MIOSPORES FROM THE DRYBROOK SANDSTONE AND ASSOCIATED MEASURES IN THE FOREST OF DEAN BASIN, GLOUCESTERSHIRE

by H. J. SULLIVAN

ABSTRACT. Miospore assemblages are described from two horizons in rocks formerly regarded as comprising the Drybrook Sandstone of the Forest of Dean. The lower assemblage was obtained from a shaly intercalation in a typical development of massive pink or white sandstones, and the palynological evidence confirms the Upper Viséan (Seminula Zone) age of these deposits. The higher horizon was a lenticular coal (herein designated the Edgehills coal) in a sequence of coarse sandstones and conglomerates and the miospores from the coal indicated a much higher stratigraphical position, probably Lower Westphalian A. This is the first time strata of an age between Upper Viséan and Westphalian D have been identified in the Forest of Dean. On the basis of this discovery, it is now possible to assess the roles played by the Sudetic and Malvernian movements in the structural evolution of the basin.

In the systematic description of the assemblages, two new genera *Fabasporites* and *Cribrosporites* are proposed, and a total of eighteen new species erected. Evidence is presented to show that *Callisporites* should be regarded as a junior synonym of *Savitrisporites*. Twelve new name combinations are suggested.

THE Forest of Dean basin is an outlier of Carboniferous rocks, 10 miles in a north–south direction and 6½ miles from east to west, which lies between the Wye Valley and the apex of the Severn Estuary. The Coal Measures rest unconformably on the Lower Carboniferous rocks over much of their outcrop, but along the south-eastern margin of the basin they transgress on to the Brownstones of Lower Old Red Sandstone age (text-fig. 1).

This paper describes spore assemblages which were obtained from two horizons in the Drybrook Sandstone of the Wigpool syncline at the north-eastern extremity of the Forest of Dean (text-fig. 1). The samples, one a coal and the other a shale, were collected from two quarries 160 yards south of the A 4136 Monmouth to Mitcheldean road on Plump Hill near Mitcheldean. These exposures form part of the well-known Plump Hill section which provides one of the best traverses through the Lower Carboniferous rocks of the Forest of Dean.

The name 'Drybrook Sandstone' was proposed by Sibly (1912, p. 420) for the arenaceous development at the top of the Main Limestone in the Forest of Dean basin. These rocks had formerly been referred to as 'Millstone Grit'; their Lower Carboniferous age was first recognized by Vaughan (1905, pp. 251–2) and a more precise dating as Main Seminula Zone [S_2] was later given by Sibly (1918, p. 25) on the basis of brachiopods obtained from a calcareous intercalation within the formation, the Drybrook Limestone of Trotter (1942, p. 12).

The tripartite division of the Drybrook Sandstone formation—two sandstone layers separated by the Drybrook Limestone—is known only from the southern part of the Forest of Dean basin. As the rocks are traced northwards, there is a lateral passage of limestone into sandstone; the sandstones become coarser in grade, and bands of quartz conglomerates appear more frequently. A progressive northward attenuation accom-

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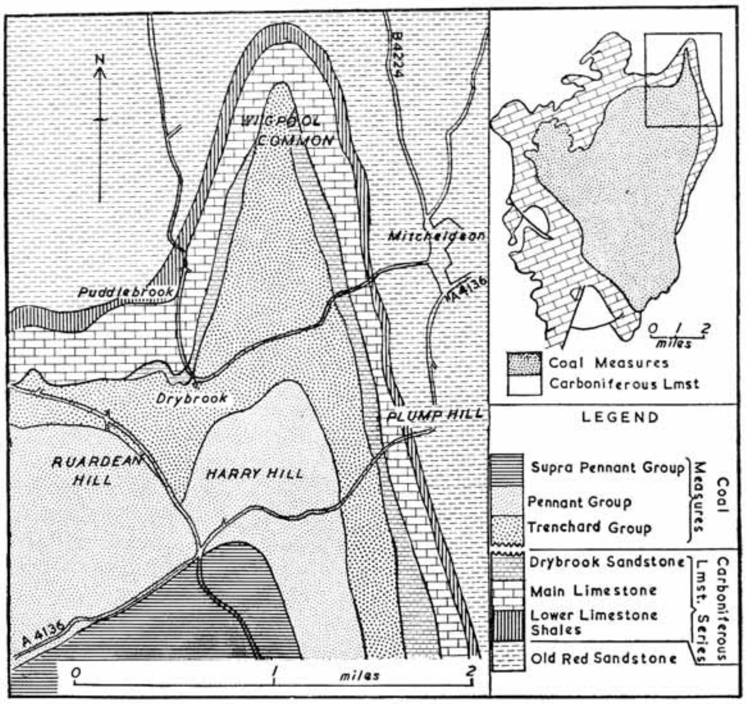
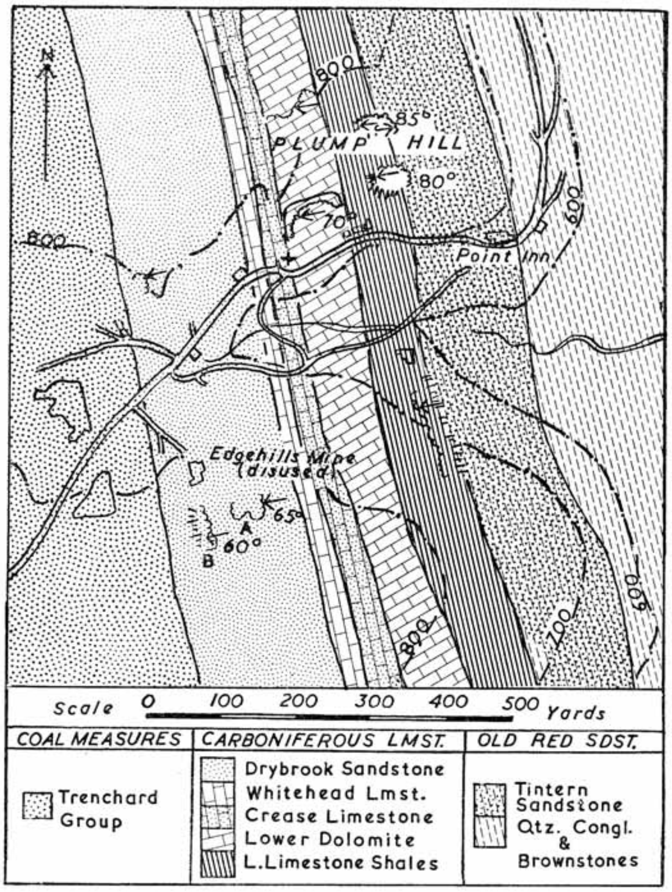
panies this facies change, and there is also a reduction in thickness due to the unconformity at the base of the Trenchard Group of Upper Coal Measures age. A synthesis of the areal distribution and facies changes within the Lower Carboniferous is given by Kellaway and Welch (1955), who suggested that the Drybrook Sandstone of the type locality of Drybrook village may be represented by only the lower part of the formation.



TEXT-FIG. 1. Sketch-map of the solid geology of the Wigpool syncline, Forest of Dean with boundaries mainly after Silby and Reynolds (1937). Inset map shows the location of the Wigpool syncline with respect to the remainder of the Forest of Dean.

PREVIOUS FOSSIL RECORDS FROM THE DRYBROOK SANDSTONE

Until the present decade the only fossil remains known from the Drybrook Sandstone of the Wigpool syncline was a species of *Lepidodendron* allied to *L. griffithi* (Brongniart) recorded by Wethered (1883, p. 215) from the lower beds in Drybrook village. Recently, Allen (1961) has described the lepidophyte sporophyll *Lepidostrobophyllum fimbriatum* (Kidston) from a bed of pink siltstone in the Drybrook Sandstone quarry at Hazel Hill near Puddlebrook. He also makes reference (p. 228) to the presence in the sporangia of poorly preserved megaspores which he tentatively assigned to *Triletes echinoides* Chaloner. Lele and Walton (1962) have described plant impressions from the same locality and horizon. A total of ten taxa were recognized: seven of these were identified specifically and the other three at generic level. These authors also gave an account of the miospores obtained from the siltstone on which the plant remains occurred. The



TEXT-FIG. 2. Geological sketch-map to show the succession and structure of Plump Hill on the eastern limb of the Wigpool syncline (boundaries mainly after Sibly and Reynolds, 1937). The exposures marked A and B are those from which the samples were taken.

assemblage was generally poorly preserved and contained twenty-eight spore types distributed between nineteen genera. There were eight species determinations (three new), five spore categories compared to existing species, thirteen identified at generic level only, and two unnamed types.

Lele and Walton (1962, p. 138) have wrongly attributed the discovery of plant stems identified by Crookall (1939) as ? *Cyclostigma kiltorkense* Haughton to the Drybrook Sandstone. These were in fact obtained from the Tintern Sandstone of Upper Old Red Sandstone age.

Sullivan and Hibbert (1964) have recently recorded a spore-bearing structure of basic tetrahedral symmetry with wing-like appendages at the apices from palynological preparations from the lower of the two horizons dealt with in this paper. These remains have been called *Tetrapterites visensis* and are also known to occur in the Basement Series of the Carboniferous Limestone of North Wales.

DESCRIPTION OF THE EXPOSURES

The location of the quarries from which the samples were taken is given in text-fig. 2. The exposures, marked A and B, were situated 160 yards south of the A 4136 road on Plump Hill near Mitcheldean (Grid Ref. SO/661168). The succession in both quarries has been measured in detail with the help of Mr. H. G. Davies and a summary of the rock sequence is given below:

	ft.	in.
Quarry B		
Coarse grey sandstone with orientated plant casts; base irregular	1	4 (seen)
Coal (Edgehills coal); impure coal with lenticles of shale and sandstone .	0	$5\frac{1}{2}$–10
Irregularly bedded, grey, loosely cemented coarse grained sandstone with carbonaceous streaks and orientated plant casts	3	0
Medium grained speckled sandstone	4	5
Gap	16	0
Pebbly sandstone	7	0
Gap	10	0
Conglomerate with pebbles of quartz, quartzite, and Carboniferous Limestone; also irregular angular blocks of shale (maximum diameter 8 in.) . .	4	10
Pebbly sandstone	2	2
Thinly bedded friable coarse grained speckled sandstone	6	0
Gap	20	0
Purple and red conglomerates and pebbly sandstone	9	0
Unexposed strata between Quarries A and B	54	0 (estimated)
Quarry A		
Massively bedded red, white, and speckled medium grained sandstone with lenticular bands of blocky purple mudstone; sandstones locally conglomeratic at the base	91	0
Red medium grained sandstone with pebbly bands and layers of pebbles embedded in siltstone and unconsolidated sands	8	0
Gap.	12	0
Red and green shale	1	7
Coaly shale (sampled)	0	6
Grey mudstone with fragmentary plant remains	0	7
Yellow siltstone with plant remains	0	7
Sandstone	1	3
Fault?		
Thinly bedded white and speckled fine and medium grained sandstones with subordinate shale and silt bands.	30	0

The total thickness of strata measured in both quarries was 285 ft. The rocks dipped steeply a few degrees north of west. There were minor variations in strike, particularly in Quarry A, which could be attributed to the effects of small strike faults. The dip of the beds in Quarry B was generally less than in Quarry A and this is probably a manifestation of the progressive reduction in the value of the dip away from the influence of the Staple Edge monocline which is the most important structural element on the eastern margin of the basin.

Spore assemblages were obtained from two horizons within the sequence. The lower sample was a shale which occurred in a belt of predominantly argillaceous strata which had been left unworked as a bluff in Quarry A. The other sample was a coal, herein designated the Edgehills coal, which lay near the top of the exposed sequence.

The spore floras from the two rocks indicated that they occupied greatly dissimilar stratigraphical positions and that there must have been considerable breaks in sedimentation. The presence of thick conglomerates with large pebbles and angular blocks is in accord with this conclusion. The position of the unconformity (there may of course be more than one) is not marked by any discordancy in dip and strike of the beds and so it is not possible to recognize the different stratigraphical units on a structural basis. The virtual absence of macrofossils precludes any means of a palaeontological subdivision. Consequently, any scheme of classification must be a lithological one: even this method is hampered by the secondary iron enrichment which has removed much of the original structures and textures of these rocks.

The shale sample came from a horizon between 32 ft. 5 in. and 33 ft. above the exposed base of the formation. This shale occurs within a typical development of Drybrook Sandstone whose lithology can be matched in numerous exposures within the Forest of Dean basin. The dating suggested by the spore assemblage from this shale is in accord with the evidence obtained from macrofossils, in particular, the brachiopods from the Drybrook Limestone.

The coal, on the other hand, appears to be much younger in age and is associated with coarse sandstones and thick conglomerates which have no obvious counterpart elsewhere in the basin. It would thus appear to be necessary to erect a new name for these rocks and the name Edgehills Sandstone is proposed. The lower boundary of this unit is taken as the first onset of thick conglomerate bands above the massively bedded sandstones. In the case of the Plump Hill succession this will be the base of the conglomerates forming the eastern wall of Quarry B.

The lateral extent of the Edgehills Sandstone is not known because it is nowhere else exposed at outcrop. Presumably, it once had a greater areal distribution and the rocks of Quarry B represent a remnant preserved in the trough of the pitching Wigpool syncline. Rocks of a similar age, or even younger, may be expected to occur at depth in the Forest of Dean basin.

PREPARATION OF THE SAMPLES

The shale had weathered to a stiff clay and a sample of this was taken a few inches below the surface. There was a violent effervescence with 40 per cent. hydrofluoric acid, the concentration normally employed in the solution of the mineral matter, and it was found necessary to control the reaction by adding three times its own volume of distilled water. Even at this dilution the reaction was complete after two hours. No oxidation of the residue was required; it was washed with a little 2 per cent. caustic potash solution and then with distilled water. Permanent slides were made using Cellosize and Canada Balsam (Jeffords and Jones 1959).

The coal was also first treated with hydrofluoric acid to remove the mineral impurities. No maceration was necessary because of its weathered condition and the humic substances were released by the addition of 2 per cent. caustic potash. The residue was washed and mounted as before.

The slides containing the type material of the species erected in this paper together with all illustrated spores have been deposited in the type collections of the Micropalaeontological Laboratory of the Geology Department, University of Sheffield.

SYSTEMATIC DESCRIPTIONS

Anteturma SPORITES H. Potonié 1893
Turma TRILETES (Reinsch) Potonié and Kremp 1954
Subturma AZONOTRILETES Luber 1935
Infraturma LAEVIGATI (Bennie and Kidston) R. Potonié 1956
Genus LEIOTRILETES (Naumova) Potonié and Kremp 1954

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

Leiotriletes cf. *priddyi* (Berry) Potonié and Kremp 1955.

Plate 57, fig. 1

Description. Size (41 specimens) 20–35μ, mean 27μ. Exine laevigate. Amb triangular with slightly concave or convex sides and broadly rounded apices. Trilete rays distinct, tecta extend between two-thirds and three-quarters radius of spore.

Remarks. These spores resemble *Deltoidospora implumis* Staplin 1960, but may be distinguished from it by their more deltoid shape, longer rays, and the absence of lips. *L. subadnatoides* Bhardwaj 1957 has longer rays and an infrapunctate exine. The inadequate description and illustration of *L. priddyi* precludes a definite assignment to this species.

Occurrence. Edgehills coal.

Leiotriletes plicatus sp. nov.

Plate 57, figs. 4–6

Holotype. Specimen illustrated as Pl. 57, fig. 6 from the Drybrook Sandstone. Size 32μ.

Diagnosis. Size (17 specimens) 25–35μ, mean 30μ; amb triangular with almost straight sides; parallel sided fold present around the equatorial region of the distal surface; proximal hemisphere markedly pyramidal.

Description. Yellow to orange-brown in colour. Exine laevigate, 2μ thick. Amb triangular with straight to slightly concave or convex sides and rounded apices. Proximal pole markedly pyramidal, apex up to 10μ above the level of the equator; faces of pyramid continue without change of slope to the equator. Distal hemisphere only slightly convex. A prominent continuous fold, 5–7μ wide, is located around the equatorial region of the distal hemisphere; the equator marks the outer limit of the fold. The inner margin is approximately parallel to the equator along the interradial regions, but there is frequently a *V*-shaped incision at one or more of the apices (Pl. 57, fig. 5). Trilete rays distinct, tecta exceed three-quarters of the spore radius, straight or sinuous.

Remarks. Leiotriletes [*Rotaspora*] *annellitus* (Horst) comb. nov. may be conspecific with *L. plicatus* although Horst (1955, p. 183) describes the exine as infrareticulate. The pseudozonate aspect of the folded exine led Potonié and Kremp (1956, p. 107) to classify this species as *Rotaspora*. The figures of the holotype (Horst 1955, Pl. 22, figs. 49a, b) clearly shows the structure to be distal. In the description Horst (1955, p. 183) writes 'Cingulum . . . , das an den inneren Ecken häufig eingeschnürt ist' and is obviously referring to the same feature as the apical incisions described above.

Occurrence. Drybrook Sandstone.

Leiotriletes pyramidatus sp. nov.

Plate 57, figs. 2, 3

Holotype. Specimen figured as Pl. 57, fig. 2 from the Drybrook Sandstone. Size 33·5μ.

Diagnosis. Size (33 specimens) 25–38μ, mean 31μ; amb rounded triangular; proximal polar region markedly pyramidal; three arcuate folds enclose the trilete rays.

Description. Colour yellow to brown. Exine laevigate, 2–2·5μ thick. Amb subtriangular with convex sides and rounded or somewhat pointed apices. Distal hemisphere slightly convex; proximal surface pyramidal with an abrupt change of slope near the equator. Three arcuate compression folds are present between the rays; folds up to 8μ wide at their mid-points and taper to approximately 2μ near the apices. The margins of the folds may be concave or straight: a characteristic combination is two folds with concave margins separated by one with a straight, or even convex outline (Pl. 57, fig. 3). Trilete rays between three-quarters and four-fifths of the spore radius, tecta straight or sinuous.

Comparison. L. tristichus Ishchenko 1958 is larger and the arcuate folds which are 2μ wide lie at a greater distance from the tecta.

Remarks. L. plicatus and *L. pyramidatus* are easily separated from each other on morphological characteristics. However, it is not clear whether they are indeed two natural species or merely two products of compression of a spore with a high pyramidal pole. *L. plicatus* has been observed in a sporangial cluster consisting mainly of *Punctatisporites platirugosus* (Waltz) comb. nov.

Krutzsch (1959, p. 10) has reported the occurrence of forms with three arcuate folds (or tori) in rocks ranging from Upper Keuper to Miocene in age. They are particularly common in Tertiary assemblages and have been described as *Laevigatosporites neddeni* (Potonié) by Thomson and Pflug (1953) and referred to various species of *Toroisporis* by Krutzsch (1959, 1962). Spores of Recent members of the Polypodiaceae, e.g. *Pteridium*, display folding of the exine similar to *L. plicatus* and *L. pyramidatus*.

Occurrence. Drybrook Sandstone.

Genus PUNCTATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species. P. punctatus Ibrahim 1933.

Punctatisporites platirugosus (Waltz) comb. nov.

Plate 57, figs. 7–9

1941 *Azonotriletes platirugosus* Waltz in Luber and Waltz pl. 1, fig. 1.
1956 *Leiotriletes platirugosus* (Waltz); Ishchenko pl. 1, fig. 1.
1958 *Leiotriletes platirugosus* (Waltz); Ishchenko pl. 1, fig. 1.

Description. Size range (100 specimens) 30–70μ, mean 52μ. Amb circular to oval. Trilete rays distinct, up to three-quarters radius of spore. Exine laevigate, about 1·5μ thick. Parallel sided compression folds common, particularly in equatorial regions (Pl. 57, fig. 7). Crescentic folds rare. Occasional specimens without folds (Pl. 57, fig. 9) resemble *Punctatisporites glaber* (Naumova) Playford 1962.

Remarks. This species was described by Waltz in Luber and Waltz (1941) and she recognized three varieties, var. *minor*, var. *major*, and var. *giganteus* based upon size. The spores described above correspond to the varieties *minor* and *major*.

Occurrence. Drybrook Sandstone.

EXPLANATION OF PLATE 57

All figures × 500.

Figs. 1–6. *Leiotriletes spp.* 1, *L.* cf. *pryddyi* (Berry) Potonié and Kremp 1955; Edgehills coal; UD2/259665, Proximal surface. 2–3. *L. pyramidatus* sp. nov.; Drybrook Sandstone. 2, Holotype. LD1/223640, Proximal surface. 3, LD1/349793, Proximal surface. 4–6. *L. plicatus* sp. nov.; Drybrook Sandstone. 4, 5, LD4/200670, Proximal and distal surfaces. 6, Holotype, LD2/109653, Proximal surface.

Figs. 7–12. *Punctatisporites spp.* 7–9, *P. platirugosus* (Waltz) comb. nov.; Drybrook Sandstone. 7, LD3/104804, Proximal surface. 8, LD1/324730, Semi-lateral view. 9, LD3/067812, Proximal surface. 10, *P. punctatus* Ibrahim 1933; Edgehills coal; UD5/095826, Proximal surface. 11–12. *P. ocellatus* sp. nov.; Drybrook Sandstone. 11, Holotype, LD3/218773, Proximal surface. 12, LD2/407813, Proximal surface.

Figs. 13–16. *Granulatisporites spp.* 13, *G.* cf. *granulatus* Ibrahim 1933; Edgehills coal; UD2/345667, Proximal surface. 14–15. *G.* cf. *microgranifer* Ibrahim 1933; Edgehills coal; 14, UD2/426807, Proximal surface. 15, UD1/ 446682, Proximal surface.16, *G. parvus* (Ibrahim) Potonié and Kremp 1955; Edgehills coal; UD1/379815, Proximal surface.

Figs. 17–18. *Cyclogranisporites* cf. *minutus* Bhardwaj 1957; Edgehills coal. 17, UD2/369709, Proximal surface. 18, UD3/088702, Proximal surface.

Figs. 19–23. *Lophotriletes spp.* 19–20, *L. labiatus* sp. nov.; Edgehills coal. 19, Holotype, UD2/482810, Proximal surface. 20, UD2/350763, Proximal surface. 21–23, *L. tribulosus* sp. nov.; Drybrook Sandstone. 21, LD3/341659, Proximal surface. 22, Holotype, LD3/372660, Proximal surface. 23, LD1/265644, Semi-lateral preservation.

Figs. 24–30. *Waltzispora spp.* 24, *W. prisca* (Kosanke) comb. nov.; Drybrook Sandstone; LD3/285799, Proximal surface. 25–30. *W. planiangulata* sp. nov.; Drybrook Sandstone. 25, LD2/329796, Proximal surface. 26, Holotype, LD1/345754, Proximal surface. 27, LD3/257807, Proximal surface. 28, LD2/122714, Proximal surface. 29, LD1/380741, Proximal surface. 30, LD4/330714, Proximal surface.

Punctatisporites punctatus Ibrahim 1933

Plate 57, fig. 10

Description. Size (54 specimens) 32–65μ, mean 46μ. Amb subtriangular to circular. Exine laevigate to slightly infrapunctate, between 1 and 2μ thick. Trilete rays prominent, exceed three-quarters radius of the spore, tecta straight.

Remarks. These spores do not fit precisely any specific category previously described. In view of the large number of species already in existence for simple circular trilete spores which differ little except in size, it is proposed to extend the lower limit of *P. punctatus*, which they otherwise resemble, from 55 to 32μ.

Occurrence. Edgehills coal.

Punctatisporites ocellatus sp. nov.

Plate 57, figs. 11, 12

Holotype. Specimen illustrated as Pl. 57, fig. 11 from the Drybrook Sandstone. Size 63μ.

Diagnosis. Size (27 specimens) 49–74μ, mean 63μ; amb circular; exine finely and densely infrapunctate, 3–4μ thick; trilete rays four-fifths total radius of the spore, tecta frequently torn and gaping at the apex.

Description. Amb circular. Exine brown in colour, 3–4μ thick. Structure of the exine is finely and densely infrapunctate, margin smooth. Secondary corrosion accentuates the structure and sometimes makes it visible at the outline. Trilete rays distinct, sinuous, simple and exceed four-fifths of the radius of the spore; tecta often torn apart at the apex to form a triangular gape. Parallel sided compression folds sometimes present.

Comparison. *P. ocellatus* resembles in some respects each of three species *P. pseudolevatus*, *P. fissus*, and *P.? callosus* described by Hoffmeister, Staplin and Malloy (1955) from the Hardinsburg Formation. *P. pseudolevatus* has identical size limits to *P. ocellatus* and is 'finely granulose'; however, the exine is thinner (quoted as 2μ). *P. fissus* displays the characteristic triangular gape at the apex, but the tecta are much shorter (half radius of the spore), and the size range (50–60μ) is more restricted. *P.? callosus* also has a smaller maximum size (65μ) and the exine is without structure. The latter species has been placed in the synonymy of *P. glaber* by Playford (1962, p. 576).

Occurrence. Drybrook Sandstone.

Infraturma APICULATI (Bennie and Kidston) R. Potonié 1956
Subinfraturma GRANULATI Dybová and Jachowicz 1957
Genus GRANULATISPORITES (Ibrahim) Potonié and Kremp 1954

Type Species. *G. granulatus* Ibrahim 1933.

Granulatisporites granulatus Ibrahim 1933

Plate 57, fig. 13

Description. Size (23 specimens) 20–35μ, mean 28μ. Amb triangular with concave sides and rounded apices. Trilete rays half to two-thirds radius of the spore. Grana 0·7–1μ in basal diameter, up to 0·5μ high and 1–1·5μ apart. Approximately 45 grana at the outline.

Occurrence. Edgehills coal.

Granulatisporites cf. *micrograrifer* Ibrahim 1933

Plate 57, figs. 14, 15

Description. Size (45 specimens) 23–27μ, mean 25μ. Amb triangular with concave sides and rounded apices. Trilete rays exceed two-thirds radius of the spore, frequently extend to the equator, tecta straight, intertectum narrow. Grana uniform in size, less than 0·5μ, hemispherical in shape, densely distributed over the whole exine. Intertectal areas sometimes darker. Margin slightly notched.

Remarks. The spores described above conform in all characters except size with the specific diagnosis of *G. micrograrifer*. The measurements given by Ibrahim (1933, p. 22) were 31 and 32·5μ. Potonié and Kremp (1955 p. 58) quote the limits as (25) 30–40μ.

Occurrence. Edgehills coal.

Genus CYCLOGRANISPORITES Potonié and Kremp 1954

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

Cyclogranisporites cf. *minutus* Bhardwaj 1957

Plate 57, figs. 17, 18

Description. Size (19 specimens) 40–50μ, mean 46μ. Amb circular to oval. Trilete rays usually distinct, half to two-thirds radius of the spore; tecta frequently bear an unequal angular relationship to each other; lips about 2μ wide, margins frilled. Grana 0·5–0·7μ in basal diameter, less than 0·5μ high.

Remarks. The spores are intermediate in size between *C. minutus* and *C. aureus* (Loose) Potonié and Kremp 1955. The other characters agree closely with the description of *C. minutus*.

Occurrence. Edgehills coal.

Subinfraturma NODATI Dybová and Jachowicz 1957
Genus LOPHOTRILETES (Naumova) Potonié and Kremp 1954

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

Lophotriletes labiatus sp. nov.

Plate 57, figs. 19, 20

Holotype. Specimen illustrated as Pl. 57, fig. 19 from the Edgehills coal. Size 30μ.

Diagnosis. Size (23 specimens) 20–40μ, mean 32μ; amb triangular with convex sides and rounded to pointed apices; exine ornamented with cones 0·5 to 1·5μ high; thickened bands accompany the rays.

Description. Colour yellow to brown. Amb triangular with convex sides and rounded to pointed apices. Trilete rays not always visible due to the presence of thickened bands which enclose them. Tecta straight to sinuous, sutures closed. Thickened bands individually 2–4μ wide and up to 4μ high. The margins of the bands are straight to scalloped and only slightly convergent in a radial direction. Exine of thickenings laevigate. Remainder of the proximal surface and the whole of the distal hemisphere are ornamented with broad-based cones up to 1·5μ in height, but often less than 1μ. Occasional spines up to 3μ high are sometimes interspersed between the cones. About 23 to 28 elements are visible at the outline.

Remarks. The form of the thickened bands is similar to that described by Hoffmeister, Staplin and Malloy (1955, pl. 39, fig. 8, p. 398) for their Spore Type E.

Occurrence. Edgehills coal.

Lophotriletes tribulosus sp. nov.

Plate 57, figs. 21–23

Holotype. Specimen illustrated as Pl. 57, fig. 22 from the Drybrook Sandstone. Size 36·5μ.

Diagnosis. Size (65 specimens) 30–45μ, mean 36·5μ; amb triangular with almost straight sides and rounded or blunted apices; exine 1–1·5μ thick, ornamented with pointed or rounded cones up to 3μ high and wide (usually about 1·5μ).

Description. Colour pale yellow, exine 1–1·5μ thick. Amb triangular with almost straight sides and rounded or blunted apices. Ornamentation consists of cones or tubercules, crests usually rounded but may be pointed or truncate: grade of ornamentation variable even on the same specimen. Basal diameter of the cones is between 1 and 2μ but may sometimes extend up to 3μ; maximum height is also 3μ. There is a tendency in some cases for the larger elements to be located at the apices. Density of ornamentation variable: the number of cones at the equator is between 10 and 32. Trilete rays are three-quarters of the spore radius or more; tecta straight, although they may be slightly sinuous near the apex. Proximal surface pyramidal, distal hemisphere oblate. Small *gulaferus* type folds are sometimes present at the apices (Pl. 57, figs. 22, 23).

Comparison. Lophotriletes [*Granulatisporites*] *tuberculatus* (Hoffmeister, Staplin and Malloy 1955) comb. nov. is more lenticular in polar section, has more concave sides and broader apices. The size of the ornament of *L. tuberculatus* was not given and a comparison based on the sculpture is not possible.

Occurrence. Drybrook Sandstone.

Genus WALTZISPORA Staplin 1960

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

Remarks. This genus was included in the Infraturma Laevigati by Playford (1962, p. 581) although the type species, *W. lobophora* displays a prominent ornamentation (Playford 1962, p. 581, records elements up to 2·5μ in basal diameter). The most characteristic feature of the genus is the tendency to display an angular junction, often with tangential expansion, between the blunted apices and the interradial margins. The spores which possess this character have an exine ornamentation ranging from laevigate to tuberculate. Since the form of the ornamentation is used in the subdivision of the Subturma Azonotriletes, the classification of *Waltzispora* within the suprageneric framework of the scheme proposed by Potonié (1958, 1960) presents a problem. One solution would be to erect a new genus for the laevigate forms now assigned to *Waltzispora*, e.g. *W. albertensis* Staplin 1960, *W. sagittata* which would be included in the Infraturma Laevigati. *Waltzispora* if restricted to the species which possess an exine ornamentation could be classified under the Infraturma Apiculati. For the present, however, no formal emendation of *Waltzispora* is proposed, but the genus is transferred to the Infraturma Apiculati.

Waltzispora planiangulata sp. nov.

Plate 57, figs. 25–30

Holotype. Specimen illustrated as Pl. 57, fig. 26 from the Drybrook Sandstone. Size 37μ.

Diagnosis. Size (43 specimens) 30–45μ, mean 38μ; amb triangular with rounded and blunted apices, usually with angular junctions with the concave sides; exine 1–1·5μ thick, ornamented with grana or cones 0·5–1·5μ in basal diameter, ornament reduced or absent on the proximal surface.

Description. Amb triangular with prominent apices, radial extremities may be blunted or broadly rounded, tangential expansion not well marked. Angular junction between the apices and the concave interradial margins more or less prominently displayed. Exine 1–1·5μ thick, yellow in colour. Trilete rays exceed three-quarters radius of the spore, usually about four-fifths. Ornamentation consists of grana and cones which vary in size from 0·5–1·5μ in basal diameter and up to 1·5μ in height. The ornament in any particular specimen is uniform in grade and shape. The variation in ornament displayed by the species is illustrated in Pl. 57, figs. 25–30. In Pl. 57, fig. 20 the low hemispherical grana are 0·5–0·8μ in basal diameter and are entirely restricted to the distal surface: the elements are barely visible at the equator. The grana are larger, 1μ wide and 0·7μ high, in the specimen (Pl. 57, fig. 28) with several cones 1·5μ high interspersed between them. The ornament is reduced on the proximal surface: absent in intertectal areas, but several low grana are located near the equator. The dominant ornament of the spore (Pl. 57, fig. 30) is of cones 1·5μ wide and 1–1·5μ high. These are smaller on the proximal exine and absent in the contact areas.

Comparison. *W. lobophora* is larger and has more prominent angular junctions. *Granulatisporites humera* Staplin 1960 is also larger and shows a reduction in the size of the elements in the apical regions of the distal surface as well as on the proximal hemisphere. *W.* [*Triquitrites*] *prisca* (Kosanke 1950) comb. nov. has a similar size range to *W. planiangulata*, but the grana (probably all on the distal hemisphere) are smaller and more widely spaced.

Occurrence. Drybrook Sandstone.

Genus ANAPLANISPORITES Jansonius 1962

Type species. *A. telephorus* (Klaus) Jansonius 1962.

Anaplanisporites denticulatus sp. nov.

Plate 58, figs. 1–3

Holotype. Specimen illustrated as Pl. 58, figs. 1, 2 from the Drybrook Sandstone. Size 46·5μ.

Diagnosis. Size (26 specimens) 42–58μ, mean 49μ; amb rounded triangular to circular; ornament of cones on the distal and equatorial regions, cones up to 1μ high and 1μ wide at the base.

Description. Exine yellow in colour, 2–2·5μ thick. Amb rounded triangular to circular, rarely oval. Ornament restricted to the distal and equatorial parts of the spore; proximal exine laevigate. Cones 0·5–1μ high and 1μ wide at the base, crests rounded to pointed. Larger elements up to 3μ high and wide occasionally present, characteristically near the distal pole; these may be verrucae or cones. Ornament arranged in a quasi-concentric manner, usually four series per radius. Cones 1·5–2μ apart, about forty present in the outermost series, barely visible at the outline. Trilete rays distinct, frequently exceed three-quarters radius of the spore, intertectum about 1μ. Folds usually accompany the rays; their combined width is 3–4μ at the apex and they taper gradually towards the equator.

Occurrence. Drybrook Sandstone.

Genus APICULATISPORIS Potonié and Kremp 1956

Type species. *A. aculeatus* (Ibrahim) Potonié and Kremp 1956.

Apiculatisporis variocorneus sp. nov.

Plate 58, figs. 4–8

Holotype. Specimen illustrated as Pl. 58, fig. 4 from the Edgehills coal. Size 73·5μ.

Diagnosis. Size (58 specimens) 40–78μ, mean 60μ; amb irregularly circular to oval; exine ornamented with cones and spines which range from 0·5–5·5μ in height; ornament variable in size, shape, and density even on individual specimens, usually absent from intertectal areas.

Description. Amb circular to oval, sometimes quadrangular due to folding. Exine yellow in colour, 1·5–2·5μ thick. Trilete rays visible to indistinct; tecta simple, threadlike, usually from two-thirds to three-quarters radius of the spore. Ornament variable in size, shape, and density and there are considerable differences even on a single specimen. In the example (Pl. 58, fig. 8) there is a fairly uniform ornament of small sharply tapered cones and spines 0·5–1μ high. The specimen (Pl. 58, fig. 6) has spines which are up to 1·5μ high and 0·5μ wide on the proximal and equatorial regions, but become more conical, by an increase in basal diameter (up to 1·5μ), at the distal pole. The ornament on the contact faces is frequently reduced (Pl. 58, figs. 4, 5, 7). In the holotype (Pl. 58, fig. 4) the spines on the distal surface reach a maximum of 5·5μ, near the equator on the proximal surface the maximum is 2·5μ and at the pole there are widely scattered cones about 0·5μ high.

Remarks. The range of variation recorded above is similar to that represented in three species of *Apiculatisporis* described by Artuz (1957, 1959) from the Sulu and Büyük seams of the Zonguldak coalfield, Turkey. The three species were *A. punctaornatus* Artuz 1957, *A. subspinosus* Artuz 1957, and *A. abditus* (Loose) Potonié and Kremp 1955 (the figured specimen of *A. abditus* in Artuz 1959, pl. 4, fig. 22 does not resemble the holotype of the species). It is not clear at this stage whether synonymy exists between *A. variocorneus* and the aforementioned species.

Occurrence. Edgehills coal.

Genus PUSTULATISPORITES Potonié and Kremp 1954

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

Pustulatisporites papillosus (Knox) Potonié and Kremp 1955

Plate 58, figs. 9, 10

Remarks. One observation may be added to the description of *P. papillosus* by Butterworth and Williams (1958, p. 365). The ornamentation of rounded tubercules and verrucae is mainly confined to the distal surface. *Pustulatisporites subornatus* Artuz 1957 may be conspecific with *P. papillosus*.

Occurrence. Drybrook Sandstone.

Subinfraturma BACULATI Dybová and Jachowicz 1957
Genus NEORAISTRICKIA Potonié 1956

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

Neoraistrickia drybrookensis sp. nov.

Plate 58, figs. 11, 12

Holotype. Specimen illustrated as Pl. 58, fig. 11 from the Drybrook Sandstone. Size 46·5μ.

EXPLANATION OF PLATE 58

All figures ×500 unless otherwise stated.

Figs. 1–3. *Anaplanisporites denticulatus* sp. nov.; Drybrook Sandstone. 1,2. Holotype, LD2/408815, Proximal and distal surfaces. 3, LD7/225749, Proximal surface.

Figs. 4–8. *Apiculatisporis variocorneus* sp. nov.; Edgehills coal. 4, Holotype, SMUD/1, Distal view. 5, UD2/331789, Semi-lateral view. 6, UD2/331675, Proximal surface. 7, UD3/046664, Lateral view. 8, UD2/172748, Distal surface.

Figs. 9–10. *Pustulatisporites papillosus* (Knox) Potonié and Kremp 1955; Edgehills coal. 9, UD2/379756, Proximal surface. 10, UD2/298860, Proximal surface.

Figs. 11–12. *Neoraistrickia drybrookensis* sp. nov.; Drybrook Sandstone. 11, Holotype, LD1/221748, Distal surface. 12, LD4/223722, Proximal surface.

Figs. 13–18. *Raistrickia spp.*; Edgehills coal. 13, UD1/175675, Distal surface. 14, UD1/178676, Distal surface. 15, UD8/222755, Distal surface. 16, UD2/394645, Distal surface. 17, UD9/379813, Distal surface. 18, UD8/253832, Distal surface.

Fig. 19. *Microreticulatisporites densus* (Love) comb. nov.; LD4/370750, Distal view, Drybrook Sandstone.

Fig. 20. *Dictyotriletes* cf. *clatriformis* (Artuz) comb. nov.; Edgehills coal. UD1/304766, Proximal surface (×1,000).

Diagnosis Size (22 specimens) 33–50μ (excluding ornamentation), mean 41μ; triangular in outline; exine ornamentation of cones and verrucae, equatorial elements baculose.

Description. Yellow to greenish-yellow in colour, often with a vitreous appearance. Amb triangular with straight, slightly concave or convex sides, and rounded apices. Proximal surface low and pyramidal, distal hemisphere more inflated. Exine 2–2·5μ thick. Trilete rays frequently obscured by ornamentation, intertectum 0·5μ, lips low and narrow; tecta sinuous, approximately three-quarters radius of spore. Proximal exine may be without ornament or may bear scattered cones, particularly near the equator, where they may reach up to 3μ in height. The distal hemisphere is ornamented with cones and verrucae. The cones are usually discrete, up to 3μ high and wide. Irregular verrucae and spatulate processes may reach up to 15μ in their longest diameter and 7μ high. The equatorial elements are of two kinds: bacula interspersed with blunted cones. The bacula have blunted or expanded crests and are up to 8μ high (usually 4–5μ) and 6μ wide (usually 3–4μ). The broad based cones are of comparable dimensions but are usually fewer in number than the bacula. Number of elements at the outline varies between 19 and 33.

Comparison. N. inconstans Neves 1961, the only other species of *Neoraistrickia* described from Carboniferous strata, is larger and has more slender elements.

Occurrence. Drybrook Sandstone.

Genus RAISTRICKIA Schopf, Wilson and Bentall 1944

Type species. *R. grovensis* Schopf 1944.

Raistrickia spp.

Plate 58, figs. 13–18

Material. The preparation from the Edgehills coal yielded a large number of specimens of *Raistrickia*. The size, shape, and density of the baculae were extremely variable and several morphological species appeared to be represented. However, because of the continuous variation which existed between the various forms, the assemblage is described as a whole.

Description. Size (87 measured specimens) 36·5–68μ, mean 52μ. The bacula measured from 2–15μ in height and were 1–5μ wide: the ratio of height to breadth ranged from 5 : 1 to 1 : 1. Crests blunted, often expanded and/or serrated. The bacula may be sparsely distributed as in the spore (Pl. 58, fig. 13). In this specimen the bacula extend up to 6μ high and are slender with partite crests; a few broader elements are also present. A form similar to this has been figured and described as *R.* cf. *superba* (Ibrahim) Schopf, Wilson and Bentall 1944 by Bhardwaj (1957, p. 114, pl. 23, fig. 31).

One specimen (Pl. 58, fig. 18) is more typical of *R. superba*. The bacula have parallel sides and extend up to 9μ in height.

The most common members of the assemblage are illustrated in Pl. 58, figs. 15–16: the bacula are set with moderate density over the exine. They are up to 8μ in height and 3–4μ in basal diameter and have slightly expanded and partite crests. Some of these examples (e.g. Pl. 58, fig. 16) resemble *R. microhorrida* (Horst) Potonié and Kremp 1955.

Densely ornamented forms with long stout bacula up to 15μ high (Pl. 58, fig. 17) are similar to *R. saetosa* (Loose) Schopf, Wilson and Bentall 1944.

Remarks. A similar variation in the density of the distribution of the bacula is apparent from the two figured examples of *R. soloria* Wilson and Hoffmeister (1956, pl. 1, figs. 18, 19). In this species, however, there is a greater proportion of conical elements.

Occurrence. Edgehills coal.

Infraturma MURORNATI Potonié and Kremp 1954

Genus MICRORETICULATISPORITES (Knox) Bhardwaj 1955

Type species. M. lacunosus (Ibrahim) Knox 1950.

Remarks. This genus was instituted by Knox (1950, p. 319) for radial and bilateral spores which possessed a reticulum with meshes less than 6μ. Potonié and Kremp (1954, p. 143) limited the genus to radial spores only. Bhardwaj (1955, p. 127) further restricted it to triangular spores in which the meshes of the reticulum were less than 3μ in diameter. The circular forms such as *M. microtuberosus* and *M. sifati* were excluded because their ornament was not a continuous microreticulum but was composed of narrow linear elements randomly distributed over the exine.

Bhardwaj (1955) has described the ornament of the triangular spores of *Microreticulatisporites* as 'extrareticulate', but perhaps a better description would be punctate or fovoleate. The 'lumina' are depressed circular pits and the exine between them (the 'muri') is flat or slightly arched.

Microreticulatisporites densus (Love 1960) comb. nov.

Plate 58, fig. 19

1960 *Lophotriletes densus* Love, pl. 1, fig. 3, p. 113.

Description. Size (17 specimens) 48–56μ, mean 52μ. Amb triangular with concave sides and broad rounded apices. Trilete rays distinct, simple, straight; tecta exceed four-fifths radius of the spore. Exine ornamented with circular pits or punctae, approximately 0·5μ in diameter, usually discrete, but locally coalescent; about 12 punctae along a radius. Exine between the pits domed, visible as minor elevations, 0·5–0·8 high, at the outline. Margin notched, between 55 and 65 elements at the equator. Thickness of exine 2–2·5μ.

Comparison. M. concavus Butterworth and Williams 1958 has less concave sides, shorter tecta which are frequently gaping, a finer denser punctation, and a thinner exine.

Occurrence. Drybrook Sandstone.

Genus DICTYOTRILETES (Naumova) Potonié and Kremp 1954

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

Remarks. As a result of the reinterpretation of the structure of the holotype of *Reticulatisporites reticulatus* Ibrahim 1933 by Neves (1964, in press), the genus *Reticulatisporites* has been emended to include only those forms with a differentiated cingulum and which possess a reticulum which is confined mainly to the distal hemisphere. Some of the species now excluded from *Reticulasporites* by this diagnosis can be accommodated in the genus *Dictyotriletes*. The latter is for azonate forms which possess either a distal reticulum, e.g. *D. bireticulatus*, or are comprehensively ornamented, e.g. *D. mediareticulatus* (Ibrahim) Potonié and Kremp. This broad interpretation of *Dictyotriletes* is used in the present paper awaiting a reappraisal of the structural organization of zonate and azonate reticulate species undertaken by a working group of the 'Commission Internationale de Microflore du Paleozoïque'.

Dictyotriletes [*Reticulatisporites*] cf. *clatriformis* (Artuz 1957) comb. nov.

Plate 58, fig. 20; Plate 59, figs. 1, 2

Description. Size (43 specimens) 20–30μ, mean 24μ. Amb circular to oval. Trilete rays indistinct. Exine laevigate, less than 1μ thick. Muri 0·7–1μ wide and vary in height from 1·5–3·5μ; about 10 muri cross the equator. Lumen rounded to polygonal, 3·5–6·5μ in maximum diameter; about 8 lumina per hemisphere.

Remarks. The specimens described above differ from those of Artuz only in size: she cites the maximum diameter as 30–45μ. Another small reticulate species recorded by Artuz, viz. *Reticulatisporites crassireticulatus*, is probably conspecific with *D. clatriformis* and merely represents a different aspect of preservation of the muri.

The dimensions of *D.* [*Reticulatisporites*] *castaneaeformis* (Horst) comb. nov. given by Horst (1955, p. 169) were 11–29μ with a mean of 11–15μ. The figure of *D. castaneaeformis* illustrated by Dybová and Jachowicz (1957, pl. 23, fig. 4) is similar to the specimens of *D.* cf. *clatriformis* from the Edgehills coal and is of comparable size (24μ).

Occurrence. Edgehills coal.

Dictyotriletes sagenoformis sp. nov.

Plate 59, figs. 5, 6

Holotype. Specimen illustrated as Pl. 59, fig. 5 from the Edgehills coal. Size 67μ.

Diagnosis. Size (34 specimens) 58–73μ, mean 67μ; circular to oval in equatorial outline; reticulation on both proximal and distal surfaces, muri 1·5–2·5μ wide and up to 10μ high, about 10 muri cross the equator.

Description. Colour yellow to brown, exine laevigate, approximately 2μ thick (excluding muri). Trilete rays frequently obscured by ornamentation, extend between two-thirds and three-quarters of the radius of the spore, margins slightly raised. Reticulum composed of prominent muri 6–10μ high and 1·5–2·5μ wide. In cross-section the muri have tapering walls and rounded to blunted crests. On compression the muri are irregularly folded over the surface of the spore; one murus overlaps the equator of the spore and runs parallel to it over much of its circumference. Lumina irregular, polygonal or quadrangular in shape and have a maximum diameter of 20μ, average 12–15μ. Number of lumina per hemisphere varies between 8 and 11.

Comparison. The reticulum of *D. sagenoformis* is similar in construction to that of *Reticulatisporites muricatus* Kosanke 1950 and *R. fimbriatus* Knox 1950, but the diameter of the spores is considerably smaller.

Occurrence. Edgehills coal.

Genus CORBULISPORA Bharadwaj and Venkatachala 1961

Type species. C. retiformis Bharadwaj and Venkatachala 1961.

Remarks. This genus was erected for Lower Carboniferous spores which had a comprehensive reticulum composed of broad low muri which were sometimes discontinuous. The trilete rays were accompanied by wide thickened labra. It is probable that the type species *C. retiformis* is conspecific with *C. cancellata* (Waltz) Bharadwaj and Venkatachala 1961.

Corbulispora subalveolaris (Luber 1938) Sullivan 1964 (in press)

Plate 59, figs. 3, 4

1938 *Azonotriletes subalveolaris* Luber in Luber and Waltz pl. 5, fig. 72
1955 *Dictyotriletes subalveolaris* (Luber) Potonié and Kremp
1960 *Dictyotriletes subalveolaris* (Luber) Potonié and Kremp; Love pl. 1, fig. 9, p. 116.

Description. Size (17 specimens) 61–68μ, mean 65μ. Amb circular to oval. Trilete rays usually obscured by ornament, but when observed they are distinct and accompanied by broad flat lips up to 7μ wide individually with irregularly scalloped outline; tecta extend three-quarters radius of the spore or more. Muri about 5μ high with rounded crests, often thickened at the junctions. Lumina polygonal, up to 21μ in diameter (average 12–15μ). The number of lumina per hemisphere is between 8 and 11.

EXPLANATION OF PLATE 59

All figures × 500 unless otherwise stated.

Figs. 1–2. *Dictyotriletes* cf. *clatriformis* (Artuz) comb. nov.; Edgehills coal. 1, UD1/304766, Proximal surface. 2, UD2/353636, Distal surface.

Figs. 3–4. *Corbulispora subalveolaris* (Luber) Sullivan 1964; Drybrook Sandstone. 3, LD2/243668, Proximal surface. 4, LD1/287833, Distal surface.

Figs. 5–6. *Dictyotriletes sagenoformis* sp. nov.; Edgehills coal. 5, UD1/249804, Distal surface. 6, UD2/271789, Holotype, Proximal surface.

Figs. 7–10. *Triquitrites tricoranatus* sp. nov.; Edgehills coal. 7, Holotype, SMUD/2, Proximal surface. 8, UD9/306713, Proximal surface. 9, UD1/486660, Proximal surface. 10, UD2/139803, Distal surface.

Figs. 11–13. *Simozonotriletes siblyana* sp. nov.; Edgehills coal. 11, Holotype, UD3/028659, Proximal surface. 12, UD3/193697, Distal surface. 13, UD5/122753, Distal surface.

Figs 14–21. *Vallatisporites spp.* 14–15, *V. ciliaris* (Luber) comb. nov.; Drybrook Sandstone. 14, LD2/279702, Distal surface. 15, LD2/425678, Proximal surface. 16, *V.* cf. *ciliaris* (Luber) comb. nov., Drybrook Sandstone; LD2/059645, Proximal surface. 17–19. *V. galearis* sp. nov.; Drybrook Sandstone; LD2/069802. Proximal view. 18, 19. Holotype, LD2/025839, Distal view; 19, × 1,000. 20–21. *V. communis* sp. nov.; Drybrook Sandstone. 20, Holotype, LD2/029775, Proximal surface. 21, LD2/308797, Proximal surface.

Remarks. The specimens of *C. subalveolaris* from the Drybrook Sandstone have a more restricted size than has previously been recorded for this species: in all other characters they are closely similar. The species is assigned to *Corbulispora* because it displays the typical development of the reticulum and of the trilete mark.

Occurrence. Drybrook Sandstone.

Turma ZONALES (Bennie and Kidston) R. Potonié 1956
Subturma AURITOTRILETES Potonié and Kremp 1954
Infraturma AURICULATI (Schopf) Potonié and Kremp 1954
Genus TRIQUITRITES (Wilson and Coe) Schopf, Wilson and Bentall 1944

Type species. T. arculatus Wilson and Coe 1940.

Triquitrites tricoronatus sp. nov.

Plate 59, figs. 7–10

Holotype. Specimen illustrated as Pl. 59, fig. 7 from the Edgehills coal. Size 58 μ.

Diagnosis. Size (28 specimens) 40–60μ, mean 50μ; amb triangular with convex sides and prominent thickened apices; radial portions of the auriculae frequently bilobate; exine of spore cavity ornamented with scattered rounded projections up to 3μ high and wide; ornament confined to distal and equatorial parts of the spore cavity.

Description. Colour yellow to brown. Outline of spore cavity triangular with straight or convex sides and rounded apices. Exine of spore cavity 1–1·5μ thick, laevigate. Ornament consists of rounded scattered projections up to 3μ high and wide interspersed with conical or baculose elements. Ornament confined to distal and equatorial parts of the spore cavity. Trilete rays prominent, tecta straight, extend almost to margin. Auriculae up to 18μ long in a radial direction: proportion of length to width 0·5:1 to 1·5:1. Radial margin blunted to broadly rounded, frequently bilobate, rarely trilobate. The auriculae may be joined by a narrow thickened zone along the interradial margins, up to 5μ wide, which sometimes overlaps on to the proximal surface of the spore cavity. Radial folds may be present at the apices and, in some cases (e.g. Pl. 59, fig. 10), continue in an arcuate arrangement on to the distal surface (kyrtomes).

Occurrence. Edgehills coal.

Subturma ZONOTRILETES Luber 1935
Infraturma CINGULATI Potonié and Klaus 1954
Genus SIMOZONOTRILETES (Naumova) Potonié and Kremp 1954

Type species. S. intortus (Waltz) Potonié and Kremp 1954.

Simozonotriletes siblyana sp. nov.

Plate 59, figs. 11–13

Holotype. Specimen illustrated as Pl. 59, fig. 11 from the Edgehills coal. Size 35μ.

Diagnosis. Size (37 specimens) 30–45μ, mean 36μ; amb triangular; three radial thickenings meet at the distal pole; equatorial border differentiated into three concentric zones of variable thickness.

Description. Colour yellow to greenish-yellow. Amb triangular with straight, or slightly concave or convex sides and rounded apices. Trilete rays distinct, tecta simple, extend to margin of spore cavity. Proximal surface markedly pyramidal, distal surface oblate. There are three radial thickenings present on the distal surface and they bisect the angles between the rays. Width of thickenings 3–5μ, but they may extend up to 8μ wide at the distal pole. Equatorial border 2–6μ wide and divided into three concentric zones by a narrow central band (rarely greater than 0·5μ wide) which appears lighter in colour than the remainder of the border. Tripartite differentiation not always apparent at low magnifications and is best seen under oil immersion. The radial thickenings arise from either the inner or outer dark zones of the border. Spore often laterally compressed and may result in a fracture along the junction between the spore cavity and the border.

Remarks. This species is dedicated to T. F. Sibly whose work contributed so much to our knowledge of the succession and structure of the Forest of Dean basin.

Occurrence. Edgehills coal.

Genus VALLATISPORITES Hacquebard 1957

Type species. V. vallatus Hacquebard 1957.

Generic description. Radial trilete miospores, amb circular or subtriangular. Exine two-layered; intexine thin and laevigate. Exoexine over the proximal portion of the spore cavity is thin and without structure or sculpture. Over the distal hemisphere it is thickened and usually displays a well-marked infrapunctation. Equatorial border internally vacuolate (Staplin and Jansonius (in press)). Adjacent to the junction with the spore cavity there is a narrow, lighter-appearing 'groove' to which the name *cuniculus* is applied. The cuniculus is located at the equator of the spore cavity and probably represents the space between the margin of the spore cavity and the inner surface of the equatorially expanded exoexine (text-fig. 3). Distal exoexine ornamented with grana, cones, verrucae, or spinose elements. The ornament is sometimes found on the proximal region of the equatorial border as well as on the distal surface. Trilete sutures indistinct; exoexine folded in a characteristic manner above the rays.

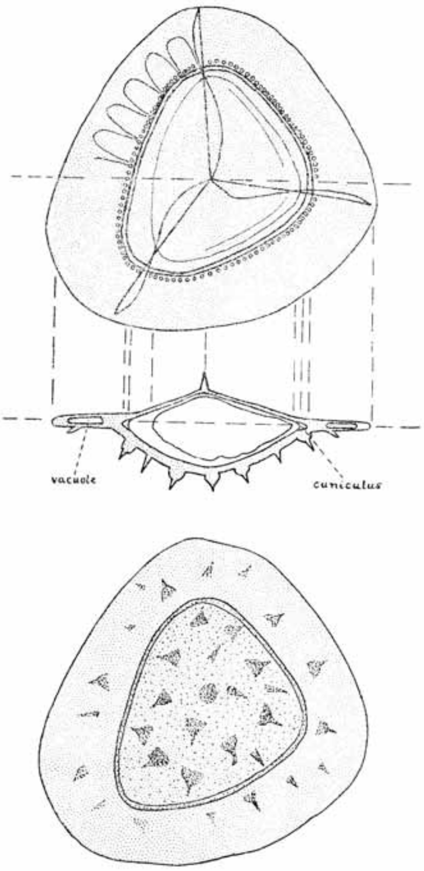
Comparison. Densosporites is distinguished from *Vallatisporites* by the more abrupt thickening of the cingulum, by the less pronounced cuniculus, the usual absence of vacuolation and folds accompanying the rays, and also by the thinner distal exoexine. *Kraeuselisporites* Leschik 1955 as emended by Jansonius (1962, pp. 46–7) bears some resemblance to *Vallatisporites*, but the equatorial border is zonate and lacks the internal vacuolation.

Vallatisporites ciliaris (Luber 1938) comb. nov.

Plate 59, figs. 14, 15

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

Description. Size (18 specimens) 50–70μ, mean 62μ. Amb triangular with convex sides and rounded apices, sometimes almost circular. Trilete rays indistinct on the intexine, tecta sinuous, extend to equator of the spore cavity. Exoexine folded above the rays, folds up to 5μ high at the apex and decrease uniformly in height towards the equator. Folds may terminate at the equator of the spore cavity or continue on to the border. Intexine thin and transparent, folded independently of the exoexine, frequently withdrawn from the margin of the spore cavity. Exoexine over proximal surface of the spore cavity is thin and without structure; over the distal surface it is thickened and possesses a well-marked infrapunctation. Ornamentation usually consists of cones with rounded or pointed crests, up to 3μ high and 3·5μ wide at the base. These cones are interspersed with other elements which consist of a sharply tapered spine on a broad bulbous base. Their shape is reminiscent of the spiked helmet or 'Pickelhaube' worn by the Prussian Guards and have been termed *galeae*. Elements of a similar shape are characteristic of certain genera of the Malvaceae, e.g. *Malvastrum*, *Gossypium*, and *Sida* whose pollen has recently been described and figured by Saad (1960). Galeae differ from mammilate elements by the length of the spine. In certain specimens of this species galeae form the dominant ornamentation. The equatorial border maintains a constant proportion of two-fifths of the total spore radius. The border appears bizonate: there is an inner light zone and an outer dark one. The boundary between the two is irregularly scalloped and close examination reveals that the light zone is formed by the lateral coalescence of adjacent vacuoles. In some areas residual strands still separate the pyriform vacuoles and impart a radially patterned appearance to the light zone. A row of circular pits 0·5μ in diameter lies on the border immediately adjacent to the cuniculus.



TEXT-FIG. 3. Diagrammatic representation of *Vallatisporites ciliaris*, approximately × 800. View of proximal surface, hypothetical cross-section, and distal surface.

Comparison. The species *Vallatisporites* [*Tholisporites*] *foveolatus* comb. nov. (Hughes and Playford 1961) is of comparable size to *V. ciliaris*, but shows an equatorial thinning of the border and the dimensions of the ornament appear to be smaller.

Occurrence. Drybrook Sandstone.

Vallatisporites cf. *ciliaris* (Luber) comb. nov.

Plate 59, fig. 16

Description. Size (5 specimens) 60–70μ. The distal ornamentation of cones and spines is lacking, but in all other characters the spores are similar to *V. ciliaris*.

Occurrence. Drybrook Sandstone.

Vallatisporites communis sp. nov.

Plate 59, figs. 20, 21

Holotype. Specimen illustrated as Pl. 59, fig. 20 from the Drybrook Sandstone. Size 54μ.

Diagnosis. Size (85 specimens) 50–65μ, mean 57μ; thickened infrapunctate exoexine of the distal hemisphere of the spore ornamented with cones, spines, and galeae up to 6μ high and 4μ wide at the base.

Description. Amb triangular with broadly convex sides and rounded apices. Trilete rays indistinct, tecta sinuous, extend almost to the margin of the spore cavity. Exoexine folded above the sutures, folds may continue to the equator of the spore. Distal exoexine thickened and markedly infrapunctate. Ornamentation consists of uniformly tapered spines which reach a maximum of 4μ and galeae which extend up to 5μ in height (usually about 3μ high and wide); elements about 2·5μ apart. In some specimens spines are concentrated in a zone below the margin of the spore cavity and here they may reach up to 6μ in height. Spines and galeae are also present on the equatorial border: typically, there is a higher proportion of spines to galeae on the border. Width of border one-third to one-half the total radius of the spore. Cuniculus well defined.

Comparison. This species differs from *V. ciliaris* by the presence of a well-marked ornamentation on the distal surface of the border and by the smaller size of the elements over the remainder of the region.

Occurrence. Drybrook Sandstone.

Vallatisporites galearis sp. nov.

Plate 59, figs. 17–19

Holotype. Specimen illustrated as Pl. 59, fig. 17 from the Drybrook Sandstone. Size 57μ.

Diagnosis. Size (19 specimens) 50–61μ, mean 55μ; amb subtriangular; ornamentation of large galeae 4–5μ wide at the base and up to 5μ high on the distal surface of the spore cavity, occasional smaller elements on the border; infrapunctation not well marked; border of uniform thickness, internally vacuolate.

Description. Amb triangular with broadly convex sides and rounded apices. Little colour differentiation between the spore cavity and the equatorial border. Trilete rays indistinct, extend to margin of the spore cavity. Thin proximal exoexine folded above the sutures; folds up to 6μ high at the apex and decrease to 2μ at their termini. Distal exoexine only slightly thickened and displays a fine infrastructure. Galeae large, 2–5μ in basal diameter and up to 5μ high; spinose portion about 2μ high, may be incurved, sometimes broken off. Bases of galeae may coalesce. Ornamentation sparse or absent on the equatorial border: small galeae and spines up to 2μ high are often visible at the equator. Width of border is about one-third of the total radius of the spore.

Comparison. The infragranulation of *V. communis* is more prominently displayed and the general size of the ornament is less than in *V. galearis*.

Occurrence. Drybrook Sandstone.

Genus SAVITRISPORITES Bhardwaj 1955

Type species. S. triangulus Bhardwaj 1955.

Synonym. Callisporites Butterworth and Williams 1958.

Remarks. The genus *Callisporites* is believed to be congeneric with *Savitrisporites*. Butterworth and Williams (1958, p. 377) differentiated *Callisporites* from *Savitrisporites* on the basis of the lack of apical thickening and the presence of a comprehensive ornamentation. Re-examination of the type material (kindly placed at the author's disposal by Dr. M. A. Butterworth and Dr. A. V. H. Smith) has established that the ornament in *Callisporites* is restricted to the distal surface. The 'slightly thickened' angles mentioned by Bhardwaj (1955, p. 127) is hardly a character worthy of generic distinction.

Savitrisporites nux (Butterworth and Williams) comb. nov.

Plate 60, figs. 1–5

Description. Size (78 specimens) 30–60μ, mean 47μ; range quoted by Butterworth and Williams (1958, p. 127) was 40–60μ. Amb triangular with straight or slightly concave sides, rarely convex (Pl. 60, fig. 3) and broad rounded apices. Proximal surface pyramidal in shape and is without ornamentation: distal surface convex. Ornamentation is composed of linear elements formed from the basal fusion of rounded cones and verrucae (e.g. Pl. 60, fig. 5); these were described by Bhardwaj (1955, p. 127) as 'peaked ridges'. Ridges up to 30μ long and 3·5μ high: in the majority of cases their length is 4 to 8 times as great as their height. Trilete rays distinct, tecta extend to margin of spore cavity. Broad low elevations (? lips) are present on either side of the rays. Individually they may be up to 5μ wide and maintain a constant breadth to the spore cavity margin. In other cases (Pl. 60, fig. 4), they become expanded into broad lobes at their termini (up to 14μ in total width). Margins of the thickened bands are straight or sinuous. Equatorial border laevigate, one-quarter to half radius of the spore.

Remarks. The size range of *S. triangulus* is given as 53–65μ and therefore lies within the limits of *S. nux*. The ornament of the two species is very similar and forms no basis for differentiation: Bhardwaj (1955, p. 127) in his diagnosis of *S. triangulus* makes no mention of the broad bands associated with the rays, but these are sometimes difficult to see unless the specimen is examined under oil immersion.

The spore figured as *Converrucosisporites triquetrus* (Ibrahim) Potonié and Kremp by Artuz (1959, pl. ii, fig. 16) is probably *S. nux*. The holotype of *Lycospora percusa* (Horst) Potonié and Kremp (in Horst 1955, pl. 24, fig. 74) is poorly illustrated but appears to have a similar organization to *S. nux*. *S. major* Bhardwaj 1957 and its probable synonym *Dictyotriletes camptotus* Alpern 1948 are larger and have more rounded outlines.

Occurrence. Edgehills coal.

Savitrisporites asperatus sp. nov.

Plate 60, figs. 6–8

Holotype. Specimen illustrated as Pl. 60, fig. 7 from the Edgehills coal. Size 40 μ.

Diagnosis. Size (53 specimens) 30–47μ, mean 40μ; amb subtriangular; distal surface irregularly thickened, proximal surface smooth; broad thickened bands accompany the rays and are expanded at their termini; equatorial region often ill-defined.

Description. Reddish-brown in colour. Amb triangular with concave or convex sides and round or blunted apices. Trilete rays sometimes obscured by body colour, vertex may be raised, tecta sinuous, extend almost to margin. Broad thickened bands (? lips) are present on both sides of the rays, 2–5μ wide, and often expanded into pad-like thickenings at the apices. Proximal surface markedly pyramidal, distal portion oblate. No distinct ornamentation elements can be recognized in the distal sculpture, but differences in the thickness of the exine are revealed by variation in the density of the colour. The area around the distal pole is often unthickened. Equatorial border sometimes obscured by overlapping distal ornamentation. Margin smooth to irregular. Spores often obliquely preserved.

Comparison. *S. asperatus* differs from *S. nux* by being smaller in size, having a more disorganized distal sculpture and more prominent labiate structures. It is possible that *S. asperatus* may be an abortive or immature form of *S. nux*.

Occurrence. Edgehills coal.

Genus BELLISPORES Artuz 1957

Type species. *B. bellus* Artuz 1957.

Generic description. Spores radial, trilete, lenticular in polar section. Amb triangular with straight or concave sides. Trilete rays prominent, tecta long and straight. Three

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EXPLANATION OF PLATE 60

All figures × 500 unless otherwise stated.

Figs. 1–5. *Savitrisporites nux* (Butterworth and Williams) comb. nov.; Edgehills coal. 1, UD3/153708, Distal surface. 2, UD2/263702, Distal surface. 3, UD2/465764, Distal surface. 4, 5. SMUD/3, × 1,000. 4, Proximal surface. 5, Distal surface.

Figs. 6–8. *Savitrisporites asperatus* sp. nov.; Edgehills coal. 6, SMUD/4. Distal surface. 7, Holotype, UD2/452650, Distal surface, 8, UD2/277663, Proximal surface.

Figs. 9–11. *Bellispores bellus* Artuz 1957; Edgehills coal. 9, 11. UD5/232830, Distal surface. 9, × 1,000, 10, UD7/372726, Proximal surface.

Fig. 12. *Cirratriradites saturni* (Ibrahim) Schopf, Wilson and Bentall 1944; Edgehills coal. UD1/032771, Distal surface.

Figs. 13–15. *Crassispora kosankei* (Potonié and Kremp) Bhardwaj 1957; Edgehills coal. 13, UD3/216680, Proximal surface. 14, SMUD/5, Distal surface. 15. SMUD/6, Proximal surface.

Fig. 16. *Laevigatosporites maximus* (Loose) Potonié and Kremp 1955; Edgehills coal; UD9/079799, Lateral view.

radial thickenings are located on the distal surface. Equatorial border narrow, of uniform thickness.

Bellispores bellus Artuz 1957

Plate 60, figs. 9–11

1957 *Simozonotriletes trilinearis* Artuz , p. 251, pl. 5, fig. 36.

Description. Size (53 specimens) 28–45μ, mean 36μ. Amb triangular with concave sides and rounded apices. Trilete rays distinct, tecta exceed four-fifths of the radius of the spore cavity. Exine of proximal and distal surfaces laevigate. Radial thickenings usually well defined (Pl. 60, figs. 9, 11), but may sometimes be indistinct (Pl. 60, fig. 10). Width of thickenings vary between 2–6·5μ, most commonly 3–5μ; maximum height about 4μ. The margins of the thickenings may be irregularly sinuous and are frequently more concave than the equator of the spore. The radial bands usually continue to the equator. Equatorial border 3–5μ wide. Irregularly distributed punctations (0·5μ in diameter) and short narrow grooves (up to 1·5μ long) are present on the radial thickenings (Pl. 60, fig. 9) and near the inner boundary of the border; elsewhere they are less common.

Comparison. B. bellus may most easily be distinguished from *Bellispores* [*Lycospora*] *nitidus* (Horst) comb. nov. by the greater concavity of the radial thickenings.

Occurrence. Edgehills coal.

Infraturma ZONATI Potonié and Kremp 1954
Genus CIRRATRIRADITES Wilson and Coe 1940

Type species. C. maculatus Wilson and Coe 1940.

Cirratriradites saturni (Ibrahim) Schopf, Wilson, and Bentall 1944

Plate 60, fig. 12

Description. Size (23 specimens) 60–93μ, mean 76μ; amb rounded triangular. Trilete rays distinct, folds accompany the rays and extend into the zona. Spore cavity infragranular, frequently pitted due to corrosion. Zona 8–11μ wide, but may extend up to 20μ wide at the apices. One clearly marked fovea is present at the distal pole, 20–23μ in diameter, surrounding wall 2μ wide. Occasionally two foveae are visible.

Occurrence. Edgehills coal.

Infraturma CRASSITI Bharadwaj and Venkatachala 1961
Genus CRASSISPORA Bhardwaj 1957

Type species. C. ovalis Bhardwaj 1957.

Generic description. Radial trilete miospores. Amb circular to oval or roundly triangular. Exoexine finely to coarsely infrapunctate; crassitudinous thickening present at the equator. Distal surface ornamented with cones and, occasionally, spines; proximal surface without ornamentation. Intexine thin and translucent, outline rarely seen; margin conformable to equator of the spore. Apical papillae visible in intertectal areas.

These are particularly well seen in over-macerated specimens (Wilson and Venkatachala (in press)). Trilete rays usually indistinct, sometimes accompanied by folds.

Remarks. Until recently, *Crassispora* had generally been regarded as an Upper Carboniferous genus, but now it is known to occur in the Lower Carboniferous successions of Spitzbergen and Britain. Bhardwaj and Venkatachala (1961) have reported *C. vestita* and *C. spitsbergense* from the Tournaisian of Spitsbergen. The Viséan rocks of that area were characterized by *Crassispora* [*Spinozonotriletes*] *balteata* (Playford 1963) comb. nov. Forms similar to *C. balteata* have been recorded from the Lower Limestone Shales of Tournaisian age from the Forest of Dean by Sullivan (1964). *Crassispora* [*Apicutatispora*] *maculosa* (Knox 1950) comb. nov. has a widespread occurrence in Upper Viséan and Namurian A rocks of Britain.

Crassispora kosankei (Potonié and Kremp) Bhardwaj 1957

Plate 60, figs. 13–15

Description. Size (50 measured specimens) 45–70μ, mean 60μ. Distal ornamentation of broad based cones up to 1·5μ high and wide with occasional spines and mammilate elements. Exine has a well-marked infrapunctation. Trilete rays indistinct, sometimes accompanied by folds (Pl. 60, fig. 15) or may have a triangular gape at the apex. Between the tecta three circular, darker-appearing areas are visible: these are the apical papillae. They often have a resinous texture and measure 2–2·5μ in diameter. There is a crassitudinous thickening of the exoexine at the equator which occupies a fifth to a third of the total radius; inner margin of thickening ill-defined. Intexine thin and translucent, often difficult to detect; only rarely is its boundary well displayed (Pl. 60, fig. 14). Secondary folds common.

Remarks. The dimensions of the specimens from the Edgehills coal span the interval between the size limits of the two species *C. kosankei* (65–85μ) and *C. ovalis* (45–55μ). These two species are otherwise indistinguishable and it seems doubtful whether they should be retained as separate entities.

Occurrence. Edgehills coal.

Turma MONOLETES Ibrahim 1933
Subturma AZONOMONOLETES Luber 1935
Infraturma LAEVIGATIMONOLETI Dybová and Jachowicz 1957
Genus LAEVIGATOSPORITES Ibrahim 1933

Type species. *L. vulgaris* Ibrahim 1933.

Laevigatosporites maximus (Loose) Potonié and Kremp 1955

Plate 60, fig. 16

Description. Size (21 specimens) 110–138μ, mean 122μ. Exine yellow in colour, laevigate. Crescentic secondary folds common. Monolete suture three-quarters to four-fifths long axis of the spore.

Occurrence. Edgehills coal.

Anteturma POLLENITES R. Potonié 1931
Turma SACCITES Erdtman 1947
Subturma MONOSACCITES (Chitaley) Potonié and Kremp 1954
Infraturma TRILETISACCITI Leschik 1955
Genus AURORASPORA Hoffmeister, Staplin and Malloy 1955

Type species. A. solisortus Hoffmeister, Staplin and Malloy 1955.

Auroraspora balteola sp. nov.

Plate 61, figs. 1–3

Holotype. Specimen illustrated as Pl. 61, fig. 1 from the Edgehills coal. Size 105μ.

Diagnosis. Size (51 specimens) 85–125μ, mean 110μ; amb circular, subtriangular or oval; spore body three-quarters total radius of the spore; exine of spore body and saccus minutely infrapunctate; trilete rays half to three-quarters radius of the spore; saccus 1·5–2μ thick.

Description. Colour pale yellow to brown. Colour contrast between spore body and saccus is variable; in most specimens (e.g. Pl. 61, fig. 1) the spore body is only slightly darker than the enclosing saccus, while in others (Pl. 61, figs. 2, 3) the spore body appears much darker. Exine of saccus infrapunctate; about 1·5–2μ thick. Spore body eccentrically placed. Secondary folds common: in a typical arrangement there is a parallel-sided fold along whole or part of the equator and crescentic folds elsewhere over the spore body. The saccus is folded independently of the spore body over the distal hemisphere and over much of the proximal surface. The saccus may be attached to the spore body at the proximal pole or possibly along the rays. Spore body circular or subtriangular in outline, about three-quarters total radius of the spore. Exine laevigate to finely infrapunctate. Trilete rays thread-like, straight, extend from a half to two-thirds radius of spore body; tecta frequently torn apart at the apex.

Comparison. A. solisortus is smaller and the proportion of the spore body to the saccus is less than for *A. balteola*. *Endosporites golatensis* Staplin 1960 is similar to *A. balteola* in the spore body/saccus ratio and in the nature of the secondary folds, but is larger (108–140μ).

Occurrence. Drybrook Sandstone.

Genus SCHULZOSPORA Kosanke 1950

Type species. S. rara Kosanke 1950.

Schulzospora ocellata (Horst) Potonié and Kremp 1956

Plate 61, figs. 4, 5

Description. Size (78 specimens) 55–100μ, mean 78μ. Amb circular to oval, outline of spore body also circular to oval. Proportion of the minimum to maximum diameter of the grains varied from 1 : 1·2 to 1 : 2·2. The oval form (Pl. 61, fig. 4) resembles the holotype of *S. ocellata* and in these forms the tilt of the spore body is usually more pronounced. Elliptical specimens (Pl. 61, fig. 5) approach the shape of *S. campyloptera*

(Luber) Potonié and Kremp, but their size is usually below the lower limit (90μ) for that species.

Occurrence. Drybrook Sandstone.

Genus FLORINITES Schopf, Wilson and Bentall 1944

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

Florinites spp.

Plate 61, figs. 6–8

Description. Size (38 specimens) 53–101μ. Specimens varied in the shape of the grain, prominence of spore body, axis of elongation of the spore body, and the relative proportions of the spore body diameter to the maximum diameter of the grain. The number of specimens was inadequate to allow full taxonomic treatment and brief descriptions only of the various members of the assemblage are given below.

Forms similar to *F. antiquus* are illustrated in Pl. 61, figs. 6, 7. They measured from 63–101μ and had a circular spore body whose radius was approximately equal to the circum-equatorial width of the saccus. In other spores (Pl. 61, fig. 7), the folded spore body had a spindle-shaped outline: their maximum diameter was 53–91μ. Specimens of *F. pumicosus* (Ibrahim) Potonié and Kremp in which no spore body was apparent ranged from 72–100μ along their long axis.

Occurrence. Edgehills coal.

Turma ALETES Ibrahim 1933
Subturma AZONALETES (Luber) Potonié and Kremp 1954
Infraturma PSILONAPITI Erdtman 1947
Genus FABASPORITES gen. nov.

Type species. *F. pallidus* gen. et sp. nov.

Generic diagnosis. Amb oval, sometimes circular. Exine thin, laevigate, or may bear dispersed grana. No monolete mark visible. Exine folded: usually there is a single fold located along the major axis of the spore.

EXPLANATION OF PLATE 61

All figures ×500 unless otherwise stated.

Figs. 1–3. *Auroraspora balteola* sp. nov.; Drybrook Sandstone. 1, Holotype, LD2/359807, Proximal surface. 2, LD2/332692, Proximal surface. 3, LD2/041712, Proximal surface.

Figs. 4–5. *Schulzospora ocellata* (Horst) Potonié and Kremp; Drybrook Sandstone. 4, LD2/237665, Distal surface. 5, LD2/231838, Proximal surface.

Figs. 6–8. *Florinites spp.*; Edgehills coal. 6, UD1/273826. 7, UD2/305682. 8, UD3/287683.

Figs. 9–11. *Fabasporites pallidus* gen. et sp. nov.; Edgehills coal. 9, UD2/357633. 10, UD10/360715, ×1,000. 11, Holotype, UD1/397678, ×1,000.

Figs. 12–13. *Cribrosporites cribellatus* gen. et sp. nov.; Drybrook Sandstone. 12, Holotype, LD2/153740, Proximal surface. 13, LD7/188749, Proximal surface.

Comparison. This genus is distinguished from *Aletes* Somers 1953 and *Inaperturopollenites* (Thompson and Pflug) Potonié 1958 by the presence of the single longitudinal fold.

Remarks. At low magnifications the fold of the exine resembles a monolete mark. This feature coupled with the bean-shaped outline can cause the spores to be mistaken for *Laevigatosporites*. The location of the fold is presumably controlled by some inherent weakness in the exine.

Fabasporites pallidus gen. et sp. nov.

Plate 61, figs. 9–11

Holotype. Specimen illustrated as Pl. 61, fig. 11 from the Edgehills coal.

Diagnosis. Size (50 measured specimens) 13–23μ, mean 17μ; amb usually oval, sometimes circular; exine thin, less than 0·5μ; in their most frequent preservation the spores have a single longitudinal fold.

Description. Amb oval, only rarely circular (Pl. 61, fig. 9). Exine pale and translucent, less than 0·5μ thick. Exine essentially laevigate, but there may be low, dome-shaped granules dispersed over parts of the exine. Folding of the exine is invariably present: folds are crescentic, usually 0·5–1μ high. The most frequent mode of preservation is illustrated in Pl. 61, fig. 11. The spore assumes a pseudo-bilateral symmetry: the bean-shaped outline is clearly evident and the single fold along the long axis simulates a monolete suture. Other minor plications are sometimes visible (Pl. 61, fig. 10).

Occurrence. Edgehills coal.

INCERTAE SEDIS

Genus CRIBROSPORITES gen. nov.

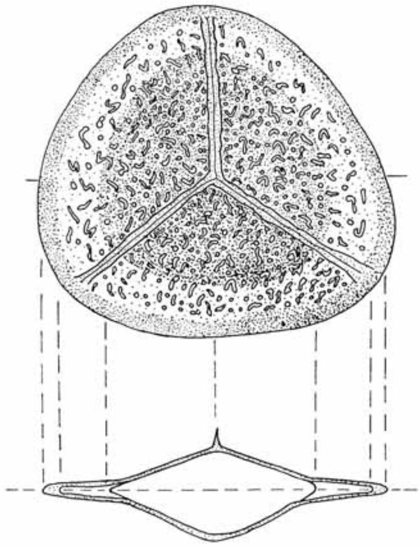
Type species. *C. cribellatus* gen. et sp. nov.

Generic diagnosis. Radial trilete miospores which have a circular or convexly triangular outline. Exine two-layered: exoexine ornamented with punctae and short sinuous channels (fragmenti-vermiculate sculpture), intexine thin and barely discernible. Folds usually accompany the rays.

Comparison. The ornament of the exoexine is similar to that described for *Foveosporites* Balme 1957, but in this genus the intexine is not visible. *Retispora* Staplin 1960 has a well-defined spore body and has a differentiation of ornament on the proximal and distal surfaces. The ornament on the proximal surface is described as granulose, and on the distal surface it varies from granulose punctate to strongly reticulate.

Remarks. The presumed structure of the genus is given in text-fig. 4. On the basis of this interpretation it cannot be assigned satisfactorily to any existing supra-generic taxon below the rank of subturma. A saccus in the strict definition of the term is not present and the spore can hardly be described as 'zonate' because there is no extension of the exoexine at the equator.

It is believed that a similar structure is displayed by other genera, particularly those which occur in the Devonian and Lower Carboniferous. *Grandispora* Hoffmeister, Staplin and Malloy 1955 and *Discernisporites* Neves 1958 serve as typical examples. Spores such as these which are characterized by an equatorial separation of the exine layers are being studied by a working group of the 'Commission Internationale de Microflore du Paleozoïque' as part of a more comprehensive project concerned with



TEXT-FIG. 4. Diagrammatic representation of *Cribrosporites cribellatus*, approximately ×750. Proximal view and hypothetical cross-section.

cavate spores. For this reason further discussion of the taxonomic position of these genera is postponed until their findings have been made known.

Cribrosporites cribellatus gen. et sp. nov.

Plate 61, figs. 12, 13; text. fig. 4

Holotype. Specimen illustrated as Pl. 61, fig. 13 from the Drybrook Sandstone. Size 54μ.

Diagnosis. Size (13 specimens) 53–88μ, mean 64μ; amb subtriangular; tecta accompanied by folds; exine punctuate with pits 0·5μ in diameter and short sinuous channels up to 3μ long; margin of intexine indistinct.

Description. Amb rounded triangular with broad convex sides and well-rounded apices; some specimens have an almost circular outline. Exoexine 1·5μ thick, ornamented with small circular pits and narrow channels (fragmenti-vermiculate sculpture). The channels which are the more common element appear to form by the lateral coalescence of adjacent punctae: channels may be straight, arcuate, geniculate, or meandering. They vary from 1–3μ in length and are 0·5μ wide. The diameter of the punctae remain constant at 0·5μ. Approximately 10–13 elements lie along one radius of the spore. Intexine thin and translucent, margin indistinct, about two-thirds total radius of the spore. Trilete rays accompanied by conspicuous folds up to 4·5μ wide and 4μ high and which frequently extend to the equator.

Occurrence. Drybrook Sandstone.

THE SPORE ASSEMBLAGE FROM THE DRYBROOK SANDSTONE

The following forty-one species (eleven new) were recorded from the preparation of the shale in the Drybrook Sandstone:

Leiotriletes implumis type A Staplin 1960, *L. inermis* (Waltz) Ishchenko 1952, *L. inflatus* (Schemel) Potonié and Kremp, *L. tumidus* Butterworth and Williams 1958, *L. plicatus* sp. nov., *L. pyramidatus* sp. nov.
Punctatisporites platirugosus (Waltz) comb. nov., *P. subobesus* Lele and Walton 1962, *P. ocellatus* sp. nov.
Granulatisporites parvigranulatus Staplin 1960
Lophotriletes tribulosus sp. nov.
Waltzispora planiangulata sp. nov., *W. prisca* (Kosanke) comb. nov.
Anaplanisporites denticulatus sp. nov.
Apiculatisporis globulus Butterworth and Williams 1958
Neoraistrickia drybrookensis sp. nov.
Camptotriletes verrucosus Butterworth and Williams 1958
Convolutispora florida Hoffmeister, Staplin and Malloy, 1955, *C. mellita* Hoffmeister, S. and M. 1955, *C. tessellata* Hoffmeister, S. and M. 1955.
Microreticulatisporites densus (Love) comb. nov., *M. microreticulatus* Knox 1950, *M. parvirugosus* Staplin 1960, *M. punctatus* Knox 1950, *M. reticulopunctatus* Hoffmeister, S. and M. 1955.
Dictyotriletes spinifer Staplin 1960
Corbulispora subalveolaris (Luber) Sullivan 1964 (in press)
Densosporites covensis Berry 1937
Anulatisporites anulatus (Loose) Potonié and Kremp 1954
Lycospora uber (Hoffmeister, S. and M. 1955) Staplin 1960
Knoxisporites stephanephorus Love 1960, *K. triradiatus* Hoffmeister, S. and M. 1955
Vallatisporites ciliaris (Luber) comb. nov., *V.* cf. *ciliaris* (Luber) comb. nov., *V. communis* sp. nov., *V. galearis* sp. nov.
Auroraspora solisortus Hoffmeister, S. and M., *A. balteola* sp. nov.
Schulzospora ocellata (Horst) Potonié and Kremp 1956
Cribrosporites cribellatus gen. et sp. nov.
Didymosporites scotti Chaloner 1958

Lycospora, mainly as *L. uber*, was the principal component and constituted 65 per cent. of the total. *Punctatisporites platirugosus* (26 per cent.) was the next most common species. The percentages of *Schulzospora ocellata* and *Convolutispora mellita* were 2 per cent. and 3 per cent. respectively.

The Age of the Drybrook Sandstone

The Drybrook Sandstone assemblage is similar in composition to the spore floras described by Love (1960) from the Lower Oil-shale Group of Scotland. Both microfloras belong to the *Camptotriletes verrucosus* zone as defined by Butterworth and Millott (1960) and are of lower Upper Viséan in age. The occurrence of such species as *Rotaspora* *sp.* and *Procoranaspora fasciculata* in the Lower Oil-shale Group indicates that it may occupy a slightly higher stratigraphical position. The assemblages recorded by Hoffmeister, Staplin, and Malloy (1955), Butterworth and Williams (1958), and Staplin (1960) are still younger in age.

Surprisingly, the preparations of the Drybrook Sandstone of Puddlebrook described by Lele and Walton (1962) possess few elements in common with the assemblage from Plump Hill. *Punctatisporites subobesus*, *Anulatisporites anulatus*, and *Lycospora* species seem to be the only ones to occur in both. The spore they call cf. *Cirratriradites sp.* could possibly be *Vallatisporites* cf. *cillaris*.

Lele and Walton have suggested that the evidence of their macroflora and of the spore assemblage indicated that the Drybrook Sandstone occupied a horizon low in the Mississippian and certainly lower than the stratigraphical position assigned to it on the basis of brachiopods. However, it is doubtful whether such a conclusion is justified. The macroflora of the Drybrook Sandstone is similar to that of the Lower Brown Limestone of North Wales (Lacey 1962) and, although a precise age is lacking, they are almost certainly of Middle to Upper Viséan. The presence in their assemblage of ten of the thirteen genera recorded by Knox (1959) from the base of the Calciferous Sandstone Series does not prove equivalence, since all the genera are long ranging and extend throughout much of the Carboniferous. The apparent simplicity of the assemblage which was dominated by *Punctatisporites* and azonate genera would appear to be a function of ecology rather than stratigraphy.

THE SPORE ASSEMBLAGE FROM THE EDGEHILLS COAL

The following forty-three species (seven new) were recorded from the Edgehills coal:

Leiotriletes cf. *priddyi* (Berry) Potonié and Kremp 1955
Punctatisporites punctatus Ibrahim 1933, *P. sinuatus* (Artuz) Neves 1961
Calamospora breviradiata Kosanke 1950, *C. microrugosa* (Ibrahim) Schopf, Wilson, and Bentall 1944, *C. mutabilis* (Ibrahim) Schopf, W. and B. 1944, *C. pallida* (Loose) Schopf, W. and B. 1944
Granulatisporites granulatus Ibrahim 1933, *G.* cf. *microgranifer* Ibrahim 1933, *G. parvus* (Ibrahim) Potonié and Kremp 1955
Cyclogranisporites cf. *minutus* Bhardwaj 1957
Lophotriletes commissuralis (Kosanke) Potonié and Kremp 1955, *L. microsaetosus* (Loose) Potonié and Kremp 1955, *L. labiatus* sp. nov.
Anapiculatisporites minor Butterworth and Williams 1958
Apiculatisporis variocorneus sp. nov.
Raistrickia digitosa Artuz 1957, *R. fulva* Artuz 1957, R. spp.
Convolutispora florida Hoffmeister, S. and M. 1955
Microreticulatisporites microreticulatus Knox 1950, *M. microtuberosus* (Loose) Potonié and Kremp 1955, *M. reticulopunctatus* Hoffmeister, S. and M. 1955
Dictyotriletes densoreticulatus Potonié and Kremp 1955, *D.* cf. *clatriformis* (Artuz) comb. nov., *D. sagenoformis* sp. nov.
Reticulatisporites polygonalis (Ibrahim) Neves 1964 (in press)
Knoxisporites stephanephorus Love 1960
Triquitrites tricoronatus sp. nov.
Simozonotriletes siblyana sp. nov.
Densosporites covensis Berry 1937
Anulatisporites anulatus (Loose) Potonié and Kremp 1954
Cristatisporites splendidus Artuz 1957

Lycospora pusilla (Ibrahim) Schopf, W. and B. 1944
Bellispores bellus Artuz 1957
Crassispora kosankei (Potonié and Kremp) Bhardwaj 1957
Savitrisporites nux (Butterworth and Williams) comb. nov., *S. asperatus* sp. nov.
Cirratriradites saturni (Ibrahim) Schopf, W. and B. 1944
Reinschospora triangularis Kosanke 1950
Laevigatosporites desmoinesensis (Wilson and Coe) Schopf, W. and B 1944, *L. maximus* (Loose) Potonié and Kremp 1956
Florinites spp.
Fabasporites pallidus gen. et sp. nov.

The assemblage was dominated by *Lycospora pusilla* (65 per cent.), with *Fabasporites pallidus* (12 per cent.) next in order of abundance. Other common constituents, with their approximate percentages were as follows: *Raistrickia spp.* (4 per cent.), *Crassispora kosankei* (3 per cent.), *Savitrisporites nux* (2 per cent.), *Calamospora mutabilis* (2 per cent.), and *Apiculatisporis variocorneus* (1·5 per cent.).

Age of the Edgehills coal

One of the most important stratigraphical indices present was *Cirratriradites saturni*. This species has not so far been recorded below the base of Westphalian A. Dybová and Jachowicz (1957) in their study of coal seams from Lower Namurian A to Westphalian D in Silesia place its appearance at the Westphalian/Namurian boundary. Kosanke (1950) also shows it at a similar horizon in the Illinois succession.

The assemblage of *Florinites* which included *F. antiquus* is indicative of a Westphalian age. This species is most common in Westphalian A and the lower part of Westphalian B; at higher horizons it is replaced by *F. mediapudens* (Loose) and *F. junior* Potonié and Kremp. The species of *Florinites* most frequently encountered in the Namurian (Neves 1961, p. 173) are *F. elegans* Wilson and Kosanke, *F. similis* Kosanke, *F. pumicosus* (Ibrahim), and *F. visendus* (Ibrahim).

Raistrickia digitosa and *R. fulva* were first described from coals of Westphalian A age. They have since been recorded from the Westphalian A of South Wales and from the Namurian C and Westphalian A of the Stainmoor coalfield (Owens and Burgess, in press). The variable assemblage of other *Raistrickia* species, too, is characteristic of Westphalian A. Although such forms as *R. saetosa* and *R. fibrata* are present at higher and lower horizons, they are particularly common at this level.

The species *Apiculatisporis variocorneus* may serve as a useful marker for Westphalian A and Namurian C strata. Forms similar to it are known from the Namurian C of the southern Pennines (Neves 1961), the Westphalian A of Turkey (Artuz 1957, 1959), and from the Westphalian A of Nottinghamshire (A. V. H. Smith, pers. comm.). Smith has also observed *Fabasporites pallidus* in the Westphalian A and B of several British coalfields. The large monolete spore, *Laevigatosporites maximus*, has only been recorded from Westphalian B (Potonié and Kremp 1956, p. 138).

Crassispora kosankei is confined to rocks younger than the base of Namurian B in the southern Pennines (Neves 1961, p. 277). Dybová and Jachowicz (1957, pp. 87–89) also indicate a range above Namurian B for their forms *Apiculatisporites apiculatus* f. *media* and *A. apiculatus* f. *minor* which are conspecific with *C. kosankei*. A recent record (R. Neves, pers. comm.) suggests that in some regions the species extends down into the uppermost part of Namurian A.

The ranges of the species discussed above, together with other species which have a restricted occurrence, are summarized in Table 1. An inspection of this chart reveals

Spore species	Namurian			Westphalian	
	A	B	C	A	B and above
L. commissuralis				×	×
L. microsaetosus			×	×	×
A. minor	×	×	×	×	
A. variocorneus			×	×	
P. papillosus	×			?	
R. digitosa			×	×	
R. fulva			×	×	
M. microtuberosus				×	×
D. densoreticulatus				×	×
C. splendidus				×	
B. bellus				×	
C. kosankei		×	×	×	×
C. saturni				×	×
R. triangularis				×	×
L. maximus					×
F. pallida				×	×
F. antiquus				×	×

TABLE 1. Table to show the known stratigraphical distribution of selected species from the Edgehills coal.

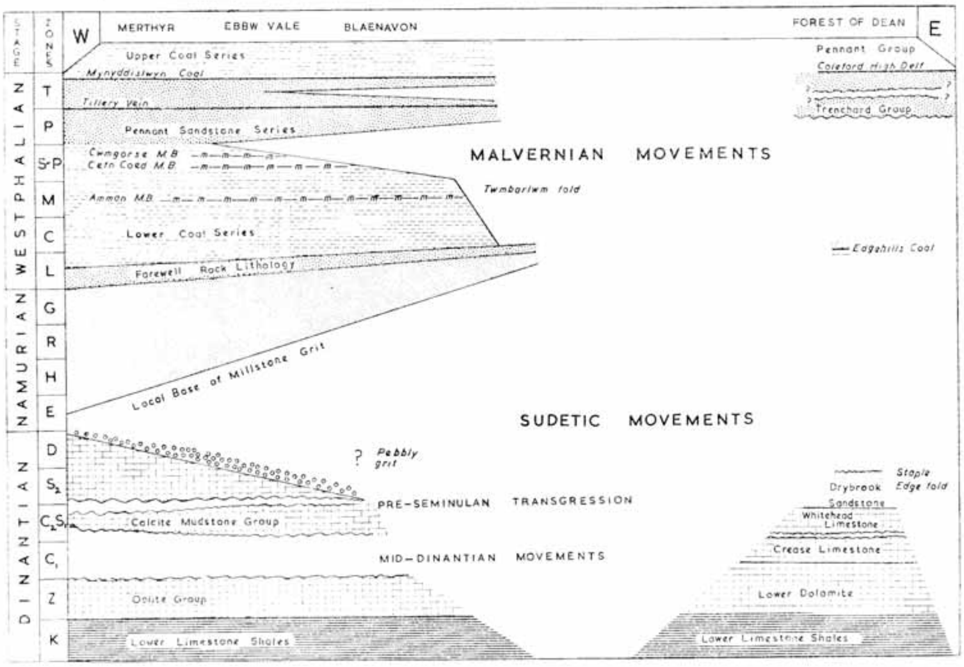
that the most likely age for the Edgehills coal is Westphalian A. The absence in the assemblage of *Cirratriradites aligerens*, *C. difformis*, *Dictyotriletes bireticulatus* and the rarity of *Laevigatosporites desmoinesensis* indicate that the lower part of the stage is represented. In terms of the non-marine lamellibranch scheme of classification, the proposed horizon would be lower to middle Lenisulcata Zone.

The Westphalian A age assigned to the Edgehills coal is borne out by the close similarity displayed by the assemblage to those of the Sulu and Buyuk seams of the Westphalian A of Turkey described by Artuz (1957, 1959). Another Westphalian A assemblage with a comparable composition has been recorded by Jachowicz and Zoldani (1960) from the Zebrak borehole, near Siedlce in Poland.

STRATIGRAPHICAL AND STRUCTURAL CONSIDERATIONS

Sibly (1912) was the first to demonstrate the unconformity below the base of the Trenchard Group although its existence had earlier been suspected by Kidston (1894) and Arber (1912) on palaeontological grounds: Groom (1910, p. 731) also thought it necessary for one to be present to explain satisfactorily the relationship between the Forest of Dean basin and the Newent coalfield.

The youngest rocks previously identified beneath the unconformity were referred to the Drybrook Sandstone and hence were of Seminula Zone age. The lowest horizon above the unconformity from which fossils have been obtained is that represented by the roof shales of the Coleford High Delf seam. The non-marine lamellibranchs indicate the presence of the Tenuis Zone (Trotter 1942, p. 35; Welch and Trotter 1961, p. 90). The plant remains are characteristic of a Westphalian D flora (Trotter 1942, p. 35; Moore in Trueman 1954, p. 139; Welch and Trotter 1961, p. 90) and so substantiate the view that this seam occupies a position high in the Upper Coal Measures of the Geological Survey classification (Stubblefield and Trotter 1957). In the Wigpool syncline, the Coleford High Delf lies approximately 350 feet above the local base of the Trenchard Group. The Trenchard Group has been correlated with the Deri Beds of South Wales



TEXT-FIG. 5. Diagram to illustrate the stratigraphical and structural relationships within the Carboniferous rocks of the eastern portion of the South Wales coalfield and of the Forest of Dean. The line of section is approximately east–west (for localities see text-fig. 6), but the effect of the Twmbarlwm fold which is not directly on the line of section is also shown. The standard palaeontological subdivisions of the British Carboniferous are given in the right-hand column. No attempt has been made to differentiate between the duration of each zone, nor have variations in thicknesses of sediments been depicted. The upper and lower boundaries of the Upper Carboniferous unconformities in South Wales have been somewhat idealized, but show the progressive increase in magnitude in an easterly direction. Sources of data not mentioned in the text are: pebbly grit of possible Seminula or Dibunophyllum Zones age (Jones and Owen 1961, *Proc. Geol. Assoc.*); relationship of the Lower Carboniferous rocks of South Wales (George 1954, *Quart. J. Geol. Soc. Lond.*). An unconformity below the Coleford High Delf in the Forest of Dean is postulated by analogy with South Wales.

(Moore 1948, p. 291) which underlie the Tillery vein and is therefore of Phillipsii Zone age (Sullivan and Moore 1956).

The unconformity at the base of the Trenchard Group on the basis of the above evidence would span the considerable time interval between the Upper Viséan and the Upper Westphalian C. During this interval, the neighbouring areas of South Wales were affected by two major phases of earth movements. The first, the Sudetic phase, was responsible for the unconformity between the Namurian and the Dinantian; the second, which is an intra-Westphalian period of movement has been termed 'Malvernian' by Trueman (1947, p. xcix), and reaches its acme in Phillipsii time and produces the spectacular Pennant Sandstone overstep along the south-east margin of the coalfield (Moore 1948). The magnitude of both unconformities increases in an easterly direction (text-fig. 5).

Since no rocks of an age between these two phases of movement have been recognized in the Forest of Dean, the role played by each of these uplifts in the production of the unconformity below the Trenchard Group has been a matter of speculation. Thus, Trotter (1942, p. 5) believed that the unconformity was the result of folding by Sudetic movements followed by progressive eastward overlap by the Upper Carboniferous strata, and this view is included with minor modifications in the recent Chepstow and Monmouth memoir (Welch and Trotter 1961).

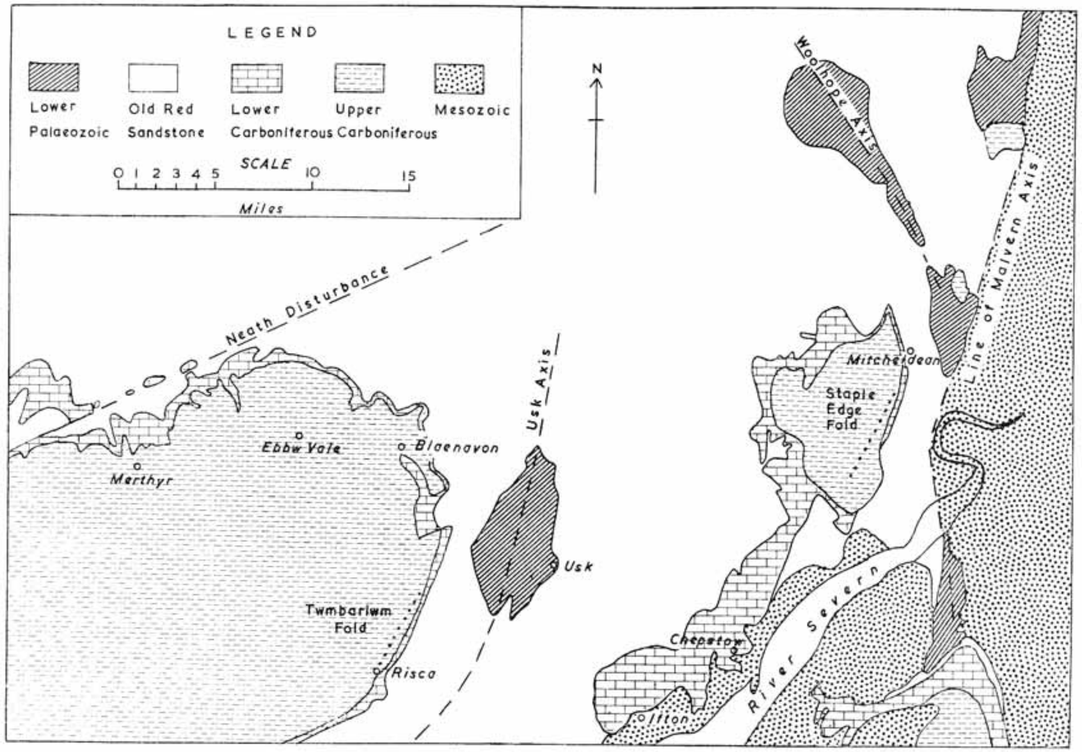
Trueman (1947) recognized the possibility that Upper Carboniferous rocks older than the Trenchard Group may have been deposited in the basin and subsequently removed by denudation. He remarked (p. lxxi) 'The unconformity in the Forest of Dean . . . may reflect the early Morganian [Malvernian], as much as the Sudetic, movements' (the present author's addition in brackets).

Moore (1948, pp. 290–1) on the basis of his revised structural interpretation of the south-east margin of the South Wales coalfield was able to demonstrate the close similarity in facies development and tectonic style between this region and the Forest of Dean. He believed that the Malvernian movements had produced the unconformity at the base of the Trenchard Group.

George (1955) in his analysis of the influence of the Usk anticline on Carboniferous sedimentation has attempted to differentiate the effects produced by the Sudetic and Malvernian movements. He maintains (p. 298) that 'The sub-Namurian structure [of the Usk axis] was a true arch' on the evidence of the almost complete removal of Dinantian strata from the eastern flanks of the South Wales coalfield by the overstepping base of the Namurian, only to reappear in a fairly complete development in the Forest of Dean on the eastern side of the Usk fold. George (pp. 298–9) believes that there was no need to postulate active movements along the Usk line in Westphalian times in order to produce the structural relationships observed in the eastern portion of South Wales and the Forest of Dean. These relationships could be accounted for by either one of the two theories discussed above, i.e. eastward overlap of Namurian and Ammanian strata (Trotter 1942) or Malvernian overstep (Moore 1948).

As Trotter (1942, p. 6) has pointed out, a necessary consequence of the theory of easterly overlap from South Wales of the Upper Carboniferous over denuded folds of Carboniferous Limestone is that there would be little chance of discovering at depth in the Main Basin of the Forest of Dean any Upper Carboniferous strata which were older than those present at the western outcrop. The age of the latter, i.e. the Trenchard Group, is at least high Phillipsii Zone age, and, therefore, no representatives of the Namurian, or Lower and Middle Coal Measures would be expected.

Moore (1948, p. 291) in discussing the significance of the sandstone pipes of Millstone Grit age described from Ifton, near Chepstow, by Dixon (1921), noted that they occurred almost on the same line of longitude as the western outcrop of the Carboniferous



TEXT-FIG. 6. Sketch-map to show the generalized outcrops of the main stratigraphical units in the vicinity of the Forest of Dean and the location of the principal structural features.

Limestone of the Forest of Dean basin (text-fig. 6). Since there was no unconformity between the Millstone Grit and Lower Coal Measures in South Wales, Moore thought it was possible that the Lower Coal Measures could have been partly developed over the area to the east of the South Wales coalfield. He argued (1948, p. 291) 'it may follow, that given sufficient depth, some Millstone Grit or Lower Coal Series may still be preserved in the Forest of Dean basin'.

The sandstones and occasional shales preserved in the limestone fissures at Ifton were assigned by Dixon (1921) to the Basal Grit of the Millstone Grit of South Wales on lithological grounds. The only palaeontological evidence was a sandstone cast of *Lepidophloios* which indicated nothing more than a Carboniferous age. The present discovery of a sandstone of Westphalian A age in the Forest of Dean resurrects a possibility considered but later rejected by Dixon that the Ifton sandstones were of Coal Measures age.

The Cornbrook Sandstone of Titterstone Clee was once equated with the Drybrook Sandstone (Vaughan 1905) and believed to be of Viséan age (Dixon 1917, Kidston 1917). George (1955) demonstrated that the Cornbrook Sandstone was unconformable on the Carboniferous Limestone and on the basis of this stratigraphical relationship, which was analogous with that in South Wales, he believed that the sandstones were of Namurian age. However, Jones and Owen (1961) discovered a Westphalian B macroflora in shales 250 feet below the top of the Cornbrook Sandstone. The estimates for the thickness of the Cornbrook Sandstone vary between 700 feet (Jones and Owen 1961) and 1,000 feet (Dixon 1917). There is no palaeontological evidence for the age of the basal portions of the formation and it is possible that strata equivalent to the Edgehills Sandstone may be present.

The revised interpretation of the succession in the Forest of Dean enables a greater degree of correlation to be made with the eastern part of the South Wales coalfield than has hitherto been possible (Moore 1948; Moore and Blundell 1952). The Edgehills Sandstone is of a similar age to the Farewell Rock of South Wales. It is now believed that the Farewell Rock was the first Upper Carboniferous deposit to extend across the Usk anticline and to reunite the South Wales and Forest of Dean depositional areas: these had been isolated during much of Namurian times by positive movements along the axis of the fold (George 1955, 1956). The succeeding Coal Measures probably also covered the dormant Usk anticline because, as Moore (1948, p. 292) has pointed out 'A thickness of 500–600 feet of Ammanian sediments near the South East Crop does not suggest a nearby limit to the coalfield during this period'. Leitch, Owen and Jones (1958, p. 482) as a result of their analysis of the isopachytes of the Lower Coal Measures remarked that the evidence indicates 'that these eastern regions formed an area of stability with appreciable subsidence occurring to the west and south-west'. However, although they believed that the Usk axis was inactive during this time, they were of the opinion that the basal Coal Measures were never deposited over the Usk or Forest of Dean areas.

The relationship between the Edgehills Sandstone and the Drybrook Sandstone is a reflection of the effects of the Sudetic movements. In the exposures on Plump Hill there is no marked discordance in the dip of the strata and this observation is in accord with the characteristics of the unconformity between the Dinantian and Namurian in South Wales.

Renewed uplift along the line of the axis of the Usk anticline reached a climax in Phillipsii Zone times. These were the Malvernian movements which increased in intensity towards the east (text-fig. 5) and resulted in an easterly overlap of Pennant Sandstone strata over an eroded base of Lower and Middle Coal Measures. There is a pronounced angular unconformity in the south-eastern part of the coalfield associated with the Twmbarlwm fold. West of the Sirhowy valley, the Pennant Sandstone follows the Middle Coal Measures without any apparent break in sedimentation (Moore 1945, Blundell 1952). Recently, Woodland, Evans, and Stephens (1957) have described an important unconformity between the Tillery and Mynyddislwyn coals which again develops in an easterly direction, and in parts of Monmouthshire it is claimed that over 1,000 feet of measures are missing.

The contact between the Trenchard Group and the Edgehills Sandstone is nowhere exposed in the Forest of Dean. However, the overstep of the basal beds of the Trenchard Group over the various divisions of the Lower Carboniferous can be demonstrated on the northern and south-eastern margins of the basin. Since the Edgehills Sandstone rests without apparent discordance on the Drybrook Sandstone it may be assumed that the relationship between it and the Trenchard Group is also one of angular unconformity. It is presumed that uplift along the Malvern axis took place at the same time as the rejuvenation of the Usk anticline and that the unconformity at the base of the Pennant Sandstone and the one at the base of the Trenchard Group can be attributed to the same phases of movements, i.e. Malvernian.

In a recent account of the structural history of the Malverns, Butcher (1962) discounts the influence of the Intra-Westphalian movements and believes that the main folding occurred during the Hercynian orogeny. However, it is necessary to postulate major elevations in pre-Tenuis times to account for the structural relationships within the Forest of Dean basin.

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REFERENCES

ALLEN, K. C. 1961. *Lepidostrobophyllum fimbriatum* (Kidston 1883) from the Drybrook Sandstone (Lower Carboniferous). *Geol. Mag.* **98**, 225–9.

ARBER, E. A. N. 1912. On the fossil flora of the Forest of Dean Coalfield (Gloucestershire) and the relationships of the coalfields of the West of England and South Wales. *Phil. Trans. Roy. Soc.*, B **202**, 233–81.

ARTUZ, S. 1957. Die Sporae dispersae der Turkischen Steinkohle vom Zonguldak-Gebiet. *İstanbul Üniv. Fen Fak. Mecm.*, B, **22**, 4, 239–63.

—— 1959. Zonguldak bölgesindeki Alimolla, Sulu ve Büyük komur damarlarinin sporolojik etüdü. *İstanbul Üniv. Fen Fak. Monograf.*, **15**, 1–73.

BHARDWAJ, D. C. 1955. The spore genera from the Upper Carboniferous coals of the Saar and their value in stratigraphical studies. *Palaeobotanist*, **4**, 29–49.

—— 1957. The spore flora of Velener Schichten (Lower Westphalian D) in the Ruhr Coal Measures. *Palaeontographica*, **B 102**, 110–38.

BHARADWAJ, D. C. and VENKATACHALA, B. S. 1961. Spore assemblage out of a Lower Carboniferous shale from Spitzbergen. *Palaeobotanist*, **10**, 18–47.

BLUNDELL, C. R. K. 1952. The succession and structure of the north-eastern area of the South Wales Coalfield. *Quart. J. Geol. Soc. Lond.* **107**, 307–33.

BUTCHER, N. E. 1962. The tectonic structure of the Malvern Hills. *Proc. Geol. Assoc.* **73**, 103–24.

BUTTERWORTH, M. A. and MILLOTT, J. O'N. 1960. Microspore distribution in the coalfields of Britain. *Proc. Int. Committee for Coal Petrog.* **3**, 157–63.

—— and WILLIAMS, R. W. 1958. The small spore floras of the Limestone Coal Group and Upper Limestone Group of the Lower Carboniferous of Scotland. *Trans. Roy. Soc. Edinb.* **63**, 353–92.

CROOKALL, R. 1939. Lycopodiaceous Stems (? *Cyclostigma kiltorkense* Haughton) from Mitcheldean in the Forest of Dean. *Bull. Geol. Surv.* **2**, 73–75.

DIXON, E. E. L. 1917. The geology of the Titterstone Clee Hill Coal Field. *Trans. Roy. Soc. Edinb.* **51**, 1064–71.

—— 1921. The unconformity between the Millstone Grit and the Carboniferous Limestone at Ifton, Monmouthshire. *Geol. Mag.* **68**, 157–64.

DYBOVÁ, S. and JACHOWICZ, A. 1957. Microspores of the Upper Silesian Coal Measures. *Inst. Geol. Prace*, **23**, 1–328.

GEORGE, T. N. 1955. The Namurian Usk Anticline. *Proc. Geol. Assoc.* **66**, 297–316.

—— 1956. Carboniferous Main Limestone of the East Crop in South Wales. *Quart. J. Geol. Soc. Lond.*, **111**, 309–22.

GROOM, T. T. 1910. The Malvern and Abberley Hills, and the Ledbury District. *Geology in the Field* (London), 698–738.

HOFFMEISTER, W. S., STAPLIN, F. L., and MALLOY, R. E. 1955. Mississippian plant spores from the Hardinsburg formation of Illinois and Kentucky. *J. Paleont.* **29**, 372–99.

HORST, U. 1955. Die Sporae dispersae des Namurs von Westoberschlesien und Mährisch-Ostrau. *Palaeontographica*, **B 98**, 137–236.

HUGHES, N. F. and PLAYFORD, G. 1961. Palynological reconnaissance of the Lower Carboniferous of Spitsbergen. *Micropalaeontology*, **7**, 27–44.

ISHCHENKO, A. M. 1956. Spores and pollen of the Lower Carboniferous deposits of the western extension of the Donetz Basin and their stratigraphical importance. *Akad. Nauk Ukr. S.S.R., Trudy Inst. Geol. Nauk. Ser. Strat. Palaeont.* **11**, 1–185 [in Russian].

——1958. Sporo-pollen analysis of the Lower Carboniferous sediments of the Dnieper–Donetz Basin. Ibid. **17**, 1–188 [in Russian].

JANSONIUS, J. 1962. Palynology of Permian and Triassic sediments, Peace River area, Western Canada. *Palaeontographica*, **B 110**, 35–98.

JACHOWICZ, A. and ZOLDANI, Z. 1960. Notatka o mikroflorze karboneskiej z otworu 'Zebrak'. *Kwart. Geol.* **4**, 662–6.

JEFFORDS, R. M. and JONES, D. H. 1959. Preparation of slides for spores and other microfossils. *J. Paleont.* **33**, 344–7.

JONES, D. G. and OWEN, T. R. 1961. The age and relationship of the Cornbrook Sandstone. *Geol. Mag.* **98**, 285–94.

KELLAWAY, G. A. and WELCH, F. B. A. 1955. The Upper Old Red Sandstone and Lower Carboniferous rocks of Bristol and the Mendips compared with those of Chepstow and the Forest of Dean. *Bull. Geol. Surv.* **9**, 1–21.

KIDSTON, R. 1894. On the various divisions of the British Carboniferous rocks as determined by their fossil flora. *Proc. Roy. Phys. Soc. Edinb.* **12**, 183–257.

—— 1917. The fossil plants of Titterstone Clee Hill Coal Field. *Trans. Roy. Soc. Edinb.* **51**, 1071–84.

KNOX, E. M. 1959. Some aspects of microspore morphology. *Trans. Bot. Soc. Edinb.* **38**, 89–99.

KOSANKE, R. M. 1950. Pennsylvanian spores of Illinois and their use in correlation. *Bull. Ill. State Geol. Surv.* **74**, 1–128.

KRUTZSCH, W. 1959. Mikropaläontologische (Sporenpaläontologische) Untersuchungen in der Braunkohle des Geiseltales. *Geologie*, **8**, Beiheft 21–22, 1–425.

—— 1962. Atlas der mittel- und jungtertiären dispersen Sporen- und Pollensowie der Mikroplanktonformen des nördlichen Mitteleuropas. Veb Deutscher Verlag der Wissenschaften, 1–108.

LACEY, W. S. 1962. Welsh Lower Carboniferous Plants. 1. The flora of the Lower Brown Limestone in the Vale of Clwyd, North Wales. *Palaeontographica*, B **111**, 126–60.

LEITCH, D., OWEN, T. R., and JONES, D. G. 1958. The basal Coal Measures of the South Wales coalfield from Llandybie to Brynmawr. *Quart. J. Geol. Soc. Lond.* **113** [for 1957], 461–86.

LELE, K. M. and WALTON, J. 1962. Fossil flora of the Drybrook Sandstone in the Forest of Dean, Gloucestershire. *Bull. Brit. Mus. (Nat. Hist.), Geol. Series* **7**, 4, 137–52.

LOVE, L. G. 1960. Assemblages of small spores from the Lower Oil-shale Group of Scotland. *Proc. Roy. Soc. Edinb.* **67**, 99–126.

LUBER, A. A. and WALTZ, I. E. 1938. Classification and stratigraphical value of spores of some Carboniferous coal deposits in the U.S.S.R. *Trans. Central Geol. Inst.* **105**, 1–45 [in Russian].

—— 1941. Atlas of microspores and pollen grains of the Palaeozoic of the U.S.S.R. *Trudy All-Union Geol. Sci. Res. Inst. (V.S.E.G.E.I.)*, **139**, 1–107 [in Russian].

MOORE, L. R. 1945. The geological sequence in the South Wales Coalfield: the 'South Crop' and Caerphilly Basin and its correlation with the Taff Valley sequence. *Proc. S. Wales Inst. Eng.* **60**, 141–227.

—— 1948. The sequence and structure of the southern portion of the East Crop of the South Wales Coalfield. *Quart. J. Geol. Soc. Lond.* **103**, [for 1947], 261–300.

—— and BLUNDELL, C. R. K. 1952. Some effects of the Malvernian phase of earth movements in the South Wales Coalfield, a comparison with other coalfields in South Britain. *C.R. 3e Congr. Strat. Géol. Carb., Heerlen*, **2**, 463–73.

NEVES, R. 1961. Namurian plant spores from the Southern Pennines. *Palaeontology*, **4**, 247–79.

—— 1964 (in press). The 'Dispersed Spore' Genus *Knoxisporites* (Potonié and Kremp) Neves 1961. *C.R. 5e Congr. Strat. Géol. Carb., Paris.*

OWEN, T. R. and JONES, G. D. 1961. The nature of the Millstone Grit—Carboniferous Limestone junction of a part of the North Crop of the South Wales Coalfield. *Proc. Geol. Assoc.* **72**, 239–49.

OWENS, B. and BURGESS, I. C. (in press). Stratigraphy and Palynology of the Stainmore Outlier, Westmorland. *Bull. Geol. Surv.*

PLAYFORD, G. 1962. Lower Carboniferous Microfloras of Spitsbergen. Part I. *Palaeontology*, **5**, 550–618.

—— 1963. Part II. Ibid. **5**, 619–78.

POTONIÉ, R. 1956. Synopsis der Gattungen der Sporae dispersae. Teil I.: Sporites. *Beih. Geol. Jahrb.* **23**, 1–103.

—— 1958. Teil II.: Nachträge Sporites, Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates. Ibid. **31**, 1–114.

—— 1960. Teil III.: Nachträge Sporites, Fortsetzung Pollenites. Mit Generalregister zu Teil I–III. Ibid. **39**, 1–189.

—— and KREMP, G. 1955. Die Sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte. Teil I. *Palaeontographica*, **B 98**, 1–136.

—— —— 1956. Teil II. Ibid. **99**, 85–191.

SAAD, S. I. 1960. The Sporoderm Stratification in the Malvaceae. *Pollen et Spores*, **2**, 13–41.

SCHOPF, J. M., WILSON, L. R., and BENTALL, R. 1944. An annotated synopsis of Paleozoic fossil spores and the definition of generic groups. *Rept. Inv. Ill. State Geol. Surv.* **91**, 1–72.

SIBLY, T. F. 1912. The carboniferous succession in the Forest of Dean Coalfield. *Geol. Mag.* **49**, 417–22.

—— 1918. On the geological structure of the Forest of Dean. Ibid. **55**, 23–28.

—— and REYNOLDS, S. H. 1937. The Carboniferous Limestone of the Mitcheldean Area, Gloucestershire. *Quart. J. Geol. Soc. Lond.* **93**, 23–57.

SOMERS, G. 1953. A preliminary study of spores from the Phalen Seam in the New Waterford District, Sydney Coalfield, Nova Scotia. *Second Conference on the Origin and Constitution of Coal, Crystal Cliffs*, 219–41.

STAPLIN, F. L. 1960. Upper Mississippian plant spores from the Golata formation, Alberta, Canada. *Palaeontographica* **B 107**, 1–40.

—— and JANSONIUS, J. (in press). Survey of basic morphologic types of the densospore group of spores.

STUBBLEFIELD, C. J. and TROTTER, F. M. 1957. Divisions of the Coal Measures on Geological Survey Maps of England and Wales. *Bull. Geol. Surv. G.B.*, **13**, 1–5.

SULLIVAN, H. J. 1962. Distribution of miospores through coals and shales of the Coal Measures sequence exposed in Wernddu claypit, Caerphilly (South Wales). *Quart. J. Geol. Soc. Lond.* **118**, 353–73.

—— 1964. (in press). Miospores from the Lower Limestone Shales (Tournaisian) of the Forest of Dean basin, Gloucestershire. *C.R. 5e Congr. Strat. Géol. Carb., Paris.*

—— and MOORE, L. R. 1956. The horizon of the Tillery Vein in Monmouthshire. *Geol. Mag.* **93**, 409–17.

—— and HIBBERT, A. F. 1964. *Tetrapterites visensis*—a new spore-bearing structure from the Lower Carboniferous. *Palaeontology*, **7**, 64–71.

THOMSON, P. W. and PFLUG, M. 1953. Pollen und Sporen des Mitteleuropäischen Tertiärs. *Palaeontographica*, **94**, 1–138.

TROTTER, F. M. 1942. Geology of the Forest of Dean Coal and Iron Ore Field. *Mem. Geol. Surv.* 1–95.

TRUEMAN, A. E. 1933. A suggested correlation of the Coal Measures of England and Wales. *Proc. S. Wales Inst. Eng.* **49**, 63–94.

—— 1947. Stratigraphical problems in the coalfields of Great Britain. *Quart. J. Geol. Soc. Lond.* **103**, lxv–civ.

—— 1954 *The Coalfields of Great Britain*. London. 1–396.

VAUGHAN, A. 1905. The palaeontological sequence in the Carboniferous Limestone of the Bristol Area. *Quart. J. Geol. Soc. Lond.* **61**, 181–305.

WELCH, F. B. A. and TROTTER, F. M. 1961. The geology of the country around Monmouth and Chepstow. *Mem. Geol. Surv.* 1–164.

WETHERED, E. 1883. On the Lower Carboniferous rocks of the Forest of Dean as represented in typical sections at Drybrook. *Quart. J. Geol. Soc. Lond.* **39**, 211–17.

WILSON, L. R. and HOFFMEISTER, W. S. 1956. Plant microfossils of the Croweburg coal. *Okla. Geol. Surv. Circ.* **32**, 1–57.

—— and VENKATACHALA, B. S. (in press) Palynology of the Dawson coal (Pennsylvanian) of Oklahoma.

WOODLAND, A. W., EVANS, W. B., and STEPHENS, J. V. 1957. Classification of the Coal Measures of South Wales with special reference to the Upper Coal Measures. *Bull. Geol. Surv.* **13**, 6–13.

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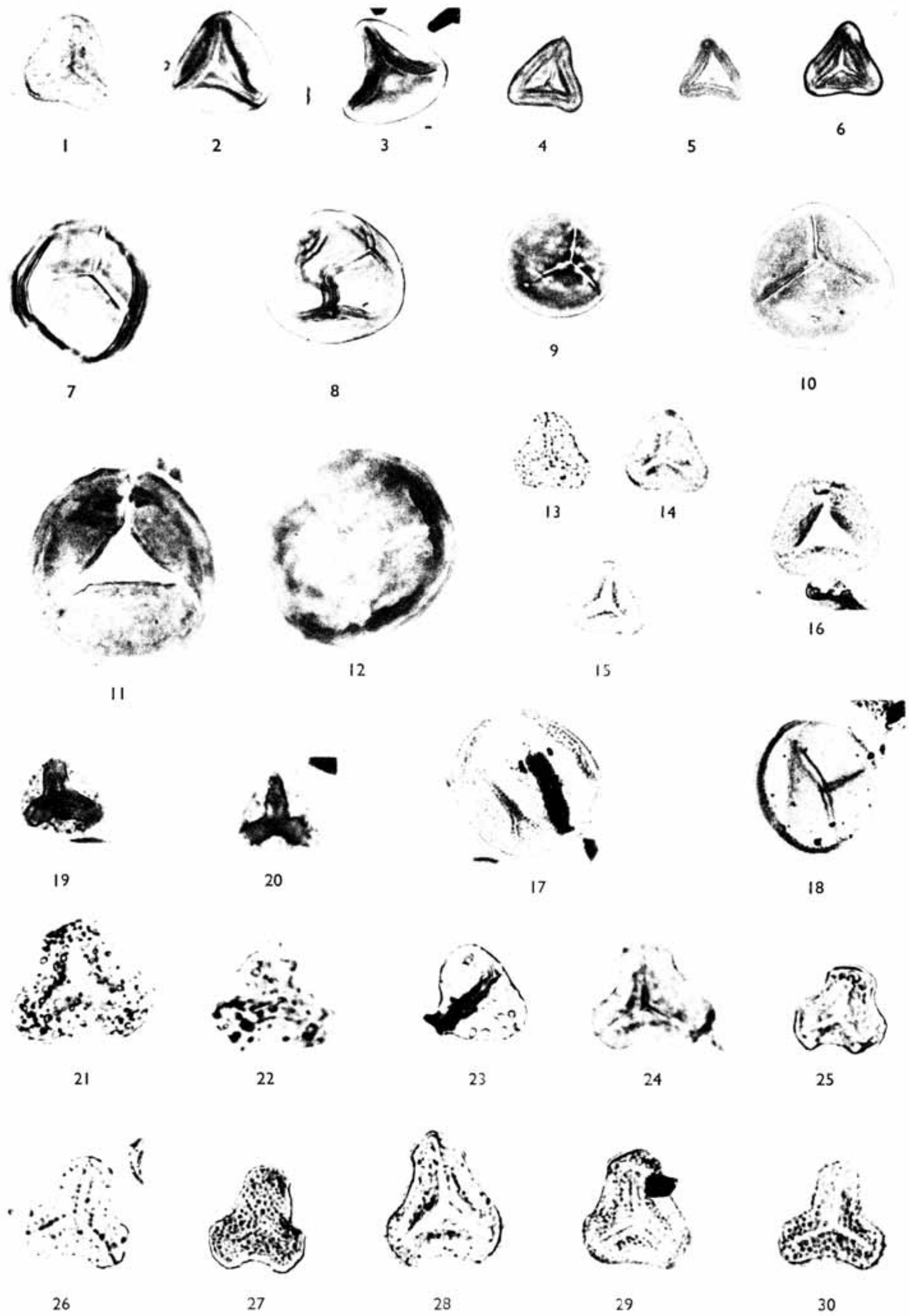

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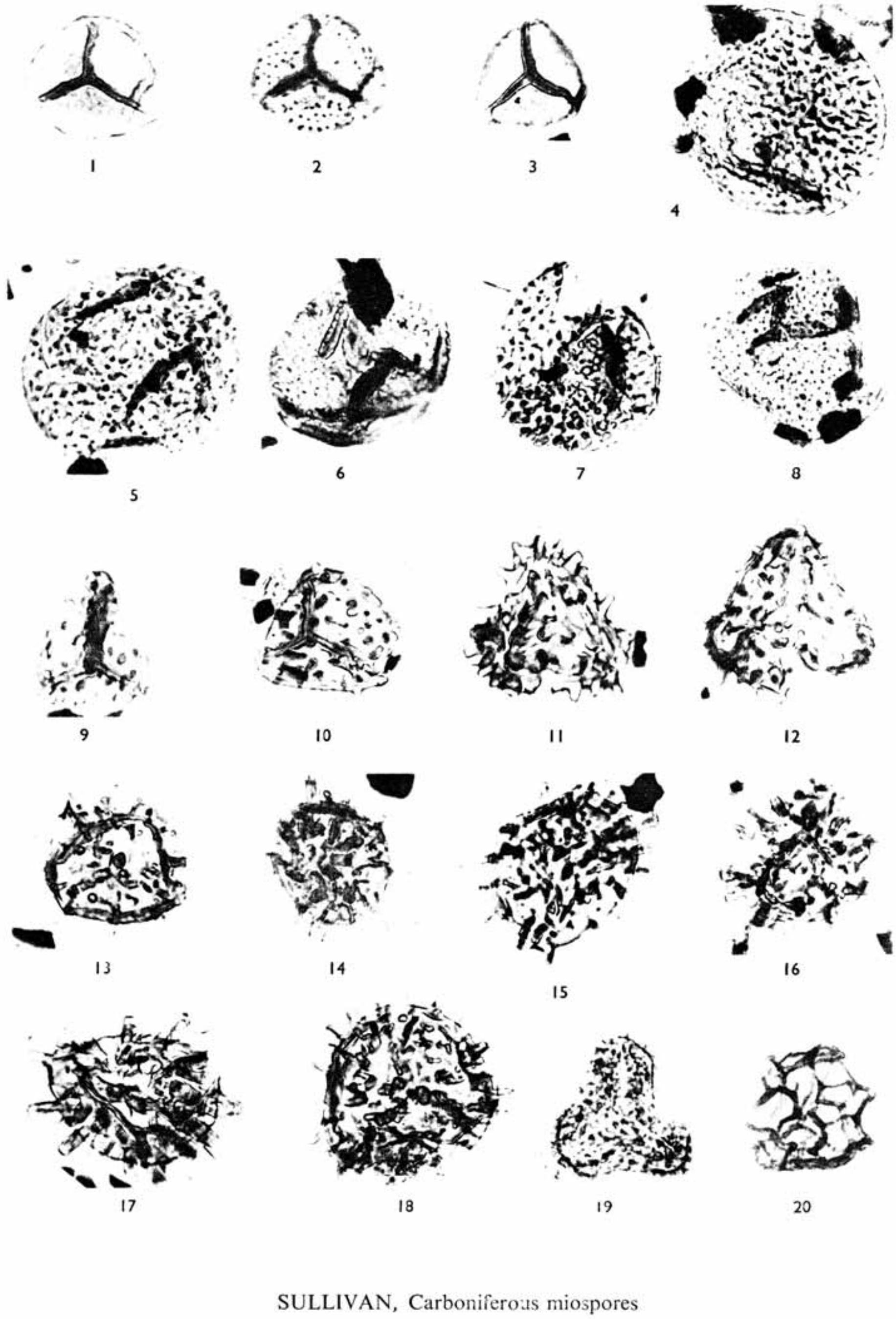

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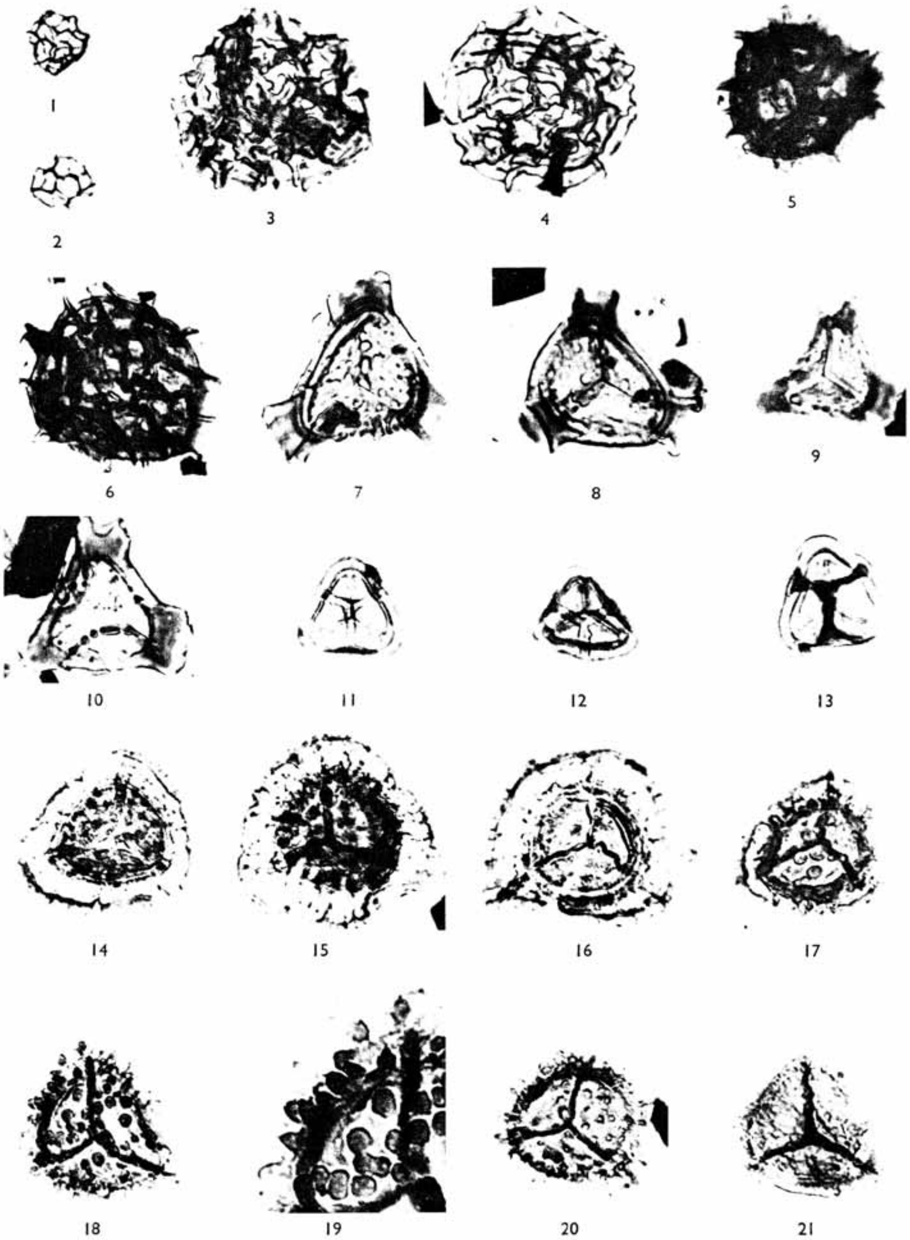

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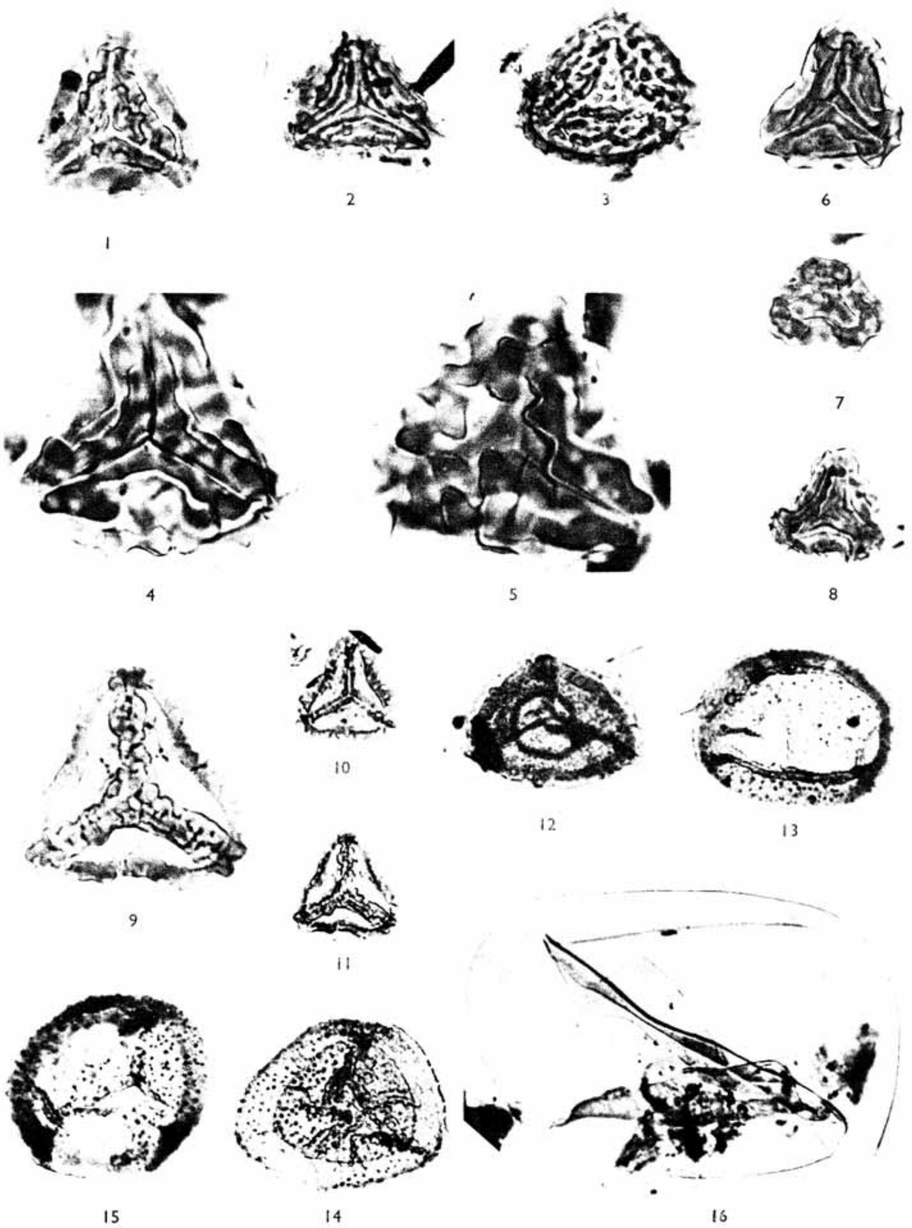

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