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NOTES ON THE CARBONIFEROUS TO CRETACEOUS PALYNOLOGY OF THE BUCHANAN, MUTTABURRA, TANGORIN AND HUGHENDEN 1:250,000 SHEET AREAS, QUEENSLAND

by

D. Burger and Elizabeth M. Kemp

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SUMMARY

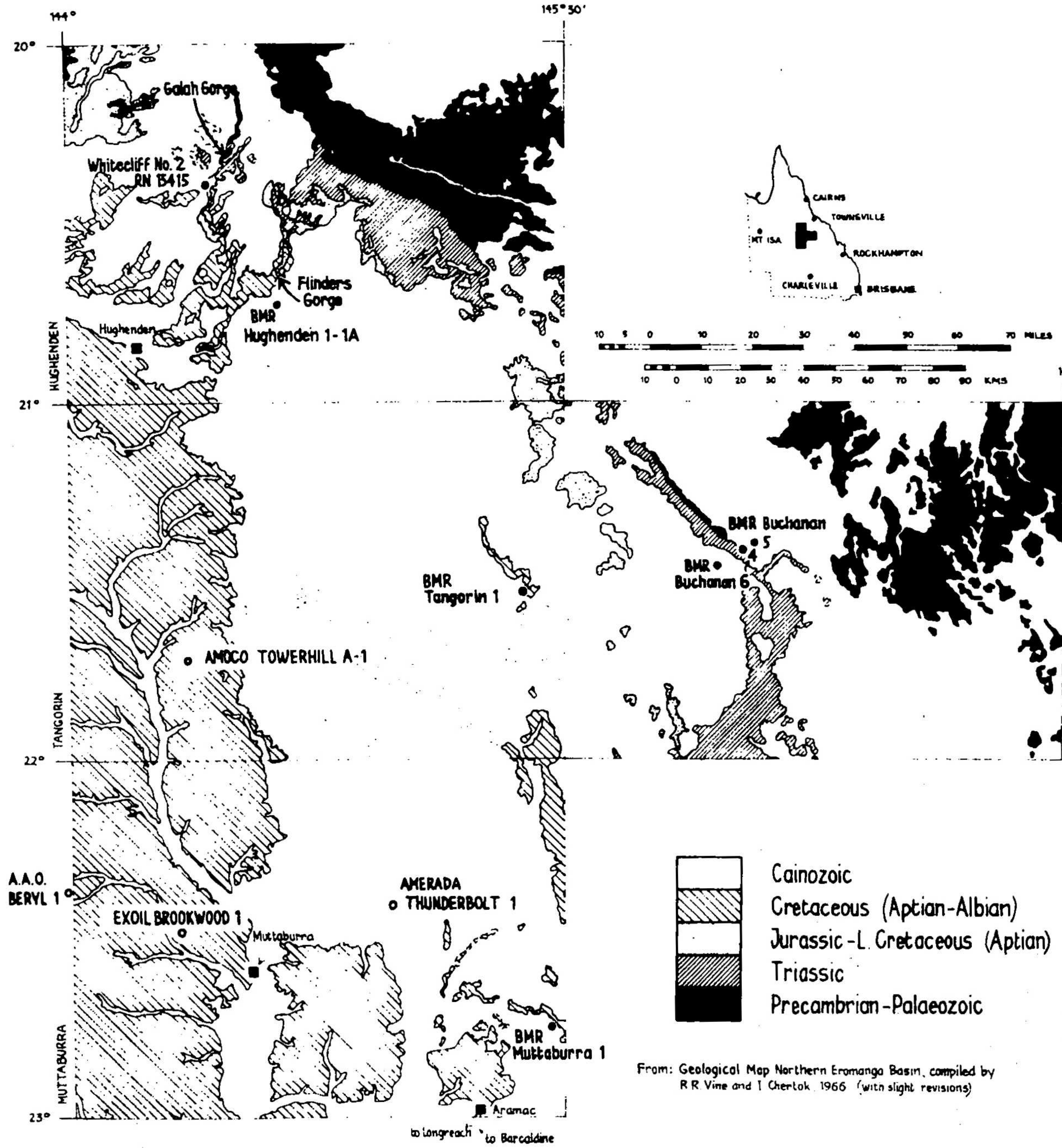
Sediments from drill holes in the Buchanan Sheet area contain Upper Permian (Buchanan No. 4), Middle Triassic (Buchanan No. 6) and one possibly Carboniferous (Buchanan No. 5) spore assemblage. To the west Permian and Triassic spore assemblages are present in Amoco Towerhill No. A-1 (Tangorin Sheet area), and in Amerada Thunderbolt No. 1 and Exoil Brookwood No. 1 (Muttaburra Sheet area); Permian spores have been reported from one outcrop in the Hughenden Sheet area.

Jurassic sediments from BMR Hughenden No. 1A, BMR Tangorin No. 1 and the Thunderbolt, Towerhill, and Brookwood wells contain units J2-3, J4, and J5-6 microfloras which are compared with those of Jurassic formations of the Surat Basin and the Tambo-Augathella area.

Cretaceous spore units K1a, K1b, and K2b+ from BMR Hughenden No. 1 and the Thunderbolt and Brookwood wells are discussed.

FIGURE 1: REGIONAL GEOLOGY AND LOCATIONS OF EXPLORATION WELLS & STRATIGRAPHIC HOLES

Burger & Kemp · Galilee & NE Eromanga Basins



From: Geological Map Northern Eromanga Basin, compiled by R R Vine and I Chertok 1966 (with slight revisions)

To accompany Record 1972/99

F55/A/155

INTRODUCTION

Permo-Carboniferous spores and pollen grains have been studied in the Galilee Basin, for stratigraphic purposes, as part of a larger study of the Palaeozoic in Queensland. Examination of contemporaneous sediments in the Buchanan 1:250 000 Sheet area are discussed in this record as a further contribution to knowledge of the Palaeozoic. More recent additional investigations in the Mesozoic of the Galilee and Eromanga Basins in the Muttaburra, Tangorin, and Hughenden 1:250 000 Sheet areas, many of which have not been previously recorded, are also referred to or discussed here.

The locations of stratigraphic holes and oil exploration wells from which samples were palynologically examined are shown on Figure 1.

PALAEOZOIC

Permo-Carboniferous sediments crop out in the Hughenden and Buchanan Sheet areas and disappear beneath the Mesozoic to the west and southwest. Palynological information was obtained mainly from subsurface material in the Buchanan area. However, a few outcrop samples from Galah Gorge, 69 km NNE of Hughenden township, also produced identifiable microfossils. Probably the oldest rock material was collected from BMR Buchanan No. 5. Core 1 (MFP 4418), at a depth of 225'6" (68.73 m), yielded abundant but rather corroded pollen and spores. Bisaccate pollen grains are particularly corroded. The assemblage included the following forms:

Retusotriletes sp.
Indotriradites sp. (common)
Verrucosisporites sp.
Cyclogranisporites sp.
Punctatisporites sp.
Anapiculatisporites sp.
cf. Raistrickia sp.
Potonieisporites cf. P. neglectus
Parasaccites cf. P. gondwanensis
Vestigisporites cf. V. rudis
Entylissa sp.
? Striate saccate form

This assemblage is indicative of Evans' (1967) Stage 1 microflora. The combination of monosaccate pollen grains, e.g. Potonieisporites neglectus and Parasaccites sp., with a distinctive suite of trilete forms such as Retusotriletes, Indotriradites, Punctatisporites, etc., is characteristic of the assemblage. Disaccate striatitid forms may be present, although saccate pollen grains were too poorly preserved for definite confirmation. Should they be present, it would indicate that the horizon represented is at the top of Stage 1 or at the base of Stage 2.

Leaving aside the doubtful presence of saccate striatitids, the assemblage is essentially similar to those recovered from 6167 feet (1379.7 m) and 6817 feet (2077.8 m) in Lake Galilee No. 1 well, and referred by Evans (in Pemberton, 1964) to the Carboniferous units C 1 and C 1-2. One difference between those assemblages and that from Buchanan No. 5 is the absence in the latter sample of the common Upper Carboniferous to Lower Permian species Punctatisporites gretensis. This may be of local significance only.

The section of Amerada Thunderbolt No. 1 (Fig. 3), from which sidewall cores were palynologically examined, penetrated Stage 1 sediments, according to Evans' brief summary (in Amerada Petroleum Corp., 1967). Results of a more detailed study of the Permian between 5052 feet (1539.8 m) and 2940 feet (896.0 m) have been discussed by Norvick (1971).

Permian strata were drilled and sampled in BMR Buchanan No. 4 Stratigraphic Hole. Core 1 (MFP 4417), at a depth of 181'5" (55.29) yielded abundant but corroded spores, pollen grains, tracheids and other plant tissue fragments. Bisaccate pollen grains were most corroded, and were consequently identified only with difficulty. The microfloral list includes:

Marsupipollenites triradiatus (common)
Lundbladispora sp.
Microbaculispora sp.
Cyclogranisporites sp.
Schizosporis dejerseyi
Gnetaceaepollenites sinuosus
Protohaploxypinus cancellatus
Striatopodocarpidites sp.

The presence of Gnetaceaepollenites sinuosus establishes the age of the assemblage as Stage 5 in Evans' subdivision of the Permian. In view of the generally poor preservation and lack of diversity of the assemblage, it is not possible to give a stratigraphically more precise determination.

Permian sediments in Brookwood No. 1 were examined by Evans (in Pemberton, 1963). Units P 1a-b (Stage 2) and P 3-4 (Stage 5) assemblages were identified from core samples in the 4744-3539 feet (1446-1078.7 m) interval (Fig. 2). Burger (1970) described fossil assemblages of Stages 2 to 5 age from Towerhill No. A-1 farther north in the Galilee Basin (Muttaburra Sheet area).

In AAO Beryl No. 1 well, Evans (in Mines Administration Pty Ltd, 1964) found units P 3-4 assemblages in cuttings from the 'Bandanna Formation' between 3340 feet (1018 m) and 3610 feet (1100.3 m), and unit P 1 assemblages in cuttings from the 'unnamed Lower Permian Formation' between 3800 feet (1160 m) and 4000 feet (1220 m). An assemblage similar to that recovered from 3900 feet (1190 m), i.e. of unit P 1a age, was recovered from an outcrop of the Boonderoo Beds in Galah Gorge, Hughenden Sheet area (Evans 1964a,c). An outcrop sample from the overlying Betts Creek Beds, at the same locality, produced an Upper Permian microflora, which was correlated with those from the 'Bandanna Formation' in the Springsure area (Table 2).

Palynological study of the Tambo and Augathella 1:250 000 Sheet areas farther south was compiled and summarized in Evans & Burger (Appendix 1, in Exon et al., in press). In the Tambo Sheet area unit P 1c (Stage 3) appeared to be associated with the Reids Dome Beds, and units P 3b-P 4 (Stage 5) microfloras were connected with the Peawaddy Formation. In the Denison Trough, unit P 3b, at the base of Stage 5, occurs near the top of the Aldebaran Sandstone, and overlying units P 3c-d are associated with the Black Alley Shale. The whole of the Permo-Carboniferous complex in the Galilee Basin and the Springsure Shelf has been discussed elsewhere in more detail (Evans, 1966b,d). However, the information so far published does not permit a close comparison with the Permian farther north.

In his review of the Permian and Carboniferous palynological Stages in eastern Australia, Evans (1967) advanced arguments which led him to believe that Stage 1 is of Upper Carboniferous age, whereas Stage 2 may be Lower Permian, being probably a time equivalent of the lower part of Walkom's (1945) Permian Glossopteris Flora. Stages 3 and 4, being the equivalents of Balme's (1964) Vittatina Assemblage, are regarded as Lower Permian, while Stage 5, representing the top of the Glossopteris Flora, probably must be regarded as mainly Upper Permian. Recent work in the Permian of the Cooper Basin led Paten (1969) to a similar dating of the Stages (Table 2).

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TABLE 1: REVIEW OF SOURCE MATERIAL

AGE	SOURCE MATERIAL	REFERENCES
CRETACEOUS	Brookwood No. 1	1
	Thunderbolt No. 1	1
	BMR Hughenden No. 1	1
JURASSIC	Thunderbolt No. 1	1
	Brookwood No. 1	1
	BMR Tangorin No. 1	1
	Towerhill No. A-1	2
	BMR Muttaburra No. 1	1
	BMR Hughenden No. 1A	1
	Beryl No. 1	3
	Flinders Gorge (outcrop)	6
TRIASSIC	Brookwood No. 1	4
	Towerhill No. A-1	2
	BMR Buchanan No. 1	1
	Thunderbolt No. 1	5
	Whitecliff No. 2 (RN 15415)	6
PERMIAN	BMR Buchanan No. 4	1
	Beryl No. 1	3
	Towerhill No. A-1	2
	Thunderbolt No. 1	5
	Galah Gorge (outcrop)	6
	Brookwood No. 1	4
CARBONIFEROUS ?	Thunderbolt No. 1	5
	BMR Buchanan No. 5	1

References:
1 - This record
2 - Burger (1970)
3 - Evans (in Mines Admin., 1964)
4 - Evans (in Pemberton, 1963)
5 - Evans (in Amerada Petroleum, 1967)
6 - Evans (1964a)

MESOZOIC

Triassic

Triassic spore and pollen assemblages have been studied from the Moolayember Formation in BMR Buchanan No. 6 (see below) and Towerhill No. A-1 (Burger, 1970). The Rewan Formation was studied in Brookwood No. 1 (Evans, in Pemberton, 1963), and the Clematis Sandstone in Thunderbolt No. 1 (Evans, in Amerada Petroleum Corp., 1967). One sample from the Warang Sandstone collected in Whitecliff No. 2 Bore (RN 15415), Hughenden area, yielded Triassic, possibly Lower Triassic spores (Evans, 1964a). Systematic palynological study of the Moolayember Formation in the southern Bowen Basin was carried out by De Jersey & Hamilton (1967). Recently, opportunity for additional examination was provided by drilling and sampling of the Moolayember Formation in the Buchanan Sheet area. Two samples from BMR Buchanan No. 6 Stratigraphic Hole, core 1, were processed. Both yielded abundant spores and pollen grains. The assemblage from the 212'9" (64.85 m) level (MFP 4420) was considerably more diverse than that (MFP 4419) from 211'9" (64.54 m) and hence permitted more precise stratigraphic assignment. Its microfloral list includes:

Falcisporites australis
Tuberculatisporites aberdarensis
Rugulatisporites stonecrofti
Dictyophyllidites mortoni
Neoraistrickia taylori
Calamospora tener
Sulcosaccispora sp.
Cycadopites sp.
Aratrisporites cf. *A. rotundus*
A. coryliseminis
A. paenulatus
Lophotriletes bauhiniae
Tigrisporites playfordi
Nevesisporites limatulus
Nathorstisporites pulcherrima
Banksisporites sp.
Schizosporis sp. indet.

Sample MFP 4419 contained:

Falcisporites australis (common)
Tuberculatisporites aberdarensis
Rugulatisporites stonecrofti
Dictyophyllidites mortoni
Stereisporites sp.
Neoraistrickia taylori
Retusotriletes junior
Aratrisporites cf. *A. rotundus*
Cycadopites sp.

Both assemblages are of probable Middle Triassic age, characteristically dominated by the pteruchid form Falcisporites australis. Sample MFP 4420 contained several species which are restricted to the lower of the two palynological units into which the Moolayember Formation can be divided in the southern Bowen Basin. These species include Lophotriletes bauhiniae, Tigrisporites playfordi and Nevesisporites limatulus. A relatively high abundance of Aratrisporites species, which is also shown in assemblage MFP 4420, is also characteristic of this unit. The unit defined by the ranges of the species mentioned is equivalent to the basal 60 m of the Moolayember Formation in the Mimosa Syncline (De Jersey & Hamilton, 1967).

The presence in the assemblages of the two megaspore species Nathorstisporites pulcherrima and Banksisporites sp. may more closely define its stratigraphic position. Previous work suggests that these forms are confined to an interval extending for only about 30-60 m from the base of the Moolayember Formation in the Carnarvon Range and Springsure Shelf areas (Kemp, in Alcock, 1969).

An unusual feature of assemblage MFP 4420 is the presence, in significant numbers, of a form of probable freshwater algal origin, referred to the genus Schizosporis.

Jurassic

Jurassic and lowermost Cretaceous sediments, unconformably overlying the Triassic, were encountered in outcrop and subsurface through most of the area considered. The Hutton Sandstone, Birkhead Formation, Adori Sandstone, Westbourne Formation, Hooray Sandstone and its correlate, which Exon (1966) described from the Tambo area, were traceable farther north in many water-bores and some deep wells, notably AAO Beryl No. 1 and Exoil Brookwood No. 1 (Vine, 1966). To the north and east the total thickness of these formations decreases considerably; each formation loses its identity (Vine, 1970), so that in the sections of the Towerhill and Thunderbolt wells the wireline and lithological logs are difficult to interpret. In the Buchanan and Tangorin areas, between the Triassic and the marine Lower Cretaceous (Aptian) Doncaster Member, a thin belt mainly of sandstone appears in outcrop, and is referred to as the Ronlow Beds (Vine, 1970). In the Hughenden area, between the Warang Sandstone and the Wallumbilla Formation, two mainly sandstone units, separated by an unconformity were mapped in outcrop. The lower sandstone was referred to as the Blantyre Sandstone (now Blantyre Beds) and the upper as the Gilbert River Formation (Vine et al., 1964). The Gilbert River Formation is discussed in the section on the Cretaceous.

Palynological relationships of the various formations are at present not firmly established and more comparative material in the form of better sampled subsurface sections is required. As far as possible the relationship of formations mentioned is illustrated in the correlation diagram of Table 3.

TABLE 2: COMPARISON OF PERMO-CARBONIFEROUS FLORAL ZONATIONS AND CORRELATION OF ASSOCIATED ROCK UNITS IN CENTRAL QUEENSLAND

WALKOM, 1945	BALME, 1964	EVANS, 1964c	EVANS, 1967	PATEN, 1969	DENNISON TROUGH	HUGHENDEN SHEET AREA (GALILEE BASIN)
FLORA	ASSEMBLAGE	UNIT	STAGE	STAGE		
	DULHUNTYISPORA	P4	5	UPPER 5	BLACKWATER	? BETT'S CREEK ?
		P3d P3c			BLACK ALLEY	
GLOSSOPTERIS		P3b		LOWER	PEAWADDY CATHERINE INGELARA	
					ALDEBARAN	
GANGAMOPTERIS	VITTATINA	P2-P3a	4	4	CATTLE CREEK	
		P1c	3	3	REIDS DOME	
	NUSKOISPORITES	P1a-b	2	2		BOONDEROO
		C2				
		C1	1			

This Table is compiled partly from Evans, 1967, Table 1 and Figure 4.

Cores cut at more or less regular intervals in Brookwood No. 1 were initially examined by Evans (in Pemberton, 1963), but re-examination of the Jurassic and Cretaceous cores became necessary at a later stage, in order to obtain more confirmatory data on the palynological zonation which developed from further studies by Evans and Burger. Full data on the section of Brookwood No. 1 will be discussed in another paper, but essential points are mentioned here.

The position of the cores which yielded microfossils and the occurrence of key fossils are plotted in the section of Figure 2. The Hutton Sandstone, regionally the oldest Jurassic formation, produced unit J 3 fossils in core 7 (MFP 2255). The succeeding unit J 4, beginning with the first appearance of Leptolepidites verrucatus, is also considered to include part of the Hutton Sandstone (Burger, 1968a); unfortunately, the sections of Towerhill No. A-1 (Burger, 1970) and Beryl No. 1 (Evans, in Mines Administration Pty Ltd, 1964), in which the equivalent interval was cored, did not confirm this opinion. Unit J 4 fossils were extracted from the Birkhead Formation in Brookwood (core 6, MFP 2254); similar assemblages were obtained from the formation in the Surat Basin (Burger, 1968a). The presence of Micrhystridium sp. (rare) may be a sign of increased salinity of the environment and seems to coincide with the occurrence of acritarchs in the Lower Birkhead Formation of Magellan Corfield No. 1 (Evans, 1962; Vine, 1966), and a similar observation in a unit J 4 microflora in the Walloon of the Warwick area, Clarence-Moreton Basin (Burger, in Exon et al., 1969). Further study may possibly decide whether these observations are related to the same event.

Sidewall cores and cuttings from the Jurassic and Cretaceous of Thunderbolt No. 1 have also been processed and examined (Fig. 3). Evans (in Amerada, 1967) reported the results of a previous palynological examination of two sidewall cores from the Jurassic part of the sequence, although he gave no details of specific composition. These cores, from 1104 feet, 336.4 m (MFP 4389) and 1124 feet, 342.5 m (MFP 4390) which Vine (1970) now regards as correlates of the lower Birkhead Formation in the Ronlow Beds, were very tentatively assigned J 5 and J 4 ages respectively by Evans. In order to establish some control for cuttings samples of higher levels, the microfloras from the sidewall cores have been re-examined, and some additional comments on their composition are given below. Remarks concerning these assemblages, which are obviously contaminated by circulating drilling mud and contain a high frequency (about 5%) of Upper Permian forms should be interpreted with caution.

The J 5 age tentatively given for the sidewall core at 1104 feet seems to rest on the presence of a single grain provisionally identified as Contignisporites sp., otherwise the assemblages are identical. The specimen in question seems, in fact, to be a form with the characteristics of both Contignisporites and Duplexisporites. Using the criterion of the incoming of Leptolepidites verrucatus, a J 4 age seems acceptable for both cores. Classopollis is not abundant, but Tsugaepollenites (al. Callialasporites) spp. and Inaperturopollenites turbatus are common. The relatively common occurrence of Cingulatisporites saevus and Nevesisporites vallatus would seem to support such a determination, suggesting a correlation with the upper part of the Hutton to the lower part of the Birkhead in the Surat Basin.

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There is, however, a group of spores present which seems to represent an older Jurassic element, although the upper limits of the distribution of its component species in the Surat and Eromanga Basins do not appear to be well enough documented to assess their significance. Included in the group are Duplexisporites gyratus and Circulisporites parvus. These species have been reported from the Precipice Sandstone and Evergreen Formation of the Surat Basin (De Jersey & Paten, 1964), from sediments of possible Rhaetic age in South Australia (Playford & Dettmann, 1965), and from the Cockleshell Gully-Cadda Formation interval (probably Liassic to Bajocian) of the Perth Basin, Western Australia (unpublished information). Classopollis simplex and a form close to Stereisporites perforatus Leschik are other species present in the Thunderbolt assemblages which have previous records indicating maximum abundances in the Lower Jurassic (De Jersey & Paten, 1964; Playford & Dettmann, 1965; Playford & Cornelius, 1967; also unpublished information from the Perth Basin). For the moment their presence in combination with what are normally regarded as younger Jurassic species can only be recorded without comment.

Cuttings samples from the following depths have been examined.

Sample number (MFP)	Depth interval feet	Depth interval metres
4755	720-750	219.5-228.5
4756	750-780	228.5-238
4757	840-870	256-265
4758	900-930	274.5-283.5
4772	930-960	283.5-292.5
4773	960-990	292.5-302
4771	990-1020	302-311
4770	1020-1030	311-314

The cuttings below 840 feet, collected from what Vine (1970) considers equivalents to the Ronlow Beds, yielded microfloras basically similar in composition to those from the sidewall cores discussed above, although species belonging to the 'older' element were present only in those below 960 feet.

All samples below 840 feet are characterized by relatively common Nevesisporites vallatus and Cingulatisporites saevus, forms with a predominantly Jurassic distribution. Tsugaepollenites spp. are abundant in these samples, further indicating the possibility of their being of Jurassic age. The absence of those species which define units J 5 and J 6 (Contignisporites spp., Murospora florida, Aequitriradites spp.) prevent a more precise dating than J 4 to J 6 for the 840-1030 feet interval.

Part of the Ronlow Beds is probably of Cretaceous age; Cretaceous microfloras have been described from the beds in the Longreach and Jericho regions (Burger, in press). Whether any of the cuttings listed above represents the Cretaceous part of the Ronlow Beds cannot be determined from the available spore data. The spore distribution chart of Figure 3 shows Cretaceous elements occurring throughout almost the whole interval below 940 feet; most are certainly contaminants from circulating drilling mud. However, the presence of Nevesisporites vallatus as high as sample no. 4757 (840-870 feet) has some value, as the species, although common in the Jurassic, ranges upwards into Lower Cretaceous (Neocomian) unit K 1a (Burger, in press), so that assemblage MFP 4757 may be Cretaceous in age, but not younger than K 1a.

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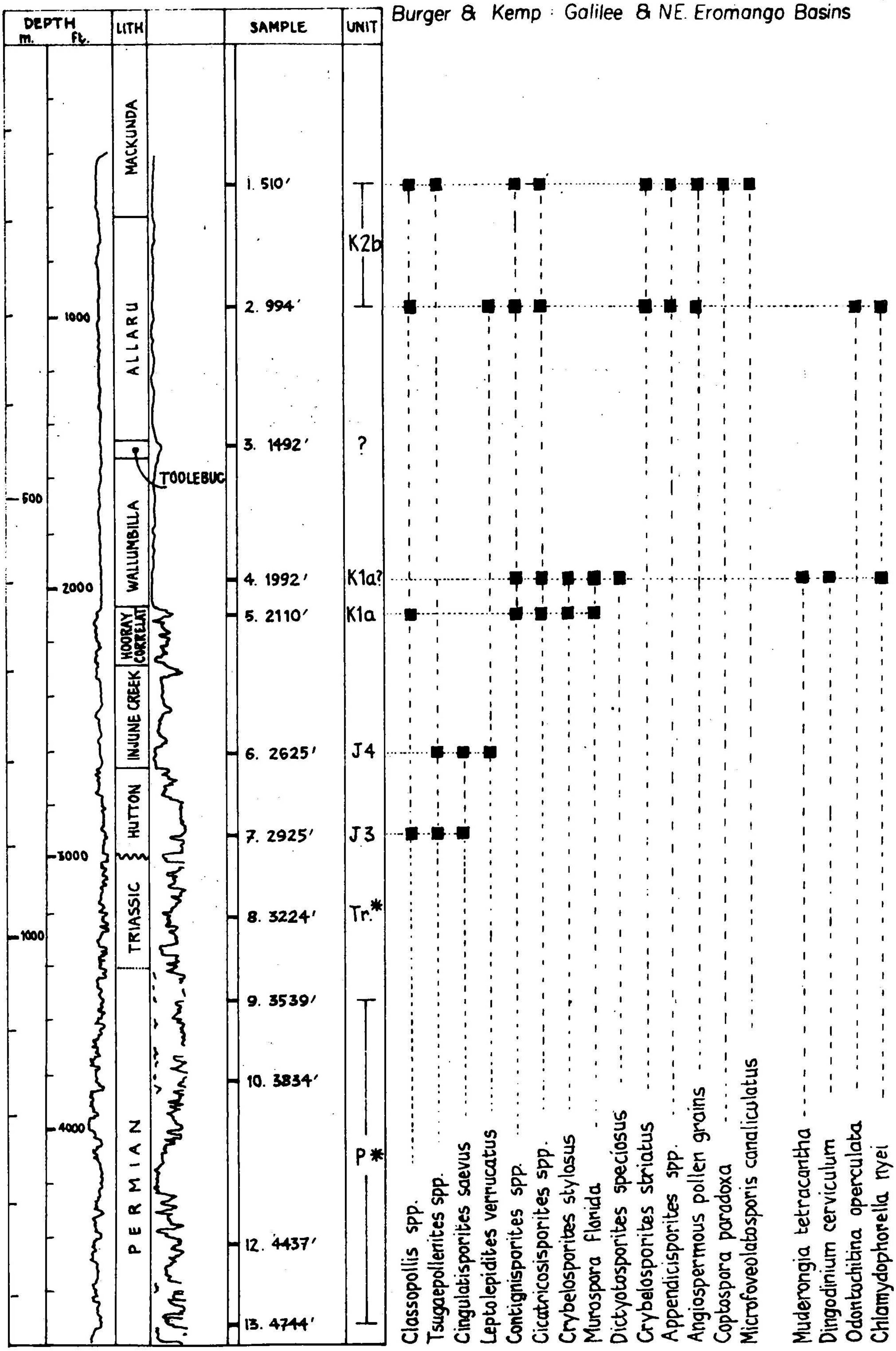
FIGURE 2: DISTRIBUTION OF KEY FOSSILS IN EXOIL BROOKWOOD No. 1

Burger & Kemp : Galilee & NE. Eromanga Basins



TOTAL DEPTH 4806′

To accompany Record 1972/99

* ACCORDING TO EVANS, 1964c

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FIGURE 3: DISTRIBUTION OF MICROFOSSILS IN AMERADA THUNDERBOLT NO. 1

FORMATION	Ronlow								Doncaster	
PALYNOLOGICAL SAMPLE NO. (MFP)	4390	4389	4770	4771	4773	4772	4758	4757	4756	4755
DEPTH OF SAMPLE	swc	swc	cutt	cutt	cutt	cutt	cutt	cutt	cutt	cutt
feet	1124	1104	1020-30	990-1020	960-90	930-60	900-30	840-870	750-80	720-50
metres	342.5	336.4	311-20	302-11	292.5-302	283.5-92.5	274.5-83.5	256-65	228.5-38	219.5-28.5
PALYNOLOGICAL UNIT	J4		J4-6					K1a?	K1b-c	
Nevesisporites vallatus	x	x	x	x	x	x		x		
Cingulatisporites saevus	x	x	x	x	x		x	x		
Duplexisporites gyratus	x	x	?							
Classopollis simplex	x	x								
Stereisporites perforatus	x	x	x	x	c?					
Circulisporites parvus	x	x								
Podosporites sp.	x				x	x				
Tsugaepollenites segmentatus	x	x	x							
Callialasporites dampieri	x	x			x	x	x	c?		x
C. trilobatus			x	x						
Exesipollenites tumulus		x								
Perinopollenites elatoides	x	x		x	x					
Inaperturopollenites turbatus	x	x	x		x					
Classopollis torosus	x	x	x	x	x	x				
Baculatisporites comaumensis	x				x	x		x		
Osmundacidites wellmanii		x	x	x	x	x				
Cyathidites australis	x									
Cyathidites spp.		x			x	x				
Alisporites australis		x	x	x					c?	
Lycopodiumsporites austroclavatidites	x	x	x					x	x	x
Biretisporites spectabilis		c	c							
Polycingulatisporites crenulatus		x	x							
Neoraistrickia truncata	x	x	x	x						
Gingkgocycadophytus nitidus		x					x			
Stereisporites antiquus		x	x							
Klukisporites scaberis	c				c?			x		
Klukisporites sp.		x		x		x				
Vitreisporites pallidus	x		x	x	x	x	x	x		
Staplinisporites caminus	x									
Lycopodiumsporites sp. nov.	x		x		x					
Leptolepidites verrucatus	x		x	x	x	x				
Concavisporites juriniensis	x		x							
Gleicheniidites circiniidites			x	x	x	x		x	x	x
Tripartina sp.			x		x	x				
Cicatricosisporites spp.			c	c		c				
Dictyotosporites speciosus										x
Pilosisporites notensis					c					
Dingodinium cerviculum			c		c	c		c?	x	x
Chlamydophorella nyei			c				c			x
Micrhystridium spp.							x	x	x	x
Odontochitina operculata				c	c				x	x
Muderongia tetracantha				c						
Hystrichosphaeridium spp.			c	c					x	x
Cyclonephelium spp.			c							
Cribroperidinium edwardsii				c						
PERMO-TRIASSIC FORMS										
Marsupipollenites triradiatus	c									
Striatiti undiff.	c	c								
Guthoerlisporites cancellatus			c							
Ceratosporites inequalis			c							
Polycingulatisporites densatus			x							

(c - secondary presence due to contamination)

The Ronlow Beds were also drilled and sampled in BMR Muttaburra No. 1 and BMR Tangorin No. 1. Few of the cored samples were suitable for palynology. Muttaburra No. 1, core 4 (MFP 4347) at a depth of 154 feet (46.9 m) yielded very few spores, among which the following forms were found:

Classopollis spp.
Callialasporites dampieri
Inaperturopollenites turbatus
Polycingulatisporites crenulatus

This microflora may be of Jurassic age and is not older than unit J 2. The rock sample is therefore not older than the upper Evergreen Formation in the Surat and eastern Eromanga Basins.

From Tangorin No. 1, cores 1, 4, and 5 were examined. Core 5 (MFP 4346; depth 270 feet, 82.3 m) was barren of fossils, while core 1 (MFP 4345; depth 53 feet, 16.2 m) produced very few badly corroded and unidentified spores.

Core 4, depth 206 feet, 62.8 m, (MFP 4344) yielded a reasonably rich spore assemblage, in which *Lycopodiumsporites austroclavatidites* and *Dictyophyllidites mortoni*, both species common in the Jurassic and Cretaceous, were the dominant forms. Other species determined were:

Classopollis spp. (ratio of 6%)
Tsugaepollenites segmentatus (fragment)
Inaperturopollenites turbatus
Ischyosporites marburgensis
Staplinisporites caminus (common)
Lycopodiumsporites rosewoodensis
Cingulatisporites saevus

The microflora, although of peculiar composition, is dateable as Jurassic. Domination of one or more species in spore assemblages usually points to local conditions rather than regional characteristics of parent vegetations. Palynologists therefore do not attach much value to such phenomena; in fact they regard them very often as disturbing factors, as the domination of one plant species upsets the balance of regional pollen sedimentation and tends to obscure the presence of stratigraphic marker fossils in the pollen spectra. In such instances caution is necessary in drawing conclusions on age and environment.

One of the few examples of the domination of one species at more than regional scale is well known from the Lower Jurassic in the Surat Basin. Evans (1964b; 1966a), De Jersey & Paten (1964), Paten (1967), Reiser & Williams (1969) noticed large proportions of the genus *Classopollis* in microfloras from the Precipice Sandstone and the Evergreen Formation corresponding with spore units J 1 and J 2. Decrease of the *Classopollis* fractions was recorded in detail in the upper Evergreen Formation, units J 2-3 (Paten, 1967; Reiser & Williams, 1969), whereas counts of 1% or less are the rule in J 4 assemblages, associated with the upper part of the Hutton Sandstone (unpublished data).

Although units J 2-4 have been identified in the Eromanga Basin (Evans & Burger, in Exon et al., in press; Evans, 1966c) it is not yet certain to what extent the above picture, can be traced into the Muttaburra, Tangorin and Hughenden areas. Evans reported 'moderate abundance' of Classopollis in Lower Jurassic spore assemblages of Beryl No. 1 (Mines Administration Pty Ltd, 1964) connected with the Hutton Sandstone, while J 4-5 assemblages in the Birkhead Formation equivalents of Thunderbolt No. 1 and Brookwood No. 1 registered extremely low Classopollis counts.

In view of all this, a count of 6% of Classopollis in assemblage MFP 4344 from Tangorin No. 1 suggests an intermediate position between units J 2 and J 3, which agrees with the absence of species such as Leptolepidites verrucatus, Contignisporites spp. and Murospora florida, which are typical of J 4-5 microfloras (Evans, 1966a; Burger, 1968a). Furthermore, Inaperturopollenites turbatus is a common form in J 2-3 microfloras, and is found less frequently in higher intervals. The presence of Cingulatisporites saevus is of value, as the first occurrence of this species indicates the start of unit J 3 in the Surat Basin and seems to be restricted to the Hutton Sandstone (Burger, in prep.). Therefore, assuming that assemblage MFP 4344 is part of unit J 3, the sample can be compared with Brookwood No. 1, core 7, in the Hutton Sandstone.

In the Hughenden Sheet area the Blantyre Beds were sampled in outcrop in the Flinders Gorge (Blantyre Station) and successfully examined for spores and pollen by Evans (1964a). The Blantyre Beds were also drilled by BMR Hughenden No. 1A, 6 km to the south. Palynological examination was carried out on samples from core 11, core 8 and core 3. Core 11, sample MFP 4350, from a depth of 394 feet, produced besides microscopic fragments of botanical tissue some insignificant microfossils. One sample from core 3, MFP 4348 (depth 212 ft 6 in, 64.77 m) failed to yield any fossils. Core 8, sample MFP 4342 (depth 258 ft, 78.6 m) produced a rich assemblage, in which, among others, the following types were encountered:

Classopollis spp. (ratio of 10%)
Callialasporites dampieri
Tsugaepollenites segmentatus
Cingulatisporites saevus
Staplinisporites caminus
Polycingulatisporites crenulatus
Foveotriletes sp.
Ischyosporites marburgensis
Inaperturopollenites turbatus
Lycopodiumsporites rosewoodensis
Contignisporites cf. C. cooksonii (1 specimen)

This assemblage is very similar to that of Tangorin No. 1, core 4. The proportion of the Classopollis group is comparable.

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Examination of the Blantyre Beds in the Flinders Gorge led Evans (1964a) to allocate a Jurassic (unit J 5-6 equivalent) age to the fossils recovered from the outcrop sample (field no. GAB 1045; laboratory no. MFP 2610). Evans listed the following species (page 5):

Cyathidites australis (common)
*Leiotriletes sp. (common)
*Baculatisporites comaumensis (fairly common)
Baculatisporites sp.
*Coronatispora perforata
Coronatispora telata
*Coronatispora sp.
*Ischyosporites cooksonii
*Lycopodiumsporites spp.
Perinotriliti sp.
Discisporites sp.
*Disaccites spp. undiff. (fairly common)
Araucariacites australis
*Callialasporites (al. Tsugaepollenites) dampieri
Inaperturopollenites (al. Laricoidites) reidi
*Inaperturopollenites (al. L.) turbatus
*Ginkgocycadophytus sp.
Microcachryidites sp.

Species marked with * were also identified in Hughenden No. 1A, core 8 (MFP 4342). Close comparison of microfloras MFP 2610 and MFP 4342 is made here on the assumption that the rock specimens were collected from the same argillaceous horizon in the Blantyre Beds (Vine, pers. comm.). In both microfloras the Classopollis group forms 10% of the total number of grains (re-examination of MFP 2610). The group of Inaperturopollenites-Tsugaepollenites-Callialasporites is also fairly well represented. These points are characteristic of lower Jurassic spore units J 2-3; the combination of Cingulatisporites saevus, Polycingulatisporites crenulatus and Inaperturopollenites turbatus in assemblage MFP 4342 is characteristic of units J 3-4. De Jersey & Paten (1964) mention Polycingulatisporites crenulatus from as high as the lower "Walloon Formation" in the Surat Basin, but it is unknown in higher Jurassic sediments.

However, the (rare) presence, in both microfloras, of Contignisporites cooksonii, the index fossil for units J 5-6, is not consistent with a Lower Jurassic age. The same also may apply to the presence of certain trilete spores assigned to the genus Coronatispora, which are rarely, if at all, seen in the Lower Jurassic. Initially Coronatispora perforata was described from the Lower Cretaceous in southeastern Australia (Dettmann, 1963), but later it also was observed in the higher Jurassic in Queensland (unpublished information).

Comparative material was discovered when sediments, recently drilled in the Richmond area (BMR Richmond No. 3 Stratigraphic Hole) were closely studied on spores and pollen grains (Grimes & Smart, 1970). Microfloras extracted from these sediments are typical of units J 5-6 in containing Murospora florida, Contignisporites spp., Leptolepidites verrucatus, as well as minor quantities of Callialasporites dampieri, C. trilobatus, Classopollis spp., Inaperturopollenites turbatus and Cingulatisporites saevus.
If the Blantyre Beds microfloras are as young as the presence of Contiquisporites cooksonii suggests, then further study of other material is desirable in search of more evidence, as neither Murospora florida nor Leptolepidites verrucatus was found in assemblage MFP 4342, despite exhaustive search of the microscope preparations. Neither do these species seem to be present in the Flinders Gorge assemblage.

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Summarizing the present information available: the Blantyre Beds microfloras can be regarded as Jurassic in age and not older than unit J 3. They bear strong resemblance to those from Brookwood No. 1 (core 7) and Tangorin No. 1. Although they contain single specimens of Contignisporites cooksonii they do not resemble the typical J 5-6 microfloras from Richmond No. 3 and elsewhere. At this time they are not restricted in age further than somewhere in units J 3-6. On these grounds the Blantyre Beds are to be correlated with some part of the Hutton Sandstone-Orallo Formation interval in the Surat Basin, or the Hutton-lower Hooray Sandstone interval in the Tambo-Augathella area, Eromanga Basin.

Cretaceous

Cretaceous sediments occur in outcrop and subsurface in the Hughenden, Tangorin, and Muttaburra Sheet areas. Outcropping rocks were unsuitable for palynological study, so that the information available was derived only from subsurface samples collected in a few shallow and deep wells. The marine Cretaceous Rolling Downs Group was sampled in BMR Hughenden No. 1, Brookwood No. 1 and Thunderbolt No. 1. The underlying Cretaceous strata are still insufficiently known. One sample from the Gilbert River Formation was collected in Hughenden No. 1, core 4, at a depth of 202 feet (MFP 4335). A reasonable rich assemblage was extracted, in which the following index fossils were found:

Spores:
- Pilosisporites notensis (1 specimen)
- Murospora florida (1 specimen)
- Classopollis spp.
- cf. Crybelosporites stylosus (1 specimen)

Microplankton:
- Muderongia tetracantha
- cf. M. mcwhaei (1 specimen)
- Cannosphaeropsis mirabilis (1 specimen)
- Dingodinium cerviculum
- Scriniodinium playfordii (al. crystallinum) (1 specimen)
- Canningia colliveri
- cf. Hystrichosphaeridium capitatum
- Chlamydophorella nyei

Acritarchs:
- Pterospermopsis australiensis
- Micrhystridium sp.

Dinoflagellates dominate the assemblage, indicating fully marine environments of deposition for the Gilbert River Formation in the Hughenden area. The presence of Dingodinium cerviculum, Chlamydophorella nyei and Muderongia tetracantha indicates that the assemblage is **Lower Cretaceous.** This agrees with the spore evidence, which proves by the co-occurrence of Pilosisporites notensis and Murospora florida that the fossils are of upper unit K 1a age (Burger, 1968c; in press). The unconformity between the Gilbert River Formation and the Blantyre Beds (Table 3) involves therefore a time-span equal to much of unit K 1a and possibly also part of units J 5-6 (Burger, in press).

TABLE 3: CORRELATION OF ROCK UNITS, NORTHEASTERN EROMANGA BASIN (MESOZOIC)

AGE	PALYN. UNITS	EXOIL BROOKWOOD 1	AMERADA THUNDERBOLT 1 BMR TANGORIN No. 1	BMR HUGHENDEN Nos 1-1A FLINDERS GORGE
APTIAN-ALBIAN	K1b-K2	ROLLING	DOWNS	GROUP*
NEOCOMIAN	K1a	HOORAY SANDSTONE	RONLOW BEDS	GILBERT R. FORM.*
JURASSIC	J5-6	WESTBOURNE FORM. ADORI SANDSTONE	RONLOW BEDS	BLANTYRE BEDS
JURASSIC	J4	BIRKHEAD FORM. (acritarch horizon)	RONLOW BEDS	BLANTYRE BEDS
JURASSIC	J3	HUTTON SANDSTONE	RONLOW BEDS	BLANTYRE BEDS

Acritarch horizon

* Marine microplankton

Pre-Wallumbilla Formation microfloras are relatively unknown in the northern part of the Eromanga Basin. Vertical and geographical distribution of dinoflagellates require more detailed study, as the microflora from MFP 4335 seems to contradict certain earlier observations from northern Queensland and Papua by Evans and Cookson & Eisenack. Scriniodinium playfordii is reported from the Jurassic in Western Australia and Papua (Cookson & Eisenack, 1958; 1960). Evans (1966c) does not mention the species from Cape York Peninsula, so that the specimen in assemblage 4335 might have been reworked from elsewhere during deposition of the Gilbert River Formation. Cookson & Eisenack (1958) described Cannosphaeropsis mirabilis from the Upper Jurassic in Omati, Papua. Evans (loc. cit.) discovered the species in A.P.C. Iehi No. 1 well within Cretaceous spore unit K 1a, but did not discover it in Cape York Peninsula (Archer River and Wenlock River areas). Its occurrence as far south as the Hughenden area may therefore be exceptional. Dingodinium cerviculum was initially described from the 'Roma Series' in northern Queensland (Cookson & Eisenack, 1958). Evans (1966c) reports the species also from (Neocomian-early Aptian) unit K 1a as part of the Dingodinium cerviculum/Scriniodinium attadalense Zone, which succeeds the interval of the range of Cannosphaeropsis mirabilis. Although there was no sign of Scriniodinium attadalense, the co-occurrence of Dingodinium cerviculum and Cannosphaeropsis mirabilis (if the specimens can be regarded as autochthonous) may indicate that the microflora is to be placed at the base of the Dingodinium cerviculum/Scriniodinium attadalense Zone, which Evans (loc. cit.) correlated with unit K 1a.

According to this evidence, Hughenden No. 1, core 4, may be correlated with the uppermost part of the Hooray Sandstone farther south, or with the upper part of the Bungil Formation in the northern Surat Basin.

Core 2 from the same borehole represents the basal part of the Doncaster Member. One sample (MFP 4331) at 181'4" (55.25 m) yielded a moderately preserved assemblage rich in dinoflagellates. Significant species are:

Spores:	Cicatricosisporites hughesii
	Dictyotosporites speciosus
	Pilosisporites notensis
	Osmundacidites cf. O. mollis
Dinoflagellates:	Goniaulacysta edwardsii
	Diconodinium multispinum
	Dingodinium cerviculum
	Muderongia tetracantha
	Chlamydophorella nyei
	Canningia cf. C. colliveri

The microplankton indicates the Zone of Dingodinium cerviculum. The spore assemblage is typical of upper unit K 1a or unit K 1b-c; the absence of Murospora florida suggests that the spores represent unit K 1b-c.

The Doncaster Member was also investigated in samples from Thunderbolt No. 1. Cuttings from the 720-750 feet (219.5-228.5 m) interval (MFP 4755) and the 750-780 feet (228.5-238 m) interval (MFP 4756) yielded only long-ranging or Cretaceous forms, with a high content of Dinoflagellates (Fig. 3). These were possibly a mixture of forms from the Dingodinium cerviculum and Muderongia tetracantha/Odontochitina operculata Zones; mixing could have been caused by caving of the drilled shaft during sampling.

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In Brookwood No. 1, cores were cut from the basal Doncaster Member and immediately underlying sediments, described as the Hooray Sandstone (Vine, 1970). It was possible to extract microfossils from samples of each core (Fig. 2). The assemblage from core 5 (MFP 2253) (depth 2110 feet, 643.1 m) was reasonably rich and contained Murospora florida, Cicatricosisporites australiensis, C. hughesii and Crybelosporites stylosus, a combination of species characteristic of spore unit K 1a. There was no trace of marine micro-organisms, so that the rock specimen must have been formed in non-marine conditions. Core 4, from the Doncaster Member (MFP 2252), at a depth of 1992 feet (607.2 m) produced an equally rich assemblage, containing Crybelosporites stylosus, Cicatricosisporites australiensis, Murospora florida, as well as the marine forms Dingodinium cerviculum, Chlamydophorella nyei and Muderongia tetracantha of the Dingodinium cerviculum Zone.

This is one of the very few observations of Murospora florida in the Rolling Downs Group. Minutely sampled subsurface sections in the Roma and Mitchell areas have proven that this species disappears in the upper part of the underlying Bungil Formation, thus dating the Doncaster Member assemblages from that area as of unit K 1b-c age (Burger, in press). There is insufficient information available at present on the full range of the species in the Eromanga Basin, so that the position of the K 1a-K 1b boundary in the lithological sequence must be discussed at a future date.

In the section of Brookwood No. 1 the Toolebuc Limestone was penetrated between 1460 feet (446.2 m) and 1530 feet (466.3 m). Core 3 was cut within this interval. A sample (MFP 2251) was taken from 1492 feet (454.8 m) for spore analysis; only few poorly preserved microfossils, among which marine forms, were recovered, so that palynological age determination was not possible. Examination of samples from the overlying Allaru Mudstone and Mackunda Formation gave better results. Core 2, depth 994 feet, 303 m (MFP 2250) contained the following zone marking fossils:

Cicatricosisporites australiensis
C. hughesii
C. ludbrookii
Appendicisporites spp.
Crybelosporites striatus
Tricolpites spp.

This assemblage is characteristic of spore unit K 2b (Burger, 1968b, c; Terpstra & Burger, 1969). Marine microplankton was present, although very rare. The following species were found:

Odontochitina operculata
Chlamydophorella nyei
Diconodinium multispinum

These forms are common constituents of the Zone of Odontochitina operculata, which Burger (1968c) considered equivalent in time with units K 2b+ in the Eromanga Basin. Muderongia tetracantha of the preceding Zone has so far not been found in post-Toolebuc formations.

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Core 1 (MFP 2249, depth 510 feet, 155.5 m) yielded a rich assemblage, in which the microplankton was also rare. The most significant zone index fossils were:

Spores:
- Cicatricosisporites australiensis
- Cicatricosisporites n. sp. (BMR No. 807)
- Appendicisporites tricornitatus
- Coptospora paradoxa
- Tricolpites spp.
- Crybelosporites striatus
- Microfoveolatosporis canaliculatus

Microplankton: Goniaulacysta sp.

This microflora is essentially the same as the previous one listed, and is typical of spore unit K 2b. Minor percentages of dinoflagellates in parts of the Allaru Mudstone are known from the Longreach area (Burger, 1968b), the Jundah 1:250 000 Sheet area (unpublished data), as well as farther south, in the Bulloo 1:250 000 Sheet area (Terpstra & Burger, 1969), which gives an impression of increasingly regressive depositional environments following those in which the Wallumbilla Formation and Toolebuc Limestone originated. This trend appears to continue in time, according to field evidence which has shown marine to paralic environments for the Mackunda Formation and non-marine environments for the overlying Winton Formation (Vine & Day, 1965).

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