

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

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Search and Discovery Article #51200 (2015)

Posted November 30, 2015

*Adapted from oral presentation given at AAPG/SEG International Conference & Exhibition, Melbourne, Australia, September 13-16, 2015

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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

- Cohen, K.M., S.C. Finney, and P.L. Gibbard, 2014, International Chronostratigraphic chart: International Subcommission on Stratigraphy, 2014/10.
- Cooper, R.A. 2004, The New Zealand Geological Timescale: Institute of Geological and Nuclear Sciences monograph 22, 284 p.
- Gradstein, F.M., J.G. Ogg, M.D. Schmitz, and G.M. Ogg, 2012, The geological time scale 2012: Elsevier B.V., Oxford, U.K.
- Raine, J.I., A.G. Beu, A.F. Boyes, H.J. Campbell, R.A. Cooper, J.S. Crampton, M.P. Crundwell, C.J. Hollis, and H.E.G. Morgans, 2015, GNS Science Report 2012/39.

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Department of Paleontology



**150 YEARS
of SCIENCE**

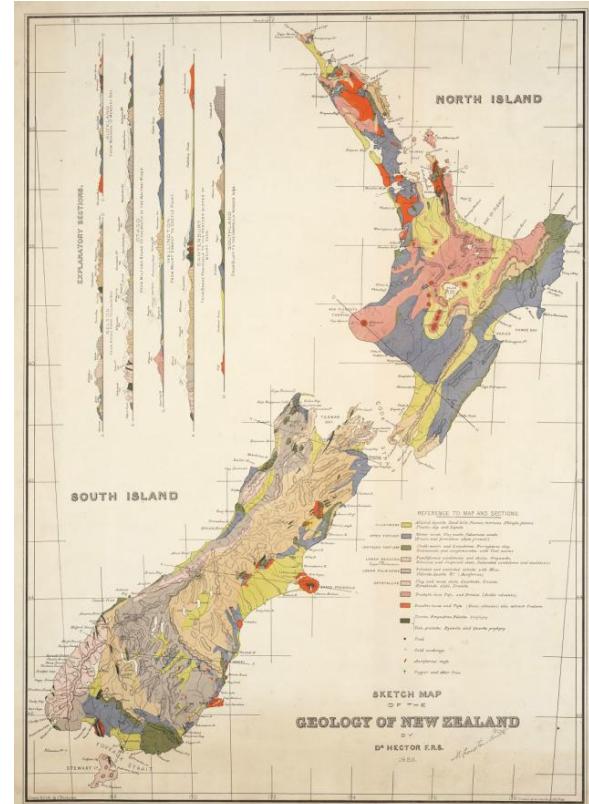
For a better New Zealand

A little history ...



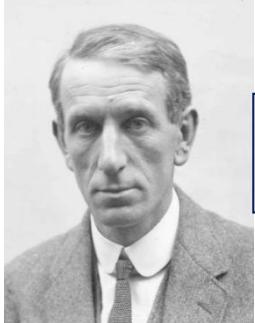
James Hector, c. 1863

- 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



Hector's 1865 map

The early 20th century ...



J.A. Thomson

ART. III.—*On Stage Names applicable to the Divisions of the Tertiary in New Zealand*
By J. ALLAN THOMSON, M.A., D.Sc., F.G.S., Director of the Dominion Museum, Wellington.

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



R.S. Allan

On the System and Stage Names applied to Subdivisions of the Tertiary Strata in New Zealand.
By R. S. ALLAN, M.Sc. (N.Z.), Ph.D. (Cantab.), F.G.S., National Research Scholar.

1934 – type localities and strata emphasised



H.J. Finlay

The Divisions of the Upper Cretaceous and Tertiary in New Zealand.

By H. J. FINLAY and J. MARWICK, New Zealand Geological Survey, Wellington.

1940 – key species of Foraminifera and Mollusca



J.A. Marwick

NEW DIVISIONS OF THE NEW ZEALAND UPPER CRETACEOUS AND TERTIARY

By H. J. FINLAY and J. MARWICK, N.Z. Geological Survey.

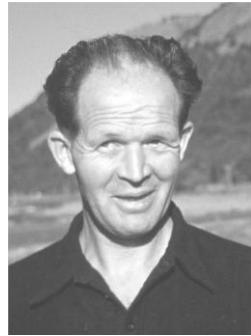
1947 – Cenozoic stages nearly all there

SERIES AND STAGE DIVISIONS OF NEW ZEALAND TRIASSIC AND JURASSIC ROCKS

By J. MARWICK, N.Z. Geological Survey, Department of Scientific and Industrial Research, Wellington.

1951 – Triassic & Jurassic stages

Later contributors ...

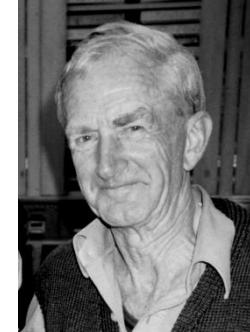


H.W. Wellman

1959
new Cretaceous stages



N. deB. Hornbrook



G.H. Scott



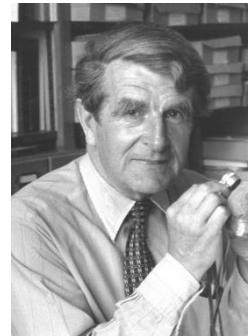
C.A. Fleming

Revisions of Cenozoic stages



J.B. Waterhouse

1966, 1967, 1982
Permian stages



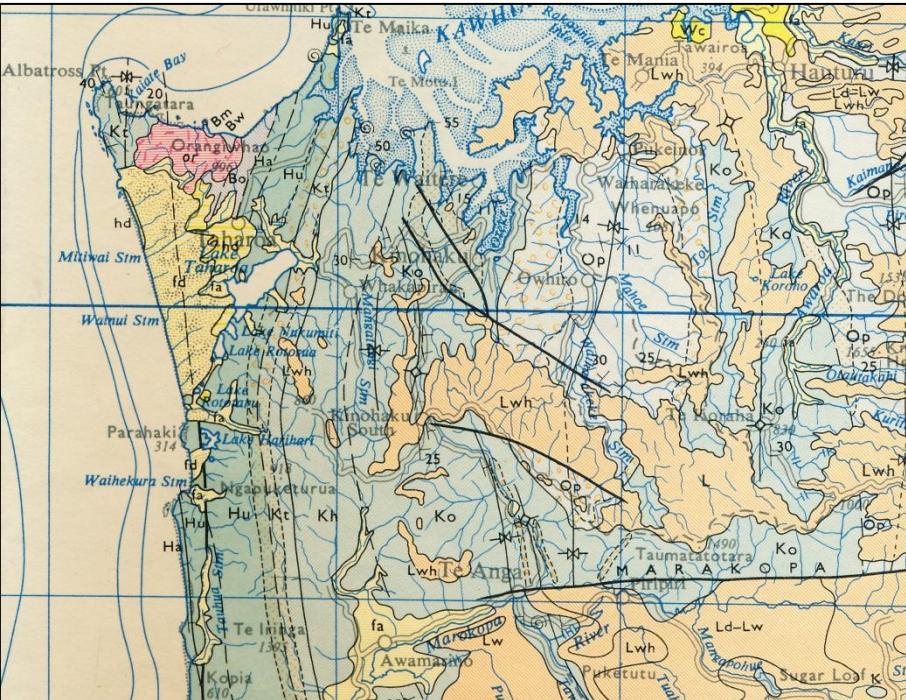
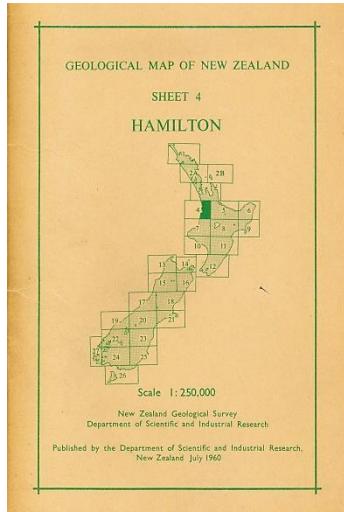
J.D. Campbell

Revisions of Triassic stages

Applications (1)

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

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

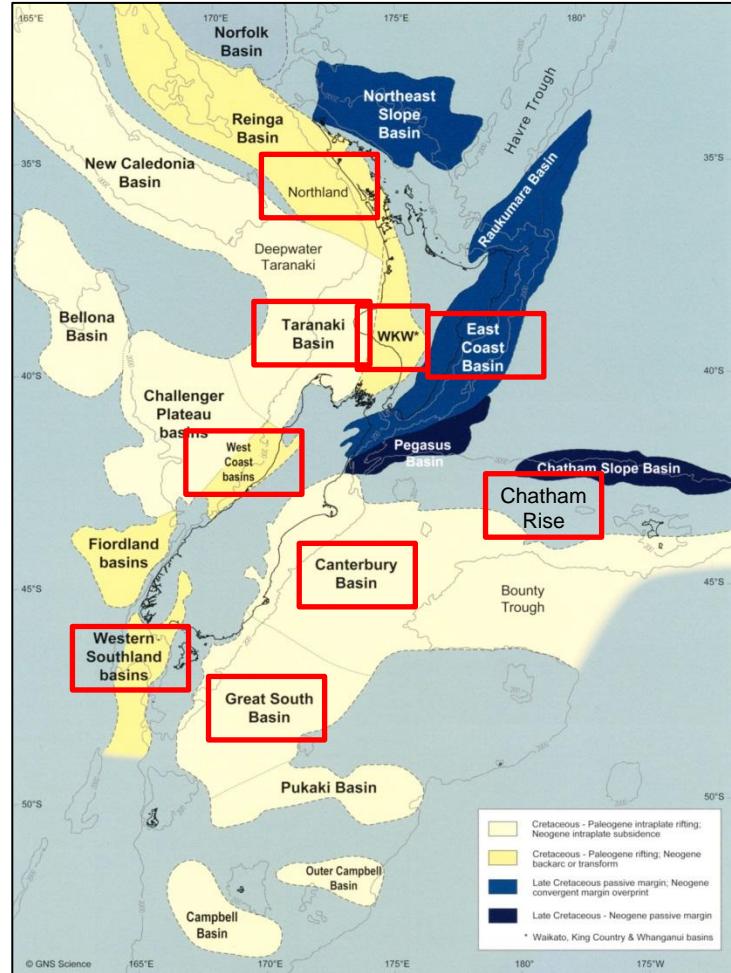
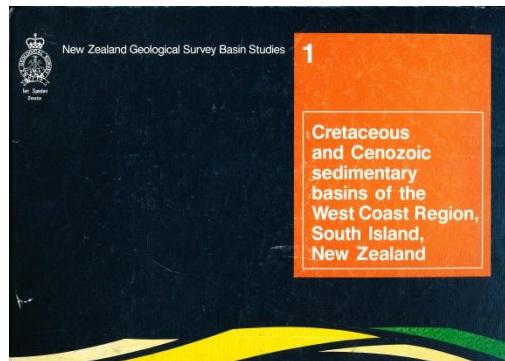


fragment of the Hamilton map – Jurassic and Oligocene around Kawhia Harbour

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



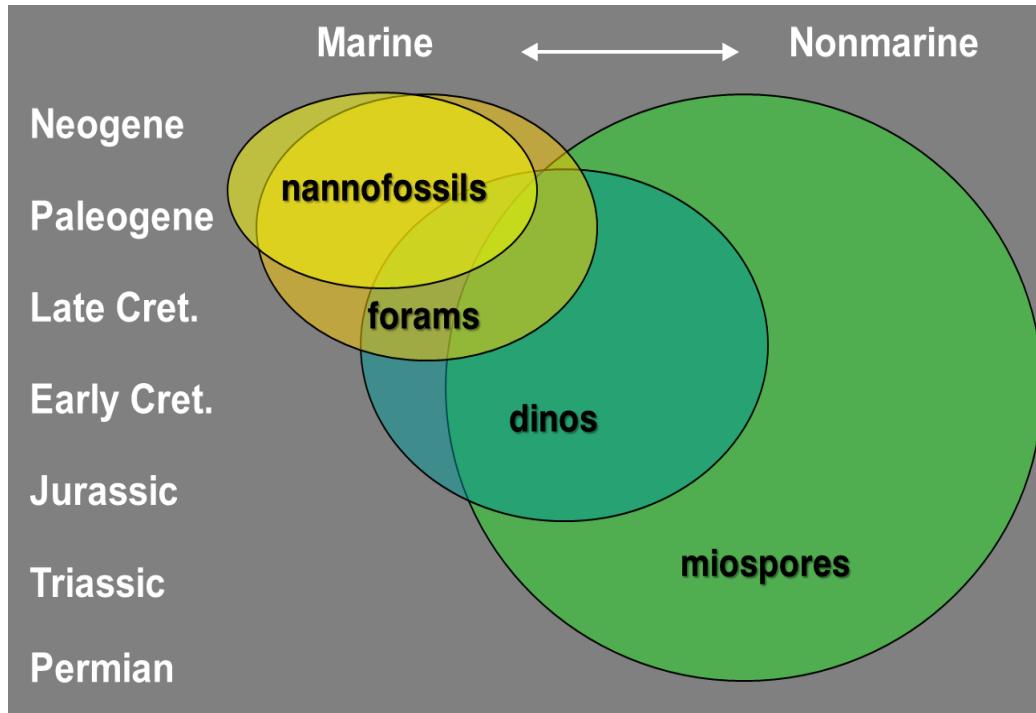
Applicability of microfossils in NZ

Increasing emphasis for:

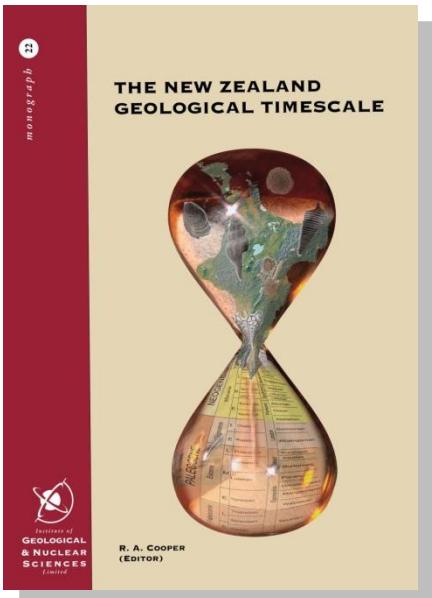
- petroleum exploration
- paleoclimate studies

Integration of zonal schemes for:

- nannofossils
- miospores
- dinoflagellate cysts



New Zealand Geological Timescale: summary



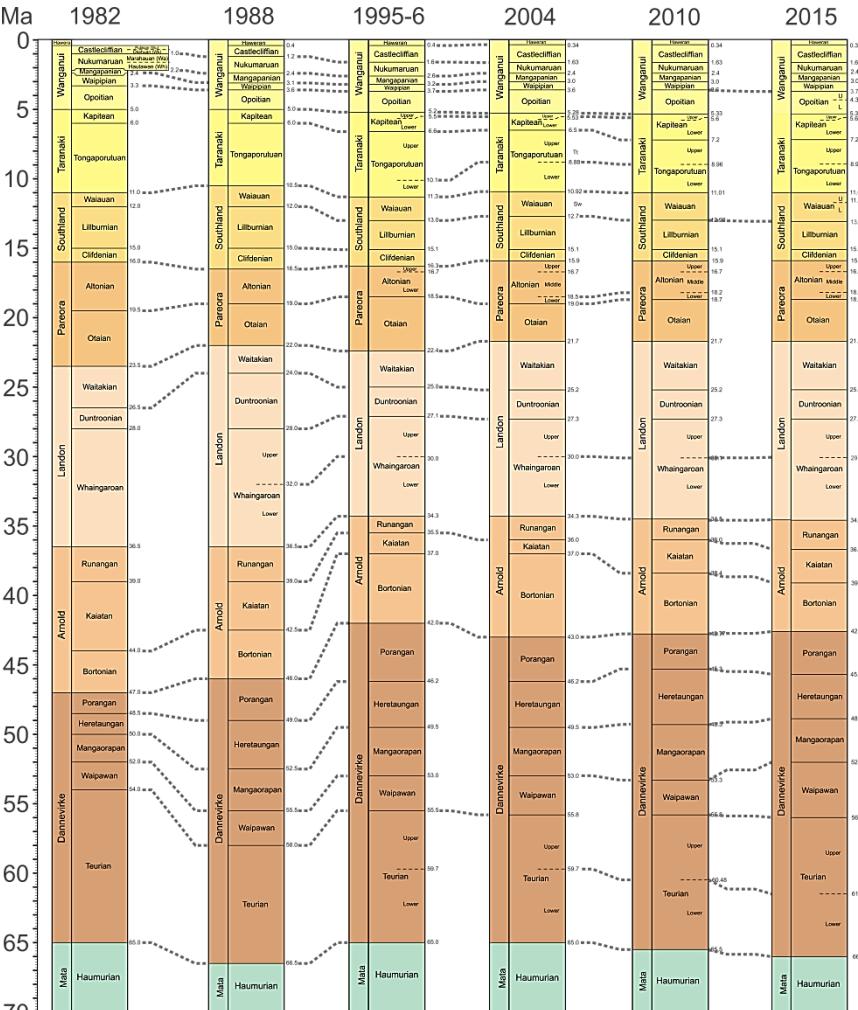
Major review – Cooper 2004

- 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

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

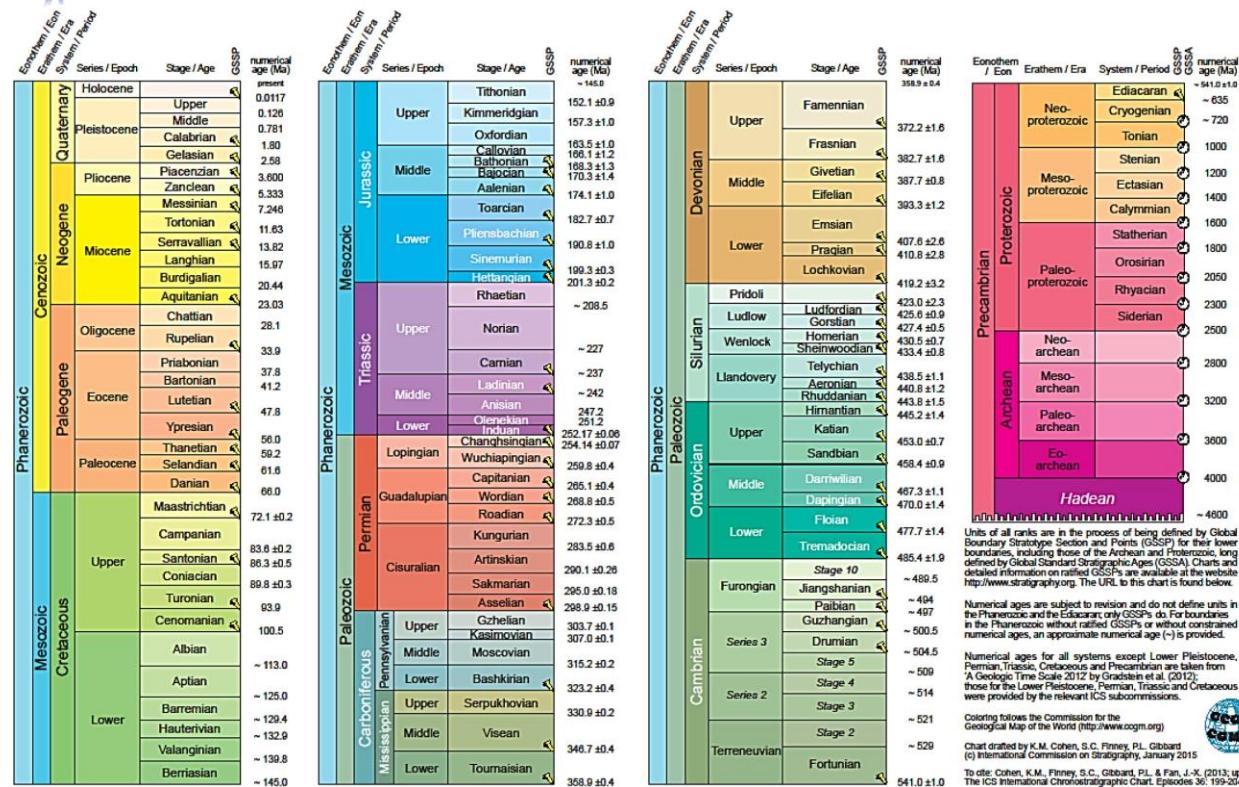


INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

www.stratigraphy.org

International Commission on Stratigraphy

v 2015/01



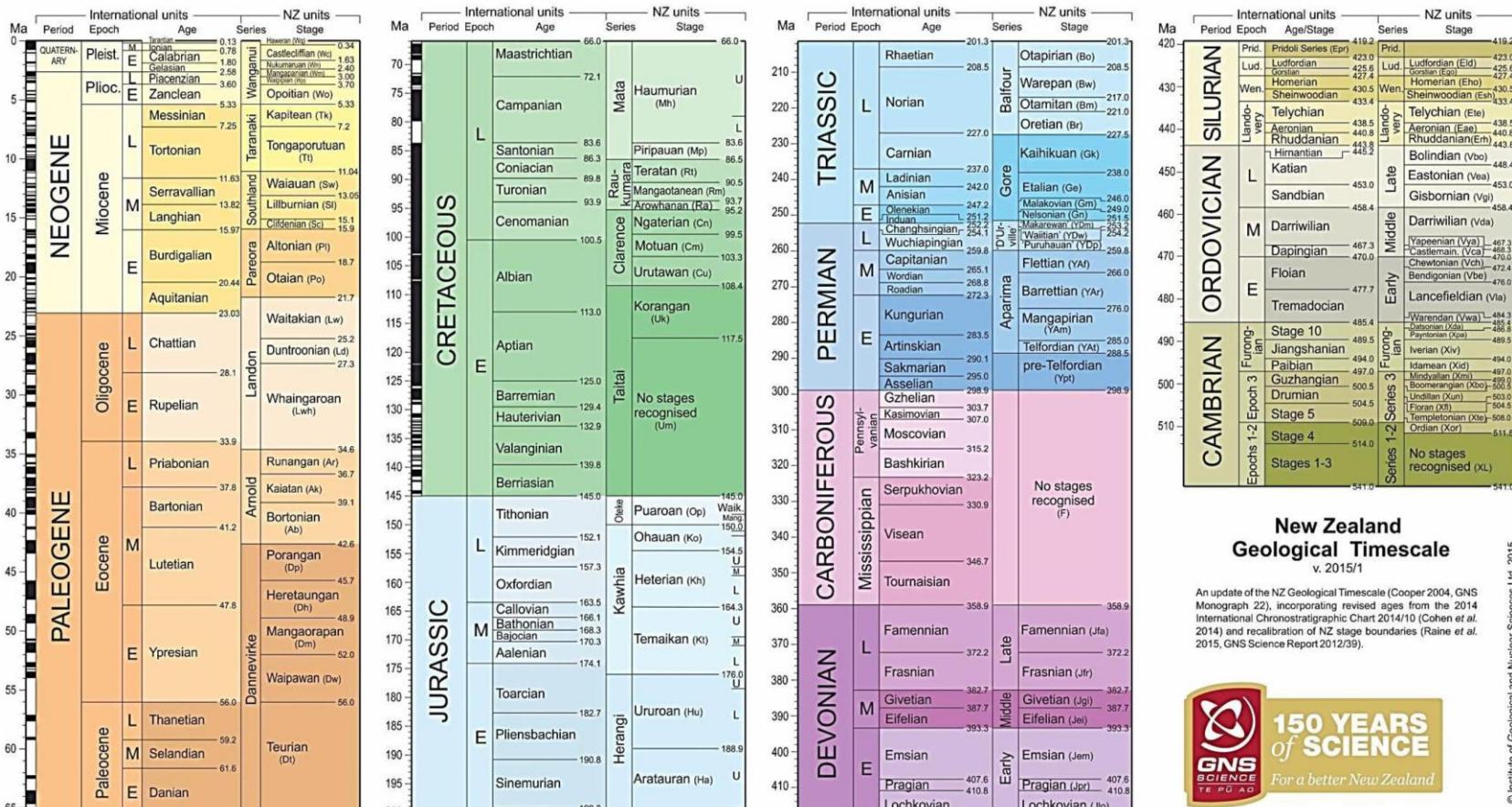
- ~ 1 update per year
- based on Gradstein et al. 2012, but with minor changes
- each ICS system
Subcommission is working at definitions of stages and series (SSPs)

NZGT 2015

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.

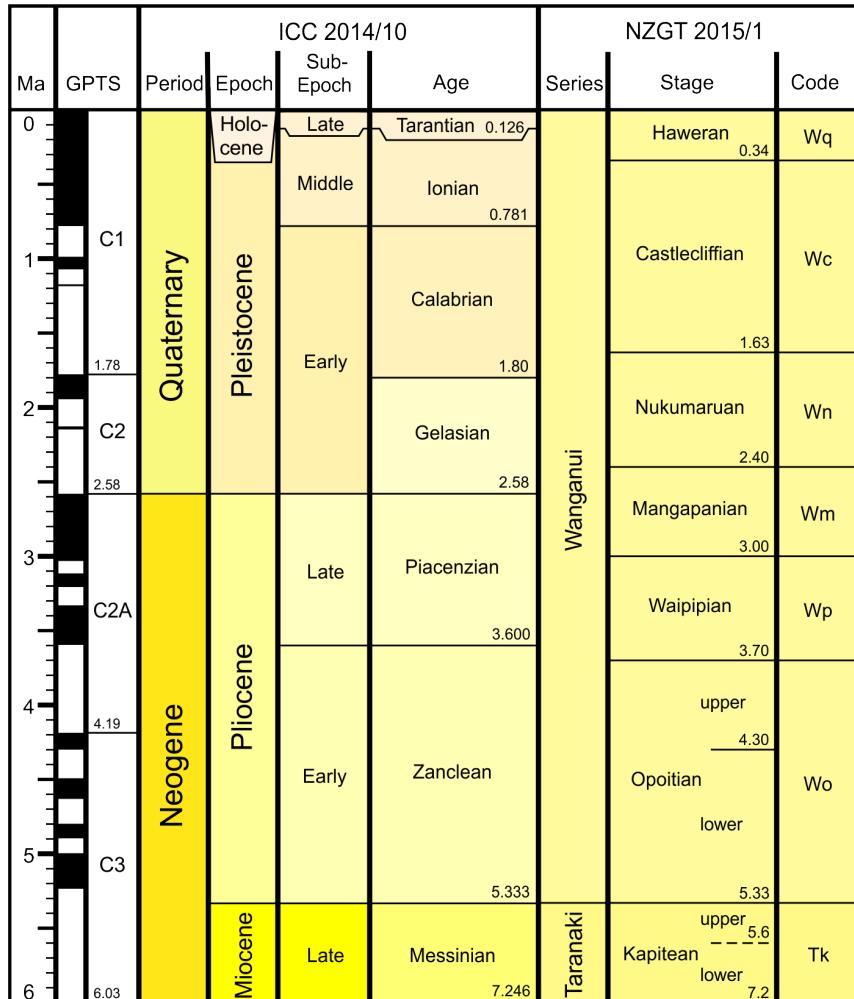


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NZGT 2015

Presenter's notes: Latest calibration of NZ timescale (2015) – supercedes interim card of 2012.
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

Rangitawa Tephra



- fission track dating, oxygen isotope stratigraphy

Ototoka Tephra

LO *Zygochlamys delicatula*

LO *Phialopecten thomsoni*

HO *Reticulofenestra pseudoumbilica*

+0.1 Ma

- fission track dating, oxygen isotope stratigraphy

- planktic forams & magnetostrat. at Site 1123

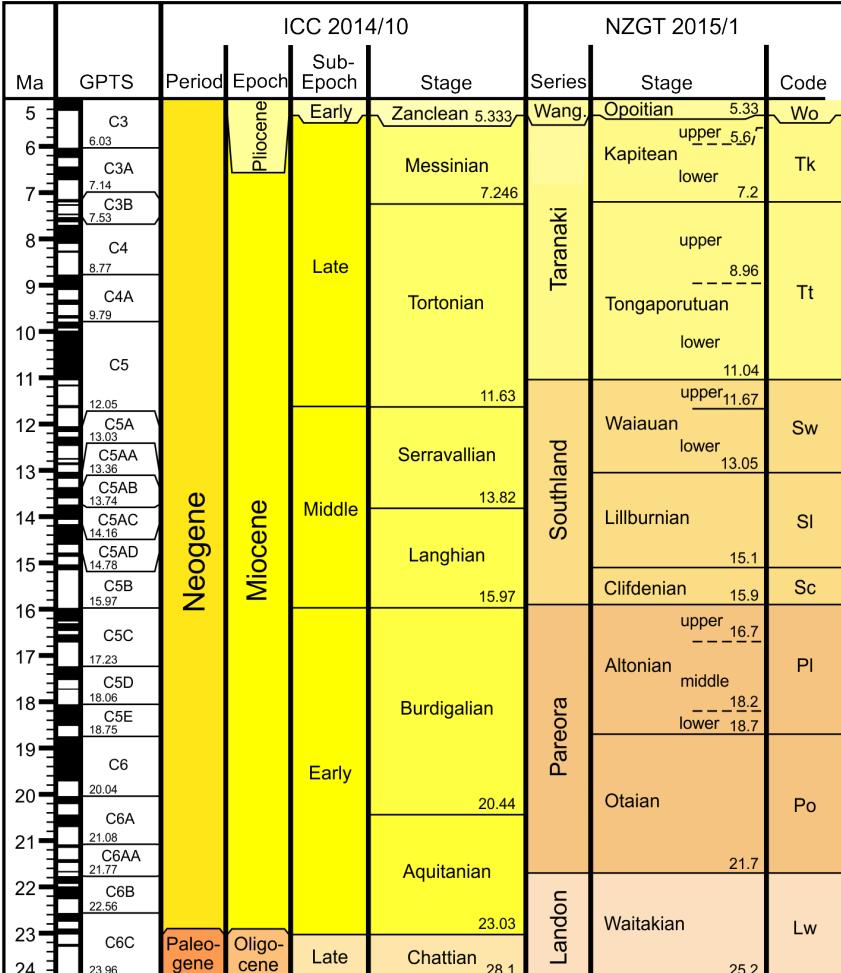
- Oxygen isotope stage G19

- magnetostrat. at Site 1123

LO *Globoconella puncticulata*

+0.05

- magnetostrat. at Sites 284, 590, 1123



Miocene

Ma change since 2004



+0.7

- magnetostrat. at Site 1123

+0.12

- magnetostrat. at Site 1123

+0.35

- magnetostrat. at Site 1171C

LO *Orbulina suturalis*

LO *Praeorbulina curva*

- global foram biozone N8/N9

- magnetostrat. at Site 1123

-0.3

- magnetostrat. at Tangakaka Stream, East Cape

- Sr isotope dating at Blue Cliffs, South Canterbury

Ma	GPTS	ICC 2014/10			NZGT 2015/1			
		Period	Epoch	Sub-Epoch	Age	Series	Stage	Code
22	22.56 C6B	Neogene	Miocene	Early	Aquitianian 23.03	Landon	Waitakian	Lw
23	23.96 C6C						25.2	
24	24.76 C7			Late	Chattian 28.1		Duntroonian 27.3	Ld
25	25.10 C7A						upper 29.8	
26	26.42 C8						lower	Lwh
27	27.86 C9		Oligocene	Early	Rupelian 33.9		34.6	
28	29.18 C10						Runangan 36.7	Ar
29	30.59 C11						39.1	Ak
30	31.16 C12			Middle	Bartonian 41.2		42.6	Ab
31	33.16 C13				Lutetian 47.8		45.7	Dp
32	35.0 C14	Paleogene	Eocene	Early	Ypresian 56.0	Arnold	48.9	Dh
33	35.71 C15						52.0	Dm
34	36.97 C16						56.0	Dw
35	38.62 C17							
36	41.15 C18							
37	41.15 C19			Middle	Thanetian 59.2			
38	42.3 C20							
39	45.72 C21				Selandian 61.6			
40	48.57 C22							
41	50.63 C23				Danian 66.0			
42	52.62 C24		Paleocene	Late	Maastrichtian 72.1	Dannevirke	61.5	Dt
43	57.1 C25							
44	58.96 C26							
45	62.22 C27							
46	63.49 C28							
47	64.96 C29			Early		K-Pg geochemical anomaly +1.0		
48	66.4 C30							
49	68.37 C31	Cretaceous	Upper					
50								
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67								

Paleocene to Oligocene

Ma change since 2004

LO *Globoquadrina dehiscens*



- Sr isotope dating at Trig Z

LO *Notorotalia spinosa*

- Sr isotope dating at Squires Farm

HO *Globigerinatheka index* +0.3

- magnetostrat. at Site 748 etc.

LO *Bolivina pontis* +0.7

- nannofossils/magnetostrat. at southern ODP sites

HO *Acarinina primitiva* +2.1

- magnetostrat. at ODP sites

LO *Globigerinatheka index* -0.4

- magnetostrat. at ODP sites

LO *Elphidium saginatum* -0.5

- planktic forams + magnetostrat. at ODP sites

LO *Elphidium hampdenensis* -0.6

- magnetostrat. at Waipara River

LO *Morozovella crater* -1.0

- magnetostrat. at Waipara River and Mead Stream

C isotope excursion +0.5

- global dating for base of Eocene

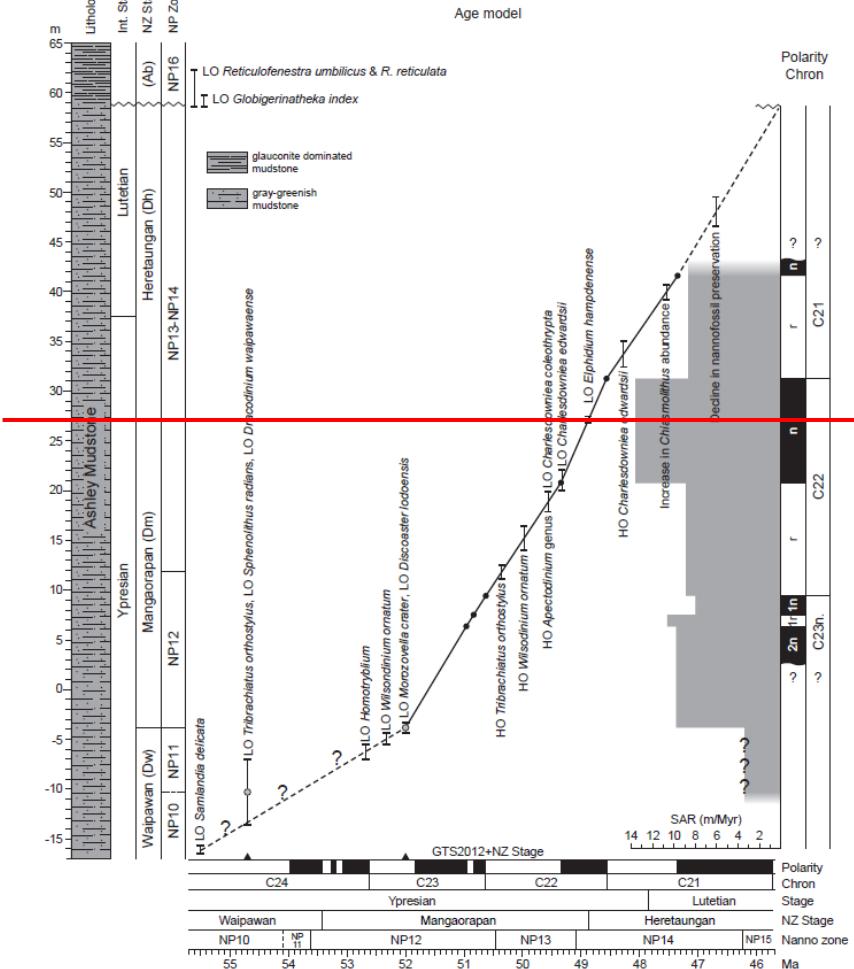
K-Pg geochemical anomaly +1.0

- global dating for base of Paleocene

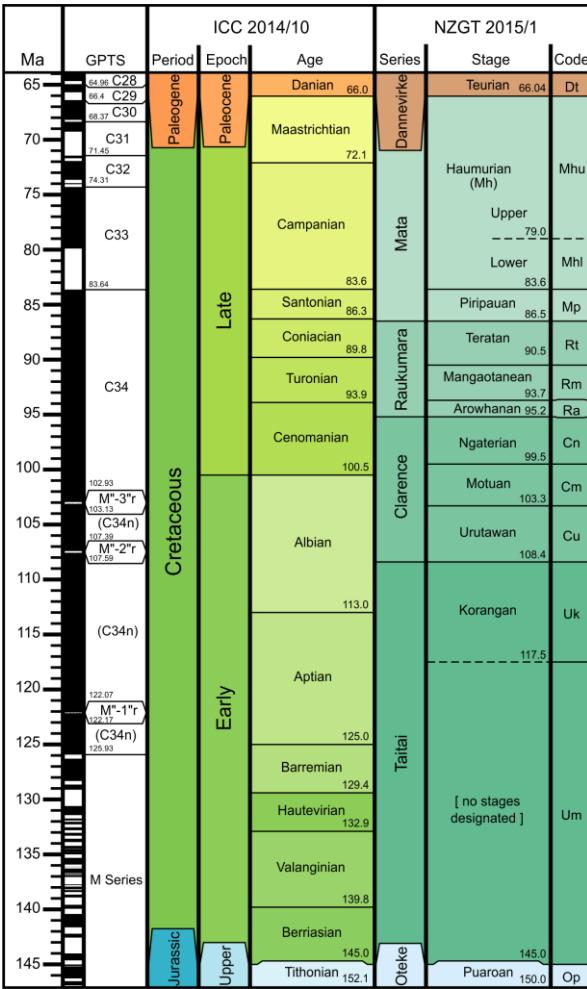
Waipara River

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



Ma change since 2004



+4.5

-0.4

+1.4

+1.6

-0.7

-0.5

- Australian dinoflagellate correlation
 - Australian dinos + magnetostrat.
- }
- Australian dinos.

- Australian dinos + C isotopes
- Australian dinos + radiometric dating
- radiometric dating
- radiometric dating

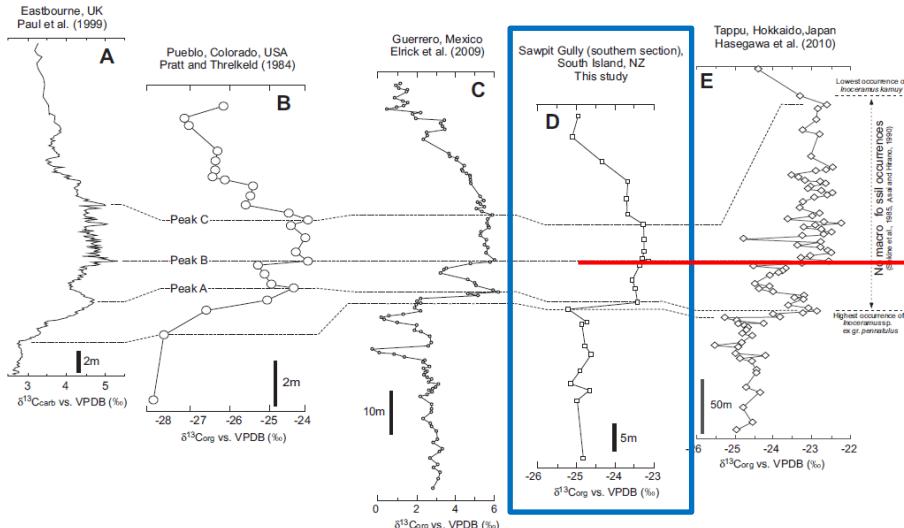
- faunal correlation

- faunal correlation

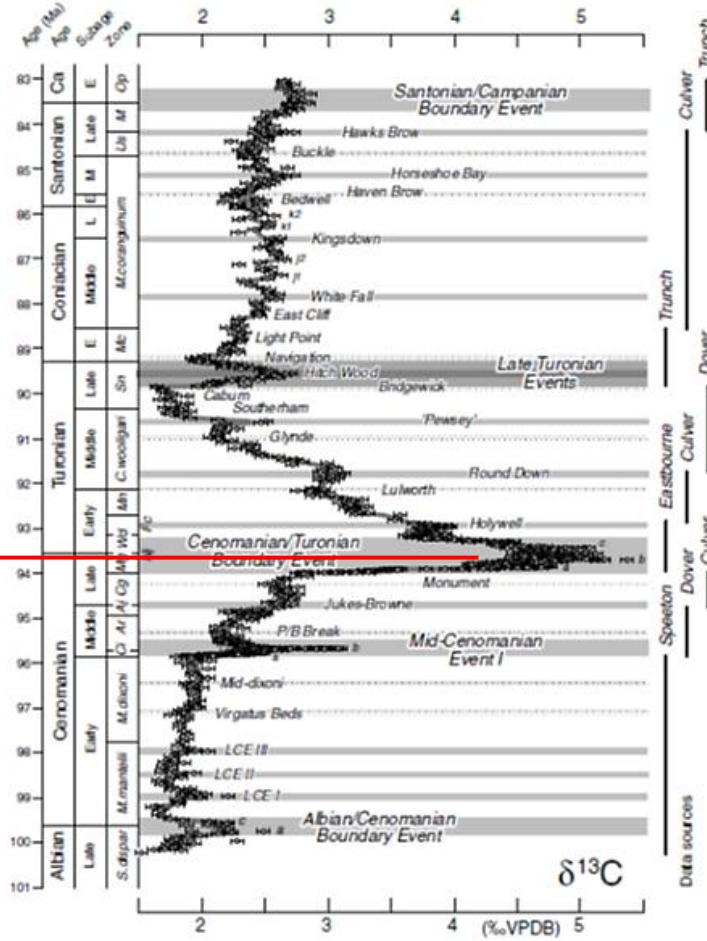
- Australian miospore correlation

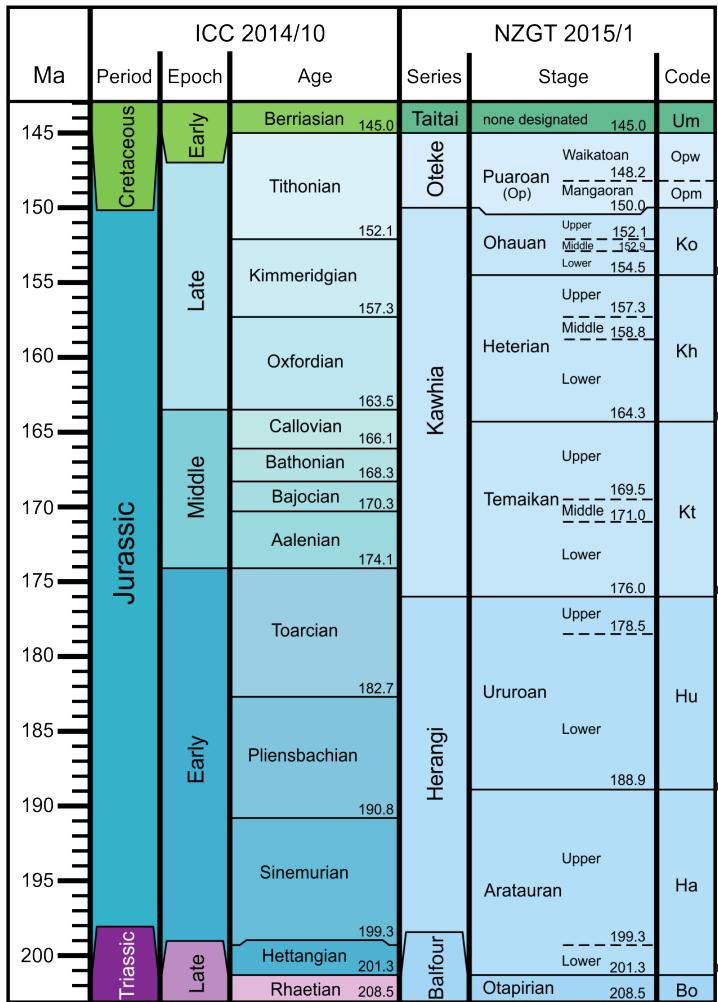
Cenomanian/Turonian boundary

- Hasegawa et al. 2012: *Cretaceous Research* 40: 61-80.
- Schioler & Crampton 2014: *Cretaceous Research* 48: 205-224.



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





Jurassic

Ma change since 2004

+1.5

LO *Hibolithes arkelli*

+1.0

LO *Retroceramus haastii*

+6.8

LO *Retroceramus galoi*

- ammonite correlation
- ammonite correlation

- ammonite and dinoflagellate correlation

+0.4

LO *Belemnopsis deborahae*

- belemnite correlation

+0.9

LO *Pseudauacella marshalli*

- ammonite correlation

+1.7

LO *Otapiria marshalli*

- ammonite correlation

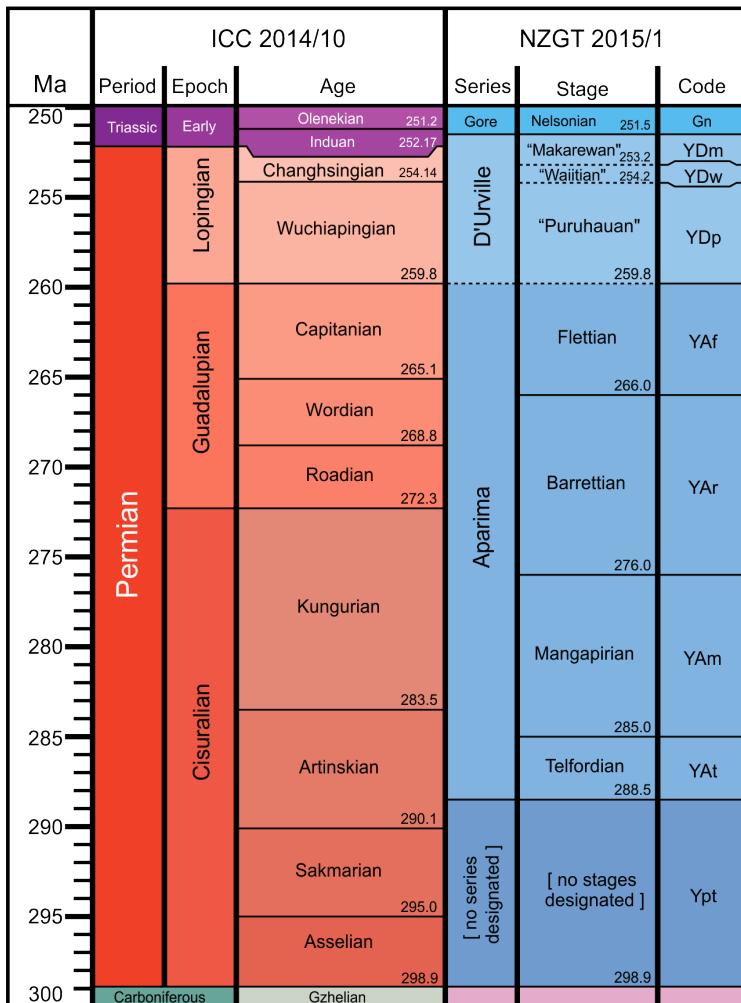
Ma	ICC 2014/10			NZGT 2015/1		
	Period	Epoch	Age	Series	Stage	Code
200	Jurassic	Early	Hettangian 201.3	Herangi	Aratauran 201.3	Ha
205			Rhaetian 208.5		Otapiroan 208.5	Bo
210				Balfour	Warepan 217.0	Bw
215			Norian 227.0		Otamitan 221.0	Bm
220					Oretian 227.5	Br
225				Gore	Kaihikuau 238.0	Gk
230			Carnian 237.0			
235					LO Alipunctifera kaihikuana 238.0	-0.5
240		Middle	Ladinian 242.0		Etalian 246.0	Ge
245			Anisian 247.2		Malakopian 249.0	Gm
250		Early	Olenekian 251.2	D'Urville	Nelsonian 251.5	Gn
			Induan 252.17		Makarewan 253.2	YDm
					Wailitan 254.2	YDw
	Permian	Lopingian	Changhsingian 254.14			

Triassic

Ma change since 2004



- LO *Rastelligera diomedea* +3.9 • faunal & miospore correlation
- LO *Monotis kiritehereensis* +5.0 • faunal correlation
- LO *Manticula problematica* +4.0 • faunal correlation, radiometric dating
- faunal correlation: ?base of Norian
- LO *Halobia austriaca*
- LO *Alipunctifera kaihikuana* -0.5 • faunal correlation
- LO *Mellarium* +1.5 • faunal correlation (ammonoids + *Daonella*)
- LO *Owenites* +3.5 • faunal correlation (ammonoids)
- LO *Durvilleoceras woodmani* +1.1 • faunal correlation



Permian

Ma change since 2004



Makarewan fauna
Waiitian fauna

-0.6

LO Puruhuan fauna

-0.5

LO *Echinolosia ovalis*

LO *Spiriferella supplanta*

+3.0

LO *Attenuatella altilis*

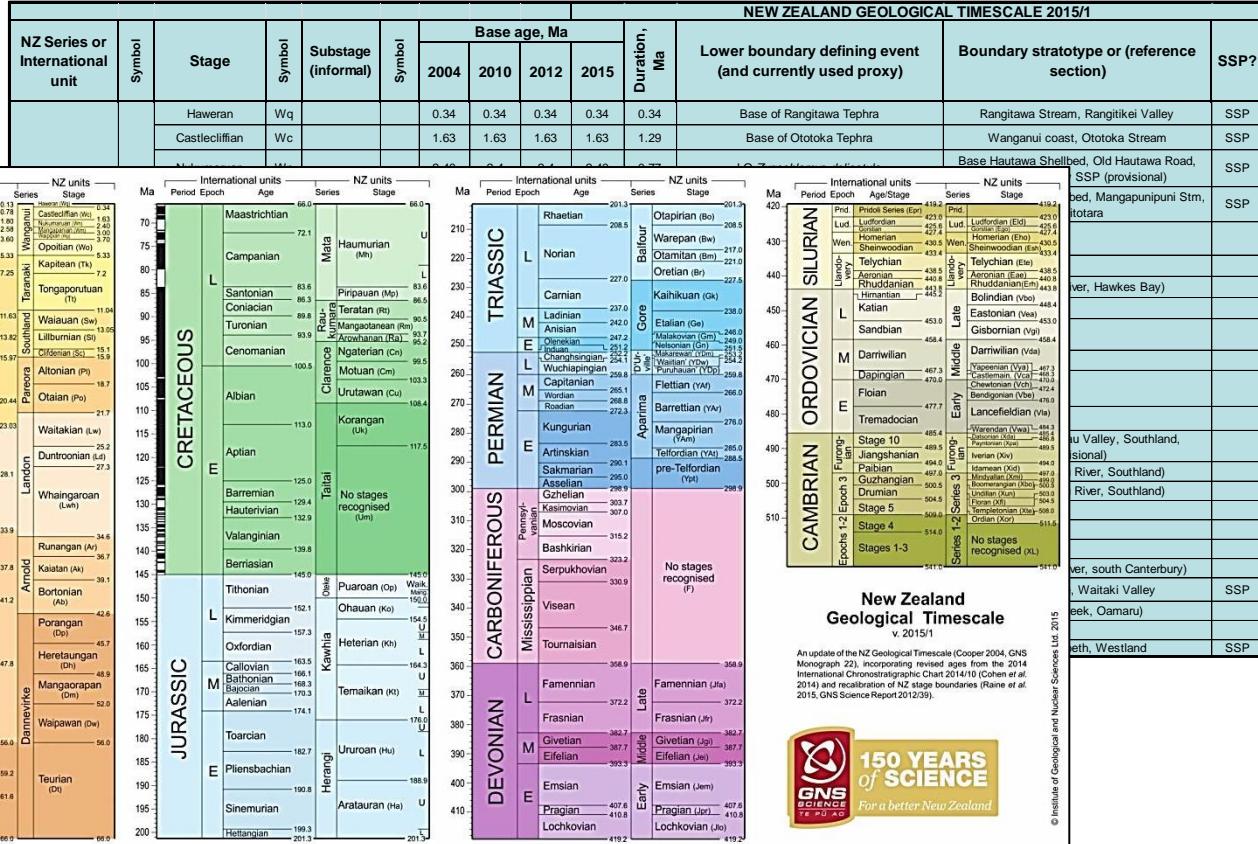
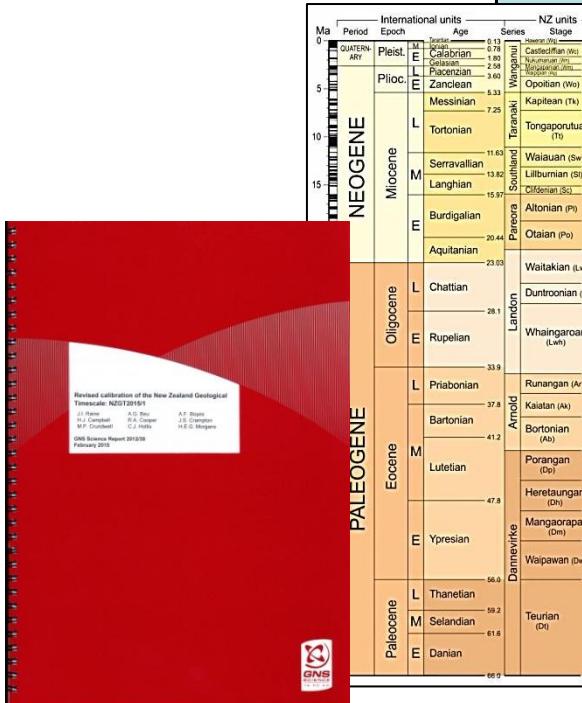
+5.0

LO *Plekonella campbelli*

+5.5

faunal correlations

Downloadable resources



<http://www.gns.cri.nz/Home/Our-Science/Earth-Science/Fossils/Online-Resources/New-Zealand-s-Geological-Timescale>