PALYNOLOGICAL EXAMINATION OF DEM BUS SWAMP 1 STRATIGRAPHIC HOLE, OTWAY BASIN, VICTORIA

D. Burger

SUMMARY

Palynological examination of 5 sidewall cores and 3 drill-stem cores from Bus Swamp 1 Stratigraphic Hole, Otway Basin, allows dating of the local sedimentary sequence from 1785m to 830m depth as Early Cretaceous. The Casterton beds and Pretty Hill Sandstone are dated as Berriasian and the basal Eumeralla Formation Valanginian-Hauterivian, and probably Hauterivian. The boundary between Pretty Hill Sandstone and Eumeralla Formation at 876m depth is probably a significant unconformity. The fossil assemblages indicate nonmarine environments of deposition. Some assemblages include spores of Early Jurassic age, whose provenance is not yet clear.

INTRODUCTION

The Department of Energy and Minerals in Victoria drilled Bus Swamp no. 1 Stratigraphic Hole in the western Otway Basin (lat. 37°31'18" s, long. 141°12'00" e). The drill-bit penetrated the top of the Eumeralla Formation at 95m, the top of the Pretty Hill Sandstone at 876m, the top of the Casterton beds at 1,776m, and struck basement at 1,826m depth. Five sidewall cores shot between 657m and 1815m, plus splits from three drill-stem cores cut from that depth interval were forwarded to AGSO in Canberra for palynological and geochemical analysis.

The sidewall cores were described and photographed in the AGSO palynological laboratory, and a portion of each core was processed to extract its palynological contents. Recovery of fossils was poor to almost nil, but 6 of 8 samples yielded sufficient assemblages to be dated with reasonable confidence. Of each assemblage 2 or 3 slides were fully scanned, and contamination of the samples by drilling mud was not apparent. The results of the examination are summarised in Table 1, and distribution of identified taxa is given in Table 2.

Sample number	Palyn Doc number	Sample depth	Formation Bed	association with spore-pollen zones
swc 41	MFP9861	657m	Eumerella	unknown, poor recovery of fossils
core 1	MFP9864	830-5m	Eumerella	middle *Cyclosporites hughesii*
swc 33	MFP9863	862m	Eumerella	middle *Cyclosporites hughesii*
swc 30	MFP9860	913m	Pretty Hill	upper *Crybelosporites stylosus*
core 2	MFP9865	1510-16m	Pretty Hill	upper *Crybelosporites stylosus*
swc 8	MFP9859	1756m	Pretty Hill	upper *Crybelosporites stylosus*
core 3	MFP9880	1785-90m	Casterton	upper *Crybelosporites stylosus*
swc 4	MFP9862	1815m	Casterton	unknown, poor recovery of fossils

Table 1. Specification and palynological zonal association of samples

LITHOSTRATIGRAPHIC INTERVAL	Casterton Beds	Pretty Hill Sandstone				Eumeralla Formation		
SPORE-POLLEN ZONAL INTERVAL	?	upper *Crybelosporites stylosus*				middle *Cyclosporites hughesii*		?
SAMPLE No. (MFP)	9862	9880	9859	9865	9860	9863	9864	9861
SAMPLE DEPTH (m)	1815	1785	1756	1510	913	862	830	657
Aequitriradites hispidus					x			
Aequitriradites spinulosus					x			
Alisporites grandis			x		?	x		
Alisporites similis		x	x	x	x	x	x	
Araucariacites australis			x					
Baculatisporites comaumensis		x	x	x	x	x		
Biretisporites spectabilis			x	x	x			
Bisaccate pollen indet.			x	x				
Callialasporites dampieri		x	x	x				
Callialasporites trilobatus		x		x				
Callialasporites turbatus		x	x	x	x			
Ceratosporites equalis		x	x	x		x	x	
Cicatricosisporites spp. indet.		x			x			
Classopollis spp.				x		x	x	
Concavissimisporites spp.					x			
Concentrisporites hallei				x		x	x	
Contignisporites cooksoniae			x		x			
Contignisporites glebulentus					?			
Contignisporites spp. indet.					x			
Cooksonites variabilis					x			
Coronatospora perforata		x	x	?	x			
Crybelosporites stylosus			x	x		?		
Cyathidites australis					x		x	
Cyathidites minor		x	x	x	x	x	x	
Cyathidites punctatus					x			
Cyclosporites hughesii		x	x	x	x	x		
Dictyophyllidites crenatus			x		x	x	x	
Dictyotosporites speciosus		x	x	x		x	x	
Foraminisporis wonthaggiensis						?	?	
Inaperturopollenites spp. indet.				x		x		
Ischyosporites punctatus						x	x	
Klukisporites scaberis		x	x	x	x	x	x	
Laevigatosporites belfordii					x			
Laevigatosporites ovatus							x	
Leptolepidites major		x	x	x				
Leptolepidites verrucatus		x	x	x		x		
Lycopodiacidites asperatus			x					
Lycopodiumsporites circolumenus		x	x	x		x		
Matonisporites cooksoniae		x	x	?			x	
Microcachryidites antarcticus		x		x		x	x	
Murospora florida		?						
Neoraistrickia truncata		x	x	x				
Nevesisporites dailyi		x	x	x		x	x	
Osmundacidites senectus					?			
Osmundacidites wellmanii		x	x	x	x	x		
Pilosisporites notensis						x	x	
Pilosisporites parvispinosus						x	x	
Podocarpidites ellipticus				x		x	?	
Podocarpidites multesimus						?		
Punctatosporites scabratus					x			
Reticulatisporites pudens		?						
Retitriletes austroclavatidites		x	x	x		x	x	
Retitriletes clavatoides				?				
Retitriletes eminulus		x	x					
Retitriletes facetus						x	?	
Retitriletes nodosus			x	x	x	x	x	
Retitriletes solidus				x				
Retitriletes tenuis				?				
Retitriletes watherooensis		?	?					
Retitriletes spp.		x				x	x	
Ruffordiaspora australiensis			x		x	x	x	
Rugubivesiculites spp. indet.		x				x	x	
Stoverisporites lunaris			?					
Trilobosporites antiquus				x		x		
Trisaccate pollen indet.								
Velosporites triquetrus		x		x				
Vitreisporites pallidus						x		
Fromea amphora		?			?			
Fromea sp. indet.				x				
Microfasta evansii			?					
Nummus sp.				x			x	
Schizosporites reticulatus								
Jurassic elements								
Alisporites lowoodensis					x			
Anapiculatisporites pristidentatus		x		x				
Nevesisporites vallatus					x			

Table 2. Distribution of palynomorph species in Bus Swamp 1

SPORE-POLLEN ZONATIONS

The biostratigraphic aspect of Cretaceous palynology in the Otway Basin has been discussed in detail by Dettmann (1963) and Dettmann & Playford (1969), and subsequently refined informally by Dettmann & Douglas (1976). The concepts of those authors are used in this report in preference of later zonations formally proposed by several authors for the reasons given below (see Fig. 1).

Burger, 1973, 1989 Helby & others, 1987	Evans 1966, 1971	Dettmann & Playford, 1969 Dettmann & Douglas, 1976	Geological age
Cyclosporites hughesii	Unit K1b-c	upper middle *Cyclosporites hughesii* lower	Barremian-Aptian Hauterivian Valanginian
Foraminisporis wonthaggiensis			
Ruffordiaspora australiensis	Unit K1a	*Crybelosporites stylosus*	Berriasian JURASSIC

Figure 1. Palynological zonal nomenclatures for the Australian Early Cretaceous

The fossil sequence interval documented from Bus Swamp 1 includes the *Crybelosporites stylosus* Zone and the *Cyclosporites hughesii* Subzone of the *Dictyotosporites speciosus* Zone of Dettmann & Playford (1969). The *stylosus* Zone commences with the first appearance of the nominate index species, and the *hughesii* Subzone is characterised by the combined occurrence of *Dictyotosporites speciosus* and *Cyclosporites hughesii*, and ends with the first appearance of *Crybelosporites striatus*. Dettmann & Douglas (1976) further subdivided the subzone into a lower interval characterised by the combined occurrence of *Murospora florida* and *Cyclosporites hughesii*, a middle interval including *Triporoletes reticulatus*, *Dictyotosporites speciosus*, and *Cyclosporites hughesii*, and an upper interval which includes those species and commences with the first appearance of *Foraminisporis asymmetricus*.

Evans (1966, *in* Reynolds, 1971) examined the palynological sequences in a number of petroleum exploration wells drilled in the Otway Basin, and his findings are of relevance to this report. He subdivided the fossil sequence into a series of palynological «units». Within the basal Cretaceous sequence he distinguished Unit K1a, which he defined as the interval including *Ruffordiaspora australiensis*, *Cyclosporites hughesii*, *Dictyotosporites speciosus*, and *Murospora florida*, and Unit K1b-c, which includes those species except *Murospora florida*, and ends with the first appearance of *Crybelosporites striatus*.

From those criteria it follows that Unit K1a coincides with the *Crybelosporites stylosus* Zone and lower *Cyclosporites hughesii* Subzone, and Unit K1b-c with the middle and upper *hughesii* Subzone.

Evans' Unit K1a was recognised also in the Great Australian Basin in Queensland, where it includes a slightly more extended interval than in the Otway Basin. Burger (1973) subdivided Unit K1a into a lower *Ruffordiaspora* (*Cicatricosisporites*) *australiensis* Subzone, a middle *Foraminisporis wonthaggiensis* Subzone, and an upper *Foraminisporis asymmetricus* Subzone, each subzone commencing with the first appearance of its nominate species. Subsequent work in the Otway and Great Australian Basins proved the upper limit of Unit K1a to be too indeterminate (see Burger, 1989), and in their palynological scheme for Australia Helby & others (1987) combined the upper interval and Evans' Unit K1b-c into a revised *Cyclosporites hughesii* Zone. Those authors also raised the preceding intervals to zonal level.

It is clear that the *Ruffordiaspora australiensis* Zone equals the *Crybelosporites*

stylosus Zone in the Otway Basin, the *Foraminisporis wonthaggiensis* Zone the lower and middle *Cyclosporites hughesii* Subzone (sensu Dettmann & Douglas, 1976), and the revised *Cyclosporites hughesii* Zone of Helby & others (1987) equals the upper *Cyclosporites hughsii* Subzone (sensu Dettmann & Douglas, 1976). The lower and middle *hughesii* Subzones are not identified as such in the Great Australian Basin, where *Triporoletes reticulatus* and *Pilosisporites parvispinosus* first appear at different levels than in the Otway Basin.

AGE OF FORMATIONS

Casterton beds

Swc 4 (MFP9862) yielded virtually no fossils. The assemblage from **core 3** (MFP9880) included *Cicatricosisporites* spp., *Dictyotosporites speciosus*, *Cyclosporites hughesii*, and cf. *Murospora florida*. The presence of those zone-indicative species, together with the apparent absence of *Pilosisporites notensis* and *Foraminisporis wonthaggiensis*, suggests that the assemblage represents the upper part of the *Crybelosporites stylosus* Zone. Evans (*in* Reynolds, 1971) recovered a very poor assemblage, which he dated Upper Mesozoic, from the equivalent beds («unnamed unit T») in Planet Casterton no. 1 well to the southeast. The evidence from Assemblage MFP9880 restricts the age of the beds in Bus Swamp 1 to the Early Cretaceous, and more specifically Berriasian to basal Valanginian (see Dettmann & others, 1992).

Pretty Hill Sandstone

Swc 8 (MFP9859), **core 2** (MFP9865), and **swc30** (MFP9860) all yielded similar assemblages, which included comparatively large spore fractions and varying pollen (mainly bisaccate) fractions. Swc 8 included the zone-indicative species *Ruffordiaspora australiensis*, *Cyclosporites hughesii*, *Dictyotosporites speciosus*, and *Crybelosporites stylosus*. All three assemblages apparently lack *Pilosisporites notensis*, *Foraminisporis wonthaggiensis*, and other species which are reported to appear later in the sequence, and the assemblages are taken to represent the upper part of the *Crybelosporites stylosus* Zone. Dettmann (1963) recovered a similar assemblage from the formation in ODNL Penola 1 well. Evans (*in* Reynolds, 1971) reported assemblages of Unit K1a from the correlative Geltwood Beach Formation («unit P») in Planet Heathfield 1 and Alliance Kalangadoo 1 wells.

On this zonal evidence the Pretty Hill Sandstone is dated Early Cretaceous, and more specifically Berriasian to basal Valanginian.

Eumeralla Formation

Swc 41 (MFP9861) was barren of microfossils, but **swc 33** (MFP9863) and **core 1** (MFP9864) yielded sufficient palynomorphs for age determination. The presence of *Pilosisporites parvispinosus*, in addition of several species mentioned above, indicates that the two assemblages are not significantly older than the middle *Cyclosporites hughesii* Subzone. No species have been found which first appear in the upper part of the subzone in the Otway Basin. Dettmann (1963) also reported assemblages which fall within this zonal interval from the lower part of the formation in ODNL Penola 1 Well. Evans (*in* Reynolds, 1971) recovered assemblages representing the upper part of his Unit K1a from the lower part of the formation («unit M») in Planet Heathfield 1 well, to the east of Bus Swamp 1.

This zonal association indicates that the lower *Cyclosporites hughesii* Subzone is either restricted to the interval between swcs 30 and 33, i.e. 862-913m depth, or absent altogether. In view of the narrowness of this depth interval it seems reasonable to assume that part of the sequence is missing, and the contact between the Pretty Hill Sandstone and Eumeralla Formation at 865m depth is therefore thought to be an appreciable (nondepositional or erosional) unconformity.

The basal Eumeralla Formation in Bus Swamp 1 is therefore dated Valanginian to Hauterivian, and probably Hauterivian.

PALAEOENVIRONMENTS

Several samples yielded aquatic palynomorphs but no dinoflagellates or acritarchs which might indicate saline or brackish conditions. The sampled strata horizons therefore represent nonmarine (non-saline) environments of deposition. The low numbers of organisms in the Bus Swamp 1 samples contrasts sharply with the often abundant acritarch assemblages found in nonmarine Lower Cretaceous sediments of the Great Australian Basin in Queensland, and may suggest comparatively rapid-current deposition.

Several assemblages from the Casterton beds and Pretty Hill Sandstone include (rare) species which have been described by De Jersey (1963), De Jersey & Paten (1964), and Reiser & Williams (1969) from Lower Jurassic strata of southeastern Queensland, and are found only very sporadically in the Early Cretaceous. Contemporaneous dispersed spores have been found also in mid-Cretaceous strata from the coastal belt of the Otway Basin, and Burger (1985, 1987) suspected them to originate possibly from Lower Jurassic inliers since removed by erosion.

REFERENCES

BURGER, D., 1973 - Spore zonation and sedimentary history of the Neocomian, Great Artesian Basin, Queensland. *Geological Society of Australia Special Publication* 4, 87-118.

BURGER, D., 1985 - Palynological report on samples from Holzers Quarry, Otway Basin, Victoria. *Bureau of Mineral Resources, Professional Opinion Geology* 85.004 (unpublished).

BURGER, D., 1987 - Palynological examination of samples from the Otway Group in the Otway Basin, Victoria. *Bureau of Mineral Resources, Professional Opinion Geology* 87.006 (unpublished).

BURGER, D., 1989 - Stratigraphy, palynology, and palaeoenvironments of the Hooray Sandstone, eastern Eromanga Basin, Queensland and New South Wales. *Queensland Department of Mines Report* 3, 28 p.

DE JERSEY, N.J., 1963 - Jurassic spores and pollen grains from the Marburg Sandstone. *Geological Survey of Queensland Publication* 313, 1-15.

DE JERSEY, N.J. & PATEN, R.J., 1964 - Jurassic spores and pollen grains from the Surat Basin. *Geological Survey of Queensland Publication* 322, 1-18.

DETTMANN, M.E., 1963 - Upper Mesozoic microfloras from south-eastern Australia. *Royal Society of Victoria Proceedings* 77, 1-148.

DETTMANN, M.E. & DOUGLAS, J.G., 1976 - Palaeontology. *In* Douglas, J.G. & others, Mesozoic. *Geological Society of Australia Special Publication* 5, 164-176.

DETTMANN, M.E. & PLAYFORD, G., 1969 - Palynology of the Australian Cretaceous: a review. *In* Campbell, K.S.W. (editor), *Stratigraphy and Palaeontology. Essays in honour of Dorothy Hill.* Australian National University Press, Canberra, 174-210.

DETTMANN, M.E., MOLNAR, R.E., DOUGLAS, J.G., BURGER, D., FIELDING, C., CLIFFORD, H.T., FRANCIS, J., JELL, P., RICH, T., WADE, M., RICH, P.V., PLEDGE, N., KEPM, A. & ROZEFELDS, A., 1992 - Australian terrestrial faunas and floras: biostratigraphic and biogeographic implications. *Cretaceous Research* 13, 207-262.

EVANS, P.R., 1966 - Mesozoic stratigraphic palynology of the Otway Basin. *Bureau of Mineral Resources Record* 1966/69, 45 p. (unpublished).

HELBY, R., MORGAN R. & PARTRIDGE, A.D., 1987 - A palynological zonation of the Australian Mesozoic. *Association of Australasian Palaeontologists Memoir* 4, 1-94.

REISER, R.F. & WILLIAMS, A.J., 1969 - Palynology of the Lower Jurassic sediments of the northern Surat Basin, Queensland. *Geological Survey of Queensland Publication* 339, 1-24.

REYNOLDS, M.A., 1971 - A review of the Otway Basin. *Bureau of Mineral Resources Report* 134, 69 p.