MIOSPORES FROM THE PURBECK BEDS AND MARINE UPPER JURASSIC OF SOUTHERN ENGLAND

by GEOFFREY NORRIS

ABSTRACT. Miospores from the marine Upper Jurassic and from the non-marine Purbeck Beds (Tithonian–Berrisanum) of southern England are described and illustrated. Three principal palynologic suites embracing a total of 77 species (13 of which are new) are recognized, each detailing broadly similar spore-pollen assemblages. Suite A characterizes the Upper Kimmeridgian (rotundus and rutilus zones), the Portlandian, and the basal Lower Purbeck Beds. Suite B characterizes the remaining Lower Purbeck and the lower part of the Middle Purbeck. Suite C occupies the remaining Middle Purbeck and all of the Upper Purbeck. The Purbeck Beds of central Sussex correlate palynologically with some of the Middle and the Upper Purbeck of Dorset and with the Serpentine and Wealden 1 to 4 of north-central Germany and Holland. The lower limit of palynologic Suite C approximately coincides with a possible Jurassic–Cretaceous boundary. The successional palynologic suites represent a progressive diversification of the spore-pollen flora derived from periodically gymnosperm-pteridophyte vegetation. Although filicalean spores are the most diverse elements in the assemblages as a whole, coniferalean pollen species are the most persistent as well as the numerically dominant elements. Bryophytic and cycadalean elements remain unimportant throughout.

This paper describes miospore assemblages from the Purbeck Beds of southern England and from the Upper Kimmeridgian and Portlandian marine sediments exposed on the Dorset coast. Couper (1958) made an extensive study of British Jurassic and Lower Cretaceous miospores but examined only a few samples from the Purbeck Beds of Durlston Bay, Dorset and Mountfield, Sussex and three palynologic assemblages from the Kimmeridgian of Scotland. He demonstrated that significant differences exist between miospore assemblages from various Jurassic and Cretaceous stages and formations but did not attempt detailed subdivision and correlation of the Upper Jurassic. Lantz (1958), however, attempted a palynologic subdivision of the English Upper Jurassic in a limited study. Hughes (1958) demonstrated a relatively detailed miospore zonation of both marine and non-marine Lower Cretaceous sediments and correlated the Wealden with the marine stages by this means. Recently, Hughes and Moody-Stuart (1969) have noted a new method to correlate palynologically the Lower Cretaceous of southern England.

The present study examines the stratigraphic value of miospores for zonation and correlation of strata developed close to the Jurassic–Cretaceous boundary in southern England and for age determination of the Purbeck Beds and equivalent strata in Dorset and Sussex.

STRATIGRAPHY AND LOCATION OF SAMPLES

The stratigraphy of the sections is summarized in text-fig. 1. Location of the sections examined are indicated in text-fig. 2. Precise stratigraphic positions of the samples within these sections are given in the Appendix to Norris (1963). Reference should be made to Arkell (1947) for a detailed account of the stratigraphy and structural setting where also a full list of references to major works on the geology of the Dorset area may be found.

<table>
<thead>
<tr>
<th></th>
<th>Sampled Interval</th>
<th>Dorset</th>
<th>Sampled Interval</th>
<th>Sussex</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wealden</strong></td>
<td></td>
<td>Variegated Marls and Sandstones</td>
<td></td>
<td>Ashdown Sand</td>
</tr>
<tr>
<td><strong>(Lower Part)</strong></td>
<td></td>
<td></td>
<td></td>
<td>Fairlight Clay</td>
</tr>
<tr>
<td><strong>Purbeck Beds</strong></td>
<td></td>
<td>Upper Purbeck</td>
<td></td>
<td>'Upper' Purbeck</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle Purbeck</td>
<td></td>
<td>'Middle' Purbeck</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower Purbeck</td>
<td></td>
<td>'Lower' Purbeck</td>
</tr>
<tr>
<td><strong>Portlandian</strong></td>
<td></td>
<td>Freestone Series</td>
<td></td>
<td>Portland Sand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cherty Series</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Portland Sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Kimmeridjan</strong></td>
<td></td>
<td>Kimmeridge Clay (Upper Part)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Text-fig. 1.** Generalized succession of strata close to the Jurassic-Cretaceous boundary in Dorset and Sussex. Correlations are not implied between the two areas.
TEXT-Fig. 2. Locality map of Kimmeridgian, Portlandian, and Purbeck sections examined in southern England, plus other areas mentioned in the text. Inset map shows localities on the Dorset coast within the area enclosed by a broken line on the main map.
Samples were selected on the basis of lithologies most suitable for palynomorph preservation in each section. In general, the samples from the Kimmeridge Clay are shales or silty shales and those from the Portland Sand are siltstones or fine-grained sandstones. Clastic material is almost entirely lacking in the Portland Stone and all samples from here are relatively pure limestones. Samples from the Purbeck Beds are more varied but in general grey and brown shales, silty shales, and clays yielded the best assemblages. Of the carbonate rocks in the Purbeck Beds, argillaceous limestones are the most satisfactory for palynologic examination.

**Table 1**

Zonal classification of the Portlandian and upper part of the Kimmeridgian in Dorset, with thicknesses of respective rock divisions exposed at West Weare Cliff (Isle of Portland) and Hounstout (Isle of Purbeck). The strata comprising the upper two Portlandian zones constitute the Portland Stone and those of the lower two zones the Portland Sand. Numbers of samples examined are indicated.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Zone</th>
<th>Isle of Portland</th>
<th>Rock Units</th>
<th>Isle of Purbeck</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Zavatkisites albidus</strong></td>
<td>22 samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Purkavia retinula</em>&lt;br&gt;Not sampled</td>
<td>(Not exposed at West Weare Cliff)</td>
<td>10 samples</td>
<td></td>
</tr>
</tbody>
</table>

**Marine Upper Jurassic**

(a) **Hounstout (Isle of Purbeck)**. A complete succession from the Upper Kimmeridgian to Portlandian, as shown in Table 1, is exposed in the face of Hounstout and surrounding cliffs at Chapman's Pool, Emmitt Hill, Pier Bottom, and St. Alban's Head on the Isle of Purbeck (Arkell 1935, 1947). Number of samples collected is shown in Table 1.

Arkell's (1935, 1947) zonal classification of the Kimmeridgian and Portlandian is followed, with modifications suggested by House (1958 a, b), and is also shown in Table 1. The top two ammonite zones of the Kimmeridge clay were examined in this study so that the typical shaley facies of the Kimmeridgian would be included.
(b) West Weare Cliff (Isle of Portland). A continuous succession from Kimmeridge Clay to Portland Stone is exposed in the cliffs on the west side of the Isle of Portland as shown in Table 1 (Arkell 1933, 1935; House 1958a). The number of samples used is also shown in the Table.

Purbeck Beds

The lower boundary of the Purbeck Beds in southern England is delimited by Portlandian sediments which belong to different zones in different areas (Arkell 1953, Taitt and Kent 1958, Falcon and Kent 1960). The Purbeck Beds are terminated by the incoming of the Wealden facies (Allen 1955). Arkell (1947, 1956) used ‘Purbeckian’ as a stage of the Jurassic system, basing it on three ostracod zones recognizable in the Purbeck Beds. However, the Purbeckian of north-west Europe is now considered as a predominantly freshwater and continental facies developed at the top of the Jurassic and the base of the Cretaceous (Mayne 1962, Oertli 1963), and to avoid confusion the term will not be used.

It has been customary in British stratigraphy for more than a century to use the term ‘Purbeck Beds’ for all those continental, freshwater, brackish, estuarine, lagoonal or partly marine, usually fine-grained and calcareous sediments developed above the Portland Beds in southern England (Fisher 1856, Bristow 1857, Topley 1875, Woodward 1895, Arkell 1933, Howitt 1964). The desirability of using the same rock unit name for similar sediments from widely separated localities is questionable. The term Purbeck Beds is used in this study for all areas because it is still in widespread use. The erection of other formational names requires more intensive work on the detailed stratigraphy at each locality than was attempted here. The present work on the Purbeck palynologic assemblages may help to resolve some problems of the stratigraphy and correlation of the Purbeck Beds.

In a later section, reference will be made to the ‘Purbeckian’ of France and Switzerland developed in and around the Jura Mountains (Arkell 1956, Donze 1958). To avoid confusion and to remove any connotation of time-concordance, these sediments will be informally termed, for purposes of discussions, the ‘Swiss Purbecks’, ‘French Purbecks’, or ‘Jura Purbecks’, depending on the context.

Some sections of the Purbeck Beds in southern England have been zoned using ostracods. The history of the zonal classification of the Purbeck Beds has been given by Anderson (1958, 1962), the later reference with particular regard to the Upper Purbeck. Anderson (1940) proposed a more detailed subdivision of the Purbeck Beds than the original tripartite division of earlier workers. This was subsequently revised by Sylvester-Bradley (1949) and Anderson (1958). In consequence, the limits of the Lower, Middle, and Upper divisions have undergone considerable fluctuations. Anderson (1958) proposed 6 ostracod zones of which the lower 2 define the Lower Purbeck, the succeeding 3 the Middle Purbeck, and the highest zone characterizes the Upper Purbeck (Table 2). The limits of these three divisions now correspond exactly to those used by Bristow (1857).

(a) Dorset Coast. The type section of the Purbeck Beds is exposed on the north limb of the Purbeck anticline in Durlston Bay. There is a general attenuation of the Purbeck Beds westwards from Durlston Bay (390 ft.), Worbarrow Bay (290 ft.), Bacon Hole (250 ft.) to Lulworth Cove (179 ft.) (see Howitt 1964, fig. 7). Purbeck assemblages have
not been recovered westwards beyond Lulworth Cove. The detailed stratigraphy of the Purbeck Beds has been described by Fisher (1856), Bristow (1857), and Damon (1884). Bristow’s sections have usually been taken as a basis for later work, but his rock units have been emended by Woodward (1895), Strahan (1898), and Arkell (1933). Some workers still use Bristow’s rock unit nomenclature in preference to Arkell’s. The two schemes are compared in Table 2, where also the ostracod zones of Anderson (1958) are indicated.

**Table 2**

Ostracod zonal classification of the Purbeck Beds from Anderson (1958), with Arkell’s and Bristow’s alternative stratigraphic nomenclature of the Dorset Purbeck sections; the Mountfield Purbeck is from Howitt (1964) including his suggested lithologic correlations with Dorset.

<table>
<thead>
<tr>
<th>Zones</th>
<th>Dorset</th>
<th>Arkell 1953</th>
<th>Mountfield, Sussex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Purbeck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cypriidea stenina</em></td>
<td>Bristow 1857</td>
<td>Viviaporus Clays</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Cypris Clay and Shales</td>
<td>Marble Beds and Ostracod Shales</td>
<td>Greys Limestone Series</td>
</tr>
<tr>
<td></td>
<td>Unio Beds</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Broken Shell Limestone</td>
<td>Unio Beds</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Broken Shell Limestone</td>
<td></td>
</tr>
<tr>
<td>Middle Purbeck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cypriidea propinqua</em></td>
<td>Chief Beef Beds</td>
<td>Chief Beef Beds</td>
<td>Shales with Beef and Clay Ironstone</td>
</tr>
<tr>
<td></td>
<td>Corbula Beds</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scallop Bed</td>
<td>Corbula Beds</td>
<td></td>
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<tr>
<td></td>
<td>Interimarne Beds</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cinder Beds</td>
<td>Upper Building Stone</td>
<td>Arenaceous Beds</td>
</tr>
<tr>
<td></td>
<td>Cherty Freshwater Beds</td>
<td>Cinder Bed</td>
<td>Cinder Beds</td>
</tr>
<tr>
<td></td>
<td>Marley Freshwater Beds</td>
<td>Lower Building Stone</td>
<td>Plant and Bone Beds</td>
</tr>
<tr>
<td>Lower Purbeck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Fulvella boltonensis</em></td>
<td>Soft Cockle Beds</td>
<td>Marks with Gypsum and Insect Beds</td>
<td>Blue Limestone Series</td>
</tr>
<tr>
<td></td>
<td>Hard Cockle Beds</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cyprius purbeckensis</em></td>
<td>Cypris Freestone</td>
<td>Broken Beds</td>
<td>Rounden Greys</td>
</tr>
<tr>
<td></td>
<td>Broken Beds</td>
<td>Caps and Dirt Beds</td>
<td>Main Gypsiferous Beds</td>
</tr>
<tr>
<td></td>
<td>Soft Cap</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard Cap</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Four Purbeck localities were examined along the Dorset Coast. The type section at Durbarston Bay was examined in most detail. One hundred and twenty samples were collected from the 390-ft. section of Lower, Middle, and Upper Purbeck at this locality. Of the 85 samples treated for palynomorphs, 69 yielded assemblages.

At Worbarrow Bay, 18 samples were collected, 15 were processed, and 12 yielded palynomorphs in the 290-ft. section.

At Bacon Hole, 73 samples were collected from the 250-ft. Purbeck section. 47 samples were processed and 37 of these yielded palynomorphs.

At Lulworth Cove, 30 samples were collected from the 179-ft. section. Of these, 17 samples were processed for palynomorphs but only 5 yielded assemblages. The poor yield at Lulworth may be related to the increased proportion of carbonates at this
locality compared with areas further east. Limestone proved to be generally barren of palfynomorphs. For the same reason, sections of the Purbeck Beds developed close to the edge of the basin at Telfont in the Vale of Wardour (Andrews and Jukes-Browne 1894), at Swindon, Wiltshire (Sylvestre-Bradley 1941), and at Hartwell, Buckinghamshire (Bailance 1965) all proved to be barren of palynomorphs and are not considered further here.

(b) Mountfield, Sussex. Purbeck Beds are brought to the surface in Sussex along the central line of the Wealden dome in the Brightling anticline (Edmunds 1954). The lower part of the Purbeck Beds is known in subsurface sections in the mine of Gypsum Ltd., at Mountfield and in various boreholes. The stratigraphy, compiled from surface and subsurface sections, has been summarized by Topley (1875), White (1928), and Allen (1960b). A more detailed account has been given by Howitt (1964). The general succession of the Purbeck Beds in the vicinity of the mine is shown in Table 2.

At Mountfield, 31 samples were collected between the lowest gypsum seam, at the base, and the Greys Limestone Series at the top of the section, a total of almost 400 ft. (Howitt 1964). These samples were from surface outcrops and from subsurface sections in the mine and from Gypsum Mines borehole M 64 (grid reference TQ 716187). Further details of this borehole are given in Appendix I of Norris (1963). Of the 23 samples processed from Mountfield, 21 yielded palynomorphs.

(c) Warlingham Borehole, Surrey. Preliminary accounts of the succession in this borehole have been published in the Summary of Progress of the Geological Survey (1957, p. 29; 1958, p. 48). The Purbeck–Wealden junction has been placed at 1,892 ft. on the basis of ostracod faunas and the top of the Middle Purbeck at 1,935 ft. (Anderson 1962; Howitt 1964, p. 105). The top of the Portland Beds is recognized at 2,150 ft. but below 2,040 ft. there appears to be a repetition of lithological and faunal types in the Purbeck Beds, which is attributed to reversed faulting.

Twenty-three core samples between 1,900 and 2,027 ft. in the borehole were examined for palynomorphs. Of these, 18 yielded assemblages.

**Fairlight Clay**

On the coast east of Hastings, the Fairlight anticline brings the Fairlight Clay to the surface (Edmunds 1954). The Fairlight Clay is the lowest Wealden formation and is generally thought to pass laterally north and westwards into, and to be overlain by, the Ashdown Sand (Allen 1960a). The complete Fairlight Clay succession has been described by Topley (1875) and by White (1928), who believed that the Purbeck Beds underlie this section, close to the surface on the crest of the anticline. Allen (1955) stated that the Upper Purbeck–Wealden junction as defined by ostracods is probably situated low down in the Fairlight Clay near the base of the Wealden as traditionally defined, i.e. the base of the Fairlight Clay. A series of calcareous clays and limestones developed between 949 and 1,080 ft. in the Henfield borehole and regarded as equivalent to the basal portion of the Fairlight Clay (on ostracod faunas) '... could equally well be classed with the Purbeck ...' (Tait and Kent 1958, p. 12). The lateral change of facies at this horizon promotes the possibility that the lower part of the Fairlight Clay on the Sussex coast may be a lateral equivalent of part of the Purbeck Beds of Dorset. Allen (1960b, p. 7) noted 'The problem of how far the Purbeckian extends upwards (if at all) into the Fairlight facies of the Wealden remains unsolved.' A detailed palynologic
study of the entire Fairlight Clay sequence would be desirable to determine its probable equivalence to the Purbeck but was not attempted in the present study. The preliminary results of a study by Hughes and Moody-Stuart (1969) using a new correlation method, however, suggest that the Fairlight Clay is in fact a lateral facies equivalent of the upper Middle and Upper Purbeck.

**EXTRACTION OF PALYNOMORPHS**

Most samples examined in this study were grey or brown fine-grained elastic rocks but a few limestones were represented. These samples were prepared by first crushing about 5 gm. (20–50 gm. in the case of limestones) to pass through a 1-mm. mesh sieve. Carbonates were removed with cold dilute hydrochloric acid. Silica and silicates were dissolved in hot 50% hydrofluoric acid (40–60 minutes treatment was sufficient). By-products from this reaction are finely crystalline or in part colloidal, gelatinous white, pink, or brown precipitates usually occurring as a distinct layer or intimately mixed with the organic residue. This by-product was reported by Norell (1953) to be composed of either aluminum fluosilicates or a mixture of double fluorides of calcium, magnesium, sodium, and potassium. It interferes with subsequent preparation procedures and consequently must be removed after hydrofluoric acid treatment by repeated washing and dissolution in hot 25% hydrochloric acid.

The organic residue remaining was treated with 20 kHz ultrasound for 20–30 seconds using a generator with a 60-W power output and a magnetostrictive transducer coupled to a steel probe with a 1:1 end area ratio. The probe tip has an acoustic power output of 2.74 W/cm². Acoustic treatment was used to disperse the finely divided organic material which characterized most residues. This finely divided material was removed from each residue after ultrasonic treatment by repeated short centrifugation in water with a few drops of non-ionic detergent added (Funkhouser and Evitt 1959). Ultrasonic treatment was used before oxidation of the residues because spores and pollen are more fragile to ultrasound after oxidation (McIntyre and Norris 1964).

Most samples were not highly carbonaceous and the residues did not require more than a few minutes oxidation in concentrated nitric acid or Schulze’s solution. Humic material remaining after oxidation was rare in most samples, but when present dilute ammonium hydroxide removed it effectively. Safranine-O was used to stain some palynomorph assemblages. Residues were mounted in glycerine jelly and stored in a mixture of glycerine and water with phenol added to prevent microbial attack.

Rock samples used in this study are stored in the Sedgwick Museum, Cambridge. Full locality details are listed for all samples in Appendix 1 of Norris (1963). Type material currently in the palynology collection of the Department of Geology, University of Toronto, will be transferred to the Sedgwick Museum for permanent storage.

**SYSTEMATIC PALYNOLGY—SPECIES LIST**

The species mentioned in the following list occur in the marine Upper Jurassic and Purbeck Beds. The species are listed morphographically using Dettmann’s (1963) modified scheme. Where applicable the original author’s name is followed by the plate
and figure number of the illustrations given in this paper. New species and new combinations are treated thoroughly in the following section on Systematic Descriptions. The stratigraphic significance of all species is discussed in a later part of the paper.

Turma triletes
Suprasubturma acavatitiletes
Subturma azonotrilites
Infraturma laevigati

Cycadilites australis Couper 1953; Plate 102, fig. 1.
Cycadilites minor Couper 1953; Plate 102, figs. 2, 3.
Deltoidospora raieti Burger 1966; Plate 102, fig. 11.
Deltoidospora psilostoma Rouse 1959; Plate 102, fig. 8.
Dictyophylilites harrisi Couper 1958; Plate 102, figs. 9, 10.
Dictyophyllilites equiexinus (Couper) Dettmann 1963; Plate 102, figs. 4, 5.
Stereisporites antiquasporites (Wilson and Webster) Dettmann 1963; Plate 102, figs. 13, 14.
Concavisporites jurienisis Balme 1957; Plate 102, figs. 6, 7.
Divisisporites sp. cf. D. eusirkelenensis Thomson and Pflug 1952; Plate 102, fig. 17.

Infraturma apiculati

Acanthotriletes varispinosus Pocock 1962; Plate 102, fig. 12.
Osmundacitites wellmani Couper 1953; Plate 102, fig. 18.
Bacilatsporites comanensis (Cookson) Potonié 1956; Plate 102, figs. 15, 16.
Converrucosporites variverrucatus (Couper) comb. nov.; Plate 102, fig. 19.
Leptolepidites psiospus sp. nov.; Plate 103, figs. 2-5.
Leptolepidites epacronatus sp. nov.; Plate 103, figs. 6-9, 11.
Rubinella major (Couper) comb. nov.; Plate 103, fig. 10.
Pilosispores trichiopapillosus (Thiergart) Delcourt and Sprumont 1955; Plate 103, fig. 1.
Pilosispores delicatulus sp. nov.; Pl. 103, figs. 12-18; Plate 104, figs. 1, 2.

Infraturma murornati

Cicatricosisporites australiensis (Cookson) Potonié 1956.
Cicatricosisporites purbeckensis sp. nov.; Plate 104, figs. 5-11.
Cicatricosisporites angicanalis Döring 1965; Plate 104, figs. 12-13; Plate 105, figs. 1, 2.
Cicatricosisporites brevilarvatatus Couper 1958; Plate 105, fig. 3.
Reticulospores semireticulatus (Burger) comb. nov.; Plate 105, figs. 4, 5.
Lycopodiacidites cernidites (Ross) comb. nov.; Plate 105, figs. 6, 7.
Lycopodiumspores asuroclavulatides (Cookson) Potonié 1956; Plate 105, figs. 8, 9.
Khukisportes pseudoreticulatus Couper 1958; Plate 105, fig. 11.
Microreticulospores diatreus sp. nov.; Plate 105, figs. 12-15.
Foveospores canalis Balme 1957; Plate 106, fig. 3.
Tripartita sp.; Plate 105, fig. 10.
Suburma zonotriletes
   Infraturma auriculati

Trilobosporites bernissariensis (Delcourt and Sprumont) Potonić 1956; Plate 106, figs. 1, 2.
Trilobosporites apiverrucatus Couper 1958; Plate 107, figs. 9, 14.
Trilobosporites obsoletus sp. nov.; Plate 106, figs. 7, 8.
Trilobosporites domitus sp. nov.; Plate 106, figs. 9, 10, 12, 13.
Appendicispores potomacensis Brenner 1963; Plate 107, figs. 1-4, 7, 10.
Plicatella abaca (Burger) comb. nov.; Plate 105, figs. 4-6, 11; Plate 107, figs. 5, 6.

Infraturma cingulati

Foraminisporis wonthaggiensis (Cookson and Dettmann) Dettmann 1963; Plate 107, figs. 11, 13.
Contignisporites dorsiostriatus (Bolchovitina) Dettmann 1963; Plate 107, fig. 12.
Duplexisporites problematicus (Couper) Playford and Dettmann 1965.

Infraturma tricrassati

Gleichenilidites senonicus Ross 1949; Plate 107, figs. 16, 17.
Sestrosporites pseudalveolatus (Couper) Dettmann 1963; Plate 108, fig. 5.
Coronatispora valdensis (Couper) Dettmann 1963; Plate 108, figs. 1, 2.

Suprasuburma perinotriletes

Densoisporites perinatus Couper 1958; Plate 108, figs. 3, 4, 6.
Heliosporites sp.; Plate 108, figs. 7, 8, 10, 11.

Tutma hilates

Aequitiradites spinulosus (Delcourt and Sprumont) Cookson and Dettmann 1961; Plate 108, fig. 9.
Couperisporites complexus (Couper) Pocock 1962; Plate 108, fig. 13.
Janiasporites tumulosus sp. nov.; Plate 108, fig. 12; Plate 109, figs. 2-4, 7.

Turma monoletes

Suprasuburma acavatomonoletes
Suburma azonomonoletes
Infraturma sculpitamonoleti

Marattisporites scabraeus Couper 1958; Plate 109, figs. 5, 6.

Anteturma pollenites
   Turma sacrites
   Suburma monosacrites
   Infraturma saccizonati

Cerebropollenites mesozoicus (Couper) Nilsson 1958; Plate 109, figs. 11, 12.
Subturma DISACCITES

*Alisporites bilateralis* Rouse 1959; Plate 109, figs. 14, 15.

*Abiitineapollenites minimus* Couper 1958; Plate 109, fig. 13.

*Vitreisporites pallidus* (Reissinger) Potonié 1960; Plate 109, figs. 8–10.

*Podocarpidites* sp. cf. *P. ellipticus* Cookson 1947; Plate 109, figs. 16, 17.

*Porvisaccites radiatus* Couper 1958; Plate 109, figs. 18, 19; Plate 9, fig. 1.

Subturma POLYSACCITES

*Calliasporites* sp. cf. *C. trilobatus* (Balme) Sukh Dev 1961; Plate 110, fig. 8.

*Calliasporites damieri* (Balme) Sukh Dev 1961 emend.; Plate 110, figs. 2, 3.

*Calliasporites obtusus* sp. nov.; Plate 110, figs. 6, 7.

*Calliasporites* sp.; Plate 110, figs. 4, 5.

Turma ALEFES

Infraturma PSILOCACTITI

*Inaperturopollenites dubyi* (Potonié and Venitz) Thomson and Pflug 1953; Plate 110, figs. 9, 10; Plate 111, fig. 19.

*Inaperturopollenites* sp.; Plate 110, figs. 11, 12.

Infraturma GRANULONAPITI

*Aratocariocites australis* Cookson 1947; Plate 110, fig. 17.

*Spheroipollenites subgranulatus* Couper 1958; Plate 110, fig. 13.

Infraturma SPINONAPITI

*Peliandrospites tener* sp. nov.; Plate 110, figs. 18, 19.

Infraturma RETICULONAPITI

*Undulatoxylonites araneus* sp. nov.; Plate 110, figs. 14–16; Plate 111, figs. 2–10.

Turma PILATES

Subturma PRAECOLPITI

*Eucommiidites troedsoni* Erdtman 1948; Plate 111, figs. 13, 14, 16.

*Eucommiidites minor* Groot and Penny 1960; Plate 111, fig. 15.

Subturma MONOCOLPITI

*Cycadopites* sp. cf. *C. nitidus* (Balme) comb. nov.; Plate 111, figs. 11, 12.

*Cycadopites carpentieri* (Décourt and Sprumont) Singh 1964; Plate 111, fig. 18.

*Monosulcites* sp. aff. *M. minimus* Cookson 1947; Plate 111, fig. 17.

Turma PORES

Subturma MONOPORINES

*Exesipollenites scabrous* sp. nov.; Plate 111, figs. 20–2.

*Perinopollenites elatooides* Couper 1958; Plate 112, figs. 6, 7.
NORRIS: Miospores from Southern England

Miospores Incertae Sedis

Classopollis torosus (Reissinger) Balme 1957; Plate 112, figs. 1-5.
Classopollis echinatus Burger 1965; Plate 112, figs. 8-13.
Classopollis hamnenit Burger 1965; Plate 112, figs. 14-16; Plate 113, figs. 1-4.
Schizosporis reticulatus Cookson and Dettmann 1959; Plate 113, figs. 5, 8.
Schizosporis springt Cookson and Dettmann 1959; Plate 113, figs. 6, 13.
Schizosporis parvus Cookson and Dettmann 1959; Plate 113, fig. 7.
Sigmapollis callosus sp. nov.; Plate 113, figs. 9-12.

Systematic Descriptions

Turma Triletes
Suprasuburta Acavatittriletes
Subturma Azonotritiletes
Infraturma Laevigati

Genus Divisiporites Thomson and Pflug 1952

Divisiporites sp. cf. D. euskirchenensis Thomson and Pflug 1952
Plate 102, fig. 17

Description. Spores radiosymmetric, complexity triletate. Amb triangular convex to irregularly sub-circular. Læsuræ long, simple, straight but dichotomizing up to the third order, reaching or almost reaching the equator. Both proximal and distal surfaces scabrate to granular. Granules usually low (occasional up to 1 μ high), closely spaced, up to 2 μ in diameter. Occasional verrucae developed at the equator up to 3 μ high and 10 μ or more in width. Exine 3-5 μ in total thickness; endexine distinct and 0.5-1 μ thick.


Distribution. Upper Purbeck, Dorset.

Remarks. These specimens differ from D. euskirchenensis by the possession of a thicker exine, more complexly divided læsuræ, and verrucae at the equator. Insufficient specimens were available to erect a new species. Lower Cretaceous specimens originally assigned to D. euskirchenensis by Cookson and Dettmann (1938) are now included in Roweispores raditus Dettmann (1963), which is distinct in structure from the present specimens.

Infraturma Apiculati

Genus Converrucosporites Potonié and Kremp 1954

Converrucosporites varicervucatus (Couper) comb. nov.

Plate 102, fig. 19

Mount 1958 Converrucosporites varicervucatus Couper, p. 142, pl. 22, figs. 4-5.

Remarks. This species is removed from Converrucosporites because of the lack of curvaturæ, and recombined with Converrucosporites on the basis of shape and ornament.
Genus *Leptolepidites* Couper 1953 emend. Norris 1968

*Leptolepidites* *psarosus* sp. nov.

Plate 103, figs. 2–5

**Holotype.** GN 109B/1, 40.4 124.5. Sample 59–1–6 (dark grey shale), Middle Purbeck, Chief Beef Beds, Durlston Bay (from the top of Bed 75, Britto 1857).

**Diagnosis.** Spores radiosymmetric, trilete, amb rounded triangular to circular. Laesurae simple, reaching the equator, usually indistinct. Proximal face entirely granulate, or only on the contact areas. Distal face with closely spaced verrucae. Exine thin in between the projections.

**Description.** Laesurae straight, reaching or almost reaching the equator, occasionally quite distinct but usually difficult to see. Granules on proximal face rounded or polygonal, 1–2 μ in diameter, dense, occasionally joining up to give a sub-rugulate sculpture, rugulae about 4 μ long. When only contact faces are granular there is a distinct levigate zone separating them from the verrucate distal ornament.

Distal verrucae 3–13 μ in diameter, 1–5 μ high, rounded sub-circular, rounded polygonal, irregular or elongated. Solitary rugulae up to 17 μ long and about 5 μ wide may be interspersed among the verrucae. Verrucae closely packed forming a distinct negative reticulum with grooves about 0.5 μ wide but varying slightly. The distal verrucae may encroach to a variable extent on to the proximal face up to the contact areas.

Exine between projections less than 0.5–1 μ in thickness. Exine on proximal face less than 0.5 μ in thickness.

**Dimensions.** Equatorial diameter: 20–44 μ (holotype, 39 μ).

**Distribution.** Middle and Upper Purbeck, Dorset, Sussex, and Surrey.

**Remarks.** Distinguished from *Converrucosporites proxigranulatus* Brenner (1963) by the more densely packed distal verrucae and by the presence of rugulae.

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**EXPLANATION OF PLATE 102**

All figures × 750 unless otherwise stated.

Figs. 1–3. *Cystatidites* spp. 1, *C. australis* Couper, GN 161/1, 32.0 127.4. 2–3, *C. minor* Couper.

Figs. 2, GN 317/2, 44.2, 128.5 μ. 3, GN 138/2, 58.2 123.1.

Figs. 4, 5, 9, 10. *Dictyophyllidites* spp. 4–5, *D. equinoxus* (Couper) Dettmann. 4, GN 146/1, 24.7 128.3, 5, GN 161/2, 53.0 117.7. 9–10, *D. harrisii* Couper. 9, GN 316/1, 32.6 114.9. 10, GN 316/1, 58.0 124.8.

Figs. 6, 7. *Converrucosporites juricenensis* Balmes. 6, GN 142/2, 43.1 112.5 μ. 7, GN 142/1, 40.1 119.6.

Figs. 8, 11. *Deltoidospora* spp. 8, *D. pilostoma* Roxas. 1113–13c, 38.3 μ. 9. 11, *D. rufescens* Burger. GN 262/2, 32.2 107.5.

Figs. 12. *Acanthothorites variopinosus* Pockock. GN 188/1, 44.0 114.5 μ. × 1250.

Figs. 13, 14. *Streitispores antiquispores* (Wilson and Webster) Dettmann. 13, GN 476/1, 51.8 112.5 μ. × 1250. 14. GN 187/1, 29.5 106.6 μ. × 1250.

Figs. 15, 16. *Baculatisporites comauensis* (Cookson) Potonié. 15, 1113–18c, 22.6 118.9 μ. 16, GN 432/2, 46.9 104.3.

Figs. 17. *Divisipores* sp. cf. *D. euskirchenensis* Thomson and Pflug. GN 345/1, 117.3 56.2.

Figs. 18. *Osmundacidites weymanni* Couper. GN 316/1, 22.2 106.6.

Figs. 19. *Converrucosporites varierverrucatus* (Couper) comb. nov. GN 338/3, 59.9 124.1.
NORRIS: MIOCENOPORES FROM SOUTHERN ENGLAND

Leptolepidites epacrorum sp. nov.

*Plate 103, figs. 6-9, 11*

*Holotype.* Slide GN 147/1, 278 119.1. Sample 60-5-22 (dark grey-brown shale), Upper Purbeck, Marle Beds and Ostracod shales, Durleston Bay (6 ft. below the top of Bed 84, Bristow 1857).

*Diagnosis.* Spores radiate symmetric, triete. Amb rounded triangular to circular. Lasaerae long but not reaching equator, simple or labiate. Proximate face levigate to subgranular. Distal face verrucate with occasional echinate projections. Exine thin.

*Description.* Lasaerae simple or with very narrow lips less than 0-75 μ wide, straight or sinuous. Ornament of proximal face very much reduced with respect to distal ornament, but distal ornament encroaches on to proximal face at apices. Distal verrucae regularly or irregularly rounded or elongate, 2-3 μ in diameter, sometimes reaching 5 μ long, up to 1 μ high and spaced about 1 μ apart. Exine 0-25-0-5 μ.

*Dimensions.* Equatorial diameter: 12-22 μ (holotype 20 μ).

*Distribution.* Middle and Upper Purbeck, Dorset, Sussex, and Surrey.

Genus *Rubinella* (Maljavkina 1949) Potonié 1960

*Rubinella major* (Couper) comb. nov.

*Plate 103, fig. 10*

1958 *Leptolepidites major* Couper, p. 141, pl. 21, figs. 7-8.

*Description.* Spores radiate symmetric, triete. Amb rounded triangular or occasionally almost circular. Lasaerae long, simple, not reaching the equator, rather indistinct. Both proximal and distal surfaces ornamented with closely spaced or touching, almost spherical, irregularly rounded or elongate verrucae. Verrucae 2-10 μ in diameter, 1-5 μ high. Exine thickness between verrucae 1-2-5 μ.

*Dimensions.* Equatorial diameter: 39-80 μ.

*Remarks.* It proved impossible to split off the larger specimens as a distinct species and consequently all are included in one species with a larger size range than that indicated by Couper in his original description. The species is transferred to *Rubinella* because of the comprehensive verrucate sculpture. *Leptolepidites* is characterized by verrucae on the distal face only (Norris 1968).

Genus *Pilosisporites* Delcourt and Sprumont 1955

*Pilosisporites delicatus* sp. nov.

*Plate 103, figs. 12-18; Plate 104, figs. 1, 2*

*Holotype.* GN 428/1, 460 128.4 Sample 61-7-5 (buff lignite clay), Upper Purbeck 7 ft. above Paludina Clays, Bacon Hole (middle of Bed 26 described in Norris 1963).

*Diagnosis.* Spores radiate symmetric, triete. Amb triangular convex with broadly rounded apices, occasionally becoming almost circular. Lasaerae short, one-third to one-half of the spore radius, straight, simple, frequently indistinct. Both proximal and distal surfaces scabrate and covered with irregularly distributed echinate processes. Processes hair-like, very narrow, straight or curved, simply terminated or briefly bifurcate,
2–5 μ long, spaced 1–2 μ apart at the equator but up to 5 μ apart at the poles. Exine 0.5–1 μ thick.

At high magnifications (greater than 1,000 diameters) the exine is seen to be distinctly microreticulate. Lumina of reticulum less than 0.25 μ in diameter and muri also very narrow. Echinulate processes very narrow and consequently indistinct. Occasionally the bases of the processes may widen up to 0.5 μ and can be seen to be hollow.


Remarks. This species is easily overlooked on account of its delicate ornament, or it may be confused with Stereisporites antiquasporites (Wilson and Webster) Dettmann.

Infrastruma murornati
Genus Cicatriciosporites Potonié and Gelletich 1933
Cicatriciosporites purbeckensis sp. nov.
Plate 104, figs. 5–11

Holotype. Slide GN 145/1, 38.8 121.9. Sample 60–5–16 (grey, slightly calcareous shale) Upper Purbeck, Marble Beds and Ostracod Shales, Durston Bay (Bed 84 of Brissow 1857).

Diagnosis. Spores radiosymmetric, trilete. Amb. triangular, Laesurae long, straight, simple or labiata. Proximal face levigate. Distal face with 3 or 4 triangular sets of widely spaced ribs running more or less parallel to equator. Ribs narrow and uneven in width, height, and spacing.

Description. Laesurae simple or bordered by very narrow lips about 0.5 μ wide, reaching equator. Distal ribs straight or sinuous, occasionally bifurcating, 0.25–1 μ wide, 0.5–1 μ high, spaced 0.5–2 μ apart (4 ribs and intervening lumina measure 9–12 μ). Ribs project at apices but not on sides of amb. Distal ribs encroach on to proximal face at apices. Ribs are characteristically uneven in width with swollen nodes at irregular intervals along their length. Exine about 1 μ thick, with a very thin layer of endexine distinguishable.

Dimensions. Equatorial diameter 30–48 μ (holotype 47 μ).

Distribution. Lower, Middle, and Upper Purbeck of Dorset and Sussex.

EXPLANATION OF PLATE 103

All figures ×750 unless otherwise stated.

Figs. 1, 12–18. Piliosporites spp. 1. P. trichopollinicus (Thiérgart) Delcourt and Sprumont, GN 338/2, 30.6 117.4. 12–18. P. delineatus sp. nov. 12, proximal surface, GN 427/1, 56.6 124.9. 13–14. Holotype, median focus and distal surface respectively, GN 427/1, 46.0 128.4. 15–16. Holotype, median focus, and distal surface respectively. ×1,250. 17–18. Proximal and distal surfaces respectively, GN 338/2, 119.7 22.2; ×1,250.

Figs. 2–9, 11. Leptolepidites spp. 2–5. L. paraeus sp. nov. 2, Proximal surface, GN 428/1, 128.5 37.0. 3. Distal surface, GN 338/3, 36.2 126.2. 4–5. Holotype, proximal and distal surfaces respectively, GN 109/1, 40.4 124.5. 6–9. L. epiporcarinius sp. nov. 6, 8, Holotype, ×750 and ×1,250 respectively, GN 147/1, 27.8 119.1. 7, GN 146/2, 52.6 125.3. 9, GN 146/2, 52.7 125.5. 11, GN 190/3, 41.6 108.9.

Fig. 10. Rubinella major (Couper) comb. nov., GN 255/1, 41.7 119.4.

Figs. 19, 20. Cicatriciosporites ausfalliens (Cookson) Potonié. 19, GN 142/1, 54.8 108.7. 20, GN 315/3, 45.5 122.8.
NORRIS, Late Jurassic and Purbeck miospores
Remarks. Distinguished from other species of *Cicatricisporites* by means of the narrow ribs of uneven width and spacing.

**Genus Reticulispores** Pot. and Kremp in Weyl. and Krieger 1953
*Reticulispores semireticulatus* (Burger 1966) comb. nov.

Plate 105, figs. 4, 5

1966 *Lycopodiumspores semireticulatus* Burger, p. 247, pl. 14, fig. 4.

Remarks. The concave amb and low muri place this species in the genus *Reticulispores*.

**Genus Lycopodiacidites** (Couper 1953) Potonié 1956
*Lycopodiacidites cernidites* (Ross 1949) comb. nov.

Plate 105, figs. 6, 7

1949 *Lycopodium cernidites* Ross, p. 30, pl. 1, figs. 1–2.

1955 *Lycopodiumspores cernidites* (Ross) Delcourt and Sprumont, p. 32.

Remarks. The distal surface is rugulate, not reticulate, thus placing this species in *Lycopodiacidites*. There appears to be a morphological transition between those forms of *L. cernidites* (Ross) with more regularly arranged regular, to forms of *Coronatispora valdensis* (Couper) Dettmann with poorly developed circum-equatorial ridges. However the latter species has a very much greater stratigraphic and geographic distribution in the sediments examined and it is likely that each species was derived from different sources, their morphological similarity being only apparent. *Reticulispores pudens* Balme from the Lower Cretaceous of Western Australia is similar but much smaller and carries an imperfect reticulum on the distal face.

**Genus Microreticulatisporites** (Knox 1930) Potonié and Kremp 1954
*Microreticulatisporites diatretus* sp. nov.

Plate 105, figs. 12–15


*Diagnosis*. Spores radiosymmetric, trilet. Amb rounded triangular. Laesurae one-half to one-third of the spore radius in length, usually with narrow lips. Both proximal and distal surfaces ornamented with a perfect microreticulum with rather variable circular to polygonal lumina never exceeding 2 μ in diameter. Exine 1–2 μ thick interradially, thinning to 0.75–1 μ at apices.

*Description*. Amb occasionally elongated along one median. The trilet scar is rather variable in development, occasionally being simple or indistinct. Muri of the microreticulum 0.5–1 μ wide, 0.3–1.5 μ in height, of slightly variable width usually widening at the junctions. Lumina 0.5–2 μ in diameter, rounded or rounded-polygonal, varying in spacing from moderately widely spaced pits to closely spaced rounded-polygonal lumina. The lumina of the proximal reticulum may be slightly radially attenuated, particularly near the ends of the laesurae.
Dimensions. Equatorial diameter: 30–40 μ.

Distribution. Middle and Upper Purbeck, Dorset and Sussex.

Remarks. Distinguished from Foveoetricites subtriangularis Brenner 1963 by the microreticulate ornament on both surfaces rather than foveolate ornament primarily developed on the distal surface.

Genus TRIPARTITS Maljavkina 1949 ex Potonié 1960

Tripartita sp.

Plate 105, fig. 10

Description. Spores radiosymmetric, trilite. Amb triangular, usually concave or straight-sided, slightly undulating. Laesurae long, reaching the equator, with lips about 2 μ wide. Proximal surface unornamented. Distal surface with irregular radial grooves 0.5–2 μ wide, spaced 1–2 μ apart, occasionally anastomosing or coalescing with adjacent grooves. Both proximal and distal face may be slightly undulose. Exine 1–2 μ thick.

Dimensions. Equatorial diameter 24–46 μ.

Distribution. Middle and Upper Purbeck of Dorset, Sussex, and Surrey.

Remarks. This species is distinguished from T. sp. cf. T. variabilis Maljavkina described by Dettmann (1963) from the Australian Cretaceous by the more broadly rounded apices and less dense distal ornament.

Subturma ZONOTRIETEIS
Infraturma AURICULATI

Genus TRICLOSPORITES Pant 1954 ex Potonié 1956

Trilobospores obsitus sp. nov.

Plate 106, figs. 7, 8

Holotype. Slide GN 163/2, 59.2 127.5. Sample 60–5–1 (buff, silty, calcareous clay), Upper Purbeck, Unio Beds, Durlston Bay (Bed 80 of Bristow 1857).

Diagnosis. Spores radiosymmetric, trilite. Amb triangular. Laesurae long, usually simple, but rather variable. Both proximal and distal faces verrucate, but sculpture sparse and more reduced on distal face. Apices each carry a very large and prominent thickening which is circular in equatorial view and is restricted to the apical equatorial region. Exine thick.

EXPLANATION OF PLATE 104

All figures ×750 unless otherwise stated.
Figs. 1, 2. Filosospores delicatus sp. nov. 1, Median focus, GN 338/2, 122.3 23.0; ×1,250. 2. Proximal surface, GN 428/2, 31.4 108.3; ×1,250.
Figs. 3–13. Cicatriscisopterites spp. 3, 4, C. australiensis (Cookson) Potonié, Distal and proximal surfaces respectively; GN 146/2, 32.0 111.8. 5–11, C. parbeckensis sp. nov. 5. Proximal surface, GN 153/2, 29.3 119.7. 6, Holotype, median focus, GN 145/1, 38.8 121.9. 7, Median focus, GN 146/2, 20.9 113.2. 8, Median focus, GN 146/2, 44.7 108.2. 9, Equatorial view, GN 153/1, 21.9 109.0. 10, Equatorial view, GN 142/2, 23.2 126.7. 11, Distal surface, GN 147/2, 32.5 125.6. 12–13, C. angicanalis Döring, proximal and distal surfaces respectively, GN 163/2, 40.8 122.7.
NORRIS, Late Jurassic and Purbeck miospores
Description. Amb with roughly straight or slightly concave sides which are undulating because of verrucate ornament. Apices rounded and extended by the apical projections. Laesurae may be narrowly labiate, two-thirds or more of radius in length, occasionally reaching the equator. Proximal face with dense, rounded, or irregular verrucae, 6–12 μ in diameter, 2–3 μ high, and spaced up to 3 μ apart. Occasionally they may fuse into large indistinct rugulae. Distal ornament variable, ranging from low, indistinct, sparse irregular granules about 3 μ in diameter to rounded, low or high sparse verrucae up to 11 μ in diameter. Apical thickenings usually restricted to the equator but occasionally extending about 4 μ towards the polar areas. Exine thickness 8–10 μ over the apical thickening which is 14–20 μ wide and has a rounded aspect in equatorial views. Endexine 0.75–1.5 μ thick. Ekutexine 1.5–3 μ thick between the projections.

Dimensions. Equatorial diameter 56–69 μ (holotype 63 μ).

Distribution. Upper Purbeck, Dorset.

*Trilobosporites domitius* sp. nov.

Plate 106, figs. 9, 10, 12, 13

Holotype. Slide GN 345/1, 57.0 111.7. Sample 60–19–3 (grey calcareous marl), Upper Purbeck, Upper Cypis Clays and Shales, Bacon Hole (6 in. above Bed 1 of Arkell 1933).

Diagnosis. Spores radiosymmetric, trite. Amb triangular, concave. Laesurae long, straight, labiate, commissures raised. Both proximal and distal faces entirely covered in closely spaced, low, irregular granules. Exine at apices undulating and usually slightly thickened in the equatorial region here, but these thickenings not extending polewards as distinct valvae. Exine thicker on proximal than distal face.

Description. Laesurae almost reach the equator, raised 1.5–2.5 μ high at the centre and provided with narrow (1 μ) tapering lips along at least half their length. Scabrate to sub-granular ornament on both proximal and distal surfaces. Granules rather irregular in outline, very low, 0.25–1 μ in diameter and spaced not more than 0.5 μ apart. The exine becomes rather undulating around the apices tending to assume a low, poorly developed, verrucate ornament, and also is slightly thickened. Exine 2–4 μ thick, increasing at apices to between 4 and 7 μ. Exine on proximal face distinctly thicker than on distal face, about 6 μ at the centre. Endexine 0.25–0.5 μ thick. Occasionally the exine is slightly thickened interradially at the middle of the concave sides. Both proximal and distal faces convex, proximal face rather flatter than distal.


Distribution. Upper Purbeck, Dorset.

Genus *Plicatella* Maljavnkina 1949

*Plicatella abaca* (Burger) comb. nov.

Plate 106, figs. 4–6, 11; Plate 107, figs. 5, 6

1966 *Cicatricosisporites abacus* Burger, p. 242, pl. 7, fig. 3.

Distribution. Middle and Upper Purbeck, Dorset, Sussex, and Surrey.
Remarks. This species is transferred to *Plicatella* on account of the apical thickenings at the equator. The distinction of *Plicatella*, characterized by weak apical thickenings, from *Appendicisporites*, with more prominent apical thickenings, is arbitrary but a convenient procedure. Hughes and Moody-Stuart (1969) have questioned the validity of the genus *Plicatella* on the basis of observations on associated spores of Cretaceous schizaeaceous ferns. They have noted that occasional apical thickenings occur in populations of *Cricracisporites*-type spores. These thickenings may be in part the result of compression in the equatorial plane. Dispersed spores, however, are difficult to relate to associated spore populations. *Plicatella abaca* has a distinctive morphology and distribution and appears to be a discrete group. Consequently it is maintained as a distinct spore species.

Suprasuburtina perinotrilites
Genus Heliosporites Schulz 1962
Heliosporites sp.

Plate 108, figs. 7, 8, 10, 11

Description. Spores radiate, trilete, zonate, consisting of a central body and an outer more complex layer. Amb of outer layer, excluding the zone, convex triangular with broadly rounded apices. Amb of inner body convex triangular with more sharply rounded or pointed apices. Inner body excentrically placed in relation to outer layer. Laesurae of inner body long, straight, simple, reaching the equator, occasionally indistinct. Laesurae of outer layer long, sinuous, labiate, reaching equator and frequently the outer zone. Lips 1 μ wide, slightly tapering, with fibril structure similar to that of outer layer. Equatorial zone 4–7 μ wide, roughly parallel to amb of outer layer, 2 μ thick and tapering very slightly towards its outer edge which is smooth except for occasional projecting spines from the dorsal surface. Entire distal surface of outer layer, including the distal surface of the zone, ornamented with irregularly distributed spines, 3–5 μ high, bases roughly circular and 3–6 μ wide, spaced 4–7 μ apart (tips spaced 8 μ apart), tapering rapidly at base but more gradually towards tips which are pointed, truncate or occasionally bifurcate. Exine of inner layer levigate, 0.25 μ or less in thickness, apparently of simple, undifferentiated structure, frequently folded, particularly near equator. Outer layer including zone, spines, and trilete mark with a fibril structure. Fibrils about 0.25 μ thick and anastomosing to form a ‘three-dimensional’

All figures × 750.

Figs. 1–3. Cricracisporites sp. 1–2. C. angicanalis Döring, 1. Proximal surface, GN 140/2, 42.6 128.5. 2. Distal surface, GN 145/2, 48.0, 128.6. 3. C. bresilaeusurus Couper, GN 265/1, 39.8, 112.9.

Figs. 4. 5. Retulculusporites semireticulatus (Burger) comb. nov. 4. Median focus, GN 189/2, 46.0, 122.5.


Figs. 6. 7. Lycopodiopsidae crassidites (Ross) comb. nov. 6. Proximal surface, GN 147/1, 29.8, 128.2. 7. Distal surface, GN 421/1, 111.8, 60.8.

Figs. 8. 9. Lycopodiumsporites diacanthus (Cookson) Potoré 8. Proximal surface, GN 147/2, 43.4, 128.2. 9. Distal surface, GN 154/1, 29.2, 127.8.

Fig. 10. Tripartita sp., distal surface, GN 182/3, 26.0, 101.4.

Fig. 11. Lycopodiumsporites pseudoeuctelatus Couper, GN 148/1, 45.3, 119.5.

NORRIS, Late Jurassic and Purbeck miospores
NORRIS: MIOCOPES FROM SOUTHERN ENGLAND

reticulum with lumina 0.25–1 \( \mu \) in diameter. Outer layer very thin on proximal surface where its fibrillar nature is difficult to determine. The outer layer is 1–2 \( \mu \) thick at equator and on distal surface.

**Dimensions.** Equatorial diameter (including zone): 30–42 \( \mu \).

**Distribution.** Upper Purbeck, Dorset.

**Remarks.** Insufficient material was available to erect a new species. It was considered appropriate to describe the specimens in detail, however, because they are extremely distinctive and possibly of stratigraphic importance.

These specimens are tentatively referred to *Heliosporites*. Schulz interpreted the type material of this genus as possessing a distal perispore. He did not distinguish a zone. This latter feature, together with the restriction of the spinose ornament to the distal surface, suggests affinities with the genus *Styxisporites* Cookson and Dettmann. This genus, however, does not possess a central spore body.

Considerable difficulty was encountered in interpreting the structure of these specimens owing, firstly, to the indistinct appearance of the central body; secondly, to the thinness of the proximal surface of the outer layer; and thirdly, to the fibrillar nature of this layer and the zone. All these features make elucidation of the equatorial structure, in particular, very difficult. Consequently this interpretation must be considered tentative until further specimens are available. In view of this uncertainty these specimens and the type material of *Heliosporites* may ultimately prove to have a similar structure. If this is so, these specimens are distinguished from the Lower Jurassic *Heliosporites altmarkensis* Schulz by their rather small size, thinner exine of the inner spore body, and rather shorter distal spines which are not truncated.

**Tutmis Hilates**

*Genus Janusasporites* (Pocock 1962) Singh 1964

*Janusasporites tumulosus* sp. nov.

Plate 108, fig. 12; Plate 109, figs. 2–4, 7

**Holotype.** Slide GN 421/1, 55.5 123.3. Sample 61–6–2 (grey, clayey shale), Upper Purbeck, Paludina Clays, Lulworth Cove, Dorset (from 2 ft. 6 in. below the highest *Vittatus* limestone).

**Diagnosis.** Spores radiosymmetric, probably trilette, with a distinct central body. Amb rounded triangular to circular or oval. Inner body thicker and ornamented with a perfect polygonal microreticulum and usually carrying a large circular aperture on one face. Outer layer is very thin and loosely fitting around the antapertural face, projecting beyond the central body at the amb and ornamented with irregularly distributed granules which are distinctly raised on hollow protuberances. Exine layers usually very thin and of indeterminate thickness.

**Description.** Exine is composed of two distinct layers, an inner thicker and an outer, thinner membranous layer almost completely enclosing the inner body. The inner layer bears an irregular but perfect polygonal micro-reticulum; muri 0.25–0.75 \( \mu \) wide; lumina 1–3 \( \mu \) wide and of polygonal shape but occasionally irregularly rounded. Reticulum always present at centre of antapertural face but usually becoming indistinct towards edges, sometimes showing a trilette distribution by development of stronger,
elongated lumina along 3 rays. The outer layer is very thin and is covered with rounded granules about 1–2 μ high and varying from 0.5–2 μ in diameter. Granules are distinctly raised on protuberances of the outer layer giving a characteristic L–O–L pattern in surface view. Granules spaced 1–2 μ apart and irregularly distributed. Occasional gemmate or papillate projections may be distributed amongst the granules. Outer layer loosely lies over the antapertural face and projects 1–6 μ from the amb. It occasionally encroaches up to the edges of the aperture but usually becomes indistinct on the apertural face.

Inner layer about 0.25 μ thick but usually indeterminate; outer layer of exine very thin with no distinguishable optical section visible under oil immersion, excluding the thickened granules.


**Distribution.** Middle and Upper Purbeck, Dorset.

**Remarks.** The outer layer of *Jamiasporites* is not referred to in the description as either a perine or a saccus since the stratification of the inner layer is not visible. This outer layer is only loosely attached on the antapertural face but becomes closely attached to the apertural face at or just beyond the amb.

**Anteturma Pollenites**

**Turma Sacccites**

**Subturma Disaccites**

**Genus Podocarpidites** (Cookson 1947) ex Couper 1953

*Podocarpidites* sp. cf. *P. ellipticus* Cookson 1947

Plate 109, figs. 16, 17

**Distribution.** Kimmeridgian and Portlandian of Dorset. Lower, Middle, and Upper Purbeck of Dorset, Sussex, and Surrey.

**Subturma Polysaccites**

**Genus Callialasporites** (Sukh Dev 1961) Potonié 1966

*Callialasporites* sp. cf. *C. trilobatus* (Balme 1957) Sukh Dev 1961

Plate 110, fig. 8

**Description.** Spores radiosymmetric, alete, with a distinct central body. Amb of central body rounded triangular, surrounded by a distinctly trilobed equatorial saccus constricted

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**Explanations of Plate 106**

All figures ×750.

Figs. 1–2, 7–10, 12–13. *Trilobosporites* sp. 1–2, *T. bernissartensis* (Delcourt and Sprumont) Potonié-1. Median focus, GN 345/1, 47.3 127.4. 2. Distal surface. GN 163/2, 51.0 122.9. 7–8, *T. obtusus* sp. nov. 7. Holotype, median focus, GN 163/2, 59.2 127.5. 8. Median focus, GN 163/2, 24.2 114.7. 9–10, 12–13, *T. donatus* sp. nov. 9, Holotype, proximal surface, GN 345/1, 57.0 111.7. 10. Median focus, GN 345/1, 57.4 120.6. 12. Equatorial view, GN 345/1, 51.6 116.5. 13. Median focus, GN 345/1, 38.4 127.8.

Fig. 3. *Foveosporites canellis* Balme, GN 168/1, 107.6 22.3.

Figs. 4–6, 11. *Plicatella abaca* (Burger) comb. nov. 4. Median focus, GN 145/2, 49.0 12.49. 5. Median focus, GN 212/2, 45.9 126.1. 6. GN 261/1, 46.6 116.0. 11. Equatorial view, GN 212/2, 40.4 126.4.
NORRIS, Late Jurassic and Purbeck miospores
at the apices of the central body. Exine scabrate or indistinctly wrinkled. Saccus 8–10 μ wide. Exine of saccus and central body indistinct and thin.

**Dimensions.** Equatorial diameter 50–51 μ.

**Distribution.** Middle and Upper Purbeck, Dorset and Sussex.

**Remarks.** These grains differ from *C. trilobatus* (Balme) Sukh Dev in the scabrate rather than rugulate central body and in the overall smaller size. 

*Callialasporites dannieri* (Balme 1957) Sukh Dev emend.

Plate 110, figs. 2, 3

1937 *Nelumbium* type Simpson, p. 673, fig. 2a.
1957 *Zonalapollenites dannieri* Balme, p. 32, pl. 8, figs. 88–90.
1958 *Zonalapollenites cf. trilobatus* Balme; Hughes and Couper, p. 1482, fig. 1 (e).
1958 *Zonalapollenites dannieri* Balme (partim); Lantz, p. 925, pl. 3, fig. 34.
1958 *Zonalapollenites trilobatus* Balme (partim); Lantz, p. 925, pl. 4, fig. 37.

**Restated diagnosis.** Spores radiosymmetric, alete, with a distinct central body. Central body amb circular to rounded triangular. One face of central body distinctly convex. Equatorial saccus surrounds central body and imparts a circular outline to the entire spore. Saccus attached by a narrow area at the equator of the central body, about one-fifth to one-seventh of the total diameter in width but decreasing and becoming irregularly constricted at the apices of the central body. The saccus is never constricted so much as to completely separate into three distinct lobes. Saccus usually carries delicate radial folds which may pass into rugulate folds on the attachment area, but is never folded on the centre of the spore body. Saccus and spore body scabrate to subgranular. Saccus wall about 1 μ thick. Exine of central body 0:25–0:5 μ thick.

**Description.** Attachment area of saccus 2–8 μ wide, distinct or indistinct, sometimes with a wrinkled appearance due to folding. Bladder usually 8 μ wide between apices but varying from 4–13 μ. Constrictions at apices reduce bladder width to the range 1–8 μ, but these are not equal and all three are not necessarily developed on any one spore.

**Dimensions.** Equatorial diameter: 47–69 μ.

**Distribution.** Kimmeridgian, Portlandian, Lower, Middle, and Upper Purbeck of Dorset, Sussex and Surrey.

**Remarks.** *C. dannieri* (Balme) is similar to *C. trilobatus* (Balme). Balme (1957) noted the similarity but in his description of *C. dannieri* did not mention any constrictions of the saccus, which however, are clearly shown in his photographs (pl. 8, figs. 88–90). In the present material the sacci are always constricted to a variable degree, frequently deeply, in three places. The more deeply constricted examples are very similar to *C. trilobatus*, particularly as Balme described the bladders of this species to occasionally coalesce to form one trilobate bladder. The central body, however, is always scabrate to subgranular rather than rugulate, the latter ornament being characteristic of *C. trilobatus*. 
C. dampieri is here emended to include forms in which the bladder is constricted to a variable degree at the apices of the central body but never sufficiently deeply to clearly delimit three bladders as are found in C. trilobatus. It is distinguished from C. trilobatus by this character, by the scabrate to subgranular rather than rugulate central body, by the narrow attachment areas of the bladders to the central body, and by the restriction of the rugulate folds to this area.

Thus emended it embraces forms variously attributed to or compared with C. dampieri (Balme) and C. trilobatus (Balme) by Lantz (1958b) and Hughes and Couper (1958). Some of these trilobed, but not trisaccate forms have a clear rugulate central body (e.g. Lantz 1958, pl. 4, fig. 40) and on this character are best left in C. trilobatus. In his original description of C. dampieri, Balme noted that 'some specimens show vestigial triradiate markings' although these were not illustrated. Saccate grains with trilette scars of various types and development have been illustrated by Hughes and Couper (1958) and Lantz (1958b) and attributed to Balme's species of Zonalapollenites. It seems advisable to remove these from Callialasporites dampieri (Balme) and C. trilobatus (Balme) to genera of the Trilitesaccii since some of the trilette marks illustrated by these authors appear to be quite well developed and not vestigial.

**EXPLANATION OF PLATE 107**

All figures ×750.

Figs. 1-4, 7, 10. *Appendicisporites potomacensis* Brenner. 1, 2. Median focus and distal surface respectively, GN 427/1, 48.0 117.6. 3. Proximal surface, GN 265/1, 122.3 44.1. 4. Median focus, GN 265/1, 50.2 111.0. 7. Median focus, GN 265/1, 48.2 123.4. 10. Median focus, GN 138/2, 50.0 102.6.

Figs. 5, 6. *Plecotella abaca* (Burger) comb. nov., distal and proximal surfaces respectively, GN 145/2, 45.5 108.4.

Fig. 8. *Duplexisporites problematicus* (Couper) Playford and Dettmann, GN 109B/1, 44.2 126.8.


Figs. 11, 13. *Foraminisporites wonskgiensiis* (Cookson and Dettmann) Dettmann. 11, GN 428/1, 58.3 110.7. 13. GN 428/1, 44.6 114.0.

Fig. 12. *Contiguisporites dorostrilatus* (Bolchovitina) Dettmann, GN 163/2, 32.4 119.1.

Fig. 15. *Coronatitispora valdensis* (Couper) Dettmann; Damaged specimen showing structure of distal surface, GN 154/1, 27.2 127.8.

Figs. 16, 17. *Gleicheniidites senonicus* Ross. 16. GN 146/2, 37.4 124.4. 17. GN 147/2, 28.2 116.9.

**EXPLANATION OF PLATE 108**

All figures ×750 unless otherwise stated.

Figs. 1, 2. *Coronatitispora valdensis* (Couper) Dettmann. 1. Proximal surface, GN 187/2, 47.4 125.3. 2. Distal surface, GN 152/1, 42.5 112.3.

Figs. 3, 4, 6. *Densoisporites perinatus* Couper. 3. Proximal surface, GN 262/1, 41.5 123.3. 4. Median focus, GN 338/1, 52.8 111.2. 6. Median focus, GN 338/3, 50.4 127.9.

Fig. 5. *Sceptrisporites pseudodinilus* (Couper) Dettmann, GN 257/1, 44.1 116.4.

Figs. 7, 8, 10, 11. *Heliosporites* sp., Median foci, 7. GN 338/2, 37.1 110.7. 8. GN 427/2, 34.9 112.6. 10. GN 338/2, 44.9 117.4. 11. GN 262/1, 53.3 114.2.

Fig. 9. *Aequitriradiatia spinulosa* (Cookson and Dettmann) Cookson and Dettmann, GN 428/2, 50.5 124.7.

Fig. 12. *Jamunisporites tumulosus* sp. nov., holotype, distal surface; GN 421/1, 55.5 123.3; ×1,250.

Fig. 13. *Coperisporites complexus* (Couper) Pocock; distal surface, GN 265/1, 59.0 115.3.
NORRIS, Late Jurassic and Purbeck miospores
Callialasporites obtusus sp. nov.

Plate 110, figs. 6, 7

Holotype. Slide GN 148/1, 48.4 109.6. Sample 60--5--24 (grey, shaley clay), Upper Purbeck, Unio Beds, Durlston Bay (from Bed 82 of Bristow 1857).

Diagnosis. Spores radiosymmetric, alete, with a distinct central body. Amb of central body circular to oval, surrounded by a saccus imparting an irregularly circular outline to the entire spore. Central body outline not clear, saccus not distinctly attached to it. Saccus very thin, standing out from central body one-tenth to one-twelfth of the total diameter, scabrate to sub-granular, carrying coarse and also fine radial folds on equatorial bladder, these passing into irregular rugulate folds on central body. Central body granular to rugulate, finer sculpture elements at poles. Exine of central body (?endo- exine) thin, about 0.05 μ m or less in thickness. Bladders (?ektexine) also thin, about 0.25 μ m thick.

Description. Bladders very narrow, usually about 5 μ m wide but varying 4--9 μ m. Bladder folded coarsely and approximately radially. Central body usually indistinct.

Dimensions. Equatorial diameter (including sacci): 38--69 μ m (holotype 61 μ m). Central body diameter: 29--44 μ m (holotype 44 μ m).


Remarks. Callialasporites obtusus sp. nov. is distinguished from Zonalapollenites segmentatus Balme by the possession of a very thin-walled central body.

Callialasporites sp.

Plate 110, figs. 4, 5

Description. Spores radiosymmetric, trilete, with a narrow equatorially attached saccus. Laeareae long, sinuous, labiate, 1--2 μ m wide reaching beyond amb of central body and occasionally reaching amb of the saccus when they fan out into folds. Amb of both saccus and central body circular to rounded triangular. Saccus scabrate but thrown into rugulate, rather than irregular folds where attached to central body. Saccus projects even beyond amb of central body a distance equal to one-sixth to one-tenth of the total diameter (4--8 μ m). Saccus almost unfolded or carrying rather coarse, irregular radial rugulate folds up to 2 μ m wide and 4 μ m long.

Dimensions. Equatorial diameter (including sacci): 39--64 μ m.

Distribution. Portlandian, Dorset. Middle and Upper Purbeck, Dorset and Surrey.

Remarks. Apart from the prominent trilete mark, this species is similar to Callialasporites obtusus sp. nov. in possessing an equatorial, radially folded bladder which is attached to a rugulate central body.

Tufina aletes

Infraorder PSILOPAITI

Genus INAPERTUROPOLENNITES (Pflug ex Thomson and Pflug 1953) Potonié 1958

Inaperturopollenites sp.

Plate 110, figs. 11, 12
Description. Spores small, sphaeroidal or occasionally of irregular shape owing to folding, inaperturate. Exine relatively thick and rigid, unfolded or carrying short arcuate folds. Exine 0.25–1 μm in thickness, usually about 0.75 μm.


Infraturna spinonapiti

Genus Peltandrinites Wodehouse 1933

_Peltandrinites tener_ sp. nov.

Plate 110, figs. 18, 19

_Holotype._ Slide GN 316/1, 42.0 123.7. Sample WM 2024/2 (grey, calcareous shale), Middle Purbeck, Warrington borehole, Surrey.

Diagnosis. Spores radiosymmetric, inaperturate, sphaeroidal, folded, entirely covered in

**Explanation of Plate 109**

All figures ×750.

Fig. 1. _Couperisporites complexus_ (Couper) Pocock; distal surface, GN 338/1, 43.4 111.0.

Figs. 2–4, 7. _Janaspiretum tumulosum_ sp. nov. 2, 3. Holotype, median focus and distal surface respectively; GN 421/1, 55.5 123.3. 4. Median focus, showing circular aperture; GN 345/1, 41.5 28.5. 7, Median focus, GN 138/2, 40.4 117.2.

Figs. 5, 6. _Marattisporites scoparius_ Couper. 5. Polar view, GN 163/2, 51.2 111.5. 6. Equatorial view, GN 147/1, 27.8 119.0.

Figs. 8–10. _Vitrinapites pahilius_ (Reissinger) Potonié. 8. GN 138/2, 28.0 122.0. 9. GN 154/2, 45.7 121.7. 10. GN 153/2, 30.7 113.5.

Figs. 11, 12. _Cerebrosporites mesococoides_ (Couper) Nilsson. 11. GN 152/1, 38.1 117.9. 12. GN 152/1, 48.0 111.1.

Fig. 13. _Albatraceopollenites minimus_ Couper, GN 265/2, 46.4 111.2.

Figs. 14, 15. _Alisporites bilatellus_ Race. 14. GN 143/2, 42.6 120.8. 15. GN 259/2, 28.6 127.2.

Figs. 16, 17. _Podocarpites sp._ cf. _P. ellipticus_ Cookson. 16. GN 431/1, 118.8 39.3. 17. GN 421/1, 47.5 123.1.

Figs. 18, 19. _Parrisaccites radiatus_ Couper. 18. Oblique polar view, GN 146/2, 37.0 124.3. 19. Oblique equatorial view, GN 186/2, 49.5 112.6.

**Explanation of Plate 110**

All figures ×750 unless otherwise stated.

Fig. 1. _Parrisaccites radiatus_ Couper, equatorial view, GN 138/2, 50.8 128.2.

Figs. 2–8. _Callusporites_ sp. 2–3. C. _lomberi_ (Balme) Sukh Dev. 2, 1113–13C, 44.2 119.4. 3. GN 421/1, 46.6 119.3. 4–5. C. _sp. 4. GN 152/1, 29.5 123.2. 5. GN 152/2, 36.1 121.8. 6–7. C. _brunus_ sp. nov. 6. Holotype, GN 148/1, 48.4 109.6. 7. GN 431/1, 23.9 118.2. 8. C. _sp. cf. C. trilobatus_ (Balme) Sukh Dev. GN 255/2, 49.7 120.2.

Figs. 9–12. _Inapariopollenites_ sp. 9–10. _I. dubius_ (Potonié and Venetz) Thomson and Pflug. 9. GN 196/1, 56.8 127.7. 10. GN 345/1, 35.9 108.6. 11–12. _L. sp. 11. GN 272/1, 44.9 117.0. ×1,250. 12. GN 421/1, 39.1 120.4. ×1,250.

Fig. 13. _Spheroopollenites subgranulatus_ Couper, GN 482/1, 34.6 109.3.

Figs. 14–16. _Undulataspores_ sp. nov. 14, 16. High and median foci respectively, GN 421/2, 43.2 126.8. 15. High focus, GN 421/2, 47.1 110.0.

Fig. 17. _Aracnacolitites australis_ Cookson, GN 265/2, 46.6 119.8.

Fig. 18, 19. _Peltandrinites tener_ sp. nov. 18, Holotype, GN 316/1, 42.0 123.7; ×1,250. 19. Tetrad, GN 281/1, 46.4 115.0.
NORRIS, Late Jurassic and Purbeck miospores
NORRIS, Late Jurassic and Purbeck miospores
short, closely spaced, irregularly distributed spines. Exine very thin, usually less than 0·25 \( \mu \) in thickness.

**Description.** Grains always carry many arcuate and crescentic folds. Spines 0·75–1 \( \mu \) long, usually about 0·25 \( \mu \) wide but occasionally up to 1 \( \mu \) wide, spaced irregularly 0·25–1 \( \mu \) apart. In some corroded specimens some of the spines are reduced to low granules. Rarely the grains occur in tetrads. Sometimes the grains are ruptured in an arcuate fashion. Optical section of exine indistinct, occasionally reaching about 0·25 \( \mu \) thick but never thicker.

**Dimensions.** Maximum diameter: 33–55 \( \mu \) (holotype 30 \( \mu \)).

**Distribution.** Kimmeridgian and Portlandian, Dorset. Lower and Upper Purbeck, Dorset.

**Remarks.** This species is easy to confuse with some acritarchs with short processes. It is only distinguished with difficulty but is clearly a pollen grain on account of its occurrence in tetrads.

*Peltraindriptides tener* is distinguished from *Araucariacites australis* Cookson by its smaller size, much thinner exine, and clearly echinulate rather than granular ornament.

**Infoturma reticulonapiti**  
*Genus Undulataspores* Leschik 1955  
*Undulataspores araneus* sp. nov.

Plate 110, figs. 14–16; Plate 111, figs. 2–10

**Holotype.** Slide GN 345/1, 25.3 107.2, Sample 60–19–3, (grey calcareous marl), Upper Purbeck, Upper Cypriot Clays and Shales, Beacon Hole (6 in. above Bed 1 of Arkell 1933).

**Diagnosis.** Spores radiosymmetric, aleate. Amb circular to oval. Exine very thin and ornamented with irregular rugulae coalescing into a very imperfect, irregular microreticulum consisting of narrow muri of constant width, and elongated irregular lumina with a radially elongated arrangement towards the periphery. Exine 0·25–1 \( \mu \) thick, possibly tectate.

**Description.** Muri and rugulae 0·25–1 \( \mu \) wide, of constant width along their length, 0·25 \( \mu \) or less up to 0·5 \( \mu \) high. Luminae 0·5–1 \( \mu \) wide and up to 3 \( \mu \) long, tortuous and bounded by anastomosing muri which show both angular and rounded bends in their courses. Spores sometimes show concentric folds close to the periphery.

**Dimensions.** Maximum equatorial diameter: 21–30 \( \mu \) (holotype 26 \( \mu \)).

**Distribution.** Upper Purbeck, Dorset.

**Remarks.** *Undulataspores araneus* sp. nov. is distinguished from *Undulataspores anguineus* Leschik by the overall smaller size, thinner exine, and shorter rugulae.

**Turma plicata**  
*Subturma monocolpate*  
*Genus Cycadopites* Wodehouse 1933 ex Wilson and Webster 1946  
*Cycadopites* sp. cf. *C. nitidus* (Balme 1957) comb. nov.

Plate 111, figs. 11, 12
1957 Entylissa nitida Balme, p. 30, pl. 6, figs. 78–80.
1962 Ginkgoceydophyus nitida (Balme) de Jersey, p. 12.


Remarks. These grains have a slightly greater over-all size range (18–39 μ long; 13–27 μ broad) than those described by Balme but also differ in their tectate and scabrate to infrapunctate exine (rather than ‘smoothly or faintly granulate’). The exine, however, has a granular appearance in some corroded specimens. Balme (1957) believed that C. nitida was derived from plants of cycadalian or beccetitallian affinities. The stratification of the exine of the present grains is not in conflict with this. Pollen grains of the modern genera Bowenia, Cycas, and Macrozamia belonging to the Cycadaceae and are illustrated by Erdtman (1957, figs. 10, 17, 46). All have tectate exines with rod-like elements supporting the tectum and closely resemble C. sp. cf. C. nitida. The exines of some of the modern forms are distinctly crassitectellate whereas the tectum of C. sp. cf. C. nitida is frequently seen to be just thinner than the gap between it and the endexine but merging into a crassitectellate exine.

TURMA POROSAE
Subturma monoporines
Genus EXESPOLLENITES Balme 1957
Exespollenites scabrosus sp. nov.

Plate 111, figs. 20–2

Holotype. Slide GN 316/1, 45.5 109.5. Sample WM 2024/2 (grey calcareous shale), Purbeck Beds, Warlingham borehole.

Diagnosis. Spores radiosymmetric, monoporate. Amb rounded triangular to circular. Both proximal and distal faces rather flattened. Distal face with a circular thickening around the centre with an over-all diameter about half the equatorial diameter. At the distal pole at the centre of the thickening is a rather thinner, distinctly depressed circular

EXPLANATION OF PLATE 111

All figures × 1,250 unless otherwise stated.

Fig. 1. Pelosdrupites teser sp. nov., GN 281/1, 54.5 121.1.
Figs. 2–10. Undulatoparites aranous sp. nov. 2–3, High and median foci respectively, GN 341/1, 27.8 128.0. 4–5, Holotype, high and median foci respectively, GN 345/1, 25.3 107.2. 6–7, GN 345/1, 30.3 112.4. 8, High focus, GN 345/1, 107.3 25.9. 9, Median focus, GN 421/1, 56.1 127.6. 10, GN 345/1, 24.3 108.9.
Figs. 11, 12. Cycadopites sp. cf. C. nitida (Balme) comb. nov. 11, GN 338/3 49.4 119.8; × 750. 12, GN 196/1 43.0 109.3; × 750.
Fig. 17. Monosclites sp. aff. M. minimus Cookson, GN 344/1, 39.2 128.6; × 750.
Fig. 18. Cycadopites carpinieri (Delcourt and Sprumont) Singh, GN 184/1, 41.9 108.8; × 750.
Fig. 19. Inoperatifolllumites dubius (Potonié and Venitz) Thomson and Pfug, GN 153/2, 23.2 122.1; × 750.
Figs. 20–22. Exespollenites scabrosus sp. nov. 20, GN 316/1, 109.3 45.5; × 750. 21–2, Holotype, distal surface, × 750 and × 1,250 respectively; GN 316/1, 45.5 109.5.
pore. Exine tectate, microreticulate, consisting of inwards projecting elements. Occasional scattered, irregular granules may occur on both faces. Exine just under 1 µ in thickness.

**Description.** Distal thickening distinct but not sharply delimited at its periphery, 11–17 µ in diameter (just greater or just less than half the equatorial diameter). Distal pore at centre of distal thickening circular, depressed 1.5–3 µ, 1–8 µ in diameter (onetwelfth to two-thirds the diameter of the distal thickening).

Microreticulate ornament developed over entire surface of grain, including the distal pore and thickening, occasionally indistinct or scabrate. When well developed the muri of the microreticulum are about 0.25 µ wide and the lumina are about 0.25 µ in diameter. This tectate ornament may be accompanied by scattered groups of irregular granules up to 1 µ in diameter developed on the outer surface of the tectum. The tectate nature of the exine is usually quite clear even though delicately marked. The inwards projecting elements of the exine are usually only seen as faint radial structures between the tectum and endexine. The radial elements may become so faint as to simulate a simply caved exine.

Exine 0.25–1 µ in total thickness. Endexine 0.25 µ or less in thickness, occasionally not clearly distinct from the exine.

Folding seldom occurs owing to the flattened nature of the spore but the amb is occasionally irregularly crumpled.


**Distribution.** Kimmeridgian and Portlandian of Dorset and Sussex. Lower, Middle, and Upper Purbeck of Dorset, Sussex, and Surrey.

**Remarks.** Exesipollenites scabrosus is distinguished from Exesipollenites tumulus Balme by the tectate nature of the thinner exine and by the microreticulate ornament. No spheroidal forms with a triangular polar thickening which Balme (1957) found associated with *E. tumulus* were found associated with *E. scabrosus*. The Lower Jurassic assemblage in which *E. tumulus* occurred also contained abundant Classopolis (Balme 1957, p. 41) as do the present samples in which *E. scabrosus* occurs.

**MIOPORES INCERTAE SEDIS**

Genus SIGMOPOLLIS Hedlund 1965

**Sigmopollis callosus** sp. nov.

Plate 113, figs. 9–12

**Holotype.** Slide GN 383/1, 48.7 108.3. Sample 60–19–22 (buff calcareous sandstone), Middle Purbeck Corbula Beds, Bacon Hole (from the base of Bed 69 of Bristow 1857).

**Diagnosis.** Spores spheroidal. One face carries a distinct, markedly sinuous split in the exine. Entire surface of grain ornamented with low bifurcating rugae which do not project at the amb. Exine about 1 µ thick.

**Description.** Grains seldom folded and consequently more or less perfectly spherical owing to the relatively thick and rigid exine.

Splitting is almost invariably developed and often takes an inverted S-shaped course
across the entire face. It does not appear to be associated with a thinning of the exine and in optical section is seen to be a simple break perpendicular to the surface of the grain.

Rugulae 1–2 µ long, up to 0.25 µ wide, branching and occasionally partly forming an imperfect microreticulum, usually not projecting at the amb but in few specimens giving the outline a slightly irregular appearance. Exine 0.75–1.25 µ thick.


Distribution. Middle and Upper Purbeck, Dorset, Sussex, and Surrey.

Remarks. Sigmapollis callosus is distinguished from Spheroepollenites subgranulatus Couper by the much thicker, more rigid exine, by the distinct rugulae which do not project at the amb, and by the distinct sinuous rupture occurring on one face.

The split in the exine is considered to be significant (possibly connected with germination) rather than fortuitous owing to its constant and similar development in most grains examined. Since it is not associated with any thinning of the exine it cannot be considered a colpus. It is similar to a monolite mark but is not associated with a differential raising of the surface of the exine and appears to transgress the entire exine thickness from the inner to the outer surface. Probably it is best considered an aleate grain.

STRATIGRAPHIC PALYNOLGY

All the samples examined from the Purbeck Beds and Upper Jurassic with few exceptions are dominated either by Classopollis toroensis or Inaperturopollenites dubius. These two species together usually constitute at least 70% and occasionally more than 90% of the total spore-pollen flora. The relative abundance of these two species may have palaeoecologic significance. They are of little use, however, for delimiting assemblages

**EXPLANATION OF PLATE 112**

All figures ×1,250 unless otherwise stated.

Figs. 1–5, 8–16. Classopollis spp. 1–5. C. toroensis (Reissinger) Balme. 1, Tretard, GN 164/1, 43.9 128.5; × 750. 2–3. Median and high foci respectively showing grain with endexine separated from ectexine; GN 414/5, 49.5 123.2. 4. Equatorial view, GN 97C/1, 43.1 107.8; × 750. 5. Polar view, GN 316/1, 37.6 128.0; × 750. 8–13. C. echninatus Burger. 8. Polar view, GN 316/1, 41.9 129.1. 9. Oblique polar view, GN 316/1, 58.9 124.6. 10. Polar view, GN 316/1, 37.0 124.3. 11. Equatorial view, GN 203/1, 31.2 128.7. 12–13. Equatorial view, median and high foci respectively; GN 97C/1, 53.8 108.5. 14–16. C. hammenii Burger. 14. Equatorial view, GN 259/1, 29.2 128.7. 15. Equatorial view, GN 162/2, 41.9 128.7. 16. Oblique equatorial view, GN 97C/2, 47.1 126.7.

Figs. 6, 7. Perinopollenites cladoide Couper. 6. GN 259/2, 50.8 118.1; × 750. 7. GN 190/3, 42.5 108.5; × 750.

**EXPLANATION OF PLATE 113**

All figures ×1,250 unless otherwise stated.

Figs. 1–4. Classopollis hammenii Burger. 1, 2. Equatorial view, low and median foci respectively; GN 316/1, 32.0 128.5. 3. Polar view, GN 154/1, 52.7 120.3. 4. Oblique polar view, GN 316/1, 40.9 129.5.

Figs. 5–8. 13. Schizosporis spp. 5, 8. S. reticulatus Cookson and Dettmann. 5. GN 260/1, 43.3 116.3; × 350. 8. GN 259/1, 53.7 127.9; × 350. 6, 13. S. spriggei Cookson and Dettmann. 6. GN 265/1, 46.2 116.5; × 350. 13. GN 163/1, 51.6 117.6; × 350. 7. S. parvis Cookson and Dettmann, GN 154/1, 47.8 125.6; × 750.

Figs. 9–12. Sigmapollis callosus sp. nov. 9–11. Holotype, low, median and high foci respectively, GN 383/1, 48.7 108.3. 12. High focus, GN 383/1, 37.5 108.7.
NORRIS, Late Jurassic and Purbeck miospores
NORRIS, Late Jurassic and Purbeck micropores
for stratigraphic purposes. On the other hand, the constituent species of the remaining fraction of the miospore samples are very diverse and may be used to define spore-pollen suites which appear to have stratigraphic significance. Suites have been recognized by study of samples collected in sequences. They delimit broadly similar spore-pollen samples, presumably derived from the same vegetational unit or units. They are described on the basis of their persistent species (those present in about 50% or more of the constituent samples in a suite) and spasmodic species (those occurring in less than half of the samples on which the suite is recognized). The composition of the suites is shown in text-fig. 3.

**Marine Upper Jurassic Assemblages**

The Upper Kimmeridgian and Portlandian of the Dorset coast and the Portland Sand of Sussex have similar miospore assemblages which are included in one miospore suite (Suite A). The basal Purbeck of Durlston Bay is also marine or brackish and is characterized by the same Suite.

Suite A is restricted in composition, most assemblages consisting of 10–15 species (listed in text-fig. 3). None of the species show restricted ranges within the intervals examined. All species occur in the overlying Purbeck Beds. The extension of their ranges into lower strata is not known in detail, owing to lack of adequate studies in the lower horizons of the Kimmeridgian, but more than half the species comprising Suite A have been reported from the Lower, Middle and Upper Jurassic of Britain by Couper (1958), Lantz (1958b), and Wall (1965).

The restricted nature of assemblages constituting Suite A is probably the result of the combination of several factors. Both the Upper Kimmeridgian and Portlandian comprise marine sediments deposited in an offshore environment. Considerable sedimentary sorting of the miospores by both wind and water is likely and may have resulted in only a fraction of the total available spore-pollen population from the adjacent land areas reaching the depositional site. This relative impoverishment may have been accentuated by the extremely limited flora that occupied coastal sites at that time as evidenced by the overlying Lower Purbeck assemblages.

At West Weare Cliff (Isle of Portland) Suite A occurs up to and including the Basal Shell Bed. Samples above this bed from the Cherty Series and Freestone Series did not yield palynologic assemblages. Suite A occurs in Portlandian samples from the West Weare Sandstone, Upper Black Nore Beds, Black Nore Sandstone, and Lower Black Nore Beds. Samples from the Exogyra Bed, the lower part of the West Weare Sandstone and upper part of the Upper Black Nore Beds were not available. At Tar Rocks below West Weare Cliff, Suite A characterizes the Kimmeridgian pallasioles zone to at least 135 ft. below the lowest row of nodules in the Black Nore Sandstone.

At Hounstout, Suite A characterizes similar horizons in the Lower Portlandian and Upper Kimmeridgian. The highest occurrence of Suite A collected at this locality was immediately below the Lower Parallel Band of the St. Alburn Head Marls. Suite A characterizes the Portlandian and Upper Kimmeridgian below this, comprising the remainder of the St. Alburn Head Marl, Emmitt Hill Marl, Hounstout Marl, Hounstout Clay, Rhychonella Marl, Lingula Shale, Rotunda Clays and Nodules, and the highest 20 ft. of the Crushed Ammonoid Shales, below which samples were not collected.

At Durlston Bay, the only Purbeck assemblage obtained below the base of the Marls
TEXT-FIG. 3. Composition of microfloral suites showing persistent species (unbroken lines) and spasmodic species (broken lines). N.B. Range in entry 16 is correct, and not that in entry 41.
with Gypsum and Insect Beds belongs to Suite A. This assemblage which was obtained from a horizon 3 ft. below the top of the Broken Beds, contains dinoflagellate cysts (Norris 1965b) suggesting marine conditions of deposition, as suggested independently by Brown (1964) using petrologic criteria.

Marine plankton. The spore-pollen assemblages of Suite A are accompanied by a large proportion of dinoflagellate cysts and acritarchs; Norris (1965) has described a few of these species. The relative numerical abundance of microplankton in the marine Upper Jurassic (expressed as a ratio—number of microplanktonic forms/number of spores) varies from 0.2 to 1.0. The relative diversity of marine Upper Jurassic microplankton species compared with spore species (expressed as a ratio) varies between 0.6 and 3.0. In contrast the saline horizons in the Purbeck Beds containing microplankton have relative numerical abundances of microplankton that rarely exceed 0.01 and relative diversities of microplankton that never exceed 0.2 and frequently are less than 0.1.

Purbeck Assemblages

The Purbeck miospore assemblages of Dorset, Sussex, and Surrey can be grouped into two suites of distinctly different composition.

Suite B. This Suite (see text-fig. 3) is similar to Suite A in terms of most of the commoner constituents; however, *Classopollis echinatus* and *Inaperturopollenites* sp. occur less frequently, and *Podocarpidites* sp. cf. *P. ellipticus*, Araucariacites australis and *Perinopollenites elaioides* more frequently. *Eucommidites minor* occurs in Suites A and C but is unknown in Suite B. Suite B is distinguished from Suite A by the presence of the following rarely occurring species:

*Acanthotrites variispinosus*, *Convervocosporites variverrucatus*, *Leptolepidites psarous*, Micro-reticulatisporites diattitus*, *Cicatricosisporites purbeckensis*, *Plicatella abaca*, *Cooperisporites complexus*, *Cycadopites carpenteri*, *Schizosporis spliggi*, *Parvisaccites radiatus*.

On the Dorset Coast, Suite B characterizes most of the Lower Purbeck and the lower part of the Middle Purbeck. At Durlston Bay, Suite B occurs up to Bristow’s (1857) Bed 53 in the Upper Building Stone, 17 ft. below the base of the Corbula Beds. At Boveston Hole Suite B occurs up to the top of the Marly Freshwater Beds (Bristow’s Bed 42). Its lowest occurrence is not clearly defined at Boveston Hole where palynologic assemblages are rare in the Lower Purbeck. At Durlston Bay, however, Suite B definitely occurs down to the base of the Marls with Gypsum and Insect Beds. Suite A occurs almost to the top of the Broken Beds.

At Mountfield, Suite B characterizes the 4 gypsum seams at the bottom of the Purbeck sequence, the highest sample containing Suite B assemblages occurring at the top of No. I seam.

In the Warlingham borehole, Suite B does not occur above 2,022 ft. but the section was not examined below 2,027 ft. and so its lowest occurrence was not determined.

Suite C. This suite is similar to Suite B in terms of most of the persistent species (text-fig. 3) but contains these additional persistent species (some of which, however, occur rarely in other suites):

*Cycadidites minor*, *Kirkatsporites pseudoreticulatus*, *Cicatricosisporites australiensis*, *Cicatricosisporites purbeckensis*, *Plicatella abaca*, *Coronatispora vulgaris*, *Parvisaccites radiatus*. 
Suite C contains all the rare species that characterize Suite B but also contains the 32 additional spasmocid species listed in text-fig. 3.

Suite C occurs in the upper part of the Middle Purbeck and the Upper Purbeck of the Dorset Coast. At Durlston Bay, this Suite ranges from a horizon 15 ft. below the top of the Upper Building Stone (Bristow's Bed 55) to the highest sample examined, a bed of limestone at the top of the Marble Beds and Ostracod Shales. The Viviparus Clays are no longer exposed at this locality. At Bacon Hole the lowest occurrence of Suite C is from near the base of the Corbula Beds (from the bottom of Bristow's Bed 60). The interval from the base of the Corbula Beds to the highest occurrence of Suite B close to the lower middle Purbeck junction is barren of miospores. Consequently the exact delimitation of Suites B and C at this locality cannot be determined accurately. Suite C occurs up to the highest sample examined from Bacon Hole, a silty clay in Wealden arenaceous facies about 8 ft. above the top of the Upper Purbeck Paludina Clays. The latter is delimited from the basal Wealden by the incoming of sandstone.

At Lulworth Cove, Suite C occurs in the Paludina Clays but its lowest occurrence has not been determined at this locality because of the lack of assemblages. Suite C is not known at Worbarrow Bay, also because of lack of palynomorph assemblages in the Upper Middle and Upper Purbeck.

At Mountfield, Suite C occurs from 13 ft. above the top of No. 1 gypsum seam throughout the remaining 'Middle' and 'Upper' Purbeck to the highest sample examined in the lower half of the Grey Limestone Series exposed in the River Line south-west of the gypsum mine (Howitt 1964, p. 86).

In the Warlingham borehole, Suite C occupies the interval from 2,004 ft. to the highest sample examined at 1,900 ft.

**DISCUSSION OF ASSEMBLAGES AND SUITES**

The three suites represent a progressive diversification of the plant microfossil assemblages (text-fig. 3). Species of Suite A are drawn from a total of 32 species. Most assemblages constituting Suite A are composed of 10–15 species. Suite B is represented by a total of 42 species, although each assemblage in this suite usually consists of less than 10 species with occasionally up to 22 species present. Suite C is the most diverse, being represented by a total of 73 species; most assemblages of Suite C contain 15–30 species although this number can be (rarely) as low as 4 or as high as 42.

Each successive suite is characterized by the entrances of new forms. There are no well-marked extinctions although local ranges may be restricted in some sections. Most of the characteristic new forms of each suite are rare types. This leads to difficulties in assigning some samples to a suite, but the use of sequential samples has allowed a more meaningful evaluation of the absence of rare types in a sample.

This progressive diversification of the assemblages may be the result of evolution, sedimentation, local phytogeography, or changing environments. The distribution and ranges of characteristic species within each Suite is not constant from section to section, which suggests that factors other than evolution and extinction are important in determining individual ranges. For example, *Pilosporites delicatus* is characteristic of Suite C in Dorset but is unknown in Sussex and Surrey. Thus local palaeoecologic control may be severe and does not allow the use of individual miospores for minutely
detailed stratigraphic correlation, although the use of miospores for general correlative purposes is possible as set out below.

There is no apparent relationship between the miospore Suites and the numerical dominants in each section. Either *Classopolis torus* or *Inaperturapollenites dubius* may dominate the assemblages constituting Suite A. At Durlston Bay and in the Warlingham borehole Suite B is characterized by relative abundances of *Classopolis torus* greater than 50%. At Bacon Hole and Mountfield, *C. torus* dominates the lower assemblages of Suite B but *I. dubius* becomes important in the higher assemblages of this Suite. Suite C is characterized by an abundance of *I. dubius* at Durlston Bay and in the Warlingham borehole. At Bacon Hole and Mountfield either *I. dubius* or *C. torus* may dominate the Suite C assemblages. Many assemblages in Suite B and C are characterized by the freshwater chlorophycean alga, *Botryococcus*, presumably reflecting the dominantly non-marine conditions of deposition.

**Botanical considerations.** It is possible to assign many dispersed spore and pollen species from the Jurassic and Cretaceous to natural plant orders and families (Potonié 1962, Brenner 1963, Dettmann 1963, Pocock 1962, Singh 1964, Norris 1967). Species constituting Suites A, B, and C are distributed amongst natural plant taxa at the ordinal or higher levels as follows:

**BRYOPHYTA:** Stereisporites antiquasporites, Foraminisporis wonthaggiensis, Aequitriradites spinulosus, Caupepisporites complexus.


**CYCADOPHYTA:** Vitreisporites pallidus, Cycadopites sp. cf. C. nitidus, C. carpentieri.


**SPORES AND POLLEN INCERTAE SEDIS:** Inaperturapollenites sp., Peltandriopites tener, Undulataportiates araneus, Monosulcites sp. aff. M. minimus, Schizosporis reticulatis, S. spaggi, S. varus, Sigmapollis callosus.

From the above list it is evident that the assemblages spanning the Jurassic–Cretaceous boundary in southern England as a whole represent principally pteridophyte–gymnosperm vegetation. Lycopsids are less important than filicole elements but some of the pteridophyte spores of uncertain affinities may belong to this group. Bryophytes and cycads are both relatively unimportant groups.

Ascending the sequence from the Upper Kimmeridgian to the Upper Purbeck there is a progressive diversification of the spore-pollen assemblages. Suite A consists principally
of coniferalean elements with a few filicalean, lycopsid, and other pteridophyte species. In Suite B conifers remain important but pteridophytes begin to diversify. Bryophytes appear in Suite B as rare elements. In Suite C conifers remain the most diverse persistent elements but pteridophytes are the most diverse of the spasmodic species. Bryophytes are commoner here than in Suite B but are still rare. Cycadophytes are rare elements in all the suites. The numerical dominants in all the suites, Classopolis torossus and Inaperturapollenites dubius, are both coniferalean species but some of the inaperturate grains could be derived from equisetalean plants (Batten 1968).

**CORRELATION AND AGE OF THE PURBECK BEDS**

**Correlation**

It is difficult to select 'index' forms or key species (Couper 1958) but the suites recognized on the basis of several species are presumably time concordant.

Correlation of the Purbeck Beds and equivalent strata in southern England on the basis of palynologic suites is shown in text-fig. 4. At Durlston Bay, Suite B is present from the top of the Broken Beds (samples from the Caps and Dirt Beds below did not yield palynomorphs) to the upper part of the Upper Building Stones. Suite C occupies the remainder of the Upper Building Stone to the top of the Marble Beds and Ostracod Shales. In Bacon Hole the boundary between Suites B and C occurs at a similar stratigraphic position, i.e. at the approximate level of the Scallop Beds (of Bristowe's 1857 terminology). Due to the westward attenuation of the strata, however, the B/C boundary is approximately 15 ft. above the Cinder Bed at Bacon Hole whereas the equivalent interval at Durlston is almost double that thickness.

Samples from the major part of the Purbeck Beds at Worbarrow Bay and at Lulworth Cove were too sparse (perhaps due to the large amounts of limestone in the sections) to locate the boundary between Suites B and C. At Mountfield, however, this boundary is well marked in the subsurface section of the Purbeck Beds just above the No. 1 gypsum seam approximately 50–60 ft. above the base of the section. This contrasts with the position of the B/C boundary approximately 260 ft. above the base at Durlston Bay. Thus the four gypsum seams and intercalated shales at the base of the Mountfield Purbeck would appear to be either a condensed sequence equivalent to the Lower and much of the Middle Purbeck of Dorset (some 260 ft.), or there is a hiatus between the underlying Portlandian and the lowest Purbeck at Mountfield which seems more likely for the following reasons.

Although the Purbeck of Dorset is apparently conformable with the underlying Upper Portlandian, in other areas there is some evidence to suggest that the Upper Portlandian is absent. In the Henfield borehole of Sussex, 2 ft. below the base of the Purbeck Beds, faunas occur indicating the Lower Portlandian albani zone (Taitt and Kent 1958). In the Portsdown borehole the Purbeck Beds rest on Portlandian equivalent to the top of the Portland Sand (Lower Portlandian) in Dorset. At Mountfield the arenaceous sediments immediately underlying the Purbeck Beds have yielded dinoflagellates characteristic of the top part of the Lower Portlandian gorei zone in Dorset (Norris 1963). Falcon and Kent (1960, p. 13) presented additional evidence from boreholes in southern England and stated that there is 'no evidence of the occurrence of Upper Portland anywhere in the Wealden area, there being a non-sequence at the base of the Purbeck'. Taitt and Kent
TEXT-FIG. 4. Palynologic correlation of the Purbeck Beds in southern England.
(1958) also ascribed this break to a non-sequence due to a regional movement causing a cessation of deposition since there are no signs of erosion and the break is of a uniform nature. The occurrence of Lower Portlandian pebbles within the Lower Purbeck of Dorset (Woodward 1895), the erosion of the Portland Beds prior to deposition of the Purbeck Beds in the Aylesbury district (Woodward 1895), and the presence of derived Kimmeridgian and Portlandian pelecypods from the basal Purbeck Beds of Swindon similar to forms from the south of England and the Boulo-nnais (Arkell 1941) indicate the possible existence of a pre-Purbeck unconformity.

The correlation of the Purbeck at Mountfield is particularly interesting whatever the reason for the absence of marine Upper Portlandian at this locality. Details of Purbeck ostracod faunas are not available. Howitt (1964) used lithologic criteria for correlation of the Purbeck sequence of the Mountfield inlier. He assigned this relatively thick sequence to the conventional tripartite subdivision: the ‘Lower’ Purbeck consists largely of gypsum and limestone; the ‘Middle’ Purbeck consists of shale, some marine limestone and arenaceous horizons; the ‘Upper’ Purbeck contains freshwater limestones, shales, and calcareous sandstones. A different correlation is suggested on the basis of miospores (text-fig. 4). Suite B characterizes the gypsiferous series at the base plus a few feet of overlying shale as detailed in the previous section. Suite C occupies the remaining Mountfield Purbeck to the middle of the Greys Limestone Series. This suggests that the entire gypsiferous series at Mountfield is equivalent to the Middle Purbeck rather than to the Lower Purbeck of Dorset as suggested by Howitt (1964). It is difficult to determine how much of the Durlston Suite B is represented at Mountfield. There appear to be no breaks in sedimentation within Suite B strata which suggests in view of their thin development that only the upper part of Suite B is represented, i.e. equivalent to part of the lower Middle Purbeck. The correlation of the higher assemblages of Suite C is difficult. *Clestricospisporites angicanalts*, a distinctive species of limited stratigraphic range, is restricted to the upper part of the Upper Purbeck in Dorset. At Mountfield, *C. angicanalts* occurs in one sample of the Greys Limestone suggesting a correlation with the upper part of the Upper Purbeck of Dorset. Thus if this correlation is correct, sedimentation of the upper part of the Middle Purbeck (above the Cinder Bed) and the Upper Purbeck proceeded at less than half the rate at Durlston Bay (183 ft.) compared with the equivalent interval at Mountfield (396 ft.).

**Age**

At the type locality on the Dorset Coast the Purbeck Beds overlie with apparent conformity the uppermost Portlandian. The Upper Portlandian has been correlated with the Middle Tithonian of the continent by Arkell (1956) on the basis of the contained ammonite faunas. Presumably the Upper Tithonian is represented by at least part of the Purbeck sequence in Dorset. The top of the Purbeck Beds is delimited by the incoming of coarse, elastic arenaceous and carbonaceous sediments of Wealden facies which have not been precisely dated but in the past have been generally assumed to be basal Cretaceous (Allen 1955).

Ostracods have been used to correlate the Purbeck Beds of southern England (Anderson 1958) and similar European formations (Anderson 1962, Arkell 1956, Bartenstein and Burri 1955). Age determinations of the Purbeck Beds, however, rest principally on occurrences of ammonites (Arkell 1956). Arkell’s arguments for a Late Tithonian age
for the Purbeck Beds have been reviewed and revised by Donze (1958) who suggested that the ammonites indicate either a Late Tithonian or Berriasian age for the French Purbeck.

The Jura Purbecks have been correlated with the Lower and Middle Purbeck by F. W. Anderson using ostracods (Arkell 1956). Their Berriasian and possibly Late Tithonian age is not inconsistent with other stratigraphic and palaeontologic evidence from underlying and overlying deposits in this region. Arkell (1956) has noted that undated limestones underlie the ammonite-bearing and other sequences of the French Purbecks. Only the lower part of the thick limestones underlying the Jura Purbecks contain ammonites and these indicate the Kimmeridgian gravesiana zone. The higher part of this limestone sequence is customarily referred to as ‘Portlandian’ but diagnostic fossils are lacking. The limestones overlying the French Purbecks are assigned to the Berriasian with little or no palaeontologic evidence but are overlain by undoubted Valanginian. The limestones and marls overlying the Jura Purbecks are considered to be Berriasian on insecure evidence (Bartenstein and Burri 1955) and the one diagnostic ammonite has been compared to a Valanginian form (Arkell 1956). The remaining fauna is not diagnostic.

Similar correlations to the above for the Swiss and French Purbecks have been suggested by other workers using fossils other than ammonites. Bartenstein and Burri (1955) correlated the Swiss Purbecks with the Serpulite and Wealden I of NW. Germany and with the higher Lower Purbeck and lower Middle Purbeck of England using ostracods and charophytes. Donze (1958) correlated the French Purbecks with a regression in the Berriasian of the ‘fosses vocontiennes’ (indicated by microfaunal and algal changes) and with the Lower Purbeck and part of the Middle Purbeck of Dorset (using ostracods). Palynologic correlations differ slightly: these suggest a correlation of the Serpulite and Wealden I of Germany and Holland with the upper Middle Purbeck and part at least of the Upper Purbeck. Thus the Berriasian regressive facies in the West Tethys may correlate with the Lower Purbeck and lower Middle Purbeck or with the upper Middle Purbeck and Upper Purbeck. Bartenstein (1959, 1962) extended the Berriasian correlation of the French Purbecks to the Jura Purbecks. He confirmed that probably only the lowest part of the Swiss ‘Berriasian’ overlying the Jura Purbecks is to be correlated with the top of the type Berriasian, most of the remainder being of Valanginian age.

Thus on the evidence from ammonites and using ostracods to correlate to the west Tethyan region, the Purbeck Beds in Dorset appear to span the Jurassic–Cretaceous boundary occupying the interval Late Tithonian–Berriasian (text-fig. 5).

Assignment of the upper part of the Purbeck Beds to the Lower Cretaceous is also suggested by palaeobotanical arguments. Hughes (1958) studied megaspores from the English Wealden and compared them with those from Dutch and German sequences. The lowest Wealden formation in the type area is the Fairlight Clay of the Sussex Coast. The Fairlight Clay is believed to immediately overlie or be a partial facies equivalent of some of the Purbeck (Allen 1960 a, b) but the base of this formation is not exposed and so exact relationships cannot be confirmed. Overlying the Fairlight Clay is the Ashdown Sand which Hughes (1958) correlated with the Lower Valanginian of the Netherlands from the occurrence in both of Thomsontia megaspore floras. Hughes also noted that Thomsontia floras are known from the German Wealden 4 and 5. The beds below the
Thomsonia horizon of the Lower Valanginian of the Netherlands contain Pyrobolospora pyriformis (Dijkstra) Hughes which is known only in the Fairlight Clay in England. These lower beds in the Netherlands are probably Berriasian or partly Lower Valanginian, suggesting a similar age for the Fairlight Clay. The Upper Purbeck is a facies equivalent of the Fairlight Clay, as suggested by Hughes and Moody-Stuart’s (1969) correlation of the Lower Fairlight Clay with the upper Middle and Upper Purbeck using a new palynologic method. This indicates that the upper Middle and Upper Purbeck may also be Lower Cretaceous (?Berriasian) in age. The uppermost Purbeck Beds at Bacon Hole contain megaspores at some horizons (see Appendix 1 in Norris 1963). More intensive study of these megaspores may help to resolve the point.

Jurassic–Cretaceous boundary in southern England

As reviewed above, the Purbeck Beds on the Dorset Coast appear to occupy the Upper Tithonian–Berriasian interval and hence straddle the Jurassic–Cretaceous boundary which is conventionally placed between the Tithonian and Berriasian stages (Arkell 1956). These stages are based on ammonite faunas occurring in marine limestones of south-east France. Correlation with non-marine and transitional strata is difficult, being based on sparse ammonite-bearing marine intercalations together with the use of non-marine fossils to extend these age determinations into other areas of non-marine rocks. In southern England (Dorset) this has led to a situation in which it is possible to say that the lower part of the Lower Purbeck is probably Upper Tithonian and that the higher part of the Upper Purbeck is Berriasian (perhaps Upper Berriasian). But it is not possible to place the Jurassic–Cretaceous boundary precisely. Casey (in Howitt 1964, p. 109) has discussed some of the problems involved in locating the base of the Cretaceous in England. He suggested tentatively that the Cinder Bed of Dorset might be taken to mark the Jurassic–Cretaceous boundary. Casey considered this to be a convenient procedure because he thought the Cinder Bed to be the most extensive of several saline horizons in the Purbeck of England. Furthermore Casey pointed out that the flooding of the Wessex Basin that led to deposition of the Cinder Bed and supposed correlative horizons was perhaps linked with the Osterwald phase of Saxonia folding in north Germany that immediately preceded deposition of the Serpulite (a possible correlative of the Cinder Bed), and whose effects might be traced in the Spilsby Sea deposits further north. If the Cinder Bed is taken to mark approximately the base of the Cretaceous, the base of microspore Suite C occurs just above the Jurassic–Cretaceous boundary (text-fig. 4). At Mountfield, the Jurassic–Cretaceous boundary on palynologic evidence would be placed at about the top of the Main Gypseferous Beds. Hence the gypseiferous series at Mountfield appear to correlate at least in part with the Cinder Bed of Dorset (text-fig. 4). This is considerably different from the correlations suggested by Howitt (1964) who equated the gypseiferous series at Mountfield with the gypseum developed in the middle of the Lower Purbeck at Durlston, more than 100 ft. below the Cinder Bed. Howitt correlated the Cinder Bed of Dorset with a 5-ft. marine limestone containing Ostrea distorta, 182 ft. above the top of the Main Gypseferous Beds. This 5-ft. limestone in fact would correlate with a horizon in the Chief Beef Beds at Durlston, assuming the palynologic correlation is correct and sedimentation was twice as rapid at Mountfield compared with Durlston (see the preceding sections). Dinoflagellate cysts and acritarchs occur in samples from the Chief Beef Beds of Durlston Bay (Norris 1963).
suggesting marine influence at these horizons and supporting the above correlation. Dinoflagellate cysts and acritarchs also occur in small quantities in the Main Gypsumiferous Beds of Mountfield but comparisons with acid-insoluble microfossil assemblages from the Cinder Bed of Dorset is not possible because this limestone bed has proved to be barren of palynomorphs. If the microfloral correlation is correct it suggests that the entire Purbeck sequence in Sussex is Early Cretaceous in age (text-fig. 5), accepting Casey’s selection of the Cinder Bed in Dorset as a marker horizon for the base of the Cretaceous. More detailed work is required in the Mountfield area to refine the correlations suggested here.

**Comparaison with Other Jurassic and Cretaceous Assemblages**

Britain

Couper (1958) noted that the spore-pollen assemblages from the Kimmeridgian of Brora (Scotland) are impoverished in both number of species and specimens and in general are similar to Oxfordian assemblages from Yorkshire and to Middle Callovian assemblages from Brora. Although details on only three Kimmeridgian assemblages, one Oxfordian assemblage, and one Callovian assemblage are available, the data are sufficient to make a general comparison. All these Upper Jurassic assemblages (the Callovian is classed variably as either Middle or Upper Jurassic by different workers) are characterized by the dominance of *Abietinaepollenites minimus* and *Abietinaepollenites microcalatus* Couper. This contrasts sharply with Suite A in the Upper Kimmeridgian and Portlandian of Dorset in which *Classopolis toroas* and *Inaperturapollenites dubius* are dominant or co-dominants. Couper’s Callovian, Oxfordian, and Kimmeridgian assemblages are clearly distinguished from the Dorset Upper Jurassic assemblages by the presence of *Sextrosporites irregularus* (Couper) Dettmann, *Cingulatisporites dubius* Couper, and *Pterocichopollenites microscapus* Couper. These three species are unknown in the Upper Kimmeridgian, Portlandian, or Purbeck Beds of southern England. Of the approximately twenty remaining species in Couper’s assemblages, a little more than half are pteridophyte spores, just less than half are conifer grains and the rest are cycads or pteridospers. All of these occur in younger strata but the following are absent in Suite A: *Cycathidites australis* Couper, *Dictyophyllidites harrisii* Couper, *Densiosporites perinatus* Couper, *Duplexisporites problematicus* (Couper) Playford and Dettmann; the distance of the parent vegetation from the site of marine deposition in Dorset may have been important in determining what miospores entered the sediment. With the onset of estuarine and non-marine conditions in southern England in the Upper Tithonian and Lower Cretaceous these species presumably were able to reach the depositional sites more easily. Species present in Suite A which are not known in Couper’s Middle or Upper Jurassic assemblage include *Exesipollenites scabrosus* sp. nov., *Inaperturapollenites* sp., *Classopolis echinitus*, *Classopolis hammoniensis*, *Rubinella major*, *Reticulatisporites semireticulatus*, *Kluiversporites pseudoreticulatus*, *Cicatricosporites australiensis*, *Coronatispora valdensis*, *Podocarpidites* sp. cf. *P. ellipticus*, *Callialasporites dampieri*, *Callialasporites obtusus*, *Callialasporites sp.*, *Pelaniopsis tener*, *Eucominitidites minor*, *Cycadopites* sp. cf. *C. nitidus*.

Couper (1958) and Hughes (1958) summarized the main differences between the
**TEXT-FIG. 5.** Correlation chart of strata close to the Jurassic-Cretaceous boundary in north-west Europe.
Wealden microflora and the Purbeck assemblages known at that time. Many of their conclusions are invalidated by the present study. Of the six species stated to characterize the Wealden, five are now known to occur in the Purbeck or Upper Jurassic (particularly in Suite C but some also in Suites A and B), viz. *Trilobosporites apiverrucatus*, *Parvissaccites radiatus*, *Appendicisporites potomacensis* (= *A. tricornitatus* of Couper 1958 in part), *Cicatriciosporites brevilaxurus*, and *Coronatispora valdensis*. *Concavisporites punctatus* was reported by Couper (1958) and by Hughes (1958) to range down to the base of the exposed Fairlight Clay and this species is not known in the Purbeck Beds. Apart from this species, however, the Fairlight Clay assemblages are closely similar to those of Suite C, as far as it is possible to judge from Couper's descriptions. The numerical dominants in the Fairlight Clay, however, are quite different: about 70% of the grains are filicalean spores and the remainder are *Abietineapolleslites*, contrasting with the abundance of *Inaperturpollenis dubius* in the Upper Purbeck. The possibility that the Fairlight Clay at least in part is a lateral facies equivalent of the upper part of the Purbeck Beds should be considered in view of recent palynological correlations suggested by Hughes and Moody-Stuart (1969). Numerical differences could be due to the clastic facies of the Fairlight Clay compared with the finer grained lithologies in the Purbeck (limestone and shale).

*Germany and Holland*

Comprehensive accounts of the palynology of strata close to the Jurassic-Cretaceous boundary have been given by Döring (1965) for north-central Germany and by Burger (1966) for the eastern Netherlands. Several difficulties, however, are involved in making comparisons with other areas. Strata close to the British Jurassic-Cretaceous boundary show relatively restricted spore-pollen assemblages. This is due either to distance from the site of the vegetation in the case of the marine sediments or to the apparently restricted and perhaps specialized nature of the coastal vegetation in the case of the estuarine and non-marine sediments. The assemblages described from the continent appear to be more diverse which in part may be a taxonomic effect due to the less conservative approach to miospore variability adopted by those continental workers. But much of this diversity appears to be a real reflection of richer parent vegetation. Detailed comparisons of individual ranges of miospores between Britain and the Dutch and German localities is not appropriate for stratigraphic purposes in this case because palaeophytogeography or palaeoecology appear to have been important in controlling miospore distribution. A general comparison of the continental palynologic suites with the palynologic suites recognized in southern England may yield more meaningful results.

Burger (1966) studied two cored sections of uppermost Jurassic and lowermost Cretaceous strata located on the western edge of the Lower Saxon Basin in the Twente area of Holland. He recognized 9 pollen zones spanning the higher Upper Malm (conventionally placed in the Tithonian, c.g. Arkell 1956) and the predominantly non-marine 'Wealden' up to the next fully marine horizon in the Middle Valanginian. Burger noted that his 9 pollen zones based on appearances and disappearances of miospore species may have only local significance. Of the 88 species occurring in the Dutch sequence, only 29 species are common to the Upper Jurassic-Purbeck sequence in England. All but 6 of these species range from Upper Malm to Middle Valanginian. Of
the 6 species of restricted range, all are present in the Upper Malm but do not occur higher than the lower part of the Middle Valanginian. Thus the following 29 species occur from Upper Malm to the base of Middle Valanginian sediments in Holland and also occur in the Upper Kimmeridgian–Purbeck of England:


Twenty of the species in the above list occur in Suites A, B, or C in England. Species marked * occur only in Suites B and C and species marked ** occur only in Suite C. Two of the latter in England are comparable with but not identical to the Dutch forms (Callialasporites trilobatus and Monosulcites minutus). Thus apart from the presence of Trilobosporella bernissartensis, C. trilobatus, and Monosulcites minutus the species from the Upper Malm that also occur in England suggest a correlation with Suite B. If the presence of the few Suite C species is considered significant, a correlation of this sequence with Suite C is indicated. But approximately forty other species also occur in the Upper Malm of Holland that are not known in the Kimmeridgian–Purbeck sequence of England. Of particular significance amongst these forms is Permonolites asplenioides Couper. This species was reported by Couper (1958) to occur in the higher parts of the Wealden but not in the Fairlight Clay, Ashdown Sand, Wadhurst Clay or Tunbridge Wells Sand (i.e. this species occurs in the Barremian–Aptian using Hughes 1958 correlation). In view of the local variations in occurrences of particular species, evidence from one species alone is not usually adequate for stratigraphic correlation. However, the presence of this species down to the Upper Malm together with the evidence from the microfloras reviewed above suggests that the Dutch Upper Malm microflora is probably no older than Suite C of England and may be younger.

Döring (1965) gave details of the stratigraphic ranges of 109 spore species (mostly trilete) in 7 boreholes penetrating strata close to the Jurassic–Cretaceous boundary from an area about 50 miles east of Hamburg, Germany. His section extended from the Upper Malm (Serpulite) to Wealden G which Döring equated with Wealden 5 and 6 of the standard NW. German sequence i.e. immediately underlying the Middle Valanginian. Only 12 of these species are known in Suites A, B, and C of England and of these, the following range from Upper Malm to Wealden G:

Dictyophyllidites equleximus, Osundacites wellmani, Pilosisporites trichopapillosus, Klukisporites pseudoreticulatus, Coronatispora valdensis, Trilobosporella bernissartensis, Cerebropollenites mesozoicus.

In England all these species occur in Suites A, B, and C except Trilobosporella bernissartensis and Pilosisporites trichopapillosus which only occur in Suite C, suggesting a correlation of the Upper Malm (Serpulite) with Suite C. This correlation is reinforced by the entrance in Wealden A (overlying the Serpulite) of Duplexispores problematicus, Aequiradiales radiatus, and Cicatricosisporites angicanalis. All these species appear in England in Suite C. Trilobosporella apiculata does not appear in the German sequence until Wealden G however, compared with Suite C in England. Thus on the basis
of trilete spores, the Serpulite and Wealden A (= Wealden 1) of Germany correlate with Suite C of England. Correlations between the English, Dutch, and German sequences are shown in text-fig. 5, incorporating palynologic correlations in the scheme based on ostracods by Anderson (1955, 1962).

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