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UPDATED JURASSIC – EARLY CRETACEOUS DINOCYST ZONATION NWS AUSTRALIA

Robin Helby, Roger Morgan, and Alan D. Partridge

VCEMP
Virtual Centre of Economic Micropalaeontology & Palynology

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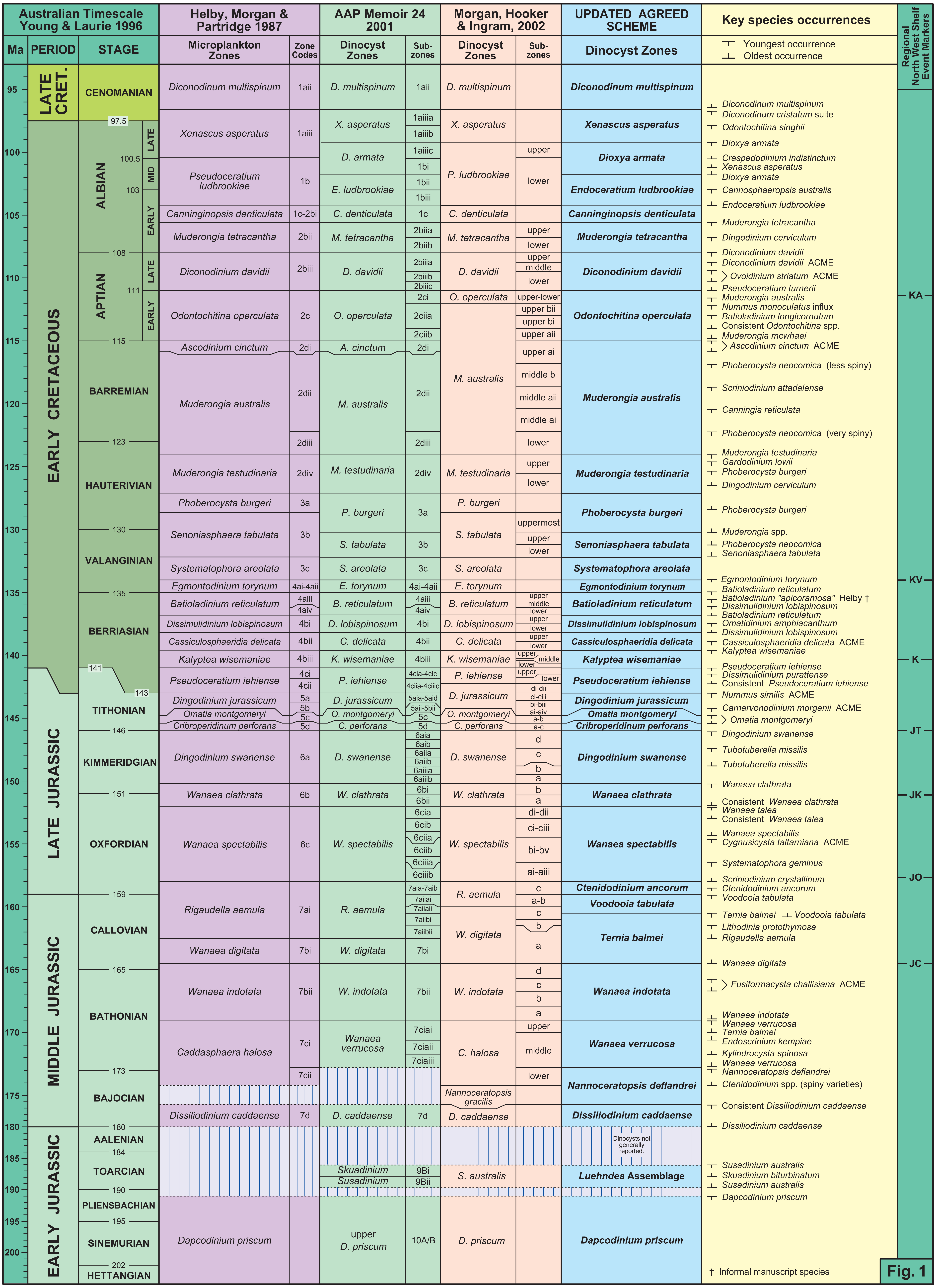

Ma	PERIOD	STAGE	Helby, Morgan & Partridge 1987 Microplankton Zones	Zone Codes	AAP Memoir 24 2001 Dinocyst Zones	Sub-zones	Morgan, Hooker & Ingram, 2002 Dinocyst Zones	Sub-zones	UPDATED AGREED SCHEME Dinocyst Zones
95	LATE CRET.	CENOMANIAN	*Diconodinum multispinum*	1aii	*D. multispinum*	1aii	*D. multispinum*		***Diconodinum multispinum***
	EARLY CRETACEOUS	97.5 ALBIAN LATE	*Xenascus asperatus*	1aiii	*X. asperatus*	1aiiia 1aiiib	*X. asperatus*		***Xenascus asperatus***
100		100.5 MID	*Pseudoceratium ludbrookiae*	1b	*D. armata*	1aiiic 1bi	*P. ludbrookiae*	upper lower	***Dioxya armata***
		103 EARLY			*E. ludbrookiae*	1bii 1biii			***Endoceratium ludbrookiae***
105			*Canninginopsis denticulata*	1c-2bi	*C. denticulata*	1c	*C. denticulata*		***Canninginopsis denticulata***
			Muderongia tetracantha	2bii	*M. tetracantha*	2biia 2biib	*M. tetracantha*	upper lower	***Muderongia tetracantha***
110		108 APTIAN LATE	*Diconodinium davidii*	2biii	*D. davidii*	2biiia 2biiib 2biiic	*D. davidii*	upper middle lower	***Diconodinium davidii***
		111 EARLY	*Odontochitina operculata*	2c	*O. operculata*	2ci 2ciia 2ciib	*O. operculata* *M. australis*	upper-lower upper bii upper bi upper aii	***Odontochitina operculata***
115 120		115 BARREMIAN	*Ascodinium cinctum* *Muderongia australis*	2di 2dii 2diii	*A. cinctum* *M. australis*	2di 2dii 2diii		upper ai middle b middle aii middle ai lower	***Muderongia australis***
125		123 HAUTERIVIAN	*Muderongia testudinaria*	2div	*M. testudinaria*	2div	*M. testudinaria*	upper lower	***Muderongia testudinaria***
130		130	*Phoberocysta burgeri*	3a	*P. burgeri*	3a	*P. burgeri* *S. tabulata*	uppermost	***Phoberocysta burgeri***
		VALANGINIAN	*Senoniasphaera tabulata*	3b	*S. tabulata*	3b		upper lower	***Senoniasphaera tabulata***
			Systematophora areolata	3c	*S. areolata*	3c	*S. areolata*		***Systematophora areolata***
			Egmontodinium torynum	4ai-4aii	*E. torynum*	4ai-4aii	*E. torynum*		***Egmontodinium torynum***
135		135 BERRIASIAN	*Batioladinium reticulatum*	4aiii 4aiv	*B. reticulatum*	4aiii 4aiv	*B. reticulatum*	upper middle lower	***Batioladinium reticulatum***
			Dissimulidinium lobispinosum	4bi	*D. lobispinosum*	4bi	*D. lobispinosum*	upper lower	***Dissimulidinium lobispinosum***
			Cassiculosphaeridia delicata	4bii	*C. delicata*	4bii	*C. delicata*	upper lower	***Cassiculosphaeridia delicata***
140			*Kalyptea wisemaniae*	4biii	*K. wisemaniae*	4biii	*K. wisemaniae*	upper middle lower	***Kalyptea wisemaniae***
	LATE JURASSIC	141 143	*Pseudoceratium iehiense*	4ci 4cii	*P. iehiense*	4cia-4cic 4ciia-4ciiic	*P. iehiense* *D. jurassicum*	upper lower di-dii	***Pseudoceratium iehiense***
		TITHONIAN	*Dingodinium jurassicum*	5a 5b	*D. jurassicum*	5aia-5aid 5aii-5bii		ci-ciii bi-biii	***Dingodinium jurassicum***
145			*Omatia montgomeryi*	5c	*O. montgomeryi*	5c	*O. montgomeryi*	ai-aiv a-b	***Omatia montgomeryi***
			Cribroperidinum perforans	5d	*C. perforans*	5d	*C. perforans*	a-c	***Cribroperidinum perforans***
150		146 KIMMERIDGIAN	*Dingodinium swanense*	6a	*D. swanense*	6aia 6aib 6aiia 6aiib 6aiiia 6aiiib	*D. swanense*	d c b a	***Dingodinium swanense***
		151	*Wanaea clathrata*	6b	*W. clathrata*	6bi 6bii	*W. clathrata*	b a	***Wanaea clathrata***
155		OXFORDIAN	*Wanaea spectabilis*	6c	*W. spectabilis*	6cia 6cib 6ciia 6ciib 6ciiia 6ciiib	*W. spectabilis*	di-dii ci-ciii bi-bv ai-aiii	***Wanaea spectabilis***
			Rigaudella aemula	7ai	*R. aemula*	7aia-7aib	*R. aemula*	c	***Ctenidodinium ancorum***
160	MIDDLE JURASSIC	159 CALLOVIAN				7aiiai 7aiiaii		a-b	***Voodooia tabulata***
			Wanaea digitata	7bi	*W. digitata*	7aiibi 7aiibii 7bi	*W. digitata*	c b a	***Ternia balmei***
165		165 BATHONIAN	*Wanaea indotata*	7bii	*W. indotata*	7bii	*W. indotata*	d c b a	***Wanaea indotata***
170			*Caddasphaera halosa*	7ci	*Wanaea verrucosa*	7ciai 7ciaii 7ciaiii	*C. halosa*	upper middle	***Wanaea verrucosa***
175		173 BAJOCIAN		7cii			*Nannoceratopsis gracilis*	lower	***Nannoceratopsis deflandrei***
			Dissiliodinium caddaense	7d	*D. caddaense*	7d	*D. caddaense*		***Dissiliodinium caddaense***
180 185	EARLY JURASSIC	180 AALENIAN 184							Dinocysts not generally reported.
190		TOARCIAN			*Skuadinium* *Susadinium*	9Bi 9Bii	*S. australis*		***Luehndea* Assemblage**
195 200		190 PLIENSBACHIAN 195 SINEMURIAN 202 HETTANGIAN	*Dapcodinium priscum*		upper *D. priscum*	10A/B	*D. priscum*		***Dapcodinium priscum***

Key species occurrences

⊤ Youngest occurrence
⊥ Oldest occurrence

⊥ *Diconodinum multispinum*
⊤ *Diconodinum cristatum* suite
⊤ *Odontochitina singhii*
⊤ *Dioxya armata*
⊥ *Craspedodinium indistinctum*
⊥ *Xenascus asperatus*
⊥ *Dioxya armata*
⊤ *Cannosphaeropsis australis*
⊥ *Endoceratium ludbrookiae*
⊤ *Muderongia tetracantha*
⊤ *Dingodinium cerviculum*
⊤ *Diconodinium davidii*
⊤ *Diconodinium davidii* ACME
⊤ ⊥ 〉 *Ovoidinium striatum* ACME
⊥ *Pseudoceratium turnerii*
⊤ *Muderongia australis*
⊤ *Nummus monoculatus* influx
⊤ *Batioladinium longicornutum*
⊥ Consistent *Odontochitina* spp.
⊥ *Muderongia mcwhaei*
⊤ ⊥ 〉 *Ascodinium cinctum* ACME
⊤ *Phoberocysta neocomica* (less spiny)
⊤ *Scriniodinium attadalense*
⊤ *Canningia reticulata*
⊤ *Phoberocysta neocomica* (very spiny)
⊥ *Muderongia testudinaria*
⊤ *Gardodinium lowii*
⊤ *Phoberocysta burgeri*
⊥ *Dingodinium cerviculum*
⊥ *Phoberocysta burgeri*
⊥ *Muderongia* spp.
⊥ *Phoberocysta neocomica*
⊥ *Senoniasphaera tabulata*
⊤ *Egmontodinium torynum*
⊤ *Batioladinium reticulatum*
⊤ *Batioladinium "apicoramosa"* Helby †
⊤ *Dissimulidinium lobispinosum*
⊥ *Batioladinium reticulatum*
⊤ *Omatidinium amphiacanthum*
⊥ *Dissimulidinium lobispinosum*
⊤ *Cassiculosphaeridia delicata* ACME
⊤ *Kalyptea wisemaniae*
⊤ *Pseudoceratium iehiense*
⊤ *Dissimulidinium purattense*
⊥ Consistent *Pseudoceratium iehiense*
⊤ *Nummus similis* ACME
⊤ *Carnarvonodinium morganii* ACME
⊤ ⊥ 〉 *Omatia montgomeryi*
⊤ *Dingodinium swanense*
⊤ *Tubotuberella missilis*
⊥ *Tubotuberella missilis*
⊤ *Wanaea clathrata*
⊥ Consistent *Wanaea clathrata*
⊤ *Wanaea talea*
⊥ Consistent *Wanaea talea*
⊥ *Wanaea spectabilis*
⊤ *Cygnusicysta taltarniana* ACME
⊤ *Systematophora geminus*
⊥ *Scriniodinium crystallinum*
⊤ *Ctenidodinium ancorum*
⊤ *Voodooia tabulata*
⊤ *Ternia balmei* ⊥ *Voodooia tabulata*
⊤ *Lithodinia protothymosa*
⊥ *Rigaudella aemula*
⊥ *Wanaea digitata*
⊤ ⊥ 〉 *Fusiformacysta challisiana* ACME
⊥ *Wanaea indotata*
⊤ *Wanaea verrucosa*
⊥ *Ternia balmei*
⊥ *Endoscrinium kempiae*
⊥ *Kylindrocysta spinosa*
⊥ *Wanaea verrucosa*
⊤ *Nannoceratopsis deflandrei*
⊥ *Ctenidodinium* spp. (spiny varieties)
⊤ Consistent *Dissiliodinium caddaense*
⊥ *Dissiliodinium caddaense*
⊤ *Susadinium australis*
⊥ *Skuadinium biturbinatum*
⊥ *Susadinium australis*
⊤ *Dapcodinium priscum*

† Informal manuscript species

Regional North West Shelf Event Markers

- KA
- KV
- K
- JT
- JK
- JO
- JC

Fig. 1

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This update of the dinocyst zonation used throughout the greater North West Shelf (NWS) of Australia is an initiative of the ***Virtual Centre of Economic Micropalaeontology and Palynology*** (VCEMP) in collaboration with biostratigraphers from Santos Ltd and Woodside Energy Ltd, and the principal consultants. In the last decade and half there has been wide acceptance within the petroleum exploration industry of the microplankton (herein dinocyst) zonation described in 1987 by Helby, Morgan & Partridge as the standard zonation scheme for the NWS. At the time of publication, the writers considered that their scheme was preliminary rather than comprehensive and indicated that further zone development was inevitable (Helby *et al*., 1987, p.1). The approach to zonation used in Helby *et al*. (1987), focussed on the first and last stratigraphic occurrences of individual species, or associations of species, with the emphasis on those zone criteria that had the most continent-wide application. In contrast, relatively little use was made of the quantitative variations in the abundance of species, which were considered likely to have more restricted or local applications.

With a maturing of the petroleum exploration and producing industry there has been an ongoing requirement for ever increased precision in correlation and age dating, down to and including intra-reservoir subdivisions. Palynologists have addressed these needs through a combination of finer subdivision of the existing microplankton zones, and increasingly by the use of event based biostratigraphic concepts, incorporating the changes in abundance and acmes of individual or multiple species. However, because the most detailed palynological studies have focussed on the reservoir intervals, which can occur in different parts of the stratigraphic column in individual petroleum provinces, these finer zone subdivision and biostratigraphic events have not necessarily been found nor adequately tested and verified in all basins.

As the original microplankton zones has evolved since 1987 the different work focus and therefore experience of the different palynological groups has also seen a divergence in the application of some of the original zone criteria. Similarly there has also developed uncertainties about the precise correlation between the various subzone and event based schemes for subdividing the original zones, which have been exacerbated by the confidentiality constraints inherent in the petroleum industry.

To bring the original zonation back into alignment and to improve correlation between the various subzones and event-based schemes a meeting between industry palynologists and biostratigraphy managers was convened by the VCEMP in December 2002 to formulate a joint approach. The main participants involved were Robin Helby and Roger Morgan advocates of subzone schemes they developed respectively in the Timor Sea and Carnarvon Basin areas. Also attending, as representatives of the principal company biostratigraphy groups, were Geoff Wood and Jeff Goodall from Santos, and Neil Marshall from Woodside Energy. Representing the VCEMP and Geoscience Australia were Clinton Foster and Eric Monteil. The focus of the meeting was the dinocyst zonation over the time interval Jurassic to Early Cretaceous as applied to the NWS. Not discussed at the meeting were the older latest Triassic zones, which have recently been reviewed by Backhouse *et al*. (2002), and the younger Late Cretaceous palynological zones, which have changed little on the NWS because of the preferential use of calcareous microfossils in that part of the section.

This publication provides an initial summary of the consensus reached at the joint meeting. The main chart (Fig.1) provides a comparison between **(1)** the original scheme of Helby *et al*. (1987), **(2)** the subzone alphanumeric codes developed mainly in the Timor Sea area by Robin Helby and published in outline in the *Association of Australasian Palaeontologist Memoir 24* (fig.2 *in* Foster, 2001), **(3)** the subzone and events based scheme developed mainly in the Carnarvon Basin by Morgan Palaeo Associates (Morgan, Hooker & Ingram, 2002), and **(4)** the final Updated Agreed Scheme that was the product of the December 2002 meeting. The four schemes are plotted against the Australia Phanerozoic Timescale developed by Geoscience Australia (Young & Laurie, 1996), with the age assignments of the zones following the latest review of the international correlation of the dinocyst zonation based on other criteria (Backhouse, 2003). A consequence of these revisions and drafting protocols is the assignment of different million year ages to the zone boundaries on these new charts, compared to those currently used in the STRATDAT database held by Geoscience Australia. This will precipitate future revision of the age dictionaries in the latter database. Finally, the two far right columns provide a selection of key taxa and the stratigraphic positions of the regional NWS Event Markers. The other charts (Figs 2 to 4) provide expanded versions of intervals that could not be adequately illustrated on the main chart. On Fig. 2 the various subdivisions of the *Cribroperidinium perforans* to *Pseudoceratium iehiense* Zones are shown in more detail, and comparison is also made with the high resolution palynostratigraphy proposed for the Wanaea and Cossack fields in the Dampier Sub-Basin by Bint & Marshall (1994). On Fig. 3 more detail is provided for the subdivision over the interval of the original *Wanaea digitata* to *Wanaea spectabilis* Zones, where unresolved conflicts in the application of the original zone definitions has necessitated the creation of three new zone names. Finally, Fig. 4 provides a comparison between the spore-pollen and dinocyst zones in the Early and early Middle Jurassic. Over this interval the dinocyst zones can become sporadic and inconsistent, and therefore practical palynological subdivision has relied on a more pragmatic application of both palynomorph groups.

Brief discussions follow of those parts of the zonation where there has been major divergence in zone terminology and agreed resolutions on those issues.

Dapcodinium priscum to *Caddasphaera halosa* Zones (Figs 1 & 4).

Riding & Helby (2001a) have documented that the application of the original *Dapcodinium priscum* Zone had been carried too high in the Early Jurassic as it included elements of the new *Luehndea* Assemblage. In their paper Riding & Helby (2001a) recognised separate *Susadinium?* and *Skuadinium* dinocyst Suites within the *Luehndea* Assemblage, but these have been suppressed in the consensus zonation because of uncertainties about their intrabasinal consistency. In the same paper the *Kekryphalospora distincta* spore-pollen Zone was discussed (Riding & Helby, 2001a, fig.12), but has also not been incorporated in the new scheme for similar reasons.

After a gap in the dinocyst succession characterised by stratigraphic section lacking diagnostic dinocyst assemblages, the succeeding *Dissiliodinium caddaense* Zone is redefined as the total range of the eponymous species. The original tripartite subdivision of the zone in Helby *et al*. (1987) based on a middle Acme of the zone species has not been demonstrated outside the Perth Basin. The overlying *Caddasphaera halosa* Zone has also proved to be poorly understood and defined in the original publication and is replaced by the new *Nannoceratopsis deflandrei* and *Wanaea verrucosa* Zones defined on much more morphologically distinctive species than the original.

Wanaea digitata to *Wanaea spectabilis* Zones (Figs 1 & 3).

Widespread inconsistency in the application of the original *Wanaea digitata* and *Rigaudella aemula* Zones has developed over the past decade due to uncertainty in the consistent identification of the oldest occurrence of *Rigaudella aemula* between basins as a consequence of facies differences. Because this problem is likely to be ongoing, and added confusion likely to be caused by the need to distinguish between any revised concepts of these zones and the zone identifications already embedded in the existing reports it was agreed that these two zones would be replaced by three new zones based on new criteria.

The new zones in ascending order are **(1)** the *Ternia balmei* Zone, for the interval from the oldest occurrence of *Wanaea digitata* to the youngest occurrence of *Ternia balmei,* **(2)** the *Voodooia tabulata* Zone, for the interval from youngest *T. balmei* to the youngest occurrence of *V. tabulata*, and **(3)** the *Ctenidodinium ancorum* Zone, for the interval from youngest *V. tabulata* to the oldest occurrence of *Scriniodinium crystallinum.* In the succeeding *Wanaea spectabilis* Zone it should be noted that contrary to the distribution shown in Helby *et al*. (1987; fig.15) the eponymous species *Wanaea spectabilis* is no longer considered to range throughout the zone (see Riding & Helby, 2001b).

Cribroperidinium perforans to *Pseudoceratium iehiense* Zones (Figs 1 & 2).

This zone interval correlated with the Tithonian to basal Berriasian Stages is shown on a much expanded scale in Figure 2. The diverse dinocyst assemblages and fine subdivision possible over this interval gives an approximate average subzone duration of less than 250,000 years. A significant misalignment of the *D. jurassicum/P. iehiense* Zone boundary has been caused by the extreme scarcity and often absence of *Pseudoceratium iehiense* towards the base of its range. A younger pick for the zone boundary has therefore been widely used in unpublished reports by Morgan Palaeo Associates, and in the high resolution palynostratigraphy study of the Wanaea and Cossack fields by Bint & Marshall (1994). The updated agreed scheme reflects a change to a new datum near the original zone definition.

Batioladinium reticulatum to *Egmontodinium torynum* Zones (Fig.1).

Difficulties have been encountered by all palynologists in applying the original definition of the *E. torynum* Zone due to **(1)** younger range extension recorded for *Batioladinium reticulatum* which defines the base of the zone, **(2)** reworking of the eponymous species *Egmontodinium torynum* above the top of the zone, and **(3)** inconsistent development of the acme of *E. torynum* which was originally considered to define an upper subzone. Pending future agreement on alternative marker taxa for the identification of the top of *B. reticulatum* Zone the current zone definitions are retained, with the understanding that the *E. torynum* Zone may have a relatively short duration.

Muderongia australis to *Odontochitina operculata* Zones (Fig.1).

Subdivision of this interval continues to be problematic. All palynologists agree that the oldest consistent occurrence of *Odontochitina operculata* is unworkable as a reliable definition for the base of the *O. operculata* Zone, and so this has been replaced by the oldest occurrence of *Muderongia mcwhaei* even though this is a relatively rare species. The underlying *Ascodinium cinctum* Acme Zone has also been difficult to reliably identify, and appears to have only local significance within the Carnarvon Basin (Loutit *et al*., 1997), and therefore has been subsumed as a local upper subzone of the *Muderongia australis* Zone.

Endoceratium ludbrookiae to *Xenascus asperatus* Zones (Fig.1).

The boundary between the *Xenascus asperatus* and *Endoceratium* (al. *Pseudoceratium*) *ludbrookiae* Zones as originally defined by Helby *et al*. (1987; p.62) has often been difficult to determine because of the inconsistent occurrence of *X. asperatus* (the name is actually a play on words expressing the problem). To alleviate this situation and provide more precision the new *Dioxya armata* Zone is introduced as an intermediate zone, and the upper boundary of the *E. ludbrookiae* Zone and the lower boundary of the *X. asperatus* Zone are redefined.

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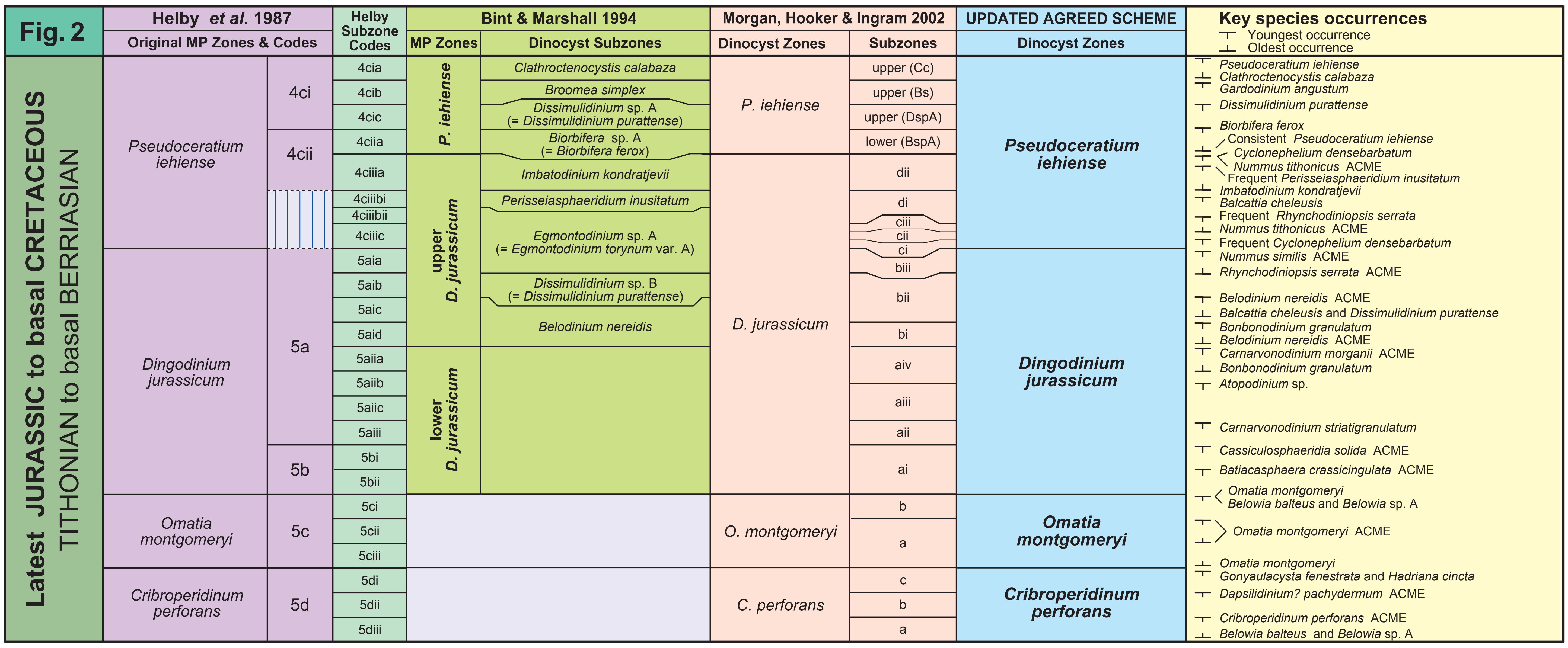

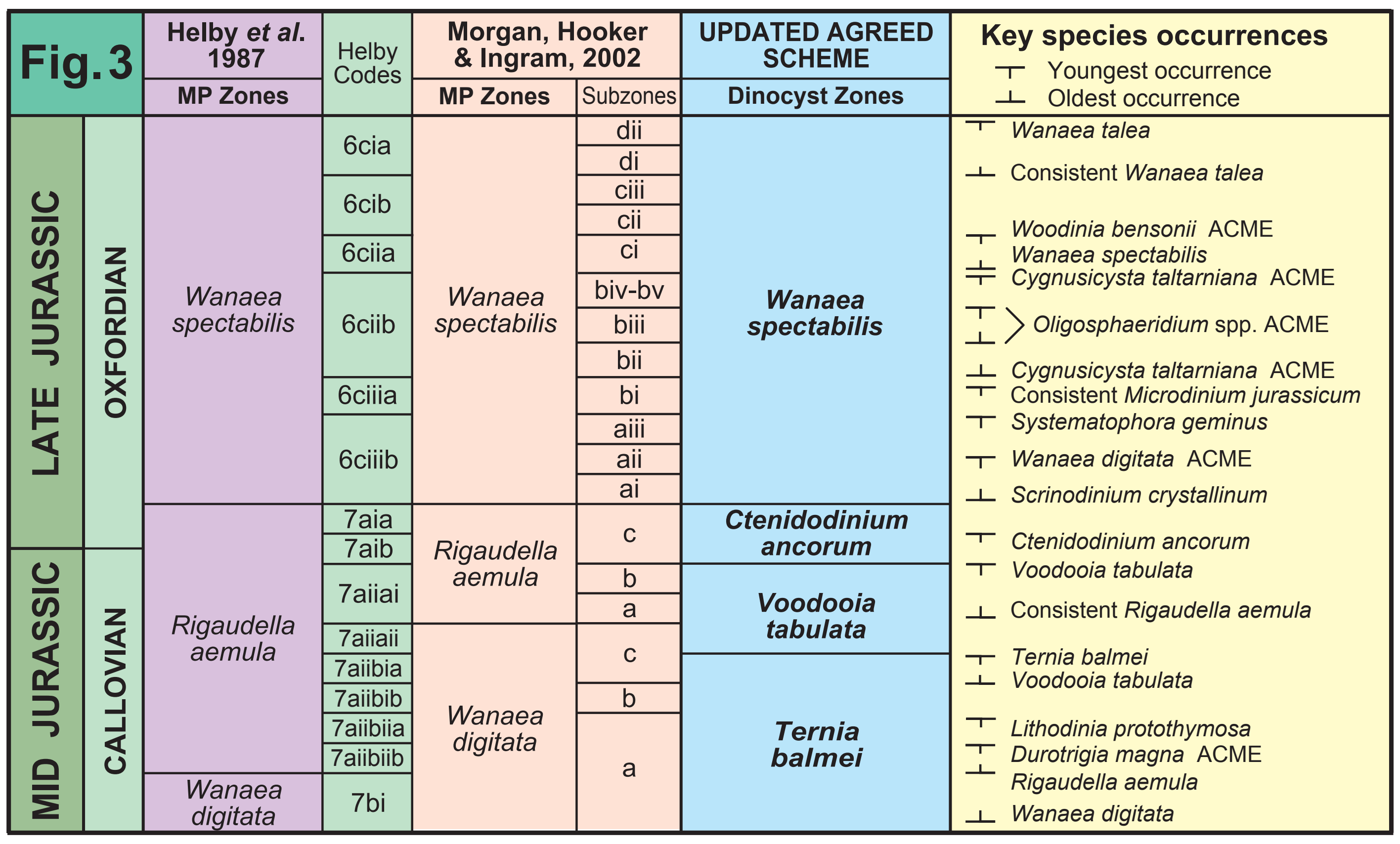

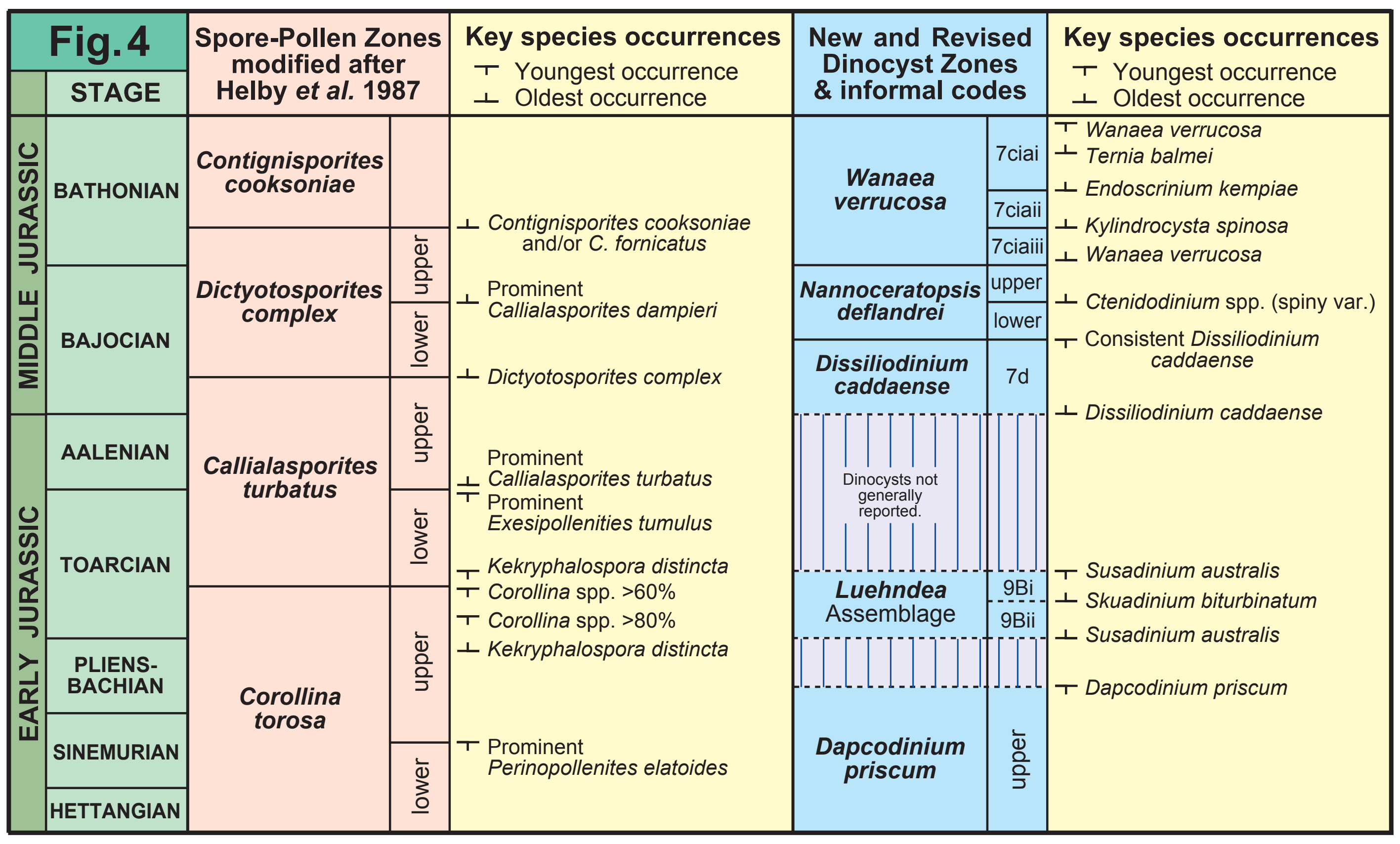

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