

SOME BRITISH WEALDEN MEGASPORES AND THEIR FACIES DISTRIBUTION

by D. J. BATTEN

ABSTRACT. Three new species of megaspores, viz. *Thomsonia alata* sp. nov., *T. fairlightensis* sp. nov., and *Minerisporites alius* sp. nov.; and four records, viz. cfA. *Arcellitites medusus* (Dijkstra 1951) Potter 1963, cfB. *A. medusus*, cfB. *Thomsonia pseudotenella* (Dijkstra 1951) Mädler 1954 and cfB. *Minerisporites marginatus* (Dijkstra 1951) Potonié 1956, are described from the British Wealden. Scanning electron microscopy resolved sculptural and structural details not revealed optically. Aspects of the distribution of megaspores in Wealden sediments are discussed. Assemblages with the greatest abundance of megaspores have been recovered from unsorted grey and brownish grey non-calcareous silts which contain sand and clay and a few small plant fragments; they are believed to have been derived from the local vegetation.

As part of an investigation of Wealden palynological facies, selected rock samples have been examined for megaspores and associated microfossils. Numerous well-preserved megaspores have been recovered and some are recorded here for their stratigraphical importance (see Hughes 1958).

Megaspores are frequently difficult to study by light microscopy because of their size and the often dense opaque nature of their exine. Problems which cannot be resolved frequently arise concerning the interpretation of certain structural or sculptural features. To assist in solving these problems, electron microscope techniques have been employed by some workers (e.g. Pettit 1966, Stainier 1965, and others). Scanning electron microscopy used here has yielded information not revealed optically and has resolved features which might have been open to misinterpretation from optical examination alone.

Sample preparation. 50 grams of rock were soaked in 20 vol. H₂O₂ solution, and then in cold 50% HCl if calcareous; the residue was then sieved, treated with HF, sieved again (using a 100-mesh sieve on both occasions) and picked by brush from water. Several selected specimens of the same species were mounted on 'Durofix' spots on 12-mm. specimen holders and coated with gold-palladium or aluminium for examination with the 'Stereoscan'. Other specimens were mounted dry or treated for 20 min. with concentrated HNO₃, cleared in dilute NH₄OH, mounted in a Clearcol film and sealed by DePeX.

Storage. Coated specimens have not been designated as types or included in the recorded data, as it is not known how long they will keep; they were of course taken from topotype material. The holders have been stored in individual dust-proof tubes.

Remarks. The diagnoses and descriptions of the new species have been based on observations of not less than 100 specimens. Adequate comparisons with similar species in the literature are not always possible because of the insufficiently detailed descriptions of some previously published species. When the diagnoses and descriptions of the records described here can be fitted into or are more or less similar to the diagnoses and descriptions of previously described species, they are called by that species name, but prefixed

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by cfA, cfB or cfC, following the procedure recommended by Hughes and Moody-Stuart (1967). At a later date after further detailed examination of similar spores from other horizons it may be necessary to give some of these records formal species names. The holotypes designated are translucent mounts.

The sectioning technique employed was that described by Hughes, Dettmann, and Playford (1962); the sections were mounted in glycerine jelly. The colour classification of the rock samples is from the Rock Colour Chart (1963) published by the Geological Society of America. Stage co-ordinates refer to Leitz Laborlux (L1) microscope, number 557187, Department of Geology, Cambridge University. The slides have been deposited in the Sedgwick Museum palynology collection.

RECORD

Anteturma SPORITES H. Potonié 1893
 Turma TRILETES (Reinsch 1881) Dettmann 1963
 Subturma PYROBOLOTRILETES Potonié 1956
 Genus ARCELLITES (Miner 1935) Ellis and Tschudy 1964

Type species. A. disciformis Miner 1935, p. 600, pl. 20, fig. 64.

cfA. *Arcellites medusus* (Dijkstra 1951) Potter 1963

Plate 62, figs. 1–11; Plate 63, fig. 1; Plate 67, figs. 1, 2, 4, 10

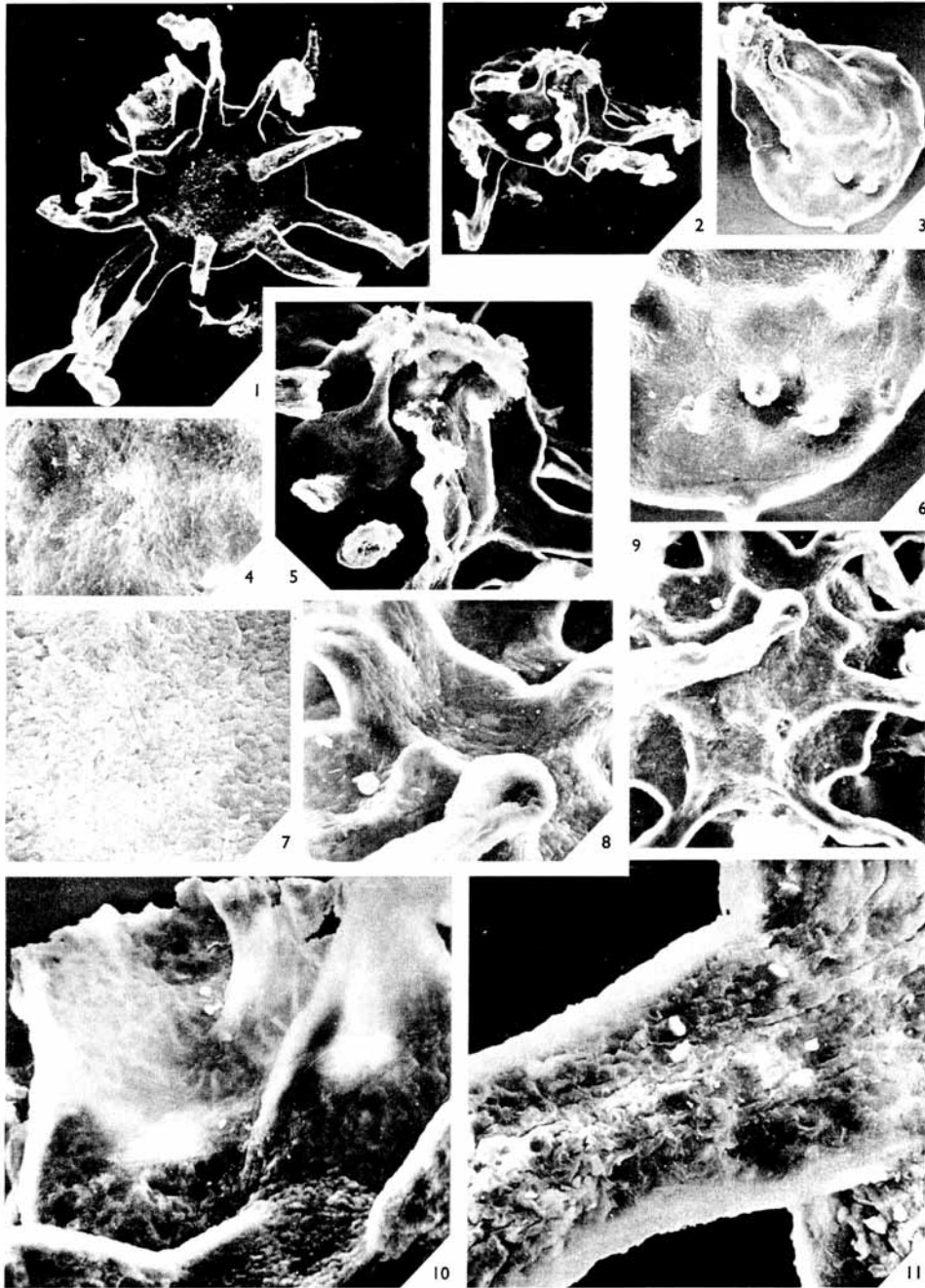
Sample. CUC 442, Cuckfield No. 1 Borehole, Sidnye Farm, Sussex, England (TQ 2962 2729), depth 442 ft.; Upper Tunbridge Wells Sand, Hauterivian. Brownish grey (5 YR 4/1) consolidated poorly sorted silt; small cuticle and wood fragments present. Prep. MT 395: megaspores recovered; 88% cfB *Minerisporites marginatus* (Dijkstra 1951) Potonié 1956, 8% *Thomsonia alata* sp. nov., 3% cfA. *Arcellites medusus* (Dijkstra) Potter 1963, and 1% cfB. *Arcellites medusus* (Dijkstra) Potter 1963.

Description. The mean and observed limits of the maximum diameter of the spore body (i.e. excluding the appendages and the neck) of this trilete megaspore are 146 (236) 319 μ (standard deviation 42.8 μ , coefficient of variation 18.1%; 100 specimens). The amb is circular or subcircular in outline. The neck is conspicuous, tapered, has an ill-defined base and is lacking in precise form. The maximum diameter of the neck (75 (142) 240 μ , 75 specimens) is generally at its base; the maximum length (75 (145) 224 μ , 67 specimens) is generally shorter than the diameter of the spore body (64 specimens) although occasionally (3 specimens) it may be slightly longer. It is a dimension which is difficult to measure with accuracy since the line of contact between the neck walls and the spore

EXPLANATION OF PLATE 62

All scanning electron micrographs.

Figs. 1–11. cfA. *Arcellites medusus* (Dijkstra 1951) Potter 1963. 1, 10, 11, Specimen on holder (SH)DB 7. 1, Laterally compressed, leaves of neck partly opened out, $\times 100$. 10, Same, neck detail; $\times 500$. 11, Same, base of appendage showing grooves and irregular ring-shaped thickenings; $\times 1,000$. 2, 5, Specimen on (SH) DB 11. 2, Obliquely compressed; $\times 100$. 5, Same, neck detail; $\times 250$. 3, 4, 6, Specimen on (SH) DB 11. 3, Compressed asymmetrically laterally with appendages incompletely formed and/or broken; $\times 250$. 4, Spore body exine, $\times 500$. 6, Same; $\times 250$. 7, Specimen on (SH)DB 11, spore body exine structure; $\times 1,000$. 8, 9, Specimen on (SH)DB 11. 8, Appendages connected at bases by ridges; $\times 500$. 9, Same; $\times 250$.



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body is variable and indistinct. It appears as if the neck is formed by 6 segments or leaves but, in view of the fact that the leaves are generally fused together along their length, microscopic examination has not fully substantiated this. The leaves are extensions of the outer layer, or ekstexine, of the spore body exine. They are thickest at their bases, becoming gradually thinner towards their extremities. They are fused at their margins forming upward-directed ridges and are usually folded inwards between these ridges (Pl. 62, fig. 3). Their basal configuration is similar to that of *Arcellites vectis* (Hughes) Potter 1963 (see Hughes 1955, text-fig. 1). Splitting has occurred along the length of the ridges on some (9) specimens with the result that one or more of the leaves have (partly) opened out. The unopened necks of some specimens appear to be somewhat shrivelled.

Within the neck is an irregular conical chamber 45–60 μ high and 30–45 μ wide at the base (seen on 3 specimens only). Weakly developed leasurae with slight adjacent thickening are at the base of the neck and completely enclosed by it (Pl. 67, fig. 4), the neck being an elevated specialized extension of the ekstexine rather than upturned extensions of the triradiate lips. The observed length of the rays is 47–73 μ (3 specimens). The triradiate mark is only visible if some of the neck leaves have been partially removed (Pl. 67, fig. 4).

The total thickness of the two layered exine is 9–20 μ (Pl. 67, fig. 10). The inner layer, or endexine, is homogenous, forming a smooth wall to the central lumen, and is 1 (2.5) 4 μ thick (31 specimens). The nature of the exine stratification is based on optical observations of whole and sectioned specimens. The outer layer has a spongy constituency and is very thick (7–18 μ). The thickness in an individual may be more or less constant or rather variable. Ridges up to 30 μ high and round swellings up to 30 μ high and 30 μ in maximum diameter may be present. At the outer edge of the outer layer, the sporopollenin units become discontinuous and the wall texture is more open and porous in appearance. This part of the wall is composed of anastomosing bars up to 5 μ wide, separated by interstitial 'spaces' 1 μ or less wide and up to 2 μ deep (Pl. 62, figs. 7–11; Pl. 63, fig. 1). The bars on the appendages are usually aligned more or less parallel to their length (Pl. 62, fig. 11) but on the central body they are generally more irregular. The interstitial spaces between the bars on the appendages tend to be deeper when the walls are thinner than usual; this may be the result of wall shrinkage. Scattered irregular rings of thickening 0.2 μ wide and 1–3 μ in diameter (Pl. 62, figs. 7, 11; Pl. 63, fig. 1) may also be present on the outer surface. They are not resolved optically. The number of appendages is variable (6 (13) 22; 94 specimens). They are tubular, commonly slightly constricted 5–40 μ above their bases but gradually increase in diameter towards their apices. They are commonly twisted and curved towards the spore body; their bases may be connected by body ridges (Pl. 62, figs. 8, 9); and their walls are thick except towards their apices where they become much thinner. Their dimensions vary: minimum width, 11 (24) 36 μ ; maximum width, 21 (48) 85 μ ; length 95 (246) 435 μ (based on measurements of 100 appendages from specimens picked at random). A few are apparently malformed, being twisted and 'lumpy' (Pl. 67, fig. 9) and some of these lack expanded tips and are much shorter (maximum length, 73 μ) than normal. Four clusters (groups of two or more spores held together by interlocking appendages) of spores were recovered.

Preservation and compression. The specimens are generally well preserved but the neck and one or more of the appendages per specimen are frequently broken. There is a

tendency for corroded specimens to have thinner and more crinkled neck-leaves and appendages than usual. The spores are spherical or sub-spherical if uncompressed, but most are compressed, usually in lateral or asymmetrically lateral aspect. Hughes (1955) has pointed out that such compression indicates that the top of the spore below and at the base of the neck is the most rigid part. The exine of the spores cfA. *A. medusus* is thickest at the base of the neck and this part of the spore is strengthened further by the neck ridges which extend on to and over part of the spore body.

Remarks. The wall structure of cfA. *A. medusus* is similar to that of some modern spores of *Selaginella*. The acetolyzed megaspore wall of *Selaginella* mainly consists of a very thick spongy outer layer and a much thinner inner layer which is not more than $\frac{1}{20}$ of the total thickness of the exine (Pettit 1966). In addition, electron micrographs of *Selaginella selaginoides* (in Afzelius, Erdtman, and Sjostrand 1954), *S. myosurus* (in Martens 1960, and Stainier 1965), *S. kraussiana* (in Stainier 1965) and *S. pulcherrima* (in Pettit 1966) have shown that the outer layer of the exine is composed of anastomosing bars of sporopollenin and that interstitial 'spaces' occur between them. Electron micrographs of *S. pulcherrima* show that, at the outer edge of the outer layer, the sporopollenin units become discontinuous and the wall texture is more open and porous in appearance. Towards the inner limit of the layer, the sporopollenin elements gradually become reduced in thickness and less widely spaced (Pettit 1966). The thin-walled expanded apices of the appendages may be deflated bladders.

Distinction

Local. CfB. *A. medusus* (Dijkstra 1951) Potter 1963 is smaller, has fewer appendages, and the proportions of the length of the neck relative to the diameter of the spore body are different.

Literature. *A. disciformis* (Miner 1935) Ellis and Tschudy 1964 differs chiefly in that it has a longer and different neck structure and shorter, wider body appendages. The body of *A. hexapartitus* (Dijkstra 1951) Potter 1963 is covered with short blunt appendages, the neck is longer and the leaves are usually slightly twisted in an anti-clockwise

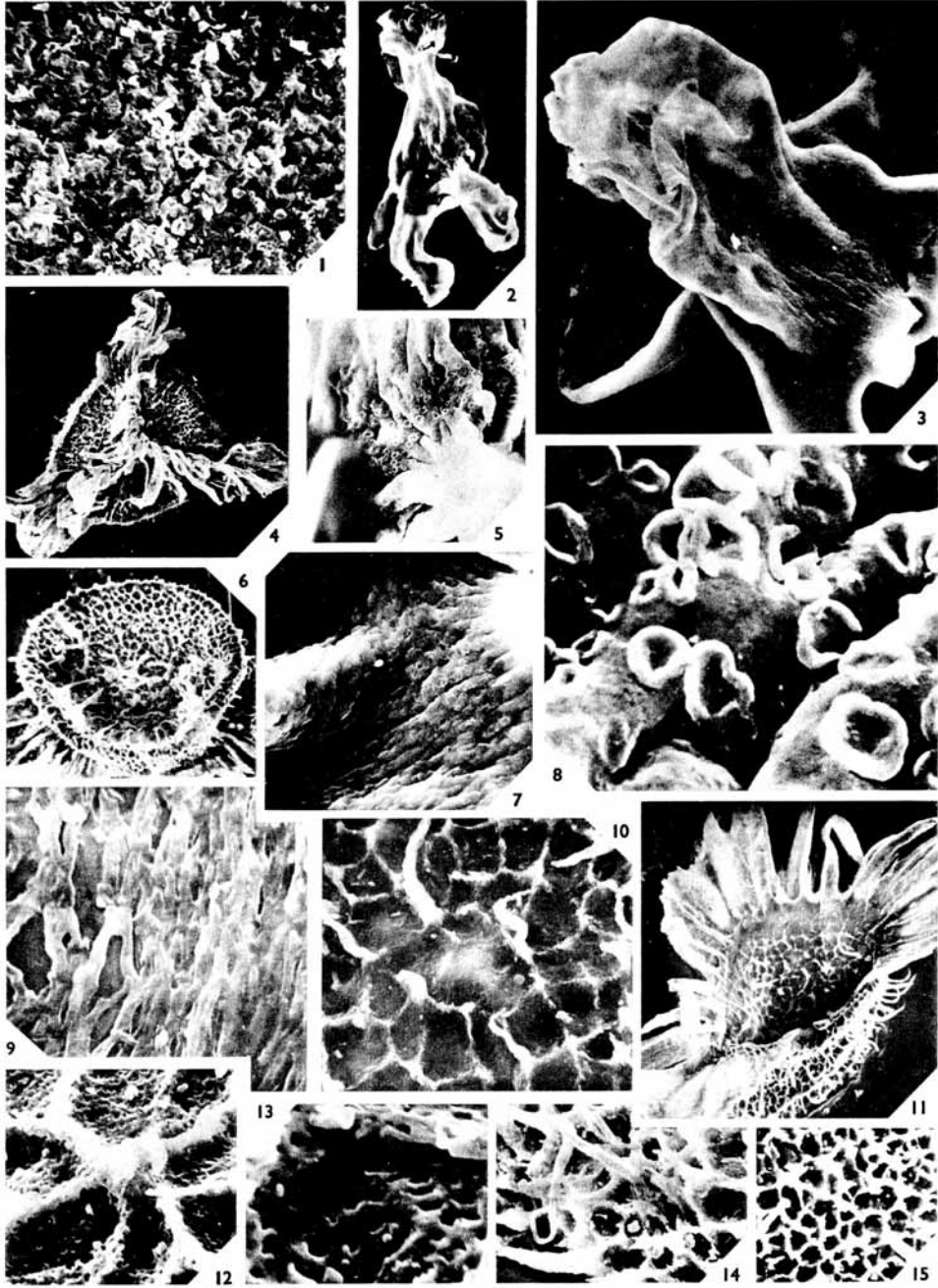
EXPLANATION OF PLATE 63

All scanning electron micrographs.

Fig. 1. cfA. *Arcellites medusus* (Dijkstra 1951) Potter 1963 to show structure of spore body exine, $\times 2,000$; (SH)DB 7.

Figs. 2, 3, 5, 7, 8. cfB. *A. medusus* (Dijkstra 1951) Potter 1963. 2, 5, 8, Specimen on (SH)DB 7. 2, Lateral aspect, $\times 200$. 5, Spore body (shrunken?) with rings of thickening. 8, Same, rings of thickening; $\times 4,000$. 3, 7, Another specimen on (SH)DB 7. 3, $\times 500$. 7, Sculpture similar to that on *A. mirus*, rings of thickening only weakly developed, $\times 500$.

Figs. 4, 6, 9-15. *Thomsonia alata* sp. nov. 4, Proximal polar view; $\times 50$, (SH)DB 11. 6, 15, Specimen on (SH)DB 10. 6, Distal surface collapsed, concave, pressed against inner surface of convex proximal face; $\times 100$. 15, Distal sculpture; $\times 250$. 9, Part of triradiate appendage, loosely connected to adjacent appendage; $\times 2,000$, (SH)DB 11. 10, 11, Another specimen on (SH)DB 10. 10, Sculpture, proximal face; $\times 500$. 11, Compressed laterally; $\times 100$. 12, Reticulum and pitting; $\times 1,000$, (SH)DB 7. 13, Part of proximal lumen and murus showing pitting; $\times 3,000$, (SH)DB 7. 14, Distal sculpture; $\times 500$, (SH)DB 11.



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direction. *Pyrobolospora vectis* Hughes 1955 has a greater number of appendages which are different in shape, extend from low ridges and are thin walled.

Comparison

Local. Similar specimens have been recovered from only one other horizon in the Upper Tunbridge Wells Sand, and from two core samples of 'Wealden' (see Lees and Taitt 1945) from the Kingsclere No. 1 Borehole, one (K475) from near the upper limit of the 'Wealden' (probably Upper Barremian (see Kemp 1968) or Aptian (Hughes 1958)) and the other (K777) from 302 feet below this (Valanginian (Hughes 1958)).

Literature. Although it is very likely that the species *A. medusus* described by Dijkstra (1951) is the same as the cfA. *A. medusus* described here, satisfactory comparison is not possible since Dijkstra's description is insufficiently detailed and is based on only four specimens. Hughes (1955) recovered a specimen from K777 which he assigned to *A. medusus*, and which I regard as indistinguishable from my specimens.

A sub-sample of some of the type material was processed, but no specimen of *A. medusus* was recovered although many other megaspores were seen.

cfB. *Arcellites medusus* (Dijkstra 1951) Potter 1963

Plate 63, figs. 2, 3, 5, 7, 8; Plate 67, figs. 5-7

Sample and preparation. As for cfA. *A. medusus* (Dijkstra 1951) Potter 1963; 27 specimens recovered.

Description. The mean and observed limits of the maximum diameter of the spore body (i.e. excluding the appendages and the neck) of this small trilete megaspore are 44 (71) 98 μ (standard deviation 14 μ , coefficient of variation 19%; 27 specimens). The average size of the spore including the appendages and neck is rather less than 200 μ . The amb is circular or subcircular in outline. The neck is similar in form to that of cfA. *A. medusus*, but is usually less tapered and has fewer and more weakly developed upward extending ridges and thus possibly fewer leaves, although the exact number has not been determined. The leaves are commonly thin and may be (partly) membraneous (10 specimens). They may be folded inwards between the ridges. Splitting has occurred along the length of the ridges of some (10) specimens and consequently one or more of the leaves have (partly) opened out. The width of the neck is 39 (60) 90 μ (23 specimens), slightly less than or equal to the diameter of the spore body. The widest part is usually at the base. The length is greater than (11 specimens) or more or less equal to the length of the spore body diameter (48 (78) 155 μ ; 23 specimens). The neck chamber was not seen. The laesurae are at the base of the neck and are completely enclosed by it. They are relatively short (12-14 μ ; 2 specimens only) and weakly developed.

The total thickness of the two layered exine is 5-9 μ ; the inner layer is 1-2.5 μ thick (6 specimens); the thickness of the outer layer is irregular (4-8 μ) and is usually greatest at the bases of the neck and the appendages. The outer layer of the spore body has a spongy consistency. At the outer edge of the outer layer the wall texture is more open in appearance and in addition irregular, occasionally anastomosing bars of sporopollenin up to 5 μ wide, separated by interstitial spaces 0.5-1 μ wide and up to 3 μ deep are usually present (Pl. 63, figs. 5 and 7). In addition, scattered irregular rings of thickening 0.5 μ

wide and 2–4 μ in maximum diameter (Pl. 63, fig. 8) are present on the outer surface. Swellings up to 13 μ high are present on the body of one specimen. One other specimen has scattered verrucae with rounded bases on the corpus, 6–9 μ in diameter and 1–2 μ high. There are few body appendages (2–7) and these are tubular, similar in structure to those of cfA. *A. medusus* although their basal diameter may be greater than the diameter of their tips (9 specimens), and their walls may be thin (membraneous) and crumpled for their entire length (Pl. 67, fig. 7). Their dimensions (based on measurements of 53 appendages) vary: minimum width, 11 (19) 47 μ ; maximum width, 17 (33) 55 μ ; length, 55 (84) 125 μ . Clusters of specimens were not recovered.

Preservation and compression. The preservation state of the specimens observed is good, but some are pitted and three are slightly corroded. All are compressed laterally or asymmetrically laterally. Some have a shrunken appearance (e.g. Pl. 63, fig. 5).

Distinction. This record is probably an abortive form of cfA. *A. medusus*. It has been found only in one sample (CUC 442) associated with that species. Until more evidence of an association has been found it has, however, been excluded from it, on the basis of size, number of appendages and the proportions of the neck relative to the diameter of the body of the spore. In addition, the rings of thickening tend to be more strongly developed (Pl. 63, figs. 5, 8).

Turma BARBATES Mädler 1954

Genus THOMSONIA Mädler 1954

Type species. *T. reticulata* Mädler 1954, p. 150 pl. 5, fig. 15.

Thomsonia alata sp. nov.

Plate 63, figs. 6, 9–15; Plate 64, figs. 1–5, 7, 9, 12; Plate 67, figs. 3, 8

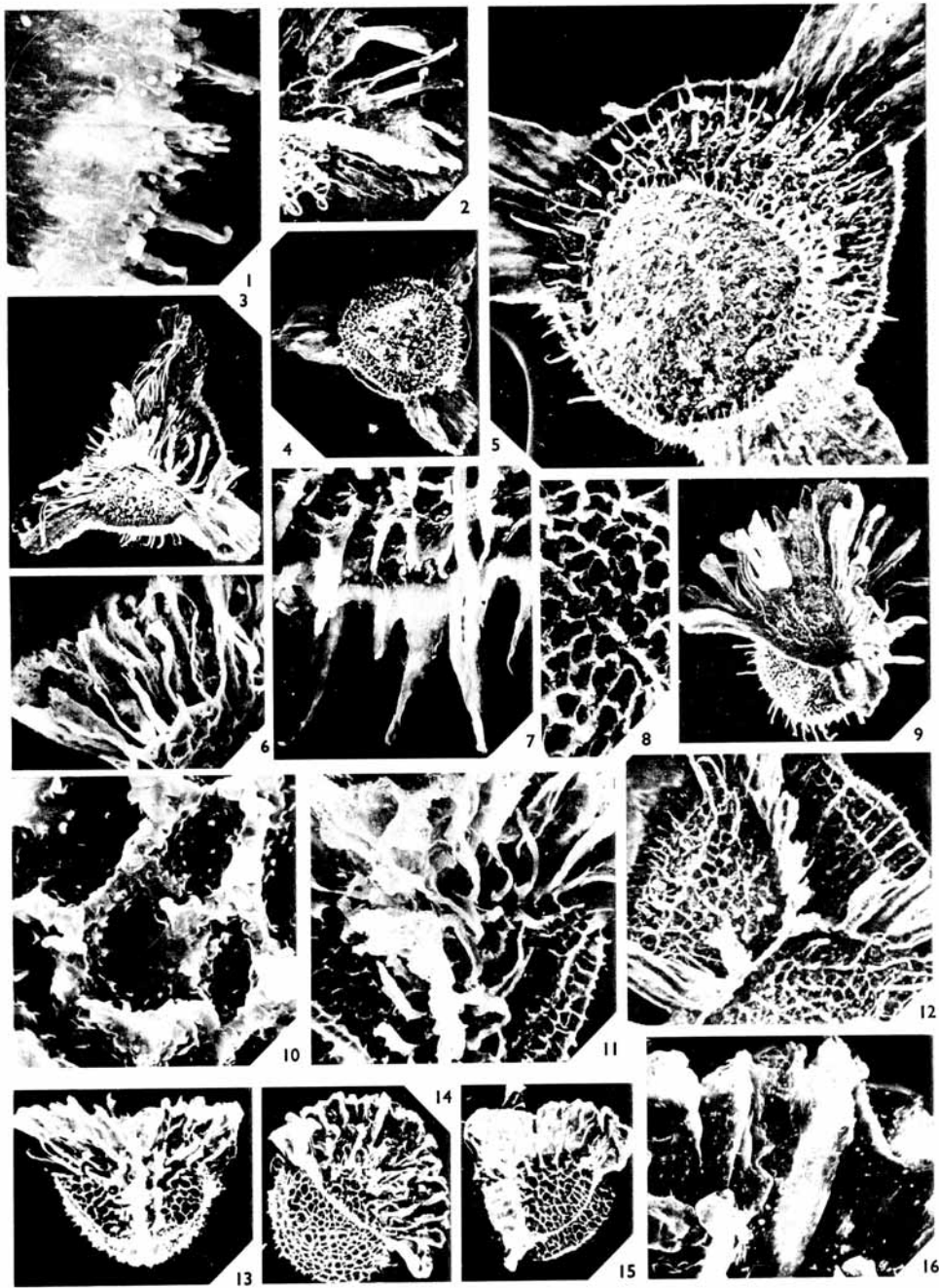
Type sample and preparation. See under cfA. *Arcellites medusus* (Dijkstra 1951) Potter 1963.

Diagnosis. Megaspore, trilete. Mean maximum diameter of spore body (i.e. excluding equatorial outgrowths and sculpture) 451 μ ; standard deviation 53.5 μ (100 specimens). Spore body spherical or subspherical if uncompressed, circular to convexly triangular

EXPLANATION OF PLATE 64

All scanning electron micrographs.

Figs. 1–5, 7, 9, 12. *Thomsonia alata* sp. nov. 1, Part of equatorial interradial zona; $\times 1,000$; (SH)DB 11. 2, 7, Another specimen; (SH)DB 11. 2, Triradial lips, detail at equatorial radial outgrowth; $\times 100$. 7, Distal sculpture; $\times 500$. 3, Proximal view; $\times 50$, (SH)DB 3. 4, Distal view; $\times 50$, (SH)DB 7. 5, Distal surface, part removed, $\times 100$; second specimen, (SH)DB 7. 9, Lateral view; $\times 50$, third specimen, (SH)DB 7. 12, Proximal face; $\times 100$, fourth specimen, (SH)DB 7.
 Fig. 6. cfA. *Thomsonia fairlightensis* sp. nov. from sample DB 170, Fairlight Clay; part of triradial lips and proximal sculpture; $\times 250$, (SH)DB 1.
 Figs. 8, 10, 11, 13–16. *Thomsonia fairlightensis* sp. nov. 8, 10, (SH)DB 15. 8, Narrow equatorial interradial ridge and sculpture on either side (proximal and distal); $\times 500$. 10, Sculpture, detail showing pitting; $\times 2,500$. 11, Detail of triradial lips and adjacent appendages; $\times 250$, second specimen. (SH)DB 15. 13, 16, Third specimen, (SH)DB 15. 13, Oblique view; $\times 100$. 16, Detail of triradial lips; $\times 500$. 14, Lateral view; $\times 100$, fourth specimen, (SH)DB 15. 15, Obliquely compressed; $\times 100$, fifth specimen, (SH)DB 15.



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in polar view. Total thickness of two layered exine, 4–9 μ : inner layer 1–3 μ thick; outer layer 2.5–6 μ (excluding sculpture). Sculpture reticulate. Tapered hair-like or spine-like appendages (capilli) frequently extend from points where the muri connect with each other (Pl. 63, fig. 10). On the distal face, the capilli are generally 35–100 μ long (longest observed near or at the distal pole) and 3–15 μ in basal diameter. There are usually fewer capilli on the proximal surface than on the distal and these tend to be shorter; occasionally they are virtually absent. Near the laesurae, however, considerably longer capilli with basal diameters up to 15 μ are usually present (longest observed, 215 μ). The muri are tapered, < 1–4 μ wide (at base) and 5–12 μ in height. The exine is also pitted in a regular manner (Pl. 63, figs. 12, 13); the pits are 0.5–1.5 μ in diameter and up to 1.5 μ apart.

The trilete mark extends to the outer margin of the radial equatorial outgrowths and is bordered by 'fibrous' labra from which extend flattened (broadest parallel to the laesurae) blunt-ended appendages (7–13 per ray) of similar structure; the 'fibres' are 0.5–4 μ in diameter (Pl. 63, fig. 9). Although most are separated except near their base, some may be partially or entirely connected along their length (Pl. 67, fig. 8). The observed limits of the maximum width of the appendages are 8–45 μ ; their lengths, including the basal (undissected) part of the labra range from 84 to 440 μ ; they are usually longest at the proximal pole and shortest on the radial outgrowths. The equatorial outgrowths are ribbed, variable in shape and size (120–440 μ long, 143–407 μ wide) and structurally similar to the triradiate appendages; the outer margin is usually serrated (Pl. 64, fig. 4). More or less equatorial, arcuate ridges connect the radial outgrowths and may project as lamellae (Pl. 64, fig. 9) up to 88 μ wide. The lamellae are structurally similar to the radial outgrowths but lack ribbing; the outer margin is irregular.

Holotype. Slide preparation MT 395/14, L1 41.7 116.2; pl. 67, fig. 3.

Description. The observed limits of the maximum diameter of the spore body are 352–605 μ . The coefficient of variation is 11.8%. The mean and observed limits of the lateral diameter of the spore body are 313 (393) 495 μ (16 specimens). Sometimes the triradiate appendages are connected only at their extremities.

Preservation and compression. The state of preservation of the material is good, with a tendency for the capilli to be shorter on corroded specimens. Specimens are commonly compressed in polar or asymmetrical polar aspect but 20 are compressed laterally; these tend to have rather longer appendages than average bordering the laesurae which would, at the time of their deposition, have counteracted the effect the equatorial outgrowths usually had in bringing about a polar orientation. Dehydration of many specimens has led to the collapse of parts of the spore wall; the collapsed wall may be concave and (closely) pressed against the inner surface of the opposite, convex face.

Distinction

Local. CfB. *Thomsonia pseudotenella* (Dijkstra 1951) Mädlar 1954 and *Thomsonia fairlightensis* sp. nov. are smaller, have smaller equatorial radial outgrowths and their triradiate lips and sculpture are different.

Literature. *Thomsonia pseudotenella* (Dijkstra 1951) Mädlar 1954 lacks a reticulum and the equatorial radial outgrowths are smaller; *T. phyllicus* (Murray 1939) Potonié 1956

is smaller and lacks pronounced equatorial radial outgrowths; *T. reticulata* Mädlér 1954, *T. thorensis* Mädlér 1954 and *T. granulata* Mädlér 1954 have smaller radial outgrowths, *T. granulata* also has granulate and warty sculpture; *T. dakotaensis* Hall 1963 has smaller, differently shaped radial outgrowths and the margins of the laesurae are different; *T. midas* (Dijkstra 1951) Mädlér 1954 and *T. divisa* (Dijkstra 1951) Mädlér 1954 are verrucate; *T. mensura* (Harris 1935) Potonié 1956, has different sculpture and lamellae, a shorter triradiate mark and is without radial outgrowths; *Minerisporites ales* (Harris 1935) Potonié 1956 has a different sculpture and the triradiate flange is more or less complete; *Triletes datura* Harris 1961 is smaller, the appendages extending from triradiate lamellae are shorter and arcuate lamellae different in nature; species of *Tenellisporites* Potonié 1956 lack radial outgrowths and possess a zona with finger-like projections.

Comparison. Local. Specimens of cfA. *Thomsonia alata* have been recovered from other horizons in the Upper Tunbridge Wells Sand.

Thomsonia fairlightensis sp. nov.

Plate 64, figs. 10, 11, 13–16; Plate 67, fig. 14

Type sample. DB 51, Fairlight Glen, near Hastings (TQ 8523 1063) approximately 50 ft. above shore; Fairlight Clay d (White 1928, p. 22) Berriasian. Medium dark grey (N4) medium silt, frequent plant remains. Preparation MTO25; megaspores uncommon but several species present; *Thomsonia fairlightensis* is the most abundant.

Diagnosis. Megaspore, trilete. Mean maximum diameter of spore body (i.e. excluding equatorial outgrowths and sculpture) $224\ \mu$; standard deviation $26.5\ \mu$. Spore body more or less spherical if uncompressed. Total thickness of the two layered exine, $4\text{--}8\ \mu$; inner layer $1\text{--}2\ \mu$ thick; outer layer $3\text{--}6\ \mu$. Sculpture, a reticulum. The muri are widest (up to $7\ \mu$) at their bases and where they intersect (Pl. 64, fig. 8); between intersections they are up to $5\ \mu$ wide basally. They are tapered, rapidly becoming membranous, $11\ \mu$ in maximum height between connections, highest (up to $23\ \mu$) where they intersect, the nodes of the reticulum net being prolonged to form short simple appendages. On the proximal face, the appendages (capilli) rapidly increase in length near to and are considerably longer (up to $140\ \mu$) adjacent to the triradiate lips (Pl. 64, figs. 11, 13–15); they are simple or (occasionally) forked, straight or curved, rounded or flattened in cross-section and up to $25\ \mu$ broad. The lumina are rounded or (occasionally) rather irregular in shape, $3\text{--}34\ \mu$ in diameter. Regular pitting of the exine is also present; the pits are small ($0.25\text{--}0.75\ \mu$ in diameter) and up to $2\ \mu$ apart (Pl. 64, fig. 10).

The laesurae extend to the equator of the spore body and are bordered by irregular, considerably elevated, delicate, irregularly ribbed, fringe-like lips (Pl. 64, figs. 11, 13–16) $70\text{--}175\ \mu$ high and $3\text{--}6\ \mu$ in basal width. Capilli may be (partly) joined to them. They are pitted but the pits become holes towards their outer margin producing a network separating rounded or elongated vesicles up to $3\ \mu$ in diameter.

The equatorial outgrowths are small, structurally similar to the triradiate lips and often crumpled from folding. They are $84\text{--}143\ \mu$ in maximum length and $70\text{--}123\ \mu$ in maximum width. Narrow equatorial interradial (arcuate) ridges connect the radial outgrowths. These are occasionally extended to form a membranous zona (maximum

width interradially, 30 μ), structurally similar to the equatorial radial outgrowths and the triradiate lips. The outer margin is irregular, having a 'frayed' appearance.

Holotype. Slide preparation MT025/3, L1 51.4 118.4; plate 67, fig. 14.

Description. The observed limits of the maximum diameter of the spore body are 165–290 μ (coefficient of variation 11.8%). The pitting of the ectexine is a structural feature and not one of corrosion. The ectexine forms the triradiate lips, reticulum, capilli and equatorial outgrowths.

Preservation and compression. The specimens are well preserved. Only about 15% of the specimens are compressed proximo-distally, the remainder are compressed laterally or obliquely. Dehydration of a few specimens has led to the collapse of parts of the spore wall.

Distinction. Literature. Although descriptive details are lacking, it is apparent that *Thomsonia reticulata* Mädlar 1954 and *T. thoerenensis* Mädlar 1954 are larger and that the laesurae are bordered by appendages and not by extended lips. Other previously published species (except *Triletes phyllicus* Harris 1961 and *T. gryensis* Dijkstra 1959, see below) possess different sculpture and/or have triradiate lips of different form or differ in these and other ways.

Comparison

Local. Specimens assigned to cfA. *Thomsonia fairlightensis* have been recovered from other Fairlight Clay samples and from the Ashdown and Lower Tunbridge Wells sands. Some recovered from the Upper Tunbridge Wells Sands appear to be slightly different and have been recorded (MS) as cfB. *Thomsonia fairlightensis* for the present.

Literature. Type, figured, and other material of *Triletes phyllicus* described by Murray (1939) from the Upper Deltaic of Rutland has been examined and it is apparent that the species is distinct from *Thomsonia fairlightensis*. *T. phyllicus* has elevated lips which obscure the laesurae but they are rarely wavy from side to side; they are more like those bordering the laesurae of cfB. *Minerisporites marginatus* except that they are higher and the outer margin may be more deeply incised. The luminae are more irregular in shape and are larger; the equatorial outgrowths may be considerably larger; the exine is thicker (10–15 μ) and one layered; and specimens much larger than any specimens of *T. fairlightensis* have been recovered (see Murray 1939). *Triletes gryensis* Dijkstra is similar but lacks long capilli near the triradiate lips.

cfB. *Thomsonia pseudotenella* (Dijkstra 1951) Mädlar 1954

Plate 65, figs. 1–8; Plate 67, fig. 16

Sample. CUC 971, Cuckfield No. 1 Borehole (TQ 2961 2731), depth 971 ft.; Ashdown Sand, Valanginian. Light brownish grey (5 YR 6/1) massive, indurated, medium silt; general size of coarse fraction, 30 μ . Cuticle common but small wood fragments rare. Preparation MT294, megaspores moderately abundant, several species present; cfB. *Thomsonia pseudotenella*, 75% of the megaspores recovered; cfA. *T. fairlightensis* sp. nov. also present.

Description. The mean and observed limits of the maximum diameter of the spore body (i.e. excluding equatorial outgrowths and sculpture) of this trilete megaspore are 190 (268) 370 μ (standard deviation 36.7 μ , coefficient of variation 13.7%; 100 specimens).

The spore body is more or less spherical if uncompressed. The total thickness of the two-layered exine is 6–13 μ ; the inner layer is 1.5–2.5 μ thick and the outer layer is 4.5–11 μ thick. The surface of the outer layer of the spore body and the spines is pitted. The pits appear to be a structural rather than a corrosional feature. The sculpture consists of spines situated on both the proximal and distal surfaces (Pl. 65, figs. 5, 8). They are solid, rounded or irregular in cross-section, tapered, and irregularly grooved. They show elongated vesicles below and more rounded vesicles at their apices. Low ridges sometimes extend from their bases which may connect with each other forming muri but a reticulum is not developed. Except near the triradiate mark the spines on the corpus are up to 65 μ long (22 μ average), up to 14 μ in maximum (basal) diameter and usually c. 5–40 μ apart; they are shortest sub-equatorially on both proximal and distal faces. Near the triradiate mark they can be up to 150 μ long and 20 μ in maximum (basal) diameter (Pl. 65, fig. 2); these occasionally bifurcate towards their extremities.

The laesurae extend to the equator of the spore body and each ray is bordered by 12–16 long, usually flattened appendages. These may be connected at their bases, and sometimes along their entire length, by a membrane. They are 80–240 μ in length and up to 50 μ in basal diameter. The equatorial radial outgrowths (Pl. 67, fig. 16) are small (maximum length 60–160 μ , maximum width 60–105 μ), more or less rectangular or slightly tapered towards their apices. Connecting the radial outgrowths are interradial arcuate ridges. These are occasionally extended as flanges (forming a zona) up to 50 μ wide (Pl. 65, fig. 6). The outer margin of the flange is irregular.

Preservation and compression. The specimens recovered from this sample (see above) are generally well preserved. They are usually compressed laterally or asymmetrically laterally.

Distinction. Literature. *Triletes samarus* Dijkstra 1951 differs in the nature of the triradiate ridge and appendages and has larger equatorial radial outgrowths; *Thomsonia midas* (Dijkstra 1951) Mädlar 1954 and *T. divisa* (Dijkstra 1951) Mädlar 1954 have larger equatorial radial outgrowths and different sculpture; *T. granulata* Mädlar 1954 has a different sculpture; *Triletes datura* Harris 1961 has shorter triradiate appendages and the arcuate lamellae are strongly ribbed.

Comparison. Local literature. Dijkstra did not indicate the origin of the sample from which he described *Thomsonia pseudotenella*, although he implied that the description was based on observations of specimens from the Netherlands Wealden. He also noted that he had recovered specimens of the species from Kingsclere No. 1 Borehole samples, from depths 466–1,020 ft. I have examined twenty megaspores from a sample from depth 777 ft. (Valanginian; Hughes 1958) from this borehole. The characters of 17 of the 20 specimens are similar to those set down by Dijkstra. The other three specimens have, however, longer body-spines and in this respect they are similar to cfB. *T. pseudotenella*. On present evidence it appears that a separation of these otherwise similar spores can be made on the basis of body-spine length, but until more evidence can indicate whether or not the erection of a new species is justified the graded comparison prefix cfB has been retained for the Cuckfield (CUC 971) population.

Other assemblages containing cfB. *T. pseudotenella* have been extracted from the Fairlight Clay.

Turma ZONALES (Bennie and Kidston 1886) Potonié 1956
Infraturma ZONATI Potonié and Kremp 1954
Genus MINERISPORITIES Potonié 1956

Type species. *M. mirabilis* (Miner 1935, p. 618, pl. 23, fig. 1) Potonié 1956.

cfB. *M. marginatus* (Dijkstra 1951) Potonié 1956

Plate 65, figs. 9–20; Plate 66, figs. 1–4; Plate 67, figs. 11, 12

Sample and preparation. As for cfA. *Arcellites medusus* (Dijkstra 1951) Potter 1963.

Description. The mean and observed limits of the maximum diameter of the spore body (i.e. excluding the zona and sculpture) of this trilete megaspore are 187 (284) 386 μ (standard deviation 41.8 μ , coefficient of variation 14.7%; 100 specimens). Both the proximal and distal faces are convex if uncompressed. The lateral diameter is 185 (248) 294 μ (7 specimens). The amb is sub-circular to convexly triangular in equatorial outline. The total thickness of the two layered exine is 3.5–5 μ , the inner layer being 0.5–2 μ thick and the outer 2–4 μ thick. The outer layer is pitted (Pl. 66, fig. 1) and imperfectly reticulate (Pl. 65, fig. 19). The pits are a structural feature < 0.5–2 μ in diameter and up to 2 μ apart. The muri of the reticulum become thinner (membraneous) above their bases, are lowest near the triradiate mark and highest on the distal surface; their maximum basal width is 2.5 μ and their maximum height is 25 μ proximally and 35 μ distally, commonly being highest at their points of intersection although this is not always the case (Pl. 65, fig. 19). The lumina are rounded or irregular in shape and 4–35 μ in diameter.

The triradiate mark extends to the outer margin of the zona and is bordered by pitted elevated labra (10–70 μ high and 3.5–5 μ in basal width) which taper towards their extremities and are of irregular height. The pits in the lips become holes towards the outer margin producing a delicate lacework. The equatorial zona is pitted and structurally similar to the triradiate lips; the margin is usually lacey and irregular. The observed width of the zona interradially at the median point is 12 (30) 56 μ , and the maximum width radially ranges from 20 to 81 μ (mean 47 μ ; 98 specimens).

Preservation and compression. The zona is more membraneous and its margin more irregular on corroded specimens. Most specimens are flattened in polar or asymmetrical polar aspect. Dehydration of many specimens has led to the collapse of parts of the spore wall (usually the distal face; Pl. 67, fig. 12). The collapsed wall is often concave and pressed against the inner surface of the opposite, convex face. Separated parts of specimens which have split apart are common. The splitting has occurred along the triradiate mark, on the distal face just below the zona or, more rarely, on the proximal face just above the zona.

Distinction

Local. The size of the lumina and the muri of the reticulum, the size range (partly overlapping) of the triradiate lips and the equatorial zona and the different structure of the zona distinguishes this species from *M. alius* sp. nov.

Literature. *Triletes mirabilissimus* Dijkstra 1961 and *Minerisporites mirabilis* (Miner 1935) Potonié 1956, differ in shape and in the nature of the triradiate lips, *T.*

mirabilissimus is also larger; *Triletes harrisi* Murray 1939 is larger, lacks an equatorial zona and has a thicker exine; *M. institutus* Marcinkiewicz 1960 and *M. volucris* Marcinkiewicz 1960 have different types of sculpture, and zona; *M. venustus* Singh 1964 is differently sculptured; *M. macroreticulatus* Singh 1964 has larger lumina and higher triradiate lips.

Comparison

Local. Assemblages containing cfB. *M. marginatus* have been recovered from other Upper Tunbridge Wells Sand samples. A single spore mass adhering to a membrane was recovered from one of these (CUC 439).

Literature. Adequate comparison with *Minerisporites marginatus* (Dijkstra 1951) Potonié 1956 is not possible since Dijkstra did not give a sufficiently detailed description of the species; however, the assemblage described here is sufficiently similar that the erection of a new species is not considered justified at present. Dijkstra (1951) made no mention of having recovered his species from the English Wealden although specimens of *Minerisporites* are frequently recovered from Wealden material. *M. borealis* (Miner 1932) Potonié 1956 is also similar but not enough details were recorded by Miner to enable satisfactory comparison. *M. richardsoni* (Murray 1939) Potonié 1956 resembles cfB. *M. marginatus* but the triradiate lips and equatorial zona are ribbed and the sculpture is different.

Minerisporites alius sp. nov.

Plate 66, figs. 5–18; Plate 67, figs. 13, 17

Type sample. H 48 T, N. F. Hughes collection, near Pett Level, Hastings, Sussex (TQ 8872 1288), mid Ashdown Sand; ?Valanginian. Brownish-grey (5 YR 4/1) consolidated, poorly sorted silt, general size of coarse fraction 50 μ . Megaspores extremely abundant and well preserved; 99% are *M. alius* sp. nov.

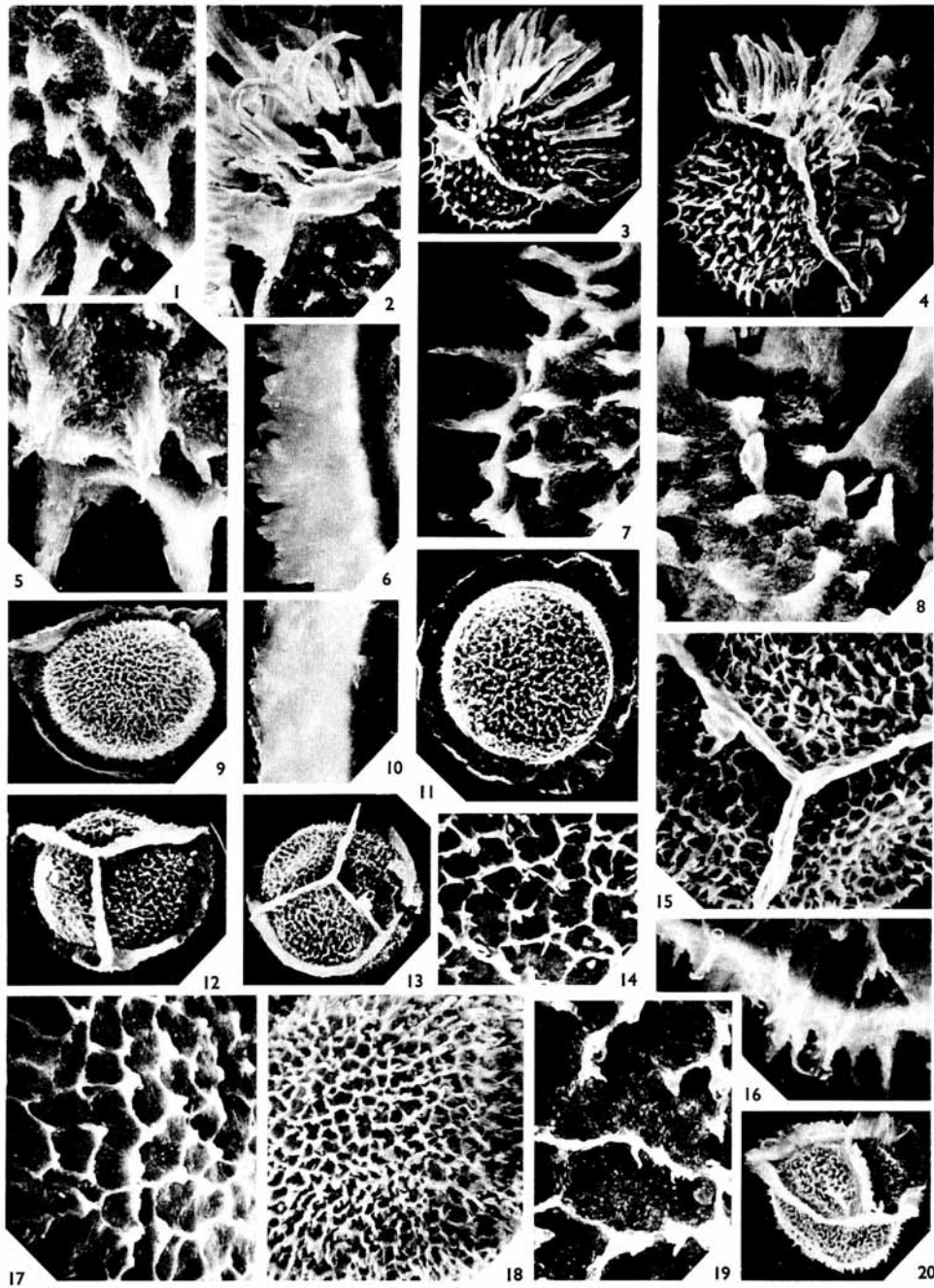
Diagnosis. Megaspore trilete. Mean maximum diameter of spore body (excluding zona and sculpture) 334 μ , standard deviation 32.9 μ (100 specimens). Mean maximum diameter of spore including zona (excluding sculpture) 413 μ , standard deviation 48.5 μ (100 specimens). Proximal and distal surfaces convex if uncompressed. Amb convexly

EXPLANATION OF PLATE 65

All scanning electron micrographs.

Figs. 1–8. cfB. *Thomsonia pseudotenella* (Dijkstra 1951) Mädlar 1954. 1, 2, 4, (SH)DB 11. 1, Distal sculpture; $\times 500$. 2, Spines increasing in length towards the triradiate mark; $\times 250$. 4, Asymmetrical aspect; $\times 100$. 3, 5, 7, Second specimen, (SH)DB 11. 3, Lateral view; $\times 100$. 5, Distal sculpture showing pitting; $\times 1,000$. 7, Distal sculpture; $\times 500$. 6, Equatorial interradial zona; $\times 500$, third specimen, (SH)DB 11. 8, Sculpture near triradiate mark including bases of large spines adjacent to the lips; $\times 500$, (SH)DB 9.

Figs. 9–20. cfB. *Minerisporites marginatus* (Dijkstra 1951) Potonié 1956. 9, 10, 18, (SH)DB 11. 9, Distal surface; $\times 100$. 10, Equatorial zona; $\times 1,000$. 18, Distal sculpture; $\times 250$. 11, Specimen with concave (collapsed) distal surface; $\times 100$, (SH)DB 12. 12, 17, Second specimen, (SH)DB 12. 12, Oblique view; $\times 100$. 17, Proximal sculpture; $\times 500$. 13, 15, Second specimen, (SH)DB 11. 13, Proximal polar view; $\times 100$. 15, $\times 250$. 14, Distal sculpture; $\times 500$, third specimen, (SH)DB 11. 16, 20, Fourth specimen, (SH)DB 11. 16, Distal sculpture; $\times 1,000$. 20, Specimen in lateral view; $\times 100$. 19, Distal sculpture; $\times 1,000$, third specimen, (SH)DB 12.



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triangular in equatorial outline. Total thickness of two layered exine, 3–7 μ ; inner layer 0.5–2 μ thick; outer layer pitted, 2–5.5 μ thick. Sculpture, usually an imperfect reticulum. The reticulum of the proximal face is smaller meshed than the distal (Pl. 66, fig. 18) and the muri near the triradiate mark are lower than on the remainder of the spore. The maximum width of the muri between their connections is 4 μ on the proximal face, and 7 μ distally. The muri are tapered, irregular in height, and are highest distally (maximum height, 17 μ on the proximal face and 55 μ on the distal face). The lumina on the proximal face are rounded, polygonal, or irregular in shape and 7–40 μ in diameter. On the distal face, the lumina are usually similar in shape although they may be rather more angular (Pl. 66, figs. 11, 14) and can be up to 80 μ in maximum diameter.

The triradiate mark extends to the outer margin of the zona and is bordered by elevated lips 3–6 μ thick at their base on each side of the laesurae, tapering to their extremities. The lips are pitted; the pits become fovea towards the outer margin producing a delicate lacework. The lip margins are usually irregular, commonly with flattened hair-like appendages or irregular elongations up to 80 μ long extending from them (Pl. 66, figs. 12, 13, 17; Pl. 67, fig. 17). The equatorial zona is scabrate, pitted, similar in nature to the triradiate lips (Pl. 66, figs. 6, 15). Hairs or elongations like those on the triradiate lips may extend from the outer margin. The range of the maximum width of the zona interradially at the median point is 30 (50) 79 μ (84 specimens) and radially is 40 (73) 126 μ (91 specimens).

Holotype. Slide preparation MT 391/2, Ll 41.3 111.3; pl. 67, fig. 13.

Description. The observed limits of the maximum diameter of the spore body are 245–406 μ (coefficient of variation 9.8%). The observed limits of the maximum diameter of the spore including the zona are 297–565 μ (coefficient of variation 11.8%). The pitting of the ectexine is a structural feature.

Preservation and compression. The muri are reduced in height, especially between connections, on corroded specimens. Specimens are usually compressed in polar or asymmetrical polar aspect. Dehydration of the spore has led to the collapse of parts of the spore wall of some specimens. Specimens with parted lips were not found although many of the fragments present have resulted from breakage along the laesurae as well as along the equator. A spore mass was recovered.

Distinction

Local. *M. alius* is distinguished from cf. *M. marginatus* chiefly by the different nature of the reticulum and the margin of the triradiate lips.

Literature. *Triletes mirabilissimus* Dijkstra 1961 and *Minerisporites mirabilis* (Miner 1935) Potonié 1956 differ in shape and in the nature of triradiate lips, *T. mirabilissimus* is also larger; *T. harrisi* Murray 1939 is larger, lacks an equatorial zona and has a thicker exine; *M. institutus* Marcinkiewicz 1960 and *M. volucris* Marcinkiewicz have different types of sculpture and zonas; *M. venustus* Singh 1964 has a different sculpture.

Comparison. Literature. *M. marginatus* (Dijkstra 1951) Potonié 1956 resembles *M. alius* but the equatorial zona is narrower, the reticulate sculpture poorly defined and the lumina smaller in diameter; *M. borealis* (Miner 1931) Potonié 1956 is similar but as

mentioned before, not enough details were recorded by Miner to enable accurate comparison; *M. richardsoni* (Murray 1939) Potonié 1956 is like *M. alius* but is somewhat larger and the sculpture is slightly different, the equatorial zone is generally narrower and the triradiate lips lower although the size ranges of these characters overlap; the proximal reticulum of *M. macroreticulatus* Singh 1964 is not reduced as in *M. alius* but in other respects the species is similar.

FEATURES OF WEALDEN MEGASPORES REVEALED OR CLARIFIED BY SCANNING ELECTRON MICROSCOPY

Since cfA. *A. medusus* has a very thick exine, optical examination of its surface is particularly difficult. The anastomosing rods of sporopollenin on the appendages and the spongy nature of the outer layer of the spore body are difficult to resolve optically, but they are clearly discernible in scanning micrographs (Pl. 62, figs. 7, 11; Pl. 63, fig. 1). These remarks also hold true for cfB. *A. medusus*. In both cases, the rings of thickening on the outer surface of the exine (Pl. 62, fig. 11; Pl. 63, fig. 8) are not resolved by light microscopy.

Micrographs elucidate the exact nature and configuration of the muri (Pl. 63, figs. 10, 12, 14, 15) and the structure of the triradiate appendages (Pl. 63, fig. 9) of *Thomsonia alata*. They established that the pitting of the exine is a structural feature rather than one of corrosion (Pl. 63, fig. 13). They show the surface sculpture of the spines of cfB. *Thomsonia pseudotenella* (Pl. 65, fig. 5) and the nature of the reticulum of *T. fairlightensis* (Pl. 64, fig. 10). The irregular form and configuration of the muri of cfB. *Minerisporites marginatus* (Pl. 65, figs. 14, 16–19) and *M. alius* (Pl. 66, figs. 8–11, 17) is clarified and the structure of the outer margin of the zona of these species is revealed (Pl. 65, fig. 10; Pl. 66, fig. 6).

POSSIBLE AFFINITIES AND ASSOCIATIONS OF THE MEGASPORES

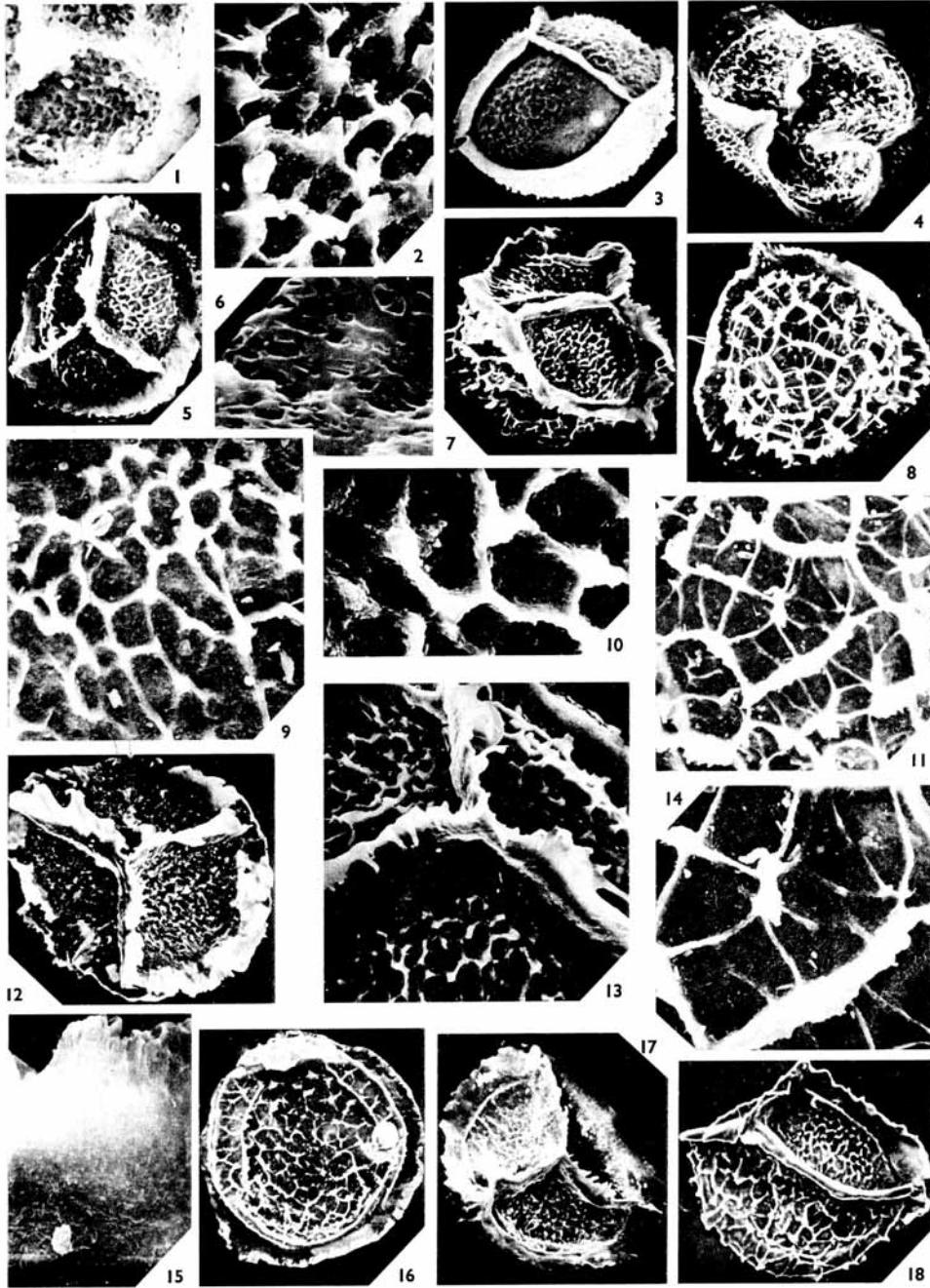
Hughes (1955) proposed an aquatic habitat for *Arcellites medusus* and morphologically similar spores. A relationship with the Hydropterideae (Marsiliaceae) was suggested by Dijkstra (1951) and supported by others. *A. medusus* may have been orientated neck-downwards when floating in water. This orientation was suggested by Ellis and Tschudy

EXPLANATION OF PLATE 66

All scanning electron micrographs.

Figs. 1–4. cfB. *Minerisporites marginatus* (Dijkstra 1951) Potonié 1956. 1, Distal sculpture, part of reticulum showing pitting; $\times 2,000$, (SH)DB 7. 2, Proximal sculpture; $\times 1,000$, (SH)DB 11. 3, Inflated; $\times 100$, second specimen, (SH)DB 11. 4, Collapsed (concave) proximal face; $\times 100$, third specimen, (SH)DB 11.

Figs. 5–18. *Minerisporites alius* sp. nov. 5, 6, 9, 13, (SH)DB 11. 5, Proximal face; $\times 100$. 6, Outer margin of zona; $\times 2,500$. 9, Proximal sculpture; $\times 500$. 13, Proximal sculpture and triradiate lips with hairs extending from them; $\times 250$. 7, 10, (SH)DB 10. 7, Lateral view; $\times 100$. 10, Proximal sculpture; $\times 1,000$. 8, 11, 14, Second specimen, (SH)DB 11. 8, Distal surface; $\times 100$. 11, Distal sculpture; $\times 250$. 14, Distal sculpture; $\times 500$. 12, Proximal polar view; $\times 100$, (SH)DB 2. 15, Part of zona; $\times 1,000$, second specimen, (SH)DB 10. 16, Concave (collapsed) distal surface; $\times 100$, third specimen, (SH)DB 10. 17, Slightly concave proximal surface; $\times 100$, (SH)DB 3. 18, Specimen compressed laterally; $\times 100$, (SH)DB 9.



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(1964) for *A. disciformis*, a morphologically similar spore. *A. medusus* may have been dispersed in masses (see cf. *A. medusus* description) or as isolated specimens. Since the specimens in the masses are not smaller or in any way different from isolated forms it is unlikely that they are immature. It is probable that their body appendages became interlocked in the sporangium so that when the sporangium dehisced they were not always separated. The function of the neck of *Arcellites medusus* is not definitely known but Ellis and Tschudy (1964) suggested that the neck of *A. disciformis* functioned in a similar way to that of modern *Marsilia*.

The spores described have not been found in tetrads but a spore mass of *Minerisporites alius* adhering to a cuticle membrane was recovered. Harris (1961) has pointed out that the occurrence of spores in this manner indicates that they were produced in large numbers in a cutinized sporangium as in *Lepidostrobus*. Hall (1963) suggested that *Minerisporites* may have been produced by either (an) offshore aquatic or near-shore terrestrial species of *Isoetes*.

Although the miospore/megaspore assemblage from which *Thomsonia fairlightensis* was described, is a diverse one, only specimens of elliptical ?monoete miospores have been found between their triradiate lips (in several topotype specimens). Unfortunately the structure and the convoluted nature of the lips obscures most of the spore exine detail. They appear to be monoete, elliptical in shape, 17–25 μ in maximum diameter and scabrate. The fact that other spore species are not found within the lips is significant in that it appears that they occurred there naturally and not by accident. They have not been recognized in the dispersed miospore preparation concerned; an explanation could be that the megaspores were transported subsequent to trapping the miospores. Jung (1958) and Dettmann (1961) have found similar although somewhat larger spores with thicker exines, in close association with species of *Nathorstisporites* Jung 1958 from the Early Mesozoic.

Monoete grains (of the type on Pl. 67, fig. 15) and fern spores are abundant in some of the palynological facies rich in megaspores; the monoete spores may constitute up to 90% of the miospores present and some significance can be attached to their presence in these assemblages since they are rarely recorded from other facies. It may be that their presence is due merely to the fact that the depositional environment was suitable for their preservation. On the other hand, it is possible that some of the megaspores and monoete grains were derived from the same parent plant or that the parent plants were ecologically related. Some species of megaspores have also been noted to occur together frequently.

DISTRIBUTION OF WEALDEN MEGASPORES

The presence of megaspores in Wealden sediments is probably due to water transport and it is assumed that most represent the presence of lycopods growing on the delta. Their spores could have dropped directly into an aquatic environment or could have been washed in along with other plant debris during times of heavy rain and flooding. Presumably many were transported over relatively short distances although their dispersal range must have partially depended on whether the spores were dispersed as isolated specimens or in masses, and whether they were adapted to floating. Forms like *Arcellites medusus*, probably produced by aquatic plants as mentioned earlier, may

have been commonly dispersed as entangled masses which could have floated for some time; the expanded extremities of the appendages of *A. medusus* probably functioned as air bladders thus assisting flotation. The flotation of other forms such as *Thomsonia alata* was probably assisted by their pronounced equatorial outgrowths. It is likely that the distribution of forms lacking prominent equatorial outgrowths or bladders probably depended to a greater extent on their weight. Some of the coarser silts and fine sands contain only a few large forms with thick exines, smaller lighter grains presumably having been transported further afield.

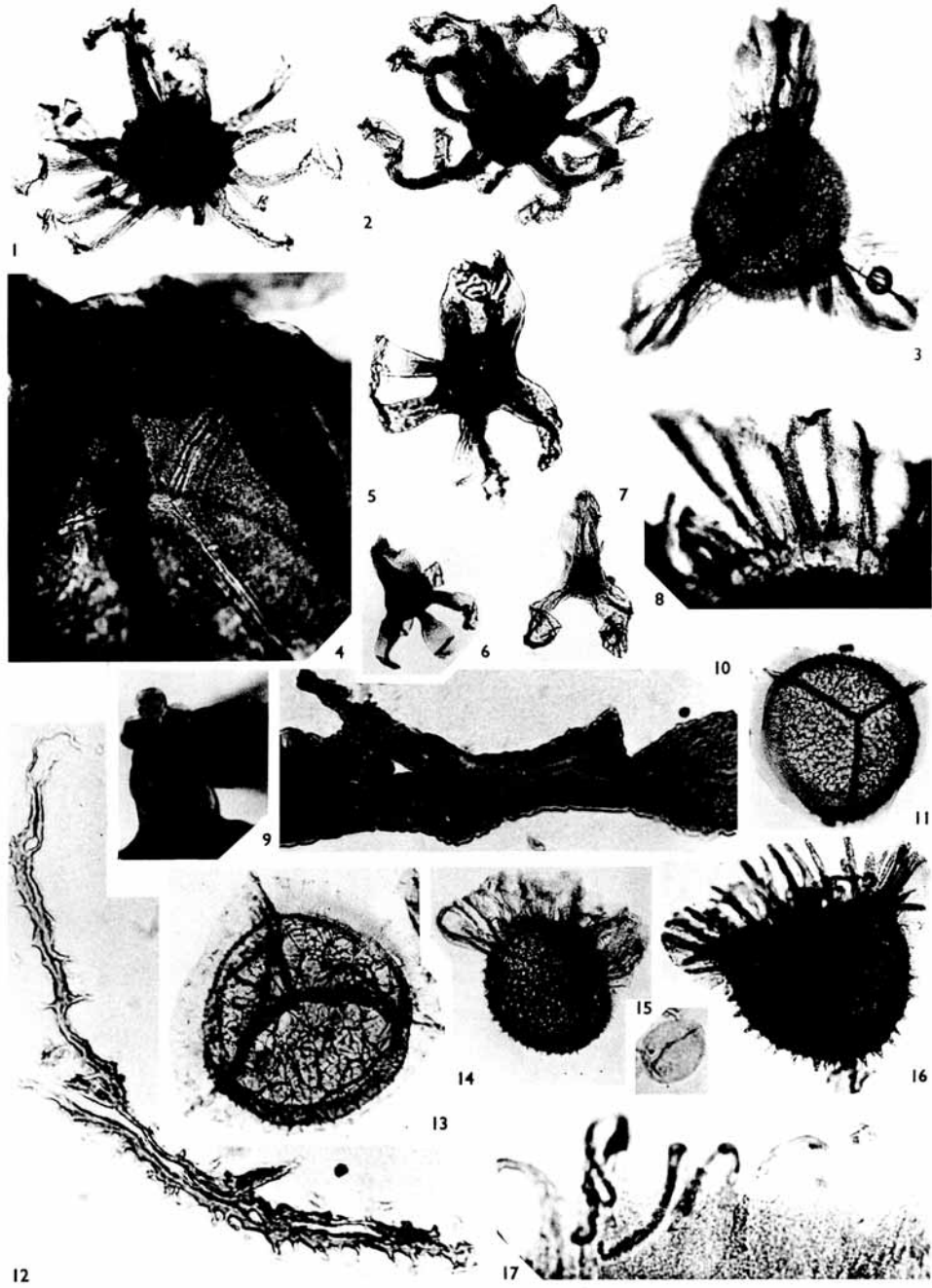
It is possible, with experience, to foretell with reasonable accuracy whether a Wealden rock sample will yield megaspores but predicting their (relative) abundance is more difficult. Pure sands contain few if any but an increase in the amount of finer material in a fine sand is usually accompanied by an increase in the numbers of megaspores. Poor sorting will also be accompanied by a larger number of megaspores since their chances of survival are improved (Dijkstra 1949).

Assemblages with an abundance of megaspores have been recovered from unaltered, unsorted, grey (N₄-N₇) or brownish grey (5 YR 4/1) non-calcareous silts which contain both sand and clay and relatively few small plant fragments. (If the plant fragments (wood and cuticle) are large and abundant, fewer megaspores are usually recovered (as noted by Hughes 1958) although several species may be present. There is therefore a direct relationship between the abundance of megaspores and the presence of plant debris.) Very small miospores (< 30 μ in maximum diameter) are common (3-30% of the miospore assemblage) or frequent (> 30%) in the miospore preparations, indicating a lack of current activity.

Most of the spores in this facies are probably of local origin, the parent plants having grown near, around and even in the body of water; few, if any, were transported from

EXPLANATION OF PLATE 67

- Figs. 1, 2, 4, 9, 10. cfA. *Arcellites medusus* (Dijkstra 1951) Potter 1963. 1, Oblique view, neck not clearly visible, swellings and ridges connecting bases of appendages, ×100; MT 395/8, L1 43·9 117·6. 2, Lateral view, neck prominent but partly obscured by appendages, spore body slightly compressed in polar aspect, ×100; MT 395/9, L1 34·3 114·7. 4, Triradiate mark at base of damaged neck, ×400; MT 395/9, L1 31·7 115·9. 9, Base of deformed but entire appendage, most of length out of focus, ×500; MT 395/9, L1 25·1 120·8. 10, Part of sectioned specimen showing two exine layers, base of neck and bases of some appendages, ×500; DBS/4A, L1 50·9 124·7.
- Figs. 3, 8. *Thomsonia alata* sp. nov. 3, Holotype, ×50; MT 395/14, L1 41·7 116·2. 8, Flattened appendages extending from triradiate lips connected by a 'lacey' membrane for most of their length, ×100; MT 395/10, L1 23·0 119·3.
- Figs. 5-7. cfB. *Arcellites medusus* (Dijkstra 1951) Potter 1963. 5, Lateral view, ×200; MT 395/8, L1 38·8 118·9. 6, Lateral view, ×100; MT 395/8, L1 42·9 119·3. 7, Lateral view, small (shrunken?) corpus, membranous appendages, ×100; MT 395/8, L1 42·2, 117·3.
- Figs. 11, 12. cfA. *Minerisporites marginatus* (Dijkstra 1951) Potonié 1956. 11, Polar view, ×100; MT 395/1, L1 33·9 128·2. 12, Section of specimen with collapsed distal wall, ×500; SDB/1B, L1 35·2 120·7.
- Figs. 13, 17. *Minerisporites alius* sp. nov. 13, Holotype, polar view, ×100; MT 391/2, L1 41·3 111·3. 17, 'Hairs' extending from the triradiate lips, ×500; MT 391/2, L1 54·0 111·3.
- Fig. 14. *Thomsonia fairlightensis* sp. nov. Holotype, lateral view ×100; MT 025/3, L1 51·4 118·4.
- Fig. 15. Monolete spore, ×500; T391/1, L1 31·3 121·3.
- Fig. 16. cfB. *Thomsonia pseudotenella* (Dijkstra 1951) Mädlér 1954, polar view; MT 294/1, L1 32·2 117·2; ×100.



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further afield. This suggestion is supported not only by the lithology and the composition of the palynological facies, but also by the fact that the spores are better preserved than usual, indicating that they have not been subjected to much transportation and oxidation. The deposition of sediment often appears to have been rapid (probably the result of flood downwash) since the wood fragments are disposed at all angles and there is no sign of bedding. The absence of water-worn fragments and the marked local dominance of certain species also indicates that the parent plants were near at hand. Presumably the deposition occurred in shallow fresh or oligohaline water. Possible environments of deposition are ponds and lakes into which flood waters and downwash brought coarse detritus; lagoons into which some of the water from a main river channel entered, rapidly dropping much of its suspended load; channels abandoned by a stream (channel-fills) and bar swalefill deposits. Apparently the depositional environments were unfavourable for the development of bottom life, perhaps because of a low oxygen content or because deposition took place too rapidly; the sediments are usually undisturbed, lacking in animal remains, burrows, rootlets, and other structures.

Megaspores also occur in many of the sorted medium- and coarse-grained silts, although seldom are they an important component, probably because the sorting has played a major part in their distribution. Sediments which accumulated in relatively high energy environments contain few if any but they are usually present and sometimes common in sediments that were deposited in lower energy environments, for example, laminated and cross-bedded (and sometimes bioturbated) fine sands and silts with silty clay partings. Pyrite may be present in these facies, some of the wood and cuticle being partly pyritized and some of the spore exines being damaged by corrosion. Mica is also a common constituent. Some assemblages show evidence of reworking; many or all of the spores have thinner exines than usual and torn specimens and fragments are common.

Many sediments, such as pure sand, as mentioned earlier, or clay are unlikely to produce megaspores. They are for instance noticeably less common in the more clayey formations of the Wealden, such as the Wadhurst. Calcareous sediments and those which contain shells (e.g. ostracods and bivalves) or much pyrite are usually barren.

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