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

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

Slide Preparation:

Slide preparations incorporating techniques and mounting media are important for long-term and reliable results in palynology. In spore analysis, as near as possible ideal microscopic observation and complete quantitative records of fossil spores 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, spore 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 handled without disturbance or dislocation of the spore 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. 597).
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 should, 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 microspore 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 Clearol (1.4), both water-soluble media. A drop of the organic residue plus Cellosize is then smeared on a coverglass and allowed to dry. The excess water from the organic residue is driven off and the microspore material remains fixed and evenly distributed. It is also found on one focal plane (against the surface of the coverglass) allowing for easy microscopic scanning. The coverglass is then
mounted on Canada Balsam smeared on a slide and
baked for 2-3 minutes at 90-100°. 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 microspores 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, advan-
ced 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 microspores from an assortment of rock matrices. No comparative material, in the form of previously prepared microspore 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 microspore dispersal on the slide and coverslip.

Storage of the organic residue is in small 1 cm 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 microspore study,
it was 1.250 x. A Zeiss photomicroscope was made available for limited photographic use.

In scanning the slides for analysis, the entire surface of two or more slides per sample (within the micropore 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 (1965, 1966) Segroves (1969) and Belas (1966). Visual (as opposed to true statistical) counts of a minimum 250 and maximum 500 micropore 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 abundances (based on 250-500 micropores) of the major micropore taxa i.e., at turns, sub-turns or infiuct-turns 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 (E°), averages 70 per cent, decreasing in relative stages to average 17 per cent in Mid-Madumabisa (E^2) shales. The total Dipaecites curve appears inversely proportional to the Sporites curve. This taxon accounts for 1-6 per cent in the Dwyka Series (E°) 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 microspores emerge from analyses taken throughout a vertical stratigraphic sequence, and only after the distribution of the microspore content into one or other category can any assemblage boundaries be distinguished. Raisvili (1939) was one of the earliest palynologists to realize this. He divided microspores into "general" and "accessory" groups. General microspores refers to those exhibiting long
vertical stratigraphic ranges and possibly fairly consistent relative abundances 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, accessory microspores, assume 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 microspore 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 microspores encountered in the Matahola Flats sequences are: *Anilimiastrum*, *Pruchoepilxympma* and *Salcatastrum*. Those of long-range with more or less finite beginnings or ends are: *Punctatisporites* (E2-E3), and *Laevicostaporites* (Upper E2-E3). Short range and potentially diagnostic genera appear to be *Zinitespora* (E0), *Quadritic stomata* (E0), *Circulaporites* (cf. *Cheomtriletes*) (Upper E2-E3); *Jaeklispores* (E3) and *Raingochespora* (E2).
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 Plate 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 Balsle (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.
Generally speaking, the problem involves an explosive increase in the number of new names proposed for microspores. 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 basis philosophy of classification, viz.,

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

(b) Whether a phylogenetic scheme is followed similar to that in modern plant systematic.

Over and above this, the problem of legitimacy 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 (1948) discusses the species concept in terms of morphospecies, chromospecies and morphochromospecies, 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 Tanzania and South African publications.

In Africa, systematic problems arise because a cosmopolitan selection of authors has to date described the Permian Gondwana siliquoses. (See Introduction - Previous palynological work.) These include such "schools" of systematics as Eurasian (Ieschik, Rilett, Hart - originally); Indian (Bose, Kar, Maheshwari, Gosh, Sen, Pant, Hoeg 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.

*European authors have 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 spore species vary considerably, although the major generic and sub-generic forms are usually common.

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

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

Approach: Due to the practical impossibility of acquiring all Permian literature, worldwide 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, 1966); Balme and Henneley (1955, 1956(a) and (b)), Balse (1966) and Segroves (1967, 1969, 1970, Australia).
and Goubin (1965, Madagascar). Many other papers of relevance were also consulted, e.g. the Congo micropore publications, (Bose and Ear, et al), in order to enlarge upon certain major micropore taxa not altogether satisfactorily dealt with by Hart. The detailed studies of synonymies 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 micropores in this study were initially pigeon-holed into the supra-generic framework 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 phylogenetic 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 phylogenetic 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 Palaeoico as well as from Norran (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) Bisaccate 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 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 Hormomegathous. Hormomegathy (Wodehouse (1935) quoted by Tschudy in Tschudy and Scott, (1989)) is the accommodation of...
STRUCTURE OF EXINE WALL

SECTION THROUGH MIOCSPORAE WALL

ERDMAN 1965

MART 1965

PRINCIPLE EXINE TYPES

SCHUY 1969

SCHUY & SCOTT 1969

SCHUY 1965

SCHUY 1965

TEXTE FIGURE 4-1

N.A. DRAWN FROM SCHUY 1965
IN SCHUY & SCOTT 1969
MART 1965 FELIX IV ANDREW 1965

PRINCIPLE EXINE TYPES

SCHUY 1969

SCHUY & SCOTT 1969

SCHUY 1965

SCHUY 1965
volume change; it is considered feasible that such indications were beginning to show in spores of the late Palaeozoic - e.g. Trioptites, Reinschlespora and Ipdospora. Spore exines are virtually structureless with only minor stratification occasionally (Functagomorites); 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 microspores 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 Exo-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. apicate) are those arising from the exo-exinal layer, and Marginate Elements (i.e. intectate) those occurring within the exo-exinal layer.

2. General Terms and Descriptions. The orientation of micropores 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 micropore 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 Bisaccate pollen, both striate and non-striate, illustrate the terminology used by Hart (1960, 1965).
METHOD FOR THE MEASUREMENT OF DISACCATES

Text Figure 4-3

POLAR VIEW

- a: TOTAL LENGTH (L-a)
- b: TOTAL WIDTH PARALLEL TO TRANSVERSE AXIS (E-B)
- c: LENGTH (L-a) CENTRAL BODY
- d: WIDTH (l-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

Note: Drawn from Jansonius 1962 & Hart 1967
a) **Disacate terminology and Method of Measurement.**

The orientation of the disacate 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 sacoi 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 sacoi 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 **stripes** (grooves) appear.
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, 1963, p. 5):

- **Longitudinal axis** (l-a) - 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.
Monolete or trilete sutures may occur proximally in Discocitrulli, (not shown). The Distal zone is that area lying between the distal roots on the central body; and a sulcus 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 5.3. This method was initially proposed by Jansonius (1962) and slightly modified by Hart (1963).

b) Miospore shapes and Apertures:

Basic miospore shapes 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)

Apertures 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 proximal hemisphere is taken to be that towards the centre of the tetrad, and the distal hemisphere that on the outside. Spherical forms are rare and may, according to Felix (in Andrews, 1961)
### Outlines of Typical Spores & Pollen

#### Non-Saccate
- Circular
- Ellipsoidal
- Reniform
- Lenticular

#### Saccate
- Deltoid + Triangular (T)
- Subtriangular = Convex (T)
- Triquetre = Concave (T)
- Trilobate

<table>
<thead>
<tr>
<th>Monosaccate</th>
<th>Disaccate</th>
<th>Polysaccate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haploxylonid</td>
<td>Dihaploxylonid</td>
<td>Multisaccate (T)</td>
</tr>
</tbody>
</table>

#### Types of Tetrads
- Radially symmetrical - Trilete sutures, three contact faces
- Bilateral - Monolete sutures, two contact faces

#### Types of Apertures
- Alete
- Monolet
- Trilete

#### Variations of Trilete Suture
- Curvature of aperture
- Curvature of suture
- Contact area
- Textura
- Carina
- Labral suture
- Lagena
- Sutura

*After Mary Haas & Tokary 1949*
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 Discocites are assigned to two basic shapes, the Eoplaxylloid (seen in polar view is more or less oval) and Bipaxylloid (seen in polar view is apparently bilobed due to variations in size of the Larson 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).

Triate terminology may be seen in text-figure 4.4. An individual line of the aperture is known as a ray or suture (commissure, in Sagrove, 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 laeura (Hart, 1965), and where the labra becomes an extension over the suture, this is termed a crested laeura (or tectum). Concave areas on either side of a Monolete suture or between the Triate sutures are known as contact areas (within the tetrad); these may be bounded by curvatures (curved outer margins) as well as sutures.
c) **Microspore sculpture:**

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:

<table>
<thead>
<tr>
<th>HART (1965) (Based on spores)</th>
<th>TSCHUDY (1969) (Based on pollen)</th>
<th>Definition</th>
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<tbody>
<tr>
<td>LABRIGATE</td>
<td>PSILITE</td>
<td>- Shiny smooth translucent surface</td>
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<tr>
<td>GRANULATE</td>
<td>SCABRATA</td>
<td>- Small rounded to flattened projections less 1 μ, in diameter; basal diameter is equal to or greater than height.</td>
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<td>APICULATE ELEMENTS</td>
<td>MURONATE ELEMENTS</td>
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<td>LAVIGATE</td>
<td>PUNCTATE</td>
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<td>GEMULATE</td>
<td>FOVEULATE</td>
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<td>GEMMATE (SEE PILLATE)</td>
<td>RECURVATE</td>
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<td>COMATE</td>
<td>MARG-VERMICULATE</td>
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<td>SPIRATE</td>
<td>AREOLATE</td>
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<td>SETATE</td>
<td>RUGATE</td>
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<td>BACKULATE</td>
<td>CRISPATE</td>
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<td>PILATE (SEE GEMMATE)</td>
<td>STRIATE</td>
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<td>CAPULATE</td>
<td>CLAVICORE</td>
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<td>VERRICATE</td>
<td>FOSSULATE</td>
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<td>APEXO-VERMICULATE</td>
<td>CORRUGATE</td>
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<td>HART (1955) (Based on spores)</td>
<td>TRESSIDOR (1969) (Based on pollen)</td>
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<td>SEATE</td>
<td>FNATE</td>
<td>SPINATE</td>
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<tr>
<td>Capsulate (Becc.)</td>
<td>Cylindraceae (partim)</td>
<td>Definition</td>
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<tr>
<td>Capsulate</td>
<td>Cylindraceae (partim)</td>
<td>Rounded or serrated projections with apices of branches rounded, flattened or pointed; short-rounded or flattened; height greater than basal diameter.</td>
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<tr>
<td>Verrucate</td>
<td>Verrucate</td>
<td>Rounded, wart-like projection; height less than or equal to diameter; base round, not constricted. (See Tschudy) See Gennato.</td>
</tr>
<tr>
<td>Apioc-verrucate</td>
<td>Hugulate (partim)</td>
<td>Irregular, elongate, narrow, undulating ridges.</td>
</tr>
<tr>
<td>Fungicate</td>
<td>Fungicate</td>
<td>A wart-like surface with a fine-grained pitted appearance; small depressions less than 1 μ in diameter.</td>
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<tr>
<td>Foveolate</td>
<td>Foveolate</td>
<td>Circular pits, 1-2 μ in diameter; diameter less than width of ridges separating them.</td>
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<tr>
<td>TSCHUDY (1969) (Based on pollen)</td>
<td>HART (1965) (Based on spores)</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>RETICULATE</td>
<td>RETICULATE</td>
<td>- Ridges forming a closed net-like pattern; walls (muri) narrower than the diameter of the spaces lumen (Hart) or lumina (Tschudy).</td>
</tr>
<tr>
<td>MICRO-VERMICULATE</td>
<td>FOSSULATE (partim)</td>
<td>- 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.</td>
</tr>
<tr>
<td></td>
<td>CANALICULATE (partim)</td>
<td>- Irregularly curved, elongate projections; length is at least twice width; tops are flat to slightly rounded; basal diameter is twice the height.</td>
</tr>
<tr>
<td></td>
<td>HUGATE</td>
<td>- Elongated, curved elevations; length at least twice width; apices pointed, curved or slightly rounded.</td>
</tr>
</tbody>
</table>
| | HUGULATE (partim) | - Elongated, carvdd elevations. length at least twice width.
<table>
<thead>
<tr>
<th>HAEF (1963) (Based on spores)</th>
<th>Tschudy (1969) (Based on pollen)</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRIATE</td>
<td>STRIATE</td>
<td>Parallel elongated ridges (ribs) separated by thinner parallel elongated grooves (striae).</td>
</tr>
<tr>
<td>CHOCHELICHE</td>
<td>Almost parallel ridges that are narrower than the grooves separating them.</td>
<td></td>
</tr>
<tr>
<td>CORRUGATE</td>
<td>Projections with irregular or regular bulges along the ridges.</td>
<td></td>
</tr>
</tbody>
</table>

(a) **Micospore Structures:**

The structural characteristics of micospores form the basis of their systematic differentiation into major taxa. These structural features are defined below and illustrated in text-figure 3.6.

1. **Equatorial structures:** Differentiation in the micospore 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 endoexinal layer in a series of small, closely spaced folds or convolutions over the micospore surface.
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 micropores. An inter-radial crassitude is restricted to the inter-radial area of triangular spores; proximal crassitude 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 exinal layer is thick, often externally highly sculptured, and bears no inner columella (structural elements). A Sacque is composed of a thin exinal layer separated from the endarine, 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.
4.7 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. Potonié (1951, 1956, 1958, 1960; and as quoted by Hart, 1965) and the information collated by the International Commission for the Microflora of the Palaezoic. A key has been drawn (see text—figure 4.7, Sporites and text—figure 4.6, Pollenites) to illustrate the ranks of the supra-generic taxa. These range from the two basic ante-turra (Sporites and Pollenites) to turra, sub-turra and infra-turra. Genera and species follow in rank, but are not included here. They are discussed in detail under section 4.4 in this chapter.

ANTE-TURRA TURRA SUB-TURRA INFRA-TURRA

SPORITES R. Potonié, 1891—spores not possessing pores, scans or colpi. Apertures are monolete or trilete; equatorial structures may be present (cone, sinclium or cave; or inter-radial or radial crassitudes). Divided on the basis of type of aperture and presence or absence of an equatorial structure.

POLLENITES (Reichn, 1851) Potonié and Kremp, 1923—spores possessing a trilete aperture and no equatorial structures.
KEY TO SUPRA-GENERIC SYSTEMS

ANTETURMA

POLLENITES

TURMA

I-SACCITES

SUBTURMA

POLY-SACCITES

INFRA-TURMA

POLY-SACCITI

DISACCITES

DISACCITI

MONOSACCITES

RADIALES

BILATERALLES

SYMMETRICALLES

I-PlicateS

MONOLIATES

DIPTYCHI

INTORTI

POLYLIATES

POLYLIATI

PRAECOVITATES

PRAECOVITATI

III ALETES

AZONALETES

PSILONAPITI

TUBERINI

GRANULONAPITI

SUBPSILONAPITI

ZONALETES

IV JUGATES

DYADITES

DYADITI

TETRADITES

TETRADITI

POLYADITES

POLYADITI

NB: not encountered in Palaeozoic:-
DICOLPATES
FICOSSES
**ARCTOTAURMA**  
**TURMA**  
**SUB-TURMA**  
**META-TURMA**

**AZONOTRILETES**  
Lieber, 1935 — Trilites without any structural complications.

**LAEVIGATT** (Bennie and Kidston, 1886)  
Potonie, 1956 — Micropores with punctate and laevigate sculpture.

**APICULATI** (Bennie and Kidston, 1886)  
Potonie, 1956 — Micropores with apicolate sculpture.

**MURONATI** Potonie and Kemp, 1956 — Micropores with muronate (intectate) sculpture.

**LAGENOTRILETES** Potonie and Kemp, 1954 — Trilites with a proximal crassitude. (Not encountered.)

**ZONALIS** (Bennie and Kidston, 1886) Potonie, 1956 — Sporites possessing a trilite aperture and an equatorial structure; (cingulum, cave, zona; or radial or inter-radial crassitudes).
<table>
<thead>
<tr>
<th>SUB-TURMA</th>
<th>TURMA</th>
<th>INFRA-TURMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>AURICULATI Potonie and Kemp, 1954 - Zonotrichites with a discontinuous cingulum, i.e., a radial or inter-radial crenatuit.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONOTRILETES Valte, 1935 - Zonales with a continuous equatorial cingulum or zona.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CINGULATI Potonie and Kemp, (Klam), 1954 - Zonotrichites with a cingulum.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONATI Potonie and Kemp, 1954 - Zonotrichites with equatorial zona.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAVATTI Hart, 1963 - Cavates with an apiculitate sculpture.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PENNOTRILETTI (Brdtman, 1947) Hart, 1965 - Cavates with a muronitate sculpture.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MONOLETES Ibrahim, 1933 - Sporites with a monolete aperture.

AZONOMONOletes Labor, 1935 - Monoletes lacking an equatorial structure.

LAEVIGATAZONOMONOletes Dybova and Jackovich, 1957 - Azonomonoletes with a laevigate or punctate sculpture.

SCULPTURAZONOMONOletes Dybova and Jackovich, 1957 - Azonomonoletes with an apiculate or muronate sculpture.

ZONOMONOletes Labor, 1935 - Monoletes with a continuous equatorial structure, i.e., a cingulum or zona.

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

SACCIRES Brittan, 1947 - Miospores possessing saci.

POLYSACCIRES Cookeon, 1947 - Miospores possessing 2 or more saci.

POLYSACCIRES Cookeon, 1947.
DISACOTTES Cookson, 1947 - Micropores with 2 sacs symmetrically opposite the central body.

DISACONTITES Part, 1955 - Central body exhibits a thickened and striated proximal cap.

DISACONTITES Leschik, 1956 - Central body lacks proximal striae or proximal aperture. Distal sulcus (colporate aperture) may be present.

DISACOTRILITES Leschik, 1956 - Central body possesses a proximal centrally placed monocote, dites or trilete aperture. Proximal ribs and striae are lacking.

MONOSACOTTES (Chitaley, 1951) - Micropores possessing a single sacus.
N.B. R. Potonie (1956) proposed the division of Monoacocites into 2 infra-turmes based on the presence or absence of a trilete aperture, i.e., Aletesacciti (Leachik, 1956) and Triletesacciti (Leschik, 1956). However, Hart (1965) suggests this to be too variable, and further proposes two infra-turmes based on the attachment of the sacci to the central body - (a) attached both proximally and distally - Dipolascociti and (b) attached either proximally or distally - Monopolarsaciti. Segroves (1969), however, mentions that in some cases a misunderstanding of the Monoacocite structure can cause confusion on this basis of classification.

Ear (1967) compiled a general classification of Monoacocites from several papers describing the abundant genera found in the Perm-Carboniferous of India and the Congo. Nine infra-turmes 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 mispores material is not available for comparison.

Palm (1966) working on the Salt Range material has divided the Monoacocite genera into two groups. Group A - Radiosymmetrical with three genera and Group B - Bilaterally symmetrical, with one genus. Segroves (1969) apportioned his Monoacocite forms into five genera with no supra-generic groupings.
Delimitations of intra-turma groupings are, therefore, somewhat confusing and for the purposes of this thesis two groups, radiosymmetrical and bilaterally-symmetrical will be considered.

**ANE-TURMA TURMA SUB-TURMA INTRA-TURMA**

**PILIGATES** Rauhova, 1957 - Pollens with colpi (grooves) and no sacchi.

**FRASCOPIATES** Potonia and Kramp, 1954 - Pollens with a single distal sulcus (colpus) and a proximal aperture (monolete, dilute or trilete). Proximal striations may occur.

**FRASCOPIATES** Potonia and Kramp, 1954.

**POLYPIATES** Brittan, 1952 - Pollen with more than two transverse grooves (colpi) lying roughly parallel.

**POLYPIATES** Brittan, 1952.


Micropores in which the colpus reaches the outline, and is wider laterally than centrally, i.e. funnel shaped.
Miospores everywhere may or may not reach the margin, and sides are parallel.

Erdtman, 1947 - Pollens in which there are two parallel transverse ooli.

Ibrahim, 1933 - Miospores lacking saccol, ooli, and apertures.

Azonaletes (I.ber, 1933) Potoni and Kneip, 1954 - Miospores without equatorial structures (zona or cingulum).

Erdtman, 1947 - lastigate Azonaletes.

Fent, 1954 - Miospores possessing a proximal deviation of the exine in the form of a cylindrical extension.

Cockson, 1947 - Granulate Azonaletes.

Erdtman, 1947 - Comate or spinate Azonaletes.
<table>
<thead>
<tr>
<th>Forma</th>
<th>Sub-Forma</th>
<th>Tetra-Forma</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZONALETTI</td>
<td>Inber, 1935</td>
<td>Aletes possessing an equatorial extension i.e. a zona or cingulum.</td>
</tr>
<tr>
<td>(Not encountered)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDEGATI</td>
<td>Brittan, 1943</td>
<td>Micropores are joined in groups of two, four or more individuals per unit.</td>
</tr>
<tr>
<td>PENTADITI</td>
<td>Pant, 1954</td>
<td>Micropores consisting of 2 joined individuals.</td>
</tr>
<tr>
<td>TETRADITI</td>
<td>Cookson, 1947</td>
<td>Micropores possessing four united individuals in a tetrad formation.</td>
</tr>
<tr>
<td>POLYADITI</td>
<td>Pant, 1954</td>
<td>Micropores consisting of more than four individuals united in one group.</td>
</tr>
</tbody>
</table>
4.4 SYSTEMATIC PALYNOLOGY


Type species (by original designation): Punctatinopites punctatus (Ibrahim), Ibrahim, 1953.

Diagnosis: Outline circular, with trilette sutures; exine basically laevigate but may be infrapunctate, thin to thick and usually unfolded.

Punctatinopites gretensis Balme and Kennelly, 1956

Plate 1: figures 1-3.

Holotype: P. gretensis Balme and Kennelly, 1956

Pl. 2, figures 11-13.

Diagnosis: Circular outline; trilette sutures straight and clearly defined; about 3 radius of spore; labres sometimes present; exine about 4 µ thick, laevigate or finely granulate (sensu Balme and Kennelly p. 245) or infrapunctate (sensu Hart, 1965).
Description: Spore circular to sub-circular with only occasional minor folding around the periphery; sub-polar compressions common.

Trilete suture: Rays extend 1/2 to 2/3 radius of spore, distinct, usually slightly open; straight, occasionally thin darkened labra frame rays.

Exine: Smooth to infra-punctate, punctine (≤ 0.5 μ) to fairly coarse (1-2 μ); exine 2-4 μ thick, with occasional concentric rings seen within the wall structure.

Dimensions (20 specimens): Diameter: 50(80)-112 μ.

Discussion: The above diagnosis encompasses features seen in the genus *Eupunctatisporites* Ehrada, 1962 and the species *E. magnificus* Bose and Maheshward, 1968 and *E. reticulatus* Pant and Brivastava. These variations are based on the great density and size of puncta (*Eupunctatisporites*); larger size range (*E. magnificus*) and concentric rings in the exine (*E. 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: *Punctatisporites cretensis* 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 Mudstones.

*Punctatisporites cretensis* forma minor Hart, 1965

Plate I: Figures 4-5

Holotype: *P. cretensis* forma minor, Hart, 1965

Pl. 1, figure 10

Diagnosis: A laevigate trilete spore, circular in outline with trilete rays extending 3 radius of spore, with or without labra (mean size range smaller than *P. cretensis* but otherwise identical).
Description: Shape: Circular to sub-circular, with minor occasional peripheral folds.

Trilobate nature: Straight, distinct rays extending about 3/4 radius of central body.

Occasional thin raised labra seen.

Exine: Isoplicate 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).

Distinction: *F. granata* forma minor is identical to *F. granata* but is smaller in mean size.

Stratigraphic range: Common to abundant in Dwyka and Black Shales and Coals; rare to absent in Madumabisa Madstones.
Genus: *Deltoidospora* Miner, 1935

Type species: *Deltoidospora halii* Miner, 1935

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


*Leiotrilites recticula* (Balme and Hennelly, 1956)

Hart, 1965

Plate 1: Figures 12-15

Holotype: *Leiotrilites rectangular* Balme and Hennelly, 1956, Pl. 1, figures 1-4

Diagnosis: Outline rounded 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 sutures: 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 (50 specimens): Diameter: 26(35)48 μ.

Discussion: *L. congocensis* Kar and Bose 1967 is synonymous with the above species although it was retained by the original authors due to the rays extending up to the margin. *L. virkii* Tiwari, 1965 is similar but has a larger size. *L. adhatua* (Kosanke) Potonia and Kraep, 1954 and *L. lukugaisaria* Kar and Bose, 1967 possess concave sides; *L. nailinga* Kar and Bose, 1967 may well be synonymous due to its similar size range, shape, and thin exine, but was originally separated on account of its indistinct tolete rays. *L. coriacea* 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 Nadumbisa Mudstones.
Helicosporum lukasennisi Kar and Bose, 1967

Plate 1: Figures 16-19


Diagnosis: Triangular trilete with thin exine; concave sides, well-developed trilete rays extending ± 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 2/5 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: Inevaginate to faintly but sparsely granulate.

Dimension (10 specimens): Diameter: 31(38)45 μ.
**Distinguishing.**  R. fukuyamensis is distinct from other species by possession of concavo-convex sides with distinctive broad darkened lobes on either side of the trilobite rays.

**Stratigraphic Range.**  Abundant to very rare in Dwyka, rare to common in Black Shales and Coalley; common in Lower Ludlowian Mudsstones, rare to absent in Upper Ludlowian Mudsstones.
Genus: *Calamospora* Schöpf, Wilson and Bentall, 1944

Type species (by original designation): *Calamospora hartungiana* Schöpf (in Schöpf, Wilson and Bentall, 1944, p. 51).

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

*Calamospora plicata* (Ihober and Valts, 1941) Hart, 1965

Holotype: *Asonotriletes plicatus* Ihober 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 1/3-2/3 radius of spore (sensu Hart, 1965, p. 155).

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

Trilete sutures: Distinct darkened rays; 0.5-2 μ wide, often tapering to a point terminally; about 1/3 radius of spore. No apparent contact areas; thin dark lines sometimes visible.
Exine: Smooth to deeply micro-graminate, 1 μ or less in thickness.
Dimensions: (20 specimens) Diameter 41(48)66 μ.

Discussion: The Rhodesian forms have been assigned to C. plicata on the grounds of general polygonal outline, due to folding and length of trilette rays. C. indigena (Malyavkina ex Inex and Welte, 1944) Hart, 1965 is smaller in size whilst C. exilis Bharawaj and Saluja and C. abilata Bharawaj and Saluja both have infra-punctate exines. C. micromachia (Ibrahim) Schopf, Wilson and Bentall, 1944 is very comparable and may be synonymous 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 trilette suture.

Stratigraphic range: Common to abundant in Dryka, rare to absent in Black Shales; and absent in Madumabisa Shales.
Genus: *Betuacotriletes* Naumova

**Diagnosis:** Leveigate 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 Rentzii. However, (as discussed by Bharadwaj, 1962) the darkened contact area is not a characteristic of *Calamospora*, but is present in *Reteacotriletes* Naumov (which is also small in size).

**Reteacotriletes diversiformia** Balme and Hennelly, 1956

**Plate 1: Figures 7-9**

**Holotype:** *Calamospora diversiformia* Balme and Hennelly, 1956, p. 2, figures 14-18.

**Synonym:** *Calamospora nigritella* (Luber and Veite) Hart, 1965

**Diagnosis:** Outline circular, smooth; trilete sutures straight, about ½ radius of spore in length; exine leveigate or finely granulate (sensu Balme and Hennelly). A contact area with curvatures 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 1/2 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 curvature in place of darkened contact areas are seen.


Distinct: Reutebothries divergiformis is distinct by its small size and darkened triangular contact area.

Stratigraphic range: Found throughout the borehole core.
Infra-turmas: APICULATI (Bennie and Kidston, 1936)
Potonie, 1956

For the purpose of this thesis all elements attributable to the turma Trilites (her. Leavisti
forms) are retained in the infra-turma Apiculatii.
The distinction between Maronati and Apiculatii is somewhat difficult to recognise with the present equipment.

Genus: Apiculatisporis Potonie and Kram, 1956

Type species: Apiculatisporis (ml. Apiculatisporites)
sculptus (Ibrahim) Potonie.

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

Apiculatisporis Cevie Balme and Hennelly, 1956

Plate 2: figures 1, 2.
Holotype: Apiculatisporites levie Balme and Hennelly,
1956, Pl. 2, figures 18-21.

Diagnosis: Circular in outline; the trilite sutures
extend the full radius of the spore;
sculpture consists of small gran or
coni 1 μ high and 1-2 μ in basal
diameter, irregularly distributed.
Sculpture is reduced proximally.
Description: Shape: Circular to sub-circular.
Trilette 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 μ thick, bearing small granal or coni, 0.1-1 μ basal diameter, and 0.3-1.5 μ high, 1-2 μ apart, irregularly spaced. Scutural 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.

*Apiculatisporus filiformis* Balme and Henneally, 1956

Plate 2: Figures 3-5
Holotype: *Apiculatisporites filiformis* Balme and Henneally, 1956, Pl. 2, figures 22-23.

Diagnosis: Circular to sub-circular outline, with indistinct trilette rays extending full radius of spore; exine bearing spind
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 sutures: Indistinct, but where discernible straight and 1/2 to full spore radius in length.
   Exines: 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. Spines irregularly disposed, well spaced to closely spaced.
   Dimensions (10 specimens): Diameter: 24(30)44 μ.

Distinction: _A. filiformis_ is distinct from other species in bearing irregularly spaced spines of a characteristic shape.

Stratigraphic range: Common in Dwyka sediments; rare in Black Shales and Coals; rare in Madumabisa Shales.
Apiculatiaporis cornuus Balse and Henney, 1956

Plate 2: Figure 3


Diagnosis: Circular to roundly triangular in outline; trilette rays slightly sinuous and extend 1/2 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.
Trilette suture: Indistinct, extending about 2/3 spore radius where discernible.
Exine: 3-4 µ thick, bearing large coni and spini, 1-3 µ wide at the base and 3-6 µ high; elements are regularly and evenly ocuate or spinate with sharp spines; frequently seen regularly disposed and about 5 µ apart.

Dimensions (10 specimens): Diameter 36(41)45 µ.
**Distinction:**
A. corning 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 Malmabisa Shales.

**Apiculatioria minima** sp. nov.

**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 2/3-1 apore radius, straight, thin and bearing no apparent labre. No contact area is discernible; exine is thin and bears dense, small coni or granii, 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 3/4 spore radius.

Exine: Conical 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: A. minutum is distinct from other species in possessing a roundly triangular shape, a small size, and numerous small conical elements regularly spaced over the entire spore exine.

Stratigraphic range: Absent in all samples except those in the Lower and Middle Madumabisa Mafstones 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 granules.

Discussion: **Granulatisporites** is distinct from other genera in bearing granis on the exine. **Microbasulatispora** Bharadwaj possesses micro-baculi. **Microfereolatispora** (Bharadwaj) Sivsali and **Lophotritea** (Nausova) Potonie and Kremp possesses elements. **Lophotritea** Kar and Bose, 1967 bears spines distally whilst **Lophotritea** Venkatachala and Kar possesses distally concentrated micro- verrucae.

**Granulatisporites tentula** (Tiwari, 1965) nov. comb.

Plate 2: Figures 9-16


Diagnosis: Triangular outline with trilete rays about 2/3 radius of spore; distal face bearing granis less than 1 μm in diameter, 0.25-0.5 μm high and about 0.5 μm apart. Proximal surface laevigate or sculpture reduced.
Shape: Triangular, with straight to slightly convex sides, and well-rounded apices.

Trilete suture: Rays extend 2/3 to 2/3 radius of apore, 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 granules concentrated distally and reduced proximally; elements rounded to sub-rounded in plan, and rounded to almost conical and almost bacillate in outline. Regularly, evenly spaced, gran diameter less than 1 μ; height 1/2 μ and less than 1/3 μ apart.

Dimension (20 specimens): Diameter 27-42 μ.
Author  Falcon R M S (Rosemary Margaret Sarah)
Name of thesis Preliminary Study Of The Karroo Palynology In The Mid-zambezi Basin, Rhodesia. 1972

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