A Revised Calibration of the New Zealand Geological Timescale: NZGT2015*

James I. Raine¹, Alan G. Beu¹, Andrew Boyes¹, Hamish J. Campbell¹, Roger A. Cooper¹, James S. Crampton¹, Martin P. Crundwell¹, Christopher J. Hollis¹, and Hugh E. Morgans¹

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¹Paleontology, GNS Science, Lower Hutt, New Zealand (i.raine@gns.cri.nz)

Abstract

The New Zealand Geological Timescale (NZGT) is a regional geochronological timescale for the Permian to Pleistocene and comprises a sequence of stages defined in New Zealand outcrop sections. The local stages have served an important role in fine-scale geological mapping since the mid-20th Century, and continue to provide a standard for stratigraphic subdivision by integrating biostratigraphic data from various fossil groups with other stratigraphic criteria (Cooper, 2004). Many of the most useful fossil groups for subsurface exploration in New Zealand Mesozoic-Cenozoic basins have essentially local biogeographic distribution, or local ranges which differ from those of other regions because of differences in paleoclimate or ocean circulation, so the sequence of local stages which is closely tied to local fossils provides a more internally consistent, precise, and refined chronostratigraphy for routine use than international stages. Nevertheless, correlation with the International Geological Timescale (IGT) is required for communication with the international community, and age-calibration of stage and substage boundaries for estimation of rates of geological processes and correlation with numerical age data from radiometric and other methods. The status of the New Zealand stages is reviewed in a new publication (Raine et al., 2015) focused on age-calibration of the stage boundaries. The revised calibration is based on calibration of the IGT by Gradstein et al. (2012), and is consistent with the International Chronostratigraphic Chart (Cohen et al., 2014). In the Cenozoic, calibration has relied mainly on correlation of planktic bioevents with the Geomagnetic Polarity Timescale (GPT), with input also from tephrochronology and
isotope stratigraphy; in Cretaceous and older stages, the main approach has been biocorrelation of stage boundary and intra-stage bioevents with the IGT, with minor input from radiometric dating, carbon isotope stratigraphy and the GPT.

References Cited


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Department of Paleontology
A little history ...

- The broad outline of NZ geology was soon established in the late 19th century.
- Macroscopic fossil fauna and flora were critical.
- British-European systems and series were used, but successful only at coarse scale.
- Many arguments about correlation because of endemism of the fauna, especially in Cenozoic.

James Hector, c. 1863

Hector’s 1865 map
The early 20th century...

1916 – laid the foundations of local stages based on NZ fossils

J.A. Thomson

1934 – type localities and strata emphasised

R.S. Allan

1940 – key species of Foraminifera and Mollusca

H.J. Finlay

1947 – Cenozoic stages nearly all there

J.A. Marwick

1951 – Triassic & Jurassic stages

NZGT 2015
Later contributors ...

1959
new Cretaceous stages

H.W. Wellman

Permian stages

J.B. Waterhouse

Permian stages

G.H. Scott

Revisions of Cenozoic stages

N. deB. Hornibrook

C.A. Fleming

Revisions of Triassic stages

J.D. Campbell
Applications (1)

1:250,000 map of New Zealand (1st series)

- completed 1950s-1960s
- whole country in 26 maps
- stage and series divisions used

fragment of the Hamilton map – Jurassic and Oligocene around Kawhia Harbour
Applications (2)

Cretaceous-Cenozoic Basins Studies Series

- completed 1980s-1990s
- 9 monographs with summaries of stratigraphy, paleogeography, key sections, and petroleum geology
- outcrop + available subsurface
Applicability of microfossils in NZ

Increasing emphasis for:
- petroleum exploration
- paleoclimate studies

Integration of zonal schemes for:
- nannofossils
- miospores
- dinoflagellate cysts
New Zealand Geological Timescale: summary

- Regional geochronological timescale for Permian to Pleistocene
- Based on outcrop sections, now using SSP principle
- 54 stages originally based on invertebrate fossils and benthic foraminifera, now include definitions based on planktic forams, palynomorphs, tephras, and isotopic events

- Global stages used for Silurian-Carboniferous
- Australasian stages for Cambrian-Ordovician
- No Precambrian record in New Zealand

Major review – Cooper 2004
Cenozoic recalibrations since 1982

Consequent on:

• new NZ biocorrelations

• new NZ magnetostrat., isotopic, geochemical and radiometric data

• revised NZ criteria

• changes in Global timescale definitions

• changes in calibration of Global timescale
2015 recalibration

Global timescale recalibration by Gradstein et al. 2012

- revised 2004 radiometric database of samples using U/Pb and Ar/Ar decay systems, leading to adjustments to almost all global stage boundaries in Paleozoic and Mesozoic
- new global biostratigraphic, magnetostratigraphic and chemostratigraphic data

New NZ data and revisions

- minor changes to Cretaceous and Cenozoic
- first reassessment of Permian to Jurassic since 2004
- basal ages of 17 stages moved >1% since 2004
Presenter’s notes: Latest international chart (~ 1 update per year).
Based extensively on Gradstein et al. 2012 compilation, but starting to diverge.
Each period has a subcommission working at definitions of stages and series (SSPs) -> ages and epochs.

Minor changes since 2010 calibration of Cretaceous and Cenozoic (Hollis et al.).

First NZ-based revision of pre-Cretaceous calibration since 2004 (Cooper monograph).
Pliocene to Holocene

Ma change since 2004

- fission track dating, oxygen isotope stratigraphy
- planktic forams & magnetostrat. at Site 1123
- Oxygen isotope stage G19
- magnetostrat. at Site 1123
- magnetostrat. at Sites 284, 590, 1123
Miocene

Ma change since 2004

LO *Globoconella conomiozea* +0.7  • magnetostrat. at Site 1123

Base of Kaiti Coiling Zone (of *Globoconella miotumida*) +0.12  • magnetostrat. at Site 1123

HO *Globoconella conica* +0.35  • magnetostrat. at Site 1171C

LO *Orbulina suturalis*  • global foram biozone N8/N9

LO *Praeorbulina curva*  • magnetostrat. at Site 1123

LO *Globoconella praescitula* -0.3  • magnetostrat. at Tangakaka Stream, East Cape

LO *Ehrenbergina marwickii* gr.  • Sr isotope dating at Blue Cliffs, South Canterbury
Paleocene to Oligocene

Ma change since 2004

- Globoquadrina dehiscens: Sr isotope dating at Trig Z
- Notorotalia spinosa: Sr isotope dating at Squires Farm
- Globigerinatheka index: +0.3
- Bolivina pontis: -0.7
- Acarinina primitiva: +2.1
- Globigerinatheka index: -0.4
- Elphidium saginatum: -0.5
- Elphidium hampdenensis: -0.6
- Morozovella crater: -1.0
- C isotope excursion: +0.5
- K-Pg geochemical anomaly: +1.0

**Paleogene**

- Upper Cretaceous
  - Maastrichtian (67.1)
- Upper Paleocene
  - Danian (66.0)
- Lower Paleocene
  - Danian (66.0)
  - Selandian (61.6)
  - Thanetian (59.2)
- Middle Paleocene
  - Lutetian (47.8)
  - Bartonian (41.2)
  - Priabonian (37.8)
- Upper Eocene
  - Rupelian (33.6)
  - Chattian (28.1)
- Lower Eocene
  - Aquitanian (23.0)

**Oligocene**

- Lower Oligocene
  - Waingaroan lower (34.6)
  - Waingaroan upper (33.8)
  - Duntroonian (27.3)
  - Waitakian (25.2)
- Upper Oligocene
  - Llanddulas (6.0)
  - Kawauian (5.8)
  - Teirikian (5.7)
  - Kaitaian (5.1)
  - Runangan (4.7)
- Lower Oligocene
  - Kaitaian (5.1)
  - Runangan (4.7)
  - Kawauian (5.8)
  - Llanddulas (6.0)
- Upper Cretaceous
  - Kaitaian (5.1)
  - Runangan (4.7)
  - Kawauian (5.8)
  - Llanddulas (6.0)
- Lower Cretaceous
  - Kaitaian (5.1)
  - Runangan (4.7)
  - Kawauian (5.8)
  - Llanddulas (6.0)

**Major Events**

- C isotope excursion (498.0)
- K-Pg geochemical anomaly (495.0)
Waipara River

Dallanave et al. (2014; submitted)

- base of Heretaungan Stage (LO *Elphidium hampdenensis*) at C22n.6 = 48.9 Ma
- by extrapolation, base of Mangaorapan Stage (LO *Morozovella crater*) in upper C23r ~ 52.0 Ma (confirmed by Mead Stream results)
### Cretaceous

<table>
<thead>
<tr>
<th>Age</th>
<th>Series</th>
<th>Stage</th>
<th>Code</th>
</tr>
</thead>
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<td>Cretaceous</td>
<td>Cretaceous</td>
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<tr>
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<tr>
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<tr>
<td>Coniacian</td>
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</tr>
<tr>
<td>Turonian</td>
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<tr>
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<tr>
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<tr>
<td>Op</td>
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**NZGT 2015**

<table>
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<th>Period</th>
<th>Epoch</th>
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<th>Stage</th>
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**GPTS**

<table>
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<tr>
<th>Faunal correlation</th>
<th>Australian dinoflagellate correlation</th>
<th>Australian dinos + magnetostrat.</th>
<th>Australian dinos + radiometric dating</th>
<th>Australian miospore correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian dinos</td>
<td>Australian dinos + C isotopes</td>
<td>Australian dinos + radiometric dating</td>
<td>radiometric dating</td>
<td>faunal correlation</td>
</tr>
<tr>
<td>Australian dinos</td>
<td>Australian dinos + radiometric dating</td>
<td>faunal correlation</td>
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<tr>
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**Ma change since 2004**

- LO *Isabelidinium pellucidum* +4.5
- LO *Nelsoniella aceras* -0.4
- LO *Inoceramus pacificus* +1.6
- LO *Inoceramus opetius* +1.1
- LO *Cremnoceramus bicorrugatus matamuus* +1.6
- LO *Magadiceramus rangatira haroldi* -0.7
- LO *Inoceramus* tawhanus -0.7
- LO *Aucellina* cf. radiostriata A.Z.  
- LO *Ruffordiaspora australiensis* -0.5
Cenomanian/Turonian boundary


Located in upper Arowhanan Stage, Sawpit Gully
Supported by dinoflagellate correlations
Jurassic

Ma change since 2004

- **LO Hibolithes arkelli** +1.5 • ammonite correlation
- **LO Retroceramus haastii** +1.0 • ammonite correlation
- **LO Retroceramus galoi** +6.8 • ammonite and dinoflagellate correlation
- **LO Belemnopsis deborahae** +0.4 • belemnite correlation
- **LO Pseudaucella marshalli** +0.9 • ammonite correlation
- **LO Otapiria marshalli** +1.7 • ammonite correlation
Triassic

Ma change since 2004

+3.9  •  faunal & miospore correlation

+5.0  •  faunal correlation

+4.0  •  faunal correlation, radiometric dating

-0.5  •  faunal correlation

+1.5  •  faunal correlation (ammonoids + Daonella)

+3.5  •  faunal correlation (ammonoids)

+1.1  •  faunal correlation
### Faunal Correlations

<table>
<thead>
<tr>
<th>LO Puruhan fauna</th>
<th>LO Echinalosia ovalis</th>
<th>LO Spiriferella supplanta</th>
<th>LO Attenuatella altillis</th>
<th>LO Plekonella campbelli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makarewan fauna</td>
<td>Waitian fauna</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>-0.6</td>
<td>-0.5</td>
<td>+3.0</td>
<td>+5.0</td>
<td>+5.5</td>
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