THE STRATIGRAPHY OF A LATE PALAEOZOIC BOREHOLE SECTION AT DOUGLAS RIVER, EASTERN TASMANIA: A SYNTHESIS OF MARINE MACRO-INVERTEBRATE AND PALYNOLOGICAL DATA

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(with one table, four text-figures and three plates)

ABSTRACT

CALVER, C.R., CLARKE, M.J. and TRUSWELL, E.M., 1984 (31 viii): The stratigraphy of a Late Palaeozoic borehole section at Douglas River, eastern Tasmania: a synthesis of marine macro-invertebrate and palynological data. *Pap. Proc. R. Soc. Tasm.*, 118: 137-161, pls 1-3. https://doi.org/10.26749/rstpp.118.137 ISSN 0080-4703. Department of Mines, Rosny Park, Tasmania and Bureau of Mineral Resources, Canberra, A.C.T.

A section 236.8 m in thickness of Late Palaeozoic (Late Carboniferous-Permian) rocks of the Lower Parmeener Super-Group was encountered in a borehole at Douglas River, eastern Tasmania. Lithological, marine macro-invertebrate and palynological data are documented and collated. The section displays many similarities with sequences elsewhere in eastern and northeastern Tasmania, but is unusual in the development of rocks (including *Tasmanites* shale) as old as Early Tamarian. This occurrence may indicate a narrow, but significant east-west breaching of the land barrier which persisted throughout the Tamarian over most of eastern and northeastern Tasmania. Acritarch swarms coeval with sedimentation occur at intervals, whereas other acritarchs may be derived from earlier Palaeozoic rocks. The Tasmanian Late Permian palynofloras lack diversity and resemble those from the Transantarctic Mountains, Antarctica, rather than those from elsewhere in eastern Australia.

INTRODUCTION

In 1978 a fully cored diamond borehole (NQ$_3$ diameter 45 mm) was drilled at Douglas River (fig. 1) as part of a programme to provide control for the interpretation of a gravity survey related to coal exploration in northeastern Tasmania (Leaman & Richardson 1981). A brief (and somewhat inaccurate) summary log is given therein (Appendix 3, p.72, Hole 045/732). Recently, as an extension of studies on Late Palaeozoic sequences in the adjacent St Marys Quadrangle (Turner, Calver, Castleden & Baillie, in press) and Maria Island (Clarke & Baillie 1981, 1984), Calver completed a detailed lithological log of the hole and recognised the hitherto unknown development of Early Tamarian rocks (including *Tasmanites* shale) in northeastern Tasmania. Clarke then became involved with the marine macro-invertebrate faunas, and samples for palynological analysis were forwarded to E.M. Truswell. The various sections and responsibilities in this communication are allocated along similar lines. Authors are listed alphabetically.

LITHOSTRATIGRAPHY [C.R.C.]

The Douglas River (or Bicheno No.10) borehole was collared in Triassic coal measures and penetrated a continuous and almost complete section of the Lower Parmeener Super-Group before entering a folded and cleaved Siluro-Devonian quartzwacke turbidite sequence of the Mathinna Beds at 333.80 m. A summary graphic log is given (fig. 2). Formal stratigraphic nomenclature is not used for the various flat-lying lithological units; instead the inform-al terms Lower Marine Sequence, Lower Freshwater Sequence and Upper Marine Sequence are employed.

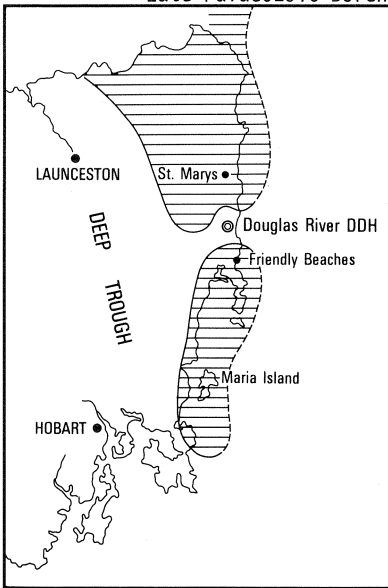## Late Palaeozoic Borehole Section at Douglas River, Tasmania

FIG. 1 - Location map, Douglas River
borehole, with inferred Early
Tamarian palaeogeography. Land
areas are horizontally rules.

FIG. 2 - Graphic log, Douglas River borehole.

Lower Marine Sequence (51.8 m thick)

The Lower Marine Sequence rests
with abrupt unconformity on folded and
cleaved Siluro-Devonian quartzwacke
turbidite Mathinna Beds. The basal
few metres consist of arkosic conglom-
erate, but for the most part, the
Lower Marine Sequence consists of poorly-sorted, dark grey and black mudstone with sporadic
sandy and granule horizons. Lonestones are present together with rare plant fragments and
forams. *Tasmanites* shale occurs in two seams between 320 and 321.50 m. The uppermost four
metres of the Lower Marine Sequence is richly fossiliferous with well-preserved bryozoans,
brachiopods and molluscans.

Lower Freshwater Sequence (56.0 m thick)

The Lower Freshwater Sequence consists of five more or less distinct units. At the
base, pebbly quartz sandstone is followed by a similar thickness of sandy, carbonaceous
mudstone. Then follow three subequal units of coarse-grained, cross-bedded quartz sand-
stone; fine-grained quartz sandstone with minor, thin, carbonaceous mudstone, thin coals
and coal streaks; and bioturbated fine-grained quartz sandstone with rare plant fragments.
The overall thickness of 56 m is similar to that of comparable sections in the St Marys
Quadrangle, but considerably greater than that of the Boullanger Formation on Maria Island
(Clarke & Baillie 1983), and freshwater sequences encountered in recent boreholes in the
midlands of Tasmania at The Quoin, Ross, Tunbridge and Bothwell.

Upper Marine Sequence (129.0 m thick)

The Upper Marine Sequence consists of three distinct units. At the base medium- to
thick-bedded, pale grey bioclastic limestone is interbedded with subordinate mudstone,
siltstone and sandstone. The unit is 78 m thick and lonestones occur throughout. Fossils
are abundant. Then follows 10 m of poorly-sorted, pebbly and sparsely fossiliferous glau-
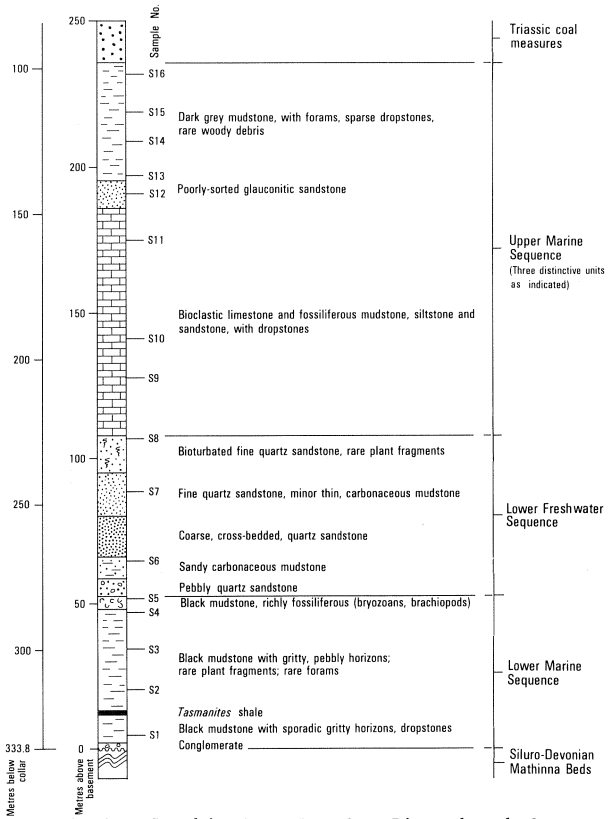
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conitic sandstone. The uppermost unit consists of 41 m of dark grey, poorly-sorted mud-stone with dispersed granules and sparse lonestones, forams in some abundance at certain horizons, and rare woody debris. The base of the overlying Triassic coal measures sequence is abrupt and disconformable on a regional scale. The Upper Marine Sequence is similar lithologically to comparable sections in the St Marys Quadrangle and elsewhere in northeastern Tasmania, Friendly Beaches and Maria Island.

MARINE MACRO-INVERTEBRATE PALAEONTOLOGY [M.J.C.]

The study of marine macro-invertebrate fossils in small diameter drill core presents certain difficulties. Whereas organisms such as stenoporid bryozoans, and both rugosan and tabulate corals which require thin section preparation, can be reliably identified, larger molluscans and spiriferid and productid brachiopods can be rarely identified with confidence beyond the genus level. In limestone in particular they are not readily sep-arated from the matrix, or the shell exfoliates leaving neither detailed exterior nor interior moulds. Acid cannot be used to produce moulds for subsequent casting. Further-more, the limited core intersections usually preclude the determination of detailed gross morphology and other critical diagnostic characters. Nevertheless, the overall lithologic-al sequence in the Douglas River borehole (within the Upper Marine Sequence at least) com-pares very favourably with nearby sections in the St Marys Quadrangle, at Friendly Beaches and Maria Island where large, well-preserved collections have been recently collected and analysed. This factor allows significant and reasonably accurate (although admittedly inferential) conclusions to be made concerning the zonal distributions of the marine macro-invertebrate faunas in the drill core. Zonal allocations are made in accordance with the scheme of Clarke & Banks (1975), Clarke & Farmer (1976), and Clarke (in Clarke & Baillie 1984).

Spiriferids previously ascribed to *Tomiopsis* Benediktova, 1956 are herein referred to *Ambikella* Sahni and Srivastava, 1956, since Benediktova's name is a junior homonym of the mammalian *Tomiopsis* Cope, 1893 (Doescher 1981).

Lower Marine Sequence

Tasmanites shale
Macrofossils were not observed in the *Tasmanites* shale at 321 m. However, the *Tasmanites* shale consistently occupies a position low in the stratigraphic sequence and yields a Stage 2 microflora at all localities where sampled (Truswell 1978, and herein). The *Tasmanites* shale doubtless represents an unique interval when an algal bloom prolifer-ated and accumulated about shorelines in the Tasmania Basin. At Latrobe, where the shale was mined on a substantial scale, a surprisingly varied macrofauna has been obtained. Forms present include *Streptorhynchus* sp.nov., *Strophalosia* sp. nov., *Ambikella* cf. *elongata* (McClung and Armstrong), *Trigonotreta stokesi*, *Pseudosyrinx* sp., *Deltopecten* sp. ex gr. *illawarensis* (Morris), *Etheripecten tenuicollis* (Dana), *Eurydesma hobartensis hobartensis* (Johnston), *Megadesmus pristinus* Runnegar, *Merismopteria* sp., *Phestia darwini* (de Koninck), *Promytilus* sp., *Pyramus laevis* (Sowerby), *Schizodus australis* (Runnegar), *Stutchburia* sp., *Keeneia twelvetreesi* Dun (the type locality - see Dun 1913), and *Peruvispira* sp. The presence of *Streptorhynchus* sp.nov., *Strophalosia* sp. nov., *Ambikella* cf. *elongata* and *Megadesmus pristinus* indicates an Early Tamarian (Faunizone 1) age.

Black mudstone
A rich, well-preserved fauna occurs in the uppermost 4 m of the Lower Marine Sequence. Forms present include *Strophalosia subcircularis* Clarke, *Trigonotreta stokesi* Koenig, *Deltopecten illawarensis* (Morris), *Etheripecten* sp., *Eurydesma* sp., *Stenopora tasmaniensis* Lonsdale and fenestellids. *Strophalosia* and the bryozoans occur in profusion and in life orientation. The presence of *S. subcircularis*, *T. stokesi* and *S. tasmaniensis* unequivocally indicates a Tamarian age. The presence of *S. subcircularis* rather than *Strophalosia* sp. nov. (a form with a markedly raised ventral adductor platform) and the absence of *Streptorhynchus* sp. nov. precludes an Early Tamarian (Faunizone 1) age, and the absence of *Sulciplica* sp. nov. and *Notospirifer* sp. suggests that the fauna is not as young as Late Tamarian (Faunizone 3) age. The fauna is therefore assigned to the Middle Tamarian

(Faunizone 2). Palynological evidence (see later) indicates that the Late Tamarian is
represented within the lower parts of the Lower Freshwater Sequence.

Upper Marine Sequence

Limestone

The thick limestone unit is richly fossiliferous. Forms identified include
Euryphyllum sp., *Gertholites* [*Thamnopora*] *wilkinsoni* (Etheridge), *Cancrinella farleyensis*
(Etheridge and Dun), *Terrakea* sp., *Wyndhamia dalwoodensis* Booker, *Ambikella* spp.,
fasciculate spiriferids including *Trigonotreta hobartensis* (Brown), *Sulciplica* spp.
including *S. tasmaniensis* (Morris), *Deltopecten limaeformis* (Morris), *Etheripecten* spp.,
Eurydesma sp., *Streblopteria* sp., *Stenopora* spp. and fenestellids. Intersections of a
coarsely-spinose productid completely cover the core surface at 214 m and 182 m. These
are almost certainly the large aulostegid *Taeniothaerus subquadratus* (Morris), but the
identification is inferential. *Wyndhamia dalwoodensis*, spiriferids, bryozoans and
Deltopecten are the commonest elements, and crinoidal debris is abundant. The tabulate
coral *Gertholites wilkinsoni* is reasonably common above 179 m in more argillaceous lime-
stone.

The main limestone unit is lithologically similar to limestone developments in the Mt
Elephant area near St Marys, the Peter Limestone at Friendly Beaches (Banks 1955) and the
Counsel Creek Formation on Maria Island (Clarke & Baillie 1984) and all are of the same
order of thickness. *Cancrinella farleyensis*, *Anidanthus springsurensis* (Booker) and
Taeniothaerus subquadratus are characteristic occurrences in the surface developments.
Gertholites wilkinsoni occurs abundantly in the upper parts of the Counsel Creek Formation.

The stratotype for the Bernacchian Stage is on Maria Island and the detailed strati-
graphic palaeontology has been recently described (Clarke, in Clarke & Baillie 1984). The
sequence at Douglas River differs from the stratotype in that there is no lithological
equivalent of the marine Skipping Ridge Formation (= Early Bernacchian) which occurs bet-
ween the Boullanger Formation (= Lower Freshwater Sequence) and the Counsel Creek Formation.
This may be the result of facies change, but this is considered to be unlikely since the
linoproductid *Terrakea* occurs from 221 m upwards; *Terrakea* is unknown before the Late
Bernacchian in Tasmania. The major part of the limestone at Douglas River is therefore
referred to the Late Bernacchian *Taeniothaerus subquadratus* Zone. Palynological data (see
later) indicate that the Early Bernacchian is represented (at least in part) within the
upper parts of the Lower Freshwater Sequence. A probable hiatus occurs between the Early
and Late Bernacchian at Douglas River. On Maria Island the uppermost 12 m of the Counsel
Creek Formation belongs with the Early Lymingtonian. A similar biostratigraphy is inferred
at Douglas River, but proof is lacking.

Glauconitic sandstone

The glauconitic sandstone unit contains much broken shell debris but little can be
positively identified. At 149 m is a large *Ambikella* with a very low fold probably belong-
ing with the *brevis-undulosa-isbelli* plexus, and part of the large alate species *Sulciplica
transversa* Waterhouse occurs at 142 m.

The glauconitic sequence at Douglas River is similar to, and occupies the same strati-
graphic position as the Marra Formation on Maria Island, and developments of glauconitic
sandstone at Friendly Beaches and elsewhere in northeastern Tasmania. Such sequences are
always thin and attenuated, and probably represent discontinuous sedimentation. At
Friendly Beaches and on Maria Island faunas range in age from Early to late Middle
Lymingtonian (Clarke, in Clarke & Baillie 1984). *Sulciplica transversa* is unknown below
the Middle Lymingtonian in Tasmania.

Upper mudstone

No macro-invertebrates were observed in the uppermost mudstone unit although forams
are abundant at certain levels together with some woody debris.

The uppermost mudstone unit is similar to, and occupies the same stratigraphic posi-

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tion as the Toarra Formation on Maria Island and similar developments elsewhere in north-eastern Tasmania. These deposits are thought to have accumulated in a shallow lagoonal embayment under estuarine conditions (Banks 1962, p.210). Normal salinities returned only briefly in a series of short-lived incursions from the south and southeast. On Maria Island (and elsewhere) a thin productid bed yields *Echinalosia ovalis* (Maxwell), *Terrakea brachythaera* (Morris) and other fossils which prove a Late Lymingtonian (Faunizone 10) age. The Douglas River area is beyond the limits of these marine incursions.

PALYNOLOGY [E.M.T.]

Palynological investigations of Tasmanian Permian sequences undertaken in the nineteenth and twentieth centuries were reviewed by Truswell (1978), in the course of a study of the older parts of the Lower Parmeener Super-Group. From that review it is evident that the palynology of Tasmanian sequences younger than Early Permian has received little attention. Previous studies of younger Permian intervals include the examination by Dulhunty & Dulhunty (1949) of microspores from coals at Pelion, Cradoc and Preolenna, and reports by Balme (in Jennings 1963, in Spry & Banks 1962, and in Banks & Naqvi 1967) of the spore and pollen content of samples from the Cygnet Coal Measures at Cygnet, the Henty River, Pelion Range, Sky Farm near Hobart, and from the Jackey Shale at Western Bluff. Species lists were given in Banks & Naqvi (1967, p.21) and the palynomorphs listed there were assigned to Balme's (1964) *Dulhuntyispora* Assemblage. A Kazanian to Tatarian age was suggested because of apparent similarities to assemblages from the Liveringa Formation of Western Australia; similarities with assemblages from the Newcastle Coal Measures also drew comment. No mention was made of the absence of the nominate form *Dulhuntyispora* from the Tasmanian species lists, but Balme (in Jennings 1963) did comment on the predominance of long-ranging Permian taxa in the Jackey Shale, and hinted at palaeogeographic differences between Tasmanian floras and those of the mainland.

The study of sections cored at Golden Valley near Poatina, and Beaconsfield, which were examined palynologically by Truswell (1978), afforded an opportunity to relate a palynological zonation (Kemp *et al*. 1977) to the faunal assemblages of Clarke & Banks (1975). From that correlative study, it became apparent that Faunizone 1 is associated with palynological assemblages referred to Stage 2 and Substage 3a, and Faunizones 2-3 are associated with Substage 3a. Glacial sediments at the base of the Parmeener Super-Group, which usually lack invertebrates, were shown to be associated with Stage 1 and Stage 2 assemblages; the *Tasmanites* oil shale with Stage 2. The Mersey Coal Measures, at all the localities at which these were sampled, contained palynofloras referable to Substage 3b.

The Douglas River borehole sequence examined here afforded the opportunity to establish the palynomorph content for the intervals encompassing Faunizones 1 to 10. The opportunity for clear faunal and floral correlation was marred by generally poor preservation of palynomorphs. In the marine intervals spores and pollen are much fragmented, probably as a result of transportation processes. In both marine and non-marine parts of the sampled sequence palynomorph walls have been ruptured and damaged by pyrite crystallization. In some cases, especially with the fragile walls of saccate pollen grains, this process has been severe enough to make identification to species level difficult.

The biostratographic scheme used here is based on the system of palynological "Stages" which Evans (1969) consolidated from his earlier work, and which has subsequently been subdivided and modified by a number of workers. Summaries of the development of the "Stage" system, and of its application to the Permo-Carboniferous of eastern Australia, are given in Kemp *et al*. (1977) and in Price (1983). In their present form, the stages, and their substages, are in fact interval zones, each unit representing the interval between horizons defined by the first appearance in time of selected taxa. In some cases the nominate taxa form part of a clearly identifiable morphologic lineage. Price (1983) has provided a formal nomenclature for the interval zones. The biostratigraphic bases for these rest on sections in the Cooper, Bowen and Galilee Basins. Their application in southeastern Australia remains to be fully tested, so for the purposes of this study the stages of Evans (1969) as defined in Kemp *et al*. (1977) have been applied, and probable correlations with the formalized interval zones indicated where appropriate.

Late Palaeozoic Borehole Section at Douglas River, Tasmania

Ranges of stratigraphically important taxa are indicated in figure 3, together with the position of palynological stage boundaries in the Douglas River section. The relative frequencies of selected species or species groups are shown in figure 4, for those intervals where preservation was good enough for counts to be made. The range chart (table 1) shows the distribution of all taxa identified.

From the base of the Douglas River sequence, the palynological units, and their lithological extent, are as follows:
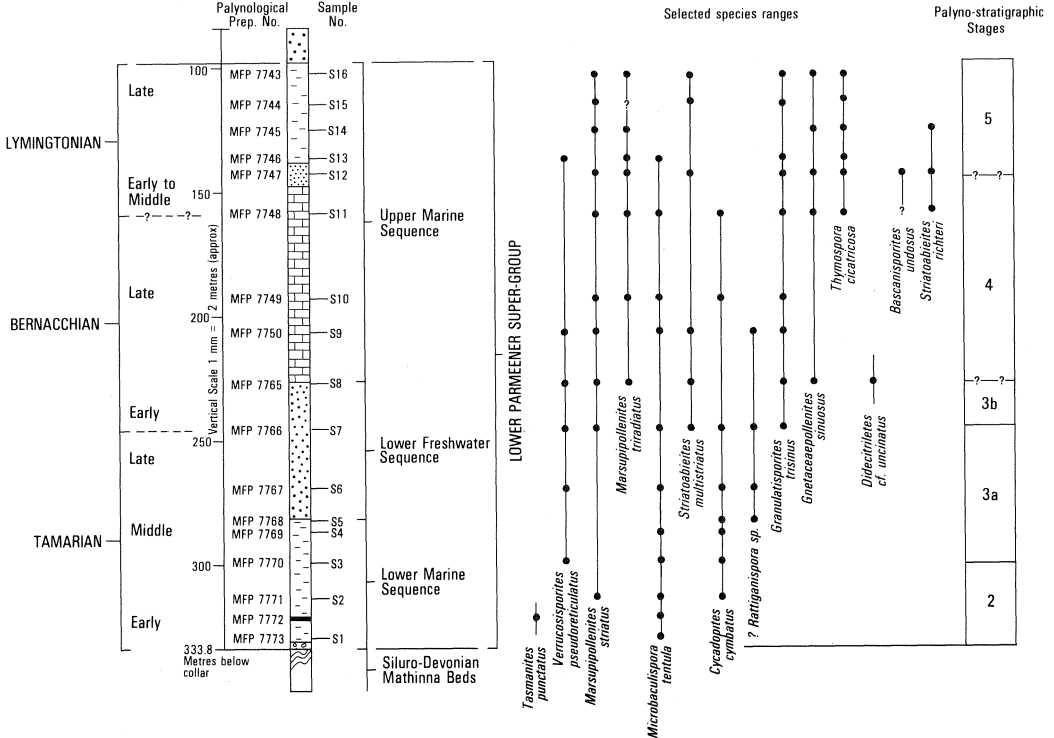
FIG. 3 - Ranges of selected spore and pollen species in Douglas River borehole. Boundaries of palynostratigraphic stages after Kemp *et al.* (1977) shown in right-hand column, and Tasmanian stage nomenclature based on marine macro-invertebrates shown in left-hand column.

Stage 2

Three cores from the lower part of the Lower Marine Sequence can be referred to Stage 2 - these are from depths of 328 m, 321 m (from the *Tasmanites* shale) and 313 m. Preservation of palynomorphs is extremely poor at all sampled levels, and diversity is low. Only the sample at 313 m was suitable for palynomorph counts to be made: this sample, like the others from Stage 2, showed a dominance of monosaccate pollen, mostly referable to *Plicatipollenites*, with less common *Potonieisporites*, and with a frequency of *Microbaculispora tentula* Tiwari of 18 per cent. This high frequency of *M. tentula* is characteristic elsewhere of upper Stage 2; the presence of *Marsupipollenites striatus* (Balme & Hennelly) and *Cycadopites cymbatus* (Balme & Hennelly) is in accord with an upper Stage 2 attribution. For the samples from 321 m and 328 m, preservation is too poor to identify subdivisions finer than Stage 2. The *Tasmanites* shale yielded a characteristically impoverished palynoflora; residues are dominated by fragments of the presumed green alga *Tasmanites punctatus* Newton, which obscures other forms; the rare pollen and spores are much fragmented and thinned.

Spores and pollen	328 m	321 m	313 m	299 m	287 m	282 m	269 m	245 m	227 m	211 m	193 m	159 m	143 m	137 m	125 m	115 m	102 m
Preparation and depth (MFP)	7773	7772	7771	7770	7769	7768	7767	7766	7765	7750	7749	7748	7747	7746	7745	7744	7743
Apiculatisporis cornutus (Balme & Henn)									X			X		X		X	X
A. sp. cf. *A. cornutus* (Balme & Henn)											X						
Barakarites rotatus (Balme & Henn)									X								
Bascanisporites sp. cf. *B. undosus* Balme & Henn												X	X				
Brevitriletes sp. cf. *B. levis* (Balme & Henn)												X					
Caheniasaccites sp.	X																
Camptotriletes biornatus Balme & Henn									X								
Cannanoropollis sp.	X								X								
Cycadopites cymbatus (Balme & Henn)			X	X	X	X	X	X	X			X	X				
Didecitriletes eoericiana (Anderson)									X								
Didecitriletes sp. cf. *D. uncinatus* (Balme & Henn)									X								
Florinites eremus Balme & Henn												X					
Gnetaceaepollenites sinuosus (Balme & Henn)									X			X	X	X	X		X
Granulatisporites micronodosus Balme & Henn					X				X	X				X			
Granulatisporites sp. cf. *G. micronodosus* Balme & Henn									X	X			X	X	X	X	X
Granulatisporites trisinus Balme & Henn									X	X	X	X	X	X	X	X	X
Horriditriletes ramosus (Balme & Henn)	X	X	X						X	X							
Indotriradites splendens (Balme & Henn)									X			X					
Indotriradites sp.									X								
'Jugasporites' sp.									X								
Leiotriletes directus Balme & Henn							X	X	X					X	X		X
Limbosporites sp. cf. *L. balmei* Foster												X					
Limitisporites sp. cf. *L. rectus* Leschik									X	X							
Marsupipollenites striatus (Balme & Henn)					X				X	X	X	X	X	X	X	X	X
Marsupipollenites triradiatus Balme & Henn									X	X	X	X	X	X	X	X	
Microbaculispora tentula Tiwari	X		X	X	X			X	X	X	X	X		X			
Neoraistrickia gracilis Foster											X		X				
Platysaccus leschikii Hart									X	X	X	X		X	X		
Plicatipollenites densus Srivastava	X		X	X	X	X	X	X				X			X		
Plicatipollenites gondwanensis (Balme & Henn)															X		
Plicatipollenites spp.	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X
Polypodiisporites leopardus (Balme & Henn)											X	X		X			X
Potonieisporites methoris (Hart)											X	X					
Potonieisporites spp.		X		X										X			
Protohaploxypinus amplus (Balme & Henn)									X	X	X	X		X		X	
Protohaploxypinus limpidus (Balme & Henn)									X	X		X	X	X	X	X	X
Pteruchipollenites sp.									X	X		X	X				
Punctatisporites gretensis Balme & Henn							X	X	X	X							
?Rattiganispora sp.							X	X	X		X						
Retusotriletes diversiformis Balme & Henn							X		X								
Scheuringipollenites maximus (Hart)									X			X		X			
Scheuringipollenites ovatus (Balme & Henn)									X			X	X	X	X	X	X
Striatoabieites multistriatus (Balme & Henn)									X	X	X		X			X	X
Striatoabietites richteri (Klaus)													X		X		
Striatoabieites sp.					X												
Striatopodocarpites cancellatus (Balme & Henn)									X	X		X				X	
Striatopodocarpites sp. cf. *S. phaleratus* (Balme & Henn)												X					
Thymospora cicatricosa (Balme & Henn)												X	X		X		X
Verrucosisporites pseudoreticulatus Balme & Henn					X			X	X	X	X				X		
Verrucosisporites sp. cf. *V. naumovae* Hart									X	X	X	X	X				
Verrucosisporites sp.																	
Vesicaspora sp.									X								
Vestigisporites sp.					X				X								
Vitreisporites signatus Leschik									X	X		X			X	X	X
Acritarchs and algal forms																	
Baltisphaeridium sp.				X	X												
Botryococcus sp												X					X
Brazilea sp.												X	X	X			
Cymatiosphaera sp. of Truswell 1978															X		
Dilatosphaera sp.					X												
Elektoriskos sp.									X								
Gorgonisphaeridium sp. A. of Truswell 1978						X	X	X									
Gorgonisphaeridium sp.													X				
Michrystridium sp. A.									X	X	X				X	X	X
Michrystridium sp. B.									X								
Peltacystia venosa Balme & Segroves									X								X
Quadrisporites horridus Hennelly										X							
Tasmanites punctatus Newton			X														
Tetraporina sp.										X							
Ulanisphaeridium berryense McMinn									X			X					
Veryhachium sp. cf. *V. riburgense* Brosius & Bitterli										X							
Veryhachium sp. A. of Foster 1979									X								
Veryhachium sp. B.										X			X	X	X		
Veryhachium sp. indet.			X						X								

TABLE 1 - Distribution of species of spores, pollen and acritarchs in samples examined.

Late Palaeozoic Borehole Section at Douglas River, Tasmania

Acritarchs are sparse in the lower part of the Lower Marine Sequence, except for *Tasmanites* at 321 m. In the counted sample at 313 m, spores and pollen outnumber
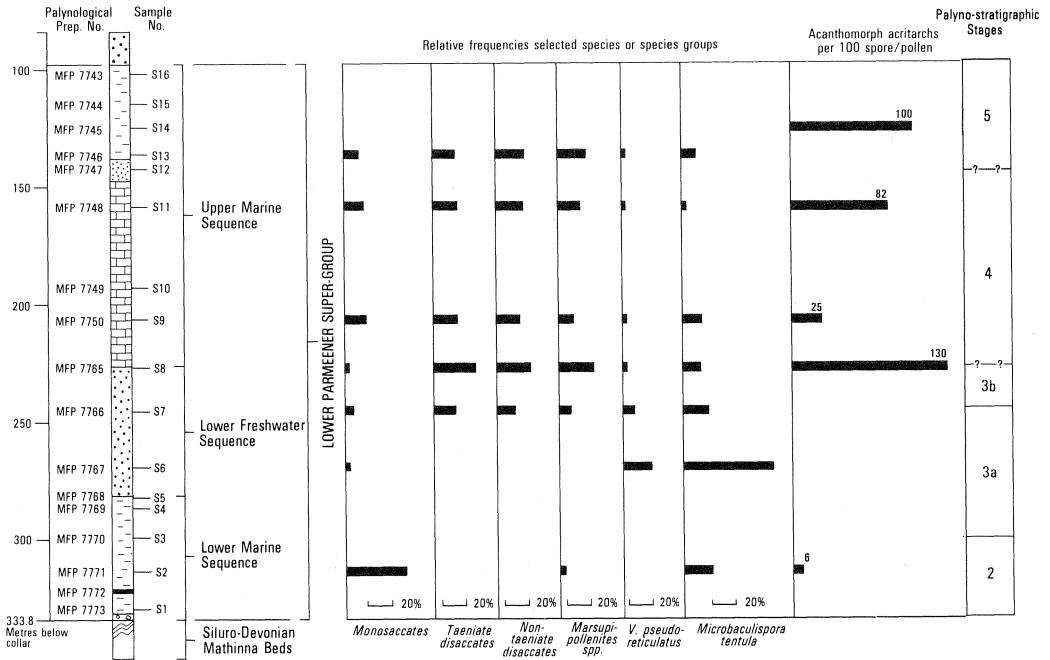

FIG. 4 - Relative frequencies of selected palynomorph species or species groups in Douglas River borehole. Frequencies are based on a count of 200 specimens: only intervals with good preservation have been counted. Second column from the right shows numbers of acanthomorph acritarchs per 100 grains of spore/pollen.

acritarchs by 10:1 (fig. 4). Prominent among the acritarch element in that sample are thin-walled, much corroded forms with long flexible processes; these are provisionally assigned here to *Baltisphaeridium* (plate 1, fig. 6,7). No such forms have been recorded previously from Australian sequences; their general morphology is more suggestive of Early Palaeozoic types, so that the possibility remains of their being reworked from the Siluro-Devonian sequences underlying the Late Palaeozoic rocks. There are no published records to date of acritarchs from the Silurian/Early Devonian in Australia, so this suggestion is impossible to test.

A single specimen referred to the Early Palaeozoic genus *Dilatosphaera* was observed at 313 m. The presence of an acritarch with distally flaring processes in unusual in the Late Palaeozoic, and again, reworking from older rocks remains possible.

Upper Stage 2 microfloral assemblages were reported previously from the lower part of the Masseys Creek Group at Beaconsfield, and from the basal part of the Quamby Mudstone at Golden Valley (Truswell 1978). At both these localities the assemblages occurred in marine sequences, were impoverished in species, and dominated by monosaccate pollen. In the Hellyer Gorge area and at Latrobe, similarly impoverished, poorly preserved assemblages occur in *Tasmanites* shale at the base of the Inglis Siltstone and Spreyton Beds respectively.

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Stage 3

The appearance of the probable fern spore *Verrucosisporites pseudoreticulatus* Balme & Hennelly (this name is used for the taxon concerned rather than the later name *Pseudoreticulatispora pseudoreticulata* except in biostratigraphic terms) has been unanimously adopted by Australian palynologists as a chronostratigraphic marker. Its appearance post-dates the incoming of the first taeniate disaccate pollen in sedimentary basins in Western Australia, South Australia, Queensland and New South Wales (see Kemp *et al*. 1977; Foster 1979, 1983; Cooper 1983; Price 1983). Its first appearance defines the base of Stage 3, or the base of the *Pseudoreticulatispora pseudoreticulata* to *Phaselisporites cicatricosus* Interval Zone of Price (1983). Thus while the hazards of defining a biozone on the appearance of a single species are admitted, the consistency of appearance of this species and its ubiquitous distribution (but see Foster 1983) appear to make it a reliable marker. The resistant nature of the species has been noted by Cooper (1983).

Substage 3a
In the Douglas River borehole the deepest observed occurrence of *V. pseudoreticulatus* was at 299 m, within the Lower Marine unit. This sample, and Stage 3 samples above it in the Lower Marine Sequence yielded assemblages of poor preservation and low diversity, differing little from Stage 2 assemblages below. They contain a consistently high component of monosaccate pollen, the trilete *Microbaculispora tentula* and the mono-colpate *Cycadopites cymbatus*. Also present in this upper part of the Lower Marine Sequence are acritarchs showing a basic similarity to those designated *Gorgonisphaeridium* sp. A by Truswell (1978).

Intervals sampled at 299 m, 287 m, 282 m and 269 m are referable to Substage 3a; this is the *Pseudoreticulatispora pseudoreticulata* to *Granulatisporites trisinus* Interval Sub-zone of Price (1983). The sample at 269 m, from the lower part of the Lower Freshwater Sequence, shows a not unexpected change in palynofacies and preservation from the intervals sampled below. In it, trilete spores are dominant, *M. tentula* and *V. pseudoreticulatus* together making up nearly 90 per cent of the assemblage (fig. 4). The species assigned tentatively to *Rattiganispora* by Truswell (1978) is also present. The assemblage is poorly diversified, with only ten species identified. The high frequency of the heavy-walled *V. pseudoreticulatus* suggests that the assemblage derives from plants growing very close to the depositional site; the near-absence of saccate pollen confirms that local, rather than regional vegetation is represented here.

Substage 3a microfloras have been identified previously in Tasmania from the Golden Valley Group near Poatina, from the Andersons Creek borehole at Beaconsfield, from the Inglis Siltstone in the Hellyer Gorge-Wynyard area, and from the Kansas Creek Beds at Fisher Tunnel (Truswell 1978). At all of these localities the biozone is developed in marine units; there is no previous record of the distinctive facies present at 269 m in the Douglas River borehole.

Substage 3b
Only one sampled level, that at 245 m, in the upper part of the Lower Freshwater Sequence, could be assigned to Substage 3b. This sample shows a marked increase in paly-nomorph diversity in comparison with the intervals sampled below. The basis for its attri-bution to Substage 3b lies in the presence of *Granulatisporites trisinus* Balme & Hennelly, the first appearance of which, in mainland successions, consistently succeeds that of *V. pseudoreticulatus*. In addition to this marker species, the Substage is distinguished by an increase in the diversity of other trilete spores; *Marsupipollenites* types assume a significant frequency, as do disaccate pollen, both taeniate and non-taeniate. This diversity, with the significantly higher frequency of winged pollen types, suggests that the pollen and spore assemblage reflects vegetation from a much wider area than is the case for the sample from 269 m.

It is notable that this is the first record for Tasmania of the Substage 3a/3b bound-ary occurring within a non-marine sequence, rather than below it. In the Golden Valley borehole near Poatina, the 3a/3b transition occurs within the marine sequence just below the non-marine Liffey Sandstone.

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Stage 4

The base of this palynostratigraphic unit is tentatively identified as lying immediately below the interval sampled at 227 m. This base is identified on the first appearance of *Gnetaceaepollenites sinuosus* (Balme & Hennelly), with the acknowledgement that this form is not always a dependable time marker, as irregularities in its appearance in the Bowen Basin have shown (Foster 1983). The species which has come to be regarded as defining the base of Stage 4, viz. *Thymospora cicatricosa* (Balme & Hennelly), does not appear until higher in the Douglas River section, but the overall composition of assemblages at 227 m seems to warrant attribution of that interval to Stage 4. At that level, disaccate pollen, both taeniate and non-taeniate, makes up over 50 per cent of the assemblage, and *Marsupipollenites* species are abundant. This composition shows a strong similarity to Stage 4 assemblages on the Australian mainland; the gross composition of suites from the Blair Athol Coal Measures, for instance, is close to that from this Tasmanian site.

The top of Stage 4 at Douglas River is estimated to lie between horizons sampled at 159 m and 143 m, but, as is explained below, it can be only tentatively drawn. It has not been possible to assign the Stage 4 interval to Substages. The comparable assemblages from the Blair Athol Coal Measures have been referred to Upper Stage 4a (Foster 1979), on the basis of the combined presence in them of *T. cicatricosa* and *G. sinuosus*, with the latter species making the later appearance in Queensland. At Douglas River these two species appear in reverse order, so that the stage subdivisions could not be satisfactorily applied. The youngest subdivision of Stage 4 in mainland eastern Australia, Upper Stage 4b, is marked by the incoming of *Acanthotriletes villosus* Balme & Hennelly, another species which was not observed in the Douglas River samples.

Stage 5

The sampled intervals at 143 m, 137 m, 125 m, 115 m and 102 m are somewhat arbitrarily considered to be equivalent to palynological Stage 5 of the mainland sequence. This assignment rests on faunal correlation only, as palynological changes within the Upper Marine Sequence are barely perceptible. None of the forms which elsewhere characterize Stage 5, or the equivalent *Dulhuntyispora* Assemblage of Western Australia, were observed at Douglas River. No representatives were seen of the *Dulhuntyispora* complex, nor were *Didecitriletes ericianus* (Balme & Hennelly) or *Microreticulatisporites bitriangularis* Balme and Hennelly observed.

The assemblages from this upper member of the Upper Marine Sequence are characterized by relatively high frequencies of both taeniate and non-taeniate disaccate pollen, by trilete spores such as *Marsupipollenites* spp., *Granulatisporites micronodosa* Balme & Hennelly, *Granulatisporites trisinus* and *Microbaculispora tentula*, and by the monolete *Thymospora cicatricosa* and *Polypodiisporites leopardus* (Balme & Hennelly). All of these trilete and monolete species begin their ranges in much older parts of the sequence; none are confined to this interval. Among the disaccate pollen, the presence of *Striatoabieites richteri* (Klaus) is noteworthy; this distinctive species was recovered only from 143 and 125 m. In the northern hemisphere it appears to be restricted to Late Permian sequences; this is its first record from Australia, so that its range here is undocumented, but it may have potential as a stratigraphic marker.

Previous records of Late Permian assemblages from Tasmania are in accord with the impoverished assemblages from the Douglas River site. For example, among species listed by Balme (in Banks & Naqvi 1967) from the Cygnet Coal Measures at Cradoc, Mt Pelion, Mole Creek and Western Bluff, only *Acanthotriletes ericianus* gave a clear correlation with Stage 5 assemblages from the mainland. Preparations from the Jackey Shale at Western Bluff (Balme, in Jennings 1963) were recently re-examined by C.B. Foster (pers. comm., 1983), who confirmed the near absence in them of Stage 5 markers, noting that there was, however, an unusual abundance of *Bascanisporites undosus* Balme & Hennelly and *T. cicatricosa*.

The causes of the impoverishment of Late Permian palynofloras in Tasmania, in which the apparent absence of the *Dulhuntyispora* complex is noteworthy, remain speculative, but are possibly to be found in Permian climatic gradients. Continental reconstructions for

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the Late Permian place Tasmania at the highest of the Australian palaeolatitudes, at
approximately 70°S (Smith, Hurley & Briden 1981). The Canning and Carnarvon Basins, where
Stage 5 palynofloras are most diverse, lay by contrast in 40°-50°S latitude. The poverty
of the Tasmanian assemblages is paralleled by that of apparently coeval assemblages from
sites in the Transantarctic Mountains of Antarctica. There, Kyle & Schopf (1982) have des-
cribed suites from the Queen Maud and Upper Mt Glossopteris Formations, which are distin-
guished by a high frequency of taeniate disaccate pollen, by *Bascanisporites undosus* and
Gnetaceaepollenites sinuosus, and which lack *Dulhuntyispora* and other "typical" Stage 5
indicators. The suggestion that climatic gradients may influence the distribution of the
Dulhuntyispora group of spores on the Australian mainland has been made recently (Brakel
1982) but the stratigraphic implications of such a distribution pattern remain to be estab-
lished.

Taxonomic Notes

1. Acritarchs

The acritarchs represent a probably polyphyletic group of organic-walled micro-
fossils. Most, however, seem likely to represent the encysted phases of aquatic algae.
The diversity and stratigraphic utility of the acritarchs is greatest in the Early Palaeo-
zoic, reaching an acme perhaps in the Ordovician. On a world-wide basis, studies of
Permian acritarchs have lagged behind those of the Early Palaeozoic. Such studies as do
exist indicate that as a generalisation, Permian acritarch assemblages are distinguished
by their low diversity and by the morphological simplicity of their constituent forms
(Jacobson, Wardlaw & Saxton 1982). The causes of such taxonomic poverty in the later
Palaeozoic remain obscure.

Late Palaeozoic (and Early Mesozoic) sediments are characterised in particular by
"swarms" of acritarchs, in which only one or two morphologically simple types predominate.
Such swarms are typical of marine basal Triassic sediments in many parts of the world
(Balme & Helby 1973), but are known from Permian sediments also (Wall & Downie 1963,
Balme 1970). In Australia, Evans (1962) was the first to report acritarchs in great abun-
dance from Permian sediments in the Denison Trough of Queensland, where simple spinose
forms provided a useful biostratigraphic marker horizon. The history of the usage and
terminology of Evans' (1962) "P3c acritarch swarm" has recently been described by Price
(1983). Spinose acritarchs suggesting brackish conditions or conditions of marine influ-
ence have been reported in lesser abundance by Foster (1974) from the Yorke Peninsula,
South Australia, by Segroves (1970) from the Perth Basin, Western Australia, by Kemp (1976)
from the Officer Basin, by Grebe (1970), Helby (1973) and McMinn (1982) from the Sydney
Basin, by Foster (1979), Rigby & Hekel (1977) and Price (1983) from Queensland Basins, and
earlier from Tasmania by Truswell (1978). In spite of this abundance of records, formal
taxonomic descriptions of Permian acritarchs have been few, and the potential stratigraphic
value of the group in Australian Permian sequences remains unrealised.

In the course of the present study, it became apparent that the acritarchs observed
had limited stratigraphic distributions within the Douglas River sequence, or were confined
to particular facies. While detailed taxonomic treatment, which requires high magnifica-
tion photomicrography and statistical treatment, could not be undertaken, it was felt that
illustration and brief description of common forms would serve to direct attention to the
possible value of the organisms in future stratigraphic refinement.

The most abundant forms seen in the Douglas River section, viz. those referred to the
genera *Michrystridium*, *Veryhachium* and *Gorgonisphaeridium*, are typical of Permian acritarch
assemblages as these are known elsewhere. Another group, which includes forms referred to
Baltisphaeridium, *Elektoriskos* and *Dilatosphaera*, are morphologically closer to Early
Palaeozoic forms and have not been recorded in Australian Permian sequences before. They
occur predominantly in the lower part of the sequence, which raises the possibility that
they may have been reworked from Early Palaeozoic rocks.

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Group ACRITARCHA Evitt, 1963

Subgroup ACANTHOMORPHITAE Downie, Evitt and Sarjeant emend Lister, 1970.

Genus *Baltisphaeridium* Eisenack emend Downie & Sarjeant, 1963

Baltisphaeridium sp.

Plate 1, figs 6,7

Remarks: Thin-walled acritarchs of near-circular outline, bearing numerous flexible, hollow, much-folded processes are referred to this category. The processes taper to an acute tip. Assignment to *Baltisphaeridium* is tentative; it assumes that the processes are closed proximally and do not communicate with the vesicle interior. This is hard to verify given the state of preservation and the intense folding of the specimens. Recorded from the middle section of the Lower Marine Sequence.
Dimensions: Vesicle diameter 38-57 μ; processes 15-25 μ long (based on 8 specimens from sample MFP 7771).

Genus *Dilatosphaera* Lister, 1970

?Dilatosphaera sp.

Plate 1, fig. 3

Remarks: This single specimen, which has a thin-walled, much-folded vesicle bearing 8 or 9 hollow, flexible processes which are distally open and flaring, is reminiscent of the chorate dinocysts found in post-Palaeozoic rocks. It has been tentatively assigned to *Dilatosphaera*, a genus which Lister (1970) erected to accommodate Early Palaeozoic acritarchs with broad, distally open processes which are proximally closed off from the vesicle cavity. The specimen figured here, from the Lower Marine Sequence, has processes which are only doubtfully closed proximally, hence the tentative generic assignment. No comparable forms have hitherto been recorded from Australian Permo-Carboniferous deposits.
Dimensions: Vesicle diameter 33 μ; processes 4-5 μ in diameter, 19-23 μ long.

Genus *Elektoriskos* Loeblich, 1970

Elektoriskos sp.

Plate 1, fig. 4

Remarks: The genus was erected (Loeblich 1970) to accommodate acritarchs with a circular vesicle outline, from which project numerous slender, flexible but solid processes. Between 50 and 60 processes are visible at the circumference. In the single specimen observed here, from the base of the Upper Marine Sequence, the wall is distinctly spongeose. The processes appear to be solid, but poor preservation makes confirmation of this difficult. Specimens of this morphology are rare in the Late Palaeozoic, and none has been recorded from Australia before.
Dimensions: Vesicle diameter 35 μ; processes 18-20 μ long, 1.0-1.5 μ in basal diameter.

Genus *Gorgonisphaeridium* Staplin, Jansonius & Pocock, 1965

Gorgonisphaeridium sp. cf. *G.* sp. A of Truswell, 1978

Plate 2, figs 8,9

cf. 1978 *Gorgonisphaeridium* sp. A, Truswell, p.27, Pl.3, fig.1-6.

Remarks: To this category are assigned acritarchs bearing numerous, solid processes which are slightly tapering and bluntly truncated apically. There may be some slight recurving at the distal extremity of the processes. At the process base there are poorly defined,

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radially arranged ridges on the vesicle wall. Excystment is apparently by simple splitting of the vesicle wall.

The morphology shows a basic similarity to specimens described by Truswell (1978) as *Gorgonisphaeridium* sp. A, except for a denser cover of processes and a less distinctly linear arrangement of these. The specimens figured here may have some stratigraphic value as they were restricted to the upper part of the Lower Marine Sequence. *Gorgonisphaeridium* sp. A was recorded (Truswell 1978) from a comparable stratigraphic interval, in the Quamby Mudstone and its correlatives, in association with a Substage 3a microflora.
Dimensions: Test diameter 34-61 µ; processes 3-4 µ high; 1.5-2.0 µ in basal diameter (based on 5 specimens from sample MFP 7770).

Gorgonisphaeridium sp.

Plate 1, fig. 5

Remarks: In the possession of a thick wall, a median split, and densely spaced solid processes, this form bears some similarity to *Gorgonisphaeridium cumulatum* Playford, from the Emsian of Ontario (Playford 1977, pl.8, figs 12-20) although processes are shorter in the Tasmanian form. It differs from the superficially similar *Michrystridium evansii* Price (Price 1983, p.177, pl.16, figs 1-6,8,13) in having apparently solid processes (hence assignment to *Gorgonisphaeridium*) and in having a thicker wall.
Dimensions: Vesicle diameter 32, 37 µ (2 specimens from sample MFP 7747, Upper Marine Sequence).

Genus *Ulanisphaeridium* McMinn, 1982

Ulanisphaeridium berryense McMinn, 1982

Plate 1, fig. 1

1982 *Ulanisphaeridium berryense* McMinn, p.82, pl.1, figs 7-9; pl.2, figs 4,6.

Remarks: In the presence of a circular pylome, 1.8-2.0 µ in diameter, and of a two-layered wall bearing a surface ornament of essentially club-shaped processes which are frequently united at their tips, there can be little doubt that the Tasmanian specimens are conspecific with *U. berryense*, described by McMinn (1982) from the northern Sydney Basin. The processes of the periphragm are very irregular; some are united to form an irregular mesh-like structure, while others remain discrete. The endophragm is homogeneous, 1.5-2.0 µ thick. McMinn placed specimens assigned by Grebe (1970, pl.6, figs 7,10), Helby (1973, pl.3, fig.10) and Foster (1979, pl.40, figs 2,3) to *Michrystridium* within *U. berryense*. In the form of its surface ornament, *U. berryense* shows some similarity to *Mehlisphaeridium regulare* Anderson, 1977 from the Ecca Series of South Africa (Anderson 1977) but the presence of a pylome has not been established for that species.
Dimensions: Vesicle diameter 27-29 µ (3 specimens from sample MFP 7765, uppermost part of Lower Freshwater Sequence).

Genus *Michrystridium* Deflandre, 1937

Michrystridium sp. A

Plate 2, figs 1-3, 5

Remarks: Grouped within this category are spinose acritarchs with an originally spherical vesicle, bearing hollow, broad-based spines which are open to the vesicle interior. The processes taper sharply to an acute tip; rarely are they bifurcating. The vesicle usually shows compressional folding. Dehiscence is by median splitting.

For acanthomorph acritarchs such as these, which show a minimum of morphological features on which their characterisation might rest, statistical studies are necessary to identify morphological discontinuities between species. Such are beyond the scope of the

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present paper. Such studies should also form the basis of meaningful comparisons with previously described taxa, but are not available in the present state of Permian acritarch research. *Michrystridium* sp. A bears some resemblance to *M. breve* Jansonius, from the Early Triassic of western Canada (Jansonius 1962), which was subsequently recorded by Sarjeant (1970) from the Salt Range, Pakistan. The Tasmanian specimens are, however, considerably larger. They are common in the Upper Marine Sequence, and occur in "swarm" proportions in sample MFP 7765, at the very top of the Lower Freshwater Sequence.
Dimensions: Vesicle diameter 21-27 μ; spines 3-5 μ long, 1.5-1.8 μ in basal diameter (based on 8 specimens from sample MFP 7765).

Michrystridium sp. B

Plate 2, fig. 4

Remarks: This category includes forms with an originally spherical vesicle and a dense cover of straight, spinose processes which are usually simple but which may bifurcate at their tips. The more dense concentration of spines, and their narrower basal diameters distinguish this form from *Michrystridium* sp. A. The straight, densely distributed processes distinguish the form from *Michrystridium* sp. A of Foster (1979) from the Baralaba Coal Measures of Queensland. *Michrystridium* sp. A was recorded here only from sample MFP 7765, at the top of the Lower Freshwater Sequence.
Dimensions: Vesicle diameter 21-25 μ, spines 6-7 μ long, 1.0-2.0 μ in basal diameter (3 specimens from sample MFP 7765).

Subgroup POLYGONOMORPHITAE Downie, Evitt & Sarjeant, 1963

Genus *Veryhachium* Deunff ex Downie, 1959

Veryhachium sp. cf. *V. ?riburgense* Brosius & Bitterli, 1961

Plate 1, figs 8-10

Remarks: Herein are grouped forms with a basically triangular or quadrangular test which bears 5 to 8 hollow processes which are very broad at the base, continuous with the vesicle interior, and which taper to an acute tip. The vesicle exterior is smooth. No dehiscence structure was observed.

Morphologically this is a highly variable, although distinctive, group. It seems best in this preliminary study to regard all variants as belonging to a single species, which is comparable to the *Veryhachium ?riburgense* plexus of Brosius & Bitterli (1961) but the Tasmanian specimens represent a much larger form. Sarjeant (1970) recognised the *V. ?riburgense* complex in the Chhidru Formation of the Salt Range, but the specimens he reported there are about half the size of those from Tasmania. None of the species reported from the German Zechstein by Schaarschmidt (1963) closely resembles the Tasmanian species; the highly variable *Veryhachium variabilis* Schaarschmidt (1963, pl.18, fig.4-6) is closest, but has processes which are more constricted at the base. In the Douglas River sequence this form occurs only in the Upper Marine Sequence, where it is most abundant in sample 7750.
Dimensions: Vesicle diameter 28-37 μ; processes 9-23 μ long, 4-10 μ in basal diameter (based on 7 specimens from sample MFP 7750).

Veryhachium sp. A of Foster, 1979

Plate 1, fig. 2

1979 *Veryhachium* sp. A, Foster, p.111, pl.40, fig. 5.

Remarks: This species includes specimens of *Veryhachium* with relatively short, broad-based processes, which show the suggestion of a bipolar distribution. The processes are much shorter in relation to vesicle diameter than they are in the cf. *V. ?riburgense* type. The vesicle wall is faintly granular. The form conforms closely to that which Foster (1979)

described from the Baralaba Coal Measures; it is probably identical to the *Veryhachium* types reported by Grebe (1970, pl.6, fig.11) and Helby (1973, pl.3, fig.12) from the basal *Protohaploxypinus reticulatus* Zone, above the youngest coal measures in the Sydney Basin. In the present study it was observed only in sample 7765, at the top of the Lower Freshwater Sequence.
Dimensions: Vesicle diameter 20, 22 µ; processes 4-6 µ long, 1.5-3.0 µ in basal diameter (based on 2 specimens from sample MFP 7765).

Veryhachium sp. B

Plate 2, fig. 6

Remarks: Within this category are placed small, thin-walled *Veryhachium* specimens with convex sides, suggesting an originally globular form of the vesicle. The processes are hollow, long and flexible, and communicate with the vesicle interior. One "apical" process is frequently bifurcating. An arcuate split was observed on some specimens, and encompasses one process. Whether or not this represents a definite excystment structure is uncertain. The form was observed only in the Upper Marine Sequence.
Dimensions: Vesicle diameter 13-17 µ; processes 9-12 µ long (based on 5 specimens from sample MFP 7750).

Subgroup SCHIZOMORPHITAE Segroves, 1967

Genus *Brazilea* Tiwari & Navale, 1967

Brazilea sp.

Plate 2, fig. 10

Remarks: Forms grouped here are spherical, and occur usually in aggregates, Individuals are frequently ruptured, with rupturing occurring along a single dehiscence line. The surface of the test ranges from finely granular, in which instance they resemble *Brazilea helbyi* Foster (Foster 1979, p.112, pl.40, fig.20,21), to forms with a dense fibrous covering. Whether this fibrous mat represents the original surface, the remains of material originally enveloping the cellular mass, or results from the breakdown of the cell walls, is uncertain. The form occurs in swarm proportions at certain levels in the Upper Marine Sequence.
Dimensions: Vesicle diameter 15-41 µ (based on 20 specimens from sample MFP 7747).

2. Spores and pollen
    Those spores and pollen described briefly here are those for which the present record represents a first report, either in Tasmania or in Australia, or represents a modification of stratigraphic ranges as previously understood.

Trilete spores

Genus *Camptotriletes* Naumova ex Potonié & Kremp, 1954

Camptotriletes biornatus Balme & Hennelly, 1956

Plate 2, fig. 11

1956 *Camptotriletes biornatus* Balme & Hennelly, p.252, pl.5, fig.55-56.

Remarks: Specimens assigned here to *C. biornatus* have greatly reduced ornament on the proximal face, well developed sinuous labra enclosing the laesurae, and a distal ornament of rugulae constructed apparently of joined verrucae. Occasional isolated verrucae are also present on the distal face.

    Camptotriletes biornatus was, at the time of the erection of the species (Balme & Hennelly 1956) recorded only from the Greta Coal Measures in the Sydney Basin. This record

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from Tasmania, from a comparable stratigraphic interval at the top of the Lower Freshwater
Sequence, appears to be the first report of the species published since then.
Dimensions: Equatorial diameter 68, 70 μ (2 specimens from sample MFP 7765).

Genus *Didecitriletes* Venkatachala & Kar, 1965

Didecitriletes sp. cf. *D. uncinatus* (Balme & Hennelly) Venkatachala & Kar, 1965

Plate 3, fig. 4

cf. 1956 *Acanthotriletes uncinatus* Balme & Hennelly, p.249, pl.3, fig.35-36.
cf. 1965 *Didecitriletes uncinatus* (Balme & Hennelly) Venkatachala & Kar, p.339.

Remarks: The single specimen reported here has a smooth, sharply delineated proximal face,
with laesurae surrounded by labra about 2.0 μ high. The spinose elements of the distal
face taper evenly from bases 0.7-0.8 μ in diameter to reach a maximum height of 3.5 μ.
They are clearly longest in the equatorial, interradial regions, and shortest in the dis-
tally subequatorial radial areas. This distribution of ornament is reminiscent of that in
Diatomozonotriletes, although reduction of ornament distally is more extreme in that genus.

The sharply triangular outline, labrate laesurae and spine shape are close to features
shown by *D. uncinatus*. That species has only been reported previously from stratigraphic
intervals equivalent to Stage 5; this Tasmanian record, from the top of the Lower
Freshwater Sequence, is from basal Stage 4. Price (1983) however, noted that acanthine
trilete forms occur in pre-Stage 5 sediments in some Queensland basins. These specimens
have a sharply delineated proximal face, which Price (pers. comm., 1983) suggests repre-
sents a difference from *D. uncinatus*, which bears reduced spines proximally. The
Tasmanian specimen may thus be conspecific with those reported, but as yet undescribed,
from Queensland Stage 3 and 4 sequences.
Dimensions: Equatorial diameter 36 μ.

Didecitriletes sp. cf. *D. eoericiana* (Anderson) comb. nov.

Plate 3, fig. 5

cf. *Microbaculispora eoericiana* Anderson, 1977, p.150, pl.55, figs 7-20.

Remarks: Only two torn specimens of this distinctive type were observed. The surface
ornament consists of two separate elements; there are spines, on average 4.5 μ long, taper-
ing smoothly to an acute tip, which are interspersed with baculae 1.0 μ high, 0.3-0.4 μ
in basal diameter, and blunt-tipped. From the fragmented specimens available, it is appar-
ent that the proximal face is smooth. Although the preservational state of the specimens
precludes precise identification, the available morphological data suggest that the
species is very close to *Microbaculispora eoericiana*, which Anderson (1977) described from
the Lower Ecca in South Africa, from an interval not far above the Dwyka Tillite. The
Tasmanian specimens were recovered from the top of the Lower Freshwater Sequence.

Genus *Granulatisporites* Ibrahim emend Potonié & Kremp, 1954

Granulatisporites sp. cf. *G. micronodosa* Balme & Hennelly, 1956

Plate 3, fig. 1

cf. *Granulatisporites micronodosus* Balme & Hennelly, 1956, p.245, pl.1, figs 9,10.

Remarks: Specimens included here are rounded triangular, deeply convex-sided in equatorial
view, with a distal ornament consisting of steep or parallel-sided processes, most of which
can be classified as baculae. In the figured specimen, distal processes are 1.0-1.2 μ high,
and 0.3-0.5 μ in basal diameter; they are spaced 1.0-1.5 μ apart, and are not confluent at
their bases. In the latter feature they differ from superficially similar forms which fall
within the range of *Verrucosisporites pseudoreticulatus*, representing a variant of that
species with steep-sided processes.

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The forms compared here to *G. micronodosa* are distinguished by their baculate distal processes; they differ from forms compared to *G. micronodosa* by Truswell (1978, p.23, pl.1, figs 15,16) in this feature and in being convex-sided. They were recorded throughout the Upper Marine Sequence.

Dimensions: Equatorial diameter 43-55 μ (based on 5 specimens from sample MFP 7765).

Monolete spores

Genus *Polypodiisporites* Potonié emend Khan & Martin, 1971

Polypodiisporites leopardus (Balme & Hennelly) Foster, 1975

Plate 2, fig. 7

For synonymy see Foster 1979, p.61.

Remarks: The presence of this species is noted here as there appears to be some uncertainty about its stratigraphic range elsewhere. In the Douglas River borehole it occurs throughout the Upper Marine Sequence in low frequencies. Previously published accounts suggest that it may be confined to the Early Permian. It was initially described from the Greta Coal Measures (Balme & Hennelly 1956) and was at that time recorded also from the Mersey Coal Measures at Tarleton and Illamatha. Recent studies in Queensland Basins have tended to reinforce the impression that the species may be restricted in its range; Foster (1979), for instance, reported the species as common in the Blair Athol Coal Measures (Stage 4) and suggested that rare specimens in the younger Baralaba Coal Measures might be reworked; Rigby & Hekel (1977) noted only a single specimen in the Black Alley Shale. The results of the present study indicate that, in Tasmania at least, the form has a range from probably Stage 3b through Stage 5.

Dimensions: Grain length 33-41 μ; width 28-33 μ (based on 5 specimens from sample MFP 7748).

Genus *Thymospora* Wilson & Venkatachala emend Alpern & Doubinger, 1973

Thymospora cicatricosa (Balme & Hennelly) Hart, 1965

Plate 3, figs 2, 3

For synonymy see Foster 1979, p.62.

Remarks: The figured specimen, which distally carries rugulate elements bearing recurved, acute spines at intervals, closely resembles the trilete form of this normally monolete species which was figured by Foster (1979, pl.19, fig.6). The distal ornament is identical to that of monolete specimens observed in the same sample, MFP 7748, from the Upper Marine Sequence. The proximal face is smooth in both morphotypes.

The occurrence and possible stratigraphic significance of these trilete variants has been discussed by Price (1983), who assigned the trilete forms to *Apiculatisporis cornutus* Balme & Hennelly; these forms bear the cicatricose, cristate, biform sculptural elements of *T. cicatricosa*, however, and are probably best retained within that species. According to Price, they appear late in Stage 3 just before the level where the monolete forms appear in Queensland sequences. The monolete forms define the lower boundary of Stage 4 (Price, in Kemp *et al*. 1977). In the Douglas River sequence both trilete and monolete forms appear first in sample MFP 7748, near the top of the basal member of the Upper Marine Sequence. The trilete types were present in this sample only; younger occurrences, in the upper part of the Upper Marine Sequence, were of monolete types only.

In the course of the present study, slides containing the type specimen of *T. cicatricosa*, from the Greta Seam, Hebburn No.2 Colliery, were examined. Both trilete and monolete morphotypes were observed to be present.

Dimensions: Grain length 34-39 μ, width 22-27 μ (5 specimens); diameter of trilete forms 34, 35 μ (2 specimens): based on specimens from sample MFP 7748.

Monosaccate pollen

Genus *Bascanisporites* Balme & Hennelly, 1956

Bascanisporites sp. cf. *B. undosus* Balme & Hennelly

Plate 3, fig. 8

cf. *Bascanisporites undosus* Balme & Hennelly, 1956, p.256, pl.10, figs 81-83.

Remarks: Two specimens from the lower member of the Upper Marine Sequence are placed in comparison only with *B. undosus*, as no corpus could be discerned in them. In other features, such as the lobate outline of the equatorial sacci, and the presence of a small trilete tetrad scar, the forms are close to *B. undosus*. Specimens from samples higher in the sequence do show an inner body but only indistinctly.
Dimensions: Equatorial diameter 49, 55 µ (2 specimens from sample MFP 7748).

Genus *Crucisaccites* Lele & Maithy, 1964

?Crucisaccites sp.

Plate 3, figs 6, 7

Remarks: A single, well-preserved specimen found in sample MFP 7748, in the lower member of the Upper Marine Sequence, is possibly referable to *Crucisaccites*. The grain is monosaccate, with the saccus attachment such that an elongate, parallel-sided saccus-free area is present on the proximal face. On the distal face a more vaguely defined area is saccus-free; the saccus roots are arcuate on that face, leaving a near-oval area at the distal pole without saccus development. The infra-reticulum of the saccus has a strong radial component. A monolete tetrad scar is conspicuous on the proximal face.

The form does not appear to have been recorded from Australian sediments before. Assignment to *Crucisaccites* is tentative only as the saccus-free areas on the two sides of the body are not at right angles to each other (see Lele & Maithy 1964, p.307).
Dimensions: Overall breadth 63 µ, corpus breadth 46 µ; overall length 36 µ, corpus length 31 µ; saccus offlap 6 µ.

Genus *Striatoabieites* Zoricheva & Sedova emend Hart, 1964

Striatoabieites richteri (Klaus) Hart, 1965

Plate 3, fig. 9

Synonymy
1955 *Lueckisporites richteri* Klaus, 1.33, fig.1.
1963 *Strotersporites richteri* (Klaus) Wilson, 1962, in Klaus, p.316, pl.15, figs 76,77.
1964 *Striatoabieitites richteri* (Klaus, 1955) Hart, p.1186, text-fig.41.
1965 *Striatoabieitites richteri* (Klaus, 1955) Hart, p.41, text-fig.91.
1979 *Striatoabieitites richteri* (Klaus) Hart, in Balme, p.32, pl.3, figs 19-20.

Remarks: Specimens examined in the present study, from the Upper Marine Sequence, are characterised by 18-20 fine proximal taeniae (which frequently show subsidiary clefts), by a clearly discernible, geniculate tetrad scar, and by distally pendant, hemispherical sacci with a fine infra-reticulum. They are morphologically very close to Klaus' (1955) type material from the German Zechstein, and to specimens identified with *S. richteri* by Balme (1979) from Late Permian and Early Triassic strata at Kap Stosch, Greenland. The northern hemisphere records indicate that the form does not appear before the Late Permian. The Tasmanian record is the first for Australia.
Dimensions: Overall breadth 72, 84 µ; corpus breadth 43, 45 µ; saccus breadth 22-29 µ; corpus length 29, 34 µ; saccus length 29-33 µ (based on 2 specimens from sample MFP 7748, Upper Marine Sequence).

C.R. Calver, M.J. Clarke and E.M. Truswell

SUMMARY

Lithostratigraphic details of the Douglas River borehole are given. The Late Palaeozoic sequence is surprisingly complete for northeastern Tasmania. The occurrence of *Tasmanites* shale and associated rocks may indicate a narrow, east-west breaching of the land barrier which occupied most of northeastern Tasmania throughout the Tamarian.

Marine macro-invertebrate and palynological distributions are documented. The marine faunas indicate that the sequence ranges in age from Early Tamarian (Late Carboniferous) to Late Lymingtonian (Late Permian). The microfloras are assigned to Stages 2-5. Some acritarchs which occur low in the sequence may have been derived from earlier Palaeozoic rocks; others, which occur in swarm proportions higher up, are coeval with sedimentation. Tasmanian Late Permian palynofloras lack diversity and resemble those from the Trans-antarctic Mountains, Antarctica, rather than those from elsewhere in eastern Australia. The German Late Permian Zechstein species *Striatoabieites richteri* (Klaus) is recorded from Australia for the first time.

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PLATE 1   (on page 158)

All magnifications × 900. Co-ordinates are those of the Leitz Orthplan
microscope 895191 in the Bureau of Mineral Resources, Canberra.

Fig. 1   *Ulanisphaeridium berryense* McMinn, 1982. CPC 24623. Slide MFP 7765/4:
          95.5, 38.9

Fig. 2   *Veryhachium* sp. A of Foster, 1979. CPC 24624. Slide MFP 7765.

Fig. 3   *?Dilatosphaera* sp. CPC 24625. Slide MFP 7771/1:96.0, 33.5

Fig. 4   *Elektoriskos* sp. CPC 24626. Slide MFP 7765/3: 101.2, 47.2.

Fig. 5   *Gorgonisphaeridium* sp. CPC 24627. Slide MFP 7747/2:94.2, 43.5.

Figs 6, 7 *Baltisphaeridium* sp. 6: CPC 24628. Slide MFP 7771/1:92.2, 33.0.
          7: CPC 24629. Slide MFP 7771/1:206.4, 31.5.

Figs 8-10 *Veryhachium* sp. cf. *V. ?riburgense* Brosius & Bitterli.
          8: CPC 24630. Slide 7750/3:97.0, 38.1.
          9: CPC 24631. Slide 7750/3:96.4, 33.5.
          10: CPC 24632. Slide MFP 7750/3:95.1, 38.8.

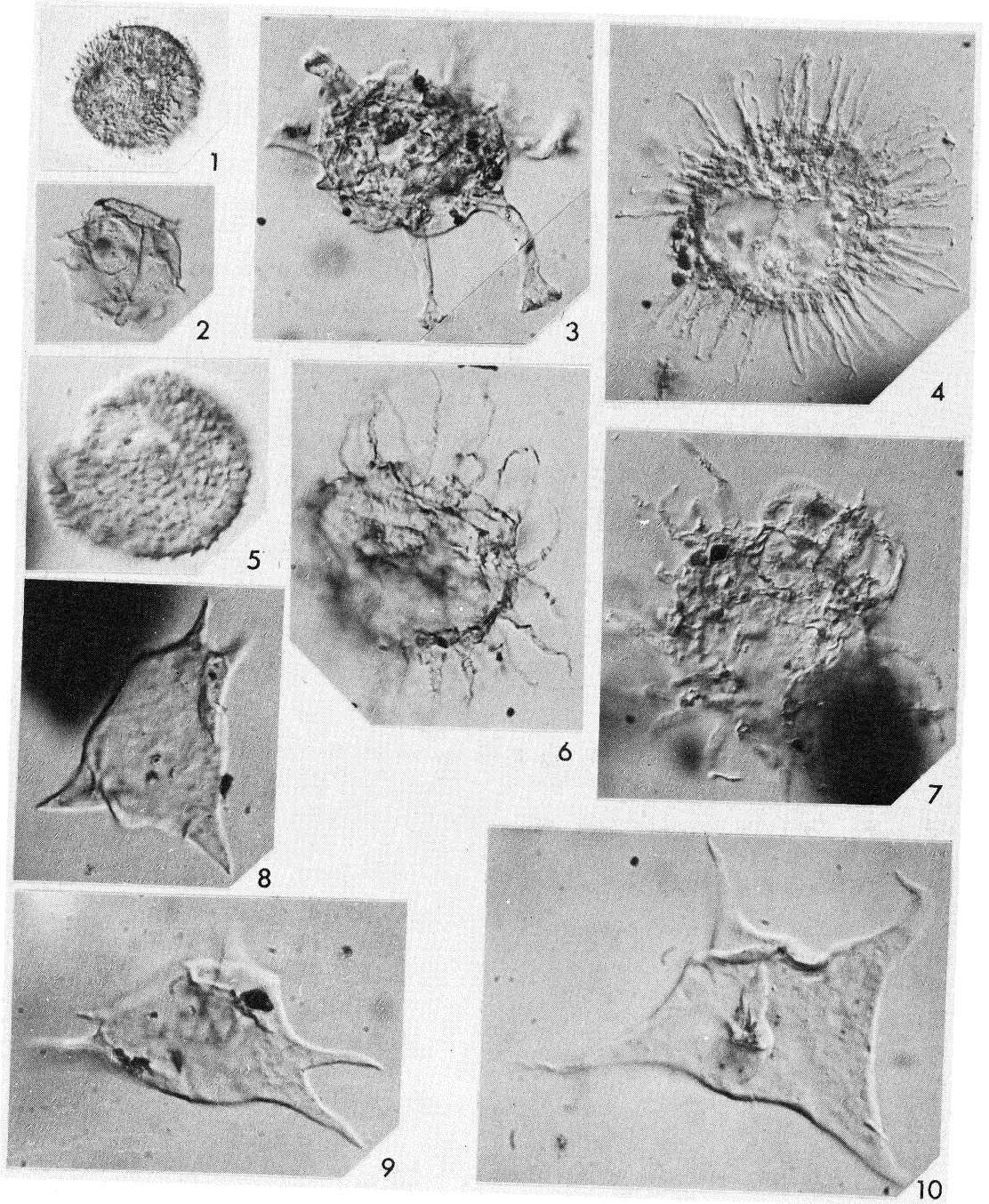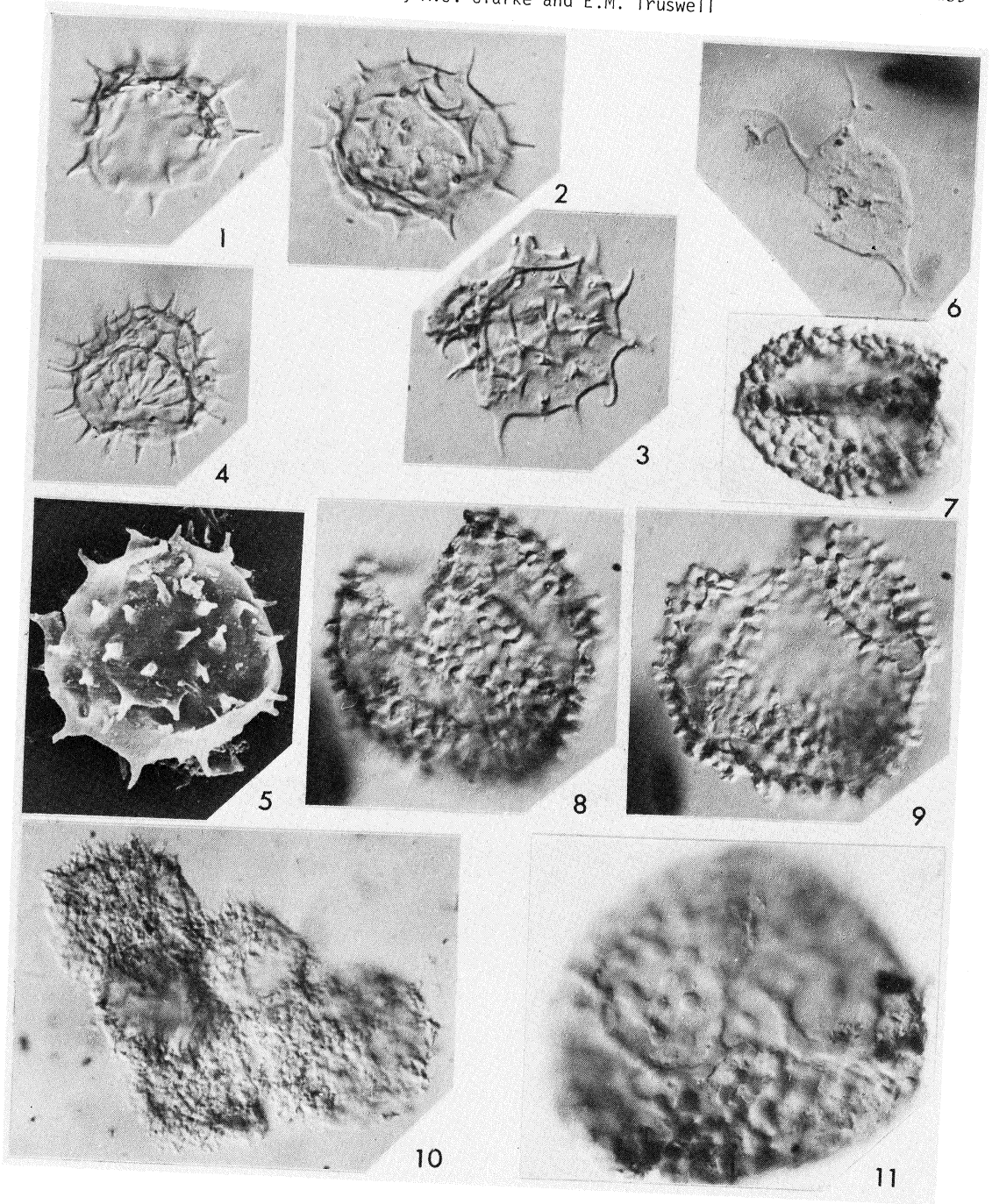Late Palaeozoic Borehole Section at Douglas River, Tasmania

PLATE 1

PLATE 2

Late Palaeozoic Borehole Section at Douglas River, Tasmania

PLATE 2   (on page 159)

All magnifications × 900 unless stated otherwise.

Figs 1-3, 5   *Michrystridium* sp. A.   1: CPC 24633. Slide MFP 7765/4:99.7, 30.5.
2: CPC 24634. Slide MFP 7765/4:110.0, 29.9.
3: CPC 24635. Slide MFP 7765/4:105.5, 30.2
5: Scanning electron micrograph, × 1080. CPC 24636. MFP 7765.

Fig. 4   *Michrystridium* sp. B. CPC 24637. Slide MFP 7765/3:99.2, 43.0.

Fig. 6   *Veryhachium* sp. B. CPC 24638. Slide MFP 7750/3:98.3, 37.1.

Fig. 7   *Polypodiisporites leopardus* (Balme & Hennelly) Foster, 1975.
CPC 24639. Slide MFP 7748/3:110.2, 26.7.

Figs 8, 9   *Gorgonisphaeridium* sp. cf. *G.* sp. A of Truswell, 1978.
CPC 24640. Slide MFP 7770/4:105.2, 31.6. High and median foci.

Fig. 10   *Brazilea* sp. CPC 24641. Slide MFP 7747/2:101.3, 41.5.

Fig. 11   *Camptotriletes biornatus* Balme & Hennelly, 1956. CPC 24642.
Slide 7765/4:107.7, 44.1. Distal aspect.

PLATE 3 (opposite)

All magnifications × 900.

Fig. 1   *Granulatisporites* sp. cf. *G. micronodosa* Balme & Hennelly, 1956.
CPC 24643. Slide MFP 7765/3:103.8, 36.5 Equatorial aspect.

Fig. 2, 3   *Thymospora cicatricosa* (Balme & Hennelly) Hart, 1965. CPC 24644.
Slide MFP 7748/2:93.5, 36.6. Proximal and distal foci on trilete form.

Fig. 4   *Didecitrilites* sp. cf. *D. uncinatus* (Balme & Hennelly) Venkatachala & Kar,
1965. CPC 24645. Slide MFP 7765/2:101.4, 37.0

Fig. 5   *Didecitrilites* sp. cf. *D. eoericiana* (Anderson) comb. nov. CPC 24646.
Slide MFP 7765/4:102.5, 45.2. Torn specimen.

Fig. 6, 7   *?Crucisaccites* sp. CPC 24647. Slide MFP 7748/4:104.7, 38.5. Proximal
and distal foci.

Fig. 8   *Bascanisporites* sp. cf. *B. undosus* Balme & Hennelly, 1956. CPC 24647.
Slide MFP 7748/2:96.0, 41.4.

Fig. 9   *Striatoabieites richteri* (Klaus) Hart, 1965. CPC 24648.
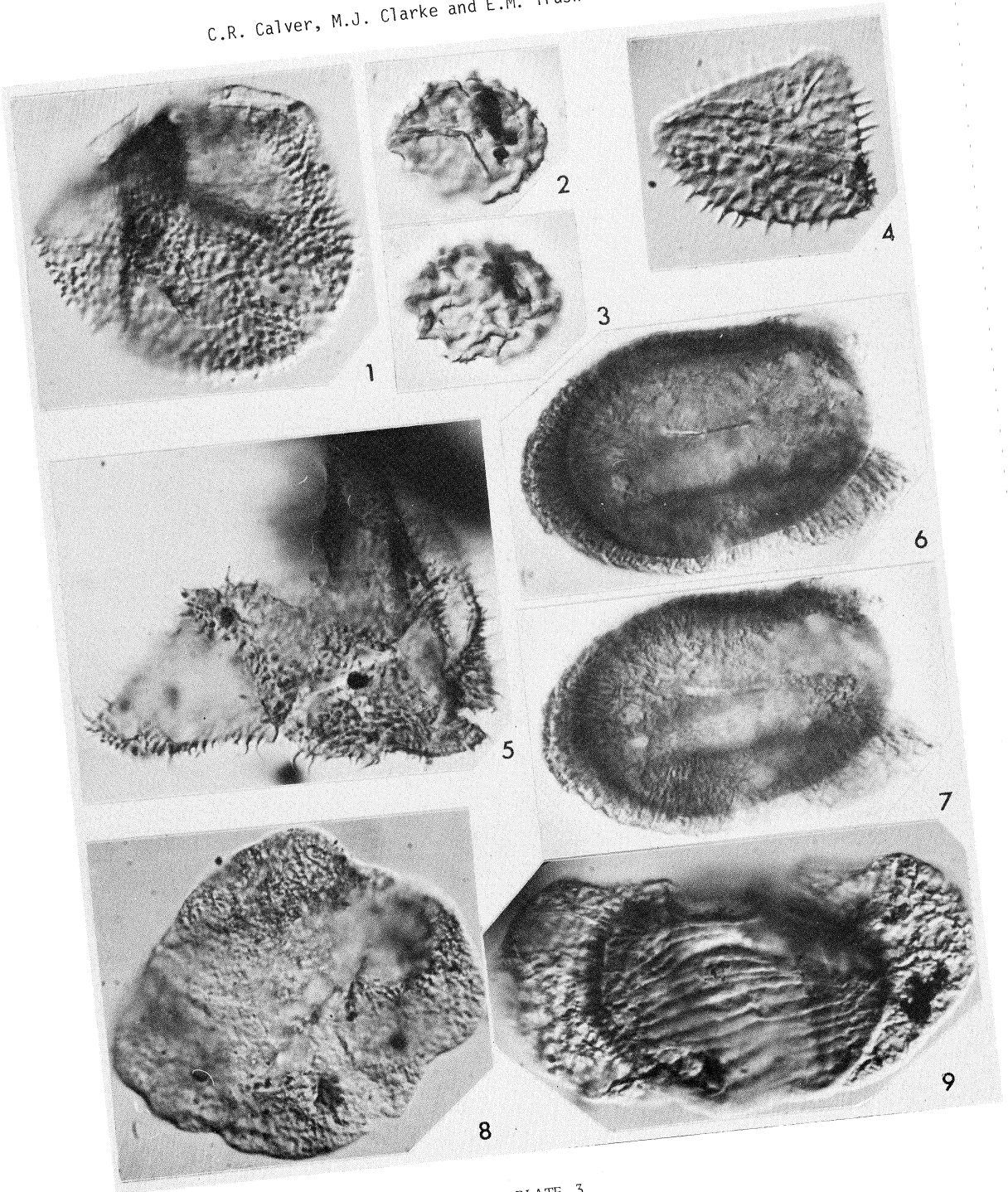Slide MFP 7748/3:95.5, 28.5.

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PLATE 3