

PROBABLE DISPERSED SPORES OF CRETACEOUS *EQUISETITES*

by D. J. BATTEN

ABSTRACT. Dispersed spores that are considered to be those of Cretaceous *Equisetites* have been recovered from Wadhurst Clay (?Valanginian) sediments of southern England. They are described as *Pilasporites allenii* sp. nov.

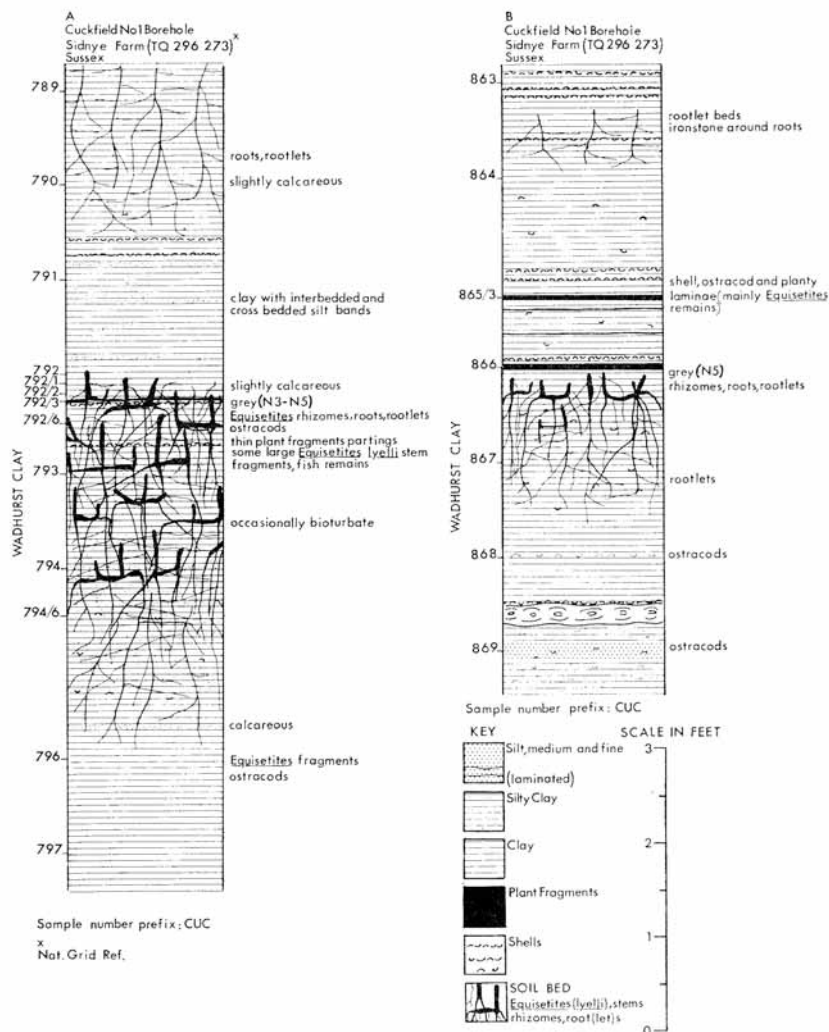
IN the course of a study of the palynology of British Wealden delta sediments, the plant microfossil content of *Equisetites* soil-beds (in which rootlets, rhizomes, and stems of *Equisetites*, in various combinations, are preserved in situ) and partings with aerial debris of *Equisetites* (Allen 1941, 1947, 1959, 1967) was examined in the hope that the spores of these plants, which have not previously been recognized in Wealden sediments, might be recovered.

Samples used in this study came from Wadhurst Clay horizons in the Cuckfield No. 1 Borehole (Stubblefield 1967) and exposures at the Railway Brickyard, Sharpthorne, and in the lower clay pit at Freshfield Lane Brickworks, Danehill (text-figs. 1, 2). The soil-bed at Freshfield Lane Brickworks was recorded by Gallois (Stubblefield 1963, p. 37) as being 'the High Brooms *E. lyelli* soil-bed, some 25 ft. below the top of the Wadhurst Clay'. Fourteen soil-bed and fragment parting samples yielded a characteristic palynological assemblage dominated (> 29.5%, based on a count of 200 specimens) by alete spores described herein from one of these assemblages as *Pilasporites allenii* sp. nov., and referred to elsewhere as cfA. *P. allenii* if not from the type assemblage, following the procedure recommended by Hughes and Moody-Stuart (1967b). Seventeen adjacent samples yielded assemblages in which these spores are frequent (> 4.5- < 30%).

Although recently some authors have been using the names of living genera for Mesozoic plants, I consider that the convention of using a different name for Mesozoic plants is a useful one and should be retained. Thus, the name *Equisetites* has been used here rather than *Equisetum*.

The apparent absence from the palynological record of spores of *Equisetites*, the common Wealden macrofossil, has in the past been variously attributed to lack of preservation, recognition, or production. The restriction of assemblages in which the inaperturate spores mentioned above are dominant, to *Equisetites* soil-beds and fragment partings, is considered to be evidence in favour of an association of these spores with *Equisetites*. Of the 350 preparations I have made from Wealden samples, and of the many preparations in the Sedgwick Museum palynology collection, only those prepared from samples associated with soil-beds and fragment partings have yielded these spores in abundance. They have rarely been recorded from other palynological facies. The relationship was tested after the association had been recognized from the Cuckfield and Sharpthorne assemblages. I decided to prepare a further series of samples collected from Danehill where

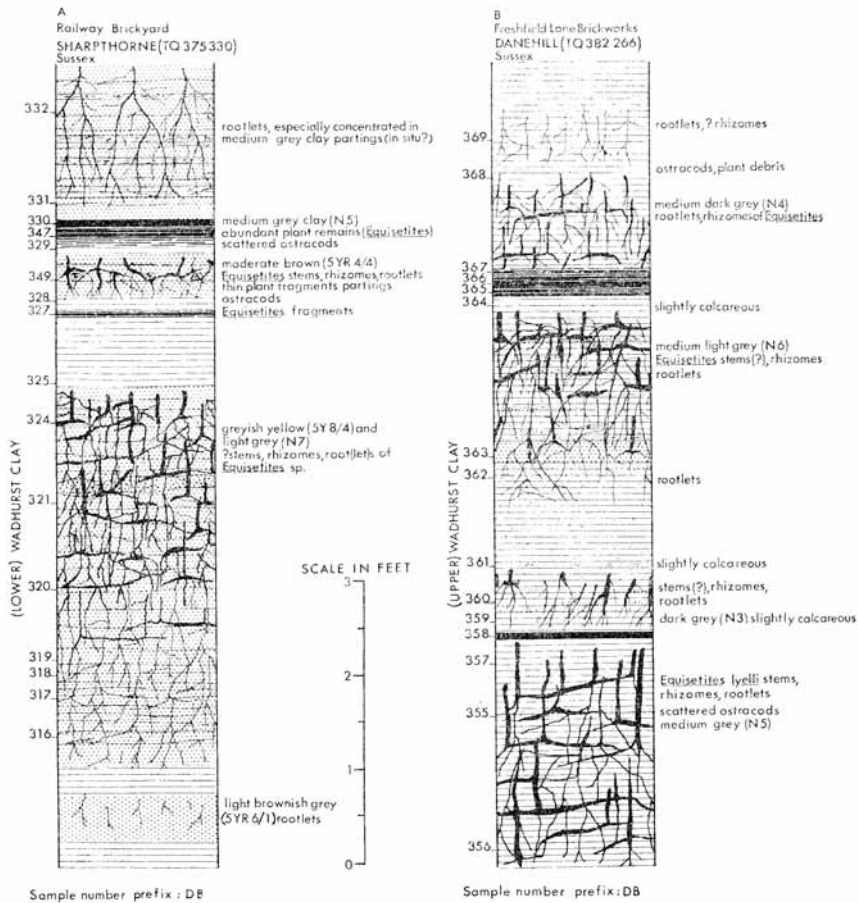
[Palaeontology, Vol. 11, Part 4, 1968, pp. 633-42, pl. 123.]



TEXT-FIG. 1. A and B, Wadhurst Clay sediment cores from Cuckfield No. 1 Borehole. Details of lithologies (diagrammatic, obtained in part from the Geological Survey log) and horizons from which samples have been prepared for microscopical examination. The colour classification (see also text-fig. 2) is from the *Rock-Color Chart* (1963) published by the Geological Society of America. Colours have generally been noted when there is a departure from the predominantly grey (N3-N7) colours of the Wadhurst sediments. For the sedimentary rock nomenclature, a modified Wentworth grade scale has been followed. In beds where rhizomes and stems have not been seen but rootlets are recorded, it is likely that the latter are those of *Equisetites*. The medium grey clays (sometimes shales) are generally interlaminated with paler, generally very thin (< 1 mm.) siltstones. The presence of shells and ostracods has only been noted when they are abundant.

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soil-beds and fragment partings had been observed in the field. The first samples processed were the fragment parting samples (DB 367, 366, 365, and 358) and I predicted that



TEXT-FIG. 2. A, Part of the (lower) Wadhurst Clay succession exposed at the Railway Brickyard, Sharpthorne, Sussex. B, (upper) The Wadhurst Clay succession exposed at Freshfield Lane Brickworks, Danehill. Details of lithologies (diagrammatic) and of horizons from which samples have been prepared for microscopical investigation. For 'Key' and other comments, see text-fig. 1.

they would yield assemblages in which cf. *P. allenii* is dominant (> 29.5%). The prediction proved to be correct. Several of the soil-bed samples were subsequently found to contain an abundance of these spores (see Table 1 and text-fig. 2B).

A Cuckfield BH

SAMPLE No (prefix CUC)	789	790	791	791/11	792	792/1	792/2	792/3	792/6	793	794	794/6	796	797
cf <i>A. P. allenii</i>	0	8	3	31	58	25	22	60	5	X	3	X	11	X
Other inaperturates	7	14	10	10	X	10	12	8	11	11	7	12	13	10
bisaccates	54	32	34	13	9	27	20	5	28	26	29	21	30	43
<i>Classopollis</i>	4	8	X	2	X	2	2	X	3	2	4	X	5	2
total 'fern' spores	28	45	46	31	23	31	35	20	45	55	51	60	25	24
<i>Cicatricosisporites</i>	X	15	14	4	5	7	9	6	12	18	17	16	X	2

B Cuckfield BH

SAMPLE No (prefix CUC)	863	864	865/3	866	867	868	869
cf <i>A. P. allenii</i>	2	28	60	67	5	X	X
Other inaperturates	7	8	7	10	8	7	8
bisaccates	49	15	12	8	29	28	41
<i>Classopollis</i>	10	2	3	2	X	3	11
total 'fern' spores	23	38	14	9	54	54	25
<i>Cicatricosisporites</i>	2	4	2	X	8	11	5

C Sharpthorne

SAMPLE No (prefix DB)	332	331	330	347	329	349	328	327	325	324	321	320	319	318	317	316
cf <i>A. P. allenii</i>			56	54	9	6	5	30		X		X	2	2		
Other inaperturates	2	4	4	9	6	6	X	7	10	12	16	10	14	X	5	12
bisaccates	25	30	16	16	27	21	43	20	41	40	25	49	24	35	40	26
<i>Classopollis</i>	40	35	5	X	32	3	25	18	16	10	18	20	30	10	25	40
total 'fern' spores	26	22	11	16	19	40	18	22	12	25	31	18	16	16	25	14
<i>Cicatricosisporites</i>	10	6	X	4	X	15	2	X	X	X	2	X	X	X	X	X

D Danehill

SAMPLE No (prefix DB)	369	368	367	366	365	364	363	362	361	360	359	358	357	355	356
cf <i>A. P. allenii</i>	11	13	35	38	64	6	6	2	6	36	46	60	6	5	1
Other inaperturates	11	20	17	10	13	14	11	12	8	6	11	12	8	7	7
bisaccates	38	34	20	24	6	41	28	24	36	24	24	8	24	30	36
<i>Classopollis</i>	3	4	3	7	X	4	X	4		X			2	1	2
total 'fern' spores	33	25	19	18	8	26	49	49	39	28	14	16	54	54	48
<i>Cicatricosisporites</i>	5	4	3	X	X	8	10	11	8	8	2	X	10	12	10

TABLE 1. Distribution of cf *A. Pilasporites allenii* and major spore and pollen groups in some of the samples studied (see text-figs. 1 and 2) recorded as percentages, based on counts of 200 specimens. A and B, Cuckfield No. 1 Borehole. C, Railway Brickyard, Sharpthorne. D, Freshfield Lane Brickworks, Danehill. X indicates presence, but 1% or less. The absolute bisaccate and fern spore counts are fairly constant (see Hughes and Moody-Stuart 1967a) and are only apparently reduced in numbers when cf *A. P. allenii* or *Classopollis* are abundant due to their non-dispersal. The sample numbers are as they appear in text-figs. 1 and 2, from the highest point to the lowest point in the successions and not in numerical order.

DISCUSSION OF THE OBSERVATIONS

Although spores of *A. P. allenii* are usually frequent in the soil-beds, some horizons lack an abundance of these spores (Table 1). This may be for several reasons. The spore species in most of the soil-bed assemblages are poorly preserved. The poor preservation is partially related to sediment type which probably in turn partly reflects the environment of deposition. Allen (1947) stated that the Wealden *Equisetites* plants probably grew in shallow waters, colonizing a specific locality for a short period of time, perhaps for as little as three or four years. If, like living *Equisetum*, they grew predominantly in aerated waters, many of their spores may thus have been deposited in an environment, at times unfavourable for preservation, in which they were largely destroyed. When and where conditions were more favourable for preservation, indicated by the generally better state of preservation of most of the spore species, cf *A. P. allenii* is found preserved in abundance. Winnowing and subsequent dispersal of these spores in the waters of the Wealden basin could account for a lack of abundance in some horizons, and so could a low rate of spore production, or seasonal production and/or a rapid sediment accumulation rate in the soil-bed localities. Since the *Equisetites* communities were probably relatively local and only existed for short periods of time, even if the plants dispersed large quantities of spores frequently, the total number produced would be small when compared with the number produced by the plants living on the near-by land. Thus if *Equisetites* spores were dispersed over a large part of the Wealden basin, the chances of obtaining an assemblage in which they constitute more than 5% of the total number of spores counted is slight. If the plants did not produce large numbers of spores, as is possible, the likelihood is even less. They have not been observed to be more susceptible to corrosion than other dispersed spores, and in fact, when abundant, they are generally better preserved than the majority of bisaccates and some of the 'fern' spores in the assemblage. The poor preservation of the latter forms may however be due to reworking.

Some movement in the water (Allen 1941, p. 371), perhaps the result of storm wave action, at times caused the destruction of the aerial stems of the *Equisetites* plants and subsequent deposition of the fragment beds and partings. The fragments are preserved as flattened carbonaceous remains as opposed to stems preserved 'in situ' in which the pith cavities have generally been filled with sediment forming pith casts. The cones (strobili) of living species of *Equisetum* rapidly fragment after spore dispersal. If *Equisetites* cones similarly decomposed, it is unlikely that a mature cone would have been preserved in Wealden sediments. Only when a cone was prevented from reaching maturity, for example if the supporting stem was broken or the entire plant became suddenly inundated with sediments, would preservation be possible. Although a strobilus has yet to be recognized, cf *A. P. allenii* spore masses are frequently found, especially in assemblages extracted from fragment partings, and are probably microscopic remains of strobili (sporangia) broken up prior to or at the time of deposition.

Elaters which characterize the spores of living *Equisetum* have not been seen surrounding cf *A. P. allenii* or separated from them in any of the assemblages. They may have been destroyed during the preparation procedure. However, unless their chemical make-up is such that they are readily destroyed by the chemicals used during preparation, or were removed from the spores at the time of deposition and rarely fossilized, they should

be present in the palynological preparations. It is possible that the Wealden *Equisetites* species concerned produced spores which lacked elaters.

Apart from some Eocene *Equisetum* spores (Chandler 1964), and *Elaterites triferens* Wilson 1943, a Pennsylvanian tri-radiate spore, no other fossil spore species recorded to date possess elaters. They were not found surrounding the spores described from *Equisetites* compressions by Halle (1908), Hartung (1933), or Gould (1968).

Specimens recorded were all those present along selected traverses of strew slides. 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 ALETES Ibrahim 1933
 Subturma AZONALETES (Luber 1935) Potonié and Kremp 1954
 Genus PILASPORITES Balme and Hennelly 1956

Type species. *Pilasporites calculus* Balme and Hennelly 1956, p. 64, pl. 3, figs. 60-4.

Remarks. Several genera have been erected for inaperturate miospores but their diagnoses are not distinct. I consider that it is not practical or helpful to attempt to distinguish this new spore from all published inaperturates of all ages; it is however, desirable and necessary to group it with and distinguish it from other Mesozoic inaperturates. *Pilasporites*, the late Palaeozoic (Permian) genus has therefore been selected instead of a Tertiary-based name. The alternative solution of erecting a new genus has been rejected because the primary purpose of this paper is to present an accurate account of the new species, rather than to classify it.

Pilasporites allenii sp. nov.

Plate 123, figs. 1-4, 6, 10-14

Type sample. CUC 792, Cuckfield No. 1 Borehole, Sidnye Farm, Surrey, England (TQ 296 273) from depth 792 ft. Wadhurst Clay, ?Valanginian. Medium dark grey (N4) clay, size of coarse fraction 25 μ ;

EXPLANATION OF PLATE 123

Figs. 1-4, 6, 10-14. *Pilasporites allenii* sp. nov.; spores from rock sample CUC 792, preparation T 210, $\times 1,000$. 1, Loose ?ektexine, dark area; T 210/10, L1 33.3 124.8. 2, Smooth form; T 210/1, L1 32.0 118.0. 3, Scabrate exine, development of major fold; T 210/5, L1 49.7 120.1. 4, Scabrate exine; T 210/1, L1 34.1 116.1. 6, More or less smooth exine, scabrate perine; T 210/1, L1 42.0 116.2. 10, Smooth exine, smooth crinkled perine; T 210/1, L1 34.7 117.1. 11, Smooth exine, closely adhering perine with granules and small verrucate elements attached to the perine; T 210/10, L1 29.0 123.4. 12, Dark area, scabrate, secondary folds developed around dark area; T 210/14, L1 55.0 126.8. 13, Split form; T 210/2, L1 30.8 123.3. 14, Split form; T 210/1 43.5 116.0.

Figs. 5, 7, 8, 9, 15, cf *A. Pilasporites allenii* sp. nov.; spores from rock sample CUC 792/3, preparation T 244, $\times 1,000$. 5, Showing dark area, only faintly visible; T 244/4, L1 27.7 118.1. 7, Major fold, loosened ?ektexine; T 244/4, L1 51.6 125.2. 8, Scabrate exine, major fold; T 244/4, L1 58.0 116.0. 9, Smooth exine, dark area, closely adhering smooth, crinkled perine; T 244/4, L1 28.1 116.0. 15, Scabrate exine, loose ?ektexine; T 244/4, L1 31.9 121.0.

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thin fine silt laminations; *Equisetites* 'in situ' and fragments of the same. Preparation: oxidation 10 minutes Schulze solution, 3 minutes 5% ammonium hydroxide, mineral separation using zinc bromide; short centrifuging: strew slides, Clearcol and Euparal. Palynological facies: *Pilasporites allenii* well preserved, the bisaccates and some of the 'fern' spores less well preserved: 58% *P. allenii*, 23% total 'fern' spores of which 7% are *Ischyosporites* and 5% *Cicatricosisporites*, 9% bisaccates (based on a count of 200 specimens).

Diagnosis. Miospores, alete, mean diameter 36.7μ , standard deviation 5.36μ (200 specimens), amb circular. Exine $1.25-1.75 \mu$ thick, smooth, or scabrate. Frequently only one (major) fold present, usually developed close to and sub-parallel to the margin of the spore. Spores sometimes split (7% of the specimens), may be surrounded by a crinkled and folded perine *c.* 0.25μ thick. Perine smooth or scabrate. An indistinct darker coloured area is seen on 4.5% of the specimens, averaging 14μ in diameter.

Holotype. Slide preparation T 210/1, L1 42-0 116-2; Plate 123, fig. 6.

Description. Maximum diameter, observed limits $28-48 \mu$; coefficient of variation 14.6%. 94.5% of specimens fall between 31 and 44μ (text-fig. 3). Shape may be distorted by folding (Pl. 123, fig. 7), 2% of spores unfolded. Exine thickness not always readily measured owing to difficulty in obtaining an optical section. The outer layer of the exine (?ektexine) which carries the sculpture, may be loosened (brought about by oxidation) and simulate a closely adhering perine. No elaters seen. The darker area may result from a thickening of the exine. Usually these spores show folds developed only around and not across the area (Pl. 123, fig. 12).

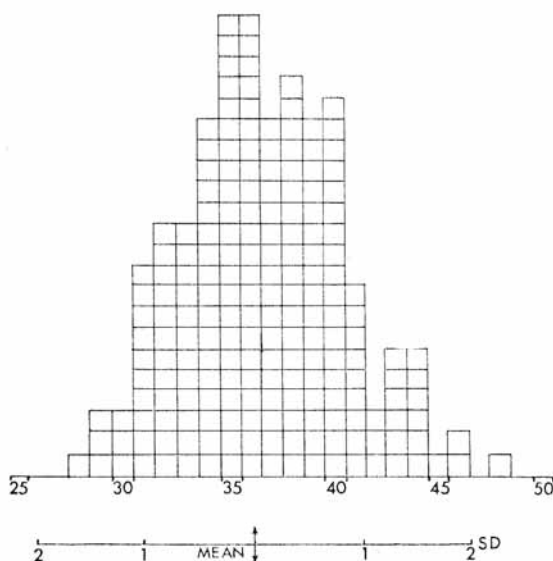
Preservation and compression. Preservation good. Spores occasionally unfolded but folds usually developed as mentioned above, probably resulting from the dehydration of the spore leading to the collapse of the spore wall in the subsequent compression. Spores very compressed.

Probable affinity. *Equisetites lyelli* (and ? other species of Cretaceous *Equisetites*).

Similarity of recent Equisetum spores. Observed acetolysed spores of 11 of some 25 living species of *Equisetum* (*E. hiemale*, *E. fluviale*, *E. pratense*, *E. moorei*, *E. sylvaticum*, *E. arvense*, *E. telmateia*, *E. variegatum*, *E. scirpoides*, *E. palustre*, *E. ramosissimum*) lack a tri-radiate mark, and frequently lack elaters which separate from the spores during acetolysis. They are apparently smooth or scabrate spherical grains mainly $30-50 \mu$ in diameter, surrounded by a sometimes scabrate folded perine. Specimens of some species show a tendency to split. Histograms of the diameters of spores of an individual species are unimodal, with a small standard deviation. Hauke (1963) states that in any one strobilus the size range of the spores is small, but strobili of different specimens of the same species may vary considerably perhaps representing differences in the age of the cones from which they come. Abortive spores also increase the size range obtained from an individual strobilus. Acetolysed specimens are frequently folded. Often only one major fold present (prep. TR002, *Equisetum telmateia*).

Distinction. Local: Couper (1958) erected the genus *Perinopollenites* for monoporate perinaceous grains, the presence of a pore being a diagnostic character although not

necessarily seen on all grains. The presence of the pore and a consistently firmly attached perine distinguishes this genus and its contained species from *Pilasporites allenii*. *Calamospora mesozoica* Couper 1958, a spore that is rarely definitely recognized in Mesozoic sediments, is distinct in possessing, by definition, a small tri-radiate mark similar to the dispersed spores of Palaeozoic *Calamospora*. *Spheripollenites scabratus* Couper 1958, differs from *P. allenii* in having a poorly defined pore, an internally scabrate exine, and in being smaller. *Exesipollenites tumulus* Balme 1957 possesses a circular depression surrounded by an area of exinal thickening.



TEXT-FIG. 3. Frequency distribution histogram of maximum diameters in microns of *Pilasporites allenii* sp. nov. Preparation T 210, 200 specimens, mean 36.7μ , standard deviation 5.36μ , coefficient of variation 14.6%.

Literature: Satisfactory comparisons are frequently difficult or impossible due to the inadequate descriptions and illustrations of the types. *Laevigatasporites maximus* Delcourt and Sprumont 1955, and the Tertiary species *L. intrapunctatus* Kedves 1961, differ from *P. allenii* in being much larger. *L. reissingeri*, a Tertiary species which Kedves (1961) refers to the 'Equisetaceae cf. *Equisetum*', is larger and has a thicker 'exospore'. *I. dubius* Pflug and Thomson 1953 has a thinner exine than *P. allenii*; *I. limbatus* Balme 1957, is larger, has a thinner exine, and possesses a dark peripheral band; *Araucariacites australis* Cookson 1947 is larger and has a different sculpture; *Pilasporites calculus* (Balme and Hennelly 1956, p. 64) has a differentially thickened exine; *Pilasporites plurigens* Balme and Hennelly 1956 is smaller; *Aulisporites* (Leschik) Klaus 1960, possesses an occasionally observable, faintly developed tri-radiate mark.

Comparison. Local: Similar spores from other samples or localities are attributed as suggested by Hughes and Moody-Stuart (1967*b*, p. 353).

cfA. *P. allenii* sp. nov.

1. Cuckfield No 1 Borehole, (TQ 296 273), depth 792 ft. 3 in., Wadhurst Clay, general size of coarse fraction of sediment 50 μ , *Equisetites* sp. soil-bed, *Equisetites* fragments; sample CUC 792/3, prep. T 244/4, preservation good, *Pilasporites* dominant. Maximum diameter 28 (35.5) 45 μ (200 specimens).

2. Cuckfield No 1 Borehole, depth 866 ft., Wadhurst Clay, general size of coarse fraction 8 μ , *Equisetites* sp. fragment parting; sample CUC 866, prep. T 269/2, preservation good, *Pilasporites* dominant. Maximum diameter 28 (36.8) 47 μ (50 specimens).

3. Sharpthorne, Sussex (TQ 375 330), (lower) Wadhurst Clay, general size of coarse fraction 50 μ , *Equisetites* sp. fragment parting; sample DB 330, prep. T 189/1, preservation moderately good, some pyrite and other corrosion, *Pilasporites* dominant. Maximum diameter 27 (35.8) 46 μ (75 specimens).

Literature: Reissinger (1950), Couper (1953), and Rogalska (1954) described and/or illustrated spores from Jurassic sediments which resemble *P. allenii*, and which they referred to the Equisetaceae (?*Equisetum*). *P. allenii* is also similar to *Pilasporites marcidus* Balme 1957, an Australian Cretaceous species, and to *Equisetosporites hallei*, the species that Nilsson (1958) erected for dispersed spores which he thought were similar if not identical to those produced by *Equisetites* (*Equisetostachys*) *suecicus* (Nath.) Halle 1908. Some of the specimens of supposed *Perinopollenites elatoides* grains which Danzè-Corsin and Laveine illustrate (in Briche *et al.* 1963, pl. 8, figs. 4-6) lack a pore and resemble *P. allenii*. Gould (1968) has described some remarkably similar spores from a cone of *Equisetum laterale* Phillips 1829 recovered from the Marburg Sandstone (Jurassic) of Australia.

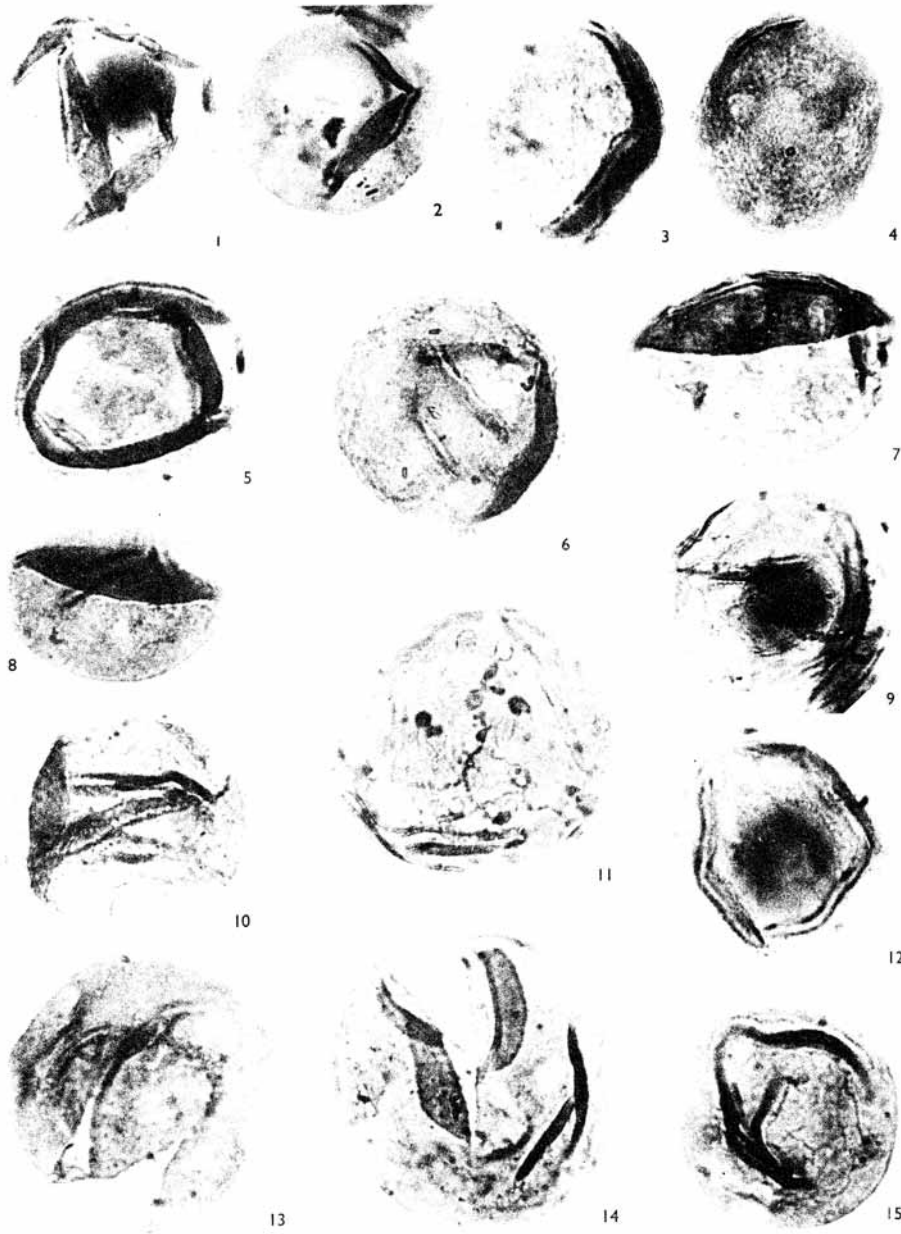
Acknowledgements. This paper was prepared in the Department of Geology, Cambridge University with the help of a N.E.R.C. studentship. Material from the Cuckfield No. 1 Borehole of the Geological Survey and access to the log was made available to Mr. N. F. Hughes by Dr. R. G. Thurrell. I thank Mr. J. G. Duckett of the Cambridge University Botany School for information. I am indebted to Mr. N. F. Hughes for discussion and critical reading of the manuscript.

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BATTEN, Lower Cretaceous dispersed spores