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A note on the systematic recording of organic-walled microfossils (other than pollen and spores) found in archaeological and Quaternary palynological preparations

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Summary

A simple system for recording organic-walled microfossils other than pollen and spores, chiefly fungal spores and algal cysts, which has been successfully applied to diverse palynological assemblages, is reported. Its basis is the creation of informal form-species or 'types' by the systematic description of the morphological characteristics of each microfossil. The system enables the accurate description of entire assemblages of microfossils without the need for the formal identification of each *'incertae sedis'* microfossil. It is therefore possible to characterise such assemblages and recognise recurring patterns of possible palaeoecological and/or palaeoeconomic significance even when the taxonomic identity of specific form-species remains unknown.

Introduction

In addition to the pollen of flowering plants and the spores of higher cryptogams and some mosses, many other organic-walled microfossils are present in palynological preparations. Such microfossils, of unknown or uncertain affinities or origin ('acritarchs'), together with fungal spores and algal encystment structures, have been used for many years in pre-Quaternary palynology both as stratigraphic zone fossils (Elsik 1968a, b; 1976; Ediger 1981) and, when used as part of a group or facies of palynomorphs, as environmental indicators (Batten 1973; Hart 1986; Jarzen and Elsik 1986).

'Acritarchs' are also common in archaeological and Quaternary palynological preparations (Faegri and Iversen 1975, 216). Many appear to be of algal or fungal origin. However, while the general affinities of these microfossils may be clear, many have not been successfully systematised and relatively few have been identified to the level of species or genera (Godwin and Andrew 1951; Van Geel and Van der Hammen 1978; Brinkkemper *et al.* 1987).

The specific, formal, identification of such organic-walled microfossils would appear to be difficult because:

(1) The taxonomy of algal and fungal bodies is commonly based on the complete living organism and its life cycle and not upon the individual spore or resting stage (cyst) alone (Graham 1971; Elsik *et al.* 1983); in consequence the morphology of cysts, fruiting bodies or spores in isolation plays a minor role in the classification of taxa into families, genera or species.

(2) At present no systematic corpus of subfossil Quaternary fungal spores, algal cysts and other organic-walled microfossils is available. The classification of these microfossils has therefore remained confused and is in need of clarification.

(3) The literature of algology and mycology is unfamiliar to palynologists and archaeologists.

In consequence this large and varied group of microfossils has generally been neglected in the reconstruction of past environments or the search for evidence of subsistence activity (Dimbleby 1978, 121). Yet this group offers considerable potential to that end (Graham 1962; Van Geel 1976). They occur in considerable numbers in conventional palynological preparations, they are thought to be resistant to decay,

they are morphologically distinct and ultimately derive from taxa with largely known ecological tolerances and whose association with human activities, both directly and indirectly, is well documented (e.g. Clark 1952; Ashbee 1957; Helbæk 1958; Watling 1974; Seaward 1976; Van Geel 1976).

To overcome the above problems several workers have created morphologically distinct microfossil 'types' which have then been recorded in the same way as other, formally named, taxa (Van Geel 1978; Brinkkemper *et al.* 1987). In Van Geel's system each new microfossil encountered is described, recorded and given a type number. Each type ". . . can be considered as a provisionally, but not formally named type species" (Van Geel 1978, 47). Consultation with suitable authorities enables the subsequent provisional identification of many of the taxa concerned. This form-species approach is ultimately derived from pre-Quaternary palynology (cf. Traverse 1988).

This 'informal form-species' or 'type' approach was adopted by the author during the palynological investigation of Quaternary cave sediments (Coles 1988). Initial difficulty was experienced with the systematic description of this diverse group of microfossils. The characteristics described below were found to be a useful means of describing morphologically distinct types of organic-walled microfossils and may in consequence be of interest to other palynologists.

The recording system

The system is based on a simple pro-forma record sheet (shown in Fig. 3). The sheet is designed to be photocopied back to back on a single sheet of A4 paper and stored in ring binders. The characteristics recorded permit the differentiation of the type from other, similar, 'taxa'. The sheet also records the location of the informal holotype (a single type specimen selected to show its main characteristics), and informal paratypes (specimens selected to show additional characteristics), of the type, enabling its subsequent examination for comparative purposes.

Each worker using the system uses an independent running series of numbers prefixed by a three letter abbreviation of the workers initials or name (workers within a single laboratory may care to erect a single 'laboratory series' for convenience). This provides for the unique identification of each series. Where a type subsequently resists formal identification, publication of the *incertae sedis* type as a form species may be appropriate (for an example see Hunt, Andrews and Gilbertson 1985).

The definition of descriptive terminology suitable for all organic-walled microfossils is beyond the scope of this note and readers are advised to consult Kremp (1965), Elsik *et al.* (1983) and Traverse (1988, 297–306) for suitable terms. It should be noted, however, that the terminology employed for the description of pollen and the higher cryptogam spores is generally inappropriate for the description of algal cysts and fungal spores since apparently similar features may have quite different functions and origins.

Each major characteristic on the record sheet has a separate field number. Related characteristics are described by sub-fields. As some information (e.g. fields 20 and 22, below) may have to be added after the analysis of a given site is completed, it is convenient to hold the records as a 'working file'; following which the new records can be checked, photographic plates added and collated within the main record. The descriptive fields are defined below:

Side 1: morphological description (Fig. 3a)

01 Type Number: the number of the type within the running series, always prefixed with the recording worker's initials, e.g. GMC 217, etc.

02 [Informal] Type Name: the name given to the type by the worker. This is an informal name and is not necessarily of taxonomic significance. If the taxon is subsequently identified, the formal name should be used.

03 Drawing: detailed drawing of the type specimen, showing (if possible) polar and equatorial views. May be annotated. Scale (in micrometers, µm) must be shown.

04.1 Transparencies: used to record the film

and frame number if transparency film is employed. A note of the storage location of transparencies should also be given.

04.2 Photograph: monochrome plate(s) of type. Again may be annotated.

04.3 Notes: used to record the film/negative number and frame number of the monochrome film used. Film type/speed and exposure information may also be given.

05 Shape: the shape or overall structure of the palynomorph (see Elsik *et al.* 1983).

06 Overall Dimensions:

06.1 length of *a*-axis (generally the polar or longitudinal axis).

06.2 length of *b*-axis (generally the equatorial or transverse axis).

06.3 length of *c*-axis (applicable to non-sphaeroidal irregular palynomorphs).

07 Internal Divisions (septa): the cross wall or any wall layer partitioning the inner space of a palynomorph. Typical forms of internal divisions (septa) are shown in Elsik *et al.* (1983).

07.1 Description: the form of the division, whether simple or complex with one or more openings (see 07.4). In some cases the dimensions of divisions (in particular the thickness) will vary, this should also be noted.

07.2 Location of divisions: transverse, longitudinal, or complex (transverse and longitudinal combined).

07.3 Number: number of internal divisions.

07.4 Apertures: location and structure of openings within internal divisions.

08 Wall Structure: the arrangement of layers within the palynomorph wall.

08.1 Description: complex (many-layered or ornamented) or simple (hyaline).

08.2 Number: number of wall layers discernible in transmitted light.

08.3 Distribution: distribution of wall layers, or differentiation in the thickness of the layers across the palynomorph; uniform, thinning towards poles, etc.

08.4 Dimensions: thickness of each layer; maximum and minimum (if applicable).

09 Wall Sculpture (ornament): features which stand out in relief on the wall surface.

09.1 Description: type of sculpture.

09.2 Distribution: orientation or distribution of sculpture.

09.3 Dimensions: dimensions of sculpture forms.

10 External Appendages/Processes: hyphal, hair- or spine-like projections which anchor or otherwise ornament various fruit bodies or spores. Generally any process or outgrowth which is elongate; whether straight or flexuous. The boundary between 'sculpture' and 'appendages/processes' is obviously arbitrary; generally an appendage is considered to be more than twice as long as it is broad. Differentiation of sculpture and processes is necessary for palynomorphs which have a sculptured surface together with distinct and separate appendages.

10.1 Description: type of appendage: hyphal, hair or spine like.

10.2 Distribution: distribution of appendages across surface of microfossil.

10.3 Dimensions: dimensions of appendages/processes.

10.4 Number: number of appendages; if greater than ten give estimated numbers or 'greater than'/'less than' figures.

11 Apertures/Attachment Scars: (Aperture—a pre-formed opening in the palynomorph wall; attachment scar—an interruption of the spore wall at the site of palynomorph). In practice it is difficult to distinguish between apertures and attachment scars since this involves an interpretation of the function of a particular opening which may not be immediately

01 Type Number:	**02 Type Name:**
03 Drawing:	
04.1 Transparency: **04.2 Photograph:**	**04.3 Notes:**
05 Shape: **06 Dimensions:** 06.1 a:	06.2 b: 06.3c:
07 Internal Divisions (septa): 07.1 Description: 07.3 Number:	07.2 Location: 07.4 Apertures:
08 Wall Structure: 08.1 Description: 08.3 Distribution: **09 Wall Sculpture (ornament):** 09.1 Description: 09.2 Distribution:	08.2 Number: 08.4 Dimensions: 09.3 Dimensions:
10 External Appendages/Processes: 10.1 Description: 10.3 Dimensions:	10.2 Distribution: 10.4 Number:
11 Apertures/Attachment Scars: 11.1 Structure: .11.3 Number:	11.2 Dimensions: 11.4 Distribution:
12.1 Colour:	**12.2 Stain uptake:**

Fig. 3 (above and opposite). Sample of incertae sedis *microfossil recording sheet. (a) (above) Side 1—morphological description.*

01 Type Number:	**02 Type Name:**
13 Similar to/different from: **14 Provisional Identification:**	
15 Holotype Location: 15.1 Slide Number: 15.3 England Finder Ref: 15.4 Micrometer (microscope):	15.2 Sample Number: hor. vert.
16.1 Storage Location of Slide: 16.2 Accession Number:	
17 Sample Site Location: 17.1 Site Name: 17.3 Country: 17.5 Publication:	17.2 Region: 17.4 Grid Ref:
18.1 Sample Preparation Methods: 18.2 Sample Mounting Medium: **19.1 Analysis by:**	 **19.2 Date:**
20 Palynological Association: **21 Ecological Association:**	
22 Provisional Age of Sample: **23 Frequency of Occurrence:**	
24 Specimen/Sample Cross Reference:	
25 Literature Cross Reference:	
26 Additional Notes:	

(b) Side 2—information on affinities/identification, find location, storage location and recovery methods.

apparent in the fossil state. In consequence they are best described together.

11.1 Structure: circular, elongate ('pores'), slit-like ('furrow'), etc.

11.2 Dimensions: length by breadth by depth.

11.3 Number: number of openings.

11.4 Distribution: random, zonate, polar, etc.

12.1 Colour: several types of palynomorph, notably fungal spores, exhibit various shades of brown due to the presence of melanin and/or other pigments. The presence or absence of colour and an estimate of the colour (using the Munsell colour system or similar) should be recorded.

12.2 Stain Uptake: state type of stain used (fuchsin, safranine, etc.) and the degree of uptake relative to pollen present in the assemblage.

Side 2: information on type affinities/identification, find location, storage location and recovery methods (Fig. 3b)

For ease of use, the Type Number (01) and Type Name (02) fields are repeated at the top of the form.

13 Comparable with/different from: list of types similar to (and hence possibly confused with) the described type. If possible note major distinguishing feature(s).

14 Provisional Identification: the affinities of the type and possible identifications.

15 'Holotype' Location: the accurate location of a given informal holotype is essential if the specimen is to be relocated for subsequent study and comparison with other, possibly homologous, taxa.

15.1 Slide Number.

15.2 Sample Number.

15.3 England Finder Reference: reference using England finder (see Traverse 1988, 483–6).

15.4 Micrometer: give the microscope used and the horizontal and vertical stage micrometer co-ordinates. The stage micrometer is to be used only if an England finder is not available since the micrometer reference will only apply to a particular microscope. All locations recorded by stage micrometer should be transcribed to England finder references before archiving.

16.1 Storage Location of Slide: the institution where the slide is permanently curated or stored.

16.2 Accession Number: institution catalogue number of the slide (if different from the slide number).

17 Sample Site Location: the locality from which the sample containing the recorded type was collected.

17.1 Site Name.

17.2 Region (or county if in British Is.).

17.3 Country.

17.4 Grid Reference (if applicable).

17.5 Publication: if the described specimen has been published, or the site from which the specimen has been recovered has been published, give the full reference of the paper.

18 Sample Preparation Methods: several authors have noted the possible effects of preparation techniques and mounting media upon the definition of surface sculpture and size of pollen grains (e.g. Faegri and Deuse 1960; Cushing 1961; Praglowski 1970). In the absence of comparable information, similar strictures may apply to other organic-walled microfossils and hence it is desirable to record the preparation techniques used and the mounting medium employed.

18.1 Preparation Methods: state methods used, give reference if applicable.

18.2 Mounting Medium: state type of mountant.

19.1 Analysis by: person making record.

19.2 Date: date of first record.

20 Palynological Association: give major pollen and spore types with which the type is associated. e.g. *Betula*—Coryloid—Gramineae. This should preferably be synonymous with the local pollen assemblage zone, if so this information will obviously need to be added after the completion of the conventional pollen and spore analysis.

21 Ecological Association: give postulated environment of deposition or if taken from a modern (known) environment, describe (for example, 'Leaf litter beneath mature oak woodland'). In addition the source of ecological association data should be indicated (i.e. inference or observation).

22 Provisional Age: of the sample or the age range through which the type is present at the type site (indicate which). For example: 'Modern comparative (1990)', '*circa* 3500 bp.' or 'Flandrian—Godwin Zone VI to VIII'. Again such information may only become available following the completion of the analysis or after radiometric dating and will need to be added retrospectively.

23 Frequency of Occurrence: estimate of frequency (in type sample or at type site); single specimen or abundant in many samples.

24 Specimen/Sample Cross Reference: note the occurrence of the described type in other samples or in other sites and contexts.

25 Literature Cross Reference: possible synonyms in published sources and comments as to the degree of similarity (e.g. 'Compare with type 98 of Van Geel 1978').

26 Additional Notes: any additional information not recorded above.

Application

In practice, new 'types' are created as they are encountered. Thus it will be apparent that the type number does not reflect the morphology of the palynomorph (since the type numbers are allocated as each type is discovered) and hence cannot express the morphological (generic) relationship of the taxon in question. While the number of described types remains small this does not present an undue problem. However as the

Type Number:	Type Name:	Type Group:	File:
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Fig. 4. Part of incertae sedis *microfossil type number allocation sheet.*

number of types grows it becomes increasingly difficult to locate previously recorded taxa and establish whether they are similar or a new, and undescribed, type. It is therefore necessary to impose a morphological order on the types.

To enable the storage of records in morphological order, an additional record of the numbers allocated must be kept to prevent duplication. This is simply a sheet listing the type numbers used, in the order of allocation, and the morphological group and sub-groups into which they have been placed (Fig. 4).

The records are allocated to morphological 'type groups' on the basis of four orders of characteristic. These are:

1st order
1. Shape/overall structure.

2nd order
2. Number of apertures/attachment scars.

3rd order
3a. Internal divisions.
3b. External appendages/processes.
3c. Wall sculpture.

4th order
4a. Wall structure.
4b. Wall colour (pigmentation).

Types are allocated to morphological groups using the rank order of characteristics. The records for each type within the first order group are held together, subdivided according to the second order characteristic, and so on. Where a type does not possess a given characteristic the next lowest rank of feature is used. For example, where sphaeroidal, inaperturate, internally undivided palynomorphs are encountered, they may only be separated on the basis of fourth order characteristics, such as the presence or absence of pigmentation and size. It should be noted that size is generally a low rank characteristic because of uncertainties regarding the possible effects of different processing techniques and mounting media.

It should be apparent that as the number of records increases, so will the potential number of subdivisions within a given group. It will also be apparent that this morphological classification of palynomorphs does not necessarily reflect the true taxonomic relationship of the living taxa from which these organic-walled microfossils are ultimately derived. Nevertheless, such classification has considerable value in permitting the accurate recording of palynomorphs of uncertain origin.

Conclusion

The system outlined above has proved sufficiently flexible to record many forms of palynomorph. The system at present forms the basis of a catalogue of *incertae sedis* organic-walled microfossils held in the Department of Archaeology at the University of Edinburgh. It is hoped that this will eventually form the subject of a published corpus of material together with a morphological key to the principal types.

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