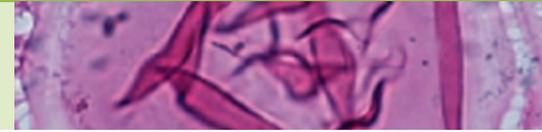


Customising the geological timescale

Applying the international geological timescale to Australia

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A standardised and precise timescale is invaluable to geological research and crucial to meaningful correlation at local, regional and global scales for both researchers and industry. Modelling of petroleum system plays and ore-body generation, for example, both depend on accurate timescales to be usefully interpreted.

The geological timescale is one of the major achievements of geoscience. It has been developed by geologists over the past two centuries to describe and understand the history of the earth.

Chronostratigraphic (relative-time) units, such as rock formations, biozones (or all the rocks characterised by a particular fossil), and magnetostratigraphy, are calibrated against a chronometric scale (an absolute age in years) to build the timescale. Absolute ages (years before present) are usually measured using radiometric dating techniques and in the Cenozoic and Mesozoic can be calibrated against high resolution orbital forcing events (that is, astronomical cycles). Modern techniques and instruments are delivering increasingly accurate ages (with precision down to ± 0.1 per cent), whilst biozonation schemes are continually refined and standardised on a global basis. As such, constant updating of the geological timescale is required and it will always remain a flexible, on-going project (see figure 1).

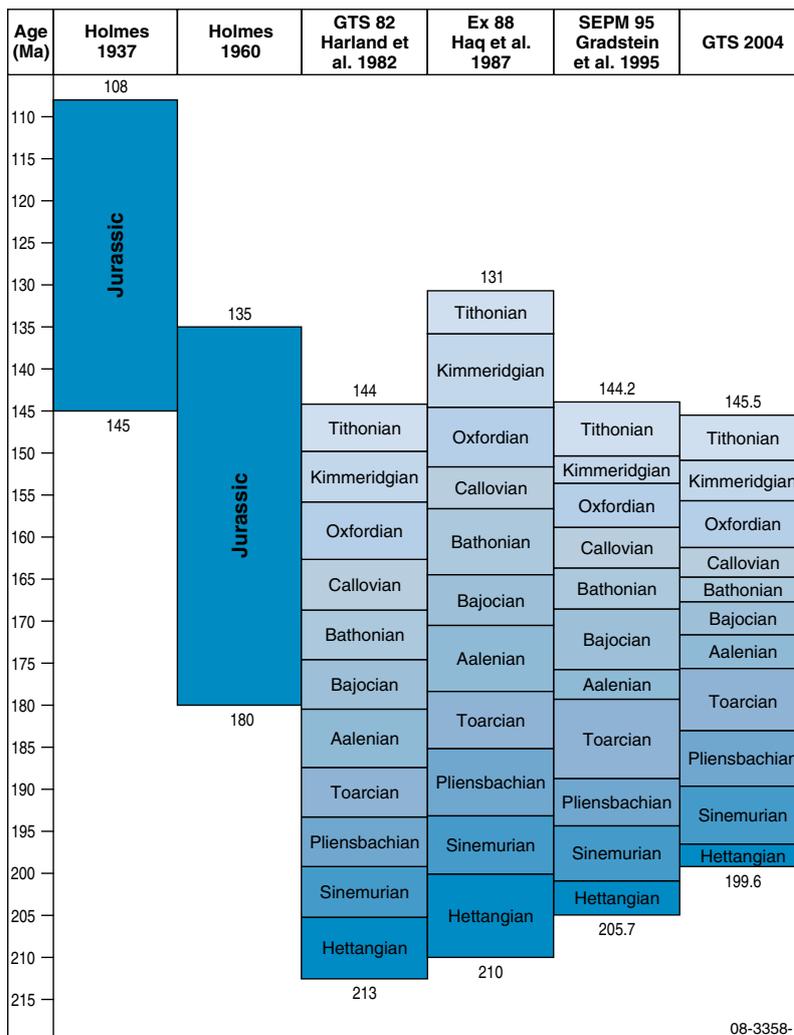


Figure 1. Illustration of the dramatic changes that have taken place with successive revisions of the geological timescale (based on Fig 1.6b in Gradstein et al 2005).

Towards an Australian timescale

Prior to the 1990s there were numerous attempts to develop a standard global timescale, but none were completely satisfactory for application within Australia. As a consequence, during the 1990s the Australian Geological Survey Organisation

(Geoscience Australia’s predecessor) developed its own ‘AGSO 1996’ standard timescale (Young & Laurie 1996) which contained all current Australian biozonal schemes. This has now been superseded by the most recent international standardised timescale – the Geological Time Scale 2004 (GTS 2004, Gradstein et al 2005). This Precambrian to Quaternary numerical and stadial scale (summarised in figure 2) has been collated during 25 years of work by the International Commission on Stratigraphy and its 14 Subcommissions. This timescale is due to be superseded by a further revision in 2010 (GTS 2010).

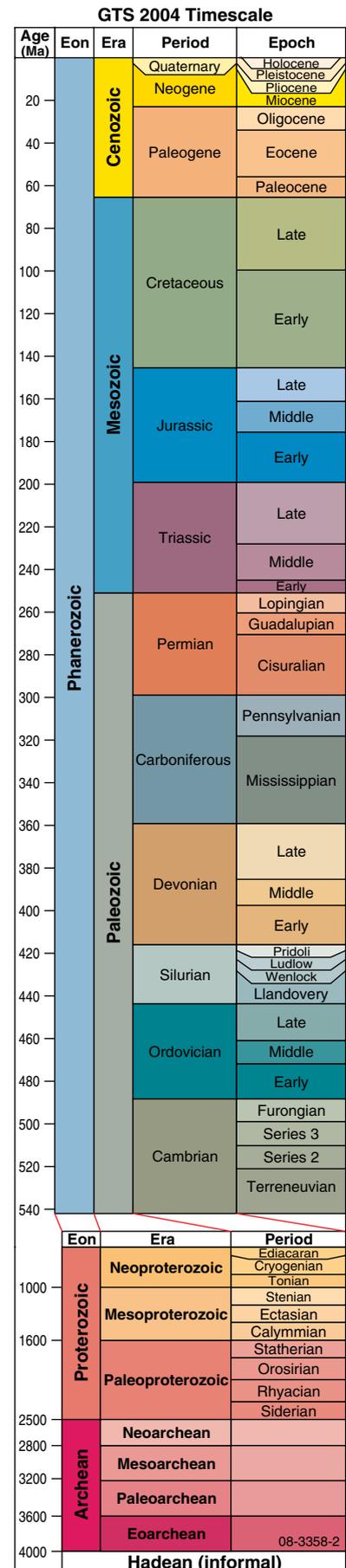
The 2004 version of the Geological Time Scale is mainly built around northern hemisphere datasets and, consequently, many of the biozones used in Australia were not included. These Australian biozones had been compiled and calibrated to the AGSO 1996 timescale, but the adoption of the GTS 2004 timescale meant each biozone needed to be recalibrated. Therefore, implementation of this timescale in Geoscience Australia has been a rather complex exercise. The main difficulty lay in the fact that there was no record of the reasoning or the data to explain how the biozones were tied to the stages, let alone the absolute ages. Furthermore, several of the local biozonal schemes have been revised during the intervening period and need to be updated in Geoscience Australia’s databases.

Calibrating biozones

A biozone (or biostratigraphic zone) is an interval of rock strata that is defined on the basis of its included characteristic fossil species. As species survive for a relatively short period before becoming extinct, if the same fossil is found in widely scattered rock units, it is most likely that those rock units were all laid down at about the same time. In the petroleum exploration industry, biozones provide the primary time framework used in basin modelling, exploration and production.

Most biozonation schemes are based on the first and last appearance datums (essentially speciation and extinction events) or occasionally acme (abundance) events of fossil species. The first appearance datums are generally the most consistent and useful markers of a single point in time, as last appearances and acme events are more likely to vary with environmental influences. A segment of the recently revised and widely utilised HMP biozonal scheme (Helby, Morgan & Partridge 2004) is shown in figure 3. The zonation, based on the stratigraphic ranges of dinocysts (microplankton), is illustrated alongside the main bioevents (or datums) that define each zone. The aim is to capture the relationship of these bioevents to the timescale as a percentage of the time from base to top of a stage. For example, the base of the *Voodooia tabulata* Dinocyst Zone is set as the first appearance of the eponymous species, which is estimated to

Figure 2. Geological Time Scale 2004 (Gradstein et al 2005)



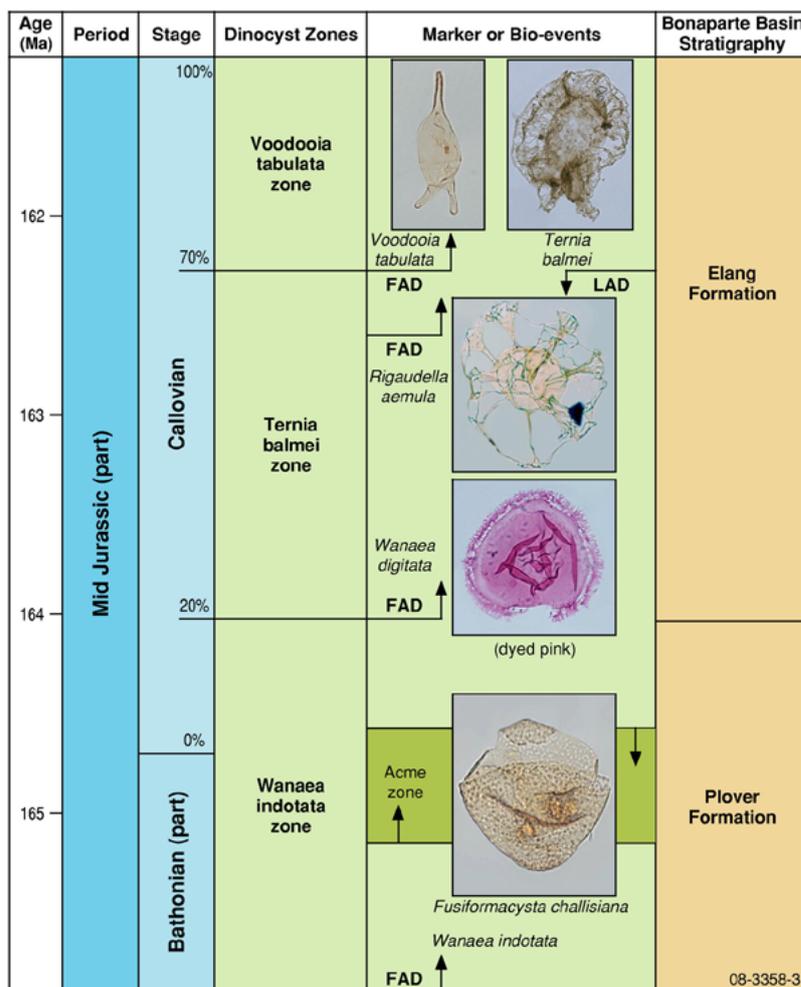
occur at 70 per cent from the base to the top of the Callovian. All the Australian biozones will be stored as such in the Geoscience Australia Timescales Database. Thus, if the base age of Callovian is updated in GTS 2010, the *Voodooia tabulata* Dinocyst Zone would automatically update to a new numerical age as it is stored as a percentile of the Callovian stage.

There are currently over 2500 biozones published in Australian biozonal schemes and capturing the relationships of these biozones to the stages will require extensive literature searches and targeted revisions of some biozonations to achieve the required recalibration. This information will then be saved in the Timescales Database, which is a core lookup table for numerous databases across the organisation. As noted above, GTS 2004 will be updated in 2010 and a further recalibration will be necessary. By then the Timescales Database will have been redeveloped to store the appropriate relationships of zones to stages thus obviating the need to repeat such a protracted 'manual' recalibration.

Creating timescales

Time Scale Creator is a software package developed by Adam Lugowski and Jim Ogg (Purdue University) that acts as a visualisation tool for the timescale data included in GTS 2004. There are two versions of this software, one freely available and one commercial. The free version, currently Time Scale Creator 3.7 (released in June 2008) contains a 'datapack' comprising the divisions of the GTS 2004, magnetic polarity zones, biozones, oxygen- and carbon-isotope curves, sequences, and sea-level curves, totalling over 10 000 event-age entries and upwards of 200 stratigraphic columns. Any permutation of these biozonal and other schemes can be chosen and displayed against the selected portion of the timescale. It is an easy-to-use software package and primarily useful for quickly generating graphic displays of chronostratigraphic schemes against GTS 2004.

The commercially available version (Time Scale Creator PRO) allows the user to generate their own datapack and either to add this to the standard version, or to replace the standard datapack. In association with Professor Jim Ogg, Geoscience Australia has been able to develop an up-to-date datapack containing all current Australian biozonations so that timescales containing Australian data can be generated separately or in association with the assorted international schemes. This is a very useful development as



FAD - First appearance datum (species inception)
LAD - Last appearance datum (species extinction)

Figure 3. Middle Jurassic portion of the Helby, Morgan and Partridge (2004) dinocyst biozonal scheme illustrated with formal marker events.

much of the original data included in the free version is based on the predominantly northern hemisphere datasets underpinning GTS 2004. This Australian datapack will be freely distributed at the 2009 APPEA Conference and Exhibition in Darwin (between 31 May and 3 June) and will also be available from the Geoscience Australia Timescales webpage from that date.

Stratigraphic data can also be inserted into Time Scale Creator PRO to allow it to generate stratigraphic columns calibrated against any biozonal scheme or schemes the user chooses. An example image generated by Time Scale Creator showing the lithostratigraphy, supersequences, basin phases, sea-level curve and relevant biozones for an Early–Late Cretaceous segment of the Great Australian Bight Basin is shown in figure 4. In collaboration with staff from some of the state geological survey organisations, Geoscience Australia has also been using Time Scale Creator PRO to generate up-to-date Basin Biozonation and Stratigraphy charts. These are replacing charts drafted about a decade ago using the now outdated AGSO 1996 timescale. Currently, Geoscience Australia has compiled, or is compiling, stratigraphic charts for the Bonaparte, Browse, Canning, Carnarvon, Great Australian Bight, Otway and Perth basins as well as the Dampier Sub-basin. These charts provide a relatively detailed stratigraphic overview of each of the basins concerned. Furthermore, when GTS 2010 replaces GTS 2004, updating these charts should be fairly straightforward as the re-developed Timescales Database will store the zonal markers and their relationships to the timescale rather than independent numerical ages.

References

- Gradstein FM, Ogg JG & Smith AG. 2005. A Geologic Time Scale 2004. Cambridge University Press
 Helby R, Morgan R & Partridge AD. 2004. Updated Jurassic–Early Cretaceous dinocyst zonation NWS Australia. Geoscience Australia.
 Young GC & Laurie JR. 1996. An Australian Phanerozoic Timescale. Oxford University Press.

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Related websites

- Timescales Webpage – Geoscience Australia
www.ga.gov.au/oceans/og_lfes_Tscales.jsp
 International Commission on Stratigraphy
www.stratigraphy.org/
 Geological Time Scale 2004
www.stratigraphy.org/gts.htm
 Time Scale Creator software
www.tscreator.com/download.php

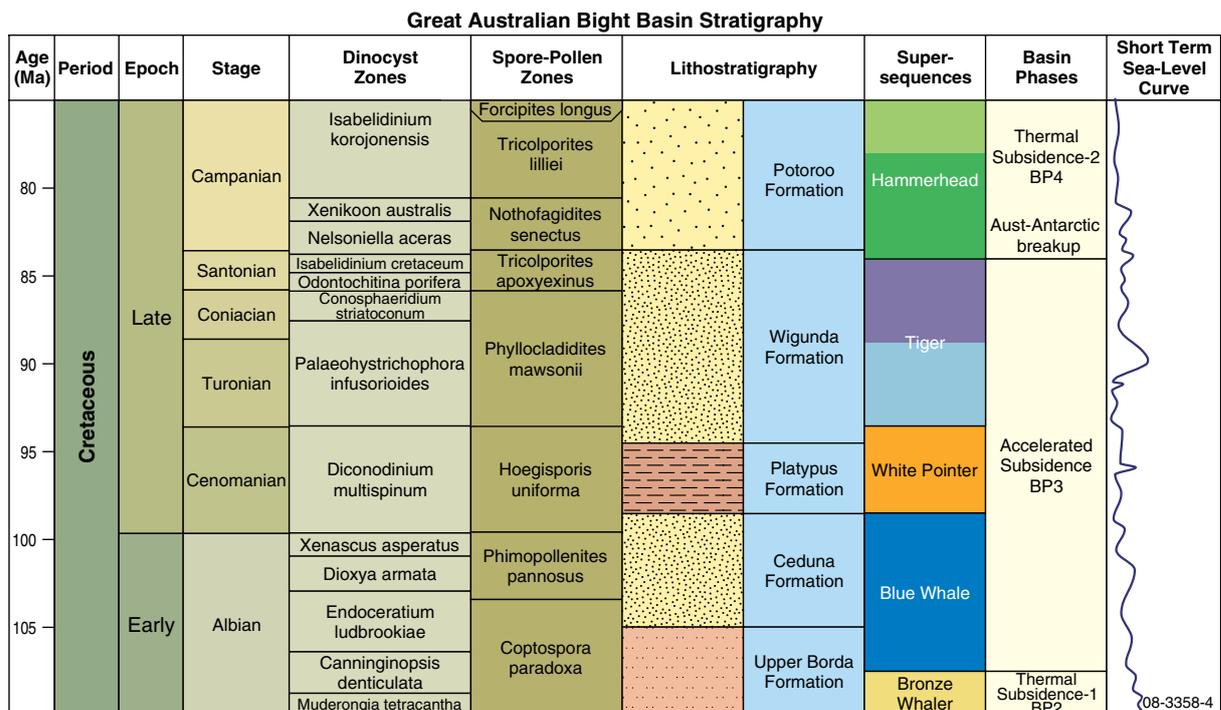


Figure 4. Sample output from Time Scale Creator software showing elements of the Great Australian Bight Basin stratigraphy against the relevant biozonal schemes and GTS 2004.