# Problems with the Cretaceous biostratigraphic system of Australia: time for a review

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**Most users of biostratigraphic results, including those based on Cretaceous sequences, assume that the biozonation applied is without serious problems, represents a time continuum, and has been firmly linked (at least partly) to standard timescales and other biozonations. However, problems in the biostratigraphic system of the Australian Cretaceous abound. They are particularly evident where, for instance:**

- **acme zones are used (e.g., the Early Cretaceous dinoflagellate *Ascodinium cinctum* Zone),**
- **a zonal boundary is defined by multiple bioevents (some of the foraminiferal C zones; see below), or**
- **bioevents are based on species from different biogeographic provinces (e.g., the nannofossils *Monomarginatus quaternarius* and *Quadrum trifidum* in the Campanian of the Perth and Carnarvon Basins respectively).**

These problems usually cause doubtful biostratigraphic assignment or imprecise correlation. Imposed on these problems is the widespread practice in oil exploration of applying informal zones whose definitions have not been published (e.g., the nannofossil KCN zones), and which therefore are not available for correlation with published zones inside and outside Australia.

Because of the demand from several disciplines (e.g., seismic stratigraphy, geological modelling, etc.), numerical ages have been assigned to Cretaceous zonal boundaries in Australia, even though links with the standard numerical timescale are commonly tenuous at best. This practice of assigning numerical ages to biostratigraphic events, although necessary, is potentially dangerous if it is allowed to mask any of the biostratigraphic problems or to render unnecessary the efforts of identifying biozonal anchor points to the standard numerical timescale. A summary of the biochronology of the Australian Cretaceous was published in the AGSO-inspired monograph 'An Australian Phanerozoic timescale' (1996: Oxford University Press), which serves as a focus for more detailed work.

A review of the Australian Cretaceous biostratigraphic system and its links with published timescales is overdue, and is being undertaken as part of AGSO's 'Timescale calibration and development' project. All relevant fossil groups are targeted in the review, primarily:

- to identify any anchor points of their zones to the standard numerical timescale,
- to diagnose points of weakness in the Australian Cretaceous biostratigraphic system as a whole, and
- to implement ways of rectifying them.

## Discussion

The ages of many local Late Cretaceous dinocyst zones (see Helby et al. 1987: Association of Australian Palaeontologists, Memoir 4, 1–94), particularly in northwest Australia, have been derived from the largely unpublished, local calcareous planktic biostratigraphy. Original data linking the two biostratigraphies are mostly unpublished, and the nannofossil or foraminiferal schemes to which Helby et al. referred were in the process of being developed. For example, the late Campanian age for the *Isabelidinium korojonense* Zone (Helby et al. 1987: op. cit., fig. 32) is based on foraminiferal data in the

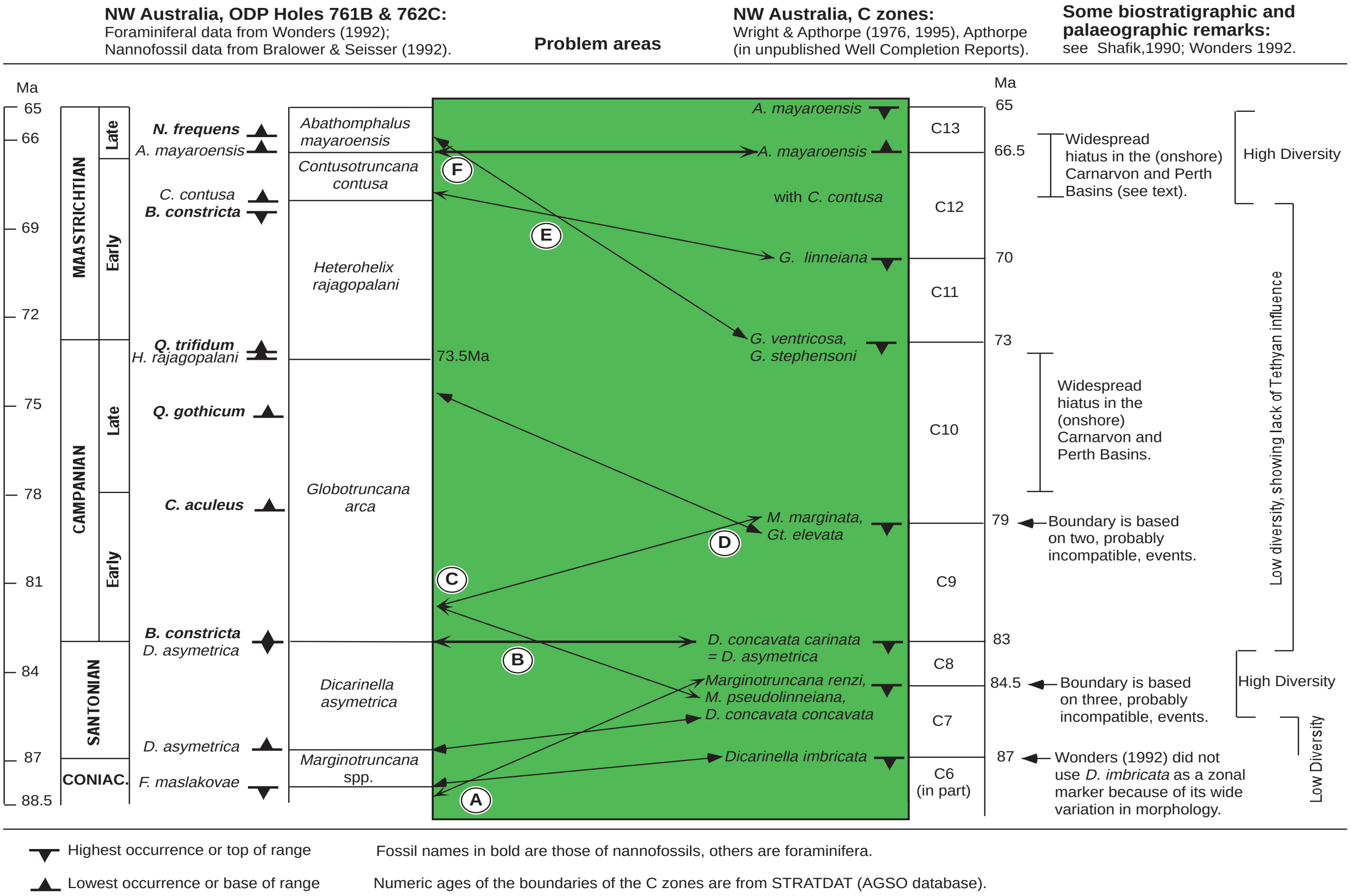

**Fig. 15. Apparent problems with the C zones in northwest Australia, as indicated by data from ODP sites 761 (Wombat Plateau) and 762 (Exmouth Plateau). The tops of the ranges of key C zone species in ODP drillholes 761B and 762C are based on data in Wonders (1992: *in* von Rad et al. op. cit., 587–599). The tops of species ranges are taken at the highest occurrences of the same species in Wonders's (1992: op. cit.) charts — regardless of their abundance below this level. Bibliographic details of other cited references are annotated in the text.**

unpublished well completion reports for Esso Zeewulf No. 1 and Houtman No. 1, and on foraminiferal and nannofossil data in an unpublished thesis. It is now time to review and update these data.

Similarly, a host of problems (graphically portrayed in Fig. 15) foreshadow the need to review the status of most of the local foraminiferal C zones of Wright (1973: BOC Australia Ltd, unpublished report), Wright & Apthorpe (1976: Journal of Foraminiferal Research, 6, 228–240), and Wright & Apthorpe (1995: Second International Symposium on Cretaceous Stage Boundaries, Brussels, 8–16 September, 1995, abstract volume, 28). These zones were developed for northwest Australia, and can be readily tested against the data acquired from the continuously cored sites on ODP Leg 122 off northwest Australia (von Rad et al. 1992: Proceedings of the Ocean Drilling Program, Scientific Results, 122; College Station, Texas).

## North West Shelf examples

The problems illustrated graphically in Figure 15 include:

**A.** In hole 762C, *Dicarinella imbricata*, the top of which defines the top of zone C6, ranges consistently above the top of *Marginotruncana renzi*, which defines the top of zone C7. Equally important, *M. renzi, M. pseudolinneiana,* and *Dicarinella concavata concavata*, whose tops define the top of zone C7, disappear upsection in 762C at different levels: the top of *M. renzi* is well below the top of *M. pseudolinneiana*, and the top of *D. concavata concavata* is in between.

**B.** In hole 762C, the top of *Marginotruncana pseudolinneiana* (= top of zone C7) is above the top of *Dicarinella asymetrica* (= top of zone C8). In hole 761B, both *D. asymetrica* and *M. pseudolinneiana* disappear upsection at the same level.

**C.** Interval C8–C9, from the top of *Marginotruncana pseudolinneiana* (top of zone C7) to the top of *M. marginata* (top of zone C9), is questionable: in hole 762C, the two species disappear upsection at the same level, the former having a consistent range and a better top.

**D.** Placing the top of zone C9, at the tops of *Marginotruncana marginata* and *Globotruncanita elevata*, introduces a possible inconsistency: in hole 762C, *M. marginata* disappears well below the top of *Gt. elevata*.

**E.** In both 761B and 762C, *Globotruncana ventricosa* (the top of its range = top of zone C10) ranges above the top of *G. linneiana* (= top of zone C11).

**F.** Interval C11–C12 is questionable: the two defining species *Gobotruncana ventricosa* (the top of its range = top of zone C10) and *Abathomphalus mayaroensis* (the base of its range = base of zone C13) overlap in holes 761B and 762C. The overlap in the ranges of *G. ventricosa* and *A. mayaroensis* is very short in 762C (because of a perceived unconformity in this hole at the base of the *A. mayroensis* Zone — discussed below), but longer in 761B, where there is no unconformity. *Globotruncana ventricosa* may not be considered reworked because it ranges to near the top of the Maastrichtian (see, e.g., Caron 1985: Cambridge Earth Science Series, Cambridge University Press, Cambridge).

The foregoing problems cannot be ignored because it is only through correlation networks that the temporal sequence of bioevents can be established — a preliminary basic step to biostratigraphy. Diachronism of bioevents is well documented, but probably cannot be used as an explanation here, because we are dealing with only a narrow range of latitude — northwest Australia during the Late Cretaceous.

Data based on core material, especially from continuously cored sites (as in ODP holes 761B and 762C), undoubtedly rank higher in the scale of confidence/reliability than those based on ditch cuttings, spot cores, or side-wall cores (as is usually the case in oil exploration) — the basis for the C zones.

In evaluating foraminiferal data from well-completion reports for input to its STRATDAT database, AGSO has preferred to use the zonation of Caron (1985: op. cit.), rather than the C zones, which currently remain mostly unpublished. Even so, the zonation of Wonders (1992: *in* von Rad et al. op. cit., 587–599), although not without problems, is better suited for northwest Australia. Nevertheless, for a precise correlation with sections outside northwest Australia, a thorough knowledge of the local stratigraphic ranges is vital. For example, does the reduced range of *Contusotruncana contusa* in northwest Australia reflect a late arrival of the species (Wonders 1992: op. cit.) or unconformity (Apthorpe 1979: APEA Journal, 19, 74–89)?

A review of the Australian Cretaceous biostratigraphic system will necessitate a rigorous interpretation of biostratigraphic data and an understanding of the local stratigraphy. For example, in a reinterpretation of published biostratigraphic data (Fig. 16), the distribution of both foraminifera and nannofossils in the Campanian–Maastrichtian section of hole 762C on the Exmouth Plateau differs from that in hole 761B on the Wombat Plateau — with two important consequences:

- On the Exmouth Plateau, the key foraminifer *Abathomphalus intermedius* is absent; there is no overlap between the nannofossil *Reinhardtites levis* and the foraminifer *Abathomphalus mayaroensis*; and the tops of *R. levis* and *Broinsonia constricta* coincide — in sharp contrast with the record from the Wombat Plateau. I interpret these observations as indicating an intra-Maastrichtian hiatus on the Exmouth Plateau, in hole 762C. This hiatus was not recognised by von Rad et al. (1992: op. cit.), even though they did not record the mid-Maastrichtian *Contusotruncana contusa* Zone at site 762.
- The thickness of the preserved zones in hole 762C is two to five times that of the corresponding zones in hole 761B, indicating much slower sedimentation rates in hole 761B, where — ironically — the mid-Maastrichtian *Contusotruncana contusa* Zone *is* present. Thus, the Maastrichtian section in hole 761B is *condensed* but *more complete*, whereas in hole 762B the section is *expanded* by comparison and includes a *hiatus*.

Evidence elsewhere suggests that the intra-Maastrichtian hiatus is widespread in northwest Australia. I have described a coeval unconformity in both the onshore Carnarvon and Perth Basins (Shafik 1990: BMR/AGSO Report 295), and Apthorpe (1979: op. cit.) has recorded a similar unconformity in offshore northwest Australia.

Identification of hiatuses and accurate determination of sedimentation rates in a sedimentary sequence are among the most significant elements in its geological interpretation. These cannot be achieved without good biostratigraphic schemes firmly anchored to a calibrated numerical timescale.

## A southeast Australian example

In the Otway Basin of southeast Australia, most of the formational boundaries in the Cretaceous Sherbrook Group coincide with (sub)zonal boundaries (spore and pollen, and dinocysts; Fig. 17). This scheme may be faultless, but it does raise a few questions:

- Such a coincidence of formational and (sub)zonal boundaries usually suggests that the (sub)zones are controlled by facies. Are they here? The answer is probably no, because the geographic distribution of the zones seems very wide in the marginal basins of both southeast and northeast Australia.
- Also, does the coincidence of formational and (sub)zonal boundaries suggest intraformational unconformities? A ‘yes’ answer cannot be ruled out in some instances, but would be difficult to prove, unless sections containing other groups of microfossils (e.g., the combination of palynomorphs, foraminifera, and nannofossils) are found. The assumption that a zonation represents a time continuum may then be challenged.

## Conclusion

The Australian Cretaceous biostratigraphic system is riddled with problems, which demonstrate the need for it to be reviewed and its basis updated. Identifying its anchor points to standard timescales is also a priority in recognition of the great importance of characterising sedimentary sections — e.g., defining hiatuses and estimating sedimentation rates — as precisely as possible.

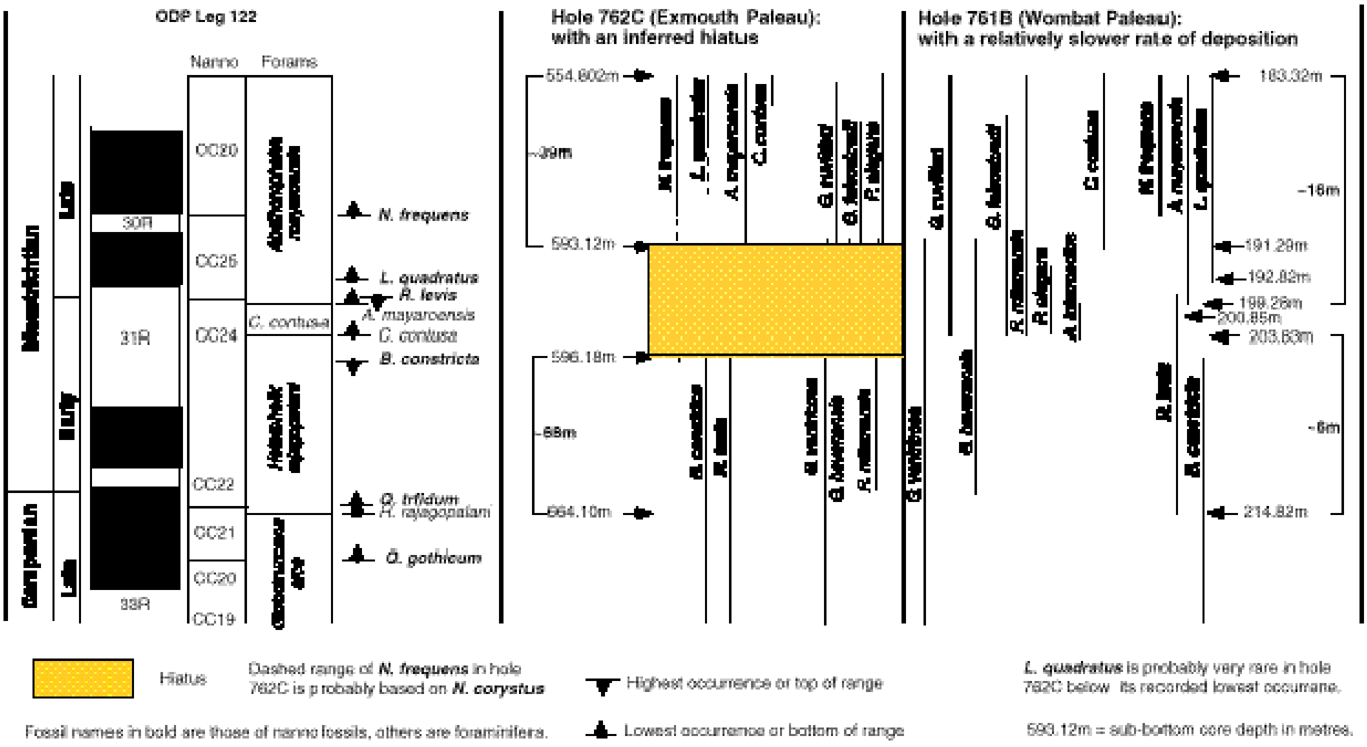

**Fig. 16. Reinterpreted nannofossil and planktic foraminiferal biostratigraphy of the Campanian–Maastrichtian of ODP holes 762C and 761B (biostratigraphic data from Wonders 1992: op. cit; and Bralower & Seisser 1992: *in* von Rad et al. op. cit., 529–556; palaeomagnetic data from Galbrun (1992: *in* von Rad et al. op. cit., 699–716).**

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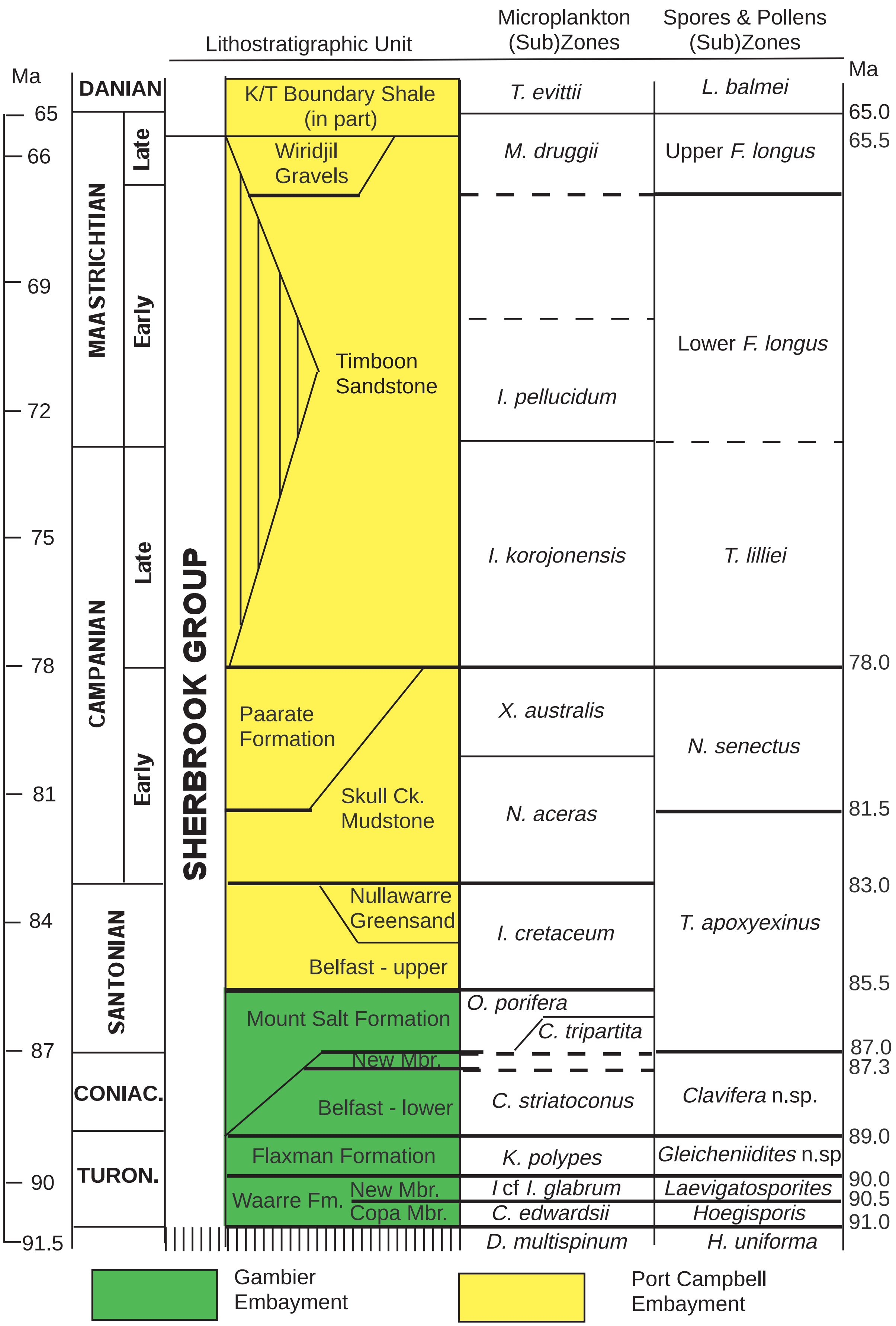

Numeric ages of (sub)zonal boundaries are from STRATDAT (AGSO database ).

**Fig. 17. Biostratigraphy of the Sherbrook Group in the Otway Basin (after Partridge 1997: PESA News, April/May, p. 9). Lines representing coinciding zonal and formational boundaries are thickened.**