A METHOD OF STRATIGRAPHIC CORRELATION USING EARLY CRETACEOUS MIOSPORES

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ABSTRACT. Spores of the *Cicatricosisporites* group are used in correlation between the outcrop Hastings Beds and the Lower Wealden of the Warlingham Borehole, Surrey. Published species are not used, and the fossils selected are described instead in terms of *biorecords* and *events*, both of which terms are defined. There is a brief discussion of the relationship of these biorecords to published taxa. The method of use of the fossils is chosen to favour (*a*) correlation on a fine scale, (*b*) easy inclusion of extensions of the observations to refine the correlations, and (*c*) storage and retrieval of essential data as free as possible from points of interpretation, which should be separately labelled and stored. The material is presented in slightly extended form so that the method itself may be criticized and improved. Some of the specific difficulties of handling *Cicatricosisporites* spores are illustrated and discussed.

BY far the most numerous fossils in the Lower Wealden rocks of southern England are dispersed miospores, and we believe that there has been a failure hitherto to use them, or other spores of similar age, successfully in any fine stratigraphic correlations (see Hughes 1958, and several other authors). Spores have served to define fairly large time divisions on the scale of an 'Age (Stage)', but this does not represent an improvement on stratigraphy using any other type of (less common) fossil. It had become apparent to us that much additional work was not yielding results in terms of stratigraphic refinement, and we now believe that this was due to a failure of method rather than to any lack of evolutionary manifestation in these plant-organ fossils. We have suggested a new approach (Hughes and Moody-Stuart 1967*b*) and we attempt here to develop it further. As we have found it necessary to reject certain current practices as unprofitable, we wish to avoid misunderstanding by stating briefly the reasons for this action, in a list of points numbered for reference in discussion:

1. In accepting the stratigraphic approach implicit on the report of the Geological Society of London's Stratigraphical Code Subcommittee (George *et al.* 1967), and developments from it (Hughes, Williams, Cutbill, and Harland 1967, 1968), we see *reference-points* as the first essential for both precision and unambiguous communication.

2. An *event* (stratigraphic) is an item of geologic information relatable (or potentially so) to the general evolutionary state of the earth, and based in a rock sample or in a general attribute (to include metamorphism, etc.) of some named rocks.

3. The identification of events is artificial and arbitrary, being dependent mainly on the accidents of collection. In stratigraphy of sedimentary sequences, an event is any character raised from a rock sample that is as closely located as possible. The borehole samples used in this paper are mainly located to 1 ft. in depth, which seems more than adequate at present but may not be so in twenty years time. The average stratigraphic spacing of events concerned with fossil information should be at most one-quarter (de Jekhowsky 1958) and probably one-tenth of the general size of scale division that is sought.

4. Stratigraphic *correlation* of a newly described 'event' (in a 'new' section), with a standard (already described) reference scale of 'events', consists of a *pair* of decisions.

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Each of the two similar decisions is: whether the newly described event represents a time before or after a selected reference scale event. The 'bracket' so obtained may be fine or coarse but is always theoretically capable of refinement, given new observations or interpretations. The correlation of whole rock sequences, however elaborately expressed, consists essentially of these primary paired decisions.

5. Events cannot be equated in time, but only ordered. The purely mental process of grouping events into some kinds of biostratigraphic zones, usually to achieve equation between sequences, is equivalent to the employment of a blunt instrument in correlation that cannot be operated successfully within the limits of the size range of its bluntness.

6. Stratigraphic zones are unacceptable to us as tools because (*a*) they cannot as abstractions be closely enough defined, and (*b*) they are based on the idea of equation in stratigraphy which is either too crude or is even wrong in concept. Excluded from this criticism is the chron (George *et al.* 1967) which is simply a rock-defined minor time division in a standard reference section.

THE PALAEONTOLOGIC PROBLEM

7. In predominantly non-marine strata such as the English Wealden, the frequently occurring fossiliferous palynologic samples may well contain assemblages with species from 25 distinct miospore 'genera'. These species have been erected and expanded by many authors on purely morphographic principles, usually with a reconnaissance description in mind; as a result they tend to have relatively long ranges. They have proved difficult to 'split' further on purely morphographic grounds, and because of general palaeontologic tradition against the practice there has been a reluctance to add any explicit stratigraphic limits to the diagnoses of the 'splits'.

8. In studying other comparable palynologic problems for possible solutions, it is difficult to assess the unpublished achievements in oil exploration. The successful German technique used in the study of Tertiary Brown Coal is more akin to Pleistocene work in its limited geographic and stratigraphic scale. Most of the many papers on the West European Carboniferous do not appear to aim at or to achieve fine stratigraphy; particularly interesting in this respect is the major work of Smith and Butterworth (1967) which, however, is unusual in being restricted to the one facies group of the coals, and also unusual in providing so much well-presented basic data, clear of its interpretation. Although much palynology is still in the reconnaissance phase of development, we have not found any solution from study of work that is already further advanced.

9. There is clearly a temptation to abandon any accepted species concept (cf. Shaw 1964, p. 220) as being too 'blunt' (see para. 5 above), and to attempt some total description of the sample assemblage that could be compared with others by machine methods. Although such description would be difficult to accomplish even on a 'module' basis without detailed preliminary interpretation, the main factors that appear to rule it out for the present are palynologic facies (see Hughes and Moody-Stuart 1967*a*) and variable preservation of miospores. The mere numbers of fossils available will eventually make machine handling of data essential, but understanding, particularly of the chemical aspects of preservation, is in our opinion insufficiently advanced to make this at all profitable.

10. Behind such considerations is the usual economic problem in biologic descriptions. Whatever observations are made in erecting a scheme, and whatever further work is

necessary to make use of it, must not involve more skilled or semi-skilled man-hours than the information is judged to be worth now or in the immediate future.

PROPOSED METHOD

11. Since variation in land-life forms, at least since the Devonian period, is assumed to have been discontinuous on the same basis as for observed recognition of extant species, it seems wiser to use this assumption rather than to ignore it (as implied in para. 9 above).

12. As a preliminary, then, to consideration of events for correlation, we intend to make in each appropriate miospore group (taken to mean approximately the current miospore genus) a set of fully documented '*biorecords*', primarily for local use in our standard stratigraphic succession (regional standard in the sense of George *et al.* 1967), which will be the Warlingham Borehole. These will approximate to species as currently used but will be outside the Rules of Nomenclature; they will instead be subject to special rules that we devised for species (Hughes and Moody-Stuart 1967*b*, pp. 348–9) but here applied to biorecords, in that they can only ever be modified (emended) by use of topotype material.

13. A *biorecord* is defined as a conceptual taxon, based on specimens from one sample or locality that are judged to have a normal distribution of continuous variation. A palynologic biorecord has a basis in not less than 100 topotype specimens. Should a biorecord prove unsatisfactory in use, it can be replaced without formality by another from the same or another sample; it can also overlap the variation of another to any degree. There is no question of priority, only one of use or discard; each biorecord bears a unique author's serial number.

14. We present here biorecords for all the kinds of *Cicatricosisporites* that we have seen in the Lower part of the Wealden of the Warlingham No. 1 Borehole (Surrey, England) from 2,040 to 1,740 ft. depth. Work on the Upper part of the Wealden, and studies on other genera such as *Aequitriradites*, *Trilobosporites*, etc., are not yet complete.

15. The events used in this paper are thus composed solely of information on *Cicatricosisporites* miospores. The occurrence of these spores in each event sample is expressed as percentages of types that are judged by eye and by measurement as distinct, and are recorded (using measurements) by graded comparisons (see Hughes and Moody-Stuart 1967*b*, p. 353) with the appropriate biorecord.

16. Events, with some additional biorecord material, based on samples from the coastal outcrop of the Fairlight Clay near Hastings are correlated with those of the borehole regional standard. Correlation with a main marine standard succession is not attempted in this paper.

17. An attempt has been made to ensure that all data generated here can be assessed and stored without further attention from a palynologist. Both these arrangements and the general method are described more fully than would normally be necessary in the hope that the principles may be discussed.

18. Although it is only partly relevant to our stratigraphic purpose, we believe that for dispersed spores our biorecord (based on topotype material only) gives a much better opportunity than does any orthodox fossil species of an approach to the spores actually produced by a once-living plant population. From our studies so far we are strongly of

the opinion that land plant evolution will, with the help of palynology, soon be demonstrable in quite fine detail; the old view that land plants evolved slowly was largely due to the obscuring effect of unthinking adherence by palaeontologists to a Linnéan system of nomenclature that had been devised and developed for living organisms with verifiable genetic limits.

ESTABLISHMENT OF A BIORECORD

The biorecord is not in essence different from a palaeontologic species at the stage of description by its originator, but differs in the use that can subsequently be made of it. The process of selection of suitable material presents the same difficulties as with species, but almost no literature search is obligatory, and no awkward description priorities need be considered. In the current case, the sequence of work appears to be:

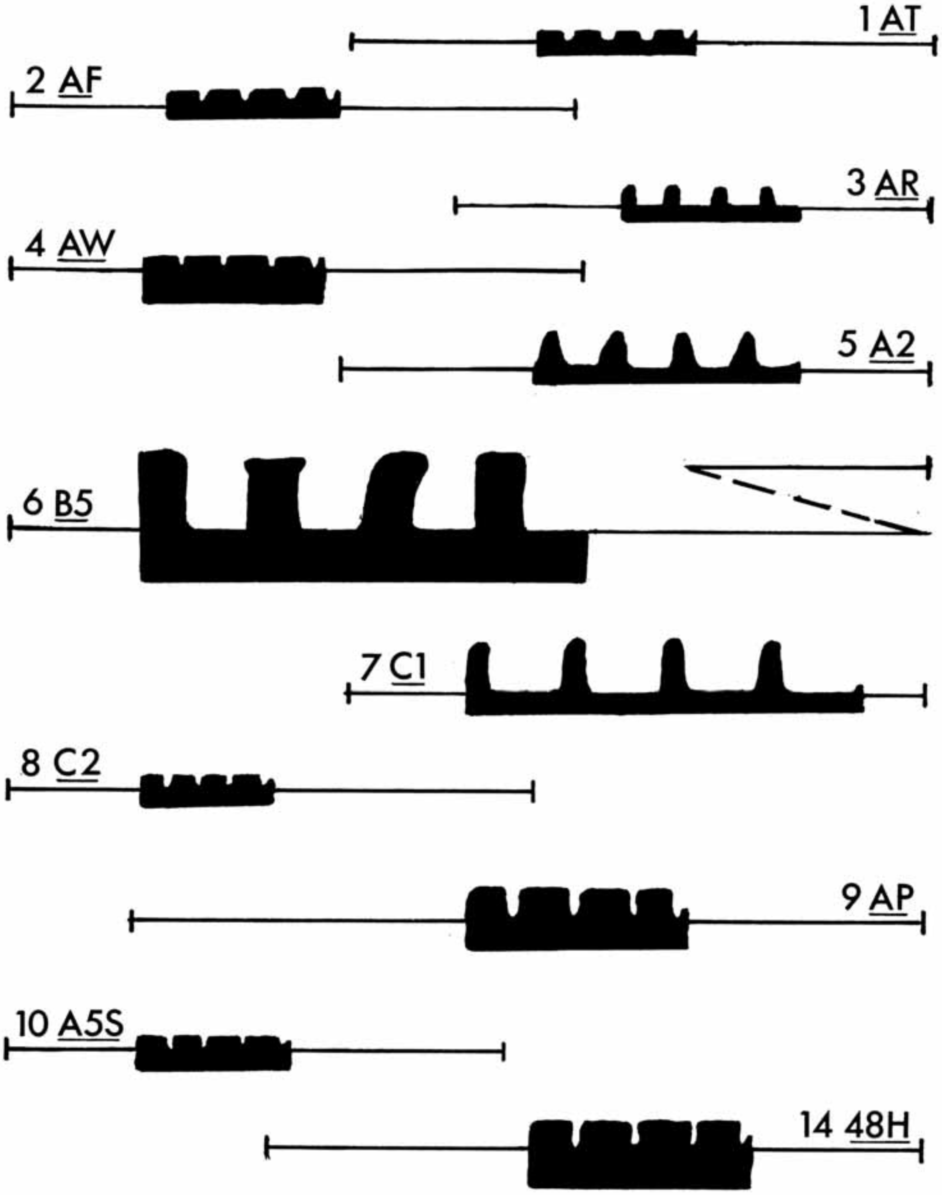
1. Reconnaissance of as many samples of the standard sequence as possible to select suitable samples for biorecords satisfying the following requirements: (*a*) adequate preservation; (*b*) adequate ease of obtaining 100 specimens; (*c*) facies that is unlikely to have modified significantly the part of the assemblage concerned, i.e. to have removed part of the size variation; (*d*) as early as possible in the stratigraphic 'range' of the form concerned; (*e*) useful biorecord, i.e. spore type seen elsewhere. The difficulty is to achieve these aims safely without too great an expenditure of time.

2. Using the selected sample, record the slide position of each specimen of *Cicatricosisporites* and record its major character as follows:
   - (*a*) Well-preserved specimens of selected type, i.e. unambiguous specimens of biorecord.
   - (*b*) Extreme specimens of biorecord, well preserved.
   - (*c*) Possible extreme specimens, poorly preserved.
   - (*d*) Unambiguous specimens of other types.
   - (*e*) Well-preserved specimens that could be extremes of two or more types present.
   - (*f*) Rare specimens that could belong to the biorecord or to any other type present. These may be aberrants, e.g. monolete, aborted, etc., or even specimens of otherwise unrepresented 'species'.

3. Make detailed measurements and analysis of first unselected 100 specimens from categories 2 (*a*), (*b*), and (*c*), and test for homogeneity in the chief characters.

BIORECORDS CRET 26 23 GB SPOR

The following biorecords are set out with sample data and diagnosis in normal type and intended for data storage; description, preservation, and distinction, etc., which are in small type (not for storage), are items that are usually given for species and are possibly helpful to other workers, but in theory if the stored data has been perfectly prepared they should not be necessary. The title heading and reference line for a biorecord (e.g. 1 CICATR *AT*) consists of (*a*) a serial number which outside this paper would be preceded by an identifier such as author initials, (*b*) an informal (but stored) classification guide, and (*c*) an author's working reference printed in italics to indicate that it is a 'non-search' item. Holotypes are not mentioned in the text because they are not necessary, but in case they are required later they are marked as designated specimens in the relevant plate explanations.



TEXT-FIG. 1. Diagram of the character 'four adjacent muri and lumina' for each of the biorecord spores, $\times 2{,}000$. The line in each case represents the mean diameter of the spore to the same scale.

The heading of this section is in the form of a suggestion for data handling and storage; the figures '26 23' stand for the time division 'Tithonian' to Hauterivian Ages/Stages, both inclusive. The Ages/Stages are those used in the 'Fossil Record' (Harland *et al.* 1967), numbered consecutively back from Recent; and they may, we suggest, be used for storage of data and for reference without hierarchical complications (see Hughes *et al.* 1968).

The graded comparisons (cfA., cfB.) used throughout follow our previous scheme (Hughes and Moody-Stuart 1967*b*, p. 353).

1 CICATR *AT*

Plate 13, figs. 1–12; text-fig. 1

Record sample. Warlingham Borehole (* see p. 97 below), depth 1,998 ft. (see also Event 3 CICATR); greenish-grey banded silty clay, general size of coarse fraction 45 μ. Preparation V067: 60 min. cold conc. HNO_3, shaken, mineral separation, short centrifuging. Palynologic facies: spores compressed, little damage, little corrosion; 8% other pollen, 2% *Classopollis*, 1% bisaccates, 29% other 'ferns' (incl. 2% *Trilobosporites*), 59% *Cicatricosisporites* (compr. 13% *AT*, 41% biorecord 2 CICATR *AF*, 5% indet.); total fern spore size index 12:77:11; many spore-sized plant fragments.

Diagnosis (100 specimens; V067/1,3; 29 02 68). Miospore, trilete, gross maximum diameter mean 44·5 μ, standard deviation 5·3 μ (100); proximal face thin, plano-convex; distal face convex. Laesura three-quarters radius, lips simple membraneous, height 4–5 μ. Exine 1(2 μ)2·5 including murus (81), radial equatorial exine 1·5(2·5 μ)4 (85). Sculpture positive/negative (Pl. 13, figs. 1, 2): three interradial sets of sub-parallel muri, height 0·5(1·1 μ)1·5 (97), width 1·0(1·8 μ)2·5 (100); four adjacent muri and lumina in a width of 7(11·9 μ)17, standard deviation 1·54 μ, coefficient of variation 12·9%; distal configuration, polar triangle with concave sides (Pl. 13, fig. 5), radial lumen.

Description. Smooth concave contact area, maximum diameter 10(21 μ)40 (53 specimens). Ratio of mean radial equatorial to normal exine thickness 1·2. Amb subtriangular, sides may be concave (Pl. 13, fig. 5) despite convex distal surface. Muri slightly sinuous at junctions that occur mainly in radial equatorial areas. Thickness of interradial exine (excl. murus) 0·8(1·2 μ)1·5 (41); because of this thin exine, folding and rupturing of exine are controlled by alignment of muri. In equatorial view, mural sets curve distally between radial equatorial areas, due to distal configuration. Observed limits of gross maximum diameter 32–60 μ, coefficient of variation 12%. Specimens in polar aspect 47%, equatorial 29%.

Preservation and compression. Thin proximal face may rupture; splitting may occur along radial lumen and adjacent laesura. Thin exine may fold between muri, thus reducing width of 4 muri and lumina, and making equatorial amb concave. In some specimens regular 'drillings' widen murus (Pl. 13, fig. 9).

Distinction local. Biorecord 2 CICATR *AF* (from same sample) has negative sculpture and no radial lumen. 3 CICATR *AR* has positive sculpture and wide lumina. 4 CICATR *AW* has wider muri. *Ruffordia goepperti* (spores) Hughes and Moody-Stuart 1966 are larger, and have wider lumina.

2 CICATR *AF*

Plate 14, figs. 1–12; text-fig. 1

Record sample. Warlingham Borehole, depth 1,998 ft.; details as in biorecord 1 above.

Diagnosis (100 specimens; V067/1; 29 02 68). Miospore, trilete, gross maximum diameter mean 42·8 μ, standard deviation 5·6 μ (100); contact areas unsculptured, plano-convex, proximal face about 2·5 μ thick (Pl. 14, fig. 10); distal face convex. Laesura two-thirds radius, lips simple, height 3–4 μ. Exine (incl. murus) 1·5(2 μ)3 thick (99), radial equatorial exine 1·5(3·5 μ)6·5 (90), ratio radial/interradial 1·0(1·7)2·6 (87 specimens). Sculpture negative (canaliculate) distal and equatorial; straight parallel lumina form 3 interradial sets (of variable number) and alternating in the radial areas; lumen depth (= murus height) 1·0(1·2 μ)2·0 (80); flat-topped murus 2·0(2·2 μ)3·0 wide (100); width of 4 adjacent lumina and muri 9·0(13·1 μ)18 (100), standard deviation 1·94 μ, coefficient of variation 14·8%; distal configuration triangle with straight sides (Pl. 14, fig. 9), or sub-parallel lumina (Pl. 14, figs. 7, 8).

Description. Amb triangular. Maximum diameter of unsculptured area 9(19 μ)30 (70 specimens). Rigidity of spore due to relatively thick exine with narrow (1 μ) lumina. Radius not crossed by lumina, radial equatorial exine particularly rigid and may be slightly thickened. Muri have sharp rectangular profile. Occasional tetrads seen and 1 monolete specimen. Observed limits of maximum diameter 26–60 μ, coefficient of variation 13%. Specimens in polar aspect 38%, equatorial aspect 34%.

Preservation and compression. When murus outline is not rectangular, this is probably due to exine 'softening' of edges of lumina (Pl. 14, fig. 10).

Distinction local. Biorecords 1 CICATR *AT* and 4 CICATR *AW* have radial lumen. 9 CICATR *AP* is larger in all dimensions.

3 CICATR *AR*

Plate 15, figs. 1–13; text-fig. 1

Record sample. Warlingham Borehole, depth 1,873 ft. 8 in.; medium grey silty clay, general size of coarse fraction 20 μ, little carbonate, much mica up to 10 μ; plant frag-

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EXPLANATION OF PLATE 13

Magnification × 1,000.

Figs. 1–12. Biorecord 1 CICATR *AT*. 1–3, Designated specimen, proximal aspect, low, mid, and high focus; V067/1, OR 48·8 116·9. 4–5, Distal aspect, low and high focus; V067/1, OR 50·7 119. 6, Equatorial aspect; V067/3, OR 43·7 121·9. 7, Proximal aspect; V067/3, OR 45·1 122·9. 8, Large specimen, high focus; V067/1, OR 38·1 116·9. 9, Distal aspect, high focus; V067/1, OR 36·4 120·2. 10, Distal aspect, high focus; V067/3, OR 36·5 119·3. 11–12, Equatorial aspect, high and low focus; V067/1, OR 55·2 116·4.

EXPLANATION OF PLATE 14

Magnification × 1,000.

Figs. 1–12. Biorecord 2 CICATR *AF*. 1–2, Designated specimen, proximal aspect, low and high focus; V067/6, OR 48·5 112. 3, Proximal aspect, high focus; V067/1, OR 50·4 119·8. 4, Oblique aspect, low focus; V067/1, OR 44·6 112·2. 5, Proximal aspect, high focus; V067/1, OR 50 119·8. 6–7, Distal aspect, low and high focus; V067/6, OR 33·7 127·7. 8, Distal aspect; V067/1, OR 39·8 122·5. 9, Distal aspect; V067/1, OR 37·3 121. 10, Equatorial aspect; V067/6, OR 55 120·4. 11, Oblique aspect, low focus; V067/6, OR 50 123·1. 12, Equatorial aspect, mid focus; V067/6, OR 19·1 117.

EXPLANATION OF PLATE 15

Magnification × 1,000.

Figs. 1–13. Biorecord 3 CICATR *AR*. 1, Distal aspect; Y528/5, OR 33 122·4. 2, Equatorial aspect; Y528/2, OR 39·3 121·3. 3–4, Equatorial aspect, low and high focus; Y528/2, OR 27·9 113·4. 5, Proximal aspect; Y528/5, OR 37·9 125. 6, Equatorial aspect; Y528/4, OR 39·3 117·3. 7, Oblique aspect, high focus; Y528/2, OR 43·7 119·9. 8–9, Distal aspect, low and high focus; Y528/2, OR 38·7 114·6. 10–11, Distal aspect, low and high focus; Y528/4, OR 28·7 110·9. 12–13, Designated specimen, proximal aspect, low and high focus; Y528/5, OR 27 117.

ments, regular bedding. Preparation Y528: 30 min. cold conc. HNO_3, mineral separation. Palynologic facies: some fern spores in good condition, but full range of corrosion and pale fragments, reworking suspected, many small wood fragments; 17% other pollen, 33% *Classopollis* (pale), 7% bisaccates (pale), 30% other 'ferns', 13% *Cicatricosisporites* (compr. 4·3% 3 CICATR *AR*, 4·7% cf. *AT*/*AW*, 1% or less cfA. 14 CICATR *48H* and cfA. 7 CICATR *C1*); total fern spore size index 45:52:03.

Diagnosis (100 specimens; Y528/2,3,4; 10 01 68). Miospore, trilete, gross maximum diameter mean 36·0 μ, standard deviation 5·45 μ (100); proximal face plano-concave, distal convex. Laesura medium long, lips simple membraneous 2–4 μ high. Sculpture positive, no radial murus. Exine (excl. murus) interradial 0·5(0·8 μ)1·3 (70), and radial 0·5(0·9 μ)1·4 (71). Distal and equatorial areas bear 3 interradial sets with 4(6)10 (84) sub-parallel muri of height 1·1(1·6 μ)3·2 (98), width 0·6(1·1 μ)2·0 (94); width of 4 adjacent muri and lumina 10·0(13·5 μ)17·0 (99), standard deviation 2·09 μ. Proximal face unsculptured triangle (Pl. 15, fig. 12) of height 12(19 μ)28 (71), distal configuration symmetrical concave-sided polar triangle.

Description. Approximately 50% of specimens have sinuous and undulose muri, and in 20% muri anastomose interradially. Polar views show 3 or 4 muri in profile crossing radial amb perpendicularly. Eight specimens have muri flattened (Pl. 15, fig. 1) interradially to apparent width 1·0(2·0 μ)3·2. Observed limits of gross maximum diameter 24–5 μ, coefficient of variation 15·1%; coefficient for width of 4 muri and lumina 14·7%. Aspect of specimens, 16% distal, 18% proximal, 33% equatorial.

Preservation. Mural height in some specimens may have been reduced by corrosion.

Distinction local. Biorecord 1 CICATR *AT* has closer, lower, more numerous muri. 5 CICATR *A2* is larger and has higher, straighter, more widely spaced muri. 14 CICATR *48H* has negative sculpture, thicker exine, wider muri. *Ischyosporites* spp. have more perfect and uniform distal mural reticulum. *Ruffordia goepperti* (spores) are larger (mean 50 μ), and have lower muri.

4 CICATR *AW*

Plate 16, figs. 1–12; text-fig. 1

Record sample. Warlingham Borehole, depth 1,945 ft.; medium grey silty clay, bedded, general size of coarse fraction 20 μ. Preparation V419: 25 min. cold conc. HNO_3, mineral separation, short centrifuging. Palynologic facies: many spores in good condition, some pale and some corroded, *Botryococcus* abundant; 32% other pollen, 19% *Classopollis*, 14% bisaccates, 32% other 'ferns', 3% *Cicatricosisporites* (compr. 3% 4 CICATR *AW*, also present cfA. 1 CICATR *AT*, cfA. 3 CICATR *AR*, cfB. 7 CICATR *C1*); total fern spore size index 47:39:14.

Diagnosis (100 specimens; V419/1; 08 04 68). Miospore, trilete, gross maximum diameter mean 43·3 μ, standard deviation 5·58 μ (100); proximal face plano-convex, distal convex. Laesura medium long, lips simple membraneous 2–5 μ high. Sculpture negative, no radial murus. Exine thickness (incl. murus), radial 2·0(3·7 μ)12·0 (88), interradial 1·4(2·3 μ)5·6 (87). Three interradial sets of sub-parallel muri of height 1·0(1·1 μ)2·5 (79), and width 1·2(2·4 μ)4·0 (100); width of 4 adjacent muri and lumina 10·0(13·4 μ)19·0 (100); distal configuration symmetrical concave-sided polar triangle, proximal sculptured.

Description. Gross maximum diameter limits 26–69 μ, coefficient of variation 12·8%; coefficient of variation of width of 4 muri and lumina 34·5%. Radial exine thickening distinct in a few specimens that could perhaps be separated. Aspect of specimens, proximal 22%, distal 19%, equatorial 24%; 1 monolete specimen seen.

Distinction local. Biorecord 1 CICATR *AT* is of the same size and configuration but has narrower muri. 2 CICATR *AF* has no radial lumen. 3 CICATR *AR* has positive sculpture, thinner exine, and is smaller.

5 CICATR *A2*

Plate 17, figs. 1–11; text-fig. 1

Record sample. Warlingham Borehole, depth 1,843 ft.; medium grey silt, general size of coarse fraction 100 μ, much mica up to 50 μ; plant fragments; disturbed, small lenses. Preparation V016: 10 min. warm conc. HNO_3, shaken, mineral separation. Palynologic facies: spores in good condition, fragments of unmacerated wood; 19% other pollen, 7% *Classopollis*, 14% bisaccates, 40% other 'ferns', 20% *Cicatricosisporites* (compr. 1% 5 CICATR *A2*, 10% cf. *AT*/*AW*, 5% 14 CICATR *48H*, 2% cfA. 3 CICATR *AR*, also present cfA. 6 CICATR *B5*); total fern spore size index 25:53:22.

Diagnosis (100 specimens; V016/1,2,3,4; 29 02 68). Miospore, trilete, gross maximum diameter mean 44·8 μ, standard deviation 6·38 μ (100); proximal face plano-concave, distal convex. Laesura medium length, lips simple membraneous low. Exine (excl. murus) interradial 0·5(1·1 μ)1·8 (71). Sculpture positive, radial lumen; distal and equatorial areas bear 3 interradial sets each with 3(5)10 (96) sub-parallel muri of height 2·0(3·2 μ)5·5 (94), width 1·5(2·7 μ)4·0 (89); width of 4 adjacent muri and lumina 12·0(20·0 μ)30·0 (90), standard deviation 6·7 μ; distal configuration symmetrical concave-sided polar triangle (Pl. 17, fig. 2), with some muri coalescing interradially (Pl. 17, fig. 7); proximal unsculptured.

Description. Muri may fold down (Pl. 17, fig. 3), increasing apparent width of murus up to 6 μ, and decreasing apparent height of murus and width of lumen, which is 0·5(2·5 μ)7·0 (90). Murus broad-based in section, making murus-width a somewhat uncertain measurement. Downfolding of exine (Pl. 17, fig. 9) between muri leads to highly variable 'width of 4 muri and lumina', coefficient of variation 33%. Observed limits of gross diameter 32–59 μ, coefficient of variation 14·2%. Aspect of specimens, 19% equatorial, 29% proximal, 19% distal.

EXPLANATION OF PLATE 16

Magnification ×1,000.

Figs. 1–12. Biorecord 4 CICATR *AW*; prep. V419/1. 1–2, Oblique proximal, low and high focus; OR 44·4 115·9. 3, Oblique equatorial, OR 23·1 117·8. 4, Designated specimen, proximal; OR 32·2 122·5. 5, Distal aspect, high focus; OR 29·5 114·8. 6–7, Proximal aspect, low and high focus; OR 42·5 126·9. 8, Proximal aspect, low focus; OR 22·1 125·2. 9, Equatorial aspect; OR 37·1 116·2. 10–11, Monolete specimen, low and high focus; OR 28·8 115. 12, Proximal aspect, torn; OR 42·3 121·5.

EXPLANATION OF PLATE 17

Magnification ×1,000.

Figs. 1–11. Biorecord 5 CICATR *A2*. 1–2, Designated specimen, distal aspect, low and high focus; V016/4, OR 38·4 122. 3, Distal aspect, high focus; V016/1, OR 43·2 120·2. 4, Distal aspect; V016/3, OR 23·3 113·1. 5, Distal aspect; V016/1, OR 40·4 123. 6, Equatorial aspect, low focus; V016/4, OR 43·7 128·6. 7, Distal aspect, high focus; V016/4, OR 34·3 112·8. 8, Proximal aspect; V016/1, OR 40·3 109·8. 9, Equatorial aspect, low focus; V016/3, OR 31·1 110·7. 10–11, Proximal aspect, low and high focus; V016/1, OR 24·3 111·5.

Distinction local. Biorecord 3 CICATR *AR* is smaller with lower and thinner muri. 7 CICATR *C1* (*Cic. lucifer* H. and M-S. 1967*b*) has narrow-based muri and wider lumina, a radial murus, and distal configuration of symmetrical straight-sided polar triangle. 6 CICATR *B5* is larger with higher and thicker muri, thicker exine and proximal sculpture. 15 CICATR *A3* is larger in all dimensions.

6 CICATR *B5*

Plate 18, figs. 1–8; text-fig. 1

Record sample. Warlingham Borehole, depth 1,834 ft.; light medium grey siltstone, well sorted with general size of coarse fraction 50 μ; lensing and disturbance throughout. Preparation V017: twice warm conc. HNO_3 totalling 1 h., shaken, mineral separation, short centrifuging. Palynologic facies: spores in fair condition, but many broken; 38% other pollen, 4% *Classopollis*, 14% bisaccates, 28% other 'ferns', 16% *Cicatricosisporites* (compr. 4% 6 CICATR *B5*, 5% cfA. 5 CICATR *A2*, 4% cfA. 4 CICATR *AW*, etc.); total fern spore size index 13:44:43.

Diagnosis (100 specimens; V017/1,2,3; 26 01 68). Miospore, trilete, gross maximum diameter mean 88·3 μ, standard deviation 13·7 μ (100); proximal face planar, distal convex. Laesura medium long, lips simple, same height as muri. Sculpture positive. Exine (excl. murus) 2·5(4·2 μ)6·0 (84) measured interradially is of even thickness, giving an apparent total radial thickness 6·0(11·0 μ)16·0 (95), including murus height 3·2(5·7 μ)10·0 (77). Three interradial sets of 5(8·5)11 (78) sub-parallel muri occupy proximal, equatorial and distal surfaces, and members of sets coalesce sub-radially (Pl. 18, fig. 8); murus width 2·2(3·4 μ)5·0 (84); width of 4 adjacent muri and lumina 23(33·4 μ)44 (94), standard deviation 5·05 μ. Distal configuration symmetrical straight-sided polar triangle.

Description. Radial lumen usually absent. 'Drillings' in muri (Pl. 18, fig. 7) occur in 84% of specimens and resulting distortion causes increased apparent murus width 3·0(5·2 μ)8·0 (92), but contrast Plate 18, fig. 8. True murus height not always measurable (Pl. 18, fig. 2) because of exine thickness which is 2·0(5·1 μ)7·2 (39); contrast with Plate 18, fig. 1. In distal configuration, only 2 specimens have symmetrical concave-sided polar triangle, and 2 specimens sub-parallel muri. Range of gross maximum diameter 54–103 μ, coefficient of variation 15·5%; coefficient for width of 4 muri and lumina 15·1%. Specimens in equatorial aspect 9%, proximal 29%, distal 38%.

Preservation. Most specimens inflated, 25% show corrosion, 37% torn; stronger oxidation than usual was necessary to clear sufficiently the opaque thick exine.

Distinction local. Biorecord 5 CICATR *A2* is smaller, has unsculptured proximal face, and always has radial lumen. 9 CICATR *AP* is smaller has negative sculpture, and will not be confused with *B5* when that spore is in good condition. 15 CICATR *A3* has fewer, wider muri.

7 CICATR *C1*

Text-fig. 1

Record sample. Warlingham Borehole, depth 1,757 ft.; for all details see record of *Cicatricosisporites lucifer* Hughes and Moody-Stuart (1967*b*).

8 CICATR *C2*

Plate 19, figs. 1–11; text-fig. 1

Record sample. Warlingham Borehole, depth 1,740 ft. 6 in.; medium grey sandy silt, general size of coarse fraction 30 μ, mica flakes to 150 μ; small plant fragments, thin banding. Preparation V416: 25 min. cold conc. HNO_3, mineral separation, short centrifuging. Palynologic facies: many spores in good condition, few pale and torn specimens, little corrosion, medium and small unmacerated wood fragments; 18% other pollen, 13% *Classopollis* (pale), 23% bisaccates (pale), 30% other 'ferns', 16% *Cicatricosisporites* (compr. 1% 8 CICATR *C2*, 5% cfA. 7 CICATR *C1*, 5% cfA. 4 CICATR *AW*, 1% 9 CICATR *AP*, 1% 10 CICATR *A5S*, 1% cfA. 5 CICATR *A2*, and others); total fern spore size index 08:50:42.

Diagnosis (100 specimens; V416/1,2,3,4,5,7,8; 29 02 68). Miospore, trilete, gross maximum diameter mean 39·9 μ, standard deviation 5·03 μ (100); proximal face plano-convex, distal convex. Laesura medium length, lips simple, 2–4 μ high. Sculpture negative (canaliculate), proximal, equatorial, and distal; straight parallel lumina form 3 interradial sets asymmetrically developed on distal face in 50% of specimens; flat-topped murus (Pl. 19, figs. 4, 5), width 1·2(1·7 μ)2·8 (99), and lumen depth 0·5(1·1 μ)1·3 (34); width of 4 adjacent lumina and muri 7·0(9·9 μ)15 (99), standard deviation 2·67 μ, coefficient of variation 27·1%. Interradial exine thickness (incl. murus) 1·3(2·2 μ)3·0 (93); unsculptured elongate radial equatorial extensions with radial dimension 1·2(4·1 μ)6·5 (88), width in equatorial plane 2·5(6·4 μ)13 (84) (Pl. 19, figs. 6, 11), and 2(5)7 (71) members from each of 2 adjacent equatorial sets of lumina terminating at base of extension; radial equatorial exine thickness 4·0(6·8 μ)9·0 (98), ratio radial/interradial 1·7(3·1)5·3 (93).

Description. Interradial amb convex. Observed limits of gross maximum diameter 29–52 μ, coefficient of variation 12·6%. 18% of specimens show unsculptured area 6·0(13·9 μ)20. Only 5% of specimens have radial extensions that are unusually wide or small. Distal configuration: straight-sided triangle 27%, concave-sided triangle 25%, sub-parallel muri 38% (73). Aspect of specimens, proximal 29%, distal 31%, equatorial only 9% presumably because of presence of radial extensions.

EXPLANATION OF PLATE 18

Magnification of Fig. 8 × 1,000; all others × 500.

Figs. 1–8. Biorecord 6 CICATR *B5*. 1, Distal aspect, high focus; V017/2, OR 44·5 109·2. 2–3, Distal aspect, low and high focus; V017/2, OR 39·2 111·9. 4, Proximal aspect; V017/2, OR 38·9 112. 5, Distal aspect; V017/3, OR 30·9 118·3. 6, Proximal aspect; V017/2, OR 31·2 119·7. 7, Oblique showing drillings; V017/3, OR 41·9 123·8. 8, Designated specimen, proximal aspect; V017/3, OR 31·1 117·4.

EXPLANATION OF PLATE 19

Magnification × 1,000.

Figs. 1–11. Biorecord 8 CICATR *C2*. 1–2, Proximal aspect, low and high focus; V416/1, OR 20·4 118·2. 3, Proximal aspect; V416/4, OR 55·8 115. 4–5, Designated specimen, distal aspect, low and high focus; V416/7, OR 51·4 116·3. 6, Distal aspect, low focus; V416/4, OR 57·3 114·8. 7, Equatorial aspect, high focus; V416/4, OR 38·8 114·6. 8, Distal aspect, low focus; V416/3, OR 22 115·1. 9–10, Distal aspect, low and high focus; V416/7, OR 35·4 123·2. 11, Proximal aspect, low focus; V416/5, OR 46·5 123·2.

Preservation and compression. In natural compression, radial equatorial extensions twist readily on relatively thin spore body; of 20 fractured specimens (= 20% of total), 18 were torn parallel to base of extension. Corrosion often appears to affect radial extension but not spore body, and vice versa.

Distinction local. Biorecord 7 CICATR *C1* has positive sculpture, and the radial extensions arise from single mural intersections. 9 CICATR *AP* is larger, has thicker exine, wider muri, and sculptured radial extension (if any). 13 CICATR *C2L* is larger in all dimensions.

9 CICATR *AP*

Plate 20, figs. 1–7; text-fig. 1

Record sample. Warlingham Borehole, depth 1,740 ft. 6 in.; all details given under 8 CICATR *C2*.

Diagnosis (100 specimens; V416/2,3,4,5,6; 29 02 68). Miospore, trilete, gross maximum diameter mean 60·4 μ, standard deviation 8·9 μ (100); proximal face plano-convex, distal convex. Laesura medium length, flanked by deep lumen, lips simple, low (Pl. 20, figs. 2, 3). Exine thickness radial equatorial (incl. murus) 4·0(9·0 μ)16·0 (98), interradial 2·5(4·5 μ)7·5 (100), ratio radial/interradial 1·0(2·0)4·0 (98). Sculpture negative, radial lumen always absent; proximal, equatorial, and distal surfaces bear 3 interradial sets of regular sub-parallel lumina of depth 1·2(2·4 μ)3·2 (37), 2·0(3·3 μ)5·0 (99) apart; width of 4 adjacent lumina and muri 12·0(16·7 μ)23·0 (100), standard deviation 4·4 μ, coefficient of variation 26·2% (Pl. 20, fig. 6); lumina of adjacent sets do not coalesce; distal configuration, symmetrical straight-sided polar triangle to sub-parallel.

Description. Observed limits of gross maximum diameter 45–83 μ, coefficient of variation 14·7%. Of spores with sub-parallel distal configuration, half had muri perpendicular (Pl. 20, fig. 1) to a radius, and half parallel to a radius. Equatorial aspect 21% of specimens, proximal 20%, and distal 24%. Thick radial exine due to thickening of internal layers of exine; radial equatorial sculpture not modified.

Preservation. 50% of all specimens were torn, 25% showed corrosion (Pl. 20, fig. 4), and 10% were 'drilled' (see description of biorecord 14 CICATR *48H*).

Distinction local. Biorecord 6 CICATR *B5* is larger, with wider, deeper lumina (i.e. positive sculpture); 12 CICATR *APP* is larger. 8 CICATR *C2* is smaller in all dimensions, and has unsculptured radial equatorial extensions. 14 CICATR *48H* has exine of even thickness and radial lumen. *Pelletieria valdensis* (spores) are similar but larger (Hughes and Moody-Stuart 1966).

10 CICATR *A5S*

Plate 21, figs. 1–12; text-fig. 1

Record sample. Warlingham Borehole, depth 1,740 ft. 6 in.; all details given under 8 CICATR *C2*.

Diagnosis (100 specimens; V416/2,4,6,7,8; 29 02 68). Miospore, trilete, gross maximum diameter mean 37·8 μ, standard deviation 5·66 μ (100 specimens); proximal face plano-convex, distal very convex. Laesura medium short, lips simple membraneous, low. Sculpture negative; not more than 1 radial lumen. Exine thickness (incl. murus), interradial 2·0(2·8 μ)3·9 (97), radial 2·0(2·9 μ)4·1 (92). Proximal, equatorial, and distal surfaces bear sub-parallel lumina, depth 0·5(1·1 μ)2·1 (71), and 1·5(2·2 μ)3·2 (100) apart; width of 4 adjacent lumina and 'muri' 7·3(11·5 μ)16, standard deviation 1·78 μ (100). Proximal configuration of concentric triangles; equatorially 2 to 4 circular lumina that may be truly continuous (11%; Pl. 21, figs. 1, 2), or inter-finger in 1 radial area (47%; Pl. 21, fig. 6), or be broken by 1 radial lumen (42%); distal configuration sub-parallel.

Description. Spore appears spherical; this is supported by distribution of spore aspects, 36% polar (11% proximal, 25% distal), 31% equatorial, 33% oblique. Sculpture may be asymmetrical. Coefficient of variation 15·0% for gross diameter, 15·5% for width of 4 lumina and 'muri'.

Preservation. Most specimens inflated; only 14% show any corrosion, but 31% are torn; this is similar for other spores of this assemblage.

Distinction local. Schizaeopsis americana (spores) has circular lumina, but is larger and has smaller sculptural elements. Biorecord 16 CICATR *A5H* is larger and has proximal configuration with lumina of each interradial set parallel to one branch of laesura.

14 CICATR *48H*

Plate 22, figs. 1–12; text-fig. 1

Record sample. Sample H48/16 (TQ 88721288), prominent 6-ft. silt bed (upper part), 20 ft. above cliff base, 150 m. east of Cliff End Point, 4 miles east of Hastings; pale grey silt, no lamination, few plant fragments. Preparation N016: 12 h. Schulze solution, cold, not renewed; mineral separation. Palynological facies: spores in good condition, plus small pale indet. fragments, cuticle, spore-masses, megaspores; 3% bisaccates, 82% other 'ferns', 15% *Cicatricosisporites* (compr. 13% cfA. 14 CICATR *48H*, 2% cfA. 1 CICATR *AT*); total fern spore size index 09:43:48.

Diagnosis (100 specimens; N016/1; 29 02 68). Miospore, trilete, gross maximum diameter mean 50·0 μ, standard deviation 5·8 μ (100 specimens); proximal face plano-convex, distal convex. Laesura long to medium, lips simple membraneous. Sculpture

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EXPLANATION OF PLATE 20

Magnification ×1,000.

Figs. 1–7. Biorecord 9 CICATR *AP*. 1–2, Designated specimen, proximal aspect, low and high focus; V416/2, OR 32·8 118·1. 3, Proximal aspect, high focus; V416/6, OR 49·3 120·2. 4, Extreme specimen; V416/2, OR 45·7 122·8. 5, Proximal aspect, high focus; V416/6, OR 35·4, 111·6 6, Distal aspect, high focus; V416/6, OR 53·3 120·3. 7, Equatorial aspect; V416/4, OR 25·4 122·6.

EXPLANATION OF PLATE 21

Magnification ×1,000.

Figs. 1–12. Biorecord 10 CICATR *A5S*. 1–2, Designated specimen, distal aspect, low and high focus; V416/8, OR 24·2 118·1. 3, Equatorial aspect, high focus; V416/8, OR 50·6 111·4. 4–5, Equatorial aspect, low and high focus; V416/7, OR 38·9 110·9. 6, Equatorial aspect; V416/6, OR 22·3 115·4. 7–8, Distal aspect, low and high focus; V416/6, OR 28·6 112·5. 9–10, Distal aspect, low and high focus; V416/4, OR 29·6 121. 11–12, Distal aspect, low and high focus; V416/6, OR 22·8 118.

EXPLANATION OF PLATE 22

Magnification ×1,000.

Figs. 1–12. Biorecord 14 CICATR *48H*; N016/1. 1–3, Designated specimen, proximal aspect, low, mid, and high focus; OR 27·4 111·3. 4, Distal aspect, high focus; OR 33·1 121·7. 5, Equatorial aspect, low focus; OR 27·2 116·1. 6–7, Proximal aspect, mid and high focus; OR 33·4 120·6. 8, Equatorial aspect, high focus; OR 26·9 116·2. 9, Distal aspect, high focus; OR 32·7 114·9. 10, Distal aspect, low focus; OR 33·1 120·1. 11–12, Distal aspect, high and low focus; OR 29·5 126·6.

negative, radial lumen always present (Pl. 22, fig. 11) on two of the radial equatorial areas. Exine (incl. murus) of equal thickness in radial and interradial areas 2·5(4·8 μ)8·0 (96). Distal, equatorial, and proximal surfaces bear 3 interradial sets of 5(8)11 (98) lumina each; the narrow 0·4(0·9 μ)2·0 (99) lumina of depth 1·5(2·0 μ)3·0 (86) are unevenly spaced and may be discontinuous, but are about 2·0(3·4 μ)5·0 (74) apart; width of 4 adjacent lumina and muri 13(16·8 μ)24, standard deviation 2·7 μ (97). Proximal configuration is unsculptured (Pl. 22, figs. 8, 12) or with concentric triangles (Pl. 22, fig. 2) of 0(2)5 lumina (65); distal configuration symmetrical polar triangle, or sub-parallel.

Description. Distal triangle at meeting of lumen sets often has few irregular short lumina asymmetrically disposed; lumina have sharply defined and sometimes sinuous edges; lines of 'drillings' midway between 2 lumina in many specimens. Laesura may be flanked by deep lumen (Pl. 22, fig. 12). Observed limits of gross maximum diameter 34–63 μ, coefficient of variation 11·6%; coefficient for width of 4 lumina and muri 16·9%. Aspect of specimens, equatorial 42%, proximal 7%, and distal 27%.

Preservation. No ordinary corrosion in this assemblage, so that 'drillings' (Pl. 22, fig. 4) appear to be characteristic of the species.

Distinction local. Biorecord 9 CICATR *AP* has no radial lumen, and may have internal thickenings. 4 CICATR *AW* is slightly smaller in all measurements except lumen width. 10 CICATR *A5S* is smaller and differs in equatorial and distal configuration.

UNCOMPLETED BIORECORDS

It is clear from the study of the coarser-grained Fairlight Clay samples that further *Cicatricosisporites* biorecords additional to those taken from the Warlingham Borehole, are potentially available in the Hastings Beds, and will be needed for continuation with other correlation. So that brief reference can be made at this stage, some are listed below. Because they have not been properly established, comparison with them is not graded.

11 CICATR *AWW*:	4 *AW*, with very wide muri; has been seen in spore-masses.
12 CICATR *APP*:	larger than 9 *AP*, and earlier.
13 CICATR *C2L*:	much larger than 8 *C2*, and much earlier.
15 CICATR *A3*:	larger than 5 *A2*.
16 CICATR *A5H*:	larger than 4 *AW*, with characteristic proximal configuration, and later.

RECORDING OF EVENTS

The location of the Warlingham Borehole is TQ 34765719, RTE 347 ft. above MSL; the samples here described are sub-samples kindly supplied by the Institute of Geological Sciences (UK), who hold the main collections and records of the borehole. The reference file for the outcrop samples of the Fairlight Clay is a field note-book (NFH) deposited in the Department of Geology, Cambridge.

SELECTED EVENTS

CRET 25 24 GB SPOR CICATR

This heading for events is again in the form of a suggestion for data storage (cf. heading above, for biorecords). The figures '25 24' indicate that the recorded events are believed to be of Berriasian–Valanginian age, and are so arranged for 'search' purposes.

Under the individual events we regard the calendar date of 'observation' given with each item as essential data.

Warlingham Borehole

4, *WM1987/1–3*. 28 02 68 CICATR: 46% cfA. 1 *AT*, 23% cfA. 4 *AW*, 12% cfA. 3 *AR*, 6% cfA. 2 *AF*, 12% *Contignisporites*.

Sample. Medium grey siltstone, small scale cross-bedding; mica, bivalve shell fragments, black indet. fragments; general size of coarse fraction 40 μ. Preparation N044–5/12–16: 12 h. cold Schulze. Palynologic facies: 30% other pollen, 28% *Classopollis*, 14% bisaccates, 23% 'other ferns', 2% *Cicatricosisporites*, 3% 'plankton'; large cuticle; fern spore size index 40:48:12.

5, *WM1968/10*. 27 02 68 CICATR: 38% cfA. 1 *AT*, 41% cfA. 4 *AW*, 12% cfA. 3 *AR*, 9% cfA. 2 *AF*.

Sample. Dark grey silty claystone; bivalve shell fragments; general size of coarse fraction 20 μ. Preparation V484/3: 25 min. HNO_3, mineral separation. Palynologic facies: 32% other pollen, 27% *Classopollis*, 4% bisaccates, 31% 'other ferns', 5% *Cicatricosisporites*; most of assemblage pale, corroded; fern spore size index 38:48:04.

7, *WM1957/2*. 06 03 68 CICATR: 60% cfA. 4 *AW*, 12% cfA. 1 *AT*, 21% cfA. 3 *AR*, 5% cfA. 2 *AF*.

Sample. Medium grey silty clay, laminated, with shell bands; general size of coarse fraction 60 μ. Preparation V503/2: 25 min. HNO_3 cold. Palynologic facies: 34% other pollen, 21% *Classopollis*, 8% bisaccates, 33% 'other ferns', 4% *Cicatricosisporites*; wood, cuticle, *Botryococcus*; fern spore size index 20:54:16.

10, *WM1945*. 29 03 68 CICATR: 42% 4 Biorecord *AW*, 28% cfA. 1 *AT*, 11% cfA. 3 *AR*, 9% cfA. 2 *AF*, 8% cfB. 5 *A2*, 2% cfB. 7 *C1*.

Sample. Medium grey fissile silty clay; general size of coarse fraction 20 μ. Preparation V419/1,3: 25 min. HNO_3 cold, mineral separation. Palynologic facies: 32% other pollen, 19% *Classopollis*, 14% bisaccates, 32% 'other ferns', 3% *Cicatricosisporites*; *Botryococcus*; fern spore size index 47:39:14.

12, *WM1941/4*. 07 03 68 CICATR: 58% cfA. 4 *AW*, 19% cfA. 1 *AT*, 19% cfA. 3 *AR*, 4% cfA. 2 *AF*, +cfB. 7 *C1*.

Sample. Medium grey laminated claystone with bivalve shells; general size of coarse fraction 15 μ. Preparation V489/1: 25 min. HNO_3 cold. Palynologic facies: 58% other pollen, 6% *Classopollis*, 13% bisaccates, 17% 'other ferns', 6% *Cicatricosisporites*; background assemblage pale, fern spores 'softened'; fern spore size index 37:56:07.

14, *WM1924/8–9*. 09 03 68 CICATR: 58% cfA. 4 *AW*, 20% 11 *AWW*, 8% cfA. 1 *AT*, 10% cfA. 3 *AR*, 2% cfB. 5 *A2*, 2% cfB. 6 *B5*, cf.2% 12 *APP*.

Sample. Grey silty claystone; ostracods; general size of coarse fraction 20 μ. Preparation V505/2: 25 min. HNO_3 cold. Palynologic facies: 21% other pollen, 8% *Classopollis*, 13% bisaccates, 34% 'other ferns', 24% *Cicatricosisporites*; wood, background assemblage pale except ferns; fern spore size index 35:51:14.

18, *WM1915/2*. 21 03 68 CICATR: 59% cfA. 4 *AW*, 8% cfA. 1 *AT*, 8% cfA. 11 *AWW*, 13% cfB. 5 *A2*, 5% cfA. 3 *AR*, 1% cfA. 12 *APP*, 1% cfA. 6 *B5*, +cfB. 7 *C1*, 5% *Contignisporites*.

Sample. Medium grey silty claystone, laminated; ostracods, pyrite; general size of coarse fraction 25 μ. Preparation V524/3: 20 min. HNO_3 cold, mineral separation. Palynologic facies: 36% other pollen, 2% *Classopollis*, 15% bisaccates, 40% 'other ferns', 7% *Cicatricosisporites*; wood, cuticle, spore-masses inaperturate pollen; fern spore size index 38:53:09.

26, *WM1887*. 26 03 68 CICATR: 56% cfA. 1 *AT*, 18% cfA. 4 *AW*, 9% cf. 11 *AWW*, 12% cfA. 3 *AR*, 3% cfA. 5 *A2*, 2% cfA. 7 *C1*.

Sample. Medium grey siltstone, with irregular lensing; general size of coarse fraction 35 μ. Preparation V493/1: 25 min. HNO_3, cold. Palynologic facies: 47% other pollen, 12% *Classopollis*, 4% bisaccates, 33% 'other ferns', 4% *Cicatricosisporites*; fern spore size index 56:41:03.

28, *WM1878/10*. 14 03 68 CICATR: 32% cfA. 4 *AW*, 7% cfA. 1 *AT*, 25% cfA. 14 *48H*, 14% cfA. 7 *C1*, 21% cfA. 3 *AR*.

Sample. Medium grey siltstone, faintly laminated; general size of coarse fraction 70 μ. Preparation V009–1/2: 5 min. HNO_3 cold, mineral separation. Palynologic facies: 66% other pollen, 3% *Classopollis*, 8% bisaccates, 20% 'other ferns', 3% *Cicatricosisporites*; cuticle; fern spore size index 61:31:08.

30, *WM1873/8*. 14 02 68 CICATR: 36% cfA. 4 *AW*, 16% cfA. 1 *AT*, 24% Biorecord 3 *AR*, 12% cfA. 7 *C1*, 9% cfA. 5 *A2*, 1% cfB. 9 *AP*, fragments cf. 6 *B5*.

Sample. Medium grey silty claystone, bedded with plant fragments; average size of coarse fraction 20 μ. Preparation: Y528/2–5: 30 min. HNO_3, mineral separation. Palynologic facies: 32% other pollen, 11% *Classopollis*, 11% bisaccates, 36% 'other ferns', 10% *Cicatricosisporites*; wood, many pale indet. spores ex count, small acritarchs; fern spore size index 52:45:03.

33, *WM1847*. 04 04 68 CICATR: 54% cfA. 4 *AW*, 18% cfA. 1 *AT*, 12% cfA. 7 *C1*, 7% cfA. 5 *A2*, 6% cfA. 3 *AR*, 3% cfA. 6 *B5*, +cf. 9 *AP*.

Sample. Green silty clay, brown mottled; lensing, bioturbation; average size of coarse fraction 65 μ. Preparation: Y529/3: 30 min. HNO_3, mineral separation. Palynologic facies: 30% other pollen, 3% *Classopollis*, 32% bisaccates, 25% 'other ferns', 10% *Cicatricosisporites*; fern spore size index 30:57:13.

36, *WM1843*. 20 02 68 CICATR: 47% cfA. 4 *AW*, 16% cfA. 1 *AT*, 15% cfA. 5 *A2*, 10% cfA. 7 *C1*, 11% cfA. 3 *AR*, +cf. 9 *AP*.

Sample. Medium grey siltstone, lensed, disturbed; plant fragments, pyrite; general size of coarse fraction 40 μ. Preparation V016/3: 10 min. HNO_3 shaken, mineral separation. Palynologic facies: 34% other pollen, 5% *Classopollis*, 22% bisaccates, 24% 'other ferns', 15% *Cicatricosisporites*; wood; fern spore size index 32:53:15.

43, *WM1819/5*. 15 05 68 CICATR: 46% cfA. 4 *AW*, 8% cfA. 1 *AT*, 20% cfA. 5 *A2*, 8% cfA. 7 *C1*, 10% cfA. 3 *AR*, 3% cfA. 8 *C2*, 2% cfA. 6 *B5*.

Sample. Medium dark grey shale; plant fragments; general size of coarse fraction 30 μ. Preparation V533/1,2: 25 min. HNO_3, mineral separation. Palynologic facies: 18% other pollen, 16% *Classopollis*, 15% bisaccates, 47% 'other ferns', 4% *Cicatricosisporites*; wood, fungal spores; fern spore size index 35:58:07.

53, *WM1740/6*. 19 01 68 CICATR: 29% cfA. 7 *C1*, 25% cfA. 4 *AW*, 8% cfA. 1 *AT*, 11% cfA. 5 *A2*, 8% Biorecord 8 *C2*, 15% Biorecord 10 *A5S*, 2% Biorecord 9 *AP*, 2% cfA. 3 *AR*.

Sample. Medium grey siltstone, laminated; large mica; general size of coarse fraction 30 μ. Preparation V416/1–8: 25 min. HNO_3, mineral separation. Palynologic facies: 21% other pollen, 14% *Classopollis*, 19% bisaccates, 38% 'other ferns', 8% *Cicatricosisporites*; wood, spinose acritarchs; fern spore size index 21:60:19.

Fairlight Clay outcrop, east of Hastings, Sussex

All samples from coast section (collected 1952–6); descriptive reference points from White (1928, fig. 5, p. 33), and stratigraphic subdivision from the same work (fig. 4, p. 22) are listed below as FC (c), (d), etc.

61, *H127*; FC (a), Fairlight anticline west limb, 18 ft. below 'Goldbury bed' and 4 ft. above HWM. 19 03 68 CICATR: 45% cfA. 1 *AT*, 30% cfA. 4 *AW*, 7% cfA. 2 *AF*, 14% cfB. 5 *A2*.

Sample. Buff blocky fine siltstone. Preparation V092/2: 30 min. HNO_3, mineral separation. Palynologic facies: 20% other pollen, 5% *Classopollis*, 36% bisaccates, 36% 'other ferns', 3% *Cicatricosisporites*; fern spore size index 17:46:37.

62, *H41*; FC (b) mid-high, shore-reefs Goldbury East. 20 03 68 CICATR: 57% cfA. 4 *AW*, 17% cfA. 1 *AT*, 6% cf. 11 *AWW*, 9% cfA. 2 *AF*, 3% cfB. 5 *A2*, 3% cfB. 7 *C1*.

Sample. Buff-grey siltstone, bedded; plant fragments, wood. Preparation V163/1: 45 min. HNO_3, mineral separation. Palynologic facies: 25% other pollen, 38% bisaccates, 33% 'other ferns', 4% *Cicatricosisporites*; wood, cuticle, spore-masses; fern spore size index 14:50:36.

63, *H58*; FC (c), 15 ft. above 'Goldbury bed' at Goldbury Point. 26 03 68 CICATR: 63% cfA. 4 *AW*, 6% cf. 11 *AWW*, 6% cfA. 1 *AT*, 6% cfA. 5 *A2*, 4% cfB. 7 *C1*, 3% cfB. 9 *AP*, 3% cfA. 3 *AR*, 3% cfB. 6 *B5*, +cf. 13 *C2L*.

Sample. Dark grey fine siltstone, unbedded; small plant fragments. Preparation V173/2: 60 min. HNO_3, mineral separation. Palynologic facies: 20% other pollen, 1% *Classopollis*, 15% bisaccates, 50% 'other ferns', 14% *Cicatricosisporites*; cuticle, megaspores, spore-masses; fern spore size index 19:45:36.

64, *H129*; FC (c), Lee Ness, 40 ft. above HWM. 29 03 68 CICATR: 54% cfA. 4 *AW*, 14% cf. 11 *AWW*, 11% cfA. 1 *AT*, 11% cfB. 5 *A2*, 2% cfA. 5 *A2*, 5% cfB. 7 *C1*, +cf. 13 *C2L*.

Sample. Pale pink-grey blocky medium siltstone; plant fragments. Preparation

V169/2: 45 min. HNO_3, mineral separation. Palynologic facies: 15% other pollen, 3% *Classopollis*, 26% bisaccates, 41% 'other ferns', 15% *Cicatricosisporites*; cuticle, megaspore, spore-masses; fern spore size index 07:61:32.

65, *H128*; FC (c) high, Lee Ness, 80 ft. above HWM. 21 03 68 CICATR: 40% cfA. 4 *AW*, 16% cfA. 1 *AT*, 10% cf. 11 *AWW*, 14% cfB. 7 *C1*, 10% cfA. 5 *A2*, +cf. 2 *AF*.

Sample. Pale grey fine siltstone; plant fragments. Preparation V168/1: 45 min. HNO_3, mineral separation. Palynologic facies: 21% other pollen, 20% bisaccates, 46% 'other ferns', 13% *Cicatricosisporites*; fern spores well preserved, cuticle and other spores not; fern spore size index 02:43:55.

66, *H71*; FC (c), 250 yd. east of Warren Glen, 5 ft. above HWM. 28 03 68 CICATR: 57% cfA. 1 *AT*, 13% cfA. 4 *AW*, 7% cfA. 3 *AR*, 2% cfB. 5 *A2*, 15% cfA. 5 *A2*, 2% cfB. 7 *C1*, +cf. 9 *AP*.

Sample. Pale grey siltstone, blocky (not laminated). Preparation V165/2: 60 min. HNO_3, mineral separation. Palynologic facies: 16% other pollen, 2% *Classopollis*, 17% bisaccates, 62% 'other ferns', 3% *Cicatricosisporites*; fern spore size index 49:40:11.

67, *H118*; FC (d), 100 yd. west of Warren Glen, at HWM in oblique bedding. 14 05 68 CICATR: 52% cfA. 4 *AW*, 8% cfA. 1 *AT*, 5% cfA. 3 *AR*, 17% cfA. 7 *C1*, 8% cfA. 5 *A2*, 8% *Contignisporites*.

Sample. Pale grey fine siltstone, bedded. Preparation V592/1: 20 min. HNO_3, mineral separation. Palynologic facies: 27% other pollen, 3% *Classopollis*, 27% bisaccates, 38% 'other ferns', 5% *Cicatricosisporites*; fern spore size index 51:44:05.

68, *H73*; FC (e), 100 yd. west of Warren Glen, 200 ft. above HWM, 2 in. below 5-ft. sandstone. 02 04 68 CICATR: 36% cfA. 4 *AW*, 5% cfA. 1 *AT*, 5% cfA. 3 *AR*, 10% cf. 17 *AWL*, 16% cf. 15 *A3*, 20% cf. 12 *APP*, 2% cfA. 7 *C1*, 2% cf. 13 *C2L*.

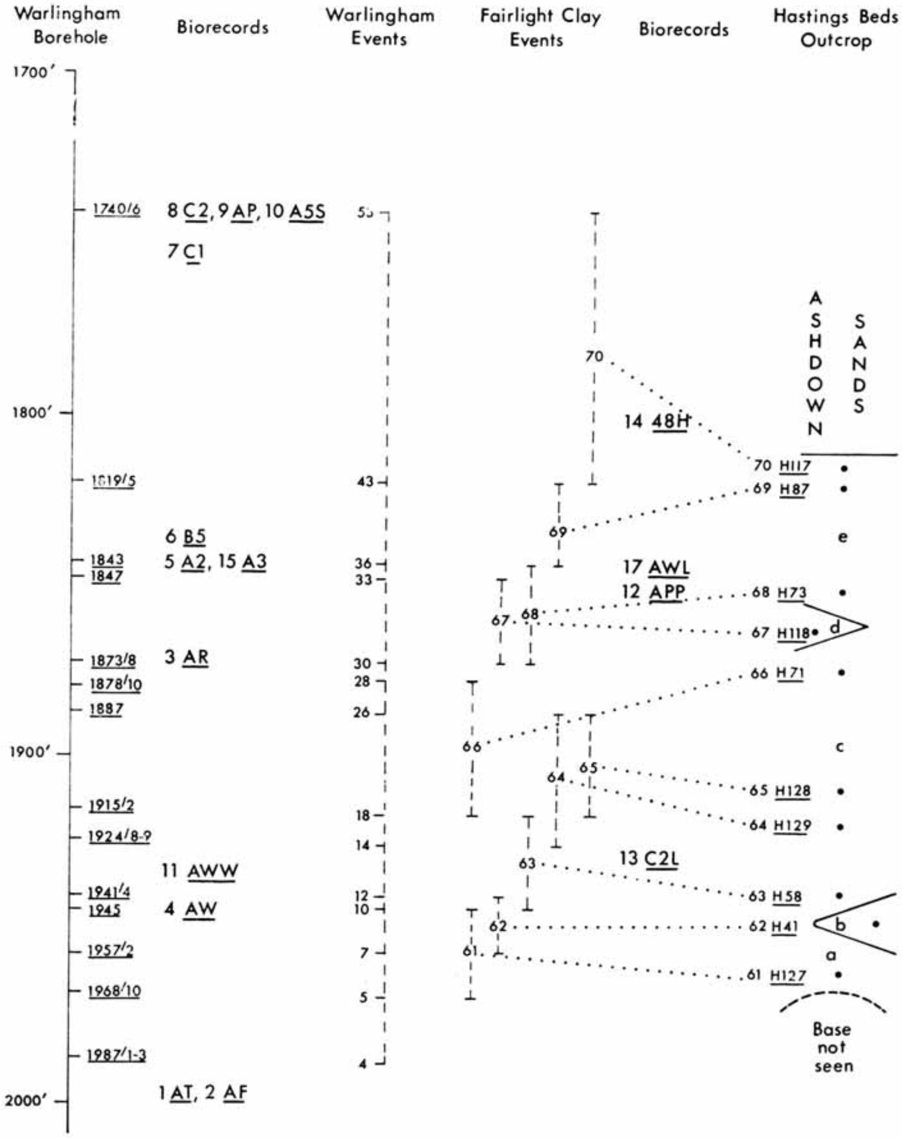
Sample. Pale buff siltstone, unbedded; medium-size plant fragments. Preparation BP391/1–3: 18 h. HNO_3 cold. Palynologic facies: 29% other pollen, 6% *Classopollis*, 30% bisaccates, 28% 'other ferns', 7% *Cicatricosisporites*; fern spore size index 20:40:40.

69, *H87*; FC (e), 75 yd. east of Ecclesbourne Glen, 6 ft. above HWM. 28 03 68 CICATR: 27% cfA. 1 *AT*, 13% cfA. 4 *AW*, 28% cfA. 3 *AR*, 20% cfA. 7 *C1*, 9% cfA. 5 *A2*, 2% cfA. 8 *C2*, 1% cfA. 9 *AP*.

Sample. Pink-grey coarse siltstone, bedded; plant fragments. Preparation V058/4–5: 20 min. Schulze, mineral separation. Palynologic facies: 31% other pollen, 3% *Classopollis*, 14% bisaccates, 43% 'other ferns', 9% *Cicatricosisporites*; cuticle, wood, fungal spores; fern spore size index 41:43:16.

70, *H117*; FC (e) top, 200 yd. east of Ecclesbourne Glen, 10 ft. above HWM. 13 05 68 CICATR: 25% cfA. 1 *AT*, 23% cfA. 4 *AW*, 6% cfA. 3 *AR*, 22% cfA. 7 *C1*, 6% cfA. 5 *A2*, 7% cfA. 8 *C2*, 2% cfA. 9 *AP*, 2% cf. 15 *A3*, 4% cf. 18 *ATT*.

Sample. Pale buff-grey medium siltstone, unbedded. Preparation V183/2: 30 min.



TEXT-FIG. 2. Diagram to show the correlation of each of ten selected Fairlight Clay samples by means of events based on *Cicatricosisporites* miospores they contain, against a sequence of similar events from the standard succession in the Warlingham Borehole.

Schulze, mineral separation. Palynologic facies: 24% other pollen, 2% *Classopollis*, 23% bisaccates, 39% 'other ferns', 12% *Cicatricosisporites*; cuticle, wood; fern spore size index 32:50:18. (Preparation C156 of Couper 1958 from this sample.)

STRATIGRAPHIC CORRELATION

As shown on the right of text-fig. 2, Hastings Beds samples giving events 61–70 can be correlated with the local standard sequence in the Warlingham Borehole as follows:

61 EVENT *H127*: Between events 5 *WM1968/10* and 10 *WM1945*; on proportion 1 *AT*/ 4 *AW* it could lie between events 4 *WM1887/1–3* and 5, but 14% cfB. 5 *A2* suggests proximity to 10; not later, on absence of 7 *C1*.

62 EVENT *H41*: Between events 7 *WM1957/2* and 12 *WM1941/4*; presence of cfB. 7 *C1*, first appearance of cf. 11 *AWW*.

63 EVENT *H58*: Between events 10 *WM1945* and 18 *WM1915/2*; very high cfA. 4 *AW*, presence of cfB. 6 *B5*.

64 EVENT *H129*: Between events 14 *WM1924/8–9* and 26 *WM1887*; high cfA. 4 *AW*, and also cf. 11 *AWW*; no cf. 6 *B5*.

65 EVENT *H128*: Between events 18 *WM1915/2* and 26 *WM1887*; change in ratio cf. 1 *AT* / 4 *AW*, presence of cfA. 5 *A2*.

66 EVENT *H71*: Between events 18 *WM1915/2* and 28 *WM1878/10*; after the main occurrence of cf. 11 *AWW*, high ratio cf. 1 *AT* / 4 *AW* as in events 24 *WM1888/3–6* to 26 *WM1887*, and low cfB. 7 *C1*.

67 EVENT *H118*: Between events 30 *WM1873/8* and 33 *WM1847*; low cfA. 1 *AT*, but no trace of cf. 8 *C2*.

68 EVENT *H73*: Between events 30 *WM1873/8* and 36 *WM1843*; low cfA. 1 *AT*, high cf. 15 *A3* and others.

69 EVENT *H87*: Between events 36 *WM1843* and 43 *WM1819/5*; low but definite occurrence of cfA. 8 *C2*.

70 EVENT *H117*: Between events 43 *WM1819/5* and 53 *WM1740/6*; similar fern spore size index to 69 event, but stronger occurrence of cfA. 8 *C2*; pre-53 event as no occurrence of cfA. 10 *A5S*, but this long interval has not yet been analysed.

The result is a ten-event correlation of the samples from the exposed Fairlight Clay of Hastings, Sussex, with the events from the Warlingham Borehole succession from depth 1,968/10 ft. to 1,819/5 ft. Other events not here described in detail from the borehole and outcrop, support the correlations. Only *Cicatricosisporites* spores have been used, but other spores in the assemblages are expected to increase the precision of correlation.

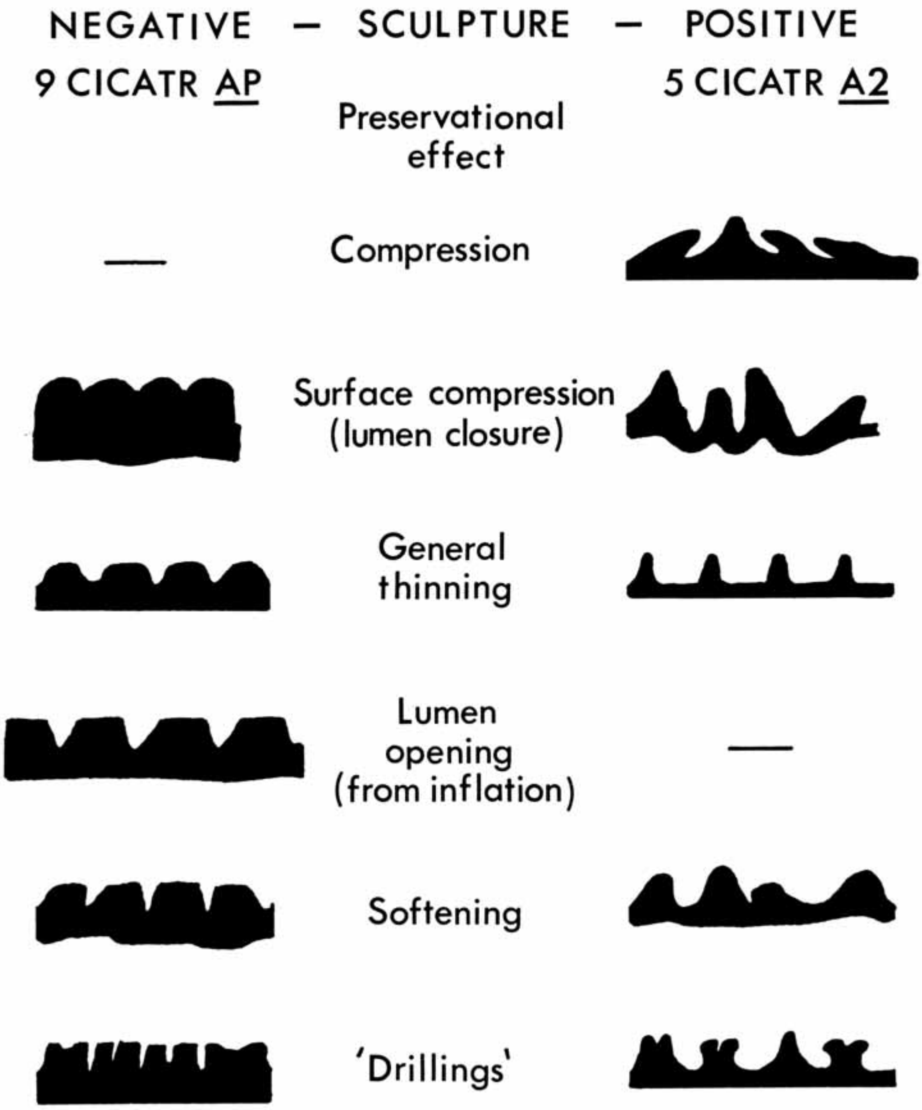
Although it seems probable that eventually much of the comparison can be done by machine, we do not believe that we yet understand the possibilities well enough to take advantage of that convenience. We admit to occasional use in both biorecords and events of the traditional 'comparative' terms of description that are now insufficiently precise, but this was due to lack of time rather than to intention.

INTERPRETATION OF *CICATRICOSISPORITES* SPECIMENS

Preservation. As shown in text-figs. 3 and 4, preservation changes can completely alter the appearance of the main characters which must be used in identifying the biorecords

	OPACITY (Under-maceration)	Full COMPRESSION of Spore	SURFACE COMPRESSION (lumen closure)	LUMEN OPENING (from inflation)	MURUS CORROSION	GENERAL THINNING (without corrosion)	SOFTENING (without thinning)	'DRILLINGS'
COLOUR	Darker	✓	✓	Lighter	Pale	Pale	✓	✓
GROSS DIAMETER	✓	✓	Decrease not significant	Increase not significant	Slight decrease	✓	Increase	✓
SHAPE CHANGE	✓	Depends on original shape	Amb less circular	Amb more circular	✓	Tends to compress	Irregular folds	✓
MURAL PROFILE (negative)	Obscures	—	Murus top more rounded	Increases apparent murus width	—	Decrease murus width and height	Distorts irregularly	Decrease murus height
MURAL PROFILE (positive)	—	Muri fold down	Increase apparent murus width	—	—	Decrease murus height	Distorts irregularly	Increase murus width; decrease height
WIDTH of FOUR MURI and LUMINA	Difficult to measure	May decrease	Decrease	Increase	✓	✓	Decrease or increase	Slight increase
INTER-RADIAL EXINE THICKNESS (excl. murus if positive)	Increase	Increase	✓	Decrease	May decrease	Decrease	Obscures – ? decrease	✓
RADIAL EXINE THICKNESS	Increase	Increase	May increase	✓	✓	Decrease	Decrease	✓
EXAMPLES on plates	6 CICATR B5 figs. 2, 3	5 CICATR A2 fig. 3	10 CICATR A5S fig. 3	8 CICATR C2 figs. 9, 10; 1 CICATR AT fig. 8; 14 CICATR 48H fig. 8	9 CICATR AP fig. 4	8 CICATR C2 fig. 7	3 CICATR AR fig. 5	6 CICATR B5 fig. 7; 8 CICATR C2 figs. 9, 10; 14 CICATR 48H fig. 4

TEXT-FIG. 3. Table of description of various preservation effects on selected *Cicatricosisporites* spore characters, expressed as differences from the characters of the 'ideally preserved' spore. 'No difference' is shown by a tick; 'not applicable' by a dash. Any apparent discrepancy between lines 4 and 5 of this table (murus profile) and the corresponding illustrations in text-fig. 4, is due to abbreviation of the wording in this table.



TEXT-FIG. 4. Diagrams of certain preservation effects on murus profile in an example of negative sculpture (Biorecord 9 *AP*) and of positive sculpture (Biorecord 5 *A2*). Scale approximately × 2,000.

or species of this group. Some allowance can be made if the various preservation possibilities are understood, but perhaps most important is confident rejection of unsatisfactory specimens from a diagnosis. In some cases (e.g. Biorecord 3 CICATR *AR* in 30 *WM1873/8*) it has been necessary to make biorecords from relatively poorly preserved material, and allowance for this is necessary throughout the use of this biorecord; it can be seen that we have made less use of 3 *AR* than of some others. We hope that increasing knowledge of the chemistry of sporo-pollenin and of its changes in diagenesis will make possible the scientific expression of the course of exine degradation even to the level at which it could be a useful tool in studying the depositional and post-depositional history of sedimentary rocks. The effects of the preservational states on sculptural and even structural features of *Cicatricosisporites* (text-figs. 3, 4) are not all mutually exclusive and frequently occur superimposed in one specimen or assemblage, but may not affect the entire specimen or assemblage.

Facies. The selection of data for supplementary description of events follows our earlier paper (Hughes and Moody-Stuart 1967*a*); it is of course only suitable for these Early Cretaceous samples from this special environment. The fern spore size index is based on 100 specimens of all trilete spores divided into percentages of those falling into the gross maximum diameter groups $< 30\,\mu{:}30\text{–}50\,\mu{:}> 50\,\mu$. The figures for the event 30 *WM1873/8* are 52:45:03, which are likely to represent an impoverishment of the assemblage. However, from this sample, the biorecord 3 CICATR *AR* has an unusually low gross maximum diameter mean of 36 μ that is unlikely to have been affected; the absence of cf. 8 *C2* (a small spore) is probably stratigraphically significant but the lack of cf. 9 *AP* and other larger spores may well not be.

Reworking. While this problem must always remain under observation, there are relatively few specific precautions that can be taken. We believe that it is worth checking for discontinuous preservation state in specimens being compared with a biorecord or species, and very unusual palynologic facies should be carefully considered. In some cases, however, where reworking seems certain from such criteria, it is clear that there was only a short time difference and thus no stratigraphic difficulty.

SYSTEMATIC TREATMENT

Relatively little published work deals with spores of Berriasian–Valanginian age. Some of our biorecords fall within the circumscription of published species that refer in part or wholly to that time; as will be shown below, however, there are very many minor problems of detail, as well as the major difficulties of stratigraphic use of such species that are already validly published. We do not discuss post-Hauterivian species, as in our opinion the evolutionary changes shown by the whole flora by Barremian time provide adequate grounds for palynologic distinction. The principle works concerned are by Bolkhovitina (1961), Döring (1965), and Burger (1966).

Genus CICATRICOSISPORITES Potonié and Gelletich 1933

Cicatricosisporites recticicatricosus Döring 1965

Remarks. Our biorecord 1 CICATR *AT* can be included here, and possibly also 2 CICATR *AF*, because a distinction of this nature has not previously been made. We believe that *C. sprumonti* Döring 1965, although recorded as being larger, is also close to this species. Most other authors have placed all such spores in the now irrelevant Eocene species *C. dorogensis* (Couper 1958, Bolkhovitina 1961, Pocock 1962), or in *C. mohrioides* Delcourt and Sprumont 1955 (Lantz 1958*b*, Burger 1966) that Delcourt *et al.* (1963) regarded as too inadequately based for further use.

Unfortunately the state of preservation of Döring's (1965) spores appears to be not very good, and his measurements on all his spores appear to be up to 20% higher than would be expected from work on spores of comparable age from other areas. His oxidation time was not stated, and it was followed by KOH treatment also of unspecified time; Smith and Butterworth (1967, p. 105) recorded serious swelling with the use of KOH, particularly in material which may have been over-oxidized naturally or in the laboratory.

The closest description to our 1 CICATR *AT* is that given by Burger (1966) under *C. mohrioides*, but in addition to the difficulty already mentioned about the holotype, Burger apparently ignored the clear statement by Delcourt and Sprumont (1955) that the measurement of 4 muri and lumina is about 18 μ. This appears to be a case for a new name if such taxonomy is to be continued.

Cicatricosisporites abacus Burger 1966

Remarks. Our biorecord 4 CICATR *AW* may be included here. The use of *Anemia exilioides* (Mal.) Bolkhovitina by Yaroshenko (1965) and other Russians appears to be similar but the illustrations are not good enough to make comparison certain. *C. sternum* van Amerom 1965 was used by Burger (1966) for similar forms, but was an Upper Cretaceous species and thus not relevant.

Cicatricosisporites globosus Döring 1965

Remarks. Our biorecord 11 CICATR *AWW* appears to belong here. Others, however, may wish to combine the species with *C. abacus* Burger, over which it has priority of name. *C. globosus* was unfortunately only illustrated by a single spore in an equatorial view.

Cicatricosisporites (*Anemia*) *sibirica* (Kara-Murza) comb. nov.

Combination. This is made on principle to record our disagreement with the Russian practice of loading the genera of extant plants with dispersed spore species which cannot be satisfactorily compared with living whole plants.

Remarks. Our biorecord 3 CICATR *AR* may be included here, judging from a photograph (Bolkhovitina 1961, pl. 17, fig. 2) rather than from a drawing in the same paper; the age of the species was given as Valanginian. Samoilovich *et al.* (1961, p. 281 and pl. XXIV, fig. 2) listed *Mohria striata* (Naum.) Bolkh. as a definite element of a Valanginian assemblage; this looks very like our *AR*, but cannot be used as Bolkhovitina (1961, p. 66) herself put it in synonymy with '*Pelletieria*' *tersa* (*tersa* is a Barremian or later spore with some radial proximal muri). The description given by Groot and Penny (1960, p. 230) under *C. goepperti* may include *AR*, but their new combination was inadmissible because it placed the megafossil fern *Ruffordia* in synonymy; Kedves and Sole de Porta (1963) followed their error. Brenner (1963) swept these spores into synonymy with the Albian *C. aralica* (Bolkh.).

Cicatricosisporites crassistriatus Burger 1966

Remarks. Our biorecord 5 CICATR *A2* is probably correctly placed here, but Burger's holotype (pl. 7, fig. 2) does show *one* radial murus although the description does not. In our *A2* occasional specimens may show one radial murus but they would be regarded as extreme variants only, of a form that essentially lacks such a feature (see our distinction of *C. lucifer* Hughes and Moody-Stuart 1967*b*, p. 352).

Cicatricosisporites grabowensis Döring 1965

Remarks. Our biorecord 6 CICATR *B5* may well belong here, but the holotype preservation is not good and the diagnosis does not agree accurately. We have also examined the description of *C. angicanalis* Döring which was, however, only based on 8 scattered specimens. As the preservation of our *B5* may also be unusual in a different way, it is perhaps better to leave its attribution undetermined.

Cicatricosisporites myrtellii Burger 1966

Remarks. Our biorecord 10 CICATR *A5S* agrees in size and in equatorially circular muri with this species. Burger (1966) described a spore which approaches this form and could perhaps be combined with it, as *C. striatus* Rouse 1962; that name, however, is not available owing to *Mohria striata* (Naum.) Bolkh. 1953, which is mentioned above under *C. sibirica.*

Cicatricosisporites lucifer Hughes and Moody-Stuart 1967*b*

Remarks. Our biorecord 7 CICATR *C1* is the same as the record of this species. Most authors have submerged such spores in the Senonian *Appendicisporites tricornitatus* Weyland and Greifeld 1953 (Delcourt and Sprumont 1955, Couper 1958, Groot and Penny 1960, Pocock 1962), or in *A. macrorhyza* (Mal.) Bolkh. (Bolkhovitina 1961, pl. 15, figs. 7*c*, *d* only). Burger (1966) gave a recognizable description under the name *Plicatella problematica*, but it is better to avoid this name as Döring (1965) re-combined *Cingulatisporites problematicus* Couper 1958 into *Contignisporites* which is very close morphologically to *Cicatricosisporites.*

Genus APPENDICISPORITES Weyland and Krieger 1953

Remarks. Although post-Hauterivian forms may truly fall in such a genus, we adhere to our view that Valanginian spores with long appendages are only extreme forms of *Cicatricosisporites* species (Hughes and Moody-Stuart 1966, p. 288; 1967*b*, p. 353).

Appendicisporites jansonii Pocock 1962

Remarks. Our biorecord 9 CICATR *AP* may be included here on the basis of our views on the genus, although it is not, of course, strictly according to Pocock's diagnosis. Burger (1966) used *A. tricornitatus* for such spores. Another earlier biorecord 12 CICATR *APP* agrees more closely in size with this species, as do *Pelletieria valdensis* (spores) which we described in 1966.

Cicatricosisporites (*Anemia*) *crimensis* (Bolkh.) comb. nov.

Remarks. Our biorecord 8 CICATR *C2* belongs here; see Bolkhovitina 1961 (p. 55, pl. 15, fig. 8), and Samoilovich *et al.* 1961 (p. 75, pl. 19). Western authors have consistently used the Senonian *Appendicisporites tricornitatus* for these spores (Couper 1958, Döring 1965); Döring (1965, pl. 12, figs. 5–7) figured a battered specimen with the broken radial area that we find characteristic in the biorecord *C2*.

Stratigraphic range. The Russians record the range of this species as Hauterivian onwards. Döring (1965) found it to be restricted to German Wealden G, which is Early Valanginian, and our records are in agreement with this. Burger (1966) had no such species, which suggests that perhaps his section may not have gone high enough to contain them. Our separate earlier biorecord 13 CICATR *C2L*, which is distinct and of a much larger spore, may fall into *Anemia pschekhaensis* Bolkh. 1961 (pl. 15, fig. 9).

Results of systematic study

From the systematic discussion above it can be seen that in no case is the attribution clear-cut and satisfactory both in taxonomy and in nomenclature. The inclusion in the discussion of any post-Hauterivian taxonomy on a morphological basis only adds to the confusion.

Ignoring the circumscriptions and names, however, it is clear that the *Cicatricosisporites* spore assemblages we have studied in Britain compare closely with those of similar age from the Netherlands (Burger 1966) and Mecklenburg (Döring 1965), if not also with those of the U.S.S.R. All of the spores they describe are recognizable in our assemblages, and we have relatively few types that they do not indicate in any way. It is even possible to suggest that Döring's (1965) German Wealden A may be later than he suggests in his table, and perhaps equivalent to about 1,940–1,920 ft. in the Warlingham Borehole.

Further work in progress covers other British sections, and firmer correlation with continental sections.

GENERAL CONCLUSIONS

1. The method used has evolved during the work, with the result that some minor decisions, such as the sample selection for biorecords, could in future be improved when starting with an agreed method; biorecords are of course not claimed as any new invention, but rather as a planned convenience.

2. Events are intended to remain open for additional data; in cases of such addition the event number could be modified by decimalized suffix with a new date.

3. It seems possible that there is some minor fault repetition (or even omission) in the Wealden of the Warlingham Borehole, as there is in the Purbeck Beds below, and it should become apparent through this form of analysis.

4. Neither the terms (*biorecord*, *event* etc.) nor the precise arrangements used need to remain unchanged. Criticism is invited (*a*) of method, and (*b*) of the execution.

5. We do not envisage this correlation method as more powerful than others over a greater distance. Long-distance (inter-province) single-item biological correlation is a pipe-dream; world-wide correlation will eventually be achieved by many consecutive steps essentially of the kind envisaged here, although certain short cuts are not precluded.

6. We believe from this study that although our scale of working approaches that of plant 'migration' time, it is still well above it.

7. A usual criticism of this kind of work is that it presupposes biological (or earth)

evolution. It makes this assumption in general, but this does not invalidate the separate investigation of evolution in detail.

8. The slightly extended presentation here is intended to draw attention to the data storage need. Future publication level in this field may have to be 'plates and diagnosis', or even 'plates alone', with the remainder advertised 'on call'. An attempt has been made to allow for data handling problems so far foreseen.

9. We believe that methods such as are presented here are necessary throughout stratigraphic palaeontology. The clear separation of basic data from interpretation is as essential in stratigraphy in the de-formalizing of the concept of zones, as it is in palaeontology in the restriction of 'Linnaean' taxonomy and nomenclature to interpretative functions alone.

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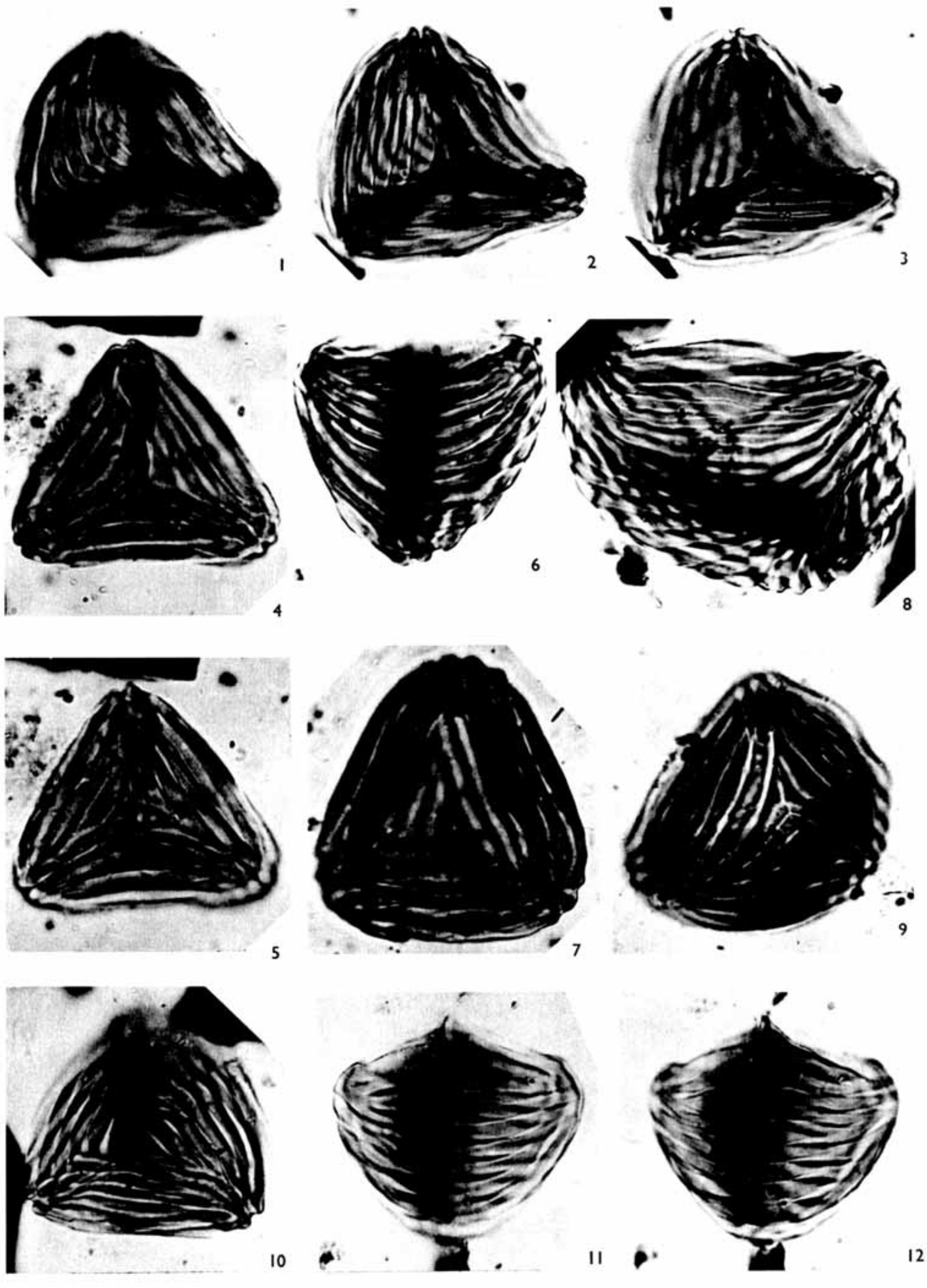

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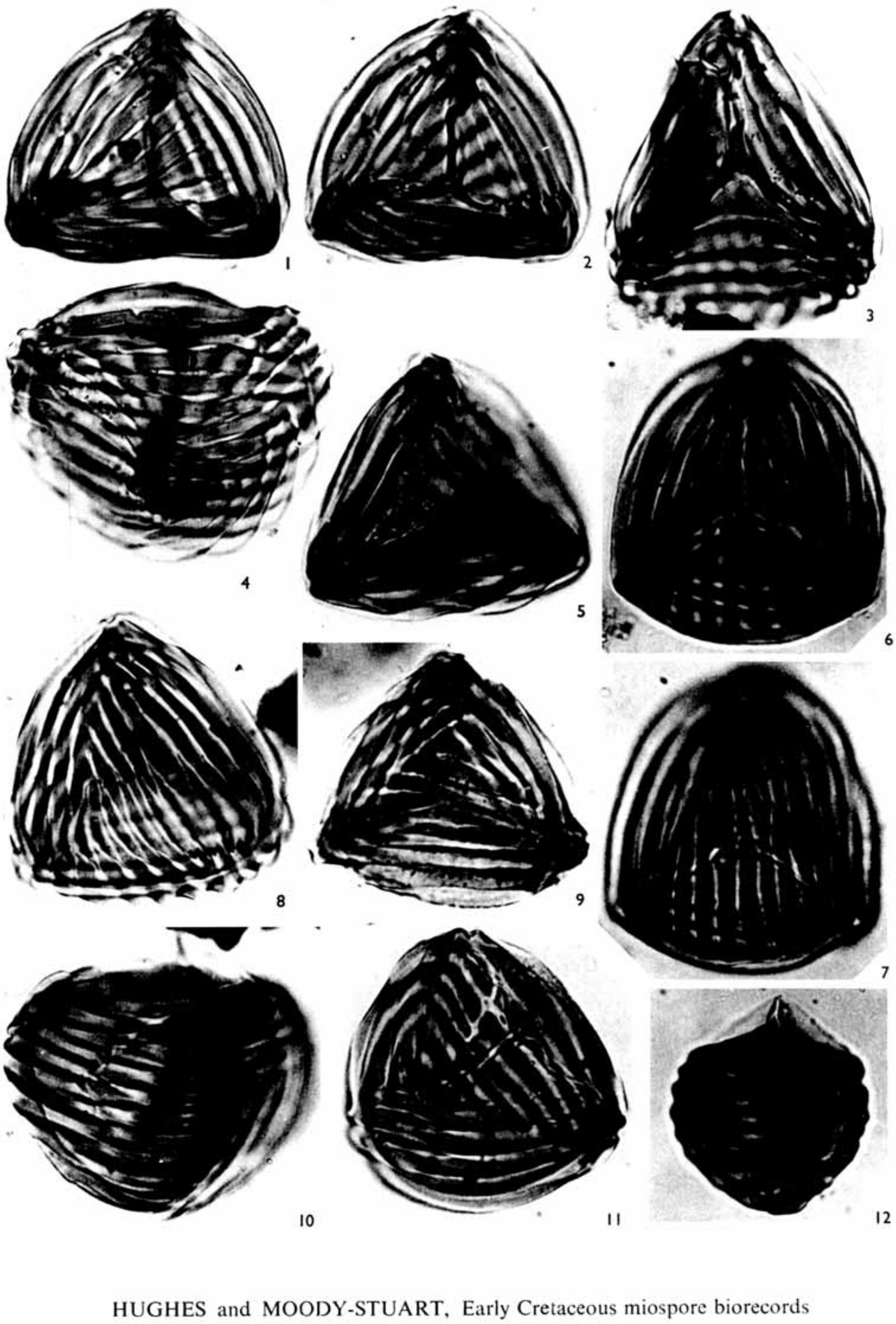

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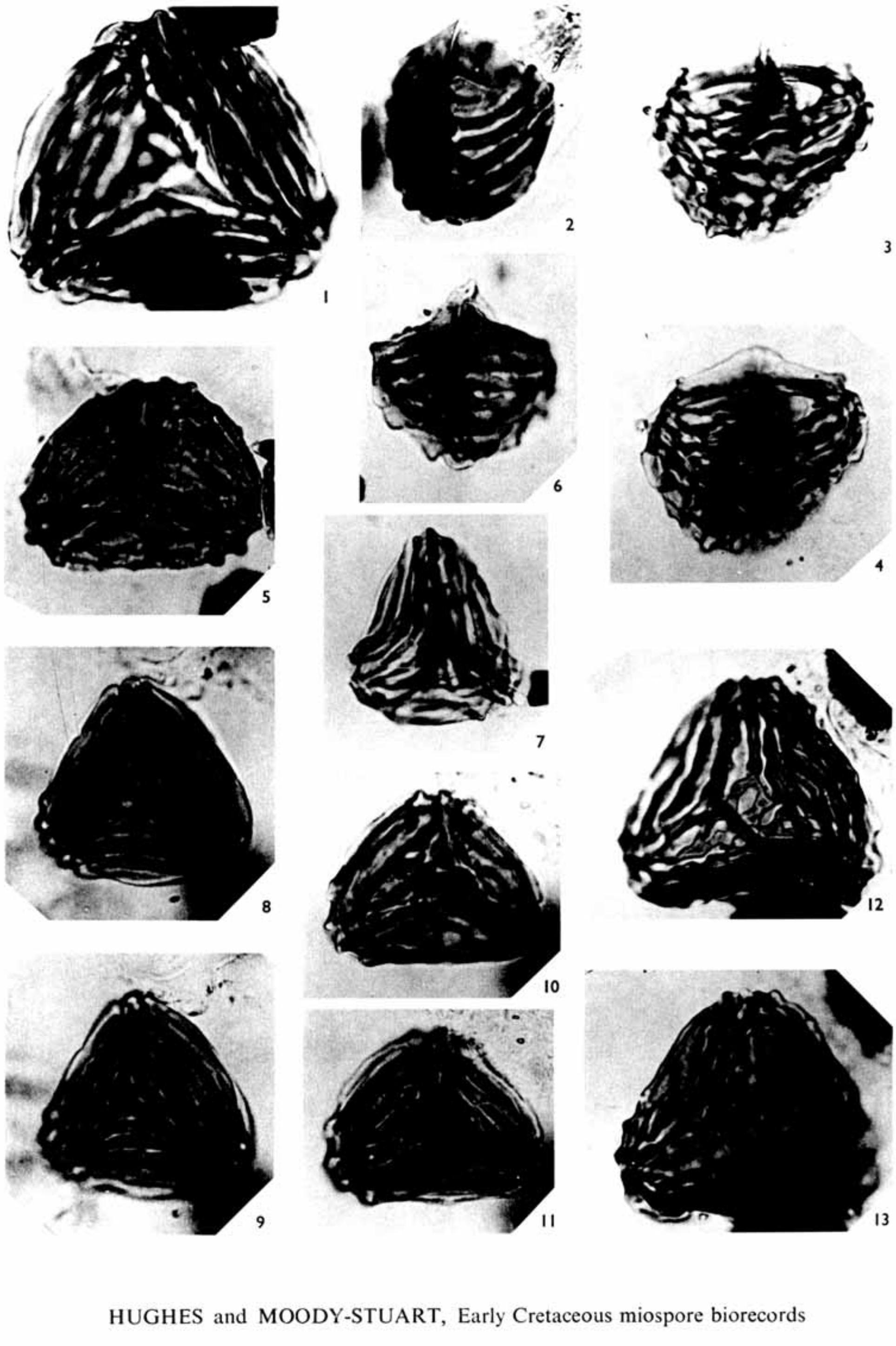

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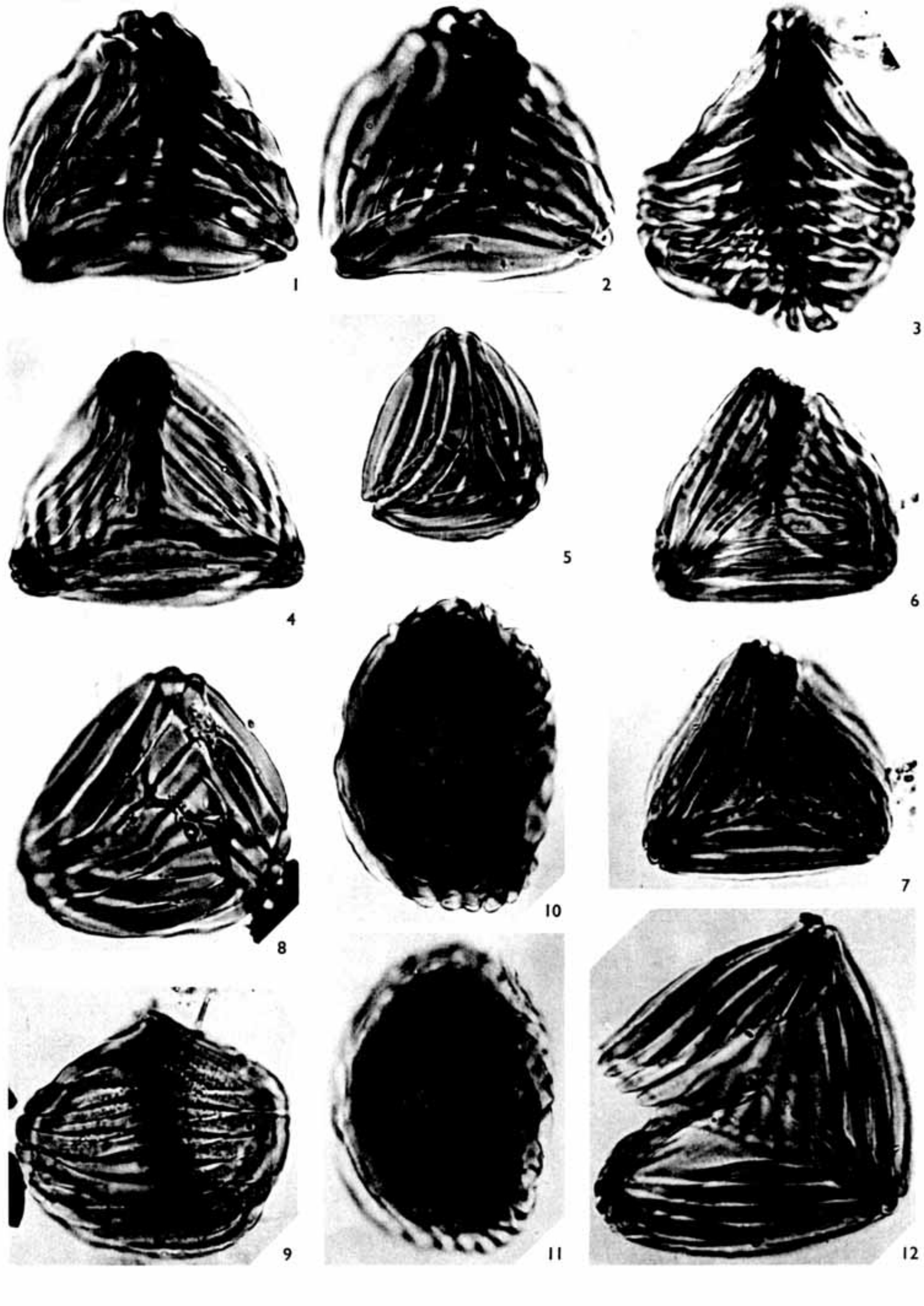

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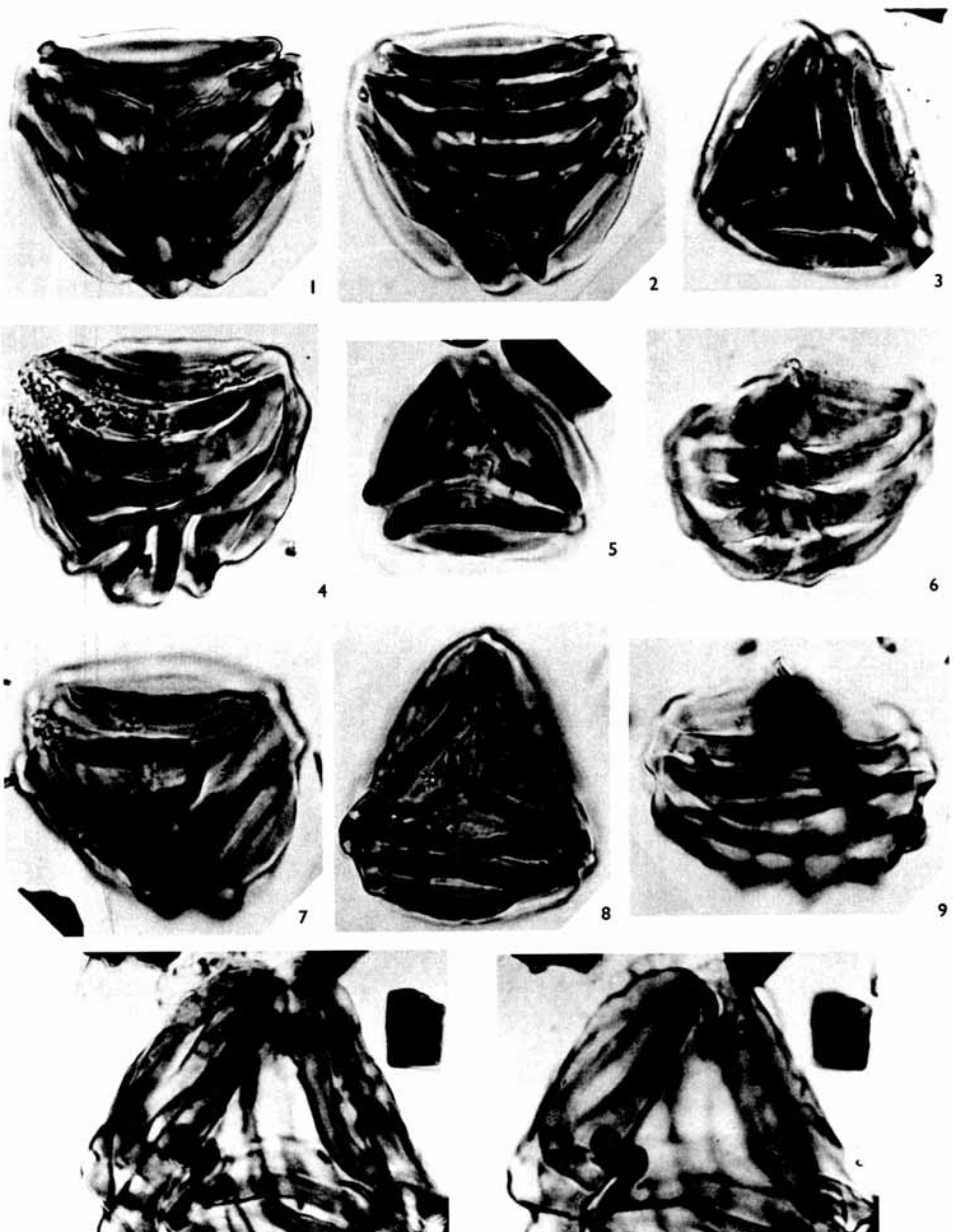

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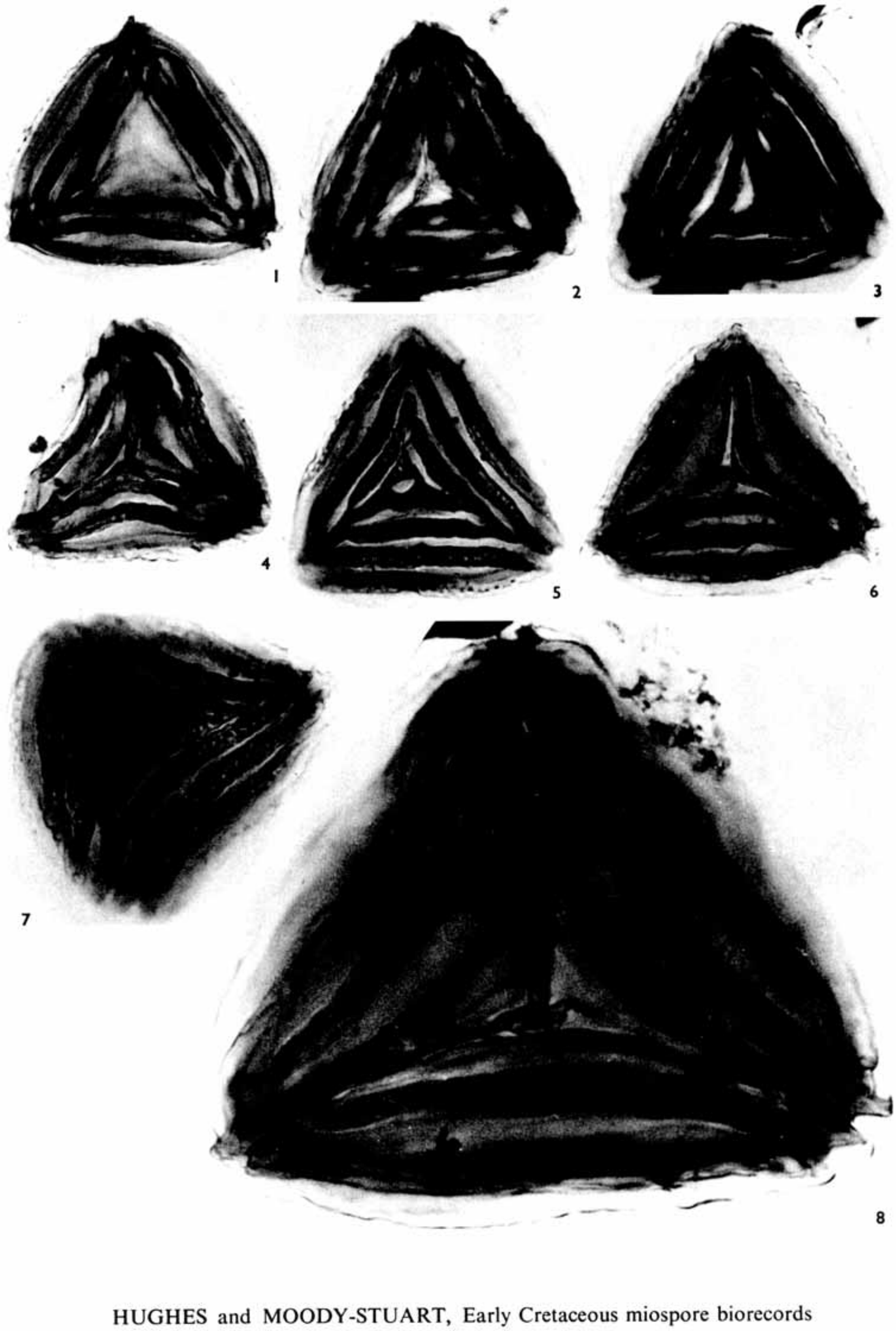

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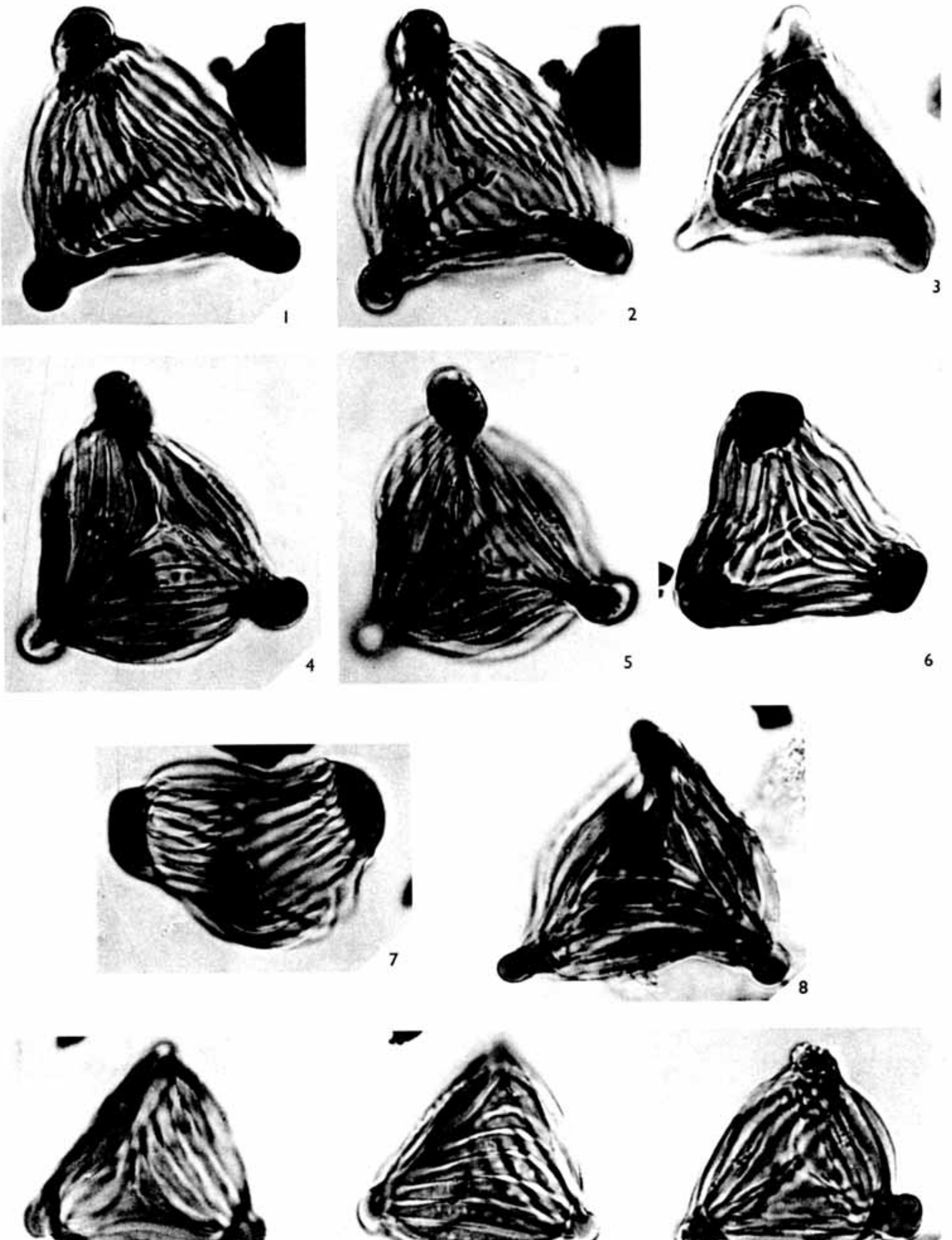

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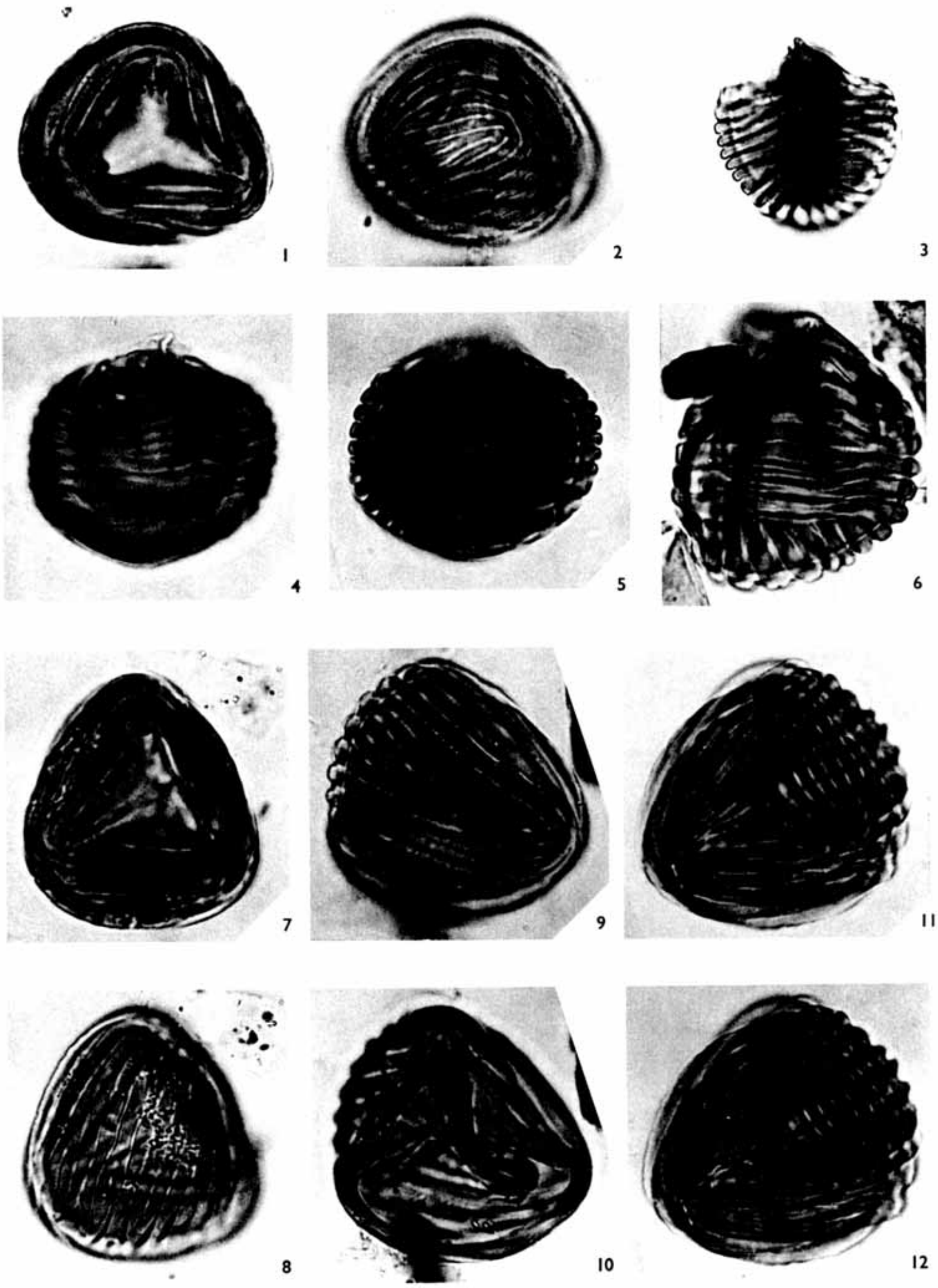

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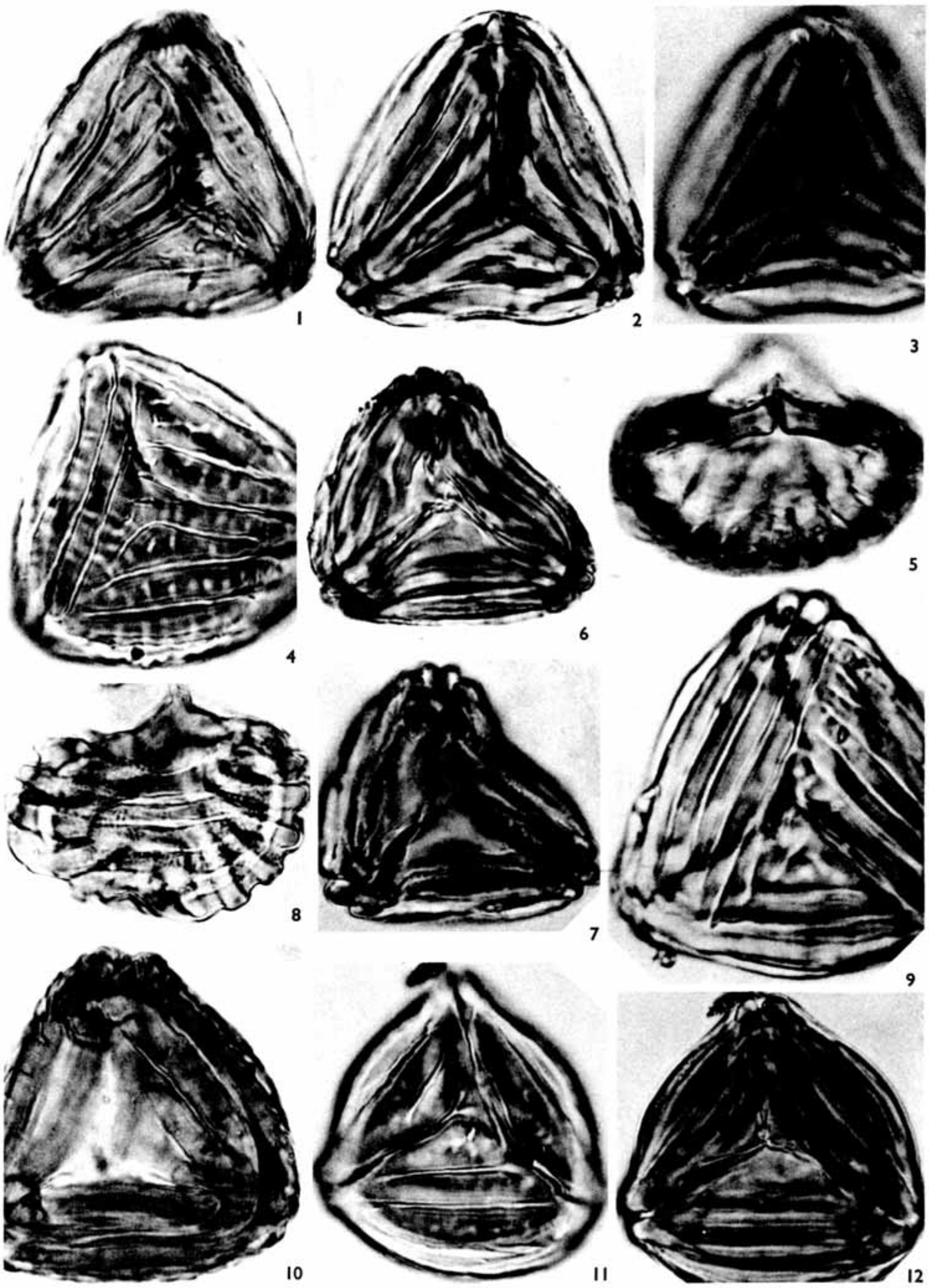

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