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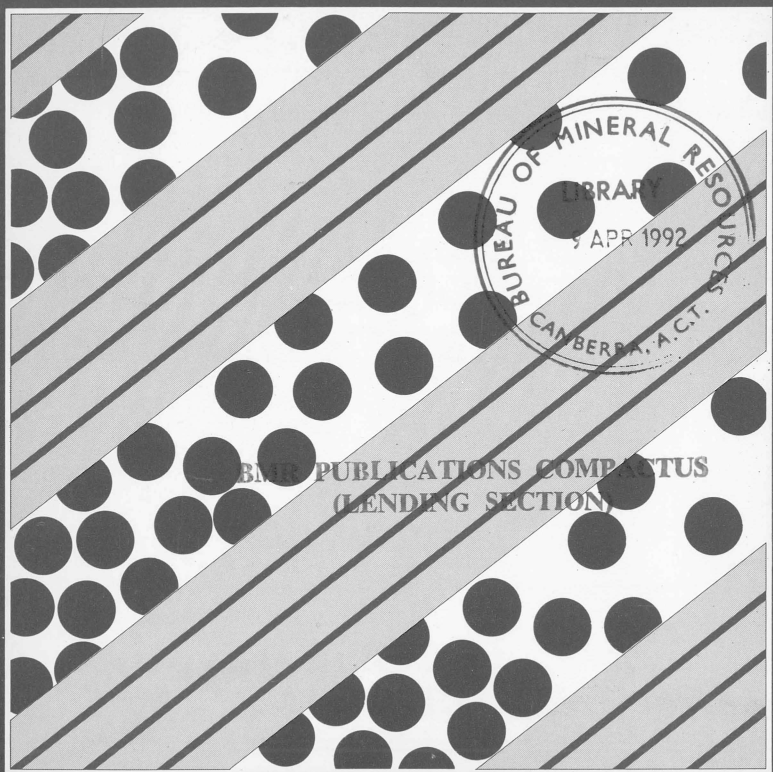
A REVIEW OF PERMIAN TO CRETACEOUS PALYNOSTRATIGRAPHY IN EASTERN AUSTRALIA

D. BURGER, C. B. FOSTER & J. L. McKELLAR



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A REVIEW OF PERMIAN TO CRETACEOUS PALYNOSTRATIGRAPHY IN EASTERN AUSTRALIA

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A CONTRIBUTION TO THE
NATIONAL GEOSCIENCE MAPPING ACCORD PROJECT:
SEDIMENTARY BASINS OF EASTERN AUSTRALIA

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CONTENTS

A REVIEW OF EASTERN AUSTRALIAN PERMIAN PALYNOZONES

C.B. FOSTER

SUMMARY

* **Palynological schemes**

- The currently applied palynological scheme that subdivides the eastern Australian Permian is an amalgam of interval-zones of P.L. Price and coworkers (Price et al., 1985; Draper et al., 1990) and of oppel-zones of Foster (1982; Foster & Waterhouse, 1988). Figure 1 shows 19 interval-zones, of various rankings (zone, subzone, etc.) spanning 45 to 50 Ma, dependent upon the placement of Period boundaries.

- The interval-zones are recognised on the first appearance of a single, key spore-pollen species, and use of a single criterion can cause problems (see below).

- Price and coworkers have correlated their scheme with previous zonations of Evans (1969) and Kemp et al. (1977). Further modifications, based on more detailed studies have been published by Foster (1982; Foster & Waterhouse, 1988) and Powis (1983, 1984; Fig. 2) and are currently in press by Jones & Truswell. Criteria used to recognise the Western Australian palynological zones of Balme (in Kemp et al., 1977), Segroves (1972), and Backhouse (1991) have not been applied to eastern Australian successions.

* **Chronologic Anchor Points**

- Despite the use of standard Permian time-terms, e.g. Kazanian, Tatarian (see Archbold & Dickins, 1991) very few anchor points exist, and supporting evidence for the application of standard stage/time nomenclature in the Australian succession is limited.

- Anchor points exist for the ?Asselian and Sakmarian with detailed studies of palynofloras from fauna-bearing sequences in Western Australia (e.g. Foster & Waterhouse, 1988; Segroves, 1972; Foster et al., 1985); and for the Chhidruan/Djulfian, Late Permian, based on palynological comparisons with

AGE			EASTERN AUSTRALIAN PALYNOZONES					
			PRE-1985		CURRENT			INDEX FORM
TRIASSIC		EARLY	Tr 1b		APT1			← *Lunatisporites pellucidus*
PERMIAN	LATE	Djulfian	Tr 1a		APP6	*P. microcorpus**		← *Rewanispora foveolata*
PERMIAN	LATE	Djulfian	Tr 1a		APP6	*P. 'crenulata'**		← *Triplexisporites playfordii*
PERMIAN	LATE	Djulfian	U Stg 5	U5b–c	APP5	5.0	.3	← *Dulhuntyispora stellata* 'radians'
PERMIAN	LATE	Djulfian	U Stg 5	U5b–c	APP5	5.0	.2	← *Michrystridium evansii* Assemblage-zone; ← *Microreticulatisporites bitriangulatus*
PERMIAN	LATE	Djulfian	U Stg 5	U5a	APP5	5.0	.1	← *Dulhuntyispora parvithola*
PERMIAN	LATE	Djulfian	L Stg 5	L5c	APP4	4.3		← *Dulhuntyispora dulhuntyi*
PERMIAN	EARLY	Baigendzhinian	L Stg 5	L5b	APP4	4.2		← *Didectriletes ericianus*
PERMIAN	EARLY	Baigendzhinian	L Stg 5	L5a	APP4	4.1		← *Dulhuntyispora granulata*
PERMIAN	EARLY	Baigendzhinian	Stg 4	U4b	APP3	3.3	.2	← *Lopadiospora vermithola*
PERMIAN	EARLY	Baigendzhinian	Stg 4	U4b	APP3	3.3	.1	← *Acanthotriletes villosus*
PERMIAN	EARLY	Baigendzhinian	Stg 4	U4a	APP3	3.2	.2	← *Acanthotriletes* 'baculatus'
PERMIAN	EARLY	Baigendzhinian	Stg 4	U4a	APP3	3.2	.1	← *Praecolpatites sinuosus*
PERMIAN	EARLY	Baigendzhinian	Stg 4	L4	APP3	3.1		← *Phaselisporites cicatricosus*
PERMIAN	EARLY	Sakmarian	Stg 3	3b	APP2	2.2		← *Granulatisporites trisinus*
PERMIAN	EARLY	Sakmarian	Stg 3	3a	APP2	2.1		← *Pseudoreticulatispora pseudoreticulata*
PERMIAN	EARLY	?Asselian	Stg 2		APP1	1.2	*Gc**	← *Microbaculispora tentula*; ← *'Granulatisporites' confluens*
PERMIAN	EARLY	?Asselian	Stg 2		APP1	1.1	?	
						—?—	—?—	
CARBONIFEROUS		?Stephanian	Stg 1		APC4	4.2	*Db*	
CARBONIFEROUS		?Stephanian	Stg 1		APC4	4.1	*Sy*	← *Monosaccate* pollen
CARBONIFEROUS		Namurian	*Grandispora maculosa* Assemblage-zone					← *Spelaeotriletes ybertii*

20–1/36

Interval-zones APC-APT of Price (1983, *in* Draper et al. 1990)

← First appearance of taxon

* Oppel-zones of Foster (1982), Foster & Waterhouse (1988)

Sy, *Spelaeotriletes yberti* Assemblage-zone of Kemp et al. (1977)

D b., *Diatomozonotriletes birkheadensis* Zone of Powis (1984)

Figure 1. Eastern Australian Palynozones

the Salt Range (see Balme, 1970; Balme & Helby, 1973; Foster, 1982). Isotopic studies, giving reliable absolute ages are in progress, and should provide further tie points with the standard section.

* Problems

- Interval-zones are based on the appearance of a single species: presence or absence may be affected by genuine evolutionary events and therefore time significant, or by environmental factors, which may mask time indices. This is a weakness of the interval-zone system.

- Oppel-zones, using associations of selected taxa offer a better way of avoiding problems arising from use of one key species. Use of oppel-zones however, requires systematic study of assemblages (e.g. Jones & Truswell, in press).

- The stratigraphic distribution of zones is often based on unpublished studies, so that further development of any scheme, based on newly observed species can be hampered.

* Future Directions

- Palynofloras from independently dated sections need to be systematically studied and published. Many species remain undescribed and their chronologic potential remains untested.

- Independent dating may be from associated palaeontologic evidence, e.g. marine faunas; or from absolute-age dated sequences.

- There needs to be a continuing documentation of palynofloras from known rock units. Moreover, samples from such units should be tied into a sequence framework, preferably using subsurface log and seismic data. Variations in assemblage composition often reflect environmental constraints, rather than time significant, plant-evolutionary controls, and using a sequence stratigraphic framework can solve such problems.

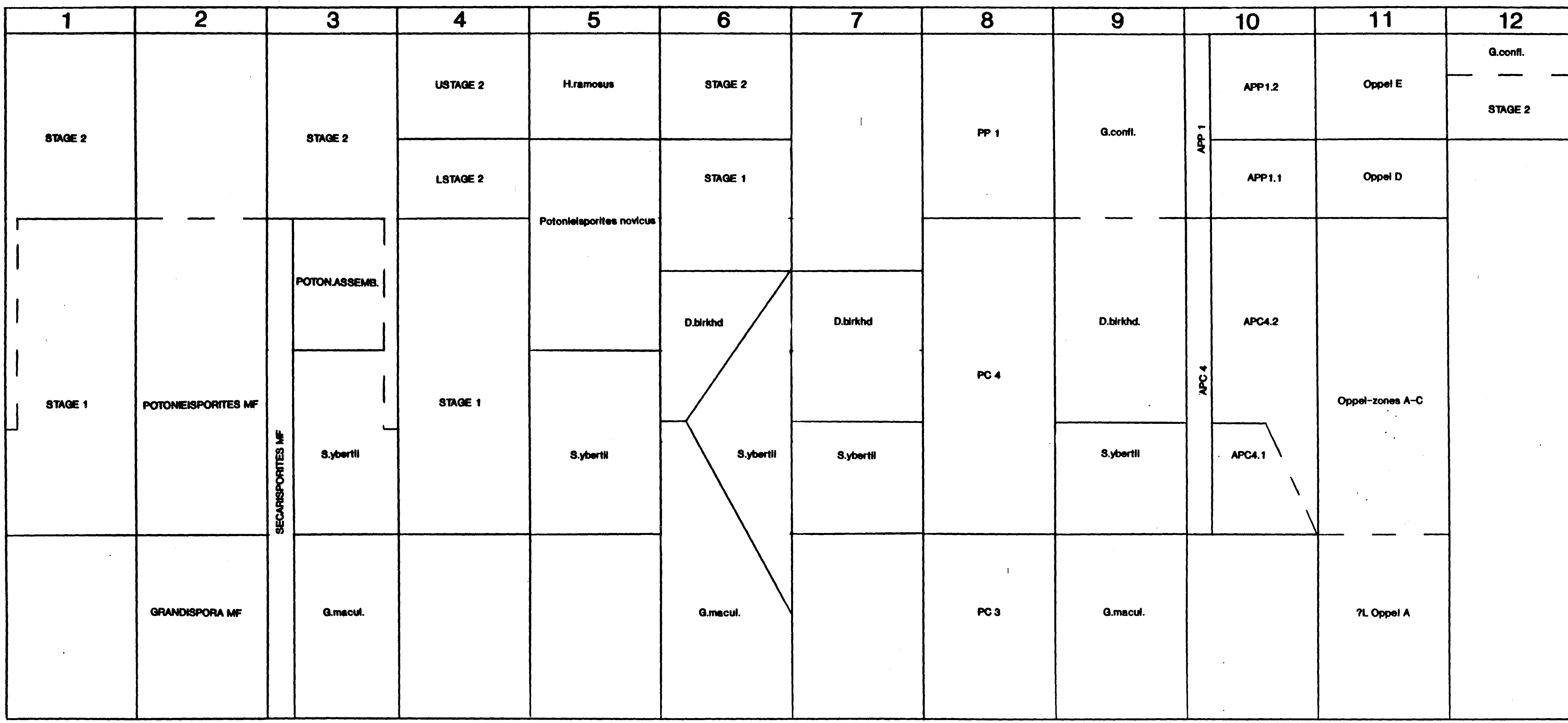
- BMR projects include study of palynofloras from:

    - the faunally-dated, Early Permian, Cranky Corner Basin succession.

    - cored samples from the faunally-dated earliest Permian of the Carnarvon Basin, Western Australia. The sequence is of apparent low thermal maturity and miospore preservation should be good enough to allow for detailed systematic study.

LATE CARBONIFEROUS AND EARLY PERMIAN PALYNOZONES: CONCEPTUAL AND NOMENCLATURAL CHANGES (see notes)

FIGURE 2



1,EVANS (1969). 2,HELBY (1969). 3,KEMP et al. (1977). 4,NORVICK (1974). 5,POWIS (1979,upubl.Ph.D.). 6,POWIS (1984). 7,POWIS (unpubl. ms). 8,PRICE et al. (1985).
9,FOSTER & WATERHOUSE (1988,and unpubl.). 10,DRAPER et al. (1990). 11,JONES & TRUSWELL (1991). 12,BACKHOUSE (1991).

- selected samples from isotopically dated sequences in the Tamworth Belt and Sydney Basin, in conjunction with John Roberts, University of New South Wales. Samples range in age from the Early Carboniferous (Visean) to Early Permian.

DATA ON ZONES

Problems of Interpretation: Examples (see Fig. 2)

* Stage 1

- Formally defined by Evans (1969) to include assemblages with monosaccate pollen, and with *Retusotriletes diversiformis* (= *R. nigritellus* and ?*Psomospora detecta* Playford & Helby 1968 - see below) but lacking striate pollen. Stratigraphic distribution of Stage 1 given by Evans included the Joe Joe Formation of the Gallilee Basin (now Joe Joe Group of Jones & Truswell, in press), 'probably Stuart Range Beds' (= Stuart Range Formation, Arckaringa Basin, in Gilby & Foster 1988), and Seaham beds of the Sydney Basin.

- Further work has, of course, rendered these criteria inadequate for fine scale subdivision (see Figure 2). Monosaccate grains occur (together with very rare striate forms) in the *Spelaeotriletes ybertii* Zone, allowing legitimate equation between the *S. ybertii* Zone and Stage 1: this view has been adopted by Price et al. (1985).

- Accepting that the initial occurrence of *R. nigritellus* is a necessary criterion for Stage 1, Jones & Truswell show it occurs in their oppel-zone D known from the Jochmus and Jericho Formations of the Joe Joe Group (see note above about Joe Joe Formation of Evans). On this basis Evans's (1969) Stage 1 can be equated with Oppel-zone D. Oppel-zone D, however, occurs above the first appearance, in Oppel-zone C, of striate pollen attributed to *Protohaploxypinus* sp. cf. *P. goraiensis*, the same species that Evans (1969) considered marked his Permian Stage 2 zone! Thus within the same basin, there is an apparent discrepancy in stratigraphic distribution. This might be explained if the identification of *R. nigritellus* -like specimens by Evans included spores of *Psomospora detecta* which is a superficially similar species.

- Jones & Truswell (in press) show *P. detecta* as a key component of their Oppel-zone B, together with monosaccate pollen, and <u>below</u> the occurrence of *Protohaploxypinus* sp cf. *P. goraiensis*. This option is more consistent with the Evans's scheme and is the likely equivalent of Stage 1 (Fig. 2).

* **D. birkheadensis Assemblage-zone**

. Named, but without any supporting detail of palynological assemblages, by Powis (1983, 1984, and in a quoted but unpublished manuscript) from Sun Oil Fairlea #1 in the Galilee Basin between 1676-2021m. Details are difficult to determine: Norvick's (1974) summary of the Galilee Basin palynology shows that only two previous samples, *above* the Powis zone, have been examined; Jones & Truswell (in press) did not consider palynofloras from this well, and missed an opportunity to tie, within the same succession, the various biostratigraphic schemes.

. Powis developed the *D. birkheadensis* Zone concept after his Ph.D. studies (1979, unpublished) in Western Australia. In the 1979 study, Powis assigned assemblages from approximately 3088ft in Wapet Fraser River #1 to the *S. ybertii* Zone. In 1984 he designated assemblages from the *same* interval from 3080ft to 3107ft to his *D. birkheadensis* Zone, which is considered to be younger. No details of species distribution were given to support the redefinition.

. According to Powis's studies (published and unpublished), the species *D. birkheadensis* first appears in assemblages previously assigned to the *S. ybertii* Zone, that is with *S.ybertii*. Foster (1986, unpublished) has recorded *D. birkheadensis* in the *G. maculosa* and *S. ybertii* Zones in the Bonaparte Basin wells, Kulshill #2 and Leseuer #1 (respectively). In the Galilee Basin, Jones & Truswell (in press) show that *D. birkheadensis* commences in Oppel-zone C, together with *Protohaploxypinus* sp. cf *P. goraiensis*. This clashes with Price's 1990 claim that *D. birkheadensis* appears *below* consistently recorded members of *Protohaploxypinus* (see Draper et al. 1990), and so brings into question the applicability of both zones.

* **Rarity of index species**

. In the eastern Australian succession certain key species such as *Dulhuntyispora stellata* (Fig. 1), *D. maewestus* and *D. spongia* occur rarely or sporadically in assemblages making zonal identification impossible. Elsewhere in Australia these taxa may be common, and all those named above are typified from Western Australian, Canning Basin assemblages.

. These problems are illustrated in the Stroud-Gloucester Trough area: McMinn (1987) working with cores from the Weismantels Formation reported 'the complete absence of *Dulhuntyispora granulata* has made it impossible to recognise zone Lower Stage 5a'. Helby et al. (1986), however, reported *D. granulata* from an outcrop of the same coal, dating the unit.

NOTES TO ACCOMPANY FIGURE 2: ORIGINAL CRITERIA OF KEY ZONES

Stage 2 - Evans (1969)

- Occurrence of *Protohaploxypinus goraiensis*-type pollen in Galilee Basin; also associated with spinose acritarchs and fauna-bearing sequences; tentative inclusion of the Cape Jervis beds of the Troubridge Basin, South Australia.

- 'Earliest forms of disaccate striate and non-striate pollen,'...and a significant number of monocolpate grains.

  Comment: The occurrence of large, disaccate grains with narrow to medium width cappula and striate cappa, assignable to *Protohaploxypinus* sp. of *P. goraiensis/charactus* occur with *G. confluens* in other basins, and seems a reasonable marker.

- Striate pollen, however, occur very rarely in *S. ybertii* and *D. birkheadensis* assemblages and using the criteria of Kemp et al. (1977), could be miscorrelated with otherwise younger palynofloras: this explains the downward extension of Stage 2 in Fig.2.

G. confluens Oppel-zone - Foster & Waterhouse (1988)

- *G. confluens* occurring with at least four of the key taxa listed in Foster & Waterhouse (1988). *Microbaculispora tentula* occurs within this zone.

  Comment: Backhouse (1991) concluded that the *G. confluens* Oppel-zone belonged to the top of Stage 2. Backhouse (1991), Price et. al. (1985; and in Draper et al., 1990), and Jones & Truswell (in press) consider that the appearance of *M. tentula* is of prime chronologic importance, and that it occurs before *G. confluens*. This concept should be tested further; to date, published data independent of that of Foster are known from the Collie Basin, Western Australia (Backhouse, 1991).

Stage 1 - Evans (1969)

- Monosaccate pollen, together with *Retusotriletes diversiformis* (*s.l.*, includes *Psomospora detecta;* see above).

- No striate pollen of the *Protohaploxypinus* sp. cf. *P. goriaensis*-type.

- Evans's suggestion that Stage 1 palynofloras were 'Probably in the Stuart Range Beds', Arckaringa Basin, can be corrected because Stages 2 and 3 palynofloras were reported by Gilby & Foster (1988) from this formation.

- Striate pollen now known to occur within *S. ybertii* and *D. birkheadensis* assemblages hence extends the concept of Stage 2 (above) and invalidates Stage 1.

- **Comment:** Stage 1 is a flawed concept with previously assigned Stage 1 palynofloras assigned to the *S. ybertii*, *D. birkheadensis*, and Stage 2 palynozones.

D. birkheadensis **Assemblage-zone - Powis (1984)**

- *S. ybertii* is not present in asemblages.
- Monosaccate pollen present.
- No striate pollen of the *P.* sp. cf. *P. goriaensis*-type.
- Compositionally similar, but with the exception of the absence of *S. ybertii*, to the underlying *S.ybertii* Zone.

Comment: Not a satisfactory zone, recognised by default with the absence of *S.ybertii*, and occurring, in section, above assemblages with *S. ybertii*. *D. birkheadensis* itself occurs with both *S. ybertii* and the older *G. maculosa* Zones.

S.ybertii **Assemblage - Kemp *et al.* (1977)**

- First occurrence of monosaccate pollen of the *Potonieisporites, Cannanoropollis, Caheniasaccites, Plicatipollenites* types.

- Distinguished from underlying *G. maculosa* Zone on these criteria.

Comment: Includes palynofloras previously assigned to Stage 1.

G. maculosa **Assemblage - Kemp et al. (1977)**

- No monosaccate pollen.
- Key species as listed by Kemp et al. (1977) and Playford & Helby (1968).
- *Dibolisporites lictor* Foster & Helby 1988 a useful zonal species.

Summary of comments:

- The definition of the *D. birkheadensis, G. maculosa,* and *S. ybertii* assemblages remains unsatisfactory with each based on a single criterion.

- The continued recognition of Stage 1 or *Potonieisporites* Assemblages by some authors is difficult to comprehend: their criteria including an abundance of monosaccate pollen, might simply reflect specialised ecologies, with little time significance. This is clearly evident in Zambian, Early Permian, Stage 3b-equivalents, with *P. pseudoreticulata* and *G. trisinus*, where monosaccate pollen, mostly of *Cannanoropollis* spp., account for between 60% and 80% of certain assemblages (Utting, 1976). Most importantly, Stage 1 is a flawed unit in that its contained palynofloras have been variously reassigned to other more rigorously defined zones; e.g., *G. confluens*/Stage 2 in the Arckaringa Basin; and *S. ybertii* Zone in the Bonaparte Basin (see also Jones & Truswell, in press).

CONCLUSIONS

* Detailed taxonomic studies of spore-pollen floras from known and/or independently dated rock units is essential.

* Oppel-zones are needed, together with more common interval-zones to effect detailed zonations.

* Previous palynological studies need to be re-assessed in the light of new evidence, preferably by the same worker to provide unambiguous continuity between zonal schemes.

* The BMR has the responsibility to establish a national data base for palynostratigraphy and needs to involve postgraduates and consultants to rapidly advance these essential studies.

REFERENCES

Archbold, N.W., & Dickins, J.M., 1991 - Australian Phanerozoic timescales - 6 Permian. A standard for the Permian System in Australia. *Bureau of Mineral Resources, Australia, Record*, 1989/36, 17 pp.

Backhouse, J., 1991 - Permian palynostratigraphy of the Collie Basin, Western Australia. *Review of Palaeobotany and Palynology*, 67, 237-314.

Balme, B.E., 1970 - Palynology of Permian and Triassic strata in the Salt Range and Surghar Range, West Pakistan. *In* Kummel, B., & Teichert, C., (editors), Stratigraphic boundary problems: Permian and Triassic of West Pakistan. *University of Kansas Press, Lawrence, Kansas*, 306-453.

Balme, B.E., & Helby, R.J., 1973 - Floral modifications at the Permian-Triassic boundary in Australia. *In* Logan, A., & Hills, L.V., (editors), The Permian and Triassic systems and their mutual boundary, *Canadian Society of Petroleum Geologists, Memoir*, 2, 433-444.

Draper, J.J., Palmieri, V., Price, P.L., Briggs, D.J.C., & Parfrey, S.M., 1990 - A biostratigraphic framework for the Bowen Basin. *In* Beeston, J.W., (compiler), Bowen Basin Symposium 1990, Proceedings. *Geological Society of Australia (Queensland Division), Brisbane*, 26-35.

Evans, P.R., 1969 - Upper Carboniferous and Permian palynological stages and their distribution in Eastern Australia. *In* Gondwana Stratigraphy, *IUGS, 1st Gondwana Symposium 1967, Buenos Aires, UNESCO, Paris*, 41-53.

Foster, C.B., 1982 - Spore-pollen assemblages of the Bowen Basin, Queensland (Australia): their relationship to the Permian/Triassic boundary. *Review of Palaeobotany and Palynology*, 36, 165-183.

Foster, C.B., Palmieri, V., & Fleming, P.J.G., 1985 - Plant microfossils, Foraminiferida and Ostracoda, from the Fossil Cliff Formation (Early Permian, Sakmarian), Perth Basin, Western Australia. *South Australian Department of Mines and Energy, Special Publication*, 5, 61-105.

Foster, C.B., & Waterhouse, J.B., 1988 - The *Granulatisporites confluens* Oppel-zone and the Early Permian marine faunas from the Grant Formation on the Barbwire Terrace, Canning Basin, Western Australia. *Australian Journal of Earth Sciences*, 35, 135-157.

Gilby, A.R., & Foster, C.B., 1988 - Early Permian palynolgy of the Arckaringa Basin, South Australia. *Palaeontographica*, B209(4-6), 167-191.

Helby, R.J., 1969 - The Carboniferous-Permian boundary in eastern Australia: an interpretation on the basis of palynological information. *Geological Society of Australia, Special Publication*, 2, 69-72.

Jones, M.J., & Truswell, E.M., in press - Late Carboniferous and Early Permian palynostratigraphy of the Joe Joe Group, Southern Galilee Basin, Queensland and implications for Gondwana stratigraphy.

Kemp, E.M., Balme, B.E., Helby, R.J., Kyle, R.A., Playford, G., & Price, P.L., 1977 - Carboniferous and Permian Palynostratigraphy in Australia and Antarctica: A review. *BMR Journal of Australian Geology and Geophysics*, 2, 177-208.

Norvick, M., 1974 - Permian and Late Carboniferous palynostratigraphy of the Galilee Basin, Queensland. *Bureau of Mineral Resources, Australia, Record*, 1974/141.

Powis, G.D., 1979 - Palynology of the Late Palaeozoic Glacial Sequence, Canning Basin, W.A. Ph.D. Thesis, University of Western Australia, Perth (unpublished).

Powis, G.D., (unpublished manuscript) - The definition and description of two late Carboniferous spore-pollen assemblage-zones from Australia. 115pp. MS & 13 pls.

Powis, G.D., 1983 - The palynostratigraphy of the Permo-Carboniferous of the Galilee Basin, Queensland. *In* Permian Geology of Queensland. *Geological Society of Australia, Queensland Division*, p. 213.

Powis, G.D., 1984 - Palynostratigraphy of the Late Carboniferous sequence, Canning Basin, W.A. *In* Purcell, P.G., (editor), The Canning Basin W.A. *Proceedings of the Geological Society of Australia/Petroleum Exploration Society of Australia Canning Basin Symposium, Perth*, 1984, 429-438.

Price, P.L., Filatoff, J., Williams, A.J., Pickering, S.A., & Wood, G.R., 1985 - Late Palaeozoic and Mesozoic palynostratigraphical units. *CSR Oil and Gas Division, Palynology Facility, Report*, 274/25 (unpublished report held by the Queensland Department of Resource Industries as CR 14012).

Segroves, K.L., 1972 - The sequence of palynological assemblages in the Permian of the Perth Basin, Western Australia. Second Gondwana Symposium, South Africa, Proceedings and Papers, *Council for Scientific and Industrial Research, Pretoria, South Africa*, 511-529.

Utting, J., 1976 - Pollen and spore assemblages in the Luwumba Coal Formation (Lower Karroo) of the North Luangwa Valley, Zambia, and their biostratigraphic significance. *Review of Palaeobotany and Palynology*, 21, 295-315.

TRIASSIC PALYNOSTRATIGRAPHY IN EASTERN AUSTRALIA, A REVIEW

D. BURGER

Triassic fluvial and rare marine deposits occur in several geographic depressions in southeastern Queensland and northeastern New South Wales. The record of Triassic deposition in that region includes many gaps; the relatively most complete sedimentary blankets occur in the Galilee and Bowen Basins (Day et al., 1983). Isolated sequences have been found also further east: in the Callide, Tarong, and Ipswich Basins, and the Esk and Abercorn Troughs (Murphy, et al., 1976; Cranfield et al., 1976). A continuous Rhaetian-Jurassic sedimentary sequence has been mapped in the Clarence-Moreton Basin (see BMR Bulletin 241, in press).

Because of the paucity of faunal evidence many sediments have been dated only on their fossil plant remains, in particular miospores and pollen grains. Marine deposits (Kin Kin beds, Brooweena Formation, carrying Early Triassic ammonoids) occur in the Gympie block (Day et al., 1983) but to the author's knowledge are not palynologically dated. From detailed regional studies several palynostratigraphic schemes for the Triassic have been proposed (Table 1). Limits of spore-pollen zones are generally defined by the oldest appearance of selected species, but some on other palynological criteria.

Geological ages of individual zones have been extrapolated by dating equivalent zonal sequences in a) Western Australia on the basis of associated ammonites, foraminifera, and conodonts (Helby et al., 1987), and b) New Zealand, on the basis of associated invertebrate faunas (De Jersey & Raine, 1990). The authors involved drew closely comparable age deductions from the two sets of evidence, the chief difference being that de Jersey & Raine (1990) placed the lower limit of the *Craterisporites rotundus* Zone in the Carnian rather than Ladinian.

Table 2 gives sedimentary successions of several regions and their palynological associations. The "Cynthia beds" of the Abercorn Trough have been dated Middle Triassic (de Jersey, 1972), and the Tarong beds in the Tarong Basin Late Triassic (de Jersey, 1970).

Active volcanism deposited tuffs and lavas in several areas. A score of isotopic analyses published give an idea of absolute ages of various volcanic events (Balme 1990). Several ages can be linked with the palynological record, but minimum deviations of 5-10% do not allow precise values to be deduced for individual zones. However, Triassic timescales recently proposed do not show large differences; Harland et al. (1989) proposed 245-241-235-208 Ma, and Odin & Odin (1990) 245-240-230-205 Ma, for the base of the Scythian-Anisian-Carnian-Jurassic respectively.

TABLE 1: TRIASSIC PALYNOSTRATIGRAPHIES FOR EASTERN AUSTRALIA

Geological age			Price, in Draper et al. (1990)	de Jersey (1975) Foster (1982)	Helby et al. (1987)
(JURASSIC)			**APT5.2**	*Ceratospor. helidonensis*	
TRIASSIC	LATE	Rhaetian	**APT5.1**	*P. crenulatus*	*P. crenulatus*
		Norian	hiatus	hiatus	
		Carnian	**APT4.2** **APT4.1**	*C. rotundus*	*C. rotundus*
					S. speciosus
	MIDDLE	Ladinian	hiatus	hiatus	*S. quadrifidus*
		Anisian	**APT3.4** **APT3.3** **APT3.2** **APT3.1**	*D. problematicus* Microflora	*A. parvispinosus*
			not zoned	not zoned	*A. tenuispinosus*
	EARLY	Scythian	**APT2.2** **APT2.1**	*P. samoilovichii*	*P. samoilovichii*
			APT1	*L. pellucidus*	*L. pellucidus*
(PERMIAN)					

z o n a l b o u n d a r i e s

———— defined by the oldest appearance of selected spore and pollen species

- - - - - defined by other palynological criteria

TABLE 2: LITHO-PALYNOLOGICAL CORRELATIONS IN EASTERN AUSTRALIA

GALILEE & BOWEN	1 CALLIDE 2 GUNNEDAH	ESK	IPSWICH		Spore-pollen zones
					Ceratospor. helidon.
	1 ----?---- Callide Coal Meas ----?----				*P. crenulatus*
			Ipsw. Coal Meas.	Brassall Subgroup -------- Kholo Subgroup	*C. rotundus*
Moolayember Formation	2 Gragin Conglom.	-----?----- Esk Form. Neara Volc.			*Aratrispor. parvispinosus*
Clematis Sandstone	Gunnee Formation	Bryden Fm. -----?-----			
Rewan Formation					*A. tenuispin.*
					P. samoilov.
					L. pellucida

REFERENCES

Balme, B.E., 1990 - Australian Phanerozoic timescales: 7. Triassic biostratigraphic charts and explanatory notes. *Bureau of Mineral Resources, Australia, Record*, 1989/37, 28 pp.

Cranfield, L.C., Schwarzbock, H., & Day, R.W., 1976 - Geology of the Ipswich and Brisbane 1:250 000 Sheet areas. *Geological Survey of Queensland, Report*, 95, 176 pp.

Day, R.W., Whitaker, W.G., Murray, C.G., Wilson, I.H., & Grimes, K.G., 1983 - Queensland Geology. A companion volume to the 1:250 000 scale geological map (1975). *Geologicaal Survey of Queensland, Publication*, 383, 194 pp.

de Jersey, N.J., 1970 - Triassic miospores from the Abercorn Trough. *Queensland Government Mining Journal*, 73, 383-385.

de Jersey, N.J., 1972 - Triassic miospores from the Abercorn Trough. *Queensland Government Mining Journal*, 73, 383-385.

de Jersey, N.J., 1975 - Miospore zones in the Lower Mesozoic of southeastern Queensland. *In* Campbell, K.S.W., (editor), Gondwana Geology. *Australian National University Press, Canberra*, 159-172.

de Jersey, N.J., 1979 - Palynology of the Permian-Triassic transition in the western Bowen Basin. *Geological Survey of Queensland, Publication*, 374, 39 pp.

Draper, J.J., Palmieri, V., Price, P.L., Briggs, D.J.C., & Parfrey, S.M., 1990 - A biostratigraphic framework for the Bowen Basin. *In* Beeston, J.W., (compiler), Bowen Basin Symposium 1990, Proceedings. *Geological Society of Australia (Queensland Division), Brisbane*, 26-35.

Foster, C.B., 1982 - Spore-pollen assemblages of the Bowen Basin, Queensland (Australia): their relationship to the Permian/Triassic boundary. *Review of Palaeobotany and Palynology*, 36, 165-183.

Harland, W.B., Armstrong, R.L., Cox, A.V., Graig, L.E., Smith, A.G., & Smith, D.G., 1989 - A geologic time scale. *Cambridge University Press, Cambridge*, 263 pp.

Helby, R., Morgan, R., & Partridge, A.D., 1987 - A palynological zonation of the Australian Mesozoic. *Association of Australasian Palaeontologists, Memoir*, 4, 1-94.

Murphy, P.R., Schwarzbock, H., Cranfield, L.C., Withnall, I.W., & Murray, C.G., 1976 - Geology of the Gympie 1:250 000 Sheet area. Queensland Geological Survey Report, 96, 157 pp.

Odin, G.-S., & Odin, C., 1990 - Échelle numérique des temps géologiques. *Géchronique*, 35, 12-21.

Stevens. J., 1981 - Palynology of the Callide Basin, east-central Queensland. *Department of Geology, University of Queensland, Papers*, 9, 1-35.

JURASSIC PALYNOSTRATIGRAPHY OF THE SURAT BASIN - A REVIEW

J.L. McKELLAR

Palynological zonation of the continental Jurassic strata in the Great Artesian Basin (Surat and Eromanga Basins) was undertaken initially by Evans (1966), but on an informal basis. Subsequently, Reiser & Williams (1969), for the Early Jurassic of the Surat Basin, produced a formalized palynostratigraphy of the Precipice Sandstone-Evergreen Formation interval and provided sample frequency and stratigraphic range data on all species recorded.

The biostratigraphic schemes introduced by de Jersey (1975, 1976) for Rhaeto-Liassic strata in the Clarence-Moreton Basin can be applied to the Precipice-Evergreen interval in the Surat Basin. Burger (1973, 1989a) subdivided the latest Jurassic-Neocomian in the Great Artesian Basin; and Helby et al. (1987) published a pan Australian zonation of the entire Jurassic succession. Application of the latter in Queensland has not been without difficulty, especially in the Middle Jurassic with the *Dictyotosporites complex* and *Contignisporites cooksoniae* Oppel Zones. There has also been problems associated with the ages of their units as Burger (1989b) has attempted to reconcile.

The alpha-numeric spore-pollen scheme of Price et al. (1985), Filatoff & Price (1988), and Price (*in* Draper et al., 1990) provides for the greatest subdivision of, and has the widest current application in, the Jurassic of Queensland. The biostratigraphic structure of this scheme and the relationship between it and lithostratigraphic units in the Surat Basin are shown in Figures 1 and 2. However, certain deficiencies are associated with it and these are as follows:

(i) It lacks formal definition;

(ii) The biostratigraphic subdivisions are interval zones, the limits of which, in each case, have been defined by the first appearance of a nominated species. However, no systematics and no comprehensive species range and assemblage data have been provided with it. Thus some difficulty can be encountered in its application, especially in sections where index species are rare and sporadically distributed; and

(iii) The biostratigraphic application of some species should be treated with caution (viz., *Nevesisporites vallatus, Retitriletes watherooensis, Ceratosporites equalis*). In particular, *R. watherooensis* must be distinguished from proximally smooth but otherwise similar spores which extend lower in the section.

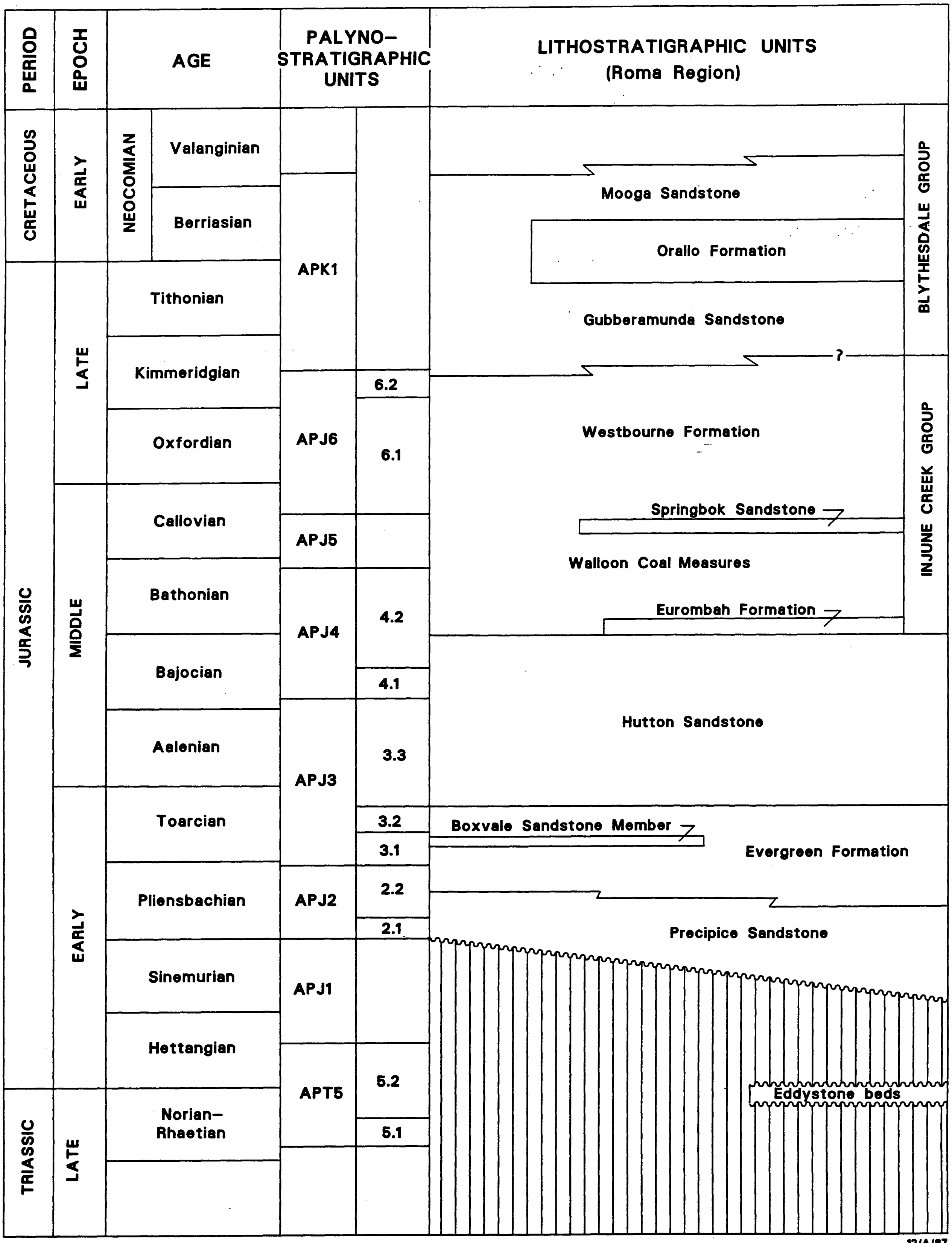


Figure 1. Relationship between biostratigraphic and lithostratigraphic units in the Jurassic of the Surat Basin

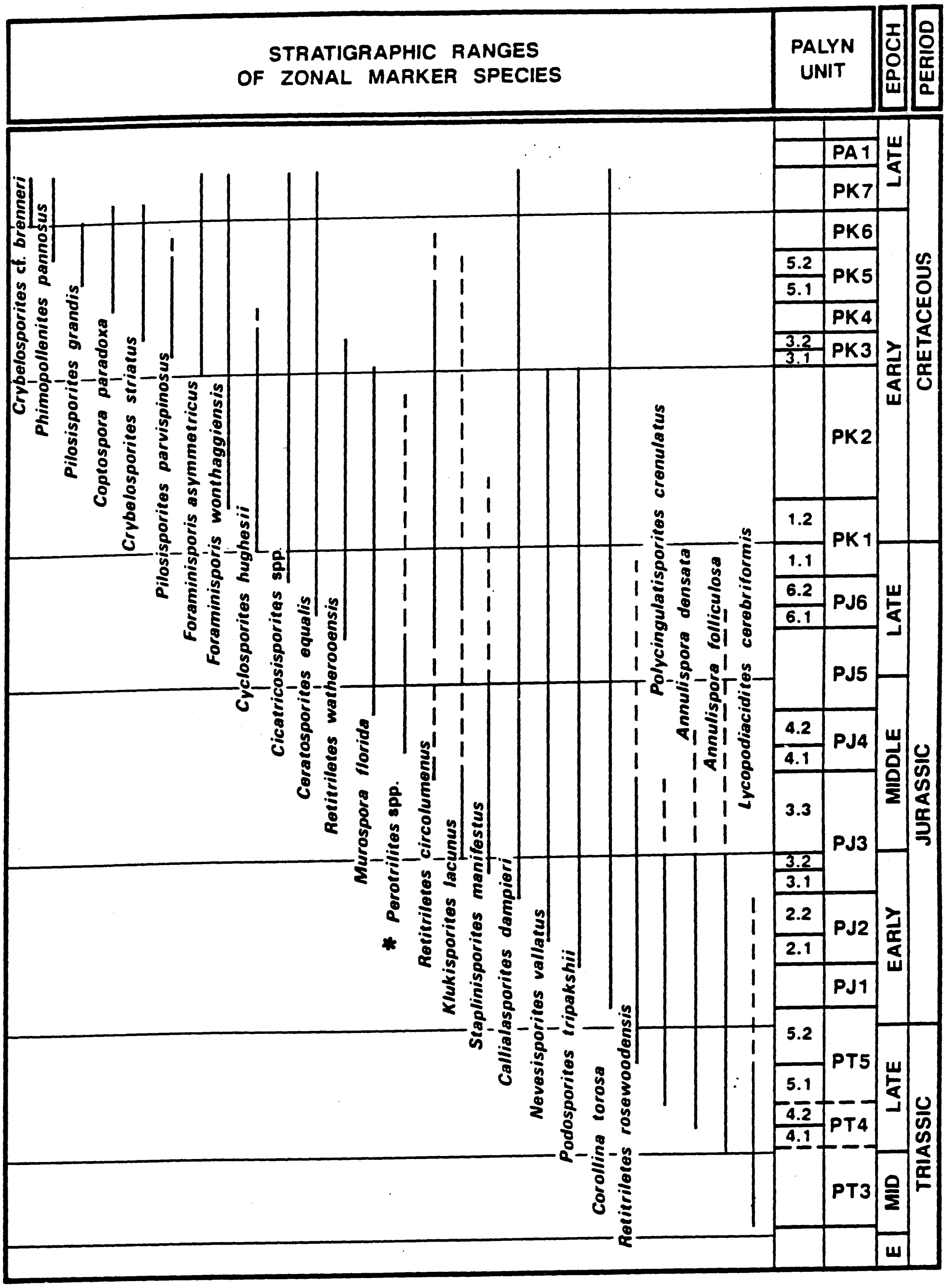


Figure 2. Palynostratigraphy based on first appearances of the nominated species (after Filatoff & Price, 1988). * *Perotrilites whitfordensis* Backhouse 1988. Figure kindly provided by P.L. Price of APG Consultants.

CURRENT WORK AND DIRECTIONS FOR FUTURE WORK

1. A comprehensive taxonomic and descriptive compilation of late Early and Middle to Late Jurassic palynomorphs from the upper Evergreen Formation-Westbourne Formation sequence in the Roma Shelf area has been undertaken at the Geological Survey of Queensland (Department of Resource Industries). This work is planned for publication in 1992. Miospore assemblage and distribution data derived from it will contribute towards a better biostratigraphic subdivision of the Jurassic in the Surat Basin. However, detailed stratigraphic charting of species and assemblages needs to be undertaken in the central and eastern areas of the basin, especially for the Middle to Late Jurassic. Existing GSQ stratigraphic bores (eg. Dalby 1, Chinchilla 4) can provide suitable material for the eastern region, but, for the central Surat, deep stratigraphic drilling may be necessary.

2. Little is known of lithostratigraphic and biostratigraphic relationships in the more southern areas of the Surat Basin in Queensland where lithofacies changes are apparent.

3. The extent of pre-Precipice strata (Eddystone beds - Price et al., 1985) in the Surat Basin in unknown. These strata, initially, recorded in GSQ Eddystone 1 within the basal section of the Precipice Sandstone (Heywood, 1978) contain a latest Triassic assemblage similar to the palynoflora associated with the basal Bundamba Group in the Moreton Basin (McKellar, 1978).

4. The stratigraphic distribution of palynomorphs in the Gubberamunda Sandstone-Orallo Formation interval in the Surat Basin is incompletely known and urgently requires attention, especially in order to:

   (i) provide better biostratigraphic control of the sequence in question; and

   (ii) obtain a better understanding of the depositional history of the equivalent top Westbourne Formation-Hooray Sandstone interval in the Eromanga Basin.

5. Confident age control throughout the Australian Jurassic is essentially lacking. However, proposed isotopic age determinations will assist in overcoming this problem, although additional determinations may be required if suitable biostratigraphically delimited sample material can be located. Moreover, the current work of de Jersey & McKellar on palynofloras from accurately dated marine Jurassic strata of New Zealand is proving to be useful in dating the Surat Basin succession.

   In the attached palynostratigraphic scheme (Figure 1), Burger's (1989b) views on the relationship between the APJ zonal units and the Jurassic Stages are followed in the main; and placement of the Triassic-Jurassic boundary is based on the opinions expressed by de Jersey (1975, personal communication) and de Jersey & Raine (1990). Moreover, within the scope of the Sedimentary Basins of Eastern Australia Project, consensus will need to be achieved on what absolute age scale should be followed.

6. High priority must be given to establishing a formal zonation of the entire Jurassic in the Great Artesian Basin. However, this can be done effectively only when the above deficiencies in our knowledge have been overcome.

REFERENCES

Burger, D., 1973 - Spore zonation and sedimentary history of the Neocomian, Great Artesian Basin, Queensland. *In* Glover, J.E., & Playford, G., (editors), Mesozoic and Cainozoic Palynology: Essays in Honour of Isabel Cookson. *Geological Society of Australia, Special Publication*, 4, 87-118.

Burger D., 1989a - Stratigraphy, palynology, and palaeoenvironments of the Hooray Sandstone, Eastern Eromanga Basin, Queensland and New South Wales. *Queensland Department of Mines, Report*, 3, 28pp.

Burger, D., 1989b - Australian Phanerozoic timescales: Jurassic. *Bureau of Mineral Resources, Australia, Record*, 1989/38, 36 pp.

de Jersey, N.J., 1975 - Miospore zones in the Lower Mesozoic of southeastern Queensland. *In* Campbell, K.S.W., (editor), Gondwana Geology - Papers presented at the Third Gondwana Symposium, Canberra, Australia, 1973. ANU Press, Canberra, 159-172.

de Jersey, N.J., 1976 - Palynology and time relationships in the lower Bundamba Group (Moreton Basin). *Queensland Government Mining Journal*, 77, 460-465.

de Jersey, N.J., & Raine, J.I., 1990 - Triassic and earliest Jurassic miospores from the Murihiku Supergroup, New Zealand. *New Zealand Geological Survey, Palaeontological Bulletin*, 62, 164 pp.

Draper, J.J., Palmieri, V., Price, P.L., Briggs, D.J.C., & Parfrey, S.M., 1990 - A biostratigraphic framework for the Bowen Basin. *In* Beeston, J.W., (compiler), Bowen Basin Symposium 1990, Proceedings. *Geological Society of Australia (Queensland Division), Brisbane*, 26-35.

Evans, P.R., 1966 - Mesozoic stratigraphic palynology in Australia. *Australasian Oil and Gas Journal*, 12(6), 58-63.

Filatoff, J., & Price, P.L., 1988 - A Pteridacean spore lineage in the Australian Mesozoic. *In* Jell, P.A., & Playford, G., (editors), Palynological and palaeobotanical studies in honour of Basil E. Balme. *Association of Australasian Palaeontologists, Memoir*, 5, 89-124.

Helby, R., Morgan, R., & Partridge, A.D., 1987 - A palynological zonation of the Australian Mesozoic. *In* Jell, P.A., (editor), Studies in Australian Mesozoic palynology. *Association of Australasian Palaeontologists, Memoir*, 4, 1-94.

Heywood, P.B., 1978 - Stratigraphic drilling report - GSQ Eddystone 1. *Queensland Government Mining Journal,* 79, 407-417.

McKellar, J.L., 1978 - Palynostratigraphy of samples from GSQ Eddystone 1. *Queensland Government Mining Journal,* 79, 424-434.

Price, P.L., Filatoff, J., Williams, A.J., Pickering, S.A., & Wood, G.R., 1985 - Late Palaeozoic and Mesozoic palynostratigraphical units. *CSR Oil and Gas Division, Palynology Facility, Report*, 274/25 (unpublished report held by the Queensland Department of Resource Industries as CR 14012).

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, *Palaeontological Papers*, 15, 1-24.

CRETACEOUS PALYNOSTRATIGRAPHY OF THE SURAT BASIN, A REVIEW

D. BURGER

The youngest known strata in the complex of Mesozoic sedimentary basins in southeastern Queensland and northeastern New South Wales have been mapped in the northern Surat Basin (Exon, 1976) and are Early Cretaceous (Neocomian to middle Albian) in age (Day, 1969, 1974; Burger, 1973, 1980, 1986; Haig, 1979). During the Aptian and early Albian several marine transgressions have left fossil records, of which ammonites, foraminifera, and marine dinoflagellates are the principal organisms by which the associated strata have been dated. The remaining nonmarine succession has been dated on (indirect) spore and pollen evidence.

Commercial and stratigraphic drilling by petroleum companies, BMR, and the Queensland Department of Mines have provided the raw material which enabled the basin's palynology to be studied at BMR, the Queensland and New South Wales Gewological Surveys, and the University of Queensland. The correlation diagram (Table 1) shows the Cretaceous succession of sedimentary formations mapped in the basin, the geological distribution of fossil faunas and floras, and the relative intervals of biostratigraphic schemes currently applied by palynologists for the eastern Australian Mesozoic.

Spore-pollen zones have been defined on oldest appearances of selected species (Dettmann & Playford, 1969; Burger, 1973, 1989; Helby et al., 1987; Filatoff & Price, 1988). Certain dinoflagellate zones have been so defined as well (Morgan, 1980), but others on less reliable palynological criteria (Helby et al., 1987), which raises questions as to the validity of a few zones. This aspect must be verified by further study of the Carpentaria Basin.

Time relationships of spore-pollen to dinoflagellate zones within the Aptian and Albian are taken from Morgan (1980) and Burger (1980), and those within the older succession from Helby et al. (1987). There is overall agreement on geological ages of various zones except for those below the Valanginian, and on this aspect there are two schools of thought.

First: In the absence of faunal evidence the *C. australiensis* Zone can be dated only indirectly, namely a) by the stratigraphic distribution of marine dinoflagellate species within the zone in the Carpentaria Basin and Western Australia (Burger, 1982; Helby et al., 1987), and b) by suggested links of Surat and Eromanga Basin formations within the zone with Neocomian global sea level movements (Exon & Burger, 1981; Burger, 1986, 1989). This evidence suggests that the lower limit of the upper *C. australiensis* Zone lies close to the Jurassic-Cretaceous boundary, and that the zone commences in the Kimmeridgian (Late Jurassic).

Second: The dinoflagellate sequence within the interval of the *C. australiensis* Zone has been dated by synchronizing dinoflagellate events in the Tethyan Atlantic and Australian regions.

TABLE 1. LITHO-BIOSTRATIGRAPHIC CORRELATIONS IN THE SURAT BASIN

Sedimentary formations		Geological distribution of fossil groups	Spore-pollen zones		Dinoflagellate zones	Age
GRIMAN CREEK FORMATION		1, 2, 5	*Coptospora paradoxa* (Unit PK5)		*P. ludbrookiae*	ALBIAN
		3, 4			*C. denticulata*	
SURAT SILTSTONE					*M. tetracantha*	
WMBILLA	Coreena Member	5	*Crybelospor. striatus* (Unit PK4)			
					Diconodinium davidii	
	Doncaster Member		*Cyclosporites hughesii* (Unit PK3)		*Odontochitina operculata*	APTIAN
	Minmi Member					
BUNGIL	Nullawurt Sandstone Member				*A. cinctum*	BARREM.
					M. australis	
					M. testudinaria	HAUTERIV
		3, 5	*Foraminisporis wonthaggiensis* (Unit PK2)		*P. burgeri*	
	Kingull Member	2			*S. tabulata*	VALANG.
					S. areolata	
MOOGA SANDSTONE			*Cicatricosisp. australiensis* (Unit PK1)	upper	*E. torynum*	
					B. reticulatum	BERRIAS.
ORALLO FORMATION					*D. lobispinosum*	TITHON.
					C. delicata	
GUBBERAMUNDA SANDSTONE				lower	*K. wisemaniae*	
		1			*P. iehiense*	KIMM.

1 spores and pollen
2 spinose acritarchs
3 marine dinoflagellates
4 planktonic foraminifera
5 shelly faunas

zonal boundaries

——— defined by the oldest appearance of selected palynomorph species

_ _ _ _ _ defined by other palynological criteria

This evidence is inconclusive but suggests that the *Pseudoceratium iehiense* Zone lies close to the Jurassic-Cretaceous boundary (Davey, 1987; Helby et al., 1987).

The correlation diagram gives the first view, because a) the *Batioladinium reticulatum* Zone in Western Australia includes basal Berriasian ammonites (Helby et al., 1987), and b) evidence from Jurassic spores, pollen, and dinoflagellates (Burger, 1991) appears to be more in keeping with a Kimmeridgian age for the basal *C. australiensis* Zone.

The present absolute time-frame for the Early Cretaceous standard stages is still wrought with uncertainties. The Early-Late Cretaceous boundary is generally accepted as being close to 95 Ma, but present radiometric data indicate no more precise age for the J-K boundary than 130-144 Ma (Burger, 1991).

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., 1980 - Palynological studies in the Lower Cretaceous of the Surat Basin, Australia. *Bureau of Mineral Resources, Australia, Bulletin*, 189, 106 pp.

Burger, D., 1982 - A basal Cretaceous dinoflagellate suite from northeastern Australia. *Palynology*, 6, 161-192.

Burger, D., 1986 - Palynology, cyclic sedimentation, and palaeoenvironments in the Late Mesozoic of the Eromanga Basin. *Geological Society of Australia, Special Publication*, 12, 53-70.

Burger, D., 1989 - Stratigraphy, palynology, and palaeo-environments of the Hooray Sandstone, eastern Eromanga Basin, Queensland and New South Wales. *Queensland Department of Mines, Report*, 3, 28 pp.

Burger, D., 1991 - Australian Phanerozoic timescales: 8. Jurassic biostratigraphic charts and explanatory notes. *Bureau of Mineral Resources, Australia, Record*, 1989/38, 32 pp.

Davey, R.J., 1987 - Palynological zonation of the Lower Cretaceous and Upper and uppermost Middle Jurassic in the northwestern Papuan Basin of Papua New Guinea. *Geological Survey of Papua New Guinea, Memoir*, 13, 77 pp.

Day, R.W., 1969 - The Lower Cretaceous in the Great Artesian Basin. *In* Campbell, K.S.W., (editor), Stratigraphy and Palaeontology: Essays in honour of Dorothy Hill. *Australian National University Press, Canberra*, 140-173.

Day, R.W., 1974 - Aptian ammonites from the Eromanga and Surat Basins, Queensland. *Geological Survey of Queensland, Publication*, 34, 19 pp.

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*, 171-210.

Exon, N.F., 1976 - Geology of the Surat Basin in Queensland. *Bureau of Mineral Resources, Australia, Bulletin*, 166, 160 pp.

Exon, N.F., & Burger, D., 1981 - Sedimentary cycles in the Surat Basin and global changes of sea level. *BMR Journal of Australian Geology and Geophysics*, 6, 153-159.

Filatoff, J., & Price, P.L., 1988 - A pteridacean spore lineage in the Australian Mesozoic. *Association of Australasian Palaeontologists, Memoir*, 5, 89-124.

Haig, D.W., 1979 - Cretaceous foraminiferal biostratigraphy of Queensland. *Alcheringa*, 3, 171-187.

Helby, R., Morgan, R., & Partridge, A.D., 1987 - A palynological zonation of the Australian Mesozoic. *Association of Australasian Palaeontologists, Memoir*, 4, 1-94.

Morgan, R., 1980 - Palynostratigraphy of the Australian Early and Middle Cretaceous. *Geological Survey of New South Wales, Bulletin*, 27, 105 pp.