NAMURIAN PLANT SPORES FROM THE SOUTHERN PENNINES, ENGLAND

by R. NEVES

ABSTRACT. Selected fossil spores from coals and carbonaceous shales of Namurian age from the Southern Pennines area of England are described, and their stratigraphic ranges given with reference to the standard sequence of goniatite stages. The types of sediment in which the spores are found are recorded, and the apparent association of certain spore types with particular sediments is discussed. Two new series of fossil spores are proposed—Pseudocingulati and Membranati; two new genera—*Secarisporites* and *Hymenospora*—and twenty-seven new species are described and illustrated. Disaccate pollen grains of the *Pityosporites-Vesicaspora* type are recorded for the first time from strata of Namurian age.

THE value of fossil plant spores for purposes of coal-seam correlation has been adequately demonstrated by Kosanke (1950), Balme and Butterworth (1952), and Butterworth and Millott (1954 and 1955). These authors were concerned with typical coal-measures sequences in which the coal seams form a prominent lithological constituent. In other sedimentary successions, however, coal seams are often absent or, if present, are of spasmodic occurrence and limited areal extent. Such is the case in the Namurian succession of the Southern Pennines area of England, where carbonaceous shales provide the most readily available source of fossil spores. The spore assemblages obtained from the thin coals are used to supplement the data obtained from studies of the shales.

Hoffmeister, Staplin, and Malloy (1955) and Neves (1958) have already indicated that the types of spores present and their relative abundance differ considerably in coal seams and closely allied carbonaceous shales. Such an occurrence is to be expected, in that the spores obtained from coal will mainly represent a parent vegetation which, although rich in constituent members, is of a somewhat restricted and specialized nature; the vegetation consisting of plants which are adapted to the swamp environment. It is probable, therefore, that certain spore types produced by a vegetation which existed outside the coal swamps will not be represented in the coal-seam assemblages. However, should some of these spores have been carried into the swamp region by wind or water agencies, their presence will be masked to the observer, by the profusion of spore types dispersed more or less *in situ* from the local swamp vegetation. The allochthonous nature of the shales, on the other hand, implies that the contained fossil spores will be derived from a variety of parent plant associations occupying various ecological stations. The assemblages preserved in shales will be representative of the vegetation which was growing in and around the basin of sedimentation. Consequently the complete microflora and the absolute time ranges of the component forms can only be obtained by an examination of all those sedimentary types which make up the geological succession of the region. In this way the succession of coal swamp vegetations, as represented by the coal seams, will be determined and the characteristics of other contemporaneous vegetation established. The sum total of this combined evidence enables a closer appreciation of the flora to be achieved, and this appears to be an essential criterion in the utilization of microfloral evidence to the problems of stratal subdivision.

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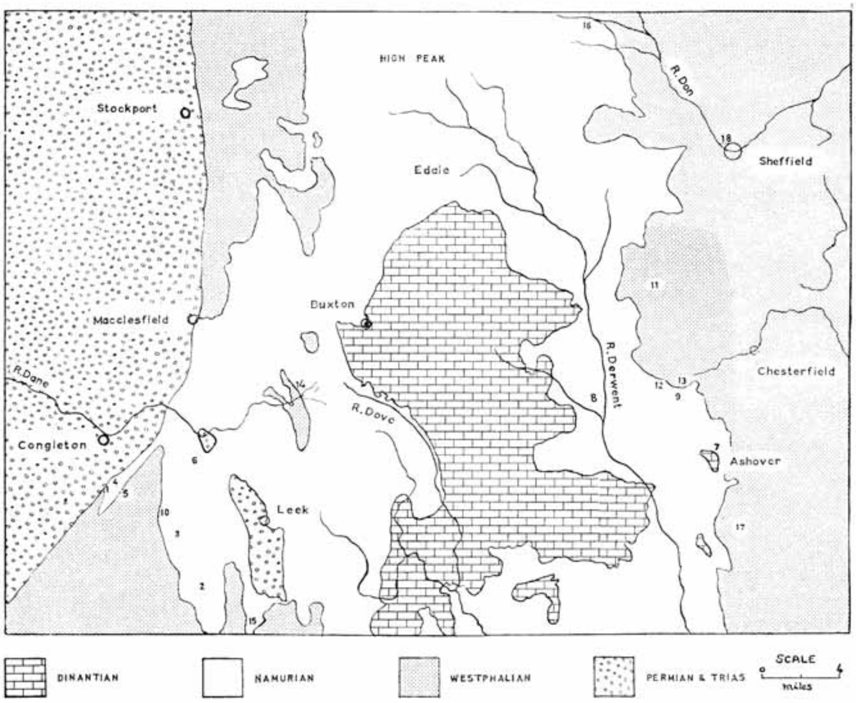
In the present paper, certain new spores are described from coals and shales of Namurian age from the Southern Pennines area of England. The stratigraphical occurrences of these spores in this region, together with several already described species, have been recorded and are shown in Table 1. These spores have been selected on account of their value as stratigraphic indicators and represent a small part of the



TEXT-FIG. 1. Index map of localities and outcrop distribution in the Southern Pennines Basin.

total Namurian microflora. The sequence of goniatite stages, which is used as the basis for Table 1, is that proposed by Bisat (1928, p. 117) and subsequently redefined by Hudson and Cotton (1943, p. 152).

The majority of the samples used during the investigation were collected by the author from outcrop and mine exposures which are described in literature and are listed below. Other samples were kindly provided by Dr. R. M. C. Eagar from the Wigan district in the west of the region. A sketch map of the region (text-fig. 1) indicates sample localities and the outcrop of the Namurian measures.

Stratigraphy and palaeogeography. The Southern Pennines area of the Central Province of England, comprising parts of Yorkshire, Lancashire, Derbyshire, Cheshire, and Staffordshire, was a region of general subsidence throughout Upper Carboniferous times. The basin of sedimentation was bounded to the south by the land mass of St. George's Land and to the north by the Lake District and Southern Uplands massifs. Within the basin, the areas of maximum subsidence and sedimentation were not constant so that locally non-sequences and even unconformities are present at the base of the Namurian successions.

The stratigraphical succession of the region, based mainly on the goniatite faunas contained in the marine shales, has been thoroughly established through the work of Bisat (1928), Bisat and Hudson (1943), Hudson and Cotton (1943, 1945), Jackson (1927), Hester (1932), Cope (1945), and Trotter (1951). In general, the lower stages of the Namurian, when present, consist of marine, argillaceous deposits interleaved with thin, sandy horizons or crowstones. The younger Namurian measures are characterized by an increased arenaceous component which takes the form of thick, lenticular beds of sandstone and gritstone, such as the Kinderscout Grit series. Observations on current bedding carried out by Gilligan (1920) in the northern areas and the author in the southern parts of the basin indicate that the arenaceous material was derived both from the north and south respectively. Sometimes associated with the sandy horizons are thin coals and bluish grey, non-marine shales, which give rise to a primitive form of rhythmic sedimentation of the coal-measure type in the higher Namurian stages.

List of sample localities and horizons examined. The locality numbers correspond to those used in text-fig. 1 and also occurring in the section dealing with the Systematic Palaeontology.

1. Exposure in lane leading to Limekiln Farm, near Congleton, Staffordshire (G.R. SJ. 861591). Astbury Coal, Pendleian stage.
2. Exposure near Moor Hall Farm, Bagnall, Staffordshire (G.R. SJ. 945509). Horizon: marine shale with *Eumorphoceras bisulcatum* Girty.
3. Stream exposure, Hollywood Dingle, near Endon, Staffordshire (G.R. SJ. 928554). Horizon: marine shale with *Anthracoceras paucilobum*.
4. Ganister Quarry, Congleton Edge, Staffordshire (G.R. SJ. 869591).
   Horizons: Marine shale with *Hudsonoceras proteum*.
   Grey Non-marine shales.
   Thin Coal Seam.
5. Tip from old workings of the Congleton Edge Coal, near Biddulph, Staffordshire (G.R. SJ. 870590). Horizon: coal seam above Congleton Edge Grit, Marsdenian stage.
6. Stream exposure south of Rushton Hall, north Staffordshire (G.R. SJ. 928614). Horizon: Marine shale with *Reticuloceras inconstans* s.l.
7. Exposure in Marsh Brook, Ashover, Derbyshire (G.R. SK. 344634). Horizon: marine shale with *Reticuloceras inconstans* s.l.
8. Stream exposure in Lindup Wood, near Rowsley, Derbyshire (G.R. SK. 255675). Horizon: marine shales with *Reticuloceras bilingue*.
9. Sandstone quarry, Stone Edge, Derbyshire (G.R. SK. 344674). Horizon: Baslow Coal, Marsdenian stage.
10. Stream exposure, Crowborough Wood, near Biddulph, Staffordshire (G.R. SJ. 902556). Horizon: marine shales with *Gastrioceras cancellatum*.
11. Smeekley Bore Hole, Cordwell Valley, Derbyshire (G.R. SK. 296767).
   Horizons: Marine shale with *Gastrioceras listeri*.
   Marine shale with *Gastrioceras subcrenatum*.
   Non-marine shale with *Carbonicola exporrecta*.
   Marine shale with *Gastrioceras cancellatum*.
12. Exposures in stream banks, Hipper Sick, Derbyshire (G.R. SK. 312683).
   Horizons: Marine shale with *Gastrioceras subcrenatum*.
   Non-marine shale with *Carbonicola exporrecta*.

Marine shale with *Gastrioceras cumbriense*.
Marine shale with *Gastrioceras cancellatum*.

13. Ganister Drift Mine, Holymoorside, Derbyshire (G.R. SK. 327680).
    Horizons: Marine shale with *Gastrioceras subcrenatum*.
    Pot Clay Coal and non-marine roof shales.
14. Stream exposure, near The Wash, Quarnford, Staffordshire (G.R. SJ. 014662). Horizons: as locality 13.
15. Stream exposure, near Consall village, Staffordshire. (G.R. SJ. 975483). Horizon: Six Inch Mine Coal. Yeadonian stage.
16. Exposure in the bank of the Little Don river, near Langsett, Yorkshire (G.R. SE. 222005). Horizons: as localities 13 and 14.
17. Ganister Quarry, Wessington, Derbyshire (G.R. SK. 349566). Horizons: marine shale with *Gastrioceras listeri*, and Alton Coal.
18. Ganister Drift Mine, Neepsend, Sheffield, Yorkshire. Horizons: as locality 17.

Previous palynological literature. Literature dealing with Namurian plant spores is available from several continents. Luber and Waltz (1938) described Lower Carboniferous assemblages from the Moscow and Karaganda Basins of the U.S.S.R.; Ischenko (1952, 1956, and 1958) published his work on the fossil plant spores from coals of the Donetz and Dneiper Basins; Horst (1955) dealt with the Namurian spores of Upper Silesia and in 1957 Dybova and Jachowicz gave a further account of Upper Carboniferous spores from this region; Artuz (1957, 1959) described the spore assemblages of three coal seams of Namurian and Lower Westphalian A age, from the Zonguldak Coalfield of Turkey. Hoffmeister, Staplin, and Malloy (1955) gave the results of an investigation into the plant spore assemblages contained in coals and shales of Upper Mississippian age from Illinois and Kentucky, U.S.A. In Britain, Millott (1939) considered briefly the fossil spores found in certain coal seams of Namurian age from north Staffordshire; Knox (1942) and Butterworth and Williams (1958) investigated the small spore content of coal seams of Namurian A age in the Limestone Coal Group and the Upper Limestone Group of Scotland. The present author (Neves, 1958) gave a preliminary account of an investigation into the plant spore content of coals and associated carbonaceous shales from the Central Province of England. Most authors, however, have been concerned with the small spore assemblages present in coal seams, with little attention having been directed to the spore content of shales. Furthermore, the stratigraphical occurrences of the various spore types are rarely referred directly to the established sequence of goniatite zones.

Maceration techniques. The various methods which have been employed for the isolation of organic remains from coals and shales have been fully described elsewhere by several authors. The technique used throughout the present work relies on Schulze solution to oxidize the humic matter which is in close association with the plant tissues. The oxidized products were then removed in a dilute solution of potassium hydroxide. The mineral matter of the shales is eliminated by digestion in hot hydrofluoric acid following an initial treatment with bromine to break the shale down. The details of the technique are more fully described in Neves (1958).

SYSTEMATIC PALAEONTOLOGY

The system proposed by Potonié and Kremp (1954) for the description and classification of the fossil dispersed spores is used in this account. Slight modifications are introduced where it is considered to be of practical advantage in light of additional information. Two new Series, Pseudocingulati and Membranati, are erected to accommodate newly described spore types. Two new genera, *Secarisporites* and *Hymenospora*, are described and illustrated together with new species of the following genera: *Leiotriletes*, *Punctatisporites*, *Acanthotriletes*, *Ibrahimispores*, *Neoraistrickia*, *Mooreisporites*, *Camptotriletes*, *Dictyotriletes*, *Convolutispora*, *Secarisporites*, *Ahrensisporites*, *Triquitrites*, *Densosporites*, *Knoxisporites*, *Stenozonotriletes*, *Cirratriradites*, *Proprisporites*, and *Tholisporites*. As a result of observations made during the course of the present investigation, the genus *Knoxisporites* Potonié and Kremp 1954 is here transferred to the Series Cingulati Details of occurrence are given in Table 1 or in the text.

All slides referred to in the text are lodged in the Micropalaeontology Laboratory, Department of Geology, University of Sheffield.

Division SPORITES H. Potonié 1893
Group TRILETES Reinsch 1881
Subgroup AZONOTRILETES Luber 1935
Series LAEVIGATI (Bennie and Kidston) Potonié 1956
Genus LEIOTRILETES (Naumova) Potonié and Kremp 1954

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

Leiotriletes densus sp. nov.

Plate 30, figs. 1, 2

Holotype. Plate 30, fig. 1.

Type locality. Non-marine roof shales of the Pot Clay Coal, Langsett, Yorkshire (Loc. 16). Yeadonian stage.

Diagnosis. Size range 85–110 μ (fifteen specimens measured), holotype 96 μ; equatorial outline triangular; trilete rays three-quarters radius of the spore; exine dense and thick.

Description. Colour dark brown. Equatorial outline triangular, sides straight to slightly convex, apices broadly rounded. Trilete rays prominent, lips thin, sutures usually closed. Exine thick, laevigate to faintly infrapunctate.

Comparison. The compact triangular shape, longer trilete rays, and the absence of a darkened contact region distinguish these spores from those of the species *L. grandis* (Kosanke) Bhardwaj 1957.

Occurrence. Upper Namurian C and Lower Westphalian A, rare.

Genus PUNCTATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species. P. punctatus Ibrahim 1933

Punctatisporites pseudopunctatus sp. nov.

Plate 30, fig. 3

Holotype. Plate 30, fig. 3.

Type locality. Non-marine shale with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 11). Yeadonian stage.

Diagnosis. Size range 90–120 μ (nineteen specimens measured), holotype 116 μ; equatorial outline subcircular; trilete rays short, approximately half spore radius; exine strongly and densely infrapunctate.

Description. Colour light brown to yellow. Tecta of the tetrad mark tapering, lips often associated with small folds. At the margin of the compressed spores a narrow 'rim', 2–3 μ wide, is present. The inner line of the 'rim', corresponding to the intexine membrane, clearly shows the infra-punctate nature of the exine. Outline smooth. Small secondary folds of the exine occur infrequently.

Comparison. The spores of this species are slightly larger than those of *P. aerarius* Butterworth and Williams 1958, and the structure of the exine is much stronger. *P. grandis* and *P. pseudoelevatus* Hoffmeister, Staplin, and Malloy 1955 differ in possessing a positive surface ornamentation.

Occurrence. Namurian A and C; sometimes common, particularly in marine shales.

Punctatisporites giganteus sp. nov.

Plate 30, fig. 4

Holotype. Plate 30, fig. 4.

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

Diagnosis. Size range 150–170 μ (ten specimens measured), holotype 158 μ; equatorial outline subcircular to subtriangular; trilete rays two-thirds to three-quarters radius of the spore; exine laevigate to strongly infrapunctate.

Description. Colour yellow-brown; exine 2–3 μ thick, margin smooth, occasional secondary folds. Trilete rays distinct; lips thin, subparallel to tapering.

Comparison. *P. obesus* (Loose) Potonié and Kremp is smaller.

Occurrence. Namurian A, rare.

Punctatisporites (*Sinuspores*) *sinuatus* (*Artuz*) comb. nov.

1958 *Punctatisporites densoarcuatus* Neves; p. 6, pl. ii, fig. 7.
1958 *Punctatisporites coronatus* Butterworth and Williams; p. 360, pl. i, fig. 12.

Remarks. *Sinuspores sinuatus* was described by Artuz (1957, p. 254) as possessing a variably thickened exine and a 'Gurtelzone'. Neves (1958, p. 6) and Butterworth and Williams (1958, p. 360) described this structure as simple exinous folding. The material examined by the current author clearly shows all stages in the development of the pronounced curving fold as seen in the holotype (Artuz 1957, pl. 7, fig. 48), from simple,

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EXPLANATION OF PLATE 30

All magnifications ×500.

Figs. 1–2. *Leiotriletes densus* sp. nov. Slide ref. s.Z. 1, holotype, 96 μ. 2, 96 μ.
Fig. 3. *Punctatisporites pseudopunctatus* sp. nov., holotype, 116 μ. Slide ref. s.H.
Fig. 4. *Punctatisporites giganteus* sp. nov., holotype, 158 μ. Slide ref. s.B.
Fig. 5. *Acanthotriletes slendidus* sp. nov., holotype, distal surface, 105 μ. Slide ref. 5.261818.
Figs. 6–7. *Acanthotriletes ? pilus* sp. nov. 6, holotype, 69 μ. 7, 84 μ. Slide ref. s.E.

small amplitude folds of the exine. Since these structures are clearly secondary effects it is proposed to transfer the species *S. sinuatus* Artuz to the genus *Punctatisporites.*

Occurrence. Artuz (1957)—Westphalian A. Butterworth and Williams (1958)—Namurian A of Scotland.

Series APICULATI (Bennie and Kidston) Potonié 1956
Genus APICULATISPORIS Potonié and Kremp 1956

Type species. A. aculeatus (Ibrahim) Potonié and Kremp 1954

Apiculatisporis maculosus (Knox) Potonié and Kremp 1955

Occurrence. Lower Namurian A, rare. Butterworth and Williams (1958) recorded this species from the Namurian A measures of Scotland.

Genus ACANTHOTRILETES (Naumova) Potonié and Kremp 1954

Type species. A. ciliatus (Knox) Potonié and Kremp 1954

Acanthotriletes splendidus sp. nov.

Plate 30, fig. 5

Holotype. Plate 30, fig. 5.

Type locality. Marine shale with *Anthracoceras paucilobum*, Hollywood Dingle, Staffordshire (Loc. 3). Arnsbergian stage.

Diagnosis. Size range 90–110 μ (ten specimens measured), holotype 105 μ; equatorial outline triangular; trilete rays two-thirds spore radius; exine ornamented with slender, broad-based spines; thirty to fifty spines overtop the equatorial margin.

Description. Colour light brown. Equatorial outline triangular, sides concave, apices rounded. Trilete rays with narrow lips, sutures sometimes open. The spines which ornament the exine are 2–10 μ high, and 2–4 μ wide at the base. The spines are not densely spaced and there is room between them for elements of equal size. Exine between spines laevigate.

Comparison. These spores are characterized by their large size and the ornament of slender spines. *Acanthotriletes horridus* Hacquebard 1957 is larger and possesses stronger more densely spaced spines.

Occurrence. Namurian A, rare.

Acanthotriletes? *pilus* sp. nov.

Plate 30, figs. 6, 7

Holotype. Plate 30, fig. 7.

Type locality. Marine shale with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Diagnosis. Size range 50–90 μ (twenty specimens measured), holotype 84 μ; equatorial outline rounded triangular; trilete rays two-thirds to three-quarters radius of the spore; exine densely covered by short, slender, 'mushroom'-topped pila.

Description. Colour light brown to yellow. Original shape ± globular, and the spores are often compressed obliquely with no preferred orientation. Trilete rays straight, tecta slightly tapering, lips thin. Exine 2 μ thick, decorated by closely spaced, discrete pila the tips of which are expanded to a mushroom form; height 2–3 μ, width at base 0·5–1 μ.

Comparison. Acanthotriletes (Azonotriletes) multisetosus (Luber and Waltz) Potonié and Kremp 1955 is superficially similar to *A? pilus*. However, the spores of the former species are rounded to oval in outline and the ornament consists of essentially parallel-sided spines.

Occurrence. Namurian C; this species has been recorded only from the type horizon.

Acanthotriletes baculatus sp. nov.

Plate 31, fig. 1

Holotype. Plate 31, fig. 1.

Type locality. Marine shale with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

Diagnosis. Size range 34–45 μ (fifteen specimens measured), holotype 34 μ; equatorial outline triangular; trilete rays two-thirds radius of the spores; exine beset with upstanding blunted spines; fifteen to twenty elements occur at the equatorial margin.

Description. Colour pale yellowish-brown. Equatorial outline triangular, sides concave, apices rounded. Rays of the trilete mark simple, often obscured by the ornamentation elements which consist of relatively long, in part parallel sided, and terminally truncate spines; height 4–10 μ, width 1–2·5 μ. The spines are not densely set and between them the exine is laevigate.

Comparison. Acanthotriletes falcatus has stouter, cone-like spines which are closely spaced; in *A. castanea* the spines are uniformly tapering and more densely set.

Occurrence. Namurian A, infrequent.

Genus IBRAHIMISPORES Artuz 1957

Type species. I. microhorridus Artuz 1957

Ibrahimispores brevispinosus sp. nov.

Plate 31, fig. 2

Holotype. Plate 31, fig. 2.

EXPLANATION OF PLATE 31

All magnifications × 500.

Fig. 1. *Acanthotriletes baculatus* sp. nov., holotype, 34 μ, distal view. Slide ref. 1.302744.
Fig. 2. *Ibrahimispores brevispinosus* sp. nov., holotype, 80 μ, distal view. Slide ref. s.Y.
Fig. 3. *Ibrahimispores magnificus* sp. nov., holotype, 81 μ, distal view. Slide ref. s.Ao.
Fig. 4. *Neoraistrickia inconstans* sp. nov., holotype, 71 μ, distal view. Slide ref. 1.285759.
Fig. 5. *Mooreisporites trigallerus* sp. nov., holotype, 77 μ, distal view. Slide ref. s.T.
Fig. 6. *Mooreisporites fustis* Neves, distal view, 75 μ.
Fig. 7. *Mooreisporites bellus* sp. nov., holotype, 105 μ, distal view. Slide ref. s.E.
Fig. 8. *Camptotriletes superbus* sp. nov., holotype, 119 μ, proximo-lateral view focus low on ornament. Slide ref. 3.240769.

Type locality. Non-marine shales with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 11). Yeadonian stage.

Diagnosis. Size range 70–100 μ (fifteen specimens measured), holotype 80 μ; equatorial outline rounded-triangular; exine ornamented with stout, hollow pointed spines which are thickened at the tips.

Description. Colour yellow-brown to brown. Equatorial outline rounded-triangular to subcircular. The rays of the trilete mark are usually associated with dark, flexuous folds of the exine; approximately three-quarters radius of the spores. The ornamentation elements are short, hollow spines, $\pm$ uniformly tapering to the sharply pointed, solid tip. Spines 6–10 μ high, 3–5 μ wide at the base and are densely spaced; forty to fifty elements occur at the equatorial outline.

Comparison. *I. microhorridus* Artuz is more circular in outline and the spines appear to be solid and without thickened tips.

Ibrahimispores magnificus sp. nov.

Plate 31, fig. 3

Holotype. Plate 31, fig. 3.

Type locality. Non-marine shale with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 11). Yeadonian stage.

Diagnosis. Size range 75–90 μ (ten specimens measured), holotype 81 μ; equatorial outline rounded-triangular, sides convex, apices broadly rounded; trilete mark often obscured by dark flexuous folds of the exine. Exine beset with long, hollow pointed spines; fifteen to twenty elements occur at the equatorial margin.

Description. Colour light brown. The large spines which decorate the exine are not densely set and elements of equal size could be placed between them. Spines 15–20 μ high, 3–8 μ wide at the base. The tips of the spines are solid and appear as darker, conical terminations; bifurcation of the spines is infrequently seen. Exine infra-punctate between the spines.

Comparison. *I. magnificus* is probably closely related to *I. brevispinosus*. However, on account of the recognizable difference in size and disposition of the ornamentation elements, it proposed as a new species.

Occurrence. Namurian C, rare.

Genus NEORAISTRICKIA Potonié 1956

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

Neoraistrickia inconstans sp. nov.

Plate 31, fig. 4

Holotype. Plate 31, fig. 4.

Type locality. Marine shale with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

Diagnosis. Size range 55–75 μ (twenty specimens measured), holotype 71 μ; equatorial outline triangular, sides concave to straight, apices rounded. Trilete rays two-thirds spore radius. Distal surface and proximal surface decorated with short baculae.

Description. Colour light brown. Trilete rays distinct, tecta straight, lips thin. Exine laevigate between ornamentation elements. The baculae which are present on the distal surface of the spores are 3–8 μ high, 2–4 μ wide, parallel-sided elements; interspersed between these are small, blunt conical projections. The ornamentation encroaches on to the proximal surface of the spores, particularly in the region of the spore body apices. Whilst the latter radial regions may be densely ornamented, the inter-radial margin is often devoid of projections.

Comparison. The triangular equatorial outline and the baculose ornamentation are typical of the genus *Neoraistrickia.*

Occurrence. Namurian A, fairly common at specific horizons.

Genus MOOREISPORITES Neves 1958

Type species. M. fustis Neves 1958

Mooreisporites trigallerus sp. nov.

Plate 31, fig. 5

Holotype. Plate 31, fig. 5.

Type locality. Marine shale with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

Diagnosis. Size range 55–80 μ (thirty specimens measured), holotype 77 μ; equatorial outline triangular; trilete rays short, half radius of the spore; apices of spore body ornamented with short, fused baculae.

Description. Colour light brown, apical ornament darker. Equatorial outline triangular, sides straight, apices expanded due to the projecting baculae. Trilete rays short, lips thin, suture narrow. Exine ornamented overall with small, scattered coni. At the apices of the spore body short baculae are developed, size 8–10 μ high; these elements are often fused laterally in the lower part.

Comparison. Triquitrites tricuspis is similar but possesses a narrow equatorial cingulum (Horst 1955, p. 175); *Tripartites lucidus* Artuz 1957 is slightly larger and the rays of the trilete mark reach the margin of the spore body. *Mooreisporites fustis* is characterized by heavy branching baculae both in the apical regions and also on the distal surface of the spores.

Remarks. Mooreisporites trigallerus sp. nov. should not be placed in the genus *Tripartites* (Schemel) Potonié and Kremp 1954 since none of the specimens observed possesses the inter-radial, equatorial flange which is present in *Tripartites vetustus*, the type species of the genus.

Occurrence. Namurian A, common at certain horizons.

Mooreisporites fustis Neves 1958

Plate 31, fig. 6

Occurrence. Spores of this species first appear in the Upper Namurian A assemblages and are to be found in both shale and coal preparations.

Mooreisporites bellus sp. nov.

Plate 31, fig. 7

Holotype. Plate 31, fig. 7.

Type locality. Baslow Coal, Stone Edge Quarry, Derbyshire (Loc. 9). Marsdenian stage.

Diagnosis. Size range 95–115 μ (fifteen specimens measured), holotype 105 μ; exine decorated with small scattered coni; apical regions with large, irregular patches of thickening and terminal baculae.

Description. Colour light brown, apical thickening dark brown. Trilete rays half radius of the spore body, suture and lips narrow. The large, bifurcating baculae, which project beyond the apical margins of the spores, arise from extensive, irregular patches of distal thickening. The latter often extend polewards on the distal surface. The baculae are 4–8 μ wide, of variable height and with partate terminations.

Comparison. *M. bellus* is characterized by spores of large size, possessing in the radial positions irregular patches of exinous thickening from which arise the squat baculae seen at the spore margin.

Genus VERRUCOSISPORITES (Ibrahim) Potonié and Kremp

Type species. *V. verrucosus* Ibrahim 1933

Remarks. The spores of this genus are very rare in the Namurian assemblages of the Central Province of England.

Verrucosisporites morulatus Knox 1950

Remarks. For description see Knox (1950) and Butterworth and Williams (1958 p. 62).

Occurrence. Lower Namurian A, rare. Butterworth and Williams (1958) found this species was confined to the Limestone Coal Group of Scotland.

Series MURORNATI Potonié and Kremp 1954
Genus CAMPTOTRILETES (Naumova) Potonié and Kremp 1954

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

Camptotriletes superbus sp. nov.

Plate 31, fig. 8

Holotype. Plate 31, fig. 8.

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

Diagnosis. Size 75–125 μ (thirty specimens measured), holotype 119 μ; equatorial outline subcircular; trilete rays long, three-quarters radius of the spore, tecta sharp and tapering. Exine ornamented with irregular, disjointed, subconical ridges.

Description. Colour golden to reddish-brown. Spore margin overtopped by twenty to twenty-five rounded, conical processes. The discontinuous ridges which ornament the surface of the spores are 3–5 μ high and up to 25 μ long; and appear as a verrucose to conate ornament in which the elements are connected laterally by irregular ridges. The ridges are separated by irregular regions of thinner, laevigate exine.

Comparison. The spores of this species are characterized by their large size and the variable nature of the rudimentary cristae.

Occurrence. Upper Namurian B–Westphalian A, common in certain coal-seam assemblages.

Camptotriletes verrucosus Butterworth and Williams 1958

Occurrence. Lower Namurian A, rare. The species was originally described from the Limestone Coal Group of Scotland.

Genus DICTYOTRILETES (Naumova) Potonié and Kremp 1954

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

Dictyotriletes tuberosus sp. nov.

Plate 32, fig. 1

Holotype. Plate 32 fig. 1.

Type locality. Marine shale with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

Diagnosis. Size range 90–120 μ (ten specimens measured), holotype 120 μ, equatorial outline subcircular to oval; exine decorated with very strong muri which appear as rounded elevations at the spore margin; the muri enclose seven to twelve large lacunae.

Description. Colour light brown, muri dark brown. Trilete rays three-quarters spore radius, lips often slightly thickened. The muri of the reticulum are heavy, solid walls, 5–10 μ wide at the base, 5–7 μ high, and rounded conical in profile. The lacunae enclosed by the muri are large and of variable shape.

Comparison. Dictyotriletes (*Azonotriletes*) *subalveolaris* (Luber) Potonié and Kremp 1955 resembles *D. tuberosus* in the nature of the muri, however in the former species, there are many more lacunae present in the reticulum. The muri in *D. tuberosus* show no tendency for the membranous zone at the spore outline, a feature which characterizes the genus *Reticulatisporites*.

EXPLANATION OF PLATE 32

All magnifications × 500.

Fig. 1. *Dictyotriletes tuberosus* sp. nov., holotype, 120 μ, distal surface, focus low. Slide ref. s.A.

Fig. 2. *Convolutispora* sp. A., distal view, 122 μ.

Fig. 3. *Convolutispora obliqua* sp. nov., holotype, 122 μ, focus low on ornament. Slide ref. 1.295827.

Figs. 4–5. *Convolutispora laminosa* sp. nov. 4, Holotype, 72 μ, distal view. Slide ref. 7.221665. 5, Proximo-lateral view, 69 μ.

Figs. 6–7. *Secarisporites lobatus* sp. nov. 6, Holotype, 81 μ, proximal view and low focus. Slide ref. 4. 175850. 7, Distal view, 80 μ.

Figs. 8–9. *S. remotus* sp. nov. 8, Distal view, 48 μ. 9, Holotype, proximal view, 46 μ. Slide ref. 8.343708.

Fig. 10. *Ahrensisporites beeleyensis* sp. nov., holotype, 56 μ, distal view, low focus. Slide ref. s.Z.

Fig. 11. *Ahrensisporites guerickei* var. *ornatus* var. nov., holotype, 66 μ, distal surface. Slide ref. 4.296768.

Fig. 12. *Triquitrites nodosus* sp. nov., holotype, 88 μ. Slide ref. s.Av.

Dictyotriletes varioreticulatus Neves 1958

Occurrence. Upper Namurian B–Westphalian A, common in some coals.

Genus CONVOLUTISPORA Hoffmeister, Staplin and Malloy 1955

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

Convolutispora sp. *A*

Plate 32, fig. 2

Description. One specimen only, size 122 μ. Equatorial outline ± circular, margin sinuous to smoothly indented. Trilete rays three-quarters spore radius, sutures thin. Exine with broad anastomosing ridges, 6–10 μ wide, and which form an irregular reticulum when seen in high focus.

Comparison. The organization of the ridges is somewhat similar to that present in *C. mellita* Hoffmeister, Staplin, and Malloy.

Occurrence. Marine shale with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Convolutispora obliqua sp. nov.

Plate 32, fig. 3

Holotype. Plate 32, fig. 3.

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

Diagnosis. Size range 100–130 μ (twenty specimens measured), holotype 122 μ; equatorial outline subcircular, spores usually compressed obliquely; exine with an ornament of long, anastomosing ridges, 2–5 μ high, 1–6 μ wide, and up to 25 μ long.

Description. Colour brown. Trilete rays two-thirds to three-quarters radius of the spores, slightly flexuous due to the ornament, suture and lips narrow. The sinuous, anastomosing ridges appear at the spore margin as subconical processes with rounded or flattened crests. Between the ridges there appear narrow channels of thinner exine. Secondary folds of the exine are infrequently present.

Comparison. *C. mellita* and *C. tessellata* are smaller, and the ridges in these species are shorter with less tendency for the linear disposition present in *C. obliqua*. *C. flexuosa* has flatter, more widely spaced ridges.

Convolutispora laminosa sp. nov.

Plate 32, figs. 4, 5

Holotype. Pl. 32, fig. 4.

Type locality. Marine shale with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Diagnosis. Size range 50–80 μ (twenty specimens measured), holotype 72 μ; equatorial outline subcircular; exine characterized by broad regions of thickening which are sinuous in outline.

Description. Colour brown. Trilete rays hair-like, two-thirds to three-quarters radius of the spores. The exine of these spores bears extensive regions of thickening, between which narrow channels of thin exine are to be found. Locally the patches of thickening break up into broad, flat, $\pm$ linear ridges. Thickenings 5–20 μ wide, length variable.

Comparison. In all other described species of *Convolutispora* the linear, sinuous ornamentation ridges predominate.

Occurrence. Namurian B–C, restricted to marine shale assemblages where the species is sometimes fairly common.

Genus MICRORETICULATISPORITES (Knox) Potonié and Kremp 1954

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

Microreticulatisporites concavus Butterworth and Williams 1958

Occurrence. Namurian A, rare and restricted to marine shale assemblages.

Series PSEUDOCINGULATI ser. nov.

This Series is proposed for those miospores in which the ornamentation of the exo-exine, large warts and lobate outgrowths, extends beyond the line of the spore body membrane (int-exine) in the equatorial region. The compressed spores are consequently characterized by a marked outer marginal rim which is deeply dissected and often discontinuous.

Comparison. Spores of the Series Membranati ser. nov. differ in that the exo-exine is membranous and encloses the spore body partially or completely, in the manner of a mantle.

Remarks. The outer zone of these spores is not a true cingulum in the sense of a continuous equatorial structure of the type present in *Densosporites*, *Lycospora*, &c. The peripheral zone in the Pseudocingulati arises as a result of the compression of upstanding ornamentation elements which overlap laterally at the spore margin.

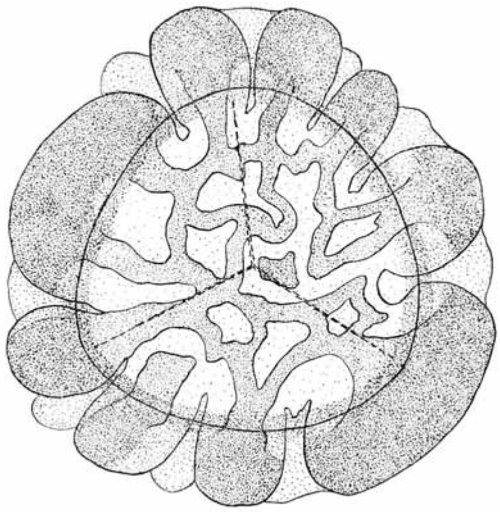
Genus SECARISPORITES gen. nov.

Text-fig. 2

Type species. *S. lobatus* sp. nov.

Diagnosis. Trilete, iso- or microspores, equatorial outline subcircular, ovate to subtriangular. The exo-exine is expanded into a series of lobate outgrowths which are of such dimensions as to give rise to an outer zone or pseudo-flange in the compressed spores. The outer zone is not continuous and deep indentations frequently occur between the bulbous lobes. The distal polar region of the spores is covered by an ornament of loosely spaced ridges and warts.

Remarks. The distal ornamentation found in some of these spores closely resembles that seen in spores of the genus *Convolutispora* Hoffmeister, Staplin, and Malloy 1955. However, the lateral overlap and fusion of the ornamentation elements in the region of the equator give rise to the discontinuous peripheral rim which characterizes the spores of this genus. With careful focusing, the spore body outline can be distinguished as a sharp line of regular form, lying ± concentric with the spore outline (Pl. 32, figs. 6 and 9). Hacquebard and Barss (1957, pl. vi, figs. 11, 12) illustrate Spore Type A, which



TEXT-FIG. 2. *Secarisporites* gen. nov. Diagrammatic reconstruction; distal surface.

closely resembles in structural oganization spores which are here attributed to the genus *Secarisporites*.

Secarisporites lobatus sp. nov.

Plate 32, figs. 6, 7

Holotype. Plate 32, fig. 6.

Type locality. Marine shales with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Diagnosis. Size range 55–85 μ (twenty specimens measured) holotype 81 μ; equatorial outline subcircular, margin lobate and deeply incised; trilete rays thin, reaching to the inner limit of the peripheral zone.

Description. Colour medium to dark brown. Equatorial outline of the spore body rounded triangular to subcircular, outer margin of the enclosing rim is ± conformable. The 'pseudoflange' is composed of lobate outgrowths of the exine, which extend 10–18 μ beyond the spore body wall. Between the rounded, in part overlapping, lobes the rim is deeply incised. The distal polar region is decorated with rounded thickenings and irregular, linear ridges.

Comparison. The spores of this species are characterized by the wide, dissected marginal rim. In *Secarisporites remotus* the rim consists of more widely spaced elements, and the spores are smaller.

Secarisporites remotus sp. nov.

Plate 32, figs. 8, 9

Holotype. Plate 32, fig. 9.

Type locality. Non-marine roof shales of the Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13). Yeadonian stage.

Diagnosis. Size range 35–50 μ (fifteen specimens measured), holotype 46 μ; equatorial outline triangular, subcircular to ovate; exine ornamented with narrow ridges and small warts; outline of spore with rounded lobes of variable size.

Description. Colour brown. Trilete rays thin, reaching to the line of the spore body wall, often obscured by the ornamentation elements. The spore outline is strongly lobate with elements of variable size and lateral continuity, height 2–8 μ and up to 12 μ wide. Over the distal surface of the spores the ornamentation consists of narrow ridges and discrete wart-like thickenings.

Comparison. These spores are characterized by their small size, the variable size and often isolated nature of the peripheral lobes.

Occurrence. Upper Namurian B–Namurian C, rare.

Division ZONALES (Bennie and Kidston) Potonié 1956
Group AURITOTRILETES Potonié and Kremp 1954
Series AURICULATI (Schopf) Potonié and Kremp 1954
Genus AHRENSISPORITES Potonié and Kremp 1954

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

Remarks. Potonié (1956, p. 16) transferred the genus *Ahrensisporites* to the Series Laevigati, Subdivision Azonotriletes. Based on observations made during the present study, the current author retains the genus in the original supra-generic position suggested by Potonié and Kremp (1954, p. 155).

Ahrensisporites beeleyensis sp. nov.

Plate 32, fig. 10

Holotype. Plate 32, fig. 10.

Type locality. Non-marine shales with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Diagnosis. Size range 45–60 μ (twenty specimens measured), holotype 56 μ; equatorial outline triangular, sides straight to slightly concave, apices rounded; kyrtome built up from a series of small, bluntly conical elements, which also occur scattered in the inter-radial regions.

Description. Colour golden-brown to brown. Exine laevigate between the ornamentation elements. Trilete mark simple, rays straight, three-quarters radius of the spores. Small blunted cones are serially arranged on the distal surface of the spores, giving rise to the characteristically dentate kyrtome. The elements are closely spaced and the bases are fused in part. Scattered cones are found also in the inter-radial regions.

Comparison. The presence of a composite kyrtome, constructed from discrete, regularly arranged, small blunted cones, distinguishes the spores of this species. Little morphological variation has been observed in this species group.

Occurrence. Upper Namurian B–Namurian C appears to be more characteristic of non-marine shale assemblages.

Ahrensisporites guerickei Horst 1955

Occurrence. Upper Namurian B–Westphalian A, common in certain assemblages.

Ahrensisporites guerickei var. *ornatus* var. nov.

Plate 32, fig. 11

Holotype. Plate 32, fig. 11.

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

Diagnosis. Size range 65–80 μ (twenty specimens measured), holotype 77 μ; equatorial outline triangular, sides straight or slightly convex, apices somewhat truncate; kyrtome arise from strong folds of the exine of the distal surface; spore body decorated with irregularly, rounded thickenings.

Description. Colour yellow-brown, kyrtome and exinous thickenings darker. Trilete rays simple, straight, three-quarters spore radius. The exine of the distal surface is ornamented with irregular thickenings of a wart-like nature. The kyrtome is a more or less continuous, heavy wall which, when compressed beyond the outline of the spores, appears to be 7–10 μ high.

Remarks. A clearly defined group of spores, closely comparable to the holotype of *Ahrensisporites guerickei* figured by Horst (1955, pl. 7, fig. 58), appears in the upper part of the Marsdenian stage (Namurian B) and persists into the Westphalian measures of the English Central province. In addition, a variety of *A. guerickei* (designated above) possessing an ornamentation of irregular exinous thickenings similar to the forms figured by Horst (1955, pl. 7, fig. 61) and Butterworth and Williams (1958, pl. iii, fig. 18) has been found during the current study to persist throughout the Namurian succession from the Arnsbergian stage to the Lower Westphalian horizons.

Genus TRIQUITRITES (Wilson and Coe) Potonié and Kremp 1954

Type species. T. arculatus Wilson and Coe 1940

Triquitrites nodosus sp. nov.

Plate 32, fig. 12 and Plate 33, fig. 1

Holotype. Plate 32, fig. 12.

Type locality. Non-marine shale with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Diagnosis. Size range 80–95 μ (fifteen specimens measured), holotype 88 μ; equatorial outline triangular, sides straight to slightly convex, apices broadly rounded; valvae broad, protruding slightly at the equatorial margin; distal surface of the spores is ornamented by conical to wart-like elements.

Description. Colour light brown, valvae darker. Trilete rays two-thirds to three-quarters radius of the spores. The valvae are centrifugal thickenings of the exine in the radial positions, projecting 3–5 μ beyond the general equatorial outline. The margins of the valvae are somewhat angular and resemble the upper part of a partially opened fan, arising from the distal surface of the apices. Blunted cones and warts are dispersed randomly over the distal surface of the spores.

Comparison. The spores of this species are distinguished by their large size, the arcuate form of the valvae, and the nature of the distal ornamentation. *Triquitrites verrucosus* Alpern 1958 is smaller and is recorded from much higher horizons.

Group ZONOTRILETES Waltz 1935
Series CINGULATI Potonié and Klaus 1954
Genus DENSOSPORITES (Berry) Potonié and Kremp 1954

Type species. D. covensis Berry 1937

Densosporites spinosus Dybova and Jachowicz 1957

Occurrence. Namurian A–B, common in some marine shale and coal seam assemblages.

Densosporites vulgaris sp. nov.

Plate 33, fig. 2; text-fig. 3

Holotype. Plate 33, fig. 2.

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

Diagnosis. Size range 50–65 μ (twenty-five specimens measured), holotype 59 μ; equatorial outline rounded triangular; trilete rays thin, reaching almost to the spore body wall; contact region thickened; cingulum smooth with slight equatorial taper.

Description. Colour light brown to yellowish. Equatorial margin generally smooth, occasionally a few scattered coni may be present. The cingulum has a faint radial, fibrous structure, an ill-defined inner thickened zone and a gradual equatorial taper. Inner thickened zone one-quarter to one-third width of the cingulum and overlapping the spore body margin 2–3 μ, proximally. The proximal polar region bears a thickened contact area, the outer margin of which is concentric with the spore body outline and lies 4–7 μ nearer the proximal pole. The exine of the spore body is laevigate to faintly infra-punctate.

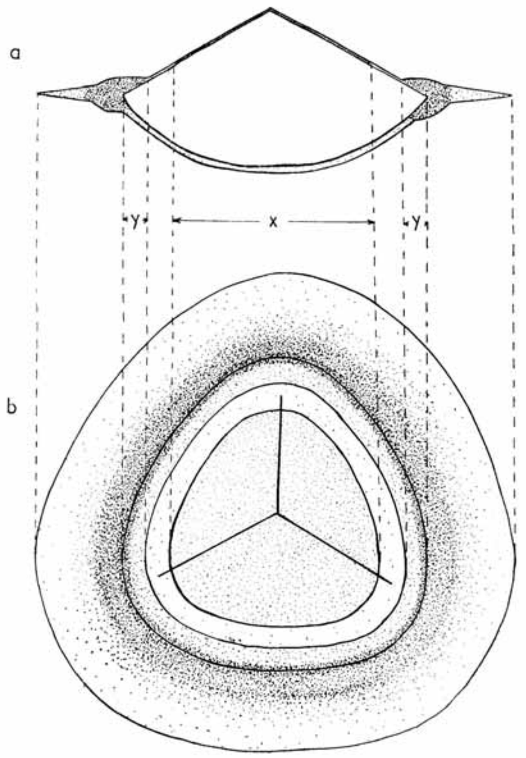
Remarks. The spores of this species are characterized by the thickened proximal polar region.

Genus KNOXISPORITES Potonié and Kremp 1954 emend.

Type species. K. hageni Potonié and Kremp 1955.

Emended diagnosis. Trilete iso- or microspores with an equatorial cingulum which is of more or less uniform thickness throughout its width, possibly tapering slightly in the immediate vicinity of the equator. The distal hemisphere of the spores is characterized by a variable pattern of radial and/or concentric bands of thickening. The equatorial outline of the cingulum is more or less conformable to that of the spore body, only departing from it locally where the fusion of radial elements and the equatorial girdle produces a swollen node of thickening. Small thickened lobes may project from the cingulum on to the proximal surface of the spore body.

Remarks. From a critical study of author's photographs and descriptions, it becomes



TEXT-FIG. 3. *Densosporites vulgaris* sp. nov. Diagrammatic reconstruction; *a*, polar section; *b*, proximal polar view.

apparent that the majority of spores allocated to the genus *Knoxisporites* Potonié and Kremp 1954 possess an equatorial extension of the exo-exine in the form of a cingulum. In the diagnosis of the type species, *K. hageni* Potonié and Kremp (1955, p. 116), the authors repeatedly refer to the presence of a cingulum. At the same time, the figure of the holotype (pl. 16, fig. 316) clearly shows the presence of a continuous equatorial girdle or cingulum. Similarly, Hoffmeister, Staplin, and Malloy (1955, p. 391), in considering *K. triradiatus*, discuss the structure in terms of 'a central body' and an 'equatorial girdle'. Furthermore, whilst the disposition of the distal thickenings varies considerably in the species groups, the equatorial girdle remains a constant feature. It is not a question of muri lying parallel with equator, as in *Reticulatisporites*, but of a definite equatorial structure, as was indeed suggested by Potonié and Kremp (1955) for the type species.

Since the presence of a cingulum has been used by Potonié and Kremp (1954) as the major criterion in the definition of the Series Cingulati, the genus *Knoxisporites* is here transferred to this Series.

Comparison. *Simozonotriletes* is characterized by a triangular equatorial outline. *Stenozonotriletes* (Naumova) Hacquebard 1957 has no thickened bars on the distal surface. *Cincturasporites* Hacquebard and Barss 1957 possesses a thickened equatorial girdle which partly overlaps the spore body polewards.

Knoxisporites dissidius sp. nov.

Plate 33, figs. 4, 6; text-fig. 4

Holotype. Plate 33, fig. 4.

Type locality. Non-marine roof shales of the Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13). Yeadonian stage.

Diagnosis. Size range 50–80 μ (twenty-five specimens measured), holotype 70 μ; equatorial outline somewhat hexagonal, margin slightly irregular; outline of the spore body rounded triangular; distal surface of the spores with a Y-shaped thickening, distal polar region unthickened.

Description. Colour yellow to brown. The hexagonal tendency of the equatorial outline is due to the prolongation of the radial bars of thickening on to the cingulum. Outline of the spore body clearly defined, rounded triangular. Trilete rays three-quarters radius of the spore body, lips thin. Cingulum fleshy, tapering only slightly towards the equatorial margin. The distal surface of the spores bears three radial bars of thickening which are rotated 60° relative to the rays of the trilete mark. The thickened bars unite over the distal surface of the spore body to enclose a circular to triangular region of unthickened exine at the distal pole. Subsidiary bars of thickening often appear proximally in the cingulum, opposite the ends of the trilete rays. Exine laevigate to infra-punctate.

Remarks. The spores of *K. dissidius* are distinguished by the rounded triangular spore body, the slightly discordant fleshy cingulum, and the pattern of distal thickenings.

Occurrence. Namurian A–Westphalian A, rare.

EXPLANATION OF PLATE 33

All magnifications ×500.

Fig. 1. *Triquitrites nodosus* sp. nov., 87 μ.

Fig. 2. *Densosporites vulgaris* sp. nov., holotype, 59 μ, proximal view. Slide ref. 9.177820.

Fig. 3. *Cirratriradites ornatus* sp. nov., holotype, 92 μ, distal view, low focus. Slide ref. s.Al.

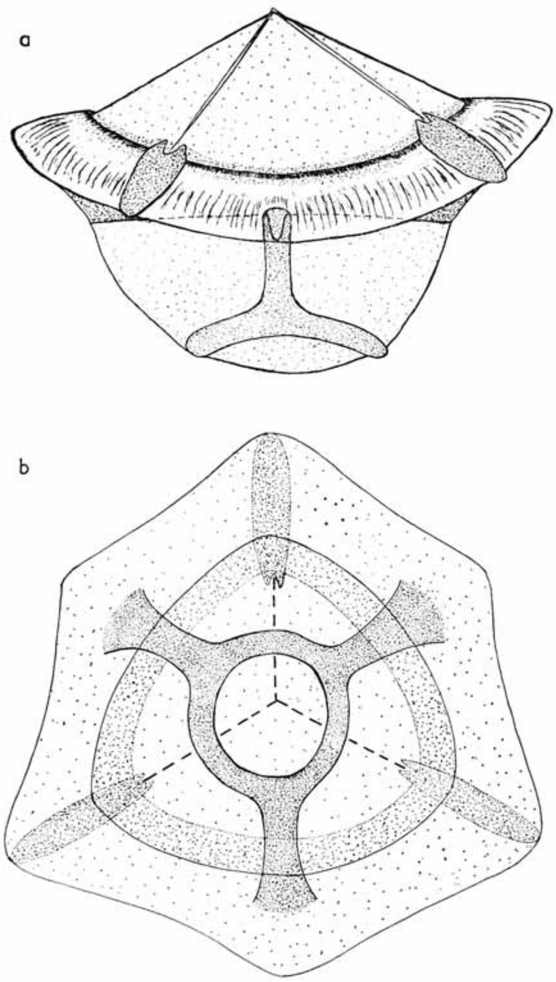
Figs. 4, 6. *Knoxisporites dissidius* sp. nov. 4, Holotype, 70 μ, distal view, low focus. Slide ref. 4.307719. 6, Distal view, 56 μ.

Fig. 5. *K. seniradiatus* sp. nov., holotype, 88 μ, proximal view, low focus. Slide ref. s.Bf.

Figs. 7–8. *Stenozonotriletes triangulus* sp. nov. 7, Holotype. 77 μ, proximal view. Slide ref. 1.361656. 8, Proximal view, 65 μ.

Figs. 9–10. *Proprisporites laevigatus* sp. nov. 9, Holotype, 77 μ, distal view, low focus. Slide ref. 5. 304770. 10, Proximal view, low focus, 101 μ.

Figs. 11–12. *Hymenospora palliolata* sp. nov. 11, Holotype, 87 μ, distal view. Slide ref. 8.319715. 12, 74 μ.



TEXT-FIG. 4. *Knoxisporites dissidius* sp. nov. Diagrammatic reconstruction; *a*, elevation; *b*, distal polar view.

Knoxisporites seniradiatus sp. nov.

Plate 33, fig. 5

Holotype. Plate 33, fig. 5.

Type locality. Non-marine shales with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Diagnosis. Size range 60–105 μ (twenty specimens measured), holotype 88 μ; equatorial outline of the spore body subcircular; distal surface with tri-radial bars of thickening, rotated 60° relative to the trilete rays of the proximal surface; rays of the trilete mark with prominently thickened lips.

Description. Colour light brown. Outline of the spore body sharp; equatorial girdle is of uniform width. Trilete rays three-quarters radius of the spore body, tecta sharp and straight; lips associated with prominent bands of thickening, 5–7 μ wide, margin away from the suture often slightly undulating. Cingulum 6–14 μ wide. The Y-shaped bars of distal thickening, 6–10 μ wide, often persist into the cingulum. Exine faintly infra-punctate.

Comparison. Knoxisporites triradiatus is very similar, but the spores of that species lack the prominent thickenings which in *K. seniradiatus* are associated with the trilete rays.

Occurrence. Namurian B–C, rare.

Genus STENOZONOTRILETES (Naumova) Hacquebard 1957

Type species. S. conformis Naumova 1953

Stenozonotriletes triangulus sp. nov.

Plate 33, figs. 7, 8

Holotype. Plate 33, fig. 7.

Type locality. Marine shales with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Diagnosis. Size range 60–80 μ (twenty-five specimens measured), holotype 77 μ; equatorial outline triangular, sides straight to slightly convex, apices rounded; equatorial girdle narrow, 4–8 μ wide, and smooth.

Description. Colour yellowish-brown. Trilete rays three-quarters radius of the spore body, lips often associated with small folds of the exine which taper towards the proximal pole; a darker contact region is often present. The equatorial girdle is of uniform width and possesses little or no equatorial taper. Exine laevigate to slightly infra-punctate.

Comparison. Stenozonotriletes conspersus Naumova 1953 is of similar shape but is smaller.

Genus CRASSISPORA Bhardwaj 1957

Type species. C. ovalis Bhardwaj 1957

Crassispora kosankei (Potonié and Kremp) Bhardwaj 1957

Occurrence. Namurian B–Westphalian A, occasionally common in certain coal-seam and non-marine shale assemblages. The first appearance of this species can be correlated accurately with measures of Namurian B age.

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

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

Cirratriradites ornatus sp. nov.

Plate 33, fig. 3

Holotype. Plate 33, fig. 3.

Type locality. Non-marine shale with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

Diagnosis. Size range 80–110 μ (fifteen specimens measured), holotype 92 μ; equatorial outline rounded triangular; trilete rays are associated with long folds which extend on to the thin, fibrous zona; the whole of the distal surface of the spores is beset with dispersed coni.

Description. Colour light brown, zona pale yellow-brown. Exine of the spore body punctate; decorated on the distal surface with delicate cones and small spines. The zona has a radial fibrous appearance, width 14–20 μ. Where the zona passes over the spore body margin, a darker band, 7–10 μ wide, is present. No foveae are present.

Remarks. C. ornatus is distinguished by its large size, the ornamentation of the distal surface, and the lack of foveae.

Occurrence. Namurian C, present in non-marine shales only, rare.

Series MEMBRANATI ser. nov.

This series is proposed for those trilete iso- or miospores in which the outer membrane of the exine, the exo-exine, has partially separated from the inner membrane or intexine, and projects at the spore margin as a clear, thin membrane. The two membranes may be attached to one another only in the region of the trilete mark, or the exo-exine can be arranged as a series of folds which run over the surface of the spore body membrane.

Remarks. The infra-reticulate structure which characterizes the cavity between the spore body wall and the saccus membrane, in many forms attributed to the Division Sacciti, is never present in the Series Membranati.

Genus PROPRISPORITES Neves 1958

Type species. P. rugosus Neves 1958

Proprisporites laevigatus sp. nov.

Plate 33, figs. 9, 10

Holotype. Plate 33, fig. 9.

Type locality. Marine shales with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

Diagnosis. Size range 70–115 μ (fifteen specimens measured), holotype 77 μ; equatorial outline of the spore body rounded triangular; trilete rays three-quarters radius of the spore body; exo-exine translucent, laevigate and strongly folded over the laevigate spore body.

Description. Colour light brown; exine laevigate. Spore body compact, outline smooth and regular. The outer spore membrane is plicated into a series of sinuous folds which run over the surface of the spore body. The folds in places lie parallel to the compressed spore margin, where they appear as membranous projections; they may also appear as subconical projections at the spore outline when the fold axis lies at an angle to the outline.

Comparison. The only other described species of this genus, *P. rugosus*, is distinguished by the strong punctation of the spore body membrane.

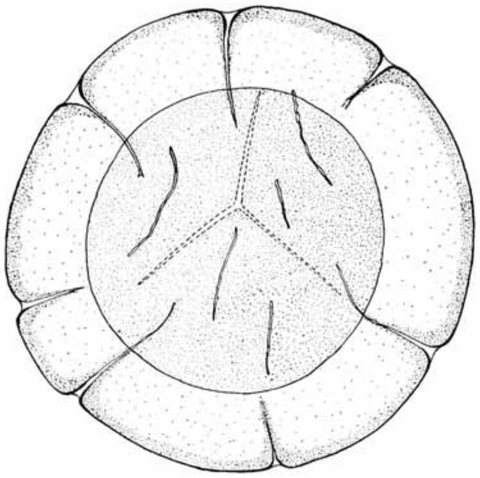
Occurrence. Namurian A–B, more typical of the marine shale assemblages.

Genus HYMENOSPORA gen. nov.

Text-fig. 5

Type species. *H. palliolata* sp. nov.

Diagnosis. Trilete iso- or microspores; equatorial outline circular to subcircular. The exo-exine is attached to the int-exine in the region of the trilete mark. In addition the



TEXT-FIG. 5. *Hymenospora* gen. nov. Diagrammatic reconstruction; distal surface.

exo-exine is deeply furrowed, and along the troughs of the furrows the two membranes are still in contact. In the compressed spores the exo-exine projects beyond the body margin as a laevigate, membranous zone.

Remarks. The zonate aspect of these spores is due entirely to the marginal projection of the exo-exine, and the outer zone is not necessarily in the equatorial position relative to the trilete mark, an essential character of the Series Cingulati and Zonati. The outer membrane, although detached for the greater part from the int-exine, is fairly rigid due to the subsidiary lines of adhesion along the furrows in the exo-exine.

Hymenospora palliolata sp. nov.

Plate 33, figs. 11, 12

Holotype. Plate 33, fig. 11.

Type locality. Marine shales with *Gastrioceras cancellatum*, Crowborough Wood, Staffordshire (Loc. 10). Yeadonian stage.

Diagnosis. Size range 70–105 μ (twenty specimens measured), holotype 87 μ; equatorial outline subcircular; trilete rays sharp, three-quarters radius of the spore body; exo-exine laevigate and crenulate.

Description. Colour of spore body light brown, outer membrane pale yellow; exine laevigate. Trilete rays three-quarters spore body radius, tecta tapering, lips thin. The mantle-like outer membrane is wrinkled into a series of narrow linear furrows, along which lines it is attached to the inner membrane. The two membranes are also in contact in the region of the trilete mark. In the compressed spores the exo-exine projects beyond the margin of the spore body as a more or less uniform rim with an outer crenulate border. An original globular form of these spores is indicated by the frequent oblique compression.

Comparison. Knox (1947, pl. 6, fig. 54) illustrates Spore Type 46K from the Limestone Coal Group of Scotland (Namurian A); this form closely resembles *Hymenospora palliolata*.

Occurrence. Namurian A and Namurian C, marine-shale assemblages only, rare.

Series PATINATI Butterworth and Williams 1958
Genus *Tholisporites* Butterworth and Williams 1958

Type species. *T. scoticus* Butterworth and Williams 1958

Tholisporites? *bianulatus* sp. nov.

Plate 34, fig. 2; text-fig. 6

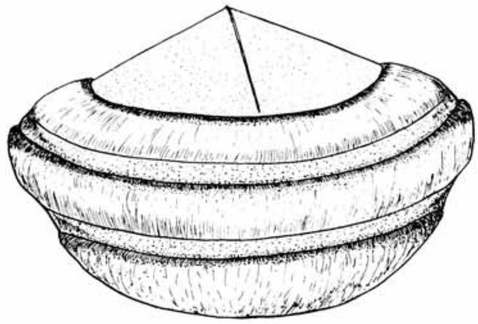
Holotype. Plate 34, fig. 2.

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

Diagnosis. Size range 55–90 μ (twenty specimens measured), holotype 80 μ; equatorial outline circular, spores commonly preserved in the lateral position; two raised bands of thickening encircle the spores subequatorially; a large circular patch of thickening is centred on the distal pole.

Description. Colour: thickenings dark brown; remainder of the exine pale brown. Exine laevigate to faintly infra-punctate. The spores are usually compressed in the plane of the polar axis, indicating an original spherical to subspherical form. Trilete rays two-thirds radius of the spores. The exine bears two thickened bands, 7–20 μ wide, which lie adjacent to the equator, displaced slightly on to the proximal and distal hemi-spheres. These annular bands are separated by a channel of thinner exine, which appears as a rounded depression at the spore margin. The distal polar region is contained within a broad, circular patch of thickening, up to 45 μ in diameter, and which is separated from the distal annular band by a narrow channel of thinner exine. The margins of all the thickenings are slightly wavy and thickened lenses may be present in the separating channels.

Remarks. These spores are tentatively referred to the genus *Tholisporites* since the thickening of the distal hemisphere is not complete.



TEXT-FIG. 6. *Tholisporites? bianulatus* sp. nov. Diagrammatic lateral view.

Division POLLENITES R. Potonié 1931
Group SACCITES Erdtman 1947
Subgroup MONOSACCITES (Chitaley) Potonié and Kremp 1954
Series EXTRORNATI Butterworth and Williams 1958
Genus REMYSPORITES Butterworth and Williams 1958

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

Remysporites magnificus

Plate 34, fig. 1

Occurrence. These distinctive spores are relatively rare in the Namurian measures of Central England, and appear to be restricted to assemblages of Namurian A age. Butterworth and Williams (1958) described this species from the Namurian A of Scotland. Horst (1955) first recorded spores of this type from the Namurian A of Upper Silesia and the Moravian Ostrau.

EXPLANATION OF PLATE 34

All magnifications $\times 500$.

Fig. 1. *Remysporites magnificus* (Horst) Butterworth and Williams 1958, 159 μ.

Fig. 2. *Tholisporites ? bianulatus* sp. nov., holotype, 80 μ. Slide ref. 18.263816. Lateral view, common habit.

Fig. 3. Cf. *Pityosporites sp.*, distal view, 105 μ.

Fig. 4. *Schopfipollenites ellipsoides* (Ibrahim) Potonié and Kremp 1955, 188 μ.

Fig. 5. *Schopfipollenites ellipsoides* var. *corporeus* var. nov., holotype, 168 μ. Slide ref. 4.236800.

Genus GRANDISPORA Hoffmeister, Staplin, and Malloy 1955

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

Grandispora spinosa Hoffmeister, Staplin, and Malloy 1955

Occurrence. Pendleian stage, Namurian A, rare. Hoffmeister, Staplin, and Malloy recorded this species from the Hardinsburg Formation of Illinois and Kentucky, U.S.A.

Series ALETESACCITI Leschik
Genus *Florinites* Schopf, Wilson, and Bentall 1944

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

Remarks. The presence of large numbers of spores of the genus *Florinites*, particularly the species, *F. elegans*, *F. similis*, *F. visendus*, and *F. pumicosus*, has been found to characterize marine shale assemblages of miospores from the Central Province of England. The presence of these spores in assemblages of Namurian A age represents the earliest known occurrence of these monosaccate grains.

Subgroup DISACCITES Cookson 1947
Genus *Pityosporites* (Seward) Potonié and Klaus 1954

Type species. P. antarcticus Seward

Cf. *Pityosporites spp.*

Plate 34, fig. 3

Horizon. Marine shales with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage, Namurian C.

Occurrence. Disaccate grains of the *Pityosporites–Vesicaspora* type are present as a minor constituent in shale assemblages at several horizons in the Yeadonian stage. This record represents the lowest horizon from which pollen grains of this type have been recorded.

Remarks. The absence of these grains in the coal-seam separations would seem to suggest that the parent plants, presumably Coniferalean type, existed outside the coal swamp regions. They were possibly associated with a marginal area of high land, as was suggested for the South Wales occurrence by Williams (1955, p. 471).

Group PRAECOLPATES Potonié and Kremp 1954
Genus SCHOPFIPOLLENITES Potonié and Kremp 1954

Type species. S. ellipsoides (Ibrahim) Potonié and Kremp 1955

Schopfipollenites ellipsoides sensu stricto

Plate 34, fig. 4

Occurrence. Plant spores of this species occur in measures of Pendleian age and range spasmodically throughout the Namurian sequence examined, and into the Westphalian.

Schopfipollenites ellipsoides var. *corporeus* var. nov.

Plate 34, fig. 5

Holotype. Plate 34, fig. 5.

Type locality. Pot Clay Coal, Consall, north Staffordshire (Loc. 15). Yeadonian stage.

Diagnosis. Size range 145–210 μ (twenty-five specimens measured), holotype 168 μ; equatorial outline oval; proximal surface with a narrow suture, characteristically bent about its middle point; distal surface bears two major longitudinal folds of the exo-exine; the inner spore membrane is preserved as a circular to ovate 'spore body'.

Description. Colour reddish-brown. Equatorial outline of the spore oval, that of the body is usually more circular. Exo-exine laevigate to faintly infra-punctate; spore body laevigate and strongly folded; the folds are arranged approximately transversely and longitudinally tending to form a more or less regular pattern. For the remainder these spores are comparable with *Schopfipollenites ellipsoides* Potonié and Kremp (1955, p. 184).

Remarks. Schopf, Wilson, and Bentall (1944, p. 38), in a discussion of the genus *Monoletes*, refer to the 'endosporal membrane', which in certain specimens appeared as a 'crumpled, translucent sack'. Although the authors gave no illustration, the structure described by them closely resembles that present in *S. ellipsoides* var. *corporeus*.

Occurrence. Namurian C; the spores of this variety are not restricted in occurrence to the same assemblages as *S. ellipsoides*.

DISTRIBUTION OF THE FOSSIL SPORES IN THE SEDIMENTS

Before it is possible to assess the stratigraphical value of the various spore types, it is necessary to consider the distribution of the spores in the different sedimentary types. Several authors (Hoffmeister, Staplin, and Malloy 1955; Neves 1958; Staplin 1960) have already drawn attention to the quantitative and qualitative variations in the fossil spore content within a short sequence of sediments.

During the current investigation, similar observations have been made and the association of certain fossil spore species with particular sediments can be readily appreciated from Table 1. Many species have been recorded only from shale preparations and the majority of the newly described species fall into this latter category. For example, spores of the genera *Ibrahimispores*, *Proprisporites*, and *Hymenospora* are restricted entirely to these allochthonous deposits. Furthermore, the species *Acanthotriletes baculatus*, *A. splendidus*, *A.? pilus*, *Hymenospor apalliolata*, and *Proprisporites rugosus* are confined to the marine-shale assemblages. In contrast, other species transgress the 'facies boundaries' and are present in coal, non-marine shale, and marine-shale assemblages. Such species as *Punctatisporites sinuatus*, *Camptotriletes superbus*, *Mooreisporites fustis*, *Secarisporites lobatus*, *Ahrensisporites guerickei* var. *ornatus*, *Crassispora kosankei*, and *Remysporites magnificus* could thus prove to be of value for wider correlation. The coal-seam assemblages are generally dominated by spores of the genera *Lycospora* and

TABLE 1. Chart showing observed stratigraphical ranges of selected spore species in the Namurian of the Southern Pennines Basin.

Densosporites which are found in association with *Calamospora*, *Apiculatisporis*, *Cyclogranisporites*, *Ahrensisporites*, and *Schulzospora*. The marine-shale assemblages from thirty horizons examined have been found to be dominated by saccate spores, principally of the genus *Florinites*; the remainder of these assemblages is variable in the relative proportions of the various spore types present, although the genera *Punctatisporites*, *Lophotriletes*, *Raistrickia*, *Convolutispora*, and *Auroraspora* usually figure prominently.

It would appear probable that the spore assemblages of the coal seams and the marine shales are representative of two completely distinct plant associations. The autochthonous peat deposits, as represented by the coal seams, contain for the greater part the spores of lycopods, calamites and pteridosperms, &c., which constituted the swamp vegetation. The widespread nature of the marine-shale deposits would necessitate the temporary withdrawal of the latter vegetation and the elimination of extensive coal swamps. Consequently, any vegetation existing on the land areas adjacent to the marine basin would automatically provide the majority of the dispersed spores entombed in the marine muds. An upland flora of the type suggested by Chaloner (1958, p. 261), clothing the St. George's Land mass to the south, forms an attractive hypothesis. The evidence for at least moderate relief in this massif can be seen in the coarse and often pebbly nature of the deltaic deposits which were swept northwards. These deposits now constitute prominent gritstone horizons such as the Ashover and Belper grits in Derbyshire, and from which abundant current-direction data are available to indicate their southerly origin.

The intermixing of the two principal spore associations is to be found in the non-marine shales, which often occupy an intermediate stratigraphic position between the coal seam below and the marine shale above. The non-marine shales represent the initial aqueous inundation of the coal swamps and the establishment of mud flats and isolated lagoons within the sedimentary basin. In this way, any masking effect by the products of the swamp vegetation will be reduced, so permitting the spores of a marginal vegetation to play an increasing role in the assemblages. This is substantiated to some extent by the diversity of the spore content of the three sedimentary rock types. The calculated average numbers of genera and species recorded in the various assemblages during the present investigation are as follows:

Assemblage	*Genera*	*Species*
Marine shale	20	32
Non-marine shale . . .	25	45
Coal	18	29

The wider diversity of morphological types present in the non-marine shale, together with the fact that these assemblages frequently contain many spore species in common with closely associated coals and marine sediments, is considered to indicate the intermixing of the two principal microfloras. Those spores which appear to be confined to the non-marine shale assemblages could be produced by plants capable of colonizing a wet, possibly brackish water environment.

In conclusion, it would appear to be essential to consider the microfloral remains from all sedimentary rock types available in order to achieve a more complete understanding of their distribution and also that of the parent plants. These studies will assist the observer to determine those spores which are sensitive to facies changes and are consequently of restricted value for the purpose of stratal subdivision.

STRATIGRAPHICAL APPLICATIONS

A general scheme for the stratigraphic subdivision of the Upper Carboniferous of the Midlands Coalfields proposed by Butterworth and Millott (1954) was based on the spore content of the coal seams. A sequence of microspore assemblages, S0 to S4 and transition zones, were defined by the occurrence of certain fossil spores with restricted stratigraphic ranges.

The Namurian spore assemblages of the Central Province fall entirely within the S0 assemblage of Butterworth and Millott. However, since the latter authors were dealing only with coal seams, it could be expected that an investigation of the carbonaceous shales would permit a finer accuracy in stratal subdivision. For the purpose of the present account certain useful spores, with restricted or characteristic ranges and those which are of interest on account of their geographical occurrence, have been extracted from the complete assemblages and are listed in Table 1.

Pendleian assemblages. These assemblages are characterized by little diversity in the spore types present, although some spores appear to be restricted to strata of this age in the southern part of the Central Province basin. Such spores are *Apiculatisporis maculosus*, *Verrucosisporites morulatus*, *Camptotriletes verrucosus*, and *Grandispora spinosa.* In addition *Ahrensisporites guerickei* var. *ornatus*, *Reticulatisporites karadanizensis*, *Schulzospora occellata*, *Auroraspora solisortus*, *Microsporites radiatus*, &c., are present in these Lower Namurian assemblages. The presence of *Florinites elegans*, *F. similis*, and *F. visendus* at these horizons represents the first record of these monosaccate grains in Namurian A assemblages. Unfortunately, due to the lack of information concerning the spore content of Lower Carboniferous sediments in this region, it is impossible at the present time to assess any change in the microflora at the base of the Namurian.

Arnsbergian assemblages. A wide range of spore types has been obtained from samples of Arnsbergian age, and many of the spores appear for the first time in this region. Whilst satisfactory preparations have not been forthcoming from the northern parts, those in the south and west have proved to be closely comparable in content. *Convolutispora* is a common constituent, as are *Florinites spp.*, *Schulzospora*, *Auroraspora*, *Callisporites*, *Cyclogranisporites*, &c. *Acanthotriletes splendidus*, *Proprisporites laevigatus*, *Hymenospora palliolata*, *Remysporites magnificus*, and *Tholisporites*? *bianulatus* occur together in an association which seems to be diagnostic of this stage. *Discernisporites* and *Mooreisporites* are present in relatively small numbers at these horizons, whilst *Alatisporites nudus* appears for the first time, although infrequently.

Sabdenian assemblages. In many respects these assemblages are comparable with those of the Arnsbergian stage. Many species persist into the Sabdenian; for example *Acanthotriletes baculatus*, *Simozonotriletes trilinearus* Artuz, *Ibrahimispores microhorridus* Artuz, and *Proprisporites laevigatus* are usually to be found in these upper Namurian A separations. *Neoraistrickia inconstans* appears to be confined to these two stages, and in certain Sabdenian assemblages exhibits a wide diversity of form. At the same time several new spore types appear, including *Secarisporites lobatus*, *Knoxisporites dissidius*, *Reinschospora speciosa*, and an undescribed species of *Grandispora*. *Tholisporites? bianulatus* has not been recorded in these assemblages.

Kinderscoutian assemblages. These assemblages have been found to be relatively impoverished in the constituent spore types present, a feature which may be related to the widespread arenaceous facies which occurs throughout the region during this stage. In the lower horizons, the assemblages are closely comparable with those of the Sabdenian. *Densosporites spinosus* is often quite common in these separations and forms approaching *Cristatisporites indignabundus* represent a similar form in which the ornamentation of the flange (laterally fused spines) becomes more strongly developed. A few spore types appear for the first time and the two species *Crassispora kosankei* and *Knoxisporites seniradiatus* are quite distinctive.

Marsdenian assemblages. Many spores make an initial appearance in the Marsdenian and persist through into the Westphalian assemblages. The former assemblages are easily distinguished, therefore, from those of the Namurian A and lower Namurian B. *Apiculatisporis* is present and is characterized by a considerable variety of morphological types, of which *A. setulosus* and *A. latigranifer* are quite distinctive and become fairly common in the overlying Yeadonian stage. *Mooreisporites bellus*, *Camptotriletes superbus*, and *Ahrensisporites beeleyensis* are completely new types and become established forms in the Yeadonian assemblages. The genera *Armatisporites* Dybova and Jachowicz and *Mooreisporites* occur commonly in the coal-seam assemblages of this stage.

Yeadonian assemblages. The Westphalian aspect of the spore assemblages, initiated in the Marsdenian stage, is developed further in the spore florules above the *Gastrioceras cancellatum* marine band. The latter horizon has been found to contain a rich and varied association of spore types in the several localities from which the shales have been examined. The related occurrence of *Acanthotriletes? pilus*, *Ibrahimispores magnificus*, *I. brevispinosus*, *Knoxisporites dissidius*, and *K. seniradiatus* in an assemblage dominated by *Florinites* appears to be typical of this horizon throughout the basin. In contrast, the overlying marine shales containing *Gastrioceras cumbriense* have yielded very poor spore assemblages from the four localities at which they were sampled. The succeeding sequence of sandstones, shales, and coals is characterized by a wide variety of spore types and the succession is distinguished by a specific morphological variation pattern shown by spores of the genus *Ahrensisporites*. The non-marine shales with *Carbonicola exporrecta* contain a diverse assemblage of fossil spores in the extreme east of the region and extending to the extreme west, in the Wigan district. The occurrence of the alga, *Botryococcus braunii*, is a persistent feature of these shales.

The coal-seam and associated non-marine roof shales, found immediately below the *Gastrioceras subcrenatum* marine band, marks the first occasion on which the entire basin was colonized by a swamp vegetation. Based on the study of the fossil spore content of the coal seam it would appear that the vegetation was relatively uniform over the whole region. The assemblage is usually dominated by spores of the genus *Lycospora*, although locally the general *Calamospora* and *Densosporites* assume the dominant role. The Yeadonian assemblages as a whole are characterized by the following species in particular, *Camptotriletes superbus*, *Dictyotriletes varioreticulatus*, *Ahrensisporites guerickei* sensu stricto, *Densosporites vulgaris*, *Cirratriradites ornatus*, *Proprisporites rugosus*, *Schopfipollenites ellipsoides* var. *corporeus*. *Crassispora kosankei* is sometimes a common constituent of both non-marine shale and coal-seam assemblages, whilst the presence of disaccate pollen grains in the shales is of particular interest on account of their possible Coniferalean affinity.

Lower Westphalian A assemblages. Lying between the marine horizons of *Gastrioceras subcrenatum* and *G. listeri* is a variable series of coal seams, sandstones, and shales which contain a microflora closely comparable in broad aspect to that of the Yeadonian stage of the Namurian. Immediately below the higher marine horizon, the Alton or Crabtree coal seam is persistent across the basin. Samples from this seam are characterized by an abundance of the species *Anulatisporites anulatus* and *Densosporites spp*. In addition, typical spores of the genus *Triquitrites* appear strongly for the first time in the succession.

Conclusions. The observed stratigraphic ranges of the fossil spores shown on Table 1 implies a characteristic 'drift' in the content of the spore assemblages from older to younger horizons. On account of this distribution pattern, spore assemblages from random samples of coal or shale from the Namurian succession of the Central Province Basin can be dated in relation to the sequence of goniatite stages. Furthermore, when the ranges of these spores are considered in conjunction with more complete assemblage data, the recognition of specific horizons is possible, as for example in the Yeadonian stage. Further investigation into the distribution of fossil spores in this type of succession could lead to an independent system of stratal subdivision, providing sufficient attention is paid to the facies characteristics of the various spore types.

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R. NEVES
Department of Geology,
University of Sheffield.

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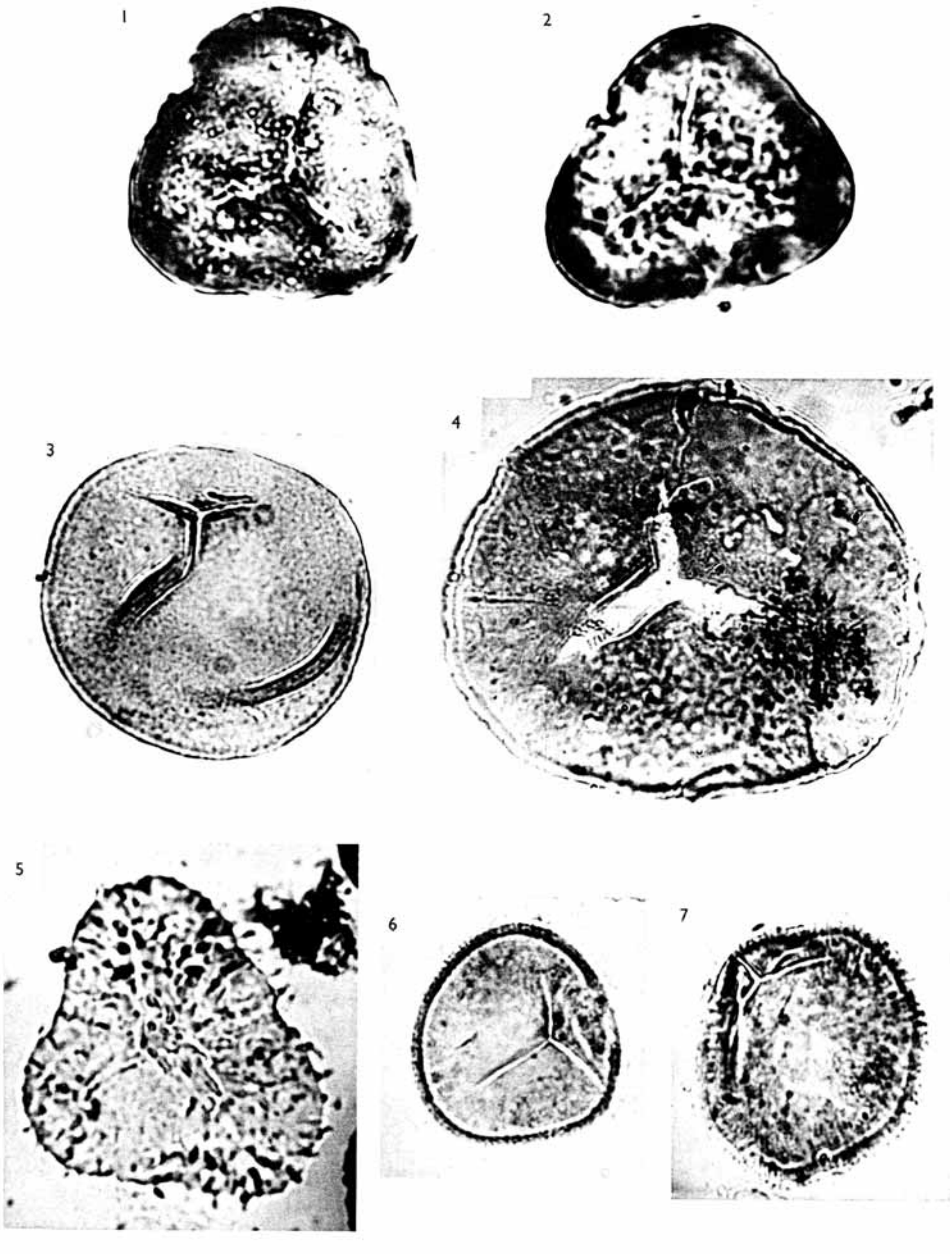
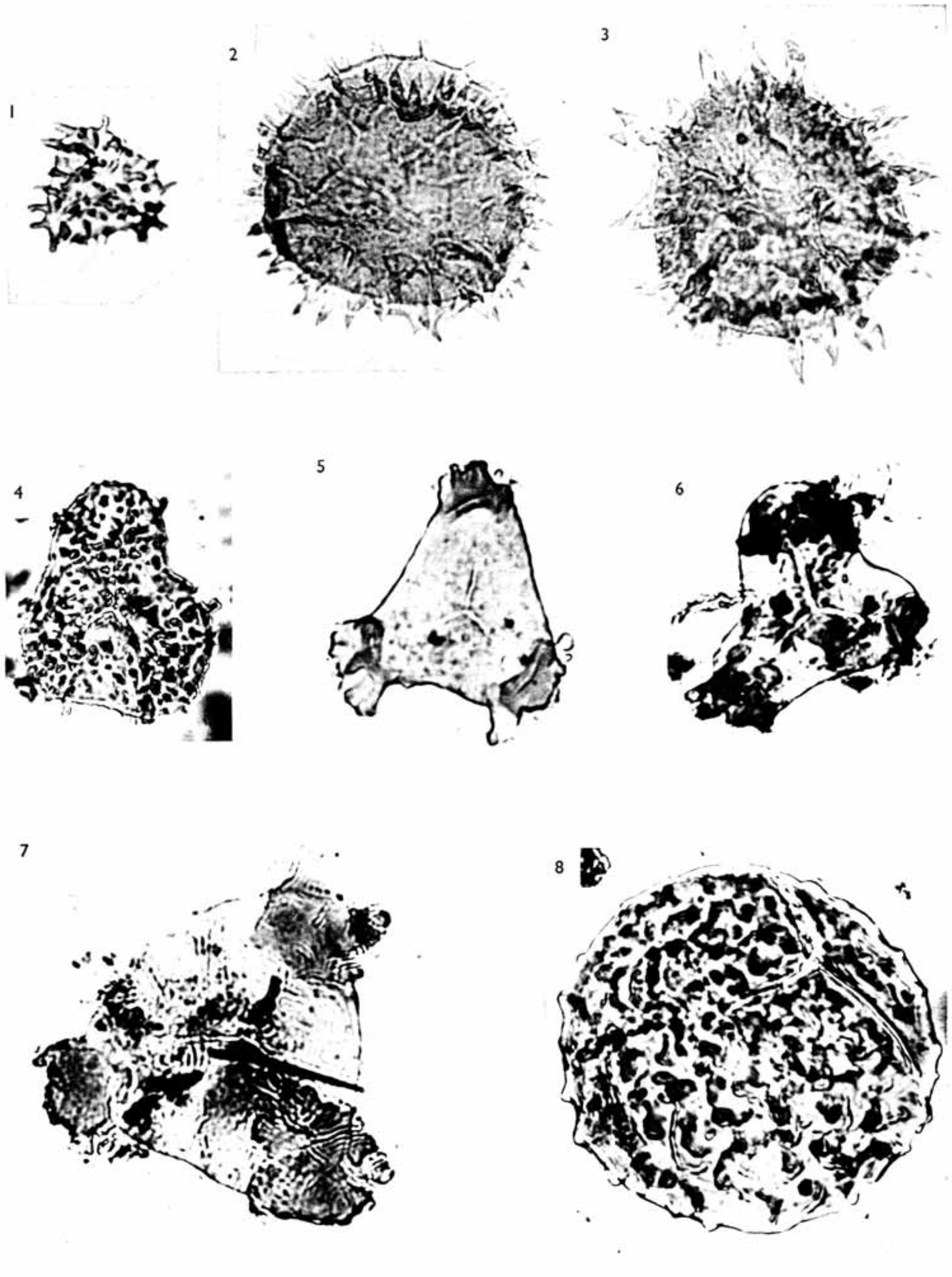


NEVES, Namurian microspores



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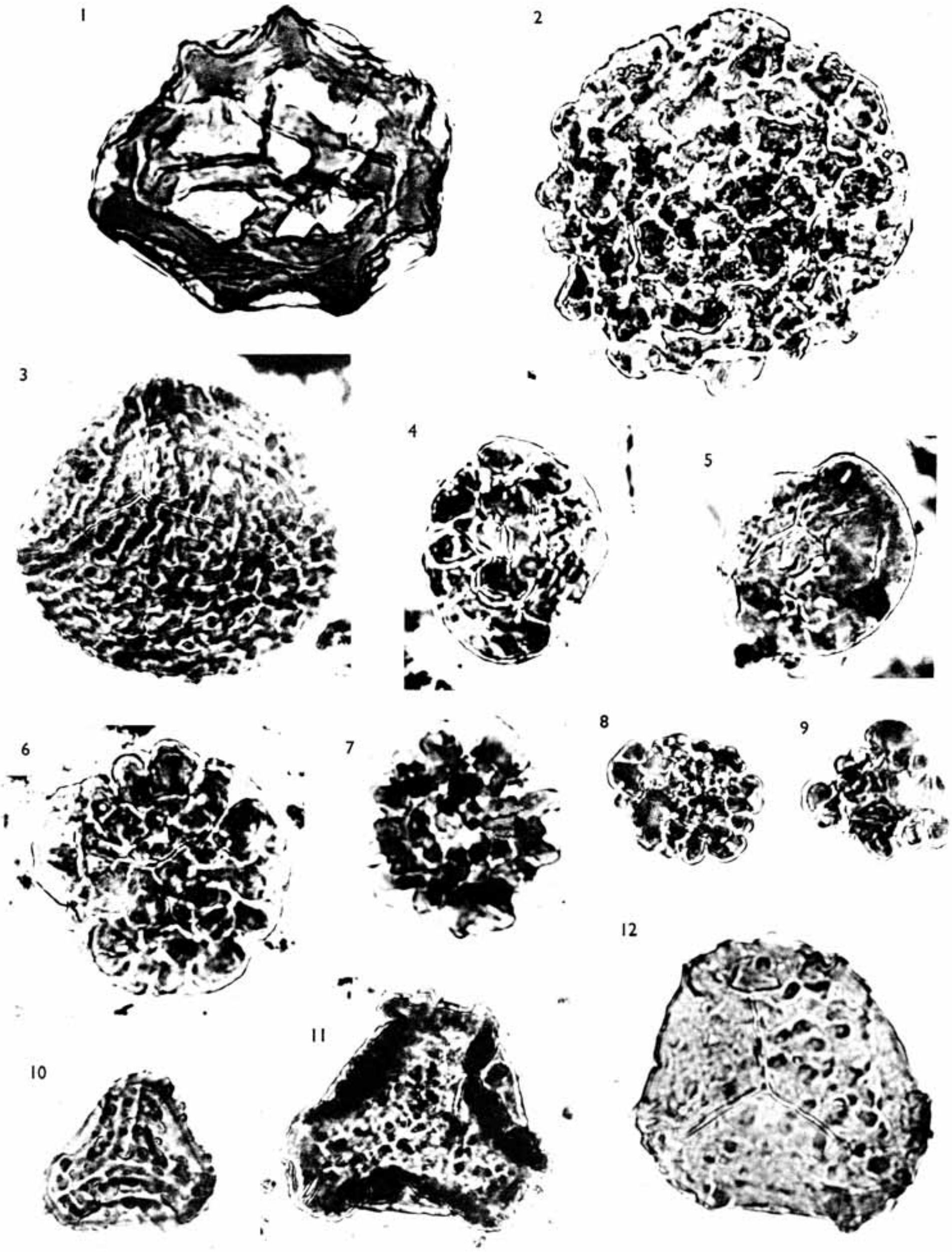
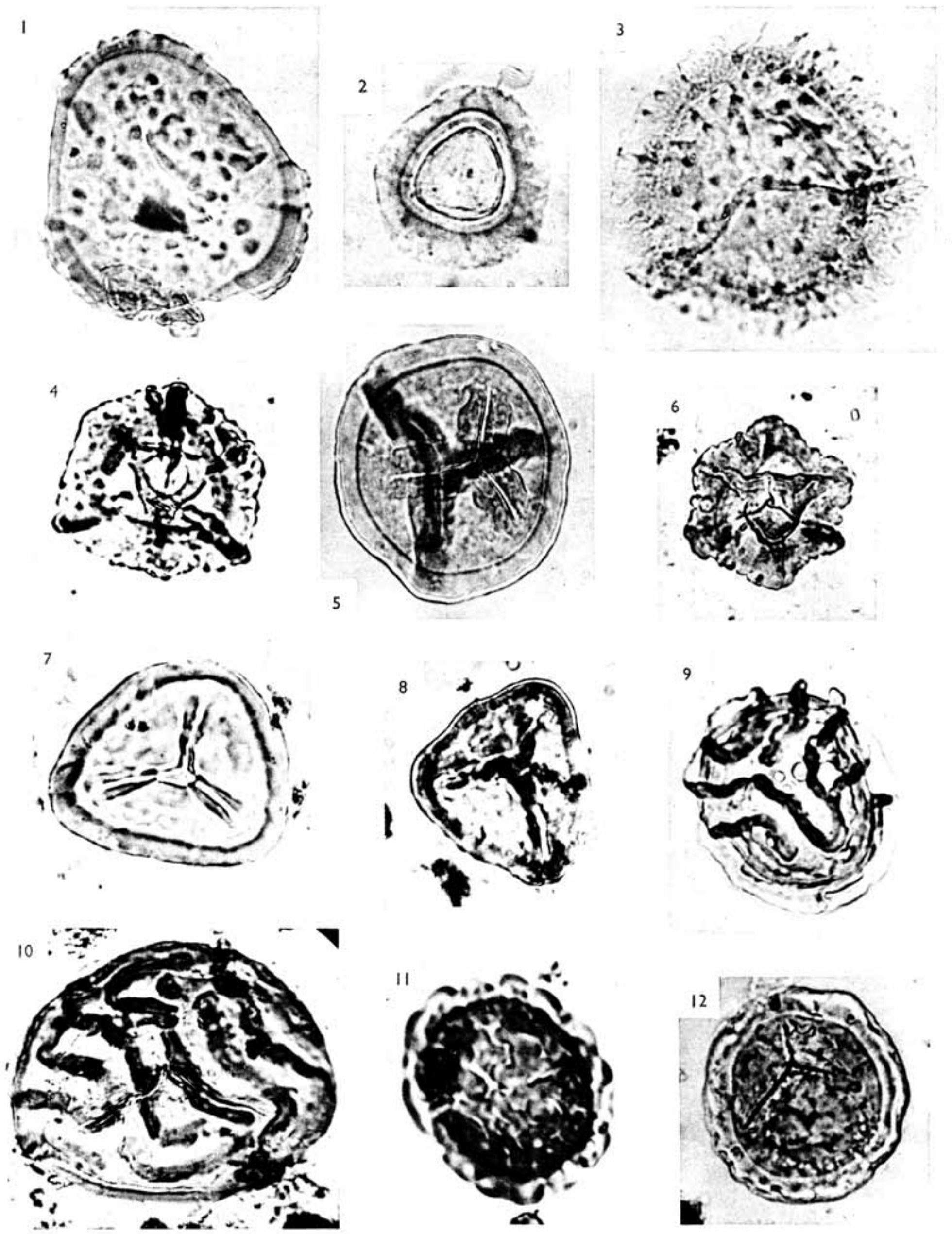


NEVES, Namurian microspores



NEVES, Namurian microspores

NEVES, Namurian microspores

TABLE. I.

NAMURIAN							WEST-PHALIAN	ASSEMBLAGES			
A			B		C						
LOWER EUMORPHOCERAS (E1) (PENDLEIAN)	UPPER EUMORPHOCERAS (E2) (ARNSBERGIAN)	HOMOCERAS (H) (SABDENIAN)	LOWER RETICULOCERAS (R1) (KINDERSCOUTIAN)	UPPER RETICULOCERAS (R2) (MARSDENIAN)	LOWER GASTRIOCERAS (G1) (YEADONIAN)	UPPER GASTRIOCERAS (G2)		COAL	NON-MARINE SHALE	MARINE SHALE	GONIATITE STAGES. / PLANT SPORE SPECIES.
								×			Apiculatisporis maculosus
								×			Verrucosisporites morulatus
								×			Camptotriletes verrucosus
								×			Grandispora spinosa
										×	Acanthotriletes baculatus sp. nov.
									×	×	Proprisporites laevigatus sp. nov.
								×	×	×	Schopfipollenites ellipsoides
								×	×	×	Ahrensisporites guerickei var ornatus var. nov.
										×	Tholisporites ? bianulatus sp. nov.
										×	Punctatisporites giganteus sp. nov.
										×	Acanthotriletes splendidus sp. nov.
										×	Microreticulatisporites concavus –
										×	Convolutispora obliqua sp. nov.
									×	×	Punctatisporites pseudopunctatus sp. nov.
								×	×	×	Remysporites magnificus
								×		×	Neoraistrickia inconstans sp. nov.
										×	Dictyotriletes tuberosus sp. nov.
										×	Mooreisporites trigallerus sp. nov.
									×	×	Densosporites spinosus
								×		×	Stenozonotriletes triangulus sp. nov.
										×	Hymenospora palliolata sp. nov.
									×	×	Knoxisporites dissidius sp. nov.
								×	×	×	Secarisporites lobatus sp. nov.
								×	×	×	Mooreisporites fustis
									×	×	Ibrahimispores brevispinosus sp. nov.
									×	×	Knoxisporites seniradiatus sp. nov.
								×	×	×	Crassispora kosankei
								×			Mooreisporites bellus sp. nov.
									×	×	Secarisporites remotus sp. nov.
								×	×	×	Densosporites vulgaris sp. nov.

							×	×	×	Dictyotriletes varioreticulatus
							×	×	×	Punctatisporites sinuatus comb. nov.
								×		Ahrensisporites beeleyensis sp. nov.
								×		Triquitrites nodosus sp. nov.
									×	Acanthotriletes ? pilus sp. nov.
								×	×	Ibrahimispores magnificus sp. nov.
								×	×	Bisaccate Pollen Grains
							×	×	×	Ahrensisporites guerickei
							×	×		Schopfipollenites ellipsoides var corporeus var. nov.
								×		Cirratriradites ornatus sp. nov.
								×	×	Leiotriletes densus sp. nov.
									×	Proprisporites rugosus