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PALYNOLOGY OF MARINE LOWER CRETACEOUS STRATA IN THE NORTHERN AND EASTERN EROMANGA BASIN, QUEENSLAND.

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ABSTRACT

Detailed systematic palynology of shallow holes, drilled in the Aptian and Albian sequence of the Tambo, Longreach and Richmond 1:250,000 Sheet areas, is undertaken as a contribution to the comparative study of the palynostratigraphy in the Cretaceous of the Eromanga Basin and the Surat Basin, Queensland.

The stratigraphic sequence penetrated comprises the Wallumbilla Formation, Toolebuc Limestone, Allaru Mudstone and basal Mackunda Formation, belonging to the Cretaceous Rolling Downs Group.

Palynological units K 1b-c, K 1d, K 2a+ are identified in the microfloral assemblages; and new evidence is uncovered, suggesting parallel time relationship between lithostratigraphy and spore zonation in the Lower Cretaceous sequence of the central and eastern Queensland area.

INTRODUCTION AND STRATIGRAPHY

Shallow holes, drilled by the Bureau of Mineral Resources for subsurface information on lithology and paleontology and selected for this study, penetrate limited portions of the Cretaceous sequence close to the outcrop margin of the Eromanga Basin over large distances (Figure 1). The total of these sections combined gives a fairly adequate coverage of most of the Rolling Downs Group in the northern and northeastern part of the Basin.

Vine et al. (1967) briefly discuss the history of the nomenclature for the Cretaceous strata; they maintain the name Rolling Downs Group of Whitehouse (1954) and give a summary of the nomenclature of the rock units within the Group. The formations identified in the sections of the shallow holes are represented in Table 1.

TABLE 1 : STRATIGRAPHIC NOMENCLATURE

<table>
<tr><th>Richmond</th><th></th><th>Longreach Tambo</th></tr>
<tr><td colspan="3">M A C K U N D A F O R M A T I O N</td></tr>
<tr><td colspan="3">A L L A R U M U D S T O N E</td></tr>
<tr><td colspan="3">T O O L E B U C L I M E S T O N E</td></tr>
<tr><td>Ranmoor Member</td><td rowspan="3">WALLUMBILLA FORMATION</td><td>Coreena Member</td></tr>
<tr><td>Jones Valley Mbr.</td><td rowspan="2">Doncaster Member</td></tr>
<tr><td>Doncaster Member</td></tr>
</table>

Richmond No. 1 was spudded in the Ranmoor Member, penetrated the Jones Valley Member from 130 to 147 feet and the Doncaster Member to 280 feet.

Richmond No. 2 was spudded in the Jones Valley Member and penetrated the Doncaster Member to 260 feet.

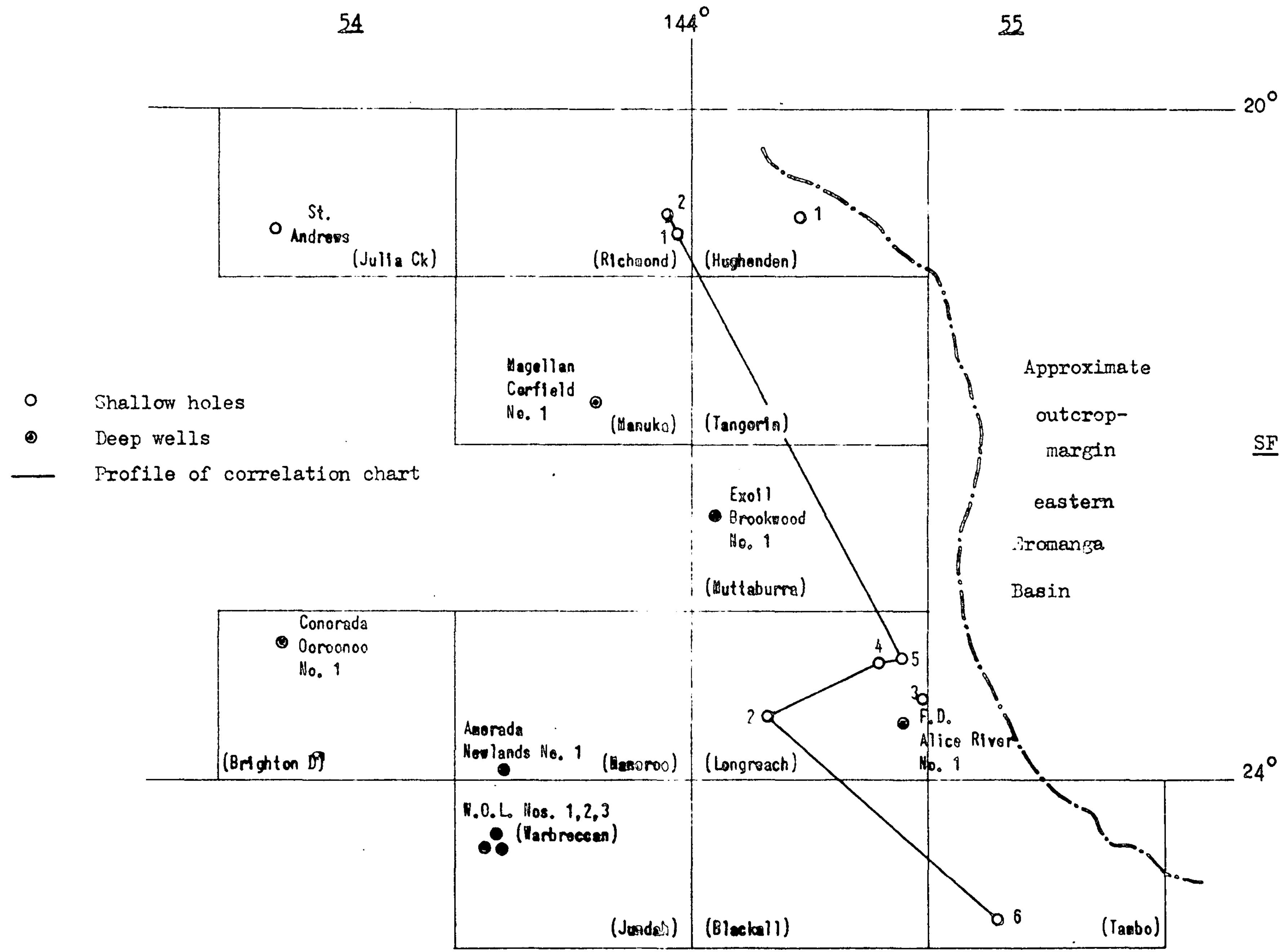


FIGURE I : WELL LOCATION MAP

Longreach No. 2 penetrated the Mackunda Formation from surface to 87 feet and the Allaru Mudstone to 164 feet.

Longreach No. 4 penetrated the Allaru Mudstone from surface to 299 feet.

Longreach No. 5 was spudded in the Allaru Mudstone, penetrated the Toolebuc Limestone from 92 to 99 feet and the Coreena Member to 147 feet.

Tambo No. 6 was drilled into the Allaru Mudstone from surface to approximately 120 feet. Between 120 and 150 feet argillaceous sediments occur which are correlated with the Toolebuc Limestone.

Schematic representation of these profiles in the correlation diagram of Figure 4 shows the positions of the successfully investigated samples and the sections of the sedimentary column in which each spore unit is identified.

Virtually continuous coring of the Longreach and Richmond bores enabled, by selecting closely spaced samples, to investigate critical intervals on palynology in great detail. Particular attention was paid to the age of the Jones Valley Member and the previously little known succession of microfloras in the interval of the K 2 units in the Great Artesian Basin.

Data of samples concerning stratigraphic position, depth below surface and catalogue number (MFP) in the B.M.R. palynological collection are listed in Table 2.

Marine Aptian and Albian fossils have been collected from the Wallumbilla Formation, whereby a sharp distinction between Aptian and Albian faunas was noticed in the Tambo area, close to the boundary between Doncaster and Coreena Members, and in the Hughenden area near the boundary between Jones Valley and Ranmoor Members (Vine & Day 1965, Day 1967, Vine et al. 1967).

Marine Albian fossils are also recovered from the Toolebuc Limestone, Allaru Mudstone and Mackunda Formation (Vine & Day 1965, Vine et al. 1967).

Sufficient data have been discovered in the course of regional field mapping to give some ideas about the history of the paleogeography in the area. Marine environments predominated during sedimentation of the formations; while paralic conditions are accepted for part of the Mackunda Formation (Vine & Day 1965).

Except for the Winton Formation in the central and northern Eromanga Basin, terrestrial rock types have only been mapped in the Coreena Member from the Tambo and Augathella areas (Exon et al. 1966). Regressive conditions during these times are confirmed by the limited lateral extent of the Toolebuc Limestone, which is not known in outcrop south of Latitude 25°20' S. and is not continuous in subsurface east of Enniskillen Anticline (western Tambo Sheet area). Terrestrial deposits known from various localities in the upper Coreena Member beyond the limits of the limestone deposition and conformably overlain by the Allaru Mudstone are considered to be stratigraphically equivalent to the Toolebuc Limestone (Exon et al. 1966).

Exon et al. suggest the possibility of a sudden temperature increase in the area, where shallow conditions prevailed. Connection with the open ocean was limited, so that higher evaporation went together with the precipitation of carbonates. Marine faunas of the Toolebuc are poor in variation, which points to unfavourable conditions of life.

It is our opinion that the forming of limestone without simultaneous precipitation of NaCl and associated evaporites (only minor quantities of gypsum have been found) can be explained by assuming a considerable supply of calcareous freshwater.

Regarding the conditions suggested for the forming of the carbonates it is highly probable that the Toolebuc Limestone constitutes a time-concordant horizon in the Lower Cretaceous rock sequence. Time equivalence of immediately underlying strata (i.e. the upper parts of the Ranmoor Member and the Coreena Member) is mentioned below in connection with zonations in the spore sequence.

Microplankton information discussed on page 16 corroborates the paleogeographic history of the area as compiled from the above evidence

PALYNOLOGY

General spore distribution

The combined results of systematic palynology of selected samples from B.M.R. Scout Holes in the Eromanga Basin, listed in Table 2, are represented in Tables 3 to 7. Each Table shows the distribution of microspores in one of the bore holes. The spore assemblages extracted from the samples are set out in stratigraphic order against the lithology of the penetrated section, giving the palynological age of each sample.

Many spore types that are continuously encountered in Jurassic and Cretaceous strata from Australia are not mentioned. Only those spores and pollen grains were selected for this report that have stratigraphic significance. The vertical distribution of each type within the sampled interval of the Rolling Downs Group, combined from the separate sections and supplemented with previous observations from other areas in Queensland, is given in the slightly schematic spore distribution diagram of Figure 2.

As the spore types are arranged in order of first and last appearance, certain horizons come out clearly as breaks in the succession of spore assemblages. Some horizons have in fact been widely recognized in the Lower Cretaceous from the eastern Australian region (Dettmann 1963, Evans 1966-a).

Spore units and Dinoflagellate Zones, established by Evans (1966-a,c) were identified and are discussed below in the light of the information following from the present study. Time relationship between spore units and microplankton zones appears to be similar to that postulated by Evans (1966-c) for the northern Queensland - Papuan area.

Additional data from previously studied subsurface material, collected from the Jundah, Maneroo, Brighton Downs, Muttaburra and Julia Creek Sheet areas (Figure 1) are taken into account, as they provide confirmation of the palynostratigraphy that emerges from the present investigation. Data from the following boreholes are specified in the text and annotated separately in the spore distribution diagram of Figure 2.

Deep wells:	Magellan Corfield No. 1 Conorada Ooroonoo No. 1 Exoil Brookwood No. 1 F.D. Alice River No. 1 A.A.P. Mayneside No. 1 Amerada Newlands No. 1 W.O.L. Nos. 1,2,3 (Warbreccan) A.A.O. No. 8 (Karumba)
BMR Scout :	Hughenden No. 1 Longreach No. 3 Augathella No. 3 Mitchell Nos. 7, 8, 10
Water bore:	St. Andrews RN 14338

Some of these data have little significance by themselves, but they are important in the scheme of microfloral distribution in time, and widely extend lateral control of the palynological zonation in the Great Artesian Basin.

Remote sections from Mornington Island, Gulf of Carpentaria, and the Mitchell Sheet area are considered but their locations are not added in Figure 1.

Palynological units.

Spore units K 1b-c.

K 1b-c microfloras have repeatedly been recovered from basal marine Cretaceous strata; among others in the "Lower Wilgunya Formation" of St. Andrews bore (Evans in Vine & Jauncey 1962) and W.O.L. No. 2 (Warbreccan) (Evans 1966-d); in the Doncaster Member of the Mitchell Sheet area (Burger in Exon et. al. 1967); in the basal Wallumbilla Formation of BMR Hughenden No. 1 (Evans, in prep.).

TABLE 2 : COMPARISON OF LITHOSTRATIGRAPHY AND SPORE ZONATION

Bore	(MFP)	Depth	FORMATION/Member	Spore unit	
Longreach No. 2	4573	61'	MACKUNDA	K 2	
	4607	81'2"	"	"	
	4575	122'2"	ALLARU	"	M3
	4576	163'7"	"	"	
Longreach No. 4	4571	80'11"	ALLARU	K 2	M3?
	4569	150'	"	"	M3
	4546	224'4"	"	"	"
	4547	250'	"	"	"
	4548	273'	"	"	"
	4549	297'	"	"	"
Tambo No. 6	4379	123'5"	TOOLEBUC/ALLARU	K 2a	M
	4380	133'4"	TOOLEBUC	"	M
Longreach No. 5	4550	95'2"	TOOLEBUC	K 2a	M3
	4564	98'11"	"	"	"
	4565	120'8"	Coreena	"	"
	4608	136'4"	"	K 2(a?)	"
Richmond No. 1	4609	113'2"	Ranmoor	K 1d	M2
	4583	120'	"	K 1(d?)	M2?
	4610	124'8"	"	K 1b-c	M
	4584	139'11"	Jones Valley	"	M
	4585	160'	Doncaster	"	M1
	4587	240'	"	"	"
	4588	278'3"	"	"	"
Richmond No. 2	4578	110'	Doncaster	K 1b-c	M1
	4579	160'	"	"	"
	4580	208'	"	"	"
	4581	257'	"	"	"

Microplankton: M3 - <u>Odontochitina operculata</u> Zone
2 - <u>Muderongia tetracantha/O. operc.</u> "
1 - <u>Dingodinium cerviculum</u> "

The units are defined as occurring in the interval between the last occurrence of Murospora florida and the first appearance of Crybelosporites striatus. This interval coincides with the lower part of the Speciosus Assemblage (Dettmann 1963) and was recognized in the Doncaster and the Jones Valley Members in Richmond Nos. 1 and 2 (Tables 3 and 4).

From the present investigation a satisfactory definition of units K 1b-c, grounded on more positive data could not be derived. The most common of the selected spores are Cicatricosisporites australiensis, Lycopodiumsporites spp., Pilosisporites notensis, Cyclosporites hughesi. Other types such as Rouseisporites reticulatus, Crybelosporites punctatus, Contignisporites multimuratus, Aequitriradites spp., Dictyotosporites speciosus, Dictyophyllidites crenatus, Foraminisporis asymmetricus, which are known to extend at least as far downwards as the base of the marine Cretaceous in Queensland, were very scarce. There was no trace of Balmeisporites holodictyus, Kraeuselisporites linearis, Leptolepidites major, known from basal marine Cretaceous and partly from older horizons, and their equivalents elsewhere in eastern Australia (Dettmann 1963).

From samples no. 4584 and 4610 (Richmond No. 1, Table 4) sufficiently rich microfloras were extracted to identify K 1b-c also in the Jones Valley and basal Ranmoor Members.

Throughout the whole interval no significant changes in the succession of microfloras were noticed. Osmundacidites cf. mollis was present in most slides, but the levels of first and last appearance in Queensland are still uncertain. Dettmann reports this spore in microfloras that also contain Crybelosporites striatus (Robe Bore No. 1) and therefore are of K 1d age. Unfortunately the interval that produces K 1d microfloras was very poorly sampled, as shown in Figure 4. O. cf. mollis may be restricted to units K 1b-c and K 1d as it was not present in the younger assemblages.

Spore unit K 1d.

Unit K 1d is characterized by the first appearance of Crybelosporites striatus (Evans 1966-a). The earliest occurrence of the spore was reported by Evans in the "Lower Wilgunya Formation" of Ooroonoo No. 1, Eromanga Basin, and in "post-Roma" strata in the Surat Basin. The unit was subsequently recognized in pre-Toolebuc horizons of St. Andrews bore (re-examination of samples, MFP 1915; depth 580 feet) and in the Coreena Member of BMR Mitchell No. 8.

More detailed information was obtained from BMR Mitchell No. 10, where the base of the Coreena Member was recognized at 270 feet. Cores 5 (150') and 6 (272' and 281') were reported to yield K 1b-c microfloras, while core 4 (83'6") produced K 1d spores (Burger in Exon et al. 1967).

K 1d microfloras were identified in the Ranmoor Member of Richmond No. 1 (Table 4). In sample no. 4583 Crybelosporites striatus was not identified beyond doubt, but sample no. 4609, seven feet higher, yielded both C. striatus and Cyclosporites hughesi, although preservation was poor. Apparently the interval of K 1d reached further downwards than was previously assumed. The incongruous results required checking of the palynological age of core 5 from Mitchell No. 10. Three samples from the following levels: 150'3-4"; 158'9-10"; 159', produced very poor microfloras. Crybelosporites striatus was encountered in level 159'.

This means a considerable downwards extension of the K 1d interval in Mitchell No. 10. Consequently, the earliest K 1d microfloras can not only be expected from basal Ranmoor horizons in the northern Eromanga Basin but also from the basal Coreena as far southeast as the Mitchell area.

Palynology appears to confirm paleontological and stratigraphic correlation of the Jones Valley Member (Richmond area) as the equivalent of the uppermost Doncaster Member (Longreach and Mitchell areas).

No major changes were observed in the spore succession. Besides C. striatus, unit K 1d seems to mark the first appearance of Pilosisporites parvispinosus, which is fairly rare in the Lower Cretaceous of the Eromanga Basin. Dettmann reports the spore from the upper part of her Speciosus Assemblage and the Paradoxa Assemblage.

Osmundacidites cf. mollis seems to disappear as C. striatus is introduced; in the Surat area however the two spores were found together in post-Doncaster strata (Burger, in prep.).

Spore units K 2a+

Microfloras of K 2 age are mainly characterized by Coptospora paradoxa (Evans 1966-a) and have been identified from post-Toolebuc formations in Queensland. In the interval of the K 2 floras, coinciding with the Paradoxa Assemblage (Dettmann 1963), Evans (1966-b) distinguished unit K 2a by the co-occurrence of C. paradoxa and Dictyotosporites speciosus; and unit K 2b, the top of which was marked by the first appearance of angiospermous tricolpate pollen grains.

The zonation within the succession of the K 2 microfloras in the Eromanga Basin is less clear, due to scattered information from locations spread over large areas. Evans (1966-d) reports K 2b microfloras throughout the "Upper Wilgunya Formation" in the W.O.L. Warbreccan wells, and the earliest angiospermous pollen grains from Cretaceous "fresh water" sequences in Ooroonoo No. 1 and from the Winton Formation in W.O.L. No. 1 (Warbreccan).

The present study shows that Coptospora paradoxa occurs in pre-Toolebuc horizons of Longreach No. 5 (MFP 4608, 4565, Table 5). The maximum downwards extension of this spore could not accurately be established because of lack of samples, but the presence of Cyclosporites hughesi in both samples strongly suggests a basal K 2 age. Although Dettmann does not report this type in the Paradoxa microfloras at all, slight overlap of the ranges of C. paradoxa and C. hughesi were also noticed in the Surat Sheet area (Burger, in prep.).

Dictyotosporites speciosus has not been reported from post-Toolebuc formations before. Its probable occurrence in what is considered as the correlate of the Toolebuc Limestone of Tambo No. 6 (sample no. 4379, Table 5) seems to restrict unit K 2a to the upper Coreena - Toolebuc strata.

The first angiospermous pollen grains appear in the uppermost Toolebuc Limestone correlate of Tambo No. 6 (MFP 4379) and form a minor but persistent part in younger assemblages, while they become relatively abundant in the Winton Formation. The vertical distribution of various types of angiosperms is being studied in detail at the present time.

It is not possible to maintain Evans' spore unit K 2b as a workable unit in the central and northern Queensland area. Additional information is required for a valuable subdivision of the K 2 units. Here new spore types draw attention in the Allaru - Mackunda interval that may prove to be of stratigraphic significance.

The appearance of Coptospora paradoxa marks an important horizon in Figure 2. Spores as Rouseisporites radiatus, Cicatricosisporites n. sp., Kraeuselisporites majus, Lycopodiacidites ambifoveolatus (*), Microfoveolatosporis canaliculatus, Peromonolites peroreticulatus (*), Trilobosporites trioreticulosus, Laevigatosporites ovatus, occur as early as the upper part of the Coreena Member (Longreach No. 5, Table 5), but do not seem to occur in K 1d microfloras. Study of the Coreena Member in the Mitchell and Surat Sheet areas suggest the possibility of a slightly further downwards extension of Rouseisporites radiatus and Lycopodiacidites ambifoveolatus, which nevertheless does not diminish the importance of the sudden change in the spore sequence. Spores marked with (*) were not reported before from the Australian region.

At the boundary of Toolebuc Limestone and Allaru Mudstone Plicatella spp., Pilosisporites grandis, and various types of tricolpate pollen grains are introduced, while Coronatispora perforata disappears. Plicatella sp. was also reported from one pre-Toolebuc horizon in Ooroonoo No. 1 (Evans 1961).

Common spores in the Allaru Mudstone of Longreach No. 4 (Table 6) are: Cicatricosisporites australiensis, Foraminisporis asymmetricus, Crybelosporites striatus, Laevigatosporites ovatus. Rare but persistent spores are: Plicatella spp., (predominantly P. tricornitata), Cicatricosisporites hughesi, Kraeuselisporites majus, Coptospora paradoxa, Trilites cf. tuberculiformis, Microfoveolatosporis canaliculatus. Angiosperms were recovered from samples 4549, 4548, 4547 and 4546.

Rare spores, until now only reported from K 2 microfloras are: Cicatricosisporites n. sp., Rouseisporites radiatus, Peromonolites peroreticulatus, Trilobosporites trioreticulosus, Pilosisporites grandis.

One probably significant horizon is marked in the Allaru Mudstone of Longreach No. 4 by the first occurrence of Ephedripites spp. and the more or less simultaneous disappearance of Contignisporites multimuratus and Dictyophyllidites crenatus, two types of which Dettmann restricted the highest occurrence to the lower Paradoxa Assemblage. Ephedripites spp. is scarce in the Allaru - Mackunda interval but becomes persistent in the Winton Formation. The (probable) presence of Couperisporites tabulatus in Longreach No. 4 (MFP 4569) means an upwards extension of the range given in Dettmann (1963) (possible recycling?).

No major alterations occur in the spore sequence near the contact between the Allaru Mudstone and the overlying Mackunda Formation (Longreach No. 2, Table 7). Peromonolites peroreticulatus and the angiosperms increase in proportion, while Lycopodiumsporites rosewoodensis does not occur in the Mackunda Formation. The poor quality of the microflora from sample no. 4573 prevented closer study of various not previously reported spores, such as Taurocusporites sp., possible new types of psilatrilete spores, cf. Stereisporites sp. Future study of Mackunda and Winton sections should disclose eventual stratigraphic merits of these types.

Spores occurring in association with C. paradoxa, but not mentioned by Dettmann in the Paradoxa Assemblage are: Contignisporites cooksonii, C. multimuratus. Lycopodiumsporites circolumenus is known from microfloras as high as the Winton Formation from various BMR Scout Holes and from W.O.L. No. 1 (Warbreccan).

SUMMARIZING: In the interval of the K 2 microfloras in the Longreach and Tambo Scout Holes a threefold division is detected: a lower division (A-1), characterized by the first appearance of Coptospora paradoxa, Microfoveolatosporis canaliculatus, possibly Trilobosporites trioreticulosus, and the last occurrence of Dictyotosporites speciosus, Cyclosporites hughesi and possibly also Coronatispora perforata. This interval was defined as spore unit K 2a by Evans (1966-b) and recognized in the Otway Basin, Victoria and S.A.; and the Murray Basin area, N.S.W. The scarcity of D. speciosus in the Cretaceous of Queensland however gives the unit a doubtful value in the spore sequence of the Eromanga Basin.

A middle division (A-2) is characterized by the first appearance of Plicatella spp., and angiospermous pollen grains, coupled with the last occurrence of Dictyophyllidites crenatus, Contignisporites multimuratus, possibly also Couperisporites tabulatus and Lycopodiumsporites rosewoodensis.

An upper division (B) is characterized by the first occurrence of Ephedripites spp. and an apparent increase in the proportion of angiosperms.

The portions of the lithology taken by these divisions are shown in Figure 2. At the present stage they are not regarded as spore units, as lateral control of their stratigraphical value does not exist. Detailed study in the Aptian - Albian of the Surat Basin, being carried out at the present time, will provide more information and enable a comparison of the spore history between the Surat - Mitchell area and the Longreach - Tambo area.

Dinoflagellate Zones.

Fossil micro-organisms, considered as microplankton and indicating marine depositional environments have been subject to extensive study in Australia and elsewhere. They are subdivided into the group of Dinophycae and the group of (incertae sedis) Acritarcha (Downie et al. 1963).

While the first group is almost entirely dependant on marine conditions, the second group includes also fresh water forms. Evans (1966-b) states that "the record of microplankton in Mesozoic sediments in eastern Australia includes several instances where acritarchs occur in the absence of dinoflagellates, and where a marine origin for the sediments may be doubted".

Evans succeeded, by taking information available from various studies (bibliography see Evans 1966-a,b,c) into account, in establishing a succession of Dinoflagellate Zones characterized by selected micro-organisms of limited vertical range. Those Zones recognized in Queensland (Evans 1966-c) are valuable for the interpretation of the microplankton sequence studied in the present report (Figure 2).

Dingodinium cerviculum Zone

Cookson & Eisenack (1958) who described D. cerviculum as a new species noticed already its restricted vertical distribution. This type was subsequently reported in the Great Artesian Basin from basal marine Cretaceous sediments in Ooroonoo No. 1 (Evans 1961); Corfield No. 1 (Evans 1962); St. Andrews Bore (Evans in Vine & Jauncey 1962); A.A.O. No. 8 (Karumba) and D.S. Mornington Island No. 1 (Terpstra & Evans 1962); Birthday Bore, Andado Station (Terpstra & Evans 1963); F.D. Alice River No. 1 (Hodgson in Hare et Ass., 1963); Cabawin No. 1 (Evans in U.K.A. Cabawin No. 1 Well Completion Report 1964); also in the Doncaster Member of some BMR Scout Holes in the Mitchell and Roma areas (not published).

Joint regional field mapping after 1960 in the eastern Eromanga Basin by the Bureau of Mineral Resources and the Geological Survey of Queensland provided a better opportunity for comparative lithological-micropaleontological study of subsurface samples. Evans (1966-e) noticed the identical ranges of spore unit K 1b-c and the D. cerviculum Zone within the "Lower Wilgunya Formation" and subsequently correlated them with the Doncaster Member of the Wallumbilla Formation (Evans 1966-a,c,d), restricting the range of the Zone only to the interval above the range of Scriniodinium attadalense.

The D. cerviculum Zone is recognized in the Doncaster Member, Jones Valley Member and lowermost Ranmoor Member of Richmond Nos. 1 and 2 (Tables 3 and 4). Common types are Muderongia tetracantha, and various species of Hystrichosphaeridium. The following types are scarce in the assemblages: Muderongia mcwhaei, Diconodinium multispinum, Goniaulax edwardsii.

The only change in the microplankton sequence noticed was the first appearance of D. multispinum and G. edwardsii in the higher part of the Doncaster Member. This might prove to be a valuable marker in the interval of the Zone.

Muderongia tetracantha/Odontochitina operculata Zone

Evans noticed from study of Ooroonoo No. 1 and St. Andrews Bore the possible stratigraphical value of Muderongia tetracantha within the range of Odontochitina operculata. He used the overlap in the ranges as a biostratigraphical horizon in the Cretaceous of the Otway Basin (1966-b), Murray Basin area (Evans & Hawkins 1967) and Great Artesian Basin (1966-c,d), and correlated this horizon in many places with spore unit K 1d.

M. tetracantha was recognized in the Doncaster and Ranmoor Members of Richmond Nos. 1 and 2, while fragments of most probably the same species were encountered as high as the upper Coreena Member in Longreach No. 5 (Table 5).

O. operculata was recognized from the basal Ranmoor Member of Richmond No. 1 upwards, so that the overlap of the ranges of both types lies within the Ranmoor/Coreena Member of the Wallumbilla Formation. According to Evans (1966-c) the top of the M.t./O.o. Zone coincides with the contact of units K 1d and K 2a and is therefore accepted as lying slightly below sample no. 4608 (136'4") in Longreach No. 5.

One possibly important phenomenon within the Zone is the overlap of the ranges of Dingodinium cerviculum and O. operculata (Richmond No. 1). This was already noticed from St. Andrews Bore (Evans in Vine & Jauncey 1962) and U.K.A. Cabawin No. 1 (Burger 1968) and seems to be restricted to the lower part of the Coreena/Ranmoor Member, coinciding with the lowermost K 1d microfloras. Continued search on this aspect will be carried out in the future.

Odontochitina operculata Zone

Evans reports the occurrence of O. operculata above the last occurrence of M. tetracantha in the Eromanga Basin from the "Upper Wilgunya Formation" (Evans in Vine & Jauncey 1962), and later from the same unit in W.O.L. Nos. 1,2,3 (Warbreccan), stating that the association of M. tetracantha and O. operculata is typical of pre-Toolebuc strata. From other areas O.o. is reported to extend at least into the Cenomanian (Evans 1966-b), but there are no microplankton records from the (partly) Cenomanian Winton Formation in Queensland.

The O.o. Zone is identified in the upper Coreena beds of Longreach No. 5 and the Allaru Mudstone of Longreach No. 4 (Table 6) and Longreach No. 2 (Table 7). The overlying Mackunda Formation seems to mark the onset of new environmental conditions probably unfavourable for microplankton growth, as appears from Longreach No. 4. Very little is yet known about the microplankton sequence in post-Allaru formations in central Queensland. Consequently, the upper limit of the O.o. Zone is at this moment indeterminable.

Common types in the Zone are Goniaulax edwardsii, Diconodinium multispinum. Hystrichosphaeridea and Leiospheres are occasionally found.

Environments.

As mentioned before, open shallow marine depositional environments were established for the Doncaster Beds in many localities of the Great Artesian Basin, while terrestrial deposits belonging to the uppermost Coreena Member were mapped in the Tambo and Augathella Sheet areas. Vine et al. (1967) suggest lagoonal or nonmarine environments for part of the Ranmoor Member. Shallow marine conditions were again established for the Allaru and Mackunda strata.

The record of microplankton in the sediments, expressed in percentages of the total of microfloras and represented in the form of a time-fluctuation diagram (Figure 3), show the greatest abundance of organisms in the Doncaster of Richmond Nos. 1 and 2. Minor fractions are recorded from the Coreena Member in the Mitchell, Roma and Surat sheet areas, and also in Longreach No. 5.

A sudden upsurge of the microplankton fraction in the Toolebuc Limestone (Longreach No. 5; mainly Hystrichosphaeridea, and its correlate in Tambo No. 6) is compared with an identical peak close to the Toolebuc horizon in St. Andrews Bore (Evans in Vine & Jauncey 1962), mainly caused by an increase of Diconodinium sp. and Leiospheres.

In the lowermost Allaru Mudstone microplankton fractions decrease to well below 10% (St. Andres Bore; Tambo No. 6). and, while maintaining low values in the St. Andrews samples, increase considerably in Longreach No. 4. Near the boundary of Allaru Mudstone and Mackunda Formation they reduce to 5%, while the Mackunda, as far as sampled, does not yield any organisms at all.

The fluctuations in the microplankton fractions have not yet been fully explained, but they are closely tied to varying conditions of life and appear to have a more than local significance. Not regarding factors such as temperature, oxygen content, various biological actions, of which the effects cannot be traced in the record, salinity is considered here as the decisive influence upon microplankton growth.

In the light of the history of the paleogeography these fluctuations have special significance. Increasingly regressive conditions prior to the birth of the "Toolebuc sea", culminating in the earlier mentioned terrestrial development of the uppermost Coreena is shown in reducing percentages of the microplankton throughout the Coreena, while the sudden increase and decrease around the Toolebuc horizon are likely to be connected with an ephemeral transgressive phase and subsequent precipitation of carbonates in an environment unfavourable for microplankton growth.

Post-Toolebuc strata seem to mark a return to average marine conditions in restricted areas, which agrees with shallow depositional environments.

Swarms of Leiosphaerids in the Coreena Member of the Eromanga Basin (Evans 1966-a) have also been noticed in Cabawin No. 1 well, Surat Basin (Burger 1968). Leiosphaerids also account for part of the sudden increase of marine organisms in the Toolebuc Limestone correlate of Tambo No. 6 (MFP 4380, Table 5). These swarms indicate facies changes but do not necessarily have to be connected with marine environments. Their affinity is unknown and they show little morphological variation. There seems to be a group of thick-walled spheres, reluctant to take stain in the microscopic preparations and less abundant than a group of smaller and thin-walled specimens, that do not take stain at all.

SUMMARY AND CONCLUSIONS

1. Correlation of palynological zonation with lithostratigraphy in the Aptian-Albian interval of the northern and eastern Eromanga Basin agrees with previous studies (Evans 1966-a,c) and is given in Figures 2 and 4.

2. Tentative zonation of the sequence of the Cretaceous K 2 microfloras, based on first and last occurrence of spores, results in a three-fold division:

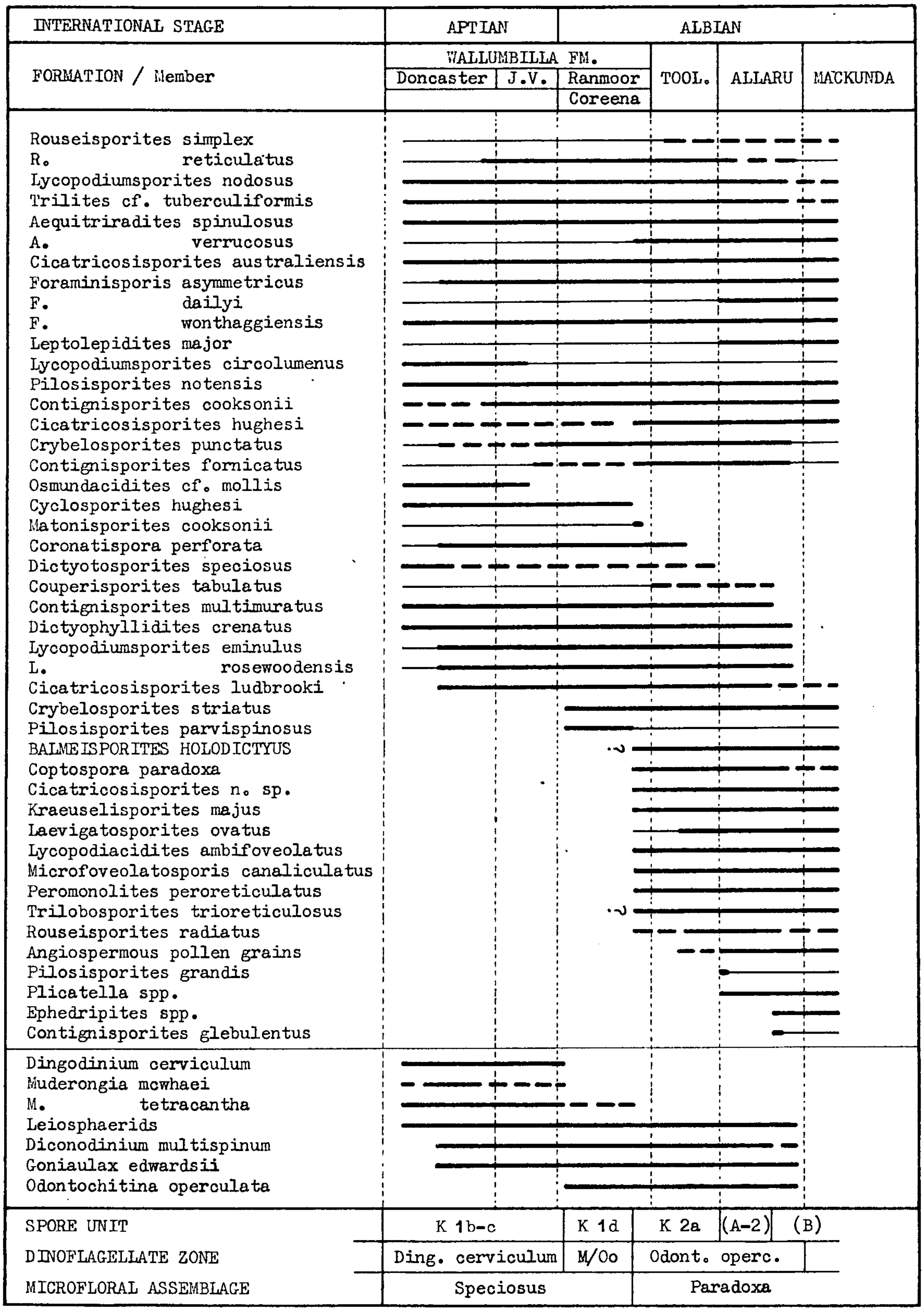
DIVISION	EQ. SPORE UNIT	CHARACTERISTICS
B	post K 2a	First occurrence of Ephedripites spp.,
A-2	"	First occurrence of Plicatella spp., and angiospermous pollen grains; last occurrence of Dictyophyllidites crenatus, Contignisporites multimuratus.
A-1	K 2a	First appearance of Coptospora paradoxa and Microfoveolatosporis canaliculatus; last occurrence of Dictyotosporites speciosus, Coronatispora perforata.

These Divisions are not considered as spore units at this stage of recognition. Future identification of identical spore successions in various parts of the Great Artesian Basin is required before accepting the Divisions as valuable units for comparative stratigraphy.

3. Combined micro- and macropaleontological information shows that a time-parallel relationship exists between the base of the Ranmoor in the Richmond and Hughenden Sheet areas and the Coreena in the eastern part of the Eromanga Basin.
   Micropaleontological data strengthen the assumption that the Toolebuc Limestone forms a time horizon in the rock sequence of the northern and northeastern Eromanga Basin.

4. Very few angiospermous pollen grains are known from samples as old as the Doncaster Member; sample frequency is extremely low. They appear persistently in post-Toolebuc microfloras in various parts of the Eromanga Basin and with the introduction of new types at the base of the Allaru Mudstone, seem to form a valuable stratigraphic marker.

FIGURE 2 : TIME DISTRIBUTION OF SELECTED INDEX MICROFOSSILS IN THE MARINE LOWER CRETACEOUS, QUEENSLAND



Observed vertical range

Known extension (Queensland) in sampled interval

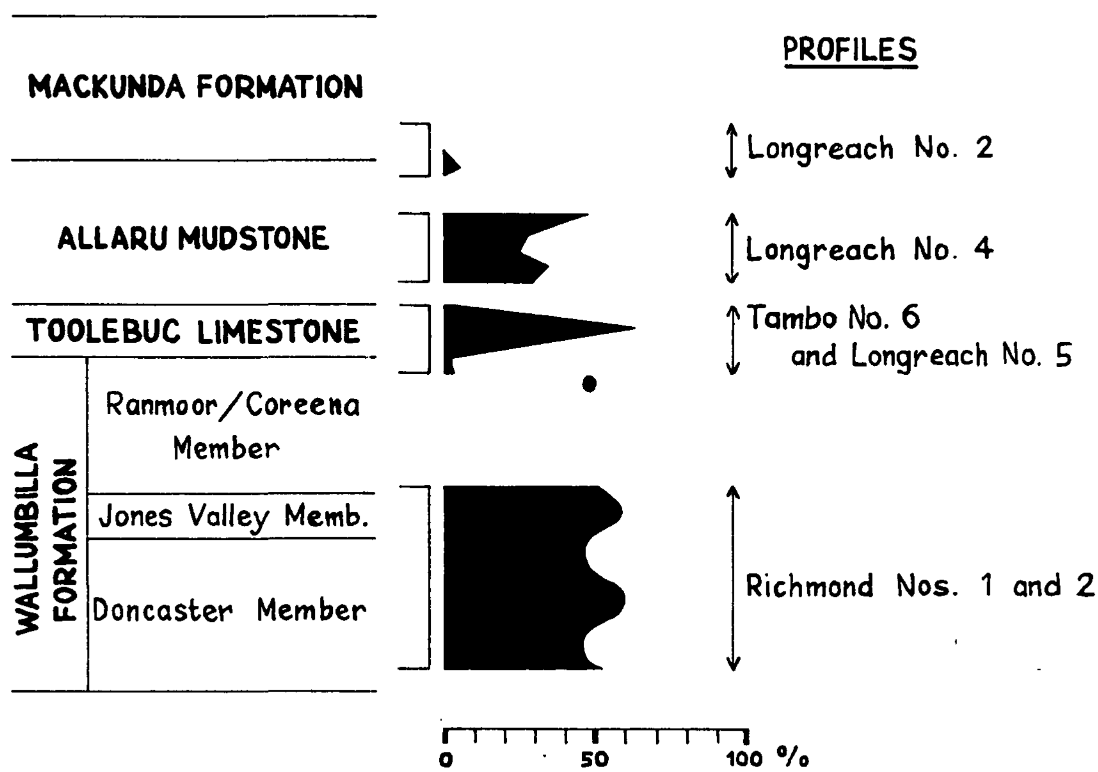


FIGURE 3 : FRACTION OF MICROPLANKTON IN THE SUM OF MICROFOSSILS

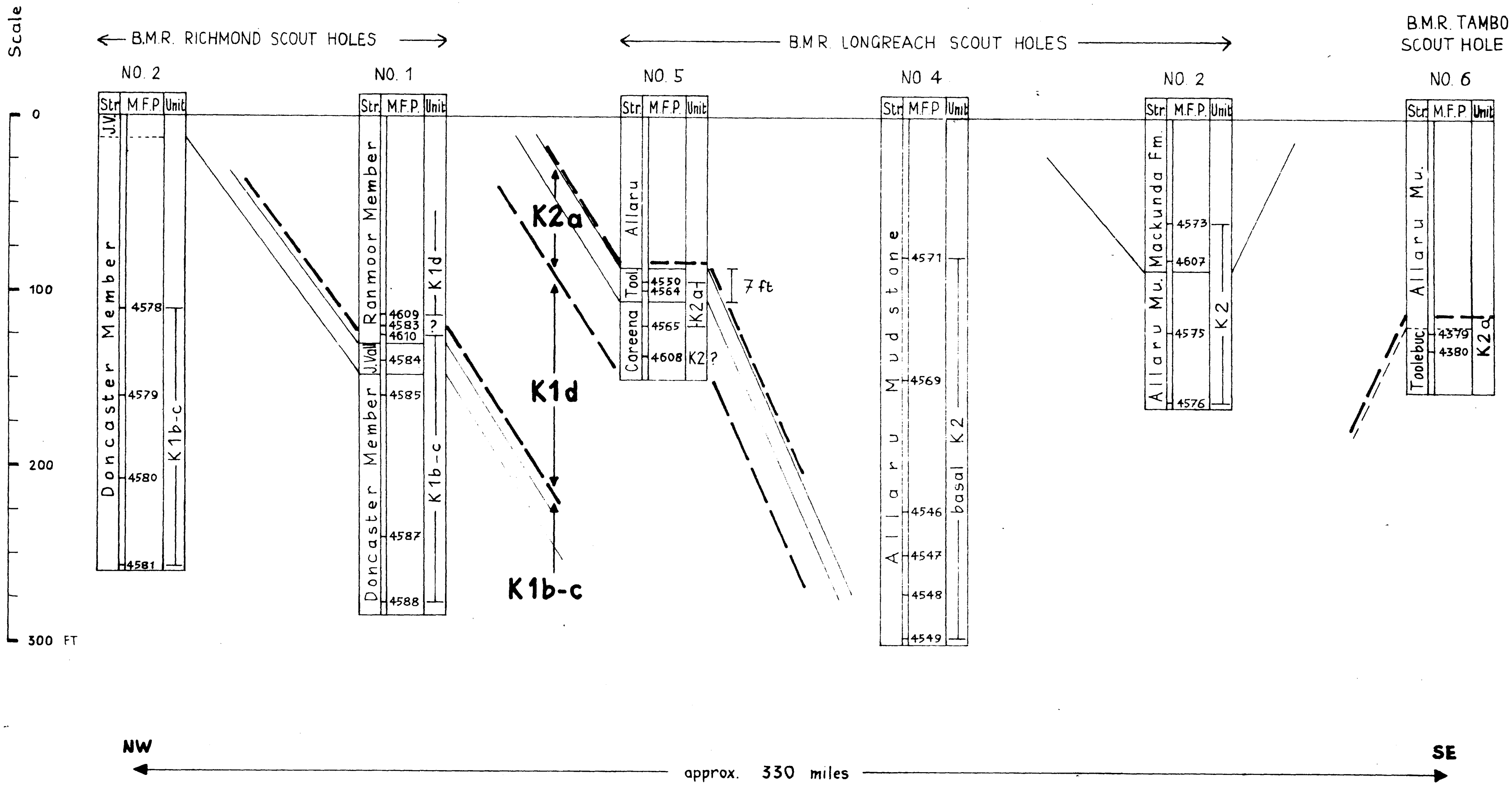


FIGURE 4 : CORRELATION OF SHALLOW HOLES IN THE NORTHERN AND EASTERN EROMANGA BASIN, QUEENSLAND

SYSTEMATIC NOTES ON SOME OF THE MICROFOSSILS

Note: Morphological terminology see Dettmann 1963, Kremp 1965.

Anteturma SPORITES Potonié 1893

Turma TRILETES Reinsch 1881 ex Dettmann 1963

Genus *Cicatricosisporites* Potonié & Gelletich 1933

Cicatricosisporites n. sp.

Reference: B.M.R. type specimen No. 807; "Upper Wilgunya Formation", W.O.L. No. 1 (Warbreccan) core 3, depth 1489-1509 feet; MFP 519. Slide coordinates 519-1; 310-1095.

Description: Trilete, amb triangular with slightly rounded corners. Trilete mark indistinct, almost reaching to equator. Exine one-layered, about 1 micron thick, striate. Proximal contact area psilate, medium large. Proximal striae arranged parallel to adjacent side; distal striae arranged in a pattern of concentric triangles and intersecting in the apical regions, so that they form muri and foveolae. Ribs slightly sinuous, about 1 micron wide, spaced 1-1.5 micron apart.
Dimensions: 40 to 50 micron.

Distribution: This type appears in horizons slightly below the Toolebuc Limestone together with *Coptospora paradoxa*; it is scarce in the Allaru Mudstone and basal Mackunda Formation, but common in the Winton Formation.

Remarks: Vaguely resembling types that are recorded by Deák in the Aptian and Albian of Hungary as *Ischyosporites estherae* (Deák 1964, pp. 103-104, Pl. 6 fig. 41-44). These spores tend to show distally placed interapical foveolae, elongated considerably parallel to the equator, so that a striate impression appears. Deák's spores are larger (60-70 micron); in the sculpture pattern the equidimensional foveolae predominate.

The Australian spores are more delicate, and the foveolae are restricted to the apical regions only. They differ from *C. australiensis* in that the ribs are sinuous and the apical regions show different sculpture.

Genus Lycopodiacidites Couper 1953 ex Potonié 1956

Lycopodiacidites ambifoveolatus Brenner 1963

1963 Brenner p. 63, Pl. 17 fig. 1,2.

Reference: B.M.R. type specimen No. 813; Winton Formation, W.O.L. No. 1 (Warbreccan) core 1, depth 500-520 feet; MFP 518. Slide coordinates 518-2; 224-1098.

Description: Trilete, amb approximately circular. Trilete mark reaching to equator. Exine two-layered, endexine 1 micron thick, ektexine including sculpture elements 4 micron thick. Sculpture verrucate-clavate, distally mainly clavate. Elements 3-4 micron high, spaced about 3 micron apart, tops irregular in outline, flattened, sometimes fused, largest diameter 5 micron. Necks 1-3 micron in diameter. Proximal sculpture reduced and less irregular.

Dimensions: between 50 and 70 micron.

Distribution: Scarce in the interval from upper Coreena to lower Mackunda, scarce to common in Winton Formation.

Remarks: Provisional assignment. Brenner describes the sculpture as verrucate, but his illustrations show both verrucate and truncated clavate elements. The type occurs throughout the Potomac Group in Maryland, U.S.A., the age is considered as Aptian-Albian.

Assumed specimens of Lycopodiacidites asperatus Dettmann 1963, from the Winton Formation possess smaller and more regular sculpture elements.

Genus Plicatella Maliavkina 1949

Distribution: From the Archer River area, Cape York Peninsula, P. tricornitata (Weyland & Greifeld 1953) Potonié 1960 was reported in association with Odontochitina operculata and undifferentiated Hystrichosphaeridea (Evans 1966-c). From the Allaru and Mackunda microfloras identical specimens were recovered, together with cf. P. (al Appendicisporites) appendicifera (Thiergart), which is characterized by longer and thinner apical processes. No distinct separation can be made between the two groups, as one merges into the other morphologically. More detailed study is being carried out at the present time.

Turma MONOLETES Ibrahim 1933

Genus Peromonolites Couper 1953

Peromonolites peroreticulatus Brenner 1963

1963 Brenner p. 94, Pl. 41 fig. 1,2.

Reference: B.M.R. type specimen No. 812; Winton Formation, B.M.R. Augathella No. 4 Scout Hole core 2, depth 97 feet; MFP 4386. Slide coordinates 4386-1; 355-934.

Description: Spore either monolete or monosulcate. Central body prolate, apices more or less rounded, aperture spanning whole length of spore. Exine psilate, about 0.6-0.8 micron thick, supporting rods that are spaced 2 micron apart, between 1 and 2 micron high and 0.5-1 micron thick. The tops are connected by bridges, which in top view give a reticulate pattern with circular to oval lumina measuring about 2 micron across, sometimes reduced near the groove. Bridges usually but not always disconnected across the aperture.

Dimensions of spore: length 18-23 micron, width 16-19 micron.

Distribution: Rare in the Allaru Mudstone, common in the Mackunda and Winton Formations.

Remarks: Brenner regards the aperture as a sulcus and places the spore in the group Spores and Pollen Incertae Sedis. It occurs throughout the Potomac Group in Maryland, U.S.A. (Aptian-Albian).

Anteturma POLLENITES Potonié 1931

Turma PLICATES Naumova 1939 emend. Potonié 1960

Genus *Ephedripites* Bolkhovitina 1953

Ephedripites sp. A

Reference: B.M.R. type specimen No. 806; "Upper Wilgunya Formation", W.O.L. No. 1 (Warbreccan) core no. 3, depth 1489-1509 feet; MFP 519. Slide coordinates 519-2; 320-1108.

Description: Polyplicate, prolate, ratio length to width about 2, apices rounded, number of ridges 10 to 12, spaced 1-2 micron apart. Exine 2 micron thick, psilate.
Maximum dimensions: 40 to 60 micron.

Distribution: Rare throughout the section above the Toolebuc Limestone. Sample frequency seems to increase in the Winton Formation.

Remarks: The spore resembles *E. rousei* Pocock 1964 (p. 148, Pl. 1 fig. 6) and *E. concinnus* (pro parte) Singh 1964 (p. 132 Pl. 17 fig. 13). Both types are reported from the Mannville Group, western Canada region (Albian).

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TABLE 3 : DISTRIBUTION OF MICROSPORES IN B.M.R. RICHMOND NO. 2 SCOUT HOLE

Formation / Member	Doncaster			
Core depth	257'	208'	160'	110'
Sample no. (MFP)	4581	4580	4579	4578
Spore Unit	K 1b-c			
Dinoflagellate Zone	Dingodinium cerviculum			
Aequitriradites spinulosus		x		
Cicatricosisporites australiensis	x	x	x	x
hughesi		?		
ludbrooki				x
Contignisporites cooksonii		?	?	x
multimuratus	x			
Crybelosporites punctatus			?	
Cyclosporites hughesi	x	x	x	x
Dictyophyllidites crenatus		x		
Dictyotosporites speciosus	x	?	x	?
Foraminisporis asymmetricus				x
wonthaggiensis		x		
Lycopodiumsporites circolumenus	?	x	x	x
eminulus			x	x
modosus	x		x	x
rosewoodensis			x	x
Osmundacidites cf. mollis		x		
Pilosisporites notensis	x	x	x	x
Trilites cf. tuberculiformis	x	x		
Diconodinium multispinum			x	x
Dingodinium cerviculum	x	x	x	x
Goniaulax edwardsii		?		
Leiosphaerids		x		
Muderongia mcwhaei		?	x	
tetracantha	x	x	x	x
Percentage of microplankton	high to very high			

TABLE 4 : DISTRIBUTION OF MICROSPORES
IN B.M.R. RICHMOND NO. 1 SCOUT HOLE .

Formation / Member	Doncaster			Jones Valley	Ranmoor		
Core depth	278'3"	240'	160'	139'11"	124'8"	120'	113'2"
Sample no. (MFP)	4588	4587	4585	4584	4610	4583	4609
Spore Unit	K 1b-c					K1d?	K 1d
Dinoflagellate Zone	Dingodinium cerviculum				?		M. tetr Od. op.
Cicatricosisporites australiensis		x	x	x	x	x	x
ludbrooki		x		x			x
Contignisporites cooksonii	?	?			?	x	
fornicatus				?			
multimuratus	x						
spp.						x	
Coronatispora perforata		x					
Crybelosporites punctatus					x		
striatus						?	x
Cyclosporites hughesi	x			x		x	x
Dictyophyllidites crenatus			x				
Foraminisporis asymmetricus		x	x	x	x	x	
dailyi		?					
wonthaggiensis					x	x	
Lycopodiumsporites circolumenus				x			
eminulus		x	x	x			
nodosus				x			
Osmundacidites cf. mollis	x	x			x	x	
Pilosisporites notensis	x			x	x		?
parvispinosus						x	
Rouseisporites reticulatus			x				
Trilites cf. tuberculiformis					x	x	
Dioonodinium multispinum	x	x	x	x	x	x	x
Dingodinium cerviculum	x	x	x		x	x	
Goniaulax edwardsii	x	x	x	x	x	x	
Leiosphaerids	x	x	x		x	x	x
Muderongia mcwhaei	x						?
tetracantha	x	x	x		x	x	x
Odontochitina operculata					?	?	x
Percentage of microplankton	high to very high						

TABLE 5 : DISTRIBUTION OF MICROSPORES IN B.M.R. SCOUT HOLES

	LONGREACH NO. 5				TAMBO NO. 6	
Formation / Member	Coreena		Toolebuc		Toolebuc	
Core depth	136'4"	120'8"	98'11"	95'2"	133'4"	123'5"
Sample No. (MFP)	4608	4565	4564	4550	4380	4379
Spore Unit	K 2a?	K 2a			K 2a	
Dinoflagellate Zone	Odontochitina operculata				O. operculata	
Aequitriradites verrucosus	x					x
Balmeisporites holodictyus	x	x				
Cicatricosisporites australiensis	x	x	x			x
hughesi	x	x				x
ludbrooki		x				
n. sp.		x				?
Contignisporites fornicatus	x					?
Coptospora paradoxa	?	x				
Coronatispora perforata		?		x		
Couperisporites tabulatus			x			
Crybelosporites punctatus		?				
striatus	x	x				
Cyclosporites hughesi	x	x				
Dictyophyllidites pectinataeformis						?
Dictyotosporites speciosus						?
Foraminisporis asymmetricus	x	x				x
wonthaggiensis		x				
Kraeuselisporites majus	x	x				x
Laevigatosporites ovatus				?	x	
Lycopodiacidites ambifoveolatus		x				x
Lycopodiumsporites eminulus	x	x	x			x
nodosus		x	x			x
rosewoodensis		x				
Matonisporites cooksonii		x				
Microfoveolatosporis canaliculatus	x			x	x	x
Peromonolites peroreticulatus		x			x	
Pilosisporites grandis						x
notensis	x	x				
parvispinosus		x				
Plicatella spp.						x
Rouseisporites radiatus	?					x
reticulatus			x			
simplex			x			
Trilites cf. tuberculiformis	x	x				x
Trilobosporites trioreticulosus	x	x				
Diconodinium multispinum					x	x
Goniaulax edwardsii	?	x				
Leiosphaerids	x	x	x	x	x	
Muderongia tetracantha		?				
Odontochitina operculata	x					
Percentage of microplankton	1	1	3	(62)	40	5

TABLE 6 : DISTRIBUTION OF MICROSPORES
IN B.M.R. LONGREACH NO. 4 SCOUT HOLE

Formation	Allaru Mudstone					
Core depth	297'	273'	250'	224'4"	150'	80'11"
Sample no. (MFP)	4549	4548	4547	4546	4569	4571
Spore Unit	lowermost K 2					
Dinoflagellate Zone	Odontochitina operculata					
Aequitriradites spinulosus	x					
verrucosus						x
Balmeisporites holodictyus					x	
Cicatricosisporites australiensis	x	x	x	x		x
hughesi		x	x		x	x
ludbrooki	?		?		x	
n. sp.					x	
Contignisporites cooksonii	?	x			x	x
fornicatus					x	x
glebulentus					?	
multimuratus			x	?		
Coptospora paradoxa	?	x		x	x	x
Couperisporites tabulatus					?	
Crybelosporites punctatus	x		?		x	
striatus	x	x		x		x
Dictyophyllidites crenatus		x	?		x	
Ephedripites spp.			x			x
Foraminisporis asymmetricus	?		x	x	x	x
dailyi		x			x	
wonthaggiensis		x				
Kraeuselisporites majus	x	x	x		?	x
Laevigatosporites ovatus	x	?	x	x	x	x
Leptolepidites major		x		x		
Lycopodiacidites ambifoveolatus		x		x		
Lycopodiumsporites eminulus			x			x
nodosus		x				
rosewoodensis	x					
Microfoveolatosporis canaliculatus		x	x	x	x	x
Peromonolites peroreticulatus		?				
Plicatella spp.	x	x	x	x	x	x
Rouseisporites reticulatus	x					
Trilites cf. tuberculiformis	x	x	x	x	x	
Trilobosporites trioreticulosus				x		x
Dicconodinium multispinum	x			x		?
Gonyaulax edwardsii		x	x	x	x	x
Leiosphaerids			x	x		x
Odontochitina operculata	?	x	?	x	x	?
Percentage of microplankton	30	35	28	39	30	47

TABLE 7 : DISTRIBUTION OF MICROSPORES
IN B.M.R. LONGREACH NO. 2 SCOUT HOLE

Formation	Allaru		Mackunda	
Core depth	163'7"	122'2"	81'2"	61'
Sample no. (MFP)	4576	4575	4607	4573
Spore Unit	K 2			
Dinoflagellate Zone	Odont. opercul.			
Aequitriradites spinulosus	x	?	x	
verrucosus		?	x	
Balmeisporites holodictyus			x	
Cicatricosisporites australiensis	x	x	x	x
hughesi		x	x	
ludbrooki	x		?	
n. sp.		x	x	
Contignisporites cooksonii		x	x	
spp.		x	x	
Coptospora paradoxa		x	?	
Crybelosporites punctatus	x	x		
striatus		x	x	
Dictyophyllidites crenatus		x		
Ephedripites spp.		x		
Foraminisporis asymmetricus		x	x	
dailyi		x	x	
wonthaggiensis				x
Kraeuselisporites majus	x		x	
Laevigatosporites ovatus	x	x	x	x
Leptolepidites major		x	x	
Lycopodiacidites ambifoveolatus	x	x	x	
Lycopodiumsporites eminulus	x			
nodosus	x		?	
rosewoodensis	x			
Microfoveolatosporis canaliculatus	x	x	x	
Peromonolites peroreticulatus	x	x	x	
Pilosisporites notensis			x	
Plicatella spp.		x	x	
Rouseisporites radiatus	x	?		?
reticulatus		?		
simplex			?	
Trilites cf. tuberculiformis		x	?	
Trilobosporites trioreticulosus			x	
Goniaulax edwardsii		x		
Odontochitina operculata		x		
Percentage of microplankton	0.0	5	0.0	0