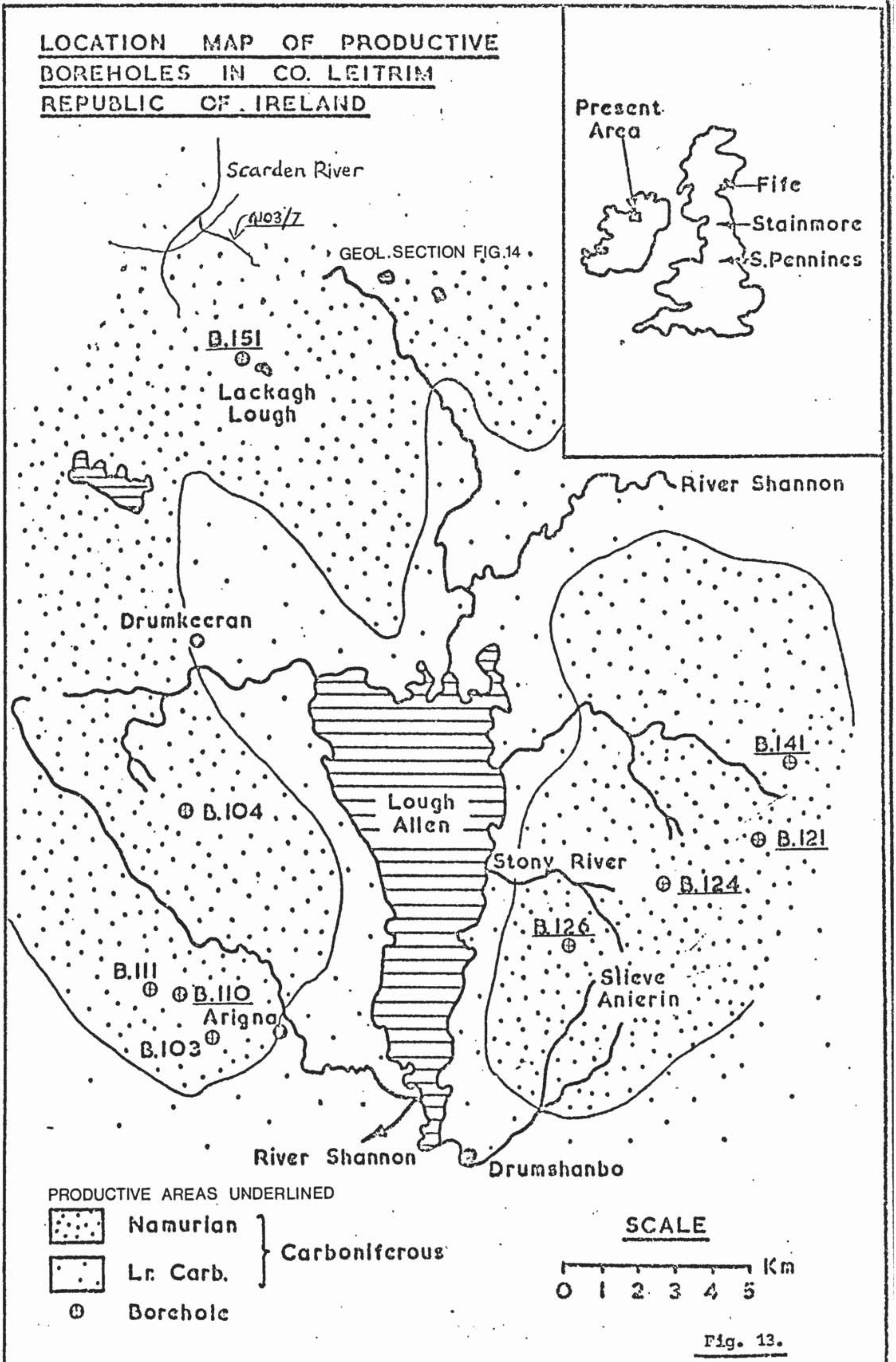
Another possible cause of increasing rank is the depth of burial, where pressure from the overburden causes the conditions for metamorphism. This could be the main reason for such consistent 'barren' results from so many samples. However, it does seem anomalous that from Tournaisian borehole material, Clayton (1974 - personal communication) obtained reasonable spore preparations from a borehole near Ennis, Co. Clare. Similarly the author also found from Leitrim the occasional horizons of shale and coal with well preserved assemblages e.g.: Samples 4201 - 4209.

It may be that such areas of less rank are pockets, which due to the structural situation at depth, have pressure released. Such an idea can only be speculation.

T. Brennan (1956- PhD thesis) (persn. comm 1975) studying the Carboniferous shales around Limmerick describes how movement in the Alpine orogony took place in these shales through minute slip planes. This micro scale movement may possibly have damaged the spores, but it does not explain why lithologies from more affected areas such as Cork are not similarly affected. Here, Clayton, Higgs, Guein and Van Gelder (1974) described some good assemblages from mudstone and shales which are strongly cleaved.

In conclusion it would appear that the absence of spores is more probably the result of secondary post depositional changes rather than unsatisfactory primary environments for preservation although the latter does appear to have been active to a lesser extent. It is possible that a combination of deep burial, plus later contact (via suitable conductors i.e.: Viséan limestone) with deep seated intrusions may have occurred and if so, would certainly have given rise to such poor assemblages.

CHAPTER V



LOCATION MAP OF PRODUCTIVE BOREHOLES IN CO. LEITRIM REPUBLIC OF IRELAND
Present Area
Fife
Stainmore
S.Pennines
Scarden River
N103/7
GEOL.SECTION FIG.14
B.151
Lackagh Lough
River Shannon
Drumkeeran
B.141
B.104
Lough Allen
B.121
Stony River
B.124
B.126
B.111
B.110
Slieve Anierin
Arigna
B.103
River Shannon
Drumshanbo
PRODUCTIVE AREAS UNDERLINED
Namurian
Lr. Carb.
Carboniferous
Borehole
SCALE
0 1 2 3 4 5
Km

Fig. 13.

GENERALISED VERTICAL SECTION IN THE LACKAGH HILLS THUR MT. & DOUGH MT. (BASED ON BRANDON 1968)

Drawing No. 16071 Date 10·VIII·76 Figure No.14

THE LEITRIM COALFIELD

1. Introduction

The Carboniferous strata of the Leitrim area consist of several outliers of Upper Carboniferous age rising from a basement of Lower Carboniferous rocks which are largely unexposed. The Upper Carboniferous sequences occur on various hills surrounding Lough Allen. Most of the productive samples in this work came from boreholes and outcrops in the Lackagh Hills to the north of Lough Allen and on Slieve Anierin to the east (text figs. 2 and 13). Brandon (1968) has described the Lackagh Hills area and the Slieve Anierin area has been described by Yates (1962).

2. The Geology of the Area

The area was first mapped for the Geological Survey of Ireland by Cruise (1878). The lower strata, a series of iron-rich shales, were compared to the Yoredale beds of Northern England and were mapped as such. The thick grit succeeding the shales, which forms a prominent escarpment on Slieve Anierin and which contains two or three coal seams, was mapped as Millstone Grit, again by analogy with the Pennine area. The black shales which cap the grit on Slieve Anierin were regarded as equivalent to the Lower Coal Measures. This classification was also used by Charlesworth (1953).

Yates (1962) collected and described a comprehensive series of goniatites from the stream sections (the Stony River in particular) on Slieve Anierin. She discovered, by analogy with goniatite faunas principally from the Pennine area of England, that the whole of the Slieve Anierin sequence is confined to the lowest stages of the Namurian Series, the Pendleian and Arnsbergian stages. She found no evidence to suggest the presence of strata younger than E_2, Arnsbergian age, and in fact the uppermost part of that was missing. Ramsbottom, (1969) in his 'Interim Report of the Namurian Working Group' to the Carboniferous Congress of 1967 suggested that the sections on Slieve Anierin would be suitable type sections for both the Pendleian and Arnsbergian stages. The absence of the lowest subzone of the Pendleian (Eumorphoceras tornquisti) on Slieve Anierin means that it will have to be combined with Pendle Hill as a type, and the absence of the higher parts of the Arnsbergian, above the subzone of Cravenoceratoides nititoides. means that an alternative section will have to be found for this part of the section.

Brandon (1968) has made a study of the Lackagh Hills area in which attention was given to both the sedimentological data and also to the goniatite faunas. He found that the succession extended from the top of the Viséan stage up to the lower part of the Arnsbergian Stage of the Namurian (text fig. 14).

3. Material Examined

Many samples, mainly of coals, were provided by the Irish Geological Survey from a number of boreholes sunk by them in the early 1960s. Details of these boreholes are given in Appendix A (only those samples with an asterisk yielded satisfactory spore separations, for the reasons given in Chapter 4). Comparative sections, with sample numbers, are shown in text fig. 16 .

Further samples were taken in both the Namurian and older rocks from Arigna and areas extending over to Sligo west of Lough Allen but only two of these were productive. The productive samples all marked with an asterisk in the appendix lists, are as follows:-

Borehole No. or locality	Sample Nos.
110	4238, 4239, 4242
121	4255,- 4257
124	4247, 4249, 4248
126	4235, 4236, 4237, 4240
141	4250
151	4201 - 4209
Scarden River	4103, 4107

All the boreholes were sampled in detail, but the vast majority were unproductive. The productive horizons appear to occur within a relatively small stratigraphical range as suggested by lithological comparisons, and hence these samples will be considered as one assemblage. The relatively high number of samples from this stratigraphical horizon may be considered useful since they represent a range of lithologies and environments, giving a more comprehensive picture of an E_2 age assemblage. A comparison between individual borehole assemblages will be discussed in a later chapter in relation to possible correlations.

The positions of all boreholes and other sampling localities are given in text figs. 2 and 13.

4. Description of Miospore Assemblages

Two distinct assemblages can be recognised in the samples examined from this area. They are referred to as Concurrent Range Biozones I and II. Details of the miospore occurrences are given in text fig. 15.

a) Concurrent Range Biozone I

Present in assemblages 4103 and 4107 collected from a tributary of the Scarden River which is described in detail by Brandon (1968) in his Appendix A, Section 17. This is an essentially mudstone sequence starting in the Dergvone Shale, and the productive samples came from below the Briscloonagh Sandstone, in the Dergvone Shale.

Brandon (Loc cit.) found goniatite evidence in the underlying Killooman Shales to suggest an E_1c age. The next piece of goniatite evidence came from the Gowlaun Shale some 500'(152.4m) higher in the sequence which yielded an E_2a age fauna. The evidence is therefore that the sampled strata are of intermediate age, but more likely E_1c, since they were obtained below the sandstones in the Scarden River section, which are themselves below the last dated E_2a horizon and occur also immediately above an E_1c dated horizon. The C.R.B. I contains 52 species, half as many found in the younger E_2a assemblages. No particular species or genus is dominant, but significant spores present include *Crassispora kosankei*, *Kraeuselisporites sp. A*, *Cingulizonates cf. capistratus*, *Savitrisporites nux*, *Florinites visendus*, *Tripartites vetustus*, *Bellispores nitidus*, *Rotaspora knoxi*, *Proprisporites leavigatus*, *Knoxisporites triradiatus*, *Crassispora aculeata*, *Cirratriradites saturni*, *C. cristatus*, *Verrucosisporites nodosus*, *V. morulatus*, *Tricidarisporites balteolus*, plus two questionable specimens of *Spencerisporites radiates* and *Rotaspora fracta*.

b) Concurrent Range Biozone II

These assemblages were obtained from borehole material provided by the Irish Geological Survey (text fig. 13). As explained previously, there was only a limited number of productive samples which occured mainly in the 'grit with coals' sequence which crops out towards the top of Slieve Anierin. These have been dated by Yates (1962) as uppermost E_2a age in the goniatite zonation.

The sum total of species numbered 105. They were dominated by Lycospora pusilla together with Densosporites and Cingulizonates. Abundant were Camptotriletes spp., Savitrisporites nux, Verrucosisporites spp., Convolutispora spp., Lophotriletes spp., and Granulatisporites. Species of stratigraphical interest, which were present in significant numbers include Crassispora kosankei, Remysporites magnificus, Knoxisporites triradiatus, Calamospora liquida, Proprisporites cf.laevigatus, Triquitrites triturgidus and Florinites visendus. Only a few specimens of both Rotaspora knoxi and Tripartites vetustus were found. In assemblages 4236, 4204 and 4249 which include boreholes from two different areas was found Spore Type A. This spore with further finds to determine its distribution, may prove useful for correlation in this area. Two new types which characterize some of the assemblages are Granulatisporites sp. and Schopfites sp. This zone can be distinguished from C.R.B. I by the presence of these species plus the virtual absence of Tripartites and Rotaspora.

Comparison with other Areas in Britain

Neves (1961) examined two samples of marine shales from the Arnsbergian stage of the Staffordshire area of the Southern Pennines. The older sample contained Eumorphoceras bisulcatum and the younger one Anthracoceras paucilobum. The miospore assemblages recovered from these horizons were closely comparable (Neves, loc. cit., table 1) and were stated to be characterized chiefly by the genera Florinites, Schulzospora, Auroraspora, Callisporites (Savitrisporites) and Cyclogranisporites. The diagnostic species of this age were listed as Acanthotriletes splendidus Neves, Proprisporites laevigatus Neves, Hymenospora palliolata Neves, Remysporites magnificus and Tholisporites biannulatus. Discernisporites and Mooreisporites were also recorded and Alatisporites nudus Neves occurred for the first time.

This assemblage is very different from those described from Leitrim, both in the common species present and in the less common species. This difference is mainly due no doubt to the fact that Neves' samples were of marine shales whereas the productive material from Leitrim consisted of coals and associated non-marine sediments. Neves (loc. cit.) concluded that 'spore assemblages of the coals and marine shales are representative of two completely distinct plant associations'. He agreed with Chaloner's (1958) opinion that the marine shale assemblages were representative of a contemporary upland flora and concluded that the larger number of species in non-marine shales resulted from a mixing of the autochthonous coal forest flora and the allochthonous upland flora.

Owens, in Owens & Burgess (1965) has described miospore assemblages from strata of Arnsbergian age in the Stainmore outlier of the North Pennines. Samples examined from the lower part of the stage comprised coal, non-marine and marine shale and therefore contained a much stronger autochthonous element than Neves' assemblage. Shales examined from 75' (7.62m) above the Stricegill Grit in the lower part of the stage yielded an assemblage closely comparable with those from Concurrent Range Biozone II and to a lesser extent C.R.B. I. The diagnostic species Tripartites trilinguis and Crassispora kosankei were both present along with Savitrisporites nux, Lycospora (Bellispores) nitida, Schulzospora campyloptera, S. ocellata, Remysporites magnificus and Florinites spp. Spores present at Stainmore which were not recorded at Leitrim included species of Grandispora and Mooreisporites; the latter also occurred in Arnsbergian of the Southern Pennines (Neves, 1961). Proprisporites laevigatus was not recorded from Stainmore and species of Rotaspora were not recorded above the shales lying immediately above the Stricegill Grit, that is some 75'(7.62m.) below the first appearance of Crassispora kosankei.

Smith & Butterworth (1967) described miospore assemblages from the Upper Limestone Group of West Fife, a rhythmic sequence of Yoredale type with relatively thin limestone and occasional thin coals. Only the coal seams were examined for miospores. Goniatites are not common in this sequence and the species found tend to differ from those in other areas, but Currie (1954) equated the Upper Limestone Group and part of the overlying 'Millstone Grit' with the Arnsbergian stage. She further equated the Calmy and Castlcary limestones with the Cravenoceratoides nitidus (E_2b) zone. It follows the part of the sequence between the Index Limestone at the base of the stage and the Calmy Limestone must represent the Eumorphoceras bisulcatum (E_2a) zone.

Smith & Butterworth examined twelve thin coals from between these two horizons in the Culross No. 2 borehole, and were able to recognise three miospore assemblages within them:

1) Seams above the Index Limestone, to within a short distance below Cadell's Parrot Seam. These contained a Rotaspora knoxi assemblage with a very varied microflora similar to that of the underlying Limestone Coal Group (Pendleian stage).

2) Seams from Cadell's Parrot Seam up to the Orchard Limestone. These represent the lower part of the Crassispora kosankei

assemblage recognised by the presence of this species which becomes increasingly common higher in the Upper Carboniferous. Characteristic species included Convolutispora cerebra Butterworth & Williams, Bellispores nitidus, Reticulatisporites carnosus, Stenozonotriletes bracteolus, Savitrisporites nux and occasional specimens of Rotaspora spp. and Tripartites spp.

3) Seams above the Orchard Limestone. These were unnamed in the Culross No. 2 Borehole but had very similar assemblages to the Lower and Upper Hirst (Jenny Pate) Seams which occurred below the Calmy Limestone in nearby boreholes. These assemblages were also placed in the Crassispora kosankei assemblage zone but they differed from those occurring below the Orchard Limestone in the absence of the diagnositc genera Rotaspora and Tripartites.

The assemblages of both Concurrent Range Biozones I and II compare most closely with the second of the above assemblages in their content of both Crassispora kosankei and species of Rotaspora and Tripartites. They differ from Scottish assemblages in the presence of Apiculatisporis varicorneous, Biannulatisporites simplex, Proprisporites cf. laevigatus Potoniesporites elegans and species of Laevigatosporites and Florinites and in the absence of Chaetosphaerites pollenisimilis (Horst) and Convolutospora cerebra.

Assemblage IV has also been recorded from the Upper and Middle Limestone Group of the Central Coalfields, and the Millstone Grit of Northumberland.

Smith & Butterworth 1967 also describe assemblages from coals regarded as E_1 age in the Limestone Coal Group of Scotland and the Upper Limestone Group of Northumberland. These form part of their Rotaspora knoxi assemblage, in which Tripartites vetustus, Cingulizonates cf. capistratus and species Rotaspora are relatively frequent, a feature more comparable with C.R.B. I.

The latter zone is distinguished by the presence of Crassispora kosankei and Florinites spp., which may again be the reflection of a marine or non-marine environment. The Upper Limestone Group of Northumberland has also been studied by Marshall & Williams (1971) in the Roman Wall District, which includes assemblages taken from coals and shales. It is noticeable that Crassispora kosankei and Florinites spp. are again absent.

C. Butcher's 1974 assemblages from the Chief Limestone and Hensingham Groups, Cumberland, include assemblages considered to be of E_1 and E_2 age. The E_1 assemblage is characterized by the appearance of Bellispores nitidus, Pustulatisporites papillosus and abundant Cingulizonates cf. capistratus, together with a relative decline in the frequency of Rotaspora fracta. These assemblages show general similarities to the C.R.B. I of Leitrim.

The Biozones G1, 2 and 3 which encompass the Hensingham Group below the Lower Coal Measures, show the appearance of many types found in the E_2a assemblages of Leitrim. These include Bellispores nitidus, Kraeuselisporites echinatus, Secarisporites lobatus, Auroraspora solisortus, Savitrisporites nux, Crassispora kosankei and Florinites similis. They also show a decline or absence of types normally associated with the upper Viséan or lowermost Namurian e.g.: species of Rotaspora and Tripartites.

In Owens et al. recent zonal scheme(personal communication,1975) proposed for the British Upper Viséan and Namurian, the upper (NC) and (TK) zones compare well with the Leitrim C.R.B. I and II respectively although a few specific ranges are not exactly coincidental. These include the extension of Raistrickia nigra into the E_2, previously limited to the E_1 Pendleian stage and the presence of Cirratriradites saturni in the Leitrim assemblages.

Owens regards C. saturni as becoming a useful stratigraphic indicator at the base of the Westphalian where it occurs frequently. Its occurrence within the Namurian he suggests as sporadic. Punctatisporites giganteus and P. pseudopunctatus are described as having their base at the top of E_1 but were not found to be present in the Leitrim assemblages.

Comparison with Areas other than Britain

Yates (1962) compared the goniatite and trilobite faunas of the E_2a beds of Slieve Anierin with those of the higher part of the Ostraver Beds in Silesia. Horst (1955), Dybova & Jackowicz (1957) and Jachowicz (1974) have described miospore assemblages from the Jaklowetzer and Porubaer Beds which are subdivisions of the Upper Ostrauer Beds.

The common spore species recorded by these authors are similar to those described from Leitrim but there are difficulties in comparing the distributions of the stratigraphically significant species because of nomenclatural differences. Jachowicz (1974),however, has published further descriptions of this section and the similarities between the Leitrim assemblages and his microfloral zones N4 - N6 (Jaklowetzer Beds and the lower part of the Porubaer Beds) are striking. The common species in Silesia are of the genera Schulzospora, Densosporites, Cingulizonates and Punctatisporites; Crassispora kosankei is present but not yet common, and species of Rotaspora and Tripartites disappear towards the top of the beds. The closest comparison can be made with Jachowicz's zone N6, that is with the base of the Porubaer Beds. In this zone Reticulatisporites carnosus and species of Tholisporites are still present and Cirratriradites saturni has made its first appearance. Species present in this part of the Silesian Succession but not recorded from Leitrim include abundant Chaetosphaerites pollenisimilis and less common Mooreisporites fustis.

Beju (1970) describes from the Romanian Carboniferous two assemblages Cb_2 and Cb_3 from the Namurian A, which show features similar to the Irish material. Assemblage Cb_2 has 30 species in common which include Raistrickia microhorrida, R. seatosa, Convolutispora varicosa, Knoxisporites triradiatus, Triquitrites triturgidus, Tripartites vetustus, Savitrisporites nux, Bellispores nitidus, Rotaspora knoxi, Cirratriradites saturni and Florinites visendus. Except for the notable absence of Crassispora kosankei, the above assemblage compares very well with Concurrent Range Biozones I and II, particularly sample 4249. The younger Cb_3 assemblage contains 17 species in common including Raistrickia seatosa and more species of Florinites. Many distinctive members mentioned above, are not present in this younger assemblage and thus suggests a closer comparison of the Leitrim material with the older Cb_2 assemblage zone.

A feature of the Cb_2 assemblage is the occurrence of Crassispora maculosa, Rotaspora fracta, the frequent occurrence of Tripartites vetustus, plus the absence of Crassispora kosankei. In the younger Cb_3 assemblage zone T. vetustus and R. fracta are absent. In general it would appear that Concurrent Range Biozone II might have most similarities with the Cb_2/Cb_3 boundary.

In the U.S.A. Felix & Burbridge (1967) describe from the Springer Formation of Southern Oklahoma an assemblage containing 104 species. Approximately 40 of these occur in common with Concurrent Range Biozone II. These include Crassispora kosankei, Florinites spp., Potoniespores elegans, Knoxisporites triradiatus and Grandispora spinosa. It would appear that the lower two thirds of the Springer Formation shows most species in common. Felix and Burbridge (1967) consider that the Springer Formation, although containing a mixture of species from both the Mississippian and Pennsylvanian forms a separate and distinct assemblage.

CORRELATION OF COALS IN THE LIETRIM AREA AS SUGGESTED BY LITHOLOGICAL AND PALYNOLOGICAL EVIDENCE

SCALE: 5metres to 1foot.

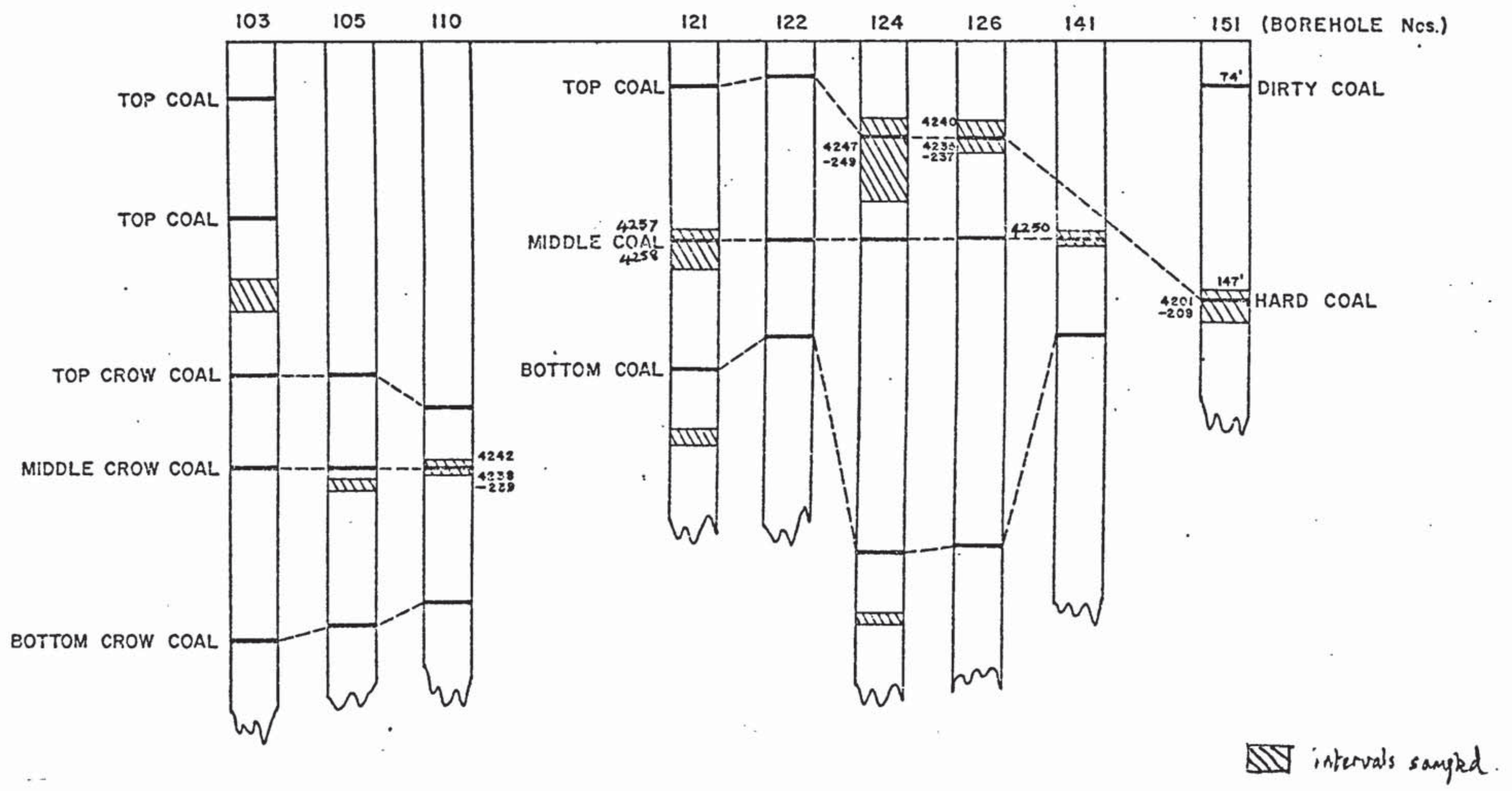


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Figure No. 16

Correlations of the Coals around Lough Allen

The Irish Geological Survey as a part of their exploration of the coals contained in that area have bored a number of holes in the region surrounding Lough Allen. A number of these bores were sampled, but not all since it was impractical for the Survey to gain access to some of the material. The success rate from these samples was poor in terms of good spore assemblages. An analysis by A.H.V. Smith of these coals revealed a very high rank over 90% explaining the poor results. The few good samples are located on the Map as in text fig. 13 and Appendix A. They are essentially from three areas situated around Lough Allen as follows:- Northern area - Borehole 151, Eastern area - Boreholes 121, 124, 126 and 141 and Western area - Borehole 110.. These areas have not been correlated in detail, as is revealed by a study of previous mapping.

Slieve Anierin was first mapped for the Geological Survey of Ireland by J.R. Cruise. In the 1878 Memoir it is stated that there are two coal seams within the grit on Slieve Anierin corresponding with the lowermost (or Crow Coal) and the Middle Coal on the Arigna Mountains. Above the grit the Lower Coal Measures are said to be brown and black splintery shales attaining a considerable thickness and apparently without the top coal seam on Altagowlan. However, the Dail Commission of Inquiry into the Reserves and Industries of Ireland (1921, p.132) reported that there was no information on the top coal, but that it was said to exist on Altagowlan and on Slieve-an-larain but not on Kilronan. Altagowlan, being 300' (91.7 m) higher than Kilronan, contains the upper strata including the third seam. On Slieve Anierin there is certainly no coal seam above the grit escarpment and it seems unlikely that it exists on Altagowlan either.

By lithological means a simple correlation can be erected for the basis of this study from borehole data provided by the Irish Geological Survey (text fig. 16). The palynological similarity of these horizons will also be discussed.

It would appear that the productive horizons of B.H. 126 containing assemblage 4236 and B.H. 124 containing assemblage 4249, link up as the "Top Coal" since these boreholes revealed an almost indentical succession.

Assemblages 4249 and 4236 are from shales approximately half a meter below the 'Top Coal'. Their spore content is very similar, both containing a large number of species of which approximately 85% coincide supporting the correlation of the overlying coals. Stratigraphically significant spores include Bellispores nitidus, Rotaspora knoxi, Crassispora kosankei, Triquitrites triturgidus, Savitrisporites nux, Sporetype A and Rugospora corporata var. laevigata. Notably assemblage 4236 does not contain Florinites.

A similar stratigraphic age is suggested, particularly by the overlapping ranges of Rotaspora knoxi and Crassispora kosankei, together with the high number of coincident species.

Boreholes 121 and 141 within the same eastern area contain three coals which would appear to correlate with those of Boreholes 124 and 126. Assemblages 4255 - 57 (B.H. 121) and 4250 (B.H. 141) are taken from coals which the Irish Survey have suggested as being the 'Middle Coal' horizon. By being so named it would appear that the Survey believe that these horizons can be correlated.

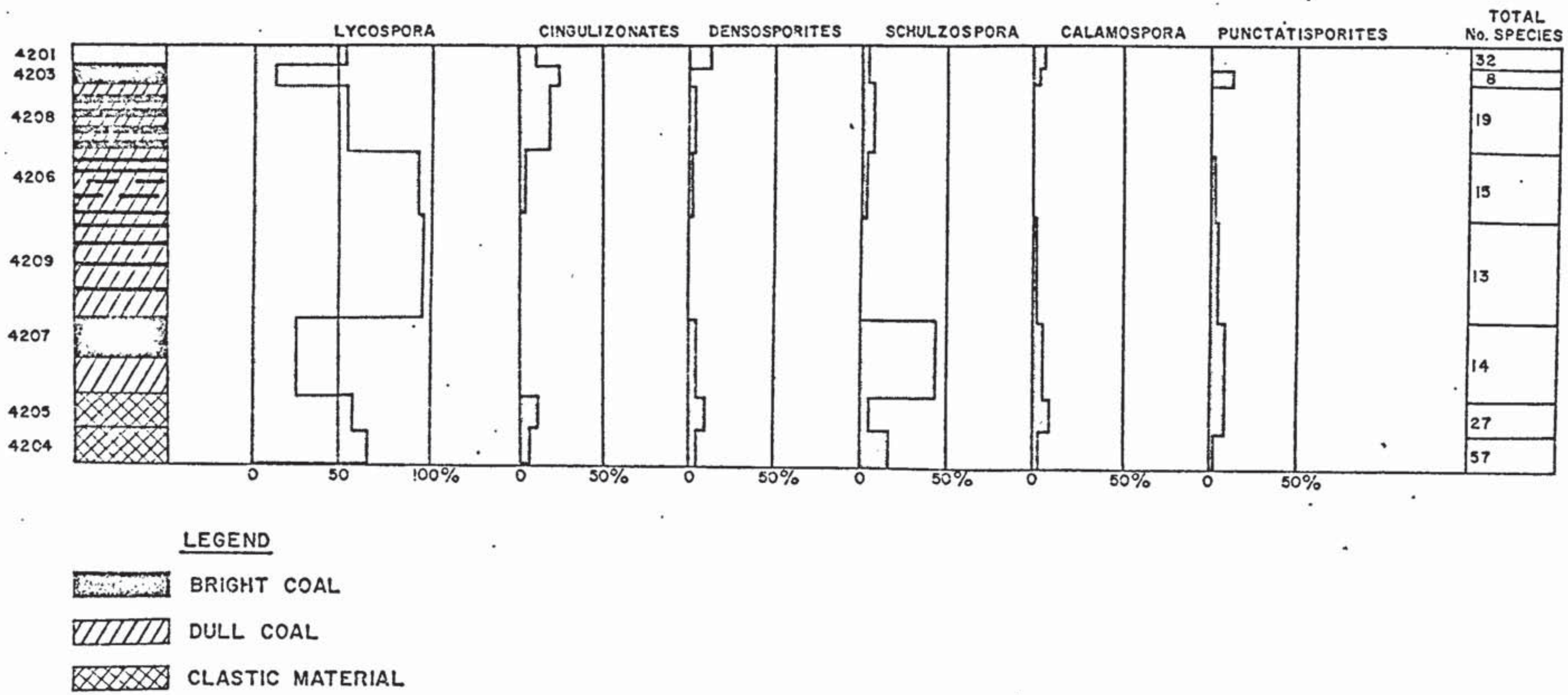
The spore content of assemblage 4250 is of poor preservation, containing 15 species which include Florinites visendus, Tripartites vetustus, Triquitrites triturgidus, Cingulizonates cf. capistratus, Densosporites pseudoannulatus and Cingulizonates bialatus. The assemblages from samples 4257, 4255 and 4256 are all relatively well preserved and contain nine different species altogether. These include Cingulizonates bialatus, Densosporites pseudannulatus, D. annulatus, Triquitrites comptus and Laevigatosporites vulgaris, but 70% of the assemblage is Tholisporites scoticus.

A comparison of these assemblages although showing some similarities, brings to light the dominance of Tholisporites scoticus, being restricted to the B. 121 Middle Coal. The geographic location of these two boreholes is relatively close suggesting that a lithological correlation might be accurate. If this is so, it would appear to highlight the facies controlled nature of Tholisporites scoticus.

A number of samples were taken from B.H. 110. This borehole is situated in the area west of Lough Allen and also contains three coals. All of these samples except for 4238, 4239 and 4242 were unproductive. The assemblages came from what the Survey named the Middle Crow Coal, suggesting its uncertain correlation with the coals elsewhere in the area. The preservation was relatively poor, needing much oxidation and producing quite dark brown coloured spores. There were a total of 21 species, dominated by Lycospora 83%, with Cingulizonates 8% and Verrucosisporites 7%. Other species included Crassispora kosankei, relatively common, Savitrisporites nux, Verrucosisporites morulatus, Stenozonotriletes bracteolus and Spelaeotriletes sp. The relative variety of spore types suggests a closer comparison with the assemblages 4236, 4249 and 4201-09 from the Top Coal and Hard Coals.

Borehole 151 from the N. West area of Lough Allen contains two coals and was similarly sampled in detail producing a number of well preserved assemblages, 4201-4209, from the lower 'Hard Coal'. A complete section was obtained by sampling the fireclay and detailed splitting of the seam and the shales above and below. This is discussed in the next section. A total of 64 species occur, which include Crassispora kosankei, Rugospora corporata

RELATIONSHIP OF SPORE FREQUENCY TO LITHOLOGY – HARD COAL BOREHOLE 151



var. leavigata, Savitrisporites nux, Grandispora spinosa, Bellispores nitidus, Rotaspora knoxi, Triquitrites triturgidus and Spore Type A. A great similarity occurs with both assemblage 4236 (48 species coincide) and assemblage 4249 (52 species coincide). Only four species are not recorded from the latter two samples, Lophotriletes gibbosus, Tholisporites scoticus, Remysporites magnificus and Cirratriradites saturni. To suggest a correlation however would be inadvisable, since the spore contents of coals above and below are really necessary for comparison. However it may be of significance that Spore Type A is restricted to assemblages 4236, 4249, and 4201 to 4209.

Leitrim Hard Coal Section

As shown in text figs. 15 and 17, the 'fireclay' and shales beneath the coal contain a similar, varied assemblage to the roof shales, although the 'fireclay' has a much greater variety of taxa. These assemblages are dominated by lycospores but also contain significant numbers of Calamospora, Cingulizonates, Densosporites, Granulatisporites, Leiotriletes and Schulzospora. Savitrisporites nux and Orbisporis are restricted to the floor samples and Crassispora to the roof, floor and lowest part of the coal seam.

The lowest part of the coals has an unusual assemblage dominated by Schulzospora and Lycospora and with significant numbers of Calamospora, Densosporites, Punctatisporites and Verrucosisporites.

The middle section of the coal has a similar assemblage to the roof and floor measures but with virtually no Calamospora; much higher numbers of Verrucosisporites and significant numbers of Remysporites magnificus.

Nutter ( ), who studied Communis Zone Coals from the Lower Coal Measures of the Sheffield area, was one of the earliest workers to recognise a cyclicity of spore assemblages occurring within coals. This work was extended by Smith (1962) to several seams in the Lower and Middle Coal Measures of Yorkshire, and he recognised four phases characterized by different spore assemblages abd occurring in different coal types - the Lycospora, Transition, Densospore and Incursion phases.

Comparative studies of the spore contents of coals and associated sediments were first studied in this country by Neves (1958) who described the assemblages present in the Six Inch Mine seam of North Staffordshire and the associated marine (Gastrioceras subcrenatum. M.B.) and non-marine sediments. Sullivan (1962) described spore assemblages from various sediments in a Westphalian A - C sequence from Wernddu Claypit in South Wales and Marshall and Smith (1965) compared the assemblages of the roof and floor measures with those of the top and bottom parts of the coals for a number of Middle Coal Measures seams in Yorkshire.

The above studies all relate to younger strata than those containing the Leitrim Hard Coal. This makes comparisons difficult, particularly as regards the recognition of phases within the coal itself. Many of the species used by Smith to characterized his phases had not evolved in Namurian times or, as in the case of Crassispora and Laevigatosporites, were still very rare. However there does seem to be evidence of a Lycospora phase in the middle part of the Hard Coal although the dominant genus is accompanied by species of Granulatisporites and Cyclogranisporites as in the younger, Westphalian coals. Schulzospora was not present in Smith's assemblages, so it is difficult to interpret the lower part of the Hard Coal where this genus forms 45% of the total assemblage. If Schulzospora is regarded as an ecological equivalent of Florinites it would form part of an incursion phase; this is supported by fairly high numbers of Schulzospora in the roof, and particularly, the floor measures of the Hard Coal, suggesting an allochthonous origin.

The highest part of the seam also contains substantial numbers of Schulzospora (text fig. 17). This suggests that the pattern in the Hard Coal is dominantly of a Lycospora phase with strong Incursion phase influences in the lowermost and uppermost parts of the seam. The open, herbaceous type flora, with a strong allochthonous element in its pollen content was replaced for a time by a dense cover of aborescent lycopods, apparently with little undergrowth and completely swamping any spores from outside the area. It is felt that further conclusions from this work cannot be drawn until work has been carried out on the petrology of the coal.

Some of the early authors' observations regarding the distributions of spores in the coals and associated sediments are relevant to the present study. The similarity of the floor and roof shale assemblages in the Hard Coal are in agreement with Marshall and Smith's statement that 'the miospore assemblages in the roof measures immediately adjacent to the coals do not differ significantly from those of the seatearths'. The present study also bears out the observation that Calamospora and Densosporites are often more common in the seatearths and sometimes in the roofs, than in the coal itself. It is interesting to note that Savitrisporites nux which is restricted to the floor of the Hard Coal, was recorded by Marshall and Smith in the seatearth of the Swallow Wood Seam. The plant bearing Orbisporis appears to have had a similar niche during Namurian times.

Conclusions

Two assemblages are described from the lowest stages of the Namurian in County Leitrim. This area includes goniatite dated sections on Slieve Anierin as described by Yates (1962) and which Ramsbottom (1969) has suggested might be suitable type sections for both the Pendleian and Arnsbergian stages.

Many samples were collected from this area the majority of which were unproductive.

C.R.B. I is based on assemblages collected from a tributary of the Scarden River, in the Dergvone Shale which occurs immediately above a goniatite dated E_1c horizon and below an E_2a dated horizon. C.R.B. II includes a series of varied miospore assemblages derived from some of the coals and non-marine sediments occurring towards the top of the E_2a substage. The above Concurrent Range Biozones are considered to be composed of three main elements.

1) Pendleian autocthonous species such as Anapiculatisporites concinnus, Rotaspora spp., Tripartites spp., Tholisporites scoticus etc. which are close to the top of this range.

2) Younger species, notably Crassispora kosankei and Laevigatosporites spp., in the earlier part of their stratigraphic range and at lower frequencies than they later achieve.

3) Contemporary upland taxa such as Potoniéspores elegans and Florinites visendus.

In the older C.R.Biozone I the first element is more obviously present. The first two elements are closely comparable to those making up the assemblage described by Smith & Butterworth (1967) from the Upper Limestone Group coals in West Fife. The third element is comparable to a certain extent to the marine shale assemblages described by Neves (1961) from the Arnsbergian stage of the Southern Pennines. C.R.Biozone II as a whole can be most closely compared with that described by Owens, in Owens & Burgess (1965) from the Arnsbergian shales 75' (22.8m) above the Stricegill Grit in the Stainmore outlier of the northern Pennines. Jachowicz (1974) records a similar assemblage to Assemblage II from the N6 zone, at the base of the Porubaer Beds which form part of the Upper Ostrauer Beds. The latter horizon has been compared by Yates (1962) with the E_2a beds of Slieve Anierin, on the basis of their trilobite and goniatite faunas. C.R. Biozones I and II are compared with the Namurian A Cb_2 assemblage recorded by Beju (1970) from the Roumanian Carboniferous and also those described by Felix & Burbridge (1967) from the lower Springer Formation of Southern Oklahoma, U.S.A.

Correlation of the various coals present in the Slieve Anierin boreholes was virtually impossible due to the uneven recovery of spores. Assemblages were obtained essentially from the two uppermost coals of the sequence, which were all of a basically similar spore composition. One Middle Coal assemblage,however, contained an unusual dominance of <u>Tholisporites scoticus</u>. It may be of significance that Spore Type A was only found in assemblages from the Top Coal of Slieve Anierin and the Hard Coal of the Lackagh Hills, and that these horizons can be correlated.

A preliminary account of the environmental significance of spore distributions was attempted in the detailed study of the Hard Coal.

It was observed that the roof and floor measures displayed similar assemblages, and that they both contained high percentages of Schulzospora, which represent the equivalent of Florinites in the 'Incursion Phase' described by Smith (1962). The remainder of the coal could be equated with his 'Lycospore Phase'. Orbisporis convolutus and Savitrisporites nux, appeared restricted to the floor of the coal.

CHAPTER VI

THE BALLYCASTLE COALFIELD

Introduction

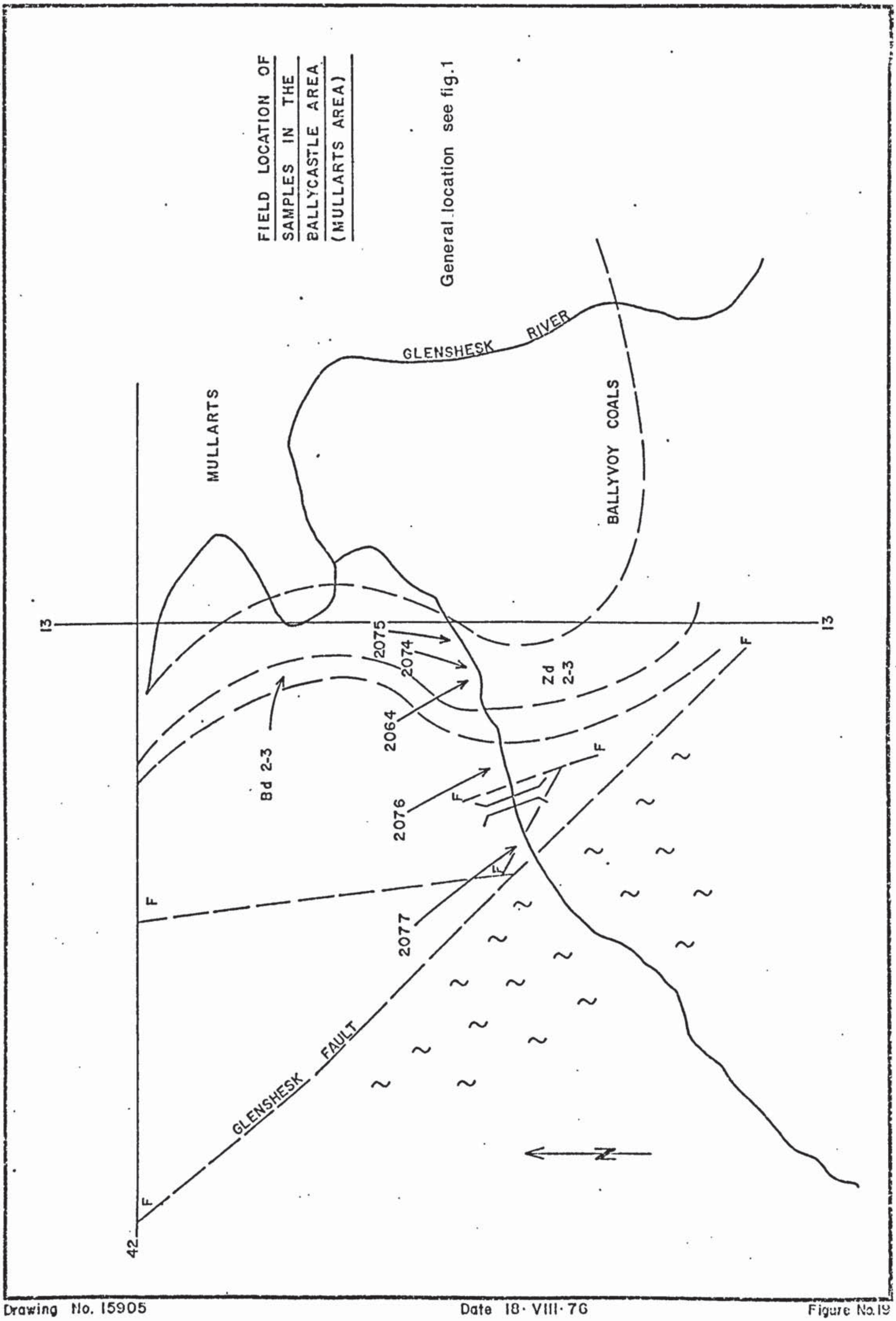
Carboniferous rocks are found in the coastal area between Ballycastle and Murlough Bay, and inland they form the low ground of Glenshesk and the Valley of the Carey River (text figs. 18 & 19). They rest probably unconformably on Dalradian schists, but most of the boundaries between them are thought to be faulted. No unconformable junctions are now seen.

The succession totals over six hundred metres and consists of sedimentary, pyroclastic and contemporaneous volcanic rocks of Viséan and Namurian age. Several coal ~~seams~~ outcrop in the coastal area (text fig. 21).

Griffith (1829) gave the first thorough geological account and correlated the succession in the mines west of Carrickmore. In 1868 John Kelly described the Coalfield and suggested that the Ballycastle coal district was a western extension of the coalfields of the Midland Valley of Scotland; he compared the succession with that of Lanarkshire.

Symes, Egan and McHenry (1888) published a Memoir explaining the first Geological Survey Map (Sheet 8) which had appeared the previous year.

In 1912 E.A. Newel Arber examined the fossil flora of the coalfield. He concluded that they were of Lower Carboniferous age and equivalents of the Scottish Carboniferous Limestone Series. In 1919 the Ballycastle Coalfield was resurveyed by the Geological Survey and a six-inch to the mile map with accompanying memoir was produced by Wright (1924).



Drawing No. 15905 Date 18·VIII·76 Figure No.19

Occasional papers have since noted the area, one of which, Turner (1952), in a discussion of the Dinantian and Namurian vulcanicity in the British Isles, grouped the Ballycastle lavas with those of the Midland Valley of Scotland i.e.: as Lower and Middle Visean age. The same author indicated a correlation with the upper beds of the Calciferous Sandstone and Lower Limestone Group of Scotland.

As a result of the mapping of new surface exposures and of additional data on the Lower Carboniferous derived from boreholes a new one-inch map of the area was published in 1963 and the accompanying Memoir three years later (Wilson & Robbie, 1966).

The Geology of the Area

The following description is based on information taken from Wilson & Robbie (1966).

The total thickness of the Carboniferous succession may be as much as two thousand and three hundred feet (708 m.) if one includes the thick basal conglomerates which are thought to lie below the lava sequence (text fig. 21). The base of the succession is not exposed nor has it been proved by boring. The known and observed thickness is about one thousand and nine hundred feet (585m). The lowest beds are sandstones, grits and pebble conglomerates, locally red in colour. Some of the sandstones are calcareous and beds of nodular limestone breccia occur. These are succeeded by a group of contemporaneous basaltic lavas, of which the greatest thickness measured was 123 feet (37.8m), followed by a series of interbedded tuffs and mudstones. There are a few thin coaly bands and carbonaceous material is not uncommon. Only plant fossils have been discovered from these beds, Samoropsis sp., Archeopteridium tschernaki (Stirr), Diplotema adiantoides (Schlotheim), Rhodea moravica (Effingshausen) and cf. Leiginopteris (Diplotmena) bermudensiformis (Schlotheim), (Wilson & Robbie, loc. cit.).

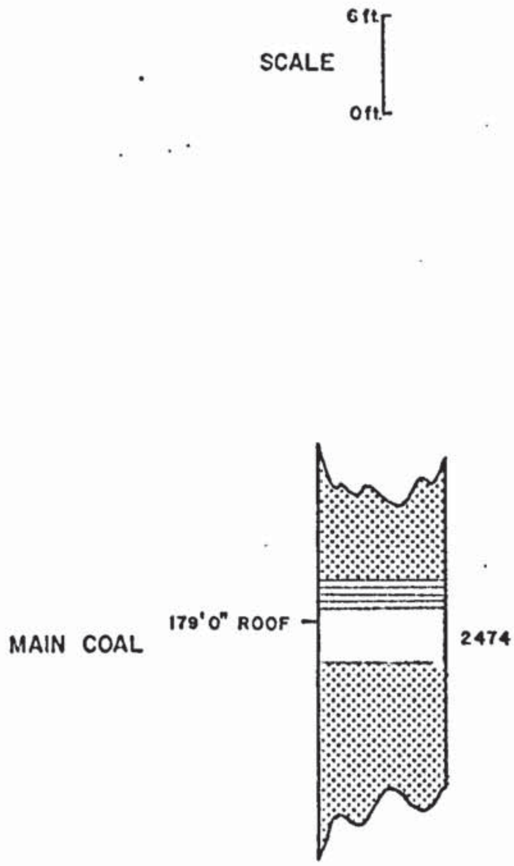
The beds below the lavas are poorly exposed but were sampled at Murlough Bay (text figs 18 & 19) and Glenshesk. These samples proved to be unproductive.

On the west side of Glenshesk, Carboniferous lavas are exposed in the stream which forms the boundary of the townlands of Mullarts and Drumeeny, and some of the overlying beds are seen in the stream to the west. The section consists of a series of sandstones, siltstones and fireclays, which have been faulted and also intruded by a 7' (2m) dolerite sill (text fig. 19). This locality was sampled at regular intervals, two of which proved productive.

The foreshore at Boat Port, Murlough Bay, contains approximately 200' (61m) of sandstones and conglomerates immediately below the lavas. This area was sampled but was unproductive.

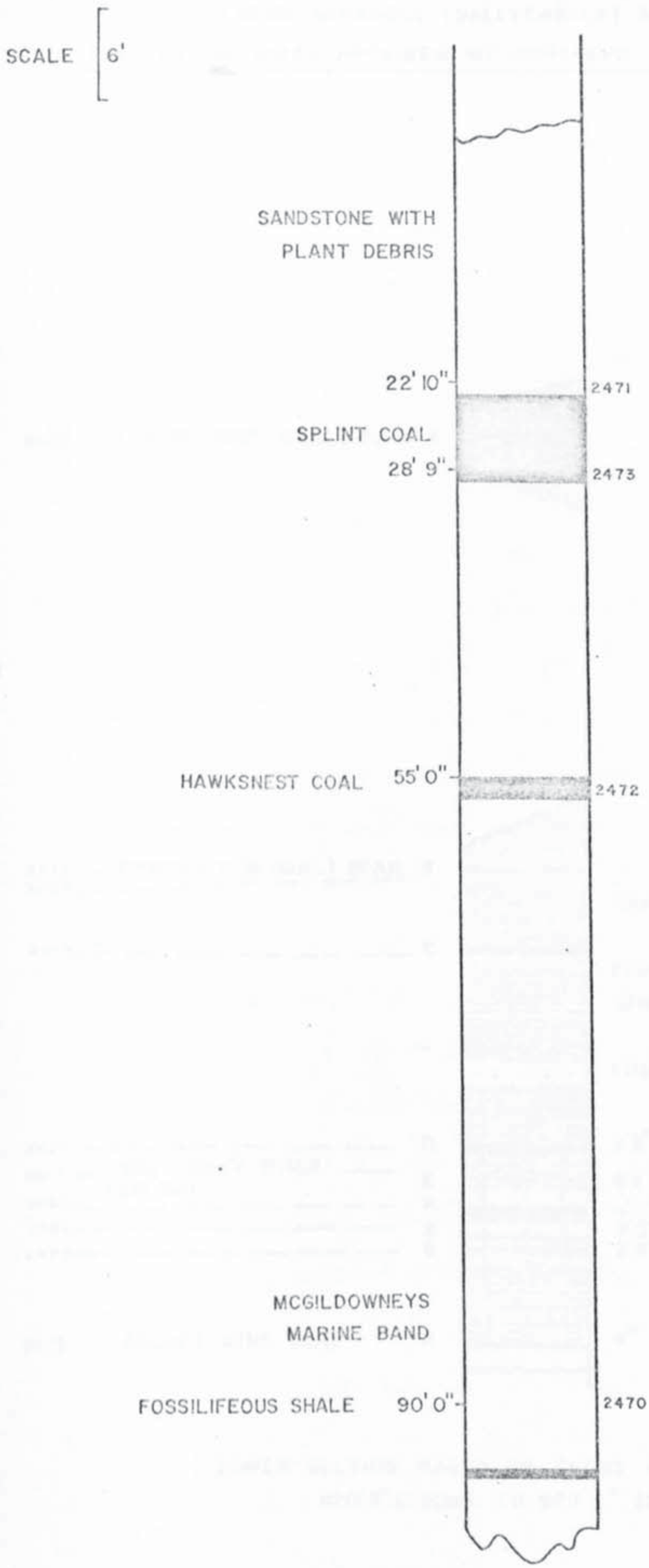
The tuffaceous sediments of the last group give place gradually to a succession of fireclays and dark shales with about ten coal seams of variable thickness and quality referred to as the Murlough Bay Coal Group. The base of the series is taken arbitrarily at the bottom of the lowest coal, but there is no clear break in the succession and tuffaceous beds are found with decreasing frequency for about 120 feet (36.5m) up into the Coal Group. The total thickness of this group was proved to be 150 feet (45.5m) in the Cross Borehole. The occurrence of marine fossils in the dark shales indicates that some, at least, of these beds were laid down during a marine transgression. The fauna is limited, Productus sp., Lingula squamiformis (Phillips) Paraparchites sp. and fish debris including Palaeoniscid and Megalicthys scales and

CRAIGFAD No.2 BOREHOLE (BALLYCASTLE) SAMPLE HORIZONS



(SAMPLE MATERIAL PROVIDED BY NORTHERN IRELAND GEOLOGICAL SURVEY)

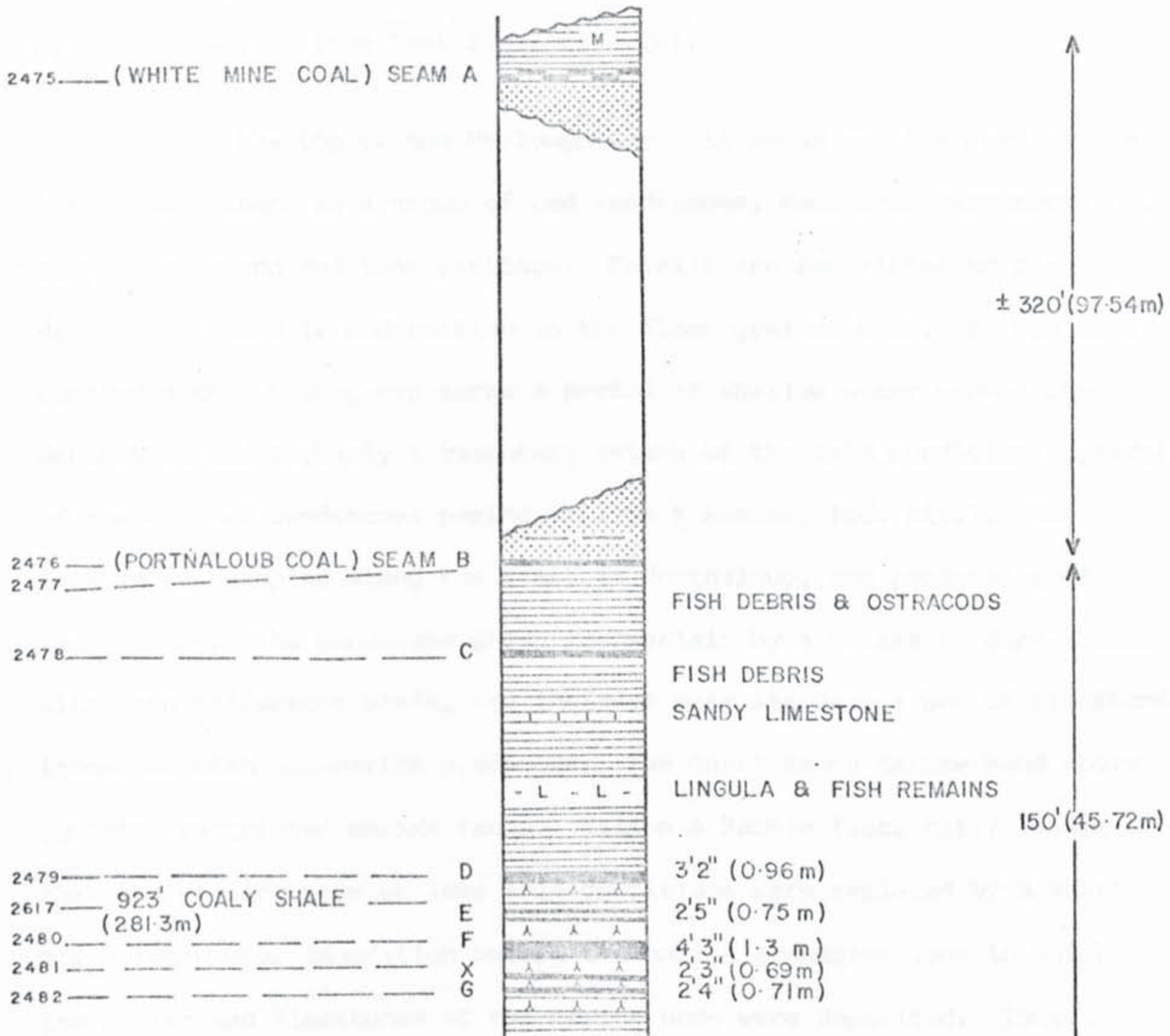
BALLYVOY No.1 BOREHOLE (BALLYCASTLE) SAMPLE HORIZONS
(SAMPLE MATERIAL PROVIDED BY NORTHERN IRELAND GEOLOGICAL SURVEY)



Drawing No. 15891 4·VIII·76 Figure No.23

CROSS BOREHOLE (BALLYCASTLE) SAMPLE HORIZONS

(SAMPLE MATERIAL PROVIDED BY NORTHERN IRELAND GEOLOGICAL SURVEY)



LOWER SECTION BASED ON CROSS BOREHOLE FROM
820'3" (250m) TO 970'2" (295·7m)

Acanthodean spines and scales were collected during the survey (Wilson & Robbie, 1966).

Many boreholes have penetrated this series of coals and a number of samples were provided by Dr. A.H.V. Smith of the National Coal Board, Yorkshire, from the Ballyvoy No. 1 Borehole and the Cross Borehole. These included the coals B. C, D, E, G, H and also coal A ≡ White Mine Coal from higher in the succession. There were also included a number of shale samples. (see text figs. 22 - 24).

Between the top of the Murlough Bay Coal Group and the Carrickmore Marine Band there is a group of red sandstones, sometimes calcareous, with clay nodules and mudstone partings. Fossils are restricted to plant debris and there is mudcracking in the finer grained beds. It has been concluded that this group marks a period of shallow water non-marine deposition and probably a temporary return of the arid conditions typical of the Old Red Sandstones period (Wilson & Robbie, loc. cit.). This section was sampled along the coast at Portnaloub, and produced good assemblages. The sandstone group is overlain by a series of dark shales with thin calcareous bands, and includes near its base a bed of blackband ironstone with non-marine ostracods. The Carrickmore Marine Band above contains restricted marine fauna. Wilson & Robbie (loc. cit.) assume that the earlier more or less arid conditions were replaced by a short lived freshwater inundation before the marine transgressions in which the shales and limestones of the marine beds were deposited. These, about 45 feet thick (14 m.) are overlain by a series of sandstones with several bands of shaley material which include two thin coals. The sandstones are in places calcareous and are mainly pink or red. This series, including the Carrickmore Marine Band, was sampled.

The Main Limestone Group follows containing grey or white sandstones followed by a few feet of fireclays and ganisters, usually with a thin coal or calcareous shale (the Limestone Coal). This is succeeded by a series of marine shales with calcareous ribs and a massive limestone, the Main Limestone. The limestone is from 5½ to 8 feet thick (1.7m to 2.4m thick), with a series of overlying fossiliferous shales ranging from 26 to 40 feet thick (7.9m to 12.2m thick). Fossils recorded from these horizons include the stratigraphically useful Gigantoproductus giganteus (J. Sowerby), a Viséan species (Wilson & Robbie, 1966).

The fossiliferous shales at the top of the Limestone Group are succeeded by micaceous sandstones and a group of pale sandstones about 90 feet (28m) thick. The sandstones are overlain by a series of sandy shales and fireclays with one or more thin coals. The most persistent of these coals is the Wee Coal. This section plus those below which extend to the Murlough Bay Coals were sampled along the coastlines west and east of Fair Head, near Ballycastle and produced good assemblages. Above is the Main Coal which is of good quality coal from 3½ to 4½ feet (1 to 1.5m) thick. It is succeeded by massive sandstones 100 feet (30.5m) thick, with a few metres of dark shale. (This horizon was sampled from Ballyvoy Borehole No. 1 - text fig. 22). After a brief shallow water phase with the deposition of fireclays, thin coals and shales comes a group of marine shales and mudstones called McGildowney's Marine Band with an abundant fauna. The fauna of the marine band is characterized by Archeocidaris spines, brachiopods and lamellibranchs. The most stratigraphically useful fossil is Schellwienella rotundata (I. Thomas); (Wilson & Robbie, loc. cit.).

The stratigraphically highest Carboniferous bed is the Upper Coal Group, a group of sandstones, shales and fireclays with at least four coals. The two lowest, the Hawks Nest and Splint seams, are the most important, and the higher coals include the Bath Lodge.

The Hawks Nest Coal varies in thickness from about 3 feet (0.9m) to over 4 feet (1.2m), and is a low grade coal with high ash content separated from McGildowney's Marine Band by a 3 to 13 feet (0.9 to 4.0m) sandstone and fireclay. The Splint Coal is rarely worth working and is about 2 feet 6 inches (0.8m) thick and consists of "foul" coal and canelloid shale. The shales above the Hawk's Nest Coal have yielded Lingula squamiformis, Curvirimula sp. and Carbonita sp. The latter two species suggest a non-marine environment (Wilson & Robbie, loc. cit.).

The sections from above the Main Coal were sampled along the coast of Fair Head and towards Ballycastle yielding good, productive assemblages (text fig. 18).

Age Determinations from Macrofossil Evidence

Faunas have been identified in the past by Dr. C.J. Stubblefield and Dr. W.H.C. Ramsbottom and by Dr. R. Crookall and W.N. Edwards, (Wilson & Robbie, 1966).

The lowest marine horizon occurs within the Murlough Bay Coal Group where Lingula squamiformis has been found.

No fauna of zonal significance has been recognised from horizons below the Main Limestone, but the Carrickmore Marine Band and the beds between it and the Main Coal were thought to be of Upper Viséan (P_1) age (Wilson & Robbie, loc. cit.). The age of the lower beds has always been uncertain, but it has been thought that the Ballycastle Carboniferous tuffs and lavas are of the same period as the "Calciferous Sandstone" igneous rocks of Ayrshire and that the sequence as a whole is of Middle Visean (B zone) age and that the Carrickmore Marine Band correlates with the Pumpherston Shell Bed.

BALLYCASTLE SCOTLAND

(AFTER E. CURRIE 1954)

Aston University

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Drawing No. 15888 Date 19·VIII·76 Figure No. 20

The calcareous shale above and below the Main Limestone yield an abundant marine fauna, including Gigantoproductus giganteus (J. Sowerby), considered a Viséan species and restricted to high P_1 or lower P_2 zone. In Scotland it occurs in the Hurlet Limestone at the base of the Lower Limestone Group and the limestone below the Hurlet. It is also considered as marking the base of the P_2 zone in Scotland. The fauna compares with that recorded from the Corrie Limestone in Arran which is regarded as the equivalent of the Hurlet Limestone of Central Scotland (text fig. 20).

McGildowney's Marine Band is suggested as a lateral equivalent of the Index Limestone which means that the intervening strata between this horizon and the Main Limestone represents a condensed version of the Scottish Lower Limestone Group and Limestone Coal Group. This interval is thus considered as P_2 and E_1 zone age.

Schellwienella rotundata which occurs in the McGildowney's Marine Band is believed to be restricted in Scotland to the Upper Limestone Group, regarded by Ethel Currie (1954, p.535) on the evidence of its goniatite fauna, as belonging to the lower part of the E_2 zone. Thus from this evidence the Carboniferous strata above the horizon of McGildowney's Marine Band could be considered of E_2 age or perhaps younger.

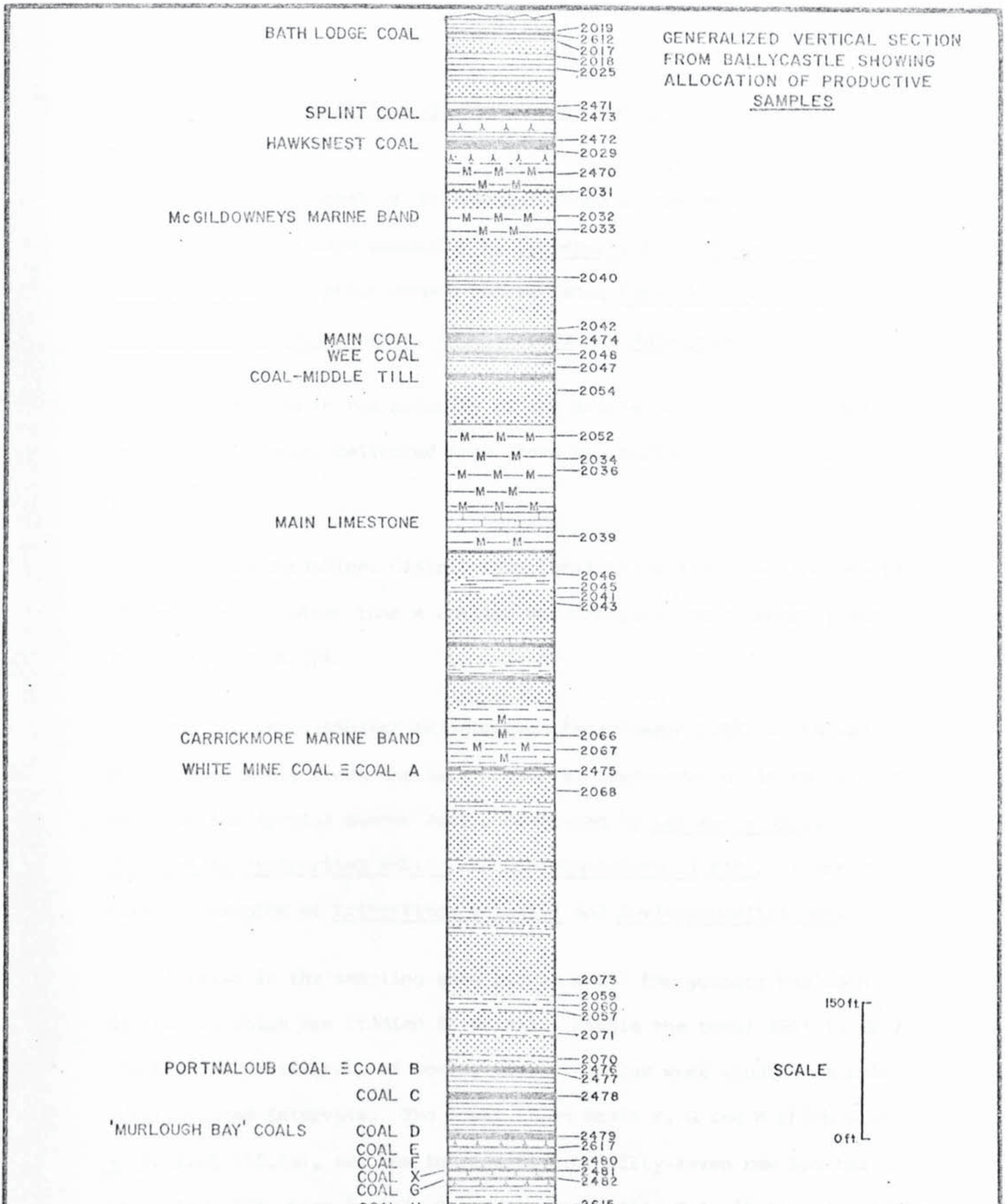
There is no indication of the dividing line between Viséan (P) and Namurian (E) from macrofossil evidence, and the limit has been arbitrarily drawn in the past at the Main Coal horizon (Wilson & Robbie, 1966, p.76).

Megaspore and microspore studies of the area by Dr. W.G. Chaloner and Dr. M.A. Butterworth will be considered in later chapters.

Text-fig. 25 can be found

as a folded chart at the

back of this book.



Drawing No. 15887 16·VIII·76 Figure No. 21

Stratigraphical Description of Miospore Assemblages

There were a total of 109 species found in the Ballycastle assemblages which were dominated by Lycospora, Punctatisporites and Densosporites with other common genera being Microreticulatisporites, Tripartites, Cingulizonates, Schulzospora and Rotaspora.

Preservation in the majority of the samples was excellent, and most of the samples collected from above the tuffaceous beds were productive.

The stratigraphical distribution consists of a gradual introduction of new species rather than a decline or disappearance of spore types (text fig. 21 & 25).

The oldest assemblage is described from Sample 2069, which was found immediately above the lave sequence. Preservation is relatively poor and the species number small, dominated by Lycospora spp., Microreticulatisporites noblis and Convolutispora florida. There are rare occurrences of Tripartites vetustus and Savitrisporites nux.

A break in the sampling then occurs until the younger Murlough Bay Coals, which are studied in detail. Within the total 150' (45.6m) thickness of this group of coals, twelve samples were studied at fairly evenly spaced intervals. The lower three coals F, G and H which span ± 40 feet (12.2m), see the introduction of fifty-seven new species (text fig. 21) which include Rotaspora ergonulii, Triquitrites marginatus, Remysporites magnificus, Crassispora maculosa, Spencerisporites radiatus, Apiculatisporis pineatus, Calamospora liquida, Verrucosisporites nodosus, Waltzispora planiangulata, Crassispora aculeata, Raistrickia nigra, Vestispora lucida, Camptotriletes cristatus and C. verrucosus. These are common constituents of the assemblages, together with Punctatisporites spp., Lycospora spp., and Densosporites spp., and they continue to be important throughout the succession.

The following samples leading up to and including the Portnaloub Coal (Coal B), mark the introduction of nine new species, which include Rotaspora knoxi, Triquitrites comptus, Leiotriletes tumidus, Tholisporites biannulatus, Tholisporites decoratus and Tricidarisporites balteolus.

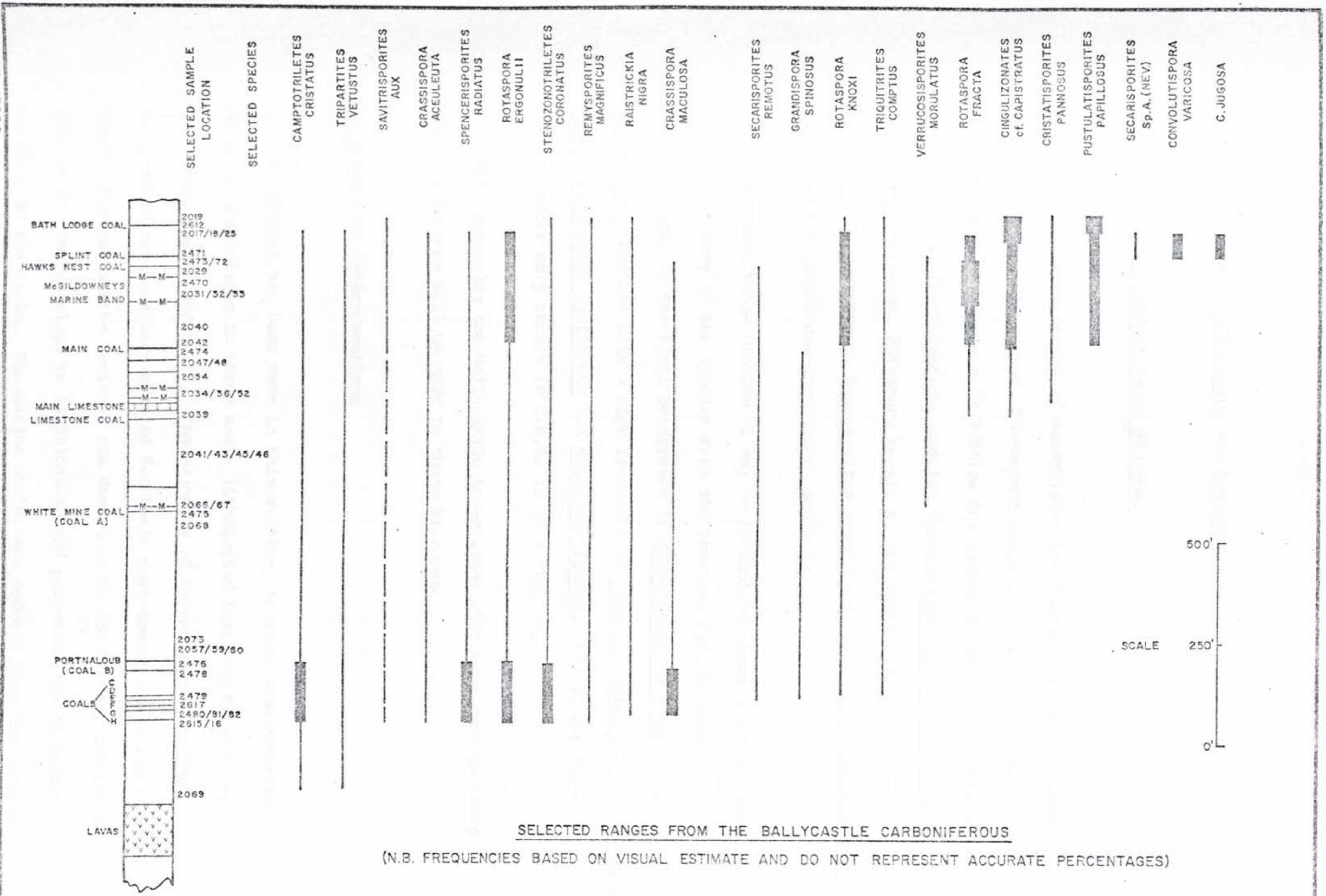
A marked gap in sampling occurs between the previous samples and the next which was taken immediately below the White Mine Coal, which displays the first appearance of Verrucosisporites morulatus, Laevigatosporites vulgaris and Ahrensisporites duplicatus.

A group of assemblages from below the Main Limestone (2039, 2045, 2046) see the incoming of ten new species including Rotaspora fracta and Cingulizonates cf. capistratus. These two species form a very minor part of the assemblage at this stage.

Immediately above the Main Coal, which was not available for thorough examination, the assemblage does not change significantly in terms of species, but Cingulisporites cf. capistratus appears (assemblage 2042) in great abundance for the first time. Assemblage 2040, approximately 50 feet (15m) higher introduce five more species including Pustulatisporites papillosus.

Between assemblage 2040 and the youngest assemblages from the Bath Lodge Coal there are only 8 new species introduced, the most significant of which are the large species Convolutispora jugosa (assemblage 2472), above the Hawks Nest Coal and Convolutispora varicosa (assemblage 2025), between the Bath Lodge and Spint Coals.

From the Main Coal to assemblage 2025 it would appear that the three species of Rotaspora are at their most abundant but then become significantly reduced in the younger samples. Here also the numbers of



SELECTED RANGES FROM THE BALLYCASTLE CARBONIFEROUS

(N.B. FREQUENCIES BASED ON VISUAL ESTIMATE AND DO NOT REPRESENT ACCURATE PERCENTAGES)

Drawing No. 15886

23-VIII-76

Figure No 26

<u>Cingulizonates cf. capistratus</u> and <u>Pustulatisporites papillosus</u> increase.

<u>Definition of Concurrent Range Biozones</u>

From the above series of assemblages two Concurrent Range Biozones may be defined. The oldest, Concurrent Range Biozone I can be defined from the lowest assemblage 2069 below the lavas, to assemblage 2048 below the Main Coal. Characteristic species include <u>Crassispora maculosa</u>, <u>Tripartites vetustus</u>, <u>Rotaspora knoxi</u>, <u>R. ergonulii</u>, <u>Camptotriletes cristatus</u>, <u>C. verrucosus</u>, <u>Remysporites magnificus</u>, <u>Microreticulatisporites spp.</u>, and the occasional <u>Crassispora aculeata</u>.

Concurrent Range Biozone II may be recognised above the Main Coal. It contains many of the species from the previous C.R. Biozone. Characteristic is the first occurrence of <u>Convolutispora jugosa</u> and <u>C. varicosa</u> together with a high frequency of <u>Cingulizonates cf. capistratus</u>, <u>Pustulatisporites papillosus</u> and <u>Rotaspora fracta</u>. The latter three species occur only rarely in C.R.B. I. text fig. 26.

When comparing the Ballycastle assemblages with work done in other areas, reference will be made to these Biozones.

<u>Environmental Interpretations</u>

An attempt has been made in this section, to study the variation of spore assemblages in three basic lithologies i.e.: marine shales, non-marine shales and coals. The majority of assemblages from the Ballycastle sequence were studied for their most common and significant types. Several marine horizons are described in the Memoir, and these were often sampled close to lithological and palaeontological marker horizons in the field. Non-marine shales are deduced from the absence of marine fauna.

Common to all the assemblages are *Lycospora*, *Densosporites*, and *Cingulizonates*. Characteristic elements of marine shale assemblages were *Cingulizonates cf. capistratus*, *Leiotriletes spp.*, and *Remysporites magnificus*, *Convolutispora varicosa* and *Pustulatisporites papillosus* occurred in significant numbers in certain samples. Non-marine assemblages commonly contained many *Punctatisporites* and sometimes *Schulzospora*. Coals included *Punctatisporites* and occasionally *Schulzospora*, *Calamospora*, *Rotaspora*, *Crassispora maculosa*, *Stenozonotriletes coronatus* and *Camptotriletes cristatus*.

The most variable factor of these three environments was the nature of the plant tissue. Coal and non-marine shale assemblages were found to have large and small well preserved plant tissue, a high percentage of which was pale and delicate. The spore assemblage also was well preserved and generally appeared clear of any fine material. The marine shale assemblages in contrast contained a high percentage of fine grained probably organic material with only a little plant debris, all of which including the spores were not well preserved.

The poor preservation associated with an allochthonous marine assemblage, and the better preserved relatively autochthonous coal and non-marine assemblages, may reflect the distance the materials were transported before deposition. The fine organic material has been associated with marine conditions where oceanic circulation is relatively poor in the Upper Jurassic of the North Sea [illegible]-personal research. Its actual composition may be kerogenous or humic, depending on whether it is derived from the pulverised spore material or decayed marine fauna.

Neves (1961) describes a simple exercise of comparing the quantitative and qualitative features between coals, marine shales and non-marine shales. From this study the non-marine shale displayed the greatest variety of species.

In the present study a similar exercise was carried out on certain selected assemblages. Samples taken from sections described in the Memoir as marine horizons include the shales of McGildowney's Marine Band 2470, 2032, the shales above and below the Main Limestone 2036, 2034 and also the shales above the White Coal 2066 and 2067. These assemblages showed a total of 62 different spore types.

Due to the increase in spore types as one passes up the Ballycastle succession, it seems more practical to take the coals from the part of the succession 2475, 2474, 2473 associated with the marine horizons. Thus this excludes the Murlough Bay Coals. The coal assemblages studied contained a total of 49 species.

For the same reasons as above it was decided to study 2471, 2472, 2045 and 2047 as representatives of the non-marine environment. These samples displayed no evidence of marine fauna in their lithology and are not described in the Memoir as being marine. With this negative evidence it is assumed that these shales are non-marine. The total number of species recorded from these assemblages was 78.

Thus the general distributions as found by Neves (1961) in his Namurian assemblages are repeated above. The ratio he observed from these lithologies was coal 29, marine shale 32, non-marine shale 45 species.

Types restricted to the marine samples of the above comparison were Verrucosisporites microverrucosus, Reticulatisporites decoratus, Grandispora echinata, and Acanthotriletes horridus. Most of these, however, are of rare occurrence.

There are 26 types restricted to the non-marine assemblages of which 15 could be described as murinate forms. Those more often found in the non-marine assemblages were Calamospora liquida, Stenozontriletes coronatus, Rotaspora ergonulii, Remysporites magnificus, Vestispora lucida, Schulzospora campyloptera and Schulzospora occellata.

Comparison with Previous Work in the Area

The Ballycastle Carboniferous has been previously studied palynologically by Chaloner (1958), Dijkstra (1956) and Butterworth (in Wilson & Robbie, 1966, p.81).

Megaspores

Chaloner made a study of the megaspores from coal and shale samples and Dijkstra described four species from one sample, the exact locality not specified. These latter four species were all recorded similarly by Chaloner.

The following list summarises the variety of megaspores recorded from the Ballycastle coalfield:- Lagenicula splendida (Zerndt) Potonié & Kremp, L. subpilosa (Ibrahim) P. & K., Forma major (Dijkstra) Ex Chaloner, Lagenoisporites simplex (Zerndt) P. & K., Setosisporites hirsutus var. brevispinosus (Zerndt) P. & K. in Horst, Zonalisporites brasserti (Stach & Zerndt) P. & K., Rotatisporites rotatus (Bartlett) P. & K., Cystosporites giganteus (Zerndt) Schopf (sensu Dijkstra), Didymosporites scotti Chaloner, Remysporites magnificus and Spencerisporites radiatus (Wilson & Robbie loc. cit.).

Species recorded from the Ballycastle coals (except Didymosporites scotti) are present in the Scottish Limestone Coal Group (Dijkstra 1956; Butterworth & Williams 1958); eight of these have also been found in the Namurian A of Germany (Horst 1955). Butterworth & Spinner (1967) describe from the north west of England an assemblage of megaspores which includes three species in common; these species occur in their Nether Hill exposure from the Oakshawford Coal Beds which are considered S_2 zone in age.

Spinner & Clayton (1973) described a south eastern Scottish assemblage of megaspores from the uppermost Calciferous Sandstone Measures and the Lower Limestone Group from Skateraw. Only Lagenicula subpilosa (Ibrahim) P. & K. forma major (Dijkstra) ex Chaloner occurs in common. This is unexpected considering that the Skateraw material is thought to be of uppermost Viséan age.

Comparison with the North American megaspore sequence given by Winslow (1959) shows that seven of the Ballycastle species occur within the Elvira (Upper Chester) to Lower Caseyville (approximately equivalent respectively to the Lower Namurian and Upper Namurian). Of these seven, two do not extend below the Caseyville strata.

Thirty megaspores from the Moscow Basin Coals (Dijkstra&Pierart,1952) of approximately Lower Viséan age, have only three species in common with the Ballycastle assemblage. The megaspore assemblage from the Egyptian Lower Carboniferous (Dijkstra,1956), has no spores in common with the Ballycastle assemblage. Generally, only three Ballycastle species have been recorded from the extensively studied Westphalian coals of Europe and North America.

Chaloner (in Wilson & Robbie,loc. cit.) concluded that the megaspore assemblages from the upper parts of the Ballycastle coals (from the Main Coal and above), are similar to those described from the Scottish Limestone Coal Group. Comparison with other sequences of megaspores from Britain, Europe and North America suggest that the upper Ballycastle sequence is most likely Namurian in age; the coals below this horizon may either be Namurian or uppermost Dinantian in age.

Previous Miospore Studies

Butterworth (in Wilson & Robbie, loc. cit) examined a number of samples from the Cross Borehole including the White Mine Coal and the Murlough Bay Coals. The former horizon contains the following species:- Punctatisporites aerarius Butterworth & Williams, Calamospora liquida, Cyclogranisporites leopoldi (Kremp) P. & K., Anaplanisporites baccatus, Crassispora maculosa, Lycospora noctuina, L. punctata Kosanke, Densosporites intermedius, D. striatus, Schulzospora ocellata, Verrucosisporites inequalis B. & W., Verrucosisporites morulatus, Anapiculatisporites minor, Convolutispora cf. mellita Hoffmeister, Staplin & Malloy, Tripartites sp., Rotaspora fracta, R. knoxi and Microsporites karczewski Zerndt (Spencerisporites radiatus).

The Murlough Bay Coals had similar assemblages but contained no species of Rotaspora and had species of Procoronaspora (Tricidarisporites) and Apiculatisporites noted previously only from a coal towards the top of the Calciferous Sandstone Series in Scotland. The Murlough Bay Coals in the present study contained assemblages similar to the above but three of the species mentioned were not found, Densosporites striatus, C. leopoldi and V. inequalis. Dr. Butterworth (personal communication,1976) considers that the specimens recorded as D. striatus were probably Cingulizonates bialatus. Punctatisporites aerarius was also not described; it was decided that specimens of this size range were better placed in P. punctatus.

In the Murlough Bay Coals examined of the present study Rotaspora ergonulii and R. knoxi were not uncommon.

Butterworth's comparisons with other assemblages known at that time (1955) indicated a similarity with those she had found in the Lower Limestone Group and Upper Calciferous Sandstone Group of Scotland.

Comparison with Areas in Britain

The Ballycastle assemblages are compared in detail with others from strata of upper Viséan and lowest Namurian age. These include essentially (i) the Limestone Coal Group, Upper Limestone Group and Oil Shale Group of Scotland, described by Butterworth & Williams (1958), Smith & Butterworth (1967), Sullivan & Marshall (1966) and Neves et al. (1973); (ii) the Lower, Middle and Upper Limestone Groups of Northumberland described by Smith & Butterworth (1967), Marshall & Williams (1970) and Whitaker (1971, M.Sc. thesis); (iii) assemblages from Leitrim of E_1 and E_2 zone age from the present study.

Neves et al. (1972/1973) describe in their miospore Biozones for the British Dinantian Series, two zones comparable with Ballycastle, i.e.: Tripartites vetustus-Rotaspora fracta (VF) zone and Bellispores nitidus-Reticulatisporites carnosus (NC) zone. The (VF) zone is closely comparable to the Concurrent Range Biozone I and to a lesser extent the C.R.B. II.

It is defined principally by the appearance of T. vetustus, R. fracta and T. nonguerickei, together with other species which have the base of their ranges within this zone including Spencerisporites radiatus, Crassispora maculosa, Tripartites trivalvis, Vestispora lucida, Grandispora spinosa, Rotaspora knoxi and Savitrisporites nux. At some stage in the Ballycastle succession all these species are recorded and a detailed comparison with this zone is considered below.

In the oldest assemblage 2069 T. vetustus is present but C. maculosa and S. radiatus do not appear until the lower two coals of the Murlough Bay Coal Series. Assemblage 2069, however, is of relatively poor preservation, and the latter species may be found to extend lower with further sampling. R. fracta appears for the first time below the Main Limestone midway in the succession and later than Tripartites vetustus. This feature can be observed in two sections described by Neves et al. (1973), from East Fife (Neville) and the Midlothian Cousland No. 1 Borehole (Gueinn), where R. fracta does not appear at the base with T. vetustus but within the designated(VF) zone.

Several sections from the (VF) zone in Northern England and Scotland compare with the Ballycastle C.R.B. I assemblages. (i) Neville's East Fife (VF) assemblage contains 35 of the listed species in common with those of Ballycastle. Rotaspora knoxi, R. fracta and Verrucosisporites morulatus appear almost together midway into his (VF) zone, followed later by Cingulizonates cf. capistratus and then in his youngest assemblage Vestispora lucida. The latter species appears earlier in the present succession, near the base of the Murlough Bay Coal. The first occurrence of Rotaspora knoxi, R. fracta and Verrucosisporites morulatus, in Ballycastle are similarly close together. In general this assemblage corresponds closely with the C.R.B. I Ballycastle assemblages. Above this the C.R.B. II includes new species such as Pustulatisporites papillosus, Convolutispora varicosa, C. jugosa and an abundance of Cingulizonates cf. capistratus distinguishing these assemblages. (ii) Spinner & Clayton (1973) describe from Skateraw, East Lothian a VF assemblage which compares well with C.R.B. I. Absent are Pustulatisporites papillosus, Convolutispora varicosa and Cingulizonates cf. capistratus, which do not appear until the uppermost samples. It is interesting to note that their assemblage contains Verrucosisporites morulatus a species restricted to the Namurian in the Roman Wall District, (Marshall & Williams, 1970) and appearing late in the Ballycastle succession. (iii) the younger parts of the Upper Oil Shale Group,West Lothian and Edinburgh Districts (in Neves et al., 1973) (iv) Cousland No. 1 Borehole, Midlothian from above the 502 ft. horizon above the Burdiehouse Limestone and Dunnet Shell Bed, (in Neves et al., loc. cit). (v) Spilmersford Borehole, East Lothian, above the 176' 3 " horizon around the Upper Long Craig Limestone (in Neves et al., loc. cit.).

Neves et al. (loc. cit.) describe a higher zone (NC) which they consider to be distinguishable from the (VF) zone. It has many elements in common with the proceeding (VF) zone including Rotaspora fracta, R. knoxi, T. vetustus and C. maculosa, but in addition the following are recorded at the base of their ranges, Cingulizonates cf. capistratus, Bellispores nitidus, Reticulatisporites carnosus (Knox) Neves and Convolutispora varicosa.

The two key members of this zone, B. nitidus and R. carnosus, are not recorded from the Ballycastle assemblages. C. cf. capistratus is well established by the Main Coal Horizon and C. varicosa makes its first appearance between the Splint and Bath Lodge Coals. Smith & Butterworth (1967) are quoted as describing an assemblage typical of this zone from the Hazon Ford Borehole at 281' 7" without the presence of

B. nitidus and R. carnosus but based on the first occurrence of C. cf. capistratus together with C. varicosa. By this analogy the (NC) zone could be applied to Ballycastle from the base of the C.cf. capistratus range or possibly between the latter and the base of the C.varicosa range. In general it would seem that their (NC) zone is not well marked in this area since the Ballycastle C.R.B. I does not significantly change at the base of the range of C.cf. capistratus. A more useful change can be defined above the Main Coal at the base of C.R.B. II where C.cf.capistratus and Rotaspora fracta become abundant and Pustulatisporites papillosus, Verrucosisporites morulatus and C.varicosa appear as noted by Smith & Butterworth (1967) and Marshall & Williams (1970) in Scotland and Northumberland. The lower Raistrickia nigra-Triquitrites marginatus (NM) zone of Neves et al. (1972), includes in its lower part the Pumpherston Shell Bed. This zone contains many species which range into the younger (VF) zone and which are present in the Ballycastle sequence. There are some species which are restricted fairly closely to the (NM) zone but which are occasionally found in the lowest (VF) assemblages. Such species include Crassispora aculeata and Perotrilites tessellatus. The presence of C. aculeata in the lowest Ballycastle assemblages might therefore indicate a possible low position in the (VF) zone. This evidence does not substantiate the correlation by Wilson & Robbie (loc. cit) of the Carrickmore Marine Band and the Pumpherston Shell Bed. The former horizon is obviously younger, occurring within the C.R.B.I. (See figs 20 & 27.)

Butterworth & Williams (1958) and Smith & Butterworth (1967) made an initial study of the Scottish Carboniferous using borehole material from the coals of the Limestone Coal Group and the Upper Limestone Group. The lower assemblages of the Ballycastle C.R.B. I have features in common suggesting some equivalence in age. It is interesting to note that Cingulizonates cf. capistratus first occurs in the Limestone Coal Group whilst in the Upper Limestone Group this species becomes more common and Rotaspora fracta begins to diminish. In the present study, R.fracta and C. cf. capistratus appear together immediately below the Main Limestone.

The former spore becomes abundant in the strata between the Hawks Nest and Splint Coals.

Smith & Butterworth (1967) also describe from their Northumberland borehole material, taken from the east near Alnwick, two more assemblages comparable to Ballycastle...The lower is the "Diatomozonotriletes saetosus assemblage" described from the Middle Limestone Group of P_2 zone age, which essentially contains Tripartites vetustus, Crassispora maculosa, Rotaspora knoxi, Tricidarisporites spp., and Tholsiporites scoticus. Notably absent is Cingulzonates cf. capistratus. The second is the "Rotaspora knoxi assemblage" of the Upper Middle Limestone Group where appeared C. cf. capistratus, large Convolutispora spp. (C. varicosa, C. jugosa)together with Rotaspora fracta. This assemblage continues into the Upper Limestone Group which is considered E_1 zone age. The Ballycastle Concurrent Range Biozones I and II similarly display these features, and would seem to correspond to the Diatomozonotriletes saetosus and Rotaspora knoxi assemblages respectively.

Marshall & Williams (1970) from the Yoredales of the Roman Wall District of Northumberland describe a series of remarkably similar assemblages of Upper Viséan and Lower Namurian age. Here they record Apiculatisporis pineatus which was not found above the Main Coal horizon and was restricted to the lower part of the P_1 zone. This species is regarded by the authors together with Love (1960) from the Lower Oil Shale Group of Scotland as indicative of Lower Carboniferous horizons. Spencerisporites radiatus was not recorded below the P_2 a zone in the Roman Wall District. The absence of such species as Verrucosisporites baccatus Staplin and Lycospora rugulosa Butterworth & Spinner, in the present study which Marshall & Williams found only in the lowest samples suggests the lowest Ballycastle horizon sampled is from above the Middle Bankhouses Limestone of the Roman Wall District. This horizon lies just above the base of the P_1 zone (Taylor et al., 1971). Above the Main Coal within the Namurian several species have comparable ranges. Cingulizonates cf. capistratus first appears in strata below the Main Limestone and becomes common in assemblages immediately above the horizon of the Main Coal. Pustulatisporites papillosus and Verrucosisporites morulatus appear with other species in assemblages from some 15 metres higher in the sequence. C. cf. capistratus first appears towards the top of the Visean in the Roman Wall District and increases in abundance at the base of their Namurian strata. Pustulatisporites papillosus, Verrucosisporites morulatus, Acanthotriletes falcatus, Convolutispora varicosa and C. jugosa, were also recorded from their Namurian, which is highly comparable to the assemblages from above the Main Coal.

Sullivan & Marshall (1966) described a number of assemblages from the Visean Upper Sedimentary and Lower Limestone Groups of Scotland. This part of the succession lies below the strata sampled by Butterworth & Williams (1958). Ballycastle assemblages compare well especially with the horizon of the Murlough Bay Coals. Forty-five of the seventy species described by S. & M. also occur in Ballycastle. Tripartites vetustus, Rotaspora knoxi and Crassispora maculosa are present throughout their sequence with Rotaspora fracta and Verrucosisporites nodosus appearing in the shale below the Black Byre Limestone (midway in the Upper Sedimentary Group). The sample below this contained Densosporites capistratus H.S. & M., similar to C. cf, capistratus described by Smith & Butterworth. Thus theseassemblages may be equivalent to some extent with the C.R.B. I. Pustulatisporites papillosus, Camptotriletes verrucosus and Savtrisporites nux which occur above the Main Coal were not recorded by Sullivan & Marshall but they record B. nitidus, normally associated with E_1 zone assemblages.

Butcher (1974 thesis) describes from Cumberland a series of assemblages from poorly dated Upper Viséan and Namurian strata. The C.R.B. I can be compared closely with his D1 and D2 C.R.Biozones which encompass the middle and upper parts of the Lower Chief Limestone Group, considered uppermost Viséan in age.

In his upper E Concurrent Range Biozone occurs Rotaspora fracta and Cingulizonates cf. capistratus for the first time. The latter spore at this stage occurs only rarely, becoming more frequent in the Biozone above. Butcher's F Biozone includes the upper Chief Limestone Group and lowermost Hensingham Group, which is considered Namurian. Here C. cf. capistratus becomes more frequent together with P. papillosus, which is comparable to C.R.B.II of the present study. It would appear that the stratigraphic distribution of the latter two species and Rotaspora fracta are similar to their occurrence in Ballycastle. The higher Biozones, considered E_2 zone in age can be distinguished by the appearance of Florinites similis and Schopfipollenites ellipsoides together with a reduction of Rotaspora and Tripartites species.

So far the C.R.B. II hs been compared closely with assemblages of uppermost P_2 and E_1 zone age. In a previous section it was noted that Currie (1954) has suggested an E_2 zone age for strata above the McGildowney's Marine Band. Neves (1961) and Owens (in Owens & Burgess 1965) describe from the South and North Pennines respectively a series of assemblages from the Arnsbergian stage. Smith & Butterworth (1967) also include in their study, coals of the Upper Limestone Group, West Fife, which are similarly described as E_2 zone age by Currie (1954). A characteristic genus of the Pennine assemblages is notably Florinites which is absent in Ballycastle. Other distinguishing types from the Southern Pennines include Hymenospora palliolata, Alatisporites nudus and species of Mooreisporites plus Crassispora kosankei and Lycospora

(Bellispores) nitidus from the North. The genera Rotaspora and Tripartites are noticeably infrequent.

The above assemblages are significantly different from those of Ballycastle and do little to substantiate an Arnsbergian age.

Smith & Butterworth (1967) include in their Rotaspora knoxi assemblage III the lower part of the Upper Limestone Group of Scotland, from the Index Limestone to a little above the Hunters Hill Limestone. Immediately above these horizons appear Crassispora kosankei and Bellispores nitidus. Also Rotaspora and Tripartites become infrequent. Since, however, these assemblages are from coals alone, it might possibly be considered that representatives of the upland flora e,g,: Florinites, more normally associated with those of E_2 zone age, are absent. The Rotaspora knoxi assemblage compares well with the upper Ballycastle assemblages and may well suggest a lower Arnsbergian age is present. The high numbers of Cingulizonates cf. capistratus and the absence of Tholisporites scoticus in Ballycastle suggests correlation with the upper part of the R. knoxi zone but the presence of R. fracta suggests lower horizons since this species was not recorded in E_2 strata by Butterworth & Williams (1958), Owens & Burgess (1965) nor by Mishell (1966 thesis) in the Bowland Fell area.

The E_2 age assemblages described from Leitrim in the present study are unlike those from Ballycastle. The presence of Florinites visendus, Crassispora kosankei, Knoxisporites triradiatus, Triquitrites triturgidus and Bellispores nitidus, together with the paucity of Tripartites and Rotaspora, again serve to distinguish these assemblages, and suggest that they are younger.

The older C.R.B. I of probable E_1c age described from Leitrim is distinguishable also by the above species but is comparable in the more frequent occurrence of Tripartites vetustus, Rotaspora knoxi, Verrucosisporites nodosus, Tricidarisporites balteolus and the presence of Crassispora aculeata.

Owens at present is compiling a range chart of the Upper Viséan and Namurian, from recent research completed at Sheffield University. He proposes a series of zones defined by the top and base occurrences of spore types. The basal (NC) zone is extended from P_2 to the top of the Pendleian E_1 stage. This is followed by the (TK) Stenozonotriletes triangulus-R. knoxi zone (lower E_2); and the (SO) Lycospora subtriquitra-Kraeuselisporites ornatus zone (upper E_2 and H). At the base of the E_1 zone he describes the incoming of Schulzospora ocellata, Grumosisporites rufus (Butterworth & Williams) S. & B. and Crassispora kosankei. Within the E_1 interval appear Mooreisporites trigallerus and Secarisporites remotus. These occur together with many species associated with the Viséan. Of these only Secarisporites remotus occurs in the Ballycastle assemblages.At the base of the E_2 appear Punctatisporites giganteus Neves 1961, P. pseudopunctatus, Stenozonotriletes triangulus and Mooreisporites fustis Neves 1958. At this horizon the following have their final occurrences Camptotriletes verrucosus, Rotaspora fracta and Raistrickia nigra. Since the latter two species are still present in the Ballycastle assemblages it would suggest a closer comparison with the E_1 zone. Punctatisporites obesus is the largest species of the genus to occur in the Ballycastle assemblages which is similar to P. giganteus and thus may suggest a link with the E_2. There is a single occurrence of a specimen of Punctatisporites which is of 162u in assemblage 2474, which is not included in the systematics.

Comparison with Areas other than Britain

Beju (1970) describes two main palynological zones in the Carboniferous sequence of the Moesian Platform of Romania. They are termed Cb_1 and Cb_2 and are thought to be Dinantian and Namurian respectivley and to straddle the Namurian/Viséan Boundary. Both of these assemblages include many species characteristic of the Ballycastle area. A total of thirty-four species occur in common with the Cb_1 assemblage and twenty-seven with the Cb_2. Species restricted to the Namurian Cb_2 zone include Microreticulatisporites concavus, M. microreticulatus, Calamospora mutabilis (Loose) S. W. & B, Convolutispora varicosa, Triquitrites bransonii, Spencerisporites radiatus. Only Convolutispora varicosa of these spores shows any indication of being restricted to the Namurian in the Ballycastle assemblages, all the others are found to occur in the Murlough Bay Coals. Significant species restricted to his Cb_1 zone are Anapiculatisporites concinnus, Tricidarisporites balteolus, Raistrickia nigra, Corbulispora cancellata, Knoxisporites hederatus, Perotrilites perinatus, Densosporites rarispinosus and Endosporites micromanifestus. Most of these species occur throughout the Ballycastle succession. Perotrilites perinatus is restricted to the youngest assemblage in the Bath Lodge Coal and was recorded by Marshall & Williams (1970) from occasional horizons in Dinantian and Namurian strata of the Roman Wall District.

Features characteristic of the Viséan/Namurian boundary indicated in the Ballycastle area seem absent from the Romanian junction of that age. Pustulatisporites papillosus and Verrucosisporites morulatus are not recorded but there is an increase in frequency of Densosporites capistratus (similar to Cingulizonates cf. capistratus) at the Cb_1/Cb_2 boundary.

Playford (1963) describes from the Spitzbergen Lower Carboniferous two assemblages, the youngest of which (Aurita Assemblage) shows a total of twenty-four species in common with the Ballycastle sequence from the Birger Johnsonfjellet and Triungen sections. Most of these spores, however, are known to be long ranging (Tournaisian/Namurian), and do not necessarily indicate a close correlation. This assemblage is described as part of the Monilospora Suite (Sullivan, 1965) and appears not to contain the more restricted and useful species of the British and European microfloras found in the Grandispora Suite, such as Rotaspora and Tripartites spp., Pustulatisporites papillosus, Raistrickia nigra and Cingulizonates cf. capistratus.

A remarkably similar spore composition occurs in the upper Viséan microfloras of the Swiety Krzyz Mountain and also the Namurian assemblages from Upper Silesia, (Central Poland) described by Jachowicz (1970, 1974). The upper Viséan based on macrofaunal evidence is divided into the lower Lechowek Beds $v^{iii}d$ and the younger Galezice Beds $v^{iii}g$, the latter of which has an assemblage comparable to those from Ballycastle. The Lechowek Beds below do not contain Rotaspora or Remysporites magnificus and so would seem older in age than those from Ballycastle. The Galezice assemblages differ in containing Diatamozonotriletes spp., Bellispores nitidus, and a variety of species from the genus Tripartites, (e.g.: T. annosus, T. horrens, T. abductus, T. parvos and T. trilinguis). Differences also include the absence of Pustulatisporites papillosus, Convolutispora varicosa and Cingulizonates cf. capistratus. The Galezice assemblages would therefore compare more closely with C.R.B. I.

In the Namurian A of Upper Silesia Rotaspora knoxi and R. fracta persist, but the presence of Crassispora kosankei and Cirratriradites saturni, in the higher parts suggest that the Ballycastle assemblages correlate with the lower zones N_1 - N_3 (Upper Malinovice-Flora Beds).

There are major differences between the assemblages of the present study and those from the Donetz Basin described by Teteryuk (1976). In the latter area the genera Florinites and Potoniespores, and Cirratriradites saturni all appear in the $C_1 3$ zone towards the top of the Visean stage, that is at comparatively low horizons.

Comparison with the American Continent

A number of papers covering the Carboniferous of the American Continent are available which describe assemblages mainly from the Upper Mississippian and Pennsylvanian. A general synopsis of this work is given by Sullivan & Mishell (1971) in their discussion of the palynological determination of the Mississippian/Pennsylvanian Boundary. In this work the Springer and Goddard Formations of Oklahoma (Wilson, 1966) are described as being possibly Upper Mississippian.

Kosanke (1964) has briefly described the characteristics of spore assemblages from eight coals in the Chester Series of Illinois. He noted the presence of Rotaspora, Tripartites, Schulzospora, Grandispora and Savitrisporites.

Also from probable Chesterian Series, Schemel (1950) describes assemblages derived from between the Belder and Madison Formation of Paggett County, Utah. The Belder Formation is correlated with the type Morrow of Arkansas (Thompson). The Madison Formation is considered late Kinderhookian and Osagean. His assemblage is dominated by Densosporites with other common genera which include Tripartites and Rotaspora. Comparison with his photographs indicates twelve similar spore types. The presence of Tripartites vetustus and Rotaspora fracta together with Reticulatisporites carnosus would suggest a relatively high Viséan age rather than Namurian, since it lacks other species normally associated with this stratigraphic horizon. Thus the Ballycastle assemblage, particularly from below the Main Coal would seem comparable to the pre-Belder/post-Madison microfloras.

In an attempt to distinguish the upper Mississippian sediments from those of the Pennsylvanian on the basis of spores, Hoffmeister, Staplin & Malloy(1955), describe assemblages derived from the Hardinsburg Formation of Kentucky and Illinois. (The Hardinsburg Formation lies approximately midway within the Chester Series of upper Mississippian age). The assemblages were dominated by Cirratriradites (in part Lycospora sp.), Punctatisporites, Densosporites, Granulatisporites and Schulzospora. Significant is the presence of Triparites vetustus, Rotaspora fracta, Triquitrites marginatus and Densosporites capistratus, and have similarities to assemblages immediately below the Main Coal.

Sullivan & Mishell (loc. cit.) regard the Hardinsburg Formation assemblages as slightly older than those of the Goddard Formation because of the absence in the former of Savitrisporites nux and Bellispores nitidus. They equate the base of the Goddard Formation with the Viséan/ Namurian Boundary in Europe.

Felix & Burbridge (1967) describe a number of samples from the Springer Formation. Palaeontological evidence has suggested the Formation to be part of the Morrowian Series by Moore, later the Springerian Series and then concluded in the Goddard Formation, Hicks (1957). Tomlinson & McBee together with Elias, excluded it from the Goddard Formation. Sullivan & Mishell (1971) suggest that it might be assigned to a Springerian Series above the Chester Series but still in the Mississippian. The assemblages from the Springer Formation, despite the fact that they have thirty species in common with the present assemblages, have many quite different features. They contain notably Florinites spp., Potoniesporites elegans, Crassispora kosankei and Knoxisporites dissidius which in Britain are more commonly associated with younger Namurian assemblages than those of the present study.

Also lacking from the Springer Formation are Crassispora maculosa, Rotaspora knoxi, R. ergonulii, Pustulatisporites papillosus, Cingulizonates cf. capistratus, Triquitrites marginatus, T. comptus and Convolutispora varicosa which are characteristic of the Upper Viséan/ Namurian E_1 assemblages. These assemblages compare a little with the C.R.B. II of Ballycastle.

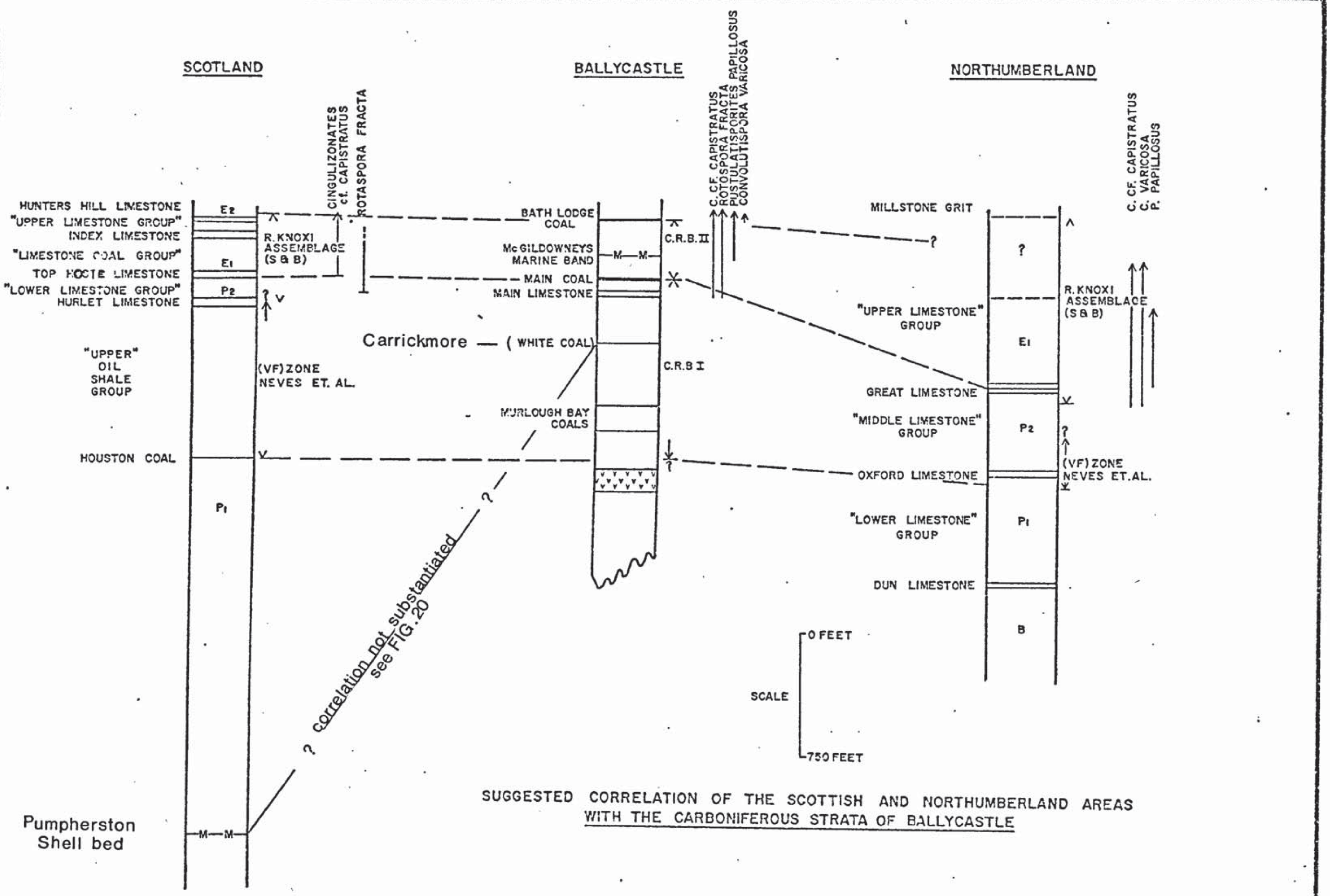
The Ballycastle assemblages can be compared more closely with the spore composition described from the Goddard and Hardinsburg Formations. Sullivan & Marshall (loc. cit.) consider the latter Formation to be older, as discussed on the previous page.

C.R.B. II can be compared with the Lower Goddard Formation since the upper part of this Formation differs in containing the occasional Florinites spp. and Potoniespores elegans. The microflora from the Hardinsburg Formation suggests an equivalence with the C.R.B. I.

Conclusions

Two Concurrent Range Biozones are described from Carboniferous strata in the Ballycastle area of Co. Antrim which has been previously dated by macrofaunal evidence as tentatively ranging from the Beyrichoceras zone of the Viséan to the Arnsbergian stage of the Namurian.

The lower C.R.B. I is defined as occurring from the base of the Murlough Bay Coals to the Main Coal horizon, previously described as B - P_2 in age. It is characterized by Tripartites vetustus, Crassispora maculosa, Rotaspora fracta, R. knoxi and Spencerisporites radiatus, and



SUGGESTED CORRELATION OF THE SCOTTISH AND NORTHUMBERLAND AREAS WITH THE CARBONIFEROUS STRATA OF BALLYCASTLE compares closely with assemblages described from the P_2 and upper P_1 of Scotland and Northern England. These include particularly assemblages from the Lower Limestone Group and uppermost Oil-Shale Group of Scotland (Neves et al., 1973, Sullivan & Marshall, 1966 and Smith & Butterworth, 1967), and the uppermost Lower and Middle Limestone Groups of Northumberland (Marshall & Williams, 1970, Smith & Butterworth, 1967, Neves et al., 1973 and Whitaker (thesis), 1971). The C.R.B. I also closely corresponds with the (VF) C.R. Biozone of Neves et al., (1973), which does not substantiate the correlation by Wilson & Robbie (loc. cit) of the Pumpherston Shell Bed with the Carrickmore Marine Band. The latter horizon is obviously younger, since it occurs within the C.R.B. I. (See Figs. 20 & 27.)

The C.R.B. II is defined as occurring from the Main Coal to the top of the succession, which is thought from previous work to include the Pendleian and Arnsbergian stages. The assemblages are characterized by abundant Cingulizonates cf. capistratus and Rotaspora fracta together with the first appearance of Pustulatisporites papillosus, Verrucosisporites morulatus and Convolutispora varicosa. Assemblages previously described from the Pendleian stage, compare well with the above Biozone and include the Limestone Coal Group, lowest Upper Limestone Group of Scotland (Smith & Butterworth, 1967) and the upper Middle and Upper Limestone Groups of Northumberland (Smith & Butterworth, 1967, Marshall & Williams, 1970). The (NC) Biozone of Neves et al. (1972) is not obviously comparable since Bellispores nitidus and Reticulatisporites carnosus are not present.

The appearance of Rotaspora fracta and Cingulizonates cf. capistratus in strata associated with the Main Limestone support its previous correlation with strata of P_2 age and the increase in frequency of the latter species together with the first appearance of Pustulatisporites papillosus in shales associated with the Main Coal support the correlation of that horizon with the base of the Namurian Series by Wilson & Robbie (loc. cit.). text fig. 27.

Arnsbergian assemblages described from both England (Neves, 1961, Owens in Owens & Burgess, 1965, Owens (personal communication), 1975). and Ireland (present study) show little in common with the youngest assemblages of Ballycastle; the former can be distinguished by the presence of Crassispora kosankei and species of Florinites. The lower E_2 zone assemblages from the Upper Limestone Group (S. & B., 1967, Scotland) are to some extent comparable and suggest the possibility of a lowermost Arnsbergian age being present in the upper C.R.B. II.

The assemblages recorded compare fairly closely with those described by Jachowicz (1970, 1974) from the Upper Viséan $V^{iii}g$ zone and Lower Namurian $N_1 - N_3$ zones in the Holy Cross Mountains and Upper Silesia respectively in Poland. From the American Continent, the assemblages are comparable with those recorded from the Mississippian Chester Series (Hardinsburg Formation and the lower part of the Goddard Formation) by Hoffmeister, Staplin & Malloy (1955 Kentucky & Illinois) and Felix & Burbridge (1967, Southern Oklahoma) respectively.

The assemblages as a whole compare most closely with those recorded from the Upper Sedimentary Group of Ayrshire by Sullivan & Marshall (1966) and from the "Yoredale Series" of the Roman Wall District of Northumberland by Marshall & Williams (1970). The Central Scotland Upper Sedimentary Group is underlain by basic lavas which could perhaps be contemporaneous with those towards the base of the Ballycastle Sequence. The split Quarrelton Coal (Francis in Craig, 1965, p. 312) could then correlate with the Murlough Bay Coal Group. Detailed palynological comparisons are not possible as the lowest horizon examined by Sullivan & Marshall (loc. cit.) was that of the Hollybush Limestone about 100 metres higher in the sequence.

In an environmental study of the miospore distributions, the general occurrence in marine, non-marine and coal lithologies proved similar to that recorded by Neves (1961). It was observed that the allochthonous marine assemblages could be distinguished by the presence of a fine grained probably organic substance, together with the poor preservation of the spores and plant material.

CHAPTER VII

SELECTED ASSEMBLAGES OF LOWER CARBONIFEROUS AGE

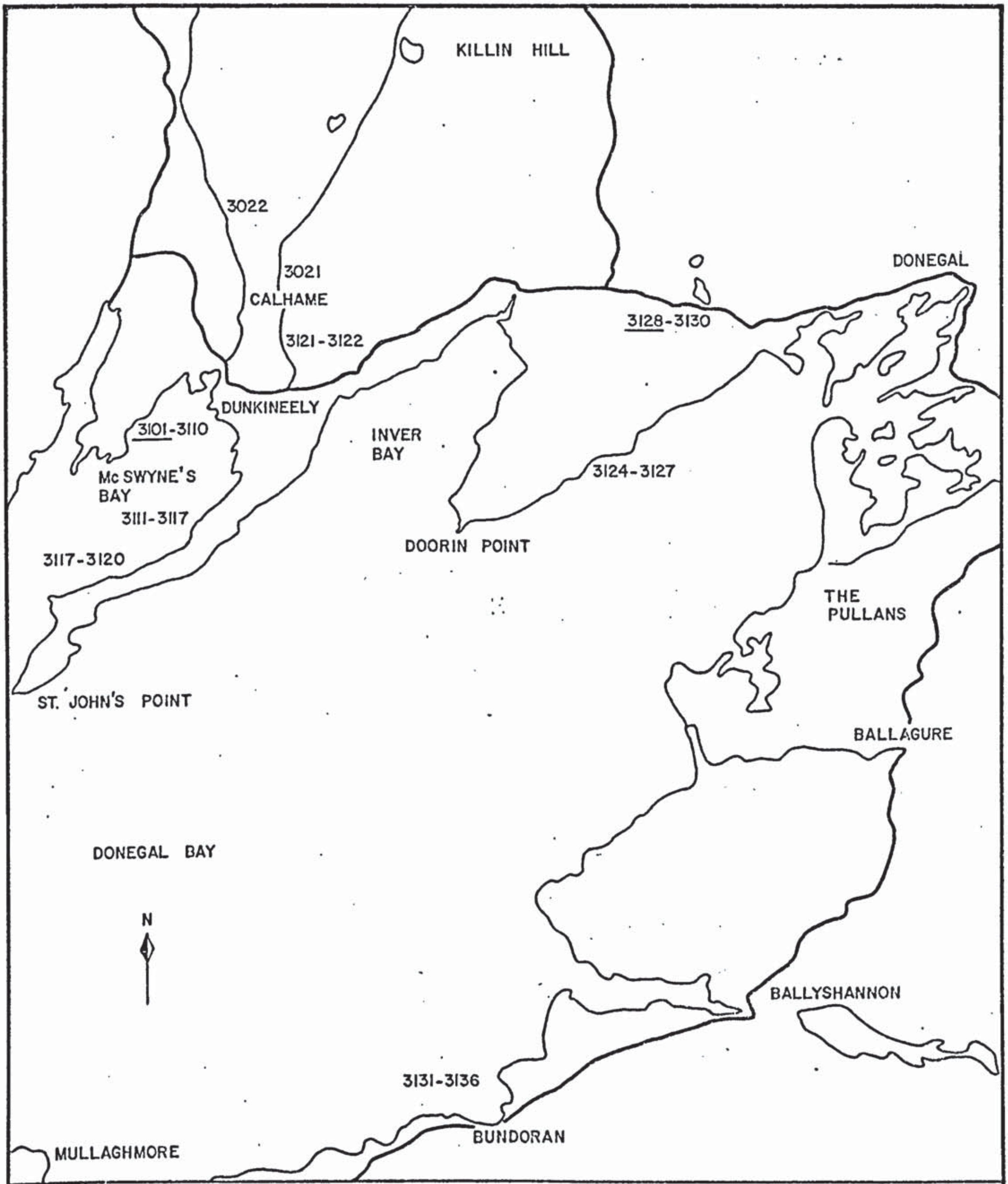
Introduction

A series of samples were collected from different areas within the Republic of Ireland taken from strata of Tournaisian and Lower Viséan age. They will be discussed in stratigraphical order.

The oldest assemblages 5040 and 5044 are from the Lower Limestone Shales of Goresbridge, County Kilkenny (text figs.9&10), the base of which is considered to be of K zone age. This area occurs to the east of the Leinster Massif which remained above the Carboniferous Sea until Upper Tournaisian times.

Younger assemblages were collected and prepared from the Donegal Syncline by C. Butcher in 1972. The succession here consists essentially of basal conglomerates and sandstones passing up into limestones of definite C_2S zone age. The Bruckless Grits at the base are thought to have been a lateral equivalent of the Ballyshannon Limestone Group, the grits being derived from the north and the limestone a clearer water facies to the south. The Limestone Group is then overlain by the Coolmore-Doorin Shales, which are followed by the Kildoney-Mount Charles Sandstone. The latter sandstone is suggested by Charlesworth as probably equivalent to the Clonelly Sandstone of the Omagh Syncline in Northern Ireland, which is of S_2 zone age.

A total of thirty-six samples were collected mainly from the Ballyshannon Limestone and equivalents, the Doorin-Coolmore shales, and the Kildoney-Mount Charles Sandstone (George & Oswald, 1957). They were essentially shales, 30% of which were calcareous. A standard preparation



SAMPLE LOCATION - DONEGAL

General location see fig.1

Productive samples underlined

0 5 miles

Drawing No. 16176 Date. 24·VIII·76 Figure No. 29

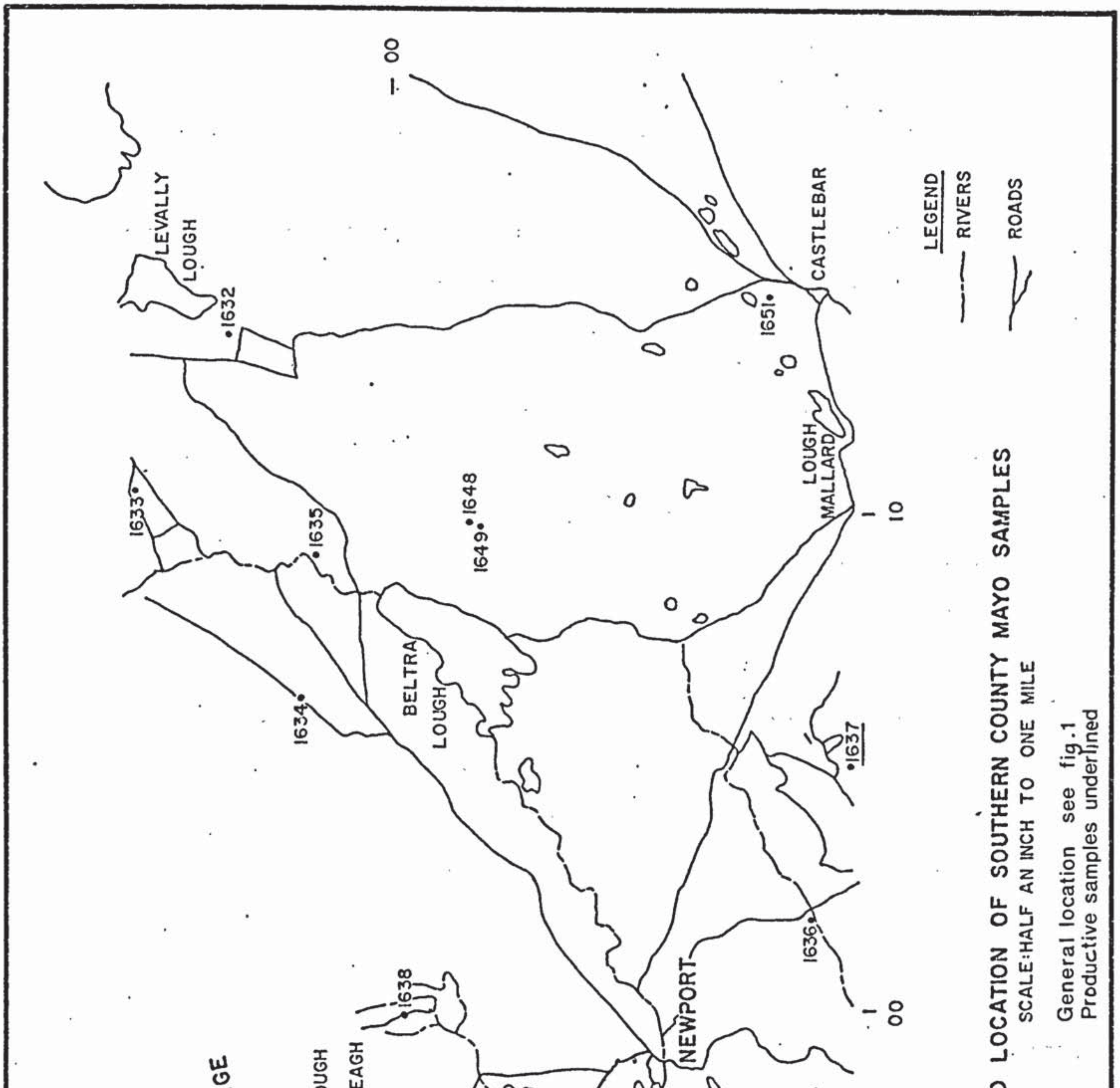


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Figure No.30

technique was used i.e.: HF, Conc. nitric. Schulze and Fuming nitric. The spore content was very poor and pyritization common. Only two assemblages were of sufficiently good preservation to be studied. These were 3128 taken from a shale intercalation within the Mount Charles Sandstone, and 3101 from within the Bruckless Grits (text fig. 29).

Butcher also collected fifteen samples from Northern County Mayo, west of Killala Bay (text fig. 2) in the Ballina Syncline. One productive sample, assemblage 1142 was obtained from here, taken from a series of alternating sandstones, flags and shales. These rocks lay between basal conglomerates to the west and dark grey limestones to the east. The limestones which contain Gigantoproductus latissimus (Charlesworth, 1953 p.264), are probably C_2S_1 zone at the base, and Viséan above with a fauna including Composita cf. gregaria. The oldest fossiliferous rocks at Aughris Head may be Viséan as they have lithostrotiontids and other fossils that age (Oswald, 1955). Thus it seems likely that assemblage 1142 belongs within the Viséan, and probably is of C_2S_1 zone age.

A further series of twelve samples was kindly supplied to the author by Dr. Ben Dhoran (Geological Survey of Ireland) from the Lower Carboniferous rocks of the Clew Bay area, Southern County Mayo (text fig. 30). Two of these samples 1637 and 1646 were productive. The former is taken from the lowest carbonates (probably equivalent to the basal limestone age of the Ballina Syncline) and the latter from the grey sandstones and siltstones immediately below. A C_2/S_1 zone age is suggested by Charlesworth for these rocks. Dhoran believes them to be V_2A or older, in the European classification, that is approximately of S_2 age in the coral-brachiopod zonation.

Description of Assemblages

The following series of samples will be dealt with in the stratigraphical order suggested by the macrofossil evidence available. Further comments on this order will be discussed later, in the conclusions.

The oldest assemblages come from Goresbridge (Text fig. 9 & 32), 5046 and 5044. They were taken from similar stratigraphical horizons and were separated by only 15' (4.5m) of strata. Since they are also very similar in their spore composition they will be treated here as one assemblage. Two species contained in assemblage 5044 are not found in the other, Umbonatisporites distinctus and Retusotriletes incohatus. The predominance of the genera Lycospora and Verrucosisporites is apparent in both and an interesting feature of these assembalages is the number of Lycospore types. Only one is similar to Viséan forms, the others differ in their style of ornament being faint or absent i.e.: Lycospora aff. pusilla; or, the amb is large and the flange irregular i.e.: Lycospora cf. pusilla.

Assemblage 1646 from southern County Mayo was taken from strata of uncertain age, but probably C_1 or C_2S_1 zone. The spores are of poor preservation but characteristic are abundant Punctatisporites together with murinate spores such as Dictyotriletes, Convolutispora and types with thick exines i.e.: Verrucosisporites amd Retusotriletes.

Assemblages 3101, 1637 and 1142 were taken from the younger C_2/S_1 horizons (text fig. 32) and were characterized by a variety of Lycospores and the genera Punctatisporites and Retusotriletes. Assemblage 1142 contains Lycospora rugulosa, L. pusilla, L. noctuina var. noctuina, L. pusilla and L. cf.pusilla; and 3101 L. cf. pusilla.

Restricted to the 3101 assemblage and those of 1646 and 1637 is the *Dictyotriletes sp. A.*, which is a spore with many features similar to *Microreticulatisporites*. Only found in the 3101 assemblage is *Dictyotriletes falsus*. Assemblage 1142 contains the Viséan species, *Vallatisporites ciliaris* which is relatively frequent, and *G. microgranifer*, together with species more commonly associated with the Tournaisian such as *Schopfites claviger* and *Auroraspora macra*. Also characteristic of this assemblage are *Rugospora minuta*, *Discernisporites crenulatus* and the frequent occurrence of *Baltisphaeridium sp.* A feature of 1637 was the common occurrence of murinate spores such as *Convolutispora* and *Dictyotriletes*.

The youngest assemblage in this series of Lower Carboniferous samples is that obtained from sample 3128 - S_2 - (text fig. 32). It is characterized by its relatively large number of 33 species, which includes three species of *Lycospora* (*L. noctuina var. noctuina*, *L. tenebricosa* and *L. rugulosa*), plus *Knoxisporites stephanephorus*, *Vallatisporites ciliaris*, *Granulatisporites microgranifer*, *G. granulatus* and *Leiotriletes inermis*. Interesting is the absence of *Lycospora pusilla* despite the other Viséan influences. It is noticeable in this assemblage that the three *Lycospore* species present, are more narrowly defined in appearance, and do not show the variation displayed in the older assemblages. Other species present include *Verrucoisporites nitidus* and *Auroraspora macra*.

For the purpose of this study it was decided to compile a range chart placing the samples in their probable chronological order, based on the available macrofossil evidence relating to their particular area (text. fig. 32).

In general from this chart it can be seen that there is little increase in the numbers of species from K to S_2 zone times. Only 16 of the 33 species found in the K zone continue into the S_2 assemblage 3128; fifteen species from the latter assemblage are not found in the K zone assemblages 5040/44.

The following species are found only in the K zone: Acanthotriletes acritarchus, Auroraspora macra, Baculatisporites fusticulatus,Raistrickia clavata, Convolutispora circumvallatus, Grandispora echinata,Kraeuselisporites sp., Retusotriletes avonensis, Spelaeotriletes cf. pretiosus and Umbonatisporites distinctus. Of these A. acritarchus, A. macra and G. echinata are known from Visean assemblages from other areas (Neves et al. 1973).

In the C_2/S_1 zone, a few species are restricted to that zone alone - Microreticulatisporites hortonensis, Anapiculatisporites ampullacea, Dictyotriletes falsus, D. Sp. A., D. castanaeformis, Pulvinispora scolecophora, Baltisphaeridium and Lycospora pusilla. Of these D. castanaeformis, D. falsus and L. pusilla are commonly found in younger Viséan assemblages (Neves et al. 1973). First appearances which range on into the younger S_2 assemblage 3128 include Anapiculatisporis hystricosus, Dictyotriletes submarginatus, Rugospora minuta, Vallatisporites ciliaris and Lycospora noctuina var. noctuina. The youngest assemblage sample 3128 is of probable S_2 age and contains the following species that appear for the first time, Lophozonotriletes bellus, Vallatisporites vallatus, Convolutispora cf. circumvallatus, Colatisporites decorus, Dictyotriletes pseudopalliatus, Granulatisporites granulatus, Gulisporites torpidos, Knoxisporites stephanephorus and Leiotriletes inermis.

It would appear that the K and S_2 zones have quite distinct and distinguishable assemblages but those from the C_2/S_1 zone appear intermediate in character and have more affinities with the S_2 assemblage with the presence of V. ciliaris, L. noctuina var. noctuina and L. pusilla.

Comparison with Assemblages described from Britain and Ireland

A comprehensive account is given by Neves et al. 1972, 73, of assemblages derived from Lower Carboniferous rocks of Scotland and Northern England from the O.R.S./Carboniferous boundary to the Viséan/Namurian. Several Concurrent Range Zones are defined. (See text fig. 12).

The K zone assemblage, derived from Sample 5040/44, can be compared with the (NV) C.R. Zone defined by Neves et al. for that age. In this zone ten species occur in common with those from assemblage 5040/44, Auroraspora macra, Baculatisporites fusticulatus, Discernisporites micromanifestus, Granulatisporites microgranifer, Knoxisporites literatus, Punctatisporites spp., Retusotriletes incohatus, Spelaeotriletes pretiosus, Umbonatisporites distinctus and Verrucosisporites distinctus. An older (PL) C.R. Zone has only seven species in common and is characterized by Spelaeotriletes (Hymenozonotriletes) lepidophytus, which does not occur in the present study.

Five species from assemblage 5040/44 are present which first appear in younger assemblages recorded by Neves et al. Acanthotriletes acritarchus, Anaplanisporites baccatus, Convolutispora circumvallatus and Schopfites claviger are reported as first appearing in their (CM) zone which is of Z zone age. A significant anomaly in the comparison, however, is the presence of Lycospora spp., which are not recorded until basal C_1 times by Neves et al.

The C_2S_1 assemblages 3101 and 1142 have twelve species in common with their (Pu) C.R. Zone, which extends into the lower half of the C_2S, Anaplanisporites baccatus, Discernisporites micromanifestus, Granulatisporites microgranifer, Lycosporea pusilla, L. noctuina var. noctuina, L. rugulosa, L. tenebricosa, Rugospora minuta, Schopfites claviger, Vallatisporites ciliaris, Retusotriletes incohatus and Punctatisporites spp. One species Pulvinispora scolecophora which occurs in assemblage 3101 is reported by Neves et al. to be restricted to their C.R. Zones of K zone age.

Also in the C_2S_1 is described another C.R. Zone (TC) which is characterized by Schulzospora and Perotrilites tessellatus, plus many other species more commonly found in younger Viséan. These species were not present.

Many characteristic species of their earlier zone are present in their C_2S_1 assemblage, such as Verrucosisporites nitidus, Retusotriletes incohatus, Lophozonotriletes bellus, Convolutispora cf. circumvallatus and Dictyotriletes submarginatus. Little overlap is observed between the ranges of Verrucosisporites nitidus and Lycospora spp., as suggested by their occurrence in assemblages from Cockburnspath and the Spilmersford Borehole; thus the presence of these latter two species particularly in assemblage 1637 would correspond more favourably with the basal part of the (Pu) C.R. Biozone.

The S_2 dated assemblage 3128 has twelve species in common with the (TC) C.R. Zone of Neves et al. 1973, Discernisporites micromanifestus, Granulatisporites microgranifer, Lycospora rugulosa, L. noctuina var. noctuina, L. tenebricosa, Rugospora minuta, Vallatisporites ciliaris, Colatisporites decorus, Granulatisporites granulatus, Knoxisporites stephanephorus, Retusotriletes incohatus and Punctatisporites spp. Also present in assemblage 3128 are Verrucosisporites nitidus and Knoxisporites literatus, which are restricted by Neves et al. to their C.R. Zones belonging to the K zone and younger. Similarly Schopfites claviger, which is also present, has the top of its range in the lower C_2S_1 zone in their work.

Notably absent from assemblage 3128 are Schulzospore and Perotrilites tessellatus, which are usually found in assemblages of this age.

Thus, overall, the comparison with Scotland and Northern England is good although the presence of Lycospora spp. in the K zone and Verrucosisporites nitidus and Knoxisporites literatus in the S_2 zone of N.W.Ireland samples are possibly anomalous. There are also many species (sixteen in all) that occur in the Irish samples which are not recorded by Neves et al.

Butterworth & Spinner 1967 report a series of assemblages from the North West of England, from rocks ranging from Z_2 to S_2 in age, based on macrofossil evidence. The lowest assemblage from the Bewcastle Beds of C_1 age contain five species in common with the K zone assemblages 5040/44, Retusotriletes incohatus, Apiculiretusispora multiseta, Knoxisporites literatus, Discernisporites micromanifestus and Perotrilites perinatus. Thus they are not entirely dissimilar. A closer comparison can be made between the assemblage from the Dodgestown Ford Beds and Cambeck Beds of C_2/S_1 age and those of 3101, 1142 and 1637. Here seven species occur in common, Anaplanisporites baccatus, Apiculiretusispora multiseta, Discernisporites micromanifestus, Retusotriletes incohatus, Vallatisporites ciliaris, Lycospora rugulosa and L. noctuina var. noctuina, plus Granulatisporites parvigranulatus which is similar to G.microgranifer. The assemblages described by B.& S. from younger Nether Hill and Lewis Burn Beds of S_2 age contain Cingulizonates, Tholisporites, Chaetosphaerites, Corbulispora and Densosporites which are not represented in the assemblages of this study. The S_2 3128 assemblage is more closely comparable with the Dodgestown Ford microflora of C_2/S_1 age in which there are eight species in common, Discernisporites micromanifestus, Lycospora rugulosa, L. noctuina var.noctuina, L.tenebricosa, Dictyotriletes pseudopalliatus, Vallatisporites ciliaris, plus Convolutispora cf. finis and Granulatisporites parvigranulatus (similar to G. microgranifer). Notably absent again is the genus Schulzospora.

Knoxisporites literatus is given as present in the C_1 Bewcastle Beds which is a more extended range than that given by Neves et al.(1971.)

Other authors who have described assemblages of S_2 age include Neves & Williams(1970)in the Bewcastle area again and Sullivan(1964)in the Forest of Dean. The latter assemblage is dominated by Lycospora uber, with more species of Viséan aspect than any of the above Irish assemblages i.e.: Schulzospora occellata, Anulatisporites anulatus, Waltzispora planiangulata and Densosporites spp. In common with the latter assemblage, 3128 contains Vallatisporites ciliaris and Knoxisporites stephanephorus, plus species of the genera Granulatisporites, Leiotriletes, Lycospora and Punctatisporites. Generally it would appear that the 3128 assemblage is relatively older since it also contains more types commonly associated with the Tournaisian. Assemblages reported from strata of K zone are described by Sullivan (1964), Dolby & Neves (1967, 70) and Neves & Utting (1970). A feature common to these assemblages is the absence of Lycospora spp., and its presence in the 5040/44 assemblages is thus anomalous. Utting & Neves describe an assemblage from the Lower Limestone Shale group of the Avon Gorge dominated by Retusotriletes and Punctatisporites (earliest K zone) which contain the following five species in common with the 3128 and 1646 assemblages, Grandispora echinata, Knoxisporites literatus, Retusotriletes incohatus, Verrucosisporites nitidus and Punctatisporites spp. Dolby (1970) describes three assemblages from the Lower Limestone Shales of Burrington Coombe, which have only Knoxisporites literatus in common. Llewellyn, Hoskin & Backhouse (1970), describe from a borehole in Leicestershire an assemblage taken from a lower-middle Tournaisian horizon below a C_1/C_2 fauna. The 1646 assemblage contains Verrucosisporites nitidus but lacks Schopfites claviger and Baculatisporites fusticulatus, suggesting a relatively older age and closer comparison with the 5040/44 assemblage.

Johnson and Marshall's(1971) assemblage from the Pinskey Gill Beds of Ravonstonedale has some aspects that are similar to the assemblages 5040/44 and 1646. There are four species in common, Verrucosisporites grumosus (in part), Retusotriletes incohatus, Grandispora echinata and Punctatisporites irrasus.

C. Butcher 1974 (thesis) describes from Cumberland a series of assemblages from the Basement Beds, both above and below the Cockermouth Lavas. These beds were not dated by means of macrofossil evidence. His lowest C.R. Zone (A_1) below the lavas is dominated by Schopfites claviger, Colatisporites decorus, Auroraspora macra and Retusotriletes incohatus. The latter zone does not compare closely with the assemblages of the present study, but appears most similar to those of 5040/44.

The C.R. Zone B higher in the Cumberland sequence is divided into B_1 and B_2, the younger of which contains the genus Lycospora. The older zone B_1 shows some similarities to assemblages 5040 and 1142. Species in common include significantly Verrucosisporites variotuberculatus, Anaplanisporites baccatus, Retusotriletes avonensis, Pulvinispora scolecophora, Grandispora echinata, Discernisporites micromanifestus, D. crenulatus, Schopfites claviger, Auroraspora macra and Verrucosisporites nitidus. The younger assemblage B_2 contains most similarities with those of 1142, 1637 and 3128 with 17 species in common, including Lycospora pulsilla, L. noctuina var. noctuina, L. rugulosa, Lophozonotriletes bellus, Knoxisporites stephanephorus and Vallatisporites ciliaris and also Discernisporites micromanifestus.

In his third C.R. Zone (C) appear new genera Densosporites, Schulzospora and species more commonly associated with younger Viséan assemblages, which distinguish this zone from the assemblages in the present study.

Two Assemblages from Clare Island described by G. Clayton

	Sample
Microreticulatisporites hortonensis	1
Cyclogranisporites palaeophytus	1
Anaplanisporites delicatus	1
Lycospora rugulosa	1 & 2
Lycospora pusilla	2
Verrucosisporites nitidus	1 & 2
Vallatisporites ciliaris	1
Rugospora polyptycha	1 & 2
Rugospora minuta	1 & 2
Corbulispora cancellata	1
Schopfites claviger	1 & 2
Vallatisporites verrucosus	1
Auroraspora macra	1 & 2
Knoxisporites literatus	1 & 2
Lophozonotriletes tuberosus	1
Punctatisporites irrasus	1 & 2
Dictyotriletes submarginatus	2
Calamospora pallida	2
Calamospora perrugosa	2
Retusotriletes incohatus	2
Pustulatisporites multicapitis	2
Discernisporites micromanifestus	2
Discernisporites crenulatus	2
Discernisporites sp. (SULLIVAN)	2
Discernisporites macromanifestus	2
Crassispora trychera	2
Grandispora echinata	2
Verrucosisporites congestus	2
Baculatisporites fusticulatus	2
Radiizonates sp.	2
Spelaeotriletes cf. pretiosus	2
Verrucosisporites papulosus	2
Latosporites sp. A. (OWENS)	2
Punctatisporites planus	2
Convolutispora circumvallata	2
Convolutispora cf. mellita	2

Interpretation: Sample 1 = CM Zone, Sample 2 = Pu Zone.

Fig. 31

Two assemblages taken from Clare Island, very near Clew Bay have been recently studied by G. Clayton 1976 (personal communication - see text fig. 31). They are separated by a "few tens of metres" and were taken from a red sandstone sequence. In general his two assemblages are very similar to those of this study, particularly the presence of forms described from Canada e.g.: Dictyotriletes submarginatus, Discernisporites crenulatus and Verrucosisporites papulosus. The lower sample (1) contains fifteen species, which include Lycospora rugulosa, Verrucosisporites nitidus, Vallatisporites ciliaris, Auroraspora macra and Schopfites claviger. Clayton includes this assemblage in the CM zone of Neves et al., and it cam be compared particularly with 1646, those of Goresbridge 5040/44 and to a lesser extent 1142.

Present in the younger assemblage (2) is Lycospora pusilla together with many new forms, totalling 29 species. Although having many species in common with the assemblages of this study, it compares better with assemblages 1637 and 3128 in which L. pusilla is present.

Clayton et al. (1974) describe a series of assemblages from the Devonian/Lower Carboniferous of the Cork Beds, Southern Ireland. They include these in the the Pu and NV zones but divide the latter into a lower Hymenozonotriletes lepidophytus-Verrucosisporites nitidus LN subzone and a younger Vallatisporites vallatus-Retusotriletes incohatus VI subzone. The Vi subzone is defined by the disappearance of H. lepidophytus and V. pusillites and so would serve to distinguish the PL and NV assemblages of the Cork Beds from those of this study.

Comparison with areas Outside of Britain

Bertlesen (1972) describes an assemblage from the Ørslev Borehole, Denmark, which bears some resemblance to those of the present study. The genus Lycospora is an important member, particularly L. rugulosa and L. pusilla, and these occur together with forms more commonly associated with the Tournaisian, Schopfites claviger, Verrucosisporites nitidus and Auroraspora macra. Assemblage 5040/44 has altogether eighteen species in common, which include Verrucosisporites nitidus, Convolutispora circumvallatus, Grandispora echinata, Umbonatisporites distinctus and Anaplanisporites baccatus. Assemblage 3128 and 1142 have both eleven species in common. Few similarities are displayed by 1646, 1637 and 3101. The latter assemblage contains Lycospores but are of a different form i.e.: L. cf. pusilla, L. aff. pusilla.

Playford (1963) and Varma (1969) describe assemblages from the Cheverie Formation and older Horton Group of Eastern Canada, which appear particularly comparable with those of the Clew Bay area. The lower part of the Horton Group (Horton Bluff Formation and Undifferentiated Horton Group), have five species in common with assemblage 1646 and show affinities also with 1142. The Cheverie Formation is more comparable, despite the absence of Viséan Lycospores, with 1637 and 3101 and includes the following species in common, Retusotriletes avonensis, Dictyotriletes submarginatus and Microreticulatisporites hortonensis. Assemblage 3128 contains Gulisporites torpidos, a type rarely mentioned elsewhere in literature.

Playford's (1962) Spitzbergen assemblages show little in common, since there are notable genera absent from this study i.e.: Densosporites, Murospora and Diatomozonotriletes. Of the above assemblages 1142 appears most similar with seven species in common with those from Birgerjohnsonfjellet.

A notable difference can be seen with those described from the Russian Tournaisian microflora of the Urals, and the Polish assemblages from the Swiety Krzyz Mountains. Here a contrast occurs not only in species but in genera. No types occurred similar to their Cavatitriletes or Perisaccus forms. Only Retusotriletes and Punctatisporites appear similar.

Conclusions

A. The assemblages from North Western Ireland (3101, 1142, 1637, 3128 and 1646) appear older in aspect when compared to other assemblages previously described from similar stratigraphical horizons. Assemblages of C_2S_1 zone age described by Neves et al. 1973 from Britain, possess in general more species characteristic of the Viséan. A summary of these assemblages is as follows:-

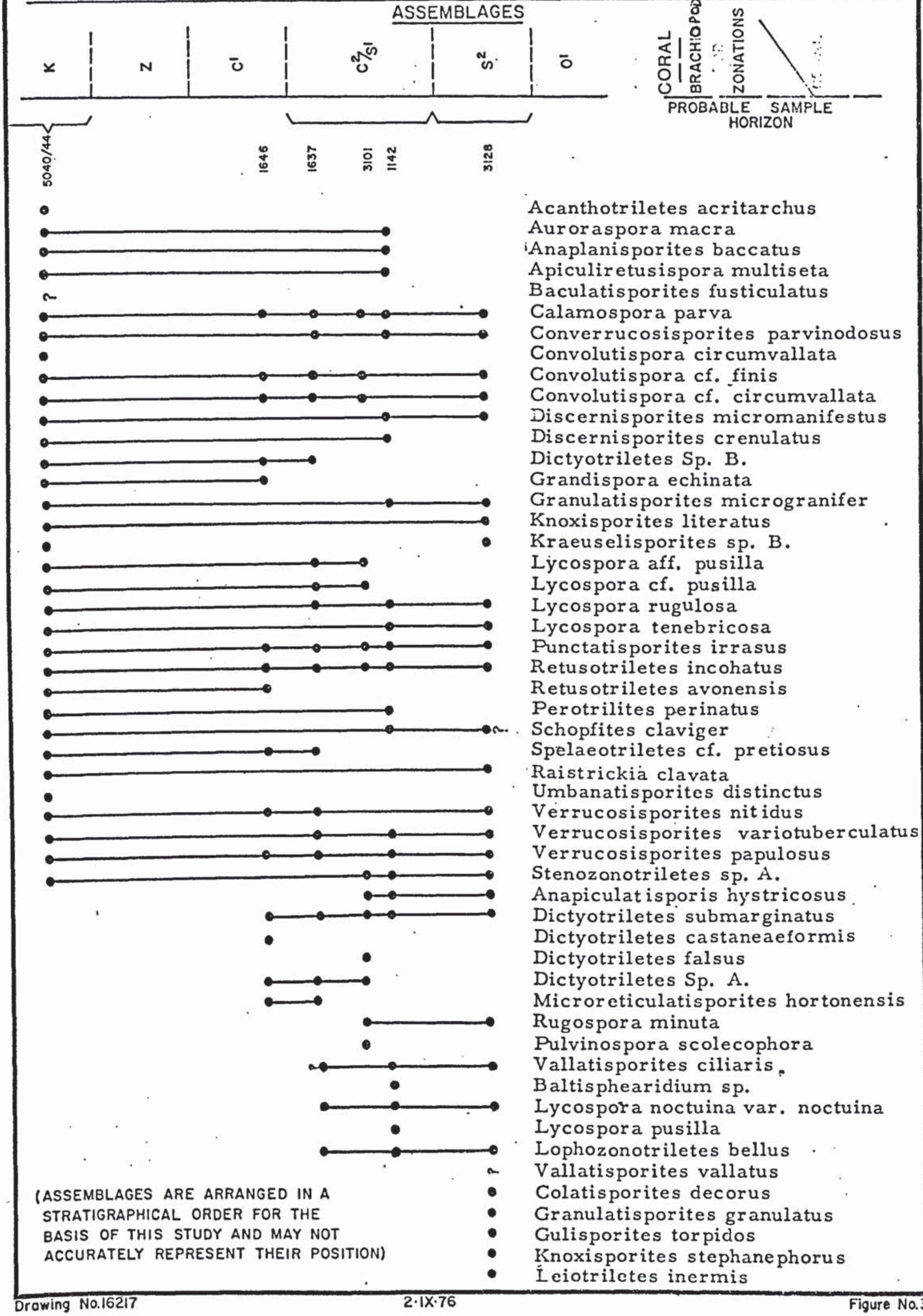
(i) Assemblage 1637 from Mayo corresponds more closely with their (Pu) C.R. Biozone (C_1 zone age), where a Tournaisian influence is still present together with the Viséan types.

(ii) The Donegal 3101 assemblage compares more closely with the (Pu) or uppermost (CM) C.R. Biozones, which would suggest a late Z or C_1 zone age.

(iii) Assemblage 1142 also from Mayo bears the closest similarity to other C_2S_1 assemblages.

(iv) Assemblage 1646 which is thought to be of C_2S_1 age or slightly older can be compared with the (NV) C.R. Biozone equivalent of K zone age, and also Neves and Uttings'Avon Gorge assemblage dated as K zone age.

STRATIGRAPHICAL DISTRIBUTION OF MIOSPORES FROM SELECTED LOWER CARBONIFEROUS ASSEMBLAGES



Drawing No.16217 2·IX·76 Figure No.32

The Palaeogeography of the Lower Carboniferous (taken from a diagram in A.G. Smith, J.C. Briden and G.E. Drewry (1973).

Aston University

Illustration removed for copyright restrictions

Lower Carboniferous about 240 ± 30 m.y.b.p.;

S-pole stereographic projection.

Fig. 28

(v) Assemblage 3128 of S_2 zone age compares well with others of this age, although again the assemblage is not so advanced, with certain commonly occurring Viséan types absent i.e.: Lycospora pusilla, Schulzospora and Densosporites.

Assemblage 5040/44 of K zone age from Goresbridge, Southern Ireland can be more closely compared with the lower (Pu) C.R. Biozone (C_1 zone). This variance with the macrofossil dating is suggested by the presence of the genus Lycospora.

B. Generally the assemblages of the present study do not compare exactly with those of Britain or other areas of the World, which suggests they may possess their own identity. Many of the species although meeting the required descriptions still often show dissimilarities. The Lycospore types in this study are a good example of this, particularly variants of L. pusilla. Other examples are included in Verrucosisporites, Convolutispora and Dictyotriletes, which show types intermediate between British and Canadian species. This affinity with Canada is demonstrated with the occurrence of other species more commonly associated with that area e.g.: Anapiculatisporis hystricosus, Retusotriletes avonensis, Gulisporites torpidos, Converrucosisporites parvinodosus and Dictyotriletes submarginatus. Lower Carboniferous assemblages from Spitzbergen and the U.S.S.R. show few similarities. Bertlesen's assemblage from Denmark seems more closely comparable with those from Britain.

This tentative conclusion is in accordance with palaeographic reconstructions based on palaeomagnetic data (Smith, Briden & Drury 1973) which show Ireland in close proximity to Canada in Lower Carboniferous times (text fig. 28).

CHAPTER VIII

Anteturma SPORONITES (R. Potonié) Ibrahim 1933

Genus CHAETOSPHAERITES Felix 1894

Type species C. bilychnis Felix 1894

Diagnosis Taken from Felix 1894, 0.272

Chaetosphaerites pollenisimilis (Horst)

Butterworth & Williams 1958

Plate 1, fig. 1

1907 Karczewski, pl.1, figs. 5,6.

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

1955 Sporonites pollenisimilis Horst, p.150, pl.24, figs. 84-87.

1957a Sporonites cylindricus (Horst); Dybová & Jachowicz, pp.56-57, pl.1, figs.1-4.

1958 Chaetosphaerites pollenisimilis (Horst); Butterworth & Williams, p.359, pl.1, figs. 1-3.

Holotype Horst 1955, pl.24, fig.84. Preparation IV 23, 27.0/77.9.

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

Diagnosis Butterworth & Williams 1958, p.359.

Description Amb oval, elongate or circular, often differentiated into a 3 or 2 lobed structure, of which the relative size of the third is often difficult to observe. The central area is dark brown which acts as a base for the globular more translucent lobes.

Size ranges 2472: 20-23μ (4 spec.).

Other authors Horst 1955 22-39μ Fu.HNO_3; Playford 1962 21(36)52μ Schulze; Smith & Butterworth 1967 18(25)30μ x 12(16)20μ Fu.HNO_3; 18(27)33μ x 14(18)24μ Fu.HNO_3.

Occurrence Ballycastle only.

Remarks Specimens conform fairly well to diagnosis, but were found to occur at the lower end of the size range given by Horst. Occurrence infrequent.

Previous records Horst 1955, Moravska-Ostrava, Namurian; Butterworth & Williams 1958, Limestone Coal Group and Upper Limestone Group, Namurian A, Scotland; Hughes & Playford 1961, Spitzbergen, Lower Carboniferous.

Anteturma SPORITES R. Potonié 1893

Turma TRILETES (Reinsch) Dettman 1963

Supra-Subturma ACAMERATITRILETES Neves & Owens 1966

Subturma AZONOTRILETES (Luber) Dettmann 1963

Infraturma LEAVIGATI (Bennie & Kidston) R.Potonié 1956

Genus LEIOTRILETES (Naumova) Potonié & Kremp 1954

Type species L. sphaerotriangulus (Loose) P & K 1954.

Diagnosis P & K 1954, p. 120.

Remarks Some specimens may be confused at times with the genus Waltzispora Staplin 1960, which is distinguished by the angular nature of its apices. Gradation of forms between the two genera was observed in Ballycastle, but not in the Leitrim material.

Leiotriletes inermis (Waltz) Ischenko 1952

Plate 1, fig.2

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

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

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

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

Holotype Not designated by Waltz.

Diagnosis Waltz 1938.

Type locality Southern Podmokovhy Basin, Karaganda, U.S.S.R.

Description Amb rounded, triangular; narrow apices; sides mainly convex or straight and only rarely concave. Suturae simple, usually ¾ of the radius. Exine relatively thick, 1-2μ often brown colour, leavigate, darkening in contact area frequent.

Size ranges 4236 35-42μ (5 spec.); 4204 36-40μ (4 spec.); 4205 40μ (2 spec.); 4201 39μ (1 spec.); 2472 35-39μ (4 spec.); 2479 37-40μ (5 spec.).

Other authors Playford 1962 28(43)57μ; Waltz 1938 40-50μ Schulze; Ischenko 1958 40-65μ ; Smith & Butterworth 1967 30(38)55μ Fu.HNO_3.

Occurrence Ballycastle, Leitrim and Donegal.

Remarks Distinguished from Leiotriletes priddyi (Berry) Potonié & Kremp 1955 by its larger size. Leiotriletes sphaerotriangulus (Loose)Potonié & Kremp 1954, has a more broadly rounded amb and concave sides. Specimens from both Leitrim and Ballycastle were similar, Occurrence infrequent.

Previous records Luber & Waltz 1941; Southern Podmokovny Basin U.S.S.R. Tournaisian-Viséan; Potonié & Kremp 1955, Karaganda Basin U.S.S.R. Tournaisian-Viséan. Hughes & Playford 1961, Spitzbergen, Lower Carboniferous. Playford 1962, Spitzbergen, Lower Carboniferous. Smith & Butterworth, Coals of Great Britain, Viséan.

Leiotriletes parvus Guennel 1958

Plate 1 fig. 4

Holotype Guennel 1958 p.57, fig.14.

Type locality Outcrop coal, Upper Block B Zone, Owen County, Indiana,U.S.A.

Diagnosis Guennel 1958 p.57.

Description Amb rounded triangular, narrow apices; sides generally concave. Exine pale in colour and folds frequent. Suturae simple, three-quarters spore radius.

Size ranges 4236 25-24μ (3spec.); 4249 23-25μ (3 spec.); 4204 22-24μ (5 spec.)

Other authors Guennel 1958 16(20)28μ Schulze.

Occurrence Leitrim.

Remarks Distinguished from Leiotriletes priddyi (Berry) Potonié & Kremp 1955 by its smaller size. Occurrence very infrequent.

Previous records Guennel 1958, Alleghanian Coals, Indiana. Smith & Butterworth 1967, Coals of Great Britain, Westphalien B-D.

Leiotriletes priddyi (Berry) Potonié & Kremp 1955

Plate 1, fig. 3

1937 Zonales-sporites priddyi Berry, p.156, fig.2.

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

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

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

Holotype Berry 1937, p.159; fig.2.

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

Diagnosis Berry 1937, p.156.

Description Amb rounded triangular, sides slightly concave, convex or straight. Suturae relatively short, $\frac{1}{2} - \frac{3}{4}$ of spore radius. Exine leavigate and pale in colour.

Size ranges 4236 27-31µ (5 spec.); Leitrim E_2 27-33µ (15 spec.); 4249 28-33µ (7 spec.).

Other authors Not more than 35µ (Berry, 1937).

Occurrence Leitrim

Remarks Amb shape was in most cases convex or straight. Suturae more varied than diagnosis which is restricted to $\frac{2}{3}$.

Previous records Berry 1937; Pennington Coal, U.S.A. Upper Mississippian. Knox 1950, Coals of Carboniferous Age.

Potonié & Kremp 1955, Pennington Coal, U.S.A., Tennessee, Lower Carboniferous.

Leiotriletes sphaerotriangulus (Loose) Potonié & Kremp 1954

Plate 1, figs. 5 & 6

1932 Sporonites sphaerotriangulus Loose in Potonié, Ibrahim, and Loose, p.451, pl.18, fig.45

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

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

1950 Plani-sporites sphaerotriangulatus (Loose); Knox, p.316, pl.17, fig.214.

1954 Leiotriletes sphaerotriangulus (Loose); Potonié & Kremp, P.120.

Holotype Potonié & Kremp 1955, pl.11, fig. 107 after Loose.

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

Diagnosis Potonié & Kremp 1955, p.41

Description Amb gently concave triangular, one or two of interradial areas occasionally straight. Broadly rounded apices. Suturae consistently ¾ of spore radius. Exine leavigate, occasionally folded, 1-2.5µ thick. Colour generally brown, sometimes yellow.

Size ranges 2471 42-47µ (5 spec.); 2472 40-42µ (4 spec.); 2474 39-42µ (3 spec.); 2478 38-42µ (5 spec.); 2480 40-43µ (4 spec.).

Other authors Potonié & Kremp 1955 (40-60µ) Schulze; Smith & Butterworth 1967 38(46)55µ.[illegible].HNO_3; Horst 1955 30-66µ HNO_3; Artüz 1959 40-48µ.

Occurrence Ballycastle only.

Remarks Conforms for most part to diagnosis. Suturae do not vary as much as the ½-¾ described by Smith & Butterworth 1967, and neither does the size, which is relatively narrow in its range. Occurrence infrequent, and restricted to the Ballycastle material.

Previous records Artüz 1959 Zonguldak Basins, Namurian and Westphalian A; Love 1960 Lower Oil Shale Group of Scotland; Lele & Provari 1962, Mississippian Spore Assemblage, Ayrshire, Scotland; Smith & Butterworth 1967, Coals of Great Britain, Westphalian A to C; Potonié, Ibrahim & Loose 1932, Upper Carboniferous, Ruhr Coalfield, Germany; Loose 1934, Upper

Carboniferous, Ruhr Coalfield, Germany; Wicher 1934, U. Carboniferous, Ruhr Coalfield, Germany; Potonié & Kremp 1955, Middle Westphalian B to Lower Westphalian C, Ruhr Coalfield, Germany; Grebe 1972, Upper Westphalian A to Upper Westphalian C, Ruhr Coalfield, Germany.

Leiotriletes tumidus Butterworth & Williams 1958

Plate 1, figs. 7 & 8

Holotype Butterworth & Williams 1958, pl.1, fig. 11.

Type locality Kilsyth Coking Seam at 1,097 ft. (334.4m), Cawder Cuilt Borehole, Central Coalfield, Scotland, Namurian A.

Diagnosis Butterworth & Williams 1958, p.359.

Description Amb rounded triangular, apices narrow, sides convex or straight. Suturae simple, accompanied by narrow folds 2-7μ wide, extending over ¼ of spore radius. Exine leavigate or slightly punctate, and relatively thick. Colour usually yellow.

Size ranges Leitrim E_2 general 42-50μ (8 spec.); 2471 37-45μ (5 spec.); 2472 41-72μ (7 spec.).

Other authors Butterworth & Williams 1958 34(42)52 Fu.HNO_3; Felix & Burbridge 1967 30-45μ.

Occurrence Ballycastle and Leitrim.

Remarks Specimens from Ballycastle tended to be more punctate and had a greater size range, 41-70μ compared with (42-50μ. This range is also greater than those described by Butterworth & Williams, and Felix & Burbridge.

Previous records Butterworth & Williams 1958, Namurian A. of Scotland, Limestone Coal Group and Upper Limestone Group; Smith & Butterworth 1967, Coals of Great Britain, Viséan and Namurian; Felix & Burbridge 1967, Springer Formation, U.S.A., Mississippian/Pennsylvanian; Neves, Gueinn, Clayton, Ioannides, Neville & Kruszewska 1973, East Fife, East, Midland

West Lothian, Cockburnspath and Berwickshire, Upper Viséan;
Love 1960, Lower Oil Shale Group (Viséan) of Scotland.

Genus PUNCTATISPORITES (Ibrahim) Potonié & Kremp 1954

Type species P. punctatus Ibrahim 1933.

Diagnosis P & K 1954, p. 120.

Remarks Spores with more or less circular amb and leavigate or infrastructured exines. Suturae more or less half of spore radius. Distinguished from Calamospora by length of suturae and infrastructural exine.

Punctatisporites irrasus Hacquebard 1957

Plate 1, fig. 14

Holotype Hacquebard 1957, pl.1, figs. 7, 8.

Type locality Horton Group, Nova Scotia, West Gore and Blue Beach Samples.

Diagnosis Hacquebard 1957, p.308.

Description Amb circular. Suturae $\frac{2}{3}$ spore radius. Exine leavigate to infrapunctate. Frequently arcuate folds present. Exine colour dark.

Size ranges 5040 60(70)85μ (15 spec.).

Previous authors Hacquebard 1957 67-83μ (20 spec.).

Occurrence Goresbridge, Donegal, Mayo and Clew Bay, N. Mayo.

Remarks Specimens characterized by arcuate folds and dark brown colour of exine.

Previous records Hacquebard 1957, Horton Group, Nova Scotia; Mississippian; Sullivan 1964a, Forest of Dean, Tournaisian.

Punctatisporites punctatus Ibrahim 1932

Plate 1 figs. 9 & 10

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

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

Holotype Ibrahim 1932, pl.15, fig. 18.

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

Diagnosis Ibrahim 1933, p.21.

Description Margin of spore smooth to minutely indented. Amb circular. Suturae simple, straight and extend 20-30µ. Exine 1.5(2µ)3µ, occasionally infrapunctate but mostly laevigate. Colour essentially golden brown. Folding rare.

Size ranges 2471 52(66)84µ (16 spec.); 2472 50(70)78µ (41 spec.); 2474 66(72)76µ (8 spec.); 2478 62(70)78µ (14 spec.); 2480 52(62)74µ (10 spec.); 2481 52(64)74µ (10 spec.); 2482 48(60)74µ (11 spec.).

Other authors P & K 1955 50-80µ Schulze; 1957 S & B 59(74)89µ (14 spec.) Fu.HNO_3; 1932 Ibrahim 77µ Schulze & KOH.

Occurrence Ballycastle and Leitrim.

Remarks Specimens differ from diagnosis in the way that they are more commonly laevigate than punctate. The two types, however, when plotted in a histogram showed a similar size range suggesting that they belong to the same group. The size range compares well with those found by other authors.

Punctatisporites aerarius B & W differs in having a minutely granulate exine which none of the specimens in the present study showed. P. irrasus Hacquebard has a narrower size range and the exine is folded more frequently. P. glaber (Naumova) Playford has a more folded exine.

Previous records Recorded by many authors from the Lower and Upper Carboniferous.

Punctatisporites nitidus Hoffmeister, Staplin & Malloy 1955

Plate 1 , figs. 12 & 13

Holotype H. S. & M 1955, pl.36, fig4.

Type locality Shale at 2,072 ft.(631.5m) Carter No. 3 Borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation, Chester Series.

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

Description Amb circular. Suturae about $\frac{2}{3}$ spore radius and extend 14-20µ. Exine laevigate 1.5µ, occasionally punctate. Folds rare.

Size ranges 2472 34(38)42µ (6 spec.); 2478 38-42µ (3 spec.).

Other authors 1955 H.S. & M. 31-43µ (HF); 1957 Hacquebard & Barss 30-38µ Schulze; 1957 S. & B. 30(43)57µ Fu.HNO_3.

Occurrence Ballycastle and Leitrim.

Remarks Differs from diagnosis in that folding is not as frequent as suggested. It would appear more similar to those described by Smith & Butterworth 1967.

Previous records H. S. & M. 1955, Lower Carboniferous, Kentucky, U.S.A.; Hacquebard & Barss 1957, Lower Carboniferous, North West Territories, Canada; Owens & Burgess 1965, Upper Carboniferous of Stainmore; S. & B. 1967, Namurian of Great Britain.

Punctatisporites obesus (Loose) Potonié & Kremp 1955

Plate 1, fig. 11

1932 Sporonites obesus Loose in Potonié, Ibrahim & 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) Potonié & Kremp, p.43, pl.11, fig.24.

Holotype Loose 1932, pl.19, fig.49.

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

Diagnosis Loose 1934, p.145.

Description Amb circular. Suturae simple, straight, two thirds of radius. A darkening occurs parallel to suturae as described by S. & B. 1957 which is the exine thickness rather than labra. Exine 2-5μ thickness, laevigate to punctate.

Size ranges 2474 110-160μ (3 spec.); Ballycastle 92-160μ.

Other authors 1955 P. & K. 100-130μ Schulze; 1957 S. & B.; 94(106)125μ (8 spec.) Fum.HNO_3.

Occurrence Ballycastle and Leitrim.

Remarks Specimens were infrequent but occurred sporadically throughout the succession.

Previous records Potonié, Ibrahim & Loose 1932, Upper Carboniferous, Ruhr Coalfield, Germany; Loose 1934, Upper Carboniferous, Ruhr, Germany; Potonié & Kremp 1955, Upper Carboniferous, Ruhr, Germany; Horst 1955, Upper Silesian Coal Measures; Grebe 1972, Upper Westphalian A-Upper Westphalian C; Ruhr.

Genus GULISPORITES Imgrund 1960

Type species G. cochlearius (Imgrund) Imgrund 1960.

Diagnosis Imgrund 1960, pp. 155-156.

Gulisporites torpidos Playford 1963

Plate 1, fig. 15

Holotype Playford 1963, pl.1, fig.13.

Type locality Horton Group, Nova Scotia, Lower Mississippian.

Diagnosis Playford 1963, p.8.

Description Amb subtriangular with rounded apices; sides straight. Suturae strongly tectate, extending to the margin; stand 7µ high, width 10µ, broadset at equator. Exine laevigate.

Size ranges 3128 42µ (1 spec.).

Other authors Playford 1963 56-85µ (15 spec.); Varma 1969 60-76u (5 spec.).

Occurrence Donegal.

Previous records Playford 1963, Horton Group, Nova Scotia, Canada.

Genus CALAMOSPORA Potonié and Kremp 1955

Type species C. hartungiana (Schopf) in Schopf, Wilson & Bentall 1944.

Diagnosis P & K 1955, P. 46.

Remarks Some morphological gradation probably occurs between Punctatisporites and Calamospora but the latter is generally recognised by the short leasurae and thinner exine.

Calamospora breviradiata Kosanke 1950

Holotype Kosanke 1950, pl.9, fig.4.

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

Diagnosis Kosanke 1950, p.41.

Calamospora cf. breviradiata

Plate 1, figs. 16 & 18

1967 Calamospora cf. breviradiata Kosanke 1950 in S & B 1967, p.132

Description Amb circular, occasionally oval, often distorted by folding. Suturae ridged 1-3µ, occasionally tectate, sinuous $\frac{1}{4}$-$\frac{1}{4}$ of spore radius. Darkened area around trilete less than length of suturae, usually $\frac{2}{3}$ and fades gradually. Exine relatively thick, 1µ or more, giving a yellow colour rather than pale. Folding limited to one or a few broad folds.

Size ranges 4236 40(65)70μ (10 spec.); 4249 43-70μ (5 spec.).

Other authors Smith & Butterworth 42(49)57μ FU,HNO_3.

Occurrence Leitrim & Ballycastle.

Remarks These spores are distinguished by their ridged suturae, which are not described by Kosanke 1950, but are mentioned by Smith & Butterworth 1967 as having prominent laesurae. They differ from Calamospora breviradiata Kosanke 1950, by having a size range which extends lower than that given by Kosanke. Species restricted to Leitrim E_2 material. Occurrence infrequent.

Previous records Kosanke 1950, Pennsylvanian of Illinois, U.S.A.; Smith & Butterworth 1967, Upper Westphalian A to Westphalian D, Coals of Great Britain; Grebe 1972, Westphalian A - C, Ruhr, Germany.

Calamospora liquida Kosanke 1950

Plate 1, fig. 19

Holotype Kosanke 1950, pl.9, fig.1.

Type locality Shoal Creek Coal Bed, Bond County, Illinois, Pennsylvanian.

Diagnosis Kosanke 1950, p.41.

Description Amb circular. Suturae straight, simple, distinct and relatively long, ranging from just under $\frac{1}{4}$ to a little above $\frac{3}{4}$ spore radius. Folding mostly concentric compression type 2-10μ broad, straight, rarely twisted. Exine laevigate 0.5-1μ thickness.

Size ranges 4204 85-110μ (8 spec.); 4236 71-85μ (7 spec.); 4249 58(75)90μ (10 spec.); 2472 45(72)100μ (20 spec.); 2476 72-89μ (5 spec.); 2482 65-86μ (5 spec.); 2480 70-75μ (5 spec.).

Other authors Kosanke 1950 76-94μ.

Occurrence Ballycastle and Leitrim.

Remarks Specimens frequent and consistent in appearance in all areas. Size range varies little from sample to sample and in the different localities. Differs from diagnosis in that the lips are rarely developed as described by Kosanke. Calamospora pedata Kosanke 1950 has a similar size range and long suturae, but is characterized by its single fold.

Previous records Kosanke 1950, Lower Westphalian B to Stephanian of Illinois, U.S.A.; B & W, 1958, Namurian of Scotland; Neves 1959, Upper Namurian B to Westphalian A of the Southern Pennines; Staplin 1960, Golata Formation (Upper Mississippian) of Alberta; Owens 1963 thesis, Namurian A to Westphalian A, Stainmore; Sabry & Neves 1971, Upper Viséan and Lower Namurian of the Sanquhar Coalfield; Williams 1971 thesis, Brampton District and Archerbeck Borehole, Dumfriesshire, Carboniferous.

Calamospora microrugosa (Ibrahim) Schopf, Wilson & Bentall 1944

Plate 1, fig. 20

1932 Sporonites Microrugosus Ibrahim in Potonié, Ibrahim & Loose, p.447, pl.14, fig.9;

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

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

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

Holotype Ibrahim 1932, pl.14, fig.9.

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

Diagnosis Potonié & Kremp 1955, p.49.

Description Amb circular, or often distorted by folding. Suturae ridged 1-3μ, or sometimes tectate, ¼-2/5 of spore radius. Folding frequent, broad 10-20µ and tapering, and often concentric. Exine pale or yellow, 1µ thickness.

Size ranges 2470 80-82µ (3 spec.); 2474 90-100µ (5 spec.); 2480 82-84µ (3 spec.).

Other authors Horst 1955 50-95µ; Luber & Waltz 1938 55-80µ; Potonié & Kremp 1955 70-100µ Schulze; Ischenko 1958 60-65µ; Playford 1962 62-104µ; Butterworth & Spinner 1967 62(80)96µ FuHNO_3; Smith & Butterworth 1967 62(82)104µ Schulze NH_4OH; Ibrahim 1933 58-96µ.

Occurrence Ballycastle.

Remarks Suturae shorter than in Playford 1962 ($\frac{1}{2}$-$\frac{2}{3}$), but more ridged than Smith & Butterworth. Size range is a little on the large side, as are those of Potonié & Kremp, Playford, Smith & Butterworth. Distinguished from Calamospora cf. laevigata by its smaller size. C. hartungiana Schopf 1944 has a similar size and appearance, but contact area is darkened. C. liquida Kosanke 1950 has longer suturae.

Previous records Horst 1955, Namurian A, Westphalian A; Love 1960; Playford 1962, Spitzbergen, Lower Carboniferous; Butterworth & Spinner 1967, Lower Carboniferous from North West England, Bewcastle Beds to the Lewis Burn Coal Group; Smith & Butterworth 1967, British Coals, Viséan to Upper Westphalian; Mishell 1966, Bowland Fells and Ingleton Coalfield, Namurian A to Westphalian A; Grebe 1972, Upper Westphalian A - Westphalian C, Ruhr, Germany.

Calamospora parva Guennel 1958

Plate 1, fig. 17

Holotype Guennel 1958, fig.16, p.71;

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

Diagnosis Guennel 1958, p.70.

Description Amb circular or distorted by folding. Suturae simple and straight, relatively short. about ¼ of spore radius. Folding narrow 2-3μ wide, sometimes twisted. Exine laevigate, coloured pale or yellow.

Size range General from Ballycastle material 32-55μ.

Other authors 1958 Guennel 32-45μ; 1966 Mishell 32-55μ; 1967 Smith & Butterworth 37(45)55μ Fu.HNO_3; Smith & Butterworth (1967) 40(45)52μ Fu.HNO_3.

Occurrence Ballycastle, Goresbridge and Mayo.

Remarks Specimens agree with diagnosis as far as size range, style of folding and short suturae are concerned, but do not show much evidence of darkening at the angles of the suturae. Calamospora minuta Bharadwaj 1957 has a similar size range but longer suturae. C. pallida (Loose) Schopf, Wilson & Bentall is larger. Occurrence infrequent.

Previous records Smith & Butterworth 1967, British Coals, Viséan to Westphalian B; Guennel 1858, Pottsville Coals of Indiana, U.S.A.; Owens 1963, Stainmore, Namurian A to Lower Westphalian B; Mishell 1966 (thesis) Bowland Fells and Ingleton Coalfield, Namurian A to Westphalian A; Felix & Burbridge 1967, Springer Formation, Oklahoma, U.S.A.

Genus RETUSOTRILETES Naumova 1953

Type species R. simplex Naumova 1953.

Diagnosis Naumova 1953.

Retusotriletes avonensis Playford 1963

Plate 2, fig. 1

Holotype Playford 1963, pl.2, figs. 2.

Type locality Horton Group (Cheverie Formation), Nova Scotia, GSC loc.6408.

Diagnosis Playford, p.9.

Descriptión Amb circular. Suturae sinuous accompanied by labra 2µ wide which extend ¾ to 4/5 of spore radius, extend to well defined curvaturae perfectae. Thickened cingulum 9-10µ wide. Exine laevigate or scrabrate.

Size range 5040 80-92µ (2 spec.).

Other authors Playford 1963 62(79)104µ

Varma 1969 50-65µ (5 spec.).

Occurrence Goresbridge.

Remarks Equatorial thickening well defined in the two specimens found.

Previous records Playford 1964, Mississippian, Horton Group, Nova Scotia; Varma 1969, Horton Group, Canada.

Retusotriletes incohatus Sullivan 1964

Plate 2, fig. 6

Holotype Sullivan 1964, pl.1, fig.7.

Type locality Lower Limestone Shales of Puddlebrook, Forest of Dean, Gloucestershire.

Diagnosis Sullivan 1964, p.1251.

Description Amb circular or rounded triangular. Suturae often sinuous accompanied by narrow labra 1-1.5µ. Curvaturae perfectae present. Thickened equatorial region 4-10µ broad. Exine laevigate, puctate, or scabrate.

Size ranges 4268 38-70µ (10 spec.); 5044 42-60µ (3 spec.); 5040 28-55µ (15 spec.).

Other authors Dolby & Neves 37(43)50µ (30 spec.); Butcher 1974 thesis 27(47)51µ (15 spec.); Butterworth & Spinner 1967 27(46)64µ (26 spec.).

Occurrence Goresbridge, Donegal, Mayo & Clew Bay area.

Remarks Distinguished from R. avonensis in having a less clearly defined, thickened cingulum, and a narrower size range.

Previous records. Sullivan 1964a, Tournasian, Forest of Dean; Sullivan 1968, Lower Carboniferous, Scotland; Butterworth & Spinner 1967, Lower Carboniferous, N.W. England; Clayton 1971, Lower Carboniferous, Scotland; Neves et al., Lower Carboniferous of Scotland and Northern England (1973).

Infraturma APICULATI (Bennie & Kidston)Potonié 1966

Genus ACANTHOTRILETES (Naumova) Potonié & Kremp 1954

Type species A. ciliatus (Knox) P & K 1954.

Diagnosis P & K 1954, p.133.

Remarks This genus is relatively infrequent in occurrence. Distinguished from Anapiculatisporites by the different distribution of ornament. Lophotriletes and Apiculatisporites are also distinguished by their differing style of ornament.

Acanthotriletes acritarchus Neville 1973

Plate 2, fig. 3

Holotype Neville in Neves et al. 1973, pl.1, fig. 4.

Type locality Sample F9, Coal at 380'6" (116 m) in the coast section between Billow Ness and Anstruther West Haven.

Diagnosis Neville in Neves et al. 1973, p.30.

Description Amb circular. Exine thin and laevigate apart from processes. Ornamented with spines up to 17µ, broad based, often bulbous, tapering gradually to a sharp point; the tips occasionally falcate. Spaced 4-5µ apart.

Size range 5040 57-58µ (4 spec.).

Other authors Neville 1973 40(62)72µ (24 spec.).

Occurrence Goresbridge.

Remarks Specimens occur in a tetrad, so difficult to observe contact area, however the thin exine and large widely set falcate spines distinguish the species.

Previous records Neville (in Neves et al. 1973), Lower Carboniferous, Northern England and Scotland.

Acanthotriletes echinatus (Knox) Potonié & Kremp 1955

Plate 2, Fig. 4

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

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

Neotype Smith & Butterworth 1967, T86/1 in collection of coal survey laboratory, Sheffield.

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

Diagnosis Knox 1950, p.313.

Description Amb circular or convex triangular. Suturae simple, indistinct ½ spore radius. Ornament of tapering slender spinae, 2-5μ high, 1-1.5μ basal diameter, spaced 2-7μ apart; 15-25μ at equator. Exine thin and pale, 1μ in thickness.

Size ranges 4236 17-30μ (8 spec.); 4249 18-31μ (5 spec.).

Other authors Smith & Butterworth 1967 12-28μ (Fu.HNO_3); Knox 1950 25μ (Schulze); Hoffmeister, Staplin & Malloy 1955 30-46μ.

Occurrence Leitrim.

Remarks Specimens tend to have shorter spines than Knox's material and fewer projecting at equator than those described by Smith & Butterworth. Distinguished from Acanthotriletes falcatus by its smaller size, more circular amb, and less incurved spinae. A. echinatus Artuz 1957 has a similar size range but more densely set spinae. Occurrence infrequent.

Previous records Smith & Butterworth 1967, Coals of Great Britain, Namurian to Westphalian C; Knox 1950, Upper Carboniferous, Scotland; Sabry & Neves, in press, Viséan and Namurian A, Sanquhar Coalfield.

Acanthotriletes horridus Hacquebard 1957

Plate 2, fig. 2

Holotype Hacquebard 1957, pl.1, fig. 20.

Type locality Horton Group (Mississippian), Nova Scotia.

Diagnosis Hacquebard 1957, p.309.

Description Amb rounded triangular; sides straight, or gently convex. Suturae distinct, relatively short, extending ½ of spore radius. ornamented with spines and cones, parallel sided or tapering; stand 6-18µ; width 1-2µ. At equator 40-50µ may project. Generally more densely set distally and at the apices, and reduced around the contact area.

Size ranges 2612 68µ (1 spec.); 4201 100µ (1 spec.); 4249 75-100µ (6 spec.).

Other authors Hacquebard 1957 124-170µ.

Occurrence Ballycastle and Leitrim.

Remarks Differs from A.acritarchus by its smaller size range. Distinguished from Spinozonotriletes by the absence of intexine, but otherwise similar.

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

Acanthotriletes falcatus (Knox) Potonié & Kremp 1955

Plate 2, fig. 6b

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

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

1955 Acanthotriletes falcatus (Knox)Potonié & Kremp, p.84.

1958 Acanthotriletes falcatus (Knox) Potonié & Kremp;Butterworth & Williams p.366, pl.1, figs. 37, 38.

Neotype Smith & Butterworth 1967, Plate 8, fig.11.

Type locality Possil Main Seam at 600ft.2ins. (182.9m.)

Cawder Cuilt Borehole, Central Coalfield, Scotland, Namurian A.

Diagnosis Knox 1950, p.312.

Description Amb trinagular, interradial areas concave or convex. Suturae simple extending $\frac{2}{3}$-$\frac{3}{4}$ of spore radius. Ornament of tapering spinae, often incurved; 3-4μ high, rarely up to 5μ, 2-3μ basal diameter. Regular distribution 2-3μ apart, 36-70 at equator. Exine 1-1.5μ thick, frequently folded.

Size ranges 2472 32-51μ (7 spec.); 2476 46-50μ (3 spec.).

Other authors Knox 1950, 55μ (Schulze); Butterworth & Williams 29(36)47μ (Fu.HNO_3).

Occurrence Ballycastle.

Remarks Specimens show little variation. Occurrence infrequent. Acanthotriletes castanea Butterworth & Williams 1958 has more slender and narrower based spines which are less incurved.

Previous records Butterworth & Williams 1958, Limestone Coal Group and UpperLimestone Group, Scotland, Namurian A; Smith & Butterworth 1967, Coals of Great Britain, Viséan and Namurian A; Knox 1948, Limestone Coal Group of Scotland, Namurian A; Owens 1963 (thesis) Stainmore, Namurian A; Neves 1961, Southern Pennines, Namurian A-C; Mishell 1966 (thesis), Bowland Fells and Ingleton Coalfield, Namurian A-B.

Genus ANAPICULATISPORITES (Potonié & Kremp) Smith & Butterworth 1967

Type species A. isselbergensis Potonié & Kremp 1954.

Diagnosis (Potonié & Kremp) S & B 1967, p.160.

Remarks Occurrence of the genus in this study was relatively infrequent.

Anapiculatisporites concinnus Playford 1962

Plate 2, fig. 8

Holotype Playford 1962, pl.80, figs. 9,10. Preparation P145B/37, 40.2/103.0 (L.995).

Type locality Triungen (Sample G1466), Spitzbergen, Lower Carboniferous.

Diagnosis Playford 1962, p.587.

Description Spores radial trilete. Amb rounded triangular with gently convex interradial margins, and very rounded apices. Suturae distinct and simple, $\frac{2}{3}$ to over $\frac{3}{4}$ of spore radius. Proximal surface laevigate. Ornament on distal surface of distinct coni 0.5-1.5μ diameter, 0.5-1μ high, set about 1-2μ apart. Distribution is regular and characteristically reduced at apices and often absent at equatorial interradial areas. Exine pale, 0.5μ in thickness. Based on 2472.

Size ranges 4236 25-29μ (5 spec.); 2472 32-43μ (5 spec.).

Other authors Playford 1962 23(32)44μ Schulze; Smith & Butterworth 1967 24(28)35μ Fu.HNO_3; Felix & Burbridge 1967 20-43μ.

Occurrence Ballycastle and Leitrim.

Remarks Ballycastle specimens are larger 30-43μ, compared with Leitrim 25-29μ. Ornament generally is of a smaller grade 0.5-1μ high, compared with Playford's 1-2μ. Distinguished from Anapiculatisporites minor (Butterworth & Williams) Smith & Butterworth, by its smaller grade of ornament. Anapiculatisporites spinosus (Kosanke) Potonié & Kremp, appears similar and may be synonymous. Occurrence infrequent.

Previous records 1967 Smith & Butterworth, Coals of Great Britain, Viséan; 1967 Felix & Burbridge, Springer Formation, Anadarko Basin, Mississippian/ Pennsylvanian; 1962 Playford, Spitzbergen, Lower Carboniferous; Mishell 1966(thesis), Bowland Fells and Ingleton Coalfield, Base of Namurian B; Sabry & Neves in press; Upper Viséan or Namurian A, Sanquhar Coalfield, Scotland.

Anapiculatisporites hystricosus Playford 1963

Plate 2, figs. 10 & 11

Holotype Playford 1963, pl.III, figs.13-15.

Type locality Horton Group (Cheverie Formation), Nova Scotia.

Diagnosis Playford 1963, p.16.

Description Amb rounded triangular; apices rounded, sides gently convex. Suturae extend to margin, accompanied by labra 2.5μ wide. At equator is what appears to be an equatorial thickening 2μ wide. Ornamented on distal surface only with broad based cones 2μ wide, with blunted profile and stand 2μ high; spaced 1-1.5μ apart. Exine relatively thick, colour brown.

Size ranges 3101c 41μ; 3128 70μ (both 1 spec. only).

Other authors Playford 1963 38-58μ (25 spec.).

Occurrence Donegal.

Remarks A specimen from Donegal appears larger than described by Playford but otherwise conforms to diagnosis.

Previous records Playford 1963, Horton Group (Cheverie Formation) Nova Scotia.

Anapiculatisporites minor (Butterworth & Williams)

Smith & Butterworth 1967

Plate 2, fig. 5

Holtype Smith & Butterworth 1967, Plate 6, fig.21.

Type locality Lyncross Seam at 558ft.10ins. (170.3m.) Darnley No.4 Borehole, Central Coalfield, Scotland, Namurian A.

Diagnosis Smith & Butterworth 1967, p.161.

Description Spores radial trilete. Amb triangular with gently curved or concave sides; apices relatively narrow. Suturae ½-¾ spore radius, not very distinct. Exine proximally and equatorially laevigate. Ornament of stout tapering cones; usually stand 1.5μ high. Distribution restricted, being reduced apically and at interradial margins.

Exine colour pale.

Size ranges 4249 19-21µ (3 spec.); 4236 19-32µ (5 spec.);
4248 30µ (1 spec.).

Other authors Butterworth & Williams 1967 14(22)28µ FuHNO_3;
Smith & Butterworth 1967 20-27µ FuHNO_3.

Occurrence Ballycastle and Leitrim.

Remarks Distinguished from other species by its relatively large ornament, The size range of the specimens in this study is greater than that given by Butterworth & Williams 1967 and Smith & Butterworth 1967. Occurrence very infrequent.

Previous records Butterworth & Williams 1958, Limestone Coal Group and Upper Limestone Group, Scotland; Marshall & Williams 1970, Namurian, Northumberland; also recorded by numerous other authors, from the Carboniferous

Genus ANAPLANISPORITES Jansonius 1962

Type species A. telephorus Klaus 1960

Diagnosis Jansonius 1962, also Smith & Butterworth, p.165.

Anaplanisporites baccatus (Hoffmeister, Staplin & Malloy)
Smith & Butterworth
Plate 2, figs. 8 & 9

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

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

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

Holotype Hoffmeister, Staplin & Malloy 1955, pl.36, fig.2.

Type locality Shale at 2,075 ft (601 m), Carter No. 3 Borehole (TCO-82), Webster County, Kentucky, U.S.A., Hardinsburg Formation, Chester Series.

Diagnosis Smith & Butterworth 1967, p.166.

Description Amb circular to subcircular. Suturae ¾ of spore radius, slightly ridged usually less than 0.5μ wide. Ornament of broadly based cones 0.5-1μ, sometimes long and tapering up to 2.5μ high, others more rounded 1-2μ high. Distribution regular over distal and equatorial areas; absent on contact area. Under oil immersion, the cones are clustered into groups of three or four or arranged in concentric arcs and show increase in height towards distal pole. Contact area laevigate, well defined by length of trilete, and described by convex lines joining the tip of each suturae. Exine pale and relatively thin..Based on 2472.

Size ranges 2472 23(28)30μ (27 spec.); 2476 27-30μ (5 spec.); 2471 28-33μ (5 spec.).

Other authors Hoffmeister, Staplin & Malloy 1955 26-46μ H.F.; Smith & Butterworth 1967 22-30μ Fu.HNO_3; Mishell 1966 25-45μ FuHNO_3.

Occurrence Ballycastle.

Remarks Density and height of ornament varied within a sample, which could be the result of the process of oxidation. When observed during maceration, a number of specimens had reached the normal oxidation level very early, even though quite large pieces of coal material containing spores had not yet been broken up. When these spores are released they are not so pale as the earlier specimens. The suturae are described by Smith & Butterworth 1967 as being the length of the spore radius, but in this study they were consistently ¾.Size range conforms more closely with Smith & Butterworth than with Hoffmeister,Staplin & Malloy.

Previous records Hoffmeister, Staplin & Malloy 1955, Hardinsburg Formation, Illinois and Kentucky, Upper Mississippian; Butterworth & Williams 1958, Limestone Coal Group and Upper Limestone Group, Scotland, Namurian A; Smith & Butterworth 1967, Coals of Great Britain, Viséan to Lower Westphalian C; Staplin 1960, Golata Formation, Alberta, Canada, Upper Mississippian; Owens 1963, Stainmore, Namurian A to Lower Westphalian B; Sullivan & Marshall 1967, Western part of Midland Valley, Scotland, Upper Viséan; Mishell 1966 (thesis) Bowland Fells & Kngleton Coalfield, Namurian A to Westphalian A; Grebe 1972, Upper Westphalian A to Westphalian C, Ruhr, Germany.

Genus APICULATISPORIS Potonié & Kremp 1956

Type species A. aculeatus Ibrahim 1933.

Diagnosis P & K 1954, p.130.

Remarks Some gradation can be seen into Acanthotriletes, but usually quite distinct. Lophotriletes differs in having a triangular amb.

Apiculatisporis abditus (Loose) Potonié & Kremp 1955

Plate 2, fig. 12

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

1934 Verrucosi-sporites abditus Loose, p.154.

1944 Raistrickia abditus (Loose), Schopf, Wilson & Bentall, p.55.

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

1955 Apiculatisporites abditus (Loose), Potonié & Kremp, p.78, pl.14, fig.237-9.

Holotype Potonié & Kremp 1955, pl.14, fig. 237 after Loose.

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

Diagnosis Potonié & Kremp p.78.

Description Amb rounded, triangular, occasionally more circular. Suturae straight, simple, ¾ spore radius. Ornament of regularly set discrete cones, broad based 3-8μ, blunted in profile, occasionally flat-topped, 3-7μ high. About 18-38 project at equator. Proximal surface appears to be almost lacking in cones. Exine relatively thick.

Size ranges 2476 52-60μ (7 spec.); 4249 30-55μ (5 spec.).

Other authors Smith & Butterworth 1967 50-70μ (1 spec.).

Occurrence Ballycastle & Leitrim.

Remarks One or two specimens showed in the distal ornament similarities to Camptotriletes; where the cones occasionally merged to form ridges. Occurrence infrequent.

Previous records Smith & Butterworth 1967, British Coals, Westphalian A-D; Grebe 1972, Ruhr, Upper Westphalian A-C.

Apiculatisporis irregularis (Alpern) Smith & Butterworth

Plate 3, figs. 1 - 3

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

Non 1955 Apiculatisporites (Raistrickia) irregularis (Kosanke), Potonié & Kremp, p.77.

Holotype Alpern 1959 pl.1, fig.8.

Type locality 1st Seam, Morsbach, Lorraine Coalfield, France, Lower Stephanian.

Diagnosis Alpern 1959, p.139.

Description Amb circular, oval, or sub-circular. Suturae indistinct or absent; frequently only a 'tear' can be observed. Exine bears small coni; stand less than 1.5μ, 0.5-1μ in diameter; occur in localized patches, leaving areas of exine laevigate. Folding common.

Size range 2617 50-60μ (5 spec.).

Other authors Alpern 1959 50-75μ (Schulze & KOH); Smith & Butterworth

40(48)56µ (Fu.HNO_3), Hafod Seam, South Wales. Westphalian C.

Occurrence Ballycastle.

Remarks Specimens conform very well with diagnosis.

Previous records Alpern 1959, Lorraine Coalfield, France, Lower Stephanian; Smith & Butterworth 1967, Coals of Great Britain, Westphalian A to D.

Apiculatisporis pineatus Hoffmeister, Staplin & Malloy 1955
Plate 2, fig. 13

Holotype H S & M 1955, pl.38, fig.38.

Type locality Illinois No. 1 Coal at 2325' (706.1 m.) (TCO-153), Saline County, Hardinsburg Formation.

Diagnosis H S & M, p.381.

Description Amb rounded triangular. Suturae straight, simple extending ¾ of spore radius. Ornament of regularly set discrete cones, often very rounded in profile, rarely tapering or flat-topped; broadly based 4-8µ, standing 2.5to 7µ high. Proximally show reduction or absence of ornament. At equator may occur 17-30. Exine colour brown, relatively thick.

Size range 2478 37-41µ (5 spec.); 2480 40-41µ (3 spec.); 2476 37-47µ (5 spec.); 2481 37-45µ (5 spec.); 4249 35µ (1 spec.).

Other authors Hoffmeister, Staplin & Malloy 1955 36-56µ.

Occurrence Ballycastle and Leitrim.

Remarks Occurrence infrequent, particularly in Leitrim where only one specimen found. Differs from A. abditus (Loose) in being smaller, although the cones also seemed more discrete, and the ridges connecting them seemed less distinct in A. pineatus.

Previous records Hoffmeister, Staplin & Malloy 1955, Hardinsburg Formation of Illinois & Kentucky, U.S.A.

Apiculatisporis Sp.A.

Plate 2, fig. 14

Description Amb rounded, Suturae simple extend $\frac{1}{2}$-$\frac{3}{4}$ of spore radius. Ornamented distally and proximally with regularly spaced cones and spines; stand 0.5-1μ high; spaced 4-10μ apart; profile may be rounded cones or pointed tapering spines. Exine relatively thin; folding concentric.

Size range 4236 73-75μ (2 spec.); 4201 40μ (1 spec.); 4249 60-71μ (2 spec.).

Occurrence Leitrim.

Remarks Differs from Apiculatisporis Sp. B. by its more pronounced and widely spaced ornament.

Apiculatisporis Sp. B.

Plate 2, fig. 15

Description Amb circular. Suturae simple extending $\frac{1}{2}$-$\frac{2}{3}$ spore radius. Ornamented proximally and distally with variably shaped coni; stand 1-1.5μ high; spaced 1-3μ apart; profile may be rounded, flat-topped (baculate), tapering and pointed. At equator between 50 and 80 project. Exine rich yellow colour. Folding thin concentric type.

Size range 4236 50-81μ (10 spec.); 4204 80u, 100μ (2 spec.); 4249 55u, 85μ (2 spec.).

Occurrence Leitrim

Remarks Differs from Apiculatisporis Sp. A by its more densely set ornament. Apiculatisporis aculeatus (Ibrahim) Smith & Butterworth has a more prominent ornament i.e. over 2.5μ, otherwise similar.

Apiculatisporis Sp. C.

Plate 2, fig. 16

Description Amb circular or oval. Suturae simple, straight, $\frac{1}{2}$-$\frac{2}{3}$ spore radius. Ornamented with cones of variable size and distribution. Proximally reduced, and attain maximum height at the distal polar area, 1.5-5µ. Profile of cones usually blunt and rounded, wide based, but can be tapering. At equator 40-65 elevations can occur. Ornament densely set, spaced 0.5-1u apart, each cone being discrete. Exine 1u thickness, coloured yellow. Narrow, flat,concentric folds characteristic.

Size range 4249 43-70µ (7 spec.).

Occurrence Leitrim.

Remarks The variable nature of the ornament, the distinctive increase in size towards the distal pole together with the size of the spores, distinguishes this species from other species of Apiculatisporis. Occurrence infrequent. Apiculatisporis variocorneus has a stronger development of cones distally, and a more clearly defined, reduced ornament proximally.

Genus APICULIRETUSISPORA Streel 1964

Type species A. brandtii Streel 1964.

Diagnosis Streel 1964, p.138.

Apiculiretusispora multiseta (Luber) Butterworth & Spinner 1967

Plate 2, fig. 17

1938 Azonotriletes multisetus Luber, in Luber & Waltz, p.32, pl.5, fig.61, p.23.

1955 Filicitriletes multisetus (Luber) Luber, pp.55-56, pl.3, fig.52.

1955 Acanthotriletes multisetosus (Luber) Potonié & Kremp,p.84.

1957 Acanthotriletes multisetus (Luber), Kedo, p.1167.

Holotype Luber 1938, pl.5, fig.61.

Type locality Karaganda Basin, U.S.S.R., Lower Carboniferous.

Diagnosis Luber 1938, p.32.

Description Amb oval to sub-circular. Suturae straight. simple or accompanied by narrow labra 1µ. In one specimen there is the suggestion of curvaturae visible. Ornamented distally and proximally, except on the contact area, with spinae 0.5-1µ in diameter, 1-1.5µ high, set very close. Exine frequently folded.

Size range 5044 50µ; 5040 47-56µ (6 spec.); 1142 63µ.

Other authors Playford 1962 42(60)78µ (30 spec.); Butterworth & Spinner 1967 43(54)70µ by 35(46)62)µ (44 spec.).

Occurrence Goresbridge and Mayo.

Remarks Distinguished from Colatisporites denticulatus Neville 1973 by its laevigate contact areas and the presence of curvaturae. The latter feature was not always convincingly displayed on all specimens.

Previous records Luber 1938, Karaganda Basin, U.S.S.R., Lower Carboniferous; Love 1960, Viséan, Scotland; Playford 1962, Spitzbergen, Lower Carboniferous; Butterworth & Spinner 1967, Bewcastle Beds, Lower Carboniferous.

Genus BACULATISPORITES Thomson and Pflug 1958

Type species B. primarius (Wolf) Thomson & Pflug 1958.

Diagnosis Thomson & Pflug 1953.

Baculatisporites fusticulatus Sullivan 1968

Plate 2, fig. 18

Holotype Slide F. 263381 - A - 04 115.0/53.0.

Type locality 100' (30.5m) above base of Cementstone Group, Ayrshire, Scotland.

Diagnosis Sullivan 1968.

Description Amb very rounded triangular. Ornament of pila and small bacula of 1-1.5µ high and very closely set, with less than 0.5µ between. Preservation only allowed the margin to be studied since the specimen was carbonized - hence the identification may be questionable. Approximately 70 pila occur at the margin.

Size range 5040 60μ (1 spec.).

Other authors-Holotype - 86μ Sullivan 1968; Butcher 1974(thesis) 49(59)65μ (15 spec.).

Occurrence Goresbridge.

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

Genus CYCLOGRANISPORITES Potonié & Kremp 1954

Type species C. leopoldi (Kremp) P & K 1954.

Diagnosis P & K 1955, p.60.

Remarks Gradation of this genus with Punctatisporites can be observed, especially in the Ballycastle material, where the fine and closely set or ornament can be confused with infrastructure.

Cyclogranisporites aureus (Loose) Potonié & Kremp 1955

Plate 3, fig. 6

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

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

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

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

Holotype Potonié & Kremp 1955, pl.13, fig.184 after Loose.

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

Diagnosis Potonié & Kremp 1955, p.61.

Description Amb circular. Suturae simple, extend around ½ spore radius. Ornamented distally and proximally by grana 1μ in diameter, 0.5-1μ high. Distribution usually close set, but bases often not touching. Occasionally laevigate areas occur but they are probably the result of corrosion. Folding frequent; broad and narrow in style. Exine relatively thick 1-2μ.

Size range 4204 56-70μ (4 spec.); 4249 60-70μ (7 spec.).

Other authors Potonié & Kremp 50-80μ Schulze;

Smith & Butterworth 59(72)82μ Fu.HNO_3.

Occurrence Leitrim.

Remarks Specimens conform in most respects to diagnosis, although appear to have a slightly finer grade of ornament. Distinguished from *Cyclogranisporites multigranus* Smith & Butterworth 1967 by its coarser grade of ornament. Occurrence infrequent.

Previous records Smith & Butterworth 1967, British Coals, Upper Westphalian A - D; Loose 1934, Westphalian B, Ruhr Coalfield, Germany; Potonié & Kremp 1955, Upper Westphalian B to Middle Westphalian C, Ruhr Coalfield, Germany; Mishell 1966 (thesis), Namurian A to Westphalian A, Bowland Fells and Ingleton Coalfield; Grebe 1972, Upper Westphalian A - C, Ruhr, Germany.

Cyclogranisporites minutus Bharadwaj 1957
Plate 3, fig. 7

Holotype Bharadwaj 1957a, pl.22, fig.22.

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

Diagnosis Bharadwaj 1957a, p.83.

Description Amb circular, rarely oval. Suturae straight, ¾ spore radius. Ornamented distally and proximally with small 0.5-1μ diameter grana, less than 0.5-1μ high. Variably distributed. Spaces between grana rarely exceed their own diameter and thus may appear densely set. At equator grana are perceptible 70-100. Exine yellow or brown. Folding infrequent.

Size range 4249 42-35μ (6 spec.); 4204 38-40μ (5 spec.); 2481 30-33μ (5 spec.); 2472 28-35μ (7 spec.).

Other authors Bharadwaj 2957a 34-43μ Schulze.

Occurrence Ballycastle and Leitrim.

Remarks Specimens conform to diagnosis and size range, but can appear visually quite different due to difference in colour of exine. Leitrim specimens tend to have less pale exines. Distinguished from Cyclogranisporites multigranus Smith & Butterworth by its smaller size. Occurrence infrequent.

Previous records Bharadwaj 1957, Westphalian C to Stephanian of the Saar Coalfield; Bharadwaj 1957, Westphalian D of the Saar Coalfield.

Cyclogranisporites multigranus Smith & Butterworth 1967

Holotype Plate 4, fig.12, Smith & Butterworth.

Type locality Seam at 491 ft. (149.9m), Seafield No. 2 Borehole, East Fife Coalfield, Scotland, Westphalian B.

Diagnosis Smith & Butterworth 1967, p.144.

Cyclogranisporites cf. multigranus

Plate 3, figs. 4 & 5

Description Amb circular or oval, often distorted by folding. Suturae ususlly indistinct. Straight, $\frac{2}{3}$-$\frac{3}{4}$ spore radius. Ornamented proximally and distally with very low grana often less than 0.1μ high and less than 0.5μ diameter, densely set with bases touching, and barely perceptible at margin where approximately 100 or more occur. Exine 0.5-1μ, pale yellow. Frequently folded, sharply tapering flat folds 4-8μ wide.

Size range 2472 40(68)75μ (12 spec); 2481 51(70)74μ (10 spec.); 2480 50(60)65μ (8 spec.);

Other authors Smith & Butterworth 1967 38(47)55μ Fu.HNO_3.

Occurrence Ballycastle.

Remarks Specimens consistent in their appearance and agree in many respects to the diagnosis of Cyclogranisporites multigranus, except that the size range in this study is much larger; the most frequent occurrence at around 70μ. Also the suturae are slightly greater in proportion to the spore radius. Distinguished from C. aureus (Loose) Potonié & Kremp 1955 by its finer grade of ornament. C. lasius Playford is more coarsely granulate. Occurrence frequent.

Previous records Smith & Butterworth 1967, Westphalian B, British Coalfields.

Genus GRANULATISPORITES (Ibrahim) Potonié & Kremp 1954

Type species G. granulatus Ibrahim 1933.

Diagnosis Potonié & Kremp 1954, p.126.

Remarks Grana were rounded in profile and unrestricted in distribution over the surface of the exine. Lophotriletes has an ornament of cones which alters the spore margin and which does not occur in the genus Granulatisporites.

Granulatisporites granulatus Ibrahim 1933

Plate 3, fig. 9

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

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

Holotype Ibrahim 1933, pl.6, fig.51.

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

Diagnosis Potonié & Kremp 1955, p.58.

Description Amb rounded triangular, sides concave, rounded apices. Ornament of grana, most of which are 1u or over in diameter, 30-60µ at margin, may project up to 0.5µ. Distribution of grana generally widely spaced, but may have areas where crowded together. Leasurae simple, variable in length ½-¾ of spore radius.

Size range 4236 26-33µ (6 spec.); 4204 29-34µ (3 spec.).

Other authors Potonié & Kremp 1955 25-35µ; Smith & Butterworth 1967 24(28)33µ Fu.HNO_3.

Occurrence Leitrim.

Remarks Granulatisporites microgranifer Ibrahim 1933 has a finer grade of ornament. G. piroformis Loose 1934, has an ornament of grana where most of the bases are touching.

Previous records Ibrahim 1933; Potonié & Kremp 1955, Ruhr Coalfield, Westphalian B-C; Horst 1943, Ostrau, Oberschlesien, Westphalian A; Kosanke 1950, Illinois, U.S.A., Lower McLeansboro, Westphalian A-D; Smith & Butterworth, Viséan-Lower Westphalian C, Coals of Great Britain; Horst 1955, Namurian A, Westphalian A; Playford 1964, Daybrook Sandstone; Grebe 1972, Ruhr, Germany, Upper Westphalian A - C.

Granulatisporites microgranifer Ibrahim 1933

Plate 3, fig. 12

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

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

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

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

1957 Granitriletes microgranifer (Ibrahim) Dybova & Jachowicz, pp.127-128, pl.31, fig.4.

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

Holotype Ibrahim 1933, pl.5, fig.32, Potonié & Kremp 1955.

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

Diagnosis Potonié & Kremp 1955, p.58.

Description Amb rounded triangular, sides concave, broad rounded apices. Ornament of tiny grana less than 1µ, commonly less than 0.5µ; widely scattered or densely distibuted, bases usually not touching. Exine pale. Leasurae simple $\frac{2}{3}$-$\frac{3}{4}$ spore radius.

Size range 4236 30-40µ (5 spec.); Leitrim E_2 general 30-40µ (10 spec.); 3128 32µ (1 spec.); 1142 31-34µ (3 spec.).

Other authors Horst 1955 14-33µ; Potonié & Kremp 1955 30-40µ Schulze; Smith & Butterworth 1967 18(23)28µ Fu.HNO_3.

Occurrence Leitrim, Donegal and Mayo.

Remarks Granulatisporites piroformis Loose 1934 and G. granulatus Ibrahim 1933 have a coarser grade of arnament.

Previous records Ibrahim 1933, sporomorphs of the Ägir horizon of the Ruhr area; Luber 1938, The Minusinsk Basin, Upper Carboniferous; Horst 1955, West-Oberschlesien, Mährisch-Ostrau, Namurian A; Dybova & Jachowicz 1957, Westphalian B -Middle Westphalian C; Horst 1943, Mahrisch-Ostrau, Namurian A-Westphalian A; Kosanke 1950, Illinois U.S.A., Namurian C-Westphalian D; Potonié & Kremp 1955, Ruhr Coalfield, Westphalian B -Lower Westphalian C; Grebe 1972, Ruhr,Germany, Upper Westphalian A-C.

Granulatisporites minutus Potonié & Kremp 1955

Plate 3, fig. 8

Holotype Potonié & Kremp 1955, pl.12, fig.147.

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

Diagnosis Potonié & Kremp 1955, p.59.

Description Amb rounded triangular, rounded apices; sides concave. Suturae simple ¾ spore radius. Ornament of grana up to 1µ in diameter and height, but more usually around 0.5µ. May be scattered or densely distributed but bases do not touch. About 30-50 elements may project at equator.

Size range 4236 22-24µ (3 spec.); Leitrim E_2 22-25 (6 spec.); 2472 21-28µ (25 spec.).

Other authors Potonié & Kremp 20-25u Schulze; Smith & Butterworth 1967 18-28µ Fu.HNO_3; S&B 18(23)27µ Fu.HNO_3; S & B 16(21)25µ Fu.HNO_3.

Occurrence Ballycastle and Leitrim.

Remarks Size range in the Ballycastle material shows no particular peak of abundance in the lower region, but instead a gradual increase in the number of specimens as they approach 28µ. Elsewhere the peak of abundance is more around 25µ. The Ballycastle specimens also show a smaller number of grana at the equator. The amb shape,generally,is consistently concave triangular.

Previous records Potonié & Kremp 1955, Ruhr Coalfield, Westphalian A-C; Smith & Butterworth 1967, Coals of Great Britain, Lower Westphalian A-C; Loboziak 1969, Basin of Northern France, Westphalian B-C; Grebe 1972, Ruhr, Germany, Upper Westphalian A-C.

Granulatisporites piroformis Loose 1934

Holotype Loose 1934, pl.7, fig.19.

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

Diagnosis Potonié & Kremp 1955, p.60.

Granulatisporites cf. piroformis Loose 1934

Plate 3, figs. 10 & 11

Description Amb rounded triangular, sides concave, apices broadly rounded or angular. Suturae simple, $\frac{1}{2}$-$\frac{3}{4}$ spore radius. Ornament of grana 0.5-1μ in diameter, closely set with bases touching giving the impression of a negative reticulum. About 40-60 at equator.

Size range 4236 27-30μ (3 spec.); general for Leitrim E_2 25-40μ (10 spec.); 2472 23-40μ (11 spec.); 2476 32-44μ (8 spec.); 2480 28-43μ (8 spec.).

Occurrence Ballycastle and Leitrim.

Remarks Some specimens have angular apices; the two extremes occurred together in the populations with many intermediate varieties. The more angular specimens are superficially similar to Waltzispora ?planiangulata Sullivan, but differ in the ornament not being reduced at all proximally. Specimens were similar from all areas. Occurrence frequent.

Granulatisporites sp.

Plate 3, fig. 13

Description Amb concave triangular; apices rounded or slightly angular. Ornamented distally and proximally with grana closely set, but bases not always in contact; diameter 1μ and less; height less than 1μ. Apices characterized by a slight thickening, giving a different darker colour to exine.

Size range 4236 34μ; 4249 27μ

Occurrence Leitrim.

Remarks Very similar in appearance to Granulatisporites cf. piroformis, but this type doesnot possess apical thickening. Both types may appear together in the same sample. Differs from Triquitres comptus by the less well defined thickenings, smaller grade of ornament which is not restricted to any part of the spore body. Waltzispora planiangulata has a more pronounced angularity to the apices, and its ornament is restricted to the distal surface.

Genus LOPHOTRILETES (Naumova) Potonié & Kremp 1954

Type species L. gibbosus (Ibrahim), Potonié & Kremp 1954.

Diagnosis P & K 1954, p.129.

Remarks Gradation occurs with Granulatisporites. There is also merging between species L. commisuralis, L. microsaetosus and L. gibbosus.

Lophotriletes commisuralis (Kosanke) P. & K. 1955

Plate 3, figs. 14 & 15

1950 Granulatisporites commisuralis Kosanke, p.20, pl.III, fig. 1.

1955 Lophotriletes commisuralis (Kosanke) Potonié & Kremp, p.73, pl.XIV, fig.222-223.

1965 Lophosporites commisuralis (Kősanke) Potonié & Kremp, Imgrund, p.164, pl.15, figs. 66-68.

Holotype Kosanke 1950, pl.3, fig.1.

Type locality Friendsville coal, Wabash County, Illinois, U.S.A., Macleansboro Group.

Diagnosis Kosanke 1950, p.20.

Description Amb rounded triangular; sides concave; Ornament of small coni, standing about 0.5μ high and widely spaced. Generally broad at the base, often rounded rather than sharply pointed in cross-section, 25-35 at the equator. Suturae simple, extending from $\frac{2}{3}$ to $\frac{3}{4}$ of spore radius. Exine pale.

Size range 4236 25-32μ (7 spec.); Leitrim general 25-32μ (10 spec.); 2481 25-34μ (8 spec.); 2480 25-26μ (6 spec.); 2472 31-32μ (5 spec.); 2479 27-31μ (5 spec.).

Other authors Kosanke 1950 25-34μ Schulze, KOH; Smith & Butterworth 24(29)35μ Schulze 5% KOH.

Occurrence Ballycastle and Leitrim.

Remarks Profiles of elements in the Ballycastle specimens are more variable being generally more distinctly pointed. A peak of abundance in the 27-30µ region is shown in the general size range for all areas. Ballycastle also differs by having the larger specimens with longer spines around 34µ. Granulatisporites microgranifer Ibrahim 1933, and G. granulatus Ibrahim 1933, have an ornament dominated by grana, rather than coni. Distinguished from other species of Lophotriletes by its finer grade of ornament.

Previous records Kosanke 1950, Mcleansboro U.S.A., Upper Westphalian C to Stephanian C; Potonié & Kremp 1955, Ruhr Coalfield, Germany, Middle Westphalian B; Smith & Butterworth 1967, Coals of Great Britain, Namurian to Westphalian D; Grebe 1972, Ruhr, Germany, Upper Westphalian A- C.

Lophotriletes gibbosus (Ibrahim) Potonié & Kremp 1954

1933 Verrucosi-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 Verrucoso-sporites gibbosus (Ibrahim), Knox, p.317, pl.17, fig.232.

1954 Lophotriletes gibbosus (Ibrahim), Potonié & Kremp, p.129.

non 1958 Lophotriletes gibbosus (Ibrahim) Potonié & Kremp, Guennel, p.62, pl.3, fig.9.

Holotype Potonié & Kremp 1955, pl.14, fig. 220.

Type locality 'Agir Seam, Ruhr Colafield, Germany, top Westphalian B.

Diagnosis Potonié & Kremp 1955, p.74.

Lophotriletes cf. gibbosus (Loose) Potonié & Kremp 1955

Plate 3, fig. 20

Description Amb rounded triangular; sides variable from slightly convex, straight to concave; apices broad. Ornament of widely spaced broad coni mainly rounded, occasionally pointed, 1-4µ high, 1-3µ wide. Laesurae simple extending ¾ of spore radius. Exine 1µ in thickness.

Size range ~~0~~236 33µ, 30µ (2 spec.); 4205 45µ (1 spec.).

Occurrence Leitrim.

Remarks Differs from Lophotriletes gibbosus and Lophotriletes microsaetosus (Loose) Potonié & Kremp 1955, in having a more widely spaced ornament, and also being smaller in size than the former.

Lophotriletes granoornatus Artüz 1957

Plate 3, figs. 17, 18 & 19

Holotype Artüz 1957, pl.2, fig.13.

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

Diagnosis Artüz 1957, p.244.

Description Amb rounded triangular, interradial areas variable, usually convex but may also be straight or concave. Suturae simple, extend ⅔ of spore radius. Ornament of coni 1-2µ in diameter, apices pointed or rounded, distributed regularly, with occasional cluster development, but bases generally do not touch. At equator 20-33. Exine pale or yellow, up to 2µ thickness.

Size range Leitrim E_2 general 33-43µ (10 spec.); 2471 38-47µ (5 spec.).

Other authors Artüz 1957 25-41µ; Smith & Butterworth 1967 27(35)44µ, Fu.HNO_3.

Occurrence Ballycastle and Leitrim.

Remarks Specimens from Ballycastle tend to be more concave interradially but otherwise similar to Leitrim material. Overall size range greater than Artüz 35ü-41µ (maceration method unknown), and more in keeping with Smith & Butterworth 1967. Most specimens, however, occur between 38-40µ.

Other species of a similar size range are distinguished by having a coarser grade of ornament.

Previous records Artüz 1957, Zonguldak Coalfield, Turkey, Westphalian A; Smith & Butterworth 1967, Coals of Great Britain, Upper Westphalian A and B.

Lophotriletes microsaetosus (Loose) Potonié & Kremp 1956

Plate 3, fig. 16

1932 Sporonites microsaetosus Loose in Potonié Ibrahim and Loose, p.450, pl.18, fig.40.

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

1934 Setosisporites microsaetosus (Loose) Loose, p.148.

1944 Granulatisporites microsaetosus (Loose), Schopf, Wilson & Bentall, p.33.

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

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

1958 Lophotriletes gibbosus (Ibrahim) Potonié & Kremp, Guennel, p.62, pl.3, fig. 9.

Holotype Potonié & Kremp 1955, pl.14, fig.229 after Loose.

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

Diagnosis Potonié & Kremp 1955, p.74.

Description Amb triangular, interradial areas concave, rarely straight. Apices broadly rounded. Suturae simple, straight, distinct, ¾ of spore radius. Ornament of cones variable in their profile, from sharply tapered to rounded or even flat-topped. Most frequently rounded; height 1.5(2.5)4μ; bases 1-3μ, spaced 1-5μ at equator.

Size range 2472 30-38μ (10 spec.).

Occurrence Ballycastle only.

Remarks Notably absent from other areas than Ballycastle. Size restricted in general from 30 to 35u. Total size range compares well with Potonie & Kremp 1955 (25-49u) Schulze. Differs from Lophotriletes microsaetosus by its more variable ornament. L. commisuralis (Kosanke) Potonie & Kremp is distinguished by its finer ornament. L. granoornatus Artuz has a larger size range.

Genus PILOSISPORITES Delcourt and Sprumant 1955

Pilosisporites verutus Sullivan & Marshall 1966

Plate 3, fig. 21

Holotype Sullivan & Marshall 1966 pl. 1, fig. 10.

Type locality Shales below the Blackbyre Limestone, Upper Sedimentary Group, Midland Valley, Scotland.

Diagnosis Sullivan & Marshall 1966, p.267.

Description Amb triangular with sides concave, or sometimes straight; rounded apices. Suturae distinct, extending $\frac{2}{3}$ of spore radius. The exine was relatively thin, and up to 1.5u, ornamented on distal and equatorial surfaces with spines of 5 to 6u in length. These were spaced 2 - 3u apart and were tapered in profile.. There was typically more ornament at the apices.

Size range 2047 48u

Other atthors Sullivan & Marshall 1966 40 - 50u (9 specimens) mean 46u.

Occurrence Ballycastle.

Remarks Specimen conformed closely to diagnosis.

Previous records Sullivan & Marshall 1966, Upper Sedimentary Group, Midland Valley, Scotland.

Genus PUSTULATISPORITES Potonié & Kremp 1954.

Type species P. pustulatus P & K 1954.

Diagnosis P & K 1954, page 134,

Remarks This genus is distinguished from Lophotriletes to which it has a superficial resemblance, by the fact that its ornament is very much reduced on the proximal surface.

Pustulatisporites papillosus (Knox) Potonié & Kremp 1955

Plate 3, fig. 22

1948 Type 16K Knox, fig.13.

1950 Triquitrites papillosus Knox, p.327, pl.17, fig. 234.

1955 Pustulatisporites papillosus (Knox) Potonié & Kremp, p.82-83.

Lectotype Smith & Butterworth 1967, pl.7, fig.9.

Type locality Dunfermline Splint Seam, Lumphinnans No. 1 Borehole, West Fife Coalfield, Scotland, Namurian A.

Diagnosis Butterworth & Williams 1958, p.365.

Description Amb rounded triangular, sides generally convex but may be concave or straight. Ornament of cones and verrucae, varying from 2-10μ wide, 2-4μ high, and restricted to distal side; 10-20 project at equator, mainly at apices. Widely spaced 3-4μ apart. Exine pale brown to yellow; about 1μ thickness.

Size range Leitrim E_2 general 33-46μ (10 spec.); 2612 41-53μ (10 spec.).

Other authors Butterworth & Williams 1958 35-65μ.

Occurrence Ballycastle and Leitrim.

Remarks Ballycastle specimens show an interesting feature of two or three elements becoming elongated lengthwise and arranged in a triangular pattern, centrally on the distal surface. General distribution of ornament agrees with Playford 1964 in being mainly distal. Pustulatisporites papillosus has more developed amd prominent ornament than P. pustulatus Potonié & Kremp 1954.

Previous records Knox 1948, Limestone Coal Group, Scotland; Butterworth & Williams 1958, Limestone Coal Group & Upper Limestone Group, Scotland; Playford 1964, Drybrook Sandstone, Lower Carboniferous; Smith & Butterworth 1967, Coals of Great Britain, Namurian A; Sullivan 1964a, Drybrook Sandstone (Viséan), Forest of Dean, Gloucestershire.

Genus RAISTRICKIA (Schopf, Wilson & Bentall)
Potonié & Kremp 1954

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

Diagnosis P & K 1955, p.85.

Raistrickia nigra Love 1960
Plate 4, figs. 1 & 2

Holotype Love 1960, pl.1, fig.5.

Type locality Pumpherston Shell Band, South Queensferry.

Diagnosis Love 1960, p.114

Description Amb circular to oval. Suturae distinct, simple, $\frac{2}{3}$ of spore radius. Ornamented distally and proximally with broadly rounded or flat-topped elements 2.5-7μ wide and 2.5-4μ high. Elements occasionally bifurcate, with a small parasitic bacula or cone projecting from the main element. Widely set up to 12μ apart; 9-18 project at equator. Exine usually laevigate, occasionally scabrate, brown or yellow in colour; 1-1.5 thickness. Rarely folded.

Size range 2472 42-50μ (5 spec.).

Other authors Love 1960, 60-75μ; Neville 1968, 41(54)59μ; Hibbert & Lacey 1960, 48(56)67μ; Sullivan & Marshall 46(54)70μ.

Occurrence Ballycastle & Leitrim.

Remarks Dimensions show a greater range than the type material but agree closely with those of Sullivan & Marshall. Specimens consistent in their appearance. Baculi of a smaller height than Love's (5-6μ), similar to those of Hibbert & Lacey 1969. Neville states that R. nigra was not found in coals in his study, but in the present study, although rare, specimens were found in several coals. Generally occurrence very infrequent.

Previous records Love 1960, Lower Oil Shale Group, Scotland; Lele & Provan 1962, Upper Sedimentary Group, Ayrshire, Scotland; Sullivan & Marshall 1966, Western part of Midland Valley, Scotland, Viséan; Neville 1968, East Fife, Upper Viséan; Hibbert & Lacey 1969, Basement beds, Menai Straits, N. Wales, Lower Carboniferous; Owens 1963 (thesis) Stainmore, Lower Namurian A.

Raistrickia saetosa (Loose) Schopf, Wilson & Bentall 1944

Plate 4, fig. 4

1932 Sporonites saetosus Loose in Potonié, Ibrahim & Loose, p.452, pl.19, fig.56.

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

1944 Raistrickia saetosus (Loose), Schopf, Wilson & Bentall, p.56.

Holotype Potonié & Kremp 1955, pl.15, fig. 264 after Loose 1932.

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

Diagnosis Potonié & Kremp 1955, p.87.,

Description Amb circular or oval. Suturae simple but not distinct, at least ¼ spore radius. Ornamented distally and to a certain extent proximally with baculate elements, parallel or gently expanding to irregular or flat tops, rarely rounded or tapering; 4-10μ height, 2-3μ wide, spaced 5-12μ apart; 11-34 may project at equator.

Elements more densely set on distal surface, proximal surface with a reduced ornament or sometimes laevigate. Exine 1 - 2μ thick, laevigate, yellow or brown.

Size range 4249 40-80μ (9 spec.).

Other authors Potonié & Kremp 1955 60-90μ; Smith & Butterworth 1967 41(50)62μ.

Occurrence Leitrim only.

Remarks Consistent in appearance. Size range falls between Smith & Butterworth and Potonié & Kremp, but most specimens do occur between 40-63μ. A few specimens demonstrate clearly in oblique view the laevigate proximal surface. Occurrence restricted to Leitrim E_2 material. Usually infrequent but in one particular sample 4249 it is more common. Raistrickia fibrata (Loose) Schopf, Wilson & Bentall 1944 is smaller and has a less coarse ornament.

Previous records Potonié & Kremp 1955, Upper Westphalian B to Middle Westphalian C of the Ruhr; Bharadwaj 1957, Saar Coals, Carboniferous; Smith & Butterworth 1967, British Coals, Westphalian A-D; Luber & Waltz 1938, Westphalian of the Donetz Basin; Neves 1961, Southern Pennines, Namurian A to Lower Westphalian B; Mishell 1966 (thesis) Bowland Fells & Ingleton Coalfield, Upper Namurian A to Westphalian A; Owens 1963, Stainmore, Namurian B to Lower Westphalian B.

Raistrickia clavata (Hacquebard) Playford 1963

Plate 4, fig. 3

Holotype Hacquebard 1957, pl.1, fig. 25.

Type locality Horton Group (Mississippian) of Nova Scotia.

Diagnosis Playford 1963, p.24.

Description The shape of the amb may be rounded to subcircular, but is often folded. The suturae can be distinct or indistinct and extend one half to two thirds of the spore radius. It is ornamented both distally and proximally with an essentially pilate sculpture, which may be club or mushroom shaped. The basal diameter of these processes varied from one to three μ, and the width of the pila heads varied from 2 - 5μ. The size and shape of these elements varied on any one specimen.

Size range 5040 50-80u (4 spec.)

Other authors Playford 1963 48-85u (mean 67u) (140 spec.).

Remarks Distinguished from R. ponderosa Playford 1963 by being smaller. Occurrence infrequent.

Previous records Hacquebard 1957, Horton Group of Nova Scotia, Mississippian; Playford 1963, Horton Group of Nova Scotia Mississippian; Higgs 1975, Upper Devonian and Lower Carboinferous of Hook Head, Ireland.

Genus SCHOPFITES Kosanke 1950

Type species S. dimorphus Kosanke 1950

Diagnosis From description in Kosanke 1950, p. 57.

Schopfites claviger Sullivan 1968

Plate 4, figs. 5 - 7

Holotype Sullivan 1968, Slide P26381 - A - 03, 125.0/26.5

Size 50u.

Type locality Bracken Bay, Heads of Ayr, Ayrshire, Tournaisian.

Diagnosis Sullivan 1968, p.121.

Description Amb sub-circular. Suturae not observed. Ornamented with clava and bacula, reaching 2µ in height, set 2-3µ apart at the equator. Distribution of ornament even, clearly absent in the proximal area. At equator 20-30 may project. Exine colour pale, generally folded.

Size range 1142 43-50µ (4 spec.); 5040/44 43-49µ (3 spec.).

Other authors Sullivan 1968 40-52µ Schulze KOH.

Occurrence Goresbridge and Mayo.

Remarks The specimens found from Goresbridge and Mayo are very poor in preservation and relatively infrequent.

Previous records Sullivan 1968, Cementstone Group, Scotland; Clayton 1971, Lower Carboniferous, Scotland; Llewellyn, Backhouse & Hoskin 1969, Tournaisian, Leicestershire; Bertlesen 1972, Lower Carboniferous, Denmark; Neves et al. 1973, Tournaisian, Scotland.

Schopfites sp.

Plate 4, figs. 8 - 10

Description Amb sub-circular. Suturae not observed. Ornamented with relatively short-stemmed clava and bacula, notably expanded, usually the tops are rounded or cone shaped and the base of the expansion flat. Stand up to 2µ high and are spaced 2-3µ apart. Proximal area shows reduction or absence of ornament. At equator 20-30 may project. Regular distribution to ornament

Remarks This type is restricted to Leitrim E_2 assemblages, but is closely similar to S. claviger of the Tournaisian. It is distinguished by its shorter clava and bacula and the nature of the expanded apices of the bacula.

Genus TRICIDARISPORITES (Sullivan & Marshall 1966)

Gueinn, Neville & Williams 1973.

Type species T. serratus (Playford) S & M, 1966.

Diagnosis Neves et al. 1973, p.31.

Remarks This was amended by Gueinn, Neville & Williams (in Neves et al. 1973) to include spores which are ornamented proximally and distally. In the original diagnosis by S & M 1966, p.268, the genus was described as having a laevigate proximal surface. However, within the genus these authors included T. arcuatus Neville (described as T.fasciculatus in Smith & Butterworth (Love) S & M and Procoronaspora fasciculata Love /which they described as having interradial portions of the proximal hemisphere ornamented with grana in an arcuate zone adjoining the equator.

Gradation of this genus with Diatomozonotriletes can occur, but no such extremes of morphology appear to exist in the present study.

Tricidarisporites balteolus Sullivan & Marshall 1966

Plate 4, figs. 11 & 12

Holotype S & M 1966, pl.1, fig.13.

Type locality Shales below the Blackbyre Limestone, Renfrewshire, Scotland, Viséan.

Diagnosis S & M 1966, p.268.

Description Amb triangular with concave or convex sides; apices rounded. Suturae indistinct, obscured by ornament. Ornamented with spines and galaea; stand up to 3μ generally, occasionally 5μ; plan view of ornament polygonal, with 5-6 sides; 2μ width. Channels between ornament very regular 0.5μ width. At equator up to 50 spines may project. Proximally laevigate.

Size range 2472 46-47μ (3 spec.); 2025 34-40μ (5 spec.).

Other authors Sullivan & Marshall 1966 36-48μ (12 spec.).

Occurrence Ballycastle.

Previous records Sullivan & Marshall 1966, Viséan of Scotland, Midland Valley, Scotland.

Genus VERRUCOSISPORITES Ibrahim 1933

Type species *V. verrucosus* Ibrahim 1933.

Diagnosis S & B 1967, p.147.

Remarks Difficulty was sometimes encountered in distinguishing between species of this genus and species of *Convolutisporites* and *Camptotriletes*. *Convolutispora* was determined by the dominant appearance of anastomosing ornament, and *Camptotriletes* by the dominance of narrow rugulate ridges.

Verrucosisporites cerosus (H S & M) Butterworth & Williams 1958.

Plate 4, figs. 13 & 14

1955 *Punctati-sporites cerosus* Hoffmeister, Staplin & Malloy, p.392, pl.36, fig.6.

1958 *Verrucosisporites cerosus* (Hoffmeister, Staplin & Malloy), Butterworth & Williams,p.361, pl.1, figs.42,43.

Holotype Hoffmeister, Staplin & Malloy 1955, pl.36, fig.6, Preparation 10, ser. 18, 823.

Type loaclity Shale at 2,071ft. (631.2m), Carter No. 3 Borehole (TCO-82), Webster County, Kentucky, U.S.A.; Hardinsburg Formation.

Diagnosis H S & M 1955, p.392.

Description Amb circular. Leasurae simple, approximately ¾ of spore radius. Verrucae are low, broad and irregular in shape. Usually poorly defined and set close together. Channels narrow to irregular. Exine moderately thick 1.5μ.

Size range 4236 32-70μ (6 spec.); 4205 40-45μ (2 spec.);

Other authors Hoffmeister, Staplin & Malloy 1955 37-53μ; Smith & Butterworth 1967 34-52μ Fu.N.

Occurrence Leitrim.

Remarks Appears similar to V. firmus Loose. Differs from other species by the broad low character of its verrucae. Specimens from this study appear to have a larger size range than that given by Hoffmeister, Staplin & Malloy. The appearance and the relative infrequency of these larger specimens does not seem to warrant the need for them to be accommodated in another species.

Previous records Smith & Butterworth 1967, Viséan & Namurian, Coal Seams of Northern Britain; Love 1960, Scottish Viséan; Butterworth & Williams 1958, Upper Limestone Group, Scotland; Lele & Provan 1962 Ayrshire, Viséan.

Verrucosisporites donarii Potonié & Kremp 1955

Plate 4, fig. 15

Holotype P & K 1955, pl.13, fig.193.

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

Diagnosis P & K 1955, p.67.

Description Amb circular. Suturae indistinct extend $\frac{3}{4}$ of spore radius. Ornamented proximally and distally with regular rectangular shaped verrucae, but can be more irregular in shape; 1(2)4u length, 1(2)3u breadth; stand 0.5-2u. Profile flat or round-topped, sometimes sharply conical. At equator 40-75 may project. Channels distinctly narrow 0.5-1μ wide. Exine 1.5-2μ, rarely folded.

Size range 4206 60-64μ (5 spec.); 4204 65-77μ (7 spec.); 4205 75-77μ (2 spec.); 4236 38-65μ (5 spec.); 4239 50-89μ (5 spec.).

Other authors Smith & Butterworth 1967 43(60)79μ Fu.N; Potonié & Kremp 1955 70μ (Holotype) Schulze.

Occurrence Leitrim.

Remarks Relatively consistent in their appearance, with most specimens occurring between 65 and 77μ. Diverge from the diagnosis only in the number of verrucae projecting at equator. Distinguished from V. microtuberosus by larger verrucae.

Previous records Numerous authors have recorded this species from the Namurian and Westphalian.

Verrucosisporites microtuberosus (Loose) Smith & Butterworth 1967.

Plate 4, figs. 17 & 18

1932 Sporonites microtuberosus Loose in Potonié, Ibrahim & Loose, p.45o, pl.18, fig.33.

1934 Tuberculati-sporites microtuberosus Loose, p.147.

1944 Punctatisporites microtuberosus (Loose), Schopf, Wilson & Bentall, p.31.

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

1955 Microreticulatisporites microtuberosus (Loose) Potonié & Kremp, p.100, pl.15, figs. 173-7.

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

Holotype P & K 1955, pl.15, fig.273 after Loose.

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

Diagnosis S & B, 1967, p.150.

Description Amb oval, circular or sub-circular. Often folded. Suturae not often visible; ½ spore radius. Ornamented distally and proximally by low small verrucae, 0.5(1)2μ diameter; stand 0.5-1.5μ. Closely pointed. At equator 60-100 may project.

Size range 4249 30-70μ (10 spec.); 4236 56-70μ (6 spec.); 4204 70-75μ (6 spec.); 2472 45-70μ (7 spec.); 2480 & 2479.

Other authors Potonié & Kremp 55-85μ Schulze; Smith & Butterworth 55(72)84μ H_2O_2.

Occurrence Ballycastle and Leitrim.

Remarks Size range agrees well with Smith & Butterworth, as most specimens occurred between 65-72μ. V. microtuberosus differs in having smaller verrucae and more oval amb, which is frequently folded. Specimens from Ballycastle and Leitrim very similar. Occurrence frequent.

Previous records Mishell 1966, Bowland Fells, Westphalian A; Loboziak 1969, Westphalian A, France; Grebe 1972, Ruhr, Germany, Middle Westphalian B - Upper Westphalian C.

Verrucosisporites microverrucosus Ibrahim 1933

Plate 4, fig. 19

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

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

1950 Verrucoso-sporites microverrucosus (Ibrahim), Knox, p.318, pl.17, fig.228.

Holotype P & K 1955, pl.13, fig.200 after Ibrahim.

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

Diagnosis Ibrahim 1933, p.25.

Description Amb circular, oval, or rarely rounded triangular. Suturae simple ½-⅔ of spore radius; not often observed. Ornamented distally and proximally with irregularly shaped verrucae. They vary considerably in plan view, but are usually bluntly conical, or flat-topped in profile. Diameter 2-8μ, stand 0.5(1.5)2.5μ. At equator 20-40 project. Channels are distinctly irregular and wide areas of between 5 and 15μ are common between verrucae. Exine thickness 1-2μ, occasionally folded.

Size range 4204 47-74μ (6 spec.); 4249 38-53μ (6 spec.); 2472 45-83μ (10 spec.); 2481 62-82μ (9 spec.); 2479 70-75μ (5 spec.).

Other authors Potonié & Kremp 1955 45-75u Schulze; Horst 1955 36-80μ.

Occurrence Ballycastle and Leitrim.

Remarks Specimens showed much variety, and their visual appearance is often very different due to the variety displayed in the plan view of the verrucae. Distinguished from other species by their irregular distribution and shape of verrucae. Size range in this study displays normal curve distribution.

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

Verrucosisporites morulatus (Knox) Smith & Butterworth 1967

Plate 4, fig. 16

1948 Type 20K Knox, fig.23.

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

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

Lectotype Pl.5, fig.15 after Knox.

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

Diagnosis Smith & Butterworth 1967.

Description Amb circular or oval. Suturae $\frac{1}{2}$-$\frac{2}{3}$ of spore radius, simple. Ornamented proximally and distally with verrucae, evenly distributed and appear quite close together 3-4μ apart. Shows reduction in contact area. Profile displays characteristic terminal expansion; in plan usually circular but those with terminal expansion may show polygonal plan; stand 3-4μ; diameter 3-5μ; at equator 40-60 may project.

Size range 2472 55-70μ (5 spec.); 4249 48-63μ (8 spec.).

Other authors Butterworth & Williams 1958 50-80μ 5% KOH.

Occurrence Ballycastle and Leitrim.

Remarks Distinguished from V. nodosus by its larger size. Specimens in this study show more verrucae projecting at equator, but otherwise conform to diagnosis. Occurrence infrequent.

Previous records Knox 1948, Namurian A, Scotland; Butterworth & Williams 1958, Namurian A, Scotland; Neves 1961, Namurian, Southern Pennines; Mishell 1966 (thesis), Namurian A to Lower Namurian B of Bowland Fells and Ingleton Coalfield.

Verrucosisporites nitidus (Naumova) Playford 1963

Plate 5, figs. 2 & 3

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

1956 Lophotriletes aff. grumosus Naumova, Íschenko, p.40, pl.7,fig.74.

1963 Verrucosisporites nitidus (Naumova) Playford pp.13-14, pl.3,figs. 3-6.

1964 Verrucosisporites grumosus (Naumova) Sullivan pp.1252-53, pl.1, figs. 9-15.

Holotype Playford 1963, pl.4, fig.7.

Type locality Petino Beds, Voronezh Region, U.S.S.R. (Upper Frasnian) after Naumova

Diagnosis As given by Naumova 1953, p.57. Amplified by Playford 1963, p.14.

Description Amb circular, oval or rounded triangular. Suturae simple, straight rarely seen; ¾ or more of spore radius. Ornamented by discrete verrucae, closely set, but may appear more widely spaced when corroded; 2-12μ diameter. Plan view may be circular or rounded polygonal; profile rounded; stand 1-1.5μ. At equator 13-19 may project. Exine (plus ornament) 3μ.

Size range 5044 17-70μ (10 spec.); 5040 32-50μ (10 spec.); 1637 35-37μ (3 spec.); 1646 48-50μ (3 spec.).

Other authors Naumova 1953 40-64μ; Ischenko 1956 30-60μ; Playford 1963 28(41)55μ; Clayton 1970 31(38)46μ.

Occurrence Goresbridge, Clew Bay Area, Mayo.

Remarks The ornament of a particular specimencould be observed to be reduced proximally to 2-3μ, a diameter similar to Converrucosisporites parvinodosus. Verrucosisporites congestus Playford 1963; and V. variotuberculatus Sullivan 1968 differ in being larger. Occurrence infrequent.

Previous records Naumova 1953 and Ischenko 1956, Upper Devonian and Lower Carboniferous of the U.S.S.R.; Playford 1963, Horton Group, Mississippian, Canada; Sullivan 1964, Forest of Dean, Tournasian; Johnson & Marshall 1971, Ravenstonedale,Lower Carboniferous; Playford 1971, Bonaparte Gulf Basin, Lower Carboniferous, Australia; Bertlesen 1972, Denmark, Lower Carboniferous; Neves et al. 1973, Lower Carboniferous, Scotland and N. England.

Verrucosisporites nodosus Sullivan and Marshall 1966

Plate 5, figs. 5 & 6

Holotype Sullivan & Marshall, pl.1, fig.20 (1966).

Type locality Shale below Blackbyre Limestone.

Diagnosis Sullivan & Marshall p.269 (1966).

Description Amb commonly circular or oval, rarely rounded triangular. Suturae not very often observed, $\frac{1}{2}$ to $\frac{2}{3}$ of spore radius. Verrucae are low, broad, and show characteristic terminal expansion frequently, otherwise parallel-sided. Stand 2(3.5)6µ high,1(2.3)6µ wide, with circular plan view. Distribution even with slight reduction proximally; spaced 1-2µ apart; 25 to 45 project at the equator.

Size range 2472 34-48µ (4 spec.); 2471 42-48µ (3 spec.); 2478 40-41µ (3 spec.).

Other authors Sullivan & Marshall 1966 34-48µ.

Occurrence Ballycastle.

Remarks Distinguished from V. morulatus in being smaller than 50µ. No specimens of V. nodosus were found in the Leitrim E_2 samples..

Previous records Sullivan & Marshall 1966, Upper Viséan, Midland Valley of Scotland; Neves et al. 1973, Lower Carboniferous, Scotland.

Verrucosisporites papulosus Hacquebard 1957

Plate 5, fig. 4

Holotype Hacquebard 1957 M101, Slide 1, 47.2/108.4.

Type locality Horton Group, Nova Scotia.

Diagnosis Hacquebard 1957, p.311.

Description Amb oval or distorted by folding. Suturae not observed. Ornamented distally and proximally by verrucae rounded in diameter and profile; 1-1.5µ diameter; 1-3µ stand; set regularly 1-2µ apart. At equator 35-50 project. Exine thickness 1-1.5µ.

Size range 5044 70µ; 1637 78µ; 1646 53µ; 1142 61µ.

Other authors Playford 1963 49(57)60µ (50 spec.) -

Occurrence Goresbridge, Mayo and Clew Bay Area, Mayo.

Remarks Distinguished from Verrucosisporites microtuberosus by the smaller number of elevations and more widely spaced verrucae.

Previous records Hacquebard 1957 Lower Mississippian, Horton Groyp, Nova Scotia, Canada; Playford 1963, Lower Mississippian, Horton Group, Nova Scotia, Canada; Varma 1969, Lower Mississippian Horton Group, Nova Scotia, Canada.

Verrucosisporites variotuberculatus Sullivan 1968

Plate 5, fig. 1

Holotype Sullivan 1968, pl.26, fig.2.

Type locality Bracken Bay, Heads of Ayr, (Ref.2830/1860), Tournaisian, 100' (30.5m) above Cementstone Group.

Diagnosis Sullivan 1968, p.121.

Description Amb oval to circular. Suturae simple, $\frac{3}{4}$ of spore radius. Ornamented proximally and distally by verrucae, oval or circular in plan view; 3-7μ broad; low, rounded or flat profile 1-2μ high. Set close together and give impression of a negative reticulum. At equator between 20-24 may project. There is a characteristic reduction of the size of verrucae in the proximal area.

Size range 5044 62-72μ (4 spec.); 1637 73μ; 1142 65μ.

Other authors Sullivan 1968 57(72)90μ (45 spec.).

Occurrence Goresbridge, Mayo and Clew Bay area, Mayo.

Remarks V. grumosus (Naumova) Sullivan 1964 resembles V. variotuberculatus but is smaller in size, has a thinner exine and a less distinct trilete mark. V. congestus Playford 1964 has no reduction in size of the verrucae in the proximal area.

Previous records Sullivan 1968, Tournaisian, Scotland.

Genus CONVERRUCOSISPORITES Potonié & Kremp 1954

<u>Type species</u> <u>C. triquetrus</u> (Ibrahim) Potonié & Kremp, 1954.

<u>Converrucosisporites parvinodosus</u> Playford 1963

Plate 5, fig. 7

<u>Holotype</u> Playford 1963, pl.3, figs. 7-9.

<u>Type locality</u> Horton Group, Nova Scotia, GSC loc.6400.

<u>Diagnosis</u> Playford 1963, p.15.

<u>Description</u> Amb oval or rounded trinagular. Suturae simple or occasionally with thin 2μ broad labra; extend $\frac{3}{4}$ of spore radius. Ornamented distally and proximally with rounded or polygonal verrucae; 1-3μ diameter; stand 0.5-1.5μ; low rounded profile. Spacing is quite close, giving impression of a negative reticulum. At equator 30 to 50 may occur. Exine plus ornament 1.5-2μ.

<u>Size range</u> 5044 38-55μ (5 spec.); 5040 30-47μ (7 spec.); 1637 45μ; 1142 41μ.

<u>Other authors</u> Playford 1963 32-51μ.

<u>Occurrence</u> Goresbridge and Mayo.

<u>Remarks</u> Specimens very close to diagnosis. The size range only extends slightly that given by Playford in the upper range.

<u>Previous records</u> Playford 1963, Horton Group, Nova Scotia, Mississippian.

Genus UMBONATISPORITES (Hibbert & Lacey)Clayton 1970

<u>Type species</u> <u>U. variabilis</u> H & L, 1969.

<u>Diagnosis</u> Clayton 1970, p.591.

<u>Remarks</u> Emended by Clayton to permit the inclusion of the morphographically related forms <u>U. abstrusus</u> (Playford) Clayton 1970, and <u>U. distinctus</u> Clayton 1970.

Umbonatisporites distinctus Clayton 1970

Plate 5, figs. 8 & 9

Apiculatisporites sp. Balme p.28, pl.4, figs.10,11.

Holotype Clayton 1970, pl.4, figs. 4; 5, & 6.

Type locality Birnieknowes Borehole 1305' (397.7m.), Calciferous Sandstone Measures, Cockburnspath.

Diagnosis Clayton 1970, p.591.

Description Amb sub-circular or rounded triangular. Suturae gape; ½ of spore radius. Ornamented with cylindrical elements 3-5μ high, with either two or three constrictions, surmounted by a spine 1-1.5μ high. Base on which spine sits, appears concave; set 4μ apart. At equator 17-26 may project. Reduction of ornament in contact area. Exine thickness 1μ; colour dark brown.

Size range 5044 43-50μ (3 spec.).

Other authors Clayton 43(65)87μ Fu.N.

Occurrence Goresbridge.

Previous records Clayton 1970, Calciferous Sandstone , Cockburnspath, Scotland; Neves et al. 1973, Lower Carboniferous, Scotland.

Genus WALTZISPORA Staplin 1960

Type species W. lobophora (Waltz) Staplin 1960.

Diagnosis Staplin 1960, p.18.

Remarks Spores of this genus are characterized by the tendency to display angular junctions between radial and interradial areas of the amb, and may show tangential expansion here. (See genus Leiotriletes).

Waltzispora polita (Hoffmeister, Staplin & Malloy)
Smith & Butterworth 1967
Plate 5, fig. 10

1955 Granulatisporites politus Hoffmeister, Staplin & Malloy, p.389, pl.36, fig.13.

1960 Leiotriletes politus (H.S. & M.) Love, p.111, pl.1, fig.1.

1967 Waltzispora polita (H.S. & M.) Smith & Butterworth, p.159, pl.6, fig.14.

Holotype Hoffmeister, Staplin & Malloy 1955, pl.36, fig.13.

Type locality Shale at 2,077ft. (633m.) Carter No. 3 Borehole (TCO-82) Webster County, Kentucky, U.S.A., Hardinsburg Formation, Chester Series.

Diagnosis Hoffmeister, Staplin & Malloy 1955.

Description Amb triangular with straight to concave sides; apices may show characteristic abrupt junctions, or tangential expansion, between the spore apices and interradial margins; apices width 15-22μ. Suturae distinct, straight extending over ¾ of spore radius. Exine laevigate; thickness 1-1.5μ.

Size range 2476 28-40μ (10 spec.); 2481 37-45μ (5 spec.); 2471 29-35μ (3 spec.); 2478 33-47μ (9 spec.); 2480 32-41μ (3 spec.).

Other authors H. S. & M. (1955) 26-38μ (Holotype 37.5μ); Sullivan & Marshall (1966) 26(32)37μ (30 spec.).

Occurrence Ballycastle only.

Remarks Size range in this study extends that given in diagnosis.

Previous records Hoffmeister, Staplin & Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois & Kentucky, U.S.A.; Love 1960, Lower Oil Shale Group, Scotland, Viséan; Sullivan & Marshall 1966, Viséan of Scotland, Midland Valley.

Waltzispora planiangulata Sullivan 1964

Plate 5, figs. 1 & 12

Holotype Sullivan 1964, pl.57, fig.26.

Type locality Drybrook Sandstone, Forest of Dean, Gloucestershire, Viséan.

Diagnosis Sullivan 1964, p. 362.

Description Amb concave triangular; apices round, broad, angular and frequently expanded. Suturae distinct, straight and variable in length; ½ to ¾ of spore radius. Ornamented with grana up to 1μ high, on the distal surface only. Profile may be rounded or rarely pointed. Approximately 40-50 project at equator. Exine thickness 1-1.5μ.

Size range 2476 31-40μ (8 spec.); 2471 32μ; 2478 34-45μ (5 spec.); 2479 40μ; 2480 35-40μ (5 spec.); 4236 35-45μ (10 spec.); 4249 31μ.

Other authors Sullivan 1964 30(38) 45μ (43 spec.).

Occurrence Ballycastle and Leitrim.

Previous records Sullivan 1964a, Drybrook Sandstone (Viséan) of Forest of Dean, Gloucs.; Mishell 1966 (thesis), Naumrian A to B of Bowland Fells & Ingleton Coalfield.

Genus PULVINISPORA Balme and Hassell 1962

Type species P. depressa Balme & Hassell.

Diagnosis Balme & Hassell 1962, p.10.

Pulvinispora scolecophora Neves & Ioannides 1974

Plate 5, fig. 13

Holotype Neves & Ioannides 1974, M.P.K. 689, pl.9.

Type location 2504'9" (763.45m) Spilmersford Borehole, E. Lothian, Lower Carboniferous.

Diagnosis Neves & Ioannides, p.74.

Description Amb triangular with rounded apices. Suturae usually distinct, straight, extending almost to equator, with clear curvaturae. Characteristic folds or wrinkles of the exine occur which appear to be restricted to the central area. Equatorial cingulum 3μ wide.

Size range 3101 32-35μ.

Other authors Butcher 1974 (thesis) 35(41)48μ.

Occurrence Donegal.

Remarks Specimens appeared to conform to diagnosis. It is interesting to note that in the Namurian sample 4236, a number of these types occurred, which were a part of a probably reworked Lower Carboniferous assemblage.

Previous records Neves & Ioannides 1974, Spilmersford Borehole, E. Lothian, Lower Carboniferous.

Infraturma MURONATI Potonié & Kremp 1954

Genus CAMPTOTRILETES (Naumova) Potonié & Kremp 1954

Type species *C. corrugatus* (Ibrahim) P.& K. 1954.

Diagnosis P. & K. 1954, p.142.

Remarks Distinguished from *Verrucosisporites* by narrow rugulate nature of ornament. *Convolutispora* has more rounded profiles to the muri.

Camptotriletes corrugatus (Ibrahim) Potonié & Kremp 1955

Plate 5, fig. 14.

1933 *Reticulati-sporites corrugatus* Ibrahim pp. 35-6, pl.V, fig. 41.

1944 *Punctati-sporites corrugatus* (Ibrahim) Schopf, Wilson & Bentall, p.30.

1950 *Microreticulati-sporites corrugatus* (Ibrahim) Knox, p.320, pl.18., fig.238.

1955 *Camptotriletes corrugatus* (Ibrahim) Potonié & Kremp, pp. 104-5, pl.16, figs. 289-290.

Holotype Ibrahim 1933, pl.V, fig. 41.

Diagnosis Ibrahim 1933, pp.35-36.

Description Amb oval to circular. Suturae relatively long and simple extending over ¾ of spore radius. Ornament of densely set ridges 2-3μ wide, rising 1-2μ with blunt, rounded verrucae, standing up to 4μ, which tended to be more developed on the distal surface. Channels between ridges narrow.

Size range Leitrim material generally 50-70μ (15 spec.).

Other authors Ibrahim 1933. 40-50μ.

Occurrence Leitrim.

Remarks Camptotriletes bucculentus (Loose) Potonié & Kremp 1955, has more widely set ornament. C. verrucosus Butterworth & Williams 1958, has a finer grade of ornament. Restricted to Leitrim material. Occurrence infrequent.

Previous records Ibrahim 1933, Upper Horster Beds, Westphalian B; Knox 1950, Coals of Carboniferous Age; Potonié & Kremp 1955, Ruhr Coalfield, Germany, Westphalian B - C.

Camptotriletes cristatus Sullivan & Marshall 1966

Plate 5, fig. 6

Holotype Sullivan & Marshall 1966, pl.1, fig.25.

Type locality Lady Ann Coal, Scotland, Viséan.

Diagnosis Sullivan & Marshall 1966, p.270.

Description Amb circular, oval or rounded triangular. Suturae simple, distinct, and sometimes slightly gaping; ¾ of spore radius. Ornament of short spinose ridges, usually densely set or narrowly tapered; 1.0(3)5μ high, 30-50 occurring at equator. Width of ridges 2-5μ, usually well defined, and rarely reduced to single spinose elements. Exine yellow to brown, 1-2μ thick. Based on 2478.

Size range 2476 40-50μ (5 spec.); 2478 38-51μ (10 spec.); 2482 46-51μ (7 spec.); 2480 40-55μ (5 spec.).

Other authors Sullivan & Marshall 1966 32(40)45μ; Neville 1968 32(40)45μ.

Occurrence Ballycastle.

Remarks Occurrence is restricted to Ballycastle material where it is frequent and consistent in appearance. Specimens do not lack the connecting ridges, leaving just the spinose elements as described by Neville 1968. Distinguished from Camptotriletes verrucosus Butterworth & Williams, by more spinose profile of the ridges, and their greater number at equator. A published comparison is not available between these two species and so in this study the division is taken at 30 elevations at the equator.

Previous records Sullivan & Marshall 1966, Western Midland Valley, Scotland, Upper Viséan; Neville 1968, East Fife, Scotland, Upper Viséan; Neves, Gueinn, Clayton, Ioannides & Kruzewska 1973, East Fife, Scotland, Upper Viséan.

Camptotriletes verrucosus Butterworth & Williams 1958

Plate 5, figs. 17 - 19

Holotype Butterworth & Williams 1958, pl.2, fig. 2.

Type locality Seam at 2851'3" (869.2m) (Upper Blackbird), Monkton House Bore, Limestone Coal Group, Namurian.

Diagnosis Butterworth & Williams 1958, p.368.

Description Amb almost always rounded triangular, only occasionally circular or oval. Suturae simple, ⅔-¾ spore radius. Ornament of densely set, round-topped, low, conical ridges; height 1-1.5μ, rarely more, often blunted and verrucose in profile; spacing 4-9μ apart, number at equator 22-44. Distally the arrangement of the ridges appears almost concentric giving a 'rosette' appearance. Occasional signs of an imperfect reticulation.

Exine thickness 1.5µ. Based on 2472.

Size range 4236 55-63µ (10 spec.); 2472 40(50)57µ (24 spec.); 2480 50(50)58µ (7 spec.); 2478 32(50)58µ (10 spec,).

Other authors 1958 Butterworth & Williams 40(53)65µ; 1964 Playford 55-71µ; 1966 Mishell 39-63µ.

Occurrence Ballycastle and Leitrim.

Remarks Specimens are sometimes abundant both in Leitrim and in Ballycastle, where they are similar in dimensions and appearance. A variation occurs in samples 2479 and 2480 where specimens are coarser and there are fewer elevations at the equator (16-25) and the profile of the elements is more blunted, reaching 2.5-5µ. These specimens have features in common with Apiculatisporis abditus (Loose) Potonié & Kremp 1955. C. verrucosus differs from C. cristatus Sullivan & Marshall 1966 in the fewer elevations at the equator, the broader channels, and the lower ridges which are more blunt in profile. C. corrugatus (Ibrahim) Potonié & Kremp is distinguished by its coarser ornament, and C. bucculentus (Loose) Potonié & Kremp, by its more widely spaced and coarser ornament. Dictyotriletes varioreticulatus Neves, has a more regular reticulum.but otherwise the grade of ornament is very similar. Occurrence frequent.

Previous records Butterworth & Williams 1958, Limestone Coal Group, Scotland, Namurian A; Neves 1961, Southern Pennines, Lower Namurian A; Playford 1964, Horton Group, Eastern Canada, Mississippian.

Genus CONVOLUTISPORA Hoffmeister, Staplin & Malloy 1955

Type species C. florida H.S. & M. 1955.

Diagnosis H.S. & M. 1955, p.384.

Remarks See 'remarks' for genera CAMPTOTRILETES and VERRUCOSISPORITES. Considerable intraspecific gradation was observed in all parts of the

Carboniferous in this study. Boundaries between certain species become sometimes arbitrary e.g.: C. jugosa and C. varicosa. Secarisporites differs in having larger, laterally overlapping and fusing lobate elements in the form of a discontinuous rim.

Convolutispora ampla Hoffmeister, Staplin & Malloy 1955.
Plate 6, fig. 7

Holotype H.S. & M. 1955, pl.38, fig. 12.

Type locality U.S.A., Kentucky, Christian County, Kelly Quadrangle, Mississippian, Chesterian, Homburg Group, Hardinsburg Formation.

Diagnosis H.S. & M. 1955, p.384.

Description Amb circular, occasionally oval and only once rounded triangular. Suturae usually indistinct $\frac{1}{2}$ - $\frac{2}{3}$ spore radius; sometimes rays not all of same length. Ornamentation of crowded verniculae and anastomosing ridges, plan shape commonly 'amoeboid', lacunae rare. Muri width 1-4μ, average 1.5-2.5;height 0.5-1μ, only rarely higher. Usually short in length, 2-5μ average, but sometimes larger, (10-15μ.). Channels variable, narrow, 0.5-1μ, or more widely set, or irregular. Number of elevations at equator 40-90. Profile conical or flat-topped. Exine 2-3μ thickness.

Size range 4236 60-90μ (10 spec.); 4249 30-72μ (18 spec.); 2472 80-88μ (7 spec.).

Other authors 1955 Hoffmeister, Staplin & Malloy (40-75μ); 1967 Smith & Butterworth 52-89μ F. Nitric.

Occurrence Ballycastle and Leitrim.

Remarks The size range extends that given by Hoffmeister, Staplin & Malloy 1955 as specimens occur down to 31μ, which is 9μ less. The characteristics of these specimens are no different to those greater in size, and do not form any particular peak of abundance in this low range. Thus no significance is given here to this discrepancy. Ballycastle specimens had a more round profile to their ornament. Occurrence frequent.

Previous records H.S. & M. 1955, Hardinsburg Formation of Illinois & Kentucky, Mississippian; Love 1960, Viséan of Scotland; Butterworth & Williams 1958, Limestone Coal Group & Upper Limestone Group of Scotland, Namurian A; Smith & Butterworth 1967, Coals of Great Britain, Namurian; Owens 1963 (thesis), Stainmore, Namurian A; Mishell 1966 (thesis) Bowland Fells and Ingleton Coalfield, Namurian A to Lower Namurian B.

Convolutispora circumvallata Clayton 1970

Plate 6, fig. 1

Holotype Specimen ML 809, Sample 5 (Birnieknowes Bore, depth 1259'5")

Type locality Lower Calciferous Sandstone Measures, Cockburnspath, Scotland, Lower Carboniferous.

Diagnosis Clayton 1970, p.582.

Description Amb circular, Suturae indistinct, straight; over ¾ of spore radius. Ornamented proximally and distally by rounded, anastomosing muri, some of which fuse together to form occasional lumina. They are variable in width and may have expanded tops; stand 3-4μ high; 4-5μ side. Approximately 19-21 may project at equator. Channels between muri are irregular in width and usually wider than the muri themselves.

Size range 5040 65-87μ (6 spec.).

Other authors Clayton 1970 64(90)112μ (33 spec.); Clayton 1970 71(89)107μ (30 spec.).

Occurrence Goresbridge.

Remarks Specimens in the present study conform to the diagnosis given by Clayton (1970) but they would appear to be on the small side when compared with his size ranges. Distinguished from Convolutispora cf. circumvallata by the thicker muri which range upwards from 3u; otherwise the fragmented reticulate nature of C. cf. circumvallata is very similar.

Previous records Clayton 1970, Lower Carboniferous, Cockburnspath, Scotland; Bertlesen 1972, Lower Carboniferous, Denmark.

Convolutispora cf. circumvallata

Plate 6, figs. 2 & 3

Description Amb circular or sub-circular. Suturae simple, straight, extend nearly full length of spore radius. Ornamented proximally and distally with rounded, anastomosing muri, some of which fuse to form lumina. The muri are characterized by expanded apices; stand 2-5μ high; 1-3μ in width; lumina 3-10μ wide, often polygonal in shape. Channels are irregular in width and wider than muri. Approximately 26-30 muri may project at the equator.

Size range 3101 65-82μ (5 spec.); 5040 62μ (1 spec.); 1637 85-115μ (4 spec.); 1646 63μ (1 spec.). Average ± 80μ.

Occurrence Goresbridge, Donegal and Clew Bay Area, Mayo.

Remarks The width of the muri are similar to Convolutispora finis Love, but in the latter species they are more closely spaced together, and do not appear to form lumina. The presence of lumina suggests a possible assignment to the genus Dictyotriletes, but the majority of specimens do not have sufficiently enclosed lumina to warrant this. C. circumvallata has wider muri, but is otherwise similar.

Convolutispora finis Love 1960

1960 Convolutispora finis Love, p.115, pl.1, fig.7 and text fig.5.

Holotype Love 1960, Pl. 1 fig. 7.

Type locality Pumpherston Shell Bed, South Queensferry.

Diagnosis Love 1960.

Remarks Specimens conform to diagnosis.

Previous records Love 1960, Oil Shale Group, Viséan, Scotland; Smith & Butterworth 1967, Coals of Great Britain, Namurian A; recorded by numerous authors from the Lower Carboniferous.

Convolutispora jugosa Smith & Butterworth 1967

Plate 6, fig. 4

1958 Convolutispora cf. mellita Hoffmeister, Staplin & Malloy; Butterworth & Williams, p.372, pl.2, figs. 21, 21.

Holotype Plate 10, figs. 1,2, Smith & Butterworth 1967.

Type locality 4" (0.09m) coal at 191'3" (58.3m), Darnley No. 3 Borehole, Central Coalfield, Scotland, Namurian A.

Diagnosis Smith & Butterworth, 1967, p.186.

Description Amb circular. Low undulating margin. Suturae simple, straight and extend $\frac{1}{2}$ - $\frac{2}{3}$ spore radius. Ornamented distally and proximally with short anastomosing muri and rugulae, of almost 5μ width. Muri rarely more than 30μ long. Set close together, channels 0.5-1μ wide. Exine plus muri 5.7μ thick; muri rarely project at equator more than 2μ, numbering 24-40. Folded infrequently. Based on 2471.

Size range 2471 95(105)115μ (10 spec.); 4249 100-115μ (5 spec.).

Other authors Smith & Butterworth 1967 84(102)119μ.

Occurrence Ballycastle and Leitrim.

Remarks Difficult sometimes to distinguish from Convolutispora varicosa Butterworth & Williams 1958, since the length of the muri on some specimens can be interpreted as long or short when around 30μ. The consistency of the circular amb shape was a notable feature.

Previous records Smith & Butterworth 1967, Coals of Great Britain, Namurian A.

Convolutispora cf. finis

Plate 6, fig. 17

(Non) 1967 Butterworth & Spinner, pl.1, fig.15.

(Non) 1963 Playford, pl.8, figs. 1, 2.

Description. Amb circular. Suturae simple, indistinct, $\frac{1}{2}$ to $\frac{2}{3}$ of spore radius. Ornamented proximally and distally with rugulae and low sinuous muri 1.5 to 3μ wide; stand 1 to 3μ; profile rounded or pointed. Lumina and channels between, irregular, 1-2μ, but closely set. Exine thickness 2μ.

Size range 5040 70-85μ (5 spec.); 1637 52-90μ (3 spec.)

Occurrence Goresbridge and Clew Bay Area, Mayo.

Remarks Specimens display features in common with Convolutispora ampla and Convolutispora finis. The latter species differs in having finer, more closely set ornament of muri 1-2μ wide. C. ampla has less sinous muri, more regularly and evenly distributed.

Convolutispora florida Hoffmeister, Staplin & Malloy 1955

Plate 6, figs. 14, 15 & 16

Holotype H.S. & M. 1955, pl.38, fig.6.

Type locality Shale at 2,086ft. (635.8m), Carter No. 3 Borehole, Webster County, Kentucky, U.S.A., Hardinsburg Formation, Chester Series.

Diagnosis H.S. & M. 1955, p.384.

Description. Amb circular to sub-circular. Suturae extend $\frac{2}{3}$ of spore radius. Ornamented proximally and distally, with muri 3-6μ wide, rounded in profile; stand 3-4μ at equator. Channels between muri narrow 1μ. Approximately 10-15 elevations at equator.

Size range 2472 42-53μ (10 spec.).

Other authors H.S. & M. 1955 39-50μ; Smith & Butterworth 36(47)56μ (15 spec.) ($Fu.HNO_3$).

Occurrence Ballycastle.

Convolutispora superficialis Felix & Burbridge 1967

Plate 7, fig. 1

Holotype F & B 1967, pl.57, fig.2.

Type locality Springer Formation, slide 03U16 - 11(5) Location 40x28 (Ref. 32.6 x 117.8).

Diagnosis F & B 1967, p.373.

Description Amb circular to sub-circular. Suturae straight $\frac{2}{3}$ - $\frac{3}{4}$ of spore radius; sometimes slight lip development. Ornamented with low, poorly defined muri; stand 0.5µ. Lumina occasionally defined, 3u x 12µ. Exine relatively thick 3-4µ.

Size range 2481 47-62µ (5 spec.); 2482 50µ; 2480 63µ; 2476 72µ; 2478 57µ; 2479 65µ; 2471 60µ.

Other authors. Felix & Burbridge 1967 54-80µ.

Occurrence Ballycastle.

Remarks Can be relatively frequent in some samples. This type may show some morphological gradation with Dictyotriletes insculptis.

Previous records Felix & Burbridge 1967, Springer Formation, Oklahoma, U.S.A.

Convolutispora tessellata Hoffmeister, Staplin & Malloy 1955

Plate 5, figs. 6 & 8 - 13

Holotype Hoffmeister, Staplin & Malloy 1955, pl.38, fig.9.

Type locality Shale at 2087-8' (636.3m) Carter No. 3 Borehole (TCO-82), Webster County, Kentucky, U.S.A., Hardinsburg Formation, Chester Series.

Diagnosis H.S. & M. 1955, p.385.

Description Amb circular, oval or rarely rounded triangular. Suturae often indistinct, usually short, about $\frac{1}{2}$ or occasionally $\frac{2}{3}$ spore radius. Ornament of relatively closely packed anastomosing verrucae and ridges;

plan view often 'amoeboid' in character, but also some more vermiculate muri; width can vary from 1-5μ, average 2-3μ, length 2-15μ, commonly 5-10μ. Channels are irregular, only occasionally narrow; profile at equator rounded or flat-topped. Number of elevations at equator, 20(38)45μ. Exine thickness without ornament 1-5-3μ.

Size range 4236. 60-78μ (9 spec.); 4207 70-73μ (7 spec.); general 53-78μ (22 spec.);

Other authors. Hoffmeister, Staplin & Malloy 40-75μ.

Occurrence Ballycastle & Leitrim.

Remarks Size range agrees closely with type material, most specimens fall between 60-70μ. Distinguished from Convolutispora ampla Hoffmeister, Staplin & Malloy 1955 by its coarser grade of ornament. C. tuberculata Hoffmeister, Staplin & Malloy, is probably synonymous. Occurrence frequent.

Previous records Love 1960, Viséan rocks of Scotland; Smith & Butterworth 1967, Coals of Great Britain, Namurian A; Butterworth & Williams 1958, Limestone Coal Group & Upper Limestone Group, Namurian A, Scotland; Hoffmeister, Staplin & Malloy 1955, Hardinsburg Formation of Illinois & Kentucky, U.S.A., Mississippian; Staplin 1960, Golata Formation, Alberta, Canada, Upper Mississippian; Owens 1963, Stainmore, Namurian A to Namurian B; Mishell 1966 (thesis), Bowland Fells & Ingleton Coalfield, Middle Namurian -C.

Convolutispora usitata Playford 1962

Holotype Playford 1962, pl.9, fig.9.

Type locality Triungen (sample G1470), Spitzbergen, Lower Carboniferous.

Diagnosis Playford 1962, p.595.

Convolutispora cf. usitata

Plate 7, figs. 2 & 3

Description Amb circular or subcircular. Suturae simple, straight or slightly curved; approximately $\frac{3}{4}$ of spore radius. Ornamented proximally and distally with low 0.5-1μ, closely spaced muri. Muri 2-6μ in width; at equator 20-30 may project. Lumina very small 0.5 - 1μ.

Size range 2481 43-62μ (5 spec.); 2472 40-50μ (5 spec.); 2478 39-57μ (5 spec.).

Occurrence Ballycastle.

Remarks Muri may give an angular impression in plan view. Very similar to description given by Smith & Butterworth,and differs in the same way from Convolutispora usitata by being smaller.

Convolutispora varicosa Butterworth & Williams 1958

Plate 6, fig. 5

Holotype Plate 10, figs.4, 5. Butterworth & Williams 1958.

Type locality Ashfield Coking Seam at 1,717ft5" (523.5m), Queenslie Bridge Borehole, Central Coalfield, Scotland, Namurian A.

Diagnosis Butterworth & Williams 1958, p.372.

Description Amb oval to circular, irregular margin of projecting muri. Suturae simple,half of spore radius, often indistinct. Distally and proximally ornamented with long, sinuous, branching muri 2-4.5μ wide, projecting 2-3μ at equator. Occasional verrucae 4x4μ diameter. Channels wide and irregular. Lumina rare, 10-20μ diameter. Elevations at equator 29-32. Based on 2249.

Size range 4249 55-85μ (9 spec.).

Other authors Butterworth & Williams 1958 77(101)140μ; Mishell 1966 77μ.

Occurrence Ballycastle and Leitrim.

Remarks Two specimens show some similarities to Convolutispora jugosa Smith & Butterworth 1967, having shorter muri around 30μ, but distribution and spacing is more in character with C. varicosa. Size range extends slightly lower than that given by Butterworth & Williams. Occurrence infrequent.

Previous records Butterworth & Williams 1958, Limestone Coal Group & Upper Limestone Group, Scotland, Namurian A; Smith & Butterworth 1967, Coals of Great Britain, Namurian A; Love 1960, Viséan of Scotland; Owens 1963 (thesis), Stainmore, Upper Namurian A; Neves 1964, La Camocha Mine, Gijon, N. Spain, Namurian A; Mishell 1966(thesis) Bowland Fells & Ingleton Coalfield, Lower Namurian A.

Genus CORBULISPORA Bharadwaj and Venkatachala

Type species C. retiformis B. & V, p.24.

Diagnosis B.& V.1961, p.64.

Remarks This genus is characterized by its reticulate ornament and the presence of prominent labra.

Corbulispora cancellata Bharadwaj & Venkatachala 1961

1938 Azonotriletes cancellatus Waltz in Luber & Waltz,p.11,pl.1, fig.8 and pl.5, fig.73.

1955 Sphenophyllotriletes cancellatus (Waltz) Luber pp.41-2, pl.4, figs.78a,b, & 79.

1955 Dictyotriletes cancellatus (Waltz) Potonié & Kremp, p.108.

1956 Dictyotriletes cancellatus (Waltz) Ischenko p.45,pl.7,figs.88,89.

1957 Dictyotriletes cancellatus (Waltz) Naumova); Kedo p.166.

1957 Reticulatisporites varioreticulatus H & B, p.17,pl.2,figs.15 & 19.

1961 Corbulispora cancellata Bharadwaj & Venkatachala, p.25.

1962 Reticulatisporites cancellatus (Waltz) Playford pp. 597-8, pl.182, figs. 11-13 amd pl.83, figs. 1 & 2.

1964a Corbulispora subalveolaris (Luber) Sullivan, p.1253, pl.1,figs.16-20.

1969 Dictyotriletes cancellatus (Waltz) Potonié & Kremp; Hibbert & Lacey, p.427, pl.79, fig. 11.

Holotype Luber & Waltz 1938, pl.1, fig. 8.

Type locality Verkoni-Goubakine Mine, Kizel Region, U.S.S.R., Lower Carboniferous.

Diagnosis Playford 1962, p.597.

Corbulispora cf. cancellata

Plate 7, figs. 4 - 6

Description Amb circular. Suturae $\frac{2}{3}$ to over $\frac{3}{4}$ of spore radius; usually simple and not accompanied by labra. Ornamented proximally and distally with muri 1.5(2)2.5µ width; stand 1(3)4µ high. Form regularly shaped lumina generally plygonal; 6(9)12µ diameter. At equator between 16 and 22 elevations may be found. Exine 2µ.

Size range 2471 60(80)90µ (20 spec.).

Other authors 1974 Clayton 45-74µ (For C. cancellata).

Occurrence Ballycastle.

Remarks The specimens in this study differ from many descriptions of C. cancellata in that labra are included as accompanying the suturae. They also differ in that the muri are consistently thinner than the range of thickness given by Playford 1962 (2.5-6.5µ). The specimens were very abundant in one sample i.e.: sample 2471.

Genus DICTYOTRILETES (Naumova) Smith & Butterworth 1967

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

Diagnosis S & B 1967, p.194.

Remarks Distinguished from Reticulatisporites by Neves 1964 to include only spores with differentially thickened cingulum and distal reticulate sculpture.

Dictyotriletes castanaeformis (Horst) Sullivan 1964

Plate 7, figs. 7 - 9

1943 Aletes castaneaeformis Horst (thesis) p.124, fig.82.

1955 Reticulatisporites castaneaeformis (Horst), Potonié & Kremp;Horst,p.169.

1964 Dictyotriletes castaneaeformis (Horst); Sullivan, p.367.

Holotype Horst 1955, pl.24, fig.82.

Type locality Peterswalder Seam, Eugen Colliery, Moravska-Ostrava, Namurian A.

Diagnosis Horst 1955, p.169.

Description Amb rounded to oval. Suturae indistinct, $\frac{3}{4}$ of spore radius. Ornamented with irregularly reticulate muri, stand 1-2μ; 1u wide. Lumina irregular in shape when complete; 3-6μ diameter. At equator 11-20 may project.

Size range 2472 25-33μ (10 spec.); 2471 30-34μ (5 spec.); 2480 35u (1 spec.); 3128 28μ (1 spec.).

Other authors Horst 1955 11-29μ Fu.HNO_3; Smith & Butterworth 1967 21(26)32μ Fu.HNO_3.

Occurrence Ballycastle and Mayo.

Remarks Size range slightly extends that of Horst and Smith & Butterworth in the upper range. Generally relatively infrequent.

Previous records Horst 1955; Potonié & Kremp 1955, Upper Westphalian B to lower Westphalian C, Ruhr Coalfield of Germany.

Dictyotriletes falsus Potonié & Kremp 1955

Plate 7, fig. 15

Holotype Potonié & Kremp 1955, pl.16, fig.303.

Type locality Ägir Seam, Friedrich Thyssen 2/5 (Wehofen) Colliery, Ruhr Coalfield, Germany, top of Westphalian B.

Diagnosis P. & K. 1955, p.109.

Description Amb outline approximately circular; modified by projecting muri. Suturae straight, simple. Muri 2-2.5μ wide; project at equator 2μ. At equator 10-17 may project. Profile rounded. Lumina 10-25u.

Size range 2476 52μ; 2478 56μ; 2482 62μ;2472 47-55μ (5 spec.).

Other authors Potonié & Kremp 45-55μ (Schulze); Smith & Butterworth 40(46)52μ Fu.HNO_3.

Occurrence Ballycastle and Donegal.

Remarks The above specimens closely conform to the previous descriptions of this species.

Previous records Potonié & Kremp 1955, Mid Westphalian B to Mid West.C; Dybova and Jachowicz 1957, Westphalian B-C, Upper Silesia; Love 1960, Lower Oil Shale Group, Scotland; Owens 1963, Upper Namurian A to Namurian B, Stainmore; Mishell 1966, Namurian of Bowland Fells; Smith & Butterworth 1967, Westphalian A - C, British Coalfields; Beju 1970, Namurian, Rumania; Grebe 1972, Ruhr, Germany, Lower Westphalian B - Upper Westphalian C.

Dictyotriletes fragmentimurus Neville 1973

Plate 8, figs. 2 & 5

Holotype Neves et al 1973, pl.1, fig.12.

Type locality Sample F61, grey shales from just above 1'2" (0.35m) irony limestone at 400' (121.9m) in the section between the fault in West Bay, Pitterween and the fairway into Pitterween Harbour.

Diagnosis Neves et al. 1973, p.33.

Description Amb circular to oval. Suturae indistinct, simple. Muri form an irregular broken reticulum; muri 1-2µ wide; stand 3.5-4.5µ. Lumina rarely delimited 2-5µ diameter. At equator 20-40 may project.

Size range 2481 28-60µ (5 spec.); 2478 56µ.

Other authors Neves et al. 1973 22(37.5)48µ (20 spec.); Neves et al. 1973 22-56µ (overall).

Occurrence Ballycastle.

Remarks The muri on some specimens approached the appearance of cristate ridges, more similar to Camptotriletes. It became difficult to distinguish from the latter genus when the reticulum became very fragmented.

Previous records Neves et al. 1973, Lower Carboniferous of Scotland & Northern England, Concurrent Range Zones CM to VF.

Dictyotriletes insculptis Sullivan & Marshall 1966

Plate 8, figs. 6 - 8

Holotype Sullivan & Marshall 1966, pl.2, fig.5.

Type locality Shale below Blackbyre Limestone, Renfrewshire, Scotland, Viséan.

Diagnosis S. & M. 1966, p.271.

Description Amb circular. Suturae indistinct, straight, simple; extend ¾ of spore radius. Ornamented distally and equatorially with thin, pale muri 1.5-2µ wide; Lumina 7-10µ, stand 1-2µ high. At equator 18-21 may project. Exine thickness 2µ.

Size range 2471 50-55µ (5 spec.); 2472 45µ.

Other authors Sullivan & Marshall 1966 38(46)52µ (17 spec.); Felix & Burbridge 1967 39-60µ.

Occurrence Ballycastle.

Remarks These specimens compare very well with the Diagnosis. Their occurrence is relatively rare, and is restricted to two samples in the Ballycastle material. The nature of the muri may give at the equator the appearance of a flange in some specimens.

Previous records Sullivan & Marshall 1966, Shale below the Blackbyre Limestone, Renfrewshire, Scotland, Viséan; Felix & Burbridge 1967, Springer Formation, Oklahoma, U.S.A.

Dictyotriletes pactilis

Sullivan & Marshall 1966

Plate 7, fig. 14

1960 Reticulatisporites type B

Holotype Sullivan & Marshall 1966, Plate 2, figs. 3 - 4.

Type locality The Shale below the Blackbyre Limestone of Scotland.

Diagnosis Sullivan & Marshall 1966, p. 270.

Description The shape of the amb may be circular or occasionally oval. The suturae are usually indistinct. The muri may be up to 1μ thick and may reach up to 12μ in height; They are frequently orientated parallel with the equator. Lumina are often polygonal in shape and the diameter varies from 10μ to 16μ.

Size range 2472 50-60μ (4 spec.).

Other authors Sullivan & Marshall 1966 52(58)63μ (11 spec.).

Occurrence Leitrim and Ballycastle.

Previous records Sullivan & Marshall 1966, Viséan spores, Scotland; Love 1960, Lower Oil Shale Group, Scotland.

Dictyotriletes sagenoformis Sullivan 1964b

Holotype Sullivan 1964b, Plate 59, fig. 5.

Type locality Edgehill Coals of the Forest of Dean, Gloucestershire.

Diagnosis Sullivan 1964b, p. 367.

Dictyotriletes cf. sagenoformis

Plate 8, figs. 3 & 4

Description Shape of amb can be oval or occasionally subcircular. Suturae are usually simple, sometimes straight, and extend approximately two-thirds of the spore radius. The exine is ornamented proximally and distally with muri of 2-2.5µ width, which may project from 6µ to 8µ at the equator. Lumina are usually complete, and only rarely fragmented, and range from 15µ to 25µ in their diameter. The general surface of the exine was laevigate. It was noticeable that the exine in some specimens seemed pale and thin, but this may have been due to the maceration process, which in these cases involved the use of KOH.

Size range 2615 40-65µ (4 spec.).

Other authors Sullivan 1964b 58-73µ, (for D. sagenoformis).

Occurrence Ballycastle.

Remarks It was observed that Dictyotriletes sagenoformis as described by Sullivan (1964b) differed slightly in the following two ways; one, that the size tended to be smaller in comparison, and also that the muri tended to be thinner (this, as stated above, may be the result of the maceration process which involved the use of KOH). Otherwise, the two species have a basically similar appearance.

Dictyotriletes falsus contained thicker muri. Dictyotriletes fragmentimurus had more fragmented lumina.

Occurrence generally infrequent.

Previous records Sullivan 1964b, Edgehhlls Coal, Drybrook Sandstone, Forest of Dean, Gloucestershire; Clayton 1970, Lower Carboniferous, Scotland; Neves et al, Lower Carboniferous, Northern England & Scotland.

Dictyotriletes submarginatus Playford 1963.

Plate 7, figs. 12 & 13

Holotype Playford 1963, pl.8, fig.9.

Type locality Horton Group (Cheverie Formation), Nova Scotia, GSC loc.6407.

Diagnosis Playford 1963, p.29.

Description Amb rounded triangular, frequently distorted by folding. Suturae straight, accompanied by labra which extend to equatorial region. Distally muri reticulate or fragmentary with rugulae.

Size range 1637 57μ (1 spec.);

Other authors Playford 1963 53(62)70μ; Varma 1969 55(45)65μ.

Occurrence Clew Bay area, Mayo.

Remarks Only has two specimens approached the appearance of D. submarginatus and these were in a corroded state. Since however this species is a useful indicator of the Tournaisian stage, they are worth a mention.

Previous records Playford 1963, 1969, Horton Group, Nova Scotia; Hibbert & Lacey 1969, Menai Straits, Lower Carboniferous, N. Wales; Neves et al. 1973, Lower Carboniferous, Scotland & Northern England; Varma 1969, Lower Mississippian, Horton Group, Nova Scotia, Canada.

Dictyotriletes varioreticulatus Neves 1958

Plate 7, figs. 10 & 11

Holotype Neves 1958, pl.2, figs. 1a,b.

Type locality Great Britain, Staffordshire, The Wash, Namurian/Westphalian Boundary.

Diagnosis Neves 1958, p.8.

Description Amb circular to oval. Ridges 1-2μ wide, generally low, rising to a maximum of 1-2µ. Reticulum relatively regular, with shallow lumina 2-4µ diameter. 30-40 equatorial projections. Distally the projections are more developed.

Size ranges General Leitrim material 45-50µ (7 spec.).

Other authors Neves 1958 70-40µ,; Smith & Butterworth 1967, 67(78)89µ Fu.HNO_3.

Occurrence Leitrim.

Remarks Distinguished from species of Camptotriletes by its more regular reticulum. Some specimens from Ballycastle belonging to C. verrucosus Butterworth & Williams in places show development of a reticulum but is not quite regular enough to include them in Dictyotriletes varioreticulatus. Specimens conform to diagnosis/ apart from their much smaller size and are restricted to Leitrim E_2 material. Occurrence infrequent.

Previous records Neves 1959 (thesis) Upper Namurian B to Lower Westphalian A of Southern Pennines; Neves 1964, Namurian B to C of La Comancha Mine, Gijon, Spain; Owens in Owens & Burgess 1965, Upper Namurian A to Westphalian A, of Stainmore; Neves in Neves, Read & Wilson 1965, Namurian C to Westphalian A, Scottish Passage Group; Mishell 1966 (thesis), Bowland Fells and Ingleton Coalfield, Upper Namurian A to Westphalian A.

Dictyotriletes vitilis Sullivan & Marshall 1966

Plate 7, fig. 16

Holotype S & M 1966, pl.2, fig.1.

Type locality Shales below the Blackbyre Limestone of Renfrewshire.

Diagnosis S & M 1966, p.270.

Description Amb irregular outline, varying from rounded to polygonal as it is modified by muri. Suturae straight, simple or occasionally ridged 1-1.5µ. Muri stand from 4.5-10µ, often 4µ thick. Large lumina defined 10-20µ wide. Exine on some specimens appears granulate.

Size range 2478 50μ; 2479 51-62μ; 2480 58μ, 57μ; 2070 70μ.

Other authors Sullivan & Marshall 1966 50-62μ.

Occurrence Ballycastle.

Remarks Specimens in this study compare reasonably with diagnosis, except that in some cases, their size is greater. D. muricatus compares with larger specimens but muri appear thinner in the latter species. Specimens with granulate exines were included in this species since in all other respects they resembled the diagnosis.

Previous records Sullivan & Marshall 1966, shales below Blackbyre Limestone, Viséan, Renfrewshire, Scotland.

Dictyotriletes Sp. A

Plate 8, fig. 9

Description Amb very rounded triangular. Suturae simple, indistinct. Ornamented by muri 1.5-2μ wide, at their narrowest; very low, planar profile; stand 1μ high. Lumina 2(4μ)8μ occasionally incomplete.

Size range 1646 55μ (1 spec.); 1637 40μ, 42μ (2 spec.); 3101 24-39μ (5 spec.).

Occurrence Donegal and Clew Bay Area, Mayo.

Remarks The planar nature of some of the muri suggest an affinity of this spore with the genus Microreticulatisporites, but the fragmented nature of the lumina and the occurrence of more rounded muri indicates a closer relationship to Dictyotriletes.

Dictyotriletes Sp. B

Plate 7, figs. 17 & 18 and Plate 8, fig. 1

Description Amb subcircular or irregular due to folded nature of specimens. Ornamented proximally and distally by relatively thick muri which form an almost regular and complete reticulum. Muri are 4-5μ wide and stand low at equator 2-3μ, making little modification to shape of amb. Lumina 10-20μ. Suturae indistinct.

Size range general size range 70-90μ.

Occurrence Mayo and Goresbridge.

Remarks Some specimens have similarities with Convlutispora cf. circumvallata, but are distinguished by the more regular reticulum. This type also resembles Reticulatisporites cancellatus (Waltz) Playford 1962.

Genus FOVEOSPORITES Balme 1957

Type species F. canalis Balme 1957.

Diagnosis This genus instituted for circular or rounded spores possessing a sculpture of 'pits or short channels irregularly distributed'. Some gradation of this genus with Microreticulatisporites and Convolutispora was observed in the present study.

Foveosporites insculptis Playford 1962

Plate 8, figs. 10 & 11

Holotype Playford 1962 Plate 85, fig. 3.

Type locality Triungen, Spitzbergen, Lower Carboniferous.

Diagnosis Playford 1962, p.601.

Description Amb circular to subcircular, often broken. Suturae $\frac{2}{3}$-$\frac{3}{4}$ of spore radius, indistinct straight. Exine sculptured with regularly distributed punctae and narrow grooves 0.5μ wide, 2-3μ apart which frequently bifurcate. At equator exine 3-4μ and only slightly modified by nature of sculpture.

Size range 4204 80u , 110u , 90u ; 4249 60μ, 50μ, 50μ, 59μ, 60μ, 48μ; 4208 72μ.

Other authors Playford 1962 63(78)97μ.

Occurrence Leitrim.

Remarks Specimens are frequently smaller than type material. Distinguished from Convolutispora cerebra by the fact that the grooves are not continuous enought to produce muri. Microreticulatisporites hortonensis Playford has punctae and grooves of a wider nature in style of lumina. The latter two species do occur as well in the samples and there does seem to be some gradation into one another.

Previous records Playford 1962 Spitzbergen, Lower Carboniferous.

Genus MICRORETICULATISPORITES (Knox) Potonié & Kremp

non sensu Bharadwaj

Type species M. lacunosus (Ibrahim) Knox 1960.

Diagnosis P & K 1954, p.143.

Remarks The broad sense of the description given by Potonié & Kremp is used here, which includes both circular and triangular forms. Bharadwaj delimited the genus to triangular forms.

Microreticulatisporites concavus Butterworth & Williams 1958

Plate 8, fig. 14

Holotype Butterworth & Williams 1958, plate 11, fig.1.

Type locality Seam at 1,872ft.7ins. (570.8m), Righead Borehole, West Fife Coalfield, Scotland, Namurian A.

Diagnosis Butterworth & Williams 1958, p.367.

Description Amb triangular with distinctly concave sides and rounded apices. Suturae indistinct, straight, simple $\frac{1}{2}$ to $\frac{3}{4}$ spore radius; rarely gape. Ornamentation microreticulate, muri 0.5-1.5µ wide, undulating 0.5-1µ. Lumina 0.5µ, rarely greater. Notched equatorial margin, 50-80 muri projecting. Exine 1µ thick.

Size range 4249 31µ (1 spec.); 2472 23-46µ (7 spec.); 2481 39-44µ (5 spec.); 2471 35(36)41µ (10 spec.).

Other authors Butterworth & Williams 1958 30(40)52µ.

Occurrence Ballycastle and Leitrim.

Remarks Specimens showed little variation from the diagnosis except that suturae not restricted to $\frac{2}{3}$ of spore radius. Only one specimen found in Leitrim material, remainder from Ballycastle. Species is distinguished by its concave interradial margin. Occurrence infrequent.

Previous records Butterworth & Williams 1958, Limestone Coal Group and Upper Limestone Group, Namurian A, Scotland; Love 1960, Lower Oil Shale Group, Scotland, Viséan; Smith & Butterworth 1967, Coals of Great Britain, Namurian; Neves 1961, Southern Pennines, Middle Namurian A; Mishell 1966, Bowland Fells and Ingleton Coalfield, Namurian A to base of Namurian B.

Microreticulatisporites hortonensis Playford 1964

Plate 8, figs. 12, 13 & 17

Holotype Playford 1964, pl.8, fig. 3.

Type locality Horton Group, Nova Scotia.

Diagnosis Playford 1964, p.28.

Description Amb generally subcircular. Suturae simple indistinct. Microreticulate sculpture present on both proximal and distal surfaces; lumina 1-3µ, irregular in shape, may be sinuous and thin. Muri broad and planar, generally 3µ wide. About 26 undulations at equator.

Size range 4249 48-52µ (4 spec.); 2471 60µ; 2482 58-63µ (3 spec.).

Other authors Playford 1964 41(49)58µ (25 spec.).

Occurrence Leitrim and Ballycastle.

Remarks Specimens in this study tend to be relatively large, especially those from the Ballycastle material.

Previous records Playford 1964, Horton Group, Nova Scotia, Mississippian.

Microreticulatisporites noblis (Wicher 1934) Knox 1950.

Plate 8, figs. 15 & 16

1934 Sporites nobilis Wicher, 326, p.186, pl.8, fig. 30.

1944 Punctati-sporites nobilis Schopf, Wilson & Bentall, 302,p.31

1950 Microreticulati-sporites nobilis Knox, 193, p.321, pl.XVIII,fig.242.

Holotype Potonié & Kremp 1955, pl.15.

Type loaclity Seam R[1], Wehofen Colliery, Ruhr Coalfield, Germany, Westphalian C.

Diagnosis P & K 1955, p.101.

Description Amb triangular, convex sides, rarely straight; apices rounded. Muri stand 1-1.5µ; lumina regular 0.5-1µ width; muri width 1-2µ. Undulations at equator 30-38. Suturae simple, straight, extend over ¾ of spore radius, often to the margin.

Size range 2476 35-45µ (10 spec.); 2478 36-45µ (6 spec.); 2482 41µ; 2479 36-40µ (5 spec.).

Other authors Loboziak 1969 (thesis) 30-45µ.

Occurrence Ballycastle.

Previous records Guennel 1958, Namurian C to Westphalian B, Lower Brazil Formation, Indiana; Loboziak 1969 (thesis) Westphalian A-C of the Houiller Basin, Northern France; Smith & Butterworth 1967, Westphalian B to C of Great Britain.

Subturma ZONOTRILETES Waltz 1935

Infraturma AURICULATI (Schopf) Dettmann 1963

Genus TRIQUITRITES (Wilson & Coe) Potonié & Kremp 1954

Type species T. arculatus Wilson & Coe 1940.

Diagnosis P & K 1954, p.153.

Remarks The auriculae of Tripartites (Schemel) P & K 1954 are more flange-like and generally larger than those of Triquitrites; they are also crinkled. Ahrensisporites is distinguished by a kyrtome.

Triquitrites bransonii Wilson & Hoffmeister

Holotype Wilson & Hoffmeister, pl.3, fig.1.

Type locality Croweburg Coal, Stewart Mine, Oklahoma, U.S.A.,Des Moines Series.

Diagnosis Wilson & Hoffmeister, p.24.

Triquitrites cf. bransonii

Plate 8, fig. 25 and Plate 9, figs. 1 & 2

Description Amb triangular with concave interradial areas. Suturae simple, extending almost to margin, to the radial crassitudes. Radial crassitudes usually well defined and smooth, often angular at the margins; extend up to 9u onto spore body. Exine otherwise laevigate.

Size range 2612 35-45µ (3 spec.); 2615 35µ.

Other authors Wilson & Hoffmeister 1956 30-42µ (Schulze and NH_4OH); Smith & Butterworth 1967 31(35)41µ (Fu.HNO_2) Westphalian D.

Occurrence Ballycastle.

Remarks These specimens also showed similarities to T. triturgidus, but the latter had a more rounded amb and the distal surface appeared more convex in cross-section.

Previous records Wilson & Hoffmeister 1956, Des Moines Series, Oklahoma, U.S.A.; Smith & Butterworth 1967, Coals of Great Britain, Upper Westphalian C and Westphalian D.

Triquitrites comptus Williams 1973.

Plate 8, figs. 22 - 24
in Neves et al.

Holotype Williams/1973, pl.1, fig. 18.

Type locality Roof shales of Little Limestone Coal, New Angerton Colliery, half a mile south of Greenhead, Cumberland (NY660,645) Namurian A.

Diagnosis Neves et al. 1973, p.35.

Description Amb triangular with straight or concave interradial areas and rounded or truncate apices. Suturae simple, $\frac{3}{4}$ or more of spore radius. Equatorial crassitude 3-5µ wide radially, and 2-3µ interradially. Thickened areas may extend onto spore body. Exine ornamented with grana or small verrucae 1-1.5µ diameter; reduced at equatorial margins, and increase in size towards apices.

Size range 4236 50-55μ (10 spec.); 4204 42-50μ (3 spec.); 2478 40μ (1 spec.); 2471 42-55μ (10 spec.).

Other authors Williams in Neves et al. 1973 38-60μ (20 spec.).

Occurrence Leitrim and Ballycastle.

Remarks Compares well with diagnosis. Leitrim and Ballycastle specimens differ very little in their appearance. Distinguished from Triquitrites marginatus by the presence of an ornamented exine.

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

Triquitrites marginatus Hoffmeister, Staplin & Malloy.

Plate 8, figs. 19 - 21

Holotype H.S. & M. 1955, pl.39, fig. 12.

Type locality Shale at 2072' (631.5m) Carter Borehole No. 3, Webster County, Kentucky, Upper Mississippian.

Diagnosis H.S. & M. 1955, p.297.

Description Amb triangular with concave sides. Apices may be angular or rounded. Suturae simple, straight, extend ¾ or more of spore radius. Equatorial crassitude, sometimes poorly developed but may extend 5-12μ onto the spore body. Exine laevigate; thickness 1-1.5u.

Size range 2471 44-52μ (10 spec.); 2476 45μ (1 spec.).

Other authors Hoffmeister, Staplin & Malloy 1955, 42-61μ, flange 5-6-11μ.

Occurrence Ballycastle.

Previous records Hoffmeister, Staplin & Malloy 1955, Upper Mississippian, Hardinsburg Formation, Illinois and Kentucky, U.S.A.; Marshall & Williams 1970, 'Yoredale Series', Northumberland; Spinner & Clayton 1974, Viséan, East Lothian; Neves et al. 1973, Lower Carboniferous, Scotland and Northern England.

Triquitrites trivalvis (Waltz) Potonié & Kremp 1956

Plate 9, figs. 3 & 4

1938 Zonotriletes trivalvis Waltz in Luber & Waltz, pl.4, fig. 41.

1956 Triquitrites trivalvis (Waltz); Potonié & Kremp, p.88.

1956 Trilobozonotriletes trivalvis (Waltz); Ischenko, p.97, pl.19, figs. 231-3.

1958 Tripartites incisotrilobus (Naumova) Potonié & Kremp; Butterworth & Williams, p.373, pl.1, figs. 2, 3, 4.

Holotype Not designated.

Diagnosis Waltz in Luber & Waltz 1938; C.E.D.P.

Description Amb subtriangular, concave to convex interradial areas, with modified apices. Suturae straight, simple, almost reaching inner margin of cingulum. Radial crassistudes at apices prominent, 25μ wide by 8μ thick. Area of amb, excluding crassitudes, 33μ diameter. Total amb 55μ. Exine thickness interradially 2μ, laevigate. Only one specimen, in sample 2471.

Other authors Sullivan & Marshall 1966 56μ.

Occurrence Ballycastle.

Previous records Luber & Waltz 1938, Lower Carboniferous, Russia; Butterworth & Williams 1958, Namurian A of Scotland; Playford 1962, Lower Carboniferous, Spitzbergen; Sullivan & Marshall 1966, Western part of the Midland Valley of Scotland, Viséan; Smith & Butterworth 1967, Coals of Great Britain, Upper Viséan and Namurian.

Triquitrites triturgidus (Loose 1932) Sch. Wils. & Bent. 1944

Plate 9, figs. 5 & 6

1932 Sporonites triturgidus Loose in Potonié, 270, p.449, pl.XVIII, fig.32.

1934 Valvisi-sporites triturgidus Loose, 229, pp.151-152.

1943 Triletes (Laevigati)triturgidus, Horst, 171, fig.31.

1944 Triquitrites triturgidus S.W. & B., 302, p.47.

1950 Triquitrites pulvinatus Kosanke, 197, p.39, pl.VIII, fig.1.

1956 Triquitrites triturgidus Pot. & Kremp, 278, p.91, pl.XVIII, fig.325.

1956 Triquitrites bransonii Wilson & Hoffmeister, 335, p.25, pl.111, fig.1.

1961 Triquitrites batillatus Hughes & Playford, 174, p.33, pl.11, figs. 11-14.

1966 Triquitrites triturgidus Coquel, 88, p.20.

Holotype Loose 1932.

Type locality Upper Horster Schichten, Westphalian B, Ruhr.

Diagnosis Loose 1932.

Description Amb triangular with convex or straight interradial areas. Suturae straight, simple or accompanied by labra up to 4μ wide. Apices rounded and thickened, may extend up to 10μ onto the proximal surface. Exine laevigate or ornamented with small widely spaced grana; 0.5μ diameter, stand 0.5μ. Exine thickness 2-4μ.

Size range 4236 60-96μ (10 spec.); 4294 80-90μ (4 spec.); 4249 38-64μ (20 spec.).

Other authors Loboziak 1969 45-60μ.

Occurrence Leitrim.

Previous records Loboziak 1969, Bassin Houiller, North France, Westphalian A-C; Jachowicz 1966, Westphalian A-D, Lublin Basin; Kosanke 1950, Tradewater Group, McLeansboro Group, Illinois, Westphalian B; Hoffmeister, Staplin & Malloy 1956, Croweburg Coal, Oklahoma, Westphalian C-D; Grebe 1972, Ruhr, Middle Westphalian B - Lower Westphalian C.

Genus TRIPARTITES (Schemel) Potonié & Kremp 1954

Type species T. vetustus Schemel 1954.

Diagnosis P & K 1954, p.154.

Remarks Has an intexine, and an exoexine covering all of intexine extended at the radial margins in the form of auriculae, which may also extend onto the distal surface. Differs from Triquitrites in shape, size, and plication of radial crassitudes.

Tripartites nonquerickei Potonié & Kremp 1956

Plate 9, figs. 9 & 10

1943 Triletes (Zonales) querickei Horst (thesis), pl.7, fig.60.

1955 Ahrensisporites querickei Potonié & Kremp; Horst, p.178, pl.23, fig. 60.

1956 Tripartites nonquerickei Potonié & Kremp, p.92.

Holotype Horst 1955, pl.23, fig. 60.

Type locality Hermann Seam, Porubaer Beds, Moravska-Ostrava, Namurian A.

Diagnosis Potonié & Kremp 1956, p.92.

Description Amb triangular, with concave sides and crenulate margins. Apices angular. Suturae simple extending $\frac{2}{3}$ - $\frac{3}{4}$ of spore radius. Radial crassitudes, 4 - 15 distal radial plications, extending on to spore body 6-12μ. Exine ornamented granulate and verrucate; thickness at apices 2.5(5)9μ; thickness at interradial areas 1-2μ.

Size range 2471 37(43)51μ (1 spec.); 2472 36(41)51μ (5 spec.).

Other authors Smith & Butterworth 1967 37(42)50μ $FuHNO_3$, Scotland, Namurian A.

Occurrence Ballycastle.

Remarks Distinguished from T. vetustus by the presence of ornament on the spore body. A certain amount of gradation of the latter species into T. nonquereckei was observed, where grana and small verrucae develop from apical area onto the body. Occurrence infrequent.

Previous records Smith & Butterworth 1967, Coals of Great Britain, Upper Viséan and Namurian.

Tripartites vetustus Schemel 1950

Plate 9, figs. 7 & 8

Holotype Schemel 1950, pl.40, fig.11.

Type locality 24" (0.61m) coal about 550ft. (167.6m) above top of Madison Formation, Daggett County, Utah, Mississippian.

Diagnosis Schemel 1950, p.242.

Description Spores radial, trilete. Amb subtriangular with modified apices and concave sides. Suturae $\frac{3}{4}$ of spore radius, simple. Apices variable in width, even on the same specimen 20-32µ (11 spec.). Distal thickening extends onto spore 6-12µ, and is usually corrugated into plications numbering from 4-15. Exine at apices is thicker 2-5(5)9u; at interradial areas 1-2µ.

Size range 2472 35(42)53µ (6-12µ) flange (25 spec.).

Other authors Schemel 1950 30-40µ (10-15µ) flange; Smith & Butterworth 1967 30(42)50µ (6-12µ) flange; Felix & Burbridge 1967 48-60µ (10-13µ) flange.

Occurrence Ballycastle and Leitrim.

Remarks Tripartites vetustus tended to show quite an amount of variation. The apical thickening shows transitional characters with Triquitrites marginatus. Occasionally grana occupy a small amount of the exine near the apical thickening on the distal surface as described by Neville 1968, but were not so extensive as T. trilinguis (Horst) Smith & Butterworth. Size Range extends that of Schemel, but agrees closely with Smith & Butterworth as does the flange width. Only 2 specimens found in Leitrim E_2 material, which were not well preserved and might easily have been reworked.

Previous records Schemel 1950, Upper Mississippian, Utah, U.S.A. Hoffmeister, Staplin & Malloy 1955, Hardinsburg Formation, Illinois and Kentucky, Mississippian; Butterworth & Williams 1958, Namurian A of Scotland; Owens & Burgess 1965, Stainmore, Namurian A; Sullivan & Marshall 1966, Western Midland Valley of Scotland; Felix & Burbridge 1967, Springer & Goddard Formation, Upper Mississippian; Smith & Butterworth 1967, Coals of Great Britain, Upper Viséan and Namurian; Neville 1968, East Fife, Upper Viséan; Neves et al. 1973, Upper Viséan, Zone VF of Northern England and Scotland.

Genus SIMOZONOTRILETES (Naumova) Potonié & Kremp 1954

Type species S. intortus (Waltz) P & K 1954.

Diagnosis P & K 1954.

Simozonotriletes trilinearis Artüz 1957

Plate 9, fig. 11

Holotype Artüz 1957, pl.II, fig.36.

Diagnosis Artüz 1957, p.251.

Description Amb triangular with concave sides. Suturae simple extending to margin of intexine. Cingulum differentiated; inner thickened zone 2μ wide, becoming slightly bulbous at apices, outer thinner area 3-4μ. Intexine similar shape as exoexine and following the contour of inner thickened zone. Ornamented with densely set grana less than 1μ in the central area.

Size range 4249 35μ.

Remarks Above specimen is smaller than size range given by Artüz. Distinguished from S. intortus var. polyformis Felix & Burbridge 1967 by its more bulbous thickenings. Only one specimen found.

Previous records Artüz 1957; Whitaker 1970 (M.Sc.), Lower Limestone Group, Northumberland, Viséan.

Genus AHRENSISPORITES Potonié & Kremp 1954

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

Diagnosis P & K 1954, p.155, translation.

Remarks Distinguished from other similar genera, by the presence of a kyrtome.

Ahrensisporites duplicatus Neville 1973

Plate 9, fig. 12

Holotype Neves et al.1973,pl.1, fig.14, page 34.

Type locality Sample RA15. 1' (0.3m) shaley fireclay, 25' (7.62m) above limestone. No. IV of Kirkby (in Geikie 1902) exposed on coast of Randerston.

Diagnosis Neves et al. 1973, p.34.

Description Amb 40μ triangular with convex and concave interradial areas. Apices modified by arcuate kyrtomes 2-3μ wide, extending over distal and proximal surfaces, and projecting at apices up to 6μ. Remainder of exine laevigate, 1μ thick. Suturae simple, ¾ spore radius. Only one specimen.

Occurrence Ballycastle.

Previous records Neville 1969(thesis), Upper Viséan, East Fife, Scotland.

Infraturma PSEUDOCINGULATI Neves 1961

Genus SECARISPORITES Neves 1961

Type species S. lobatus Neves 1961.

Diagnosis Nevés 1961, p.260.

Remarks Secarisporites differs from Convolutispora having larger laterally overlapping and fusing lobate elements in the form of a discontinous rim.

Secarisporites remotus Neves 1961

Plate 9, fig. 13

Holotype Slide ref. 8.343708. Sheffield University, Micropalaeontology Laboratory. Neves 1961, plate 32, fig. 9.

Type locality Non-marine roof shales of the Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13) Yeadonian Stage.

Diagnosis Neves 1961, p.262.

Description Amb circular to rounded triangular. Suturae thin, straight, ¾ of spore radius. Ornamentation of irregular lobes and verrucae. Central distal area characterized by relatively thin muri 1.5-3µ; and verrucae 1-2µ in diameter. Muri are irregularly distributed centrally but become more radially orientated towards the margin where they become lobate; width 5-8µ. Proximal surface mostly laevigate. Distal muri may develop a crenulate edge. Lumina occur infrequently, up to 10µ diameter. At equator 8-12 elevations.

Size range 4249 37-42µ (4 spec.); 2476 54,55µ (2 spec.); 2478 34-37µ (4 spec.); 2479 40-50µ (5 spec.);2480 50µ (1 spec.).

Other authors Felix & Burbridge 1967 (35-60µ; Neves 1961 35-50µ.

Occurrence Ballycastle and Leitrim.

Remarks Ballycastle and Leitrim specimens similar in appearance. Most specimens were distinguished from Convolutispora florida by their pronounced cingulate appearance created by the lobate nature of the muri at the equator.

Previous records Felix & Burbridge 1967, Surface Goddard Formation, Upper Mississippian, Johnston County, Oklahoma;. Neves 1961, Upper Namurian B-C, Southern Pennines.

Secarisporites Sp. A. Sullivan 1966

Plate 9, figs. 23 & 24 & 14

Diagnosis Sullivan p.269, figs. 22-23.

Description Amb rounded triangular or subcircular. Suturae indistinct. Ornamented distally with irregular, partly overlapping verrucae 4-7µ width, and generally 9µ in length. At equator the verrucae are more distinct, with often terminal expansion; stand 4-5µ. Proximal surface laevigate.

Size range 2025 45-46μ (4 spec.).

Other authors Sullivan 1966 34-46μ.

Occurrence Ballycastle.

Remarks Apiculatisporis pineatus Hoffmeister, Staplin & Malloy, is distinguished by its thinner exine and shows less differentiation of body and equatorial ornamentation.

Previous records Sullivan 1966 Viséan of Midland Valley, Scotland.

Genus BELLISPORES (Artüz) Sullivan 1964

Type species B. nitidus (Horst) Sullivan 1964.

Diagnosis Sullivan 1964, p.374.

Bellispores nitidus (Horst) Sullivan 1964

Plate 9, figs. 15 & 17

1943 Triletes nitidus Horst (thesis) pl.8, fig.81.

1955 Lycospora nitida (Horst) Potonié & Kremp in Horst, p.181, pl.24, fig. 81.

1964 Bellispores nitidus (Horst); Sullivan, p.375.

Holotype Horst 1955, pl.24, fig.81.

Type locality Justa Seam, Michael Colliery, Moravaska-Ostrava, Namurian A.

Diagnosis Horst 1955, p.181 and Artüz 1957, p.255.

Description Amb commonly rounded triangular with concave sides. Spore margin is crenulate; distal surface has lumina less than 1μ in diameter spaced 2μ apart. Cingulum 3-5μ wide. Proximal surface laevigate; labra 3-4μ wide which extend to apices. Crenulations not always regular.

Size range Leitrim E_2 general material 31-43μ (25 spec.).

Other authors Sullivan & Marshall 39μ (1 spec.); Felix & Burbridge 1967 30-42μ (25 spec.).

Occurrence Leitrim.

Remarks Specimens in this study have distinctly concave sides and would thus be distinguished from B. bellus Artüz 1957, which is said to have less concave sides to the radial thickenings. All specimens were consistent in their appearance. Occurrence very infrequent and restricted to E_2 Leitrim material.

Previous records 1943 Horst (thesis); 1938 Luber & Waltz; 1948 Knox, Fifeshire, Limestone Coal Group; 1955 Potonié & Kremp, Mahrisch-Ostrav, Namurian A; 1957 Artüz, Westphalian A, Nur im Floz, Buyuk; 1964 Sullivan; 1967 Smith & Butterworth, Namurian to Westphalian A, Coals of Great Britain.

Genus SAVITRISPORITES Bharadwaj 1955

1958 Callisporites Butterworth & Williams, p.376.

Type species S. triangulus Bharadwaj 1955.

Diagnosis Bharadwaj 1955, p.127.

Remarks Sullivan 1964, p.373 considers Callisporites to be congeneric with Savitrisporites following his re-examination of the type specimen of C. nux B. & W. 1958, which established that the ornament in this species is confined to the distal surface.

Savitrisporites nux (Butterworth & Williams) Sullivan

Plate 9, figs. 18 & 20

1958 Callisporites nux Butterworth & Williams, p.377, pl.3, figs.24,25.

1964 Savitrisporites nux (Butterworth & Williams);Sullivan, p.373, pl.60, figs. 1-5.

Lectotype Plate 15, figs, 1,2 Smith & Butterworth 1967.

Type locality Upper Hirst Seam at 2,310ft 4ins. (204m) Brucefield Borehole, West Fife Coalfield, Scotland, Namurian A.

Diagnosis Smith & Butterworth 1967, p.224.

Description Amb rounded triangular with straight to convex interradial areas; broad apices. Ornament consists distally of series of almost concentric ridges 1.5-4μ wide, which may be smooth, crenulated, cristate or verrucate. Height of ornament rarely exceeds 2-3μ. Cingulum laevigate, regular in thickness, 3-7μ wide, and distinctly tapering occasionally. Suturae simple, ¾ and over of spore radius. Proximal thickenings 1.5-3μ occur parallel to trilete. Based on 4236.

Size range 4249 36(46)65u (14 spec.); 4236 46(47)52u (10 spec.).

Other authors Playford 1964 30(47)60μ; Butterworth & Williams 1958 45(56)64μ; Felix & Burbridge 1967 40-60μ; Sullivan 1964 30(47)60μ.

Occurrence Ballycastle and Leitrim.

Remarks *Savitrisporites cingulatus* is distinguished by its reduced ornament and obvious cingulum. Specimens in this study showed considerable variation of the latter, making a division between the two species difficult. The forms with reduced ornament are thus included in *Savitrisporites nux*. The majority of specimens occur between 42 and 52μ (21 out of 25). Specimens recorded from Ballycastle rare.

Previous records Butterworth & Williams 1958, Limestone Coal Group and Upper Limestone Group, Namurian A, Scotland; Neves 1961, Southern Pennines, Namurian A to Westphalian A; Playford 1964, Drybrook Sandstone; Felix & Burbridge 1967, Goddard & Springer Formation, Upper Mississippian; Smith & Butterworth 1967, Coals of Great Britain, Namurian A to Westphalian B; Love & Neves 1963, Innismore, Scotland, Westphalian B; Neves 1964, La Camocha, Gijon, North Spain, Upper Namurian A to Westphalian B; Sullivan 1964, Forest of Dean, Edgehills Coal, Westphalian A; Mishell 1966 (thesis) Bowland Fells & Ingleton Coalfield, Namurian A to Westphalian B.

Infraturma CINGULATI (Potonié & Klaus) Dettmann 1963

Genus STENOZONOTRILETES (Naumova) Potonie 1958

Type species *S. conformis* Naumova 1953.

Diagnosis Hacquebard 1957, p.313.

Remarks It was sometimes difficult to distinguish the cingulum from the thick wall of a *Punctatisporites*.

Stenozonotriletes bracteolus (Butterworth & Williams)

Smith & Butterworth 1967

Plate 9, fig. 22

1958 Lycospora bracteola Butterworth & Williams, p.375, pl.3, figs.26,27.

Holotype Smith & Butterworth, pl.14, fig.1.

Type Locality Lower Hirst Seam at 1,854ft. 2ins. (565.1m), Kincardine Borehole, West Fife Coalfield, Scotland; Namurian A.

Diagnosis B & W 1958, p.375.

Description Amb circular, rarely rounded triangular. Suturae simple or accompanied by labra 1-2.5µ; extend to cingulum where curvaturae are present. Cingulum 2-7µ width. Exine ornamented,densely covered in grana 0.5-1µ diameter, sometimes rugulae 2-3µ; bases may or may not touch; set up to 1.5µ apart. Often ornament may occur in small clusters; at equator up to 100 may project.

Size range 4236 35-45µ (5 spec.); 2481 30-52µ (15 spec.); 2482 35-42µ (3 spec.); 2480 35-38µ (6 spec.).

Other authors Smith & Butterworth 1967 36(43)54µ Schulze.

Occurrence Ballycastle and Leitrim.

Remarks Cingulum width tends to be most frequently 2µ or 4.5µ. Some confusion of this form with Lycospora tenebricosa was found during this study, which is a form that this species superficially resembles.

Previous records Butterworth & Williams 1958, Namurian A of Scotland; Love 1960, Lower Oil Shale Group of Scotland; Smith & Butterworth 1967, Namurian of Great Britain

Stenozonotriletes coronatus Sullivan & Marshall 1966

Plate 9, fig. 21

Holotype Sullivan & Marshall 1966, pl.3, fig.2.

Type locality Shale below the Blackbyre Limestone.

Diagnosis Sullivan & Marshall, p.273.

Description Amb rounded triangular. Suturae distinct, straight or sinuous, slightly ridged with lips or folds 1-3.5μ in total width. Usually extend over ¾ of spore radius, and may often appear to develop curvaturae imperfectae. Cingulum frequently poorly developed and narrow, 1-6μ wide. Ornamented distally with cones, usually wide bases 0.5-1.5μ diameter, rounded profile together with sharp process above; sometimes however give appearance of being thin and needle-shaped; stand 1.5-2μ high, usually 2 to 3μ apart; 30 to 35 project at the equator.

Size range 2471 39-46μ (5 spec.); 2472 40-46μ (5 spec.); 2476 40-56μ (10 spec.); 2478 42-51μ (6 spec.); 2479 44-48μ (5 spec.); 2480 42-45μ (5 spec.); 2481 38-57μ (20 spec.).

Other authors 1968 Neville 32(44)55μ; Sullivan & Marshall 1966 37(46)55μ (23 spec.).

Occurrence Ballycastle.

Remarks General appearance of S. coronatus varied according to the effect of corrosion. A particular feature was the variation in ornament, from needle to mammilate type cones. This species was abundant in most samples from Ballycastle.

Previous records Sullivan & Marshall 1966, Viséan, Scotland; Neville 1968, Viséan, East Fife, Scotland; Neves et al. 1973, Lower Carboniferous, Scotland.

Stenozonotriletes triangulus Neves 1961

Plate 10, fig. 1

Holotype Neves 1961, pl.33, fig.7.

Type locality Marine shales with Gastrioceras cancellatum, Hipper Sick, Derbyshire, Yeadonian Stage.

Diagnosis Neves 1961, p.268.

Description Amb commonly rounded triangular, occasionally more circular, sides rarely straight. Suturae simple or with labra 0.5-1μ which extend to margin of amb. Cingulum 3.5-7.5μ wide. Exine up to 4μ thick; laevigate, rarely punctate.

Size range 4249 50-80μ (10 spec.); 4236 40-79μ (8 spec.).

Occurrence Leitrim.

Other authors Neves 1961 60-80μ (25 spec.), holotype 77μ

Remarks Size range extended in the lower regions, to that quoted by Neves, Stenozonotriletes clarus Ischenko is a similar type, both in range and thickness of cingulum. The only difference appears to be the more triangular shape of S. triangulus, and possess labra. The latter were not present on all specimens in this study but it was decided to include them in the same species.

Previous records Neves 1961, Southern Pennines, Namurian.

Stenozonotriletes Sp. A.

Plate 10, fig. 2

Description Amb circular or rounded triangular. Suturae simple, straight, may be thinly ridged and extend to margin, where curvaturae occur. Cingulum may extend 4-5μ wide. Exine laevigate.

Size range 5040 45-55μ (3 spec.); 1142 52μ (1 spec.); 3128 50-56μ (3 spec.).

Genus KNOXISPORITES (Potonié & Kremp) Neves 1961

Type species K. lageni P. & K. 1954.

Diagnosis Neves 1961, p.264 - 266.

Remarks Dictyotriletes differs in being non-cingulate, and bearing a reticulate sculpture. (See Reticulatisporites).

Knoxisporites danzei Agralí 1965

Plate 11, figs. 1 & 2

1964 Knoxisporites danzei non publié Agrali (3).

Holotype Agrali 1965, pl.XV, fig.22.

Type locality Amasra, sondage 25, 103.7/118.3, Westphalian A.

Diagnosis Agrali 1965, p.174.

Description Amb subcircular to polygonal. Suturae simple, extending upto 15µ in length. Exine ornamented with grana, cones and warts, often densely set with bases almost in contact. Profile of cones characterised by an angular or chamfered tip; stand 2-3µ, 1.5-2µ wide. Ornamented distally by 6 to 8 muri 2-3.5µ wide, which in some specimens radiate from a central point at the distal pole; lumina 22µ. Equatorial area characterized by a cingulum 8-14µ wide, which displays some suggestion of differentiation into an inner thickened zone and thinner outer flange.

Size range 4236 49(55)100µ (5 spec.); 4249 52-60µ (4 spec.).

Other authors Agrali 1965 65-85µ.

Occurrence Leitrim and Ballycastle.

Remarks This species is distinguished by its densely or regularly distributed ornamant on the exine. Reticulatisporites decoratus may possess a small amount of ornamant but is usually laevigate. K. danzei possesses a cingulum which appears to be differentiated into zones characteristic of Reticulatisporites and may be more suitably placed in this genus.

Previous records. Agrali 1965 Amasra, Westphalian A.

Knoxisporites dissidius Neves 1961

Plate 10, fig. 8

Holotype Neves 1961, pl.33, fig.4.

Type locality Non marine roof shales of the Pot Clay Coals, Holymoorside, Derbyshire (Loc.13). Yeadonian Stage.

Diagnosis Neves 1961, p.266.

Description Amb sub-circular - hexagonal, margin irregular. Suturae extend ¾ of spore radius; suggestion of thin 1µ thickenings along suturae. Cingulum 10µ wide displays inner thickened 5µ wide zone and an unusual irregular surface feature (fleshy). Distal surface bears three radial bars of thickening

3u wide rotated 60° relative to suturae; distal thickenings join at distal side to enclose a triangular region.

Size range 4249 43μ (1 spec.).

Other authors Neves 1961 50-80μ (25 spec.).

Remarks Only one specimen found, which is smaller than size range given by Neves 1961. However, this distinctive spore otherwise closely resembles the diagnosis. The continous equatorial zone which displays differentiation into a thickened inner zone displays features characteristic of the genus Reticulatisporites, and may be better placed in this genus.

Previous records Neves 1961, Southern Pennines, Namurian.

Knoxisporites literatus (Waltz) Playford 1963

Plate 10, figs. 3 & 4

1938 Zonotriletes literatus Waltz in Luber & Waltz, p.18, pl.2, fig.21.

1956 Euryzonotriletes literatus (Waltz) Ischenko, pp.52-53; pl.9, fig. 108.

1956 Anulatisporites literatus (Waltz) Potonié & Kremp, p.111.

1957 Cincturasporites literatus (Waltz) Hacquebard & Barss, pp.23-24, pl.3, figs. 2-5.

1963 Archeozonotriletes literatus (Waltz) Naumova var. triangularis Kedo pl.8, figs. 191-193.

1970 Knoxisporites literatus (Waltz) Playford 1963 var. triangularis (Kedo) Clayton 1970, p.584, pl.2, fig.5.

Holotype Waltz 1938, p. 18.

Type locality

Diagnosis Clayton 1970, p.584.

Description Amb circular; suturae simple or very thinly ridged (1μ wide), Exine at equator 10μ wide, distal bars of thickening 7-9μ wide; diameter of lumen 48μ. Apart from distal thickenings, spore body leavigate,.

Size range 5044 100u-92μ (3 spec.); 3128 58-70μ (3 spec.).

Other authors Playford 1963 56(76)102μ (75 spec.).

Occurrence Goresbridge and Donegal.

Remarks Specimens compare closely with those of Clayton 1970.

Previous records Kedo 1963, Tournasian, U.S.S.R.; Clayton 1970, Lower Carboniferous, Cockburnspath, Scotland.

Knoxisporites seniradiatus Neves 1961

Plate 10, figs. 6 & 7

Holotype Neves 1961, Plate 3, fig. 5.

Type locality Non-marine shales with Carbonicula exporrecta, Hipper Sick, Derbyshire.

Diagnosis Neves 1961, p.268.

Description Amb circular. Equatorial thickening uniform width 5-6μ. Suturae straight, accompanied by labra 2-10μ wide, extend to inner edge of equatorial thickening. Distally occur Y shape bars of thickening, which incurve towards the pole; minimum width 8-12μ. Exine otherwise generally laevigate.

Size range 4249 55-92μ (5 spec.);4204 72μ.

Other authors Neves 1961 60-105u

Occurrence Leitrim.

Remarks Exine on one particular specimen had a few circular verrucae randomly set on the distal and proximal surfaces. Two specimens extend a little lower than the size range given by Neves. Distinguished from Knoxisporites triradiatus by the presence of labra and the incurved nature of the distal bars. Occurrence very infrequent.

Previous records Neves 1961, Namurian B & C of Southern Pennines; Owens in Owens & Burgess 1965, Upper Namurian A to Namurian B of Stainmore;

Previous records Neves 1961 Namurian B & C of Southern Pennines; Owens in Owens & Burgess 1965, Upper Namurian A to Namurian B of Stainmore; Mishell 1966 M.Sc., Lower & Middle Namurian A.

Knoxisporites stephanephorus Love 1960

Plate 10, fig. 5

Holotype Love 1960, pl.11, fig.1.

Type locality Pumpherston Shell Bed, South Queensferry, Viséan, Scotland.

Diagnosis Love 1960, p.118.

Description Amb radial trilete, commonly circular or oval, rarely rounded triangular. Suturae distinct and straight, occasionally accompanied by thin 2μ labra. Equatorial cingulum varied 3-9μ wide. Distal ring of thickening 19-55μ diameter; 2(4)17μ width. Central boss 7(10)22μ diameter. Distal ornament was always concentric, but the channels varied in width. Connecting muri from the inner ring of thickening to the cingulum sometimes were indistinct. Exine laevigate, thickness 2-4μ.

Size range 2481 50-77μ (10 spec.);

Other authors Felix & Burbridge 1967 30-60μ; Love 1960 70μ; Butcher 1974 (thesis) 39-61μ (15 spec.).

Occurrence

Remarks Distinguished from most other species by the presence of a central boss. Tholisporites biannulatus Neves has a similar appearance, but lacks connecting muri from the inner ring of thickening to the equatorial cingulum.

Individual specimens compared well with the diagnosis and showed little variation. Size range is greater than reported by Felix & Burbridge 1967, but the greater majority of specimens did occur between 40 and 50μ. Occurrence frequent.

Previous records Love 1960, Lower Oil Shale Group of Scotland, Viséan; Sullivan 1962, Westphalian A to C, Caerphilly, South Wales; Owens in Owens & Burgess 1965, Namurian A to B of Stainmore; Sullivan & Marshall 1966, Viséan of Midland Valley, Scotland; Felix & Burbridge 1967, Springer Formation, Oklahoma, U.S.A.; Sabry & Neves in press, Namurian to Westphalian A, Sanquhar Coalfield, Scotland.

Knoxisporites triradiatus Hoffmeister, Staplin and Malloy 1955.
Plate 10, fig. 11

Holotype H.S. & M. 1955, pl.37, figs. 11, 12.

Diagnosis H.S. & M 1955 p.391.

Type locality U.S.A. Kentucky, Webster County, Carter No. 3.Borehole, Hardinsburg Formation, Mississippian.

Description Amb usually circular, occasionally rounded triangular. Suturae distinct and straight usually accompanied by labra 2-3.5µ wide in total width. Cingulum very obvious and regular in width on the same specimen, 5-13µ. Distal muri 6-13µ in their narrowest width, either distinctly parallel or arcuate so that junction area considerably wider. Exine laevigate, 2.5-4µ thickness. Based on 4249.

Size Range 4204 65-72µ (4 spec.); 4249 55-92µ (8 spec.); general 55-92µ (15 spec.).

Other authors 1955 Hoffmeister, Staplin & Malloy 50-88µ; 1967 Felix & Burbridge 48-78µ.

Occurrence Leitrim and Ballycastle.

Remarks One specimen had on the proximal and distal exine circular and oval warts 5-6µ diameter, but not regularly distributed. Occurrence infrequent. Size range agrees closely to type material.

Previous records H.S. & M. 1955, Hardinsburg Formation, Mississippian, Illinois & Kentucky, U.S.A.; Felix & Burbridge 1967, Springer Formation, Mississippian/Pennsylvanian, Oklahoma; Love 1960, Lower Oil Shale Group of Scotland, Upper Viséan; Owens 1963 (thesis) Stainmore, Upper Namurian A to Namurian B; Mishell 1966 (thesis) Bowland Fells & Ingleton Coalfield, Namurian A.

Genus LOPHOZONOTRILETES (Naumova) Potonié 1958

Type species L. lebedianensis Naumova 1953.

Diagnosis Potonié & Kremp 1958, p.28.

Lophozonotriletes bellus Kedo 1963

Plate 10, figs. 9 & 10

Holotype Kedo 1963

Type location In Kedo 1963 (Russian)

Diagnosis Kedo 1963.

Description Amb triangular with rounded apices and gently convex sides. Suturae simple and extend over ¾ of spore radius. Ornamented with relatively large verrucae, with rounded to flat apices; 5u width maximum, and stand 2-3.5u high; occur on distal surface mainly, approximately 13 may project altogether.

Size range 1142 33-32µ (3 spec.); 3128 35-55µ (2 spec.).

Other authors Clayton 1970 31(40)53µ (6 spec.).

Occurrence Donegal and Mayo.

Remarks Specimens tend to be relatively small in this study, compared with those described by Clayton 1970, in both size of verrucae and diameter of spore body.

Previous records Kedo 1963, Tournaisian, U.S.S.R.; Clayton 1970, Lower Carboniferous, Cockburnspath, Scotland.

Genus ORBISPORIS Bharadwaj & Venkatachala 1962

Type species

Diagnosis B & V. 1962.

Orbisporis convolutus Butterworth & Spinner 1967

Plate 10, figs. 12 & 14

Holotype Plate 1, fig. 19.

Type locality One inch coal in right bank of Barret's Sike, Lewis Burn, Northumberland; Lewis Burn Coal Group (Sample 7).

Diagnosis Butterworth & Spinner 1967 p.9.

Description Amb circular or subcircular. Suturae distinct, $\frac{3}{4}$ of spore radius; accompanied by labra 6-18μ wide. Ornament on the distal surface which may be branched and sinuous or short and verrucate. At the margin occurs a circular ring of muri, 6-10μ in from the equator, leaving a cingulate appearance to the remaining exine. Proximally laevigate,except for labra, exine is laevigate.

Size range 4236 70-105μ (5 spec.); 4204 79-119μ (5 spec.); 4249 62(78)95μ (20 spec.).

Other authors Butterworth & Spinner 1967 69(91)116μ Fu.HNO_3.

Occurrence Leitrim.

Remarks Specimens differ from Butterworth and Spinner in having thinner muri and labra. The overall size range conforms very well. Specimens were common in a limited number of samples and remained consistent in their appearance. The lack of ornament proximally distinguishes *Convolutispora harlandii* Playford 1962.

Previous records Butterworth & Spinner 1967, Lewis Burn Coal, Northumberland, Lower Carboniferous.

Genus MUROSPORA Somers 1952

Type species *M. kosankei* Somers 1952.

Diagnosis Somers 1952, p.20.

Remarks Playford 1962 considers *Murospora* Somers and *Simozonotriletes* Naumova, as synonymous.

Murospora aurita (Waltz) Playford 1962

Plate 10, fig. 15

1938 *Zonotriletes auritus* Waltz in Luber & Waltz, p.17, pl.2, fig.23.

1956 Simozonotriletes auritus (Waltz) Potonié & 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 Murospora varia Staplin, p.30, pl.6, figs. 16-18.

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

1962 Murospora aurita (Waltz) Playford p.609-610, pl.87, figs. 1-6.

Holotype Designated by Playford 1962, p.610, pl.2, fig.23, of Luber & Waltz 1938.

Type locality U.S.S.R., Kizel region, New Kizel Mines, oblique shaft, 24, bed 4.

Diagnosis Playford 1962, p.609.

Description Amb rounded triangular. Exine laevigate. Cingulum 7-14µ wide often having an undulating edge. Suturae simple extending to inner edge of cingulum; occasionally a parallel dark band occurs with trilete.

Size range 2472 48µ; 2474 70-89µ (5 spec.).

Other authors Hibbert & Lacey 1969 49-73µ (mean 59µ); Playford 1962 45-94µ; Luber & Waltz 45-95µ.

Occurrence Ballycastle.

Remarks Lips indistinct and not as pronounced as described by Playford and Hibbert & Lacey. Size range generally agrees with that of previous authors.

Previous records Luber & Waltz 1938, Lower Carboniferous of U.S.S.R.; Hacquebard & Barss 1957, 60, Upper Mississippian of Canada; Hughes & Playford 1961, Lower Carboniferous, Spitzbergen; Hibbert & Lacey 1969, Menai Straits, N. Wales, Basement Beds, Lower Carboniferous.

Murospora strigata (Waltz) Playford 1962

Plate 10, fig. 16

1941 Zonotriletes strigatus Waltz in Luber & Waltz, p.19, pl.3, fig.41.

1958 Simozonotriletes strigatus (Waltz) Ischenko, p.88, pl.11, fig.141.

1962 Murospora strigata (Waltz) Playford, p.615,pl.86,figs.20,21;text fig.86.

Holotype Waltz pl.3, fig.41.

Type locality Selizharovo region, U.S.S.R., Lower Carboniferous.

Diagnosis Waltz 1941, p.19.

Description Amb triangular with gently convex or concave sides; apices broadly rounded. Suturae simple, extend ¾ of spore radius. Exine laevigate to finely punctate. Proximal surface of cingulum differentiated into three concentric bands consisting of a smooth, flat-topped, outer equatorial ridge separated from a similar inner ridge by a continuous channel approximately the same width as the ridges. The distal surface is occasionally ornamented with cones 3-4µ diameter; stand 3µ high; up to 9 project at equator.

Size range 2471 53-71µ (10 spec.).

Other authors Playford 1962 60-82µ (15 spec.).

Occurrence Ballycastle.

Remarks Specimens from the present study differ from the diagnosis in that they possess occasional cones on the distal surface, otherwise the spores conform closely with the description. Their occurrence is restricted to one sample

Previous records Luber & Waltz 1941, Lower Carboniferous of Selizoharovo Region, U.S.S.R.; Ischenko 1958, Dnieper-Donetz Basin, Viséan; Playford 1962, Lower Carboniferous, Spitzbergen.

Genus RETICULATISPORITES (Ibrahim) Neves 1964

Type species R. reticulatus Ibrahim 1933.

Diagnosis Neves 1964, p. 1066.

Remarks Distinguished from Dictyotriletes by Neves 1964, who wished to include in Reticulatisporites only the spores with differentially thickened cingulum and distal reticulate sculpture.

Reticulatisporites decoratus Hoffmeister, Staplin & Malloy 1955

Plate 11, figs. 3 & 4.

Holotype H.S. & M. 1955, plate 38, fig. 15.

Type locality TCO-82, 2075' (631.8m) Hardinsburg Formation.

Diagnosis H.S. & M. 1955.

Description Spores radial, trilete. Amb oval to polygonal in outline. Suturae very indistinct and simple, approximately $\frac{2}{3}$ of spore radius. Muri high and membranous; 1.5 to 3μ thick; 8-10μ wide. Lacunae up to 22μ high in diameter; 6 to 10 may project at equator. Exine of spore wall occasionally ornamented with warts, cones, grana or pila, 2-3μ high; 2μ diameter, set widely apart. Exine thickness 1-2u.

Size range 4236 52-60μ (10 spec.); 4249 52-60μ (5 spec.); 2472 55-67μ (5 spec.); 2476 61μ (1 spec.).

Other authors H.S. & M. 1955 48-60μ; Felix & Burbridge 1967 50-70μ.

Occurrence Ballycastle and Leitrim.

Remarks Ornamentation inconsistent Size ranges are slightly above those described by H.S. & M. 1955, but agree with Felix & Burbridge 50-70μ. Spores from Leitrim and Ballycastle were similar in size range and appearance.

Previous records Felix & Burbridge 1967, Goddard Formation, Upper Mississippian, Oklahoma, U.S.A.; H.S. & M., 1955, Hardinsburg Formation. Upper Mississippian of Illinois & Kentucky, U.S.A.

Reticulatisporites peltatus Playford 1962

Plate 11, fig. 5

Holotype Playford 1962, pl.84, figs. 1, 2.

Type locality Birger Johnson fjellet, Spitzbergen, Lower Carboniferous.

Diagnosis Playford 1962, p.599.

Description Amb subcircular, modified by projecting muri. Suturae straight, indistinct. Ornamented proximally and distally with muri, laevigate and rounded 3-5.5μ width; stand 4μ. At junctions of muri, peltate processes stand up to 4μ. Lumina polygonal 13μ.

Size range 4249 55μ (2 spec.)

Other authors Playford 1962 50-105μ.

Occurrence Leitrim and Ballycastle.

Previous records Playford 1962, Lower Carboniferous, of Spitzbergen.

Genus ROTASPORA Schemel

Type species R. fracta Schemel 1950.

Diagnosis Neville 1969, p.206.

Remarks The equatorial extension is considered by Smith & Butterworth 1967 to be more in the nature of a zona, as originally described by Schemel, than of a cingulum as suggested by Potonié & Kremp (1954, p.159).

Rotaspora ergonulii (Agrali) Sullivan & Marshall

Plate 11, figs. 8 & 9

Rotasporites ergonuli Agrali, 1963, p.150, pl.22, fig.1 .

Rotaspora ergonulii (Agrali) Sullivan & Marshall 1966.

Holotype In Agrali 1963, pl.22, fig.11.

Diagnosis Sullivan & Marshall 1966, p.272.

Description Amb rounded triangular with gently convex interradial areas. Spore body may have gently convex or straight sides. Suturae ¾ of spore radius. Distal surface ornamented with cones or grana (0.5 to 1.5µ) high; 0.5 to 2µ diameter; rarely spines 1 to 1.5µ high. Spaced evenly 2-4µ apart, extend on to cingulum. Cingulum varies in width from 3.5 to 0.5µ. Exine generally brown or yellow in colour.

Size range 2471 30(35)40µ; 2476 31(35)40µ; 2478 30(35)40µ; 2479 31(35)37µ; 2479 30(35)40µ.

Other authors Neville 1968 24-37µ; Sullivan & Marshall 1966 30(35)42µ.

Occurrence Ballycastle.

Remarks Specimens as described by Sullivan & Marshall, do occasionally display a very much reduced cingulum, giving the appearance then of the genus *Tricidarisporites*. Ornament may vary from sample to sample, but remains similar in style within the same samples. Size range narrowly restricted to the 31-40µ, particularly abundant in coal samples.

Previous records Agrali 1963, Namurian of Tarla-Agzi; Sullivan & Marshall 1966, Hurlet Coal & Blackbyre Limestone; Neville 1968 East Fife, Upper Viséan.

Rotaspora knoxi Butterworth & Williams 1958.

Plate 11, fig. 10

1948 Knox, p.157, fig.5.

1958 *Rotaspora knoxi* Butterworth & Williams, p.378, pl.3, figs.21-23.

Holotype Butterworth & Williams, pl.15, fig.15.

Type locality Lower Garscadden Ironstone Seam at 1,010ft. 2 ins. (307.8m), Cawder Cuilt Borehole, Central Coalfield, Scotland, Namurian A.

Diagnosis Butterworth & Williams 1958, p.378.

Description Amb rounded triangular, sides convex to straight; size range 29-32µ. Inner area triangular, darker in colour and bordered by 2µ wide rim of thickening. The thin flange characteristically is folded over or reduced at the apices and is 2-4µ wide along the interradial margins. Suturae simple ¾ of spore radius, with sometimes a darkened area around the suturae.

Size range E_2 material general 29-32µ; 2612 41-46µ (10 spec.); 2471 29-36u (8 spec.); 2472 32-42µ (8 spec.).

Other authors Neville 1968 30(34)38µ; Butterworth & Williams 24-45µ; Smith & Butterworth 1967 26(32)44µ.

Occurrence Leitrim and Ballycastle.

Remarks Specimens found in Ballycastle and Leitrim differ in that their general size and width of the flange, 3-4µ, was greater in the former. Distinguished from Rotaspora fracta H.S. & M. and Rotaspora ergonulii Agrali by its laevigate exine. Two specimens from sample 2472 showed very faint ornament, intermediate between R. ergonulii and R. knoxi and similar to Sullivan and Marshall's Rotaspora cf. knoxi. Ballycastle examples often occur in pairs.

Previous records Knox 1948, Limestone Coal Group, Fifeshire; Butterworth & Williams 1958, Limestone Coal Group & Upper Limestone Group, Scotland; Venkatachala & Beju 1962, Romania, Namurian; Kruszewska 1963, Upper Silesian Basin, Namurian; Owens & Burgess, 1965, Stainmore, Namurian A; Sullivan & Marshall 1966, Western part of Midland Valley of Scotland, Upper Visean; Smith & Butterworth 1967, Coals of Great Britain, Visean and Namurian A.

Rotaspora fracta (Schemel) emend S & B 1967
Plate 11, figs. 11 &12

Holotype Schemel 1950, pl.40, fig.8.

Type locality 24ins. coal about 550ft. (167.6m) above top Madison Formation, Daggett County, Utah, Mississippian.

Diagnosis Smith & Butterworth 1967, p.227.

Description Amb rounded triangular. Body triangular, concave interradial areas, occasionally straight. Suturae simple extending over $\frac{3}{4}$ of spore radius. Distal surface evenly ornamented with cones or grana, less than 1u apart. Maximum width of zona at interradial positions 3.5(3.5)7μ, folded over at apices. Exine of body 1-2μ thickness; body diameter 26-32μ. Based on 2471.

Size range 2471 30-35μ (14 spec.); 2474 30-33μ (5 spec.).

Other authors Schemel 1950 (28-35μ); Butterworth & Williams 1958 20-40μ Fu.HNO_3; Neville 1968 27(29)30μ.

Occurrence Leitrim, Ballycastle.

Remarks Individual specimens remained consistent in their characters. They conform to the emended diagnosis by Smith & Butterworth 1967 except for the presence of distal ornament, which however is discernible in their photographs. The size range is narrowly limited to 30-35μ, which agrees with Schemel. Found only in Ballycastle material. Occurrence infrequent.

Previous records 1950 Schemel, Upper Mississippian Coal of Utah; Hoffmeister, Staplin & Malloy 1955, Hardinsburg Formation (Chesterian) Illinois & Kentucky; Ischenko 1956, Donetz Basin; Jachowicz 1964, Lower Carboniferous, Poland; Butterworth & Williams 1958, Limestone Coal Group & Upper Limestone Group, Scotland, Namurian A; Owens & Burgess 1965, Stainmore, Lower Namurian A; Sullivan & Marshall 1966, Western part of Midland Valley of Scotland, Viséan; Smith & Butterworth 1967, Coals of Great Britain, Viséan & Namurian A; Neves et al. 1973, Uppermost Viséan, East Fife, Spilmersford Borehole, East Lothian & Cockburnspath.

Genus SPENCERISPORITES Chaloner 1951

Type species S. radiatus (Ibrahim) Felix and Parks 1959.

Diagnosis Chaloner 1951, p.861.

Spencerisporites radiatus (Ibrahim) Felix and Parks 1959

Plate 11, figs. 15 & 16

1932 Sporonites radiatus Ibrahim in Potonié, Ibrahim and 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 and van Vierssen Trip. p.64, pl.4, fig. 40.

1951 Spencerisporites karczewskii (Zerndt); Chaloner, p.862, figs. 1,2, 6 & 7.

1955 Endosporites? radiatus (Ibrahim); Dijkstra, p.342, pl.45, fig.54.

1956 Microsporites radiatus (Ibrahim) Dijkstra, Potonié & Kremp, p.156, pl.20, figs.449, 450.

1959 Spencerisporites radiatus (Ibrahim) Chaloner; Felix and Parks p.362, pl.1, figs. 1-4 and pl.2, figs. 1-4.

Holotype Potonié & Kremp 1955, pl.20, fig.400.

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

Diagnosis Chaloner 1951, p.562.

Description Amb often rounded triangular. Intexine more circular. Exoexine ornamented with a foveolate texture; foveoli less than 0.5µ. Exoexine was more laevigate towards proximal polar area. The intexine and contact area were chacterized by ridges 1µ wide, non birfurcating, radiating from three centres each of 60(80)100µ diameter. Diameter of intexine 130-175µ; suturae ridged up to 11µ and folded over. Exoexine often folded.

Based on 2472 (10 spec.).

Size range 2472 210-300u (130-175)intex(10 spec.); 2478 250-310u (170-190u)intex(3 spec.).

Other authors Potonié & Kremp 270-440u Schulze; 1967 Smith & Butterworth 240-260μ; 1968 Neville 208(233)272μ; 1957 Chaloner 127 (153)178μ Schulze and NaOH.

Occurrence Ballycastle.

Remarks Ratio of intexine to total diameter shows a large range 0.4(0.55)0.8 (15 spec.), but most fall between 0.48 and 0.68μ(14 spec.). The poor quality of preservation may explain this. Occurrence infrequent.

Previous records Chaloner 1951, Arley Seam, Burnley, Westphalian A; Smith & Butterworth 1967, Coals of Great Britain, Viséan to Westphalian D; Neville 1968, East Fife, Upper Viséan; Neves 1959 (thesis) Southern Pennines, Namurian A to Westphalian A; Owens 1963 (thesis) Stainmore, Namurian A to Westphalian B.

Supraturma CAMERATITRILETES Neves & Owens 1966

Subturma SOLUTITRILETES Neves & Owens 1966

Infraturma PLANATI N. & O. 1966.

Genus AURORASPORA Hoffmeister, Staplin & Malloy 1955

Type species A. solisortus H.S. & M. 1955.

Diagnosis H.S. & M. 1955, p.381.

Remarks Distinguished from Endosporites Wilson & Coe by H.S. & M. 1955, by the relative thickness of the intexine to the exoexine. Potonié [illegible] (loc. cit.), [illegible] (loc. cit.), [illegible] (loc. cit.) and [illegible] (loc. cit.) distinguish the [illegible] of a [illegible] or [illegible].

Auroraspora macra Sullivan 1968

Plate 11, figs. 13 & 14

Holotype Sullivan 1968, pl.27, figs. 6-10.

Type locality Bracken Bay, Heads of Ayr, Ayrshire, Tournasian.

Diagnosis Sullivan 1968, p.124.

Description Amb circular or rounded triangular. Suturae distinct often sinuous, with occasionally ray folds from 1-4μ high; extend almost full radius of intexine. Intexine usually circular, but can be subtriangular. Exoexine pale, densely infrapunctate, or faintly granulose, rarely laevigate.

Size range 5044 52-55μ (5 spec.); 5040 41-55μ (6 spec.); 1142 42-46μ (5 spec.).

Other authors Sullivan 1968 48-68μ Schulze. KOH; Clayton 1970 51(54)61μ FuN.

Occurrence Goresbridge and North Mayo.

Remarks Forms similar to this species were found in the Leitrim E_2A assemblages, but their state of preservation was considered to be too poor to be identified with confidence.

Previous records Sullivan 1968, Cementstone Group, Scotland; Llewellyn, Backhouse and Hoskins 1969, Tournasian, Central Province, England; Johnson & Marshall 1971, Tournasian, Ravonstonedale, England; Clayton, 1971, Calciferous Sandstone Measures, East Scotland; Neves et al. 1973, Lower Carboniferous, Scotland.

Auroraspora solisortus Hoffmeister, Staplin & Malloy (1955)
Plate 11, figs. 6 & 7

Holotype H. S. & M. 1955, pl.37, fig.8.

Type locality U.S.A. Kentucky, Webster County, Bald Knob Field, Carter No. 3 Borehole.

Diagnosis H.S.& M. 1955, p.381.

Description Amb circular or sub-circular often folded and thus irregular. Suturae indistinct to distinct extending to margin of intexine. Intexine dark and circular. Exoexine thin and flimsy, punctate or coarsely granulate but often corroded.

Size range 4236 40-72μ (7 spec.).

Other authors Butcher 1974 (thesis) 38(62)71μ (15 spec.); Felix & Burbridge 1967 60-82μ (25 spec.); 1955 Hoffmeister, Staplin & Malloy 61-78μ.

Occurrence Leitrim and Ballycastle.

Previous records H.S. & M. 1955, Hardinsburg Formation of Kentucky, U.S.A., Upper Mississippian; Butterworth & Williams 1958, Namurian A of Scotland; Mishell 1966 (thesis), Namurian A to Westphalian A of the Bowland Fells and Ingleton Coalfield; Felix & Burbridge 1967, Springer Formation, Oklahoma, U.S.A.

Schulzospora Kosanke 1950

Type species S. rara Kosanke 1950.

Diagnosis Smith & Butterworth 1967, p.273, expanded from Kosanke 1950, p.53.

Remarks Specimens of this genus were abundant at certain horizons in the Arnsbergian stage in County Leitrim. A biometrical study was made of these in an attempt to clarify the distinctions between the species present. Approximately 100 specimens were measured from the following samples in B.H. 151 in the Lackagh Hills of Leitrim:-

2" shale at 145'7" (4201

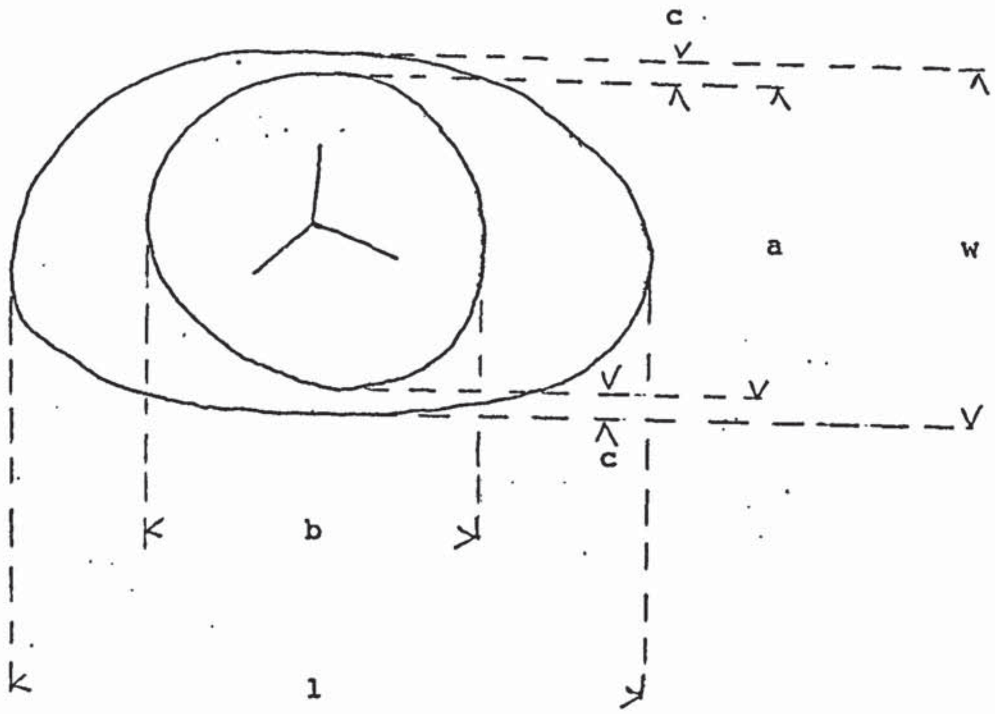
2" coal at 146'5" (4209)

2" coal at 146'7" (4297)

2" shale at 146'11" (4204)

The overall length and breadth of the specimens seemed to be the most significant parameters and these were plotted in the form of scatter diagrams (text figs. 33 - 37).

Dimensions used in a statistical study of the genus Schulzospora.



l – length

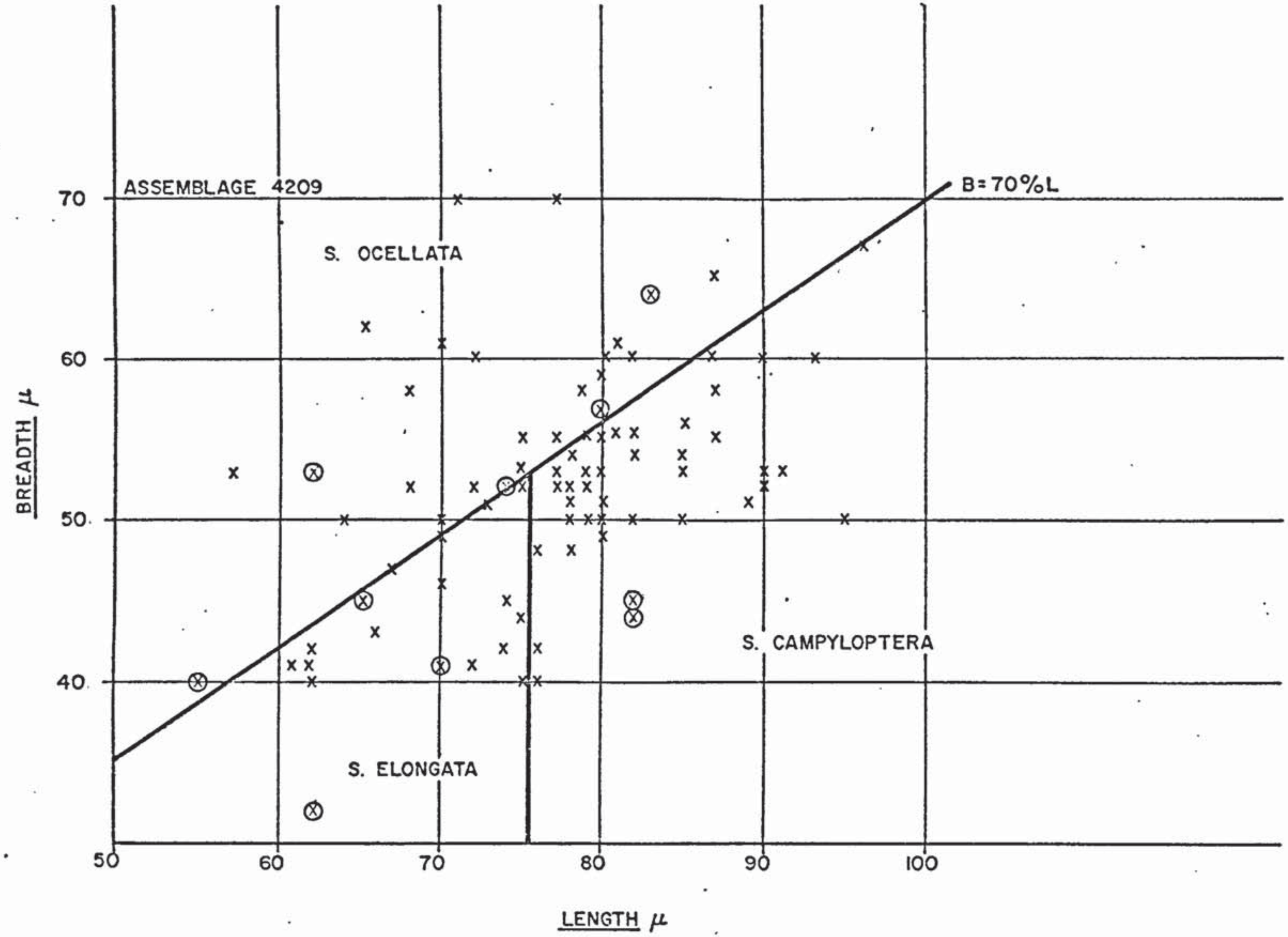
w – width

a – diameter of intexine parallel to shortest axis of the spore saccus.

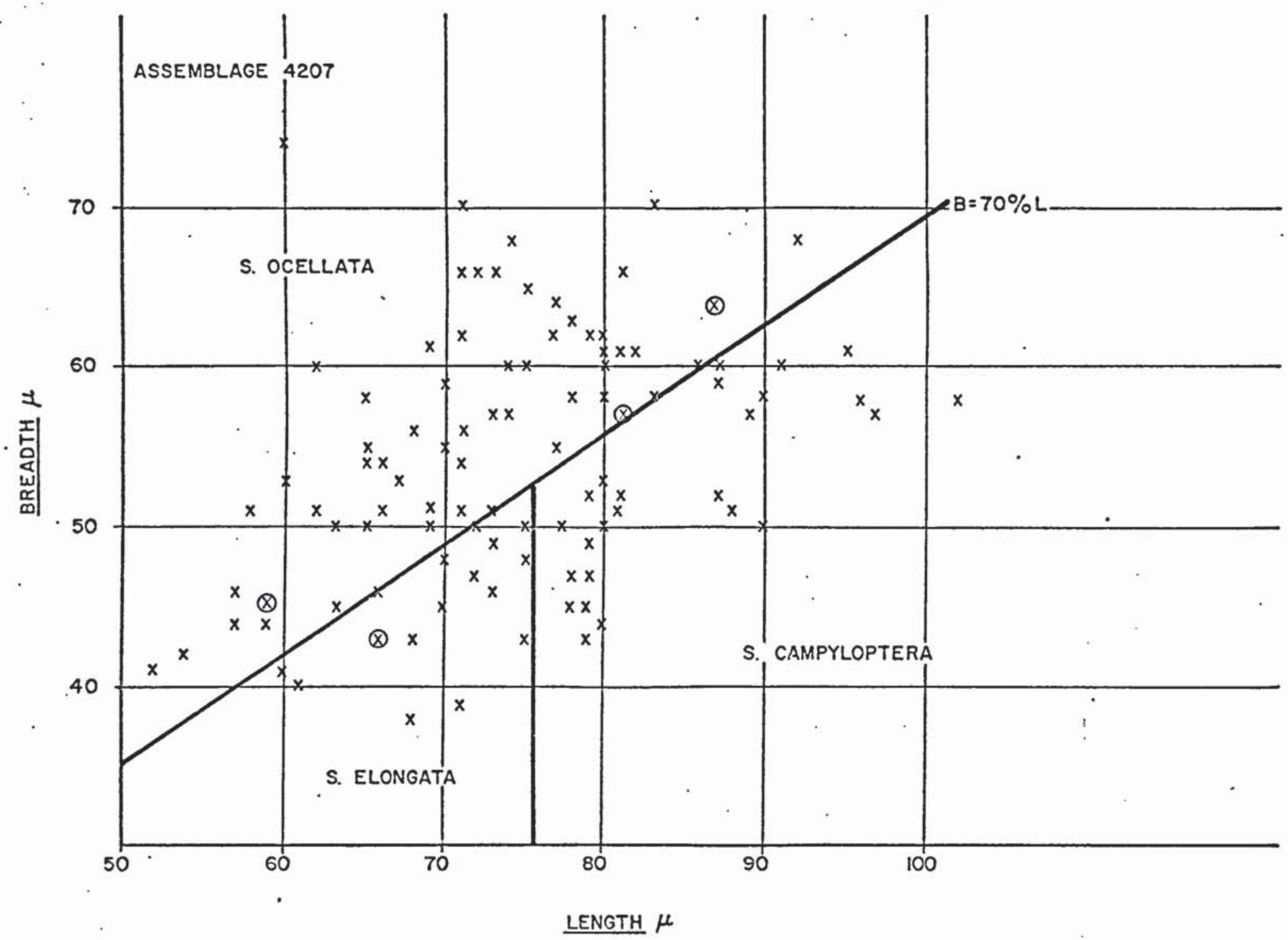
b – diameter of intexine parallel to the largest axis of the spore saccus.

c – distance between outer wall of intexine and the outer wall of the exoexine.

Fig. 33



SCHULZOSPORA: DISTRIBUTION CHART LENGTH AGAINST BREADTH



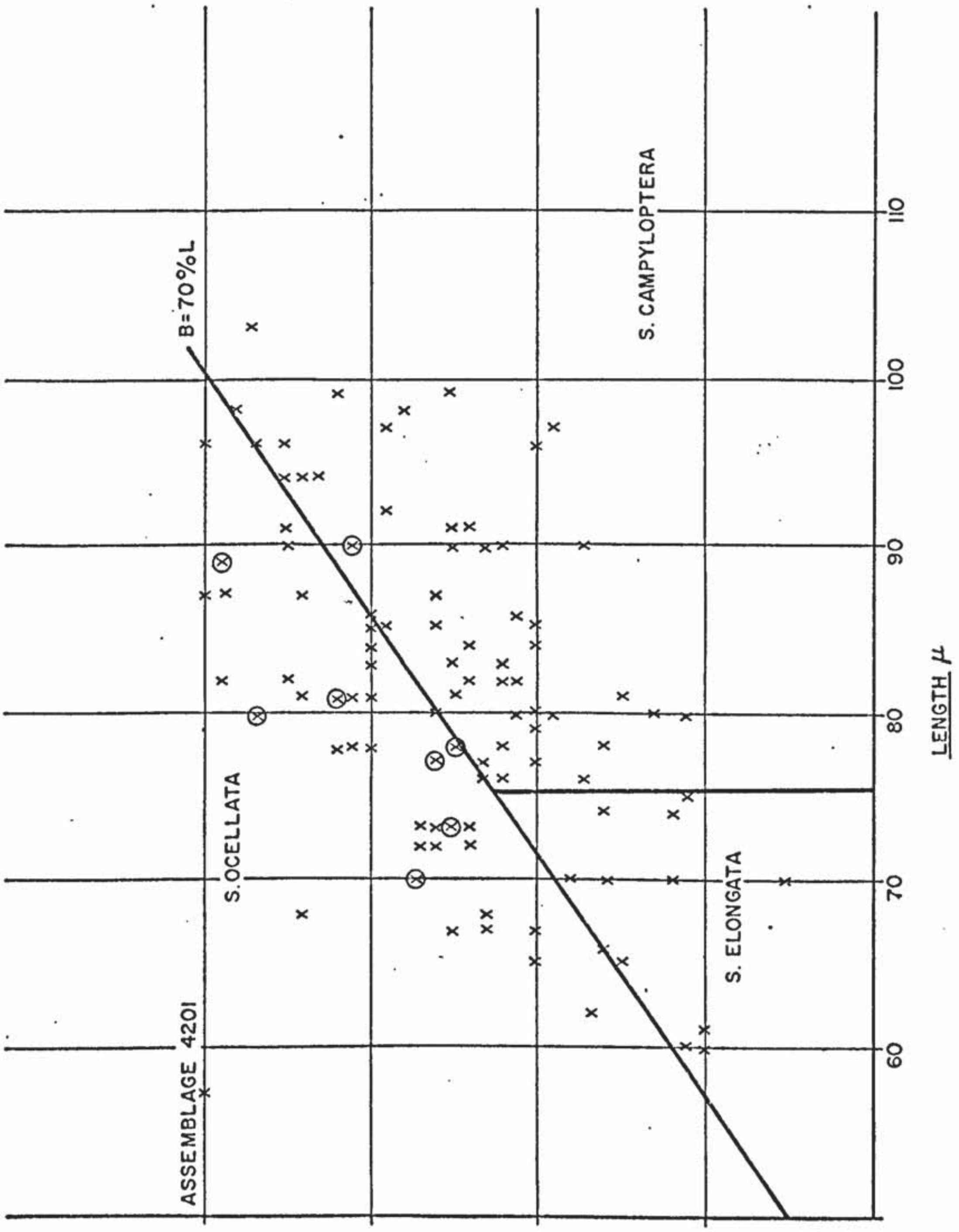
SCHULZOSPORA: DISTRIBUTION CHART LENGTH AGAINST BREADTH

○ INDICATES ⅄ ONE OR MORE SUTURAE PARALLEL TO LONG AXIS OF SPORE

Drawing No.16215

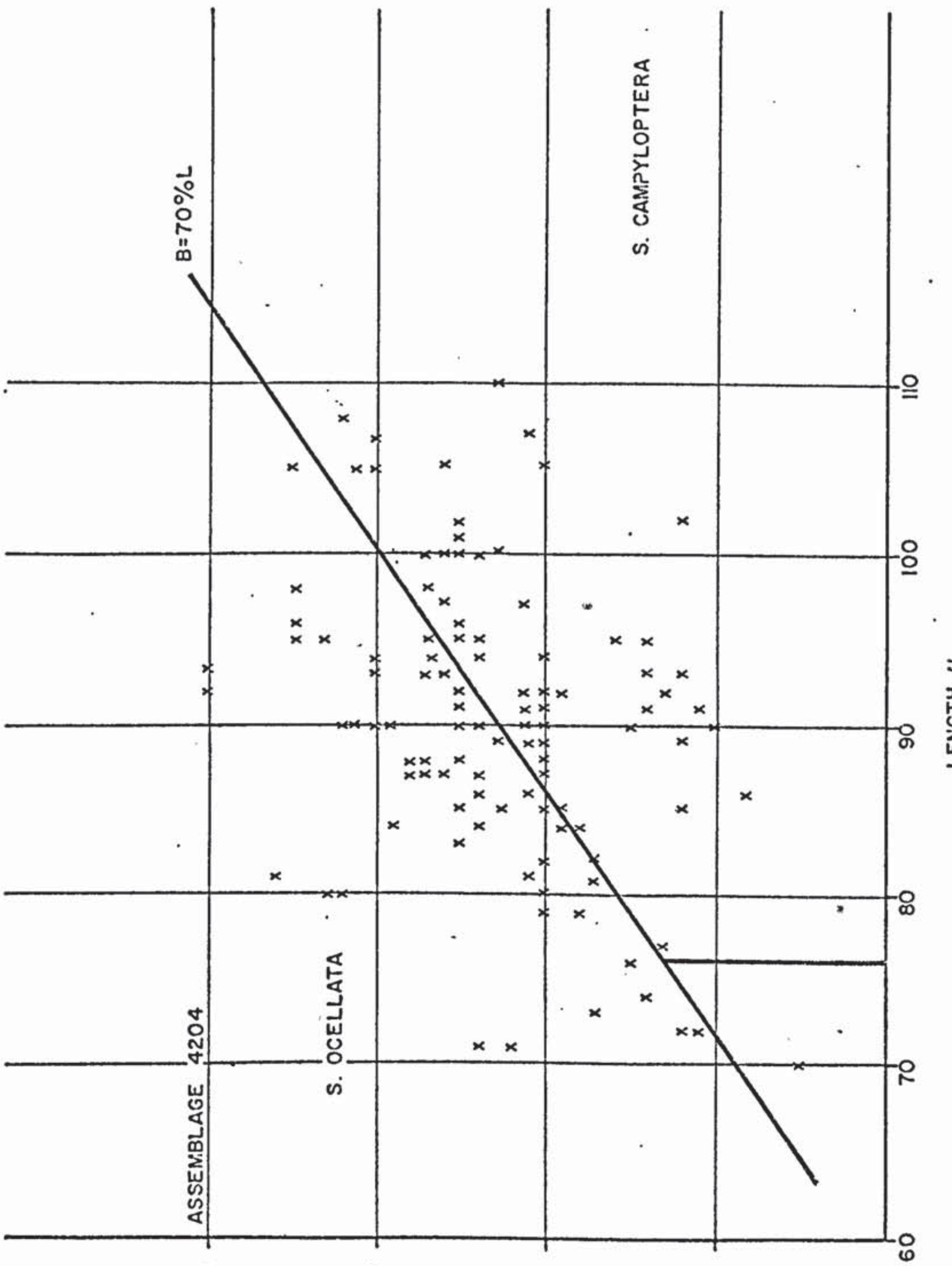
1·IX·76

Figure No.35



SCHULZOSPORA: DISTRIBUTION CHART LENGTH AGAINST BREADTH

Drawing No. 16213 31·VIII·76 Figure No. 36



SCHULZOSPORA : DISTRIBUTION CHART LENGTH AGAINST BREADTH

The lowest population, from the shale sample 4204, was distinctive because it consisted of relatively large specimens - 80% were 85µ long or longer and 74% were greater than 60µ in width; 14% were wider than 70% and this group were not represented in the other populations measured. A high proportion of the specimens with breadth greater than 60µ, and with breadth forming 70% or more than the length, had the long axis of the body at right angles to the long axis of the pseudosaccus, and in most of the remainder of this group the overall breadth of the spore was 15µ or more greater than the diameter of the body in that direction. These two characteristics may not be related but they were found only in spores with breadth 70% or more of length and they were scattered uniformly through that population

It is considered that this wider part of the population could represent Schulzospora ocellata (Horst) Potonié & Kremp. Horst gave the length as 61-130µ, and the body as 25-59µ. Smith & Butterworth 1967 measured a population from the Namurian A of Northumberland which gave the following figures:

76(92)110 x 60(69)88µ, body 56(66)77 x 52(61)74µ

cf. 4204 70-107 x 50 - 80µ.

The remainder of the population from 4204, that is to say those specimens with breadth less than 70% of the length, could also be distinguished by the facts that the long axes of their bodies were never at right angles to the long axis of the pseudosaccus, and the overall breadth of the spore was never more than 10u wider than the diameter of the body in the same direction.

It is considered that these spores probably represent the elongate species Schulzospora campyloptera (Waltz) Hoffmeister, Staplin & Malloy. All excepting one specimen in 4204 fell into the range :-

Length 77-110 x 48-72μ

cf. Waltz 90-114 x 65-75μ (These populations were both from

S.&B. 76-100 x 44-62μ Lower Carboniferous horizons)

Smith & Butterworth 1967 distinguished the species from Schulzospora elongata Hoffmeister, Staplin & Malloy on size alone, using an arbitrary limit of 76μ length.

The basal coal sample, 4207, yielded a smaller population, only 15% being greater than 85μ in length, compared with 80% of 4204, and 72% being less than 60μ in breadth compared with 26% in 4204. The relative proportions of breadth to length were similar with both rounded and elongated forms being present in more or less equal proportions.

The higher coal(4209) yielded a population with a similar overall size range but there was a greater proportion present of more élongate forms.

The shale above the coal (4201) contained higher proportions of larger spores - 37% were 85μ or longer, but only one greated than 100μ, and 33% were 60μ or broader, but only one greater than 70μ. This therefore has certain similarites to the lower shales but the assemblage is not so extreme.

Conclusion S. campyloptera and S. ocellata are the two most abundant species distinguished in the above four assemblages. S. elongata can also be recognised but occurs less frequently. The former two species occur in approximately equal amounts in the shale assemblages, but in the coals a pattern is not so obvious. In the coal 4207, S. ocellata is significantly more common but in 4209 S.campyloptera is marginally the more abundant. A study of the overall size ranges of Schulzospora suggests the coals contain smaller forms than those of the shales.

Schulzospora campyloptera (Waltz) Hoffmeister, Staplin & Malloy 1955.

Plate 12, fig. 7

1884 No. 619 Reinsch 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 campyloptera (Waltz); Hoffmeister, Staplin & Malloy, p.396.

Holotype Not known.

Type locality Seam 46, Skakulin Colliery, Selizharovo, Moscow Basin.

Diagnosis Luber & Waltz (translation No. 1443.).

Description Amb oval to very slightly triangular. Pseudosaccus strongly microreticulate, particularly on the 'wings' rather than the body. Suturae not all of equal length extending ½ to ¾ of body radius. Body in its largest axis usually not more than 10u less than pseudosaccus breadth.

Size range 4209 76-95 x 40-66µ (42 spec.); 4201 76-104 x 35-68µ (44 spec.); 4204 77-110 x 48-72µ (48 spec.); 4207 76-102 x 38-61µ (26 spec.).

Other authors Luber & Waltz 1938 90-114 x 65-75µ, body 60-70µ Schulze; Smith & Butterworth 1967, 76(87)100µ x 44(55)62µ, body 46(54)66 x 40(48)60µ Fu.HNO_3, Northumberland, Viséan.

Occurrence Leitrim and Ballycastle.

Remarks Smith & Butterworth 1967 distinguished this species from S. elongata Hoffmeister, Staplin & Malloy on size alone, using an arbitrary limit of 76µ length.

Previous records Recorded by numerous authors from the Carboniferous younger than Tournaisian including Smith & Butterworth (1967) Coals of Great Britain, Viséan and Namurian.

Schulzospora elongata Hoffmeister, Staplin & Malloy 1955

Plate 12, fig. 6

1955 Schulzospora elongata H.S. & M. p.396, pl.39, fig.2.

Holotype Hoffmeister, Staplin & Malloy 1955.

Type locality 2,072ft. (631.5m) Carter No. 3 Borehole, Webster County, Kentucky, U.S.A.

Diagnosis H.S. & M. 1955, p.396.

Description Amb oval, containing a circular to oval intexine, which remains consistent in its central position within the exoexine. The exoexine is strong to weakly infrapunctate. Trilete mark extends from half to three quarters of spore radius.

Size range 4201 60-75 x 35-50µ (11 spec.); 4207 38-75 x 74µ (14 spec.); 4209 60-75 x 32-52µ (17 spec.).

Other authors Hoffmeister, Staplin & Malloy 1955 60.8 x 30.5, body 35 x 25.7u HF; Smith & Butterworth 1967 52(63)76 x 34(40)52u body 30(39)48 x 24(33)42, Fu.HNO_3 Lothians, Scotland, Namurian A; 50(66)76 x 30(39)44, body 28(37)46 x 26(34)40µ, Fu.HNO_3, Northumberland, Namurian A.

Occurrence Leitrim & Ballycastle.

Remarks Distinguished by its breadth being less than 70% of its length; and its length below 76µ. The latter length is based on a line observed by Smith & Butterworth 1967, which divided their assemblage into two well defined groups S. elongata and S. campyloptera.

Schulzospora ocellata (Horst) Potonié & Kremp 1956

Plate 12, figs. 3, 4 & 5

1943 Triletes (Zonales) ocellatus Horst (thesis) figs. 40,41.

1955 Schulzospora ocellata (Horst) Potonié & Kremp in Horst, p.195, pl.21, figs. 40 a, b.

1956 Schulzospora ocellata (Horst); Potonié & Kremp, p.166.

non.1958 Schulzospora ocellata (Horst) Potonié & Kremp; Butterworth & Williams pl.4, fig.15.

Holotype Horst 1955, pl.21, figs. 40 a, b.

Type locality Osmara Seam, Michael Colliery, Moravska-Ostrava; Namurian A.

Diagnosis Horst 1955, p.195.

Description Amb oval to almost round or triangular. Pseudosaccus usually oval, with long axis at right angles to length of body. Suturae extend $\frac{1}{2}$ - $\frac{3}{4}$ of pseudosaccus radius, almost always of unequal lengths. Body exine finely infragranulate.

Size range. 4201 60-92 x 45-80µ (48 spec.); 4204 70-107 x 50-80µ (51 spec.); 4207 52-92u x 42-70µ (60 spec.); 4209 55-86 x 40-70µ (31 spec.).

Other authors Horst 1955 61-130 x 25-59µ (Fu.HNO_3); Smith & Butterworth 1967 76(92)110 x 60(69)88, body 56(66)77 x 52(61)74µ Fu.HNO_3, Northumberland, Namurian A.

Occurrence Leitrim and Ballycastle.

Remarks It was generally found that in assemblages of Schulzospores those with their breadth forming more than 70% of the length, displayed the feature of the long axis of the body at right angles to the long axis of the pseudosaccus. Also the breadth of the spore pseudosaccus was often up to 15u more than the body diameter, although this feature was displayed in other species of Schulzospora.

Smith & Butterworth 1967 suggest S. rara generally occurs with the long axis of the oval body approximately parallel to the long axis of the pseudosaccus, and S. ocellata at right angles. In figs the 'black dots' refer to spores with the long axis at about 90° to the long axis of the pseudosaccus. The author concludes little relationship between this feature and size, and suggests that the orientation of the body shape is of doubtful importance in dividing these broader forms into two species.

It may suggest that both S. ocellata and S. rara occur in these assemblages, in relatively even amounts but it seemed rather arbitrary to decide in which of these species a specimen should be placed.

It is the author's opinion that these rounder forms of Schulzospora might be all included in S. ocellata.

Previous records Recorded by numerous authors from the Carboniferous. Younger than Tournaisian including Kosanke 1950, W.C. Illinois, Namurian; Hoffmeister, Staplin & Malloy 1955, Upper Mississippian, Hardinsburg Formation; Love 1960, Upper Viséan, Oil-Shale Group. Neves 1964, Namurian B to Westphalian B to Westphalian A; Felix & Burbridge 1967, Mississippian to Pennsylvanian, Oklahoma. Smith & Butterworth 1967, Coals of Great Britain, Viséan and Namurian.

Schulzospora plicata Butterworth & Williams 1958

Plate 12, figs. 8 - 10.

Holotype B. & W. 1958, pl.23, fig.4.

Type locality Seam at 18555 ft 4 ins. (474m), Righead Borehole, West Fife Coalfield, Scotland, Namurian A.

Diagnosis Butterworth & Williams 1958, p.388.

Description Amb elongate-elliptical, constricted in the region of the intexine. Intexine circular distinct, and often a much darker colour; size range 36-65µ. Exoexine densely ornamented with minute 0.5u grana; a series of folds and plications occur where constricted.

Size range 2472 63-95µ, intexine 35-65µ.

Other authors Smith & Butterworth 1967 44-64µ intexine 25-40µ; 40-100µ Schulze KOH.

Occurrence Leitrim and Ballycastle.

Remarks Some specimens do not display strong plications or folds, and can appear similar to the genus Auroraspora.

Previous records Smith & Butterworth 1967, Viséan to Westphalian A, Coals of Great Britain.

Genus REMYSPORITES Butterworth & Williams 1958

Type species R. magnificus (Horst) B. & W. 1958.

Diagnosis Mishell 1966, M.Sc. p.103.

Remarks Distinguished from Endosporites Wilson & Coe by the character of the external ornament of the pseudosaccus and the absence of a limbus. Vestispora has a distinctive ornament of the exoexine and an operculum. Remysporites has also distinctive folding in the polar areas.

Remysporites magnificus (Horst) Butterworth & Williams 1958

Plate 12, figs. 1 & 2.

1943 Triletes (Zonales) magnificus Horst (thesis), fig. 37.

1955 Endosporites magnificus (Horst) Potonié & Kremp, Horst, p.194,pl.21., fig.37.

1956 Endosporites magnificus (Horst); Potonié & Kremp, p.161.

1958 Remysporites magnificus (Horst); Butterworth & Williams, p.386., pl.4, figs. 7-9.

Holotype Horst 1955, pl.21, fig.37.

Type locality Seam C, Gleiwitzer Coalfield.

Diagnosis Butterworth & Williams 1958, p.387.

Description Amb oval to sub-circular, often folded. Suturae relatively short 20-50μ (½ to ⅓) of total amb radius; often ridged 2μ but also sometimes simple. Contact area of exoexine wrinkled; towards centre verrucae and rugulae may appear 1-4μ in length. Remainder of exoexine is laevigate. Broad flat tapering folds are frequent 23-30μ wide and frequently extend the amb length. The intexine is circular, very distinct 65(115)170μ, 1-2.5μ thickness, rarely folded and probably laevigate. Exoexine 1-3u thick.

Size range 2472 230-95μ (25 spec.); 2471 115-170μ (5 spec.); 4208 150-155μ (7 spec.).

Other authors Horst 1955 84-249μ; Chaloner in Butt. & Will. 1958 169-225μ; Butt. & Will. 1958 138-184μ; Neville 1968 89(134)163μ.

Occurrence Leitrim and Ballycastle.

Remarks Difficult to distinguish from R. albertensis Staplin 1969, p.35, since the size range has been increased to nearly that of R. magnificus. Also R. albertensis displays the same ornamented contact area. General size range compares well with Horst 1955, but is smaller than described by Butterworth, Williams & Chaloner. Leitrim and Ballycastle specimens very similar, except the exines of the latter area are consistently thicker. All show ornamented contact area. Occurrence frequent.

Previous records 1967 Smith & Butterworth, Coals of Great Britain, Viséan & Namurian; 1958, Butterworth & Williams, Limestone Coal Group, Upper Limestone Coal Group; 1968 Neville, East Fife, Upper Viséan; 1961 Neves, Southern Pennines, Namurian A; 1961 Bharadwaj & Venkatachala, Spitzbergen, Lower Carboniferous; 1964 Neves, La Camocha, Gijon,N.Spain, Namurian A; 1965 Owens & Burgess, Stainmore, Namurian A; 1965 Horst, Moravian Ostrava, Namurian A.

Infraturma DECORATI Neves & Owens 1966

Genus CRASSISPORA (Bharadwaj) Ioannides 1971

Type species C. kosankei Bharadwaj 1957.

Diagnosis Ioannides 1971, p.173.

Remarks The intexine was not at all obvious in most of the species. In assemblages treated with KOH, the intexine structure gives the appearance also of Spelaeotriletes, but since these specimens seem closely related in ornament and general appearance to C. maculosa it was decided to use the genus Crassispora.

Crassispora aculeata Neville 1968

Plate 13, fig. 4

Holotype Neville 1968, pl.2, fig.5.

Type locality East Fife, Scotland, Sample F.75.

Diagnosis Neville 1968, p.445.

Description Amb usually folded giving polygonal shape. Suturae accompanied by labra, up to 5μ wide. Exine densely covered by minute grana, and spines; spines broad based, 2-4μ, rapidly tapering, height 5-12μ, average 6-8μ, widely set 7-10μ apart; number at equator 13-30. Crassitude often indistinct, 5μ wide.

Size range Ballycastle material in general - 58(70)83μ (10 spec.); sample 2472 78μ; 2476 58μ; 2481 70-80μ (4 spec.);2478 70-83μ (3 spec.); 2480 70μ.

Other authors Neville 1968 56(73)96u.

Occurrence Ballycastle.

Remarks Occurrence very infrequent and restricted to Ballycastle material. Crassitude is often indistinct as described in Neville 1968. Spines seem to lack bulbous bases which are also described in Neville's specimens. Size range agrees closely with previous studies.

Previous records Neville 1968, East Fife, Upper Viséan; Neves et al.1973, West Lothian, Upper Viséan.

Crassispora kosankei (Potonié & Kremp) Bharadwaj 1957

Plate 13, fig. 5

1955 Planisporites kosankei Potonié & Kremp, p.71, pl.13, figs.208-13.

1957 Apiculatisporites apiculatus Dybova and Jachowicz,pp.87-9,pl.15, figs.1-4.

1957 Crassispora kosankei (Potonié & Kremp); Bharadwaj p.127.

1964 Crassispora kosankei (Potonié & Kremp);Bharadwaj;Sullivan,p.376, pl.60, figs.13-15.

Holotype Potonié & Kremp 1955, pl.13, fig.208.

Type locality Seam R_1, Friedrich Thyssen 2/5 (Wehofen) Colliery, Ruhr Coalfield, Germany; Westphalian B.

Diagnosis (emended from Potonié & Kremp 1955,p.71 in S. & B. 1967, p.234).

Description Amb oval, often folded or subcircular. Suturae rarely observed, seldom intact, usually split giving triangular opening. Distal coni show little variation in style; 1-2µ high; 1-2µ diameter; 27-55 average (27-40) at equator. Three apical papillae, 4µ diameter occasionally present on contact area. Exine very minutely and densely granulate, less than 0.5µ diameter; exine thickness towards equator.

Size range 4236 (56-60µ) (3 spec.); 4204 60-77µ (5 spec.); 4249 48(55)68µ (10 spec.).

Other authors Potonié & Kremp 1955 68-85µ Schulze; Playford 1964 45(60)70µ; Felix & Burbridge 56-72µ; Mishell 1966 57(77)94µ.

Occurrence Leitrim.

Remarks Size ranges have not been used too rigidly to distinguish Crassispora ovalis as maceration, especially the use of alkali have been shown by Smith & Butterworth 1967 and Playford 1964 to variably inflate the exines. The tapering coni of C. kosankei distinguish it from the 'mammillate' grana of C. maculosa (Knox) Sullivan 1964. Many specimens showed the triangular shaped suture split, as described by Felix & Burbridge 1967 and Smith & Butterworth 1967. C. greggsii McGregor 1964 and C. brondtii Streel 1964 are distinguished by their prominent laesurae and distal sculpture of minute cones and grana. Occurrence frequent.

Previous records Lele & Provan 1962, Ayrshire;Neves 1961, Southern Pennine Basin, Namurian A and B; Felix & Burbridge 1967, Springer Formation, Upper Mississippian; Smith & Butterworth 1967, Coals of Great Britain, Namurian to Westphalian D; Potonié & Kremp 1955, Upper Westphalian A to Lower Westphalian C of the Ruhr; Love & Neves 1963, Innismore, Scotland, Upper Westphalian B; Owens 1963, Stainmore, Upper Namurian A to Lower Westphalian B; Neves 1964, La Camocha, Gijon, North Spain, Namurian A to Upper Westphalian B; Mishell 1966 (thesis), Bowland Fells and Ingleton Coalfield, Namurian A to Westphalian B.

Crassispora maculosa (Knox) Sullivan 1964

Plate 13, figs. 1 & 3

1948 23K Knox, p.158, fig.26.

1950 Verrucoso-sporites maculosus (Knox), p.318

1955 Apiculatisporites maculosus (Knox), Potonié & Kremp, p.78.

1964 Crassispora maculosa (Knox), Sullivan, p.376.

Lectotype Plate 18, fig.8, Knox preparation 360A (T83/1) Coal Survey Laboratory, Sheffield.

Type locality Dunfermline Splint Seam, Lumphinnans No. 1 Colliery, West Fife Coalfield, Scotland, Namurian A.

Diagnosis Smith & Butterworth 1967, p.235.

Description Amb oval to sub-circular. Intexine observed, laevigate, sub-circular ⅔ to over ¾ of amb radius. Suturae tectate extending to curvaturae at the crassitude; tecta up to 15μ in length, average 3-6μ wide, 0.5μ thickness. Exine 2-3μ thick, densely covered by tiny grana less than 0.5μ, bases touching. Ornamentation also includes low cones and grana 1-2.5μ high, rounded profile or mamillate, 2(1.5μ)3μ diameter; discretely set wide apart 1-7μ, evenly distributed and rarely clustering. Contact area laevigate, 75-90μ wide, delimited by curvaturae which can be prominent or indistinct, 6-8μ wide, occasionally 10μ. Based on 2472.

Size range 2472 78(100)110μ (30 spec.); 2481 87(105)141μ(12 spec.); 2478 90(100)125μ (11 spec.).

Other authors Neville 1968 69(82)96μ KOH; Sullivan & Marshall 1966 63(77)93μ; Smith & Butterworth 1967 76(94)111μ Fu.HNO_3; Knox 1955 100-120μ; Owens 1963 100-126μ; Mishell 1966 83-110μ.

Occurrence Ballycastle.

Remarks The ratio of the crassitude width to total diameter 0.71 - 0.91. Differs from Spelaeotriletes arenaceus by the lack of thickening of the contact area, and by crassitude less than spore radius in width, upper size limit greater than previous records. However KOH 5% was used for a short period of time on these specimens. Occurrence very frequent in certain samples.

Previous records. Knox 1958, Limestone Coal Group of Scotland, Namurian A; Butterworth & Williams 1958, Namurian A of Scotland; Neves 1961, Southern Pennines, Lower Namurian A; Bharadwaj and Venkatachala 1961, Lower Carboniferous of Spitzbergen; Owens 1963 (thesis) Stainmore, Lower Namurian A; Sullivan & Marshall 1966, Western part of Midland Valley, Scotland, Upper Viséan; Felix and Burbridge 1967, Springer Formation, Upper Mississippian; Smith & Butterworth 1967, British Coals, Namurian to Westphalian D.

Genus ACULEISPORES Artuz 1957

Type species A. aculeus Artuz 1957.

Diagnosis Artuz 1957, p.257.

Aculeispores sp.

Plate 19, figs. 7 & 10

Description Amb oval to subcircular. Intexine rounded triangular. Suturae straight, simple, extend almost to the edge of the intexine. Exoexine bears minute cones and grana 0.5μ diameter; stand 0.5μ, densely set with bases almost touching. A frequent feature is for the exoexine to fold over at the apices of the intexine. Exoexine often folded; folding sinuous.

Size range 4249 52-80μ intexine 38-50μ.

Remarks This species is abundant in sample 4249, but not recorded elsewhere in this study.

Genus GRANDISPORA (Hoffmeister, Staplin & Malloy)

Neves and Owens 1966.

Type species G. spinosa H.S. & M. 1955.

Diagnosis Neves & Owens 1966, p.346.

Remarks Distinguished from Spinozonotriletes by the fact that the latter genus has a solid flange, and the intexine and exoexine are attached distally and proximally. In Grandispora the attachment is at the laesurae.

Grandispora echinata Hacquebard 1957

Plate 13, figs.7&8

Holotype Hacquebard 1957, pl.3, fig.17.

Type locality Horton Group of Nova Scotia.

Diagnosis Hacquebard 1957, p.317.

Description Amb rounded triangular. Intexine shape similar to exoexine, thin and usually clearly defined. Suturae often indistinct, obscured by folding above; sometimes gape. Ornamented with galaea and cones 1-1.5μ in diameter; stand 1-3μ, set 1-3μ apart; restricted to distal surface. Remainder of exoexine leavigate or finely infrapunctate.

Size range 5044 62-64μ (3 spec.); 5040 60-72μ (6 spec.); 1646 42-55μ (5 spec.).

Other authors Sullivan & Marshall 1966 50(64)77μ; Hacquebard 1957 62-93μ (cb.47-20μ) (12 spec.); Playford 1963 59-96μ (32 spec.).

Occurrence Goresbridge and S. Mayo.

Previous records Hoffmeister, Staplin & Malloy 1955, Hardinsburg Formation of Illinois & Kentucky, U.S.A., Mississippian; Wiggins 1961, Upper Mississippian Chainman Formation of Nevada; Neves 1961, Namurian A of Southern Pennines; Owens & Burgess 1965, Namurian A of the Stainmore Outlier; Sullivan & Marshall 1966, Upper Viséan of Western part of Midland Valley, Scotland; Neville 1968, Upper Viséan, East Fife, Scotland.

Grandispora spinosa Hoffmeister, Staplin & Malloy 1955

Plate 13, fig. 2

Holotype H.S. & M. 1955 pl.39, figs. 10,14.

Type locality U.S.A. Webster County, Carter No. 3M. Mississippian, Hardinsburg Formation.

Diagnosis H.S. & M. 1955, p.388.

Description Amb circular or subcircular.. Intexine well defined and a similar shape to exoexine. Exoexine ornamented on distal and equatorial surfaces with sharply pointed spines and galaea. Elements 3-5μ length, 2-4μ width at base, spaced 7-10μ apart. Suturae simple, straight extend to margin of spore body. Exoexine relatively thick; pale brown in colour.

Size range 4204 165μ, intexine 140μ; 4249 75-95μ (4 spec.).

Other authors Hoffmeister, Staplin & Malloy 1959,100-143 (84-100μ).

Occurrence Leitrim and Ballycastle.

Previous records H.S. & M. 1955, Hardinsburg Formation, Mississippian, Illinois & Kentucky, U.S.A.;Staplin 1960, Upper Mississippian of Alberta, Canada; Bharadwaj & Venkatachala 1961, Lower Carboniferous of Spitzbergen;

Sullivan & Marshall 1966, Upper Viséan, Midland Valley of Scotland; Mishell 1966 (thesis) Lower Namurian A of Bowland Fells; Felix & Burbridge 1967, Springer Formation, Oklahoma, U.S.A.; Neville 1968, Upper Viséan, East Fife, Scotland.

Genus PEROTRILITES Couper 1953

Type species P. granulatus Couper 1953.

Diagnosis Couper 1953, p.31.

Perotrilites perinatus Hughes & Playford

Plate 13, fig. 6

Holotype H. & P. 1961, pl.2, fig.7.

Type locality Lower Carboniferous of Spitzbergen.

Diagnosis H. & P. 1961, p.33.

Description Amb oval to circular. Suturae simple, straight, extending over three quarters of spore radius. Perine thin but not excessively folded. Exine relatively thick 1-2μ, laevigate.

Size range 2615 48-57μ (3 spec.).

Other authors Sullivan & Marshall 1966 55-68μ; Butterworth & Spinner 1967 40(52)68μ and 44(70)90μ; Hughes & Playford 1961 44(67)90μ (16 spec.).

Occurrence Ballycastle.

Previous records Sullivan & Marshall 1966, Viséan spores of Midland Valley, Scotland; Hughes & Playford 1961, Lower Carboniferous of Spitzbergen; Butterworth & Spinner 1967, Lower Carboniferous N.W. England, Bewcastle Beds.

Genus SPELAEOTRILETES Neves & Owens 1966

Type species S. triangulus.

Diagnosis Neves & Owens p.342-344.

Spelaeotriletes arenaceus Neves & Owens 1966

Plate 13, figs. 11 - 13 and Plate 14, fig. 1

Holotype Neves & Owens 1966, pl.3, fig.4.

Type locality Lower Bentham Grit Coal, Lancashire; Sabdenian stage, Namurian A.

Diagnosis Neves & Owens 1966, p.345.

Description Amb triangular with convex sides, rounded spines. Suturae straight, tectate extending to margin of amb; may stand 1-3µ high towards the centre of amb; suggestion of curvaturae. Amb margin defined by thickness of exine or possible crassitude 2µ wide. Ornamented distally with galeae, verrucae, cones and grana 1-1.5µ diameter; 1-1.5µ high. Project rarely at equator; spaced 1-2µ apart. Intexine suggested by a dark shadow which appears more rounded triangular than amb.

Size range 4249 76-86µ (3 spec.); intexine 38-50µ.

Other authors Neville 1968 83-2(103.1132.8µ (30 spec.); Neves & Owens 1966 82-144µ; Intexine 44-90µ (67 spec.).

Occurrence Ballycastle and Leitrim.

Remarks Ballycastle forms are larger, ornamented with only grana and cones, which may not always cover entire distal surface, but otherwise similar. Lophotriletes conifer us of Felix & Burbridge 1967 appears to be similar.

Previous records Neves & Owens 1966, Stainmore Outlier, Namurian A to Lower Namurian C; Neville 1968, Viséan spores of Scotland.

Spelaeotriletes cf. pretiosus (Playford) Neves & Belt in Clayton 1970

Plate 9, figs. 9 & 10

Holotype Neves & Belt (1971), pl.3, figs.7,8.

Type locality

Diagnosis Neves & Belt (1971).

Description Amb rounded triangular with convex interradial areas. Suturae accompanied by high sinuous ray folds 1-1.5u, extending to amb margin, where curvaturae perfectae occur. Exoexine ornamented with verrucae, galeae, grana, usually rounded in profile but may be more pointed; rounded or irregular in plan view 0.5-3u diameter. Proximally granulose; distally and equatorially verrucae and galeae. Intexine similar shape to amb not always very distinct.

Size range 4268 62u; 5040/44 63μ cb.55μ; 1646 34-50μ cb.28-43μ.

Other authors Clayton 1970 59(75)101u.

Occurrence Goresbridge and S. Mayo.

Remarks S. pretious is much larger in size.

Previous records Clayton 1970, Cockburnspath, N.E. England, Tournaisian.

Genus RUGOSPORA Neves & Owens 1966

Type species R. corporata var. leavigata Neville 1968,p.450.

Diagnosis Neves & Owens 1966.

Rugospora corporata Neves & Owens var.verrucosa Neville 1968

Plate 14, figs. 2 - 4

1966 Velamisporites rugosus Bharadwaj & Venkatachala.

1966 Rugospora corporata Neves & Owens, pl.2, fig.4-5.

1968 Rugospora corporata var. verrucosa Neville, p.450, pl.3, fig.2-3.

Holotype Neville 1968, pl.3, fig.2.

Type locality Sample F100 lower of the two coals 3' (0.91,) below the Mid Kinniny Limestone.

Diagnosis Neville 1968, p.450.

Description Amb rounded triangular or oval. Intexine often a different shape rounded triangular or circular. Exoexine can be ornamented with verrucae 2-3μ, rugulae 1-1.5μ and tiny grana 0.5μ. Occasional larger verrucae up to 7μ diameter. Channels between verrucae narrow 0.5μ. Rugulae in places become difficult to distinguish from plicae which may radiate from a more random arrangement in the polar region have a more polygonal pattern

2-3µ diameter. Specimens frequently folded.

Size range 4249 77-115µ (intexine 52-83µ); 4236 90µ (intexine 49µ); Ballycastle general 110-140µ, intexine 65-110µ.

Other authors Neves & Owens 1966 105-175µ, intexine 66-102µ; Neville 1968 59-192µ.

Occurrence Ballycastle and Leitrim.

Remarks Ballycastle specimens are larger than those from Leitrim. Ratio of intexine diameter to exoexine differs also - Leitrim 0.55-0.66, Ballycastle 0.71-0.81. General appearance is otherwise similar. Occurrence very infrequent.

Previous records Neves & Owens 1966, Southern Pennines, Namurian; Sullivan & Marshall 1966, Upper Viséan, Scotland; Neville 1968, Viséan of Scotland; Clayton 1971, Viséan Cockburnspath, Scotland; Neves et al. 1973, Lower Carboniferous, N. England, Scotland.

Rugospora minuta Neves & Ioannides 1974

Plate 14, figs. 5 & 6

Holotype N. & I. 1974, pl.4, fig.4.

Type locality Spilmersford Borehole, East Lothian, Lower Carboniferous.

Diagnosis N. & I. 1974, p.35.

Description Amb oval, rounded triangular or circular. Suturae indistinct, rarely visible, $\frac{1}{2}$ to $\frac{3}{4}$ of spore radius. Exoexine plicated into series of closely set radially arranged rugulae variable in width 0.5-2µ; 20-40 elevations at equator. Rugulae usually more densely set and also thinner in the polar regions. Exine 1u thickness. Rarely folded.

Size range 2476 35-50µ (5 spec.); 2481 32-52µ (15 spec.); 4236 44-60u (7 spec.); 4204 56-60µ (5 spec.); 4249 37-50µ (4 spec.); 2471, 478, 480, 482µ.

Other authors Clayton 1974 35-57μ.

Occurrence Ballycastle and Leitrim.

Remarks Structure of specimens conforms to that of diagnosis. Specimens from Leitrim tend to be larger, and display a dark band at the region of proximal attachment. Suturae also larger in proportion to body. General occurrence infrequent.

Previous records Neves & Ioannides 1974, Spilmersford Borehole, East Lothian, Lower Carboniferous; Neves et al. 1973, Lower Carboniferous, East Lothian, Scotland.

Rugospora Sp. A.

Plate 14, figs. 7 - 9

Description Amb oval or circular. Suturae simple, indistinct; extend over ¾ of spore radius. Exoexine set closely to intexine; ornamented with scattered pila and small verrucae; stand 1u, 0.5μ diameter. Clusters of pila occur more on distal surface. Rugulae 1-1.5μ width frequent at the equator, arranged in a radial pattern; these are less frequent in the polar areas and also more randomly distributed. Remainder of exine laevigate. Exine yellow, frequently folded.

Size range 2472 50-56μ (10 spec.); 2476 43-52μ (10 spec.); 2052 42μ; 2475 41-49μ (5 spec.).

Occurrence Ballycastle.

Remarks Size range is notably limited in Sample 2472, between 50 and 56μ. Occurrence is restricted to Ballycastle area. Differs from Rugospora minuta in its thinner rugulae, presence of pila, and areas of the exoexine that are laevigate.

Subturma MEMBRANATITRILETES Neves & Owens 1966

Infraturma CONTINUATI Neves & Owens 1966

Genus DISCERNISPORITES (Neves) Neves & Owens 1966

Type species D. irregularis (Neves) Gueinn 1969 M.Sc.

Diagnosis Gueinn 1969 M.Sc., p.120.

Discernisporites crenulatus (Playford) Clayton 1970

Plate 14, figs. 10 - 12

1963 Granulatisporites crenulatus Playford, p.11,pl. 2, figs. 8,9,10.

1970 Discernisporites crenulatus (Playford) Clayton,p.583,pl.2, figs. 2,3, & 4.

Holotype Playford 1963, plate 2, fig.10.

Type locality Horton Group (Craignish Farm), Nova Scotia,GSC 10c.6405.

Diagnosis Clayton 1970, p.583.

Description Amb very rounded triangular, almost circular, trilete and camerate. Suturae distinct, straight or slightly sinuous, may be slightly ridged; extend almost to spore margin. Exoexine and intexine are similar in shape and are separated by only a small distance 0.5μ. Intexine only a few microns smaller. Ornamented by densely set grana less than 0.5μ diameter.

Size range 5044 31-42μ (5 spec.).

Other authors Playford 1963 36(44)54μ (40 spec.); Clayton 1970 30(41)53μ (50 spec.).

Occurrence Goresbridge

Remarks Specimens generally poorly preserved but conform to Clayton's description. Superficially similar to Lycospora spp. but distinguished by the absence of a thickening and flange.

Previous records Playford 1963, Horton Group, Nova Scotia, Lower Carboniferous; Clayton 1970, Cockburnspath, Lower Carboniferous, Scotland.

Discernisporites micromanifestus Hacquebard 1957

Plate 15, figs. 1 & 2

1956 Hymenozonotriletes aff. variabilis Naumova, Ischenko, p.62, pl.11, figs. 129-30

1957 Endosporites micromanifestus Hacquebard, p.317, pl.3, fig.16.

1958 Discernisporites concentricus Neves, p.5, pl.3, fig. 7.

1960 Auroraspora micromanifestus (Hacq.) Richardson, p.51.

1960 Endosporites micromanifestus Hacq; Love, p.121, pl.2, fig.6

1960 Auroraspora sp.A. Love, p.120, pl.2, fig.5.

1961 Endosporites micromanifestus Hacq.; H. & P., p.44, fig.8.

1963 " Hacq;Playford, p.652, pl.93, figs.17,19.

1964 " " Playford, p.37, pl.11, fig.2.

1965 " " Owens in Owens & Burgess pl.4, fig.7.

1966 " " Sullivan & Marshall p.278, pl.3,fig.18

1967 " " Felix & Burbridge p.408, pl.63,fig.2.

1967 Perotrilites perinatus Hughes & Playford; Butterworth & Spinner pl.1, fig.14.

in press Discernisporites micromanifestus (Hacq.) Sabry & Neves.

Holotype Hacq. 1957, pl.3, fig.16.

Type locality Horton Group, Nova Scotia.

Diagnosis Hacquebard 1957, p.317.

Description Amb triangular with convex, or more rarely straight sides. Intexine shaped similarly or more rounded. Suturae simple or accompanied by ray folds standing up to 7.5μ. Exine leavigate or scabrate

Size range 2472 42-60μ c.b. 30-50μ (5 spec.); 2476 42-73μ cb.31-48μ (4 spec.); 2478 60-62μ cb.42-48μ (5 spec.); 2481 60-64μ cb.40-44μ (5 spec.); 2482 60-70μ cb.40-42μ (6 spec.); 4236 71-91μ cb.52-70μ (10 spec.).

Other authors Hacquebard 1957 58-100μ (14 spec.); Sullivan & Marshall 1966 40(55)74μ; Varma 1969 55-75μ (15 spec.); Felix & Burbridge 1967 42-60u cb.30-48μ.

Occurrence Ballycastle and Leitrim.

Remarks Observed size range extends slightly that of Hacquebard in the lower range. The width of the flange to the central body was variable, but seemed to show relatively consistent ratios. Leitrim specimens appear larger than those from Ballycastle.

Previous records Hacquebard 1957, Lower Mississippian, Horton Group, Nova Scotia, Canada; Love 1960, Lower Oil Shale Group, Viséan, Scotland; Playford 1962, Lower Carboniferous of Spitzbergen; Playford 1964, Horton Group, Nova Scotia, Canada; Sullivan & Marshall 1966, Upper Viséan, Midland Valley of Scotland; Butterworth & Spinner 1967, Lower Carboniferous of Northern England; Felix & Burbridge 1967, Springer Formation, Oklahoma, U.S.A.

Discernisporites aff. micromanifestus (Hacquebard) Sabry & Neves (1971)

Plate 15, figs. 3 - 4

Description (Hacq.) S & N. (1971), pl.16.

Description Amb triangular with generally gently convex sides, more rarely straight; apices rounded. Intexine shape similar to amb, although sometimes could be more rounded. Suturae simple, or accompanied by ray folds; stand 1-3μ; extend to margin of amb or midway on to the flange. Flange varied in width 10-20μ. Exoexine ornamented usually with densely set grana of 0.5-1μ width; low profile; evenly distributed over the amb.

Size range 4236 71-90μ (10 spec.); 4249 48-87μ (10 spec.); 4204 70μ (1 spec.); 2472 73μ; 2471 50-100μ (4 spec.); 2478 61-108μ (4 spec.); 2482 68μ (1 spec.).

Occurrence Ballycastle and Leitrim.

Remarks Distinguished from D. micromanifestus by presence of ornament on the exoexine. Leitrim and Ballycastle specimens similar in appearance.

Infraturma CINGULICAMERATI Neves & Owens 1966

Genus CINGULIZONATES (Dybova and Jackowicz) Butterworth, Jansonius, Smith and Staplin 1964

Type species C. bialatus (Waltz) S. & B. 1967.

Diagnosis B.J.S. & S. 1964, p.105.

Remarks Corrosion and effects of maceration affected specimens of Cingulizonates especially around the edge of the flange, giving a superficial resemblance to species of Densosporites. Thus it is often difficult in practice to distinguish between a corroded C. bialatus and Densosporites intermedius Butterworth & Williams 1958.

Genus generally characterized by a sharply differentiated cingulum which thins into a zona towards the equator.

Cingulizonates bialatus (Waltz) Smith & Butterworth 1967

Plate 15, figs. 5 - 7

1938 Zonotriletes bialatus Waltz in Luber & Waltz, p.32, pl.4, fig.51.

1941 Zonotriletes bialatus var. undulatus Waltz in Luber & Waltz, p.28, pl.5, figs. 71 a, b.

1941 Zonotriletes bialatus var. costatus Waltz in Luber & Waltz, p.29, pl.5, fig.72.

1956 Densosporites bialatus (Waltz); Potonié & Kremp, p.114.

1956 Hymenozonotriletes bialatus var. undulatus; Ischenko, pp.63,64, pl.12, figs.135-7.

1957 Cingulizonates tuberosus Dybova & Jachowicz, p.171, pl.53, figs. 1-4.

1958 Densosporites striatus (Knox); Butterworth & Williams, p.380, pl.3, fig.36.

Holotype Not designated.

Type locality Bed 6, Verkhni-Goubakin Colliery, Kalinin Shaft, Kizel Region, U.S.S.R., Lower Carboniferous.

Diagnosis Waltz in Luber & Waltz 1941, p.28.

Description Amb rounded triangular, sometimes oval or circular. Cingulum differentiated into a distinct thickened inner zone in most cases occupying half width, but may project a little more or less, leaving a thin pale flange extending to the equator. Modification of this often occurs with lobes extending out from thickeining on to flange, or with V shaped lacunae, one, two or three placed at apices. Suturae variable, can be indistinct, simple or ridged. Usually no ornament, although central distal area is often minutely punctate.

Size range Leitrim general material 31(36)45μ (25 spec.); Sample 2472 40(44)48μ, intexine 18(23)24μ (13 spec.); 2476 42(45)47μ, intexine 22(24)25μ (10 spec.); 2481 40(47)52μ, intexine 24(27)31μ (10 spec.); 2471 42(45)48μ, intexine 18(22)23μ (10 spec.); 2478 40(43)48μ, intexine 20(23)27μ (10 spec.); 2482 37(45)51μ, intexine 18(25)31μ (10 spec.); 2480 40(42)52μ, intexine 19(23)30μ (10 spec.).

Other authors Luber & Waltz 70-80μ Schulze; Luber & Waltz 1941 25-60μ cb. 20-35μ; Playford 1963 46(60)77μ cb.21(27)24μ Sch.NH_4OH; Smith & Butterworth 1967 22(37)45μ F.HNO_3.

Occurrence Ballycastle and Leitrim.

Remarks Ratio of central body to amb 0.42(0.48)0.62 (100 specimens). Individual samples show that the ratio can be more narrowly limited e.g. 2476 0.51-0.53μ (10 spec.); 2478 0.48-0.58μ (10 spec.);

2480 0.48-0.55μ (10 spec.). Within the Ballycastle material the mean dimensions are relatively consistent from sample to sample. These specimens are larger than those of Leitrim. Radiizonates striatus (Knox) Staplin & Jansonius 1964 is distinguished by its radial plications on the thin outer flange. Cingulizonates bialatus seems to have much in common with Densosporites tenuis Hoffmeister, Staplin & Malloy 1955, and a certain amount of gradation may exist, especially with effects of corrosion.

Previous records 1941 Luber & Waltz, The Kizelovsky District Lower Carboniferous; 1956 Potonié & Kremp, Karaganda Basin, Tournasian to Viséan; 1957 Dybova & Jachowicz, Silesian Coalfield, Namurian A - Westphalian B; 1958 Butterworth & Williams, Namurian A , Scotland, Limestone Coal Group & Upper Limestone Group; 1967 Smith & Butterworth, Coal Seams of Great Britain, Viséan & Namurian.

Cingulizonates cf. capistratus (Hoffmeister, Staplin & Malloy) Staplin & Jansonius 1964

Plate 15, figs. 8 - 11

1958 Densosporites capistratus Hoffmeister, Staplin & Malloy; Butterworth & Williams pl.3, figs. 44,45.

1958 Densosporites variabilis (Waltz) Potonié & Kremp; Butterworth & Williams, pl.3, figs. 32-34.

Description Amb rounded triangular. Suturae with labra 1.5-2μ wide extending on to proximal ring of thickening, 3(5)6μ. Central distal area distinctly foveolate (0.5μ) passing equatorially into radial costae 3-10μ wide which often enclose lacunae, and form a valum 3-4μ in width. The pale flange containing the valum may extend further, but is frequently corroded.

Size range Leitrim material E_2 general 39(46)55μ (25 spec.); 2472 42(55)70μ (25 spec.); 2471 42(55)61μ (10 spec.); 2612 62(68)70μ (8spec.); 2029 60(62)70μ (5 spec.); 2018 46(58)66μ (5 spec.).

Other authors Smith & Butterworth 1967 41(52)60 and 41(50)60μ; Hoffmeister, Staplin & Malloy 1958 41-61μ.

Occurrence Ballycastle and Leitrim.

Remarks Ratio of central body to amb ratio varies generally 0.36-0.51μ (40 spec.), but shows a peak of abundance at 0.45μ. Overall size range of total amb 42-70μ (53 specimens) with most of these falling between 50 and 60μ (40 spec.), which agrees relatively well with Smith & Butterworth. The suturae were more ridged in some specimens than described in the type material and the distal central area is not granulate. It differs from Radiizonates aligerens (Knox) Staplin & Jansonius 1964 by having a narrower cingulum, and more pronounced costae. Radiizonates tenuis appears to be quite similar but is smaller in size. Neville 1968 suggests that the distal central area bears a series of vermiculate ridges which sometimes connect to form a rudimentary reticulum. Specimens in this study however seem better described as having a foveolate sculpture, the ridges being more continuous. Densosporites variabilis (Waltz) Hughes & Playford 1961 appears similar to Cingulizonates cf. capistratus.

Genus CRISTATISPORITES (Potonié & Kremp) Butterworth, Jansonius, Smith & Staplin 1964

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

Diagnosis B.J.S. & S. 1964 in Staplin & Jansonius, p.108.

Remarks Distinguished from other genera by its prominent distal sculpture.

Cristatisporites pannosus (Knox) Butterworth & Smith 1967
Plate 15, figs. 12 & 13

Densosporites pannosus Knox 1948, fig. 9K, plate 1.

Holotype Not designated.

Type locality Fifeshire, Limestone Coal Group.

Description Knox 1950, p.325.

Description Amb broadly triangular in outline, size range 36-50µ. Cingulum and central area often densely covered in cristae, rising to spines 2-5µ high, sometimes central area with reduced spines or grana. Labra distinctive, 2-3µ wide, extending to equatorial margin.

Size range Leitrim E_2 material general 36-50µ (7 spec.); Ballycastle general 50-78µ (5 spec.).

Occurrence Ballycastle and Leitrim.

Remarks Distinguished from Densosporites spinifer Hoffmeister, Staplin & Malloy in possessing labra, and cristae rather than discrete spines. Specimens from both Leitrim and Ballycastle appear similar in style.

The size range includes smaller specimens around 36µ, similar to that recorded by Butterworth & Williams 1958. Occurrence very infrequent.

Previous records Knox 1950, Carboniferous; Owens (thesis) 1963, Namurian B-C of Stainmore; Butterworth & Williams 1958, Namurian A, Scotland; Neves (thesis) 1959, Namurian B-C, Scotland.

Genus DENSOSPORITES (Berry) Butterworth, Jansonius, Smith & Staplin 1964.

Type species D. cavensis Berry 1937.

Diagnosis B.J.S. & S. 1964, p.101.

Remarks (See Cingulizonates). Prominent cingulum; only tapers gently towards equator, or constant in thickness. Exoexine may be ornamented on distal surface of the cingulum. Spores camerate.

Densosporites anulatus (Loose) Smith & Butterworth 1967

Plate 15, fig. 14

1932 Sporonites anulatus Loose in Potonié, Ibrahim & Loose, p.451, pl.18, fig.44.

1934 Zonales-sporites (Anulati-sporites anulatus Loose, p.151.

1944 Densosporites annulatus (Loose), Schopf, Wilson & Bentall, p.40.

1956 Anulatisporites anulatus (Loose); Potonié & Kremp, p.112, pl.17, figs.365-72.

1950 Denso-sporites reynoldsburgensis Kosanke p.33, pl.6, figs.9-11.

Holotype P. & K. 1956, pl.17, fig.365.

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

Diagnosis P. & K. 1956, p.112.

Description Amb subtriangular to circular. Suturae simple, rarely observed. Intexine leavigate 17(20)27µ. Central area of exoexine thin and laevigate. Cingulum relatively narrow, less than 50% of spore diameter.

Size range 2472 35-45µ (10 spec.), intexine 20-26µ; 2474 34-41µ (5 spec.), intexine 20-23µ; 2481 34-41µ (5 spec.), intexine 18-26µ; 2471 36-42µ (5 spec.), intexine 21-25µ; 2482 37-43µ (4 spec.), intexine 37-43µ; 2480 27-37µ (5 spec), intexine 17-24µ; 2479 25-36µ (5 spec.), intexine 18-22µ;

Other authors Smith & Butterworth 1967 32(48)56µ Fu.HNO_3, 33(40)43µ Fu.HNO_3, 26(34)42µ Fu.HNO_3, 28(37)42µ Fu.HNO_3.

Occurrence Ballycastle and Leitrim.

Remarks Distinguished from D. pseudannulatus by the cingulum being less than 50% of total spore radius. Corrosion effects on Cingulizonates cf. capiatratus and D. intermedius can reduce the pale flange to give the effect of a cingulum like that of D. anulatus.

Previous records Smith & Butterworth 1967, Viséan to Lower Westphalian C, Coals of Great Britain; Sullivan & Marshall(1970)Roman Wall District, Lower Namurian E^1. Recorded by numerous other authors in the Carboniferous.

Densosporites intermedius Butterworth & Williams 1958

Plate 15, fig. 15

1958 Densosporites intermedius Butterworth & Williams, p.379,figs.38,39.

1955 Densosporites tenuis Hoffmeister, Staplin & Malloy, p.387, pl.36, figs. 18,19 & 23.

Holotype B. & W. 1958 pl.19, fig. 10.

Type locality Seam at 2,082 ft. 2 ins. (634.6m), Righead Borehole, West Fife Coalfield, Scotland, Namurian A.

Diagnosis B. & W. 1958, p.379.

Description Amb circular or sub-triangular. Central area of exoexine thin, and usually laevigate, or slightly ornamented; minute grana or infrapunctate; corrosion would seem to affect this area. Ratio of intexine to exoexine generally 50:50, but can be a little more or less in proportion; size range (2472) 19-25µ, sample 2476 20-26µ, sample 2481 21-26µ. Suturae simple or ridged; o.5µ labra.

Size range 2472 31(45)51µ, intexine 19-25µ (20 spec.); 2474 35-40µ, intexine 12-22µ (5 spec.); 2476 42(45)47µ, intexine 20-26µ (10 spec.); 2481 36(45)47µ, intexine 21-26µ (10 spec.); 2471 42-45µ, intexine 19-20µ (4 spec.); 2478 47µ, intexine 21µ; 2482 43-46µ, intexine 22-26µ (4 spec.); 2480 42-45µ, intexine 22-28µ (4 spec.); 2479 40µ, intexine 24µ; Leitrim general 37-46µ (19 spec.).

Other authors Smith & Butterworth 1967 37(43)51µ Fu.HNO_3; Butterworth & Williams 1958 35-60µ Schulze.

Occurrence Ballycastle and Leitrim.

Remarks In nearly all the specimens a characteristic notch was observed in the thickening at the apices. The thickening at this point was either corroded away or possibly an original feature. Corrosion can also cause confusion with Cingulizonates bialatus since the latter species can appear to be similar in morphology when its thin flange is reduced.

Previous records Smith & Butterworth 1967, Viséan to Westphalian A, Coals of Great Britain; recorded by numerous authors from the Carboniferous.

Densosporites pseudoannulatus Butterworth & Williams 1958

Plate 15, fig. 16

Holotype. Butterworth & Williams, pl.19, fig.11.

Type locality Seam at 2,082ft. 2 ins. (634.6m), Righead Borehole, West Fife Coalfield, Scotland.

Diagnosis Butterworth & Williams 1958, p.379.

Description Amb oval to subcircular. Suturae slightly ridged or not observed. Cingulum width often greater than 50% spore radius. The inner equatorial area very often the central area at distal surface are foveolate, or otherwise laevigate. Based on 25 specimens the ratio of the central area to amb was found to have narrow limits 0.42-0.52.

Size range Leitrim E_2 material general 37-52µ (15 spec.); Sample 2472 38-41µ (8 spec.); 2471 42-58µ (10 spec.); 2612 48-65µ (8 spec.);

Other authors Butterworth & Williams 1958 35-55µ Schulze 5% KOH.

Occurrence Leitrim and Ballycastle.

Remarks Frequently corroded, which often leads to spore margin appearing tapered, and then difficult to distinguish from Densosporites intermedius Hoffmeister, Staplin & Malloy. Distinguished from Densosporites anulatus (Loose) Smith & Butterworth 1967, by its cingulum being proportionally greater than 50%.

Densosporites triangularis Kosanke 1950, would appear to be very similar in its more laevigate or foveolate form. The foveolate dissections in both species have the appearance of being another result of corrosion. Occurrence very frequent.

Previous records 1958 Butterworth & Williams, The Limestone Coal Group and Upper Limestone Group, Namurian A-B; 1967 Smith & Butterworth, Coals of Great Britain, Viséan and Namurian; 1969 Loboziak, Houiller Basin of Northern France, Westphalian B.

Densosporites rarispinosus Playford 1963

Plate 15, fig. 17

Holotype Preparation P145C/1 Playford 1963 Plate 89, fig.20.

Type locality Triungen, Spitzbergen, Lower Carboniferous.

Diagnosis Playford 1963, p.630.

Description Amb circular to rounded triangular. Suturae simple or ridged extending to inner edge of cingulum. Intexine laevigate, not always extending to cingulum, intexine to the amb is restricted to 0.5 -0.66 (15 spec.). Ornament of thin 'hair like' spines sharply tapering and pointed, 1-2.5µ long, 0.5µ diameter spaced 2-3µ apart at equator; 30-50 at equator. Distribution approximates to concentric rows of which 2-4 may be counted on the cingulum. Based on sample 2472.

Size range 2472 32-45µ (10 spec.); cb. 19-27µ; 2474 40-46µ (5 spec.), cb. 20-22µ.

Other authors Playford 1963 37(51)67µ cb. 18(24)33; Felix & Burbridge 40-50µ cb. 20-23µ.

Occurrence Ballycastle.

Remarks The specimens in this study differ slightly from Playford's diagnosis, in the occasional presence of ridged suturae. Also the ornament sometimes appears a little denser in distribution than that shown in his photographs. Occurrence seems to be restricted to Ballycastle.

Distinguished from Densosporites spinifer Hoffmeister, Staplin & Malloy by lack of granulate exoexine and finer grade of ornament.

Previous records Playford 1963, Spitzbergen, Lower Carboniferous; Felix & Burbridge 1967, Springer Formation, Upper Mississippian.

Densosporites spinifer Hoffmeister, Staplin & Malloy 1955
Plate 15, fig. 18

Holotype Hoffmeister, Staplin & Malloy 1955, pl.36, fig. 17.

Type locality Shale at 2,075' (632.4m) Carter No.3 Borehole (TCO-82), Webster County, Kentucky, U.S.A., Hardinsburg Formation, Chester Series.

Diagnosis Hoffmeister, Staplin & Malloy 1955, p.386.

Description Triangular amb. Dark brown very distinct outer zona 5μ wide. The cingulum has large set spines 3μ long, and 2μ at the base, situated at the equatorial margin, smaller cones occurring elsewhere scattered over distal polar area and cingulum.

Size range Leitrim E_2 general 35-40μ (10 spec.); Sample 4236 40-45μ (5 spec.).

Other authors 1955 Hoffmeister, Staplin & Malloy 32-48μ; 1967 Smith & Butterworth 31(40)53μ.

Occurrence Ballycastle and Leitrim.

Remarks Specimens from Ballycastle had a less coarse ornament (1-2.5μ) high, than those of Leitrim, which averaged 3μ. The cingulum width varied from 34-50% spore diameter (10 specimens). The central body was proportionally greater than the cingulum. Densosporites glandulosus Kosanke 1950 differs in having glandulose elements which are bulbous at the base, otherwise the spore is very similar. Occurrence infrequent.

Previous records Hoffmeister, Staplin & Malloy 1955, Hardinsburg Formation, Mississippian; Smith & Butterworth 1967, Coals of Great Britain, Viséan and Namurian.

Densosporites spinosus Dybova & Jachowicz 1957

Plate 15, fig. 19

1950 Denso-sporites indignabundus (Loose) S.W. & B in Kosanke 1950, plate 7, fig.2.

1957 Densosporites spinosus Dybova S., Jachowicz A, Plate 4, fig.12.

Holotype Dybova & Jachowicz 1957, pl.XLIX, fig.1.

Type locality 17, Silesia, Polska.

Diagnosis Taken from Dybova & Jachowicz.

Description Amb rounded triangular, zona 6-11µ wide, inner thickening 2-4µ, ornamented with abundant discrete coniiand spines up to 4µ in length, but usually 2-3µ. The distal and proximal polar area had small coni and grana. In some specimens the crowding of ornament gives a less clear distinction of the central body intexine from the zona.

Size range Leitrim E_2 material general 35-53µ.

Other authors Mishell 1966 35-60µ.

Occurrence Leitrim.

Remarks Cristatisporites alpernii Staplin & Jansonius 1964 and C. indignabundus (Loose) Staplin & Jansonius 1964, differ in that the ornament is of ridges or cristae and are not discrete cones and spines. Specimens conformed to diagnosis, and agree closely to the size range given by Mishell. Occurrence infrequent.

Previous records Dybova & Jachowicz 1957, Namurian A - Westphalian B, Silesia, Poland; Jachowicz 1958, Upper Silesia, Westphalian A; Owens 1963 (thesis) Stainmore, Namurian A - Westphalian A; Neves 1964, La Camocha, Gijon, North Spain, Namurian A; Mishell 1966, Bowland Fells & Ingleton Coalfield, Namurian A to Westphalian B.

Genus LYCOSPORA (Schopf, Wilson & Bentall) Potonié & Kremp

Type species L. micropapillata (Wilson & Lee) Schopf, Wilson & Bentall.

Diagnosis (P. & K.) Y. Somers.

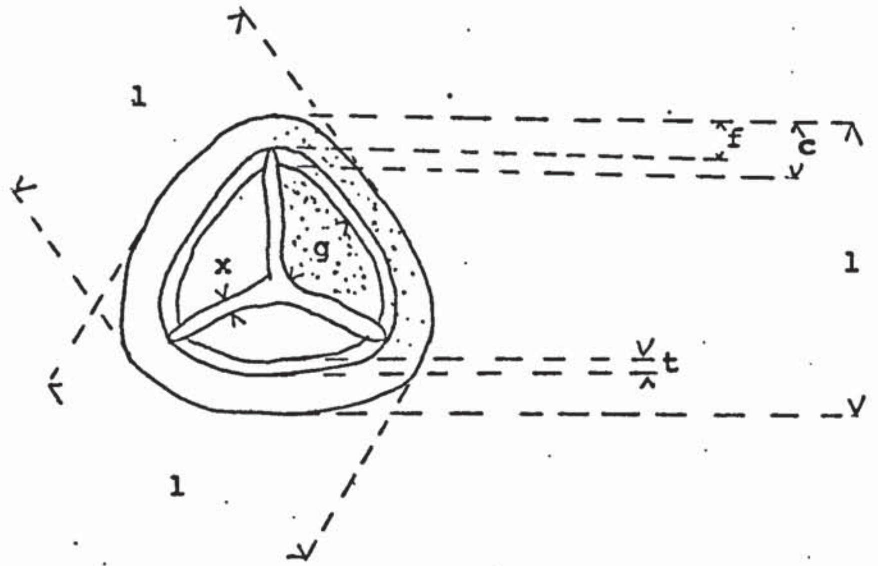
Remarks This genus has been studied in detail by Somers 1972 who concluded that the large number of species that have been ascribed to Lycospora can be reduced considerably to four.

A further statistical study of the genus was made in an attempt to discover if sufficient variation existed amongst populations of L. pusilla of differing ages in Ireland to suggest environmental or stratigraphical significance. The measurements were made on 100 specimens from each of the assemblages 4204 and 5055. The former is a fireclay of Namurian E_2 age from Borehole 151 in the Lackagh Hills area of Leitrim. Assemblage 5055 is of Westphalian age (text. fig. 10 & 11), the one productive sample from the Slieve Ardagh Hills. The samples were prepared using similar maceration techniques, i.e.: 5 minutes HNO_3 followed by 15 minutes in Schulze solution. The dimensions used in this study are shown in text fig. 38.

A normal distribution curve was obtained for most of the features measured within one sample, suggesting little opportunity for subdivision. By comparing peaks of occurrence within the two samples, for any one particular feature, it was hoped that some significant shift of the mean value might occur, possibly as a result of the different ages of the assemblages.

To compare the length of the lycospores, the three possible measurements of the diameter were totalled and their average was taken. The mean value in both samples is similar i.e.: 34.3u for assemblage 5055 and 34.1u in assemblage 4204. The mean width of the 'flange' is again similar for both samples, but the total range of values in assemblage 4204 would seem greater

Dimensions used in the statistical study of the granulate forms of the genus Lycospora.



l - length or diameter (in this study the three diameters indicated were measured and their average taken to allow for distortion of the spore).

c - cingulum width

f - flange width

t - thickening width

x - labra width

g - the number of grana which occurred along this line was used as an indication of ornament density.

Fig. 38.

i.e.: 1u - 5.5u compared with 1.5u - 5.0u in assemblage 5055. However, the difference is slight.

This pattern is repeated for the width of the thickening around the cingulum, but assemblage 4204 would appear to have the greater width on average i.e.: mean 2.44u, mode 2.0u compared with 1.9u mean in 5055. The labra width were greater in assemblage 4204 than 5055, but only by a small amount i.e.: the latter has a range of values which predominate between 0.5 and 1.5u (mean 1.0u); assemblage 4204 predominates between 1.0 and 2.0u (mean 1.5u).

The ornament of the lycospores was studied by measuring grana down to 1u in size, and then those below this group were considered as less than 1u. To assess the density of the ornaments the number which lay on a line projected from the centre (pole) to the inner edge of the thickening, was used as a guide.

Certain grades of ornament were selected in order to study their relationship to such features as the mean length. The density of the ornaments varied from 17 grana along the line taken from the centre (pole) to the inner edge of the thickening. In assemblage 4204 and 5055 the predominant values lay between 4 and 12; the mean value was 8 and 9 respectively. Thus, density of ornament appears to display dimilar variation in both samples.

The mean diameter for lycospores with grana >1u were almost the same as those determined earlier in the section and which included all grades of ornament. These varied only slightly around the value 34u. For those types with ornament greater than 1u the mean length is only fractionally smaller i.e.: 33.2u (assemblage 4204), 33.4u (assemblage 5055).

A similar study was made on another sample 4209 taken from the coal above the fireclay 4204. Although the measurements will be affected by differing oxidation methods applied to this sample i.e.: 5 minutes HNO_3, 5 minutes Schulze solution and 20 minutes Fu.HNO_3, the results display a similar small reduction in the average size as the ornament becomes coarser.

Rugulate types:	mean diameter 29.8u	Assemblage 4209
Grana >1u :	mean diameter 31.6u	
Types devoid or almost devoid of ornament:	33.0u	

Conclusions: There would appear to be little evidence that the morhpological variation displayed within the species *Lycospora pusilla* is sufficient to warrant its subdivision. There does appear to be a greater width to the labra and marginal thickening in the Namurian assemblage 4204 specimens which further study may prove to be a difference between populations from the Namurian and Westphalian stages.

Lycospora noctuina var. *noctuina* Butterworth & Williams 1972
Plate 16, figs. 12 - 16

1958 *Lycospora noctuina* Butterworth & Williams p. 376, pl.1.

1972 *Lycospora noctuina* var. *noctuina* Somers plate 8, fig. 13.

Holotype Smith & Butterworth plate 20, fig. 4.

Type locality 9 ins. (0.22m) coal at 256' 11" (78.32m), Darnley No. 3 Borehole, Central Coalfield, Scotland, Namurian age.

Diagnosis Somers 1972, P. 70.

Description Amb sub-triangular, sides convex. The suturae are distinct, straight, and often thickened extending almost to the spore margin. The cingulum consists of a wide extension of the exine with a thickened inner zone and a broad thinner flange. The exine in the distal central area is ornamented with irregular shaped verrucae.

elongate rugulae.

Size range 5055 30(35)44μ (31 spec.); 4204 33(36.1)45μ (35 spec.), modal width of thickening 2.5μ, cingulum 3-4μ modal value, cingulum/thickening ratio 1.5 (modal value).

Other authors Butterworth & Williams 1958 30-45μ; Butterworth & Spinner 1967 26(30)35μ (35 spec.); Felix & Burbridge 1967 20-40μ; Smith & Butterworth 1967 31(35)38μ Fu.HNO_3 Durham Coalfield; 27(36)47μ Fu.HNO_3 West Fife, Scotland.

Occurrence Ballycastle, Leitrim, Mayo and Donegal.

Remarks See 'Genus remarks'.

Previous records Recorded by numerous authors from the Carboniferous.

Lycospora pusilla (Ibrahim) Somers 1972

Plate 16, figs. 1 - 3

1932 Sporonites pusillus Ibrahim in Potonié, Ibrahim & 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) Somers pl.XXI and XII.

Holotype Potonié & Kremp 1956, fig. 351 after Ibrahim.

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

Diagnosis Somers 1972, p.67.

Description Amb rounded triangular to subcircular. Suturae simple, often gaping, or more rarely with thin labra 0.5-2μ extending usually to edge of thickened zone. Cingulum divided into inner thickened zone 1.5-3μ wide and a thin 1-5.5 outer flange. Exine, including cingulum, thin and ornamented with grana not more than 1.5μ diameter and frequently much less.

Size range 4204 28(34.1)44µ (100 spec.); 5055 23(34.3)44µ (100 spec.).

Other authors Smith & Butterworth 1967 20(27)32µ Fu.HNO_3 Barnsley Seam; 22(27)35µ Fu.HNO_3 Yorkshire; Potonié & Kremp 1956 25-40µ, holotype 38u; Somers 1972 22(31.1)41µ.

Occurrence Ballycastle,Leitrim and Donegal.

Remarks See 'Genus remarks'.

Previous records Recorded world-wide by previous authors in Carboniferous strata younger than Tournaisian.

Lycospora cf. pusilla

Plate 16, figs. 4 & 5

Description Amb rounded triangular. Suturae accompanied by labra, thin 1u or ray folds; extend to thickening. Thickening usually consistent feature of specimens 2.5µ. Flange 2µ, thin and often not evenly developed. Ornamented densely and evenly over the amb,bases touching or almost touching; 0.5µ grana and coni diameter; stand 0.5µ.

Size range 5040 48µ 40µ 45µ 41µ 37µ 42µ 40µ 46µ.

Occurrence Goresbridge.

Remarks Lycospora cf. pusilla seems to differ from L. pusilla in terms of larger size. Also the flange is not as consistent a feature around the whole amb.

Lycospora aff. pusilla

Plate 17, figs. 6 - 8

Description Amb rounded triangular. Suturae simple amd extend to thickening; often open. Structure along the inner margin of the cingulum, possibly a thickening; 1.5µ width. Flange thin 2-3µ wide. Exine thickness thin; pale colour; probably laevigate.

Size range 3101c 19μ; 5040 47u, 52μ.

Occurrence Goresbridge.

Remarks "Thickening" difficult to study since this area is often modified by the presence of pyrites in the central area of the amb. Ornamentation is also difficult to determine because of the poor preservation, but it seems most likely to be laevigate, or minutely granulate. Size range is generally quite variable.

Lycospora rugulosa Butterworth & Spinner 1967

Plate 16, figs. 9 - 11

Holotype Butterworth & Spinner 1967, pl.2, fig.1.

Type locality Half inch Coal, Lewis Burn Group; Lewis Burn, Northumberland, Sample 5.

Diagnosis Butterworth & Spinner 1967, p.10.

Description Amb subcircular to rounded triangular. Suturae simple extending to inner margin of the thickening 2.5μ wide. Rugulae and grana cover distal body, but difficult to discern to what extent the proximal surface is covered; grana 0.5μ diameter, rugulae may reach 1u at equator. Three apical papillae occur proximally.

Size range 1142 24-30μ (4 spec.).

Other authors Butterworth & Spinner 1967 26(29)38μ (60 spec.).

Occurrence N. Mayo.

Remarks Specimens conform to diagnosis. Particularly characteristic of these specimens were the three apical papillae which occur close to the proximal pole. This species is not included by Somers in the genus *Lycospora*.

Previous records. Butterworth & Spinner 1967, Lower Carboniferous spores from North-west England; Bertlesen 1972, Lower Carboniferous, Denmark, (Pu zone of Neves et al.); Butcher 1974 (Ph.D. thesis), Hensingham Group.

Lycospora tenebricosa Staplin 1960

Plate 16, figs. 17 - 21

Holotype Staplin 1960, pl.4, fig.15.

Type locality Upper Mississippian of Alberta, Golata Formation, Canada.

Diagnosis Staplin 1960, p.20.

Description Amb circular or rounded triangular. Suturae tectate 2-3u, straight, extending to edge of intexine. Suggestion of curvaturae present on some specimens. Exoexine ornament scrabrate to densely granulate, bases touching 0.5µ width; stand 0.5µ. Appears to have an intexine 26-38µ diameter, similar in shape to exoexine.

Size range 2481 28-42µ (10 spec.); 5044, 5040.

Other authors Butterworth & Spinner 29(36)44µ.

Occurrence Ballycastle, Goresbridge.

Remarks The structure of this spore is not clear, particularly the extension of the exoexine on to the proximal surface. Similar spores are found in the Lower Carboniferous Beds around Bewcastle as described by Butterworth & Spinner 1967. This species has features in common with Rugospora Sp. A. of this study, but differs in the absence of rugulae.and tecta. Auroraspora macra has intexine of smaller proportions. Perotrilites differs in being leavigate and absence of tecta. Somers (1972) and Staplin (in Somers, loc. cit. p.86) considers that this species should not be assigned to Lycospora. Somers thinks that it may be close to Stenozonotriletes bracteolus Butt. & Will. L. tenebricosa was found in Goresbridge (Tournaisian) and Ballycastle (Visean); both areas displaying no real differences in morphology.

Previous records Staplin 1960, Golata Formation, Upper Mississippian, Canada; Butterworth & Spinner 1967, Bewcastle Beds,Lower Carboniferous, Northern England.

Genus KRAEUSELISPORITES (Leschik) Jansonius 1962

Type species K. dutatus Leschik 1955, p.37, plate 4, fig.21.

Diagnosis Jansonius 1962, p.46.

Remarks Jansonius 1962 claims that the exoexine extends only as far as the edge of the flange onto the proximal surface. Owens & Mishell claim no evidence of a junction here and that the leasurae are frequently accomapnied by folds that extend onto the flange without interruption.

The genus is chacterized by a prominent equatorial flange and an ornament of spinae or coni on the distal surface of spore body and flange.

Kraeuselisporites echinatus Owens 1976

Plate 17 figs. 3 & 4

Holotype Owens 1976 .- plate 22, fig.3.

Type locality Shale above Little Limestone (E^1), Argill Beck, Stainmore, Namurian A.

Diagnosis Owens 1976, p.226.

Description Amb rounded triangular, apices pointed. Cingulum differentiated into an inner narrow thickened region 2-6µ wide, and a pale outer flange radially striated 7-11µ wide. Suturae accompanied by labra, which are slightly tectate 1.5-4µ thickness. Intexine similar shape to amb. Exoexine ornamented distally by cones 7-8µ high; broad-based and tapering; widely set 5-8µ apart. Proximal surface laevigate, or scabrate. Folding infrequent.

Size range 4249 63-110µ (20 spec.).

Occurrence Leitrim.

Remarks Cingulum very consistent in width, the ratio between the intexine and exoexine being 0.7.

Previous records Mishell 1966 (thesis),Namurian A to Upper Namurian B, Bowland Fells and Ingleton Coalfield; Neville 1968, Upper Viséan of East Fife, Scotland.

Kraeuselisporites Sp. A. Owens, Mishell & Marshall 1976

Plate 17, figs. 5 & 6

Holotype Owens, Mishell & Marshall 1976, pl.2, figs. 5-7.

Description O, M, & M 1976, p.154

Description Amb broadly rounded triangular. Intexine forms similar shape and is completely surrounded in most cases by exoexine. Suturae straight extending almost to margin of body, accompanied by tecta up to 5μ high. Pale unthickened flange 12-18μ wide. Ornamented with galeate processes on distal surface; 4-5μ high, 45-50 counted on the distal surface. Flange smooth and may bear smaller cones, 1.5μ high. Cones chacterized by their bulbous base, passing into sharply tapering cone..

Size range 4204 115μ, intexine 79μ; 4249 75-80μ, intexine 48-51μ (5 spec.).

Other authors Owens, Mishell & Marshall 1976, 72-88μ (3 spec.).

Occurrence Leitrim.

Remarks This form is distinguished from other species of Kraeuselisporites by its chacteristic galeate processes. One specimen figured in the photograph shows exoexine separated from intexine to give appearance of the genus Vallatisporites, but this space can be distinguished from a true valum as it is not contained within the flange.

Previous records Owens, Mishell & Marshall 1976, Lower Namurian A (1_1) in the Stainmore Cutlier & Bowland Fell areas.

Kraeuselisporites Sp. B.

Plate 16, figs. 22 - 24 and Plate 17, figs. 1 - 3

Description Amb rounded triangular; intexine 60μ with a thickening 6-7μ wide. Suturae straight and distinct accompanied by labra sinuous and tapering 2-3μ wide, which extend to edge of the thickening. Ornamented in the distal central area with densely set spines; stand 2μ high, which are needle-like in profile with a broad base. Flange pale 10-20μ wide.

Size range 5044 82-90μ (3 spec.); 5040 58-82μ (3 spec.)

Occurrence Gorebridge.

Remarks These specimens superficially appear similar to Vallatisporites vallatus Hacquebard, but no vallum was observed. The central area of most of the specimens contained pyrites cubes which destroyed much of the detail. Characterized by a relatively small wide flange area, with which it can be distinguished from most other species of this genus.

Genus CIRRATRIRADITES Wilson & Coe 1940

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

Diagnosis S. W. & B. 1944, p.43.

Cirratriradites saturni (Ibrahim) Schopf, Wilson & Bentall 1944

Plate 17, figs. 7 & 8

1932 Sporonites saturni Ibrahim in Potonié, Ibrahim & Loose, p.448, pl.15, fig. 14.

1933 Zonales-sporites saturni Ibrahim, p.30, pl.2, fig.14.

1938 Zonotriletes saturni (Ibrahim), Luber in Luber & Waltz pl.8, fig.102.

1944 Cirratriradites saturni (Ibrahim); Schopf, Wilson & Bentall, p.44.

Holotype Ibrahim 1932 pl.15, fig.14, Potonié & Kremp 1956, pl.18, fig.412, after Ibrhaim.

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

Diagnosis Potonié & Kremp 1956, p.128.

Description Amb triangular, sides convex, apices broadly angular. Suturae accompanied by labra 2-2.5µ wide and extend to the margin of amb. Cingulum, striate and relatively pale 11-13µ wide, with an inner thickening 5-7µ wide. Intexine similar shape relatively dark brown in colour. Ornamented distally with grana, small verrucae and cristae of 1µ diameter. Between the positive sculpture occur occasional pits or foveoleae. Usually one large circular distal foveoli 9µ diameter. One specimen contained three.

Size range 4249 90-100µ (4 spec.); 4266 100µ (2 spec.); 4265 110µ (1 spec.).

Other authors Smith & Butterworth 1957 68(79)91µ Schulze, Bottom Robins Seam, Cannock Chase, Coalfield; Potonié & Kremp 1956 70-100µ Schulze.

Occurrence Leitrim.

Remarks This species compares well with the diagnosis. It is a form rarely recorded from strata of Lower Namurian age and extends the range proposed by Owens et al. (in press) which suggests a base in the Westphalian. Recent communication with Owens suggests that a significant number of the species may be present in the Westphalian, whereas their occurrence is infrequent within the Namurian.

Previous records Smith & Butterworth 1957: Coals of Great Britain, Upper Namurian to Westphalian C.

Genus VALLATISPORITES Hacquebard 1957

Type species V. vallatus Hacquebard 1957

Diagnosis Hacq. 1957, p.312.

Remarks Distinguished from Spinozonotriletes by a marked vacuolated extension of the exoexine.

Vallatisporites ciliaris (Luber) Sullivan 1964

Plate 17, figs. 9 & 10

1938 Zonotriletes ciliaris Luber, in Luber & Waltz, p.25, pl.6, fig.82.

1964b Vallatisporites ciliaris (Luber) Sullivan, p.370, pl.59, figs. 14, 15.

Holotype Sullivan 1964b, pl.59, fig.14.

Type locality Drybrook Sandstone (Visean) Forest of Dean, Gloucestershire.

Diagnosis Sullivan p.370.

Description Amb rounded triangular with convex interradial areas. Suturae accompanied by labra 1-2µ which extend to margin of intexine. Intexine shaped similar to amb, bordered by a thickening 4-7µ wide. Cingulum pale extended by the vallum, up to 9µ. Distal and central area ornamented by galaea and spines up to 2µ high; 0.5 to 1µ in diameter; set 1-3µ apart.

Size range 3128 52-95µ (5 spec.); 1637 58-85µ (5 spec.); 1142 54-62µ (10 spec.).

Other authors Sullivan 1964; Butterworth & Spinner 1967 49(58)73u; 49(58)78µ; Luber 1938 40-50µ.

Occurrence Mayo & Goresbridge.

Remarks Specimens show little variation, and are consistent in appearance. Vallum sometimes barely perceptible. Occurrence often frequent.

Previous records Luber & Waltz 1938, Lower Carboniferous of Karaganda Basin, U.S.S.R.; Sullivan 1964, Drybrook Sandstone (Viséan), Forest of Dean, Gloucestershire; Butterworth & Spinner 1967, Lower Carboniferous of N.W. England.

Vallatisporites vallatus Hacquebard 1957

Plate 18, fig. 1

Holotype M101, Slide 6, at 39-6/106.3 Hacquebard.

Type locality West Core and Blue Beach samples, Horton Group, Nova Scotia.

Diagnosis Hacquebard 1957, p.312.

Description Amb rounded triangular; interradial areas convex and apices rounded. Suturae indistinct, but usually straight, extending almost to equator. Central area ornamented distally with grana and cones which extend onto zona area and may project at the margin, 1u diameter; stand 1-1.5µ high.

Size range 4268 40-65µ, intexine 33-35µ; 5040 63µ, intexine 55µ.

Other authors Butcher 1974 47-60µ (7 spec.); Playford 1963 52-71µ (35 spec.).

Occurrence Leitrim and Goresbridge.

Remarks Specimens in this study differ in that the ornament of grana may develop into small coni. Preservation generally poor.

Previous records Hacquebard 1957 Playford 1963; Varma 1969, Horton Group, Nova Scotia; Neves 1959, Upper Namurian B to Namurian C, Southern Pennines; Owens 1963, Namurian A to Lower Namurian C, Stainmore; Sullivan 1968, Tournasian, Scotland.

Infraturma MEMBRANATI(Neves) Neves & Owens 1966

Genus PROPRISPORITES Neves 1958

Type Species P. rugosus Neves 1958.

Diagnosis Neves 1958.

Proprisporites laevigatus Neves 1961

Holotype Plate 33, fig.9, Neves 1961.

Type locality Marine shales with Hudsonoceras proteum, Congleton Edge ganister quarry, Staffordshire (Loc. 4) Sabdenian stage.

Diagnosis Neves 1961, p.269.

Proprisporites cf. laevigatus

Plate 18, figs. 2 - 4

Description Amb oval or circular. Suturae simple, straight, extend ⅔ of spore radius. Perisporal membrane covering intexine laevigate, and folded into ridges which tend to occur parallel to longer axis of spore if oval; 3-4μ high, width 1.5-3μ. In one view about 5-7 ridges traverse the amb. The sinuous folds end abruptly at the poles, leaving a small area laevigate.

Size range 4249 50(55)70μ (25 spec.).

Other authors Neves 1961 70-115μ, for P. laevigatus.

Occurrence Leitrim.

Remarks Size range differs markedly from Neves 1961. Most of specimens occurred between 50-60μ. In all other respects they do not differ from the type material. Occurrence restricted to one sample,where it is very common.

Previous records Neves 1961 Southern Pennines, Namurian A-B; Owens 1963, Stainmore, Upper Namurian A; Mishell 1966 Bowland Fells & Ingleton Coalfield, Namurian A to Lower Namurian B; F & B 1967, Springer Formation, Oklahoma, U.S.A.

Infraturma PATINATI (Butterworth & Williams) Smith & Butterworth 1967

Genus THOLISPORITES Butterworth & Williams 1958

Type species T. scoticus B. & W. 1958.

Diagnosis B. & W. 1958.

Tholisporites biannulatus Neves 1961

Plate 18, figs. 5 & 6

Holotype Neves 1961, pl.34, fig.2.

Type locality Marine shales with Eumorphoceras bisulcatum, Gity, Bagnall, Staffordshire; Arnsbergian Stage.

Diagnosis Neves 1961, p.271.

Description Amb circular to oval. Suturae straight, extend to margin of spore body. Two distinct bands of thickening; 7µ wide, inner band 33µ maximum diameter. Central boss 17µ. Channels between narrow, 0.5µ Proximal surface laevigate. Exine thickness 2.5µ.

Size range 2029 38-41µ; 2470 51µ; 2473 42µ.

Other authors Neves 1961 55-90µ.

Occurrence Ballycastle and Leitrim.

Remarks Distinguished from Knoxisporites stephanephorus Loose by the absence of connecting bars between the distal thickenings. Also the distance between the concentric thickenings is generally very small in T. biannulatus.

Previous records

Neves 1961, Southern Pennines, Arnsbergian; Mishell 1966, Namurian, Bowland Fells (thesis).

Tholisporites decoratus Gueinn 1973

Plate 18, figs. 7 & 8

1966 Knoxisporites stephanephorus Love in Sullivan & Marshall pl.3,fig.7.

Holotype Gueinn 1973, pl.2, fig.8.

Type locality Cousland No. 1 Borehole of 2409' (734.2m), Midlothian, Scotland.

Diagnosis Neves et al. 1973, p.39.

Description Spores radial, trilete. Amb oval to circular. Proximal equatorial thickening 11-12µ wide; distal equatorial thickening concentric 11u x 40-53µ diameter; distal boss oval to circular fitting closely to distal thickening 15-35µ diameter. Proximal surface ornamented with grana, verrucae and sometimes rugulae, often closely set. Suturae simple ½ and over, of spore radius. Exine laevigate.

Size range 2472 56μ (1 spec.); 2471 51-52μ (2 spec.); 2478 52-53μ (3 spec.).

Other authors Butcher 1974 (thesis) 32-47μ; Neves et al. 1973 30(40.5)48μ (10 spec.), 32(41)51μ (21 spec.).

Occurrence Ballycastle.

Remarks Distinguished from Tholisporites biannulatus Neves by presence of ornament on the proximal surface and by its smaller size. Knoxisporites stephanephorus Love has usually more widely set thickenings and connecting muri, and also lacks ornament on the proximal surface. Specimens found in Ballycastle material only. Occurrence infrequent.

Previous records Sullivan & Marshall 1966, Viséan of Midland Valley of Scotland; Mishell 1966 (thesis), Lower Namurian A of the Bowland Fells; Neves et al. 1973, Lower Carboniferous of Scotland and Northern England.

Tholisporites scoticus Butterworth & Williams 1958

Plate 18, figs. 9 & 10

Holotype Butterworth & Williams 1958, plate 3, fig.48.

Type locality Seam at 1,872ft. 7 ins. (570.8m) Righead Borehole, West Fife Coalfield, Scotland, Namurian A.

Diagnosis Staplin & Jansonius 1964, p.105.

Description Amb generally oval to subtriangular, with size range 35(50)52μ. The cingulum, width 7-10μ, did not appear differentially thickened. The distal crassitude appeared relatively thin and inflated in the central area. Suturae were rarely observed and extended only to inner margin of the cingulum. The exine was often foveolate giving a spongy appearance, but the nature of the lumina suggested they were possibly the result of corrosion.

Size range Leitrim general: 35(50)52μ.

Other authors Butterworth & Williams 1958 30(43)55μ.

Occurrence Leitrim.

Remarks Tholisporites foveolatus Hughes & Playford 1961 is more ornamented and has longer ridged laesurae. The orientation of spores is distinctive, the inflated distal crassitude often resulting in oblique compression. This species is particularly abundant in sample 4257 where it dominates approximately 80-90% of the assemblage

Previous records Butterworth & Williams 1958 Limestone Coal Group, Namurian A, Scotland; Smith & Butterworth 1967, Coal Seams of Great Britain, Viséan-Namurian A; Bharadwaj & Venkatachala 1961, Lower Carboniferous of Spitzbergen.

Turma MONOLETES Ibrahim 1933

Supra-Subturma ACAVATOMONOLETES Dettmann 1963

Subturma AZONOMONOLETES Luber 1955

Infraturma LAEVIGATOMONOLETES Dybova & Jachowicz 1957

Genus LAEVIGATOSPORITES Ibrahim 1933

Type species L. vulgaris Ibrahim 1933.

Diagnosis Potonié & Kremp 1954, p.165.

Remarks Characterized by a monolete, laevigate exine. Species are based essentially on arbitrary size ranges.

Laevigatosporites minor Loose 1934.

Plate 18, figs. 11 & 12

1934 Laevigato-sporites vulgaris minor Loose, p.158, pl.7, fig.12.

1957a Laevigatosporites minor (Loose) Potonié & Kremp; Bharadwaj p.109, pl.29, fig.8,9.

Holotype Loose 1934, pl.7, fig.12.

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

Diagnosis Ibrahim 1933, p.39.

Description Spores monolete bilateral. Amb oval in plan view, but has a proximal surface that may be less curved or incurved in cross-section. Suturae simple $\frac{2}{3}$ - $\frac{3}{4}$ of spore length. Exine pale and laevigate. Sometimes folded with minor wrinkles.

Size range 4236 47-60µ x 31-35µ (8 spec.); 4204 63-50µ x 45-30µ (8 spec.); 4249 62-44µ x 41-28µ (10 spec.).

Other authors 1957 Bharadwaj 35-45µ; Smith & Butterworth 1967, p.284.

Occurrence

Remarks A minor division occurs in the size range of *L. minor* and *L. vulgaris* Ibrahim at around 65µ, which is taken by Smith & Butterworth 1967 as an arbitrary length at which to split the two species but it is not reached in this study. *Laevigatosporites latus* Kosanke 1950 has a similar size range but has narrow lips. *L. modicus* Kosanke 1950 has a slightly granular exine. Occurrence infrequent.

Previous records Bharadwaj 1957, Saar Coals; Smith & Butterworth 1967, Coals of Great Britain, Namurian to Westphalian B.

Laevigatosporites vulgaris Ibrahim 1933

Plate 18, fig. 13

1932 *Sporonites vulgaris* Ibrahim in Potonié, Ibrahim & Loose, p.448, pl.15, fig.16.

1933 *Laevigato-sporites vulgaris* Ibrahim p.39, pl.2, fig.16.

Holotype Potonié & Kremp 1956, pl.19, fig.429 after Ibrahim.

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

Diagnosis Ibrahim 1933, p.39.

Description Spores monolete, bilateral. Oval in plan view; the proximal surface in cross-section was less curved than the distal, and occasionally incurved. Suturae $\frac{2}{3}$ of spore length. Exine pale and laevigate. Folding usually present on a small scale, with a few short sinuous wrinkles.

Remarks Specimens agree closely with diagnosis. Distinguished from Laevigatosporites minor Loose by its larger size. L. robustus Kosanke has a larger size range 80-150μ, otherwise similar. Occurrence infrequent.

Previous records Bharadwaj 1957, Saar Coals; Smith & Butterworth 1967, Coals of Great Britain, Westphalian B; Mishell 1966 (thesis), Bowland Fells and Ingleton Coalfield, Namurian A to C.

Anteturma POLLENITES Potonié 1931

Turma SACCITES Erdtman 1947

Subturma MONOSACCITES (Chitaloy) Potonié & Kremp 1954

Infraturma ARADINTES Bharadwaj 1957

Genus FLORINITES Schopf, Wilson & Bentall 1944

Type species F. pellucidus (Wilson & Coe) Wilson 1958.

Diagnosis S.W. & B. 1944, p.56.

Florinites visendus (Ibrahim) Schopf, Wilson & Bentall 1944

Plate 18, figs. 14 - 16

1933 Reticulato-sporites visendus Ibrahim, p.39, pl.8, fig.66.

1944 Florinites visendus(Ibrahim),; Schopf, Wilson & Bentall, p.60.

Holotype Potonié & Kremp 1956, pl.21, fig.477.

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

Diagnosis Potonié & Kremp 1956, p.170.

Description Amb circular or oval. Intexine not usually present. Suture mark not observed. Exoexine laevigate and irregularly infrareticulate; muri 1μ, lumina 2-3μ. Equatorial region more densely infrareticulate and exoexine here frequently darker, giving appearance of a band 3-4μ wide. Folding infrequent; broad 5-10μ.

Size range 4249 210-125μ x 145-95μ (7 spec.)

Other authors 1956 Potonié & Kremp 150-175μ; Smith & Butterworth 1967 122(151)186μ x 79(112)146μ Schulze, Westphalian C; Felix & Burbridge 1967 130-240μ (50 spec.).

Occurrence Leitrim E_1 and E_2 assemblages.

Remarks Specimens conform closely to material previously described. Little indication of intexine seen, except for one specimen which showed a rounded triangular pale region centrally within the exoexine. Presumably this was where the intexine was once attached. This form is very similar to Potonieispores elegans both in size range and morphology, but is distinguished by orientation of intexine. It is suspected by the author however that this feature may not be significant, since the intexine of Florinites is obviously easily dislodged.

Previous records Potonié & Kremp 1956, Upper Westphalian B to Lower We Westphalian C of the Ruhr; Mishell 1966 (thesis), Middle Namurian A to Westphalian A of Bowland Fells and Ingleton Coalfields; Smith & Butterworth 1967, Upper Westphalian A to Westphalian D of Great Britain.

Turma HILATES Dettmann 1963

Supra -Subturma CAVATIHILATES Smith & Butterworth 1967

Genus VESTISPORA (Wilson & Hoffmeister) Wilson and Venkatachala 1963

Type species V. profunda Wilson & Hoffmeister 1956.

Diagnosis W. & H. 1963, p.96.

Remarks Vestispora is distinguished from other genera by the presence of an operculum on the proximal surface.

Vestispora lucida (Butterworth & Williams) Potonié 1960

Plate 19, figs. 1 & 2

1958 Glomospora lucida Butterworth & Williams, p.384, pl.4, figs. 4-6.

1960 Vestispora lucida (Butterworth & Williams); Potonié, p.52.

Holotype Garibaldi Ironstone Seam at 1,058ft 3ins. (322.5m), Cawder Cuilt Borehole, Central Coalfield, Scotland, Namurian A.

Diagnosis Butterworth & Williams 1958, p.385.

Description Amb frequently oval, sometimes circular. Intexine oval or circular. Suturae simple, straight $\frac{1}{2}$-$\frac{2}{3}$ spore radius, usually distinct. Exoexine has spiral costae, widely spaced 12-20μ apart, standing 4.5-5μ high, and 1-1.5μ wide. Exoexine relatively thin and laevigate, frequently folded. Operculum not distinct. Based on 2472.

Size range 65-100μ (12 specimens) intexine 55-68u.

Other authors Butterworth & Williams 1958 70-150μ cb. 50-110μ; Sullivan & Marshall 1966 73-120μ.

Occurrence Ballycastle.

Remarks Size range when compared with diagnosis shows that the specimens in this study tend to be at the lower end of the scale. Distinguished from Vestispora costata (Balme) by its greater size and less frequent costae. Proprisporites laevigatus Neves 1961 has similar spiral costae but lacks intexine and operculum. Occurrence sporadic, except for sample 2472 where it is very abundant.

Previous records Butterworth & Williams 1958, Limestone Coal Group & Upper Limestone Group, Scotland; Sullivan & Marshall 1966, Viséan of Scotland; Smith & Butterworth 1967, Coals of Great Britain, Upper Westphalian B and C.

Incertae sedis

Genus BIANNULATISPHAERITES Neville 1973

Type species B. simplex Neville 1973.

Diagnosis Neves et al. 1973, p.40, Roy. Soc, Eding.

Biannulatisphaerites simplex Neville 1973

Plate 19, fig. 9

Holotype Pl. 1, fig. 1 in Neves et al. 1973.

Type locality Sample F59. Upper of two seat-earths 50' (15.24m) below

1'2" (0.35m) 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. 1973, p.40.

Description Amb circular to subcircular; alete. Exine laevigate. A band of thickening 2-5μ width occurs on both surfaces. Occasionally a polar thickening may be present; 5μ width. Exine relatively thick; yellow colour.

Size range 4236 29-31μ (3 spec.); 4204 30μ.

Other authors In Neves et al. 1973 21(28)32μ.

Occurrence Leitrim.

Previous records Neves et al. 1973, Lower Carboniferous of Scotland and Northern England, Concurrent Range Zones CM to VF.

Genus COLATISPORITES Williams 1973

Type species C. decorus (Bharadwaj & Venkatachala) Williams.

Diagnosis In Neves et al. 1973, p.40.

Colatisporites decorus (Bharadwaj & Venkatachala) Williams 1973
Plate 19, figs. 3 & 4

1961 Tholisporites decorus Bharadwaj & Venkatachala p.39, pl.10, figs. 142 to 146.

Holotype Bharadwaj & Venkatachala 1961, pl.10, fig.142.

Type locality Spitzbergen, Lower Carboniferous.

Diagnosis Williams in Neves et al. 1973, p.41.

Description Circular to oval; suturae indistinct, approximately ¾ of spore radius. Cameration present, but often difficult to discern in some specimens. Infra-punctation usually relatively consistent in the specimens.

Size range 3128 58-60µ (3 spec.);

Other authors Neves et al. 1973 40-52µ Spitzbergen assemblages; 45(53)75µ (64 spec.) Brampton.

Occurrence Donegal.

Remarks Specimens conform to diagnosis. Occurrence rare.

Previous records Bharadwaj and Venkatachala 1961, Lower Carboniferous, Spitzbergen; Neves et al. 1973, Lower Carboniferous CM to VF zones; N.E. England and Scotland.

Genus POTONIEISPORES Artüz 1956

Type species P. bizonales Artüz 1957

Diagnosis Translation from Artüz 1957, pps. 553-4.

Remarks This genus was erected to accomodate monosaccate miospores with oval and eliptical ambs, infra-reticulate saccus, and a monolete rectilinear slit running parallel to the long axis.

Potonieispores elegans (Wilson & Kosanke) Wilson & Venkatachala 1964

Plate 19, fig. 13

1944 Florinites elegans Wilson & Kosanke p.330, fig.3.

1964 Potonieispores elegans (Wilson & Kosanke) Wilson & Venkatachala, pp.67-68, figs. 1,21.

Holotype Wilson & Kosanke, fig.3, 1944.

Type locality Angus Coal Company Mine, Iowa; Des Moines Series.

Diagnosis Wilson & Kosanke 1944, p.330.

Description Monosaccate, elliptical or oval. Monolete suture parallel to long axis. Numerous folds, probably distal, orientated perpendicular to the suture, together with minor folds along the margin of the intexine. Intexine laevigate, exoexine infra reticulate.

Size range 150 x 105μ.

Other authors Felix & Burbridge 1967 100 x 137 to 145 x 200μ, intexine 70-72μ to 102 x 108μ (50 spec.).

Occurrence Leitrim.

Remarks Only one specimen, found in the Leitrim E_2a material. This form is distinguished from species of Florinites by the orientation of the intexine (i.e.: the monolete is parallel to the long axis of the exoexine.(See 'remarks' F. visendus).

Previous records Wilson & Kosanke 1944; Wilson & Venkatachala 1964; Felix & Burbridge 1967, Springer Formation, Southern Okalhoma, U.S.A.; Kosanke 1950, Upper Tradewater (Westphalian B - C) of Illinois and Kentucky, U.S.A.

Spore Type A.

Plate 19, figs. 5 & 6.

Diagnosis Circular amb. Circular to pentamerus structure which may be a thickening 1-3μ wide with five processes radiating from it extending 1-3μ; or a negative feature of the same form, bordered by a darkened zone 1.2μ either side. Exine generally pale, rarely yellow in colour. Folding frequent.

Description Circular amb at equator, but probably polar orientation will be oval. A trilete has not been observed. The only structure on the exine in most specimens is a ring defined by a negative feature, bordered by a darkened zone 1-2μ wide or a thickening 1-3μ wide, 21-29μ diameter, which is often pentangular in shape with, at each of the five corners, a short radiating depression or thickening extending 1-3μ. Only in two specimens have all five of these projections been observed. Exine generally is pale, occasionally having a thicker yellow colour. Folding is frequent, broad, flat generally, oaccasionally thin and twisted.

Size range 4236 60-120μ (20 spec); 4249 40-50μ (3 spec.); 4204 40-124μ (6 spec.).

Remarks The unusual structure gives little indication of being proximal or distal. The absence of a trilete suggests that these spores be placed in Hilates or Aletes. Hilates are defined by Dettmann as spores with structural and/or sculptural modification at and about the distal or proximal pole where a hilum may develop as a result of a natural sclerinous breakdown. The pentagonal nature of the structure described above suggests that it is basically unlike other members of Hilates.

Group ACRITARCHA Evitt 1963

Subgroup ACANTHOMORPHITAE Downie, Evitt and Sarjeant 1963

Genus BALTISPHAERIDIUM Eisenack 1958

Type species B. longispinosum Eisenack 1931

Baltisphaeridium sp. (sensu lato)

Plate 19, fig. 8

Description Body oval to circular; wall very thin and pale; may be minutely granulate; two crescentic folds characteristically occur, which may extend nearly the length of the body. Ornamented with small thin spiny processes; contact with body quite distinct; 0.5u broad and stand from 0.5 - 2u high, although occasionally reach 5u; approximately 20 to 30 may occur at the equator. Distal end of processes are usually tapering and sharp, rarely bulbous.

Size range 1142 22(28)33u (10 spec.); 5040 30u (1 spec.).

Remarks The specimen from assemblage 5040 displayed bulbous tips but was otherwise very similar in its morphology to those of assemblage 1142.

CHAPTER IX

SUMMARY OF CONCLUSIONS

In this study approximately four hundred samples were collected and prepared from the Carboniferous strata of Northern Ireland and the Republic of Ireland. Twenty-seven of these were obtained from the type locality of Slieve Anierin in County Leitrim which include goniatite dated atrata of the late Pendleian and early Arnsbergian stages. Seventy-seven assemblages were obtained from Ballycastle, Co. Antrim, which includes poorly dated strata of B_2 to possibly E_2 zone age. Seven assemblages were also obtained from strata of various ages within the Lower Carboniferous. These include two from Co. Mayo of probable C_2S_1 zone age and two other assemblages from the Donegal Syncline of C_2S_1 and S_2 zone age. Two more assemblages of K zone age were obtained from Goresbridge Co. Kilkenny.

Difficulty was experienced in obtaining assemblages, despite the large number of samples collected. The assemblages from Ballycastle were relatively well preserved and few were unproductive. Only a small number of poor quality assemblages however were obtained from the areas sampled in the Republic of Ireland. Several different methods of oxidation were applied but with little success. A vitrinite reflectance study by A.H.V. Smith on some of the coals from Leitrim revealed that the rank in this area was generally too high to expect good spore preparations. In a brief discussion of the factors controlling preservation characteristics it is tentatively suggested that secondary post depositional changes rather than unsatisfactory primary events may be the cause of such poor assemblages.

The above assemblages were described and compared with others recorded from similar intervals within the Carboniferous. The results of these findings are summarized as follows.

A. Leitrim Area

(i) Two Concurrent Range Biozones are described. C.R.B. I is from a goniatite dated E_1c zone horizon in the Dergvone Shale and C.R.B. II includes a series of varied miospore assemblages from some of the coals and non-marine sediments occurring towards the top of the E_2a substage. The above C.R. Biozones are considered to be composed of three main elements.

1) Pendleian autochthonous species such as Anapiculatisporites concinnus, Rotaspora spp., Tripartites spp., Tholisporites scoticus etc., which are close to the top of their range.

2) Younger species, notably Crassispora kosankei and Laevigatosporites spp., in the earlier part of their stratigraphic range, and at lower frequencies than they later achieve.

3) Contemporary upland taxa such as Potoniespores elegans and Florinites visendus. In the older C.R.B. I, the first element is more obviously present.

(ii) The latter C.R. Biozones are compared with several assemblages previously described from similar stratigraphical horizons. Close comparisons can be made with those assemblages from the Arnsbergian shales 75' above the Stricegill Grit in the Stainmore Outlier of the Northern Pennines described by Owens, in Owens and Burgess (1965).

(iii) Correlation of the various coals present in the Slieve Anierin boreholes was virtually impossible, due to the uneven recovery of spores. An unusual dominance of Tholisporites scoticus however, was noted from the Middle Coal assemblages of Borehole 121.

(iv) A preliminary account of the environmental significance of spore distributions was attempted in a detailed study of the Hard Coal. The _Lycospore_ phase of Smith (1962) could be recognised within the coal, and the Incursion phase equated with the roof and floor measures.

B. Ballycastle Area

(i) Two Concurrent Range Biozones, C.R.B. I and C.R.B. II are described from the strata below and above the Main Coal horizon respectively. They are both characterized by the presence of _Tripartites vetustus_, _Crassispora maculosa_, _Rotaspora fracta_, _R. knoxi_ and _Spencerisporites radiatus_, but can be distinguished by the first appearance of _Punctatisporites papillosus_, _Verrucosisporites morulatus_ and _Convolutispora varicosa_, together with abundant _Cingulizonates cf. capistratus_ and _Rotaspora fracta_. The assemblages as a whole most closely compare with those recorded from uppermost Visean (D_2) and Pendleian (E_1) age,strata of particularly the Upper Sedimentary Group of Ayrshire by Sullivan and Marshall (1966) and the Yoredale Series of the Roman Wall District of Northumberland by Marshall & Williams (1970).

(ii) There is miospore evidence to support the correlation of the Main Coal horizon with the base of the Namurian Series of Wilson & Robbie (loc. cit.).

(iii)Assemblages above the Main Coal appear closely comparable with those only of Pendleian E_1 zone age, and hardly at all with Arnsbergian assemblages. This does not support the correlation of McGildowney's Marine Band with the Index Limestone of Scotland which is based on the presence of _Schwellwienella rotundata_ in the Marine Band.(Wilson & Robbie, loc. cit.).

(iv) Similarly the correlation by Wilson & Robbie, of the Pumpherston Shell Bed, Scotland (S.zone of the Visean by Wilson & Robbie, 1966, fig.11), with the Ballycastle Carrickmore Marine Band is not supported since the latter occurs within the C.R.B. I.

(v) The general distribution of spores in marine shales, non-marine shales and coal lithologies proved similar to that recorded by Neves (1961). It was observed that the allodthonous marine assemblages could be distinguished by the presence of a fine, probably organic substance together with the poor preservation of the spores and plant material.

C. Lower Carboniferous Assemblages

(i) The assemblages from north-western Ireland appear older in aspect when compared to others previously described from similar stratigraphical horizons. Assemblages of C_2S_1 zone age described by Neves et al. (1973) from Britain possess in general more species characteristic of the Visean. The Goresbridge assemblage from Southern Ireland can be more closely compared with the lower (Pu) C.R.Biozone described as equivalent to C_1 zone age.

(ii) The assemblages in general do not appear to compare exactly with those from Britain or other areas in the World, although some affinity with Canada can be detected. This conclusion is in accordance with the palaeogeography of the time which shows Ireland in close proximity with Canada in Lower Carboniferous times.

D. Statistical Studies

A statistical study of the genera Schulzospora and Lycospora was attempted to study their morphological variation and the possibility of subdivision into useful species. This was based essentially on assemblages from the Leitrim Hard Coal, together with one isolated assemblage from the Ardargh Coalfield.

There is little evidence that the variation displayed within the genus Lycospora is sufficient to warrant subdivision into any further groups than L.pusilla and L. noctuina var. noctuina. A greater width in the labra and marginal thickening was observed in the Namurian Hard Coal assemblage, when compared with those of the Westphalian Slieve Ardagh assemblage.

The Schulzospores from four assemblages associated with the Hard Coal, suggested that S. campyloptera and S. ocellata are the two most abundant species. These occurred in approximately equal numbers in the roof and floor shale, but in the coal the pattern was less obvious and included also the smaller form S. elongata.

APPENDIX A

ALL PRODUCTIVE SAMPLES UNDERLINED

BOREHOLE 103

CONNAUGHT COALFIELD 1960-61 TULLYTAWEEN TOWNLAND. 6" ROSCOMMON 2

SURFACE LEVEL 989·6' (301·6 m) OD

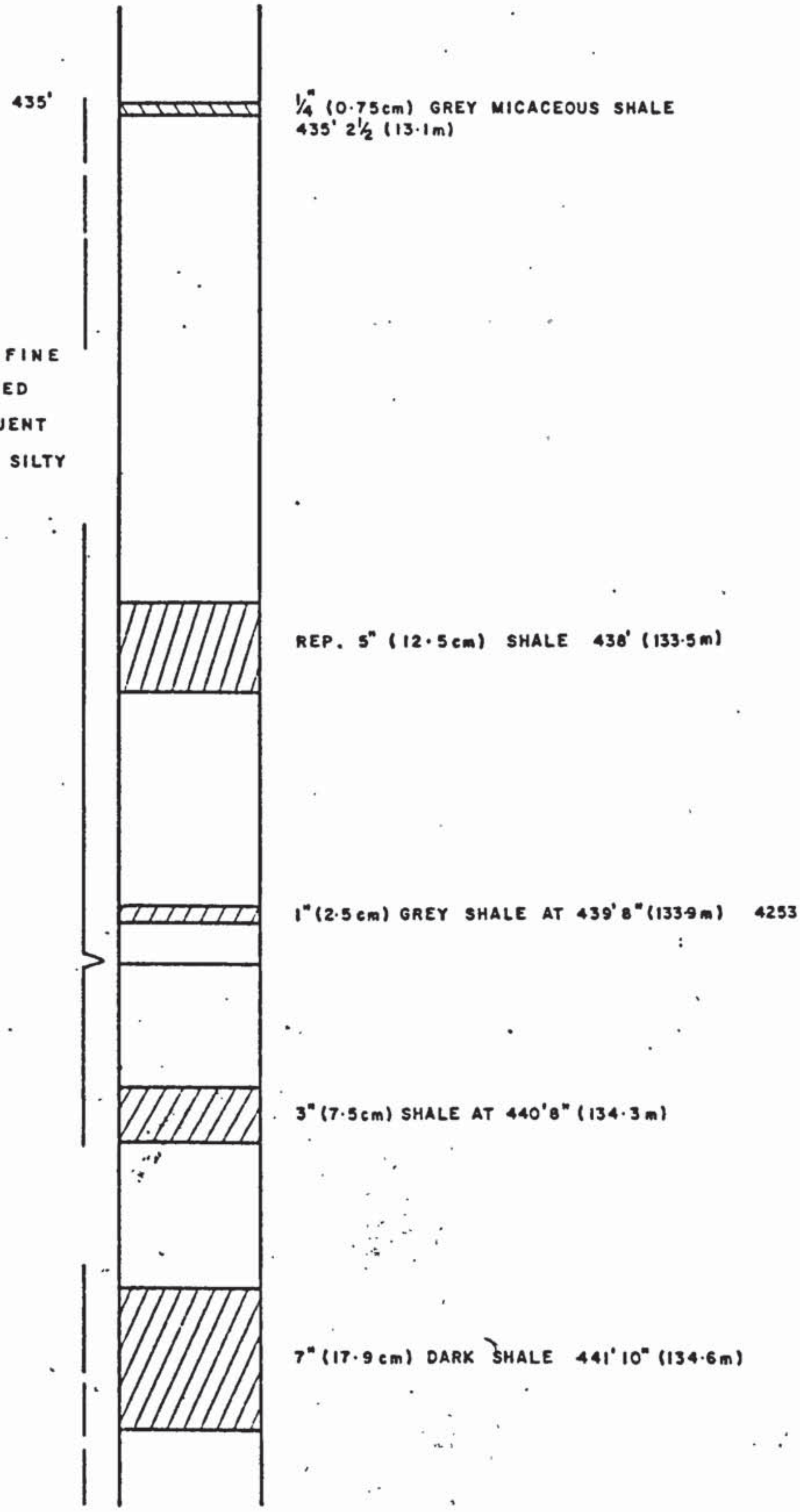
MAIN COAL 1'9" (0·53m) 423'9" (129·2 m)

MIDDLE CROW COAL 0·9" (0·23m) AT 507'4" (154·6m)

CORED TOP COAL 1" (0·3m) THICK AT 381'3" (116·2m)

UPPER CROW COAL 0·7" (0·17m) AT 476'4" (145·2m)

LOWER CROW COAL 0·8" (0·18m) AT 561'5" (171·1m)



Drawing No. 15897

Date 16·VIII·76

BOREHOLE 104

CONNAUGHT COALFIELD 1960 - GLACKAUNADARRAGH TOWNLAND 6" LEITRIM 20A

SURFACE LEVEL 1,373·6' (418·6m) O.D.

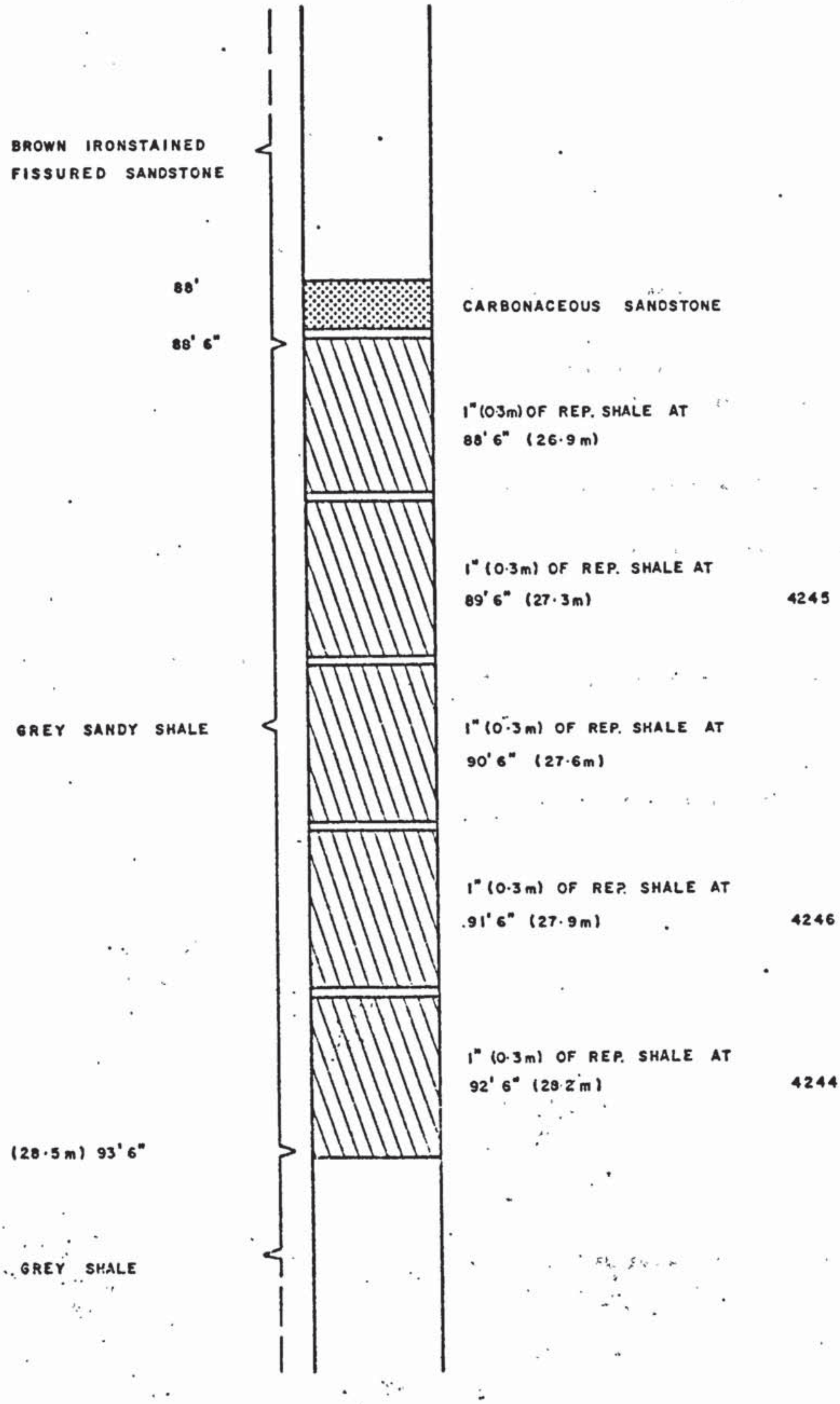
COMMENCED ABOUT MAIN COAL HORIZON (not noted)

CORED UPPER CROW COAL 1'5" (0·44m) THICK AT 55'3" (16·9m)

CORED MIDDLE CROW COAL 2'8" (0·8m) AT 81'6" (24·8m)

CORED LOWER CROW COAL 0·3" (8cm) AT 131'0" (39·9m)

ENDED 223' (67·9m)



Drawing No. 15896 Data 17 · VIII · 76

BOREHOLE 110

CONNAUGHT COALFIELD 1960-62 GUBBRUDA TOWNLAND 6" ROSCOMAN 1

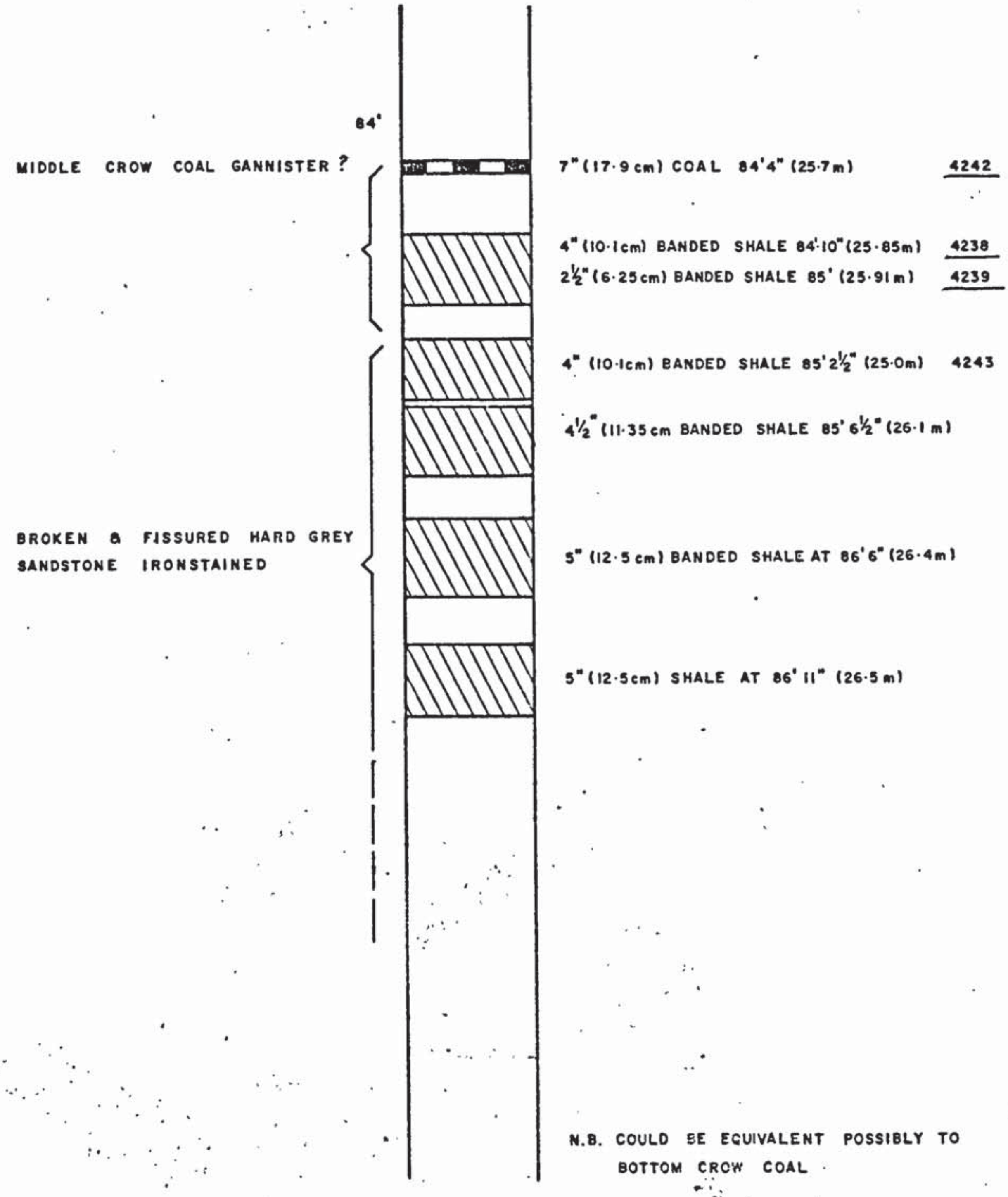
SURFACE LEVEL 1055·9' (321·8m) O.D.

UPPER CROW COAL 0·6" (0·15m) AT 61' 3" (18·7m)

MIDDLE CROW COAL 1'7" (0·49m) AT 84' 4" (25·7m)

LOWER CROW COAL 1'5" (0·44m) AT 117' 8" (35·8m)

ENDED AT 210' (64m)



Drawing No. 15898

Date 18·VIII·76

BOREHOLE 121

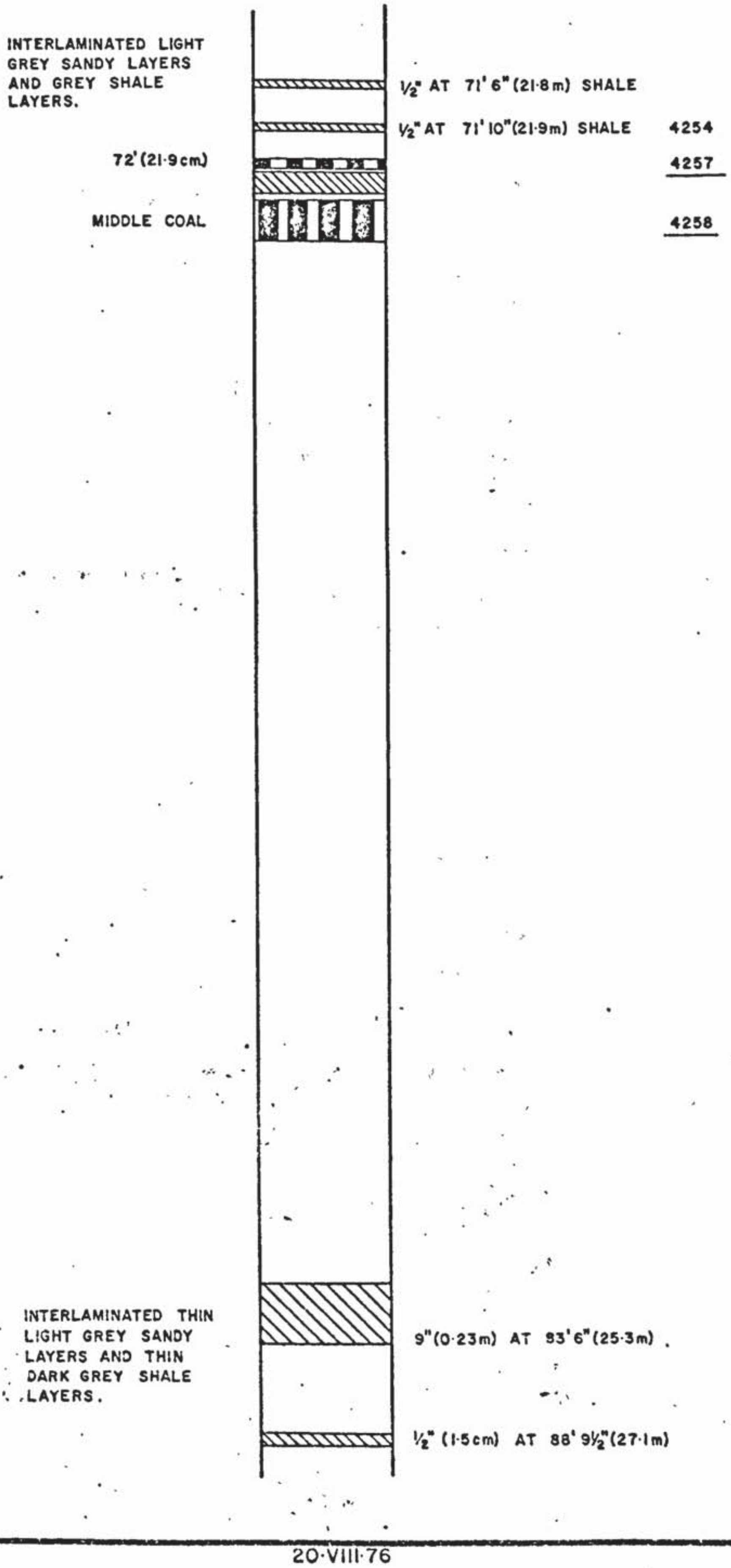
CONNAUGHT COALFIELD: SLIEVENAKILLA TOWNLAND: 6" LEITRIM 21

SURFACE LEVEL 1257'(383·1m) O.D. CORED TOP COAL 2'7"(0·79m) AT 25'4"(7·7m)

MIDDLE COAL 0'8"(0·24m) AT 72'8"(22·1m) BOTTOM COAL 2'0"(0·61m) AT 113'7"(34·6m)

ENDED AT 305'(92·9m)

SCALE: 2cm. to 10ft.(3·05m)



Drawing No. 15904 20·VIII·76

BOREHOLE 122

CONNAUGHT COALFIELD 1960-62 SLIEVENAKILLA TOWNLAND 6" LEITRIM

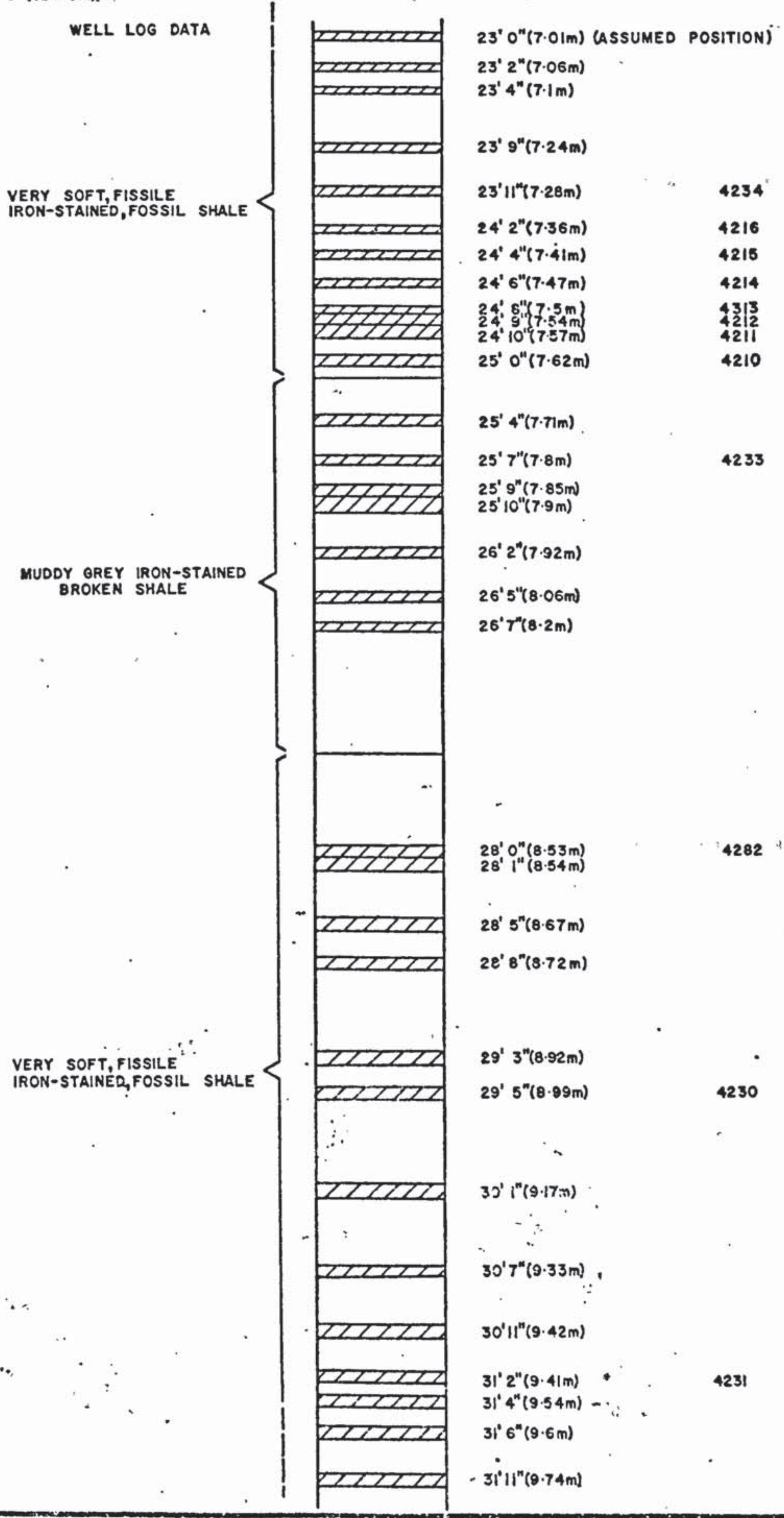
SURFACE LEVEL: 1514·8'(461·7m) O.D. COMMENCED IN COAL MEASURES SHALE

CORED TOP COAL 2'8"(0·8m) AT 168' 10" (51·4m).

CORED MIDDLE COAL 0' 11"(0·29m) AT 223'8"(68m)

CORED BOTTOM COAL 1' 6"(0·46m) AT 265'0"(80·7m).

ENDED AT 414' 6"(126·3m).



Drawing No. 15895 17·VIII·76

BOREHOLE 124(1)

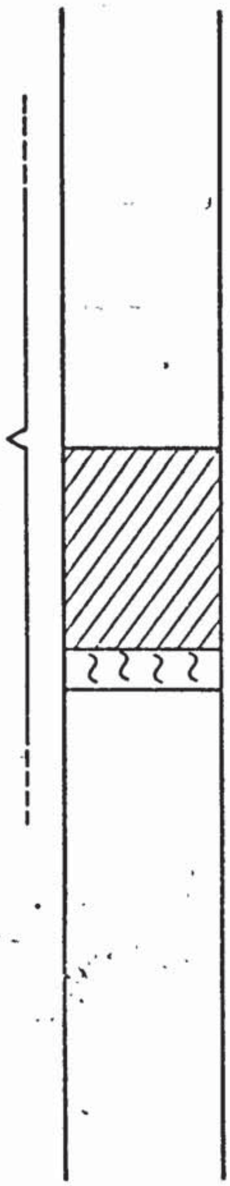
CONNAUGHT COALFIELD 1960-62 SRADRINAGH TOWNLAND 6" LIETRIM 21

WELL LOG DATA

SURFACE LEVEL 1793·1'(546·5m) O.D. COMMENCES AT BASE OF C.M. SHALES;
CORES 'TOP COAL' 1'-3" AT 45'4"; MIDDLE COAL 0'-9"(0·23m) AT 77'-2"(23·5m); BOTTOM COAL
4'-2"(1·26m) THICK AT 177'-1"(53·9m); ENDED AT 244'-0"(74·4m)

WELL LOG DATA

ASSUMED POSITION



Drawing No. 15902

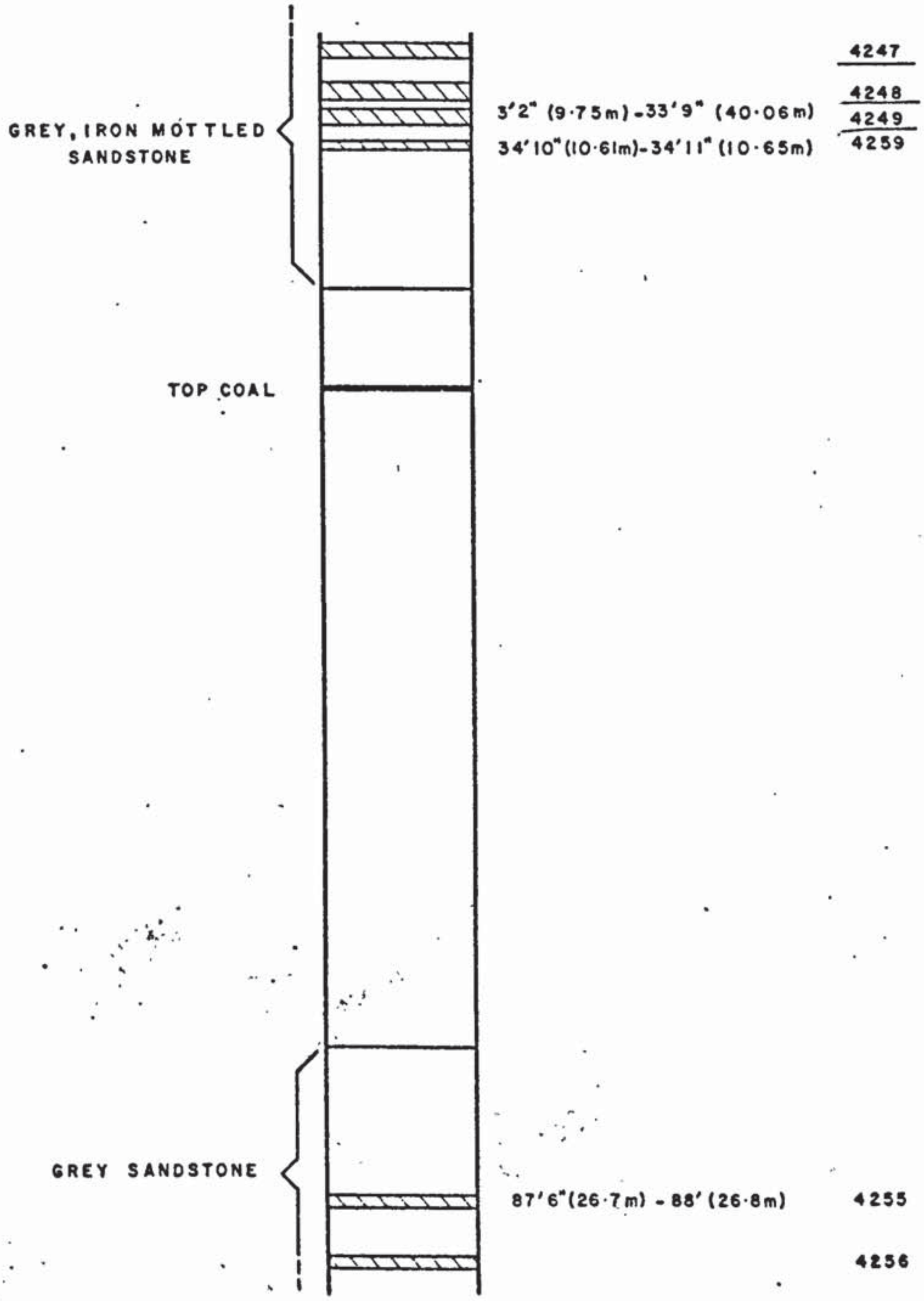
18·VIII·76

BOREHOLE 124(2)

CONNAUGHT COALFIELD 1960-62 SRADINAGH TOWNLAND 6" LEITRIM

SURFACE LEVEL 1793·1'(546·5m)O.D, COMMENCES AT BASE OF C.M. SHALES. CORES TOP COAL 1'-3"(0·38m) THICK AT 45'-4"(13·8m), CORES MIDDLE COAL 0'-9"(0·23m), AT 77'-2"(23·5), BOTTOM COAL 4'-2" (1·26m) AT 177'-1"(53·9m). ENDED AT 244'-0"(74·4m).

SCALE :1" (2·5m) = 10' (3·05m)



BOREHOLE 126

CONNAUGHT COALFIELD 1960-62 BARNAMEENAGH TOWNLAND 6" LEITRIM 21

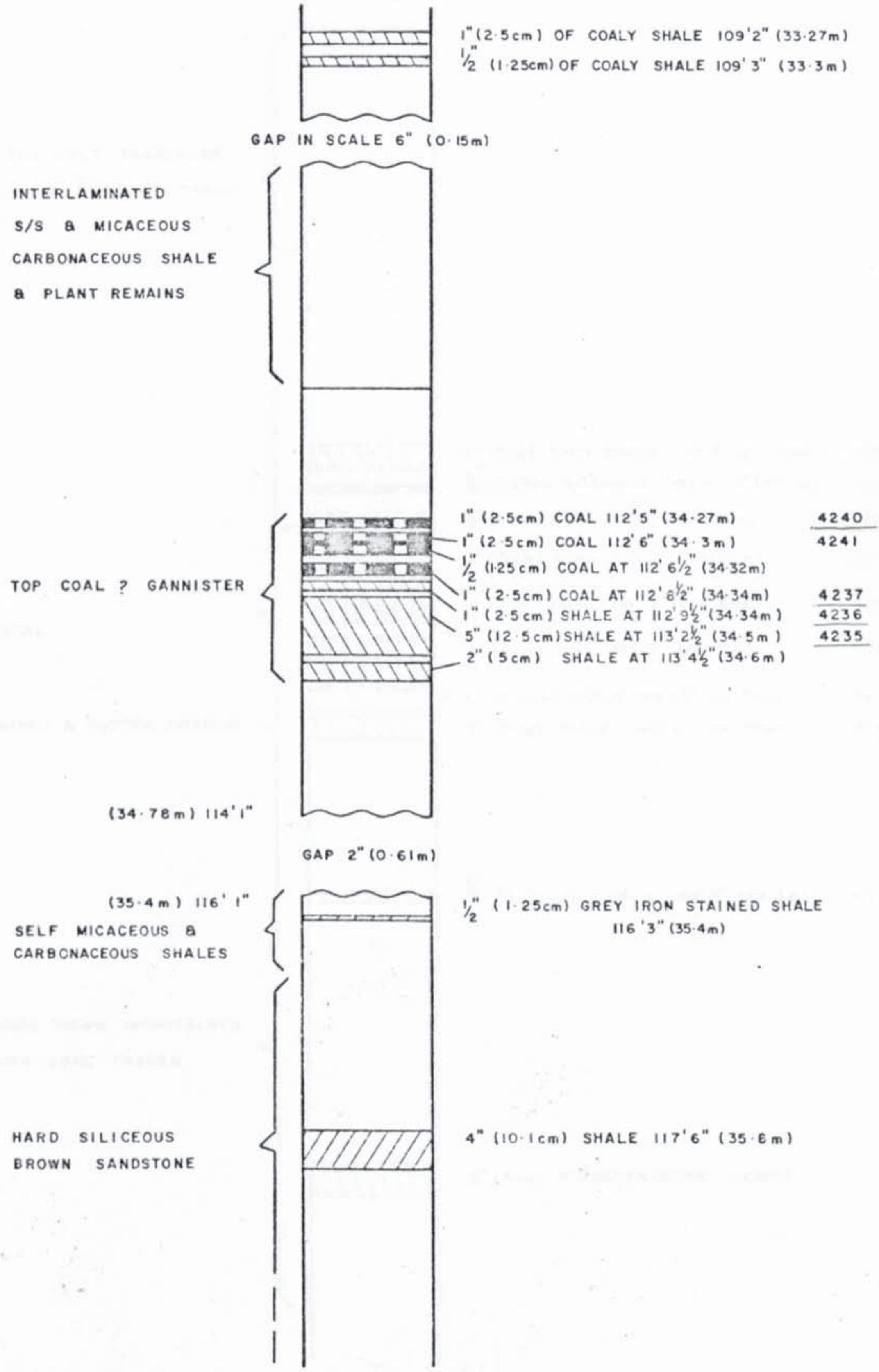
SURFACE LEVEL AT 112' 5" (34·27 m) COMMENCED IN COAL MEASURE SHALES

CORE TOP COAL AT 12" (0·35 m)

MIDDLE COAL 3' 2" (0·96 m) AT 142' 6" (43·4 m)

BOTTOM COAL 4' 0" (1·22 m) AT 245' 3" (74·75 m)

ENDED AT 387' 0" (117·9 m)



Drawing No 15899

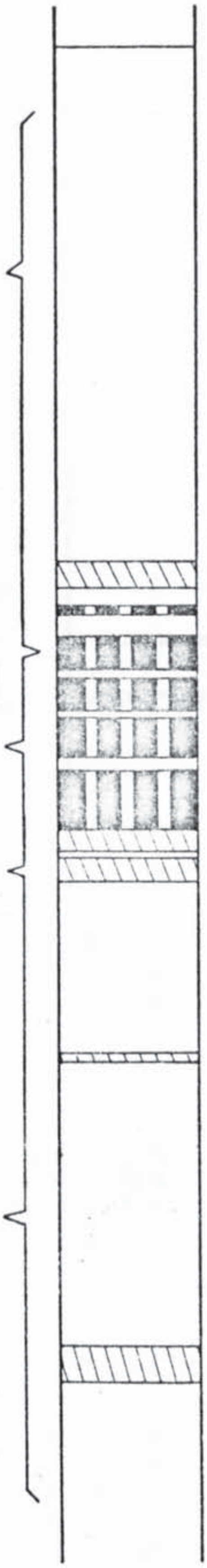
Date 13 · VIII · 76

BOREHOLE 151

CONNAUGHT COALFIELD 1960-62 LACKAGH TOWNLAND 6" LIETRIM 16

SURFACE LEVEL 1286·7 O.D. (392·1m) ENDED AT 458'5" (139·7 m)

SURVEY WELL LOG | ASSIMILATED SECTION | FIND



2'3" (0·69m) HARD GREY SANDSTONE
COAL BANDS UP TO 3/4" (2cm) THICK
145'0" (44·2 m)

1'8" (0·51m) COAL

2" (5cm) WEATHERED & ROTTEN FIRECLAY

23'0" (7·01m) HARD BROWN IRONSTAINED
SANDSTONE WITH COAL TRACES

2" (5cm) GREY SHALE 145'7" (44·36m)	4201
1/2" (1·25cm) VITRINOUS COAL 145'11" (44·5m)	4203
2" (5cm) COAL 146'1" (44·53m)	4208
2" (5cm) COAL 146'3" (44·45m)	4206
2" (5cm) COAL 146'5" (44·64m)	4209
3" (8cm) COAL 146'7" (44·7m)	4207
1" (2·5cm) SHALE 146'10" (44·74m)	4205
2" (5cm) SHALE 146'11" (44·79m)	4204
1/2" (1·25cm) SHALE 148'3" (45·2m)	4202
2" (5cm) REPRESENTATIVE SAMPLE	

Drawing No. 15900 Date 17·VIII·76

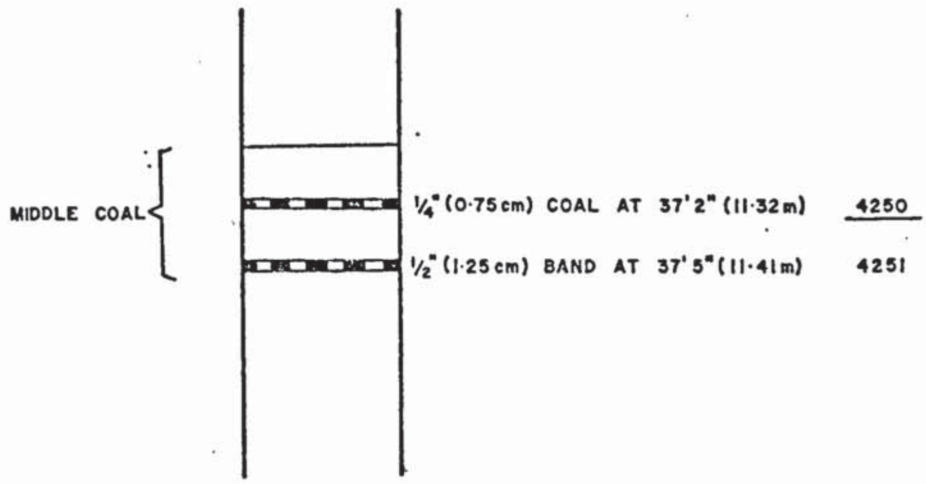
BOREHOLE 141

CONNAUGHT COALFIELD 1960-62. SLIEVENAKILLA TOWNLAND. 6" LEITRIM 19.

SURFACE LEVEL 1312·3'(399 9m) O.D. COMMENCES BELOW HORIZON OF TOP OF COAL.

CORED MIDDLE COAL 0' 6"(0·15m) AT 37' 0"(11·28m) CORED BOTTOM COAL 1'6"(0·46m) AT 61'0"(18·6m)

ENDED AT 296'0"(90·2m)



APPENDIX B

LOCALITY		FIELD NUMBER	LAB. NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3			
North Western Ireland, Leitrim and surrounding counties.	Borehole 151	4201	201		X		5	10	10				
	151	4202	202		X		5	15	20				
	151	4203	203	X				10		25			
	151	4204	204		X		5	15	10				
	151	4205	205		X	5	5	15					
	151	4206	206	X				5	5	30			
	151	4207	207	X				5	10	25			
	151	4208	208	X			10	5	5	22			
	151	4209	209	X				5	5	20			
	122	4210	210		X		5	5	10				
	122	4211	211		X		5	5	15				
	122	4212	212		X		5	15	20				
	122	4213	213		X		6	5	20				
	122	4214	214		X		6	10	10	5			
	122	4215	215		X			5	15				
	122	4216	216		X	6	5	15					
	Arigna	Arigna	217		X		6	5	10				
	"	4218	218	X		6	5	5	5				
	"	4219	219	X				15	10	21			
	"	4220	220	X				5	5	20			
	"	4221	221	X				8	5	22			
	"	4222	222	X				5	10				
	"	4223	223	X				10		30			
	"	4224	224	X				5	10				
	"	4225	225	X			6	5		30			
	"	4226	226	X				5		35			
	"	4227	227	X			10		30				

LOCALITY	FIELD NUMBER	LAB. NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3			
Leitrim-Arigna	4228	228	X				5	10				
"	4229	229		X		6						
Borehole 122	4230	230		X	5	6	5	25				
122	4231	231		X	5	6						
122	4232	232		X		7	5	30				
122	4233	233		X		7	10	40				
122	4234	234		X		7	5	20				
126	4235	235		X		7						
126	4236	236		X		7	5	15				
126	4237	237		X		7						
110	4238	238		X		7	10	15				
Borehole 110	4239	239	X				10	5	20			
" 126	4240	240	X				10		30			
" 126	4241	241	X				10		30			
" 110	4242	242	X				10		30			
" 110	4243	243	X				15		10			
" 104	4244	244		X		8	5	10				
" 104	4245	245		X		5	5	10				
" 104	4246	246		X		8	5	20				
" 124	4247	247		X		8	5	15				
" 124	4248	248		X		8	5	15				
" 124	4249	249		X		5	5	15				
" 141	4250	250		X		5	5	10				
" 141	4251	251		X		5	5	10				
" 124	4252	252		X		5	5	20				
" 103	4253	253		X		5	5	20				
" 121	4254	254	X				10	5	20			

LOCALITY	FIELD NUMBER	LAB. NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3	FU. SCHULZE	NaOH	
Borehole 12	4255	255	X				10	5	30			
" 12	4256	256		X		5	5	20				
" 121	4257	257		X		5	5	20				
" 124	4258	258		X		5	5	10				
" 121	4259	259		X		5	5	20				
Odonells Rock	4063	260		X	2	4	5		25			
"	4068	261		X	2	4	5		5			
"	4072	262		X	2	4	5		25			
"	4095	263		X		4	5		10			
Lackagh Hills	4096	264		X		4	5		25			
"	4103	265		X		4	5		10			
"	4107	266		X		4	5		10			
Leitrim	4109	267		X	2	5	5		10			
"	4020	268		X		4	5		10			
"	4023	269		X		4	5		10			
"	4025	270		X		4	5		30			
"	4028	271		X		4	5		10			
Carrane Hill	4032	272		X		4	5		10			
"	4037	273		X		4	5					
"	4042	274		X		4	5		10			
"	4048	275		X		4	5					
"	4049	276		X		4	5		10			
Ballinafad	4001	277		X	3	7	5		5	10		
"	4002	278		X	3							
"	4003	279		X	3	7	5		35			
"	4004	280		X	3	7	10		20			
"	4005	281		X	3	7	5		15			

LOCALITY	FIELD NUMBER	LAB. NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3	FU. SCHULZE	NaOH	
Ballinafad	4006	282		X	4	7	5	30				
"	4007	283		X	5	7	10	60				
"	4008	284		X	5	7	5		5	10		
"	4009	285		X	6	7	5		10			
"	4010	286		X	3		5		10			
Lough Dargan	4011	287		X	5	7	5		5	10		
"	4012	288		X			5	30				
Ballysadare	4014	289		X	3	7	5		15			
"	4015	290		X	3	7	5		10			
Lacagh Hills	4097	291		X		8	5		30			
"	4098	292		X		7	5		10			
Ballybunion	6095	293		X	6	8	5		5	60		
Kilshinnen	5020	294		X	2	8	5		5	240		
Ballybunion	6135	295		X		8	6		20		35	
Goresbridge	5143	296		X			5		120	10hrs		
Carlow	5027	297		X	3	8	5		5	4		
Cashel	5065	298		X		8	6		20		20	
Ballybunnion	6098	299		X			5		5	5	10	
Kilashinnen	5017	400		X	2	8	10		10	10		
"	5012	401		X		8	10		35	5		
Carlow	5023	402		X		8	10		50	5		
Ballybunion	6145	403		X		8	10		5	5		
Tralee	6152	404		X	3	10	10	60			10	
Ballybunion	6146	405		X			10	120				
Hags Head	6075	406		X		8	5		5	30		
Cliffs of Moher	6089	407		X		10	10		10			

LOCALITY	FIELD NUMBER	LAB. NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3	FU. SCHULZE	NaOH	
CARLOW	5028	408		X		7	5		180			
" "	5019	409		X		8	5	6hrs	5			
"	5010	410		X		8	5	6hrs	5			
Ballybunion	5147	411		X		7	5	3hrs				
"	6147	411B		X		4	5	5	30			
Kilshinnen	5014	412		X		7	5	6	5			
Lehavel	6069	413		X		8	10	2				
"	6069	413B		X		4	5	5	30			
Carlow	5031	414		X		8	5	3				
Earlshill	5055	415		X		8	5	60	5			
"	5055	415B		X		4	5	60	20			
"	5055	415C		X		4	5	120				
"	5055	415D		X		9	5	60				
Goresbridge	5040	416		X		4	5	2				
Earlshill	5056	417		X		8	5	60				
"	5057	418		X		8	5		5	10		
Carlow	5053	419		X		8	5	150				
"	5053	419B		X		4	5	5	30			
Cashel	5065	420		X		4	5	60				
Cliffs of Moher	6082	421		X		8	5		5	10		
Ballybunion	6098	422		X	4	8	5		5	30		
"	6102	423		X		7	5		5	30		
"	6107	424		X		7	5		5	30		
"	6107	424B		X		8	5	30				
"	6097	425		X		8	5	30				
Earlshill	5064	426		X		8	5	60				
Carlow	5032	427		X		4	5	30				

LOCALITY	FIELD NUMBER	LAB NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3	FU. SCHULZE	NaOH	
Carlow	5015	428		X		4	5		30			
Tralee	6151	429		X		4	5	10	30			
Ballybunion	6148	430		X		8	5		30			
"	6120	431		X		8	5		30			
Carlow	5011	432		X		8	5		30			
Cliffs of Moher	5087	433		X		4	5		30			
Ballybunion	5127	434		X		4	5	5				
Carlow	5025	435		X		8	5		50			
"	5002	436		X		8	5	10				
Tralee	6149	437		X	4	8	5		50			
Carlow	5024	438		X		4	5	10				
"	5007	439		X		4	5		60			
	5018	440		X		5	10	10				
	5021	441		X		5	10	10				
	5029	442		X		5	5	10				
	5034	443		X		5	5	10				
	5035	444		X		5	5	10				
	5036	445		X		5	5	10				
	5037	446		X		5	5	10				
	5038	447		X		5	5	10				
	5041	448		X		5	5	10				
	5042	449		X		5	5	10				
	5070	450		X			5		60			
	5071	451		X			5		60			
Earlshill	5060	452		X			5		60			
	5072	453		X			5		60			
	5074	454		X			5		60			

LOCALITY	FIELD NUMBER	LAB. NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3	FU. SCHULZE	NaOH	
	5030	455		X			5		60			
Carlow	5033	456		X			5		30			
	5109	457		X			5	5	30			
	5050	458		X			5	5	30			
Goresbridge	5044	459		X			5		60	60		
	5039	460		X			5		60	60		
	5106	461		X		4	5		30			
Cliffs of Moher	6088	462		X		4	5	10				
Carlow	5052	473		X		8	5	10				
	6113	464		X		8	5	10				
Abbeyfeale	6047	465		X		8	5		10			
	6093	466		X		8	5		30			
	6065	467		X		8	5		10			
	6114	468		X		8	5		30			
	6086	469		X		8	5		30			
Ballycastle	Ballyvoy No. 1	470		X		3	5		10			
	"	470		X		3	3		20			
	"	470		X		3	5		25			
	"	470		X		3	5		25			
	"	471		X		3	5		15			
	"	472	X			3			26			
	"	472	X			3			26			
	"	473	X			3	5		24			
	"	473B	X			3	5		24			
	"	473C	X			3	5		2hrs			
	"	473D	X			3	5	50				

LOCALITY	FIELD NUMBER	LAB. NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3	FU. SCHULZE	NaOH	
	Craigfad Borehole	474	X			3	10		40			
	Seam A	475	X			5	5		60			
	Seam (i)B	476	X			5	5		60			
	Seam (ii)B	477	X			5	5		60		5	
	Seam C	478	X			5	5		60		5	
	Seam D	479	X			5	5		60		5	
	Seam F	480	X			5	5		70		90	
	Seam X	481	X			5	5		60			
	Seam G	482	X			5	5		70		5	
	2032	483		X		5	5		45			
	2038	484		X		5	5		35			
	2018	485		X		5	5		35			
	2016	486		X	X	5	5		40			
	2017	487		X		5	5		30			
	2039	488		X	X	5	5		35			
	2047	489		X		5	5		35			
	2038	490		X		5	5		45			
	2049	491		X		5	5		45			
	2048	492		X		5	5		45			
	2056	493		X	X	5	5		40			
	2057	494		X		5	5		30			
	2012	495		X		5	5		30			
	2059	496		X		5	5		30			
	2060	497		X		5	5		20			
	2058	498		X		5	5		45	10		
	2029	499		X		5	5		20			

LOCALITY	FIELD NUMBER	LAB. NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3	FU. SCHULZE	NaOH	
County Mayo	1648	600		X		5		over night				
	1644	601	X		X	5		"				
	1632	602		X	X	5		"				
	1640	603		X		5		"				
	1651	604		X	X	5		"				
	1634	605		X		5		"				
	1639	606		X		5		"				
	1646	607		X		5		"				
	1645	608		X		5		"				
	1638	609		X		5		"				
	1641	610		X		5		"				
	1633	611		X		5		"				
Ballycastle	2022	612		X	X		5		15			
	2023	613		X	X		5		15			
	Cross Borehole	614		X			5		15			
	Seam H	615	X									
County Mayo	1649	616		X	X	5	5	over night				
	1647	617		X	X	5	5	"				
	1636	618		X	X	5	5	"				
	1637	619		X		5	5	"				
	1643	620		X		5	5	"				
	1642	621		X		5	5	"				
	1635	622		X		5	5	"				
Ballycastle	2024	623		X		6	5			15		
	2001	624		X		6	5			15		
	2042	625		X		6	5			15		

LOCALITY	FIELD NUMBER	LAB. NUMBER	COAL	SHALE	HCL	HF	HNO_3	SCHULZE SOL.	FU. HNO_3	FU. SCHULZE	NaOH	
	2026	626		X		6	5			20		
	2025	627	X				5		25			
	2040	628		X		6	5			20		
	2034	629		X		6	5			20		
	2071	630		X		6	5			15		
	2068	631		X		6	5			15		
	2036	632		X		6	5			15		
	2041	633		X		6	5			20		
	2037	634		X		6	5			20		
	2064	635		X		6	5			15		
	2035	636		X		6	5			20		
	2046	637		X		6	5			20		

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PLATE 1

ALL PHOTOGRAPHS x 500

Fig. 1 Chaetosphaerites pollenisimilis (Horst) Butterworth & Williams 1958 2472 (i) 14.5/67.3

Fig. 2 Leiotriletes inermis (Waltz) Ischenko 1952 4236 (i) 17.0/65.1

Fig. 3 Leotriletes priddyi (Berry) Potonie & Kremp 1955 4236 (i) 18.3/101.2

Fig. 4 Leiotriletes parvus Guennel 1958 4249 (i) 12.0/68.0

Fig. 5 Leiotriletes sphaerotiangulus (Loose) Potonie & Kremp 1954 2471 (i) 18.0/75.0

Fig. 6 Leiotriletes sphaerotriangulus (Loose) P. & K. 1954 2471 (i) 18.9/104.1

Fig. 7 Leiotriletes tumidus Butterworth & Williams 1958 2475 (iii) 18.5/84.2

Fig. 8 Leiotriletes tumidus B. & W. 1958 2471 (iii) 24.5/71.3

Fig. 9 Punctatisporites punctatus Ibrahim 1932 2612 (i) 9.3/75.0

Fig.10 Punctatisporites punctatus Ibrahim 1932 2472 (iii) 18.0/72.3

Fig.11 Punctatisporites obesus (Loose) P. & K. 1955 4250 (i) 8.9/69.5

Fig.12 Punctatisporites nitidus Hoffmeister, Staplin & Malloy 1955 2472 (i) 17.3/101.1

Fig.13 Punctatisporites nitidus H.S. & M. 1955 2472 (i) 20.0/76.5

Fig.14 Punctatisporites irrasus Hacquebard 1957 3101c (i) 26.3/79.5

Fig.15 Gulispores torpidos Playford 1963 3128c 28.2/78.0

Fig.16 Calamospora cf. breviradiata 2476 (i) 6.1/67.5

Fig.17 Calamospora parva Guennel 1958 5040 (i) 2.1/65.5

Fig.18 Calamospora cf. breviradiata 4107 (i) 15.2/76.5

Fig.19 Calamospora liquida Kosanke 1950 4236 (i) 17.2/110.0

Fig.20 Calamospora microrugosa 2474 (i) 22.6/64.5

PLATE I

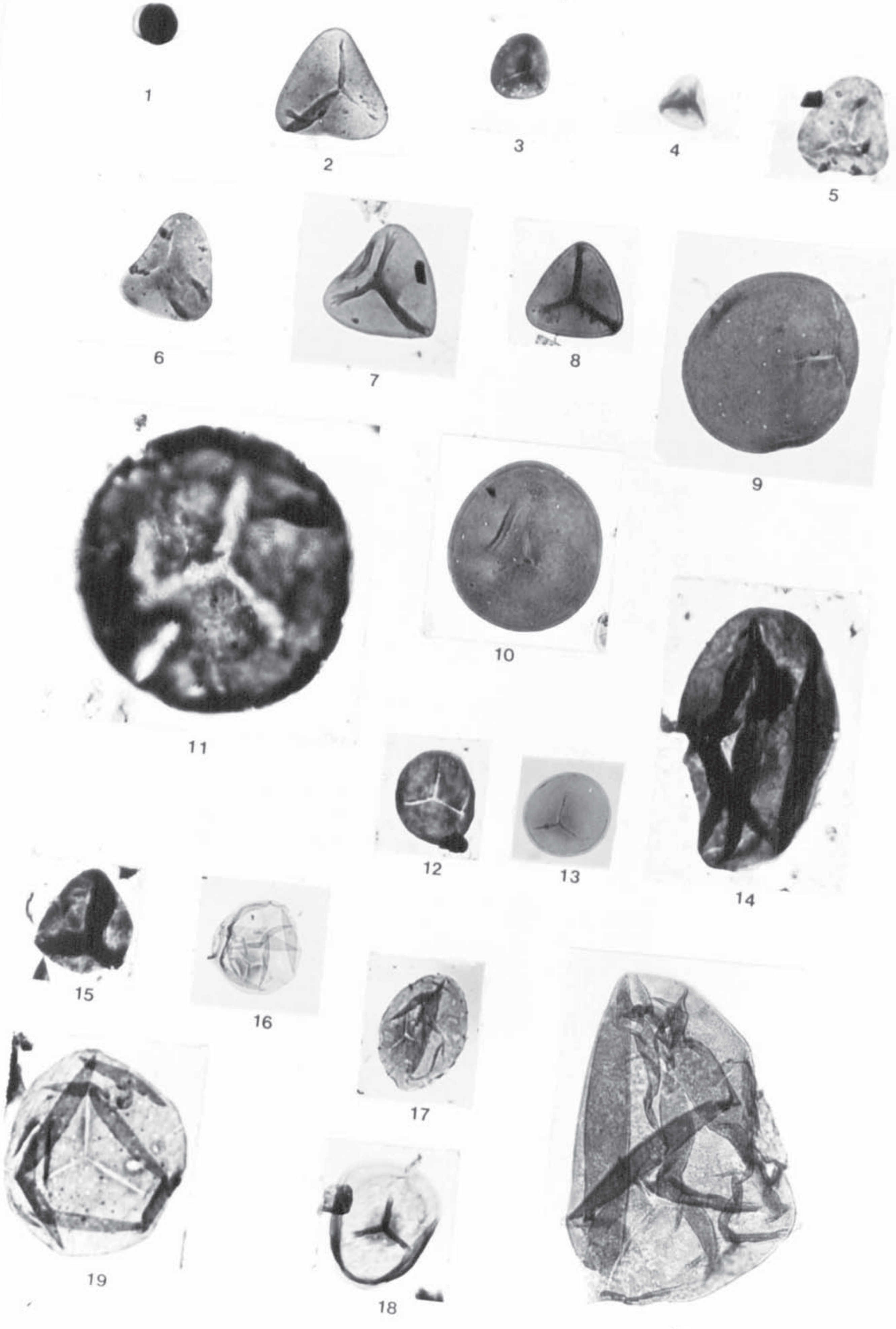

PLATE 2

Fig. 1 Retusotriletes avonensis Playford 1963 5040 (i) 16.0/73.2

Fig. 2 Acanthotriletes horridus Hacquebard 1957 4249 (i) 117.2/32.5

Fig. 3 Acanthotriletes acritarchus Neville 1973 5040 (ii) 6.4/82.1

Fig. 4 Acanthotriletes echinatus (Knox) P. & K. 1955 4236 (i) 17.3/98.1

Fig, 5 Anapiculatisporites minor (Butterworth & Williams) Smith & Butterworth 1967 (i) 19.5/80.5 (sample 4236)

Fig. 6 Retusotriletes incohatus Sullivan 1964 1637 (i) 17.4/77.5

Fig. 6b Acanthotriletes falcatus (Knox) P. & K. 1955 2472 (i) 16.4/79.0

Fig. 7 Anapiculatisporites concinnus Playford 1962 2472 (ii) 68.4/10.2

Fig. 8 Anaplanisporites baccatus (H.S. & M.) Smith & Butterworth 1967 2472 (ii) 21.7/78.7

Fig. 9 Anaplanisporites baccatus (H.S. & M.) S. & B. 1967 5040 (i) 29.9/74.0

Fig. 10. Anapiculatisporites hystricosus Playford 1963 1142B 18.3/71.1

Fig. 11 Anapiculatisporites hystricosus Playford 1963 1142B 25.0/74.7

Fig. 12 Apiculatisporis abditus (Loose) P. & K. 1955 2476 (i) 13.0/67.2

Fig. 13 Apiculatisporis pineatus H.S. & M. 1955 2478 (i) 8.3/100.1

Fig. 14 Apiculatisporis Sp. A. 4249 (i) 19.1/89.9

Fig. 15 Apiculatisporis Sp. B. 4249 (i) 20.1/100.3

Fig. 16 Apiculatisporis Sp. C. 4249 (i) 16.0/97.3

Fig. 17 Apiculiretusispora multiseta (Luber) Butterworth & Spinner 1967 1142 H 22.3/67.5

Fig. 18 Baculatisporites fusticulatus Sullivan 1968 5040 (i) 9.2/70.5

PLATE 2

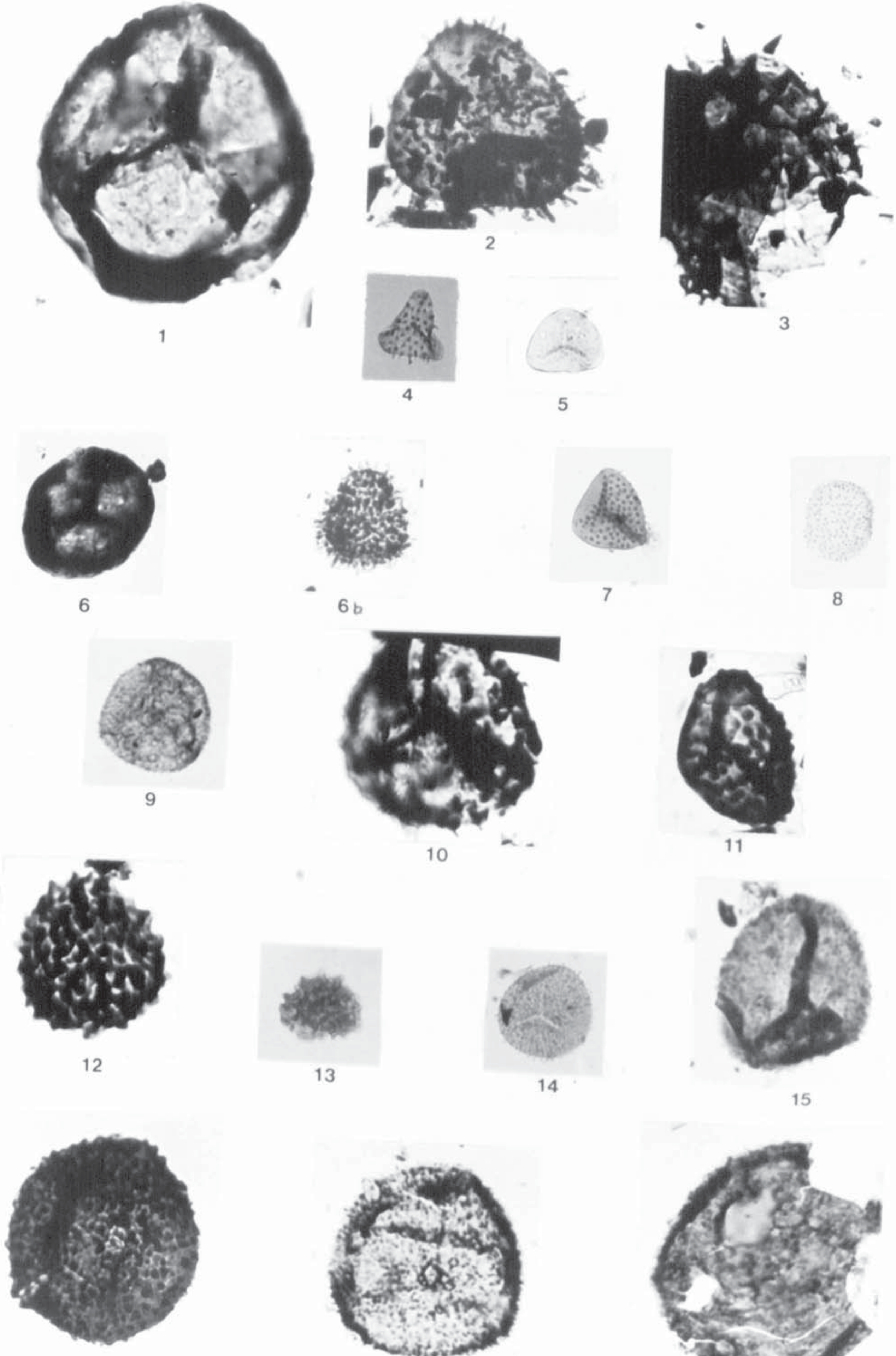

PLATE 3

Fig. 1 Apiculatisporis irregularis (Alpern) Smith & Butterworth 2617 (i) 1.3/77.0

Fig. 2 A. irregularis 2617 (i) 4.3/61.0

Fig. 3 A. irregularis 2617 (i) 5.0/65.4

Fig. 4 Cyclogranisporites cf. multigranus 2617 (i) 5.0/74.4

Fig. 5 C. cf. multigranus 2472 (iv) 30.0/75.2

Fig. 6 C. aureus (Loose) P. & K. 1955 4236 13.0/79.4

Fig. 7 C. minutus Bharadwaj 1957 4249 C_3 3.5/66.6

Fig. 8 Granulatisporites minutus P. & K. 1955 4236 (i) 5.0/68.0

Fig. 9 G. granulatus Ibrahim 1933 4236 (i) 23.3/71.2

Fig.10 G. cf.piroformis 2471 (iii) 5.0/68.0

Fig.11 G. cf. piroformis 4236 (i) 17.6/75.1

Fig.12 G. microgranifer Ibrahim 1933 4236 (i) 17.0/95.1

Fig.13 Granulatisporites sp. 4236 (i) 18.3/91.0

Fig.14 Lophotriletes commisuralis (Kosanke) P. & K. 1955 2481 (i) 29.1/72.7

Fig.15 L. commisuralis 2481 (iii) 8.2/72.0

Fig.16 L. microseatosus (Loose) P. & K. 1955 2472 (i) 27.9/81.2

Fig.17 L. granoornatus Artuz 1957 2471 (i) 2.6/71.3

Fig.18 L. granoornatus 2471 (i) 2.6/71.3

Fig.19 L. granoornatus 4236 (i) 18.7/71.1

Fig.20 L. cf. gibbosus 4236 (i) 18.0/93.0

Fig.21 Pilosisporites verutus Sullivan & Marshall 1966 2047 (ii) 8.7/78.3

Fig.22 Pustulatisporites papillosus (Knox) P. & K. 1955 2471 (i) 16.0/98.1

PLATE 3

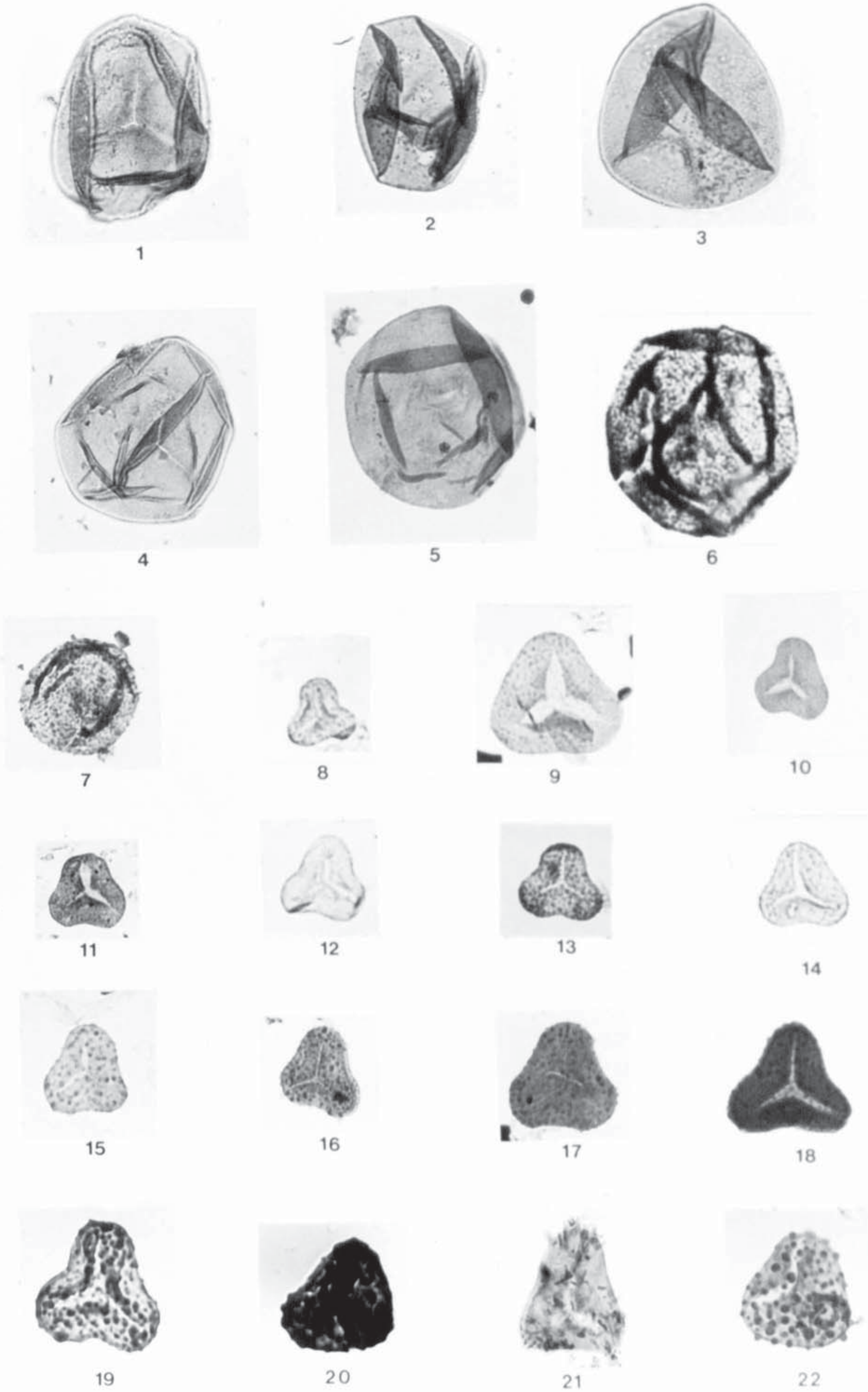

PLATE 4

Fig. 1 Raistrickia nigra Love 1960 2039 (iii) 80.5/8.4

Fig. 2 R. nigra 2039 (ii) 39.2/100.6

Fig. 3 R. clavata Hacquebard 1957 5040 (i) 16.1/93.4

Fig. 4 R. seatosa (Loose) Schopf, Wilson & Bentall 1944 4249 (i) 97.5/48.6

Fig. 5 Schopfites claviger Sullivan 1968 5040 (iii) 3.4/75.0

Fig. 6 S. claviger 5040 (i) 24.6/70.6

Fig. 7 S. claviger 5040 (iii) 38.1/103.4

Fig. 8 Schopfites sp. 4249 (i) 29.4/97.1

Fig. 9 Schopfites sp. 4249 (i) 21.0/101.6

Fig.10 Schopfites sp. 4249 (i) 20.1/96,3

Fig.11 Tricidarisporites balteolus Sullivan & Marshall 1966 2025 (i) 13.6/75.2

Fig.12 T. balteolus 2482 (ii) 4.8/83.0

Fig.13 Verrucosisporites cerosus (H. S. & M.) Butterworth & Williams 1958 4236 (i) 19.0/97.3

Fig.14 V. cerosus 4236 (i) 21.3/103.0

Fig.15 V. donarii P. & K. 1955 4236 (i) 17.0/88.7

Fig.16 V. morulatus (Knox) S. & B. 1967 4239 (ii) 19.0/107.0

Fig.17 V. microtuberosus (Loose) S. & B. 1967 4249 (i) 19.3/89.9

Fig.18 V. microtuberosus 4249 (i) 21.0/70.1

Fig.19 V. microverrucosus Ibrahim 1933 4204 (i) 16.3/89.0

PLATE 4

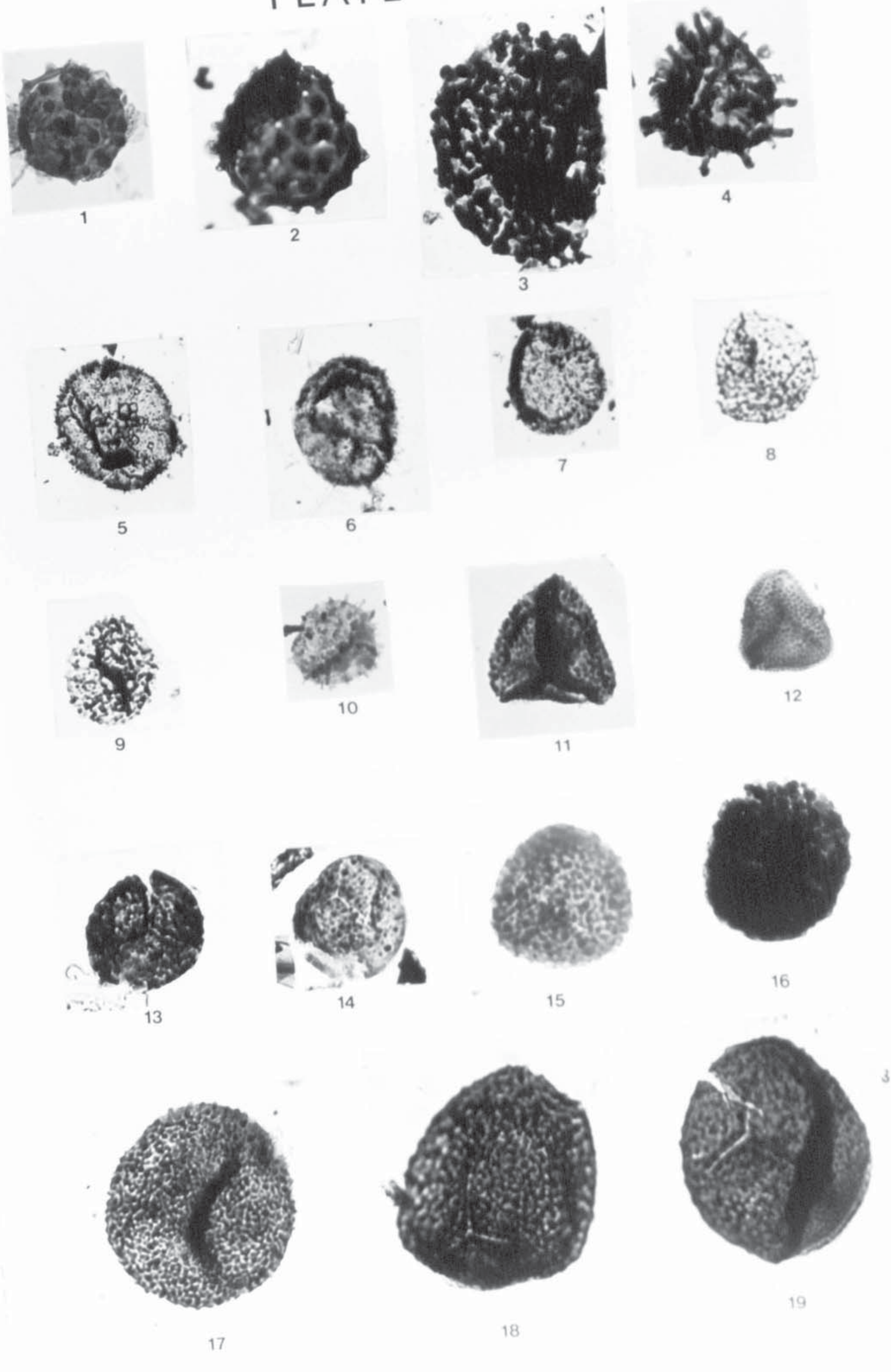

PLATE 5

Fig. 1 Verrucosisporites variotuberculatus Sullivan 1968 1637 (i) 7.6/84.0

Fig. 2 V. nitidus (Naumova) Playford 1963 1637 (iii) 26.0/65.0

Fig. 3 V. nitidus 5040 (i) 16.0/73.2

Fig. 4 V. papulosus Hacquebard 1957 5044 (i) 9.2/70.5

Fig. 5 V. nodosus Sullivan & Marshall 2472 (i) 24.8/71.8

Fig. 6 V. nodosus 2042 (i) 7.2/75.5

Fig. 7 Converrucosisporites parvinodosus Playford 1963 5044 (i) 10.0/68.2

Fig. 8 Umbanatisporites distinctus Clayton 1970 5044 (i) 10.0/69.1

Fig. 9 U. distinctus

Fig. 10 Waltzispora polita (H. S. & M.) S. & B. 1967 2476 (iii) 10.0/78.2

Fig. 11 W. planiangulata Sullivan 1964 2476 (ii) 24.2/76.4

Fig. 12 W. planiangulata 2479 (i) 9.5/78.3

Fig. 13 Pulvinospora scolecophora Neves & Ioannides 1974 1637 (i) 16.6/75.8

Fig. 14
Fig. 15 Camptotriletes corrugatus (Ibrahim) P. & K. 1955 4236 (i) 17.2/110.0

Fig. 16 C. cristatus Butterworth & Williams 1958 2480 (i) 28.6/80.4

Fig. 17 C. verrucosus B. & W. 1958 2472 (i) 19.0/110.0

Fig. 18 C. verrucosus 2472 (ii) 26.4/73.2

Fig. 19 C. verrucosus 2472 (i) 21.0/68.5

Fig. 20 Convolutispora cf. circumvallatus 5044 (i) 18.2/75.8

PLATE 5

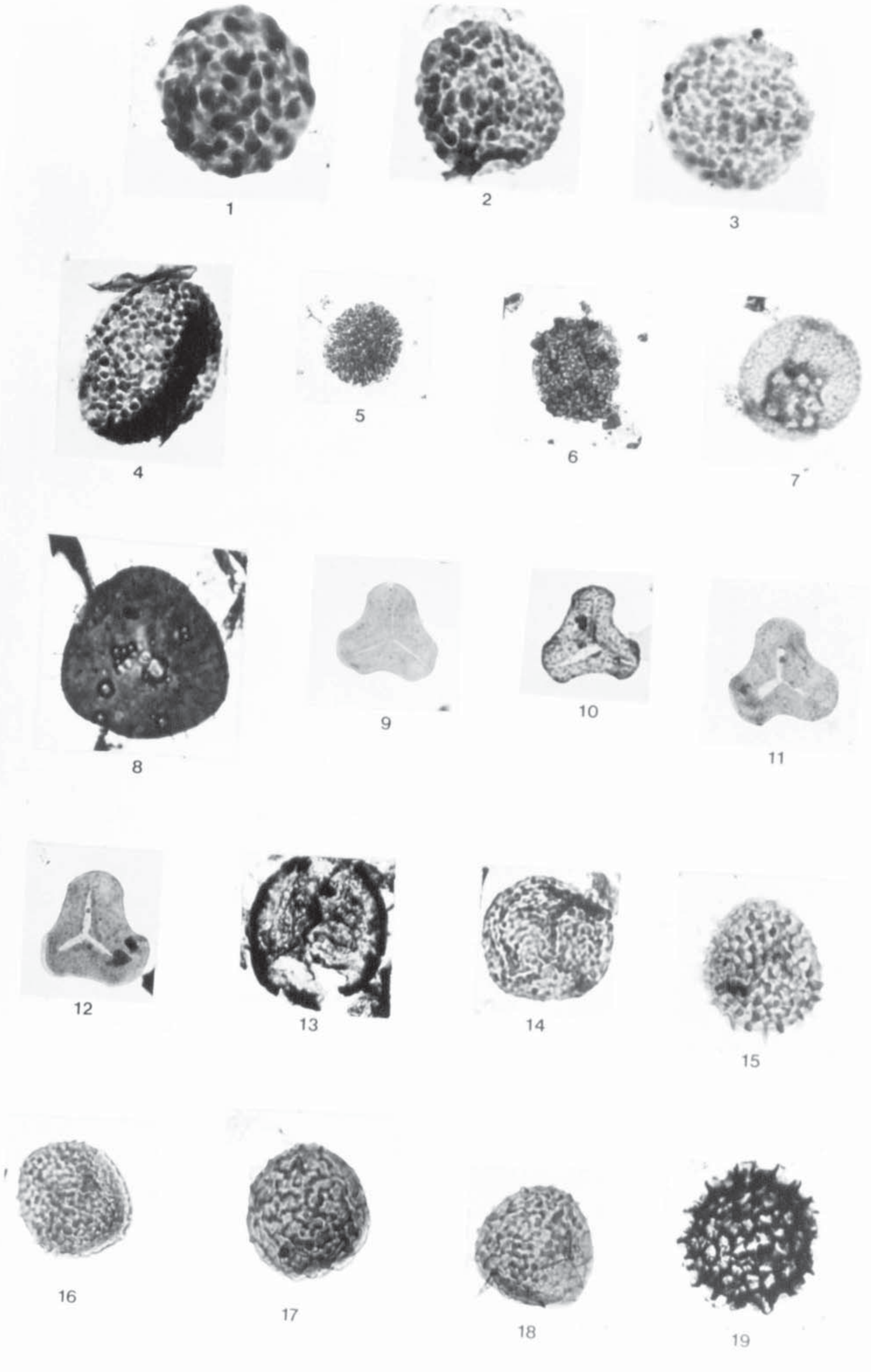

PLATE 6

Fig. 1 Convolutispora circumvallata Clayton 1970 5040 (i) 20½9/70.2

Fig. 2 C. cf. circumvallata 1646 (i) 19.9/67.0

Fig. 3 C. cf. circumvallata 5040 (i) 19.3/71.0

Fig. 4 C. jugosa Smith & Butterworth 2471 (iii) 21.3/81.5

Fig. 5 C. varicosa Butterworth & Williams 1958 2025 (i) 16.5/101.3

Fig. 6 C. tessellata H.S. & M. 1955 4236 (i) 15.0/78.2

Fig. 7 C. ampla H.S. & M. 1955 (i) 134.4/21.4 4236

Fig. 8 C. tessellata H. S. & M. 1955 4206 (ii) 19.3/69.8

Fig. 9 C. tessellata 4207 (i) 20.0/71.1

Fig.10 C. tessellata 4207 (ii) 7.1/109.9

Fig.11 C. tessellata 4236 (ii) 25.0/79.9

Fig.12 C. tessellata 4236 (i) 10.2/106.8

Fig.13 C. tessellata 4236 (i) 8.8/100.1

Fig.14 C. florida H. S. & M. 1955 2472 (i) 21.0/67.6

Fig.15 C. florida 2472 (iii) 6.0/70.1

Fig.16 C. florida 2472 (iii) 7.5/100.1

Fig.17 C. affinis Love 1960 1646 (i) 12.6/76.4

PLATE 6

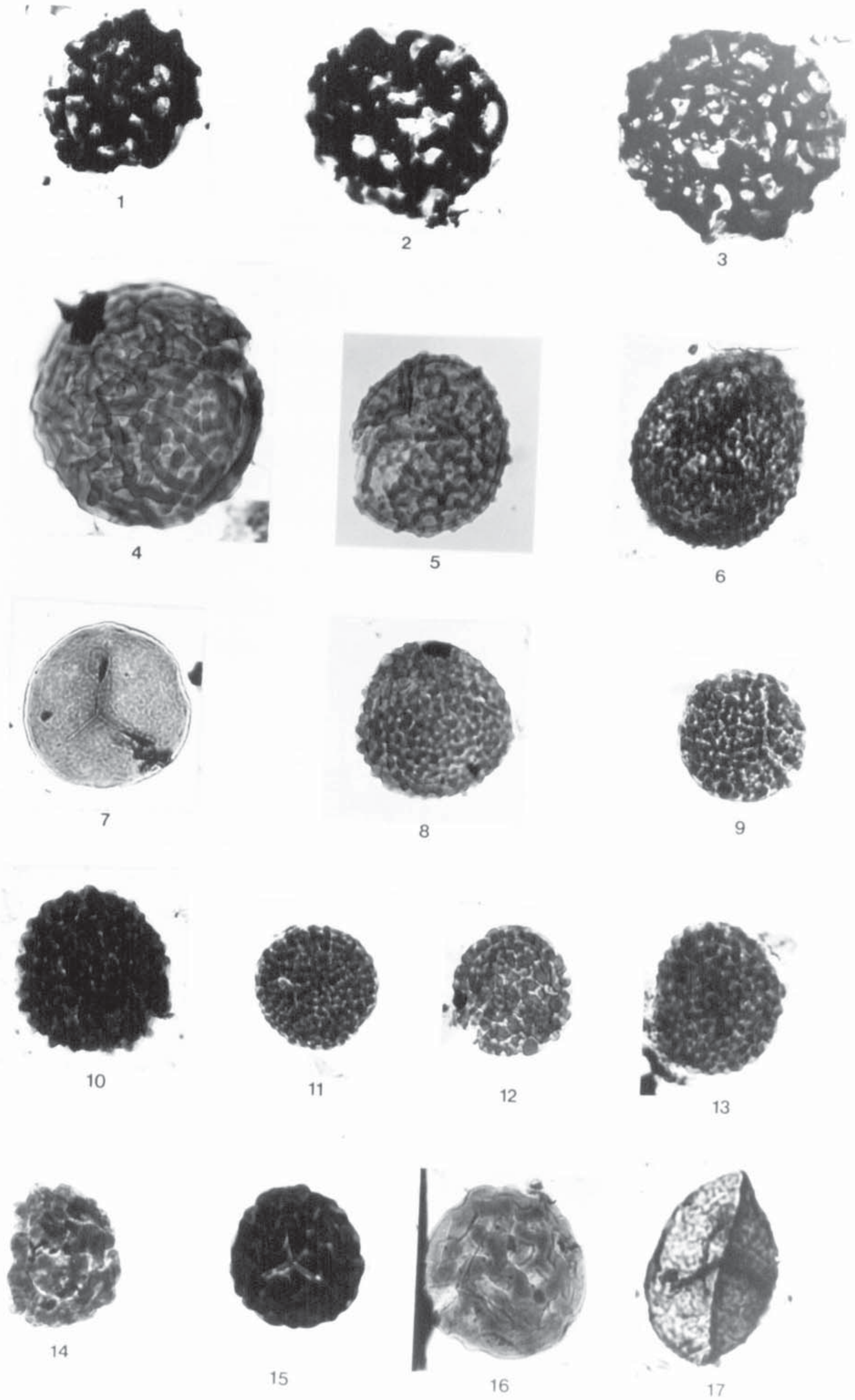

PLATE 7

Fig. 1 Convolutispora superficialis Felix & Burbridge 1967 2481 (ii) 21.4/65.7

Fig. 2 C. cf. usitata 2472 (i) 18.1/75.9

Fig. 3 C. cf. usitata 2478 (i) 16.9/105.1

Fig. 4 Corbulispora cancellata Bharadwaj & Venkatachala 1961 2471 (iii) 13.3/65.5

Fig. 5 C. cf. cancellata 2471 (i) 9.5/75.3

Fig. 6 C. cf. cancellata 2471 (i) 14.7/77.0

Fig. 7 Dictyotriletes casteneaeformis (Horst) Sullivan 1964 2472 (ii) 21.7/78.7

Fig. 8 D. castaneaeformis 2472 (ii) 29.3/96.0

Fig. 9 D. castaneaeformis 4204 (i) 104.0/30.3

Fig.10 D. varioreticulatus Neves 1958 4204 (iii) 42.4/12.3

Fig.11 D. varioreticulatus 4204 (i) 29.2/100.6

Fig.12 D. submarginatus Playford 1963 1101c 26.4/70.2

Fig.13 D. submarginatus 1101c 18.9/71.3

Fig.14 D. pactilis Sullivan & Marshall 1966 2472 (ii) 78.0/6.4

Fig.15 D. falsus P. & K. 1955 2472 (i) 4.1/80.5

Fig.16 D. vitilis Sullivan & Marshall 1966 2039 (i) 23.0/99.8

Fig.17 Dictyotriletes sp. B. 5040 (i) 20.9/70.0

Fig.18 Dictyotriletes sp. B. 1637 (ii) 11.2/78.2

PLATE 7

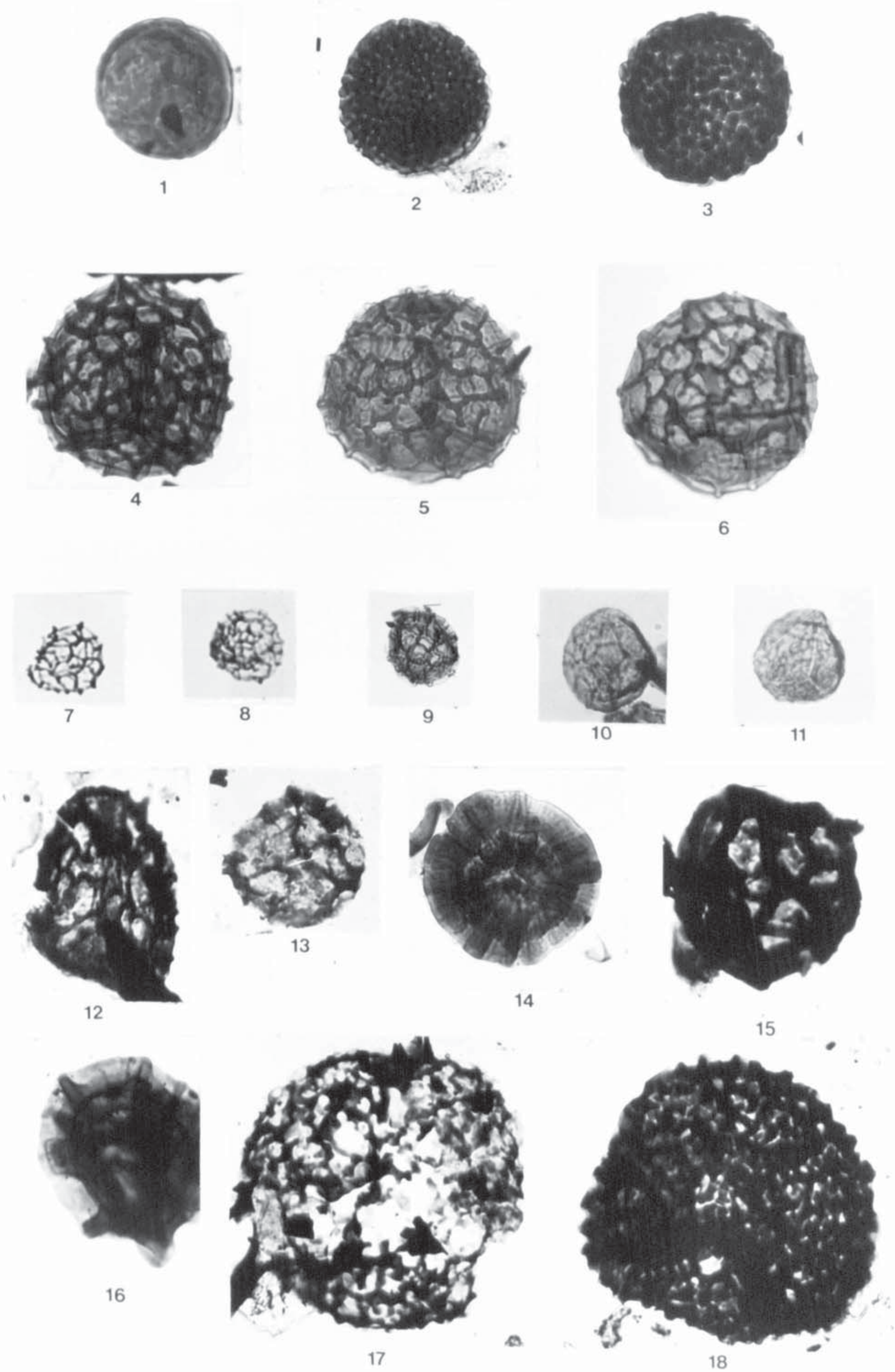

PLATE 8

Fig. 1 Dictyotriletes sp. B. 1637 (i) 8.2/71.9

Fig. 2 D. fragmentimurus Neville 1973 2612 (iii) 31.0/99.3

Fig. 3 D. cf. sagenoformis 2612 (ii) 32.4/106.0

Fig. 4 D. cf. sagenoformis 2612 (iii) 52.1/100.4

Fig. 5 D.fragmentimurus 2025 (i) 30.0/100.1

Fig. 6 D. insculptis Sullivan & Marshall 1966 2472 (i) 9.5/75.9

Fig. 7 D. insculptis 2472 (i) 13.3/81.1

Fig. 8 D. insculptis 2472 (i) 9.6/101.0

Fig. 9 Dictyotriletes sp. A. 1646 (iii) 28.2/72.5

Fig.10 Foveosporites insculptis Playford 1962 4249 (i) 11.1/80.4

Fig.11 F. insculptis 4249 (i) 13.5/100.5

Fig.12 Microreticulatisporites hortonensis Playford 1964 1646 (i) 26.0/98.3

Fig.13 M. hortonensis 1646 (i) 11.0/81.0

Fig.14 M. concavus Butterworth & Williams 1958 2471 (iii) 27.2/78.9

Fig.15 M. noblis (Wicher) Knox 1950 2476 (ii) 27.3/76.9

Fig.16 M. noblis 2478 (i) 12.7/78.4

Fig.17 M. hortonensis 1646 (i) 13.0/93.0

Fig.19 Triquitrites marginatus H.S. & M. 1955 2471 (i) 5.21/74.1

Fig.20 T. marginatus 2471 (i) 4.1/79.5

Fig.21 T. marginatus 2471 (ii) 1.8/77.2

Fig.22 T. comptus Williams 1973 2473 (i) 26.8/83.0

Fig.23 T. comptus 2018 (i) 2.6/78.5

Fig.24 T. comptus 2473 (i) 7.1/76.5

Fig.25 T. cf. bransonii 2615 (ii) 8.0/75.0

PLATE 8

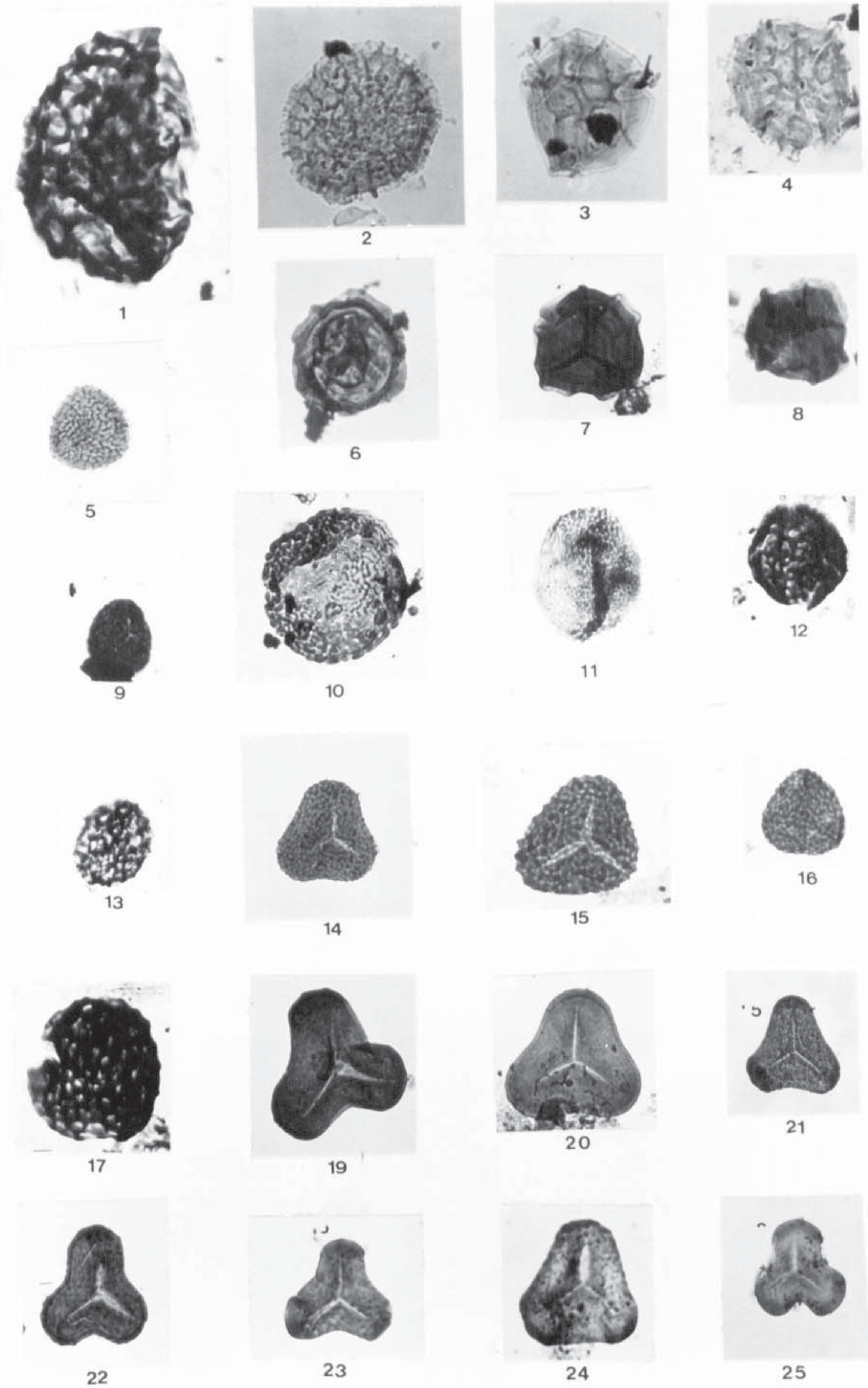

PLATE 9

Fig. 1 Triquitrites cf. bransonii 2615 (i) 21.0/79.0

Fig. 2 T. cf. bransonii 2612 (i) 19.1/68.1

Fig. 3 T. trivalvis (Waltz) P. & K. 1956 2471 (i) 20.4/73.0

Fig. 4 T. trivalvis 2471 (iii) 18.3/103.1

Fig. 5 T. triturgidus (Loose) S.W. & B. 1944 4204 (i) 112.0/34.8

Fig. 6 T. triturgidus 4204 (ii) 103.1/35.0

Fig. 7 Tripartites vetustus Schemel 1950 2472 (i) 18.1/78.9

Fig. 8 T. vetustus 2472 (i) 19.3/61.4

Fig. 9 T. nonquerickei P. & K. 1956 2471 (iv) 41.0/104.0

Fig.10 T. noquerickei 2471 (i) 35.4/107.8

Fig.11 Simozonotriletes trilinearis Artüz 1957 4249 (ii) 34.5/104.5

Fig.12 Ahrensisporites duplicatus Neville 1973 2475 (i) 28.6/76.4

Fig.13 Secarisporites remotus Neves 1961 2617 (ii) 8.2/79.9

Fig.14 Secarisporites sp. A. Sullivan 1966 2472 (ii) 2.9/71.4

Fig.15 Bellispores nitidus (Horst) Sullivan 1964 4249 A^1 29.0/72.8

Fig.16 B. nitidus 4236 (i) 31.8/111.4

Fig.17 B. nitidus 4249 A^1 20.3/79.2

Fig.18 Savitrisporites nux (B. & W.) Sullivan 4236 (i) 17.3/96.0

Fig.19 S. nux 4236 (i) 15.5/79.0

Fig.20 S. nux 4236 (ii) 31.0/100.0

Fig.21 Stenozonotriletes coronatus S. & M. 1966 2472 (i) 15.3/69.9

Fig.22 S. bracteolus (Butterworth & Williams) S. & B. 1967 2615 (i) 17.8/99.9

Fig.23 Secarisporites sp. A. 2472 (i) 6.1/100.1

Fig.24 Secarisporites sp. A. 2472 (i) 3.0/79.0

PLATE 9

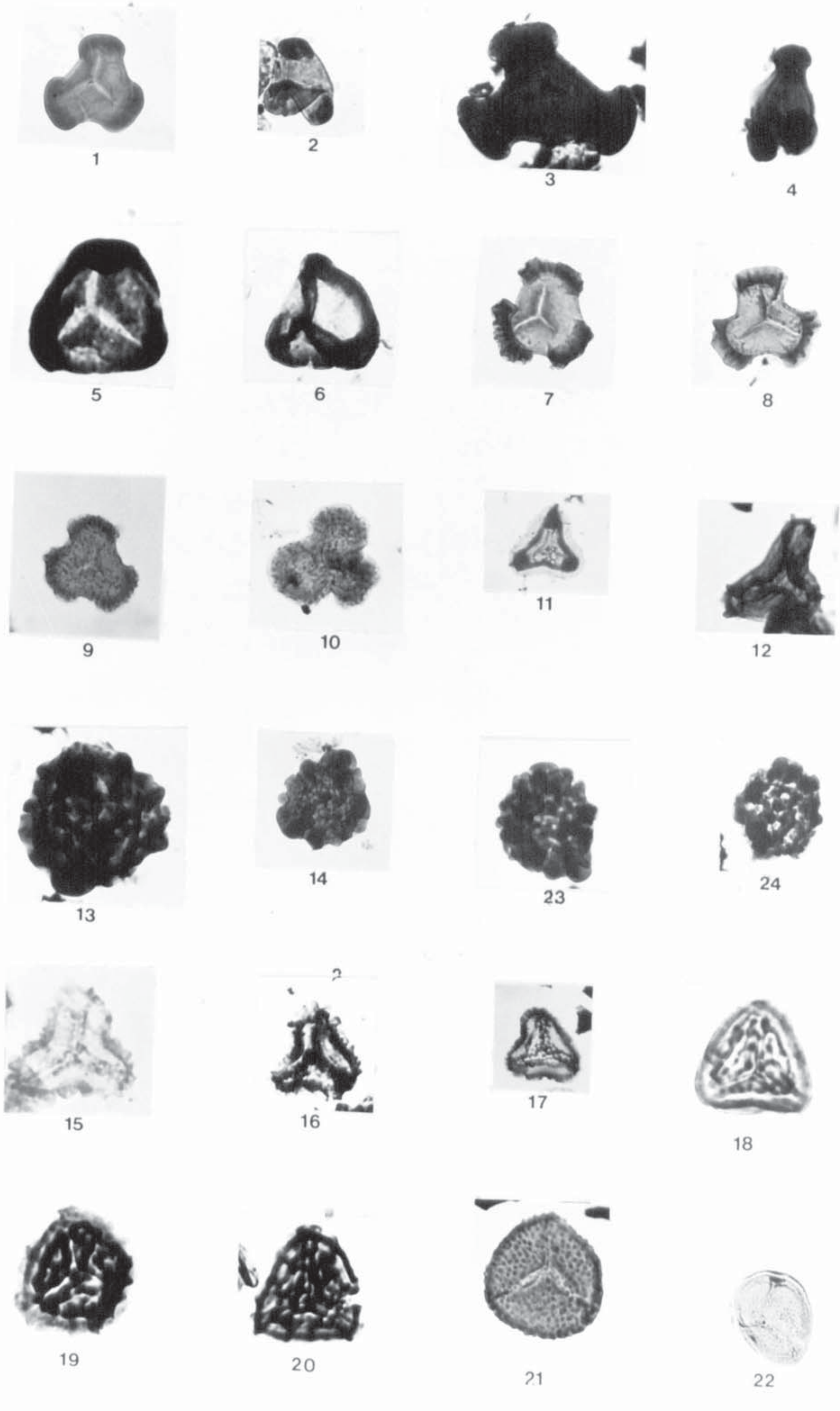

PLATE 10

Fig. 1 Stenozonotriletes triangulus Neves 1961 4236 (iii) 91.3/47.9

Fig. 2 Stenozonotriletes sp. A. 3101 (i) 18.2/80.5

Fig. 3 Knoxisporites literatus 5044 (i) 5.8/80.3

Fig. 4 K. literatus 5040 (iii) 49.7/110.0

Fig. 5 K. stephanephorus Love 1960 2472 (i) 15.0/77.0

Fig. 6 K. seniradiatus Neves 1961 4249c$_3$ 79.4/21.8

Fig. 7 K. seniradiatus 4249C$_3$ 24.3/86.1

Fig. 8 K. dissidius Neves 1961 4249C$_3$ 7.5/70.0

Fig. 9 Lophozonotriletes bellus Kedo 1963 3128 (i) 83.0/16.5

Fig. 10 L. bellus 3128 (i) 98.1/11.0

Fig. 11 Knoxisporites triradiatus H.S. & M. 1955 2040 (ii) 27.6/76.9

Fig. 12 Orbisporis convolutus Butterworth & Spinner 1967 2040 (i) 9.2/69.3

Fig. 13 O. convolutus 4204 (i) 43.7/106.2

Fig. 14 O. convolutus 4204 (i) 93.7/36.0

Fig. 15 Murospora aurita (Waltz) Playford 1962 2474 (i) 8.7/75.9

Fig. 16 M. strigata (Waltz) Playford 1962 2471 (iii) 43.5/94.4

PLATE 10

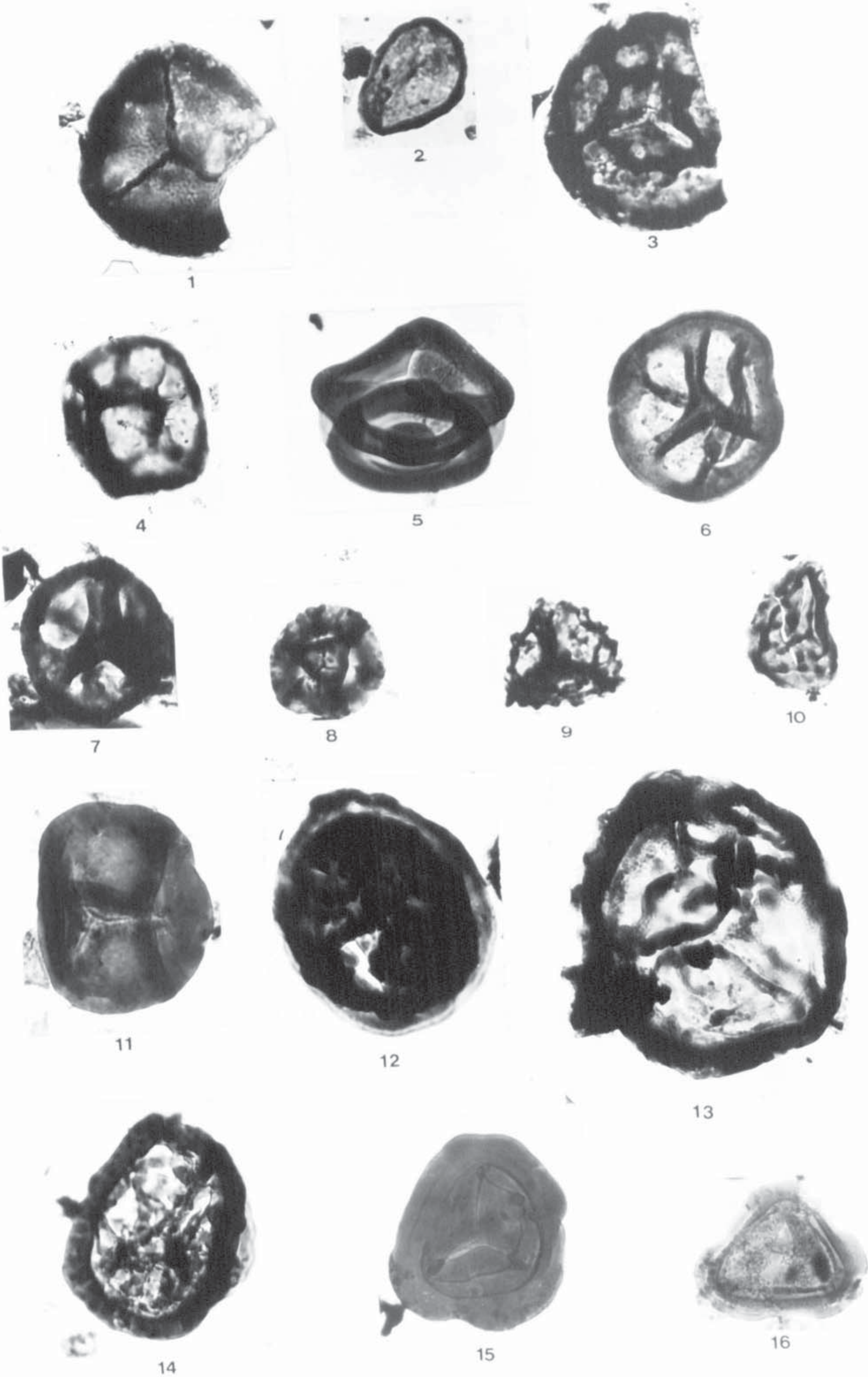

PLATE 11

Fig. 1 Knoxisporites danzei Agrali 1965 4236 (ii) 103.3/40.0

Fig. 2 K. danzei 4236 (ii) 107.0/33.3

Fig. 3 Reticulatisporites decoratus H. S. & M. 1955 2472 (iii) 8.2/76.5

Fig. 4 R. decoratus 2472 (i) 9.8/89.9

Fig. 5 R. peltatus Playford 1962 4107 (i) 12.0/95.3

Fig. 6 Auroraspora solisortus H. S. & M. 1955 4204 (i) 94.6/40.0

Fig. 7 A. solisortus 4204 (ii) 35.5/100.5

Fig. 8 Rotaspora ergonulii (Agrali) Sullivan & Marshall 2479 (ii) 20.7/71.8

Fig. 9 R. ergonulii 2478 (i) 12.7/79.1

Fig.10 R. knoxi Butterworth & Williams 1958 2473 (iii) 7.2/71.3

Fig.11 R. fracta (Schemel) S. & B. 1967 2471 (i) 28.5/80.4

Fig.12 R. fracta 2471 (i) 3.0/77.8

Fig.13 Auroraspora macra Sullivan 1968 5040 (i) 17.8/67.2

Fig.14 A. macra 5044 (i) 23.0/81.0

Fig.15 Spencerisporites radiatus (Ibrahim) Felix & Parks 1959 2478 (i) 29.7/75.0

Fig.16 S. radiatus 2025 (i) 10.4/80.1

PLATE II

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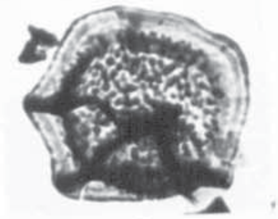

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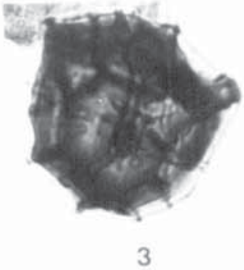

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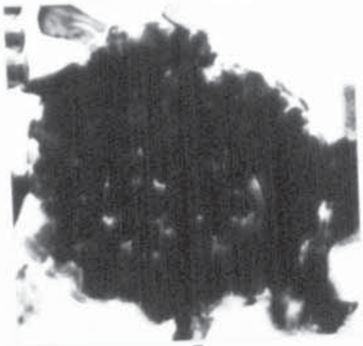

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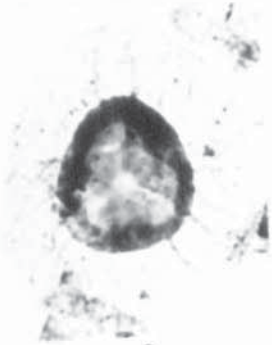

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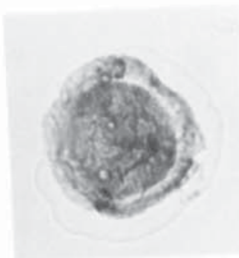

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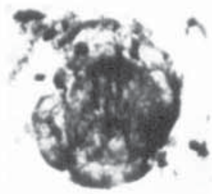

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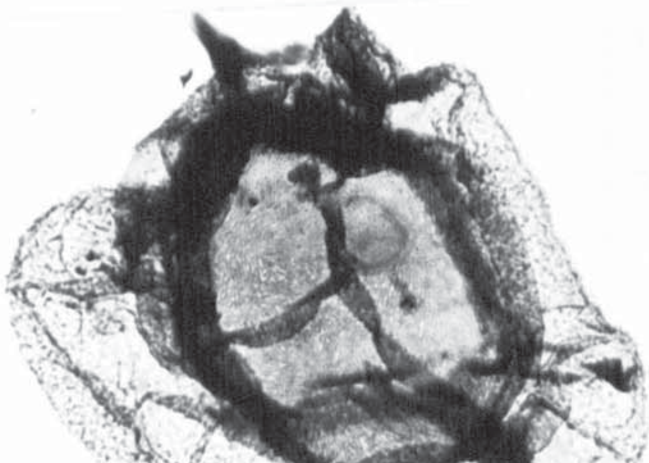

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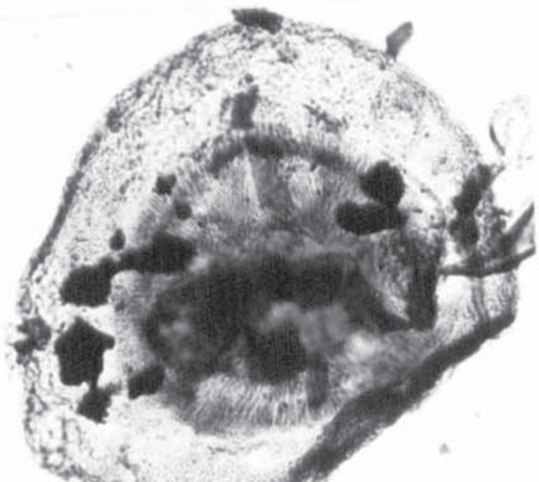

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PLATE 12

Fig. 1 <u>Remysporites magnificus</u> (Horst) B. & W. 1958 2471 (i) 28.9/67.5

Fig. 2 <u>R. magnificus</u> 2471 (i) 31.3/71.0

Fig. 3 <u>Schulzospora ocellata</u> (Horst) P. & K. 1956 4236 (i) 21.0/102.3

Fig. 4 <u>S. ocellata</u> 4236 (i) 12.2/94.0

Fig. 5 <u>S. ocellata</u> 4236 (i) 11.6/88.1

Fig. 6 <u>S. elongata</u> H. S. & M. 1955 4201 (i) 92.9/19.9

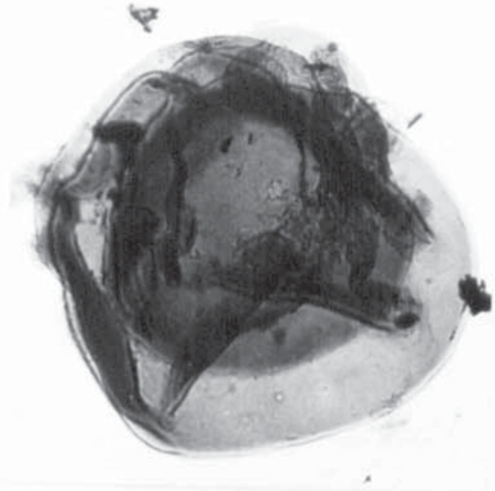
Fig. 7 <u>S. campyloptera</u> (Waltz) H. S. & M. 1955 4249 (i) 100.9/21.0

Fig. 8 <u>S. plicata</u> Butterworth & Williams 1958 2470 (iv) 25.6/80.0

Fig. 9 <u>S. plicata</u> 2470 (ii) 7.1/67.9

Fig. 10 <u>S. plicata</u> 2470 (i) 18.8/71.1

PLATE 12



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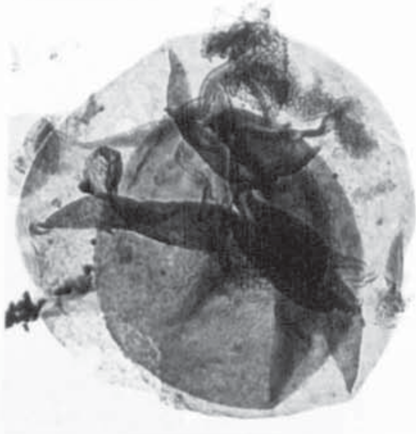

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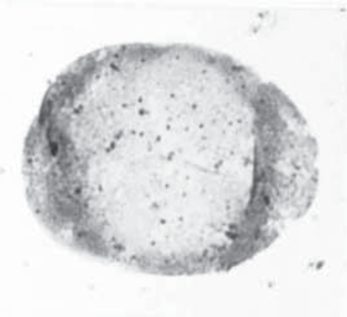

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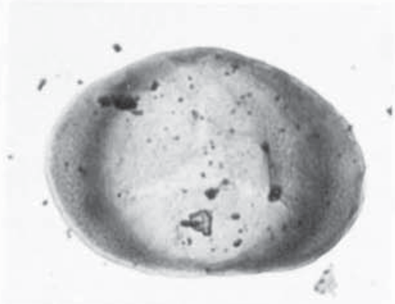

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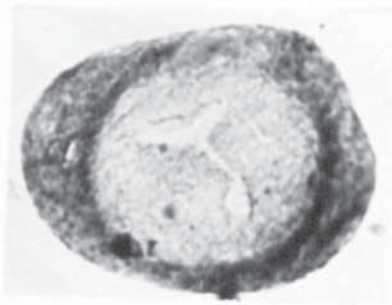

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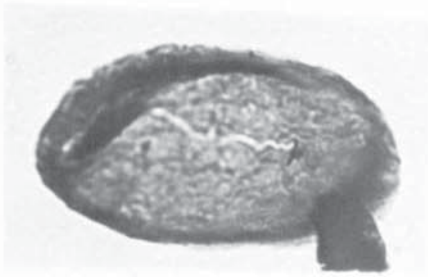

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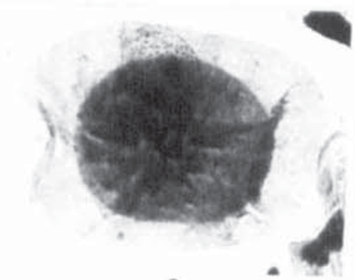

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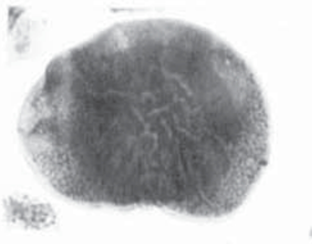

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PLATE 13

Fig. 1 Crassispora maculosa (Knox) Sullivan 1964 2472 (ii) 15.6/69.4

Fig. 2 Grandispora spinosa H. S. & M 1955 4204 (i) 108.2/43.0

Fig. 3 Crassispora maculosa 2472 (ii) 17.7/86.6

Fig. 4 C. aculeata Neville 1968 2475 (ii) 17.5/69.0

Fig. 5 Crassispora kosankei (P. & K.) Bharadwaj 1957 4204 (i) 87.0/45.9

Fig. 6 Perotrilites perinatus Hughes & Playford 1961 5040 (i) 76.6/20.1

Fig. 7 Grandispora echinata Hacquebard 1957 1646 (i) 4.2/72.0

Fig. 8 Grandispora echinata Hacquebard 1957 1646 (i) 3.7/80.1

Fig. 9 Spelaeotriletes cf. pretiosus (Playford) Neves & Dettmann 1637 (iii) 16.7/72.0

Fig.10 S. cf. pretiosus 1637 (iii) 6.6/72.9

Fig.11 S. arenaceøus Neves & Owens 1966 2476 (ii) 24.9/67.1

Fig.12 S. arenaceøus 2476 (ii) 19.6/75.5

Fig.13 S. arenaceøus 4239 (iii) 88.2/35.4

PLATE 13

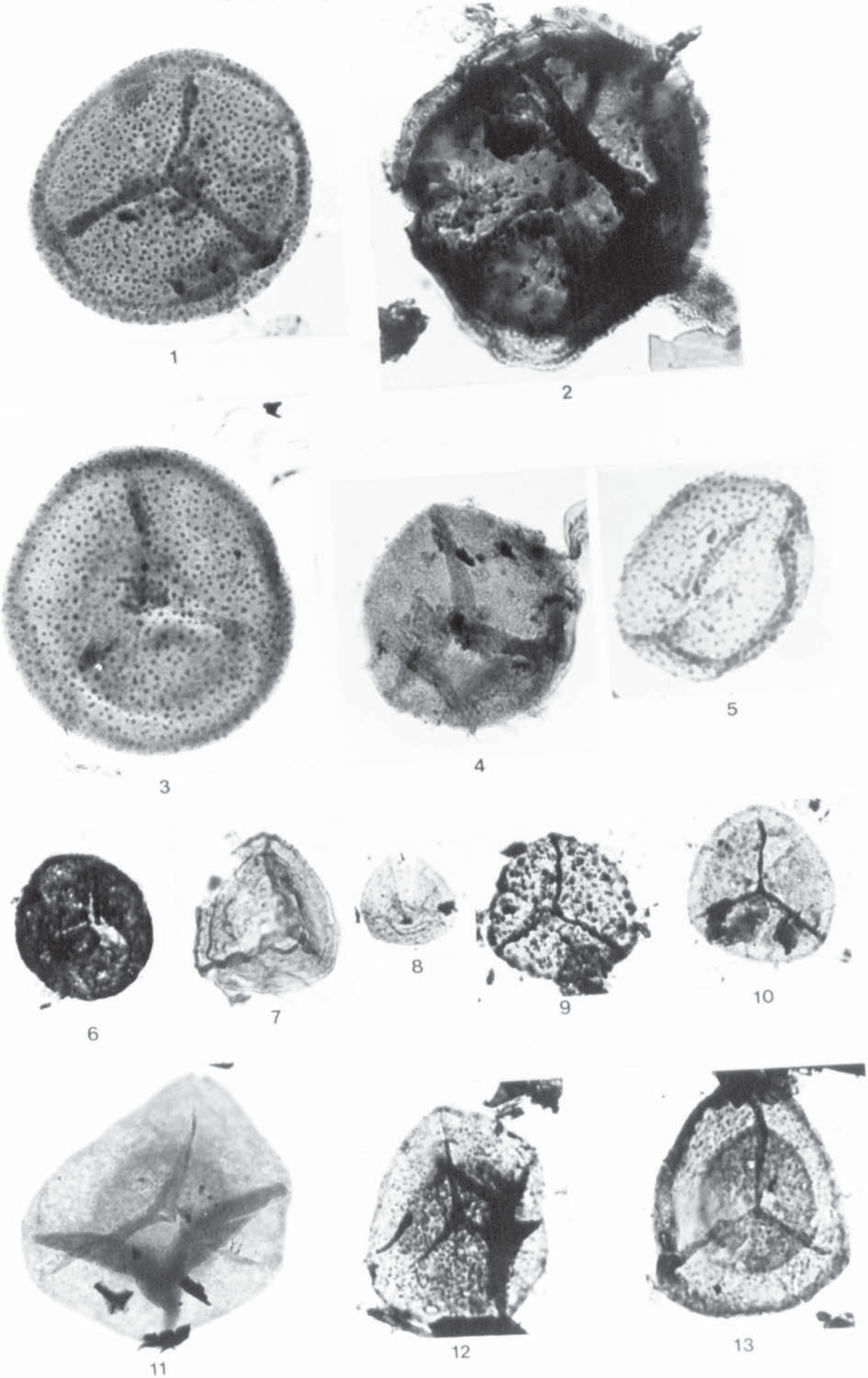


PLATE 14

Fig. 1 Spelaeotriletes arenaceous Neves & Owens 1966 2476 (i) 19.0/75.0

Fig. 2 Rugospora corporata Neves & Owens var. verrucosa Neville 1968 2476 (i) 4.0/76.5

Fig. 3 R. corporata var. verrucosa 2482 (ii) 5.3/76.5

Fig. 4 R. corporata var. verrucosa 2472 (i) 3.5/73.5

Fig. 5 R. minuta Neves & Ioannides 1974 2482 (i) 19.9/73.9

Fig. 6 R. minuta 3128B 11.6/76.0

Fig. 7 Rugospora sp. A. 4249 (i) 19.1/84.6

Fig. 8 R. sp. A. 4249 (iii) 6.4/88.7

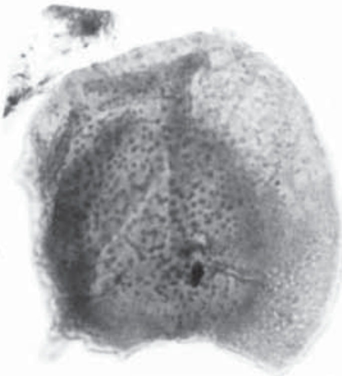
Fig. 9 R. sp. A. 2477 (i) 12.2/105.0

Fig.10 Discernisporites crenulatus (Playford) Clayton 1970 1142F 26.4/85.5

Fig.11 D. crenulatus 1142C 11.5/76.3

Fig.12 D. crenulatus 1142C 8.8/69.3

PLATE 14



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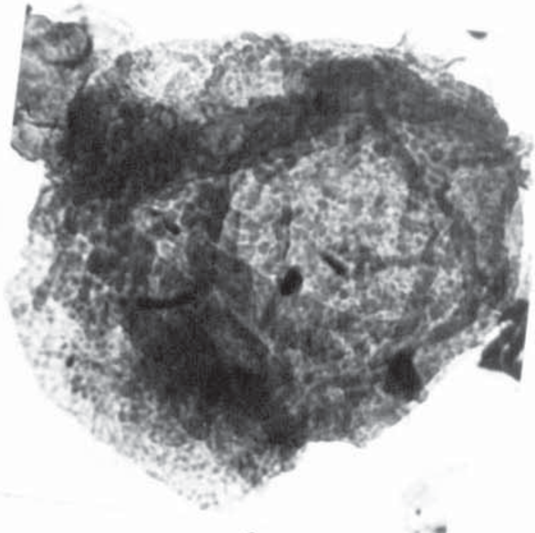

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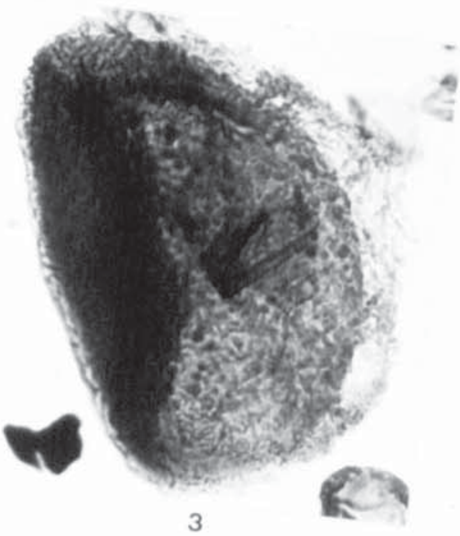

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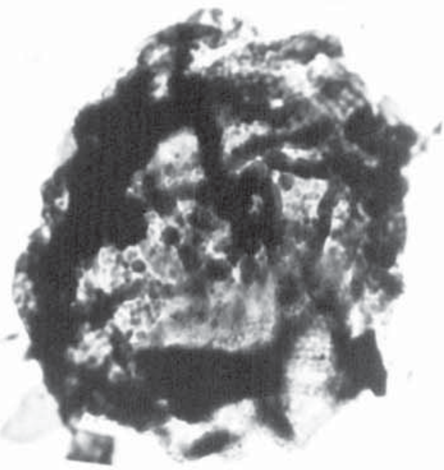

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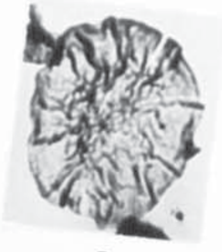

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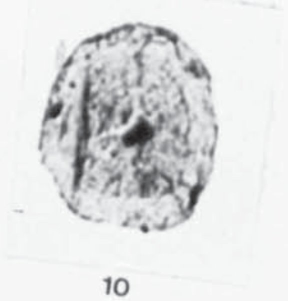

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PLATE 15

Fig. 1 Discernisporites micromanifestus Hacquebard 1957 2472 (i) 19.3/76.5

Fig. 2 D. micromanifestus 2472 (i) 18.6/100.9

Fig. 3 D. aff. micromanifestus 2472 (iv) 6.7/76.0

Fig. 4 D. aff. micromanifestus 2478 (i) 21.0/76.9

Fig. 5 Cingulizonates bialatus (Waltz) S. & B. 1967 2472 (iii) 17.6/77.3

Fig. 6 C. bialatus 2472 (i) 28.9/67.5

Fig. 7 C. bialatus 2472 (i) 23.5/70.1

Fig. 8 C. cf. capistratus (H. S. & M.) Staplin & Malloy 1964 2472 (i) 28.0/83.3

Fig. 9 C. cf. capistratus 2471 (i) 31.0/41.1

Fig.10 C. cf. capistratus 2472 (ii) 19.1/88.8

Fig.11 C. cf. capistratus 2472 (i) 23.0/106.1

Fig.12 Cristatisporites pannosus (Knox) B. & S. 1963 4236 (i) 84.6/33.2

Fig.13 C. pannosus 4236 (ii) 31.0/79.9

Fig.14 Densosporites anulatus (Loose) S. & B. 1967 2025 (i) 12.5/75.2

Fig.15 D. intermedius B. & W. 1958 2472 (i) 16.1/107.3

Fig.16 D. pseudannulatus B. & W. 1958 2612 (i) 14.4/84.1

Fig.17 D. rarispinosus Playford 1963 2472 (i) 18.2/78.5

Fig.18 D. spinifer H. S. & M. 1955 4236 (i) 19.5/75.3

Fig.19 D. spinosus Dybova & Jachowicz 1957 4204 (ii) 17.3/100.1

PLATE 15

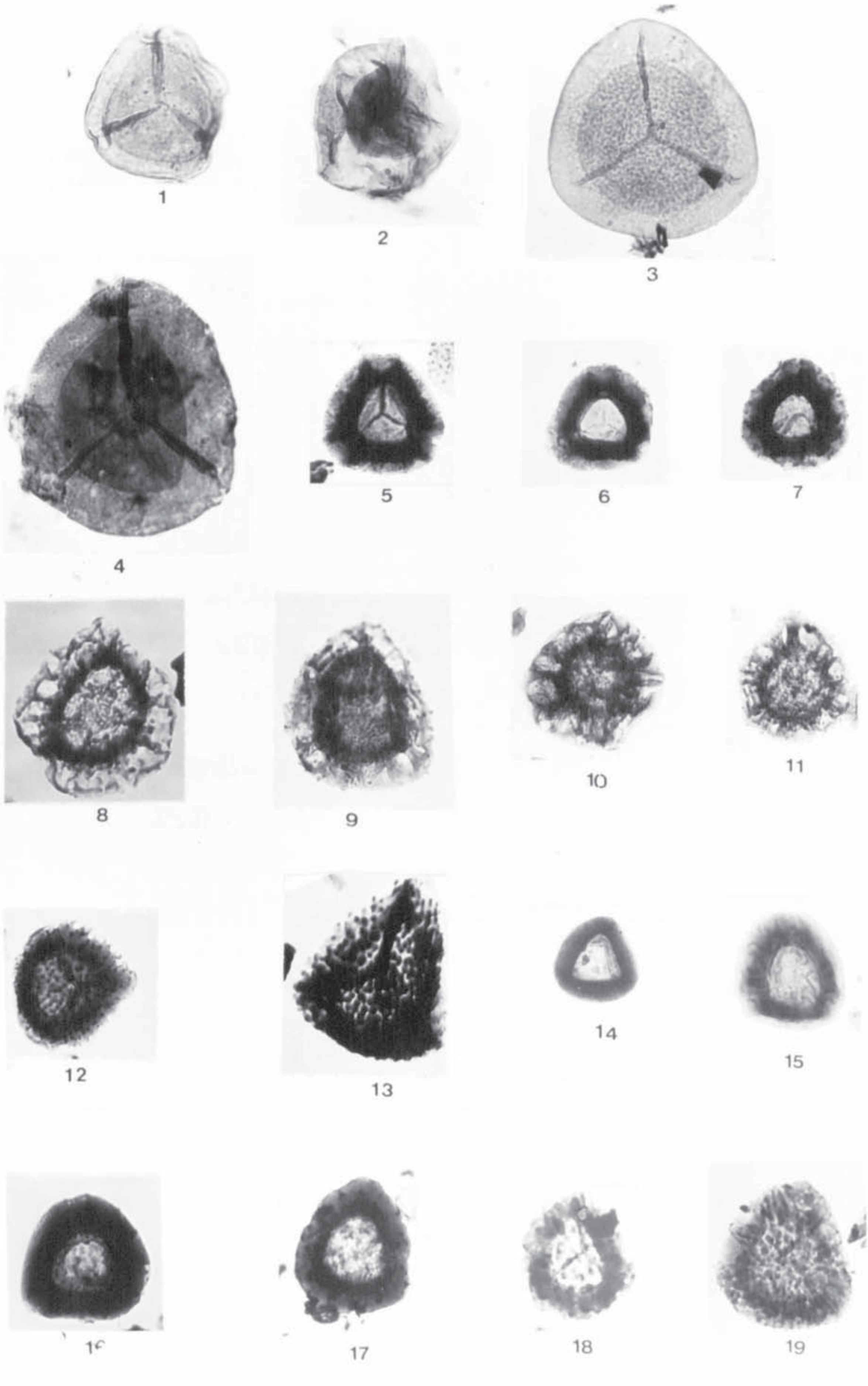


PLATE 16

Fig. 1 Lycospora pusilla 4236 (i) 19.0/86.3

Fig. 2 L. pusilla 4236 (i) 18.1/87.4

Fig. 3 L. pusilla 1142B 11.5/75.0

Fig. 4 L. cf. pusilla 5416 (i) 7.9/72.1

Fig. 5 L. cf. pusilla 1637 (i) 8.6/69.0

Fig. 6 L. aff. pusilla 5040 (i) 11.9/80.9

Fig. 7 L. aff. pusilla 3101c 13.0/86.1

Fig. 8 L. aff. pusilla 5044 (i) 12.0/79.9

Fig. 9 L. rugulosa 5044 (i) 18.0/70.7

Fig.10 L. rugulosa 1142H 4.6/65.9

Fig.11 L. rugulosa 1142H (ii) 8.7/6.4

Fig.12 L. noctuina var. noctuina Butterworth & Williams 1972 1142G 1.2/80.9

Fig.13 L. noctuina var. noctuina 3128 (i) 3.4/83.4

Fig.14 L. noctuina var. noctuina 4236 (i) 15.1/108.4

Fig.15 L. noctuina var. noctuina 3128B 26.4/85.2

Fig.16 L. noctuina var. noctuina 3128B 20.0/88.1

Fig.17 L. tenebricosa Staplin 1960 2481 (i) 8.3/87.2

Fig.18 L. tenebricosa 2481 (i) 21.7/69.5

Fig.19 L. tenebricosa 1142C 8.7/69.3

Fig.20 L. tenebricosa 1142C 11.3/104.2

Fig.21 L. tenebricosa 2482 (i) 14.0/80.4

Fig.22 Kraeuselisporites sp. B 5040 (iii) 2.8/69.6

Fig.23 K. sp. B 5040 (iii) 2.4/73.0

Fig.24 K. sp. B 5040 (iii) 7.8/69.6

PLATE 16

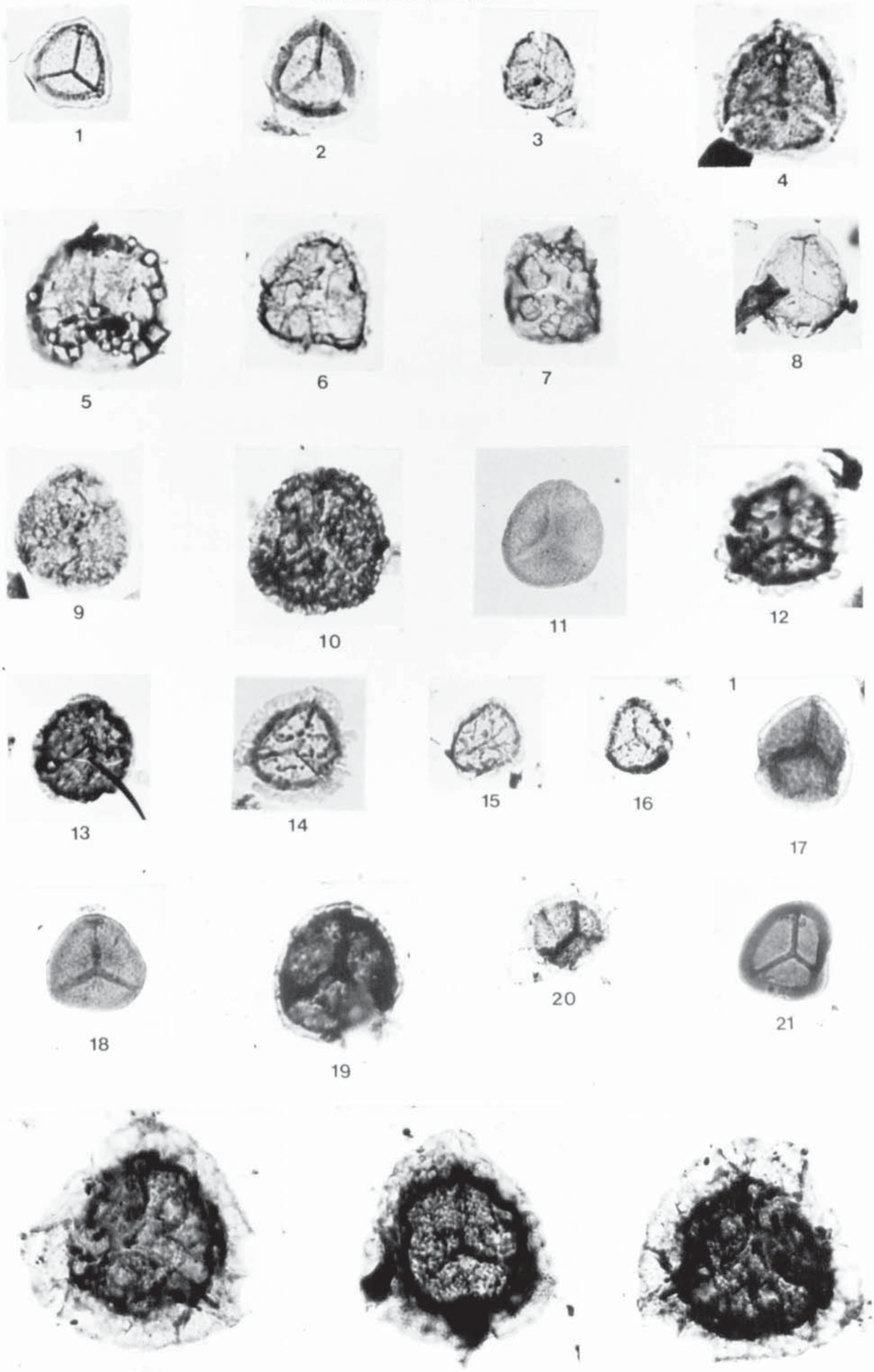


PLATE 17

Fig. 1 Kraeuselisporites sp. B. 5040 (i) 5.8/81.5

Fig. 2 K. sp. B. 5044 (i) 4.9/79.5

Fig. 2b K. sp. B. 5040 (iii) 2.8/69.6

Fig. 3 K. echinatus Owens, Mishell & Marshall 1975 4249 A^1 50.8/94.6

Fig. 4 K. echinatus 4249 A^1 50.0/92.8

Fig. 5 K. sp. A. Owens, Mishell & Marshall 1975 4244 (i) 110.5/35.5

Fig. 6 K. sp. A. 4249 (i) 111.1/43.0

Fig. 7 Cirratriradites saturni (Ibrahim) S.W. & B. 1944 4249 (i) 95.5/46.4

Fig. 8 C. saturni 4205 (i) 84.9/41.6

Fig. 9 Vallatisporites ciliaris (Luber) Sullivan 1964

Fig. 10 V. ciliaris 1142C 24.1/67.8

PLATE 17

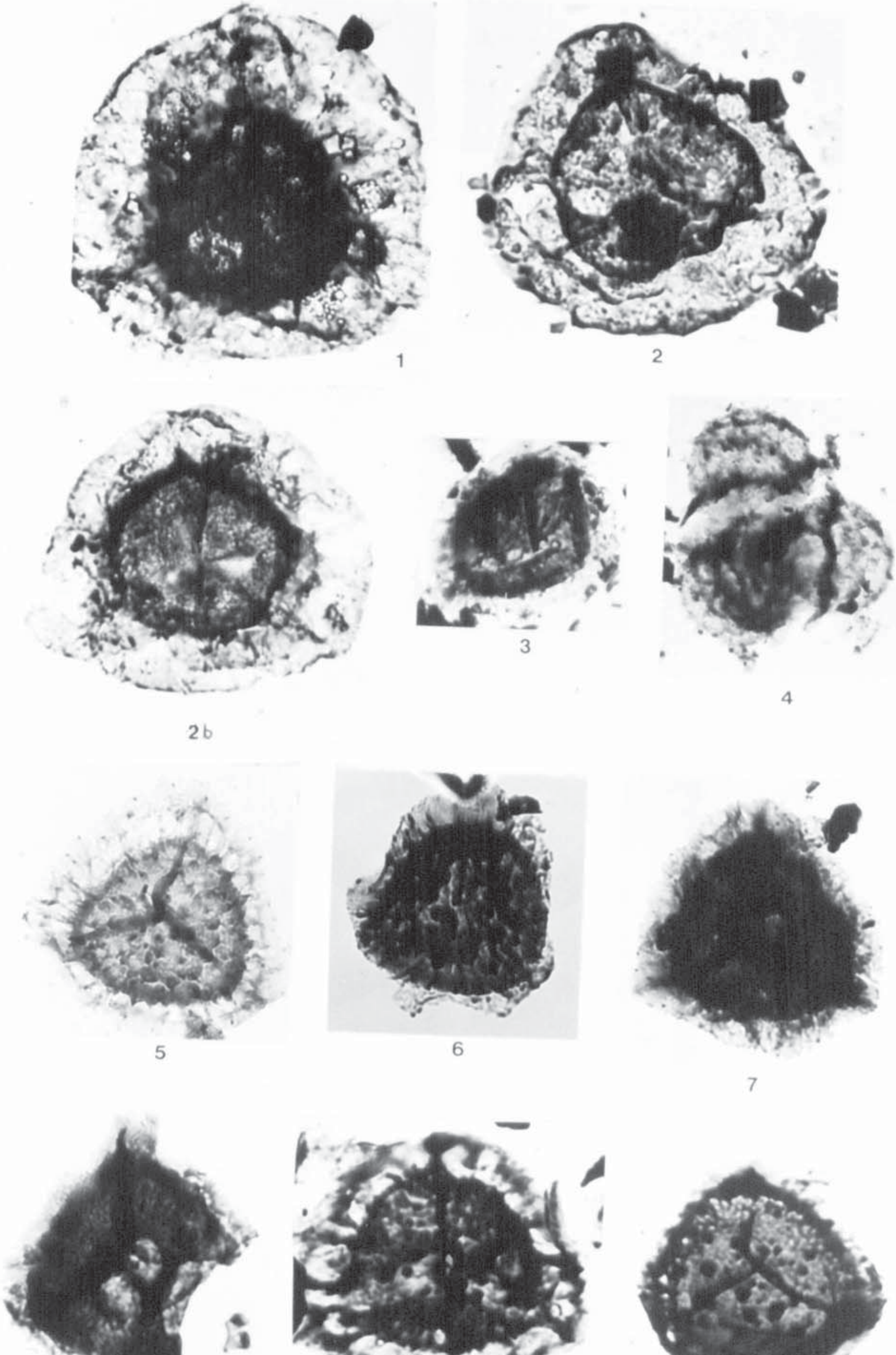


PLATE 18

Fig. 1 Vallatisporites vallatus 3128c 6.1/72.8

Fig. 2 Proprisporites cf. laevigatus 4249c_3 11.1/91.1

Fig. 3 P. cf. laevigatus 4249C_3 5.2/82.0

Fig. 4 P. cf. laevigatus 4249C_3 13.4/76.0

Fig. 5 Tholisporites biannulatus Neves 1961 2473 (i) 4.2/68.9

Fig. 6 T. biannulatus 2471 (i) 3.2/81.3

Fig. 7 T. decoratus Gueinn 1973 2478 (ii) 18.0/85.0

Fig. 8 T. decoratus 2478(i) 26.0/79.1

Fig. 9 T. scoticus Butterworth & Williams 1958 4255(i) 51.6/95.4

Fig.10 T. scoticus 4255 (i) 56.5/107.7

Fig.11 Laevigatosporites minor Loose 1934 2034 (iv) 19.1/76.2

Fig.12 L. minor 2039 (iv) 24.0/105.2

Fig.13 L. vulgaris Ibrahim 1933 4249 A^1 50.8/94.6

Fig.14 Florinites visendus (Ibrahim) S.W. & B. 1944 4249 (ii) 20.6/102.8

Fig.15 F. visendus 4249 (ii) 45.1/1 0.0

Fig.16 F. visendus 4249 (ii) 29.2/108.0

PLATE 18

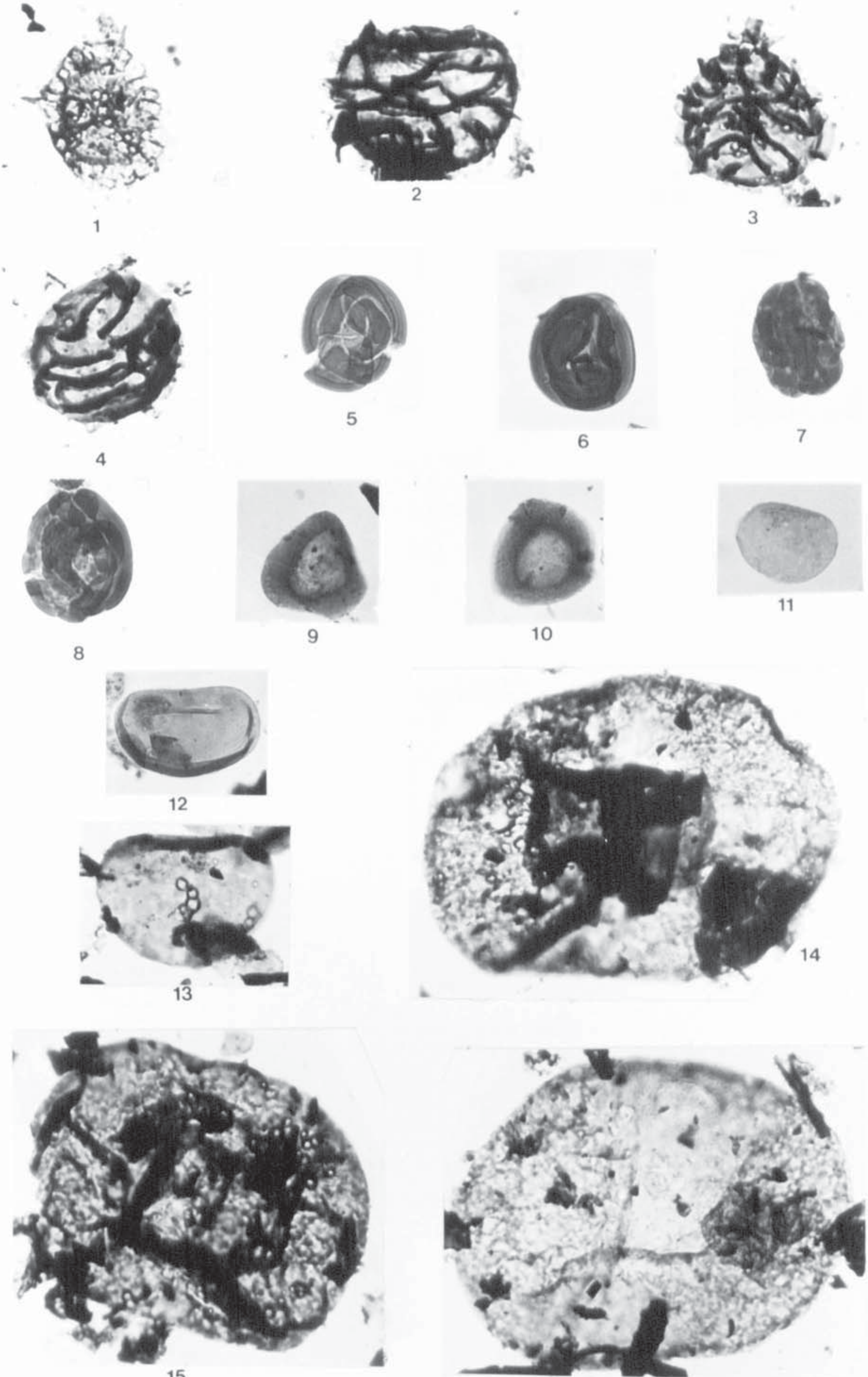


PLATE 19

Fig. 1 Vestispora lucida (B. & W.) Potonié 1960 2471 (i) 27.3/93.5

Fig. 2 V. lucida 2471 (ii) 29.4/79.8

Fig. 3 Colatisporites decorus (Bharadwaj & Venkatachala) Williams 1973 3128 (i) 7.1/93.0

Fig. 4 C. decorus 3128 (ii) 8.8/96.1

Fig. 5 Spore type A. 4236 (i) 97.4/43.3

Fig. 6 Spore type A. 4236 (i) 100.1/36.5

Fig. 7 Aculeispores sp. Artuz 1957 4249 (ii) 43.5/106.4

Fig. 8 Baltishpaeridium sp. 142C 2.3/63.3

Fig. 9 Biannulatisphaerites simplex Neville 1973 4236 (i) 109.2/40.6

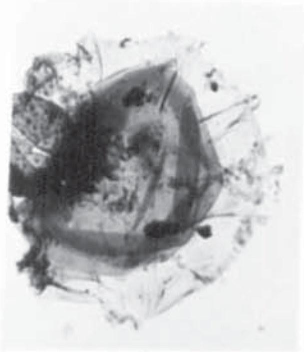
Fig. 10 Aculeispores sp. Artuz 1957 4249 (i) 112.2/41.2

Fig. 11 Plant cuticle 1142C 8.7/69.3

Fig. 12 Plant cuticle 1142F 1.7/71.5

Fig. 13 Potoniespores elegans (Wilson & Kosanke) Wilson & Venkatachala 1964 4236 (ii) 100.2/42.0

PLATE 19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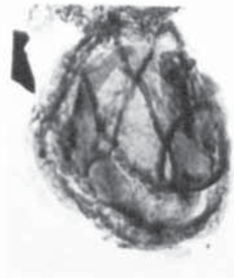
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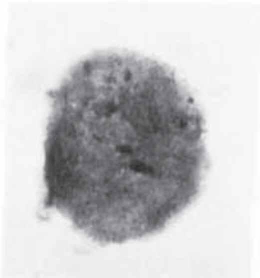
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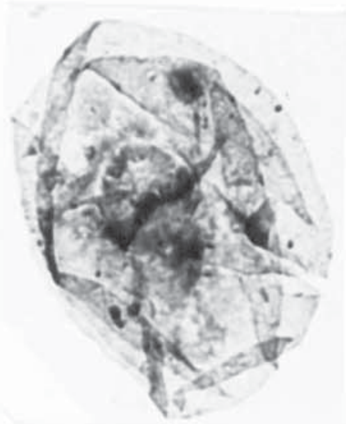
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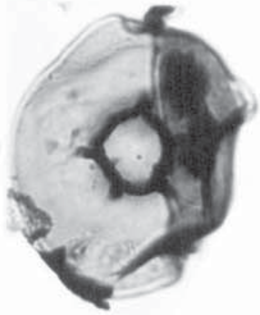
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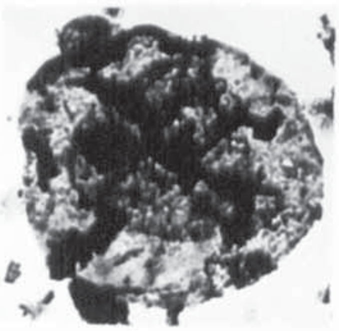
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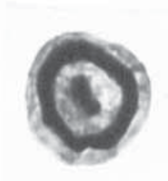
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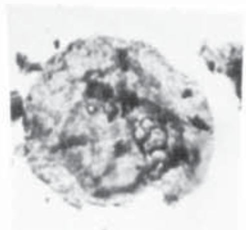
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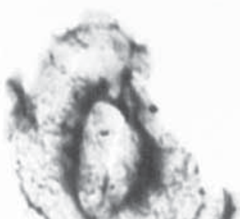
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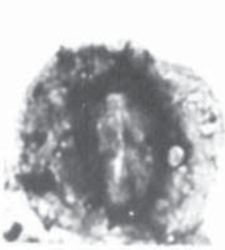
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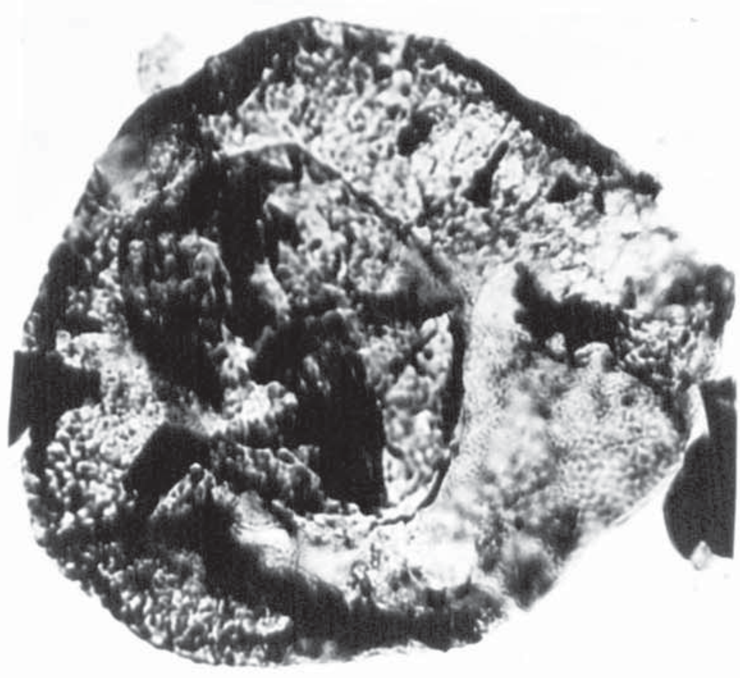
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