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REVIEW OF THE PERMIAN PALYNOLOGY OF THE SYDNEY BASIN, NEW SOUTH WALES

by

P.R. Evans

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ABSTRACT

Published and unpublished data concerning the distribution of spores, pollen and microplankton in the Permian of the Sydney Basin are summarized and reviewed in terms of stratigraphic palynological units previously applied to the Permian of the Bowen, Galilee and Cooper Basins.

Little useful information is available from south of the Hunter Valley region: assemblages in the few sections examined are carbonized beyond recognition. Outcrop samples from the lower Hunter Valley region, ranging from the Seaham Formation of the Kuttung Group to the basal Lampton Subgroup of the Newcastle Coal Measures, have yielded sufficient fossils to permit identification, at a first approximation, of the palynological age of most of the recognized formations of the uppermost Carboniferous and Permian sequence.

The glacigene Seaham Formation correlates with the outcrop Joe Joe Formation of the Springsure area, Queensland. The Rutherford and perhaps uppermost Allandale compare with the Reids Dome Beds of the Dennison Trough, Bowen Basin. The Greta Coal Measures and basal Branxton Formation approximately correlate with the Cattle Creek Formation of the Dennison Trough. Information from the upper Branxton Formation and younger beds is sparse, but the Muree Formation appears to correlate within the range of the Ingelara and younger Permian formations. When the microfloral data are combined with the macrofaunal evidence of a post-Ingelara age for the Muree Formation, an hiatus of some kind, developed below the Muree Formation, might be considered.

On the basis of tenuous evidence, the top of the Permian unit P4 appears to lie within, not above the Newcastle Coal Measures.

Small numbers of acritarchs are present in interseam shales in the Lampton Subgroup of the Newcastle Coal Measures and indicate that brackish or marine conditions probably influenced deposition of the subgroup.

Better preserved microfloras have been found in deep wells in the northerly extension of the Sydney Basin referred to as the north-western coalfield region. The Boggabri Volcanics are confirmed as correlates of the Dalwood Group. The subsurface section within the Kelvin No. 1 Well cannot be reconciled with the stratigraphy of nearby outcrops.

The problem of carbonization (coalification) of fossil spores and some of the variables which possibly influence the process are briefly discussed.

INTRODUCTION

The Basins Study Group of the Petroleum Exploration Branch, Bureau of Mineral Resources, with collaboration from the Department of Mines, New South Wales, is currently reviewing aspects of the subsurface geology of the Sydney Basin. As a contribution to the project, existing palynological data from the Permian* of the basin have been reviewed in order to determine where microfloral changes of correlative value might occur, to discover the potential usefulness of palynology to the project and to indicate areas where additional information of value to stratigraphic, environmental and other geological aspects of the basin might be sought. The results of this review are presented below.

The subsurface study project is mainly confined to sediments within latitudes 32° and 36° South and longitudes 149° and 153° East. However, in the palynological review consideration was given to a few outcrops and wells as far north as latitude 30° South which are pertinent to problems in the Sydney Basin (figure 1): they do not include Permian sediments to the east of the longitude of Tamworth and north of the Hunter Valley.

Both published and unpublished data are considered. The unpublished data are only those available in the Bureau of Mineral Resources. Data which might be available in the Department of Mines, the Joint Coal Board or the C.S.I.R.O. Coal Research Division will be considered as need and opportunity arises in later reports.

This paper formed the basis of a lecture given at the Second Newcastle Symposium on the Sydney Basin, in April, 1967, but its final content and format are modified as a result of other topics discussed at the symposium.

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* The "Permian" is taken as the conventional concept of Dalwood Group - Newcastle Coal Measures for the purposes of discussion.

OBSERVATIONS - PUBLISHED

Taxonomy

Dulhunty (1945) first described sporomorphs from coal seams in the coal measures of the basin. He distinguished forms by a morphological key based on a) ornament and wing number, and b) body shape and tetrad mark, from which he derived forty five categories. Categories 41-45 (three winged grains) included no Permian types, and among the remainder Dulhunty recognized fifty form species. He recorded no type specimens or type localities. Some of the forms were illustrated by photographs, the remainder by line drawings only.

Balme & Hennelly (1955, 1956a, 1956b) supplied Linnaean names to photographically illustrated sporomorphs from the Permian of several parts of Australia, including the Permian of the Sydney Basin. The names qualify as legitimate taxa under the Botanical Rules of Nomenclature. Balme & Hennelly upheld twenty of Dulhunty's types, made no mention of the remainder and added thirty four new forms of their own (Table 1). Since then no taxonomic revision has been undertaken, although palynologists in other countries have revised Balme & Hennelly's work (e.g. Potonie, 1956-60; Hart, 1960-65; numerous papers by Bharadwaj, Lele and their Indian co-workers).

Careful re-appraisal and circumscription of taxa of stratigraphic value in the Sydney Basin is therefore a prime task if palynology is to be of much use to the subsurface project.

Stratigraphy

Dulhunty (1946) discussed the distribution of spores among coal measures at forty seven sample points around the Sydney Basin, referring to David (1932), Raggatt (1938) and Jones (1939) for the stratigraphic positions of his material (Table 3). He found that spores are relatively abundant in coals from all but the South Coast (Illawarra) Coalfield and took note of:

a) Relative abundance of spore-types, irrespective of age.

b) Palaeogeographic distribution of spore-types in the Newcastle Coal Measures.

c) Stratigraphic distribution of percentage abundance of spore-types in the Greta, Tomago and Newcastle Coal Measures (average of all fields).

d) Stratigraphic distribution and horizons of maximum abundance of fourteen selected spore-types which had limited vertical ranges.

e) Distribution of morphological groups, based on "Morphological" (shape, aperture, number of wings) and "Ornamentation" (exine ornament, possession of wings) characters.

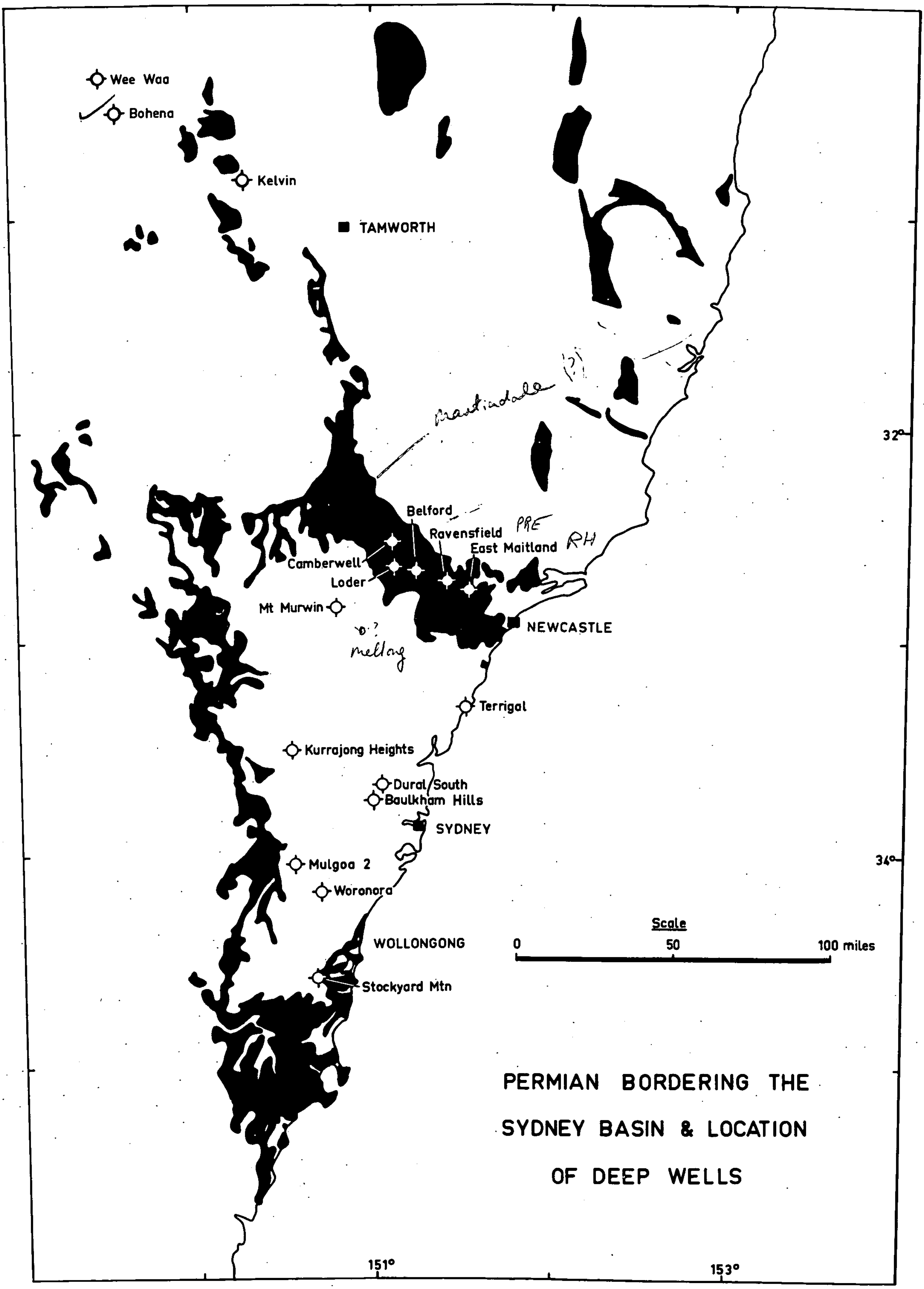
Wee Waa
Bohena
Kelvin
TAMWORTH
Belford
Ravensfield
East Maitland
Camberwell
Loder
Mt Murwin
NEWCASTLE
Terrigal
Kurrajong Heights
Dural South
Baulkham Hills
SYDNEY
Mulgoa 2
Woronora
WOLLONGONG
Stockyard Mtn
Scale
0
50
100 miles
32°
34°
151°
153°
PERMIAN BORDERING THE SYDNEY BASIN & LOCATION OF DEEP WELLS

FIGURE 1

TABLE 1: CHECK LIST OF SPECIES

DULHUNTY	BALME & HENNELLY	OTHERS	BMR
P1A	Leiotriletes directus	Microfoveolatispora[5]	(110 (p)
		Deltoidospora[1]	(158 (p)
P1B(part,+)	Granulatisporites trisinus	Microfoveolatispora[5]	703
6A)		Granulatisporites[1]	
P4B(part)	Punctatisporites gretensis		5
P16A+	Acanthotriletes ericianus	Anapiculatisporites[5,1]	115
		Didecitriletes[10]	
P21A+	Tholosporites egregius	Dulhuntyispora dulhuntyi[8]	122
P26A(part)	Granulatisporites micronodosus		
P28A	Verrucososporites leopardus	Thymospora[1,7]	
		Polypodiidites	
P29A	Verrucosisporites parmatus		
P29B	Verrucosisporites trisecatus	Cyclobaculisporites[5]	
P32A	Cirratriradites splendens	(part) Indotriradites[9]	
		(part) Kraeuselisporites[15] apiculatus	127
		Cirratriradites[1,4]	
P34A) P34B)	Nuskoisporites gondwanensis	Plicatipollenites[12]	(190
		Nuskoisporites triangularis[6]	(52
		(part) Virkiipollenites	(162
		mehtae[12]	(175
		V.obscurus[12]	(173
		V.densus[12]	(176
		(part) Cordaitina walensis[1]	
		(part) C.triangularis[1]	
P34C	Nuskoisporites rotatus	Barakarites[12]	
		Cordaitina balmei[1]	
P38A+	Lueckisporites limpidus	Protohaploxypinus sewardi[1]	209
P40D+	Lueckisporites fusus	Striatopodocarpidites[1,14]	141
		Platysaccus cf. P.papilionis[15]	
P40D+	Lueckisporites multistriatus	Striatites[13]	149
		Striatoabietites[1,4]	
	Lueckisporites amplus	Lunatisporites[6]	147
		Protohaploxypinus[1]	
	Lueckisporites cancellatus	Striatites[5]	143
		Striatopodocarpidites[1,2,4]	
	Lueckisporites phaleratus	Striatopodocarpidites[4]	210
	Pityosporites giganteus		
	Alisporites milvinus	Vesicaspora[1]	
	Vestigisporites rudis	(part) Vestigisporites gondwanensis[1]	193
	Vestigisporites spm. "A"	(part) Vestigisporites thomasi	
	Florinites eremus		
	Florinites ovatus	Alisporites[1,15]	138
		Sulcatisporites[5]	
		Vesicaspora[3]	

DULHUNTY	BALME & HENNELLY	OTHERS	BMR
	Laevigatosporites vulgaris f. colliensis	Latosporites colliensis[10]	132
	Laevigatosporites scissus	Schizosporis spheripollenites[5]	131
	Tuberculatosporites modicus		
	Verrucososporites cicatricosus	Thymospora[1] Polypodiidites[16]	134
	Verrucososporites hamatus	Thymospora[1] Polypodiidites[16]	133
	Calamospora diversiformis	Retusotriletes[5] Calamospora nigritella[1]	6
	Apiculatisporites levis	Apiculatisporis[1]	
	Apiculatisporites filiformis	Acanthotriletes[13] Apiculatisporis[1]	
	Apiculatisporites cornutus	Apiculatisporis[1]	
	Acanthotriletes tereteangulatus	Lophotriletes[7]	113
	Acanthotriletes dentatus	Anapiculatisporites[7] Didecitriletes[10]	
	Acanthotriletes villosus	Microbaculispora[5]	
	Acanthotriletes uncinatus	Didecitriletes[10]	114
	Acanthotriletes ramosus	Neoraistrickia[3] Horriditriletes[7]	
	Verrucosisporites pseudoreticulatus	Microfoveolatispora[5]	146
	Verrucosisporites bullatus	Zinjispora bullata[1]	
	Microreticulatisporites bitriangularis		121
	Camptotriletes biornatus		
	Tholosporites parvitholus	Dulhuntyispora[1]	123
	Bascanisporites undosus	Bascanites[1]	139
	Entylissa cymbatus	Ginkgocycadophytus[6] Cycadopites[1,15]	
P3A	Entylissa vetus	Ginkgocycadophytus[6] Cycadopites[1,15]	154
P8A(part)+	Marsupipollenites triradiatus		(152
	M.triradiatus f.striatus	Marsupipollenites striatus	(164
P3B+	Marsupipollenites sinuosus	Gnetaceaepollenites[5] Schopfipollenites[1]	(208 (153 (151
	Marsupipollenites scutatus	Vittatina[5] Pakhapites[1]	
	Marsupipollenites fasciolatus	Vittatina[5] Pakhapites[1]	
	Pilasporites calculus		
P5C+	Pilasporites plurigenus	(part) Spheripollenites elphinstonei[15]	

DULHUNTY	BALME & HENNELLY	OTHERS	BMR
P2A			
P3B			
P3C+			
P4A			
P4C			
P5A			
P5B			
P7A			
P8A			
P9A			
P9B			
P10A			
P10B			
P13A+			
P14A			
P15A			
P17A			
P18A			
P19A			
P20A			
P23A			
P23B+			
P30A			
P33A+			
P33B			
P35A+			
P40A			
P40C			
P41A+			

Footnotes

+ Specimens of these form groups were photographically illustrated.

1 Hart, 1965a

2 Hart, 1965b

3 Hart, 1960

4 Hart, 1964

5 Bharadwaj, 1962

6 Potonie & Lele, 1961

7 Bharadwaj & Salujha, 1964

8 Potonie, 1956

9 Tiwari, 1964

10 Venkatachala & Kar, 1965

11 Lakanpal, Sah & Dube, 1960

12 Lele, 1964

13 Tiwari, 1965

14 Potonie, 1958

15 Jansonius, 1962

16 Playford & Dettmann, 1965

TABLE 2: GENERALIZED DISTRIBUTION LIST*

TYPE		NEWCASTLE/ TOMAGO	GRETA
P21A	Dulhuntyispora dulhuntyi	+	
P33A		+	
P34A	"Nuskoisporites" gondwanensis	+	
P40B	Striatopodocarpidites fusus	+	
P40A		+	
P33B		+	
P13A		+	
P 3B	"Marsupipollenites" sinuosus	+	
P 9A		+	
P30A			+
P32A	"Cirratriradites" splendens		+
P15A			+
	Punctatisporites gretensis		+
	Apiculatisporis filiformis	+	
	Apiculatisporis cornutus		+
	Lophotriletes tereteangulatus	+	
	Didecitriletes dentatus	+	
	Didecitriletes uncinatus	+	
	Horriditriletes ramosus	+	
	Verrucosisporites pseudoreticulatus		+
	Zinjispora bullata	+	
	Cyclobaculisporites trisecatus	+	
	Verrucosisporites parmatus		+
	Microreticulatisporites bitriangularis	+	
	Camptotriletes biornatus		+
	Dulhuntyispora parvithola	+	
	Bascanisporites undosus	+	
	Striatopodocarpidites cancellatus	+	?
	Prothaploxypinus sewardi	+	?
	Striatopodocarpidites phaleratus	+	
	"Pityosporites" giganteus		
	Vesicaspora milvina	+	
	Vestigisporites rudis		+
	"Florinites" eremus	+	
	Vesicaspora ovata	+	
	Marsupipollenites triradiatus f. striatus	+	
	Pakhapites scutatus		+
	Pakhapites fasciolatus	+	
	Cycadopites cymbatus	+	
	Pilasporites calculus		+

* As reported by Dulhunty (1946) and Balme & Hennelly (1955, 1956a,b).

Balme & Hennelly (opera cit.) did not follow Dulhunty's approach to stratigraphic palynology, and paid more attention to the systematic description of their fossils. They tabulated the general distribution of trilete spores, but only individual seams or coal measures in which monolete spores, monocolpate and saccate pollen were found under each description (Tables 2 and 3).

Hennelly (1958) noted that a radically different microflora entered the region close to the base of the Narrabeen Group. His observations provided a means of identifying a palynological equivalent of the accepted top of the Permian in Australia.

Rade (1963) listed microspores of Newcastle type from the Narrabri - Curlewis area, which confirmed Dulhunty's comparison of the Gunnedah - Curlewis flora with those of the Newcastle Coal Measures. Rade used Balme & Hennelly's terminology and added to the list forms which he referred to the European species Endosporites emineus, Accinctisporites nexus and Succinctisporites grandior although he did not figure them. He listed assemblages from three localities; one each from Gunnedah and Preston "collieries", presumably in what Hanlon (1949a) referred to the Black Jack Formation, the third from Killarney Gap where Permian outcrops were mapped by Hanlon (1949c) as Nandewar Group.

OBSERVATIONS - UNPUBLISHED

Outcrop

Samples from outcrops in the lower Hunter Valley were collected and examined by E.A. Hodgson in 1962, but none of his results were compiled into a generally available report. Hodgson's preparations have been re-examined for the purposes of this review. Not all samples were fossiliferous, but each sampled locality is listed below so that in any future examination of the outcrop, the sections may be avoided. Hodgson's estimated stratigraphic position of each sample is plotted in figure 2. They are based on information supplied by Mr McKellar, Professor Ritchie, Dr Rattigan and Dr Dickins, who accompanied Hodgson on the collecting excursion.

Samples from the underlying Kuttung Series, which were collected by Dr Rattigan of Newcastle University, have been processed by Mr R. Helby of the Department of Mines. The contents of one sample from the Seaham Formation at the top of the Kuttung Series, and provided by Mr Helby and Dr Rattigan, are listed and discussed below because they are relevant to the problem of correlating Permian sequences elsewhere in Australia.

These data are insufficient for erecting a local zonal scheme at this stage and so they are allocated to palynological units recognized elsewhere in eastern Australia (Evans, 1964, 1066b-d). The key fossils by which these determinations are made are noted for each assemblage. Their stratigraphic implications are considered in the following chapter.

Newcastle Coal Measures

No detailed information is yet available from outcrops of the Newcastle Coal Measures. Provisional examination of samples collected from exposures along the Newcastle foreshores during the pre-Symposium excursion has shown

TABLE 3: LOCATIONS OR SEAMS SAMPLED BY DULHUNTY AND BALME & HENNELLY

DULHUNTY

COALFIELD	SEAM	COAL MEASURES
Western	Katoomba	Newcastle
"	Dirty	"
"	Lithgow+	"
Northern	Wallarah	"
"	Great Northern	"
"	Fassifern	"
"	Pilot	"
"	Burwood	"
"	Nobby's	"
"	Dirty	"
"	Young Wallsend	"
"	Borehole+	"
North-Western	Gunnedah, Curlewis and Western Creek	"
Ulan Baerami	Top (?Katoomba)	"
"	Seam below Top	"
"	Bottom (?Lithgow)	"
South Coast	No. 3 or Dirty	"
"	No. 4	"
South-Western	Bulli	"
"	No. 3 or Dirty	"
Northern	Big Ben+ or Tomago Thick	Tomago
"	Rathluba	"
"	Liddell	"
"	Rix Creek	"
"	Greta+	Greta

BALME & HENNELLY

Seams marked (+) in list above.		
Muswellbrook Seam		Greta C.M.
Coal band at 248'7", Dobb's Drift, Lithgow		Newcastle C.M.
South Wallarah No. 2,	719' (Fassifern)	"
South Wallarah No. 3,	679' (Fassifern)	
South Wallarah No. 5,	377' (base of Wallarah)	"
"	685' (Fassifern)	"
"	688' (Fassifern)	"
Newston No. 2	755' (between Fassifern and Young Wallsend)	"

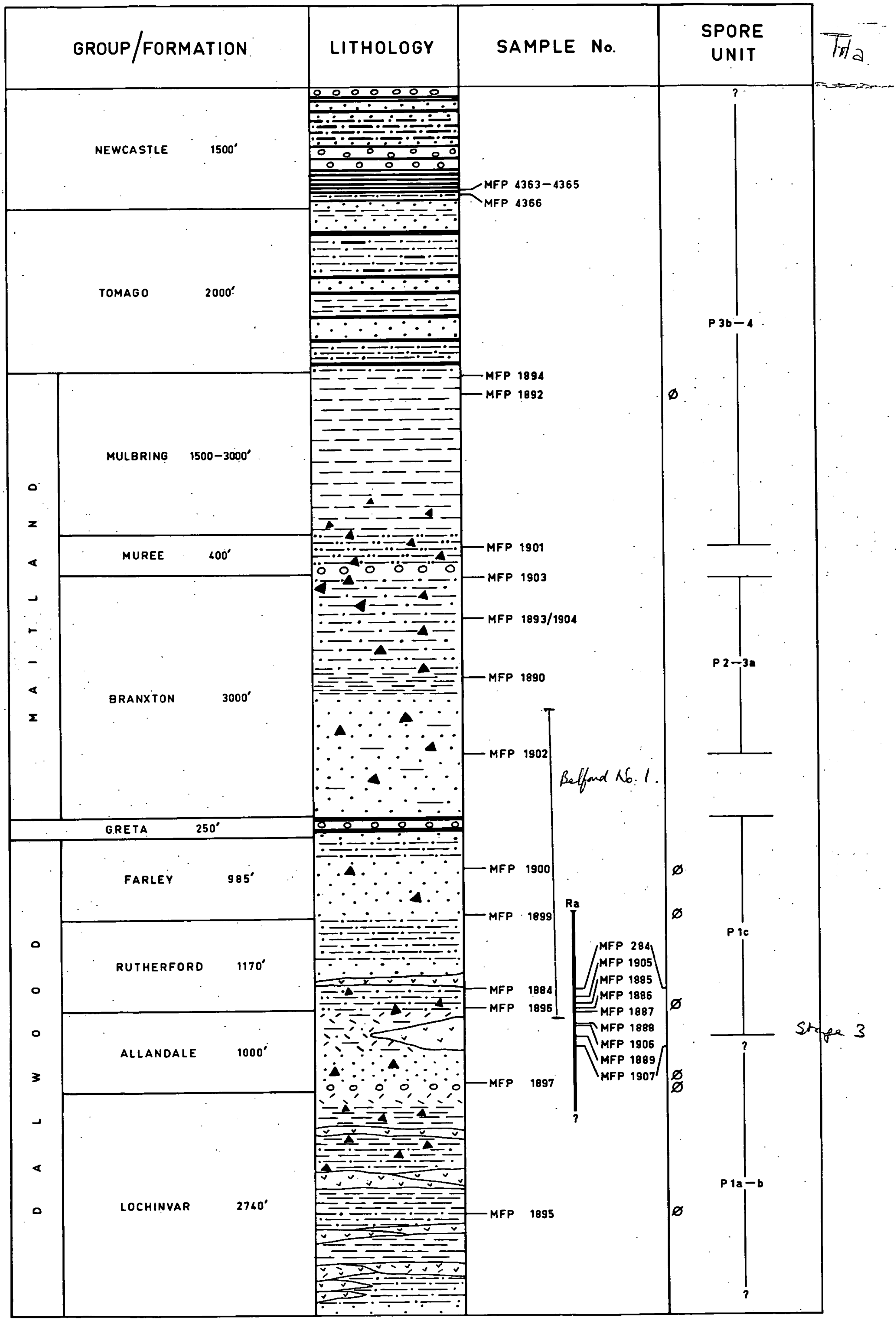
GROUP/FORMATION
LITHOLOGY
SAMPLE No.
SPORE UNIT
NEWCASTLE 1500'
TOMAGO 2000'
MAITLAND
MULBRING 1500–3000'
MUREE 400'
BRANXTON 3000'
GRETA 250'
DALWOOD
FARLEY 985'
RUTHERFORD 1170'
ALLANDALE 1000'
LOCHINVAR 2740'
MFP 4363–4365
MFP 4366
MFP 1894
MFP 1892
MFP 1901
MFP 1903
MFP 1893/1904
MFP 1890
MFP 1902
MFP 1900
MFP 1899
MFP 1884
MFP 1896
MFP 1897
MFP 1895
Ra
MFP 284
MFP 1905
MFP 1885
MFP 1886
MFP 1887
MFP 1888
MFP 1906
MFP 1889
MFP 1907
Belford No. 1.
P 3b–4
P 2–3a
P 1c
P 1a–b
Stage 3
Ra — Sun Oil No.1 (Ravensfield)
Ø — Barren Sample

FIGURE 2

that spores and pollen are present, although poorly preserved, in shales of the Bogey Hole Formation, Lampton Sub-group near the base of the Newcastle Coal Measures, and in interseam sediments of the Dudley Seam. A detailed study of these samples will be made at a later date. However, each one has yielded several specimens of acritarch Veryhachium spp. and Micrhystridium spp., which are suggestive of deposition under brackish or marine conditions. Their fossil origin may be questionable in view of the samples origins on the coastline: they could be contaminants. The preservation state of the acritarchs fits that of the undoubtedly fossil spores, but a check of borehole material is desirable to confirm that the organisms are autochthanous. The samples taken were:

Dudley Seam - interseam sediments. MFP 4365: Newcastle Beach Pavilion, just to right of fault-plane. MFP 4364: At track level in cliff section at Bogey Hole. MFP 4363: Seat earth to upper split of Dudley Seam at Bogey Hole.

Bogey Hole Formation. MFP 4366. Signal Hill rock platform.

Maitland Group

Mulbring Siltstone: near the top of the formation (Dochra Mudstone). MFP1894*: Singleton Railway Bridge, SINGLETON** 416E 976N.

Small yield of:

Retusotriletes diversiformis	6	
Parasaccites spp.		
Disaccites sp.		
Striatiti spp.		
Marsupipollenites triradiatus	152	
Didecitriletes ericianus	115	$(^{m}1)$

$(^{m}1)$ Marker fossil: range P3a-P4, usually seen in P3b and younger.

Muree Formation. MFP 1901: SINGLETON 432E 932N, 2 miles west of Branxton Station.

Moderate yield of:

Punctatisporites gretensis	5	$(^{m}2)$
Retusotriletes diversiformis	6	
Microbaculispora villosa		$(^{m}1)$
Granulatisporites trisinus	703	
Polypodiidites leopardus		
Camptotriletes biornatus		$(^{m}2)$
?Apiculatisporis cornutus		$(^{m}2)$
Cyclobaculatisporites trisecatus		$(^{m}1)$
Leiotriletes directus	207	
Polypodiidites cicatricosus	134	$(^{m}2)$
aff. Bascanisporites undosus	137	$(^{m}1)$
Protohaploxypinus amplus	147	
Striatopodocarpidites cancellatus	143	
Marsupipollenites triradiatus	152	
"Marsupipollenites" sinuosus	151	$(^{m}1)$
Pilasporites calculus		
Cycadopites cympatus		
Parassaccites spp.		

This diverse assemblage contains components of both units P3b-4 ($^{m}1$) and units P2-3a ($^{m}2$).

<u>Branxton Formation</u>: 10 feet below base of Muree Formation. MFP 1903: SINGLETON 445E 930N, Bow Wow Creek. Only a few fossils found, including:

<u>Punctatisporites gretensis</u>	5
<u>Retusotriletes diversiformis</u>	6
"<u>Marsupipollenites</u>" sp.	208
<u>Granulatisporites trisinus</u>	703
<u>Protohaploxypinus</u> sp.	

<u>Branxton Formation, "Thamnopora Zone"</u>. MFP 1893, 1904: SINGLETON 445E 930N, Bow Wow Creek.

<u>Granulatisporites trisinus</u>	703	
<u>Marsupipollenites triradiatus</u>	152	
<u>Apiculatisporis cornutus</u>		
<u>Disaccites</u> spp.		(fairly common)
Striatiti spp.		(" ")
Cingulati spp. indet.		

<u>Branxton Formation, "Fenestella Zone"</u>. MFP 1890: SINGLETON 435E 962N, 1200 yards west of Branxton Station.

<u>Leiotriletes directus</u>	207	
<u>Granulatisporites</u> sp.	110	
<u>Granulatisporites trisinus</u>	703	
<u>Polypodiidites cicatricosus</u>	134	
cf. <u>Limitisporites</u> sp.	142	
cf. "<u>Marsupipollenites</u>" sp.	208	
<u>Cycadopites vetus</u>	154	
<u>Striatoabietites</u> cf. <u>multistriatus</u>	150	
Disaccites spp.		(fairly common)
incl. sp.	137	
<u>Parasaccites</u> spp.		(fairly common)
"<u>Nuskoisporites</u>" <u>rotatus</u>		
Straititi spp.		

These three samples from the Branxton Formation are inconclusively dated but the assemblages favour a pre P3b-4 age.

<u>Branxton Formation, below the "Fenestella Zone"</u>. MFP 1902: SINGLETON 438E 963N, on the Singleton - Dalwood Road, a well preserved, diverse assemblage:

<u>Punctatisporites gretensis</u>	5
<u>Retusotriletes diversiformis</u>	6
<u>Leiotriletes directus</u>	207
<u>Granulatisporites trisinus</u>	703
<u>Granulatisporites</u> sp.	110
?<u>Apiculatisporis cornutus</u>	
<u>Polypodiites leopardus</u>	

+ Vitrei. pallidus
Parasaccites sp.

Polyoodiidites cicatricosus	134
Marsupipollenites triradiatus	152
?Apiculati sp.	118
aff. Ovalipollis sp.	136
(Striatisporites) ~~Vesicaspora~~ ovata	138
Protohaploxypinus amplus	147
Limitisporites sp.	142
cf. Protohaploxypinus sp.	198
Tasmanites sp.	
Circulisporites parvus	
Veryhachium sp.	
Micrhystridium spp.	
Cymatiosphaera sp.	
Sphaeromorphitae gen. et spp. undet.	

Gral. micronodosus
Cycadopites cf. follicularis

greater diversity of acritarchs than comparable horizon in Belford No. 1
Same sparse-spined MICR does occur though.

This is characteristically a P2 assemblage. The form of Cymatiosphaera closely resembles a member of the same genus found in P2 in the Bowen Basin.

Greta Coal Measures

No samples taken.

Dalwood Group

Farley Formation. MFP 1900: SINGLETON 453E 954N, Farley Road, 150 yards from Farley Station. Barren.

Farley Formation, Ravensfield Sandstone Member. MFP 1899: SINGLETON 453E 954N (about). Barren.

Rutherford Formation: near base. MFP 1896: SINGLETON 443E 955N, stock route near Allandale Station. Barren.

Allandale Formation: MFP 1897: cutting near crest of Harpers Hill on New England Highway. Barren.

Lochinvar Formation. 1280 feet above base of formation. MFP 1895: SINGLETON 447E 956N. 0.3 miles north of Lochinvar. Barren. Details are not available, but the coincidence between the estimate of the locality's stratigraphic position above the base of the formation, and the locality given by David (1950) for the first record of Gangamopteris, is taken as evidence that David's classic locality was sampled.

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* BMR palynological preparation number

** The 1:250,000 Sheet areas on which sample co-ordinates are measured are named for brevity by the sheet name in capitals.

ø Numbers ascribed to the species in the BMR collection.

Kuttung Series

Seaham Formation: University of Newcastle sample no.1914 (samples provided by Mr R. Helby and Dr J. Rattigan). MFP 4314, 4373: PATTERSON 638E 664N.

Calamospora sp.	4*
Retusotriletes diversiformis	6
Punctatisporites sp.	7 (common)*
Perinotriliti sp.	10*
Acanthotriletes	19
Dictyotriletes sp.	43*
Monosaccites spp. incl.	*
Parasaccites sp.	50
Monosaccites sp.	44

Preparations held by Mr Helby also include:

Verrucosisporites sp.	22*
Vallatisporites sp.	37*

* Key fossils: unit Cl.

Although fourteen deep wells were subsidized (Table 4), palynological information is available from only eight of them, and none is published or presented in B.M.R. Record form. It is therefore either repeated or amplified below. Data from the unsubsidized Baulkham Hills No. 1, Sun Well No. 1 (Ravensfield Dome) and Kamileroi Kulnura No. 1 are also listed.

SUBSURFACE

A.O.G. Baulkham Hills No. 1

Cuttings were examined at the company's request shortly after the well was drilled to test whether marine Permian sediments had been encountered near the base of the well. Samples were taken for examination from:

SAMPLE NO.	DEPTH	COMMENT
MFP 1351	3166-75'	
MFP 1352	3255-3268'	
MFP 1353	3320-25'	
MFP 1354	3359-67'	Cuttings only
MFP 1355	3379-96'	
MFP 1356	3415-28'	
MFP 1357	3443-63'	
MFP 1358	3485-008	

All were barren of spores or yielded only a few carbonized grains.

TABLE 4: LOCATIONS OF SUBSIDIZED OIL & GAS EXPLORATION WELLS

COMPANY	WELL	LATITUDE	LONGITUDE	HEIGHT		TOTAL DEPTH
				GROUND	DATUM	
A.O.G.	BELFORD NO. 1	32°39'23"S	151°17'05"E	244'	248'	3854'
AMOSEAS	BOHENA NO. 1*	30 31 32	149 36 24	840	852	5414
A.O.G.	CAMBERWELL NO. 1	32 32 30	151 06 09	288	302	6256
PLANET	EAST MAITLAND NO. 1*	32 45 46	151 36 58	15	31	10004
MID-EASTERN	KELVIN NO. 1*	30 50 33	150 18 54	949	965	5201
EXOIL/A.O.G.	KURRAJONG HEIGHTS NO.1*	33 31 45	150 37 15	1863.5	1879	9132
A.O.G.	LODER NO. 1	32 38 07	151 08 00	338	355	6767
A.O.G.	MULGOA NO. 2*	33 48 40	150 38 27	501	501	5630
A.O.G.	MOUNT HUNTER NO. 1	34 03 30	150 38 50	282	285	3512
A.O.G.	MOUNT MURWIN NO. 1*	32 50 45	150 55 20	1453	1456.4	2910
SHELL	DURAL SOUTH NO. 1*	33 42 37	151 01 02	35	649	10035
FARMOUT DRILLERS N.L.	STOCKYARD MOUNTAIN NO.1	34 36 05	150 47 10	163	174.3	3516
AMOSEAS	WEE WAA NO. 1*	30 21 08	149 31 02	689	701	2706
A.O.G.	WORONORA NO. 1	34 11 40	150 54 50	1160	1172	7587

* Wells of which palynological studies have been made.

Amoseas Bohena No. 1

Reference: Gerrard (1963a)

Section:

AGE	FORMATION	DEPTH	THICKNESS
Cainozoic	Alluvium	12'	33'
Jurassic (?) Cretaceous		45'	1258'
Triassic (with Tertiary teschenite intrusions)		1303'	734'
Permian	Coal seams and minor sandstone and shale	2037'	284'
Tertiary	Teschenite	2283'	38'
Permian	Interbedded shale with siltstone and sandstone	2321'	395'
	Coal seams with shale, some siltstone and sandstone	2716'	356'
	Shale	3072'	260'
	Volcanics	3332'	2082'
	with shale interbeds at	3505-3566'	
		4236-4300'*	
		4379-4312'	
(Total Depth)		5414'	

* poorly developed kerogen shale

Fossils: no macrofossils. Microflora reported by Evans (in Gerrard, 1963a) and amplified as follows:

Core 6, 2164 - 74 feet

Carbonaceous sandstone and shale.

Retusotriletes diversiformis	6
Granulatisporites sp.	59
Vesicaspera sp.	137
Striatopodocarpidites sp. ?	210

Quadrisporites horridus		211*	
Apiculatisporis sp.		226	
Striatiti sp.		260*	
Striatiti sp.	?	262*	
Peltacystia calvitium	sp.	625+	(fairly common)
Striatiti spp. undiff.			
Polypodiidites aff. T. cicatricosus		134	(fairly common) – ? includes some Anati., others Tuberculati. cf alcodalensis

* Key fossils, indicating Lower Triassic Tr1a.

\+ Facies fossil.

Cuttings, 2210 - 20 feet.

Coal (CCl_4 float).

Striatiti spp. (Permian types)	
Marsupipollenites triradiatus	152
Leictriletes directus	207
Peltacystia calvitium	625+

Appears to completely lack any Tr1a forms and a Permian ? P4 age is assigned to it.

\+ Facies fossil.

Core 7, 252 feet

Carbonaceous sandstone

Parasaccites sp.		52	
Polypodiidites cicatricosus		134	
Leiotriletes directus		207	
"Marsupipollenites" sp.		208	
Anapiculatisporites sp.	aff.	615	
Microbaculispora villosa		*	
"Nuskoisporites" rotatus			
Parasaccites sp.		190	(fairly common)
Dulhuntyispora dulhuntyi		122*	
Disaccites spp.			(common)
Striatiti spp.			
Acritarcha undiff.			(rare)*

* Indicators of unit P3b: The overlap of D. dulhuntyi and P. cicatricosus implies that section low in P3b is represented. Further support for this correlation is gained from the relatively high content of Parasaccites spp. and "N". rotatus.

\+ Indicators of a marine or brackish environment.

Core 8, 2800 - 10 feet

Retusotriletes diversiformis	6	
Granulatisporites sp.	111	
Verrucosisporites pseudo-reticulatus	68*	
Polypodiidites cicatricosus	134*	
Granulatisporites trisinus	703	
Apiculatisporis cornutus		
Disaccites spp.	*	
Striatiti spp.	*	(fairly common)
"Nuskoisporites" rotatus		
Vesicaspora sp.	137	
Leiotriletes directus	207	

* Indicators of units Plc - P2. The high proportion of Striatiti spp. and presence of A. cornutus favours a late Plc or preferably P2 age.

Core 9, 3172 - 82 feet

Parasaccites spp.	*	(common)
Striatiti spp.	*	
Verrucosisporites pseudo-reticulatus	68*	
Parasaccites sp.	50	
Parasaccites sp.	190	
Laevigatosporites sp.	158	
Striatoabietites sp.	188	
Vestigisporites cf. rudis	193	
aff. Granulatisporites sp.	59	
Apiculatisporis sp. cf.	62	
Parasaccites sp.	191	
Monocalpates sp.	164	
Disaccites spp.		
aff. Botryococcus		

* Key forms: the high proportion of Parasaccites spp., presence of V. pseudoreticulatus and apparent absence of P. cicatricosus and A. cornutus suggests a lower Plc age.

Sidewall Core 4264 feet

Barren.

Sidewall Core 4271 feet

Monosaccites spp.		(common)*
Striatiti spp.		(present, rare)*
Monosaccites sp. cf.	44*	
Parasaccites sp.	50	
Retusotriletes diversiformis	6	
Parasaccites sp.	52	
Sphaeromorphitae		(common)

* Permian: Plb-c. Abundance of Sphaeromorphitae compares with similar developments in Plc beds in Kelvin No. 1 (q.v.).

Shell Dural South No. 1

Reference: Shell Development (Australia) Pty Ltd, 1967

Section:

AGE	FORMATION	DEPTH(Top)	THICKNESS
Triassic	Undifferentiated	Surface	2730'
Permian	Newcastle Coal Measures	2730'	503'
	Tomago Coal Measures	3233'	2063'
	Maitland Group	5296'	4709'
?	Economic basement	10005'	30'
(Total Depth)		10035'	

A dolerite sill intrudes the Tomago Coal Measures between 4584 and 4730 feet, with a low grade metamorphic zone up to 4503 feet and down to 4820 feet.

Fossils: Microfaunas were examined by Shell Geological Laboratory. A selection of core samples and sidewall cores from the Permian were submitted by Shell for palynological examination. No useful assemblages could be extracted. The few spores noted were so fragmental or carbonized to be specifically indeterminate.

SAMPLE NO.		DEPTH	COMMENT
MFP 4187		3099'	No spores.
MFP 4188		3297'	Traces of spores seen.
MFP 4189		3680'	Grains obviously present, but extremely carbonized.
MFP 4190		4826'	Translucent woody tissue only.
MFP 4191		5065'	No spores.
MFP 4097	c.1	5511'	No spores.
MFP 4192		5673'	No spores.
MFP 4098	c.2	6374'	No spores.
MFP 4099	c.3	7035'	Indeterminate fragments ? spores.
MFP 4100	c.3	7042'	No spores.
MFP 4196	c.5	8018'	No spores.

Planet East Maitland No. 1

Reference: Hamling & McKellar, 1963

Generalized Section (formation names as quoted):

AGE	FORMATION	DEPTH(Top)	THICKNESS
Permian	Tomago Coal Measures	Surface	190'+
	Maitland Group		
	Mulbring Siltstone	190'	1300'
	Branxton Formation	1490'(?) fair preservation	3159'
	Muree Sst. Memb.	1964'	356'
	Cessnock Sst. Memb.	4583'	66'
	Greta Coal Measures	4649'	144'
	Greta Seam	4649'	14'
	Undifferentiated	4663'	130'
	Dalwood Group		
	Farley-Rutherford Fmns	4793'	1436'
	Ravensfield Sst. Memb.	6083'	23'
	Allandale-Lockinvar Fmns	6229'	3784'+
Total Depth		9993'	

Fossils: Neospirifer sp. in core 23, 6988-98 feet (Dickins, Appendix 5 in Hamling & McKellar).

In Appendix 3, Hamling & McKellar recorded invertebrate fossils in:

core 7, 2264-72 feet
core 8, 2594½-2601 feet
core 9, 2888-98 feet
core 10, 3200-3206 feet
core 17, 5648-58 feet
core 23, 6988-98 feet.

Helby, in Appendix 4 to Hamling & McKellar, examined most cores for their microfloral content. His report is quoted in full and no alterations to his taxonomy is made:

"Core	Depth	Quality of Separation
1	495 - 505 ft.	Fair
2	835 - 845 ft.	Fair
3	1156 - 1166 ft.	Fair
4	1480 - 1490 ft.	Fair
5	1831 - 1841 ft.	Poor
7	2264 - 2274 ft.	Poor
8	2594 - 2604 ft.	Poor
10	3200 - 3210 ft.	No spores observed
11	3450 - 3459 ft.	Very poor
12	3970 - 3980 ft.	No spores observed
13	4450 - 4467 ft.	No spores observed
15	4677 - 4689 ft.	Very poor
16	5165 - 5175 ft.	No spores observed
17	5649 - 5659 ft.	No spores observed
18	5720 - 5729 ft.	No spores observed
19	6101 - 6111 ft.	No spores observed
	6998 -	No spores observed

"Although most of the samples examined lacked or had very low spore contents, they all contained large amounts of finely divided plant tissue. In nearly every preparation it was possible to recognise tracheids and other wood material of small size. It is interesting to note that no marine micro-organisms were observed, even in samples with abundant shelly fauna.

"Age

Most possibly Artinskian. Due to the lack of spore occurrences in the lower parts of the section it has not been possible to attempt sub-division of the section on the basis of the contained microfloras. However, it could be suggested from the contained forms that the samples in the upper part of the section were Maitland Group equivalents by virtue of the mixing of forms which have previously been reported as confined locally to the upper Tomago and Newcastle Coal Measures and the lower Greta Coal Measures.

Sporomorph	Core No. 1	2	3	4	5	7	8	11	15	Known Range (Local)
Aliporites ovatus		X	X							N.
Acanthotriletes ericianus	X		X	X						N. T. G.
Apiculatisporis cornutus	X									G.
Calamospora diversiformis	X									N. T. G.
Cirratriradiates splendens		X		X						N. G.
Dulhuntyispora egregius	X	X								N. T.
Granulatisporites micronodosus		X								N. T. G.
Granulatisporites trisinus	X	X	X	X						N. T. G.
Leiotriletes directus	X	X	X		X		X			U. Pal. -Mes.
Marsupiopollenites sinuosus		X								N. T. G.
Nuskoisporites gondwanensis	X		X			X				N. T. G.
Nuskoisporites rotatus	X			X	X	X				N. T. G.
Punctatisporites gretensis								X	X	
Striatites limpidus		X								N. T.
Striatites multistriatus	X									N. T. G.
Verrucosisporites cf. parmatus	X									G.
Verrucososporites cicatricosus	X	X	X			X	X			G.
Vittatima Scutatus	X	X			X					G.

N. Newcastle Coal Measures

T. Tomago Coal Measures

G. Greta Coal Measures".

Mid-Eastern Kelvin No. 1

Reference: Hall & Perry (1965)

Section:

AGE	FORMATION	DEPTH(Top)	THICKNESS
Cainozoic	Alluvium	0'	323'
Permian	Interbedded rhyolite and shale	323'	3287'
	Interbedded basalt and shale	3610'	750'
?*	Spillite and shale	4360'	820'
	Agglomerate and tuff	5180'	21'
(Total Depth)		5201'	

* Hall and Perry attributed the entire section to the Permian.

Fossils: Macroflora - core 10, 3392 feet. Glossopterid leaf fragment.

Microflora - reported by Evans (in Hall and Perry, 1965) and amplified as follows:

Core 5, 1728 feet

Spores and pollen relatively abundant, but carbonized.

Parasaccites spp. (common)*	
Disaccites spp. indet.	
Striatiti spp. undet.	
Marsupipollenites triradiatus	152*
Leiotriletes sp.	158
Verrucosisporites sp. cf. V. pseudoreticulatus	68*
Punctatisporites gretensis	5*
Apiculati spp. indet.	

* Key forms: unit Plc.

Core 9, 2914 feet

Very poor preservation.

Parasaccites spp.
Sphaeromorphitae (very common)

Core 10, 3392 feet

? Disaccate pollen grain.

Kamilaroi Oil Kulnura No. 1

Near Kulnura, north of Gosford.

Cuttings from Kulnura No. 1 are preserved in the B.M.R. museum and portions of them were examined in order to check the position of the Permian/Triassic boundary. The hole was re-opened and deepened by A.O.G. in 1964, but no material from the lower section has been examined. Condon et al. (1958) and Booker (1960) placed the top of the Permian at 2700 feet. Booker quoted Raggatt's choice of the depth of 3778 feet, based on the occurrence of foraminifera, for the top of the Maitland Group. Thus the samples listed below were taken from the Triassic or the uppermost levels in the Permian coal measures.

SAMPLE NO.	DEPTH	COMMENT
MFP 1092	2686-91'	Q. horridus present. ? Triassic
MFP 1093	2696-70'	Rare, indeterminate grains.
MFP 1094	2701-06'	Rare spores with D.parvithola G. trisinus: P4-Trla
MFP 1095	2731'	D. parvithola, P.amplus and P. "limpidus" - Permian P4.

A.O.G. - Exoil Kurrajong Heights No. 1

Reference: Stuntz, Perry & Webb in Bureau of Mineral Resources, 1965.

General Section:

AGE	FORMATION	DEPTH(Top)	THICKNESS
Triassic	Hawkesbury Sandstone	16'	724'+
	Narrabeen Group	740'	2175'
Permian	Lithgow Coal Measures ?	2915'	452'
	Tomago Coal Measures ?	3367'	1128'
	Capertee Group	4495'	3370'
"Permo-Carboniferous"?			
	Volcanics	7965'	1267'
(Total Depth)		9132'	

Fossils: No macrofaunas reported. Crespin in Stuntz et al., recognized foraminifera from 4656 feet to total depth.

Hennelly and Hodgson attempted unsuccessfully to extract spores from cores 29 and 31. Hennelly stated: "I have carried out a palynological examination of three samples from the above cores. The search was limited to three samples as the material was too oxidized to justify a further search. The results are:-

(a) 7,797' - 7,798' - No palynological matter. Highly oxidized plant fibres of gymnospermous origin and coal fragments of fusinised material. Dark carbonaceous shale.

(b) 7,798' - 7,799' - Similar to (a).

(c) 8,162' - 8,165' - Dark in colour but not carbonaceous. No fossil material of any type.

"From this the only conclusion to be drawn is that (a) and (b) are of presumed Permian age".

Hodgson reported, "Two samples from the well have been examined palynologically. No spores were seen although Core 29 from 7,797 feet, contained some rare organic fragments; the sample from the bottom of the hole (Core 31 - 8,162 feet) was devoid of such material".

A.O.G. Mount Murwin No. 1

Reference: Stuntz & Wright, 1963.

Generalized Section:

AGE	FORMATION	DEPTH(Top)	THICKNESS
Triassic	Hawkesbury Sandstone	Surface	270'
	Narrabeen Group	270'	2263'
Permian	Newcastle Coal Measures	2533'	377'+
(Total Depth)		2910'	

Fossils: No macrofossils. Microfloras at selected intervals were examined by Helby (Appendix A in Stuntz & Wright). His report is reproduced in full below.

"SAMPLE NO.	SAMPLE INTERVAL	QUALITY OF SEPARATION
MM 1	2168 - 2178 ft.	Barren
MM 2	2278 - 2288 ft.	Barren
MM 3 (Core 6)	2308 - 2312 ft.	Barren
MM 4	2313 - 2323 ft.	Barren
MM 5	2371 - 2379 ft.	Quite fair
MM 6	2428 - 2438 ft.	Barren
MM 7	2486 - 2496 ft.	Very poor
MM 8	2538 - 2544 ft.	Good

"Samples MM 1 - 4 and 6

"In view of the results of the investigation it is not surprising that large numbers of barren samples are encountered at these above intervals. It would appear that the lower part of the Narrabeen Group, generally, does not represent conditions which were favorable for the preservation of the contained microflora. This condition has been noted from several other localities.

"Sample MM 5

"Contains - <u>Pityosporites nigracristatus</u>
<u>Pityosporites reticulatus</u>
also six previously undescribed forms.

From the contained forms this sample is of lower Narrabeen age. There is some evidence of caving, forms from the uppermost Narrabeen occurring.

"Sample MM 7

"Contains - Quadrisporites horridus
Punctatisporites sp. (P. plicatus)
Also a large bisaccate pollen.

This sample contains several of the forms which are characteristic of a narrow transitional zone between the Narrabeen Group and the 'Upper Coal Measures'. No forms attributable to the 'Upper Coal Measures' were observed. Assuming contamination due to caving to be negligible, this sample would be of basalmost Narrabeen age.

"Sample MM 8

"Contains - Apiculatisporis bulliensis
cf. Raistrickia sp.
Cyclogranisporites sp.
Megaspore fragments

Acanthotriletes ramosus
Apiculatisporis filiformis
Cirratriradites splendens
Dulhuntyispora gondwanensis (sic)
Granulatisporites micronodosus
Striatites cancellatus
Striatites limpidus

"This sample contains mainly forms which are characteristic of the 'Upper Coal Measures'. However, the upper three forms have previously been encountered (within the Sydney Basin) in the basal part of the lowermost Narrabeen. This sample presents two possibilities -

1. The interval of the sample includes the boundary

or

2. a) The upper forms represent caving, sample being 'U.C.M.'.

b) Due to the present state of knowledge the complete ranges of these forms is not known and that they could in fact extend down into the 'Upper Coal Measures', sample being 'U.C.M.'.

"This latter would appear the more reasonable.

"Conclusions

"Due to the possibility of caving the downward extent of forms must be suspect. Thus the first appearances in the downward direction would represent the diagnostic/occurrences. However, as few samples are involved the considerations appear to be of minor consequence.

"As sample MM 7 displays forms characteristic of the basalmost Narrabeen and sample MM 8 is almost certainly 'Upper Coal Measure' (with slight possibility of some very basal Narrabeen) equivalent, the boundary of the Narrabeen Group and the 'Upper Coal Measures' would occur within the interval 2486 - 2544 feet in the Mt. Murwin No. 1 Well".

A.O.G. Mulgoa No. 2

Reference: McGarry (in Bureau of Mineral Resources, 1965)

Section:

AGE	FORMATION	DEPTH(Top)	THICKNESS
Triassic	Wianamatta Group	Surface	70'
	Hawkesbury Sandstone	70'	750'
	Narrabeen Group	850'	1648'
Permian	Lithgow Coal Measures	2498'	367'
	Coal Measures undiff.	2865'	732'
	Capertee Group	3597'	2033'

Fossils: No macrofossils: Irene Crespin examined the well for microfossils, with negative results.

Samples of the Permian section examined for microfloras as listed below, but no useful results were obtained.

SAMPLE NO.		DEPTH
MFP 960	cutt.	2496 - 2506'
MFP 961	core	2642 - 2642'
MFP 1066	core	2642
MFP 1067	core	3099 - 3100'
MFP 1068	core	3425 - 3426'
MFP 1069	core	3805
MFP 1070)	core	4211 - 4212'
MFP 1071)		
MFP 1072	core	4593'
MFP 1073	core	4995'
MFP 1074	core	5397'- 5398'

Sun Well No. 1 (Ravensfield Dome)

Drilled in 1959-60 near Ravensfield Quarries, north of Farley (Fisher & Taylor Rogers, 1960), Sun Well No. 1 cut a section of the Dalwood Group (Lloyd, in Dickins, 1964).

Section: (On opinion of J.H. Rattigan, reported by Lloyd).

AGE	FORMATION	DEPTH (Top)
Permian	Farley Formation	Surface
	Ravensfield Sandstone Member	Surface
	Rutherford Fmn	?
	Allandale/Lochinvar Formation	1248'
(Total Depth)		2074'

Fossils: No report of macrofossils known. A few foraminifera were recorded by Lloyd (op. cit.)

Hodgson examined core samples from the following depths.

SAMPLE NO.	DEPTH	CONTENT
MFP 284	1014'	Abundant spores
MFP 1905	1107'	" "
MFP 1885	1185'	Spores present
MFP 1886	1245?	" "
MFP 1887	1255-1300'?	Very few spores present
MFP 1888	1430'	" " " "
MFP 1906	1450'	" " " "
MFP 1889	1583'	Spores fairly common
MFP 1907	1697-1710'	Barren

Core, 1014 feet

Verrucosisporites pseudoreticulatus	68*	
Leiotriletes directus	207	
Granulatisporites sp.	110	
Retusotriletes diversiformis	6	
Parasaccites spp.	*	(common)
Disaccites spp. undet.	*	
Striatiti spp.	*	
Verrucosisporites parmatus	118*	
Vittatina sp.		
Sphaeromorphitae spp.		

* Key fossils: unit Plc.

Core 1185 feet

Verrucosisporites pseudoreticulatus	68
Leiotriletes directus	207
Parasaccites spp.	(common)
incl spp.	50, 52, 190*
Marsupipollenites triradiatus	152*
Granulatisporites trisinus	703
Striatiti spp. incl.	*
aff. *Protohaploxypinus amplus*	147
Protohaploxypinus sp.	198
Apiculati sp. cf.	204
Granulatisporites sp.	110
Disaccites spp. indet.	
Retusotriletes diversiformis	6

* Key fossils: unit Plc.

Core 1245? feet

Limitisporites sp. cf.	142*
Parasaccites spp.	(common)*
Verrucosisporites pseudoreticulatus	68*
Granulatisporites trisinus	703*
among many fragmented grains	

* Key fossils: unit Plc.

Core 1430 feet

Parasaccites spp.	(common)
Vestigisporites rudis	193
Striatiti spp.	(rare)
Sphaeromorphitae	

Assigned to unit Plc by stratigraphic position.

Core 1583 feet

Parasaccites spp.	(common)
incl. spp.	50, 52,176,190, 191*
Granulatisporites sp.	110
Apiculati sp.	204
Verrucosisporites pseudoreticulatus	68*
Striatiti spp. incl.	
Protohaploxypinus sp. cf.	198
Monocolpate sp.	186
Protohaploxypinus goraiensis	187*
Vestigisporites rudis	193
Apiculati sp.	199
Granulatisporites trisinus	703*

* Key fossils: basal unit Plc/Plb.

Amoseas Wee Waa No. 1

Reference: Gerrard (1963b)

Section:

AGE	FORMATION	DEPTH(Top)	THICKNESS
Cainozoic	Alluvium		62'
Jurassic	Sandstones and Shales	62'	383'
	Pilliga Sandstone	445'	770'
	Quartz sandstone		
	Purlawaugh Formation	1215'	213'
	Sandstone siltstone and chocolate shale		
(Tertiary?)	Teschenite	1428'	280'
Triassic	Napperby Formation Sandstone, shale and conglomerate	1708'	226'
Permian-?Triassic	Coal seams, sandstones and siltstones	1934'	284'
Permian	Siltstone	*2218'	180'
	Conglomerate	2398'	180'
	Altered volcanics	*2598	57'
?Pre-Permian	Banded rhyolites	2635'	71'
(Total Depth)		2706'	

*Gerrard referred these levels to the tops of "?Black Jack Formation", "Upper Marine", "Lower Marine" respectively.

Fossils

No macrofossils.

Microflora reported by Hodgson (in Gerrard, 1963b) and amplified as follows:

Core 6, 2101-2109 feet

Parasaccites sp.	52
Apiculatisporis sp.	107
Didecitriletes ericianus	115*
Vitreisporites sp.	135*
aff. Ovalipollis sp.	136

Vesicaspora sp.	137
Leiotriletes directus	207
Striatopodocarpidites phal-eratus	210*
Striatiti sp.	260
Alisporites aust	277
Peltacystia calvitium	625

* Marker fossils: Permian P4 or Triassic Trla.

DISCUSSION

The only data in the lists above which are useful for age determination were obtained at shallow depths in the lower Hunter Valley region and the Narrabri district. There are insufficient for inter-well correlation, but enough for an approximate correlation with other Permian sediments in eastern Australia, and for deduction of where the major microfloral changes might occur in the Sydney Basin.

The palynological sequence through the uppermost Carboniferous and Permian is divisible into a number of units (Evans, 1964, 1966b-d). Changes in the floral plexus throughout this interval are presented in summary in figure 3, which includes only the known stratigraphically significant species or morphogroups. Variations in line width are intended to show changes in relative abundances of certain forms, but width is not calculated against any percentage scale. Several of the palynological divisions are grouped together to form the basis for discussion. The smaller units are applicable only to limited areas or their use in the Sydney Basin is not warranted by the present limited state of knowledge.

Base of the Permian

The change from the Rhacopteris to the Glossopteris floras is usually taken to represent the Carboniferous - Permian boundary in Australia (David, 1950), although some reservations about such a choice have been voiced, particularly by Hill (1955) and Hill & Denmead (1960). Balme (1960, 1964), and Alpern et al. (1964) chose the incoming of the gymnospermous monosaccate pollen of the Parasaccites (al. Nuskoisporites) type, the Striatiti and the Monocolpates as the palynological beginning of the Permian. It is apparent in Queensland that the Parasaccites types and certain monocolpate forms enter the stratigraphic section in association with elements of the Rhacopteris flora prior to the appearance of Striatiti and the Glossopteris flora (Evans, 1964; White in Mollan et al., 1964; White, 1965). This is now confirmed by the assemblage from the Seaham Formation, the classical repository of the Rhacopteris flora (Walkom, 1944; David, 1950; Engel, 1965) which has yielded a large component of Potonieisporites and minor Parasaccites associated with Vallatisporites sp. 37, Verrucosisporites sp. 22 and a large component of Punctatisporites sp. 7, which is typical of unit Cl in the Queensland and Western Australian successions. The lower limit of unit Cl in New South Wales appears to lie at about the level of the Patterson Volcanics because samples from below that formation contain no monosaccate pollen (R. Helby, pers. comm.), although some forms characteristic of Cl, such as Vallatisporites sp. 37 are recognizable within them.

There is clearly a discrepancy between the macro- and microfloral choices of the Permian/Carboniferous boundary. Additional complications were raised by Naumova and Rauser-Chernousova (1964) who demonstrated a correlation between the Orenbourgian and the Stephanian C; the Asselian and the Autunian. Those authors placed the Asselian in the Carboniferous. The Orenbourgian contains abundant gymnospermous pollen, including the genus Cordaitina (which Hart, 1965, considers to be synonymous with Nuskoisporites and Parasaccites) and well established forms of Striatiti and the monocolpate Ginkgocycadophytus. If intercontinental correlation by broad pollen groups is acceptable, because the Monosaccites (of Parasaccites type), Monocolpates and Striatiti were already established in Carboniferous time, it might be necessary to look higher in the Australian sequence, after the appearance of the Striatiti, for the base of the Permian.

This matter is being treated elsewhere and for the present purposes the Rhacopteris/Glossopteris macrofloral and the Cl-2/Pla-b microfloral changes are employed as indicators of the system boundary.

Units Pla-b = Early 3

No assemblages of Pla-b age have been recovered from the Hunter Valley area. However, the presence of a basal Plc assemblage in the Allandale or upper Lochinvar Formation in the Ravensfield bore implies that most of the Lochinvar Formation could be of Pla-b age. According to David (1950, p.338) the oldest occurrence of Gangamopteris, of the Glossopteris flora, lies about 1280 feet above the base of the Lochinvar Formation and hence there is room for beds even as old as Cl-2 within that formation.

No adequately dated section of Pla-b age have been discovered north of the Sydney Basin, although sediments of this age could have been cut in Kelvin No. 1 and Bohena No. 1. The oldest fossiliferous sample in Kelvin No. 1 at 1728 feet was of Plc-2 age and undated section was penetrated for a further 3473 feet. The undated section included Glossopteris at a depth of 3392 feet, which would be no older than unit Pla or C2. The lowest spore bearing sample at 2914 feet contained abundant Sphaeromorphitae spp. undet., similar to ones in Bohena No. 1 at 4271 feet, which could be of Pla-b age. Both sample horizons were in volcanic suites referred by Hall & Perry (1965) to the Boggabri Volcanics and by Gerrard (1963a) as "Lower Marine Equivalent" respectively.

Whereas this evidence might indicate an age for at least part of the Boggabri Volcanics, complications arise from the position of the Kelvin well relative to nearby outcrop, which has been variously mapped by Lloyd (1934), Hanlon (1949c) and Voisey & Williams (1964) as "Upper Kuttung" Currabubula Formation. Lloyd provided the only available description of these outcropping blocks, "....heavy conglomerates, tillites, grits, sandstones and shales interbedded with flows of rhyolites, together with tuffs of similar composition". Hanlon mentioned lavas, tuffs and conglomerates, the lavas comprising rhyolites, felsites, andesites and pitchstones. Whetten (1966) described in detail the Currabubula Formation at the southern end of the Werrie Basin, where it is dominantly a pebble conglomerate with about 10% fine sandstone and mudstone and about 20% tuff. He mapped a disconformity with about 3000 feet of relief between the Currabubula Formation and the overlying conglomeratic sandstones with Gangamopteris (Carey, 1935) and noted that the Permian had little matrix in contrast to the Currabubula

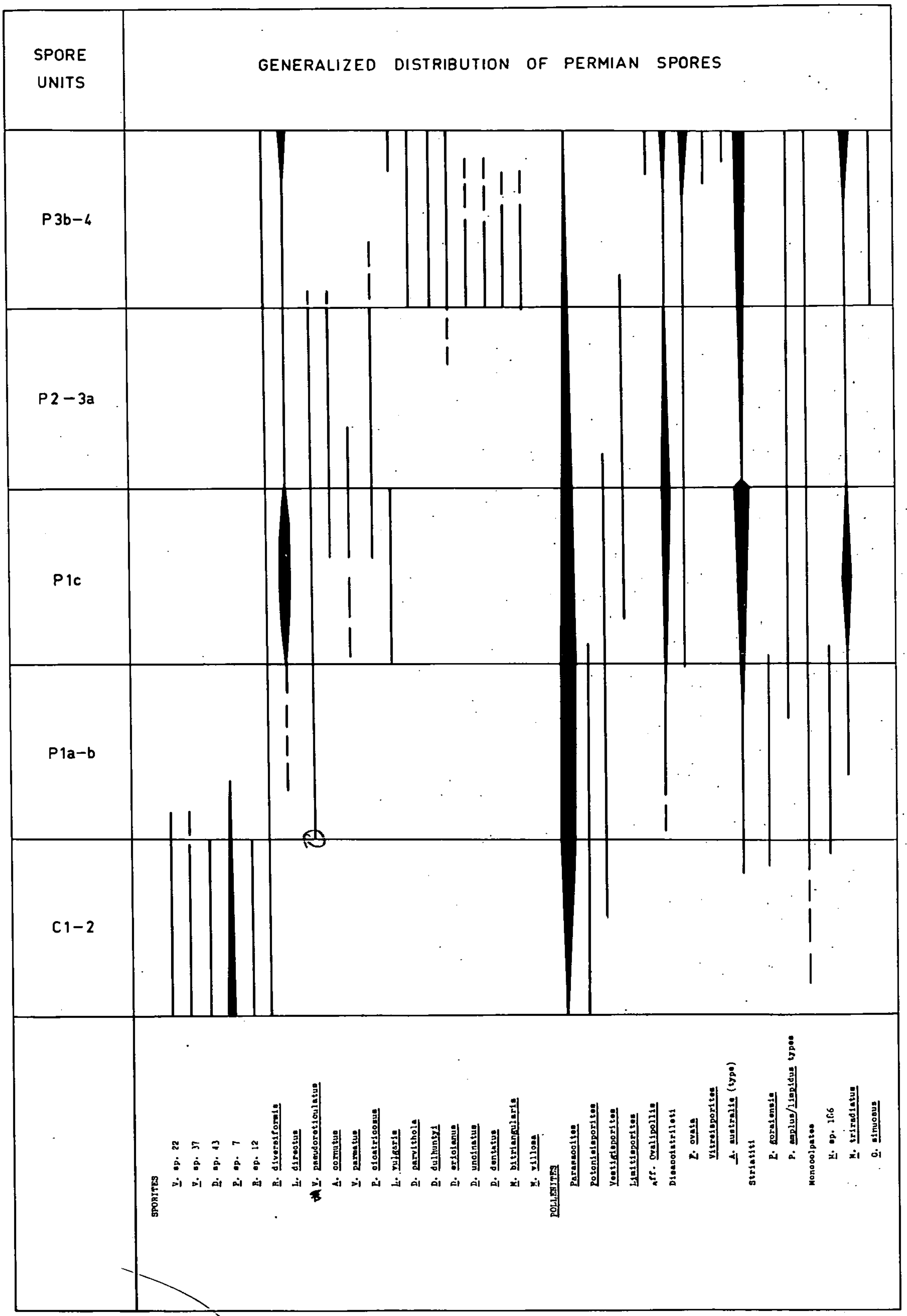
SPORE UNITS
GENERALIZED DISTRIBUTION OF PERMIAN SPORES
P3b-4
P2-3a
P1c
P1a-b
C1-2
SPORITES
V. sp. 22
V. sp. 37
D. sp. 43
P. sp. 7
R. sp. 12
R. diversiformis
L. directus
V. pseudoreticulatus
A. cornutus
V. parmatus
P. cicatricosus
L. vulgaris
D. parvithola
D. dulhuntyi
D. ericianus
D. uncinatus
D. dentatus
M. bitriangularis
M. villosa
POLLENITES
Parasaccites
Potonieisporites
Vestigisporites
Limitisporites
aff. Ovalipollis
Disaccitriletti
F. ovata
Vitreisporites
A. australis (type)
Striatiti
P. goraiensis
P. amplus/limpidus types
Monocolpates
M. sp. 166
M. triradiatus
G. sinuosus

FIGURE 3

Formation. Carey (1937) noted interposition of tuffs and lavas within the "Upper Kuttung Series" in the Merlewood section to the south of Kelvin.

From the position of Kelvin No. 1, similar lithologies to the Currabubula Formation might be expected in the well section. Although volcanics of both rhyolitic (above) and basaltic (below) character were encountered by the drill the rock suite, in Hall & Perry's opinion, compared with interbedded shales, Boggabri Volcanics and Werrie Basalt. The Currabubula Formation in outcrop to the south of Kelvin contains abundant Rhacopteris (Carey, 1937); the Boggabri Volcanics are regarded as equivalent to the Permian Glossopteris bearing "Lower Marines" or Dalwood Group (Hanlon, 1949c) and the Werrie Basalt is also of Permian age (Carey, 1934). Rationalization of these data and opinions leads to the conclusion either that the well penetrated equivalents of the Currabubula Formation, which were younger than the dated outcrop sections to the south of Kelvin, that the Currabubula Formation extends across the transition from the Rhacopteris to Glossopteris floras, and that the formation is partly equivalent to the Baggabri Volcanics as identified in Bohena No. 1; or, preferably, the well passed through a reverse fault near surface on which Currabubula Formation has overridden younger sediments equivalent to the Boggabri Volcanics and Werrie Basalt. Whatever the answer, the problem of Kelvin should be kept in mind in discussions of the relationships of the Kuttung Series and neighbouring rock suites in the Keepit area.

Units Plc - P3a

The base of unit Plc appears to be close to the sampled horizon in the Allandale or Lochinvar formations at 1583 feet in the Ravensfield well. Distinction of P2 from Plc depends on the presence in P2 of acritarchs. Although this criterium worked in the limited area of the Denison Trough, it has no validity in other areas and facies, such as in the Sydney Basin. New criteria for units solely based on spore and pollen distribution are required. However, continuing for the present with the old system, a sample characteristically of P2 type was taken from an outcrop of the lower Branxton Formation (MFP 1902). Components of Plc should be sought below that level.

The problem of distinguishing palynological units of about Plc - P2 age in the absence of acritarchs was also encountered in a brief study of the Cooper Basin (Evans, 1966d) where the relative abundance of striate disaccate pollen in higher levels, compared to the dominant monosaccate pollen in lower strata, was apparent. The same criterium cannot be applied satisfactorily to the Sydney Basin and it appears that scales appropriate to each depositional area are needed. One factor of perhaps universal application, however, may be the relatively late appearance of P. cicatricosus (sp. 134) compared to that of V. pseudoreticulatus (sp. 68), which might prove a useful means of distinguishing upper and lower sections within the range Plc - P2.

Unit P3a is also a division with an unsatisfactory history of identity and needs better understanding. For most purposes it is conveniently grouped with unit P2 and for the present need not be positively identified. However, the group P2 - P3a appears to extend up to the top of the Branxton Formation (MFP 1903).

No subsurface data of value to problems in units Plc - P3a are available from the Hunter Valley area. Helby had poor or no recovery of fossils from East Maitland No. 1. No samples from the other subsidized wells in the area, Loder No. 1, Camberwell No. 1 and Belford No. 1 have yet been examined.

To the north of the Sydney Basin, core at 1728 feet in Kelvin No. 1 yielded a microflora of Plc age, located in a suite of interbedded rhyolites (Boggabri Volcanics, according to Hall & Perry, 1965) and shales. In Bohena No. 1, shales between 3172 and 3332 feet, which overlie the volcanics and were regarded as "Lower Marine Equivalents" by Gerrard 1963a), yielded a Plc microflora. Hanlon (1949c) dated the Boggabri Volcanics, which outcrop on a line between Bohena and Kelvin, with a "Lower Marine age". If the identity at least in part of the volcanics at Bohena and Kelvin as Boggabri Volcanics is correct, so is Hanlon's correlation feasible from a palynological point of view. Gerrard's reference to the shales above the volcanics in Bohena No. 1 as "Lower Marine Equivalents" is also correct. The lack of P. cicatricosus and A. cornutus at this level suggests an early Plc, at least pre-Greta Coal Measures age. However, no acritarchs of marine origin were found in the one sample from this interval: it yielded only the alga aff. Botryococcus which is thought to be a freshwater organism.

Hanlon (1949c) recognized the Nandewar Group above the Boggabri Volcanics. The group comprises the Vickery Conglomerate above the Wean Formation. The latter unit consists of shales, sandstones and conglomerates at least 350 feet thick in the type area. The undifferentiated group further to the north, in the Narrabri area, is of the order of 1000 feet in thickness (Hanlon, 1949e). On the basis of its Glossopteris content Hanlon tentatively correlated the group with the "Lower Coal Measures". Coal seams with shale, some siltstone and sandstone between 2716 and 3072 feet in Bohena No. 1, which Gerrard referred to as "Lower Coal Measures Equivalent" and which yielded typical Plc microfloras, are of closely comparable lithological character and thickness to the Wean Formation. Again both Hanlon and Gerrard's correlations are compatible with the palynological data.

Hanlon placed reservations on his correlation because Dr J.A. Dulhunty stated of a coal from the Wean Formation: "I was unable to find any of the types which usually characterize the Greta ... the spore assemblage in the coal in question certainly appeared more like Upper Coal than that of Maul's Creek and Werris Creek materials which could be Greta from their spore contents". (Hanlon, 1949c, p. 258). Without commenting on the fact, Rade (1963) later supported Dulhunty's contention by listing a unit P3b-P4 microflora from Killarney's Gap, where Hanlon (1949c) mapped outcrops as Nandewar Group. Hanlon rejected Dulhunty's opinion because of the lithological relationships of the Vickery Conglomerate and because at the time he suspected, and later showed (Hanlon, 1949e), that the northern extension of the Nandewar Group in the Narrabri area underlay fossiliferous "Upper Marine Series" "Barra Group".

The extent of outcrop of the "Barra Group" and the possible lateral relationships of this "group" and formations of the Nandewar Group do not appear resolved. Dulhunty and Rade might have been viewing lateral equivalents of the "Barra Group" or a version of the "Upper Coal Measures" which have been taken as part of the Wean Formation or even an upper part of the Wean Formation which is of P3b-4 age. After all, late Permian coal bearing sediments in an onlapping relationship were cut by the Bohena and Wee Waa wells and crop out at least to the south near Boggabri and evidence of the same relationship might be expected at Narrabri. Further examination of Dulhunty's and Rade's fossils or topotypes and additional mapping and spore sample collecting (exposures permitting) might help elucidate the problem. Probably of equal importance is the need to avoid the implied time correlations induced by extension of the Hunter Valley terminology to these northern outcrops, particularly in view of the apparent ranges of "Upper" and "Lower Coal Measures" assemblages into the "Upper" and "Lower Marine Series".

Units P3b-P4

The group of units P3b-P4 are readily identified by the presence of a number of species, although the base of the group is specifically identified by the first appearance of the genus Dulhuntyispora. Helby recorded Dulhuntyispora from the Mulbring Formation of East Maitland and No. 1, but the lower limit of P3b-P4 is taken into the Muree Formation on account of the presence in that unit of Microbaculispora villosa, Cyclobaculisporites trisecatus, aff. Bascanisporites undosus and "Marsupipollenites" sinuosus.

Subdivision of P3b-P4 is based on the successive appearance of acritarch species and cannot be applied to the Sydney Basin on present knowledge. Coals of unit P4 age yield a great dominance of striate disaccate pollen associated with fairly common Marsupipollenites triradiatus, and Vesicaspora spp. Apart from Leiotriletes directus, trilete spores are generally rare. The only samples of Newcastle Coal Measures available for direct study, from the Lampton Sub-group at the base of the Coal Measures, contained poorly preserved microfloras which generally complied with this pattern, except that each sample contained acritarch Veryhachium and Micrhystridium in minor proportions. These acritarchs have not yet been compared in detail with Queensland Permian forms.

Dulhunty showed (1946, fig. 5) stratigraphic variation in assemblages of microspores belonging to different groups. Saccate pollen (morphological groups E, F and G; ornamentation group 7) form a significantly minor proportion of the total assemblage in the Newcastle Coal Measures, although he stated (op.cit), p. 250). "Biwinged-monolete spores belonging to Morphological Group G and winged spores of Ornamentation Group 7 are considerably more numerous in the Northern Coalfield than in marginal areas of deposition". Balme & Hennelly (1956b, p. 256) showed that, "In the Newcastle Stage ..... the spore assemblages of shales are composed predominantly of bisaccate pollen grains......while trilete and monocolpate sporomorphs make up a high proportion of individual assemblages in the coals". As most P4 microfloras in Queensland have been extracted from shales, rather than coals, the Newcastle microfloras may bear a closer resemblance to the former than might otherwise be supposed - as already indicated by microfloras from the outcrop Lampton Subgroup. Even so, the few samples of late Permian coal from Queensland to yield spores and pollen contained a high proportion of bisaccate pollen in general contrast to their New South Wales correlates.

To the north of the Hunter Valley, Dulhunty (1946) and Rade (1963) recognized P3b-P4 assemblages in the Black Jack Formation near Gunnedah, but there is no record of microfloras in the underlying Gladstone (Marine) and Porcupine Formations. At Killarney Gap, east of Narrabri Rade (op. cit.) recognized M. villosa and B. undosus of unit P3b-4 in what Hanlon (1949e) recognized as Nandewar Group. Dulhunty (in Hanlon op cit.) had previously recognized an assemblage of "Newcastle type" in the typical development of Nandewar Group. In the Bohena No. 1 Well, samples from interbedded shale, siltstone and sandstone between 2321 and 2716 feet, which Gerrard (1963a) referred to an "Upper Marine Equivalent (Maitland Group?)" also yielded a P3b-4 microflora, which included a few acritarchs of probable marine or brackish origins. Gerrard (1963b) noted the on-lapping arrangement of these marine strata northwards towards Wee Waa No. 1. At present it is uncertain whether all of this marine section at Bohena should be referred to P3b-4 (the basal 200 feet of the unit were not sampled), but the possible development below the unit of an hiatus should be considered. The succeeding coal measures from 2037 to 2283 feet, at Bohena, referred to by Gerrard (1963a) as "Upper Coal Measures Equivalent (Black Jack Formation?)", also yielded a P3b-4 microflora. A coal float from 2210 feet contained the typical P4 assemblage of abundant striate pollen, M. triradiatus and L. directus with virtually nothing else but the ?algal form Pelacystia calvitium. Gerrard identified an upper and lower division in this formation with a boundary at 2151 feet so that this P3b-4 (probably P4) age refers to the lower division. The upper division is discussed below.

Unit Trla

Hennelly (1958) described a distinctive microfloral assemblage, including Quadrisporites horridus, "Nuskoisporites" radiatus, "Pityosporites" nigricostatus and "P". reticulatus from roof shales above the Bulli Seam and from 87 feet of the overlying "Lower Narrabeen" sediments in A.I.S. Appin No. 4 Bore. His descriptions led to recognition of unit Trla in Queensland (Evans, 1966a) where, above the highest coal measures assemblages, P. amplus, P. limpidus and M. triradiatus are very rare and D. parvithola occurred together with Q. horridus, "V". radiatus, Alisporites spp. and several undescribed forms which continue into the overlying, typical Rewan Formation. The relationship of beds containing the Trla assemblages to the underlying Blackwater Group (P4 age) and overlying Rewan Formation is still debatable. In the Springsure and Taroom areas, they are mapped as part of the Rewan Formation, although an intervening unconformity below the Brumby Sandstone Member of the Rewan Formation could be the upper limit to Trla. (Mollan et al., 1964; Jensen et al., 1964).

To this point the development of Trla immediately above the last major coal developments in the southern Sydney Basin is closely paralleled in the southern Bowen Basin. Smyth (1967) suggested from a petrological view point that the Bulli Seam correlates with the Great Northern Seam in the Northern Coalfield, rather than the overlying Wallarah Seam, top major seam of the Newcastle Coal Measures. Diessel et al.(1966) suggested that an unconformity developed at varying distances above the Bulli Seam due to erosion by a river system which left about 30 feet of section conformably upon the Bulli Seam at Appin No. 4. Most of Hennelly's samples were cut from within three feet of the roof of the seam and so underlay the unconformity. It might be supposed on the basis of these observations and correlations that Hennelly's Q. horridus/ "N". radiatus assemblage immediately overlies the Great Northern Seam. At present there is no direct evidence that this is the case, although indirectly it may be probable. The discovery of a mixed P4/Trla assemblage in coal measures at Bohena and Wee Waa indicates that these microfloras appeared before coal formation ceased in the region north-west of the Sydney Basin. Furthermore, Balme & Hennelly recorded only one sample from above the Great Northern Seam - from the base of the Wallarah Seam - and only one species from that sample - Striatopodocarpites cancellatus. Samples from just above the highest coal seam in Terrigal No. 1 yielded a microflora assignable to P4, although a few species more characteristic of the Triassic, such as Alisporites australis and a number of previously unrecorded types were present. Q. horridus was not found. In her lecture on the Newcastle Coal Measures, Adrian (1967) intimated that the highest members of the Newcastle Coal Measures may not be represented at Terrigal. Lack of the higher zones could explain the apparent lack of the Q. horridus/"N". radiatus horizon just above the highest seam in the well.

A careful check of the youngest horizons in the northern coalfield is clearly required before the precise position of unit Trla in the stratigraphic sequence may be measured.

COMPARISON OF MACROFAUNAL AND MICROFLORAL SEQUENCES

Dickins (1964) compared the macrofaunal sequences in both the Bowen and Sydney Basins in terms of four faunal units. The lower fauna, Fauna I occurs in the Bowen Basin at the top of the Lizzie Creek Volcanics and possibly in equivalents of the Cattle Creek Formation. The succeeding Fauna II is well represented by the typical Cattle Creek fauna, and Dickins recognized it in the Farley and lower Branxton Formation of the Sydney Basin. This correlates the Greta Coal Measures, between the Farley and Branxton Formations, to part of the Cattle Creek Formation. The spores of the Greta and lower Branxton are of P2 type. The one sample of lower Branxton even contained an acritarch (Cymatiosphaera sp.) of Cattle Creek type. The microfloral evidence therefore lends weight to Dickins' correlations.

The Rutherford Formation contains spores of Plc age. As Fauna I occurs in the basal Cattle Creek Formation, it could be expected to occur in P2 times also, above the lower Rutherford. Dickins found the Rutherford fauna too poor for its position relative to Faunas I and II to be determined. Like the fauna of the Allandale Formation, it is possibly older than Fauna I.

The Muree Formation bears a typical Fauna IV which appears above the Ingelara Formation in the Bowen Basin. The Ingelara fossils are allocated to Fauna III, which Dickins considers is not well represented in the Hunter Valley. The spores of unit P3b-4 commence below the Ingelara and would therefore be expected to extend below the Muree. However, the two samples available from high in the Branxton Formation yielded sparse microfloras, which appear to be older than P3b. On the very limited data available, it is impossible to resolve this dilemna, but the question arises, whether there could be an hiatus between the Branxton and the Muree?

A possible correlation between formations of the Bowen and Sydney Basins is shown in Table 5.

CARBONIZATION OF SPORES

Dulhunty (1946) first pointed to the carbonized state of preservation of spores in the southern coalfield of the Sydney Basin. Evans (1963, 1965) raised the question of spore exine degradation in relation to oil and gas occurrence in the Bowen Basin, and pointed to the general absence of well preserved microfloras in the Sydney Basin. The question of hydrocarbon occurrence has been of interest to many overseas oil geologists but few publications on the topic are available. Wilson (1961) related spore preservation to coal rank in the Arkoma Basin of Oklahoma. Gutjahr (1966) attempted objective measurement of preservation character and demonstrated the relationship of this character to oil and gas occurrence in the Gulf area of the U.S.A.

Relative to Permian spores elsewhere in Australia, the microfloras of the Sydney Basin are not well preserved. Attempts to extract pollen from the Permian of Dural South No. 1, Baulkham Hills No. 1, Kulnura No. 1, and Kurrajong Heights No. 1 failed. The few grains extracted from samples of Tomago Coal Measures and the Maitland Group in Dural South No. 1 were highly carbonized and only just determinable as fossil pollen. In contrast, identifiable grains were obtained from fresh outcrop material from the lower Hunter Valley, although Helby's record from East Maitland No. 1 implies this success may not be general to that area. Helby (pers. comm.) possesses identifiable microfloral extracts from stratigraphically low in the Kuttung Series. Spores are identifiable throughout the north-western coalfield, although at depth they are very poorly preserved.

Evans (1963) used a few of the available proximate analyses from the northern and southern coalfields of the Sydney Basin to illustrate his argument. The significance of his calculated carbon-ratios may be questioned as they take no account of the methods of sampling and analysis or of coal type. Shell Development Australia Pty Ltd (1967) analysed by reflectance methods all coals penetrated by the Dural South No. 1 Well and plotted the calculated carbon-ratios against depth. According to Evans' determinations, it is surprising to see any spores at all at the levels sampled in Dural South No. 1 which the curves show to have a carbon ratio equivalent of 85-90%. The relationship of increasing spore coalification to increasing coal rank is not disproved, but apparently standard means of expressing both preservation and coalification are required in any study of the spore coalification problem.

Other points which appear to be of significance to the problem are as follows:

a) Method of palynomorph extraction. A partial oxidation process is usually employed to remove insoluble bitumens. The process could be prolonged for a coal and omitted for some clastics. The B.M.R. method is relatively standard, but limited variations in this maceration stage undoubtedly occur, depending on the chemical nature of the sample and the operator's experience.

b) Type of rock processed. Most of the samples examined in the B.M.R. are by preference taken from clastics. Coals are avoided because they tend to contain assemblages whose characters are greatly controlled by local plant communities and which are thus not so representative of the

Period	Series	Flora	SPORE UNIT	SPRINGSURE SHELF	DENISON TROUGH	NARRABRI—GUNNEDAH	HUNTER VALLEY
PERMIAN	Upper	Glossopteris	P4	BLACKWATER		BLACK JACK	NEWCASTLE
			P3d	BLACK ALLEY			TOMAGO
			P3c				
	Lower		P3b	PEAWADDY		? GLADSTONE ? PORCUPINE ? BARRA ?	MULBRING MUREE
				COLINLEA ? ?	CATHERINE INGELARA FREITAG		? ? ? ? ?
			P2-P3a		ALDEBARAN CATTLE CREEK	NANDEWAR	BRANXTON GRETA
			P1c	REID'S DOME			FARLEY RUTHERFORD
			P1a-b	JOE JOE		BOGGABRI ? ? ? ?	ALLANDALE LOCHINVAR
CARBONIFEROUS		Rhacopteris	C1–2				SEAHAM PATERSON
							MT JOHNSTON

TABLE 5 : FLORAS & REPRESENTATIVE FORMATIONS IN QUEENSLAND & N.S.W.

regional floras. Nevertheless, examples exist of good floral extracts from particular coal seams in areas where the associated clastics have produced few well preserved fossils. Success is improved by preselection of the coal type most likely to contain spores. Differences also exist between one clastic type and another, possibly because of variation in depositional history and environment, which affect oxidation potential and the amount of extraneous organic content. Cases are known when highly carbonized grains have been extracted in association with disseminated macroplant debris from shale which overlies shale with apparently lower organic content, but with well preserved grains.

c) Type of palynomorph examined. Both Wilson (1961) and Evans (1963) described carbonization of spores and pollen in aggregate assemblages. Gutjahr (1966) recognized the inherent variability of this approach and restricted his studies to a particular group with single layered, smooth walls. Evans (1966) noted the different states of preservation attained by spores in contrast to gymnospermous pollen.

This is particularly apparent, for example, when spores from the Devonian of western New South Wales are compared with multi-wall layered gymnospermous saccate pollen of the Permian; the Devonian forms are almost opaque, whereas the saccate grains, in which the inner wall disappears and the outer wall develops thinnings and swellings which mark the once present, fine mesexinous ornament.

d) Initial precipitation of spores. At present the most important palynological criterium to prediction of oil and gas potential of a region is simply the preservation or otherwise of spores. If they are too carbonized to be preserved, the carbon-ratio probably exceeds 70-75%, and the region is unlikely to produce either oil or gas. But the apparent absence of spores in unweathered material could be due to other causes. In certain areas where generally high energy, fluviatile sands were deposited it is sometimes difficult to extract spores and pollen, even from fine grade sandstone and siltstone intercalations with abundant organic debris, possibly on account of winnowing stream action. Of significance to the Permian in particular is the often extremely small content of otherwise well preserved palynomorphs in sediments attributed to a fluvioglacial origin. Oxidation in past geological time, at deposition (to give red beds), or during aerial exposure during uplift could also remove the spores. Care must be taken to ascertain that none of these factors is the reason for an apparent absence of spores.

Each of these matters must be considered if the relationship of spore preservation to oil and gas occurrence in the Sydney Basin is to be pursued.

RECOMMENDATIONS

Pursuit of correlation of the Permian across the Sydney Basin by palynological means is fruitless because of the carbonization problem. Examination of East Maitland No. 1, Camberwell No. 1 and Belford No. 1 should be effected to improve knowledge of the palynological sequence in the Hunter Valley region, the only area where suitably preserved spores are likely to remain.

Depending on the results of these examinations, further outcrop collections or preferably shallow drilling should be undertaken to obtain suitable samples.

The acritarchs in the basal Newcastle Coal Measures suggest that brackish or marine conditions affected this group. In the interests of both regional correlations and local environmental studies a search for acritarchs in shale interbeds, particularly in the Tomago Coal Measures, should be made.

Doubt concerning the position of the P4/Trla boundary within or above the Newcastle Coal Measures remains. Its resolution affects regional correlations and the intrabasin problem of correlating the uppermost coal seams in the northern and southern fields. Bore or mine material from the Wallarah Seam and its adjacent sediments need to be examined in detail. Application to the Joint Coal Board for material from the Tomago and Newcastle Coal Measures would be necessary, to resolve both the boundary and environmental questions.

In the interests of defining areas of hydrocarbon occurrence, further investigations of spore preservation quality and areal distribution of particular grades should be undertaken. Construction of a "zero-spore preservation" contour map might be possible: it would define sections which by current theory are poor prospects for both gas and oil.

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