INTRODUCTORY STUDY OF THE PALYNOLOGY
OF THE NARRABEEN GROUP.
INTRODUCTORY STUDY OF THE

PALYNOLOGY OF THE

NARRABEEN GROUP.

By
Robin Helby B.Sc.

A thesis submitted to the University of Sydney as partial requirements for the Degree of Master of Science.

1962
INDEX

Introduction. ................................................. 1

1.1 Botanical Introduction to Palynology. .................. 2

1.2 Glossary of Morphological Terminology. ............... 3

1.3 Preparation Techniques. .................................. 8

1.3.1 Mechanical Reduction of Sample ...................... 8

1.3.2 Extraction of Microfossils. ............................. 9

1.3.3 Preparation of Slides. ................................ 10

1.3.3.1 Preparation of Bulk Mounts. ....................... 10

1.3.3.2 Preparation of Single Specimen Mounts. .......... 11

1.4 Measurement of Specimens. ............................... 12

2. Systematics. ............................................. 13

2.1 Discussion. ............................................ 13

2.2 Systematic Descriptions. ................................. 14

Retusotriletes rimalis sp. nov. ......................... 15
Punctatisporites narrabeenensis sp. nov. ............... 16
" plicatus sp. nov. ........................................ 17
Calamospora grosei sp. nov. .............................. 17
Granulatisporites microgranulatus sp. nov. ............. 18
Cyclogranatisporites plicatus sp. nov. ........ .......... 19
" tuberculata sp. nov. ..................................... 20
Apiculatisporis bulliensis (Hennelly) amend. ........ 21
Acanthotriletes hennelli sp. nov. ...................... 22
Verrucisporites taylori sp. nov. ......................... 23
Microreticulatisporites bendensis sp. nov. .......... 24
Distalanulisporites triangulatus sp. nov. ............. 26
Discisporites cooksoni sp. nov. ......................... 27
Marsupipollenites dispertitus sp. nov. ................. 28
Trizonaesporites grandis (Leschik) amend. .......... 29
" circularis sp. nov. ...................................... 31
" multiformis sp. nov. .................................... 32
Lueckisporites noviaulensis (Leschik) nov. comb. .... 33
" virkiiae Potonie & Klaus ................................ 34
Klausipollenites balmei sp. nov. ....................... 35
" leschiki sp. nov. ........................................ 36
Pityosporites nigracristatus (Hennelly) amend. ....... 37
" nubilus (Leschik) nov. comb. .......................... 38
Hennelliisporites reticulatus (Hennelly) nov. comb.

Partitisporites reticulatus sp. nov.

Monocolpopollenites irregularis sp. nov.

Quadrissporites horridus (Hennelly) **amend**.

**Incertae Sedis No. 1**

3.1 Stratigraphic Introduction.

3.1.1 Caley Formation.

3.1.2 Grose Sandstone.

3.1.3 Burralow Formation.

3.2 Stratigraphic Palynology.

3.3 Age of the Narrabeen Group as implied by the Microfloras.

Summary and Conclusions.

Acknowledgments.

Bibliography.
INTRODUCTION.

The aims of this study were,

1. To determine the possibility of division of the Narrabeen Group, within the Burragorang, on the basis of palynology.
2. To investigate the age relationships of any palynological divisions of the Narrabeen Group within the area.
3. To provide a basis for the introduction of morphological palynology.

The area in which the study was instituted is that part of the lower Burragorang as defined by Helby (1961), bounded by the Wollondilly and Nattai Rivers to the west, the Warragamba River to the north, Sheehy's Creek to the south, extending to the east about six miles from the Wollondilly - Nattai escarpment.

Stratigraphic division of the Narrabeen Group within the area is based on examination of cores and logs of cores from some sixteen diamond drill holes, interpolation from air photographs and limited measurement of creek sections. Palynological samples were obtained from three diamond drill cores in the north of the area, by kind permission of Coal Rights Pty. Ltd.

The author was hampered initially by fundamental lack of technique and understanding of basic principles of the discipline, due to the lack of formal and informal course work at Sydney University. It was also found that there is a deficiency of 'good' introductory textbooks and literature generally. It is for these reasons that the introductory section has been included in this thesis.
PTERIDOPHYTES

Text Fig. 1.

FERNS

Sporophyte

Sporangium

ASEXUAL PHASE

Tetrad

Individual Spores

Germinating Spore

SEXUAL PHASE

Ovule

Zygote

Sperm

Prothallium

GYMNOSPERMS

Tree

Cone

Microsporangium

Seed

Zygote

Megasporangium

Megaspore

Pollen
1.1 Botanical Introduction to Palynology.

In morphological studies it is advantageous if the function of the organism and its position in the complete life cycle is understood. Thus the position of both spores and pollen with relation to the life cycles of the parent plants will be discussed. It is necessary for the purposes of conciseness to consider only one example of spore and one example of pollen type, for which the generalised life cycles of the pteridophytes and the gymnosperms, respectively, will be briefly discussed.

Reproduction in the pteridophytes consists of a sexual and an asexual phase. The cycle is illustrated in Text Fig. 1, which shows:

1. the development of sporangium on the mature fern,
2. development of tetrads within the sporangium by division of the germ gels,
3. dehiscence, releasing the tetrads from the sporangium and release of the individual spores from the tetrads,
4. settling and germination of the spores to form a prothallium, an organism containing ovule producing structures, the archegonia, and sperm producing structures, the antheridia,
5. release of the male and female units from the parent structures, resulting in fertilization and the formation of a zygote,
6. simple cell division of the zygote which gives rise to a Sporophyte, from which the new plant develops.

In the gymnosperms, reproduction consists of one sexual phase. This is illustrated in Text Fig. 1, which shows:

1. development of micro- and megasporangium,
2. the release of the microspores or pollen form the microsporangium and the fertilization of the megaspore within the sporophyl,
3. resultant formation of the zygote with development of a protective coating, thus forming a seed,

4. broadcasting and germination of the seeds to form the new plant.

Both the *pteridophytes* and the *gymnosperms* have more complex additions to these generalised patterns, the most common being the diversification of the asexual phase resulting in the formation of sexed organisms. However, there is no evidence of this development taking place in the fossil plants.

1.2   Glossary of Morphological Terminology.

Amb,  outline of the spore with one of the poles exactly uppermost, i.e. the polar axis is directly vertical to the observer.

Apex,  the point of protrusion of the polar axis, lying at the centre of the Y mark. (abstract)

Area contagionis,  see contact area.

Auricular,  ear-like in shape.

Baculae,  cylindrical projections, not tapered, base spreads, top often truncated. Synonym - Stabchen.

Bladder, the air sac of a pollen grain as distinct from the central body. May occur singularly or as bisaccate or polysaccate forms.

Caniculate,  type of cicatricle ornamentation in which the ridges and the grooves are approximately equal in width.

Capilli,  see fimbriae.

Caput,  see pila.

Central body,  actual body of the pollen grain in saccate types as distinct from the bladders.

Cicatricate,  parallel ridges, often superimposed on another set.

Cingulum,  a flange like extension of the exine around the equatorial region of the spore. Usually consisting of contorted or ligamentous membrane.

Collum,  see pila.

Colpi,  equatorial, usually longitudinal apertures.
Commissure, the line of dehiscence in the tetrad scar.

Coni, echinate projections, usually not of much greater length than twice basal diameter, rounded at the top.

Contact area, those faces of the spore which are in contact with the other three spores, form the contact area.

Contact face, the area adjacent to the tetrad scar. In trilette spores the contact face is determined by the length of the leasurae and equals the proximal surface only when the leasurae extend to the equator.

Contravertex, further manifestation of the Y mark within the subtectum, only apparent on very low focusing.

Corona, is the equatorial manifestation of a fimbriate etc. ornament.

Costae, regular, well defined elevations or corrugations, more or less encircling the spore.

Cristae, confused combination of ornaments, such as verrucae with superimposed spines.

Curvaturae, represents the delineation of the contact face away from the polar regions.

Curvimurat, wavy, corrugated muri, often fragmented and broken.

Dehiscence mark, is that mark which appears on spores from tetrahedral tetrads as a tetrad or Y mark, or on spores from tetragonal tetrads etc. as a monolette mark.

Distal face, those parts of the spore which were turned outward in the tetrad. In the case of spores it is the surface opposite the dehiscence mark.

Echinate, projecting ornament, apex more or less sharp, trunk tapers, base broad.

Ectonexine, the outer, thick not very refractive zone of the nexine.

Ectosexine, the upper part of the sexine. Synonym - exolamellae.

Endonexine, the inner, thin more refractive zone of the nexine.

Endosexine, the basal part of the sexine. The endosexine in pollen grains is often baculate. Synonym - Isoliershicht.

Endospore, see Intine.

Equator, the border line between the two faces of a spore.
Exine, the main, outer, usually resistant layer of a sporoderma.

Exolamellae, see ectosexine.

Fimbriae, approximately cylindrical, ligamentous, contorted, knotted branching or anastomosing projections, occasionally straight.

Fissure, represents the labra side of the tecta, particularly when referring to the ornament.

Foveo-reticulate, has pits large enough and close enough to form a reticulum, comprised of lumina or lacunae and the intervening muri.

Fovelae, large scrobiculae, but still not reticulate.

Grana, the elements comprising a granulate ornament.

Granulate, more or less isodiametric projections, usually not more than one twentieth of the diameter of the spore.

Gula, represents the structure encountered when the tecta in the vicinity of the apex become expanded, vertically, so as to form a dehiscence 'cone'.

Infrareticulate, an infrareticulate ornament is a sexinous ornament, similarly arranged to an ordinary reticulum.

Infra-skulptur, internal ornamentation. (all infra- features are internal).

Intine, the inner usually not very resistant sporoderm layer. Synonym - Endospore.

Intratectum, the space between the tecta.

Isoliyerschicht, see endosexine.

Isopolar, condition showing no differentiation of the faces.

Kalotte, exine thickening of the proximal surface of the central body of certain pollen grains.

Kyrtome, arcuate folds, sub-parallel to the Y mark, meeting at the equator. Synonym - Tori.

Labra, inward side of the tecta, usually when the suture is open, but can also apply when the suture is closed.

Lacunae, see Lumina.
Text Fig. 3.

Polar Views

Central body
Perisaccate
Bladder

Central body
Bisaccate

1 Amb.
Laeusura
2 Apex
Psilate

Commissure
Cingulum
Dehiscence mark (Trilet)

Contact face
Equator

Laeusura
Vertex

Sub tectum
Labra
Tecta
Intratectum
Laesurae, the single rays of a trilette or monolete scar. It includes the commissure and also the margo when it is visible.

Limbus, zone due to various affects allowing delineation of the central body and bladders of pollen grains.

Lophate, ridged, with simple flange like ridges, often anastamosing.

Lumina, the space between the muri of a reticulum.

Margo, a transition zone between the commissures of the tetrad scar and the remainder of the exine. It is distinguishable by an increase in thickness of the exine or modification of the skulptur, or both.

Microreticulum, small reticulum, units usually less than 5μ.

Monosaccate, see perisaccate.

Muri, ridges separating the lumina of an ordinary reticulum.

Negative reticulum, see Reticuloid.

Nexine, the inner sculptured part of the exine. Synonym - intexine.

Overall shape, see Amb.

Papillate, apex more or less rounded to truncate, trunk not markedly tapered, projections.

Perine, the outermost, extra-exinous sporoderm layer. Synonym - perispore.

Perispore, see perine.

Pila, sculptural elements consisting of swollen apices (caput) and a rod like neck (collum), projections.

Polar areas, this represents those areas of a spore with proximity to the polar axis.

Polar axis, a perpendicular line connecting the poles of a spore, directed outward from the centre of the tetrad.

Pole, those areas joined by the polar axis, one initially being directed towards the centre of the tetrad and one being directed outward from the tetrad.

Proximal face, that part of the spore surface which is directed towards the centre of the tetrad.

Psilate, smooth, without ornament.

Perisaccate, surrounded by a saccus. Synonym - Monosaccate.
Raised Commissure, the actual line of dehiscence carried on the narrow ridge above the general surface of the spore.

Reticuloid, represents a negative reticulum or inverted reticulum. Often formed by closely set verrucae etc.

Reticulum, consists of a network of ridges, muri, surrounding polygonal lumina.

Rugulae, wrinkled elements, irregularly distributed, long in one dimension.

Sac, see bladder.

Scabrate, flecked with minute pits or elevations less than one micron.

Scrobiculae, luminae which have become very small in comparison to the muri, so much so that the reticulum is no longer apparent.

Sexine, outer layer of the exine.

Skulptur, (sculpture) ornamentation which shows in relief on the upper surface.

Spines, long, conspicuous and generally sharp pointed projections, exceeding three microns in length.

Spinules, small spines, not exceeding three microns in length.

Secondary folding, folding resulting from compression during sedimentation. Often characteristic within a species.

Stabchen, see Baculae.

Subtectum, represents the intratectum at its broadest point.

Sulcus, opening between tecta of some single furrowed gymnospermous and monocotyledenous pollens. In contrast to the laesurae of spores it faces outward from the tetrad.

Suture, opening between the tecta (abstract).

Tecta, high, sometimes low, but characteristically developed, ridged or raised folds in the exine. They pass outwards to the equator from the apex.

Tetrad scar, see laesurae and Dehiscence mark.

Tori, see Kyrtome.

Tubercules, large, isolated hemispherical projections (in excess of 3 μ).

Vermiculate, irregular projecting ornament, shape irregular, usually elongate in one direction. Similar to rugulate with greater expression of a second horizontal axis.
Verrucae, wart like sculptinous projections, often similar to large
granal.

Vertex, represents a line along the highest point of the testa.

Y mark, see Dehiscence mark.

Zone, membranous extension of the exine in the equatorial regions
of a spore.

1.3 Preparation Techniques.

1.3.1 Mechanical Reduction of Sample.

The material examined consisted of diamond drill core.

Initially the core was sawn into quarters with a rotary diamond saw. One
quarter was then thoroughly washed to remove all drilling 'mud' and
all other possible contaminants. Having dried this quarter and having
determined the length of the sample, the sample is then transferred
to a cast-iron mortar and crushed by means of sharp but light blows
with the pestle. It was found that this treatment produced less powder
and consequently a less fragmented sample yield than that produced
by a grinding motion. After a set number of blows the crushed material
was sieved and the -56u fraction was removed. The +1mm. fraction
was returned to the mortar, including regular removal of the -1 mm.
fraction. The process was continued till the sample was completely
reduced. The fraction +56u. - 1 mm. was found optimum for minimising
fragmentation of the fossils and digestion in the maceration treatment to
follow.

1.3.2 Extraction of Microfossils.

1. About 10 grams of the crushed sample was placed in a beaker
and treated with 32N. HCl. All samples are tested in this
fashion to determine the presence of carbonates which lead to the formation of insoluble fluorides. When all reaction with HCl had ceased, the sample was washed several times by decanting with water.

2. The sample was then transferred to a platinum crucible and covered to a depth of about half an inch of HF (commercial). All subsequent treatment was carried out, as far as possible, in a fume cupboard. The mixture in the platinum crucible was then heated for about five minutes allowing it to boil several times, and was then cooled. The cooling process was often facilitated by means of a cold water bath. It is advisable that the mixture should be cooled before handling to avoid the toxic and corrosive effects of HF.

The cooled sample was then transferred to a polythene centrifuge tube, stoppered and centrifuged. After centrifuging, the liquid was decanted and the residue washed with distilled water and centrifuged. The mixture was then subjected to further HF treatment. On completion of this second HF treatment, the residue was retained in the polythene tubes and about 30 mls. of 10% HCl were added. This mixture was heated in a hot water bath. After several minutes heating the mixture was centrifuged and decanted. The residue was then washed, centrifuged, decanted and transferred to a platinum crucible.

3. The H.F. treatment was repeated, with constant examination, till silica was removed.

4. On completion of the fluoridation treatment the sample was then subjected to chlorination, which consisted of stirring the residue with a mixture of 5mls. of glacial acetic acid, ½ ml. of concentrated
and a few drops of saturated KClO₃. This treatment helped to oxidise carbonaceous material. The treatment was allowed to proceed for several minutes, dependant on the amount of carbonaceous material. The sample was then centrifuged, decanted, washed in acetic acid, centrifuged decanted and washed several times with distilled water.

5. The residue was then transferred to a 400 ml. beaker and covered to a depth of about one inch with 5% NH₄OH solution. This caustic treatment served to remove humic acid derivatives liberated during the chlorination process. The treatment was allowed to proceed for several hours. After this time the solution was diluted to 400 mls. with distilled water, allowed to stand for an hour and then decanted. After decanting the solution was then diluted to 400 mls again. This dilution was repeated till the residue was almost free of alkali.

6. The residue was then transferred to a specimen tube and stained with several drops of alcoholic safranin. Excess safranin was removed by washing with alcohol.

The samples were now ready for storage or preparation of slides.

1.3.3 Preparation of Slides.

1.3.3.1 Preparation of bulk mounts.

Glass slides were placed on a heating device, easily manufactured by placing a 30 watt globe in a tin the size of a shoe box. A small piece of glycerine jelly was placed on the slide and allowed to melt. Several drops of the sample suspension were placed in the melted jelly by means of an eye dropped and mixed in with a small needle. The slides were removed from the 'heater' and an 18 mm. square cover slip was allowed to settle on the suspension in the centre of the glass slide.
The slide was then allowed to cool so that the jelly could set. The slide was then cleared of excess jelly by scraping a razor blade around the sides of the cover slip. After washing off any remaining jelly, the slide was dried and a thin margin of lacquer applied around the extremities of the cover slip with a fine brush. This served to seal the gelatine suspension thus preventing dehydration. These slides were then labelled and stored for examination.

1.3.3.2. Preparation of Single Specimen Mounts.

Towards the end of the study it became necessary for the purposes of isolating type specimens etc., to perfect a method of obtaining single sporomorphs on a slide.

Glass slides were placed on the "heater" and a small piece of jelly allowed to melt. Several drops of the suspension required were added to the jelly and mixed. The slide was then heated till the jelly-suspension mixture became so viscous as not to run. The slide was then inverted and allowed to stand for a further five minutes. After this time the "heater" was switched and the slide left to cool.

Having cooled, the suspension has become quite rigid. Several hours are allowed for hardening of the jelly. The slides are then placed on a microscope and examined. Having located a desirable specimen a low power objective is placed on the microscope. A clean, sharp needle is taken and used to cut the jelly surrounding the grain, usually in the form of a rectangle. It is possible by careful manipulation of the needle to separate a piece of jelly less than twice the area of the contained grain.
Text Fig. 5.

- MD - Mean diameter
- D - Diameter
- L - Length
- W - Width
- LB - Body length
- BB - Body breadth
- LA - Bladder length
- BA - Bladder breadth
- BD - Body depth

On general acceptance of any one of the systems. Of the systems at present in use, three 'schools' are apparent. The first is that of the Tertiary - Quaternary workers who use the neobotanical classifications. The second consists of those systems which are purely artificial in their construction, based on morphological divisions. The third 'school' consists of a compromise between the first two schools - the "half-natural" school, characterised by the use of organ genera.

Within the second, 'school', the artificial school, there are many variations of classification. Nearly all workers in the Paleozoic and the lower Mesozoic conform to one of these artificial systems. Complication arises within the artificial school, particularly at generic level, due to application of different nomenclatural systems. On the one
The isolated piece of jelly is then picked up with the needle point and transferred to a clean glass slide. The glass slide is then placed on the 'heater' and the jelly caused to melt. Any undesirable material may be removed at this stage. Extra jelly is then applied to allow application of the cover slip. The procedure then reverts to the normal cleaning and finishing as with bulk mounts. The individual grains are however, ringed by placing some marking device on the coverslip.

1.4 Measurement of Specimens.

Specimens are measured essentially along the lines set out by Couper (1958). This system, with amendments, is set out in Text Fig. 5. All measurements shown in this thesis are illustrated with the letter 'u' to signify microns. (u)
2. Systematic Descriptions.

2.1 Discussion.

Palynological systematics are governed by the rules of the International Code of Botanical Nomenclature. Under these rules (as interpreted by Faegri, 1956) two alternatives exist for the classification of fossil spore and pollen grains:

1. Classification of the fossil into an accepted neobotanical taxon or ..

2. If the fossil cannot be referred to a natural taxon it must be included in a form taxon or a new form taxon must be established for it.

For palynologists working on pre-quaternary material it becomes increasingly difficult to apply the first rule. In the lower Mesozoic and the Palaeozoic it is almost impossible to refer fossil sporomorphs to natural taxa.

Due to the diversification of the application of these rules, many classification systems have been put forward, but as yet there is no general acceptance of any one of the systems. Of the systems at present in use, three 'schools' are apparent. The first is that of the Tertiary - Quaternary workers who use the neobotanical classifications. The second consists of those systems which are purely artificial in their construction, based on morphological divisions. The third 'school' consists of a compromise between the first two schools - the "half natural" school, characterised by the use of organ genera.

Within the second 'school', the artificial school, there are many variations of classification. Nearly all workers in the Palaeozoic and the lower Mesozoic conform to one of these artificial systems. Complication arises within the artificial school, particularly at generic level, due to application of different nomenclatural systems. On the one
hand there are a vast number of workers who use purely morphological nomenclature, whilst others prefer commemorative nomenclature and some use both methods.

When considering the desirability of any classification, one must consider the end to which the system will be used. It is therefore apparent that the botanist would prefer a neobotanical classification system while the geologist, who desires only a workable stratigraphic tool, would be satisfied with an artificial system.

Various artificial systems have been proposed, e.g. Naumova (1937), Thompson and Pflug (1953), Van der Hammen (1954) and Potonie and Kremp (1954). None of these systems has been universally accepted, although that of Potonie and Kremp is possible the most widely used. The failure of the systems is due to the fact that there is no control over the individual palynologist dictating the use of a uniform system. Also, the present form of the rules of priority and synonymy prevent institution of new systems universally. The artificial systems commonly suffer from the defect that they allow the lumping together of completely unrelated plant units into unities in the new systems. However, this is possibly a lesser evil than the incongruity of natural species in a stratigraphic succession and certainty of identification along natural lines is not very probable, as many differing plants from different families have similar spores.

For the purposes of description the classification of Potonie and Kremp (1954) has been adopted.

2.2 Systematic Descriptions.

Anteturma Sporites H. Potonie. 1893.
Turma Trilolutes (Reinsch 1881) Pot. & Kr. 1954.
Subturma Azonotrilolutes Luber 1935.
Infraturma Laevigati (Bennie & Kidston 1886) R. Pot. 1956.

Retusotriletes Naumova 1953

Type Species Retusotriletes simplex

Generic Description. Genoholotype 30 - 35u, trilete microspore. Amb sub-triangular to circular, contact area recognisable e.g. it exhibits Curvaturae imperfectae at the end of the rays, or may also show joining of the rays by Curvaturae. (free translation from Klaus 1960)

Retusotriletes rimalis sp. nov.

Plate A Figs. 1 - 3, Text Sketch 1 Fig. 1.

Type Locality C.R.B.D.D.H. No. 1, 622 ft.

Holotype T.S. Slide No. 12

Diagnosis. Circular to oval sporomorph with very distinct exine thickening in the equatorial regions. Trilete, contact faces distinct, Curvaturae present.

Dimensions. 33 - 45u, mean 40u. (25 sp.)

Description. Most specimens are circular although oval forms do occur. An equatorial thickening occurs, sometimes due to folding but mostly due to exine thickening. Thickness of the exine varies from less than 1u in the centre of the sporomorph to about 2.5u at the equator. Contact faces are clearly recognisable, laesurae extending to the equatorial thickening. Curvaturae well developed. Ornament is usually absent from the rim, the contact faces showing infra-reticulation.

Comparisons. This form could be confused with Circulina but the strong laesurae in this form show it belongs to Retusotriletes.

Discussion. This form appears in sample 722 and extends upward throughout the rest of the section examined.

Punctatisporites (Ibrahim 1933) amend Pot. & Kr. 1954

Type Species Punctatisporites punctatus (Ibrahim 1933) amend Pot. & Kr.
Generic Description. Trilete iso- or microspores, equatorial shape circular or nearly circular with only slight indication of triangular shape; smooth margin. Exine 'skulpturos', ornament not being recognised as punctate or infra-reticulate or infra-granulate, although it may be locally punctate, e.g. along the laesurae. The laesurae are usually longer than half radius of the spore. Distinguishable from Calamospora by the length of the laesurae and the area contagionis. (free translation from Pot. & Kr. 1954)

Punctatisporites narrabeenensis sp. nov.

Plate A, Figs. 4.5.


Holotype Slide T.S. No. 18.

Diagnosis. Circular or slightly oval sporomorphs, infra-reticulate, length of the laesurae varying from about two thirds radius, very occasionally extending almost to the periphery.

Dimensions. 33 - 50u, mean 43u. (30 sp.)

Description. Circular to oval in shape. Exine about 1.5u thick, opaque, colour gold to dark brown. Laesurae variable in length, usually closed, often raised. There is usually minor development of secondary folding on most specimens.

Comparisons. This form is distinguished from the other species of Punctatisporites occurring in the Permian and Triassic by its size and variability of the length of the laesurae.

Remarks. This form occurs only in the Triassic, appearing initially in sample 722. It occurs throughout the higher part of the Narrabeen Group from where its name is derived.
Size Frequency Graph of 100 Specimens of *Punctatisporites plicatus*
**Punctatisporites plicatus** sp. nov. (group ?)

Plate A Figs. 6 – 8.

Type Locality C.R.B.D.D.H. No. 3, 1156'7" – 1156'11".

Holotype. Slide T.S. No. 1.

Diagnosis. Circular to oval sporomorphs. Trilete laesurae extending almost full radius. Spore body invariably folded and often torn.

Infra = punctate.

Dimensions 33 – 103u, mean see graph opposite. (100 sp.)

Description. Amb may be circular to oval in the case of folded specimens. Exine 2u thick, translucent, always folded. Laesurae extend almost full radius, may be closed or open and often slightly raised.

Ornament varies from infra-punctate to infra-reticulate.

Discussion. Examination of the size frequency graph of the specimens examined shows three distinct curves. It has not been possible to distinguish between the individuals within the limits of the various curves on the basis of morphology, to hand.

**Calamospora** S. W. & B. 1944

Type Species. **Calamospora harrungiana** Schopf 1944

Generic Diagnosis. Trilete micro - or mega - spores up to 350u in diameter. Laesurae usually not longer than half radius of the flattened spore, usually shorter, occasionally not clear. Fissure sometimes open. Indications of the contact area often recognisable, but no Curvaturae, only differential colouring of the area. Outline smooth, exine without sculpture. Ornament very seldom recognisable, usually some infra-type, strong secondary folding because of the thin exine. (free translation from Pot. & Kr. 1954)

**Calamospora grossi** sp. nov.

Plate A Figs 9,10.


Holotype. Slide T.S. No. 7.
Diagnosis. Circular or slightly oval sporomorph, laesuræe extending about half radius, ornament infra-punctate.

Dimensions. 60 - 100u, means 71u. (15 sp.)

Description. Circular to oval in shape. Exine slightly less than 2u thick, opaque, colour gold to tan. Laesuræe about half radius in length mostly closed. Body of the spore invariably folded with crescentic of lensic thickenings.

Comparisons. Certain specimens of this type are similar to specimens of *Punctatisporites plicatus* sp. nov.. Distinguishing features are the length of the laesuræe and the shape of the foldings.

Discussion. This form occurs throughout the upper part of the Grose Sandstone and the Burralow Formation. It derives its name from the Grose Sandstone in which it first appears.

Subinfraturma Granulati Dyb. & Jach. 1957.

*Granulatissporites* (Ibrahim 1933) *emend* Pot. & Kr. 1954

Type Species. *Granulatissporites granulatus* Ibrahim 1933

Generic Diagnosis. Trilete almost triangular iso - or micro - spores without any other differentiation than the dense granular sculpture of the exine. The grana are rather circular and usually formed with equal dimensions. In optical section the surface of the grana are flat or rounded. (free translation from Pot. & Kr. 1954)

*Granulatissporites microgranulatus* sp. nov.

Tect Sketch 1, Fig. 2

Type Locality. C.R.B.D.D.H. No. 1, 622 ft.

Holotype. Slide T.S. No. 23. (destroyed)

Diagnosis. Sporomorphs, triangular with strongly convex sides. Trilete to the periphery, very finely granulate, auricular apices.

Dimensions. 36 - 47u, mean 40u. (10 sp.)
Description. Amb triangular with strongly convex sides. Trilete to the periphery, very finely granulate in the vicinity of the laesurae. Laesurae extend to the auricular apices and are often slightly raised. Auricular apices project outwards from the general outline to give triangular form in almost circular types. Exine opaque, 1.5µ thick, ornament granulate, varying from very fine grana up to those with bases nearly 1µ in diameter.

Comparisons. This species bears some similarities to some of the cingulate genera, but definitely lacks a cingulum, beyond the apices.

Discussions. It is often difficult to detect the granulate nature of the ornament due to the state of preservation of the material. This form is confined to the Triassic part of the section, appearing initially in sample 722.

_Cyclogranisporites_ Pot. & Kr. 1954

Type Species. _Cyclogranisporites leopoldi_ (Kremp 1952) _amend_ Pot & Kr.

Generic Diagnosis. Trilete microspores whose equatorial outline is circular. Mostly the circular shape does not show any reference to a triangular shape at all; if, however, there is some indication of triangular shape it is only inferred; always the form is nearly a circle. Other than this it shows the same characteristics as _Granulatisporites_. (free translation from Pot. & Kr. 1954)

_Cyclogranisporites plicatus_ sp. nov.

Plate A Fig. 11

Type Locality C.R.B.D.D.H. No. 3, 1156'7" - 1156'11".

Holotype. Sample C, slide No. 1, 072, 453 (C.T.S.)

Diagnosis. Circular to oval sporomorphs, distinctly trilete, ornament granulate, body invariably torn or folded.
Dimensions. 46 - 90u, mean 63u. (18 sp.)

Description. Holotype 70u, amb circular, laesurae distinct, slightly raised and extend to the periphery. Exine thin, about 1u, transparent. Thinness of the exine possibly accounts for the tendency of most of the specimens to be torn or folded or otherwise deformed. Ornament granulate, grana less than 1u in basal diameter, closely packed.

Comparisons. The smaller forms of this species are similar to \textit{C. congestus} Leschik 1955, in that the laesurae extend to the periphery and the tendency of the form to collapse.

Discussion. It is possible that this species represents a species group, comprising two forms, differentiated by size, the smaller having a mean size in the vicinity of 50u, while the larger has a mean size in the vicinity of 70u. The state of preservation of this form prevented any large scale measurement of size ranges.

The species is abundant in the lowermost six inches of the section.

\textit{Cyclogranisporites tuberculata} sp. nov.

Plate A Fig. 12, Text Sketch 1 Fig. 4

Type Locality. C.R.B.D.D.H. No.1, 622 ft.

Holotype. Slide T.S. No. 14

Diagnosis. Circular sporomorph, granulate, weakly developed laesurae, concentric folding developed. Isolated tubercules occurring over the body.

Dimensions. 48 - 60u, mean 52u. (10 sp.)

Description. Circular or slightly oval in shape. Exine thick 2.5u, opaque. Ornament consists of grana 1 - 1.5u in basal diameter with
occasional superimposed tubercules about 3u in basal diameter and 2u high. These tubercules are irregularly distributed, often less than five occurring on a face in polar view. Although trilite the length of the laesuriae are difficult to determine due to their weak development. They usually extend about two thirds radius. Concentric folding is prominent. Comparisons. Although it possesses tubercules, the dominant ornament of this form is granulate. It is, however, similar to some forms of Tuberculatisporites (Ibrahim) Pot. & Kr.

Discussion. The occurrence of this form is confined to the Grose Sandstone.

Infuratorma Apiculati (Bennie & Kidston 1886) R. Pot. 1956
Supinfuratorma Nodati Dyb. & Jach. 1957.

Apiculatisporites (Ibr. non Benn. & Kid) amend Pot. & Kr. 1954.

Type Specimen. Apiculatisporites aculeatus Ibrahim 1933.

Generic Diagnosis. Trilite iso - or micro - spore, little differentiation, equator shape circular. Upper surface thickly set with large, almost cone shaped coni which often possess a considerably broad base, and whose height can exceed the width of the base. The relative height of the ornament is thus moderate, seldom exceeding double the diameter of the base. The ornament is of constant size, shape and distribution, although often slightly thicker and closely packed on the distal surface. The ornament is invariably broader than the gaps between the individual projections. In some cases the bases of the projections are so broad as to almost touch, causing the bases to assume a polygonal shape. (free translation from Pot. & Kr. 1954)

Apiculatisporites bulliensis (Hennelly 1958) amend.

Plate A Figs. 14, 15., Text Sketch 1 Fig. 3.

Type Locality. Appin Bore No. 4, 1696'10" - 1697'5".
Diagnosis. Amb circular to oval, occasionally sub-triangular, laesurae extending almost to the periphery. Exine moderately thick, echinate with spinules and coni.

Dimensions 18 - 40μ, mean 26μ. (SO sp.)

Description. Exine about 2 - 3μ thick, translucent, usually gold in colour. Ornamentation consists mainly of spinules about 2μ in length often interspersed with coni of similar dimensions. Projections about 1.5μ across the base. It is suggested that the spines are the original ornament but in the case of the coni the tip has been lost. This is evidenced by the fact that in the specimens showing better preservation the spines are the dominant ornament. Trilete, laesurae extending to the periphery, seldom open.

Comparisons. Similarities occur between this form and A. levis of the Collie Horizon, Collie, W.A. However, in this form the suture is seldom prominent and the ornament is larger.

Discussion. This form is particularly abundant in the lowermost foot of the succession in the Burragorang and at the Appin locality. It is also suspected in the Upper Bowen of Queensland.

Acanthotriletes (Naumova 1937) amend Pot. & Kr. 1954

Type Species. Acanthotriletes ciliatus (Knox) Pot & Kr.

Generic Diagnosis. Trilete iso- or micro-spores decorated with spines on all sides. The spines have little space between them. They are seldom truncated at the tips, and are gradually attenuated towards the tips. They are usually longer than double the diameter of their base, thus allowing distinction from Lophotriletes and Apiculatispora (free translation from Pot. & Kr. 1954)

Acanthotriletes hennellii sp. nov.

Plate A Fig. 13, Text Sketch 1 Fig. 5

Type Locality. C.R.B.D.D.H. No. 3, 1156'7" - 1156'11".
Holotype. Sample C, Slide No.1, 158, 573(C.T.S.)

Diagnosis. Triangular sporomorphs, trilete, laesurae extending to the apices. Ornament consists of spines up to 8μ in length, 1.5 - 3μ wide at the base.

Dimensions. 20 - 38μ, mean 31μ. (14 sp.)

Description. Amb triangular often with strongly concave sides, rounded apices. Ornament consists of spines, 3 - 8μ in length and 1.5 - 3μ in basal diameter, about 3 - 4μ apart at the bases, irregularly arranged. All spines are strongly tapered and often bent or broken. Some specimens show an indistinct trilete mark. The laesurae extend to the periphery.

Comparisons. Some of the specimens with smaller spines resemble A. Tereteangulatus Balme & Hennelly, but distinction is made in the constantly larger spines.

Discussion. This form is not particularly abundant and has not been found above the basal foot of the succession.

Subinfraturma Verrucati Dyb. & Jac. 1957

Verrucosisporites (Ibrahim 1933) Pot. & Kr. 1954

Type Species Verrucosisporites verrucosus Ibrahim 1933

Generic Diagnosis. Trilete iso- or micro-spores of circular or nearly circular shape and without other differentiation than through the thickly placed wart like sculpture of the exoexine. The warts are often larger than the grana of Granulatisporites which are usually uniform. They possess broad bases and the upper surface is almost flat. They are not rounded like grana but are rather irregular in shape and may be stretched. They are seldom dispersed, but usually closely packed. (free translation from Potonie and Kremp 1954)

Verrucosisporites taylori sp. nov.

Plate A. Figs 16 - 19.
Type Locality. C.R.B.D.D.H. No. 5, 1067 ft.

Holotype. T.S. Slide No. 19.

Diagnosis. Circular or almost circular sporomorphs with verrucose ornament. Trilete, laesurae difficult to distinguish.

Dimensions. 75 – 100μ mean 83μ. (10 sp.)

Description. Shape circular to oval. Ornament consists of verrucae 3 – 4μ across the base, 2 – 3μ high and about 1.5μ apart. Overall shape irregular, particularly at the bases. Trilete, laesurae very indistinct, extend almost to the periphery. Exine dark brown in colour, opaque due to the nature of the ornament, thickness undetermined.

Comparisons. This form is very similar to the type species but differs in that the laesurae are longer and less distinct.

Discussion. This form is confined to the Grose Sandstone.

Infraturma Murornati Pot & Kr. 1954

Microreticulatisporites (Knox 1950) Pot. & Kr. 1954

Type Species Microreticulatisporites lacunosus (Ibr. 1933) Knox.

Generic Description. Trilete iso- or micro-spores. Shape triangular to circular. Exine extrareticulate with small lumina, whose diameter does not exceed 6μ, mostly the lumina are smaller. The muri are sometimes imperfect and broken or branches. The lumina have a corresponding shape. Occasionally the muri vary in height and are sometimes turned over. The outline of the spore is finely crenulated or undulating. (free translation from Pot. & Kr. 1954)

Microreticulatisporites bendensis sp. nov.

Plate B Figs 1,2. Text Sketch 1 Fig. 6

Type Locality. C.R.B.D.D.H. No.3, 1156'7" – 1156'11".

Holotype. Slide T.S. No. 21.
Text Sketch 1.

1. Retusotriletes rimalis
2. Granulatisporites microgranulatus
3. Apiculatisporis bulliensis
4. Cyclogranisporites tuberculata
5. Acanthotriletes hennelii
6. Microreticulatisporites bendensis
7. Discisporites cooksoni
8. Distalanulisporites triangularis

50 μ
Diagnosis. Triangular or sub-triangular to rounded sporomorphs with very distinct microreticulum. Trilete laesurae extend to the periphery, one longer than the other two.

Dimensions 60 - 85μ, mean 68μ. (10 sp.)

Description. Amb triangular with strongly convex sides and rounded apices. Laesurae very distinct, fissure often open about 2μ. Laesurae extend to the periphery, one ray being slightly longer than the other two. There is a tendency for the spore to collapse along one of the rays, causing a folding under. Exine thick, opaque, ornament microreticulate, lumina small and almost rounded, 1.5 - 2μ in diameter. Muri are strongly developed being up to 1.5μ thick, causing the outline of the spore to appear crenulated.

Comparisons. The form is very similar to the type species. It is distinguished by its larger size and its folding tendencies.

Similar to blusterless Pulmonispora parvitholus B.& H.

Discussion. This form is not particularly abundant and is confined to the basal foot of the succession.

**Distalanulisporites** Klaus 1960.

Type Species **Distalanulisporites punctus**

Generic Diagnosis. Trilete microspores with round or rounded triangular shape, without zone, cingulum or special equatorial differentiation. Y mark longer than half radius, and can reach to the periphery, almost straight, without observable thickenings, occasionally accompanied by weak swellings. Their ends may be forked and mostly indistinctly developed curveturcae imperfectae or &. perfectae is developed. Characteristically there is a circular broad, centrally, symmetrically arranged thickening of the exine on the distal side. The diameter and thickness of the ring vary, strongly. Exine ornament on the outside of the ring on the distal side is smooth to granulate. Similar ornamentation can be found on the proximal side. Never is the thickening found on the proximal side.

*(free translation from Klaus 1960)*
Distalanulisporites triangulatus sp. nov.

Plate B Figs 3,4, Text Sketch 1 Fig. 8

Type Locality. C.R.D.D.H. No. 1, 622ft.

Holotype. Slide T.S. No. 11.

Diagnosis. Rounded triangular sporomorph. Trilete, laesurae extend to the periphery, exine thickened in the central portions of the sporomorph, possibly on the distal side, forming an area whose border is almost parallel to the equator of the sporomorph.

Dimensions. Overall diameter 36 - 45u, mean 40u. (10 sp)
Equatorial thickening 24 - 33u, mean 31u.

Description. Shape of the specimens vary from distinctly triangular as in the case of the holotype, to sub circular. Shape of the central thickened portion is less strongly triangular than the equator but tends to sub-parallel it. Due to the state of preservation it was not possible to distinguish if the thickening was confined to the exine of the distal face. Laesurae extend across the thickening to the periphery, are strongly developed and in isolated specimens are slightly raised, with a tendency to weaker development away from the thickened area. Ornament of the sporomorph as a whole is very finely granulate.

Comparisons. This form is distinguished from Discisporites cooksoni sp. nov. by its distinct triangularity and gradational thickening of the central portion.

Discussion. Although this genus has previously been described from the middle Keuper, the present species occurs very close to the boundary of what could possibly be the Permo-Triassic border.
Turma Zonales (Bennie and Kidston 1886) Pot. 1956

Subturma Zonotriletes Waltz 1935

**Discisporites** Leschik 1955

Type Species **Discisporites niger** Leschik 1955

Generic Diagnosis. Two major zones recognisable. In the central part there is a weakly developed Y mark. Outer zone is equally broad.

(free translation from Leschik 1955)

**Discisporites cooksoni** sp. nov.

Plate B. Figs. 5 - 8., Text Sketch 1 Fig. 7.

Type Locality. C.R.B.D.D.H. No. 1, 622 ft.

Holotype. Slide T.S. No.13

Diagnosis. Circular sporomorph, possessing a cingulum. Laesurae weakly developed passing to the periphery of the central body. Ornament of central body and cingulum finely granulate.

Dimensions. Overall Diameter. 34 - 39u, mean 36u. (40 sp)

Central body. 18-26u, mean 22u.

Description. The overall shape of the sporomorph is circular to oval, occasionally sub-triangular. The junction of the spore body and the cingulum is distinct, shape of the spore body being circular. Exine is relatively thin, about 1u and ornamented with fine granulation. Laesurae are weakly developed and when observed extend to the inner margin of the cingulum.

Comparisons. There is some resemblance between this form and specimens of **Distalunulisorites triangulatus** sp. nov., but the distinct triangularity of the central portion and its gradational thinning towards the equator in the latter species differentiated similar types.

Turma Plices (Naumova 1937) Pot. 1960
Subturma Praecolpates Pot. & Kr. 1954.

**Marsupipollenites** Balme & Hennelly 1956

**Marsupipollenites triradiatus** Type Species.

Generic Diagnosis. Amb circular or oval. Single furrow on the distal face delimited by two longitudinal folds in the exine. These folds may be in contact or overlapping at the distal pole in unexpanded sporomorphs. In ruptured grains an irregular rent occurs in the distal face, bordered by a narrow zone of folded exine. A trilete or monolete tetrad scar may be present on the proximal face. Sexine ornament rugose, granulate, verrucate or striate. (Verbatim Balme & Hennelly 1956)

**Marsupipollenites dispertitus** sp. nov.

Plate B Fig. 9, Sketch Fig 2, Figs. 1,2.

Type Locality. C.R.B.D.D.H. No.1, 622 ft.

Holotype. Slide T.S. No.10

Diagnosis. Sporomorphs irregularly oval to circular, not trilete or monolete mark visible. Exine thin, possibly psilate to infra-reticulate. Two sub-parallel exine folds on the 'distal' surface.

Dimensions. 35 - 50u, mean 42u. (10 sp)

Description. Shape of the form varies from distorted oval to circular (see Figs. 1, 2, Sketch 2). Two folds, crescentic in shape occur facing each other on the 'distal' face. Folds about fifteen microns apart. If the shape of the grain is distorted the distortion takes place sub-parallel to the folds. Width of the folds varies from 3 - 6u. Ornament is usually psilate, possibly due to the state of preservation (slightly oxidised) although infra-reticulate and infra-granulate forms occur.

Comparisons. This form has some similarities with **Duplicisporites dispertitus** (Leschik) Klaus, particularly the more rounded forms. However, the crescentic folds in this local form are reversed to those of the
Keuper type, also there is definitely no trilete mark.

Discussion. This form occurs sparsely in the upper member of the Grose Sandstone and in the Burralow Formation.

Anteturma Pollenites R. Potonie 1931

Turma Saccites Erdtman

Subturma Monosaccites (Chitaley 1951) Pot. & Kr. 1954.

Infraturma Aletesaccati Leschik 1955

*Trizonaesporites* (Leschik 1955) amend.

Type Species. *Trizonaesporites grandis* (Leschik 1955) amend.

Amended Generic Diagnosis. Monosaccate pollen grains without any definite dehiscence mechanism. In isolated specimens a centrally located part of the central body may be differentiated for a hitherto undetermined purpose. The shape of the grains varies from round to oval with a high proportion of the specimens assuming bi-, tri-, and poly-saccate shapes. Ornament consists of a reticulum, lumina usually less than 3μ in diameter.

Discussion. Leschik's original generic diagnosis "spores with three zones. Structure of the zones arbietinoid reticulum. Y mark missing," was a misconception of the actual structures present. Potonie (1958) says "this genus may, because of accidental peculiar conditions of preservation be represented by this single example (the type species, genoholotype). This is true for the so called central body. The actual central body includes the central deformed part together with the so called middle zone. It would be recommended not to use this genus."

However, the presence of the central structure in the central body is not a single example, as at least a dozen examples of this feature, in two species, have been noted in the Burrarorang samples.
It is, however, acknowledged that the central and middle zones as
described by Leschik do, in fact, represent the central body of the pollen.
It would, however, be unwise to dismiss the presence of the central portion
as the result of peculiar conditions of preservation. It is suggested
that it may have some particular function, perhaps representing some type
of dehiscence pad. It is therefore considered that an amended generic
diagnosis is warranted.

*Trizonaesporites grandis* (Leschik 1955) amend.

Plate B. Figs 10 - 12.

Type Locality. Zechstein von Neuhof.

Diagnosis. Monosaccate pollen. Overall shape varies from circular,
ove to multibladder forms. No trilette mark visible.

Dimensions. 132 - 164, mean 144ü Overall diameter.

Diameter of central body undetermined due to overlap of
bladder. (50 ü sp.)

Description. Overall shape varies from circular to oval, some forms
showing manifestation of two, three and four zones of the single bladder
giving a multisaccate form. Both the central body and the bladder are
ornamented with an infra-reticulum, that of the body being slightly
smaller than that of the bladder. Shape of the central body is presumed
to be circular from the shape the overlapping bladder assumes. The bladder
overlap is often regular, width varying from 30 - 50ü. The central body
in isolated specimens possesses a centrally positioned round structure
varying from 20 - 40ü in width.

Comparisons. This form could have affinities with such species as
*Nuskoisporites dulhuntrialia* Pot. & Kl. 1954. It would be difficult to
distinguish between the forms if it were not for the trilette mark in
the *Nuskoisporites* types.

Discussion. This form is confined to the Grose Sandstone and the very
base of the Burralow Formation as represented by the transition between
Microfloras 2 & 3.

*Trizonaesporites circularis* sp. nov.

Plate C Figs 1,2.

Type Locality. C.R.B.D.D.H. No. 1 1034 ft.

Holotype. Slide T.S. No.6

Diagnosis. Monosaccate pollen, almost circular or sub-circular.
No dehiscence mark visible, Ornament of both bladder and central body
infra-reticulate.

Dimensions. Overall Diameter 96 - 120u, mean 113u. (50 sp.)

  Central body 80u (1 specimen, overall 120u).

Description. Shape circular to slightly oval with occasional specimen
showing polysaccate tendencies. Central body almost circular as revealed
by one specimen with an oxidised bladder attachment zone. Several specimens
have had the differentiated central portion of the central body preserved.
Reticulation units of the bladder have a mesh of about 2. - 2.5u, while
those of the central body are slightly smaller. Very occasionally the
central body will be overlapped by the bladder in the polar regions.

Comparisons. This form is differentiated from *T. grandis* by its size
and its constant circularity, and uniformity of overlap. It also appears
earlier in the succession.

Discussion. This form appears low in the Grose Sandstone Formation and
is particularly localised to the lower member.
Trizonaesporites multiformis sp. nov.

Plate C Figs. 3 - 5.

Type Locality. C.R.B.D.D.H. No. 1, 1034 ft.

Holotype. Slide T.S. No. 5

Diagnosis. Monosaccate pollen, bladder showing tendencies to the development of multibladder types. Ornament of both central body and bladder infra-reticulate. Limbus typically developed.

Dimensions. Overall diameter 75 - 90 u, mean 79u
Central body 51 - 63u, mean 55u
Limbus 5 - 9u. <22 sp.>

Description. Central body circular, exine 1.5u thick, translucent, ornamented with infra-reticulum. Central body surrounded by continuous bladder, often showing the development of two or four separate lobes. Bladder also very prone to distortion due to folding, possibly because of thin exine. Bladder never envelopes the central body as in other species within the genus. Bladder ornament infra-reticulate, units 2u.

Comparisons. This form bears some resemblance to Accinctisporites (Leschik) but does not have a smooth body and the bladder shape is particularly variable.

Discussion. This form occurs in moderate abundance in the lower part of the Grose Sandstone.

Subturma Disaccites Cookson 1947
Infraturma Striati Pant 1954.

Lueckisporites Pot. & Kl. 1954.

Type Species Lueckisporites virkkiae Pot. & Kl. 1954

Generic Diagnosis. Bisaccate pollen without Y mark. The infra-reticulate bladders are distally joined. The lines of attachment of
the bladders converge distally, so that the meridional shape of the spore shows a greater clearance proximally than distally. The smooth and structureless intexine of the central body is proximally covered by a strongly developed infra-baculate exoexine Kalotte. It is especially noted that this kalotte exhibits at least one or more parallel fissures. These fissures are stretched parallel to the long axis of the central body and could reach from one bladder root to the other. The middle fissure is reminiscent of a monolete mark. In the distal regions the exine layer is weak or completely missing. (free translation from Pot. & Kl. 1954).

Lueckisporites (Taeniaesporites), noviaulensis (Leschik) amend.
Plate C Figs 6,7.
Type Locality Zechstein von Neuhof.

Holotype Leschik 1956, Tab. 22, Figs. 1,2.

Diagnosis. Bisaccate pollen, central body possessing four broad stripes separated by three slightly smaller grooves.

Dimensions. L.B. 40 - 50u  
B.B. 43 - 60u  
L.A. 48 - 55u  
B.A. 25 - 35u  
Overall length 70 - 90u (10 sp.)

Description. Central body oval in the long direction of the grain, infra-reticulate, possessing four stripes, slightly raised, about 8u wide, separated by grooves 4 - 6u wide. Bladders disposed laterally but do not meet. Ornamentation of the bladders infra-reticulate, units about 3u.

Comparisons. There are some superficial resemblances between this form and Lueckisporites (Taeniaesporites) krausell (Leschik) Klaus 1960, but differences in size, number and width of the separating grooves are immediately apparent.

Discussion. As the specimen described by Leschik (1956) possesses only four stripes it cannot be classified within the genus Taeniaesporites as originally defined by Leschik himself. The
form however, conforms to the diagnosis of *Lueckisporites*.

*Lueckisporites virkkiae* Potonie & Klaus 1954.

Plate C Figs. 8, 9. Text Sketch 2 Fig. 5

Type Locality. Claybench in the upper 'Kalilager' of the Werra Series.

Diagnosis as originally stated,

Dimensions.  
| L.B.  | 30 - 46u, mean 37u |
| B.B.  | 38 - 48u           |
| L.A.  | 27 - 45u           |
| B.A.  | 22 - 42u           |
|       | Overall length     |
|       | 46u                |
|       | 60 - 78u, mean 73u |
|       | (10 sp.)           |

Description. Central body oval in the long direction of the grain.

Exine about 1.5u thick, translucent, infra-reticulate, mesh units 2u.
Bladders laterally disposed, seldom overlapping distally. Bladder ornament infra-reticulate, units about 3u. The body possesses a single raised stripe, usually about 5u wide, often bordered by grooves on either side. The stripe is always asymmetrically positioned to either side of a central fissure or groove. None of the Burragorang specimens examined so far have shown equal development of the Kalotte on either side of the body fissure.

Comparisons. The specimens described above are similar to some specimens of *L. virkkiae* of samples obtained from the Hilton Plant Beds of the British Saxonian.

*Taeniaesporites* (Leschik 1955)

Type Species *Lueckisporites* (*Taeniaesporites*) *krausei* (Leschik) Kl.

Generic Diagnosis. Microspores with two bladders. The spore body is divided by six or more stripes.

type species  

Discussion. The *genoholotype*, as figured by Leschik does not conform to the diagnosis concept of *Taeniaesporites*, rather to that of *Lueckisporites*. R. Potonie has already reclassified the form as *L.(T)*
*kraeuseli* (Leschik 1955) Pot. 1958. However, since the inception of
the generic concept in 1955 various forms have been described
according to Leschik's diagnostic concept but not con-generic with
the type species. As the genus *Taeniaesporites* has reverted to a
junior synonym of *Lueckisporites* due to the congenerity of the forms
*L. virkiae* and *L. (T.) kraeuseli*, a new genus is needed to comply
with those forms described as *Taeniaesporites* but not congeneric
with *L. (T.) kraeuseli*. Thus a new genus, *Klausipollenites* with
the type species *Klausipollenites balmei* is proposed for those forms
conforming to the following diagnosis.

*Klausipollenites* gen. nov.

Type Species. *Klausipollenites balmei* sp. nov.

Generic Diagnosis. Bisaccate pollen grains, no Y mark evident. The
bladders may be joined distally but are separated proximally at the
equator. The central body is divided into six or more raised stripes,
by grooves (fissures). These fissures will usually be smaller than
the raised stripes between them. The stripes will be sub-parallel to
each other and parallel to the long direction of the central body.
Ornamentation of both the central body and the bladders infra-reticulate,
-baculate or -granulate.

*Jansonius, Palæontographica, 110B, p.55.* Use now
*Klausipollenites balmei* sp. nov.

Plate 3. Figs. 10,11.

Type locality. C.R.B.D.D.H. No. 1, 1034 ft.

Holotype. Slide T.S. No. 4.

Diagnosis. Bisaccate pollen, central body bearing 6 - 8 stripes.

Both bladder and central body infra-reticulate.

Dimensions. L.B. 26 - 50u mean 41u
B.B. 32 - 50u 44u
L.A. 27 - 50u 42u
B.A. 22 - 33u 28u

Overall length 60 - 75u, mean 70u.
Description. Central body slightly oval in the long direction of the grain. Body infra-granulate. Bladders infra-retticate, mesh units 3u. Bladders laterally disposed often meeting in midpolar positions. Central body is ornamented by grooves running parallel to the long direction of the grain. These grooves are about 1u wide and 1u deep. They are separated by raised stripes, in which the exine is slightly thickened, about 4u wide. There is a tendency for the central stripes to be thicker than those more marginally disposed.

Discussion. This form is confined to the lower part of the Grose Sandstone, occurring in sample 1034 and much less abundantly in sample 1067.

*Klausipollenites leschiki* sp. nov.

Plate C Fig. 12

Type Locality C.R.B.D.D.H. No. 5, 1067 ft.

Holotype. Slide T.S. No. 17.

Diagnosis. Bisaccate pollen, central body exhibiting six sub-parallel stripes.

Dimensions.  
L.B.  42 - 48u mean 44u  
B.B.  54 - 40u  49u  
L.A.  40-54u  48u  72 - 90u, mean 82u.  
B.A.  30 - 36u  32u  

(25 sp.)

Description. Central body occasionally rounded, usually oval in the long direction of the grain. Divided by six stripes, separated by grooves 1 - 2u wide. Exine 1u thick, translucent, infra-retticate, mesh units 2u where visible. Bladders laterally disposed, sometimes meeting equatorially, but seldom overlap the body by more than 12u lateral minimum. Bladders infra-retticate, mesh units 2,5u.
Comparisons. Although similar in appearance to *K. balmei* sp. nov.,
distinction is obtained by consulting the various size ratios.

Discussion. This form comes in higher up the succession (sample
1067) than other forms typical of the lower member of the Grose
Sandstone.

*Infraturma Disacciatrineli* (Leschik) *amend* R.Pot.

*Pityosporites* (Seward 1914) Pot. & Kl. 1954

**Type Species** *Pityosporites antarcticus* Seward 1914

**Generic Diagnosis.** Bisaccate microspore generally without, only
seldom with a Y mark. The bladders are not as in older forms, exactly
equatorially and meridionally disposed, rather as according to Florin
(1944) as for the younger forms it is more and more true that they are
pushed and distended in a distal direction as to form a protective
barrier around an ill defined germinal furrow. Overall shape including
the bladders is oval. Meridional shape is boomerang like with the
distal side of the central body lying in the indentation. The wing
roots converge from the distal to the proximal sides of the narrow
region lying between the bladder wing roots the ill defined germinal
furrow is mostly recognisable only by the greater thinning of the
exine. The bladders are infra-reticulate. In meridional and also
equatorial section the outline of the bladders passes into the central
body without a sharp break. The single bladder has a half moon shape
in meridional section and can be, by minus variation, diminished to
a sickle shape but an expansion due to plus variation cannot cause a
greater than half moon shape. The exoexine of the central body can
be proximally thickened. They seem to be stronger than the remaining
arbietinoid types. (free translation from Pot. & Kr. 1954).

*Pityosporites nigracristatus* (Hennelly) *amend*.

Plate C. Fig. 13, 14, Plate D. Figs. 1 - 3

**Type Locality.** Appin Bore No. 4, 1196'9" - 1197'9".
Diagnosis. Bisaccate pollen with tendencies for wing roots to oxidise.

Bladders infra-reticulate. Germinal furrow usually obvious.

Dimensions.   L.B. 30 - 45u, mean 39u  
B.B. 30 - 45u  38u  Overall length  
L.A. 20 - 42u  32u  45 - 85u, mean 64u  
B.A. 21 - 32u  26u  (100 sp.)

Description. Central body usually circular, exine thin 1u, ornamented infra-reticulate or -granulate. Crests as mentioned by Hennelly (1958) in the original description have not been observed in examination of over fifty specimens. Several specimens show a small 'vestigial' scar. Bladders are laterally disposed, overlapping the central body in the long direction of the grain, by about 15u. The roots of the bladders are often slightly oxidised, causing a darkening of colour, characteristic of the species. The bladders are usually smaller than the central body. A groove, about 9u wide, possibly the germinal furrow is usually present on the distal side. The bladders are ornamented with an infra-reticulum, lumina about 2u, muri less than 1u.

Comparisons. This form bears superficial resemblances to P. pallidus Reissinger, although the latter form is very small. There is also a strong resemblance to P. zapfei Pot. & Kl. 1954, occurring higher in the sequence, but size differences also occur.

Discussion. The occurrence of specimens of this form, in better state of preservation than those of the Appin samples, has necessitated the amendment of this species.

Pityosporites (Jugasporites) nubilus (Leschik) nov. comb.

Plate D Figs. 4, 5.

Type Locality. Zechstein von Neuhof.
Holotype. Leschik 1956, Tab. 21, Fig. 14.

Diagnosis. Bisaccate pollen, central body very darkly coloured. Bladders laterally disposed, slightly distal in attitude, almost of equal area to body or slightly larger.

Dimensions.  
L.B. 34u, mean 40u  
B.B. 34 - 45 u, mean 39u  
L.A. 42 - 50u  
B.A. 30 - 40u  
70 - 79u, mean 74u.  
(18 sp.)

Description. Central body almost circular. Exine opaque, very dark in colour causing difficulty in determination of ornament. Exine of central body thick. Bladders laterally disposed, but may meet at the equator, seldom overlapping laterally. Bladder ornament infrareticulum lumina in excess of 2u. Bladders of this species are quite large in comparison with other species within the genus.

Comparisons. This species is quite distinct from most other types of Pityosporites. Although the bladders are quite distinct from most of the central bodies, a few forms occur in which there is a smooth transition of the bladders into the central bodies, as required by the generic diagnosis.

Discussion. Of the specimens examined, none revealed the presence of a transverse structure on the central body. It is suggested that the structure shown on the central body of the form illustrated by Leschik (1956) is the result of preservation conditions. This form occurs abundantly in the lower member of the Grose Sandstone.

Infrafururma Pinosacciti (Erdtman) Potonie 1960.

Hennelliisporites gen nov.

Type Species. Hennelliisporites reticulatus (Henelly) nov. comb.

Derivatio nominis. After J. Henelly who originally described the
Type species *Pityosporites reticulatus* (Hennelly 1958).

Generic Diagnosis. Bisaccate pollen without proximal laesurae. Central body circular or oval in either the long or short direction of the grain. Bladders laterally disposed but often meet equatorially, isolating the central body and in many cases may completely envelope it. Central body may exhibit a germinal furrow, distally. Ornament of both central body and bladders is infra-reticulate, that of the central body possessing a slightly smaller mesh unit than that of the bladders. Muri are characteristically strongly developed. Bladders usually well developed in the lateral direction, allowing distinction from the more oval forms such as *Alisporites* Daugherty 1941.

*Hennelliisporites reticulatus* nov. comb.

Plate D Figs. 6 - 8

Type Locality. Appin Bore No. 4, 1623' - 1697'9"

Diagnosis. Bisaccate pollen, oval to rounded square in shape. Both central body and bladders infra-reticulate. Distal furrow visible on occasional specimens. Shape of central body variable.

Dimensions. Due to the nature of the ornament and the persistent overlapping of the bladders on the proximal and distal faces, individual measurements are restricted to specimens exhibiting oxidation of the bladder attachments.

Overall length 75 - 128u  Body length 50 - 70u. (30 5p)

Description. The shape of the central body varies from circular to oval, mostly in the long direction of the grain. It is only possible to determine the true shape in those specimens showing oxidation as above. As few specimens are preserved in this fashion it is difficult to determine dimensions due to the almost undifferentiated infra-reticulums of the bladders and the central body. This is further accentuated by the tendency of the bladders to pass into the central
body without any definite demarkation. When the outward lateral
growth of the bladders is retarded, almost circular forms occur, very
similar to some monosaccate types. In such forms it is possible to
determine the ovality of the central body. Those forms showing
delineation of the central body and the bladders exhibit a smaller
infra-reticulum of the central body than that of the bladders.
Bladder reticulation is strongly developed, luména 3 -4u in diameter,
muri 1.5 - 2u in width.

Comparisons. This form is distinguished from H. dulhuntni sp. nov.
mainly on the basis of size, but distinction also occurs in that the
latter form has tendencies towards the development of multisaccate
types.

Discussion. As mentioned by Hennelly 1958 this form is very abundant
in the lower half of the Narrabeen succession. Some forms of this
species are very similar to forms of Ullmannia sp. (as shown by
Zauer (1960) of the uppermost Permian of the Solikamsk area, U.S.S.R.)

Hennelliispórites dulhuntni sp. nov.

Plate D. Figs. 9,10. Plate E. Fig. 1.

Type Locality. C.R.B.D.D.H. No. 5, 1067 ft.

Holotype. Slide T.S. No.15

Diagnosis. Bisaccate pollen with overall oval shape. Shape of the
central body obscured by the polar development of the bladders.
Ornament of both central body and bladders infra-reticulate, coarsely
developed.

Dimensions. Similar ornament to H. reticulatus
Text Sketch 2.

1. Marsupipollenites dispertitus (2)
2. Partitisporites reticulatus
3.
4. Monocolpopollenites irregularis
5. Lueckisporites virkkiae
Overall length 130 - 177u, body length 75 - 120u. (44 sp.)

Description. Due to the nature of the ornament, constant envelopment of the central body by the bladders, the nature of the junction of the bladders and central bodies, almost transitional in some specimens it is difficult to determine the nature of the central body. In well preserved specimens with slight oxidation of the wing roots, an oval form, oval in the lateral direction to the long axis of the grain, is often distinguished. However, it is suggested that this shape is not the overall shape of the central body, but a tendency for thinner parts of the exine to oxidise. The bladders may overlap at the equators, often to a depth of 15u, isolating the central body in monosaccate form. Ornament in both central body and bladders consists of an infra-reticulum, that of the central body being slightly smaller than that of the bladders, when distinguishable.

Comparisons. This form is distinguished from H. reticulatus by size differences. It also has resemblances to forms of Ullmannia of the Russian Permian.

Discussion. This form is very distinctive due to its large size. It occurs in the upper part of the lower member of the Grose Sandstone.

Subturma Circumpolles Klaus

Infrraturma Singulipollenites Klaus.

Partitisporites Leschik 1955

Type Species Partitisporites novimundanus

Generic Diagnosis. The spore consists of two parts that lie in a plane. There is not an overall triangular shape as in Duplicisporetes, rather an oval shape. (free translation from Leschik 1955)
Partitisporites reticulatus sp. nov.

Plate E Figs. 2,3. Text Sketch 2, Fig. 3

Type Locality. C.D.B.D.D.H. No. 1, 622 ft.

Holotype. Slide T.S. No. 9

Diagnosis. Circular to oval sporomorph with a flange like thickening of the exine interrupting the outline over about half the equator. Weakly trilete to the periphery. Ornament infra-reticulate.

Dimensions. Maximum diameter. 30 - 45u, mean 36u. (10 sp)

Description. Main body of the sporomorph usually circular, but the amb is irregular due to the presence of a projecting flange of thickened exine on one side of the spore body. Exine about 1.5u thick on spore body, smooth with infra-reticulum, usually light brown in colour. Laesurae extend to the periphery of the body and into the thickened flange. The flange varies in shape from crescentic with sharp ends, in which case there is little disruption of the amb, to sub-crescentic with flat ends which cause strong interruption of the amb. Radial width of the flange varies from 6 - 10u.

Comparisons. This form strongly resembles the type species, as figured by Leschik (1955) as Partitisporites novimundanus (No. 3) but differs from it in that the other forms illustrated as P. novimundanus do not occur in any of the Burrarorang samples. There is also a distinction in the ornament. It differs quite strongly from forms figured by Klaus (1960) also in shape. (Abb.12,p.160)

Discussion. This form appears in the upper member of the Grose Sandstone and the Burrallow Formation.

Turma Monocolpates Iverson & Troels Smith.
Subturmata Monoptyches (Naumova) Potonie.

Monocolpopollenites. Thomson & Pflug.

Type Species Monocolpopollenites tranquillus (R.Pot) Th. & Pflug.

Generic Diagnosis. A colpus, this being parietal, i.e. running on
the proximally broad side in the symmetry plane, lying asymmetrically
to the equator. Amb not bean shaped. Colpus frequently has
bordering swellings.

Monocolpopollenites irregularis sp. nov.

Plate E Figs. 4,5, Text Sketch 2 Fig. 4

Type Locality C.R.D.D.H. No. 1, 722 ft.

Holotype T.S. Slide No. 8

Diagnosis. Lense shaped sporomorph, divided into two asymmetrical
parts by a colpus. Size extremely variable as is the ornament.

Dimensions Long axis 29 - 77u, short axis 20 - 54u. (40 sp.)

Description. Amb strongly biconvex lense shaped. Body divided
into two asymmetrical parts by a colpus running almost sub-parallel
to the long axis of the grain. Position of the colpus varies
between specimens from median to almost equatorial positions.
The colpus is defined on one side by a distinct thickening and
darkening of the exine, the convex side of the colpus if it curves.
The colpus often exhibits a central 'knick' directed towards the
thickened side of the grain. Exine thick, 2 - 3u, ornamented
usually by grana, varying from very fine up to 1.5u in basal
diameter.

Comparisons. This form is extremely common throughout the entire
sequence, and thus could possibly extend into the higher Triassic
where Leschik (1955) has described a similar but slightly smaller
form as M. levis. Leschik.

Discussion. Due to its wide range this form is of little value.

Turma Jugates (Erdtman) Potonie 1960
Subturma Tetradites Cookson 1947

Quadrisporites (Hennelly 1958)

Type Species. Quadrisporites horridus (Hennelly 1958) amend.

Generic Diagnosis. The name Quadrisporites is proposed as a form genus for persistant tetragonal or hexagonal tetrads of microspores of vascular plant origin but otherwise of unknown affinities, and whose dehiscence mechanism is either alete or so obscured as to be indeterminate.

Quadrisporites horridus (Hennelly 1958) amend

Type Locality Appin Bore No. 4, 1696'10" - 1697'5"

Diagnosis. Tetragonal or rhombohedral tetrads of sporomorphs, approximately spherical and of similar dimensions. Ornament echinate, superimposed on an infra-ricetulum.

Dimensions. Measurements represent dimensions of the maximum length of one of the sides of the tetrad, in the case of the tetragonal tetrads, and maximum diameter through the centre of the tetrad in the case of rhombohedral tetrads.

21 - 49u, maxima occurring in the size frequency graph at 29u and 34u. (100 spp)

Description. Amb almost square but varies with the type of tetrad. Exine about 1.5u thick and opaque when the ornament is preserved, translucent if the ornament is lost. Ornament consists of spines up to three microns in length and 2u in basal diameter, which may be tapered or conical. There is however, a tendency for the ornament to be lost, revealing the underlying infra-ricetulation. It is possible for the specimens to have lost their entire spine covering, becoming nude.
Discussion. This form is confined to the basal few feet of the succession. It has been reported from sediments containing typical coal measure microfloras in the upper Bowen.

Incertae Sedis.

Plate E Figs 10 - 12

Diagnosis. Large circular to rounded triangular 'sporomorphs' without any apparent germinal mechanism, fine granulate external ornament and an inner reticulum.

Dimensions Overall Diameter. 70 - 150u, mean 104u. (??sp?)

Description. Shape varies from rounded triangular, through oval to circular. Exine thick, up to 4u, opaque. As the exine is almost invariably torn it is possible to obtain internal views, showing an internal reticulum. Outer ornament is granulate, grana being slightly smaller than 1u in basal diameter. The grana are covered by an outer layer, very thin, which becomes detached, forming filamentous processes to the outer margin. The body is invariably cracked and torn. There is also the tendency to the development of concentric folding, often lying on the equator.

Discussion. Occurs in one sample only, 1170. Distinguishable from other plant material due to brown staining with safranin.
3.1. Stratigraphic Introduction.

The samples examined in this study were obtained from core, drilled from sediments of the Narrabeen Group in the vicinity of the junction of the Cox, Warragamba and Wollondilly Rivers. The stratigraphy of the Narrabeen Group and its correlations throughout the southern part of the Sydney Basin are discussed in earlier works (see Helby 1961).

The area through which the lower part of the Wollondilly River flows represents the Burragarang as referred to in this thesis. Continuous sedimentation took place in the lower two thirds of the Narrabeen Group of the Burragarang. The section is thus complete through the lower and middle Narrabeen, the upper Narrabeen being only partially represented, the uppermost formations having undergone erosion prior to sedimentation and contemporaneous with sedimentation of the Hawkesbury Formation.

The Narrabeen Group, as it occurs in the Burragarang is comprised of three formations. These formations are very similar in lithology to the Narrabeen occurrences of the Grose River area, as described by Crook (1956), consequently the nomenclature proposed by Crook has been accepted for the Burragarang Narrabeen sediments.

3.1.1 Caley Formation.

"The Caley Formation immediately overlies the Nattai Seam of the Lithgow Coal Measures, and is delineated at the top by the occurrence of a series of massive sandstones, representing the lower member of the Grose Sandstone." (Helby 1961)
The formation consists of sandstones, grits, conglomerates and shales. Overall thickness varies from 120 ft to 185 ft., thickness variation possibly due to the increased shale content of the sections of lower thickness. It has been possible to divide the formation into five members, portions of which are remarkably constant.

The lowermost member, often referred to as the "passage beds" (David), consists of interbanded sandstones and shales, extending from 20 ft. to 50 ft. above the Nattai Seam. There is no doubt in my mind that sedimentation was continuous, no wide scale erosion of the top of the Nattai Seam having taken place before deposition of this member. Evidence of this is seen in examination of the "Ash Profiles of the Nattai Seam" Helby (1961), which show gradual increase in the ash content towards the top of the seam in the upper six inches, while one profile which is suspected of exhibiting erosion, shows no increase at all.

The second lowest member is a sandstone unit, occasionally with small interbedded components, varying in thickness from 15 ft. to 45 ft.. The middle member of the formation consists of a major shale horizon, showing lateral variation in thickness from 20 to 50 ft.. Increases in thickness are mainly due to the presence of small interbedded sandstone units. The fourth member is a predominantly sandy unit with conglomeratic phases, small shale beds occurring in the areas of thickest accumulation.

The uppermost member is a far more composite and irregular unit than any of those underlying it. It consists essentially of interbedded shales and sandstones, sandstones with conglomeratic phases and occasional claystones. Overall thickness of this member
Text Fig. 6.

Hawkesbury Sandstone

Burralow Formation


Grose Sandstone
upper member


Grose Sandstone
lower member

Caley Formation

CRB DDH No. 1  CRB DDH No. 3  CRB DDH No. 5

NATTAI SEAM
fluctuates in the vicinity of 45 ft.

3.1.2. Grose Sandstone.

"The Grose Sandstone overlies and delineates the Caley Formation. It is itself delineated at the top by the occurrence of the Burrabalow Formation" Helby (1961)

The formation consists of a succession of massive grits and sandstones. The formation is represented in outcrop by the characteristic vertical cliffs of the Burragarang valley systems. Thickness of the formation varies from 475 to 600 ft. of sediments. One of the main characteristics of the formation is the development of green shales and claystones. Attempts to subdivide the Grose Sandstone have led to the delineation of two members.

The lowest member is easily recognised in that it represents the first series of massive sandstones, of any thickness, throughout the entire Narrabeen succession. Shale bands occur within the member, seldom attaining far greater proportions of the total section than two percent. The thickness of the member is reasonably constant in an east-west direction but varies from 175 ft. to 275 ft. in the north-south direction.

The upper member of the formation is divided into three sub-members. This member represents a change in the overall stability of the sediments in that there is a greater tendency for the accumulation of interbedded units rather than massive units of shale or sandstone.

The lowermost submember, is delineated at the base by the occurrence of a thick shale horizon. This horizon is represented
by green of grey shales, well laminated, varying laterally with green-grey siltstones with occasional red dy phases. This submember is typified by the finely interbedded units, consisting of green shales and fine green sandstones. Overall thickness of the submember varies from 60 ft. to 150 ft., dependent on the development of the overlying submember.

The middle submember of the upper member of the Grose Sandstone is very similar to both the overlying and underlying submembers. Its delineation is achieved by the identification of brown shale lenses, showing sub-plastic deformation, popularly known as "shale breccias". These "shale breccias" possibly result from peri-contemporaneous erosion of shale or claystone deposits, yet unconsolidated at the time of redistribution. Such shales do occur further to the south and east in the form of the Stanwell Park Claystone.

The uppermost submember, as previously mentioned is very similar to the lowest submember. It differs in that it contains massive sandstones up to 70 ft. thick. It still retains the interbedded units of fine green sandstone and shale so characteristic of the upper member of the formation. Dependent on the development of the underlying submember thickness of the formation varies from 100 ft. to 200 ft.

3.1.3 Burralow Formation.

"The Burralow Formation is delineated at its base by the occurrence of a massive claystone. The nature of this claystone varies from locality to locality, essentially consisting of interbanded green and red
clays and shales. The top of the formation is delineated by the base of the Hawkesbury Sandstone. Helby (1961)

Although occurring throughout the Burragorang area, the Burralow Formation has undergone large scale erosion of its upper portions causing thickness variation from 10 ft. to 150 ft. Although difficult to subdivide, the formation exhibits three characteristic units, comprising a lower shale or claystone with marked lateral phase variation and variations in thickness. It is this horizon which delineates the Burralow Formation from the Grose Sandstone.

Above the lower claystone horizon, sections may exhibit a thick sandstone unit, often varying laterally with interbedded units. This unit is overlain by a further major claystone horizon. The lithologies of this upper horizon are somewhat more consistent than those of the lower claystone horizon, being essentially red with minor lateral variation to green phases. There are seldom any interceding sediments between this unit and the overlying Hawkesbury Formation.

3.2 Stratigraphic Palynology.

The sporomorph occurrences of the Narrabeen Group of the Burragorang area fall into three distinct groups or microfloras. These microfloras, although distinct in combinations of types comprising them, are subject to a certain amount of overlapping, possibly representing the period of the interval of change between the optimum conditions for either macroflora.

The lowermost microflora, No. 1, has tentatively been divided into two submicrofloras, No. 1a and No. 1b. The lowermost submicroflora No. 1a has previously been described in detail by Hennelly
<table>
<thead>
<tr>
<th>Species</th>
<th>Trans 1170</th>
<th>1034</th>
<th>1067</th>
<th>722</th>
<th>700</th>
<th>622</th>
<th>456</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apiculatisporites bulliensis</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 1a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 2a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acanthotriletes hennelli sp. nov.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accinctisporites sp.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Anguisporites sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calamospora grossi sp. nov.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concavisporites sp. No. 1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Cyathidites australis nimalis Balme</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyclogranispores plicatus sp. nov.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cirritiradiates sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cristatisporites sp.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crustaesporites sp.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Densosporites sp.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discisporites cooksoni sp. nov.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distalanulisporites triangulatus sp. nov.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Duplicisporites sp.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxon</td>
<td>Trans 1170</td>
<td>1034</td>
<td>1067</td>
<td>722</td>
<td>700</td>
<td>622</td>
<td>456</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Endosporites sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entylissia sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granulatisporites microgranulatus sp. nov.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trisinus Balme &amp; Hennelly</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hennelliisporites dulhunii sp. nov.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>reticulatus (Hennelly) nov. comb</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Klausipollenites antiquus (Leschik) projected</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>balmei sp. nov.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>leschiki sp. nov.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krauseisporites sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laevigatosporites sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leiotriletes cf. gulaferus</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lophotriletes sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labiisporites cf. granulatus Leschik</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lueckisporites amplus Balme &amp; Hennelly</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>cancellatus B. &amp; H.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>multistriatus B. &amp; H.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>novialensis (Leschik) amend</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>virkiiae Potonie &amp; Klaus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limitisporites cf. latus Leschik</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>cf. rectus Leschik</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marsupipollenites dispersitus sp. nov.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Plant Name</td>
<td>Trans 1170</td>
<td>1034</td>
<td>1067</td>
<td>722</td>
<td>700</td>
<td>622</td>
<td>456</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Marsupipollenites sinuosus Balme &amp; Hennelly triradiatus B. &amp; H.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Microreticulatisporites bendensis sp. nov.</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Monocolpophollenites irregularis sp. nov.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monosulcites sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuskoisporites radiatus Hennelly</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. klausj Grebe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Paracirculina sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partitispores reticulatus sp. nov.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pityosporites nigracristatus (Hennelly) amend nubilus (Leschik) nov. comb.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. delasaucei Potonie &amp; Klaus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. schauberi P. &amp; Kl.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. zapfei P. &amp; Kl.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Punctatisporites narrabeenensis sp. nov.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Punctatisporites plicatus sp. nov.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Punctatasporites sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadrisporites horridus (Hennelly) amend</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raistrickia sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retusotritetes rimalis sp. nov.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thompsonisporites sp. No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sp. No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuberculatisporites sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trizonaesporites grandis (Leschik) amend.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>circulcaris sp. nov.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>multiformis sp. nov.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxon</td>
<td>Trans</td>
<td>1170</td>
<td>1034</td>
<td>1067</td>
<td>722</td>
<td>700</td>
<td>622</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Triquitrites sp. No. 1</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verrucosisporites taylori sp. nov.</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vittatina cf. cincinnati (Lub.) Samoilovich</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zonalisporites sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incertae sedis No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(1958). This microflora, No. 1a, extends from the top of the Nattai Seam, or Bulli Seam as described by Hennelly, to about six feet above the Nattai Seam. In the Burratorang area this zone is represented characteristically by such forms as *Apiculatisporis bulliensis* (Henn.), *Quadrisporites horridus* (Henn.), *Punctatisporites plicatus* sp. nov., *Pityosporites nigracristatus* (Henn.), and *Acanthotriletes hennellii* sp. nov.. This assemblage differs from that of the Appin district by the absence of *Cirratiradiates fibulatus* Henn. and *Nuskoisporites radiatus* Henn., and the prominence of *P. plicatus* sp. nov. and *A. hennellii* sp. nov. which do not occur in the Appin samples. This difference is possibly explained by the tendency of Narrabeen plants to occur in great profusion as isolated and distinct groups. (Burgess 1935)

The upper part in the lower microflora, submicroflora No. 1b, extends from an arbitrarily determined top of the lower submicroflora, to the top of the Caley Formation. It is characterised throughout this zone by the occurrence of *Hennelliisporites reticulatus* nov. comb., occasionally accompanied by *Pityosporites nigracristatus* (Henn.) fragmented plant tissue and megaspores. The lower portion of this upper submicroflora was examined at length by Hennelly, results being excellently illustrated in his Palynological Summary (P.365). There is great difficulty in examining this zone due to the poor state of preservation of the microfossils and the constant interception of barren zones. Towards the top of the Caley Formation there is a distinct tendency towards accumulation of a new microflora, possibly transitional to microflora No. 2.
The second microflora, No. 2, occupies the section covering the lower member of the Grose Sandstone. It is apparent by the sharp but transitional delineation of this microflora with that of the submicroflora below it, that the conditions prevailing during the sedimentation of the massive sandstones of this member, were optimum for development of the macroflora associated with microflora No. 2.

The microflora, No. 2, is characterised by the occurrence of *Hennelliisporites reticulatus* (Henn.) nov. comb., *H. dulhuntii* sp. nov., *Trizonaspores grandis* (Leschik), *T. circularis* sp. nov., *T. multiformis* sp. nov., *Klausipollenites balmei* sp. nov., *K. leschiki* sp. nov., *Pityosporites zapfei* Pot. & Kl., *P. schauberghi* Pot. & Kl., *Lueckisporites noviaulensis* (Leschik) nov. comb. and forms similar to *L. virkkiae* Pot. & Kl..

The uppermost microflora of the Burrarorang Narrabeen occurrences, No. 3, is distinct from either of the underlying microfloras. As previously mentioned there is a sharp division of microfloras No. 2 and No. 3, at the boundary of the members within the Grose Sandstone. There is however, a short transition zone as evidenced by sample 722. Microflora No. 3 is characterised by diminishing numbers of striate pollen and the complete disappearance of the large monosaccate and bisaccate forms.

The microflora, No. 3, is also characterised by the rapid expansion of such forms as *Discisporites cooksoni* sp. nov., *Distalarulispores triangulatus* sp. nov., *Retusotriletes rimalis* sp. nov., etc. This sudden dominance of the bladderless forms is a striking contrast to the situation in the lower parts of the Grose Sandstone and the
Caley Formation. It is interesting to note that this complete change in the trend of the microflora is accompanied by a change in type and nature of lithology. Although this change is not immediately apparent in the Burragorang area, lithological correlation to the south reveals the presence of the Stanwell Park Claystone.

This upper microflora, No. 3, extends from the base of the upper member of the Grose Sandstone to the top of the Burralow Formation, as it is represented in the Burragorang. Due to this erosion it was not possible to trace the microfloras upward vertical extent. Only preparations from the upper part of the Hawkesbury Sandstone have been examined, and as these represent a completely different microflora, the upper limit of microflora No. 3 remains undetermined.

3.3 Age of the Narrabeen Group as implied by the Microfloras.

The lowermost microflora of the Narrabeen group is particularly interesting in that the lower submicroflora, No. 1a, retains elements of the microflora of the upper coal measures of eastern Australia. Such forms as Lueckisporites amplus, L. limpidus, L. cancellatus Balme & Hennelly, Granulatisporites trisinus B. & H., Marsupipollenites triradiatus B. & H. etc., although not occurring abundantly, are prominent. The possibility of reworking has not been overlooked but has been discarded due to the excellent preservation. It is interesting to note that one of the main components of the microflora, No. 1a, Quadrisporites horridus (Henn.) has been encountered in bores "below levels containing M. sinuosus B. & H. and Tholosporites parvitholus" (Dr. Evans, pers.
comm.). Dr. Evans has also encountered *Q. horridus* (Henn.) and *Apiculatisporites*, c.f. *bulliensis* (Henn.) at the top of a succession containing a typical upper coal measures microflora in the upper Bowen of Queensland.

The occurrence of the *Thinnfeldia* flora within the lowermost part of the Narrabeen Group has been the criteria upon which the hitherto Triassic age has been based. It is however, noted that Whitehouse (1933) reports a mixing of the *Thinnfeldia* and *Glossopteris* floras in the Jericho area of Queensland, concluding that the age of the beds is Permian. Further of the inconsistency of the *Thinnfeldia* Triassic datings is evidenced in examinations of the Hermit Shale (Permian) which White (1929) reported the presence of remains of *Supaia*, acknowledged by Walkom and others as very closely related and possibly synonynous with well known Australian *Thinnfeldia* forms. Further macrofloral correlation with microflora No. 1a is shown by Dun (1910, 1911) and Walkom (1925), who have described plant remains from immediately above the uppermost seam in the central and southern parts of the Sydney Basin, concluding that "this collection of species is obviously more closely related to the Permian flora than to the typical Mesozoic flora.............."(Walkom, 1925).

It is therefore suggested that the section, represented by submicroflora No. 1a is Permian in age, representing continuous sedimentation from the underlying coal measures.

The upper part of the microflora, submicroflora No. 1b, is characterised by the voluminous presence of *Hennelliisporites reticulatus* nov. comb.. As there is no way of ageing this microflora
without a complete assemblage ageing is based on its stratigraphic position, between submicroflora la and microflora 2. There is however, a strong resemblance between the forms of *Ullumannia* occurring in the upper Permian Solikamsk microflora and *H. reticulatus*.

Of the forms occurring in the assemblages making up the middle, No. 2, microflora, few are represented in known Australian upper Permian or Lower Triassic sediments. However, there is some resemblance between the forms occurring in this microflora, No. 2, and the assemblages of parts of the European Zechstein. The occurrence of such forms as *Trizonaesporites grandis* (Leschik) and the alpine suite of *Pityosporites* types, *P. zapfei*, *P. schauberghi* and *P. c.f. delasaucei* Pot. & Kl., with *Lueckisporites* (*Taeniaesporites*) *noviaulensis* (Leschik), with some forms reminiscent of forms of *L. virkkiae* Pot. & Kl. from the Hilton Plant Beds of the British Saxonian.

By comparison of this microflora, No. 2, with those of the Kokatea-Blina sections of Western Australia and the Paddy and Kahntah Shales of the Canadian Scythian it is apparent (by the absence of the cingulate types and the dominance of the striate forms, in the Narrabeen occurrences) that the N.S.W. material is older than the hitherto accepted basal occurrences of Scythian sediments, which have accessory dating due to their marine nature. However, Dr. Balme (pers. comm.) has informed me that established Permian material of the Liveringa Formation is older than that of the Narrabeen occurrences. This would therefore leave a gap in the overall section equivalent to the lower part of the Tartarian. Photo correlation of the microfloras of the Tartarian and the lower member of the Grose
Sandstone shows moderate similarity.

The age of the middle microflora, No. 2, is therefore considered to be uppermost Permian in age with a strong possibility of extension into the very basal Scythian.

The uppermost microflora of the Narrabeen Group, No. 3, is distinct in that it contains the first definite "Triassic" forms to appear, *Distalanulisporites triangulatus* sp. nov., *Discisporites cooksoni* sp. nov., etc. representing genera, most of which have only been described from Triassic sediments. Overall there is a moderate comparison between the marine Scythian material of Western Australia and Canada with the samples representing No. 3 microflora of the Burragorang Narrabeen occurrences. It is therefore suggested that the age of this microflora, No. 3, is definitely Scythian.
SUMMARY and CONCLUSIONS

1. From the beginning of the study and throughout, it has been apparent that an efficient, up to date, morphologically inclined text book of introductory palynology is needed. Section 1 included a very elementary introduction to the botany of both spores and pollen, a comprehensive glossary of morphological terminology and very dated methods of treatment of material.

2. Within the area studied, palynological division of the Narrabeen Group, on the basis of the occurrence of three new microfloras, is possible.

3. It became apparent during the latter part of the study that the palynological divisions of the Narrabeen of the Burrarorang and possibly of the southern part of the Sydney Basin, coincide quite markedly with lithological divisions.

4. Descriptive systematic studies of the microfloras revealed the presence of at least 120 recognisable species of plant microfossils, of which thirty were represented in sufficient quantity (at least ten well preserved specimens) to allow full systematic description. It is thus immediately apparent that the remaining forms must be studied to determine their use as indicators, assess their correlation value, and record their presence formally.

5. Age relationships of the three microfloras with each other and the underlying Permian coal measures were examined, with revolutionary results. The apparent continuation of the Permian into the
hitherto Triassic Narrabeen Group has been substantiated, although further detailed macrofloral and microfloral investigations should be undertaken to substantiate these findings on a more detailed scale.
ACKNOWLEDGMENTS

I wish to extend my gratitude to the many people who helped in many ways throughout the course of this study. In particular I must thank my advisor, Dr. Dulhunty and Mr. J. Hennelly for initiating and sustaining my interest through the preliminary stages of this study, and for help and encouragement throughout. I am also obliged to Drs. Balme, Evans and Jansonius for their correspondence and constant help and advice. To my colleagues, particularly Mr. A. Wright, Mr. J. Mahoney and Mr. D. Strusz, I extend sincere thanks for helpful discussion and patience. I thank Miss J. Forsyth and Mr. Woodward-Smith for help in illustrating this thesis. I also extend thanks to the Vice Chancellor of Sydney University, Professor S.H. Roberts for permission to attend German courses, without which it is possible that this study may not have been finished.
BIBLIOGRAPHY


1956. Pt. 3. Ibid. 100, pp. 66-121.


Zauer, V.V. 1960, Late Permian Floras from Solikamsk. Special translation for Imperial Company from Paleontolog, Journal, 1960, No. 4.
<table>
<thead>
<tr>
<th>Fig.</th>
<th>Sporomorph</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2,3</td>
<td><em>Retusotriletes rimalis</em> sp. nov.</td>
<td>15</td>
</tr>
<tr>
<td>4,5</td>
<td><em>Punctatusporites narrabeenensis</em> sp. nov.</td>
<td>16</td>
</tr>
<tr>
<td>6,7,8</td>
<td><em>Punctatusporites plicatus</em> sp. nov.</td>
<td>17</td>
</tr>
<tr>
<td>9,10</td>
<td><em>Calamospora grosei</em> sp. nov.</td>
<td>17</td>
</tr>
<tr>
<td>11</td>
<td><em>Cyclogranisporites plicatus</em> sp. nov.</td>
<td>19</td>
</tr>
<tr>
<td>12</td>
<td><em>Cyclogranisporites tuberculata</em> sp. nov.</td>
<td>20</td>
</tr>
<tr>
<td>13</td>
<td><em>Acanthotriletes hennelli</em> sp. nov.</td>
<td>22</td>
</tr>
<tr>
<td>14,15</td>
<td><em>Apiculatisporis bulliensis</em> (Hennelly) <em>amend.</em></td>
<td>21</td>
</tr>
<tr>
<td>16,17,18,19</td>
<td><em>Verrucosisporites taylori</em> sp. nov.</td>
<td>23</td>
</tr>
<tr>
<td>Fig.</td>
<td>Sporomorph</td>
<td>Page</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------</td>
<td>------</td>
</tr>
<tr>
<td>1,2</td>
<td>Microreticulatisporites bendensis sp. nov.</td>
<td>24</td>
</tr>
<tr>
<td>3,4</td>
<td>Distalanulisporites triangulatus sp. nov.</td>
<td>26</td>
</tr>
<tr>
<td>5,6,7,8</td>
<td>Discisporites cooksoni sp. nov.</td>
<td>27</td>
</tr>
<tr>
<td>9.</td>
<td>Marsupipollenites dispersitus sp. nov.</td>
<td>28</td>
</tr>
<tr>
<td>10,11,12</td>
<td>Trizonaesporites grandis (Leschik) amend.</td>
<td>29</td>
</tr>
<tr>
<td>Fig.</td>
<td>Sporomorph</td>
<td>Page</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------</td>
<td>------</td>
</tr>
<tr>
<td>1,2</td>
<td><em>Trizonesporites circularis</em> sp. nov.</td>
<td>31</td>
</tr>
<tr>
<td>3,4,5</td>
<td><em>Trizonaesporites multiformis</em> sp. nov.</td>
<td>32</td>
</tr>
<tr>
<td>6,7</td>
<td><em>Lueckisporites noviaulensis</em> (Leschik) nov. comb.</td>
<td>33</td>
</tr>
<tr>
<td>8,9</td>
<td><em>Lueckisporites virkkiæ</em> Pot. &amp; Kl.</td>
<td>34</td>
</tr>
<tr>
<td>10,11</td>
<td><em>Klausipollenites balmei</em> sp. nov.</td>
<td>35</td>
</tr>
<tr>
<td>12.</td>
<td><em>Klausipollenites leschiki</em> sp. nov.</td>
<td>36</td>
</tr>
<tr>
<td>13,14</td>
<td><em>Pityosporites nigracristatus</em> (Hennelly) <em>amend.</em></td>
<td>37</td>
</tr>
<tr>
<td>Fig.</td>
<td>Sporomorph (×430)</td>
<td>Page</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>1,2,3</td>
<td><em>Pityosporites nigracristatus</em> (Hennelly) amend.</td>
<td>37</td>
</tr>
<tr>
<td>4,5</td>
<td><em>Pityosporites nubilus</em> (Leschik) nov. comb.</td>
<td>38</td>
</tr>
<tr>
<td>6,7,8</td>
<td><em>Hennelliisporites reticulatus</em> (Hennelly) nov. comb.</td>
<td>39</td>
</tr>
<tr>
<td>9,10</td>
<td><em>Hennelliisporites dulhuntri</em> sp. nov.</td>
<td>41</td>
</tr>
<tr>
<td>Fig.</td>
<td>Sporomorph (x\text{430})</td>
<td>Page</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>Hennelliisporites dulhunii sp. nov.</td>
<td>41</td>
</tr>
<tr>
<td>2,3</td>
<td>Partitisporites reticulatus sp. nov.</td>
<td>43</td>
</tr>
<tr>
<td>4,5</td>
<td>Monocolpopollenites irregularis sp. nov.</td>
<td>44</td>
</tr>
<tr>
<td>6,7,8,9</td>
<td>Quadrissporites horridus (Hennelly) amend.</td>
<td>45</td>
</tr>
<tr>
<td>10,11,12</td>
<td>Incertae Sedis</td>
<td>46</td>
</tr>
<tr>
<td>13.</td>
<td>c.f. Nuskoisporites klausi Grebe</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Lueckisporites sp.</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Lueckisporites cancellatus B. &amp; H.</td>
<td></td>
</tr>
</tbody>
</table>