EARLY CRETACEOUS ACOLUMELLATE SEMITECTATE POLLEN FROM EGYPT

by JAMES H. J. PENNY

ABSTRACT. Scanning electron microscope observations were made of more than one thousand specimens of acolumellate semitectate pollen, all of which originate from the borehole Mersa Matruh 1, North-West Desert, Egypt. The detail observed enables thirteen forms to be distinguished from this set of specimens. It is suggested that the acolumellate pollen group should be separated from affinities with described columellate taxa. The newly described variety in this group gives it improved stratigraphic value.

THE pollen grains discussed in this paper are distinguished from other semitectate monosulcates by their lack of columellae, a feature which has otherwise only been reported in a few forms of the distinctive genus *Afropollis* Doyle *et al.*, 1982. This acolumellate semitectate group has been referred to generally as the '*Retimonocolpites reticulatus–peroreticulatus*' Gruppe Schrank, 1982. The purpose of this paper is to attempt to clarify the taxonomic variety in the acolumellate group using specimens from the early Cretaceous of Egypt. Much similar variation must have been overlooked in previous LM based studies.

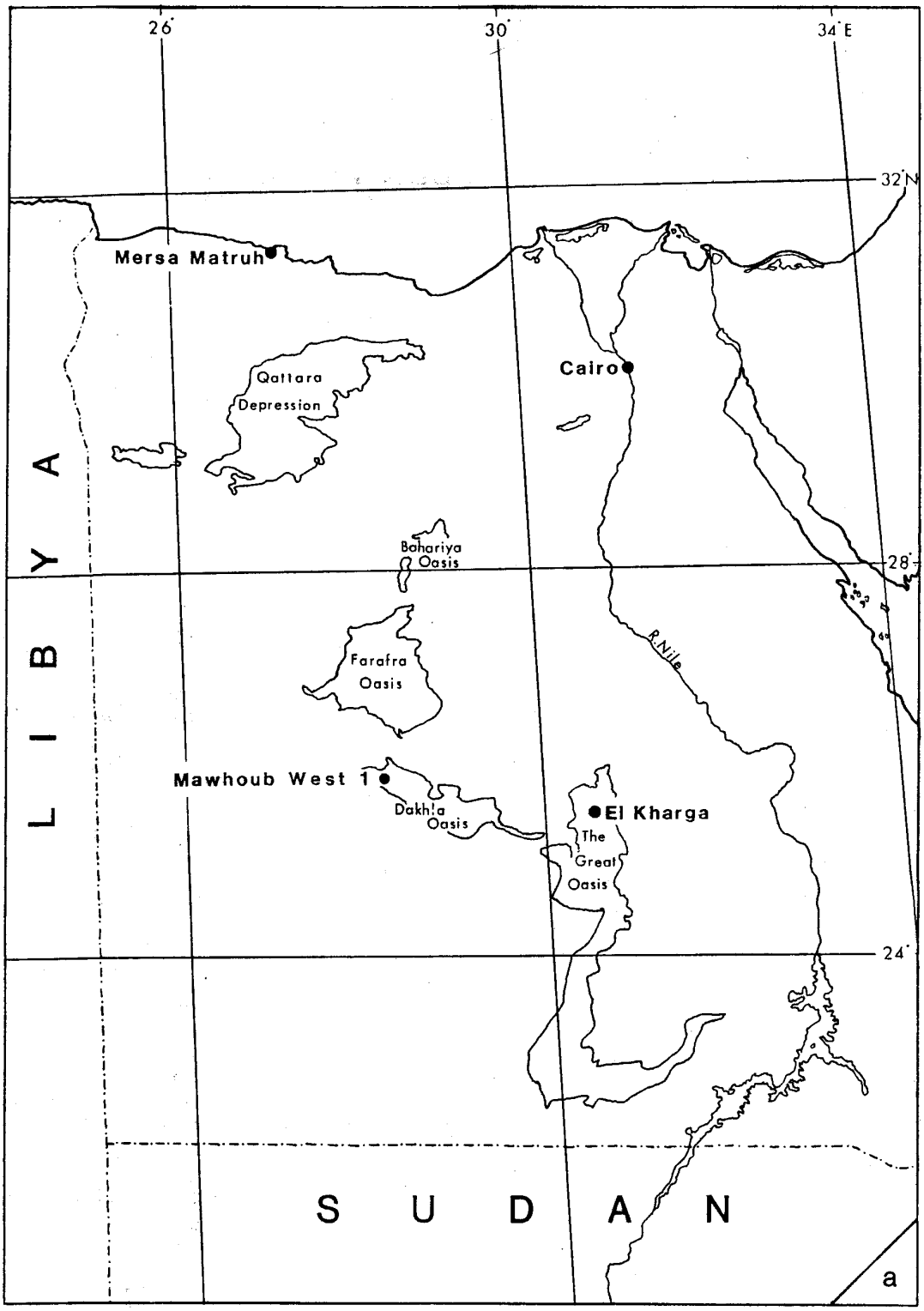
The first observations of such pollen were made by Brenner (1963) who recovered early Cretaceous (?Barremian to Albian) specimens from samples of the Potomac group of Maryland. Brenner described these as 'monosulcate sporomorphae; sulcus extending the whole length of the grain(s); outline in polar view fusiform'. The 'outer layer' (sexine) was interpreted as a perisporium because it sometimes passed over the aperture without interruption, an effect which is now known to be due to rotation of the nexine within the sexine causing aperture misalignment. Brenner placed his specimens in the perinate monolete spore genus *Peromonolites* Couper, 1953, describing two new species, *P. reticulatus* and *P. peroreticulatus*.

Subsequent observations contributed to a growing suspicion of the probable angiospermous affinities of this pollen, culminating in its transfer to *Liliacidites* Couper, 1953 by Singh (1971). Further observations, ranging from ?Barremian to Cenomanian, increased the stratigraphic range while the geographic occurrences included most sites examined in Laurasia and Gondwana.

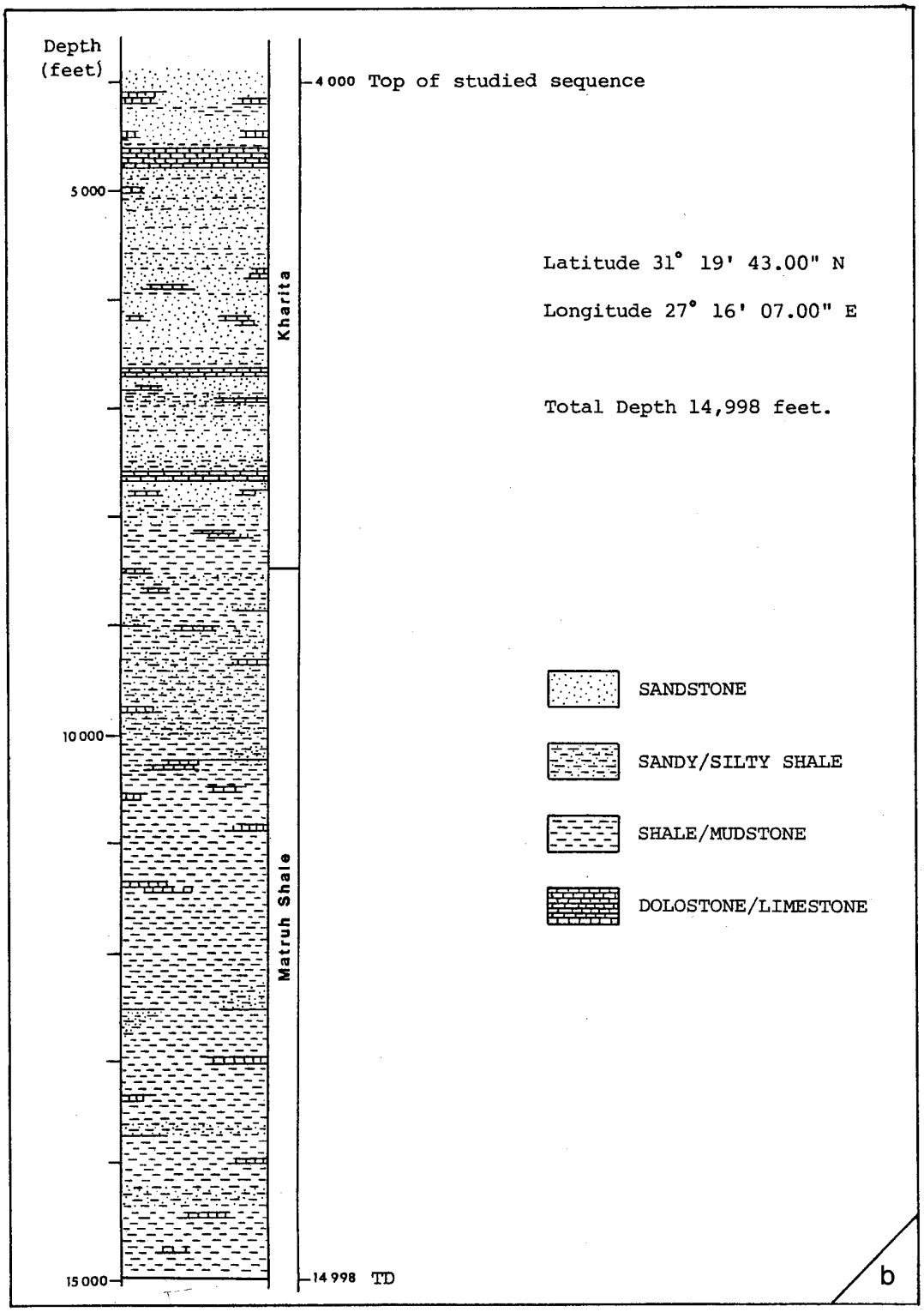
Doyle *et al.* (1975) examined new material from Brenner's type locality in the Arundel Clay, using combined light, scanning electron and transmission electron microscopy. Their LM measurements of fifty grains showed a clear separation into two possibly closely related angiospermid forms. However, SEM revealed new features that prevented confident assignment of these specimens to the two original Brenner species, both of which had been transferred to *Retimonocolpites* Pierce, 1961 in the same paper, *Liliacidites* being reserved for grains with a bimodal distribution of lumina size. Hence the two forms recognized by Doyle *et al.* (1975) were designated as *R. peroreticulatus* and *R.* cf. *reticulatus*, the latter providing the first hint of the probability that future more detailed observations might enable further pollen with similar morphology to be recognized. Similar difficulties were experienced by Laing (1975), who found specimens whose morphologies overlapped with both the Brenner species, providing evidence of a wide and poorly understood range of morphology. In spite of numerous further reports of similar specimens no new species were recognized, and many of these observations were attributed to the now less than useful *R. peroreticulatus*, albeit with a certain lack of conviction (e.g. 'aff.' and 'cf.' being used to indicate uncertainty).

This taxonomic perplexity and stratigraphic confusion, which partly relates to the lack of detailed (i.e. SEM) observations of many specimens, is clearly reflected by Schrank (1982), who viewed the

[Palaeontology, Vol. 31, Part 2, 1988, pp. 373–418, pls. 28–38.]



TEXT-FIG. 1. *a*, Location of Mersa Matruh 1.

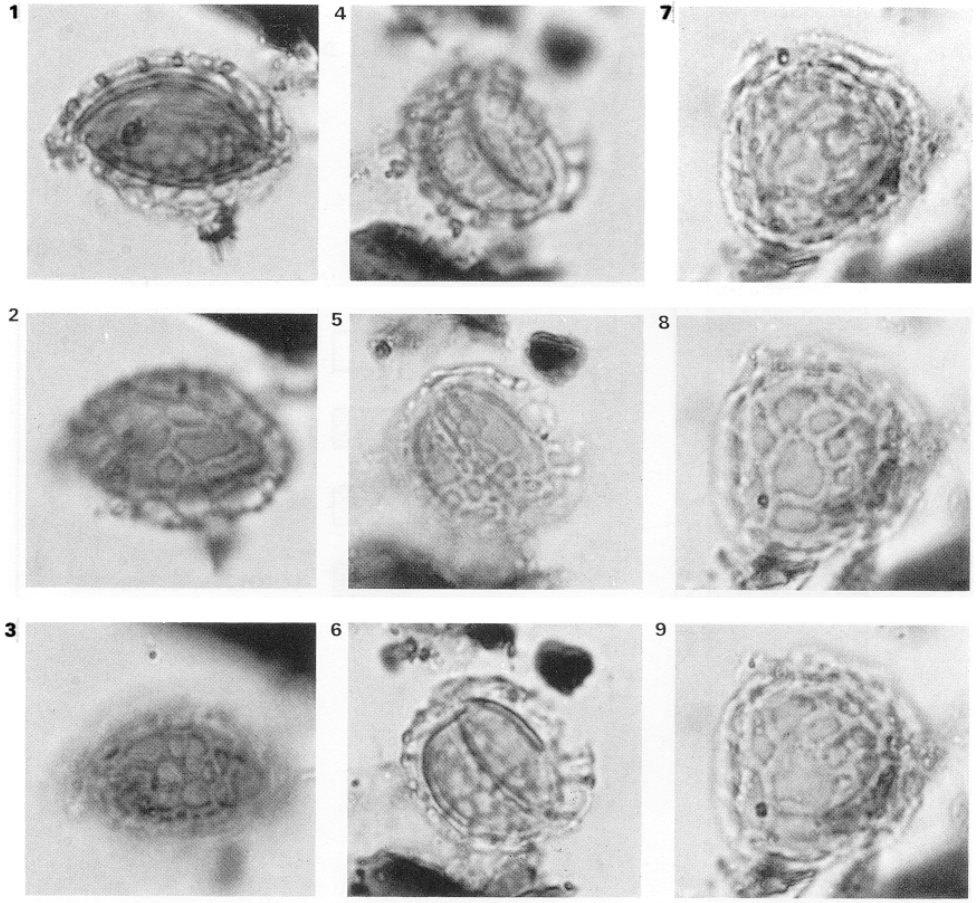


TEXT-FIG. 1. *b*, stratigraphic log of Mersa Matruh 1.

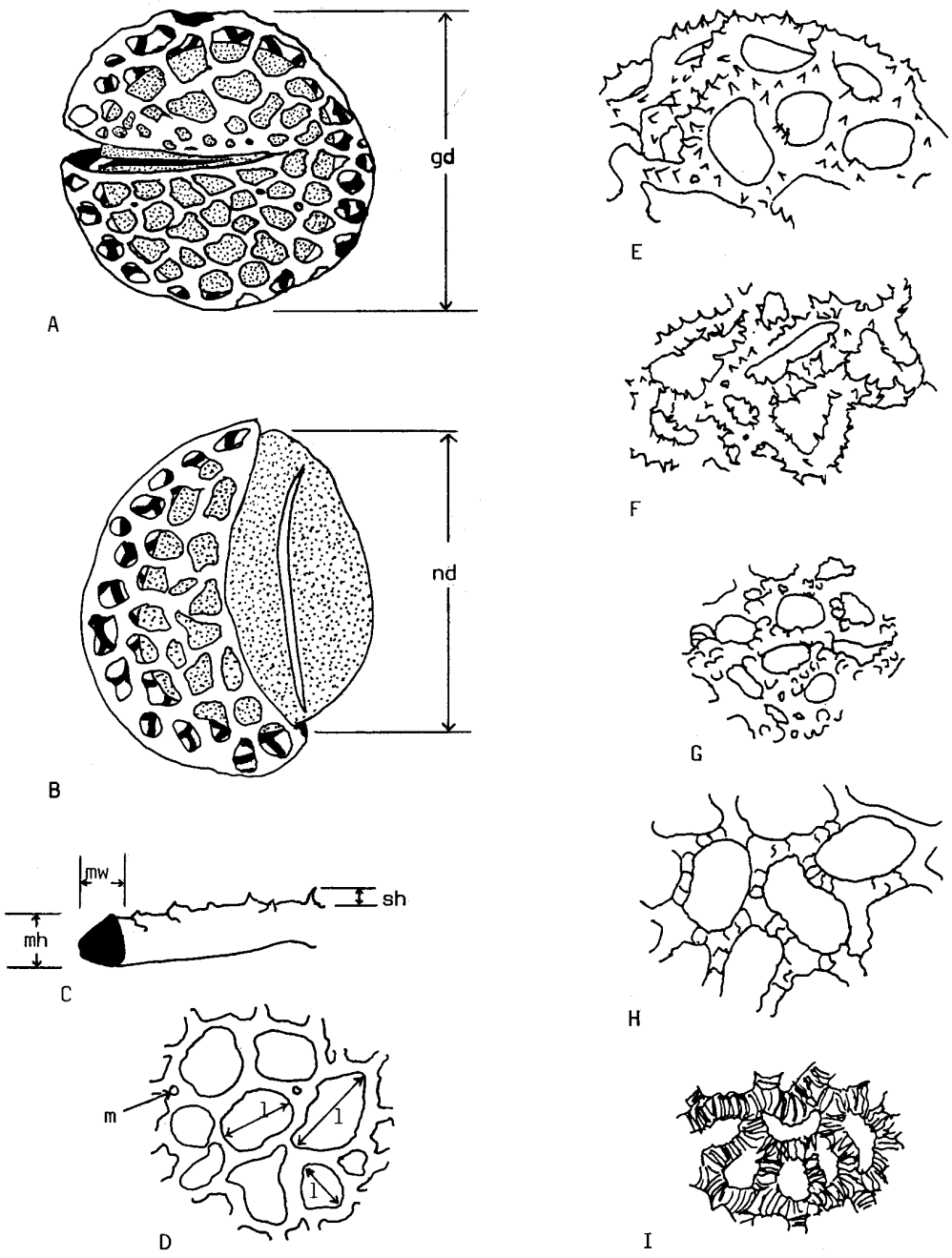
whole group as an unresolved complex of forms, the *R. peroreticulatus–reticulatus* Gruppe. Juhász and Góczán (1985) tried to clarify the status of *R. reticulatus* and *R. peroreticulatus*, transferring them to a new genus, *Brenneripollis*. This work was based on LM observation and did not fully reveal the range of morphology of the group. In addition they defined *Brenneripollis* as containing both columellate and acolumellate pollen, which I prefer to distinguish separately.

MATERIALS AND METHODS

The specimens studied were recovered from cuttings (marked * in the text) and core samples of the borehole Mersa Matruh 1, which is situated at 31° 19′ 43.00″ N. and 27° 16′ 07.00″ E. in the North-West Desert of Egypt (text-fig. 1). The borehole was logged in feet and sample numbers therefore correspond to their original depth in feet in the well. The age range of the samples, which were dated by palynological correlation, is early Aptian to



TEXT-FIG. 2. Micrographs of three grains from sample MMX-1 7885 illustrating the typical appearance of acolumellate pollen under light microscopy; each grain is shown at three levels of focus (all magnifications × 1600).



TEXT-FIG. 3. The main descriptive features of the *Retimonocolpites reticulatus–peroreticulatus* group Schrank, 1982. A, general morphology of the sexine, showing the aperture with smaller adjacent lumina (upper margin) or with ungraded lumina (lower margin); gd, grain diameter. B, sexine partially removed to reveal the nexine (stippled), which has a simple slit-like aperture and is not attached to the sexine; nd, nexine diameter. C, a section of a murus illustrating the absence of columellae on the lower surface; mh, murus height, mw, murus width, sh, spine height. D, a section of the reticulum illustrating the occurrence of microlumina (m); l, maximum internal diameter of the lumen. E–I, sketches illustrating the range of supramural sculpture present in the group; E, single spines, F, paired spines, G, lobes, H, lobes and ridges, I, transverse ridges.

early Albian (Penny 1986*a*). A detailed general account of the sedimentary history and palynology of the sequence is given elsewhere (Penny 1986*a*).

Standard palynological techniques involving HCl, H_2F_2, and oxidation with HNO_3 were used in the preparation of the samples. In order to conserve the very small palynomorphs the residues were not sieved. Material from the organic residues was spread evenly over the surfaces of stubs equipped with Cambridge Geology SEM grids (Hughes *et al.* 1979). After coating with gold the stubs were searched systematically using a Phillips 501B Scanning Electron Microscope and selected specimens photographed using black and white 70 mm Ilford FP4 film. Grid coordinates were recorded for future relocation of the specimens.

More than one thousand specimens referable to the *R. peroreticulatus–reticulatus* group were located during the scan searches of the strew mount preparations. Each was recorded photographically at routine magnifications of × 1300 and × 7000, detailed measurements being taken directly from the photographs. LM was only used for general sample assessment because insufficient detail is observed with this technique (text-fig. 2).

The important features of the grains illustrated in text-fig. 3 include maximum diameter, maximum internal diameter of lumina, murus height and width, and form of the supramural sculpture. Total exine thickness could be measured only where broken grains were available and nexine diameter was often obscured by the sexine. Total diameter measurements therefore include the sexine and were taken across the widest part of the grain, which was not invariably along the aperture axis. Internal diameters of the lumina were measured across their widest points. Muri widths and heights were measured only from suitably oriented muri in order to avoid oblique measurements. Pronounced supramural sculpture was not included in murus height measurements. As many measurements of muri and lumina as possible were taken from each grain.

The form of the supramural sculpture was found to be very important in distinguishing grain types. Although there were several clearly recognizable categories of sculpture it was difficult to express this variability numerically. Careful observation of each grain was therefore required and several features were defined by which objective separation might be achieved. These features included the degree of spine development (e.g. absent, truncated, short, long); spine arrangement (e.g. random, opposite pairs, densely-packed, sparse) and transverse ridge development (e.g. random swellings, opposite lobes, entire ridges). Some of these sculptural forms are illustrated in text-fig. 3 and also in the plates.

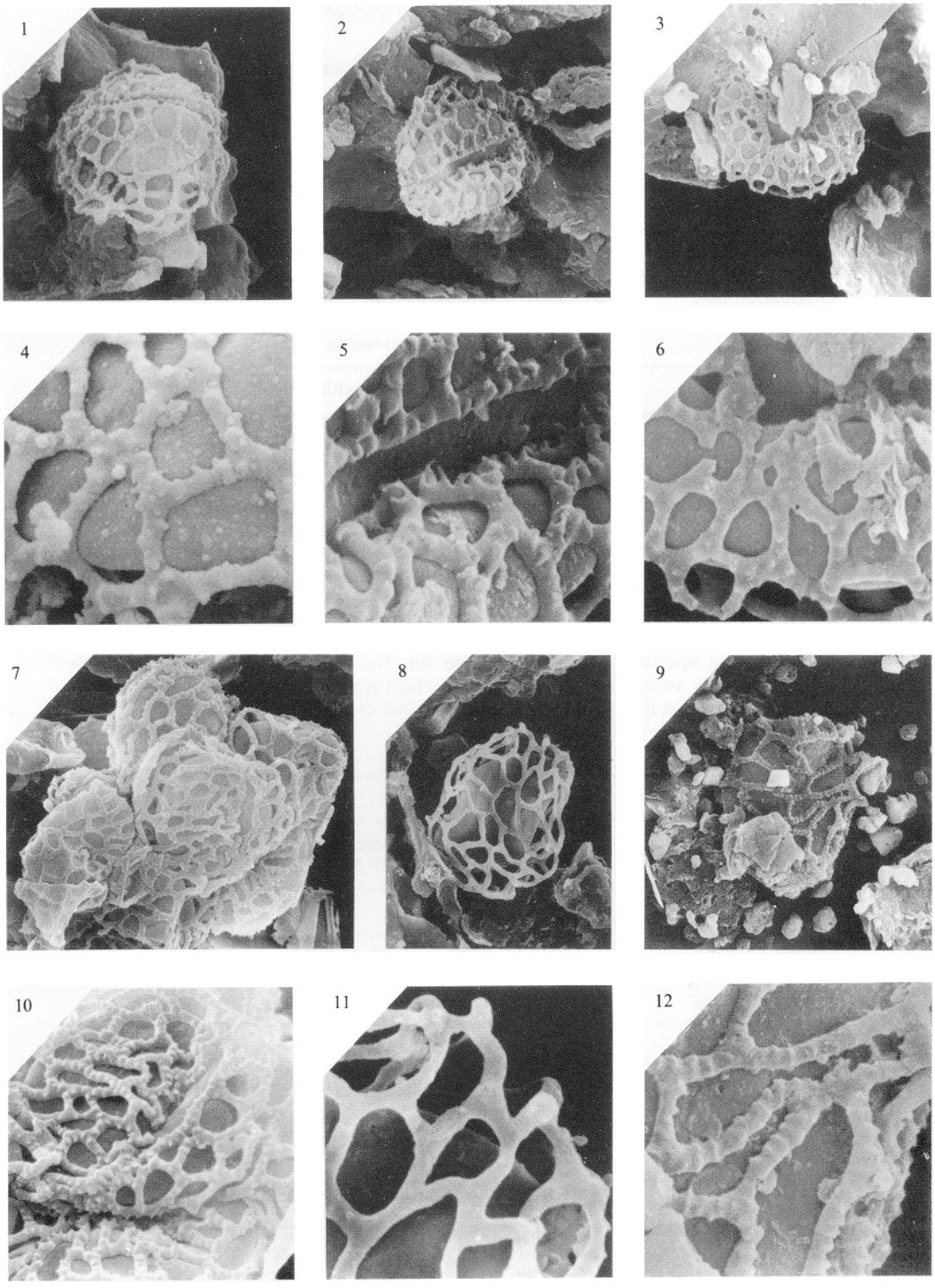
All samples, preparations, and specimens discussed here are deposited in the Sedgwick Museum, Cambridge University, UK.

SYSTEMATIC PALAEONTOLOGY

Recording methods. The pollen forms described below were recorded using the biorecord/comparison record system of Hughes (1976) in the format suggested by Hughes (1986). The most important concept of this system is that of the unalterable reference observation (i.e. biorecord). Subsequent observations must refer back to the original biorecord, which consequently needs to be established with the greatest detail of as many specimens as possible. All the specimens in any record originate from a single sample. The similarity of subsequent records to the referenced biorecord is assessed and these records stored separately (graded comparison records). More extended discussions of the difficulties involved in using conventional nomenclature for fossil pollen are given by Hughes (1986) and Penny (1986*b*).

EXPLANATION OF PLATE 28

Figs. 1–12. RETIMONO-NECKLACE. 1 and 4, grain number JPR 135/2 (Biorecord), sample MMX-1 5203, prep. JP 063, stub JPS 103, coordinates 768 × 293. 1, × 1600, neg. 69/28; 4, × 7000, neg. 259/2. 2 and 5, grain number JPR 135/4 (Biorecord), sample MMX-1 5203, prep. JP. 063, stub JPS 103, coordinates 765 × 275. 2, × 1600, neg. 70/2, 5, × 7000, neg. 70/4. 3 and 6, grain number JPR 135/5 (Biorecord), sample MMX-1 5203, prep. JP 063, stub JPS 103, coordinates 848 × 283. 3, × 1600, neg. 72/16; 6, × 7000, neg. 72/17. 7 and 10, grain number JPR 650/9 (CfA), sample MMX-1 5440*, prep. JP 043, stub JPS 77, coordinates 798 × 365 (a group of grains). 7, × 1600, neg. 64/3; 10, × 4000, neg. 64/16. 8 and 11, grain number JPR 653/41 (CfA), sample MMX-1 8597, prep. JP 023, stub JPS 109, coordinates 798 × 218 (slightly smoother muri than usual). 8, × 1600, neg. 132/9; 11, × 7000, neg. 132/10. 9 and 12, grain number JPR 15/1 (CfA), sample MMX-1 10617, prep. JP 030, stub JPS 104, coordinates 768 × 315. 9, × 1600, neg. 75/14; 12, × 7000, neg. 75/15.



PENNY, Retimono-necklace

TABLE 1. Biorecord: RETIMONO-NECKLACE.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/early Albian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 7 July, sixteen 45.
Taxon name	K	Biorecord: RETIMONO-NECKLACE.
Description	M	(All observations made with SEM.) Monocolpate pollen, rounded outline, maximum diameter 12·7(16·0)18·0 μm. Exine semitectate, reticulate, lumina large, irregularly subcircular with even size distribution, maximum internal diameter 1·5(2·2)2·8 μm. Microlumina absent. Muri rounded in cross-section or with flattened lower surfaces, 0·4(0·43)0·5 μm wide, 0·4(0·42)0·5 μm tall; upper surfaces of muri sculped with low undulations, transverse ridges, and occasional small blunt spines. The combination of narrow muri and transverse ridges causes variations in murus width, giving the muri an undulating segmented appearance when viewed perpendicularly; the lobes and transverse ridges sometimes appear to extend down the sides of the muri, which are otherwise unsculped; lower surfaces of muri unsculped; columellae absent. Aperture long, extending up to half the circumference of the grain. Aperture margins entire, unspecialized, no tendency for adjacent lumina to be smaller than elsewhere on the grain. Corresponding aperture in nexine a simple slit. Nexine smooth, rounded to slightly reniform, loosely attached to the sexine from which it may be separated by a large gap; nexine often rotated inside sexine. Maximum nexine diameter 11·3(13·1)14·5 μm.
Variation record	N	Recorded under M.
Number of specimens	L	7.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt Grid ref. 31° 19′ 43.00″ N. 27° 16′ 07.00″ E.
Rock formation	D	Kharita.
Sample position	E	MMX-1 5203, at depth 5203 ft.
Sample lithology	E	Grey silty shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparation JP 063. Stubs JPS 102, JPS 103.
Earlier records	S	None.
Conclusion	T	Ends.

TABLE 2. Biorecord: RETIMONO-SPINEROW.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/late Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 8 July, fifteen 36.
Taxon name	K	Biorecord: RETIMONO-SPINEROW.
Description	M	(All observations made with SEM.) Monocolpate pollen, rounded outline, maximum diameter 14·5(17·5)20·0 μm. Exine semitectate, reticulate, lumina rounded to irregularly polygonal with even size distribution, maximum internal diameter 0·9(2·0)3·1 μm. Microlumina absent. Muri rounded in cross-section or slightly wider than tall, height 0·4(0·5)0·6 μm, width 0·5(0·7)0·9 μm; upper surface of muri sculped with distinct spines up to 0·4 μm tall and often arranged in pairs on opposite sides of the muri, bases of spines may be united to form transverse ridges; sides and lower surfaces of muri unsculped, columellae absent. Aperture long, up to half the circumference of the grain, margins continuous, unspecialized with no tendency for adjacent lumina to be smaller than on the main body of the grain; there is a corresponding slit-like aperture in the nexine. Nexine smooth, sometimes closely applied to the sexine but usually separated by a distinct gap. Accurate nexine measurement obstructed by sexine, range 12·9–20·0 μm. Nexine may be rotated inside the sexine.
Variation record	N	Recorded under M.
Number of specimens	L	9.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N. 27° 16′ 07.00″ E.
Rock formation	D	Kharita.
Sample position	E	MMX-1 7890, at depth 7890 ft.
Sample lithology	F	Fine-grained yellow sandstone.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparations JP 066, 180. Stubs JPS 228, 229, 230.
Earlier records	S	None.
Conclusion	T	Ends.

In this paper a biorecord is a reference observation which includes sufficient detail for adequate taxonomic circumscription. 'Cand' is a reference observation which lacks the full descriptive information (e.g. too few specimens or incomplete observation), while 'spot' is a reference observation of a single distinctive specimen. For clarity only these reference taxon descriptions are included here. These, together with all their associated comparison records, are also deposited in the Department of Earth Sciences, University of Cambridge, UK.

Genusbox RETIMONO

Descriptive limits: Monocolpate pollen, semitectate, reticulate, acolumellate. Lumina size distribution not markedly bimodal.

Biorecord: RETIMONO-NECKLACE

Plate 28; Table 1

Comparison and remarks: RETIMONO-NECKLACE. This pollen is mainly distinguished by the muri, which are narrow and often have the appearance of strings of beads because of the variations in width caused by the sculpture of transverse ridges and swellings. The lumina are also large in relation to the murus width, giving the reticulum a very open appearance that is accentuated by the large discrepancy that frequently exists between the sizes of the nexine and sexine which are consequently liable to be separated by a large gap.

Similar types include RETIMONO-TYPESIX, which is distinguished by its smaller diameter and finer reticulum and also lacks the large gap between sexine and nexine.

A single similar specimen was illustrated by Chapman (1982, figs. 29–31) from a Portuguese sample of late Albian age, but this specimen differs slightly in its possession of microlumina along the aperture margins.

There is one CfB record, JPR 655, which is a single slightly larger grain from sample MMX-1 8900*.

Occurrence of RETIMONO-NECKLACE (*biorecord and CfA records*). Grains with this morphology range between samples MMX-1, 5203 (early Albian) and MMX-1 10617 (early Aptian). They are most common in the upper part of their range, where they peak at 11·9 % of the total angiosperm grains recovered in sample MMX-1 5440* (early Albian).

Deposited records of RETIMONO-NECKLACE (sample number MMX-1 . ./number of specimens). Biorecord: 5203/7; CfA: 5430*/1, 5440*/8, 6050*/1, 7695/2, 8597/8, 8818/2, 9170*/3, 9182/1, 9867/1, 10617/3; CfB: 8900*/1.

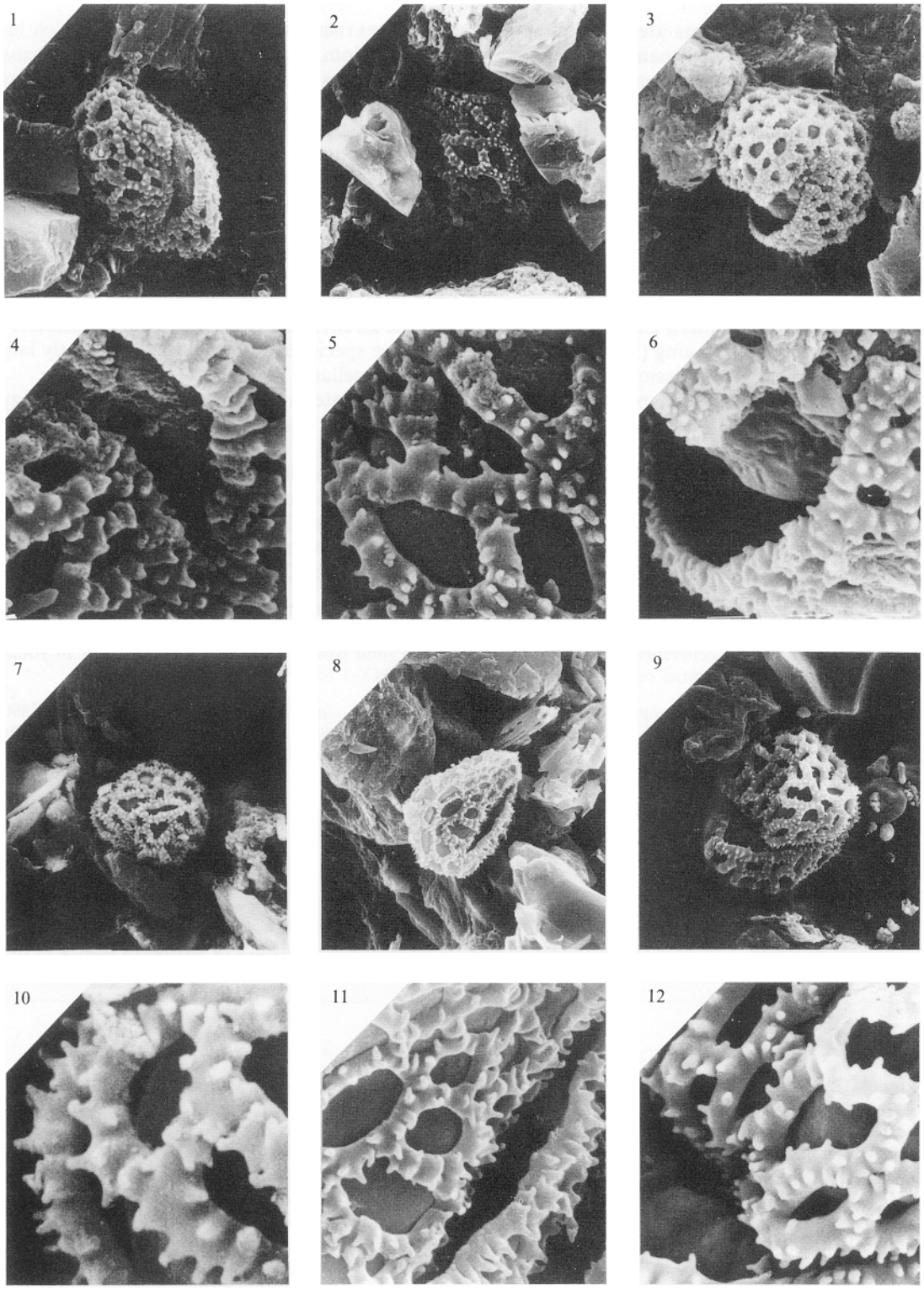
Biorecord: RETIMONO-SPINEROW

Plate 29, Table 2

Comparison and remarks: RETIMONO-SPINEROW. This is the second most common pollen type in the group, occurring throughout the sequence. It is distinguished by the regular occurrence of opposite pairs of spines, although single spines placed at random may also occur. Sometimes there may be three or more spines in rows across the muri.

EXPLANATION OF PLATE 29

Figs. 1–12. RETIMONO-SPINEROW. 1 and 4, grain number JPR 670/1 (Biorecord), sample MMX-1 7890, prep. JP 066, stub JPS 228, coordinates 825 × 385. 1, × 1600, neg. 190/5; 4, × 7000, neg. 190/6. 2 and 5, grain number JPR 670/5 (Biorecord), sample MMX-1 7890, prep. JP 066, stub JPS 228, coordinates 835 × 318. 2, × 1600, neg. 190/14; 5, × 7000, neg. 190/15. 3 and 6, grain number JPR 670/24 (Biorecord), sample MMX-1 7890, prep. JP 066, stub JPS 228, coordinates 758 × 235. 3, × 1600, neg. 193/16; 6, × 7000, neg. 193/17. 7 and 10, grain number JPR 663/26 (CfA), sample MMX-1 6050*, prep. JP 040, stub JPS 71, coordinates 782 × 357. 7, × 1600, neg. 259/5; 10, × 7000, neg. 259/6. 8 and 11, grain number JPR 666/58 (CfA), sample MMX-1 7310*, prep. JP 195, stub JPS 245, coordinates 817 × 286. 8, × 1600, neg. 242/32; 11, × 7000, neg. 242/33. 9 and 12, grain number JPR 676/30 (CfA), sample MMX-1 8818, prep. JP 182, stub JPS 251, coordinates 732 × 318. 9, × 1600, neg. 212/32; 12, × 7000, neg. 212/33.



PENNY, Retimono-spinerow

The most similar forms are RETIMONO-SPOTSPINES and RETIMONO-HEDGEHOG, both of which have spines which are predominantly placed singly and at random, although they do have occasional paired spines. Single specimens with few paired spines are thus difficult to distinguish, as they may represent extremes of either of these three forms. The existence of these marginal forms argues for a possibly close relationship between these three spinose varieties. The single spine types are rarer in the early part of the sequence, becoming dominant in the younger sediments. RETIMONO-SPINEROW declines in the more recent strata, eventually being represented only by CfB records which consist of smaller grains with finer reticula and reduced spines. It is possible that when more specimens become available these CfB records will be described as a separate form with a RETIMONO-SPINEROW ancestry, a hypothesis supported by the transitional nature of the grains in sample MMX-1 6050*, where both the CfA and the CfB morphologies are represented.

There are several published SEM pictures of similar grains. The earliest examples are from the earliest Aptian of southern England and were illustrated as Biorecord(cand): RETISULC-DUBDENT by Hughes, Drewry, and Laing (1979, pl. 64, figs. 1–4). These specimens differ in having slightly larger lumina and in their possession of basal remnants of columellae.

Later examples include specimens illustrated from the late Aptian to early Albian of Egypt (Schrank 1983), the late Albian of Portugal (Chapman 1982), and the Albian to Cenomanian of southern England and northern France (Laing 1973, 1975). Laing's example differs in having slightly shorter spines, but the specimens of Schrank (1983) are very similar and would be acceptable as records of CfA status, especially as they are from sediments of similar age to those from which RETIMONO-SPINEROW was recovered. Chapman's specimens are also very similar (1982, figs. 4–6, 13–15) and she also illustrated a specimen with rows of three or more spines across the muri (figs. 16–18), comparing closely with the specimen illustrated here (pl. 29, figs. 2 and 5).

Occurrence of RETIMONO-SPINEROW (*biorecord and CfA records*). The earliest is in sample MMX-1 10617 (early Aptian). Similar specimens occur throughout the Aptian, becoming more frequent in younger sediments. The youngest core sample occurrence is in sample MMX-1 7695 (mid Aptian), but CfA records occur in younger cuttings samples, the topmost occurrence being in sample MMX-1 6050* (late Aptian).

Deposited records of RETIMONO-SPINEROW (sample number MMX-1 . . /number of specimens). Biorecord: 7890/9; CfA: 6050*/6, 6210*/1, 7020*/3, 7310*/6, 7695/2, 7875/5, 7880/10, 8183/4, 8188/2, 8577/9, 8597/2, 8810/10, 8818/9, 8900*/2, 9170*/2, 9182/2, 9508/2, 9522/2, 9640*/1, 9700*/1, 9760*/1, 9867/3, 10350*/3, 10477/1, 10617/3; CfB: 5400*/3, 5430*/2, 5440*/1, 6030*/4.

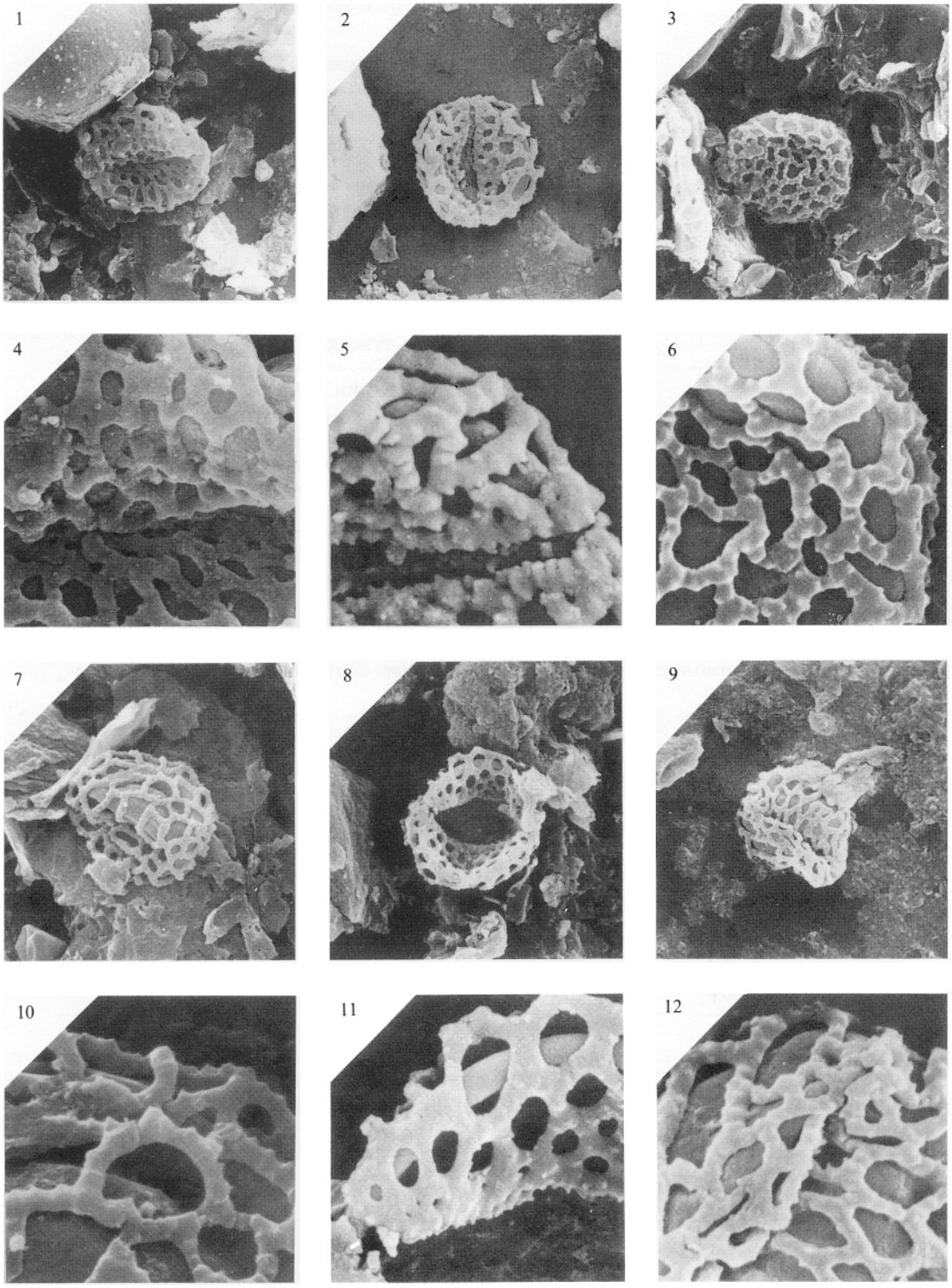
Biorecord: RETIMONO-TYPESIX

Plate 30; Table 3

Comparison and remarks: RETIMONO-TYPESIX. This pollen is distinguished by its small size and by the supramural sculpture, which takes the form of a continuous sequence of raised lobes, ridges, and swellings which may be very pronounced, giving the muri the appearance of strings of beads; at other

EXPLANATION OF PLATE 30

Figs. 1–12. RETIMONO-TYPESIX. 1 and 4, grain number JPR 693/13 (Biorecord), sample MMX-1 7875, prep. JP 014, stub JPS 95, coordinates 830 × 288. 1, × 1600, neg. 98/3; 4, × 7000, neg. 157/132. 2 and 5, grain number JPR 693/1 (CfA), sample MMX-1 7880, prep. JP 022, stub JPS 105, coordinates 792 × 305. 2, × 1600, neg. 92/25; 5, × 7000, neg. 259/11. 3 and 6, grain number JPR 689/11 (CfA), sample MMX-1 6210*, prep. JP 192, stub JPS 246, coordinates 782 × 325. 3, × 1600, neg. 249/14; 6, × 7000, neg. 249/15. 7 and 10, grain number JPR 669/13 (CfA), sample MMX-1 9182, prep. JP 011, stub JPS 97, coordinates 885 × 345. 7, × 1600, neg. 49/1; 10, × 7000, neg. 49/2. 8 and 11, grain number JPR 695/19 (CfA), sample MMX-1 7890, prep. JP 066, stub JPS 228, coordinates 785 × 206. 8, × 1600, neg. 192/30; 11, × 7000, neg. 192/31. 9 and 12, grain number JPR 700/12 (CfA), sample MMX-1 9290*, prep. JP 095, stub JPS 141, coordinates 888 × 250. 9, × 1600, neg. 154/1; 12, × 7000, neg. 154/2.



PENNY, Retimono-typesix

TABLE 3. Biorecord: RETIMONO-TYPESIX.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/late Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 8 July, fifteen 10.
Taxon name	K	Biorecord: RETIMONO-TYPESIX.
Description	M	(All observations made with SEM.) Monocolpate pollen, rounded outline, maximum diameter 12·3(13·5)14·5 μm. Exine semitectate, reticulate, lumina small, rounded or irregularly subcircular, even size distribution, maximum internal diameter 0·7(1·6)2·6 μm; occasional microlumina are present. Muri usually rounded in cross-section, sometimes wider than tall, width 0·3(0·5)0·7 μm, height 0·3(0·4)0·5 μm; upper surfaces undulating, sculped with raised lobes and ridges with a tendency for lobes to be opposite, sometimes forming transverse ridges which extend down the sides of the muri causing them to vary in width; lower surfaces of muri smooth, unsculped. Columellae absent. Aperture long, extending whole length of grain, margins entire, with a slight tendency for the adjacent lumina to be smaller than on the main body of the grain; there is a corresponding slit-like aperture in the nexine. Nexine is smooth, usually closely applied to the sexine or separated from it by a narrow gap. Accurate nexine measurement obstructed by the sexine, range 9–12 μm. Nexine may be rotated inside the sexine.
Variation record	N	Recorded under M.
Number of specimens	L	12.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Kharita.
Sample position	E	MMX-1 7875, at depth 7875 ft.
Sample lithology	F	Grey sandy shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparation JP 014. Stubs JPS 35, 36, 95.
Earlier records	S	None.
Conclusion	T	Ends.

TABLE 4. Biorecord: RETIMONO-BASKET.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, thirteen 30.
Taxon name	K	Biorecord: RETIMONO-BASKET.
Description	M	(All observations made with SEM.)

Monocolpate pollen, rounded outline, maximum diameter 15·5(18·3)19·7 μm. Exine semitectate, reticulate, lumina slightly elongated, irregularly polygonal, rounded rather than angular with even size distribution. Maximum internal diameter of lumina 0·9(2·3)4·5 μm. Microlumina rarely present. Muri rounded in cross-section, occasionally slightly wider than tall, height 0·5(0·7)0·9 μm, width 0·5(0·7)1·1 μm; upper surfaces sculped with sparse low undulations and lobes which sometimes form complete transverse ridges; occasionally transverse ridges occur which are slightly peaked or with a single, usually truncated, spine; transverse ridges not extending down the sides of muri, which are unsculped; lower surfaces unsculped, columellae absent. Aperture long, extending almost halfway round the circumference of the grain; aperture margins entire, unspecialized with no tendency for adjacent lumina to be smaller than on the main body of the grain. There is a corresponding aperture in the nexine. Nexine smooth and may be closely applied to the sexine, more usually separated from it by a distinct gap. Nexine may be rotated inside the sexine. When a distinct gap is present between the nexine and sexine the sexine is usually distorted, suggesting that some support is gained when the two layers are in closer proximity, perhaps indicating that the nexine is of robust construction. Broken grains were rare. Accurate nexine diameter measurement obstructed by sexine, range 14–16 μm.

Variation record	N	Recorded under M.
Number of specimens	L	19.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Matruh Shale.
Sample position	E	MMX-1 8577, at depth 8577 ft.
Sample lithology	F	Dark shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparations JP 067, 183. Stubs JPS 226, 235, 236, 252
Earlier records	S	None.
Conclusion	T	Ends.

times the sculpture is less exaggerated. Another distinguishing feature is the tendency for the lumina adjacent to the aperture to be slightly smaller than those on the main body of the grain.

There are several similar forms which include RETIMONO-NECKLACE, RETIMONO-BASKET, RETIMONO-KNOBBLE, and RETIMONO-SMALLHOLE. RETIMONO-NECKLACE is distinguished by its slightly larger size and by its larger lumina size: murus width ratio. RETIMONO-BASKET is bigger with larger lumina and wider muri. The wider muri result in the sculpture being less concentrated, while there is also a tendency for this pollen to have slightly peaked transverse ridges on the muri, a feature which does not occur in RETIMONO-TYPESIX. RETIMONO-KNOBBLE is similar in size and supramural sculpture, but has broader muri and a smaller lumina size:murus width ratio. RETIMONO-SMALLHOLE is again distinguished by its larger size, although it has quite similar lumina size and murus sculpture. There are no clearly comparable published forms.

There are several CfB records which differ in being more rounded with very small lumina. These may represent examples of another very rare type, but too few were found to discount the possibility that they are simply extreme variants of RETIMONO-TYPESIX.

Occurrence of RETIMONO-TYPESIX (*biorecord and Cf A records*). The earliest reliable occurrence of grains with this morphology is in sample MMX-1 9522 (early Aptian). Similar specimens occur up to the mid-Aptian, where the topmost core sample occurrence is in sample MMX-1 7695. CfA records also occur in younger samples, the topmost occurrence being in sample MMX-1 6210* (late Aptian). There is also one occurrence below the main range in cuttings sample MMX-1 9590* (early Aptian).

Deposited records of RETIMONO-TYPESIX (sample number MMX-1../number of specimens). Biorecord: 7875/12; CfA: 6210*/5, 7020*/1, 7310*/1, 7695/2, 7880/2, 7890/3, 8188/1, 8577/3, 8900*/3, 9182/10, 9290*/4, 9508/2, 9522/1, 9590*/1; CfB: 8597/2, 9508/4.

Biorecord: RETIMONO-BASKET

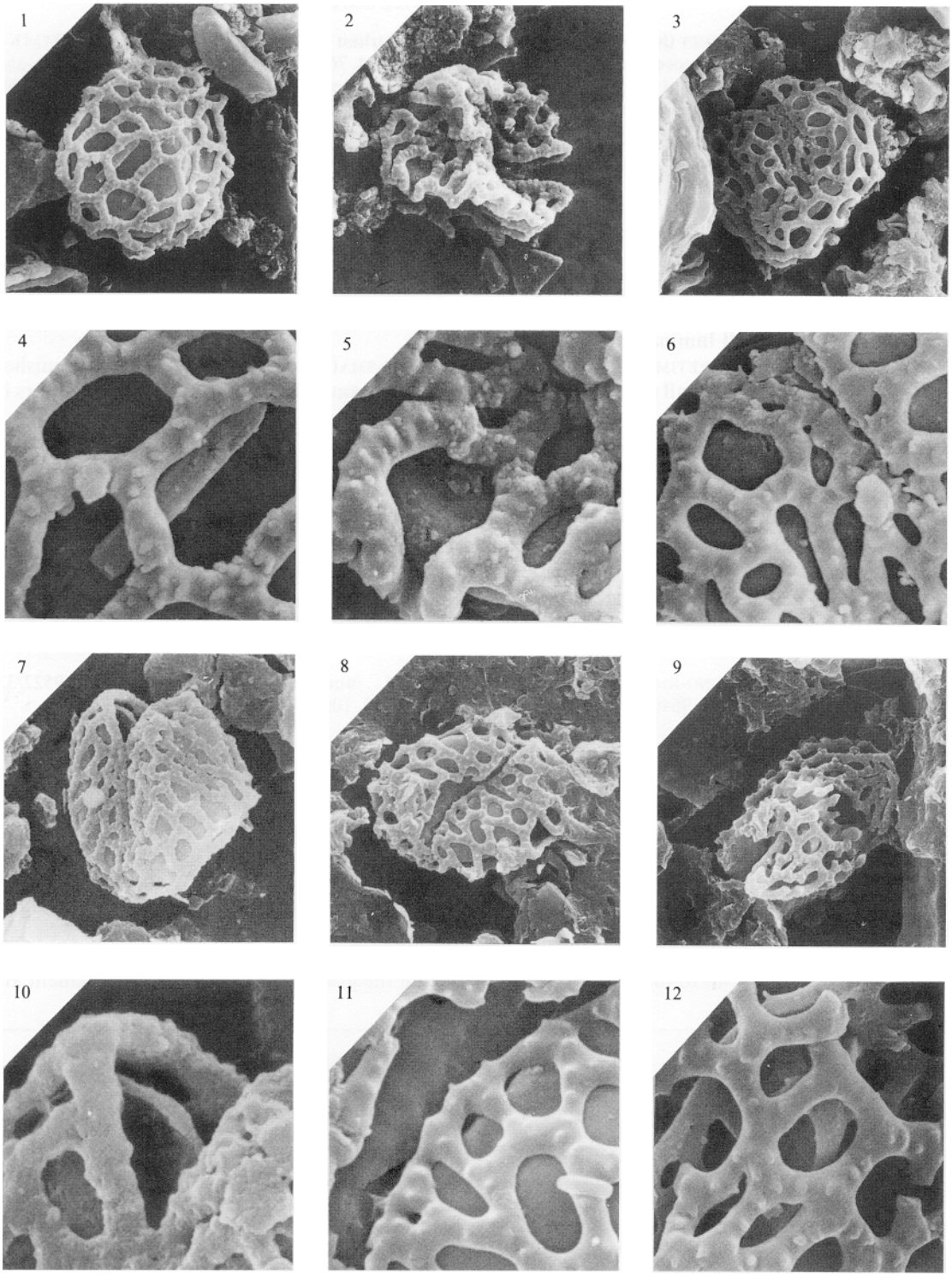
Plate 31; Table 4

Comparison and remarks: RETIMONO-BASKET. RETIMONO-BASKET is distinguished by the tendency for there to be fairly sparse supramural sculpture and by the distortion of the sexine which often occurs as a result of its separation from the nexine by a distinct gap. It may be confused with RETIMONO-TYPESIX which is smaller. There is also a tendency for RETIMONO-BASKET to have slightly peaked transverse ridges on the muri which may lead to its confusion with RETIMONO-RIDGED, but the latter type is easily recognized by its much more regular pattern of transverse ribbing.

The grain figured as *Retimonocolpites* cf. *reticulatus* by Doyle *et al.* (1975, pl. 5, fig. 8) is similar in the form of its mural sculpture, but RETIMONO-BASKET is more rounded. The Doyle *et al.* example also has more concentrated sculpture, and the sexine and nexine are more closely attached. It is possible that some of the LM observations attributed to *R. reticulatus* might be comparable with RETIMONO-BASKET but SEM detail would be needed before this could be confirmed.

EXPLANATION OF PLATE 31

Figs. 1–12. RETIMONO-BASKET. 1 and 4, grain number JPR 712/16 (Biorecord), sample MMX-1 8577, prep. JP 183, stub JPS 252, coordinates 734 × 245. 1, × 1600, neg. 218/26; 4, × 7000, neg. 218/27. 2 and 5, grain number JPR 712/36 (Biorecord), sample MMX-1 8577, prep. JP 183, stub JPS 252, coordinates 824 × 273. 2, × 1600, neg. 215/27; 5, × 7000, neg. 215/28. 3 and 6, grain number JPR 712/48 (Biorecord), sample MMX-1 8577, prep. JP 183, stub JPS 252, coordinates 884 × 262. 3, × 1600, neg. 214/5; 6, × 7000, neg. 214/6. 7 and 10, grain number JPR 713/38 (CfA), sample MMX-1 8597, prep. JP 023, stub JPS 109, coordinates 793 × 225. 7, × 1600, neg. 132/7; 10, × 7000, neg. 132/8. 8 and 11, grain number JPR 705/16 (CfA), sample MMX-1 7020*, prep. JP 194, stub JPS 244, coordinates 850 × 379. 8, × 1600, neg. 232/34; 11, × 7000, neg. 232/35. 9 and 12, grain number JPR 706/38 (CfA), sample MMX-1 7310*, prep. JP 195, stub JPS 245, coordinates 798 × 358. 9, × 1600, neg. 240/25; 12, × 7000, neg. 240/26.



PENNY, Retimono-basket

Occurrence of RETIMONO-BASKET (*biorecord and CfA records*). The earliest reliable occurrence is in sample MMX-1 8818 (Aptian). The topmost core occurrence is in sample MMX-1 7695 (mid Aptian). Specimens were also recovered from both younger and older cuttings samples, the earliest occurrence being in sample MMX-1 10590* (early Aptian) and the most recent in sample MMX-1 7020* (mid Aptian).

Deposited records of RETIMONO-BASKET (sample number MMX-1../number of specimens). Biorecord: 8577/19; CfA: 7020*/4, 7310*/6, 7695/14, 7875/9, 7880/4, 7890/2, 8188/16, 8597/15, 8818/3, 8900*/1, 9170*/1, 9290*/5, 10590*/1.

Biorecord: RETIMONO-KNOBBLE

Plate 32; Table 5

Comparison and remarks: RETIMONO-KNOBBLE. This pollen is distinguished by its small size and fine reticulum, with a small lumina size: murus width ratio.

Similar forms include RETIMONO-WALNUT and RETIMONO-SMALLHOLE. The former is distinguished by the tendency to have small spines on the muri and its very small lumina, while the latter differs in being larger.

A very similar grain was figured from the late Albian of Portugal by Chapman (1982, figs. 32–34) which is sufficiently similar to be of CfA status. Chapman noted that this form was very rare and was unable to confirm its acolumellate condition which is only easily detected when larger numbers of specimens are available. The broken grain illustrated in Plate 32 (figs. 3 and 6) was particularly useful in this respect.

Occurrence of RETIMONO-KNOBBLE (*biorecord and CfA records*). The earliest reliable occurrence of grains with this morphology is in sample MMX-1 10477 (early Aptian) and the youngest in sample MMX-1 8188 (mid Aptian). It is especially common in sample MMX-1 9522 where it accounts for 43% of the total angiosperm pollen grains recovered.

Deposited records of RETIMONO-KNOBBLE (sample number MMX-1../number of specimens). Biorecord: 9522/33; CfA: 8188/4, 8597/3, 9508/8, 9640*/5, 10240*/3, 10350*/2, 10477/3, 10590*/1.

Biorecord: RETIMONO-SPOTSPINES

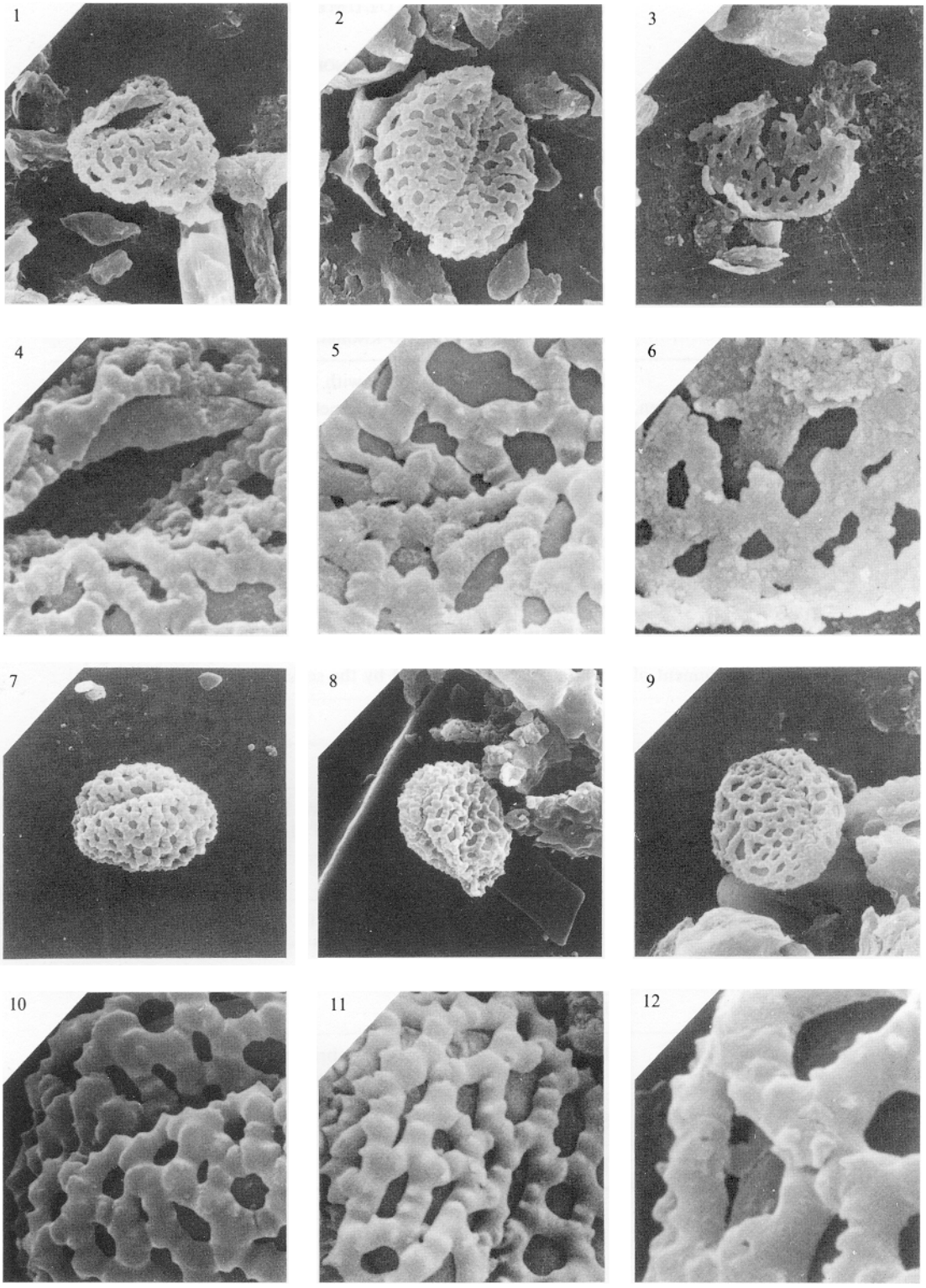
Plate 33; Table 6

Comparison and remarks: RETIMONO-SPOTSPINES. This is the commonest angiosperm pollen in the upper part of the Mersa Matruh sequence. At the top of its range it represents more than 30% of the angiosperm pollen recovered. Its main distinguishing feature is the possession of supratectal spines which are randomly placed, only very rarely appearing in opposite pairs as they are in the similar RETIMONO-SPINEROW.

RETIMONO-HEDGEHOG is a very similar form which has the same spine arrangement as RETIMONO-SPOTSPINES and is difficult to distinguish from it. When all the grains with this spine arrangement are

EXPLANATION OF PLATE 32

Figs. 1–12. RETIMONO-KNOBBLE. 1 and 4, grain number JPR 722/11 (Biorecord), sample MMX-1 9522, prep. JP 087, stub JPS 125, coordinates 818 × 232. 1, × 1600, neg. 82/1; 4, × 7000, neg. 82/2. 2 and 5, grain number JPR 722/17 (Biorecord), sample MMX-1 9522, prep. JP 087, stub JPS 125, coordinates 856 × 283. 2, × 1600, neg. 84/5; 5, × 7000, neg. 84/6. 3 and 6, grain number JPR 722/8 (Biorecord), sample MMX-1 9522, prep. JP 087, stub JPS 125, coordinates 720 × 255. 3, × 1600, neg. 185/25; 6, × 7000, neg. 185/27. 7 and 10, grain number JPR 719/34 (CfA), sample MMX-1 8188, prep. JP 187, stub JPS 241, coordinates 760 × 225. 7, × 1600, neg. 229/37; 10, × 7000, neg. 229/38. 8 and 11, grain number JPR 719/23 (CfA), sample MMX-1 8188, prep. JP 187, stub JPS 241, coordinates 800 × 348. 8, × 1600, neg. 228/27; 11, × 7000, neg. 259/22. 9 and 12, grain number JPR 726/7 (CfA), sample MMX-1 10477, prep. JP 068, stub JPS 181, coordinates 765 × 362. 9, × 1600, neg. 125/24; 12, × 13000, neg. 126/26.



PENNY, Retimono-knobble

TABLE 5. Biorecord: RETIMONO-KNOBBLE.

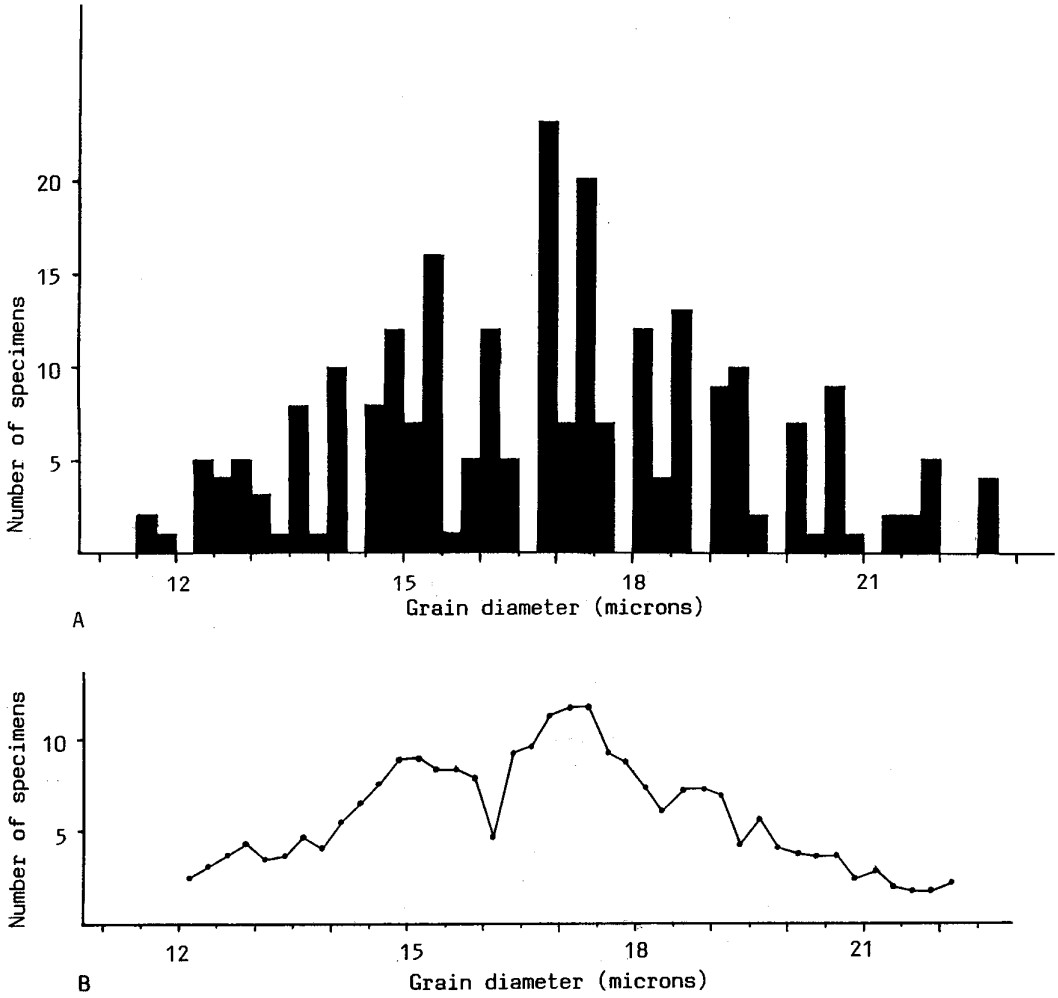
REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/early Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, fourteen 10.
Taxon name	K	Biorecord: RETIMONO-KNOBBLE.
Description	M	(All observations made with SEM.) Monocolpate pollen, rounded outline, maximum diameter 12·3(15·0)18·1 μm. Exine semitectate, reticulate, lumina small, rounded, subcircular, elongate or irregularly polygonal, with even size distribution, and maximum internal diameter 0·5(1·3)3·2 μm. Microlumina occasionally present. Muri rounded in cross-section or slightly wider than tall with flattened lower surfaces, width 0·5(0·7)0·9 μm, height 0·5(0·6)0·8 μm; upper surfaces with sculpture of smooth lobes and peaked transverse ridges; there are no spines and the ridges and lobes often extend down the sides of the muri which have a corrugated to irregularly segmented appearance; lower surfaces of muri unsculped columellae absent. Aperture long, extending up to half the circumference of the grain with entire, unspecialized margins with no clear tendency for adjacent lumina to be smaller than on the main body of the grain. Corresponding aperture in nexine a simple slit. Nexine smooth, rounded, usually closely applied to the sexine but sometimes separated from it by a narrow gap. Precise measurement of nexine diameter obstructed by the sexine, range 11–16 μm.
Variation record	N	Recorded under M.
Number of specimens	L	33.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Matruh Shale.
Sample position	E	MMX-1 9522, at depth 9522 ft.
Sample lithology	F	Dark Shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparations JP 016, 087. Stubs JPS 39, 40, 125, 126.
Earlier records	S	None.
Conclusion	T	Ends.

TABLE 6. Biorecord: RETIMONO-SPOTSPINES.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/early Albian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, fourteen 30.
Taxon name	K	Biorecord: RETIMONO-SPOTSPINES.
Description	M	(All observations made with SEM.)

Monocolpate pollen, rounded outline, maximum diameter 12·3(15·2)20·7 μm. Exine semitectate, reticulate, lumina small, rounded to irregularly subcircular, evenly sized, maximum internal diameter 0·5(1·6)3·5 μm. Occasional microlumina present. Muri rounded in cross-section or slightly wider than tall, height 0·3(0·5)0·8 μm, width 0·3(0·6)1·0 μm; upper surfaces sculped with distinct spines up to 0·3 μm tall, randomly placed, never organized in opposite pairs or uniting to form transverse ridges; lower surfaces smooth, unsculped, columellae absent. Aperture long, extending up to half the circumference of the grain; margins entire, unspecialized, no clear tendency for adjacent lumina to be smaller than on the main body of the grain. Corresponding aperture in nexine a long slit with smooth margins. Nexine smooth, closely applied to the sexine or separated from it by a narrow gap. Accurate nexine measurement obstructed by sexine, range 11–19 μm; nexine may be rotated inside sexine.

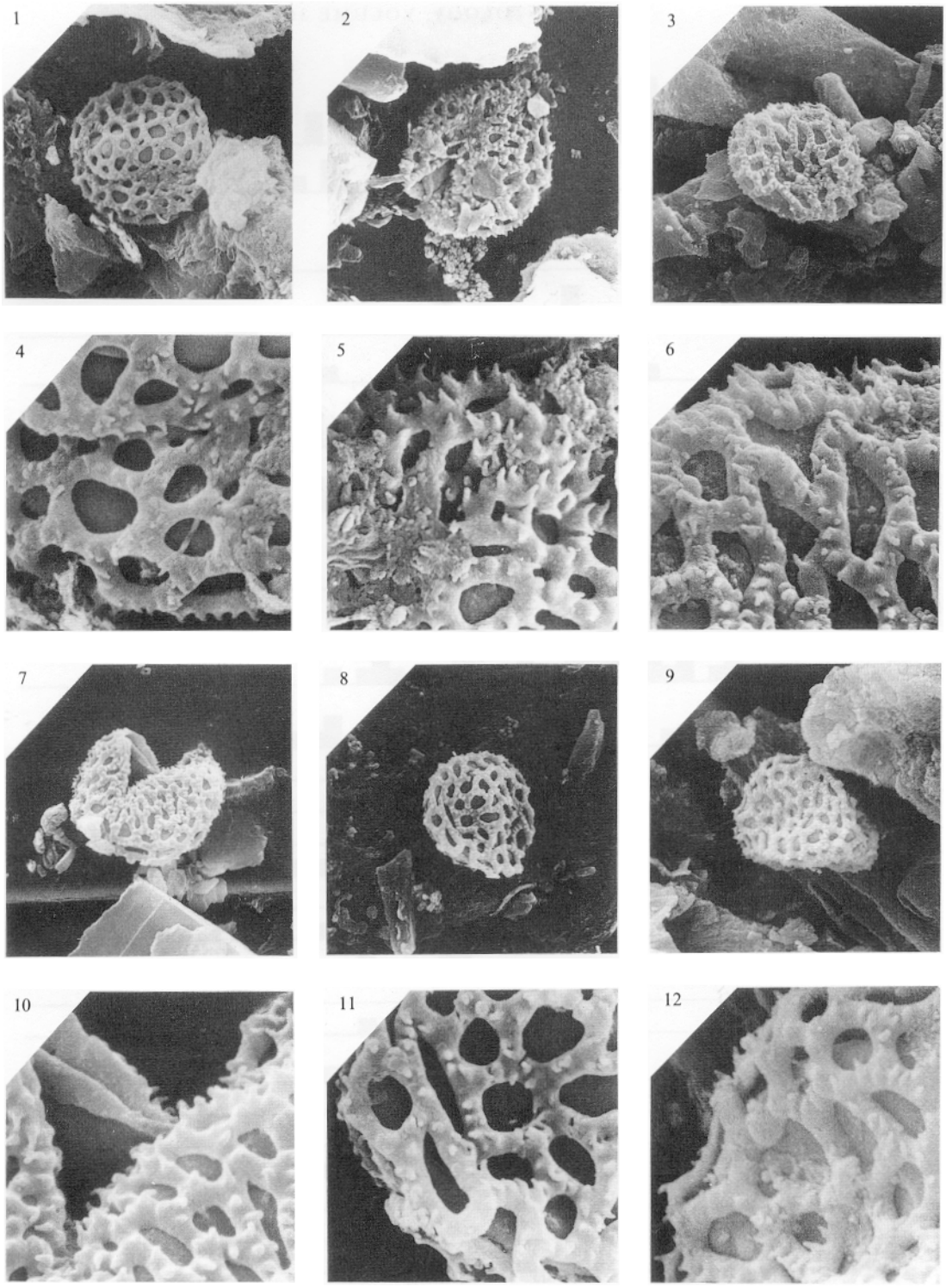
Variation record	N	Recorded under M.
Number of specimens	L	53.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Kharita.
Sample position	E	MMX-1 5203, at depth 5203 ft.
Sample lithology	F	Grey silty shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparation JP 063. Stubs JPS 102, 103.
Earlier records	S	None.
Conclusion	T	Ends.



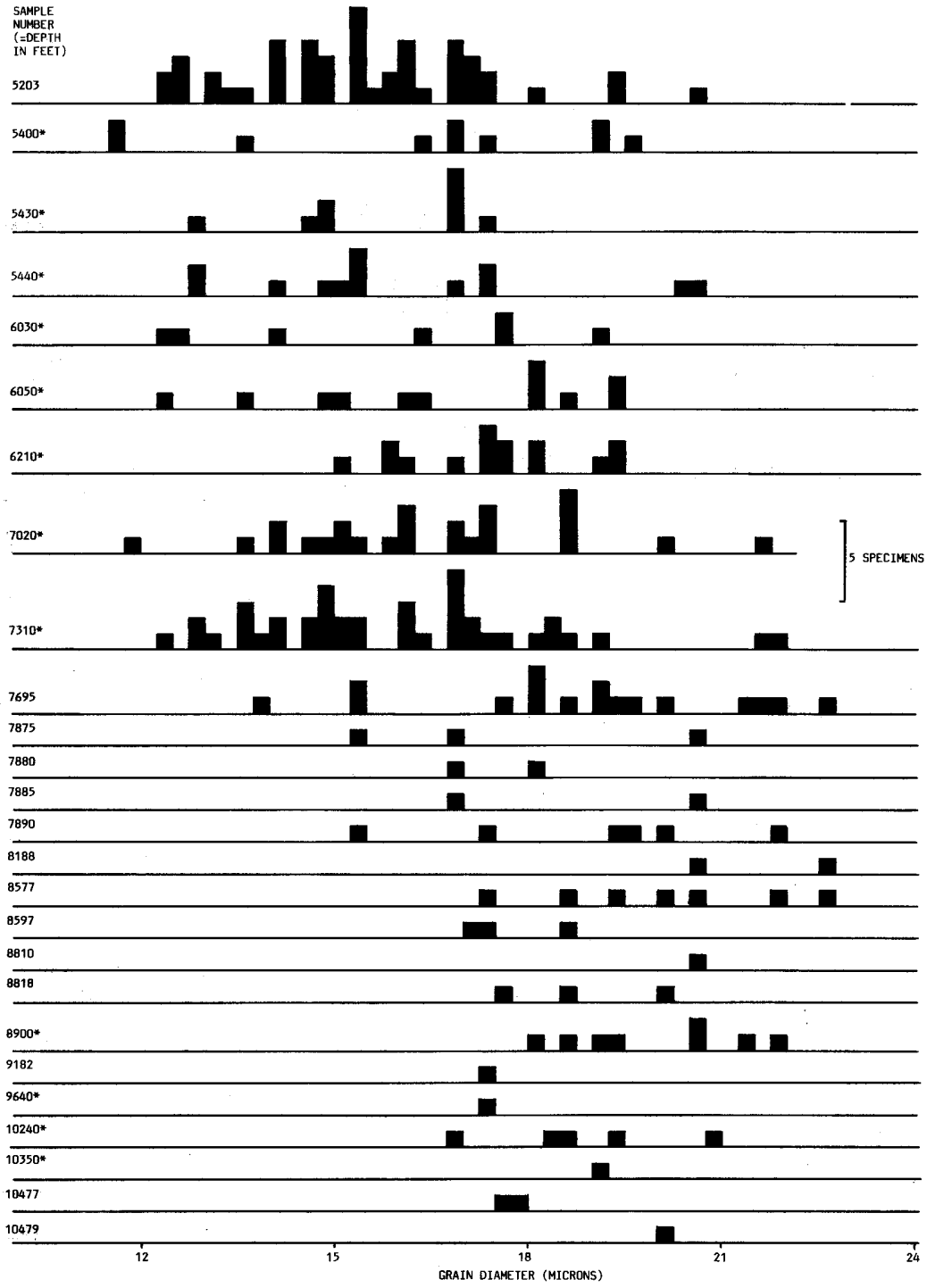
TEXT-FIG. 4. The combined distribution of grain diameter for RETIMONO-SPOTSPINES and RETIMONO-HEDGEHOG. A, basic histogram. B, 5-point moving average of the data in A.

EXPLANATION OF PLATE 33

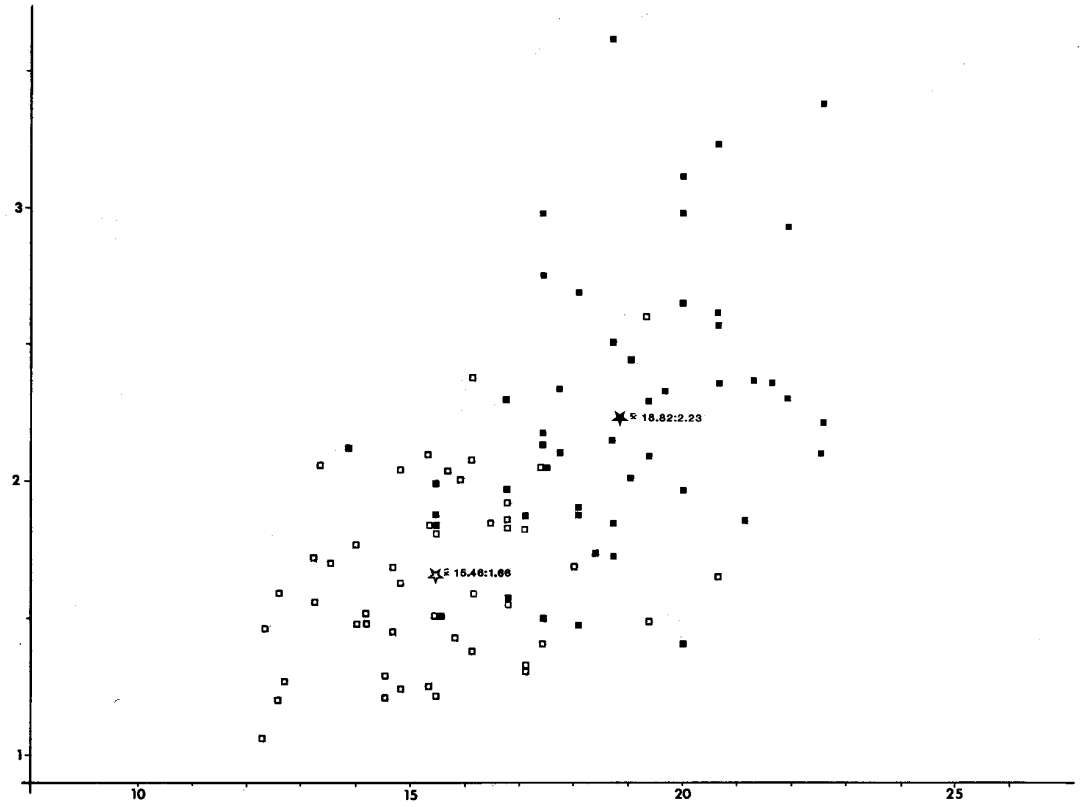
Figs. 1–12. RETIMONO-SPOTSPINES. 1 and 4, grain number JPR 134A/10 (Biorecord), sample MMX-1 5203, prep. JP 063, stub JPS 103, coordinates 778 × 343. 1, × 1600, neg. 70/47; 4, × 7000, neg. 70/48. 2 and 5, grain number JPR 134A/38 (Biorecord), sample MMX-1 5203, prep. JP 063, stub JPS 103, coordinates 876 × 285. 2, × 1600, neg. 196/27; 5, × 7000, neg. 196/28. 3 and 6, grain number JPR 134A/1 (Biorecord), sample MMX-1 5203, prep. JP 063, stub JPS 102, coordinates 800 × 278. 3, × 1600, neg. 257/129; 6, × 7000, neg. 257/130. 7 and 10, grain number JPR 245A/16 (CfA), sample MMX-1 5440*, prep. JP 043, stub JPS 77, coordinates 796/382. 7, × 1600, neg. 63/32; 10, × 7000, neg. 63/33. 8 and 11, grain number JPR 134A/52 (Biorecord), sample MMX-1 5203, prep. JP 063, stub JPS 103, coordinates 875 × 335. 8, × 1600, neg. 197/3; 11, × 7000, neg. 197/4. 9 and 12, grain number JPR 134A/2 (Biorecord), sample MMX-1 5203, prep. JP 063, stub JPS 102, coordinates 798 × 284. 9, × 1600, neg. 259/28; 12, × 7000, neg. 259/29.



PENNY, Retimono-spotspines



TEXT-FIG. 5. Stratigraphic distribution of grain diameter for RETIMONO-SPOTSPINES and RETIMONO-HEDGEHOG.



TEXT-FIG. 6. Maximum internal diameter of lumina: grain diameter plotted for the core sample occurrences of RETIMONO-SPOTSPINES and RETIMONO-HEDGEHOG.

viewed together (i.e. all records of RETIMONO-SPOTSPINES and RETIMONO-HEDGEHOG) there is an apparently continuous variation through the sequence with a tendency towards smaller grain diameter in the younger samples. Indeed, when all 287 of these grains are plotted together on a grain diameter distribution graph an apparently normal Gaussian distribution is observed (text-fig. 4A). This might be taken to indicate that all these grains are representatives of a single 'species' which displays a continuous variation in diameter. However, plotting the 5-point moving average (text fig. 4B) reveals a possible bimodal distribution of the data, although useful separation is impossible without stratigraphic information.

When the data are recorded stratigraphically using biorecords it is possible to plot grain diameter distributions separately for each sample (text-fig. 5) and it becomes clear that there are at least two clearly recognizable forms which can be distinguished on grain diameter and which have quite separate stratigraphic ranges, the upper range (RETIMONO-SPOTSPINES) including samples from MMX-1 7310* up to MMX-1 5203 and the lower (RETIMONO-HEDGEHOG) including samples from MMX-1 7695 down to MMX-1 10479. The grains in the earlier part of the sequence also tend to have larger lumina, so it is possible to plot grain diameter against maximum lumina diameter (text-fig. 6), thus illustrating more clearly the separation of the two forms which is evident from text-fig. 5.

RETIMONO-BIGHOLE is another similar form with randomly placed spines, but is distinguished separately because it has larger lumina and a greater separation of sexine from nexine.

Published examples which might compare include the specimens illustrated from the Aptian to lower Albian? of North America (Doyle *et al.* 1975, pl. 5, figs. 1, 9 10) as *R. peroreticulatus* and from the middle Albian of Oklahoma (Walker and Walker 1984, figs. 70–72). These grains compare well with both RETIMONO-SPOTSPINES and RETIMONO-HEDGEHOG. The more recent, illustrated by Walker and Walker, are approximately 17 μm wide, falling in the size range of RETIMONO-SPOTSPINES, which has a similar stratigraphic occurrence. The two older grains illustrated by Doyle *et al.* are larger, being approximately 21–23 μm in diameter, thus agreeing better with RETIMONO-HEDGEHOG which is again of similar stratigraphic occurrence. This suggests that when more SEM data are available for North America a size gradation might be observed in grains of this morphology which is similar to that observed for the Egyptian examples.

Another similar grain illustrated by Chapman (1982, figs. 19–21) from the late Albian of Portugal is sufficiently close in size (approximately 14 μm) and stratigraphic position to merit CfA status.

Occurrence of RETIMONO-SPOTSPINES (*biorecord and CfA records*). This pollen type occurs almost exclusively in cuttings samples, only the youngest occurrence being in a core (MMX-1 5203, early Albian). The earliest of the cuttings occurrences is in sample MMX-1 7310* late Aptian).

Deposited records of RETIMONO-SPOTSPINES (sample number MMX-1../number of specimens). Biorecord: 5203/53; CfA: 5400*/12, 5430*/9, 5440*/15, 6030*/8, 6050*/16, 6210*/18, 7020*/32, 7310*/41.

Biorecord: RETIMONO-HEDGEHOG

Plate 34; Table 7

Comparison and remarks: RETIMONO-HEDGEHOG. This pollen, distinguished by the arrangement of its spines, has already been discussed with the very similar RETIMONO-SPOTPINES described above, from which it is distinguished by its larger size and wider lumina.

Similar published examples include the grains illustrated by Doyle *et al.* (1975) as *R. peroreticulatus* and Walker and Walker (1984). The Walker and Walker example (middle Albian, figs. 70–72) differs in being smaller, but the Doyle *et al.* specimens (Aptian to early Albian?, pl. 5, figs. 1, 9, 10) are of similar size, differing only in the shape, which is more convoluted, and in having a wider separation of the sexine and nexine.

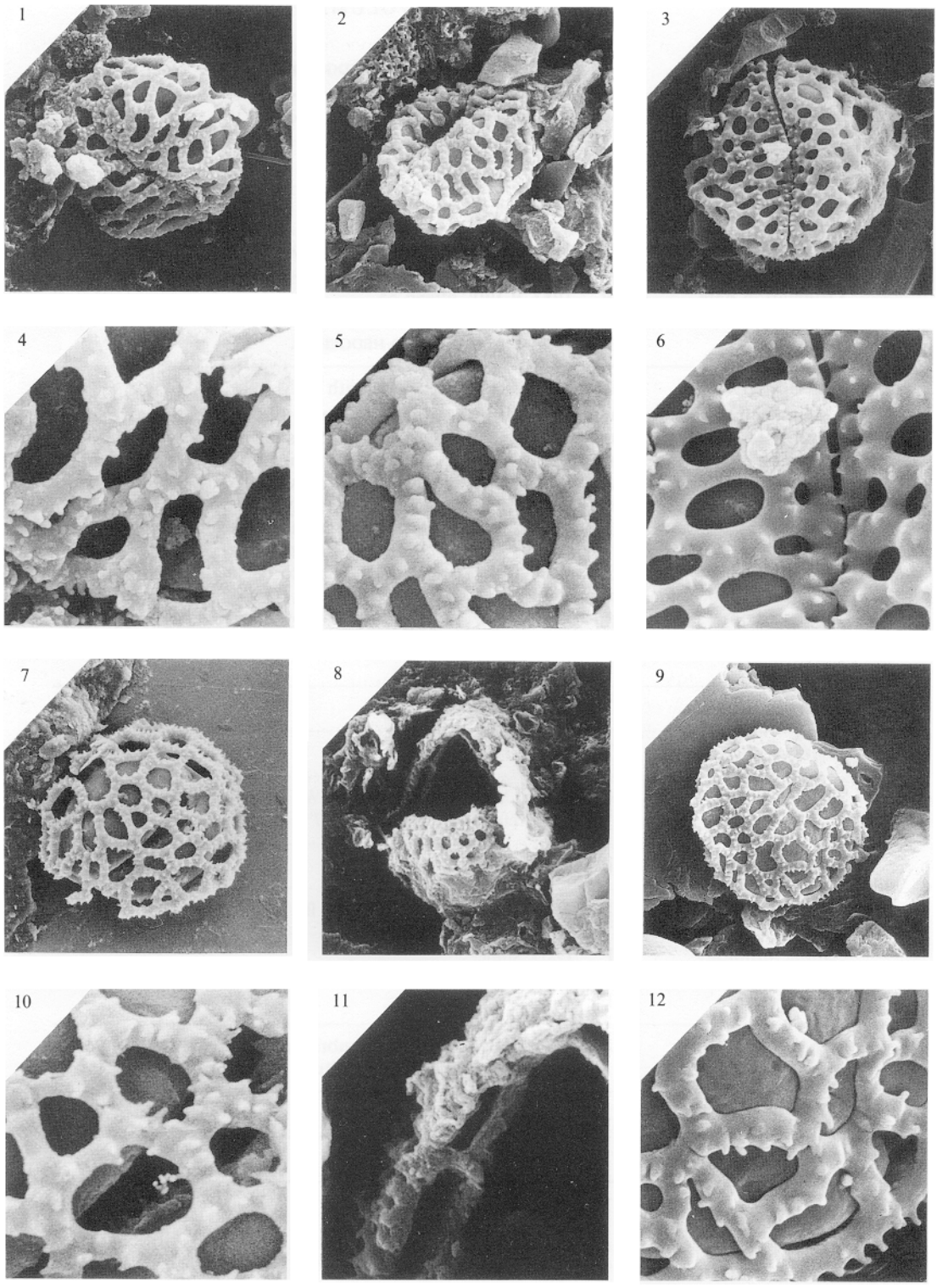
Another specimen illustrated by Chapman (1982, figs. 19–21) from the late Albian of Portugal is similar in spine arrangement but is smaller and does not correspond stratigraphically.

Occurrence of RETIMONO-HEDGEHOG (*biorecord and CfA records*). This pollen first appears in sample MMX-1 10479 (early Aptian) and occurs regularly in the sequence, increasing in frequency towards the top of its range where it makes its final appearance in sample MMX-1 7695 (mid Aptian).

Deposited records of RETIMONO-HEDGEHOG (sample number MMX-1../number of specimens). Biorecord: 8577/7; CfA: 7695/29, 7875/3, 7880/4, 7885/2, 7890/11, 8188/3, 8597/4, 8810/1, 8813/3, 8900*/8, 9170*/2, 9182/1, 9290*/1, 9640*/1, 9867/1, 10240*/5, 10350*/1, 10477/2, 10479/1; CfB: 10825/1.

EXPLANATION OF PLATE 34

Figs. 1–12. RETIMONO-HEDGEHOG. 1 and 4, grain number JPR 734/21 (Biorecord), sample MMX-1 8577, prep. JP 183, stub JPS 252, coordinates 763 × 282. 1, × 1600, neg. 217/31; 4, × 7000, neg. 217/32. 2 and 5, grain number JPR 734/38 (Biorecord), sample MMX-1 8577, prep. JP 183, stub JPS 252, coordinates 807 × 307. 2, × 1600, neg. 216/8; 5, × 7000, neg. 216/9. 3 and 6, grain number JPR 733/30 (CfA), sample MMX-1 8188, prep. JP 187, stub JPS 241, coordinates 778 × 353. 3, × 1600, neg. 229/27; 6, × 7000, neg. 229/28. 7 and 10, grain number JPR 731/29 (CfA), sample MMX-1 7885, prep. JP 008, stub JPS 58, coordinates 765 × 332. 7, × 1600, neg. 11/10; 10, × 7000, neg. 259/31. 8 and 11, grain number JPR 732/15 (CfA), sample MMX-1 7890, prep. JP 066, stub JPS 228, coordinates 783 × 348. 8, × 1600, neg. 192/18; 11, × 7000, neg. 192/19. 9 and 12, grain number JPR 737/9 (CfA), sample MMX-1 8818, prep. JP 182, stub JPS 251, coordinates 765 × 256.



PENNY, Retimono-hedgehog

TABLE 7. Biorecord: RETIMONO-HEDGEHOG.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, fifteen 45.
Taxon name	K	Biorecord: RETIMONO-HEDGEHOG.
Description	M	(All observations made with SEM.) Monocolpate pollen, rounded outline, maximum diameter 17·4(20·1)22·6 μm. Exine semitectate, reticulate, lumina small, rounded to irregularly subcircular, evenly sized, maximum internal diameter 1·2(2·3)3·8 μm. Occasional microlumina present. Muri rounded in cross-section or slightly wider than tall, height 0·6(0·7)0·8 μm, width 0·6(0·8)0·9 μm; upper surfaces sculped with distinct spines up to 0·3 μm tall, randomly placed, never organized in opposite pairs or uniting to form transverse ridges; lower surfaces unsculped, columellae absent. Aperture long, extending up to half the grain circumference, margins entire, unspecialized with no clear tendency for the adjacent lumina to be smaller than on the main body of the grain. Corresponding aperture in nexine a long slit with smooth margins. Nexine smooth, closely applied to sexine or separated from it by a narrow gap. Accurate nexine measurement obstructed by sexine, range 15–20 μm; nexine may be rotated inside the sexine.
Variation record	N	Recorded under M.
Number of specimens	L	7.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Matruh Shale.
Sample position	E	MMX-1 8577, at depth 8577 ft.
Sample lithology	F	Dark shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparations JP 067, 183. Stubs JPS 226, 235, 236, 252.
Earlier records	S	None.
Conclusion	T	Ends.

TABLE 8. Biorecord: RETIMONO-SMALLHOLE.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, sixteen 00.
Taxon name	K	Biorecord: RETIMONO-SMALLHOLE.
Description	M	(All observations made with SEM.) Monocolpate pollen, rounded outline, maximum diameter 14·8(17·3)21·0 μm. Exine semitectate, reticulate, lumina small, rounded or irregularly subcircular with even size distribution, and maximum internal diameter 1·2(1·9)2·8 μm. Microlumina rarely present. Muri rounded in cross-section or slightly wider than tall, height 0·5(0·6)0·7 μm, width 0·6(0·63)0·9 μm; upper surfaces sculped with low undulations which may coalesce to form transverse ridges. Small spines may also be present, usually being situated at random towards the sides of the upper surfaces, sometimes centrally on the muri, occasionally in opposite pairs. Transverse ridges may partially extend down the sides of the muri causing slight variations in width. The sides and lower surfaces of the muri are otherwise unsculped, columellae absent. Aperture long, extending whole length of distal surface, margins entire, unspecialized, no clear tendency for adjacent lumina to be smaller than on the main body of the grain. The corresponding aperture in the nexine is a simple slit. Nexine smooth, usually closely applied to sexine, sometimes separated by a narrow gap, sometimes rotated inside sexine. Precise measurement of nexine diameter obstructed by sexine, range 14–16 μm.
Variation record	N	Recorded under M.
Number of specimens	L	22.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Matruh Shale.
Sample position	E	MMX-1 9182, at depth 9182 ft.
Sample lithology	F	Dark shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparations JP 011. Stubs JPS 21, 22, 29, 30, 63, 64, 97.
Earlier records	S	None.
Conclusion	T	Ends.

Biorecord: RETIMONO-SMALLHOLE

Plate 35; Table 8

Comparison and remarks: RETIMONO-SMALLHOLE. RETIMONO-SMALLHOLE is distinguished by its small lumina and larger size. Similar types include RETIMONO-KNOBBLE and RETIMONO-TYPESIX, both of which can be distinguished by their smaller size, and RETIMONO-BASKET which has larger lumina. There are no clearly comparable published forms.

Occurrence of RETIMONO-SMALLHOLE. The earliest occurrence of grains with this morphology is in sample MMX-1 10479 (early Aptian). They then range up through the sequence, becoming less frequent in the top part of its range, the youngest occurrence being in sample MMX-1 7695 (mid-Aptian).

Deposited records of RETIMONO-SMALLHOLE (sample number MMX-1../number of specimens). Biorecord: 9182/22; CfA: 7695/2, 7875/5, 7890/3, 8577/2, 8810/4, 8818/10, 8900*/6, 9290*/11, 9640*/1, 9700*/1, 9867/13, 10477/2, 10479/4; CfB: 10825/1.

Biorecord: RETIMONO-RIDGED

Plate 36; Table 9

Comparison and remarks: RETIMONO-RIDGED. RETIMONO-RIDGED is distinguished by the transverse ridges on the muri, a feature which has not previously been observed in grains of this type, although it does appear in certain columellate forms (e.g. Penny 1986*b*; Walker and Walker 1984).

Similar forms in Mersa Matruh include RETIMONO-BASKET which sometimes has slightly peaked transverse ridges on its muri. However, these are never as uniform or numerous as they are in RETIMONO-RIDGED.

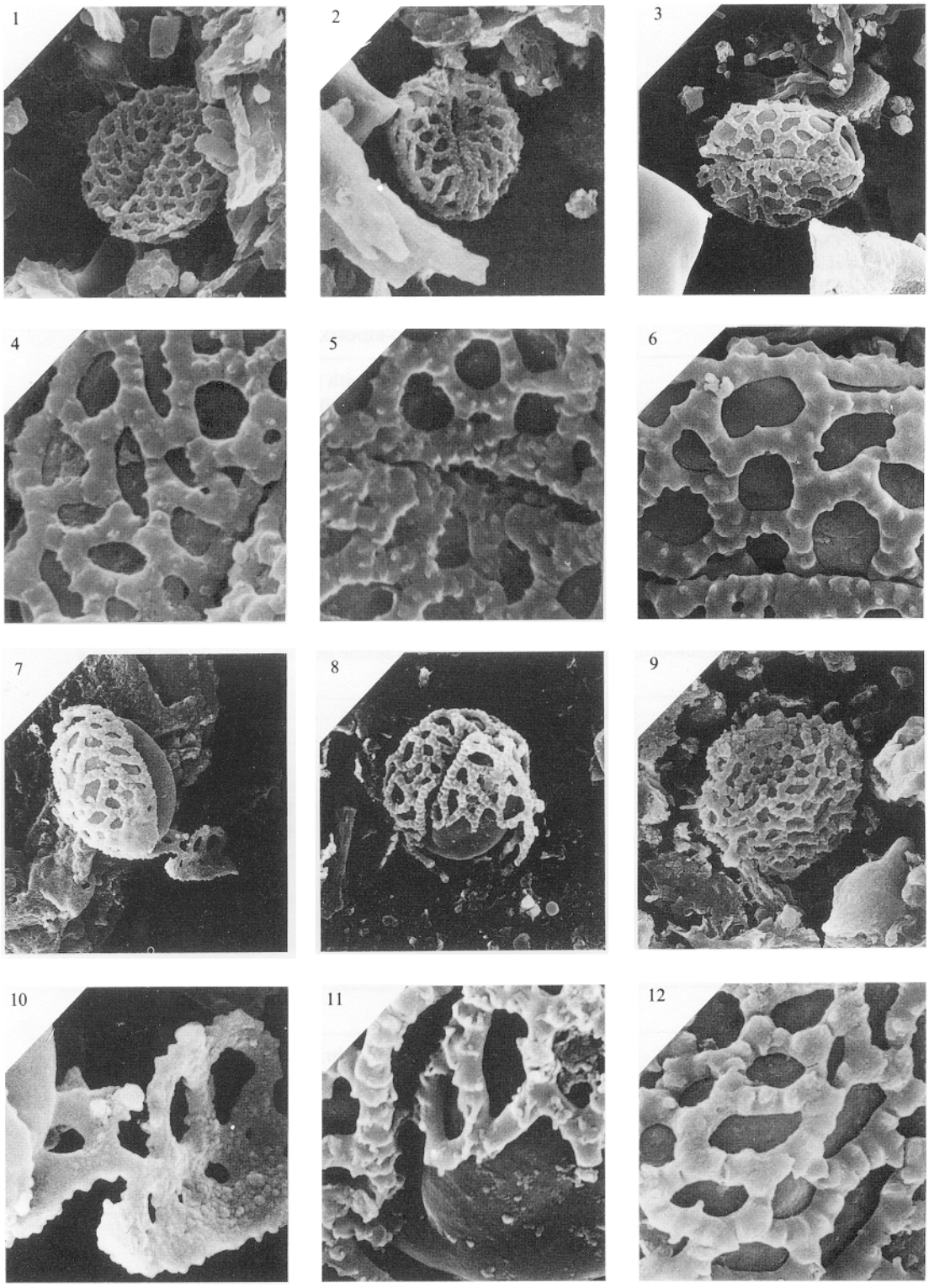
There are no clearly comparable published examples, but the LM illustrations of Doyle (1969, fig. 1j, k) and Doyle and Robbins (1977, pl. 1, figs. 9–11) have a hint of the transverse ribbing which is typical of this form, this being most clearly seen in the example in plate 1, fig. 10 of Doyle and Robbins (1977). However, SEM detail is needed before closer comparison becomes possible.

Occurrence of RETIMONO-RIDGED (*biorecord and CfA records*). The first appearance is in sample MMX-1 10477 which is early Aptian in age. They range up through the sequence at between 2 and 15% of the total angiosperm representation, making a final appearance in sample MMX-1 7695 which is mid-Aptian.

Deposited records of RETIMONO-RIDGED (sample number MMX-1../number of specimens). Biorecord: 8818/15; CfA: 7695/2, 8188/5, 8577/6, 8597/9, 8810/7, 9182/7, 10477/3.

EXPLANATION OF PLATE 35

Figs. 1–12. RETIMONO-SMALLHOLE. 1 and 4, grain number JPR 756/11 (Biorecord), sample MMX-1 9182, prep. JP 011, stub JPS 97, coordinates 785 × 384. 1, × 1600, neg. 54/4; 4, × 7000, neg. 54/5. 2 and 5, grain number JPR 756/2 (Biorecord), sample MMX-1 9182, prep. JP 011, stub JPS 97, coordinates 828 × 265. 2, × 1600, neg. 44/40; 5, × 7000, neg. 44/42. 3 and 6, grain number JPR 754/32 (CfA), sample MMX-1 8818, prep. JP 182, stub JPS 251, coordinates 837 × 272. 3, × 1600, neg. 206/29; 6, × 7000, neg. 206/30. 7 and 10, grain number JPR 753/19 (CfA), sample MMX-1 8810, prep. JP 181, stub JPS 250, coordinates 774 × 232. 7, × 1600, neg. 202/20; 10, × 7000, neg. 202/22. 8 and 11, grain number JPR 751/4 (CfA), sample MMX-1 7890, prep. JP 066, stub JPS 228, coordinates 835 × 255. 8, × 1600, neg. 190/20; 11, × 7000, neg. 190/21. 9 and 12, grain number JPR 749/44 (CfA), sample MMX-1 7695, prep. JP 185, stub JPS 240, coordinates 727 × 303. 9, × 1600, neg. 226/33; 12, × 7000, neg. 226/34.



PENNY, Retimono-smallhole

TABLE 9. Biorecord: RETIMONO-RIDGED.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, sixteen 30.
Taxon name	K	Biorecord: RETIMONO-RIDGED.
Description	M	(All observations made with SEM.)

Monocolpate pollen, rounded outline, diameter 12·9(16·0)20·7 μm. Exine semitectate, reticulate, lumina diameter 0·6(1·6)4·1 μm; lumina usually in the mid part of this size range, extremely large or small lumina less frequent; lumina rounded to irregularly subcircular in shape. Muri rounded or flattened in cross-section, sculped with transverse ridges which appear to be the result of the union of reduced lateral supratectal processes, an idea supported by the occasional appearance of incomplete ridges which have gaps in the median position and also by the occasional appearance of small spines on the outer margins of the ridges; muri measure 0·5(0·6)0·8 μm tall and 0·5(0·7)0·9 μm wide; ridges low, never exceeding 0·1 μm in height; columellae absent; no submural sculpture. Aperture long, extending up to half the grain circumference; margins entire, unspecialized, adjacent lumina never show a marked grading of size, although smaller lumina are sometimes present. Nexine smooth, normally closely applied to sexine but often withdrawn leaving a distinct gap.

Variation record	N	Recorded under M.
Number of specimens	L	15.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Matruh Shale.
Sample position	E	MMX-1 8818, at depth 8818 ft.
Sample lithology	F	Dark shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparations. JP 010, 182. Stubs JPS 19, 20, 27, 28, 61, 62, 101, 233, 234, 251.
Earlier records	S	None.
Conclusion	T	Ends.

TABLE 10. Biorecord: RETIMONO-WALNUT.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/early Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, sixteen 45.
Taxon name	K	Biorecord (cand): RETIMONO-WALNUT.
Description	M	(All observations made with SEM.)

Rounded monocolpate pollen, maximum diameter 15·2(16·3)17·4 μm. Exine semitectate, reticulate, lumina very small, rounded, polygonal or slit-like, maximum internal diameter 0·5(0·9)1·5 μm. Muri wider than tall, height 0·5(0·54)0·6 μm, width 0·6(0·7)1·1 μm; upper surfaces sculped with lobes and peaked swellings, sculpture occasionally extending laterally so that the muri appear to vary in width when viewed perpendicularly; sides and lower surfaces unsculped, columellae absent. Aperture long, extending up to half the grain circumference, margins entire, unspecialized, no tendency for adjacent lumina to be smaller than those on the main body of the grain. There is a corresponding slit-like aperture in the nexine. Nexine smooth, rounded and closely applied to sexine; precise nexine measurement obstructed by sexine.

Variation record	N	Recorded under M.
Number of specimens	L	4.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Matruh Shale.
Sample position	E	MMX-1 9867, at depth 9867 ft.
Sample lithology	F	Dark shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparation JP 033. Stubs JPS 67, 68, 201, 202.
Earlier records	S	None.
Conclusion	T	Ends.

Biorecord(cand): RETIMONO-WALNUT

Plate 37; Table 10

Comparison and remarks: RETIMONO-WALNUT. It is easily distinguished by its very small lumina and wide muri, which may have small spines in addition to the lobes and peaked swellings on their upper surfaces. There are no clearly comparable published examples.

Occurrence of RETIMONO-WALNUT (*cand and CfA records*). This grain type appears first in sample MMX-1 9867 (early Aptian) and ranges up to sample MMX-1 9522 (also early Aptian). There is one younger occurrence in a cuttings sample MMX-1 7310*.

Deposited records of RETIMONO-WALNUT (sample number MMX-1../number of specimens). Biorecord (cand): 9867/4; CfA: 7310*/3, 9522/2, 9640*/1.

Spot: RETIMONO-HAIRY

Plate 38, figs. 1, 2, 4, 5; Table 11

Comparison and remarks: RETIMONO-HAIRY. This form is distinguished by the very large and densely packed supratectal spines. Unfortunately it is rare, only three examples having been recovered, so the possibility that it is simply an extreme variant of one of the other spinate forms cannot be excluded. There are no clearly comparable published forms.

Occurrence of RETIMONO-HAIRY (spot and CfA records). Of the three grains recovered, one is from core sample MMX-1 8183 (mid Aptian), the other two are from cuttings samples, the younger of these being from sample MMX-1 5430* (early Albian).

Deposited records of RETIMONO-HAIRY (sample number MMX-1../number of specimens). Spot: 7310*/1; CfA: 5430*/1, 8183/1.

Biorecord(cand): RETIMONO-BIGHOLE

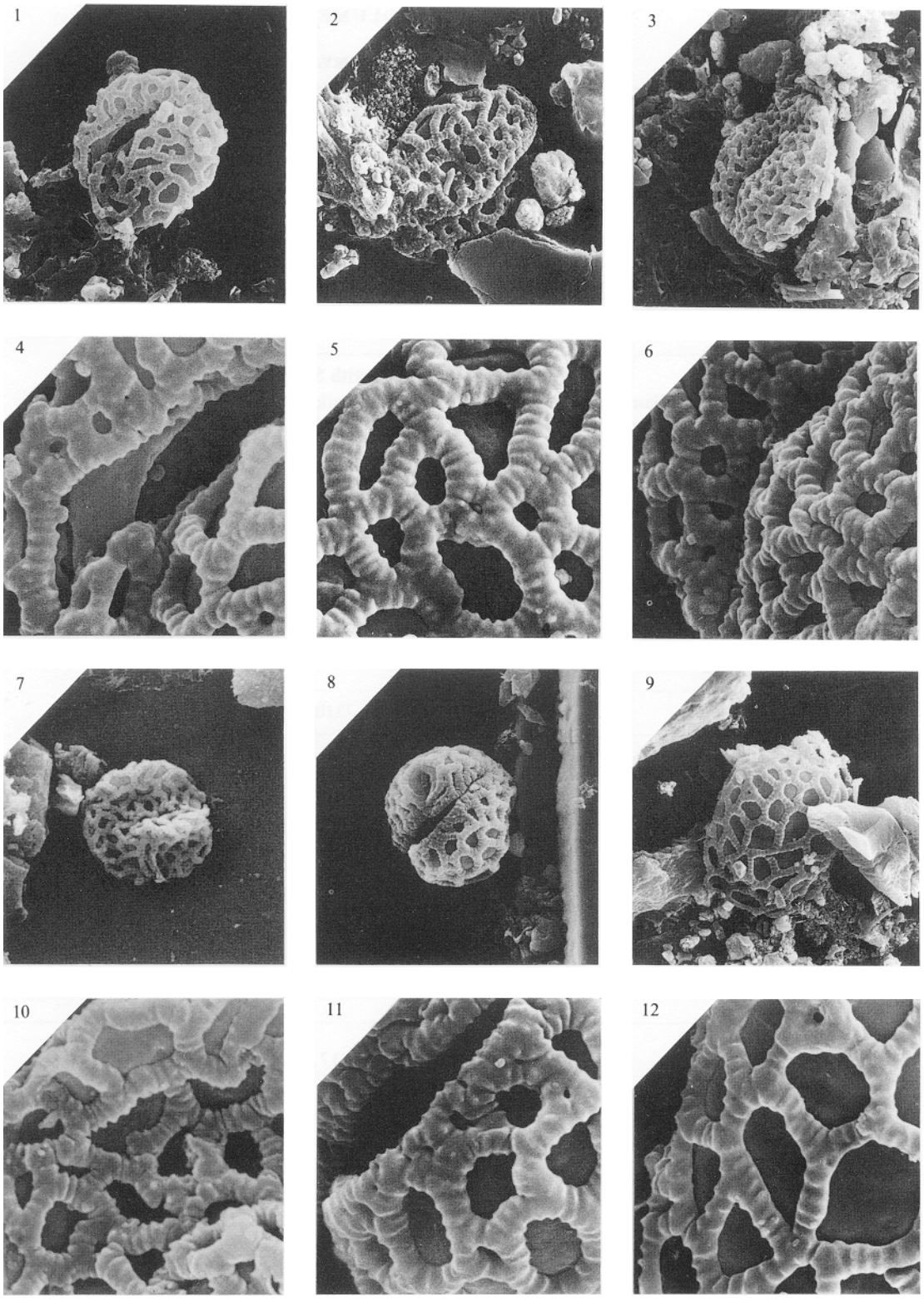
Plate 38, figs. 3, 6, 9, 12; Table 12

Comparison and remarks: RETIMONO-BIGHOLE. This pollen is quite similar to RETIMONO-SPOTSPINES and RETIMONO-HEDGEHOG in the nature of the supramural sculpture, but is distinguished by its larger lumina and the large gap between sexine and nexine.

In spite of this distinction the rarity of this pollen does not exclude the possibility that it is simply an extreme morphological variant of either of these two similar forms. However, if this were the case RETIMONO-SPOTSPINES would be the more likely normal form, since the size ranges of RETIMONO-BIGHOLE and RETIMONO-HEDGEHOG do not overlap significantly. RETIMONO-SPOTSPINES is sufficiently different in diameter and lumina size to justify the separation of RETIMONO-BIGHOLE as a distinct form. There are no clearly comparable published forms.

EXPLANATION OF PLATE 36

Figs. 1–12. RETIMONO-RIDGED. 1 and 4, grain number JPR 186/4 (Biorecord), sample MMX-1 8818, prep. JP 182, stub JPS 251, coordinates 759 × 273. 1, × 1600, neg. 211/31; 4, × 7000, neg. 211/32. 2 and 5, grain number JPR 186/2 (Biorecord), sample MMX-1 8818, prep. JP 182, stub JPS 251, coordinates 855 × 282. 2, × 1600, neg. 206/9; 5, × 7000, neg. 206/10. 3 and 6, grain number JPR 186/8 (Biorecord), sample MMX-1 8818, prep. JP 182, stub JPS 251, coordinates 768 × 359. 3, × 1600, neg. 211/7; 6, × 7000, neg. 211/10. 7 and 10, grain number JPR 525/1 (CfA), sample MMX-1 8597, prep. JP 023, stub JPS 109, coordinates 875 × 246. 7, × 1600, neg. 259/18; 10, × 7000, neg. 129/13. 8 and 11, grain number JPR 526/1 (CfA), sample MMX-1 8188, prep. JP 187, stub JPS 241, coordinates 734 × 278. 8, × 1600, neg. 230/19; 11, × 7000, neg. 230/20. 9 and 12, grain number JPR 526/3 (CfA), sample MMX-1 8188, prep. JP 187, stub JPS 241, coordinates 884 × 300. 9, × 1600, neg. 227/9; 12, × 7000, neg. 227/10.



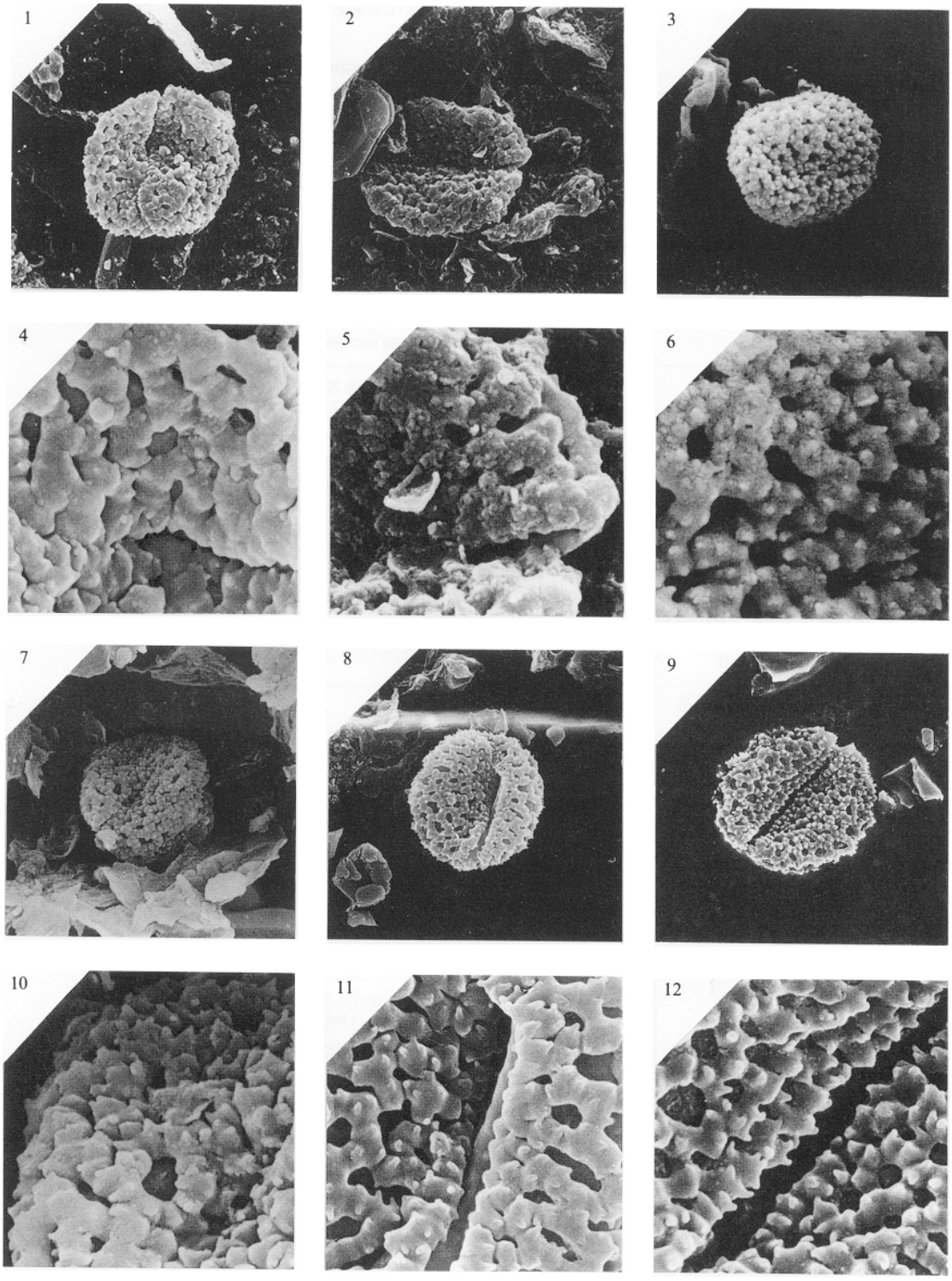
PENNY, Retimono-ridged

TABLE 11. Spot: RETIMONO-HAIRY.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/late Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, seventeen 15.
Taxon name	K	Spot: RETIMONO-HAIRY.
Description	M	(All observations made with SEM.) Rounded pollen, diameter 17·4 μm. Exine semitectate, reticulate, lumina diameter 2·2–3·8 μm; microlumina absent. Murus height up to 0·6 μm, width 0·7–0·9 μm; upper surfaces with distinct sculpture of tall densely packed spines up to 0·8 μm tall, columellae absent. Nexine smooth, no aperture observed.
Variation record	N	Recorded under M.
Number of specimens	L	1.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Kharita.
Sample position	E	MMX-1 7310*, at depth 7310 ft.
Sample lithology	F	Dark shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparation JP 195. Stub JPS 245.
Earlier records	S	None.
Conclusion	T	Ends.

EXPLANATION OF PLATE 37

Figs. 1–12. RETIMONO-WALNUT. 1 and 4, grain number JPR 99/2 (cand), sample MMX-1 9867, prep. JP 033, stub JPS 68, coordinates 822 × 238. 1, × 1600, neg. 163/14; 4, × 7000, neg. 163/15. 2 and 5, grain number JPR 99/3 (cand), sample MMX-1 9867, prep. JP 033, stub JPS 68, coordinates 816 × 345. 2, × 1600, neg. 163/28; 5, × 7000, neg. 163/29. 3 and 6, grain number JPR 766/2 (CfA), sample MMX-1 9522, prep. JP 087, stub JPS 125, coordinates 752 × 242. 3, × 1600, neg. 259/36; 6, × 7000, neg. 259/37. 7 and 10, grain number JPR 766/27 (CfA), sample MMX-1 9522, prep. JP 087, stub JPS 125, coordinates 721 × 295. 7, × 1600, neg. 185/28; 10, × 7000, neg. 185/29. 8 and 11, grain number JPR 765/44 (CfA), sample MMX-1 7310*, prep. JP 195, stub JPS 245, coordinates 790 × 245. 8, × 1600, neg. 241/5; 11, × 7000, neg. 241/6. 9 and 12, grain number JPR 765/37 (CfA), sample MMX-1 7310*, prep. JP 195, stub JPS 245, coordinates 798 × 395. 9, × 1600, neg. 240/23; 12, × 7000, neg. 240/24.



PENNY, Retimono-walnut

TABLE 12. Biorecord: RETIMONO-BIGHOLE.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/early Albian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, seventeen 30.
Taxon name	K	Biorecord (cand): RETIMONO-BIGHOLE.
Description	M	(All observations made with SEM.) Monocolpate pollen, rounded or subcircular in outline, maximum diameter 15·8(18·5)21·0 μm. Exine semitectate, reticulate, lumina large, rounded or irregularly subcircular, maximum internal diameter 1·2(3·9)7·1 μm. Microlumina absent. Muri rounded in cross-section or slightly wider than tall, height 0·5(0·6)0·7 μm, width 0·6(0·7)0·8 μm; upper surfaces sculped with distinct spines which are up to 0·6 μm tall and randomly placed, not organized in opposite pairs and not united to form transverse ridges; lower surfaces smooth, unsculped, columellae absent. Nexine smooth, separated from sexine by a gap which may be very wide; accurate nexine measurement obstructed by sexine, range 14–16 μm. Nexine may be rotated inside the sexine. The details of the aperture were not observed, there being no suitably orientated grains.
Variation record	N	Recorded under M.
Number of specimens	L	4.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Kharita.
Sample position	E	MMX-1 5400*, at depth 5400 ft.
Sample lithology	F	Dark shale.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparation JP 041. Stubs JPS 73, 74.
Earlier records	S	None.
Conclusion	T	Ends.

TABLE 13. Biorecord(cand): RETIMONO-PIMPLE.

REFERENCE TAXON DESCRIPTION		
Group of organisms	J	Monocolpate pollen.
Sequence age	G	Mesozoic/Cretaceous/Aptian.
Originator	A	Penny, J. H. J. Cambridge University, UK.
Origination date	B	1987, 9 July, seventeen 45.
Taxon name	K	Biorecord (cand): RETIMONO-PIMPLE.
Description	M	(All observations made with SEM.)

Monocolpate pollen, rounded, maximum diameter 14·8(15·5)16·1 μm. Exine semitectate, reticulate, lumina small, rounded or irregularly subcircular, maximum internal diameter 1·4(1·8)2·4 μm. Microlumina absent. Muri rounded in cross-section, height 0·5(0·54)0·6 μm, width 0·56(0·58)0·8 μm; upper surfaces with sculpture of truncated spines; sides and lower surfaces unsculped; columellae absent. Aperture long, extending half-way round the circumference of the grain and bordered by wide tectate margins that have heavily concentrated sculpture. Lumina adjacent to aperture, smaller than those on the main body of the grain. Nexine smooth, rounded, separated from sexine by a narrow gap. Precise measurement of nexine obstructed by sexine.

Variation record	N	Recorded under M.
Number of specimens	L	2.
Locality	C	Mersa Matruh borehole, N.-W. Desert, Egypt. Grid ref. 31° 19′ 43.00″ N., 27° 16′ 07.00″ E.
Rock formation	D	Kharita.
Sample position	E	MMX-1 7890, at depth 7890 ft.
Sample lithology	F	Medium pale yellow sandstone.
Preservation	P	Good.
Repository	R	Dept. Earth Sciences, Cambridge University, UK. Preparations. JP 066, 180. Stubs JPS 228, 229, 230, 249.
Earlier records	S	None.
Conclusion	T	Ends.

Occurrence of RETIMONO-BIGHOLE *(cand and CfA records)*. The first reliable occurrence of grains of this morphology is in sample MMX-1 8183 (mid-Aptian). They then range up through the sequence, the youngest occurrence being in sample MMX-1 5203 (early Albian). There is one occurrence outside this range in cuttings sample MMX-1 10240* (early Aptian). This form is rare, becoming slightly more frequent towards the top part of its range.

Biorecord(cand): RETIMONO-PIMPLE

Plate 38, figs. 7, 8, 10, 11; Table 13

Comparison and remarks: RETIMONO-PIMPLE. This grain type is rare, being represented by only three specimens. Nevertheless it is very easily distinguished by the broad tectate aperture margins and by the markedly smaller size of the lumina adjacent to the aperture. There are no clearly comparable published examples.

Occurrence of RETIMONO-PIMPLE. Grains with this morphology occur in only two samples, MMX-1 7890 and MMX-1 8818, both of which are mid-Aptian.

Deposited records of RETIMONO-PIMPLE (sample number MMX-1../number of specimens). Biorecord(cand): 7890/2; CfA: 8818/1.

DISCUSSION

Diversity and taxonomic status

This study has shown that detailed SEM examination of large numbers of specimens makes it possible to distinguish many different forms within the large *Retimonocolpites peroreticulatus–reticulatus* group. There were several other varieties in addition to the thirteen described above, but these are not currently known in sufficient detail to be described.

In the past, assignments to several genera have been suggested for grains of the *R. peroreticulatus–reticulatus* group, two of these being *Liliacidites* Couper, 1953 and *Retimonocolpites* Pierce, 1961.

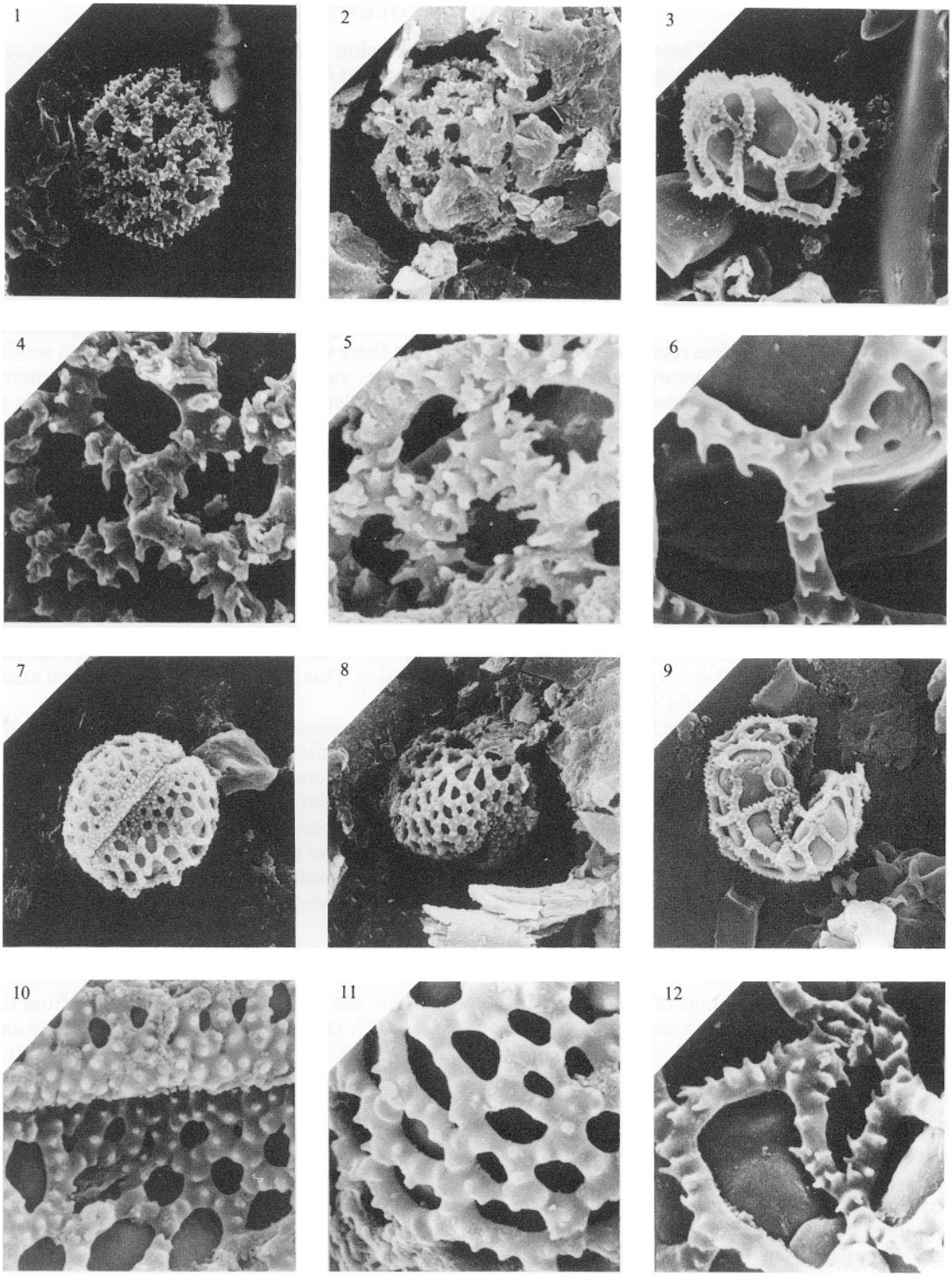
The form genus *Liliacidites* was described by Couper (1953) from the Upper Cretaceous to Eocene in New Zealand, the distinctive features being monosulcate (occasionally trichotomosulcate) apertures, elongated outlines and reticulate, columellate sexine with lumina in the reticulum being of variable size. The precise circumscription of this genus is still disputed, but Doyle *et al.* (1975) restrict it to grains with 'differentiation of the reticulum into coarsely and finely reticulate areas', this being their reason for using *Retimonocolpites* for *R. peroreticulatus*, *R. reticulatus*, and related forms. Unfortunately *Retimonocolpites* is also unsuitable. It was erected for 'reticulate, monocolpate pollen', but the type species, *R. dividuus* Pierce, 1961, is described as columellate although this feature was not specified in the generic description because at the time acolumellate pollen was not known making the

EXPLANATION OF PLATE 38

Figs. 1, 2, 4, 5. RETIMONO-HAIRY. 1 and 4, grain number JPR 770/34 (spot), sample MMX-1 7310, prep. JP 195, stub JPS 245, coordinates 785 × 352. 1, × 1600, neg. 240/15; 4, × 7000, neg. 240/16. 2 and 5, grain number JPR 769/2 (CfA), sample MMX-1 5430*, prep. JP 042, stub JPS 75, coordinates 815 × 315. 2, × 1600, neg. 60/5; 5, × 7000, neg. 60/6.

Figs. 3, 6, 9, 12. RETIMONO-BIGHOLE. 3 and 6, grain number JPR 243B/13 (cand), sample MMX-1 5400*, prep. JP 041, stub JPS 73, coordinates 768 × 248. 3, × 1600, neg. 39/29; 6, × 7000, neg. 39/30. 9 and 12, grain number JPR 134B/24 (CfA), sample MMX-1 5203, prep. JP 063, stub JPS 103, coordinates 876 × 290. 9, × 1600 neg. 70/32; 12, × 7000, neg. 70/33.

Figs. 7, 8, 10, 11. RETIMONO-PIMPLE. 7 and 10, grain number JPR 763/26 (cand), sample MMX-1 7890, prep. JP 066, stub JPS 228, coordinates 754 × 365. 7, × 1600, neg. 193/22; 10, × 7000, neg. 193/23. 8 and 11, grain number JPR 763/35 (cand), sample MMX-1 7890, prep. JP 066, stub JPS 228, coordinates 742 × 338. 8, × 1600, neg. 193/29; 11, × 7000, neg. 193/30.



PENNY, Retimono-hairy, bighole, pimple

distinction unnecessary. There has since been much discussion about what can be included in this form genus. Walker and Walker (1984) made combined LM/SEM/TEM studies of single grain preparations and in their discussion they noted that *R. peroreticulatus* should be placed in a separate genus, although they reserved that separation for the future when more specimens had been examined.

Juhász and Góczán (1985) attempted to clarify the classification of early Cretaceous angiosperm pollen, describing several new genera and species from their Albian Hungarian material. One of these new genera, *Brenneripollis*, was partly distinguished by the tendency for sexine and nexine to be loosely connected, and *R. peroreticulatus* and *R. reticulatus* were transferred to it. However, these species are still not clearly comparable with *Brenneripollis* because they are acolumellate while the genus description specifically refers to columellate varieties.

Juhász and Góczán used only light microscopy, thus limiting their scope for clear recognition of taxa, but they nevertheless recognized the probability that there were many more species with similar morphologies than *R. peroreticulatus* and *R. reticulatus*, suggesting that in the past limited observation had led to misidentifications. Thus, *R. peroreticulatus* and *R. reticulatus* still remain as problematic taxa; neither can be properly compared with the forms described in this study because SEM detail is unavailable for the type material and even SEM examination of new specimens from the type locality leaves the problem unresolved (Doyle *et al.* 1975).

Both Doyle *et al.* (1975) and Walker and Walker (1984) provided SEM illustrations of grains referred to as *R. peroreticulatus*. These grains are different in size, although they share the feature of randomly placed spines which distinguishes RETIMONO-SPOTSPINES and RETIMONO-HEDGEHOG. The specimen illustrated by Doyle *et al.* (1975) compares quite well with RETIMONO-HEDGEHOG while that of Walker and Walker (1984) is more similar to RETIMONO-SPOTSPINES, these similarities also extending to their respective observed stratigraphic ranges. Clearly it is possible that these two published specimens might indeed belong to completely separate forms, although this could only be confirmed by SEM examination of more specimens from North America. This being the case the problem arises as to which, if either, should be called *R. peroreticulatus*.

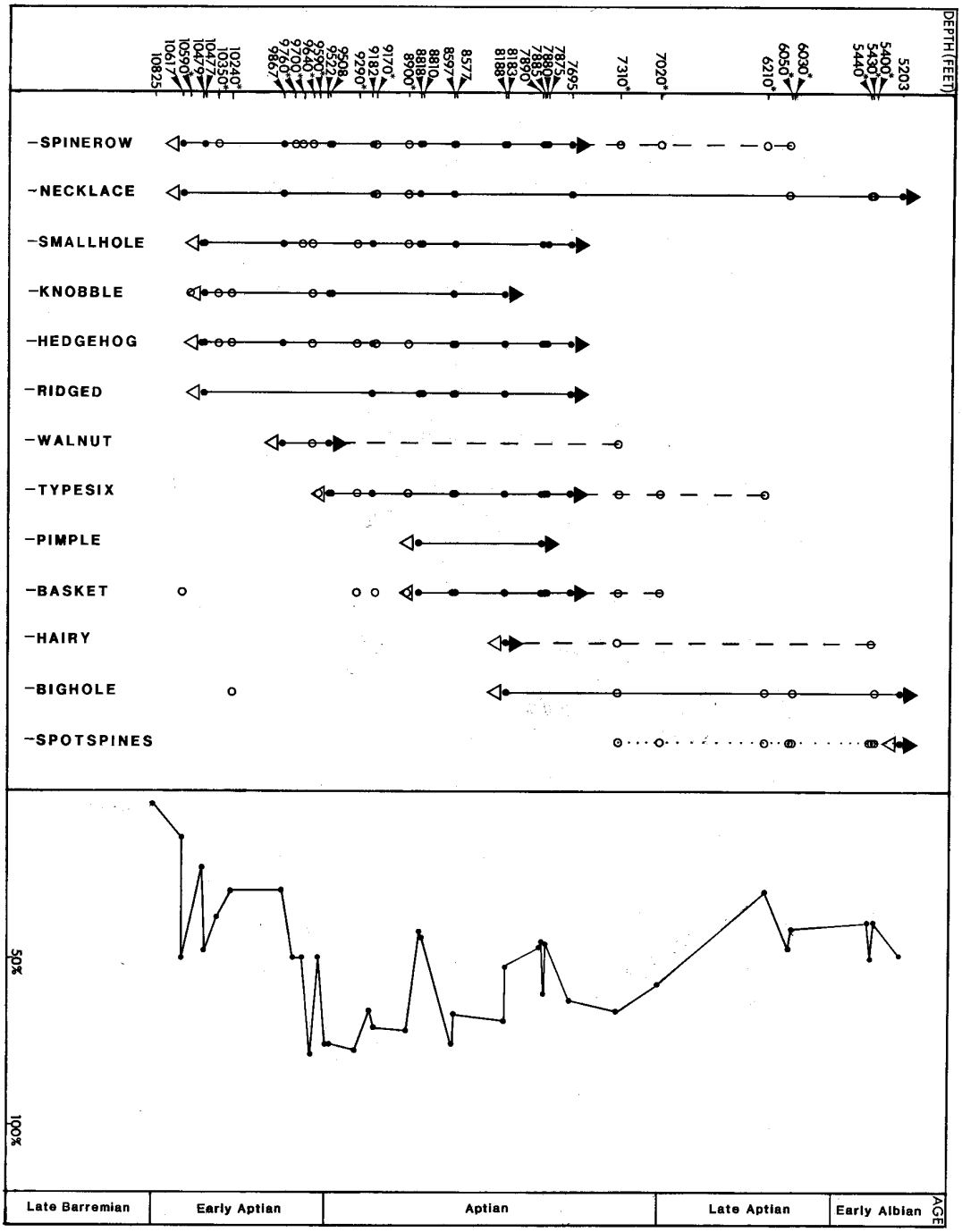
In view of the wide range of forms which can now be distinguished I feel there is justification for the complete separation of grains of this morphology from any affinity with the established generic groups, one of the main criteria for this separation being their complete lack of columellae.

Furthermore, in the light of the obvious difficulties associated with attributions to the two existing species *R. peroreticulatus* and *R. reticulatus*, I feel that these two species should be retained only for the storage of the lower resolution LM data, while new forms which are more precisely distinguished with SEM detail must be accommodated in entirely new taxa, thus avoiding the problems associated with misattribution and consequent ballooning of taxa for which the whole ranges of morphology are not available.

Stratigraphic information

The earliest recorded grains of this group are of possible late Barremian or early Aptian age from the Potomac group of North America (Brenner 1963; Doyle 1969; Doyle and Robbins 1977; Hickey and Doyle 1977), Alberta (Singh 1971, 1975), and Israel (Brenner 1974). Unfortunately the dating control of these observations is uncertain, either because of the lack of independent stratigraphic evidence or because of the possibility of sample contamination (e.g. through caving (Brenner 1974)). However, comparison with better dated sequences such as those from southern England (e.g. Hughes *et al.* 1979) indicates that these first occurrences are certainly not younger than early Aptian. Definite Aptian and Albian occurrences are confirmed by many observations, sometimes backed by finer stratigraphic control through megafossils (e.g. Singh 1975) or lithostratigraphic correlation (Schrank 1983). The topmost occurrences are of probable Cenomanian age (Laing 1975), although Morgan (1976) figures some similar grains as *L. textus* from sediments which are possibly as recent as Turonian.

The stratigraphic ranges of the forms described in this study are illustrated in the range chart (text-fig. 7). The earliest appearance is in sample MMX-1 10825, from which only three grains were recovered. One of these is CfB to RETIMONO-HEDGEHOG and one is CfB to RETIMONO-SMALLHOLE. The



TEXT-FIG. 7. Stratigraphic distribution of the RETIMONO forms in Mersa Matruh 1 and their abundance expressed as a percentage of the total angiosperm pollen. Solid circles, core sample occurrences; open circles, cuttings sample occurrences; open triangles, no older core sample occurrences; solid triangles, no younger core sample occurrences; solid line, stratigraphic range in core samples; dashed line, distribution in cuttings above older core occurrences; dotted line, probable distribution in cuttings below younger core occurrences.

age of this sample is ?Barremian to early Aptian, making this first appearance roughly equivalent to the earliest records of similar grains elsewhere.

Considerable diversification then takes place in the mid Aptian, with a peak diversity in the mid to late Aptian followed by a slight decline in the late Aptian to early Albian part of the sequence. Numerical abundance, expressed as percentage of the total angiosperm pollen grains recovered, follows the same trend (text-fig. 7).

It can be seen from text-fig. 7 that there is a good potential for the use of these grain types in biostratigraphy. Obviously the usefulness of this information will be greatly influenced not only by the morphological detail of any new records but also on the numbers of specimens which are available for comparison, particularly as some of the forms described above are easily confused.

The forms with the greatest stratigraphic potential are those that can be recognized most easily. In this respect RETIMONO-RIDGED would be an ideal marker for the early to mid Aptian because it is easily picked out by its distinctive transverse ribbing. RETIMONO-PIMPLE has similar advantages but its rarity will limit its usefulness. The later part of the sequence is characterized by the presence of RETIMONO-BIGHOLE, which is fairly easily distinguished by its large lumina, and RETIMONO-SPOTSPINES, which is more difficult to identify without examination of many specimens because it can easily be confused with the slightly larger RETIMONO-HEDGEHOG. Single or few grains are therefore not very useful in this separation, because there is an overlap in size range between the two types. However, it seems that most of the published examples are of the spinate forms, being similar to RETIMONO-SPOTSPINES or RETIMONO-HEDGEHOG (e.g. Doyle *et al.* 1975; Walker and Walker 1984) or to the forms with spines in pairs such as RETIMONO-SPINEROW (e.g. Schrank 1983). The apparently exaggerated rarity of the non-spinous varieties might be due to the extensive use of LM only, with which it is impossible to distinguish them. Nevertheless, the much greater numerical abundance of the spinous forms gives them the main potential for future stratigraphic correlation. It is, therefore, most important that future comparisons are made only when SEM detail and large numbers of specimens are available, otherwise this potential will be lost and the distinction between the various forms confused by misattribution and consequent taxonomic ballooning.

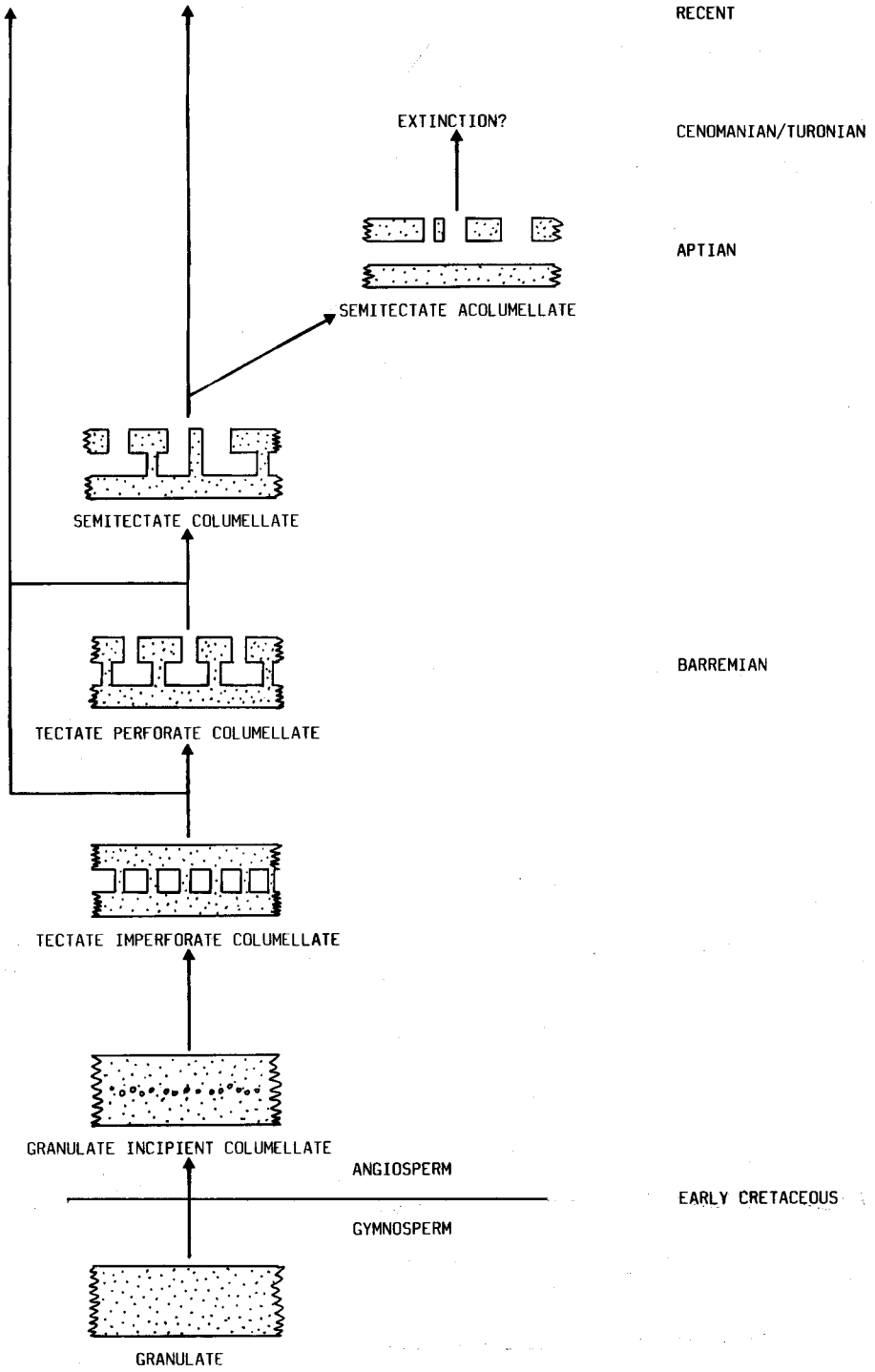
Speculation on the evolutionary relationships of the group

One of the most interesting and distinctive features of the pollen types in this group is the complete absence of columellae. Doyle *et al.* (1975) regarded this as a feature which distinguished the group as an 'extinct experimental line' that had become secondarily acolumellate by reduction, hinting that the tendency towards the acolumellate condition might also account for the relatively sparse columellae of forms such as *R. dividuus* Pierce, 1961.

The earlier appearance of columellate varieties has been well documented, the earliest being recorded from southern England (Hughes *et al.* 1979; Hughes and McDougall 1987). In addition to the columellate varieties Hughes *et al.* (1979) recovered pollen which was very similar to RETIMONO-SPINEROW. These were recorded as Biorecord(cand): RETISULC-DUBDENT and exhibited the interesting feature of short basal remnants of columellae. Independent dating reveals that these are the oldest accurately dated examples of acolumellate pollen, being of earliest Aptian age.

The similarity of RETISULC-DUBDENT to the RETIMONO forms described above, together with the possession of remnants of columellae, places this form in an intermediate position between the early columellates and the typical acolumellate varieties. In my view this provides an important clue to the origin of the acolumellate forms supporting the suggestion of Doyle *et al.* (1975) that the group is indeed secondarily acolumellate (text-fig. 8).

Acknowlegements. This work had the financial support of a NERC case award (no. GT4/82/GS/19) with Robertson Research International Limited of North Wales, to whom I am also grateful for providing the samples and obtaining permission from the original drilling company for publication of my results. I am greatly indebted to my supervisor Dr N. F. Hughes who provided much advice and useful discussion. Drs M. C. Boulter and J. A. Doyle made very helpful criticisms of the text. I thank Mr D. Newling and Mr R. Lee for their assistance with the photography and G. W. J. Penny for assistance with the preparation of the plates.



TEXT-FIG. 8. A chronological scheme for the early evolution of tectate angiosperm exine structure (modified after Walker 1976).

REFERENCES

BRENNER, G. J. 1963. The spores and pollen grains of the Potomac Group of Maryland. *Bull. Md. Dep. Geol. Mines*, **27**, 215 pp.

—— 1974. Palynostratigraphy of the Lower Cretaceous Gevar'am and Talme Yafe formations in the Gevar'am 2 well. *Bull. Geol. Surv. Israel*, **59**, 1–27.

CHAPMAN, J. L. 1982. Morphology, classification and interpretation of Aptian and Albian angiosperm pollen from Portugal. Ph.D. thesis (unpublished), University of Cambridge.

COUPER, R. A. 1953. Upper Mesozoic and Cainozoic spores and pollen from New Zealand. *Palaeont. Bull. Wellington*, **22**, 1–77.

DOYLE, J. A. 1969. Cretaceous angiosperm pollen from the Atlantic coastal plain and its evolutionary significance. *J. Arnold Arbor.* **50**, 1–35.

—— JARDINE, S. and DOERENKAMP, A. 1982. *Afropollis*, a new genus of early angiosperm pollen, with notes on the Cretaceous palynostratigraphy and paleoenvironments of northern Gondwana. *Bull. Centres Rech. Explor.-Prod. Elf-Aquitaine*, **6** (1), 39–117.

—— and ROBBINS, E. I. 1977. Angiosperm pollen zonation of the continental Cretaceous of the Atlantic coastal plain and its application to deep wells in the Salisbury Embayment. *Palynology*, **1**, Proc. VIIIth Ann. Mtg. AASP, Houston, 43–78.

—— VAN CAMPO, M. and LUGARDON, B. 1975. Observations on exine structure of *Eucommiidites* and Lower Cretaceous angiosperm pollen. *Pollen Spores*, **17** (3). 429–486.

HICKEY, L. J. and DOYLE, J. A. 1977. Early Cretaceous fossil evidence for angiosperm evolution. *Bot. Rev.* **43** (1), 3–104.

HUGHES, N. F. 1976. *Palaeobiology of angiosperm origins*, 242 pp. Cambridge University Press, Cambridge.

—— 1986. The problems of data-handling for early angiosperm-like pollen. *In* SPICER, R. A. and THOMAS, B. A. (eds.). *Systematic and taxonomic approaches to palaeobotany*. Systematic Association series no. **31**, 235–253.

—— DREWRY, G. E. and LAING, J. F. 1979. Barremian earliest angiosperm pollen. *Palaeontology*, **22** (3), 515–535.

—— and MCDOUGALL, A. B. 1987. Records of angiospermid pollen entry into the English Early Cretaceous succession. *Rev. Palaeobot. Palynol.* **50**, 255–272.

JUHÁSZ, M. and GÓCZÁN, F. 1985. Comparative study of Albian monosulcate angiosperm pollen grains. *Acta biol., Szeged.* **31**, 147–172.

LAING, J. F. 1973. Angiosperm and gymnosperm pollen from the upper Albian to middle Cenomanian of southern England. Ph.D. thesis (unpublished), University of Cambridge.

—— 1975. Mid-Cretaceous angiosperm pollen from southern England and northern France. *Palaeontology*, **18** (4), 775–808.

MORGAN, R. P. 1976. Albian–Senonian palynology of site 364, Angola Basin. *Init. Rep. DSDP*, **40**, 915–951.

PENNY, J. H. J. 1986*a*. Early Cretaceous angiosperm pollen from Egypt. Ph.D. thesis (unpublished), University of Cambridge.

—— 1986*b*. An early Cretaceous angiosperm pollen assemblage from Egypt. *Spec. Papers in Palaeontology*, **35**, 119–132.

PIERCE, R. L. 1961. Lower Upper Cretaceous plant microfossils from Minnesota. *Bull. Minn. geol. Surv.* **42**, 1–86.

SCHRANK, E. 1982. Kretazische Pollen und Sporen aus dem Nubischen Sandstein des Dakhla-Beckens (Agypten). *Berliner Geowiss. Abh.* **A 40**, 87–109.

—— 1983. Scanning electron and light microscopic investigations of angiosperm pollen from the Lower Cretaceous of Egypt. *Pollen Spores*, **25** (2), 213–242.

SINGH, C. 1971. Lower Cretaceous microfloras of the Peace River area, northwestern Alberta (2 vols. and appendix). *Bull. Res. Coun. Alberta*, **28**, 1–299 and 301–542.

—— 1975. Stratigraphic significance of early angiosperm pollen in the mid Cretaceous strata of Alberta. *Spec. Pap. geol. Ass. Can.* **13**, 365–389.

WALKER, J. W. and WALKER, A. G. 1984. Ultrastructure of lower Cretaceous angiosperm pollen and the origin and early evolution of flowering plants. *Ann. Mo. Bot. Gdn.* **71**, 464–521.

J. H. J. PENNY
Department of Earth Sciences
Cambridge University
Downing Street
Cambridge CB2 3EQ

Typescript received 12 January 1987
Revised typescript received 17 July 1987