be forced up into the sinter funnel was almost as effective, although draining of the water took longer.

For the decanting of acids, Utting suggests the use of a filter pump plus T-tube to facilitate decanting with the minimum of disturbance to the organic residue (Utting, correspondence).

<u>Slide Preparation</u>:

Slide preparations incorporating techniques and mounting media are important for long-term and reliable results in palynology. In miospore analysis, as near as possible ideal microscopic observation and complete quantitative records of fossil miospores are necessary. This also requires that slides must be durable for long-term storage (in order to facilitate re-checking) and that the appearance of the microfossils should not change with time. Regarding dispersal in slide-making, miospore concentration should be such that as few pollen grains as possible should appear at the same time in the field of vision.

Fluid mounting media (glycerine) or solid mounting media (glycerine jelly, Canada Balsam) are generally used. In the former case, viscosity permits rotation of the individual grains, an advantage which is impossible in the solid media. However, in the latter case slides may be handed without disturbance or dislocation of the miospore grains, thus making them more durable. In practice, a good combination is that of a well-sealed slide, ringed externally, using a liquid mounting media internally (Anderson, p. 593).

However, for the immediate purposes on hand, personal experience has shown the solid media to be more practical, and in particular Canada Balsam rather than glycerine jelly. In slide making, the latter must be kept fluid by heating (solidifying on cooling). Also, should any water remain on the slide before final preparation, this will be trapped till evaporation eventually takes place several months later - leaving a most unsightly mess (Owens, correspondence). This <u>should</u>, however, be avoided by centrifuging the organic residue in warm glycerine prior to the addition of glycerine jelly. This mounting medium is not recommended for use in hot climates, unless well-sealed. However, one useful advantage is its low refractive index, 1.43, which produces a favourable difference when examining pollen exines whose refractive indices are 1.55 to 1.60. Canada Balsam has a refractive index of 1.53 which is too high for miospore work, but this is, nevertheless, a popular mounting medium.

In using Canada Balsam (as described by Utting and Anderson, correspondence), the residue is first mixed with Cellosize (1.50 - 1.51) or Clearcol (1.4), both water-soluble media. A drop of the organic residue plus Cellosize is then smeared on a coverslip and allowed to dry. The excess water from the organic residue is driven off and the miospore material remains fixed and evenly distributed. It is also found on one focal plane (against the surface of the coverslip) allowing for easy microscopic scanning. The coverslip is then mounted on Canada Balsam smeared on a slide and baked for 2-3 minutes at 90-100°C. Dr. Kulkarni allowed a drop of organic residue to dry on a coverslip, and then mounted this on a slide of Canada Balsam/xylol solution - with similar results.

Staining of miospores appears to be a rather personal matter, and in several cases is not introduced at all. In experimentation, little advantage was found in the mass-produced method of staining. It may prove of value in individual samples in future study. It is, however, advocated for several reasons:-

i. To increase the contrast in morphological details.

ii. To help differentiate pollen and spores from organic detritus and other microscopic matter, and

iii. To make inconspicuous and thin-walled grains more visible.

The stain used in experiments on the present samples and by palynologists in favour of this procedure is Safranin, in very dilute proportions - 0,5% aqueous solution as used by Balme. Over-staining is to be avoided as pollen grains are then impenetrable to light, and, in some cases, transparency in dense spore exines is lessened causing difficulty in phase contrast microscopy.

Summary:

The standardised maceration schedule, as outlined in tabular form, has performed a valuable function - that of releasing miospores from an assortment of rock matrices. No comparative material, in the form of previously prepared miospore samples and slides, was available on which to base this maceration schedule or with which to compare the standards of cleanliness. Many of the highly productive samples are relatively clear of detritus although the individual rock types and in particular coal samples do need more specialised treatment. One problem not well resolved was that of miospore dispersal on the slide and coverslip.

Storage of the organic residue is in small 1 mm tubular glass phials with cork stoppers. They are housed in a vertical position, in bundles of ten, in a cabinet drawer in the Department of Geology, University of Rhodesia, Salisbury. The glass slides are kept in sectioned envelopes and catalogued at present at the Bernard Price Institute of Palaeontology, University of the Witwatersrand, Johannesburg.

3.3 METHODS OF ANALYSIS

Microscopy:

A Laborlux D Leitz Microscope was used for general scanning and statistical counts. Magnification for this purpose was 500 x, but in the case of detailed miospore study, it was 1 250 x. A Zeiss photographic microscope was made available for limited photographic use.

In scanning the slides for analysis, the entire surfaces of two or more slides per sample (within the microspore co-ordinate range) was traversed for genera and species; whilst random traverses were scanned for the overall quantitative count.

Counting techniques:

Counting procedures were similar to those employed by Hart (1963, MS 1966) Segroves (1969) and Balme (1966). Visual (as opposed to true statistical) counts of a minimum 250 and maximum 500 miospore specimens were conducted in the quantitative study and 2 000 or more in the qualitative study. Control checks were taken on several samples where more than one maceration batch increased the number of available slides, and both quantitative and qualitative analyses were found to tally. In detailed qualitative analysis five grades of abundance are used: very rare (not present in the 250-500 count but seen in scanning); rare (1 per cent or less); common (1-10 per cent); abundant (10-25 per cent); and dominant (more than 25 per cent).

Analyses are divided into two major groups:

a) Quantitative analysis
b) Qualitative analysis

a) Quantitative Analysis:

The purpose of this analysis is to study the distribution throughout the borehole core of the percentage relative abundancies (based on 250-500 miospores) of the major miospore taxa i.e. at turma, sub-turma or infra-turma levels. Quantitative analyses are of use in local or regional correlation. The general trends of these major taxa within the stratigraphic range of this borehole core are more than apparent (see figure 2). An example of this may be illustrated by the percentage relative abundance variation of the Sporites group which, within the Dwyka Series (K^o), averages 70 per cent, decreasing in relative stages to average 17 per cent in Mid-Madumabisa (MK^5) shales. The total Disaccites curve appears inversely proportional to the Sporites curve. This taxon accounts for 1-6 per cent in the Dwyka Series (K^o) and up to 75 per cent in Mid-Madumabisa Shales.

b) Qualitative Analysis:
This represents the study of the generic and specific content of microfloral assemblages. Together with the quantitative assessment, it forms an integral part of any microfloral analysis.

Two categories of miospores emerge from analyses taken throughout a vertical stratigraphic sequence, and only after the distribution of the miospore content into one or other category can any assemblage boundaries be distinguished. Raistrick (1939) was one of the earliest palynologists to realise this. He divided miospores into "general" and "accessory" groups. General miospores refers to those exhibiting long vertical stratigraphic ranges and possibly fairly consistent relative abundancies whose zonal aptitudes are minimal. The point of introduction or cessation of such a genus or species is, however, of some diagnostic interest. The second group, <u>accessory miospores</u>, assumes more importance in terms of zonal schemes as it includes those of short, better-defined vertical stratigraphic ranges. These may possibly be the product of fast-evolving plant types, or plants subject to narrow ecological toleration, (i.e. only suited to certain climatic or environmental conditions). Whatever the reason for their short duration, such miospore forms become invaluable in widespread regional or inter-continental correlation. General correlation, however, requires the combined analysis of quantitative as well as qualitative studies in order to obtain reliable results.

Examples of long range miospores encountered in the Matabola Flats sequences are: <u>Apiculatisporis</u>, <u>Protohaploxypinus</u> and <u>Sulcatisporites</u>. Those of long-range with more or less finite beginnings or ends are: <u>Punctatisporites</u> (K^0-K^4), and <u>Laevigatosporites</u> (Upper K^{2-3}-MK^5). Short range and potentially diagnostic genera appear to be <u>Zinjisporа</u> (K^0), <u>Quadrisporites</u> (K^0), <u>Circulisporites</u> (cf. <u>Chomotriletes</u>) (Upper K^{2-3}); <u>Lueckisporites</u> (MK^5) and <u>Reinschospora</u> (LK^5).

4. SYSTEMATICS

4.1 APPROACH TO SYSTEMATICS

Purpose: The major purpose of this palynological research is to classify and describe the miospore content of the Matabola Flats borehole core. From these descriptions and subsequent analyses it is hoped to obtain:

a) A detailed catalogue of miospores from the productive horizons in the geochronological sequence;

b) The vertical ranges of the individual miospore components and the percentage abundance patterns of the major miospore taxa; and

c) From the comparison of all this information with other miospore assemblages, to obtain the relative ages of the beds.

Problems: The major problems in palynology, over and above those affecting the final physical state of the miospores, are those of systematic classification. Schopf (in Tschudy and Scott, 1969, p. 49) and Balme (1966) are amongst the numerous authors who have discussed this problem. J. Anderson (Ph.D. thesis, unpublished), in his detailed taxonomic monograph, also makes lengthy reference to this.

<u>Generally speaking</u>, the problem involves an explosive increase in the number of new names proposed for miospores. The only common factor in their diverse application is that of the binary form corresponding to the requirements of the "International Code of Botanical Nomenclature". This great increase in names is the result primarily of divergence in the basic philosophy of classification, viz.,

(a) Whether a morphological and somewhat artificial system is used, based on physical criteria, or

(b) Whether a phyllogenetic scheme is followed similar to that in modern plant systematics.

Over and above this, the problem of legitimacey of names is a formidable one. A legitimate name is that established fully in accordance with the "International Code of Botanical Nomenclature" which requires that forms be fully described and illustrated with the type material easily accessible. Unfortunately this is often not the case.

The concept of species distinction is, like the larger issues, a very subjective exercise. Hart (MS) discusses the species concept in terms of morphospecies, chronospecies and morphochronospecies, i.e. the species limit may be a range of morphological criteria or a vertical time span. In terms of morphology, different criteria may be used, e.g. Leschik (1959) divided his species on the basis of preservational differences, whilst the Indian authors (Bose and Kar, et al) describing the Congo material frequently used minor structural defects which were not recognised by Hart in his Tanzanian and South African publications.

In Africa, systematic problems arise because a cosmopolitan selection of authors has to date described the Permian Gondwana miospores. (See Introduction - Previous palynological work.) These include such "schools" of systematics as European (Leschik, Hilett, Hart - originally); Indian (Bose, Kar, Maheshwari, Gosh, Sen, Pant, *Høeg and *Pierart) and South African (Hart, recently). Little has been done to upgrade or compile all the material so far published, although J. Anderson (Ph.D. thesis, in press) is in the process of completing such a task.

Most palynological work in the Southern Hemisphere or Gondwana Permian sediments has been published in Australia and India (the latter has greater quantity, but is less consistent and not so easy to follow). Less abundant, but equally important contributions stem from Madagascar and South America. Almost all the material described is closely comparable, and illustrates very similar microfloral changes and assemblage patterns throughout the Gondwana era.

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* European authors here associated with Indian authors

Publications on Northern Hemisphere Permian palynology are very prolific in North America, Europe, Russia, China and Mid-Asia. However, Hart (1965, 1969) draws attention to the fact that Southern Hemisphere and Northern Hemisphere miospore species vary considerably, although the major generic and supra-generic forms are usually common.

In conclusion the systematic problems facing a palynologist in Africa at present involves

a) Several schools of systematic thought;
b) Different species concepts (adopting morphological, chronological, phyllogenetic or preservational criteria), and
c) Frequently ill-defined taxonomic forms often with inadequate illustrations.

<u>Approach</u>: Due to the practical impossibility of acquiring all Permian literature, world-wide or even covering Gondwanaland, the approach adopted herein is to follow one major taxonomic system, that of G.F. Hart (1963, 1964, 1965(a) and (b), 1967(a) and (b), 1969). In order to supplement this system in which few photographs appear, and often inadequate descriptions and coverage of certain major taxa, six other important sources of taxonomic works are consulted; those of Jansonius (1962, Canada); Bharadwaj (1962, 1[illegible]); Balme and Hennelly (1955, 1956(a) and (b)), Balme (1966) and Segroves (1967, 1969, 1970, Australia);

and Goubin (1965, Madagascar). Many other papers of relevance were also consulted, e.g. the Congo miospore publications, (Bose and Kar, et al), in order to enlarge upon certain major miospore taxa not altogether satisfactorily dealt with by Hart. The detailed studies of synonomies are therefore primarily concerned with previously described African material, but do include forms referred to in the major sources of reference.

Therefore, using the above basic standards of reference, the miospores in this study were initially pigeon-holed into the supra-generic frame-work as outlined in a following section. Thereafter the genera and species were distinguished on the grounds of their basic morphological criteria, then fully described and compared.

The systematic approach has therefore been an essentially practical one, as the distinction between an overall concept of a morphological as opposed to a phyllogenetic scheme is beyond the scope of this thesis. Future research (i.e. that of J. Anderson, op.cit.) may shift the emphasis to a more neontological phyllogenetic approach. The layout and proposed names of the genera and species described here are such that they may be relatively easily recombined to fit this type of scheme at a future date.

Due to the widely varied sources of publications in Africa, sections outlining (a) the terminology used and (b) the supra-generic groupings adopted are included in this chapter, following this section.

Due to the limited use of a photographic microscope, inadequate film processing facilities and therefore only a few plates, line drawings of each species are included below the relevant descriptions.

4.2 TERMINOLOGY

The terminology employed in this thesis is for the most part, based on that of Hart (1960, 1965). This author (Hart) has in turn adopted recently suggested terms from the International Commission for the Microflora of the Palaeozoic as well as from Norem (1958, quoted by Hart). Other terms employed are followed by their authors in brackets.

This section is sub-divided into:-

1. General morphology of spores and pollens;
2. General terms and descriptions:-
   - (a) Disaccate terminology, and method of measurement;
   - (b) Miospore shapes and apertures;
   - (c) Miospore sculpture;
   - (d) Miospore structures.

1. General Morphology of spores and pollens

Morphology of Exines See text-figure 4.1.

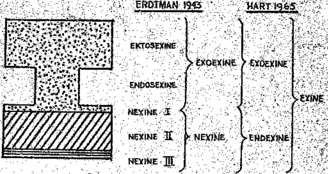
The function of the spore exine is to serve as a means of protection of the protoplasmic contents during transport and prior to germination. Exines may, therefore, be thick-walled (to guard against excessive evaporation), thin-walled (when the habitat is naturally wet and tropical) or walls bearing thickened portions in order to allow a certain degree of inflation or deflation of moisture (during desiccation) without rupture of the wall. The latter condition of the wall is said to be Harmomegathous. Harmomegathy (Wodehouse (1935) quoted by Tschudy in Tschudy and Scott, (1969)) is the accommodation of

STRUCTURE OF EXINE WALL

Text Figure 4-1

NB. DRAWN FROM TSCHUDY IN TSCHUDY & SCOTT 1969, HART 1965, FELIX & ANDREW 1961.

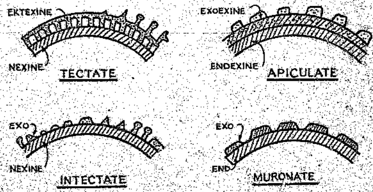
SECTION THROUGH MIOSPORE WALL



PRINCIPLE EXINE TYPES

SENSU TSCHUDY IN TSCHUDY & SCOTT 1969

SENSU HART 1965



volume change; it is considered feasible that such indications were beginning to show in spores of the late Palaeozoic - e.g. Triquitrites, Reinschospora and Indospora. Spore exines are virtually structureless with only minor stratification occasionally (Punctatisporites); sculpture is, however, variable and diagnostic.

Pollen grains require to be transported to the female gametophyte or flower in order to effect fertilisation; the shape and structural features of the pollen grain must therefore be consistent with this function - and from Cretaceous sediments onwards adaptations of the exine to these requirements became highly specialised. However, Late Palaeozoic pollen grains were yet in their evolutionary infancy - but whatever modifications there were may prove interesting in indicating their methods of dispersal in those early times, as well as early evolutionary trends prior to later modification.

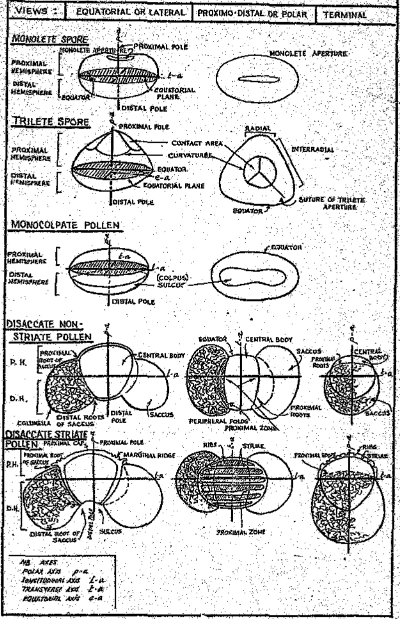
The pollen grain consists of three concentric layers:

1) The inner layer comprises the living protoplasmic material which is never seen in fossil forms.
2) The Intine or middle layer which is a cellulosic covering and easily destroyed, and
3) The Exine, the third and outermost layer, which is all that remains in fossil miospores and therefore forms the basis

of palynological study. The exine is a complex coat, and is divided basically into two parts (following Hart and Faegri and Iversen): (i) the Endexine an inner homogeneous and continuous membrane, and (ii) the Exo-exine or Ekto-exine, the outer layer of complex structure. The latter is composed of countless small elements which (a) when free and isolated and discontinuous over the endexine comprises the Intectate type of wall structure; and (b) when fused to form a continuous "roof" over the endexine gives rise to the Tectate type of wall structure, from this further elements may arise. Hart incorporates two further terms to illustrate the basic exo-exinal variation. Apiculate Elements (i.e. Tectate) are those arising from the exo-exinal layer, and Muronate Elements (i.e. Intectate) those occurring within the exo-exinal layer.

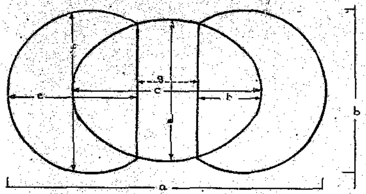
2. General Terms and Descriptions The orientation of miospores into conventional views may be seen in text - figure 4.2. Polar (or proximo-distal) and equatorial (or lateral) views are seen of 5 major miospore types, with polar, longitudinal and transverse axes, proximal and distal surfaces or hemispheres. Trilete and Monolete sutures are illustrated on the two spore examples with these relevant features. The diagrams of Disaccate pollen, both striate and non-striate, illustrate the terminology used by Hart (1960, 1965).

GENERAL TERMS OF DESCRIPTION Text fig 4-2



METHOD FOR THE MEASUREMENT OF DISACCATES Text-figure 4-3

POLAR VIEW



- a. TOTAL LENGTH (l-a)
- b. TOTAL WIDTH PARALLEL TO TRANSVERSE AXIS (t-a)
- c. LENGTH (l-a) CENTRAL BODY
- d. WIDTH (t-a) CENTRAL BODY
- e. LENGTH (t-a) SACCUS
- f. WIDTH (t-a) SACCUS
- g. DISTANCE BETWEEN THE DISTAL BLADDER BASES OVER THE DISTAL POLE. I.E. DISTAL ZONE
- h. INTERMARGINAL OVERLAP

- axb. OVERALL SIZE
- cxd. CENTRAL BODY
- exf SACCUS (BLADDER)

N.B. DRAWN FROM JANSONIUS 1962 & HART 1965

a) Disaccate terminology and Method of Measurement:

The orientation of the disaccate pollen grain (as also seen in text-figure 4.2) may be further clarified (see Hart, 1965 p. 5):-

Longitudinal axis (l-a) - is the line joining the median extremities of each sacci and passing through the central body;

Polar or Vertical axis (P-A) - the line joining the distal and proximal poles;

Equatorial or Transverse axis (t-a) - the line at right angles to the other two and passing through two median points in the equatorial plane of the central body.

The Lateral view contains the longitudinal and vertical axes in the plane of the diagram, whilst the polar view contains the longitudinal and transverse axes; and the terminal view the vertical and transverse axes.

The Central body (or inner pollen body) is attached to the sacci by means of roots (distal and proximal); occasionally the distal roots are thickened, when seen in polar view, and are termed attachment lines. The central body in the Striatiti is proximally thickened into the proximal cap on which ribs (thick strips) and striae (grooves) appear.

a) <u>Disaccate terminology and Method of Measurement</u>:

The orientation of the disaccate pollen grain (as also seen in text-figure 4.2) may be further clarified (see Hart, 1963 p. 5):-

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<u>The Lateral view</u> contains the longitudinal and vertical axes in the plane of the diagram, whilst the <u>polar view</u> contains the longitudinal and transverse axes; and the <u>terminal view</u> the vertical and transverse axes.

<u>The Central body</u> (or inner pollen body) is attached to the <u>sacci</u> by means of <u>roots</u> (distal and proximal); occasionally the distal roots are thickened, when seen in polar view, and are termed <u>attachment lines</u>. The central body in the Striatiti is proximally thickened into the <u>proximal cap</u> on which <u>ribs</u> (thick strips) and <u>striae</u> (grooves) appear.

Monolete or trilete sutures may occur proximally in Disaccitrileti, (not shown). The <u>Distal zone</u> is that area lying between the distal roots on the central body; and a <u>sulcus</u> is a groove that occurs on the central body both proximal or distal, transverse or longitudinal.

Disaccate measurement, as opposed to the simple diametrical or axial measurements of other spore and pollen groups, is somewhat complex, as illustrated in text-figure 4.3. This method was initially proposed by Jansonius (1962) and slightly modified by Hart (1963).

b) <u>Miospore shapes and Apertures</u>:

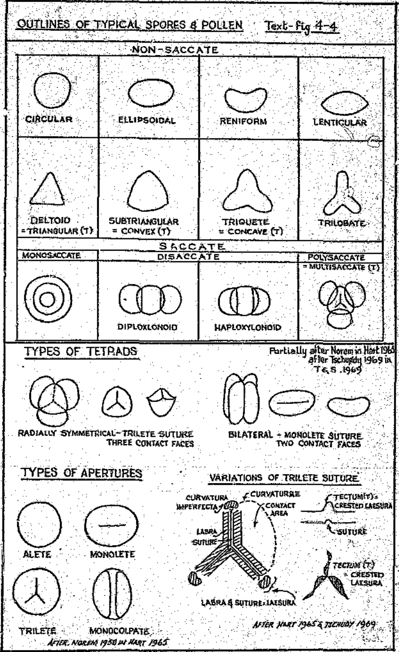
Basic miospore <u>shapes</u> are shown in text-figure 4.4, but many gradational variations exist. Miospore configurations are basically of two types:

a) Bilateral (elongate or boat-shaped)

or

b) Radial (circular)

<u>Apertures</u> may be slit-like (Monolete) or radial (Trilete) with 2 and 3 contact faces respectively depending on the tetrad arrangement, which may be tetragonal or tetrahedral. The <u>proximal hemisphere</u> is taken to be that towards the centre of the tetrad, and the <u>distal hemisphere</u> that on the outside. Spherical forms are rare and may, according to Felix (in Andrews, 1961)



OUTLINES OF TYPICAL SPORES & POLLEN Text-Fig 4-4 only be immature members of a broken tetrad. When no aperture is evident, this is termed Alete and is the simplest form with undefined affinities.

The Disaccites are assigned to two basic shapes, the Haploxylonoid (seen in polar view is more or less oval) and Diploxylonoid (seen in polar view is apparently bilobed due to variations in size of the sacci relative to the central body).

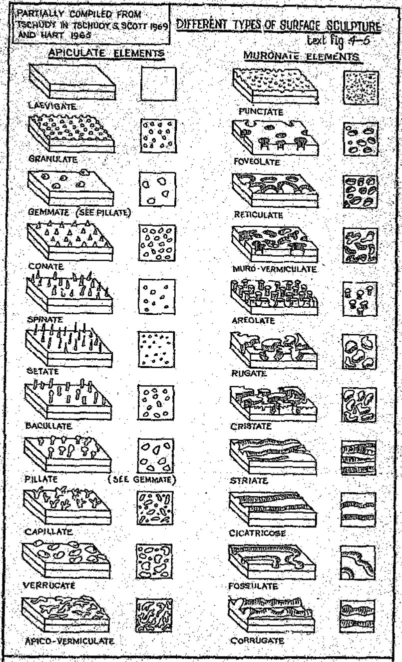
Slightly more complex apertures are those of colpi (grooves) and pores (or circular holes). In Palaeozoic specimens, colpi are by far the more common of the two (e.g. Plicates).

Trilete terminology may be seen in text-figure 4.4. An individual line of the aperture is known as a ray or suture (commissure, in Sagroves, 1967), whilst a thickened lip on either side of the suture is termed a labra (margo). A combination of the two makes a unit known as a laesura (Hart, 1965), and where the labra becomes an extension over the suture, this is termed a crested laesurae (or tectum). Concave areas on either side of a Monolete suture or between the Trilete sutures are known as contact areas (within the tetrad); these may be bounded by curvaturae (curved outer margins) as well as sutures.

c) <u>Miospore sculpture</u>:

In order to standardise the descriptive terminology of Palaeozoic spores, the International Commission for the Microflora of the Palaeozoic was responsible for the compilation of a list of terms which forms the basis of Hart's terminology. Tschudy (in Tschudy and Scott, 1969) makes a reference to this Commission and compiles a table of comparative spore/pollen descriptive terms, as he maintains that "sculptural elements and patterns found on Palaeozoic (and recent) spores are essentially the same as those found on pollen grains". See text-figure 4.5 (adopted from Tschudy, (in Tschudy and Scott, 1969), and Hart, (1965)), and the definitions below:

HART (1965) (Based on spores)	TSCHUDY (1969) (Based on pollen)	Definition
LAEVIGATE	PSILATE	- Shiny smooth translucent surface
GRANULATE	SCABRATE	- Small rounded to flattened projections less 1 μ. in diameter; basal diameter is equal to or greater than height.


PARTIALLY COMPILED FROM TSCHUDY IN TSCHUDY & SCOTT 1969 AND HART 1965
DIFFERENT TYPES OF SURFACE SCULPTURE
text fig 4-6
APICULATE ELEMENTS
MURONATE ELEMENTS
LAEVIGATE
PUNCTATE
GRANULATE
FOVEOLATE
GEMMATE (SEE PILLATE)
RETICULATE
CONATE
MURO-VERMICULATE
SPINATE
AREOLATE
SETATE
RUGATE
BACULLATE
CRISTATE
PILLATE (SEE GEMMATE)
STRIATE
CAPILLATE
CICATRICOSE
VERRUCATE
FOSSULATE
APICO-VERMICULATE
CORRUGATE

HART (1965 (Based on spores)	TSCHUDY (1969) (Based on pollen)	Definition
CONATE)	ECHINATE	- Spiny projection with rounded base tapering to a sharp point; height is less than twice basal diameter.
SPINATE)		- Spiny projection with rounded base tapering to a sharp point; height is more than twice basal diameter.
SETATE		- Filamentous unbranched projections; height is greater than basal diameter (less 1 μ), and parallel sided.
BACULATE	BACULATE	- Rod-like unbranched projections with height greater than basal diameter; rounded bases, more or less parallel sides and truncated tops.
PILLATE	CLAVATE GEMMATE (partim)	- Club-like projections with enlarged rounded heads born on narrow shafts. (Gemmate projections are merely constricted at their base.)

HART (1965 (Based on spores)	TSCHUDY (1969) (Based on pollen)	Definition
CAPILLATE	ECHINATE (partim)	– Branched or serrated projections with apices of branches rounded, flattened or pointed; shaft rounded or flattened; height greater than basal diameter.
VERRUCATE	VERRUCATE	– Rounded, wart-like projection, height less than or equal to diameter, base ± round; not constricted. (See Tschudy) See Gemmate.
APICO-VERMICULATE	RUGULATE (partim)	– Irregular, elongate, narrow, undulating ridges.
PUNCTATE		– A mat-like surface ..th a fine-grained pitted appearance, small depressions less than 1 u in diameter.
FOVEOLATE	FOVEOLATE	– Circular pits, 1-2 μ in diameter; diameter less than width of ridges separating them.

HART (1965) (Based on spores)	TSCHUDY (1969) (Based on pollen)	Definition
RETICULATE	RETICULATE	– Ridges forming a closed net-like pattern; walls (muri) narrower than the diameter of the spaces lumen (Hart) or lumina (Tschudy).
MURO-VERMICULATE	FOSSULATE (partim) CANALICULATE (partim)	– Irregular, elongate, narrow, undulating holes or ridges not forming a definite pattern. Fossulate possesses narrow undulating grooves forming a negative reticulum; Canaliculate has narrow parallel grooves.
RUGATE	RUGULATE (partim)	– Irregularly curved, elongate projections; length is at least twice width, tops are flat to slightly rounded; basal diameter is twice the height.
CRISTATE	RUGULATE (partim)	– Elongated, curved elevations, length at least twice width; apices pointed, serrated or slightly rounded.

HART (1965) (Based on spores)	TSCHUDY (1969) (Based on pollen)	Definition
STRIATE	STRIATE	- Parallel elongated ridges (ribs) separated by thinner parallel elongated grooves (strias).
	CICATRICOSE	- Almost parallel ridges that are narrower than the grooves separating them.
	CORRUGATE	- Projections with irregular or regular bulges along the ridges.

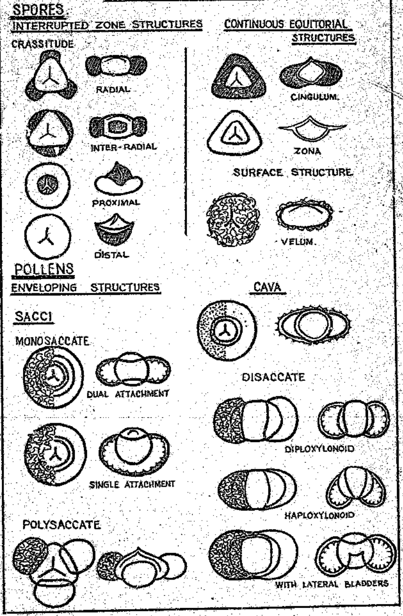
(d) Miospore Structures:

The structural characteristics of miospores form the basis of their systematic differentiation into major taxa. These structural features are defined below and illustrated in text-figure 4.6.

1. Equatorial structures: Differentiation in the miospore wall results in either a surrounding thin exoexinal equatorial extension or flange named a zona; or a thick equatorial extension termed a cingulum; or a velum in which the exoexinal layer partly separates from the endexinal layer in a series of small, closely spaced folds or convolutions over the miospore surface.

STRUCTURAL FEATURES Text Fig. 4-6

PROXIMAL & DISTAL VIEWS



2. Interrupted structures or thickenings are of 4 types:- a _radial crassitude_ arises only in radial (or apical) areas in the equatorial plane of triangular miospores. An _inter-radial crassitude_ is restricted to the inter-radial area of triangular spores; _proximal crassitudes_ are isolated thickenings (or series of) on the proximal surface. _Distal crassitudes_ exhibit local thickenings on the distal surface.

3. The formation of air pockets by means of the swelling of the outer exinal layer from an inner layer is responsible for two basic enveloping structures: A _Cava_ is an air sack in which the separated exoexinal layer is thick, often externally highly sculptured, and bears no inner _columella_ (structural elements). A _Saccus_ is composed of a thin exoexinal layer separated from the endexine, and bearing distinct columella (or structural elements) on the inner surface (infra-reticulation, etc.). Basic types of sacci are seen in the text - figure 4.6.

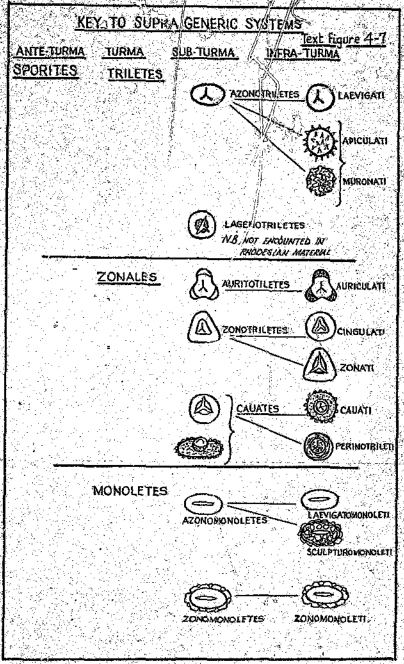
4.3 SUPRA-GENERIC TAXONOMY

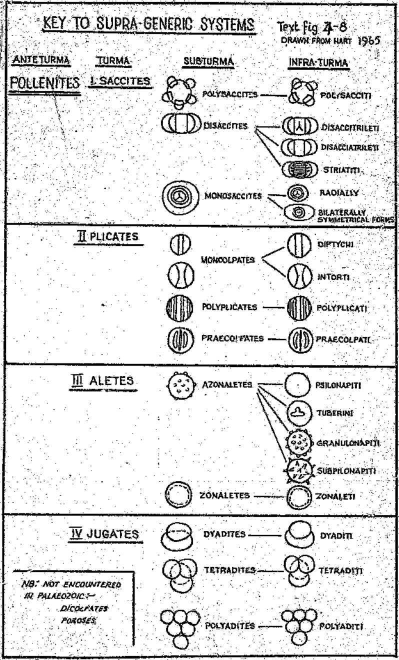
The supra-generic system of classification followed in this study is basically that compiled by Hart (1965), based on the classification of R. Potonie (1931, 1956, 1958, 1960, and as quoted by Hart, 1965) and the information collated by the international commission for the Microflora of the Palaeozoic. A key has been drawn (see text - figure 4.7, Sporites and text - figure 4.8, Pollenites) to illustrate the ranks of the supra-generic taxa. These range from the two basic ante-turma (Sporites and Pollenites) to turma, sub-turma and infra-turma. Genera and species follow in rank, but are not included here. They are discussed in detail under section 4.4 in this chapter.

ANTE-TURMA TURMA SUB-TURMA INFRA-TURMA

SPORITES H. Potonie, 1893 - miospores not possessing pores, sacci or colpi. Apertures are monolete or trilete; equatorial structures may be present (zona, cingulum or cava; or inter-radial or radial crassitudes). Divided on the basis of type of aperture and presence or absence of an equatorial structure.

TRILETES (Reinch, 1881) Potonie and Kremp, 1954 - miospores possessing a trilete aperture and no equatorial structures.


KEY TO SUPRA GENERIC SYSTEMS
Text figure 4-7
ANTE-TURMA
TURMA
SUB-TURMA
INFRA-TURMA
SPORITES
TRILETES
AZONOTRILETES
LAEVIGATI
APICULATI
MURONATI
LAGENOTRILETES
N.B. NOT ENCOUNTED IN RHODESIAN MATERIAL
ZONALES
AURITOTILETES
AURICULATI
ZONOTRILETES
CINGULATI
ZONATI
CAUATES
CAUATI
PERINOTRILETI
MONOLETES
AZONOMONOLETES
LAEVIGATOMONOLETI
SCULPTUROMONOLETI
ZONOMONOLETES
ZONOMONOLETI


KEY TO SUPRA-GENERIC SYSTEMS
Text fig 4-8
DRAWN FROM HART 1965
ANTETURMA
TURMA
SUBTURMA
INFRA-TURMA
POLLENITES
I SACCITES
POLYSACCITES
POLYSACCITI
DISACCITES
DISACCITRILETI
DISACCIATRILETI
STRIATITI
MONOSACCITES
RADIALLY
BILATERALLY SYMMETRICAL FORMS
II PLICATES
MONOCOLPATES
DIPTYCHI
INTORTI
POLYPLICATES
POLYPLICATI
PRAECOLPATES
PRAECOLPATI
III ALETES
AZONALETES
PSILONAPITI
TUBERINI
GRANULONAPITI
SUBPILONAPITI
ZONALETES
ZONALETI
IV JUGATES
DYADITES
DYADITI
TETRADITES
TETRADITI
POLYADITES
POLYADITI
NB: NOT ENCOUNTERED IN PALAEOZOIC:—
DICOLPATES
POROSES

ANTE-TURMA TURMA SUB-TURMA INFRA-TURMA

AZONOTRILETES Luber, 1935 - Triletes without any structural complications.

LAEVIGATI (Bennie and Kidston, 1886) Potonie, 1956 - miospores with punctate, and laevigate sculpture.

APICULATI (Bennie and Kidston, 1886) Potonie, 1956 - miospores with spiculate sculpture.

MURONATI Potonie and Kremp, 1956 - miospores with muronate (intectate) sculpture.

LAGENOTRILETES Potonie and Kremp, 1954 - triletes with a proximal crassitude. (Not encountered.)

ZONALES (Bennie and Kidston, 1886) Potonie, 1956 - Sporites possessing a trilete aperture and an equatorial structure; (cingulum, cava, zona; or radial or inter-radial crassitudes).

ANTE-TURMA	TURMA	SUB-TURMA	INFRA-TURMA
		AURITOTRILETES Potonie and Kremp, 1954 - Zonales with a discontinuous cingulum, i.e. a radial or inter-radial crassitude.	
			AURICULATI Potonie and Kremp, 1954.
		ZONOTRILETES Valts, 1935 - Zonales with a continuous equatorial cingulum or zona.	
			CINGULATI Potonie and Kremp, (Klaus), 1954 - Zonotriletes with a cingulum.
			ZONATI Potonie and Kremp, 1954 - Zonotriletes with equatorial zona.
		CAVATES I.C.M.P. 1963 - Zonales with a cava.	
			CAVATI Hart, 1965 - Cavates with an apiculate sculpture.
			PERINOTRILETI (Erdtman, 1947) Hart, 1965 - Cavates with a muronate sculpture.

ANTE-TURMA TURMA SUB-TURMA INFRA-TURMA

MONOLETES Ibrahim, 1933 - Sporites with a monolete aperture.

AZONOMONOLETES Luber, 1935 - Monoletes lacking an equatorial structure.

LAEVIGATOMONOLETI Dybova and Jachowicz, 1957 - Azonomonoletes with a laevigate or punctate sculpture.

SCULPTUROMONOLETI Dybova and Jachowicz, 1957 - Azonomonoletes with an apiculate or muronate sculpture.

ZONOMONOLETES Luber, 1935 - Monoletes with a continuous equatorial structure, i.e. a cingulum or zona.

ZONOMONOLETI Luber, 1935.

POLLENITES R. Potonie, 1931 - Miospores possessing sacci, colpi (grooves) or pores. Divided on the basis of presence or absence or sacci and type of aperture.

SACCITES Erdtman, 1947 - Miospores possessing sacci.

POLYSACCITES Cookson, 1947 - Miospores possessing 3 or more sacci.

POLYSACCITI Cookson, 1947.

ANTE-TURMA TURMA SUB-TURMA INFRA-TURMA

DISACCITES Cookson, 1947 - Miospores with 2 sacci symmetrically opposite the central body.

STRIATITI Pant, 1955 - Central body exhibits a thickened and striated proximal cap.

DISACCIATRILETI Leschik, 1956 - Central body lacks proximal striations or proximal aperture. Distal sulcus (colpate aperture) may be present.

DISACCITRILETI Leschik, 1956 - Central body possesses a proximal centrally placed monolete, dilete or trilete aperture. Proximal ribs and striations are lacking.

MONOSACCITES (Chitaley, 1951) - Potonie and Kremp, 1954 - Miospores possessing a single saccus.

N.B. R. Potonie (1958) proposed the division of Monosaccites into 2 infra-turma based on the presence or absence of a trilete aperture, i.e. Aletesacciti (Leschik, 1956) and Triletesacciti (Leschik, 1956). However, Hart (1965) suggests this to be too variable, and further proposes two infra-turma based on the attachment of the saccus to the central body - (a) attached both proximally and distally - Dipolsacciti and (b) attached either proximally or distally - Monpolsacciti. Segroves (1969), however, mentions that in some cases a misunderstanding or the Monosaccate structure can cause confusion on this basis of classification.

Kar (1967) compiled a general classification of Monosaccates from several papers describing the abundant genera found in the Permo-Carboniferous of India and the Congo. Nine infra-turma and eighteen genera are proposed, based on the presence or absence and type of aperture, methods and patterns of attachment of sacci to the central body and associated fold systems. This structure of classification is highly detailed and somewhat difficult to adapt where miospore material is not available for comparison.

Balme (1966) working on the Salt Range material has divided the Monosaccate genera into two groups. Group A - Radiosymmetrical with three genera and Group B - Bilaterally symmetrical, with one genus. Segroves (1969) apportions his Monosaccate forms into five genera with no supra-generic groupings.

Delimitations of infra-turma groupings are, therefore, somewhat confusing and for the purposes of this thesis two groups, radiosymmetrical and bilaterally symmetrical will be considered.

ANTE-TURMA TURMA SUB-TURMA INFRA-TURMA

PLICATES Naumova, 1937 - Pollens with colpi (grooves) and no sacci.

PRAECOLPATES Potonie and Kremp, 1954 - Pollens with a single distal sulcus (colpus) and a proximal aperture (monolete, dilete or trilete). Proximal striations may occur.

PRAECOLPATI Potonie and Kremp, 1954.

POLYPLICATES Erdtman, 1952 - Pollen with more than two transverse grooves (colpi) lying roughly parallel.

POLYPLICATI Erdtman, 1952.

MONOCOLPATES (Wodehouse, 1935) Iversen and Troels-Smith, 1950. Pollens exhibit a single distal transverse colpus and lack proximal apertures.

INTORTI (Naumova, 1937) Potonie, 1958. Miospores in which the colpus reaches the outline, and is wider laterally than centrally, i.e. funnel shaped.

ANTE-TURMA	TURMA	SUB-TURMA	INFRA-TURMA
			DIPTYCHI (Naumova, 1937) Potonie, 1958. Miospores where colpus may or may not reach the margin, and sides are parallel.
		DICOLPATES Erdtman, 1947 - Pollens in which there are two parallel transverse colpi.	
	ALETES Ibrahim, 1933 - Miospores lacking sacci, colpi and apertures.		
		AZONALETES (Luber, 1935) Potonie and Kremp, 1954 - Miospores without equatorial structures (zona or cingulum).	
			PSILONAPITI Erdtman, 1947 - laevigate Azonaletes.
			TUBERINI Pant, 1954 - Miospores possessing a proximal deviation of the exine in the form of a cylindrical extension.
			GRANULONAPITI Cookson, 1947 - Granulate Azonaletes.
			SUBPILONAPITI Erdtman, 1947 - Conate or spinate Azonaletes.

ANTE-TURMA TURMA SUB-TURMA INFRA-TURMA

ZONALETES Luber, 1935 - Aletes possessing an equatorial extension i.e. a zona or cingulum.

ZONALETI Luber, 1935 - (Not encountered).

JUGATES Erdtman, 1943 - Miospores are joined in groups of two, four or more individuals per unit.

DYADITES Pant, 1954 - Miospores consisting of 2 joined individuals.

DYADITI Pant, 1954.

TETRADITES Cookson, 1947 - Miospores possessing four united individuals in a tetrad formation.

TETRADITI Cookson, 1947

POLYADITES Pant, 1954 - Miospores consisting of more than four individuals united in one group.

POLYADITI Pant, 1954.

4.4 SYSTEMATIC PALYNOLOGY

Ante-turma: SPORITES Potonie, 1893

Turma: TRILETES (Reinsch) Potonie and Kremp, 1954

Sub-turma: AZONOTRILETES Luber, 1935

Infra-turma: LAEVIGATI (Bennie and Kidston) Potonie, 1956

Genus: Punctatisporites (Ibrahim, 1933) Potonie and Kremp, 1954

Type species (by original designation): Punctatisporites punctatus (Ibrahim), Ibrahim, 1933.

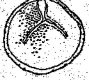
Diagnosis: Outline circular, with trilete suture: exine basically laevigate but may be infra-punctate, thin to thick and usually unfolded.

Punctatisporites gretensis Balme and Hennelly, 1956

Plate 1: figures 1-3.

Holotype: P. gretensis Balme and Hennelly, 1956 Pl. 2, figures 11-13.

Diagnosis: Circular outline; trilete sutures straight and clearly defined, about $\frac{3}{4}$ radius of spore; labra sometimes present; exine about 4 μ thick, laevigate or finely granulate (sensu Balme and Hennelly p. 245) or infra-, unotate (sensu Hart, 1965).



Description: Shape: Spore circular to sub-circular with only occasional minor folding around the periphery; sub-polar compressions common.

Trilete suture: Rays extend ½ to ⅔ radius of spore, distinct, usually slightly open; straight, occasionally thin darkened labra frame rays.

Exine: Smooth to infra-punctate, puncta fine ($< 0,5\ \mu$) to fairly coarse ($1\text{-}2\ \mu$); exine $2\text{-}4\ \mu$ thick, with occasional concentric rings seen within the wall structure.

Dimensions (20 specimens): Diameter: 60(80)112 μ.

Discussion: The above diagnosis encompasses features seen in the genus Eupunctatisporites Bharadwaj, 1962 and the species P. magnificus Bose and Maheshwari, 1968 and P. reticulatus Pant and Srivastava. These variations are based on the great density and size of puncta (Eupunctatisporites); larger size range (P. magnificus) and concentric rings in the exine (P. reticulatus) - all of which are seen in the Rhodesian forms.

Insufficient evidence and overlapping of characteristics indicate a better grouping under one form species for the present.

Distinction: <u>Punctatisporites gretensis</u> is distinct in possessing a circular smooth usually unfolded outline, often finely infra-punctate thick exine, large size and distinct trilete suture.

Stratigraphic range: Common to abundant in Dwyka; common to rare in Black Shales and Coals; rare to absent in Madumabisa Mudstones.

<u>Punctatisporites gretensis forma minor</u> Hart, 1965

Plate 1: Figures 4-6

Holotype: <u>P. gretensis forma minor</u>, Hart, 1965 Pl. 1, figure 10

Diagnosis: A laevigate trilete spore, circular in outline with trilete rays extending ¾ radius of spore, with or without labra (mean size range smaller than <u>P. gretensis</u> but otherwise identical).

Description:	Shape:	Circular to sub-circular, with minor occasional peripheral folds.
	Trilete suture:	Straight, distinct, rays extending about ¾ radius of central body. Occasional thin raised labra seen.
	Exine:	Laevigate to very finely infra-punctate.
	Dimension (20 specimens):	Diameter 35(42)58 μ.
Discussion:	The Rhodesian specimens fall into a smaller mean size range than found in Tanzania by Hart (1965).	
Distinctions:	P. gretensis forma minor is identical to P. gretensis but is smaller in mean size.	
Stratigraphic range:	Common to abundant in Dwyka and Black Shales and Coals; rare to absent in Madumabisa Mudstones.	

Genus: Deltoidospora Miner, 1935

Type species: Deltoidospora halii Miner, 1935

Diagnosis: Laevigate spore with a triangular outline; apices may be rounded or convex, and the sides concave or convex

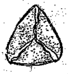
Synonym: Leiotriletes (Naumova) Potonie and Kremp

Deltoidospora directa (Balme and Hennelly, 1956) Hart, 1965

Plate 1: Figures 12-15

Holotype: Leiotriletes directus Balme and Hennelly, 1956, Pl. 1, figures 1-4

Diagnosis: Outline roundly triangular, with slightly rounded apices and straight or slightly convex sides. Trilete rays extend about 2/3 radius of spore.



Description: Shape: Outline triangular, with rounded fairly broad apices and straight to slightly convex sides.

Trilete suture: Rays usually distinct, straight to sinuous, extending about 2/3 to ¾ radius of spore; often ribbon-like, thin raised labra are seen, which may be confused with exinal folds when compressed.

Exine: Smooth about 1 μ thick, occasionally infra punctate to finely and faintly granulate.

Dimensions (30 specimens): Diameter: 26(35)48 μ.

Discussion: L. congoensis Kar and Bose 1967 is synoncomous with the above species although it was retained by the original authors due to the rays extending up to the margin. L. virkkii Tiwari, 1965 is similar but has a larger size. L. adhatus (Kosanke) Potonie and Kremp, 1954 and L. lukugaensis Kar and Bose, 1967 possess concave sides; L. psilatus Kar and Bose, 1967 may well be syncnomous due to its similar size range, shape, and thin exine, but was originally separated on account of its indistinct trilete rays. L. corius Kar and Bose is characterised by a roundly triangular shape, thick exine and larger size.

Distinction: L. directus is distinguished by its small size, triangular outline and thin laevigate to finely granulate exine.

Stratigraphic range: Rare in Dwyka, rare to common in Black Shales and Coals; rare in Madumabisa Mudstones.

Deltoidospora lukugaensis Kar and Bose, 1967

Plate 1: Figures 16-19

Holotype: Leiotriletes lukugaensis Kar and Bose, 1967, Pl. 1, figure 4

Diagnosis: Triangular trilete with thin exine, concave sides, well-developed trilete rays extending ¾ radius of spore and distinct, broad but not raised labra.

Description: Shape: Triangular with distinctly concave inter-apical sides and broadly rounded to blunt apices.

Trilete: Rays extending 2/3 to 4/5 spore radius, distinct, straight to slightly sinuous; broad darkened labra, slightly raised, usually distinctly outlined in the section closest to the proximal pole fading out towards the apex; labra curved concavely between the rays; 8-12 μ wide.

Exine: Laevigate to faintly but sparcely granulate.

Dimension (10 specimens): Diameter: 31(38)45 μ.

Distinction: *D. lukugaensis* is distinct from other species by possession of concave sides with distinctive broad darkened labra on either side of the trilete rays.

Stratigraphic range: Absent to very rare in Dwyka; rare to common in Black Shales and Coals; common in Lower Madumabisa Mudstones, rare to absent in Upper Madumabisa Mudstones.

Genus: <u>Calamospora</u> Schopf, Wilson and Bentall, 1944

Type species (by original designation): <u>Calamospora hartungiana</u> Schopf (in Schopf, Wilson and Bentall, 1944, p. 51).

Diagnosis: Laevigate Triletes, with a circular to roundly triangular outline; exine is thin and often greatly folded.

<u>Calamospora plicata</u> (Luber and Valts, 1941) Hart, 1965

Holotype: <u>Azonotriletes plicatus</u> Luber and Valts, 1941, Pl. XIV, figure 226b.

Diagnosis: Roundly triangular to circular in outline, usually obscured by large scale folding giving an irregular polygonal outline. Trilete rays extend $\frac{1}{2}$ - 2/3 radius of spore (sensu Hart, 1965, p. 135).

Description: Shape: Circular to sub-circular with numerous random folds imparting a polygonal effect.

Trilete suture: Distinct darkened rays, 0,5-2 μ wide, often tapering to a point terminally; about $\frac{1}{3}$-$\frac{1}{2}$ radius of spore. No apparent contact areas; thin dark labra sometimes visible.

Exine: Smooth to densely micro-granulate; 1 µ or less in thickness.

Dimensions (20 specimens): Diameter 41(48)68 µ.

Discussion: The Rhodesian forms have been assigned to C. plicata on the grounds of general polygonal outline due to folding and length of trilete rays. C. inderiensis (Malyavkina ex Luber and Valts, 1944) Hart, 1965 is smaller in size whilst C. exila Bharadwaj and Salujha and C. aplata Bharadwaj and Salujha both have infra-punctate exines. C. microrugosus (Ibrahim) Schopf, Wilson and Bentall, 1944 is very comparable and may be synonomous with the Rhodesian forms except for its darkened contact area.

Distinction: C. plicata is distinct in possessing a basically circular but much folded outline, thin exine, and short distinct trilete suture.

Stratigraphic range: Common to abundant in Dwyka, rare to absent in Black Shales; and absent in Madumabisa Shales.

Genus: Retusotriletes Naumova

Diagnosis: Laevigate Triletes with a circular outline, small size and a distinct small darkened contact area, circular to roundly triangular in shape, between the short trilete rays.

Discussion: Balme and Hennelly (1956) and Hart (1965) include this form in the genus Calamospora Schopf, Wilson and Bentall. However, (as discussed by Bharadwaj, 1962) the darkened contact area is no a characteristic of Calamospora, b is present in Retusotriletes Naumov (which is also small in size).

Retusotriletes diversiformis Balme and Hennelly, 1956

Plate 1: Figures 7-9

Holotype: Calamospora diversiformis Balme and Hennelly, 1956, Pl. 2, figures 14-18.

Synonym: Calamospora nigritella (Luber and Valts) Hart, 1965

Diagnosis: Outline circular, smooth; trilete suture straight, about ½ radius of spore in length; exine laevigate or finely granulate (sensu Balme and Hennelly). A contact area with curvaturae is present, or contact area is marked by a darkened triangular thickening at proximal pole.

Description: Shape: Circular usually unfolded and smooth; often seen in polar to slightly off-polar compressed states.

Trilete suture: Short distinct rays, about ⅓ to ½ radius of spore; often open and 2-3 μ wide, closing terminally to a sharp point. Contact area well defined and darkened between rays, roundly triangular in shape; occasionally specimens with distinct curvaturae in place of darkened contact areas are seen.

Exine: 2-3 μ thick, smooth, laevigate to finely and sparcely infra-punctate.

Dimensions (20 specimens): Diameter: 18(26)32 μ.

Distinction: Retusotriletes diversiformis is distinct by its small size and darkened triangular contact area.

Stratigraphic range: Found throughout the borehole core.

Infra-turma: APICULATI (Bennie and Kidston, 1886) Potonie, 1958

For the purpose of this thesis all elements attributable to the turma Triletes (bar Laevigati forms) are retained in the infra-turma Apiculati. The distinction between Muronati and Apiculati is somewhat difficult to recognise with the present equipment.

Genus: Apiculatisporis Potonie and Kremp, 1956

Type species: Apiculatisporis (al. Apiculatisporites) aculaetus (Ibrahim) Potonie.

Diagnosis: Apiculate spores, circular to roundly triangular in outline; sculpture consisting of grani or coni.

Apiculatisporis levis Balme and Hennelly, 1956

Plate 2: figures 1, 2.

Holotype: Apiculatisporites levis Balme and Hennelly, 1956, Pl. 2, figures 19-21.

Diagnosis: Circular in outline; the trilete sutures extend the full radius of the spore; sculpture consists of small grani or coni 1 μ high and 1-2 μ in basal diameter, irregularly distributed. Sculpture is reduced proximally.

Description:	Shape: Circular to sub-circular.
	Trilete suture: Rays are straight distinct and extend the full width of the spore radius; sometimes framed by very thin darkened lips (labra).
	Exine: About 2 u thick, bearing small grani or coni, 0,1-1 µ basal diameter, and 0,5-1,5 µ high, 1-2 µ apart, irregularly spaced. Sculptural elements are reduced or lacking on the proximal face.
	Dimensions (10 specimens): Diameter: 24(26)34 µ.
Distinction:	A. levis is distinct from other species on the basis of its small size, and very small, irregular grani and coni.
Stratigraphic range:	Rare to common in Dwyka sediments; rare to common in Black Shales and Coals; rare to common in Madumabisa Mudstones.

Apiculatisporis filiformis Balme and Hennelly, 1956

Plate 2: Figures 3-5

Holotype:	Apiculatisporites filiformis Balme and Hennelly, 1956, Pl. 2, figures 22-23.
Diagnosis:	Circular to sub-circular outline, with indistinct trilete rays extending full radius of spore; exine bearing spini

1-2 μ in basal diameter and up to 5 μ in height; irregularly spaced, but usually up to 5 μ apart.

Description: Shape: Circular to roundly triangular.
Trilete suture: Indistinct, but where discernible straight and ¾ to full spore radius in length.
Exine: About 2 μ thick, bearing spinate elements 1-2 μ wide basally, and up to 5 μ high; darkened and rounded at base, narrowing to sharp apices. Spini irregularly disposed, well spaced to closely spaced.
Dimensions (10 specimens): Diameter: 24(38)44 μ.

Distinction: A. filiformis is distinct from other species in bearing irregularly spaced spini of a characteristic shape.

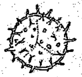
Stratigraphic range: Common in Dwyka sediments; rare to common in Black Shales and Coals; rare in Madumabisa Shales.

Apiculatisporis cornutus Balme and Hennelly, 1956

Plate 2: Figure 5

Holotype: *Apiculatisporites cornutus* Balme and Hennelly, 1956, Pl. 2, figure 24.

Diagnosis: Circular to roundly triangular in outline; trilete rays slightly sinuous and extend ¾ spore radius. Sculpture consists of irregularly disposed coni with basal diameter 1-4 μ and height 3-5 μ.



Description: Shape: Circular to roundly triangular.

Trilete suture: Indistinct, extending about 2/3-¾ spore radius where discernible.

Exine: and 2μ thick, bearing large coni and spini, 1-3 μ wide at the base and 3-6 μ high; elements are regularly and evenly conate or spinate with sharp apices; frequently seen regularly disposed and about 5 μ apart.

Dimensions (10 specimens): Diameter: 36(41)45 μ.

Distinction: *A. cornutus* is distinct by possessing large and evenly distributed coni and spini.

Stratigraphic range: Absent in Dwyka; rare in Black Shales and Coals, rare to absent in Madumabisa Shales.

Apiculatisporis minutus sp. nova

Holotype: Plate 3: Figures 8, 9. Paratype: Plate 3: Figure 7

Diagnosis: Roundly triangular in outline, with off-polar compressions common. Trilete suture distinct, extending 2/3–¾ spore radius, straight, thin and bearing no apparent labra. No contact area is discernible; exine is thin and bears dense, small coni or grani, rounded to sub-rounded and oval in plan and pointed in profile; basal diameter equals or is greater than the height of the elements; and is equal to the space between them.

Description:	Shape: Roundly triangular, unfolded; polar to off-polar compressions usually found.
	Trilete suture: Distinct straight, thin (0,5 μ wide) and extending 2/3 to $\frac{3}{4}$ spore radius.
	Exine: Conate elements 0,5-1 μ wide in basal diameter and in height, and 1 μ or less apart.
	Dimension (8 specimens): Diameter: 24-28 μ.
Distinction:	<u>A. minutus</u> is distinct from other species in possessing a roundly triangular shape, a small size, and numerous small conate elements regularly spaced over the entire spore exine.
Stratigraphic range:	Absent in all samples except those in the Lower and Middle Madumabisa Mudstones where this form is a rare constituent.

Genus: Granulatisporites (Ibrahim, 1933) Potonie and Kremp, 1954

Type species: Granulatisporites granulatus Ibrahim

Diagnosis: An Apiculate trilete spore with triangular outline and sculpture consisting of grani.

Discussion: Granulatisporites is distinct from other genera in bearing grani on the exine. Microbaculatispora Bharadwaj possesses micro-baculi, Microfoveolatispora (Bharadwaj) foveoli and Lophotriletes (Naumova) Potonie and Kremp conate elements. Inkugasporites Kar and Bose, 1967 bears spini distally whilst Lacinitriletes Venkatachala and Kar possesses distally concentrated micro-verrucae.

Granulatisporites tentula (Tiwari, 1965) nov. comb.

Plate 2: Figures 9-16

Holotype: Microbaculispora tentula Tiwari, 1965, Pl. 2, figures 35-37.

Diagnosis: Triangular outline with trilete rays about 2/3 radius of spore; distal face bearing grani less than 1 μ in diameter, 0,25-0,5 μ high and about 0,5 μ apart. Proximal surface laevigate or sculpture reduced.

Description: Shape: Triangular, with straight to slightly convex sides, and well-rounded apices.

Trilete suture: Rays extend 2/3 to $\frac{3}{4}$ radius of spore, straight to sinuous; labra may or may not be present in the form of thin narrow raised ribbon-like structures. Often labra and exinal folding part at the terminal extremity of the ray in a faint and brief dichotomous manner. Rays may be open or closed, and when open (2-3 μ wide) form a characteristic "star" pattern with darkened margins and sharp terminal points.

Exine: Finely granulate, with grani concentrated distally, and reduced proximally; elements rounded to sub-rounded in plan, and rounded to almost conical and almost bacullate in outline. Regularly, evenly spaced, grani diameter; less than 1 μ; height $\frac{1}{4}$-$\frac{1}{2}$ μ and less than $\frac{1}{2}$ μ apart.

Dimension (20 specimens): Diameter: 27-42 μ.