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SGT SG 2015 Caloundra

Australia Nuna and Beyond

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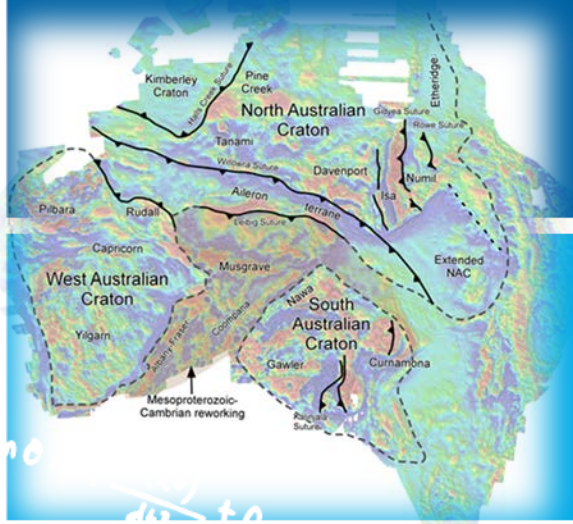
Ross Cayley – Geological Survey Victoria
Louis Moresi – Dept. Earth Sciences - UofMelb
David Moore – School of Earth, Atmosphere and Environment - Monash



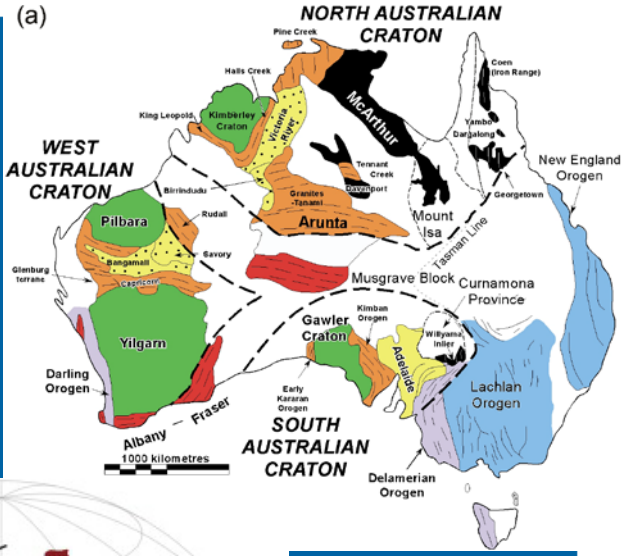
MSGG

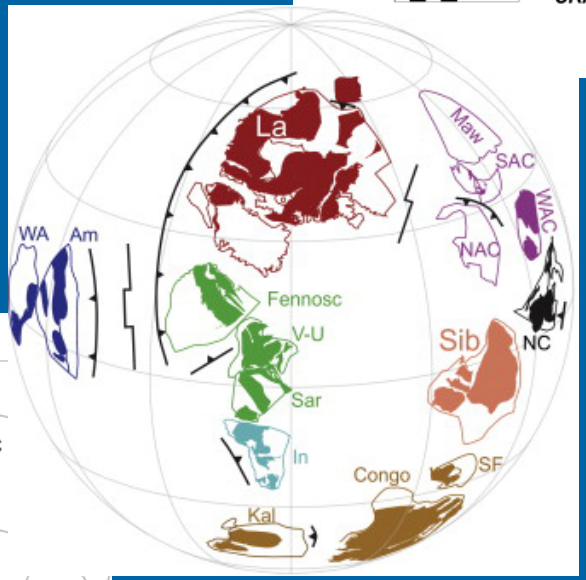
Take Home Message

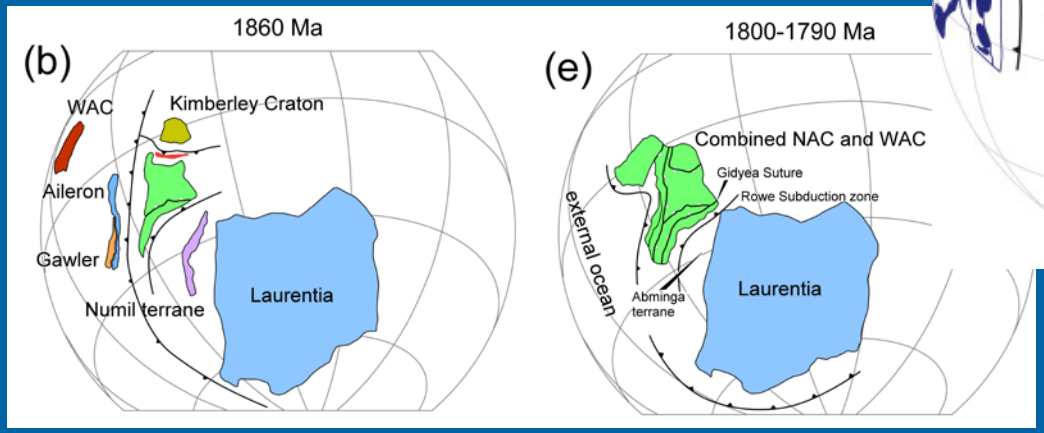
- Growth of the Australian continent can be viewed in the context of accretionary orogenesis

Ribbon tectonics.

Nuna and east Gondwana - facing an external ocean.







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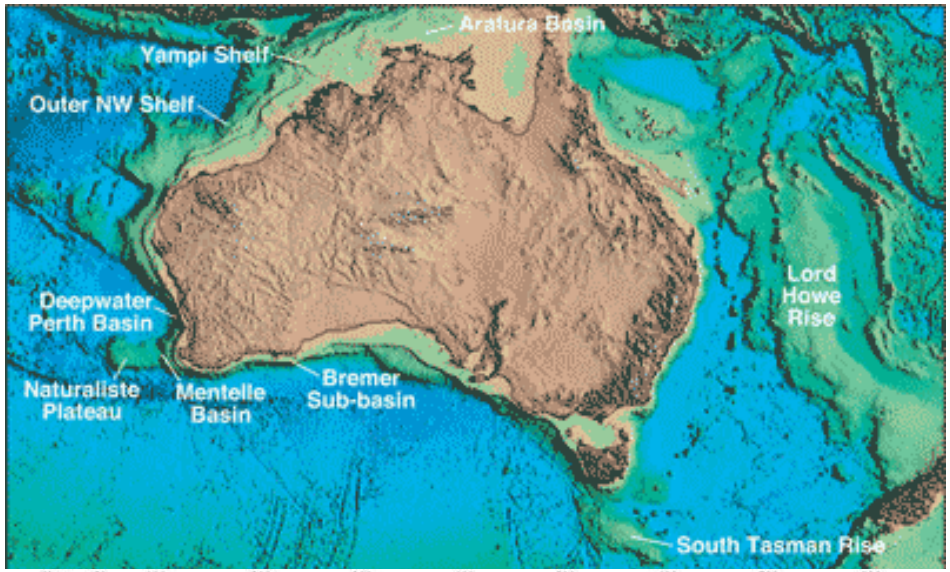
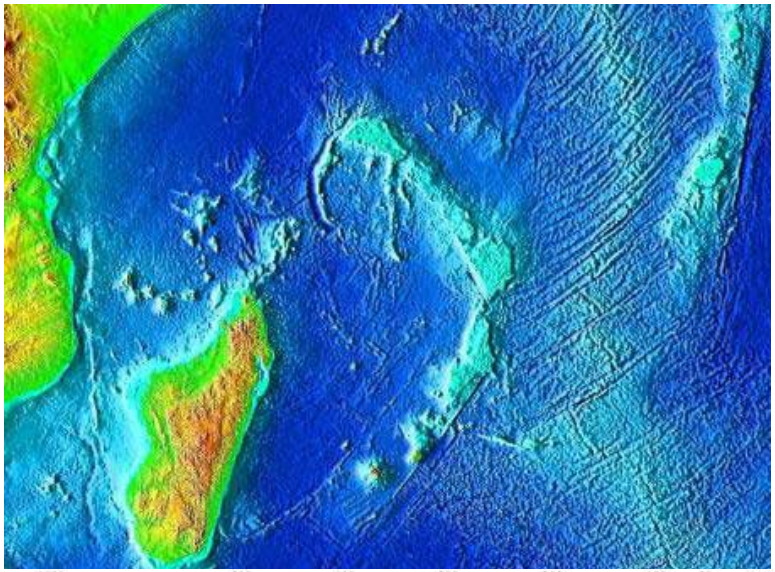
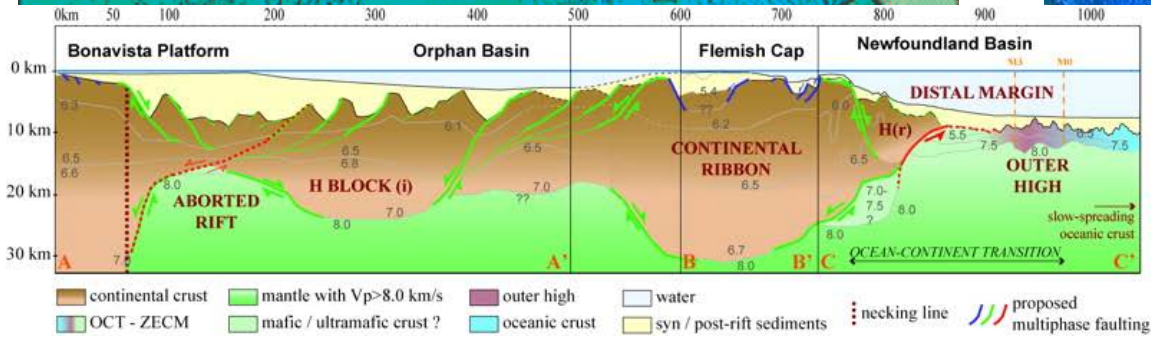
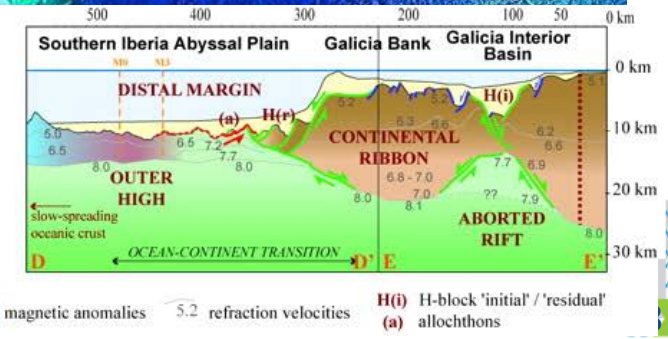
RIBBON MICROCONTINENTS

- How do micro continents form?
- Convergent margins – rollback - Lord How Rise
- Incipient Ocean formation – ridge jumping & type 1 passive margins





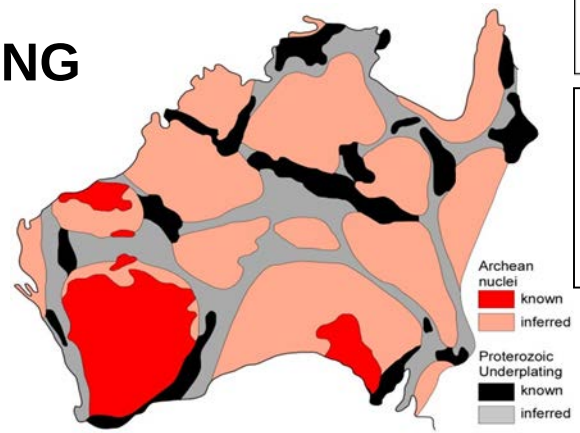




PROGRESSION OF THINKING

Intra-plate models

- Isotopes - evolved signature
- model ages 2400-2200 Ma
- Intraplate tectonic bias



Orogenesis and tectonic process in the early to middle Proterozoic of northern Australia

Etheridge, M.A., Rutland, R.W.R. and Wyborn, L.A.I. American Geophysical Union Geodynamic Series, v. 17

Precambrian Research, 40/41 (1988) 37–60 37
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

PETROLOGY, GEOCHEMISTRY AND ORIGIN OF A MAJOR AUSTRALIAN 1880–1840 Ma FELSIC VOLCANO-PLUTONIC SUITE: A MODEL FOR INTRACONTINENTAL FELSIC MAGMA GENERATION

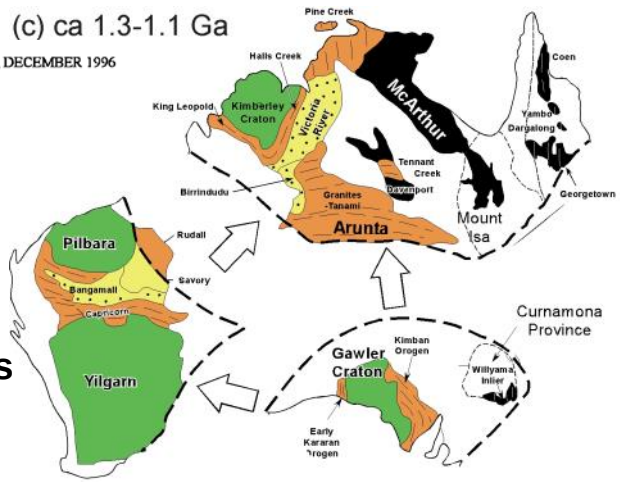
LESLEY A.I. WYBORN

(c) ca 1.3-1.1 Ga

TECTONICS, VOL. 15, NO. 6, PAGES 1431-1446, DECEMBER 1996

Tectonic evolution of Proterozoic Australia

John S. Myers,[1] Russell D. Shaw,[2] and Ian M. Tyler[1]



- Concept of NAC, WAC, and SAC
- Amalgamation - Rodinia
- Independence of cratonic elements

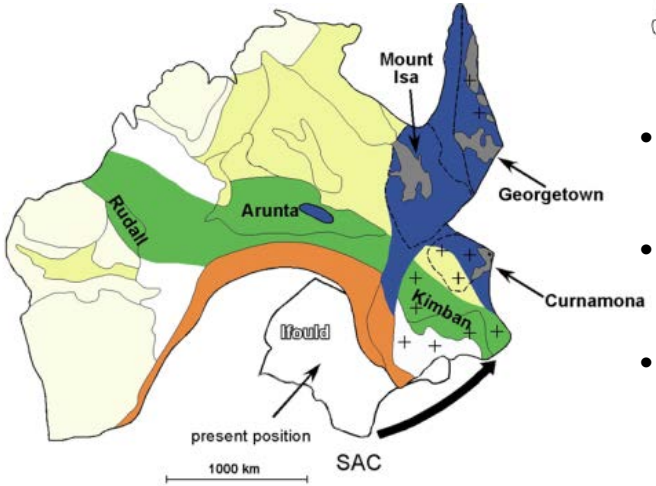
Plate tectonic models

1.8–1.5-Ga links between the North and South Australian Cratons and the Early–Middle Proterozoic configuration of Australia

David Giles*, Peter G. Betts, Gordon S. Lister

School of Geosciences, Australian Crustal Research Centre, Monash University, Melbourne VIC 3800, Australia

Received 6 February 2003; accepted 20 November 2003



- Concept of NAC, WAC, and SAC (later)
- Internal movements within the continent
- Rodinia – reconfiguration event

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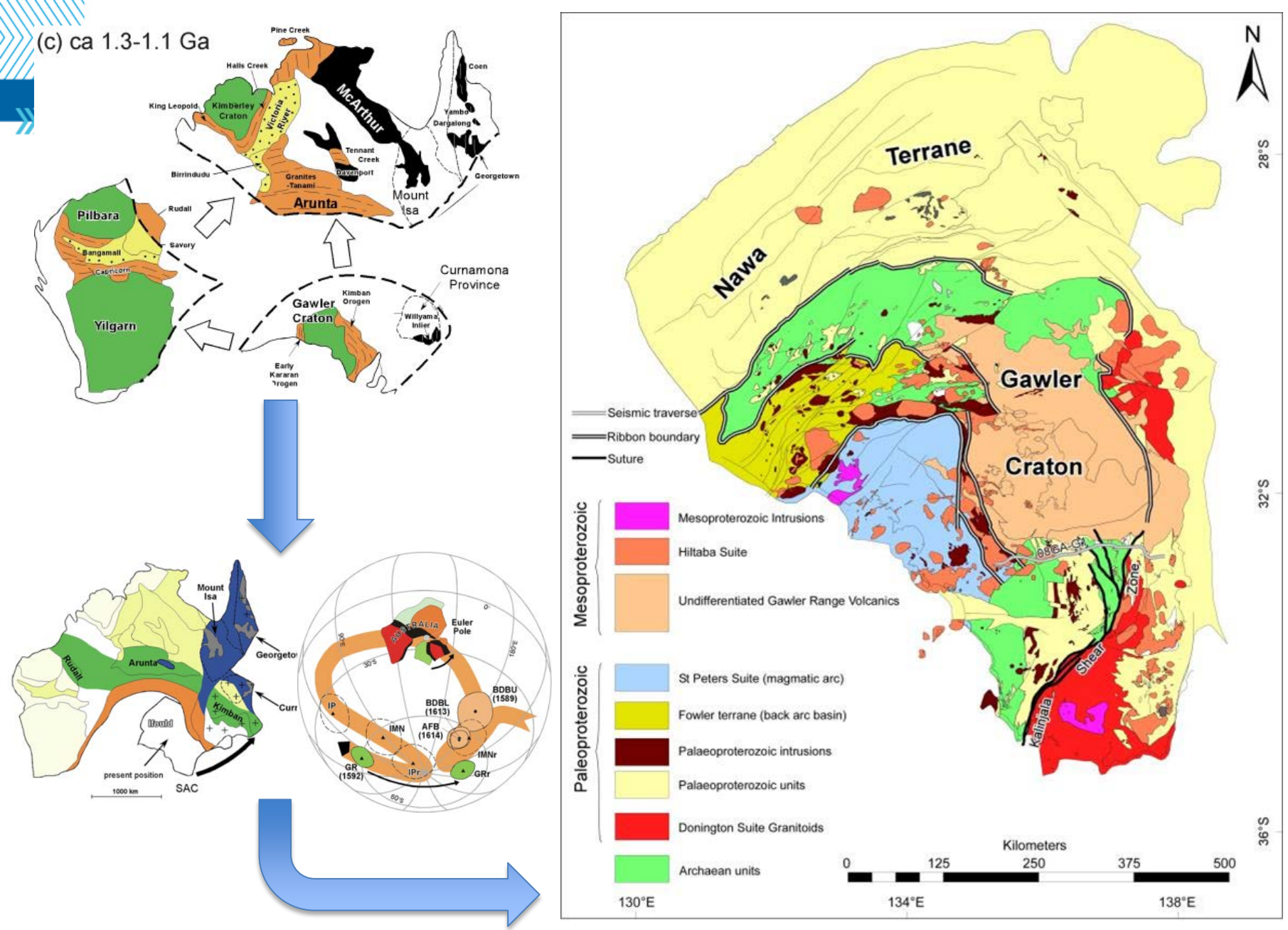

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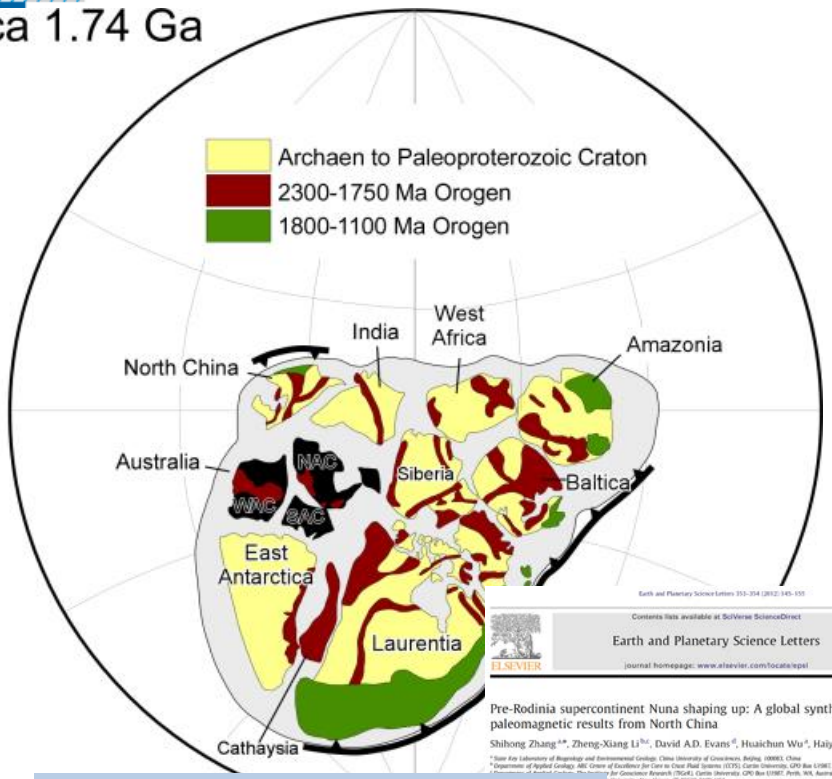
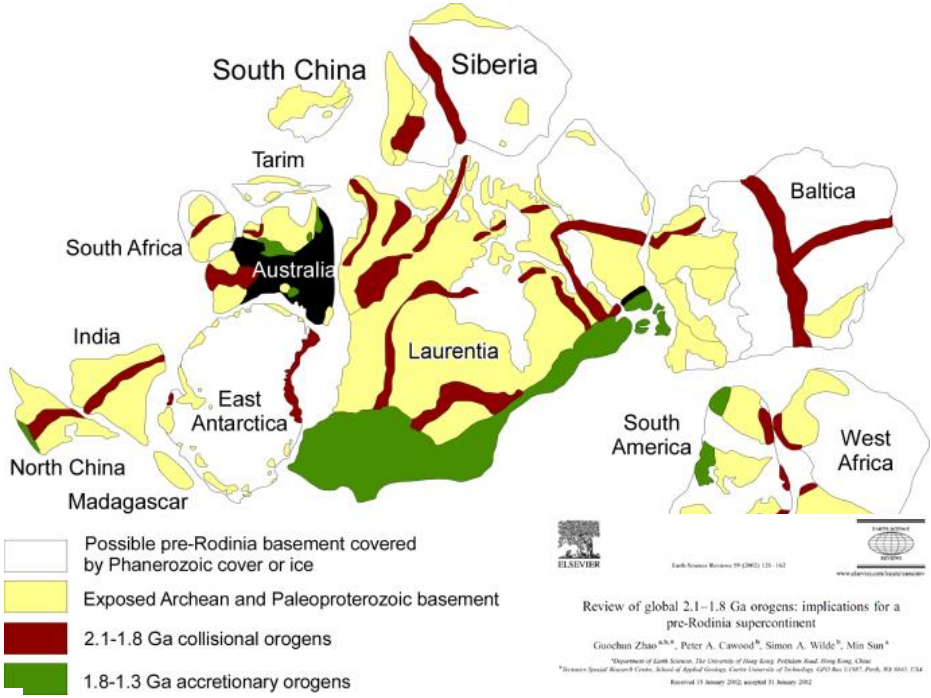
Figure 6

AUSTRALIA and NUNA



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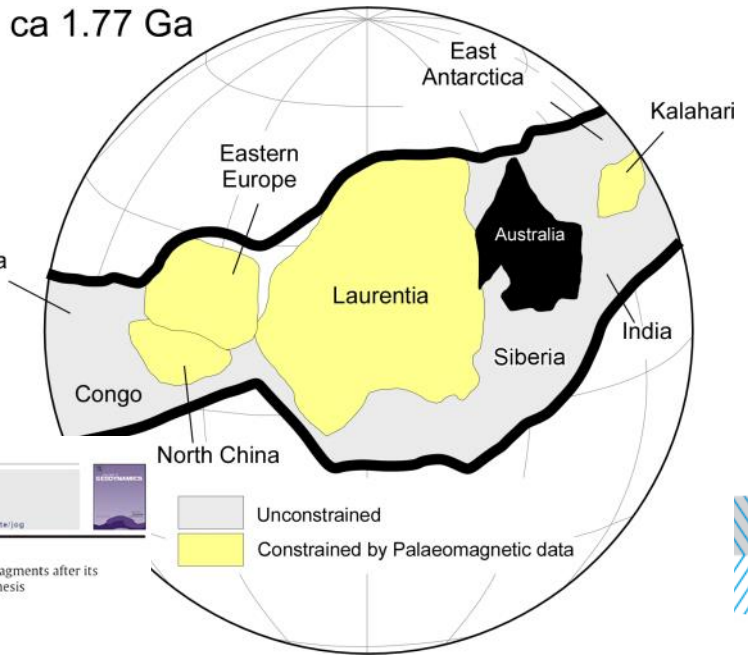
Pre-Rodinia supercontinent Nuna shaping up: A global synthesis with new paleomagnetic results from North China

Shihong Zhang, Zheng-Xiang Li, David A.D. Evans, Huaichun Wu, Haiyan Li, Jin Dong

Review of global 2.1–1.8 Ga orogens: implications for a pre-Rodinia supercontinent

Guochun Zhao, Peter A. Cawood, Simon A. Wilde, Min Sun

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Restoring the supercontinent Columbia and tracing its fragments after its breakup: A new configuration and a Super-Horde hypothesis

Alexander Yakubchuk

Some Aussie issues!

- **Australia in an internal position when all of the geology suggests an external position**
- **Australia-Antarctica configuration same as Gondwana**
- **Australia treated as a single entity**

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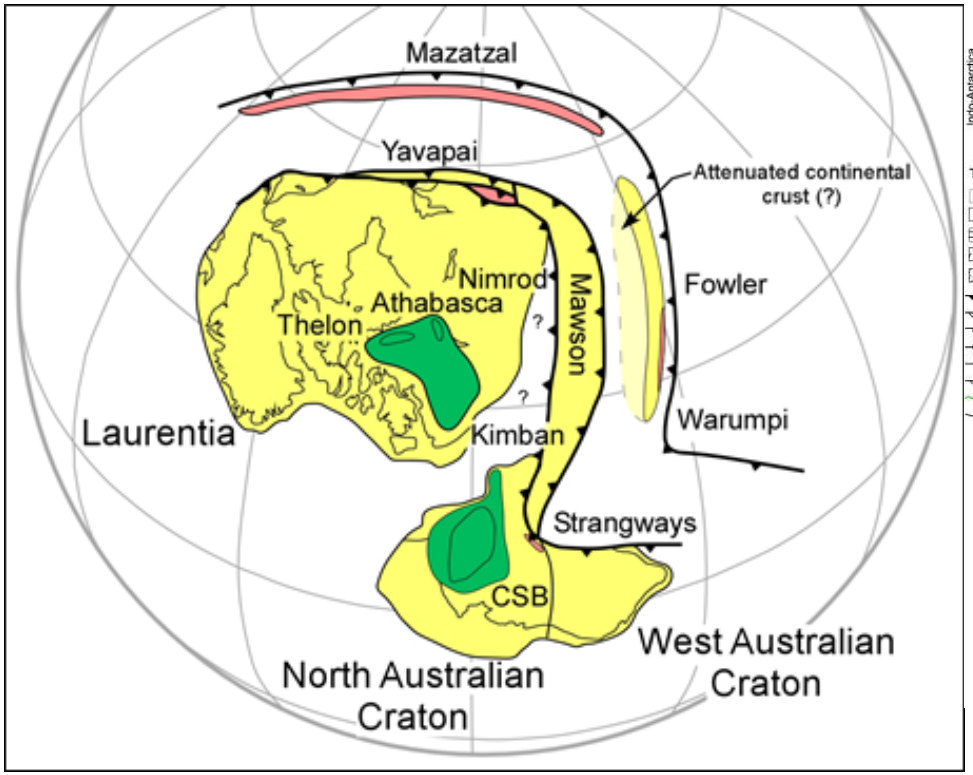
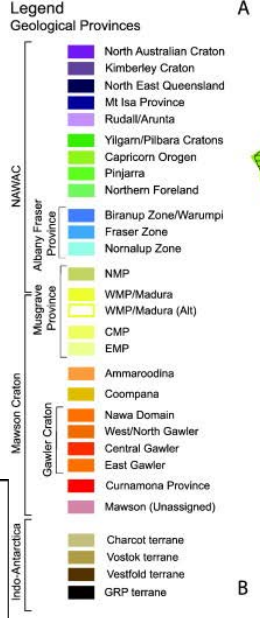
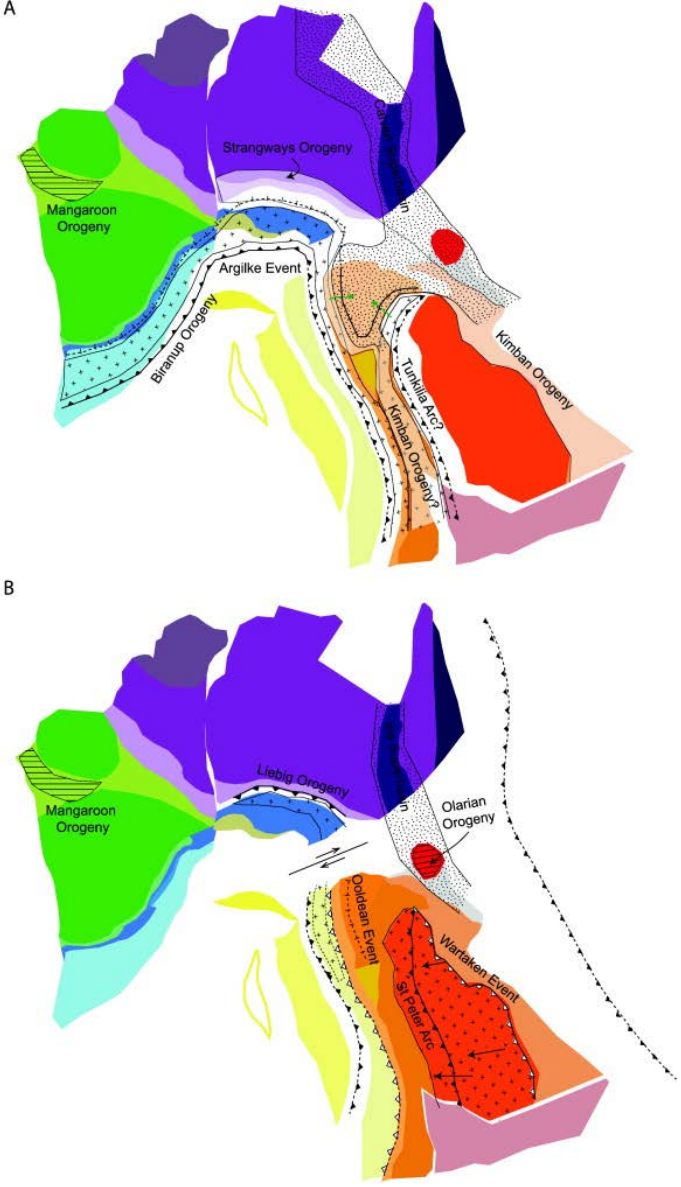
AUSTRALIA and NUNA

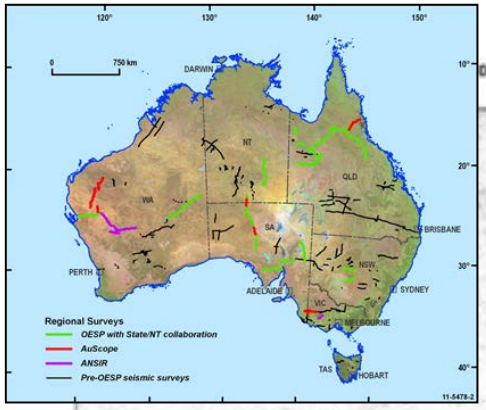


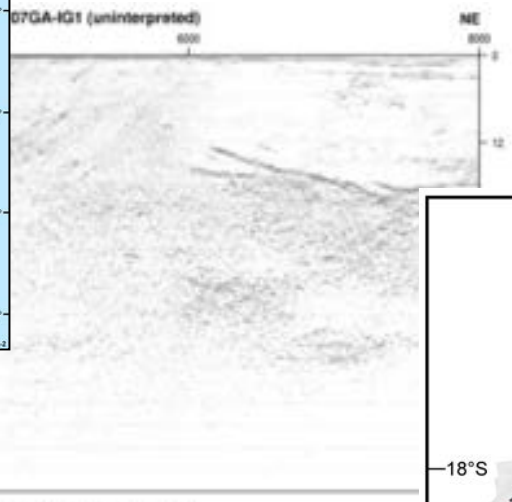


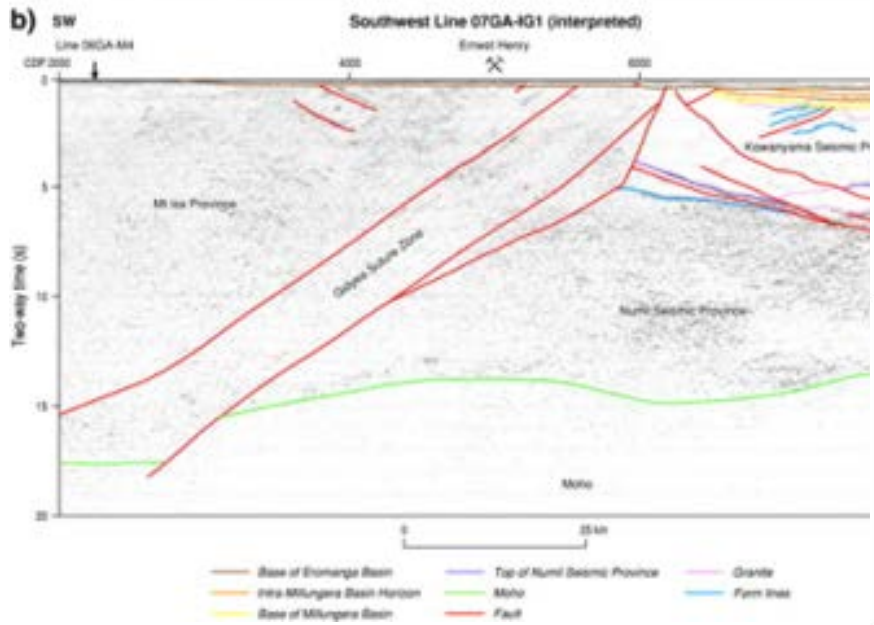


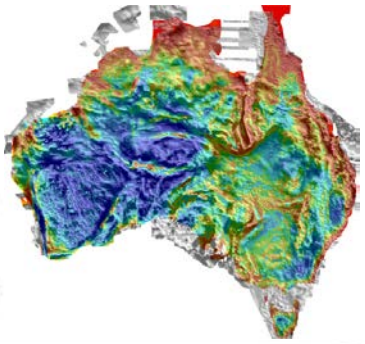
Crustal scale deep seismic reflection data and continental scale geophysics grids

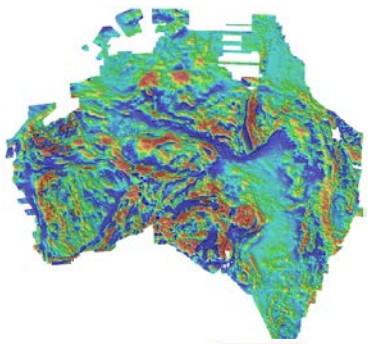
Courtesy of Geoscience Australia

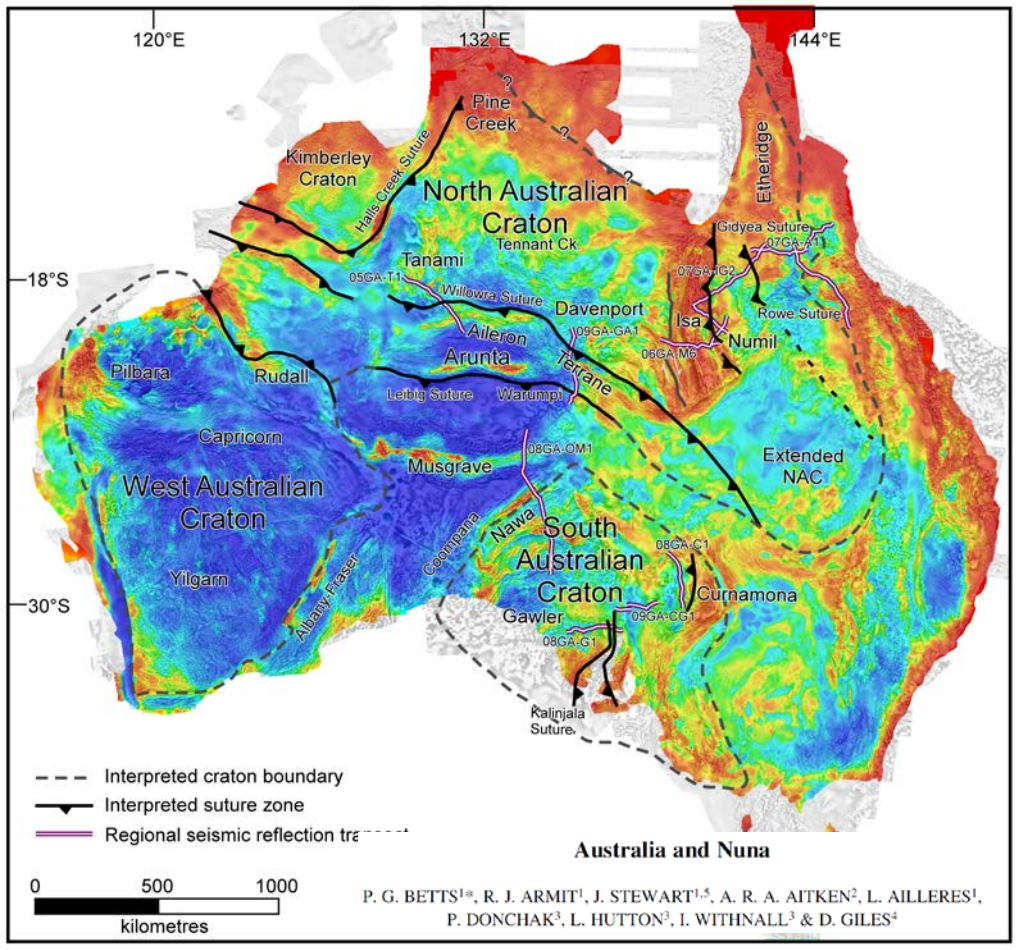


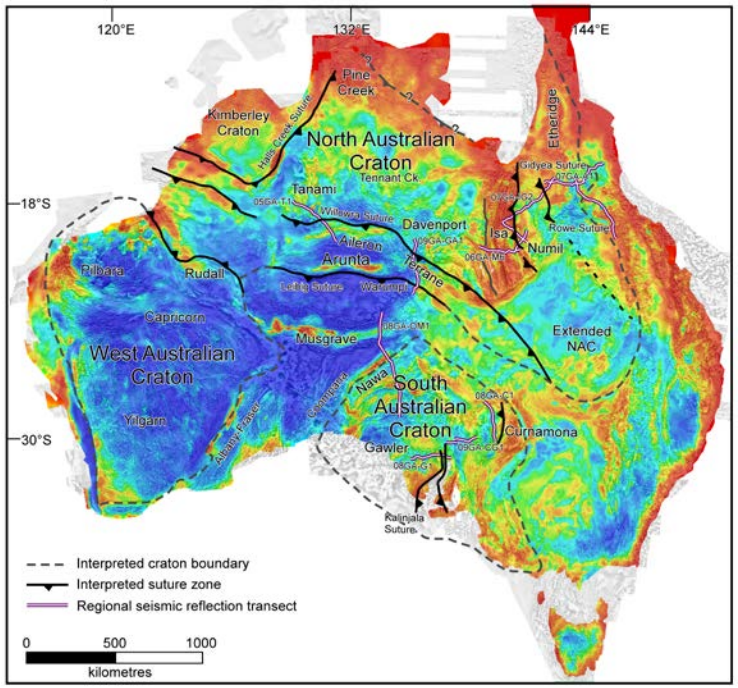


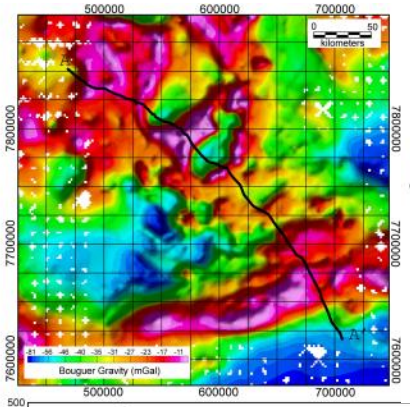


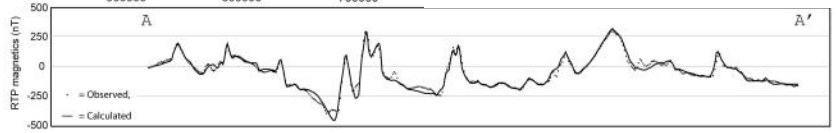


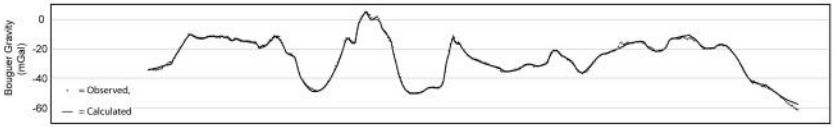


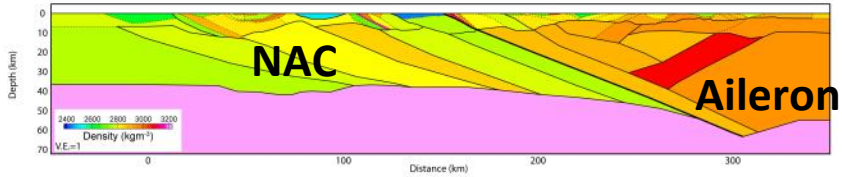


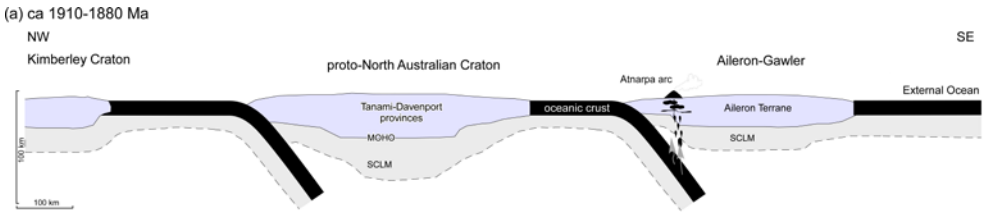


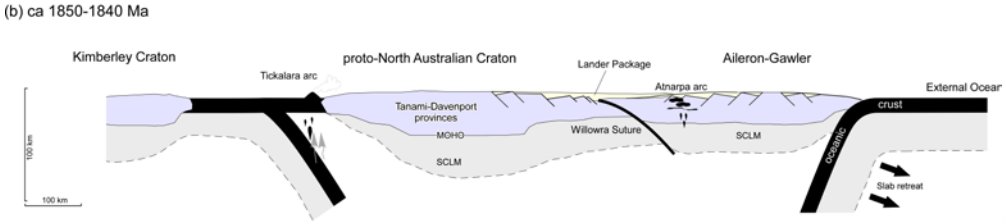












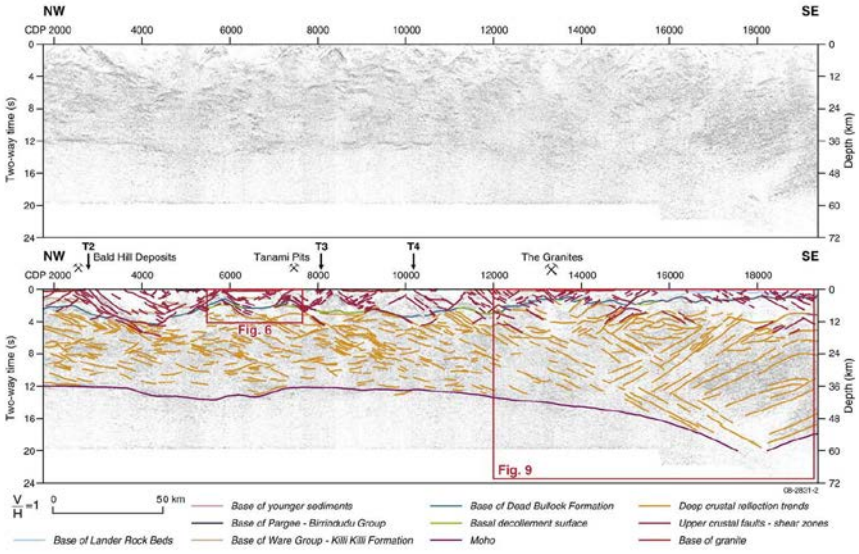


Figure 5

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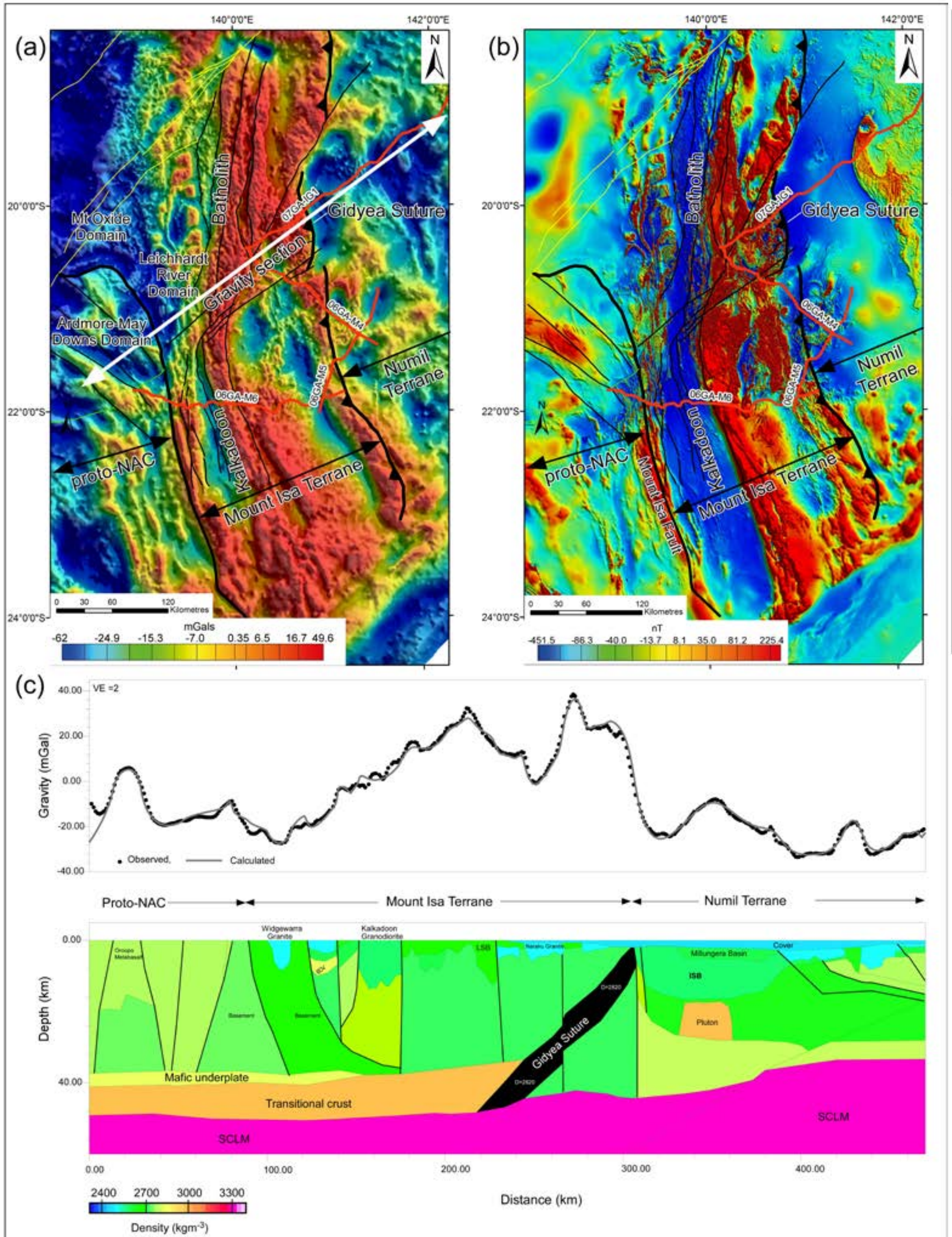
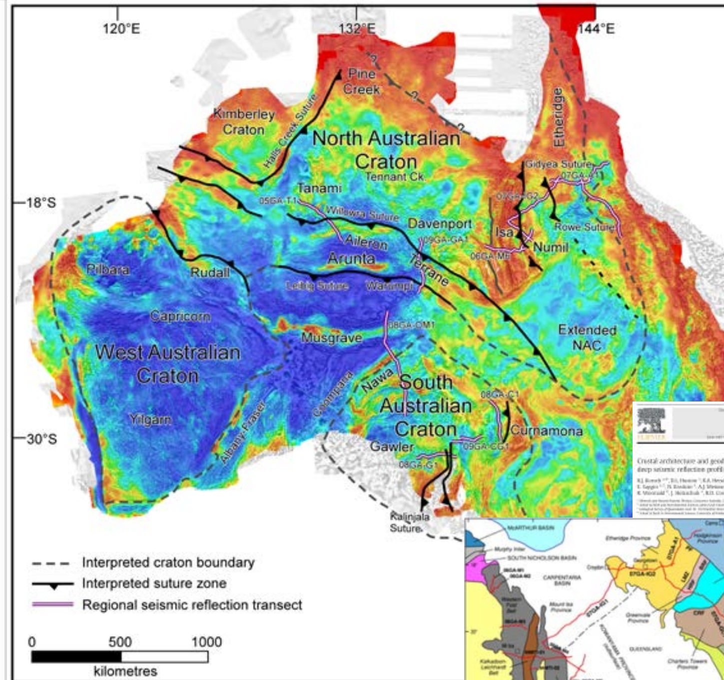
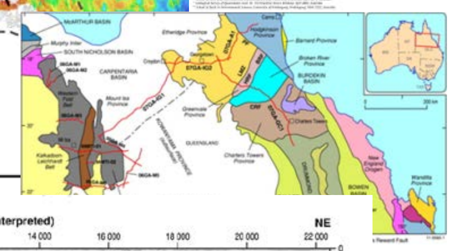
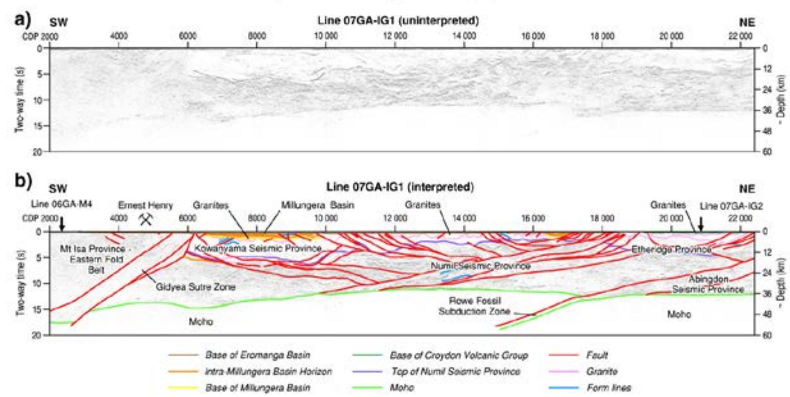


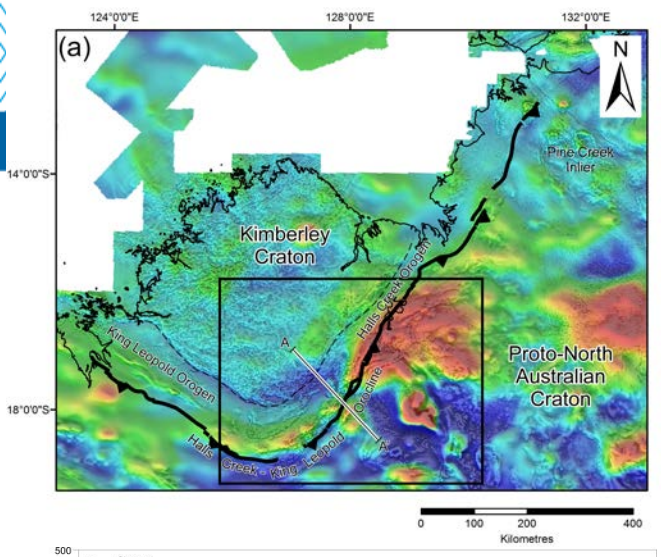


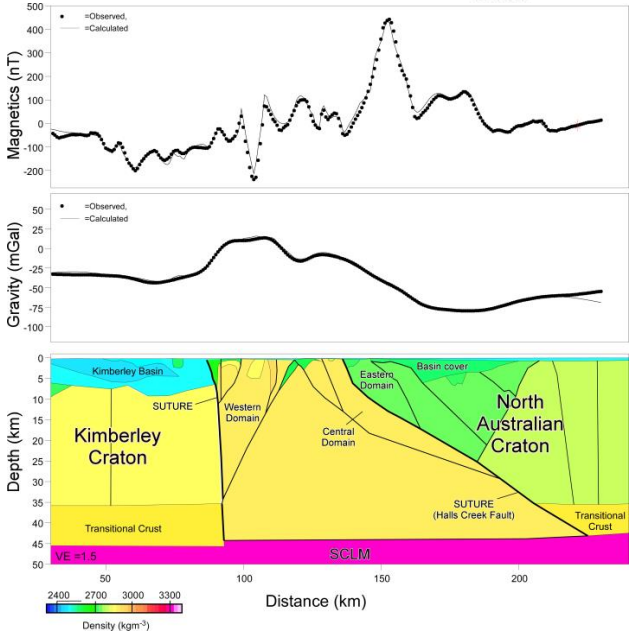


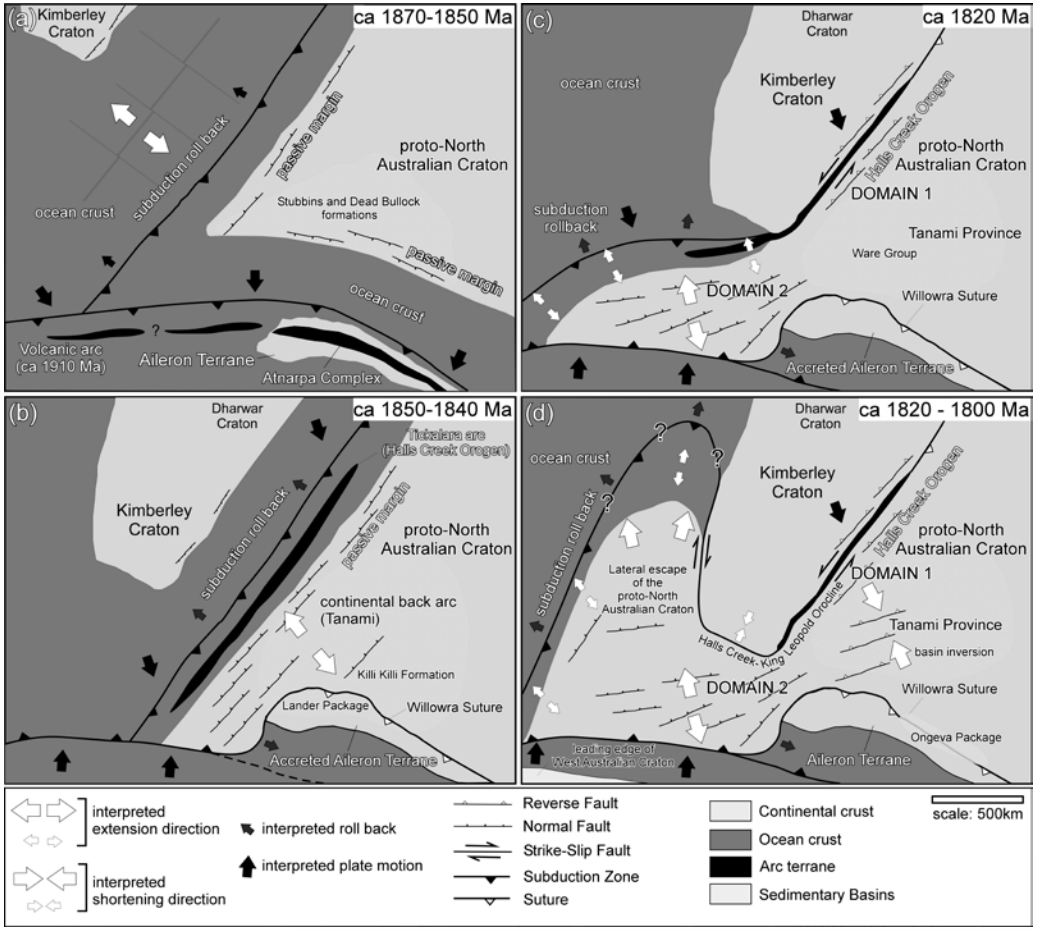


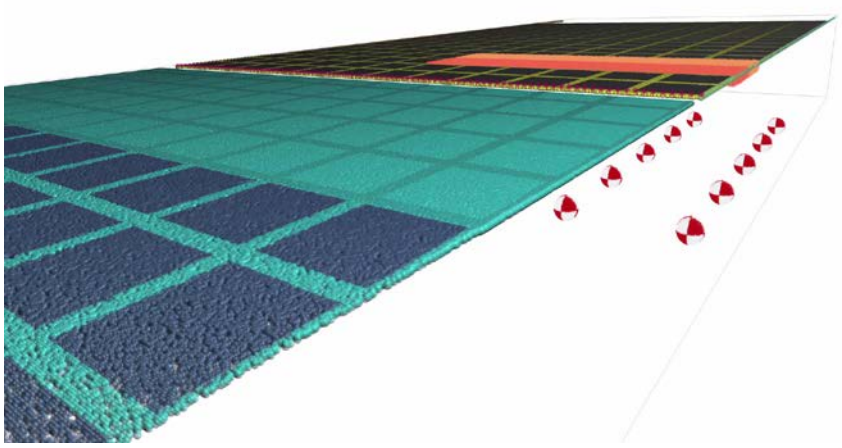
- **Kalkadoon Batholith ca 1850 Ma – arc or back arc**
- **Gidyea Suture – collision of Numil terrane and the Mount Isa terrane.**
- **1850 Ma – 1800 Ma (younger basins)**

Figure 6









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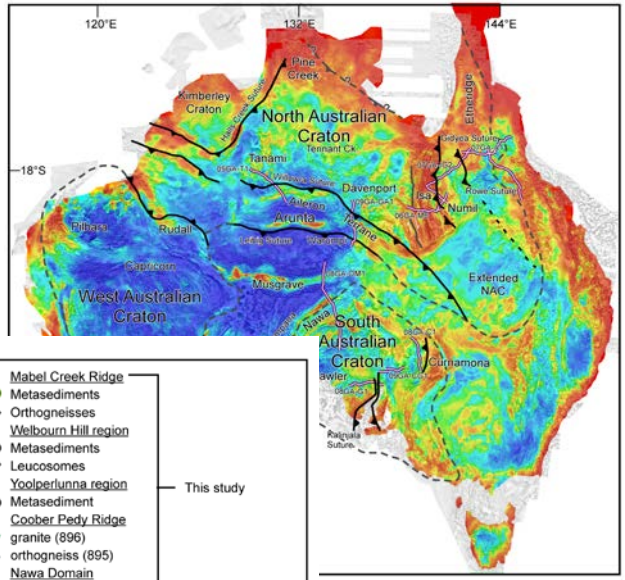
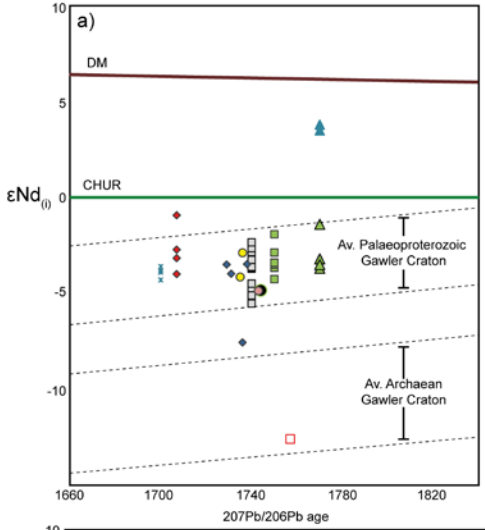
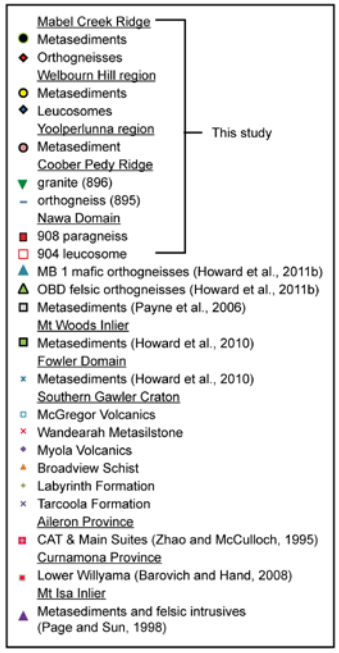
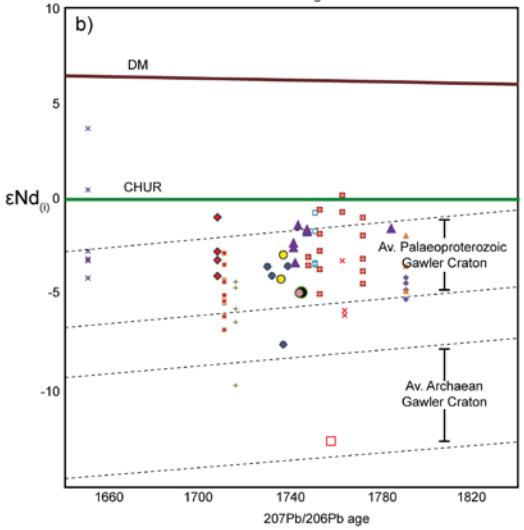
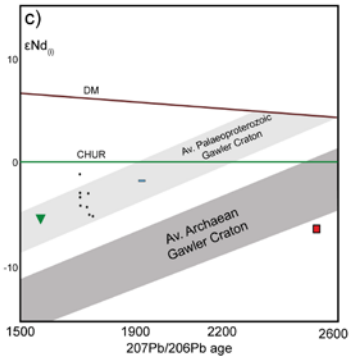
Isotopic Data

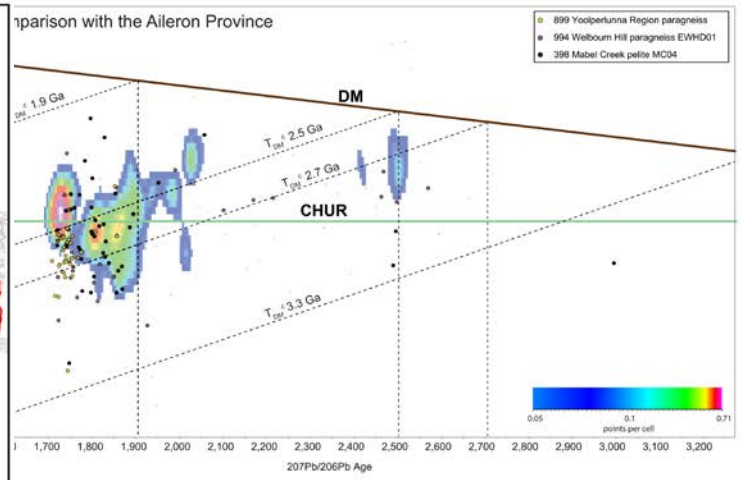


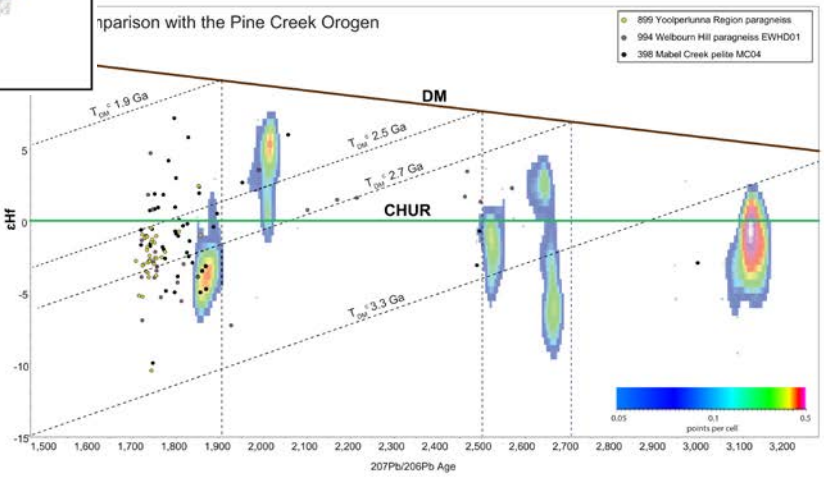


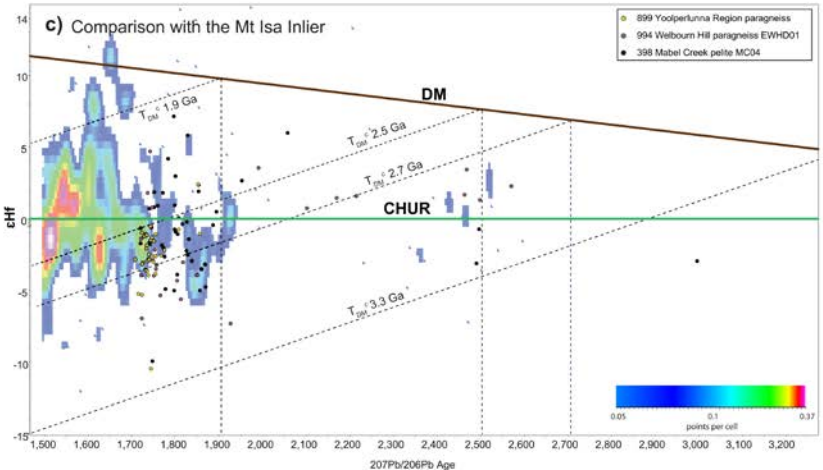


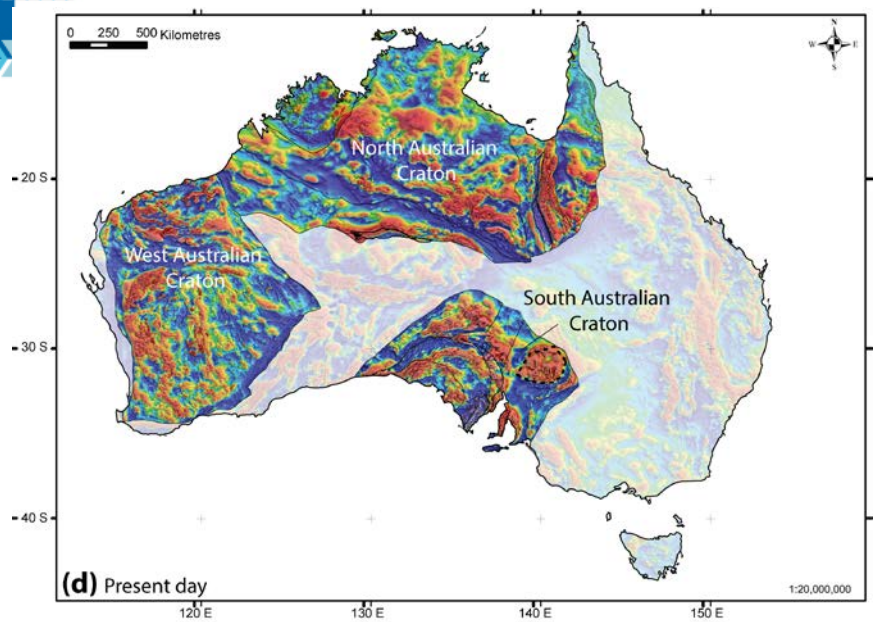


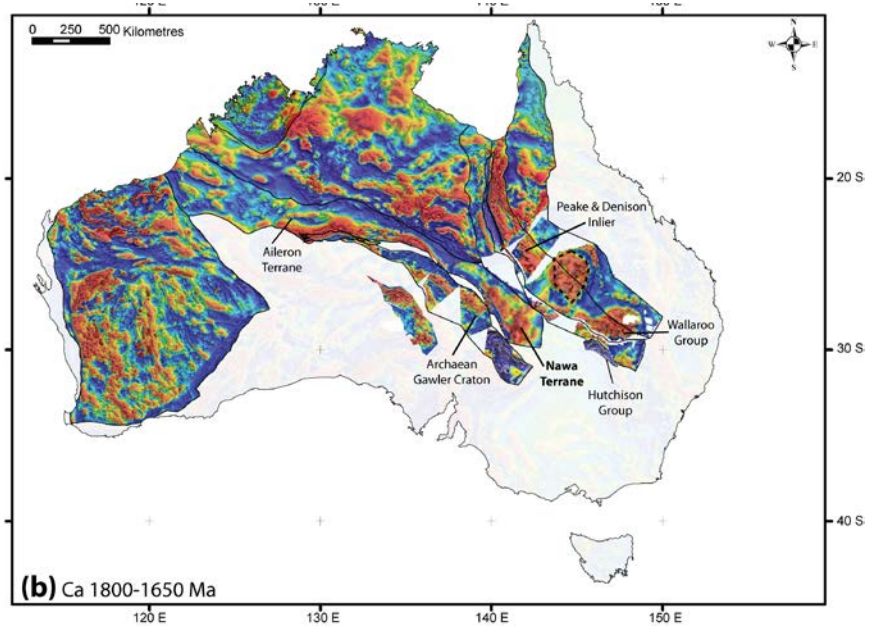


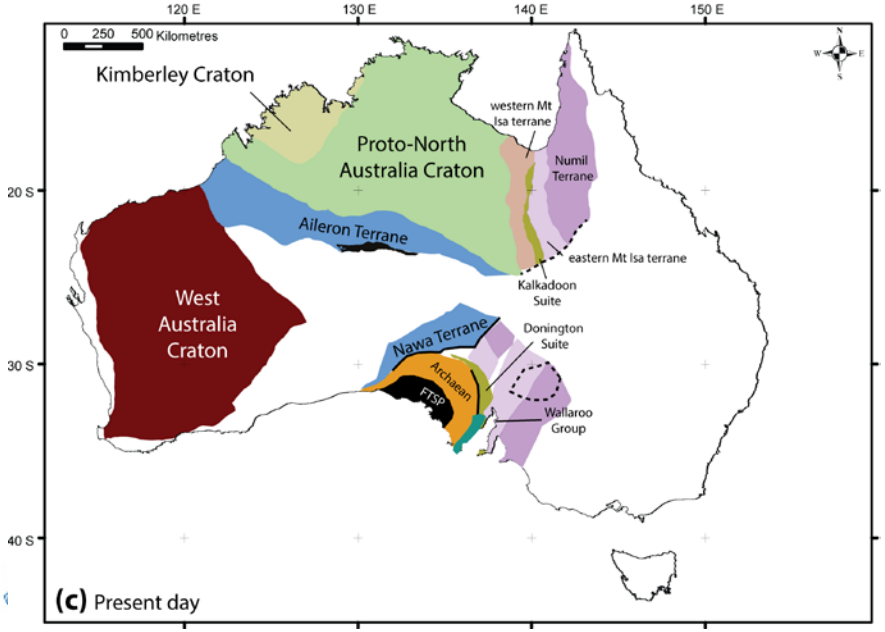


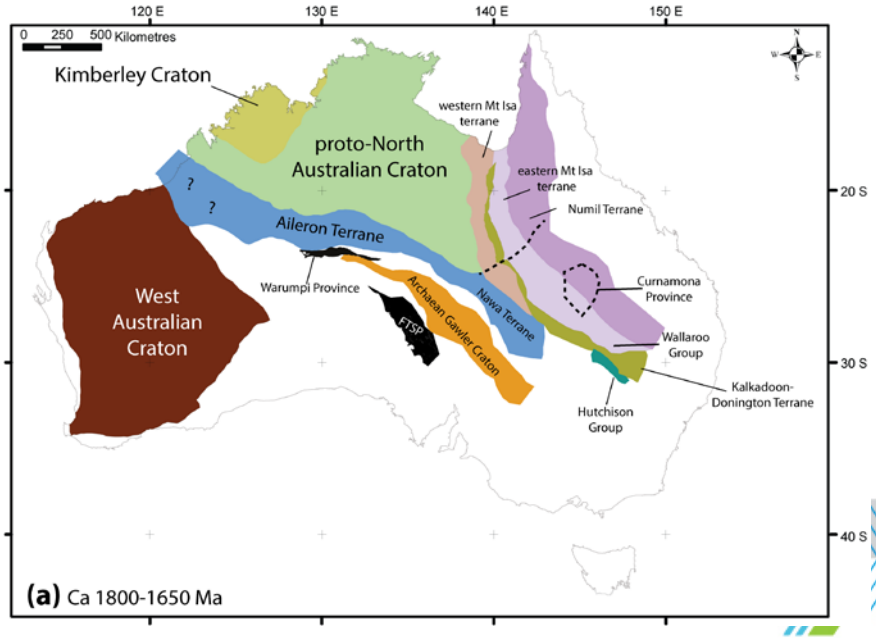


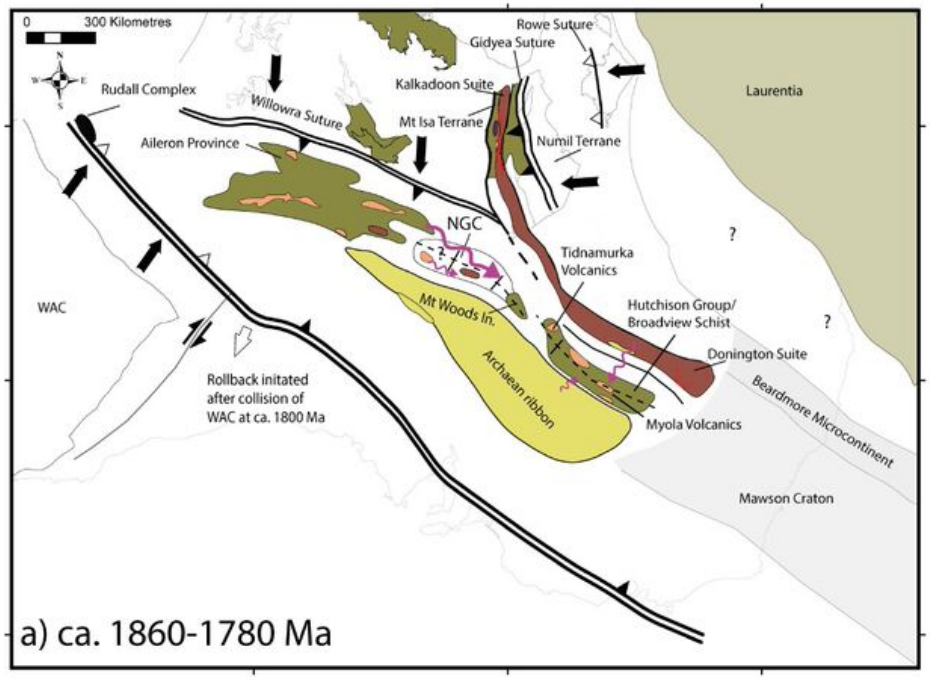


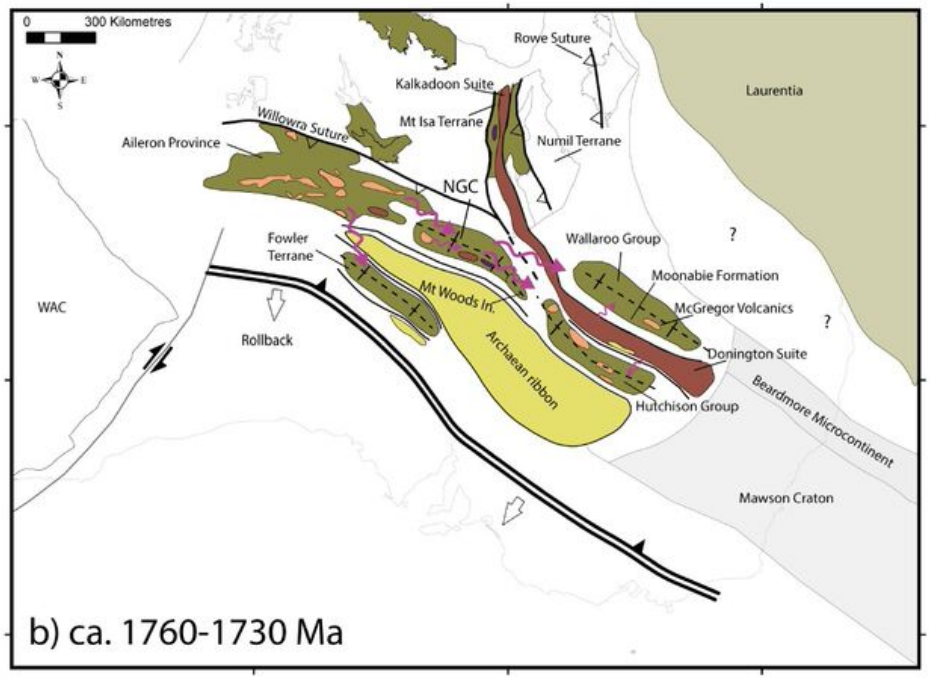

0 250 500 Kilometres
North Australian Craton
West Australian Craton
South Australian Craton
20 S
30 S
40 S
120 E
130 E
140 E
150 E
(d) Present day
1:20,000,000

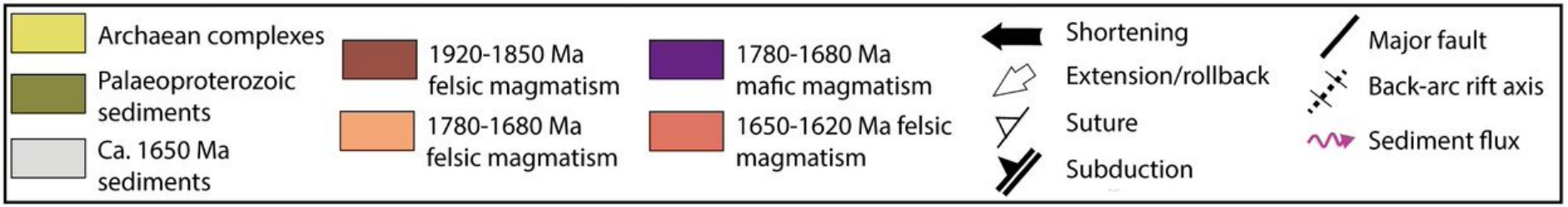

0 250 500 Kilometres
Peake & Denison Inlier
Aileron Terrane
Wallaroo Group
Archaean Gawler Craton
Nawa Terrane
Hutchison Group
20 S
30 S
40 S
120 E
130 E
140 E
150 E
(b) Ca 1800-1650 Ma

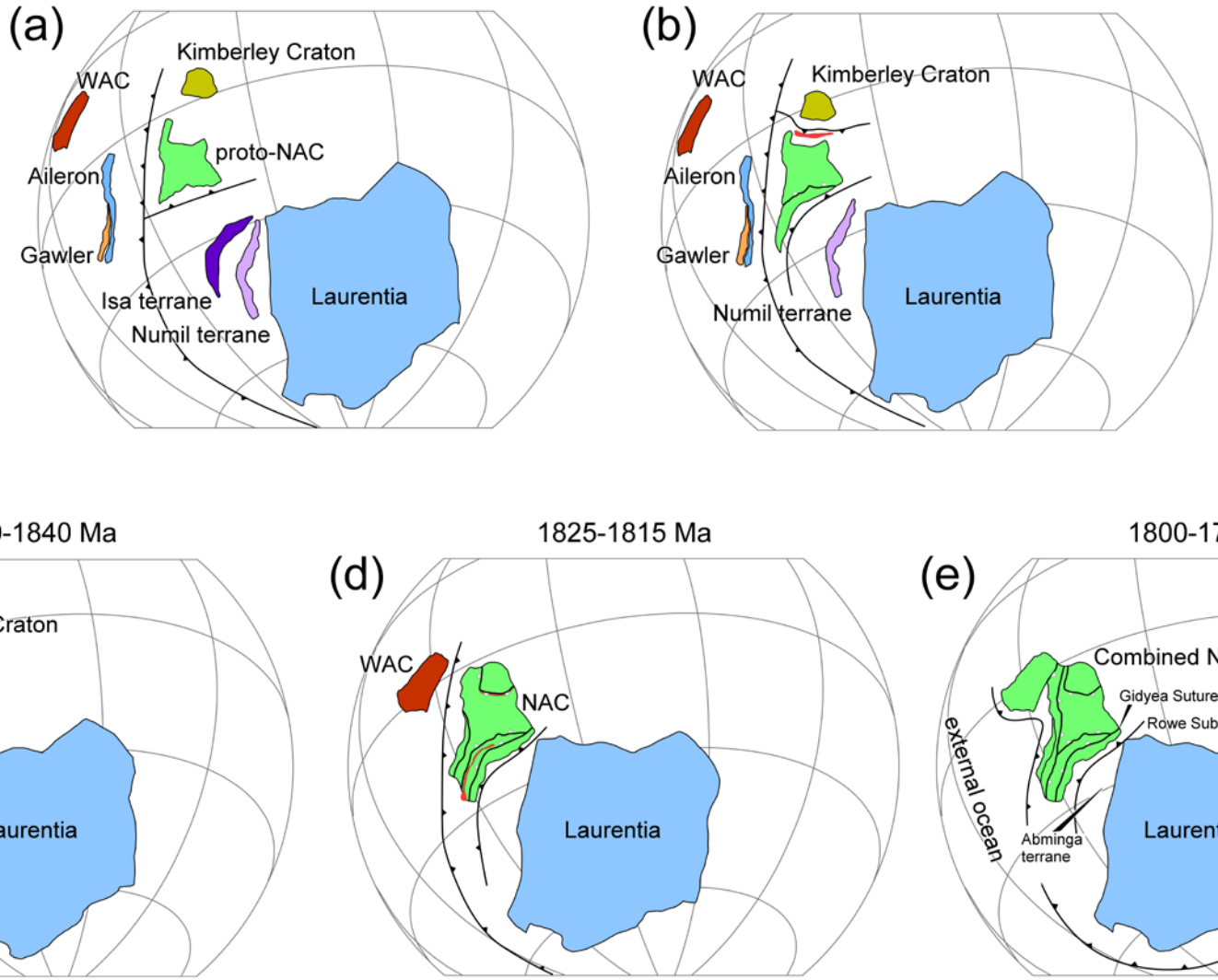

0 250 500 Kilometres
Kimberley Craton
western Mt Isa terrane
Proto-North Australia Craton
Numil Terrane
Aileron Terrane
eastern Mt Isa terrane
Kalkadoon Suite
West Australia Craton
Nawa Terrane
Donington Suite
Archaean
FTSP
Wallaroo Group
20 S
30 S
40 S
120 E
130 E
140 E
150 E
(c) Present day


0 250 500 Kilometres
Kimberley Craton
western Mt Isa terrane
proto-North Australian Craton
eastern Mt Isa terrane
Numil Terrane
?
?
Aileron Terrane
Warumpi Province
Archaean Gawler Craton
Nawa Terrane
Curnamona Province
FTSP
West Australian Craton
Wallaroo Group
Kalkadoon-Donington Terrane
Hutchison Group
20 S
30 S
40 S
120 E
130 E
140 E
150 E
(a) Ca 1800-1650 Ma

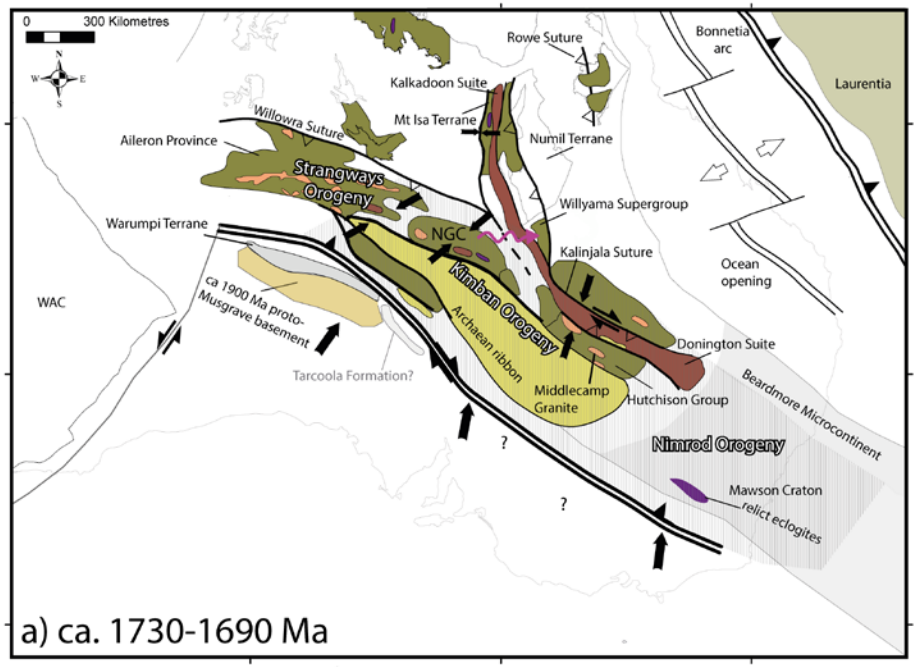

0 300 Kilometres
Rudall Complex
Willowra Suture
Aileron Province
Rowe Suture
Gidyea Suture
Kalkadoon Suite
Mt Isa Terrane
Numil Terrane
Laurentia
NGC
Tidnamurka Volcanics
Hutchison Group/ Broadview Schist
Donington Suite
Myola Volcanics
Mt Woods In.
Archaean ribbon
Beardmore Microcontinent
Mawson Craton
WAC
Rollback initated after collision of WAC at ca. 1800 Ma
a) ca. 1860-1780 Ma

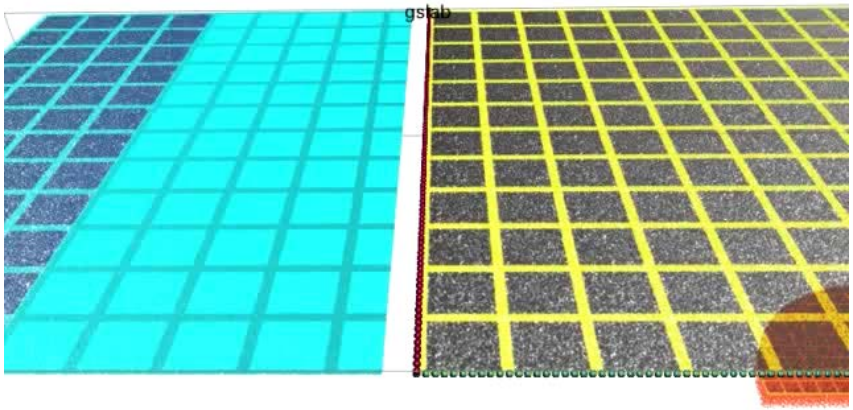

0 300 Kilometres
Rowe Suture
Kalkadoon Suite
Laurentia
Willowra Suture
Mt Isa Terrane
Aileron Province
Numil Terrane
NGC
Fowler Terrane
Wallaroo Group
Moonabie Formation
McGregor Volcanics
Donington Suite
Hutchison Group
Mt Woods In.
Archaean ribbon
Beardmore Microcontinent
Mawson Craton
WAC
Rollback
b) ca. 1760-1730 Ma

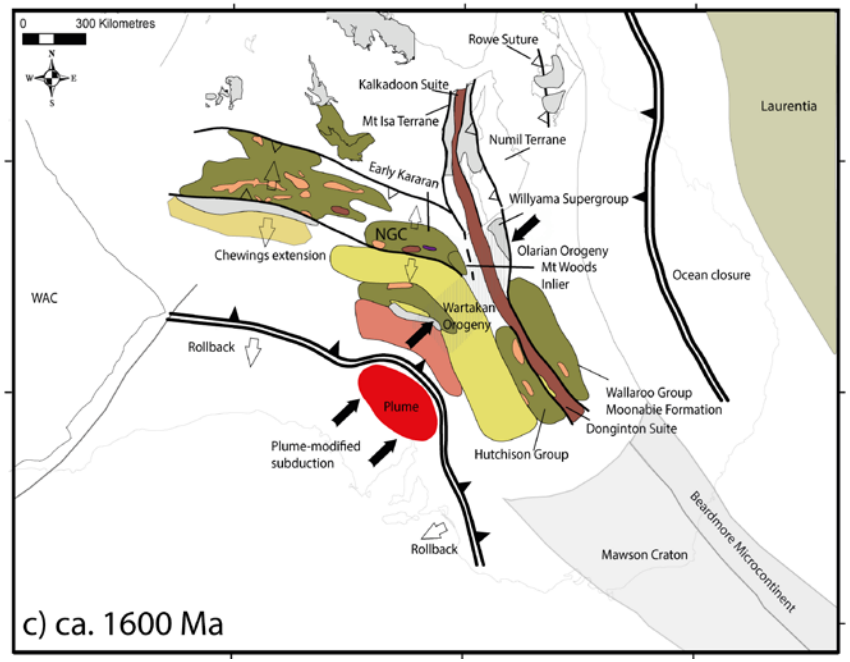

Archaean complexes
Palaeoproterozoic sediments
Ca. 1650 Ma sediments
1920-1850 Ma felsic magmatism
1780-1680 Ma felsic magmatism
1780-1680 Ma mafic magmatism
1650-1620 Ma felsic magmatism
Shortening
Extension/rollback
Suture
Subduction
Major fault
Back-arc rift axis
Sediment flux



- Six fragments - ribbons
  1. Proto-North Australia Craton
  2. Aileron Province (include Gawler)
  3. Isa terrane
  4. Numil terrane (parts of Curnamona)
  5. Kimberley Craton (Plateau: Lindsay et al.)
  6. West Australian Craton
- Evidence for juvenile arc terranes (e.g., Kirkland et al., 2012)







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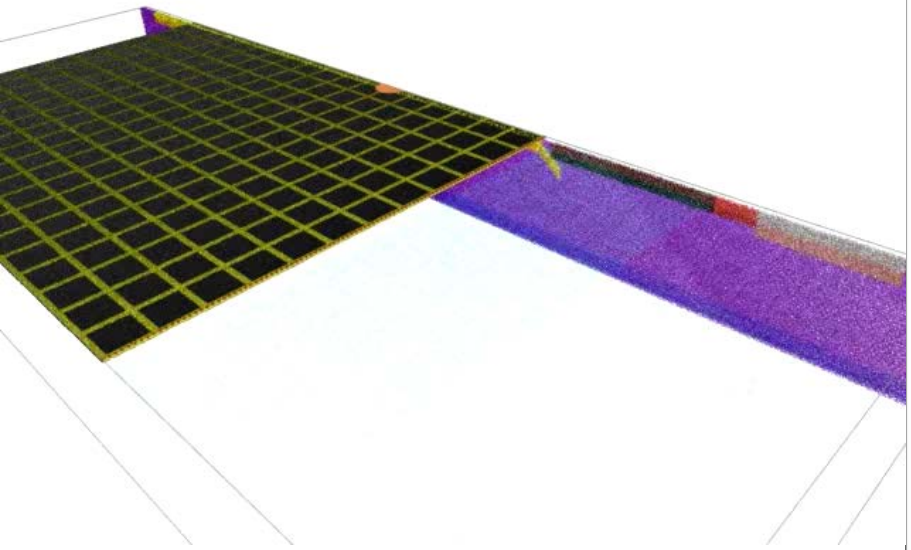

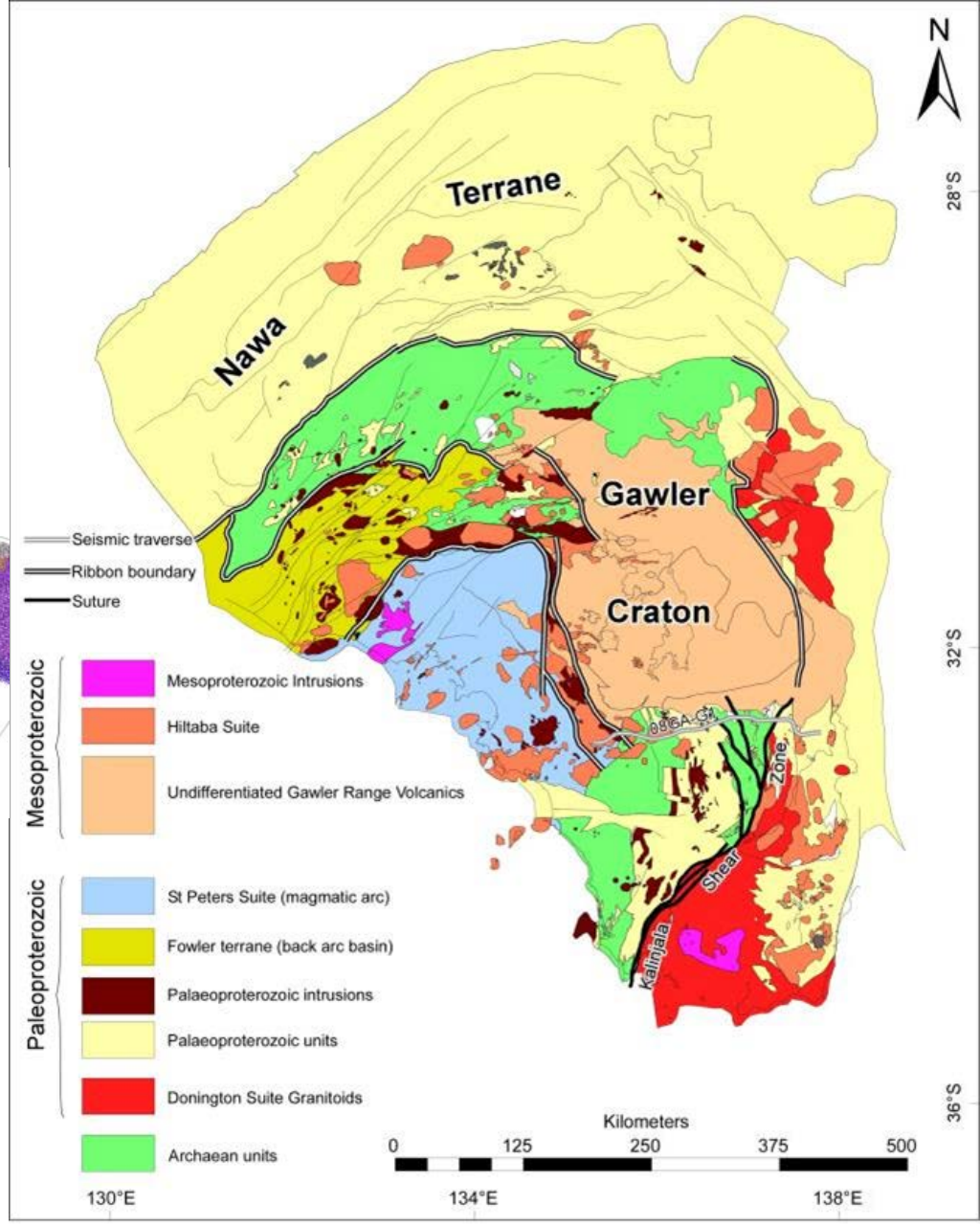

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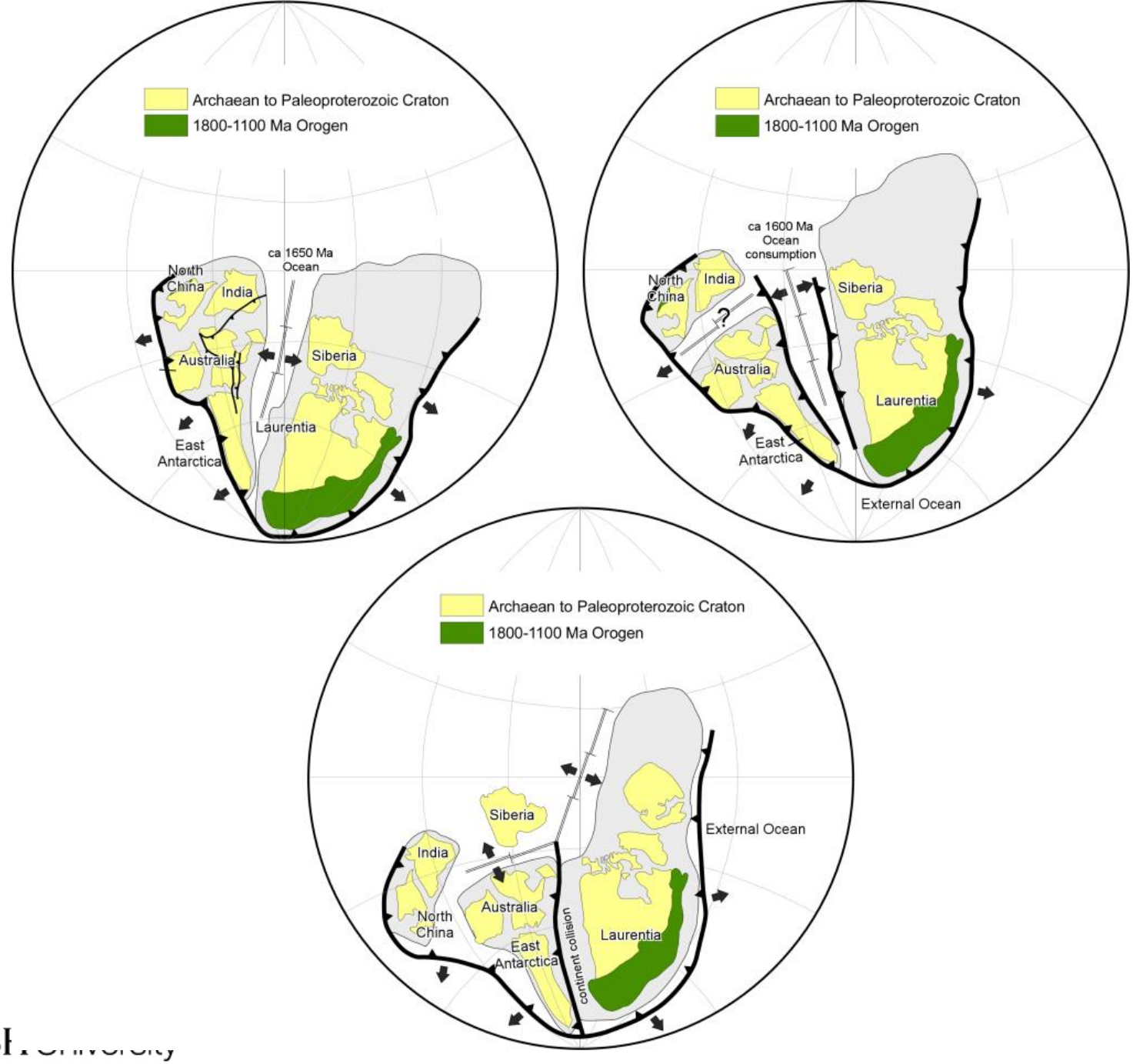
Figure 6


Archaean to Paleoproterozoic Craton
1800-1100 Ma Orogen
North China
India
Australia
East Antarctica
Siberia
Laurentia
ca 1650 Ma Ocean
ca 1600 Ma Ocean consumption
?
External Ocean
continent collision

The Tasmanides

Recent Game changes – in my opinion

1. **Recognition of the Selwyn Block**
(Cayley and Taylor, 2002).

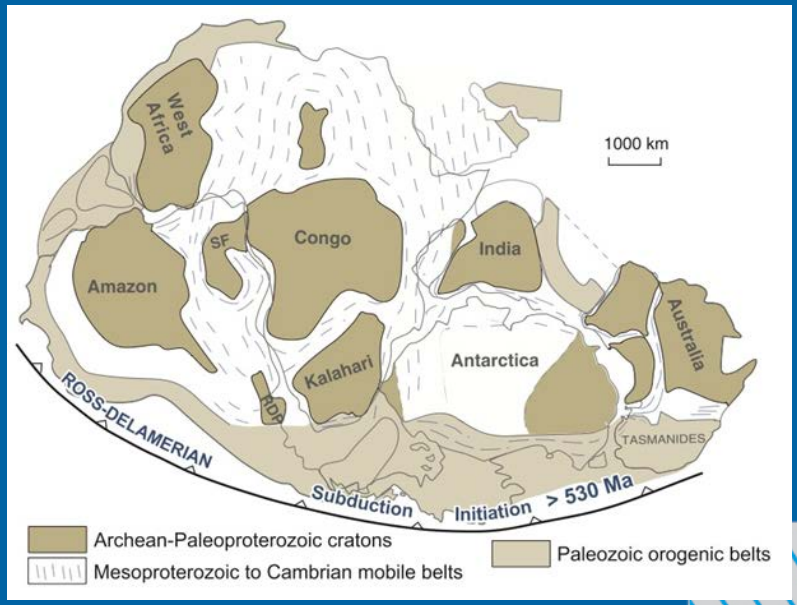
2. **Hot (*and extensional*) Orogens**
(Collins, 2002).

3. **VanDieland micro-continent concept**
(Cayley, 2011).

4. **High resolution geophysical data under-cover.**

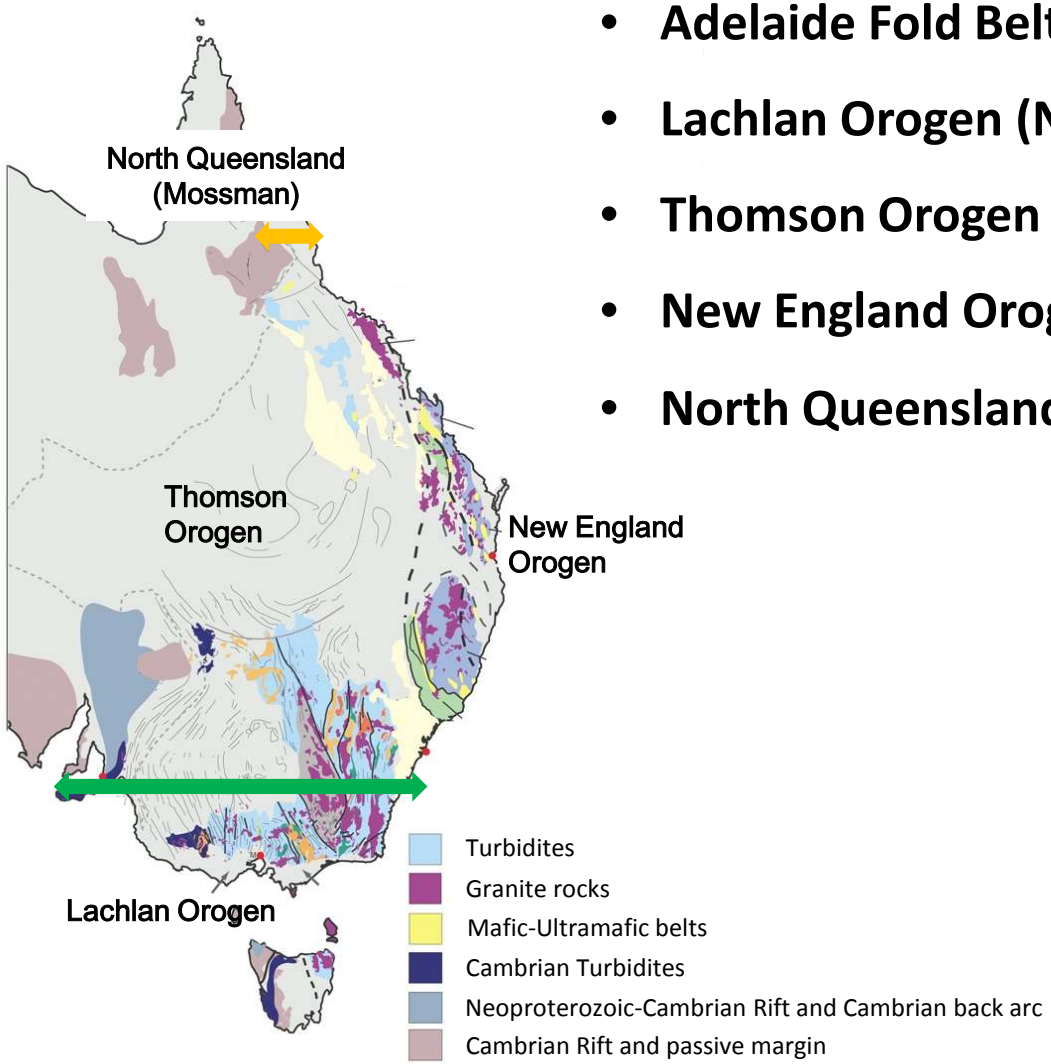
6. **Temporal constraints** (e.g., Fergusson/Henderson)

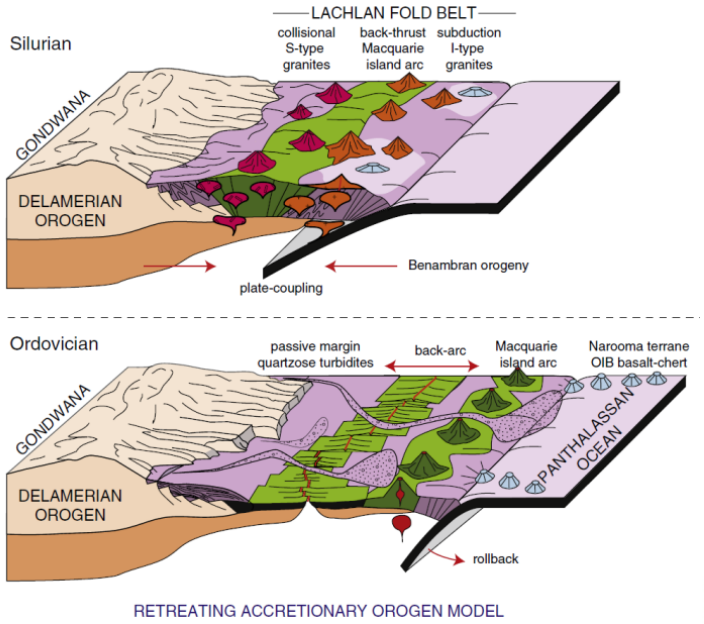
5. **"Cayley model" in all its intricacies**
(Cayley in prep).



The Tasmanides

- Adelaide Fold Belt (Neoproterozoic-Ordovician).
- Lachlan Orogen (Neoproterozoic-Carboniferous).
- Thomson Orogen (Neoproterozoic – Triassic)
- New England Orogen (Cambrian-Triassic).
- North Queensland (Neoproterozoic-Triassic).





RETREATING ACCRETIONARY OROGEN MODEL

Aichison and Buckman 2012

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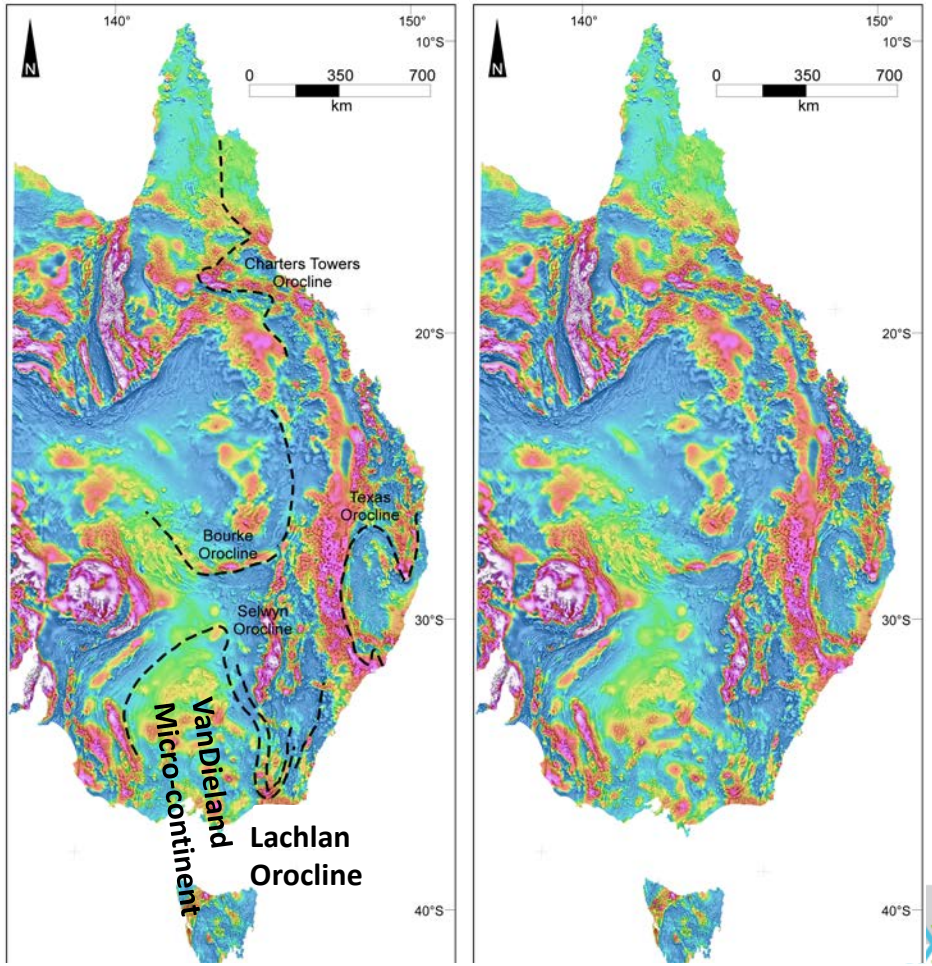
Oroclines are the flavour of the month! Highlights the 3D problem

- Characterised by several large oroclinal features
- Silurian (or older) to Carboniferous
- Combination of roll-back and accretion.



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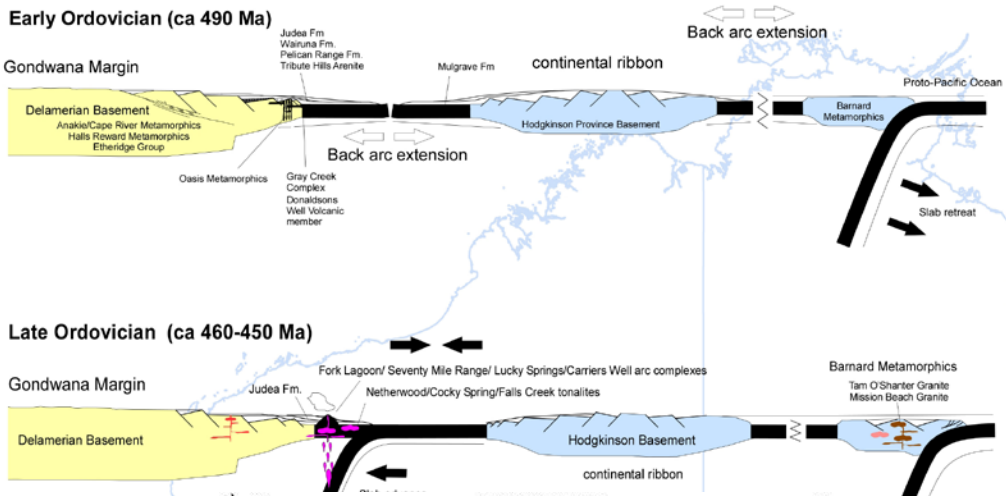
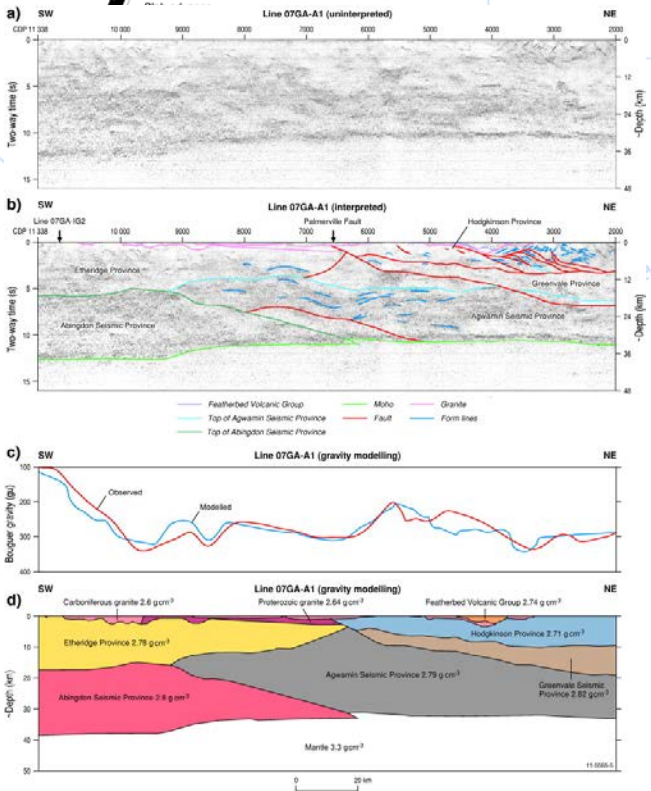
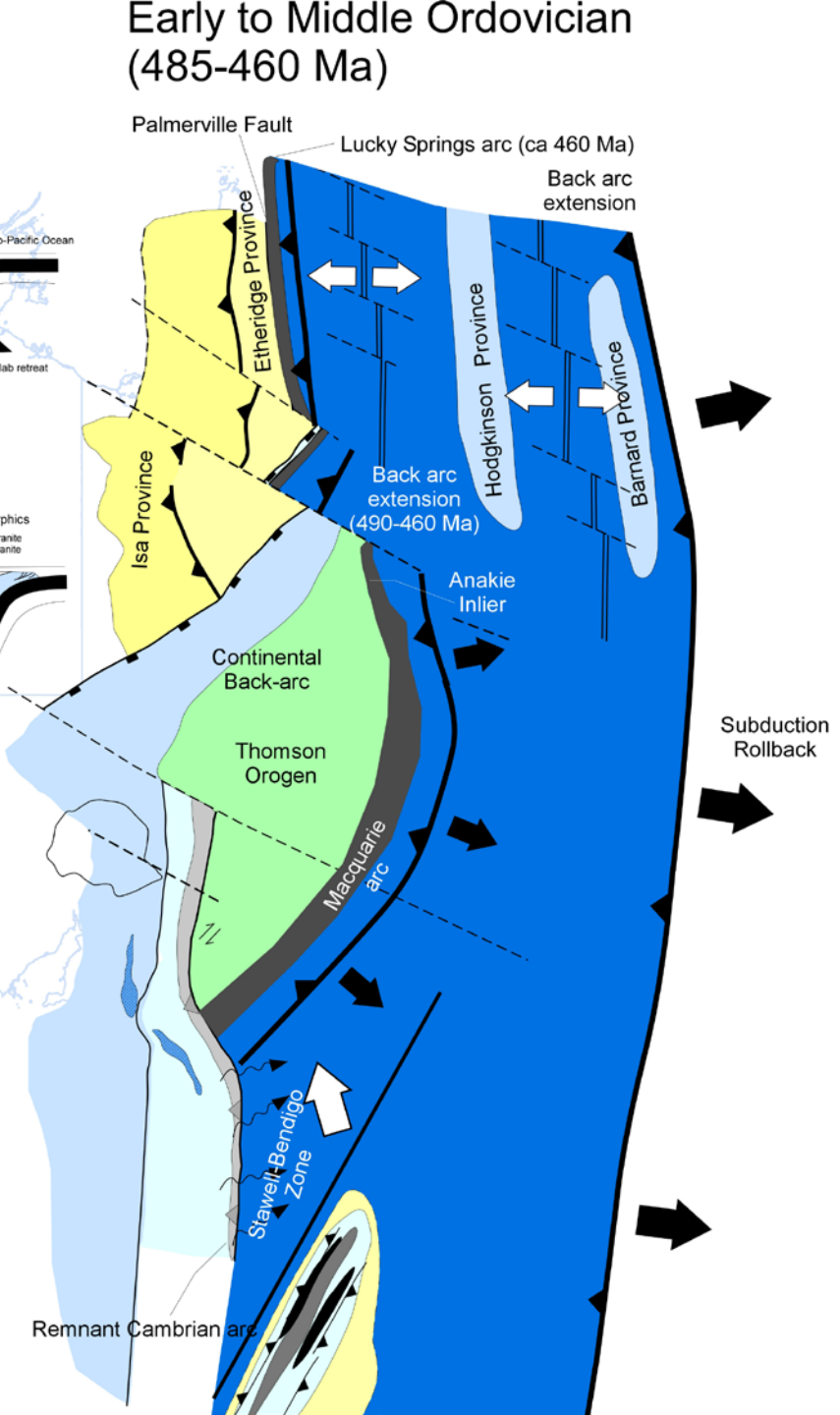
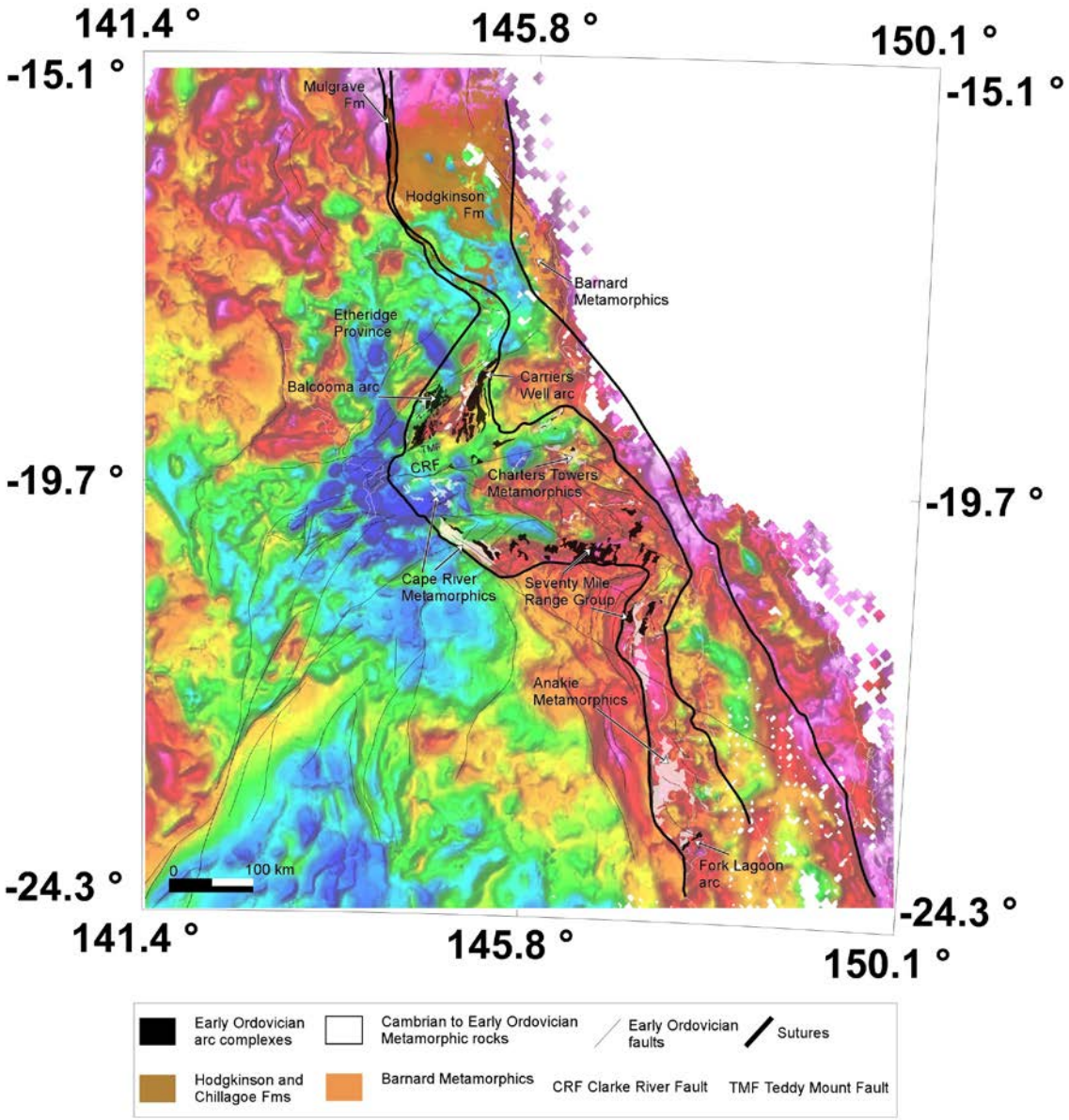
East Gondwana margin



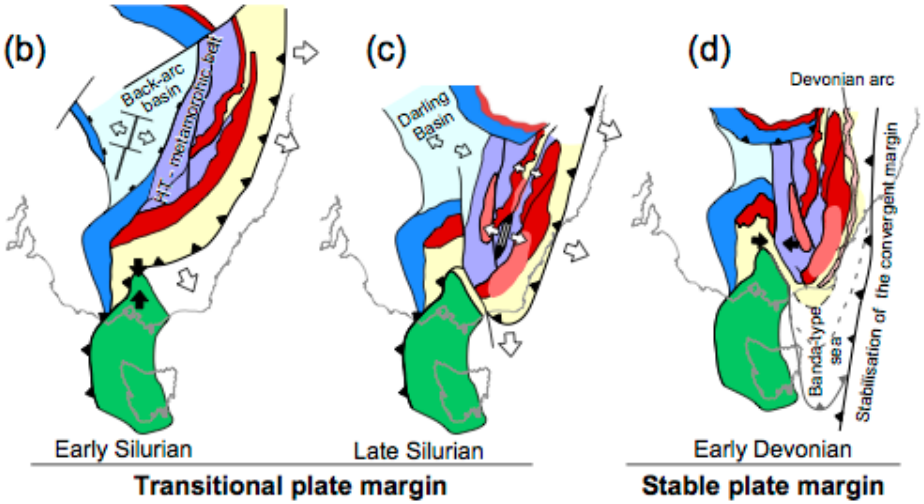




East Gondwana margin

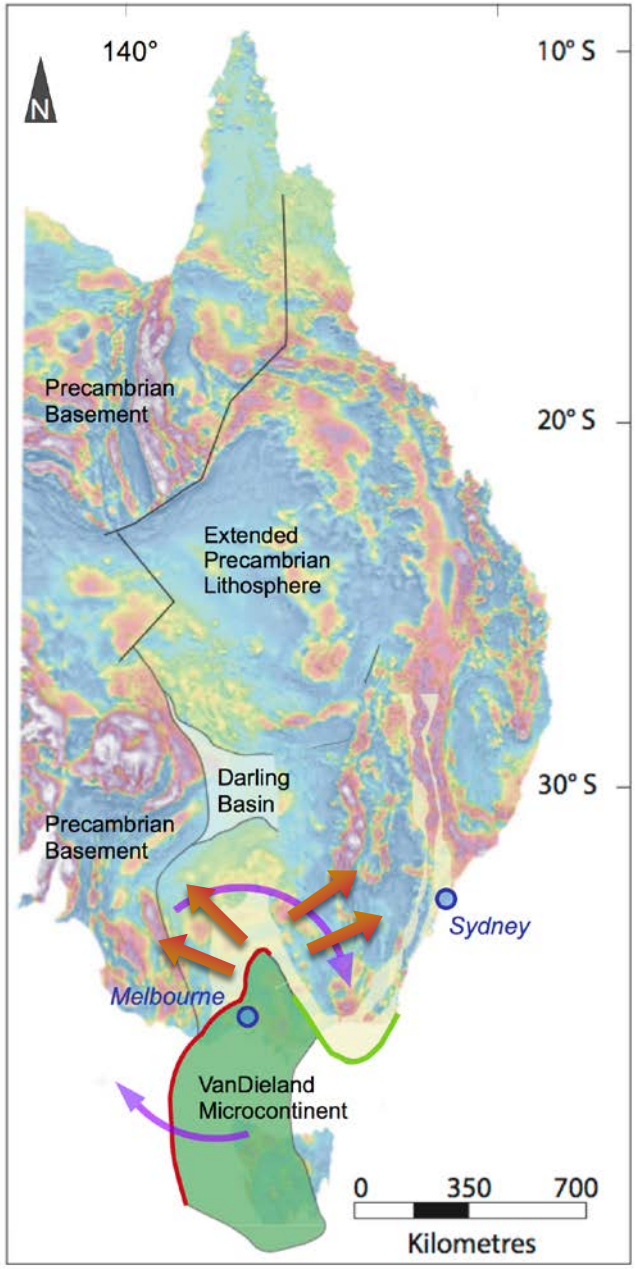


VanDieland an embedded terrane



- **The Australian accretion of the VanDieland micro-continent resulted in the terrane being deeply embedded in the over-riding plate and left largely undisturbed since then.**

- **Evidence of rotations in present day structural grain (from potential fields, paleomagnetism and other geological indicators).**



Moresi, L., Betts, P. G., Miller, M. S., & Cayley, R. A. (2014). Dynamics of continental accretion. *Nature*. doi:10.1038/nature13033

Micro-continent ribbon accretion

Weak slab-strong over-riding plate

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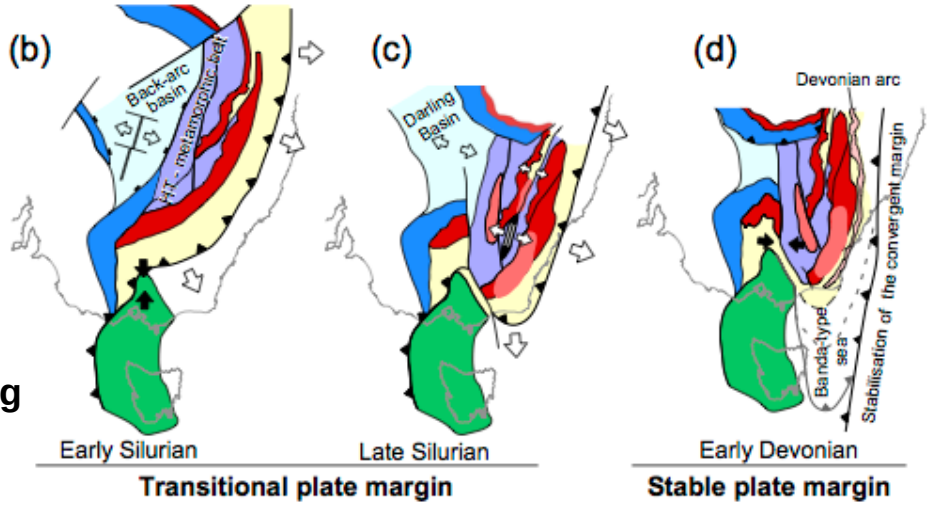
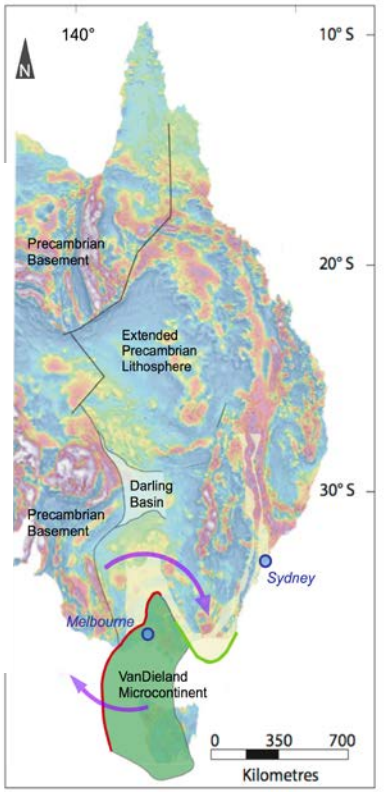
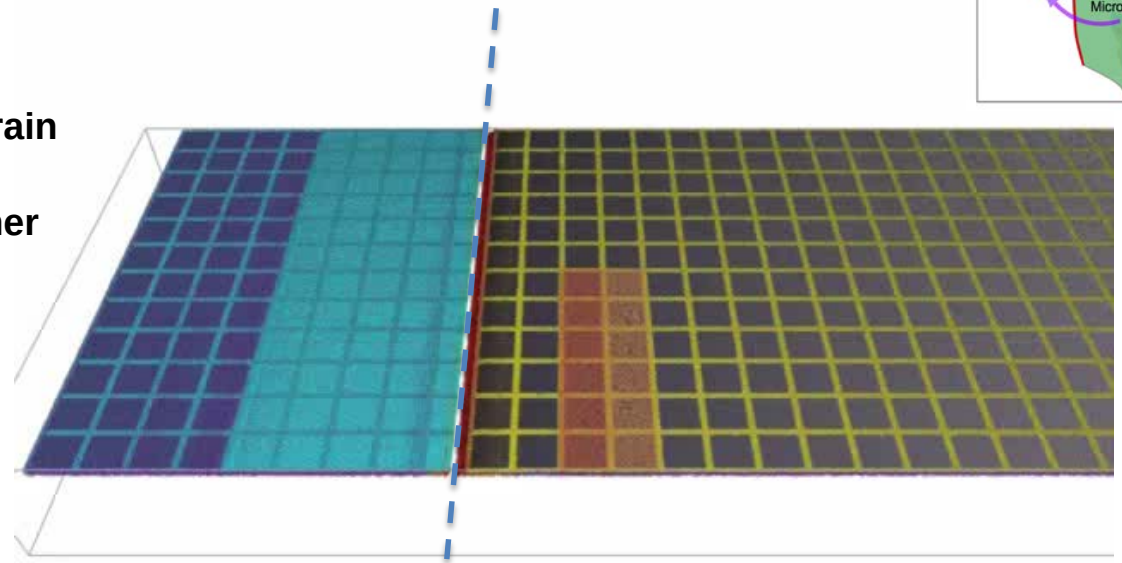
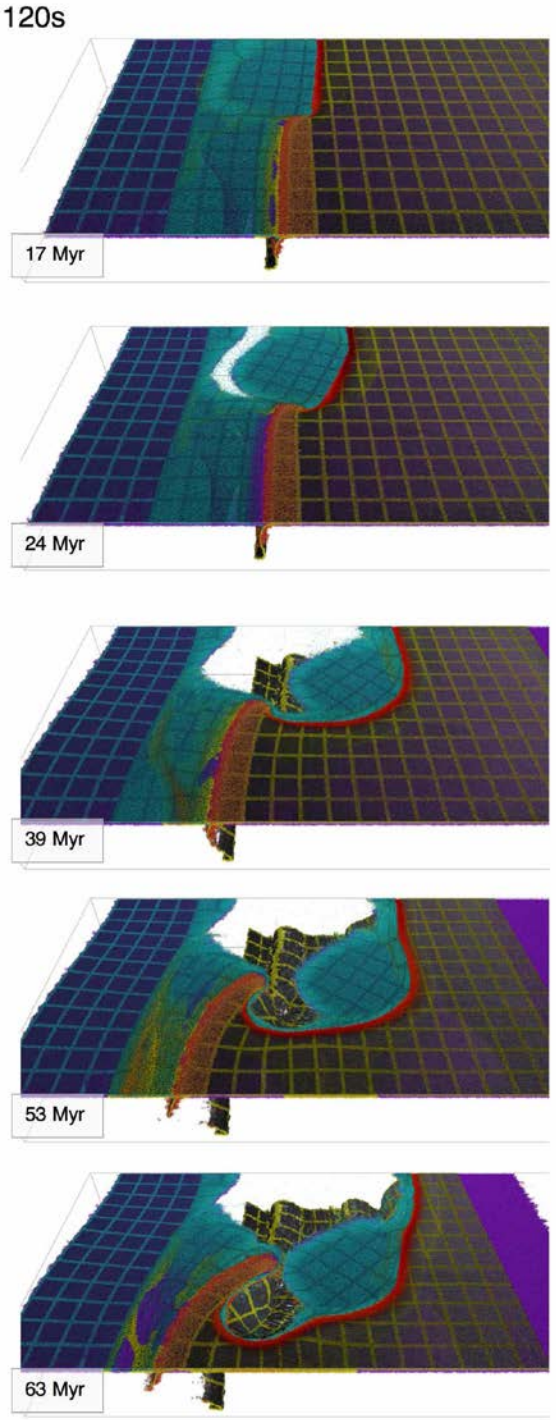






VanDieland accretion

- **Stage 1 – in initial accretion of the micro-continent**
  - Shortening in front of the micro-continent and extension driven by roll back away from accretion.
  - Different behaviors along the length of the margin
- **Stage 2 – transitional phase**
  - Roll-back and lateral escape of the overriding plate
  - Trench migration in two directions
  - Embedding of the micro-continent
  - Back arc extension - oceanic
  - Arc migration
- **Stage 3 – re-establishment of stable subduction and convergent margin**



Moresi et al., 2014

Summary

- **Long known that the Australian continent in the formed during two major accretion events.**
- **Rapid amalgamation (50-70 my) associated with the formation of Nuna via the accretion of several microcontinents adjacent to Laurentia – Paleoproterzoic.**
- **Followed by 1300 my of adjustments and modification internally (WAC, NAC, SAC) formation**
- **Microcontinental accretion played a significant role in the lateral expansion of the East Gondwana margin from the Ordovician – Devonian.**
- **Contorted the margin – oroclines.**
- **In both periods of amalgamation the Australian continent faced a large external ocean (rollback the favoured mode of subduction – which promoted ribbon formation and recycline of continental fragments)**
- **The entire evolution of the Australian Plate can be viewed is dominated by ribbon tectonic accretions.**