# THE GIANT LACHLAN OROCLINE OF EASTERN AUSTRALIA –

## A rAdiCaL new way of thinking about the Ordovican-Devonian tectonics and mineral systems of eastern Australia

Discoveries in the Tasmanides 4-6 September 2024 Albury, NSW

Ross Cayley and Bob Musgrave

5 September, 2024

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GEOLOGICAL SURVEY OF VICTORIA

ANSIR NATIONAL RESEARCH FACILITY FOR EARTH SOUNDING

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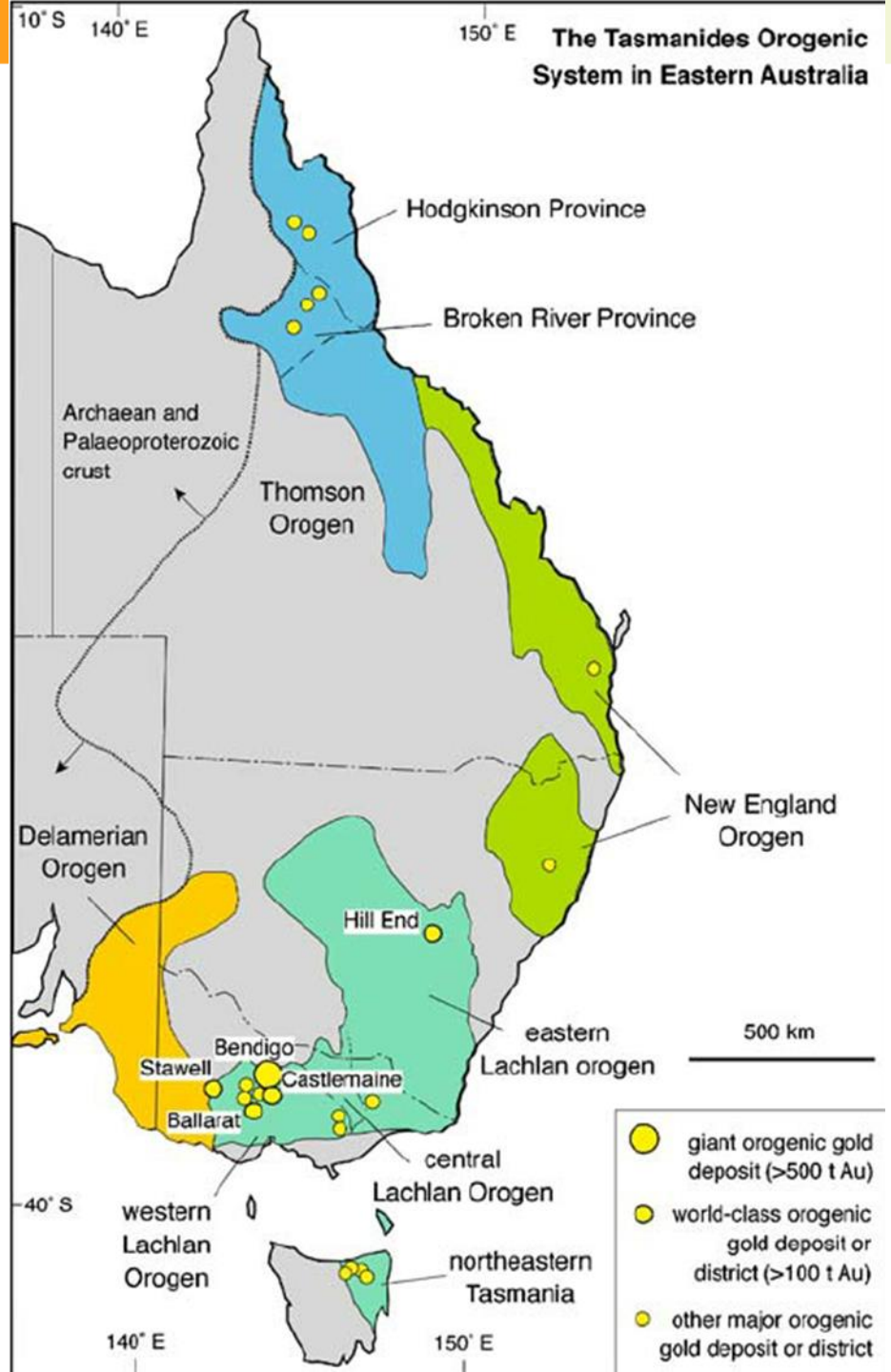



Early Palaeozoic rocks of similar age, provenance and appearance, with similar structural history, widespread throughout Eastern Australia.

Central-west Victoria: a cluster of proven giant orogenic gold deposits.

Central NSW: a cluster of proven giant intrusion-related base metals+gold deposits.

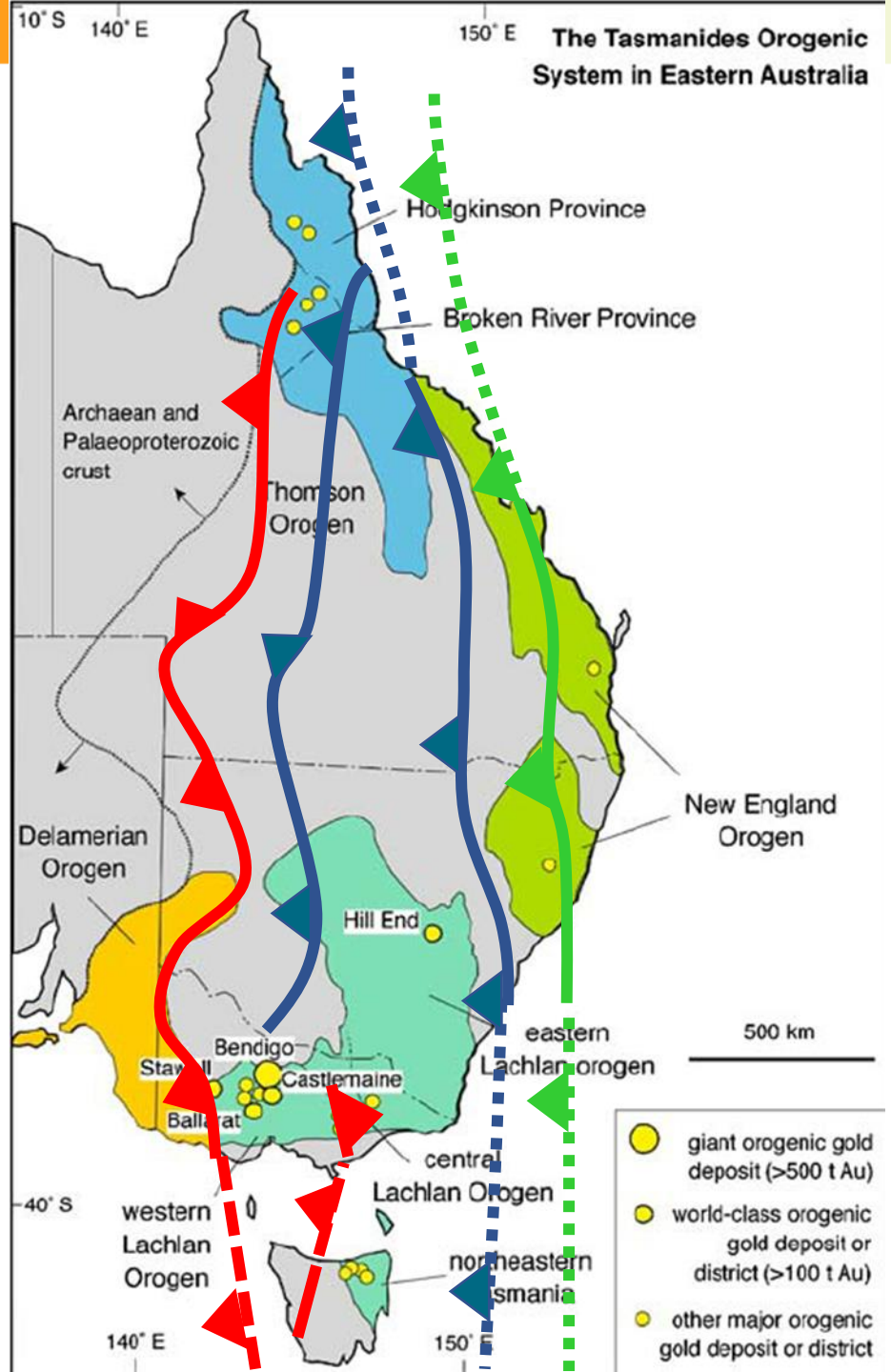
Western NSW: a cluster of proven giant VMS deposits

Tasmania: a cluster of proven giant VMS-related deposits

Why?

Are there other areas potentially as good, but not yet discovered?

And: WHERE MIGHT THESE OTHER AREAS BE?




The Tasman Fold Belt System –

3-4 cycles of Early-Mid Palaeozoic subduction-accretion that progressively built eastern Australia….

(Personally I think most were continent-dipping, but debate continues……)

Todays talk is predominantly about the Lachlan Orogen

# Talk outline

- Geological Systems Analysis – a logical way to categorize tectonic ambiguity / complexity
- Competing tectonic models for Lachlan Fold Belt development – confusing for mineral explorers
- Palaeogeography – a key constraint for Lachlan Fold Belt retrodeformation
- Fundamental Constraints – the Delamerian, Benambran, Quidongan, Bindian and Tabberabberan (and Kanimblan) Orogenies. Where are they? Where **AREN'T** they?
- Structural / stratigraphic mapping + potential field and seismic reflection geophysics – taking understanding to crustal scale
- A constrained retrodeformation scenario for the Ordovician-Silurian Lachlan Fold Belt - the Lachlan Orocline
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# Convergent margin key elements and systematics

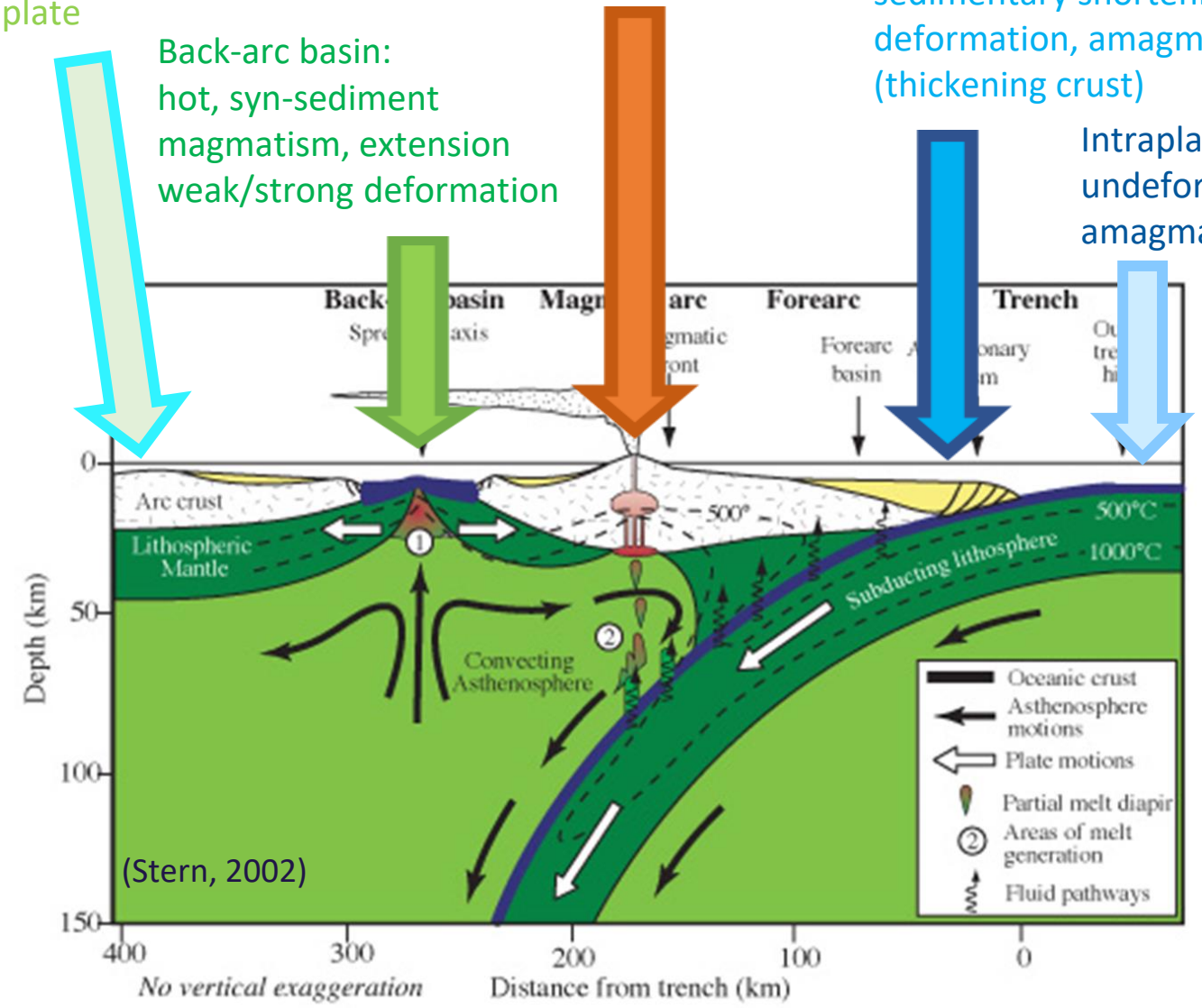
Distal back-arc: transition to intraplate

Back-arc basin: hot, syn-sediment magmatism, extension weak/strong deformation

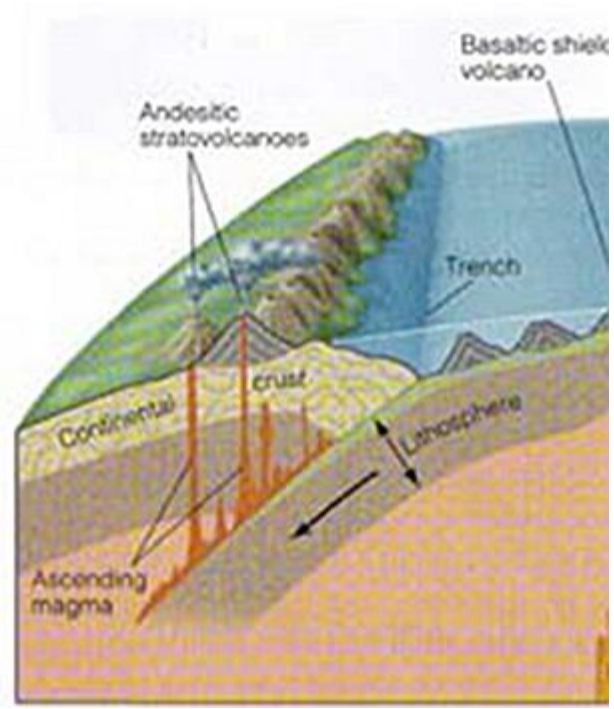
Magmatic arc: hot, igneous-dominated

Accretionary wedge: cold, inherent strong syn-sedimentary shortening deformation, amagmatic (thickening crust)

Intraplate: cold, undeformed, amagmatic




(Stern, 2002)



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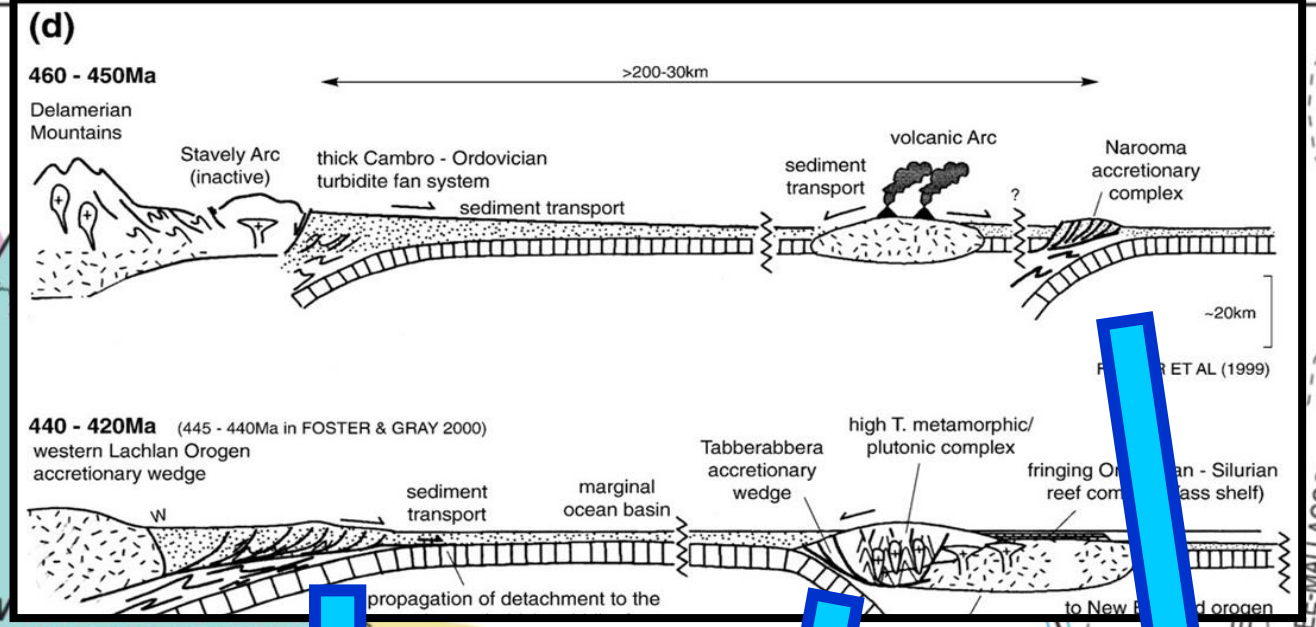
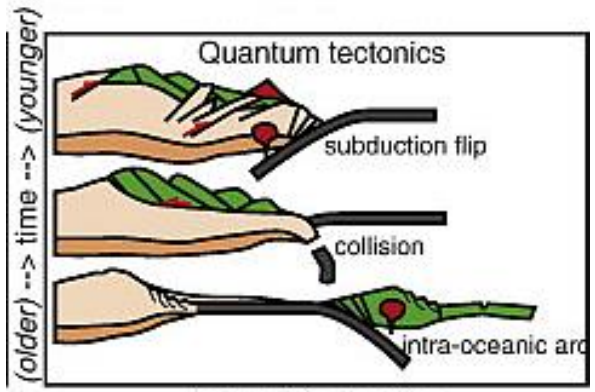


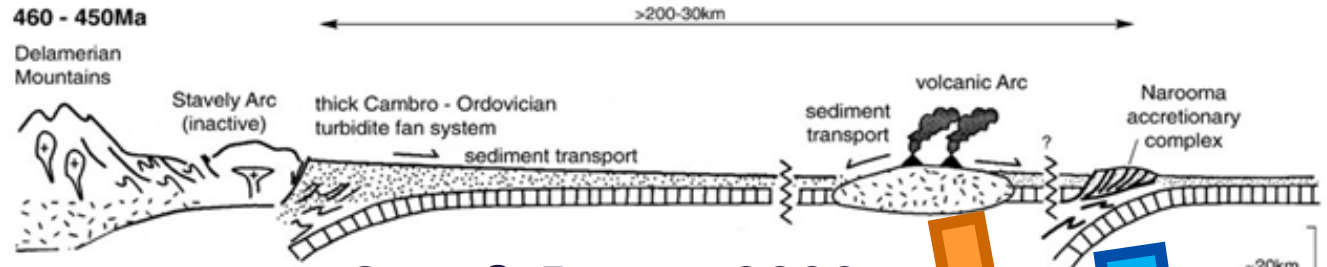

Inter-plate transfer:
Arc-continent collision and subduction flip

Aitchison & Buckman, 2012

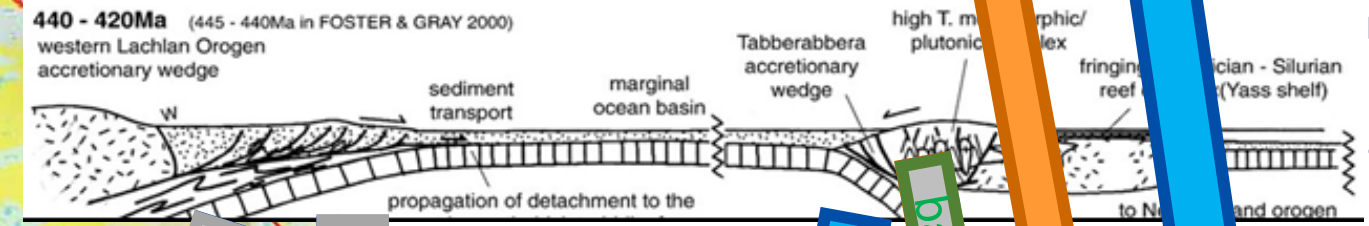
Gray & Foster, 1999, 2000:

A breakthrough tectonic model that honoured structural vergence, deformation timing, and the accretionary character of some Ordovician stratigraphy

Benambran deformation – Late Ordovician




Gray & Foster, 2000




Subduction / accretion models for Late Ordovician Victoria –

….they don't work perfectly.



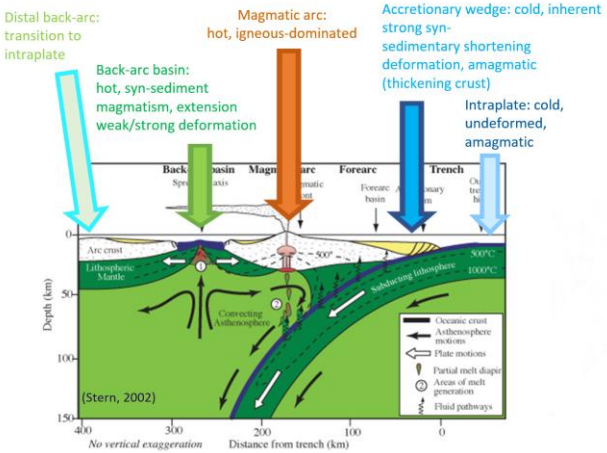

Too old (Delamerian)
Miller et al., 2003



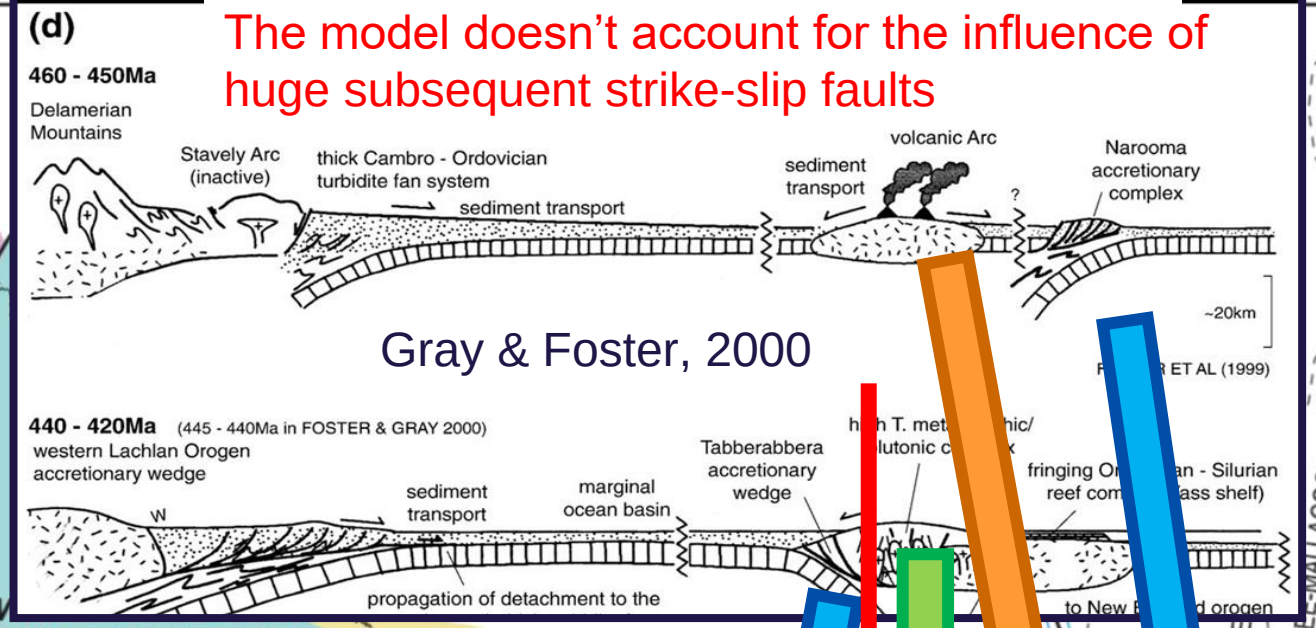




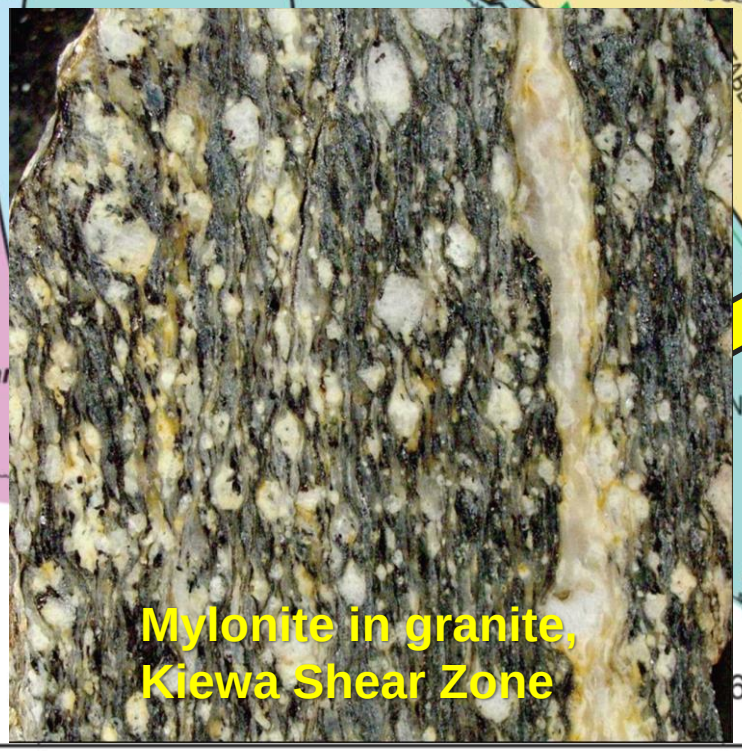




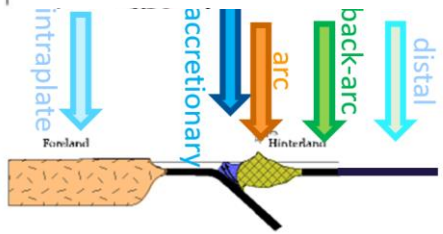
The model doesn't account for the influence of huge subsequent strike-slip faults




Gray & Foster, 2000

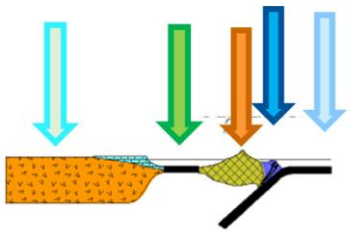


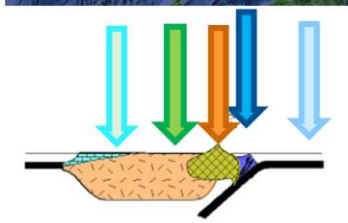

**Blue** (accretionary wedge) against **Green** (back arc):
a relationship not observed in simple convergent margins



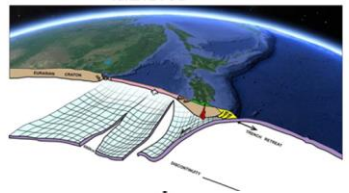


Continent-Island Arc Collision

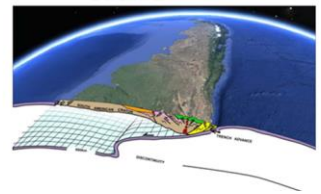




Island Arc



Cordilleran



**System geometry must have been modified since it was active……**

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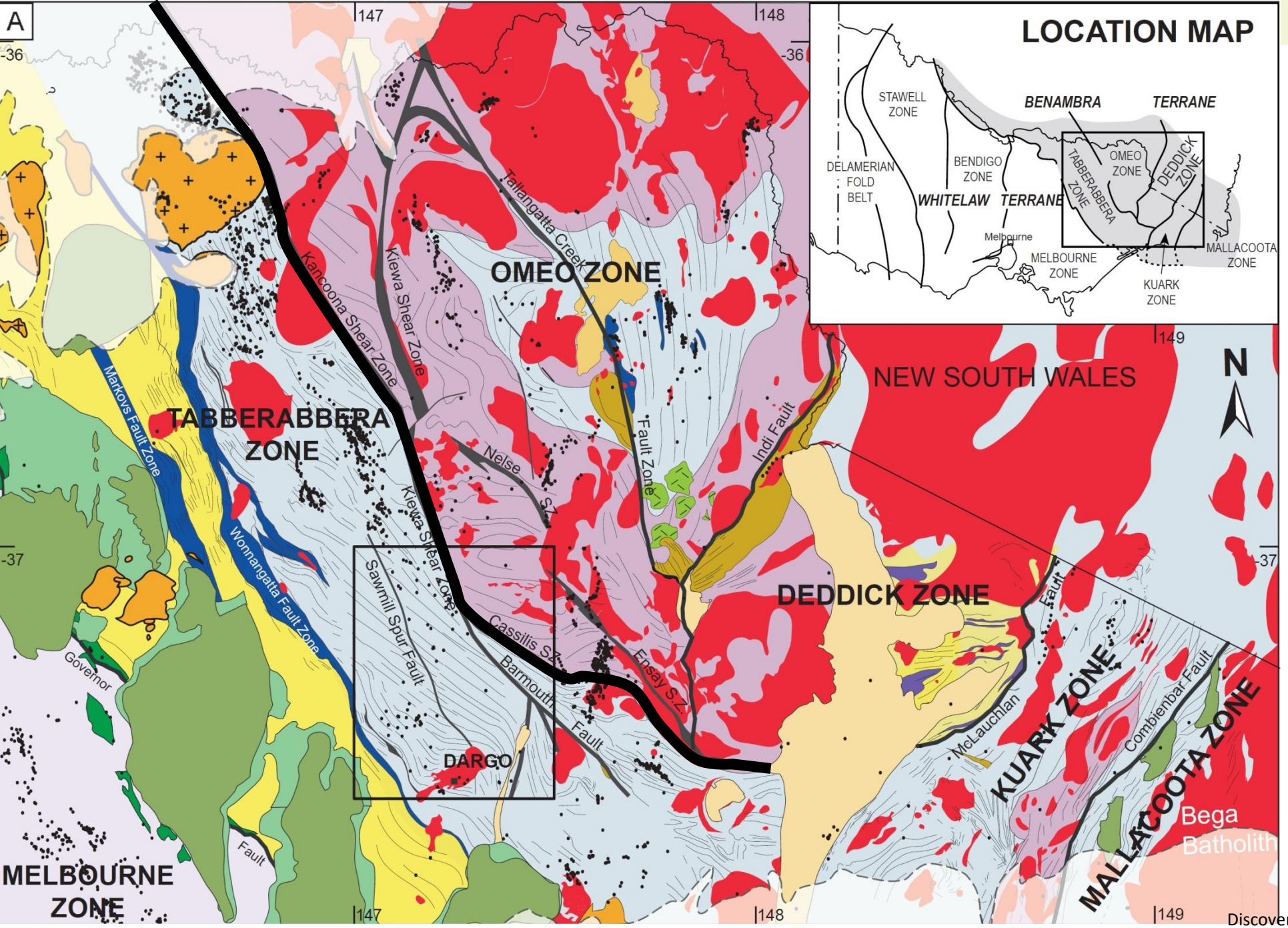



Kiewa-Kancoona Shear Zone position – separating:

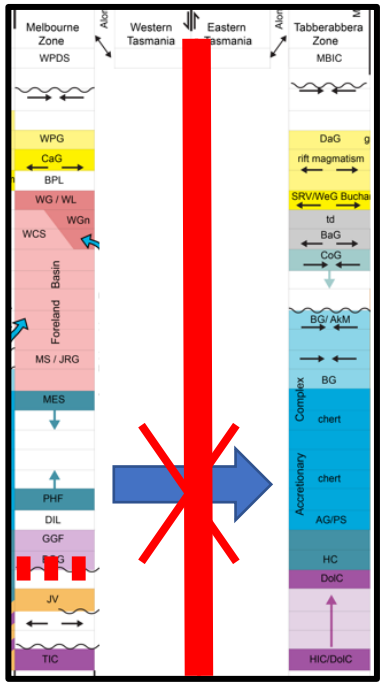
hot Omeo Zone (backarc)

from

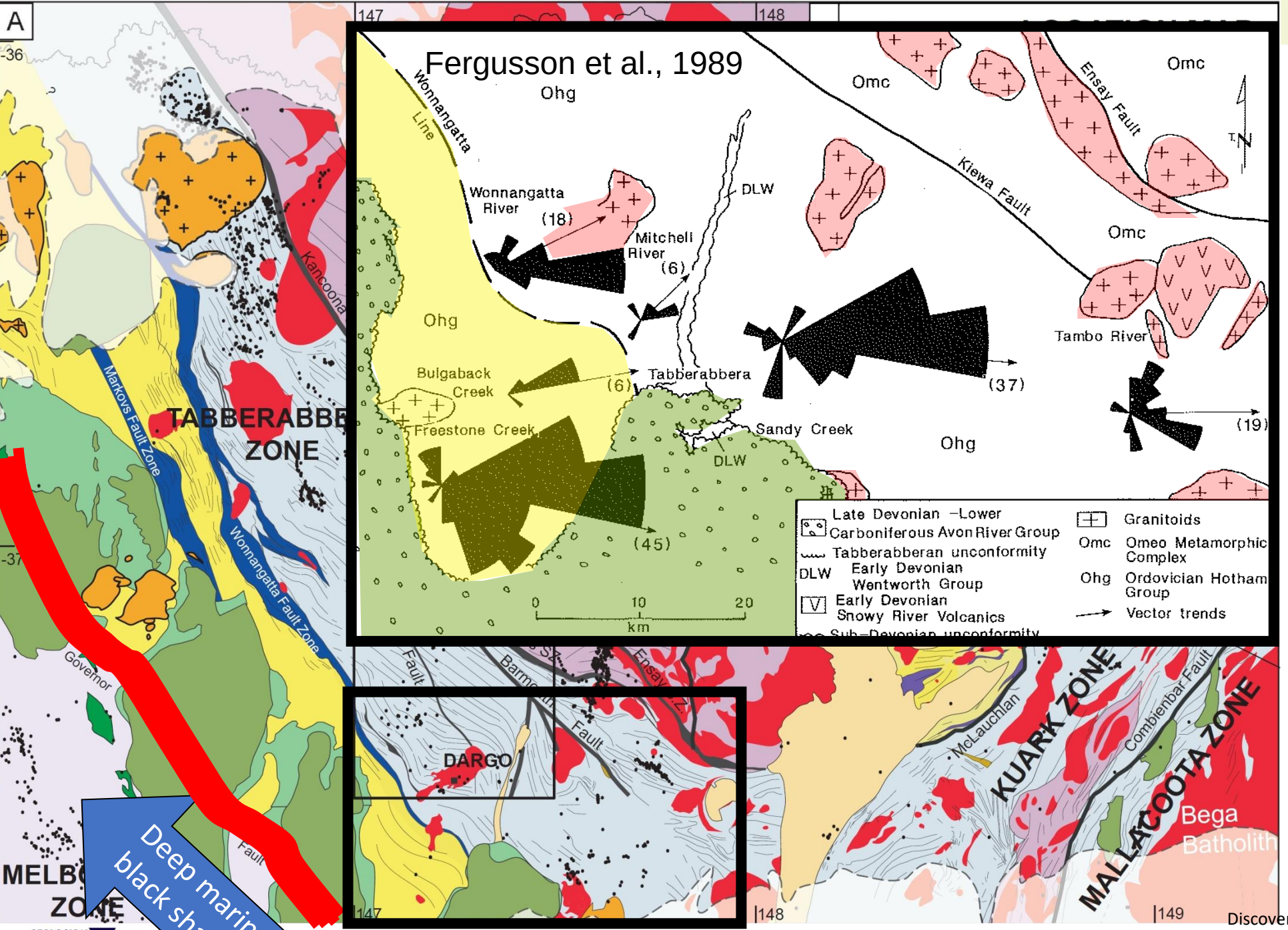
cold Tabberabbera Zone (forearc-accretionary wedge)

Field geology – Sedimentology, Palaeogeography can also provide critical constraints…

southern Tabberabbera Zone
Ordovician turbidites apparently sourced from Melbourne Zone direction, but can't be from Melbourne Zone (deep marine black shale, chert in Ordovician):
a major paleogeographic conundrum




Fergusson et al., 1989

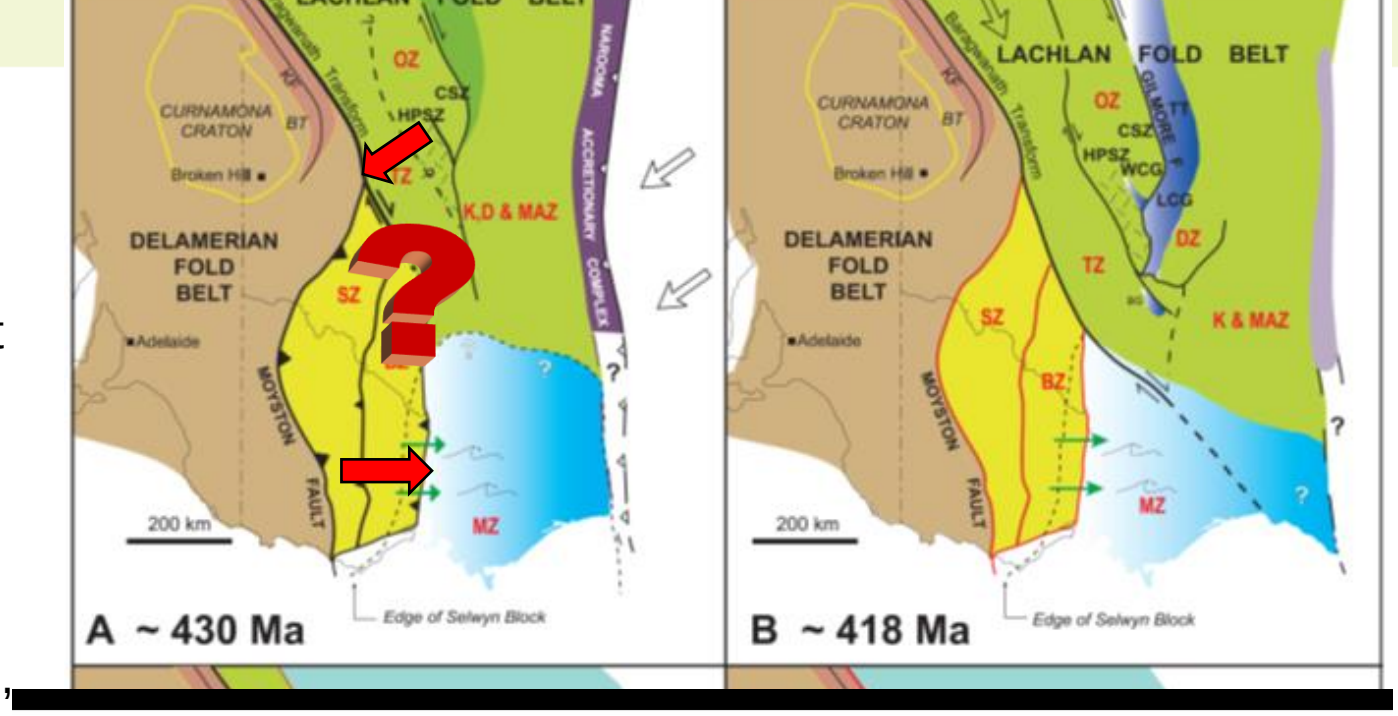



Field geology – Sedimentology, Palaeogeography can also provide critical constraints…

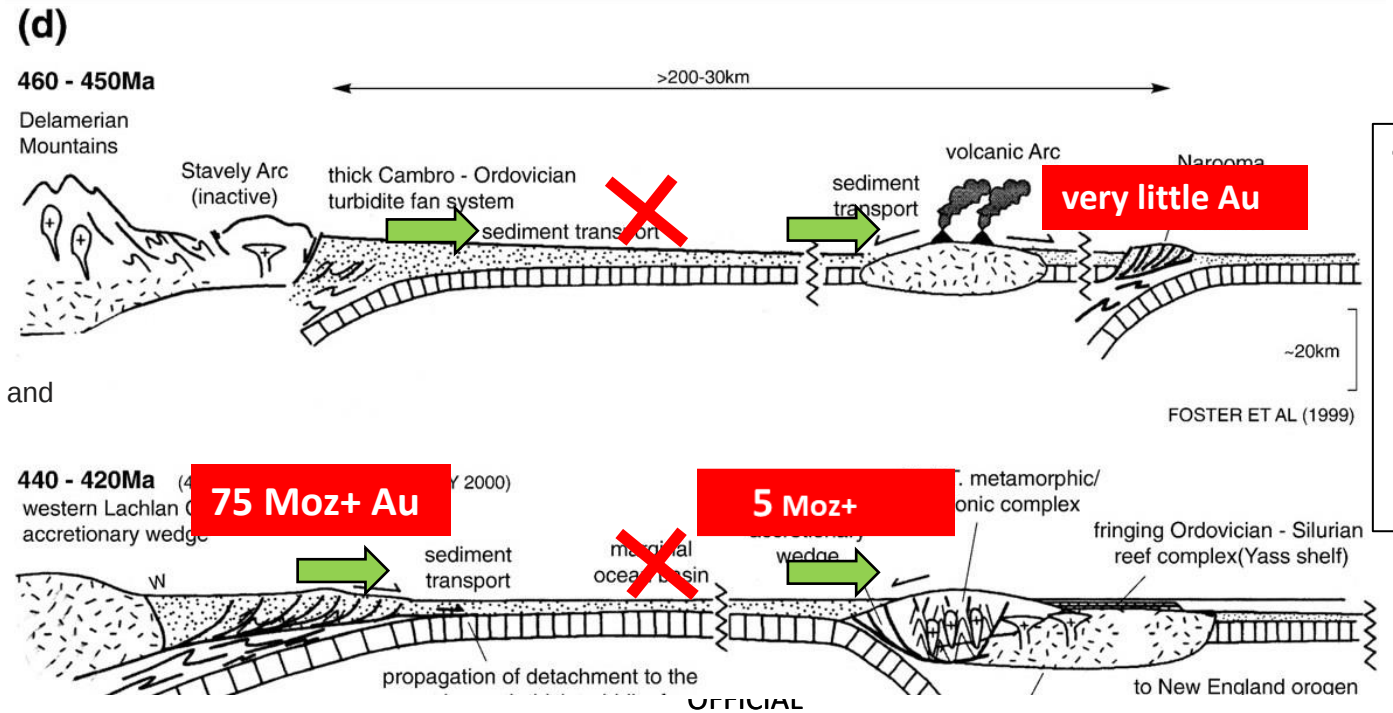
Models that honour paleogeographic constraints, and account for strike-slip faults…..

eg. the Baragwanath Transform concept…

(VandenBerg et al. 2000, Willman et al., 2002)




‘Baragwanath Transform’ model could explain the palaeocurrent data conundrum, but wasnt consistent with mapped structural geometries (eg changes in crustal-scale structural vergence) and had no known cause




‘divergent multiple subduction’ model inconsistent with the palaeocurrent data, and didn’t account for large strike-slip faults

**Tectonic models of the 1990’s-early 2000’s all have major shortcomings…**
**and don’t specifically help predict gold location or endowment either!**

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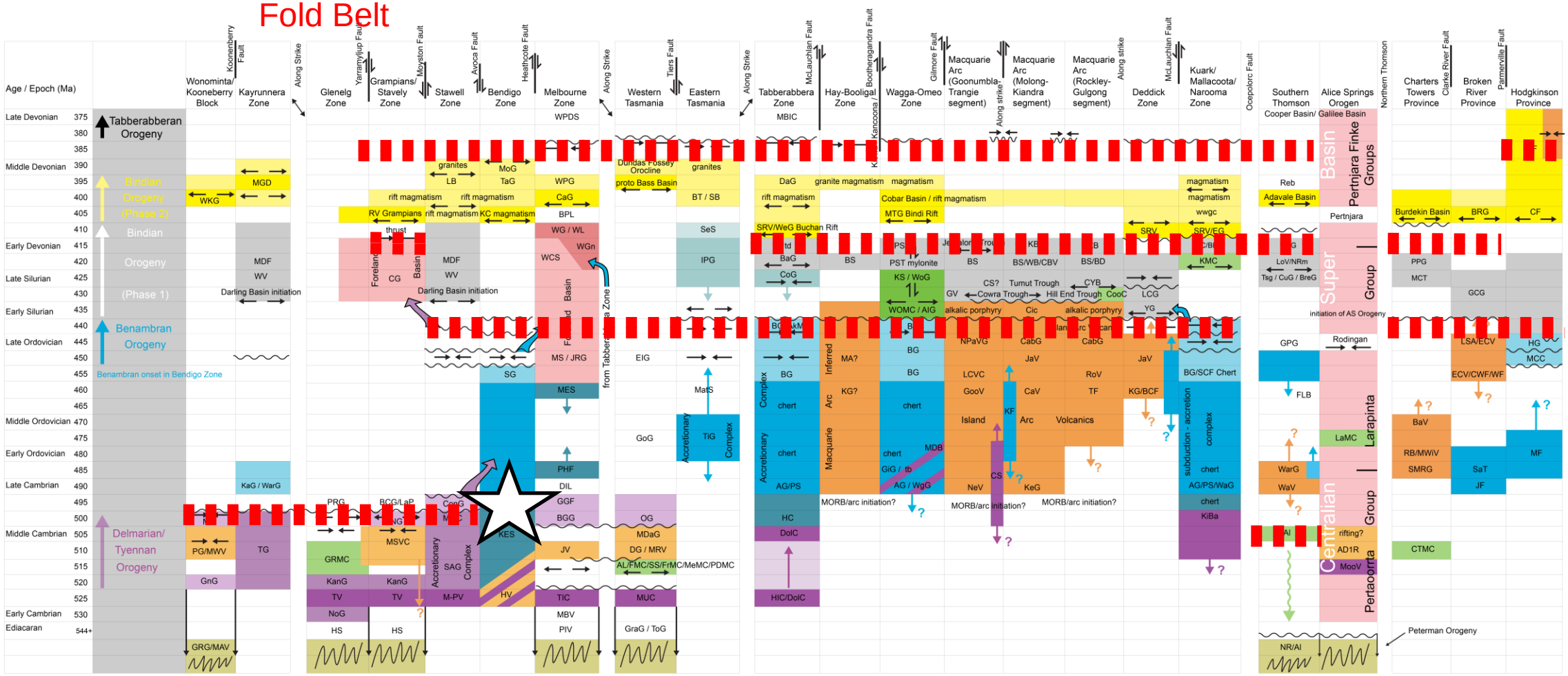
Delamerian Fold Belt

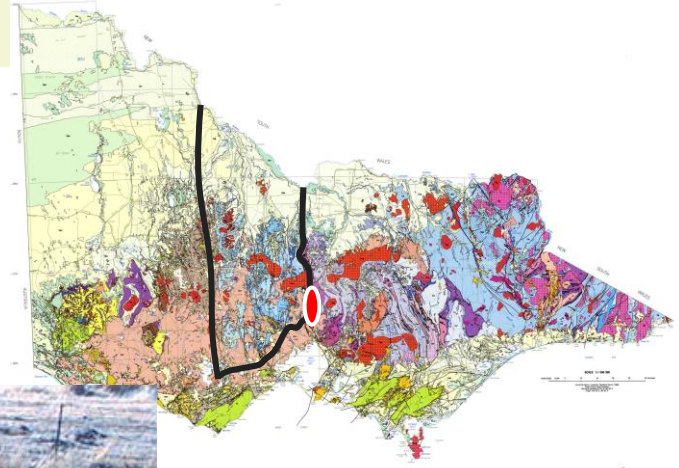
## Lachlan Fold Belt



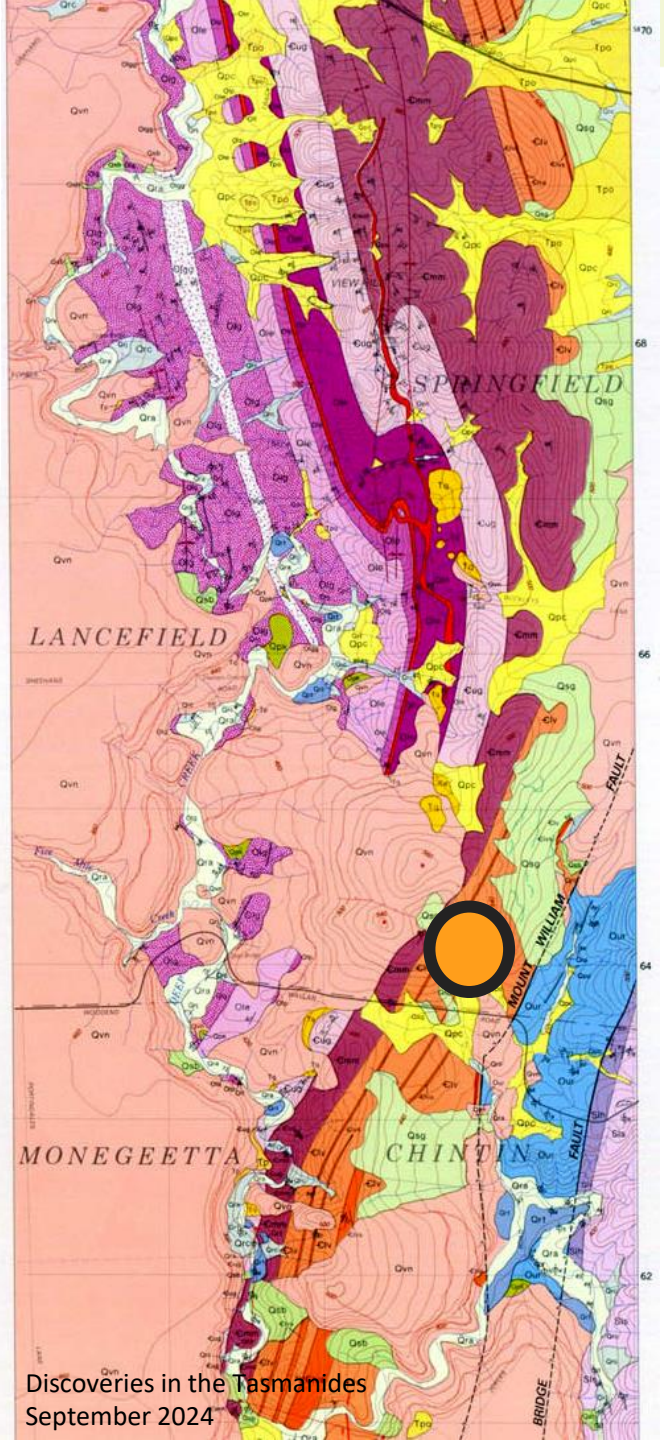

# Time-space plot : Eastern Australia

Cayley & Musgrave, in prep

# Bendigo Zone:
## plenty of Cambrian rocks,
## but NO Delamerian Orogeny!



VandenBerg, 1991



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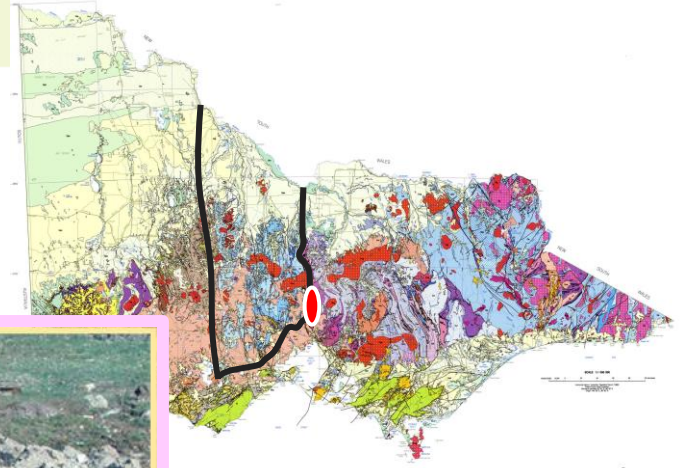
Conformable deep marine transition from Early Cambrian into the Ordovician



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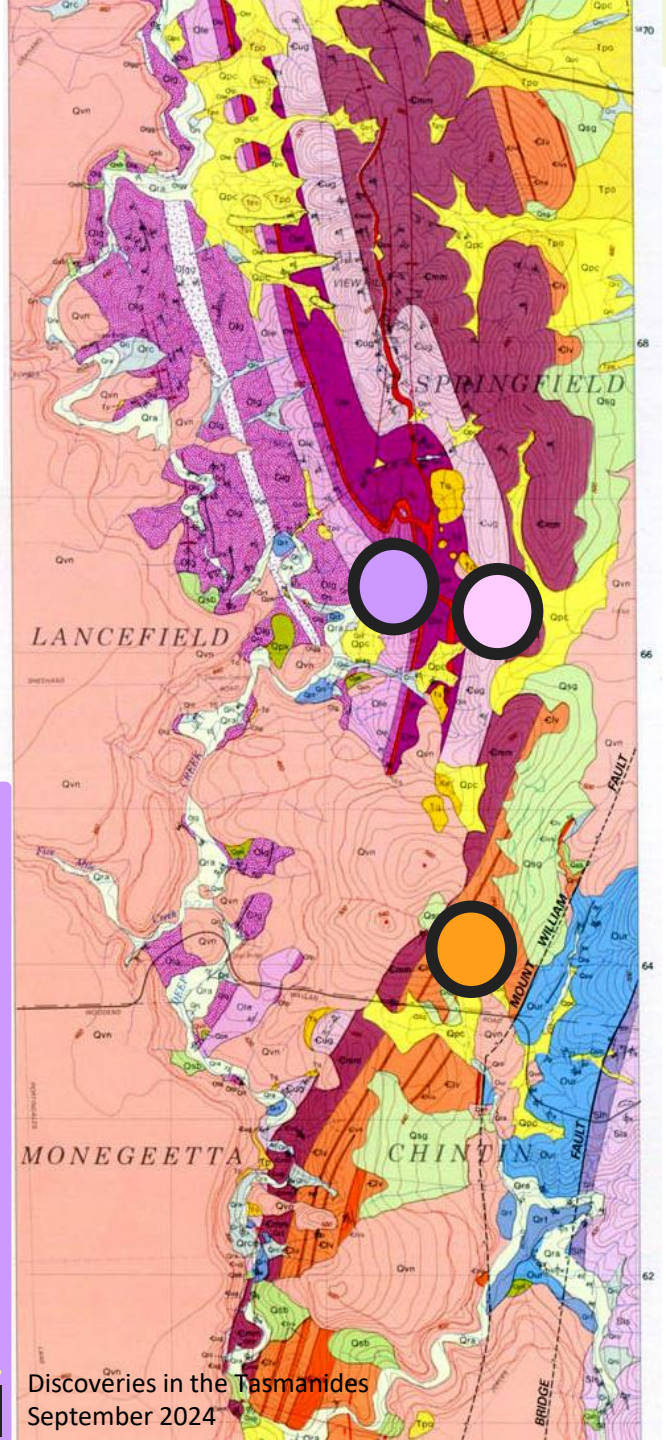
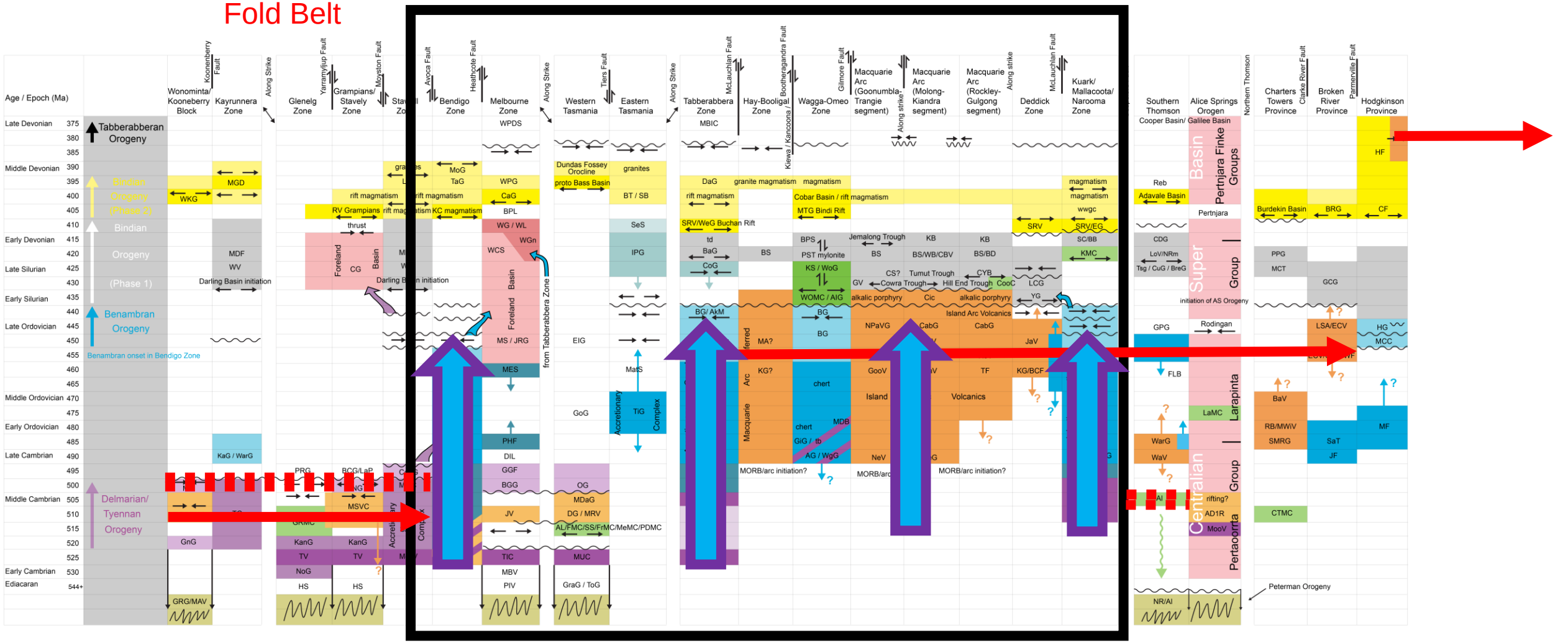


Delamerian Fold Belt

Lachlan Fold Belt




The ‘Lachlan Fold Belt’: defined by the mappable absence of deformation/uplift at the Cambrian-Ordovician boundary

# Time-space plot : Eastern Australia

Cayley & Musgrave, in prep

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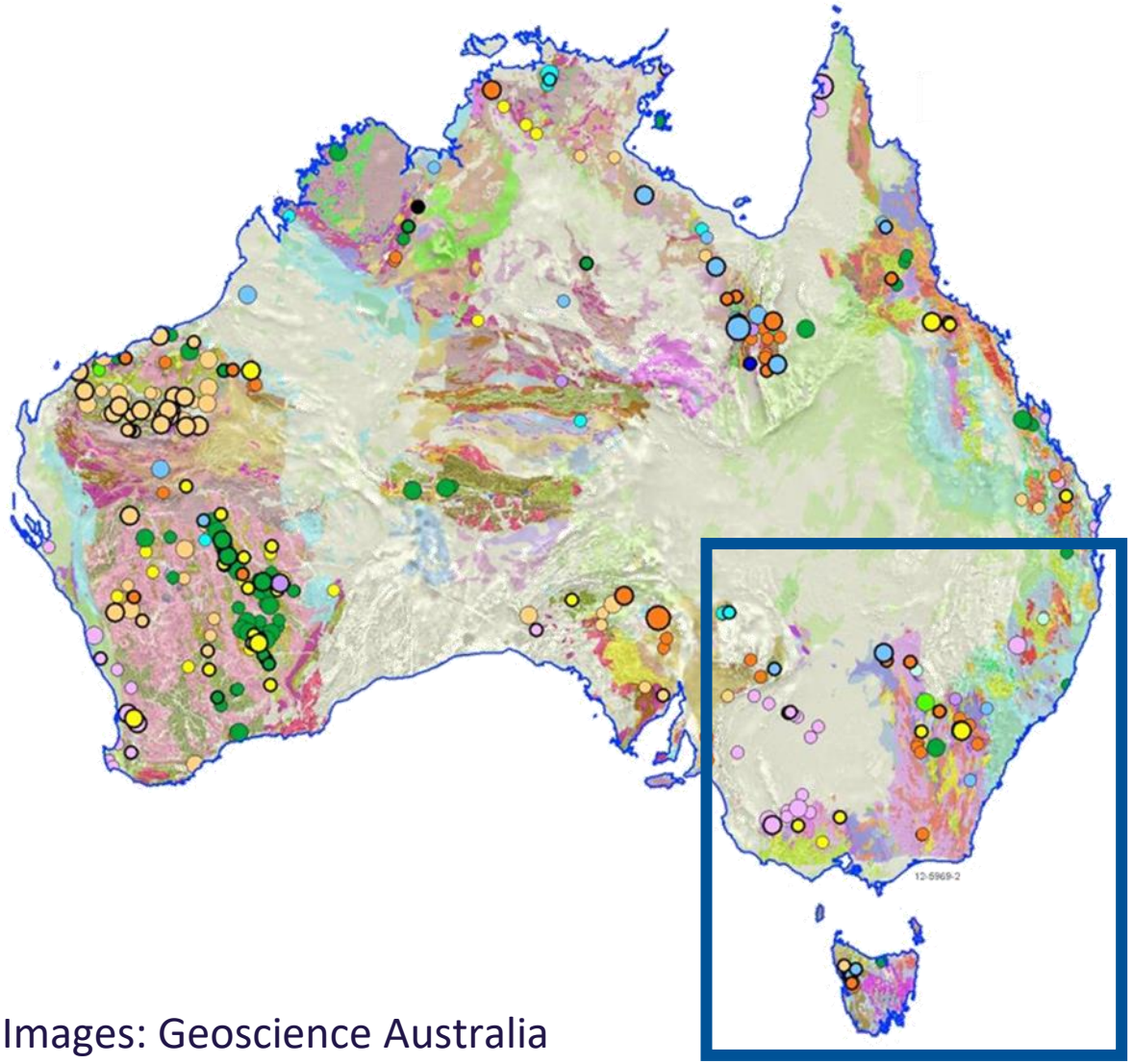

Images: Geoscience Australia

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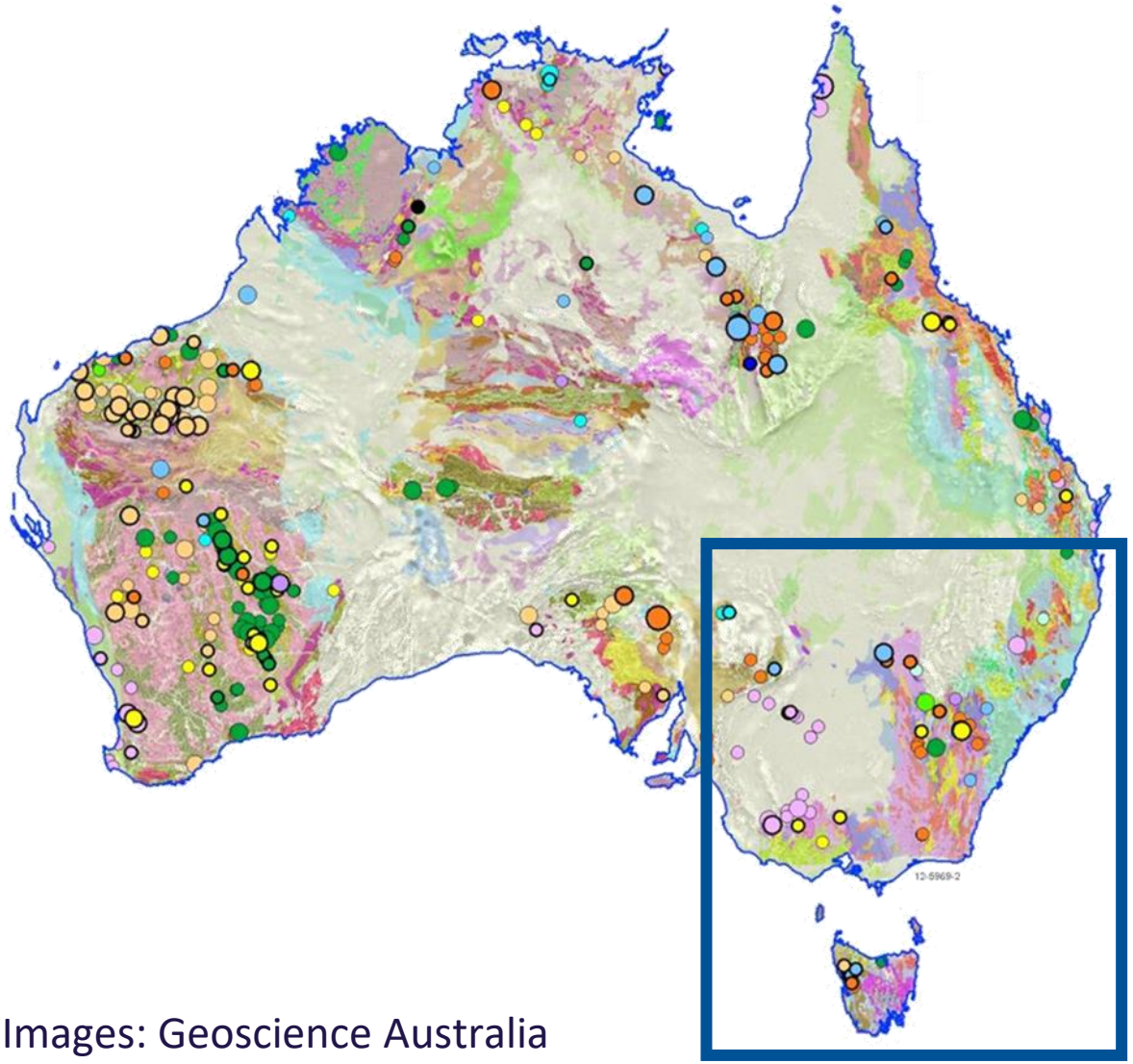
Discoveries in the Tasmanides
September 2024

Google Earth TM



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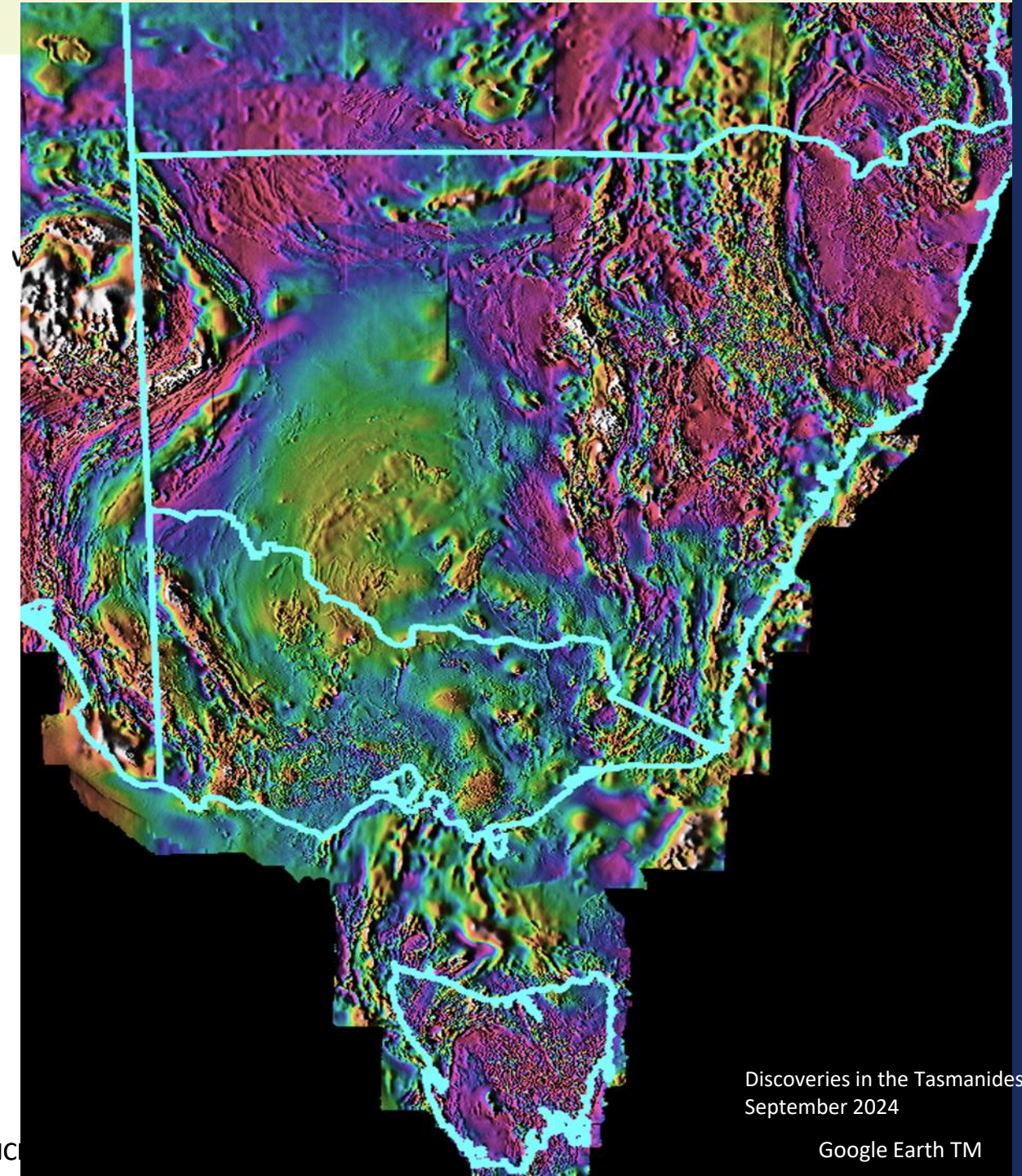


Discoveries in the Tasmanides
September 2024

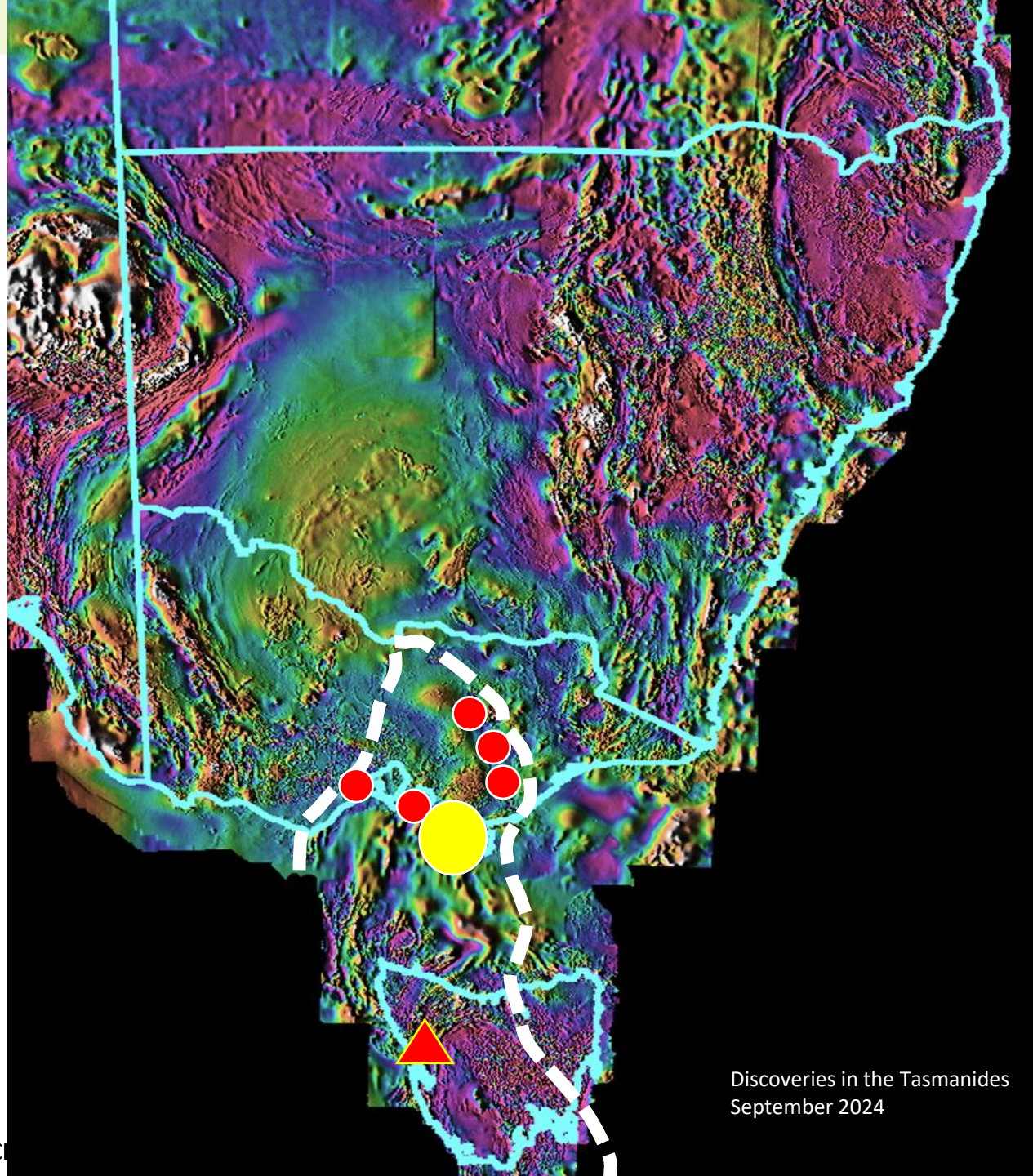
Google Earth TM

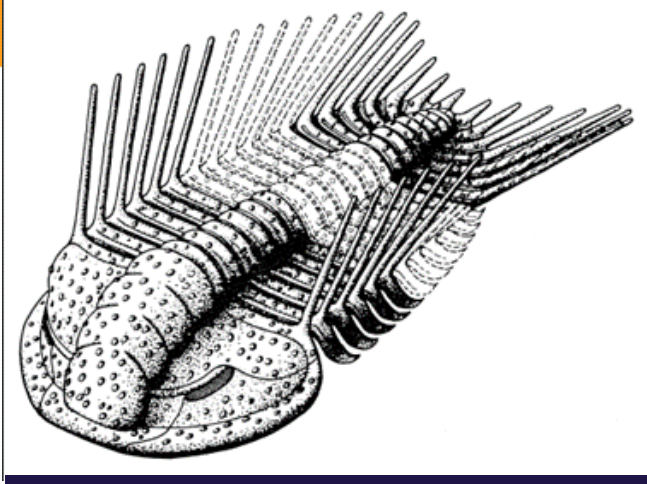
Western Tasmania and its northern extension…
the Selwyn Block.
(Cayley et al., 2002)

The Vandieland microcontinent –
Proterozoic crust beneath central Victoria
(Cayley, 2011)

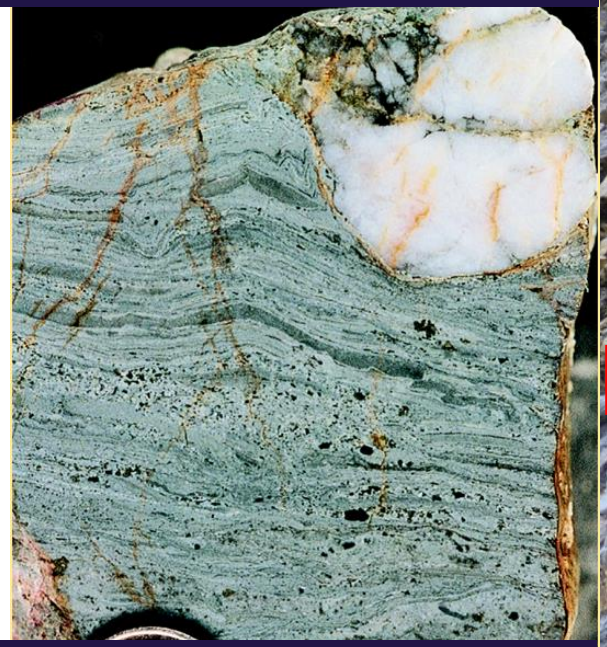
Cambrian Jamieson Volcanics (Vic)

coeval with (and along strike from)
Mount Read Volcanics
Dundas ‘Trough’ (Tas) ▲





Early Lancefieldian – ~490Ma+

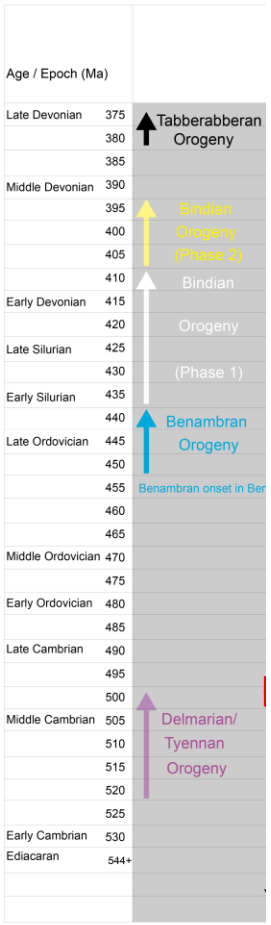


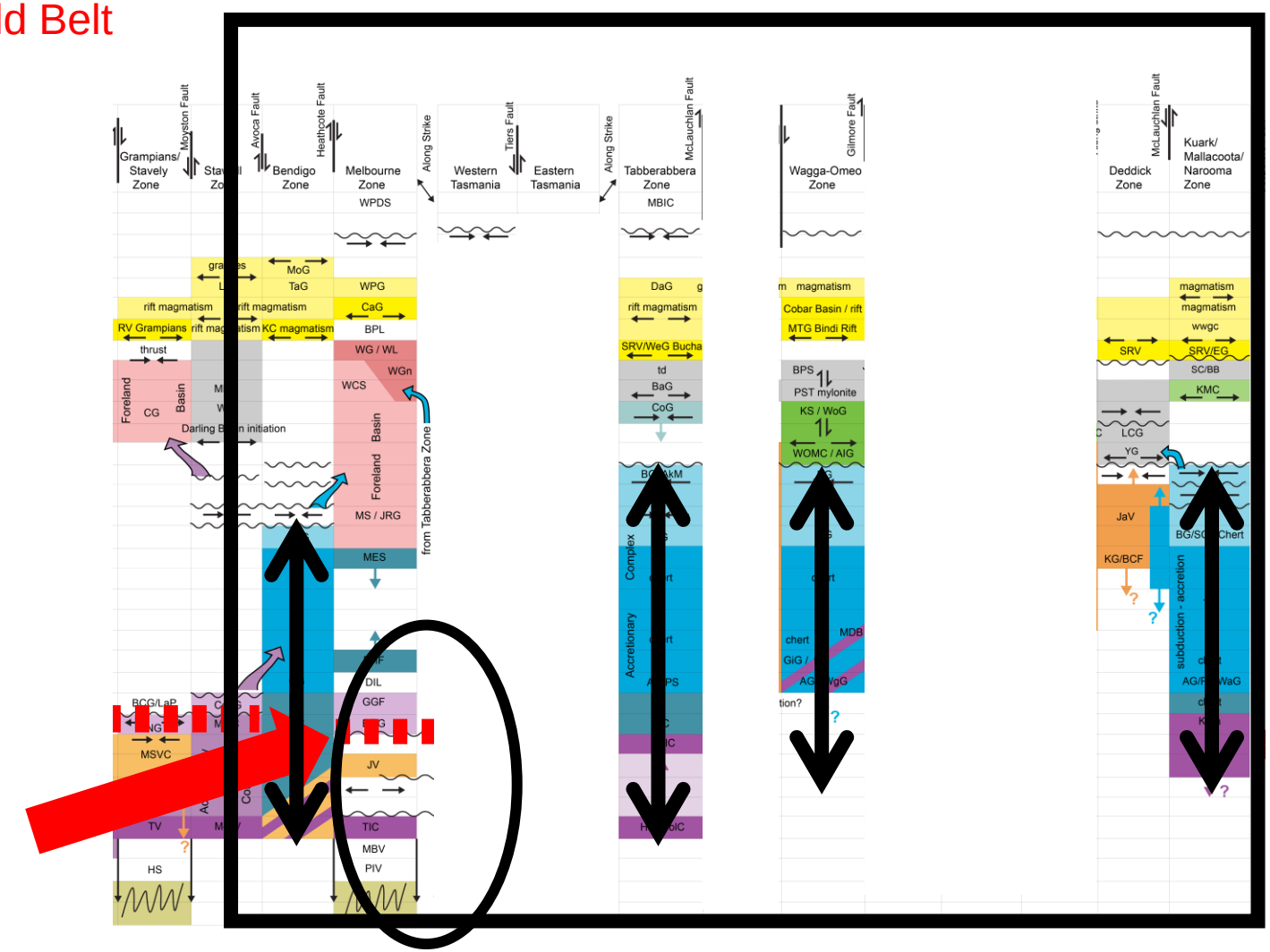
**Bear Gully Gritstone**

Demonstrated by a major, latest Cambrian unconformity beneath central Victoria

Delamerian Fold Belt

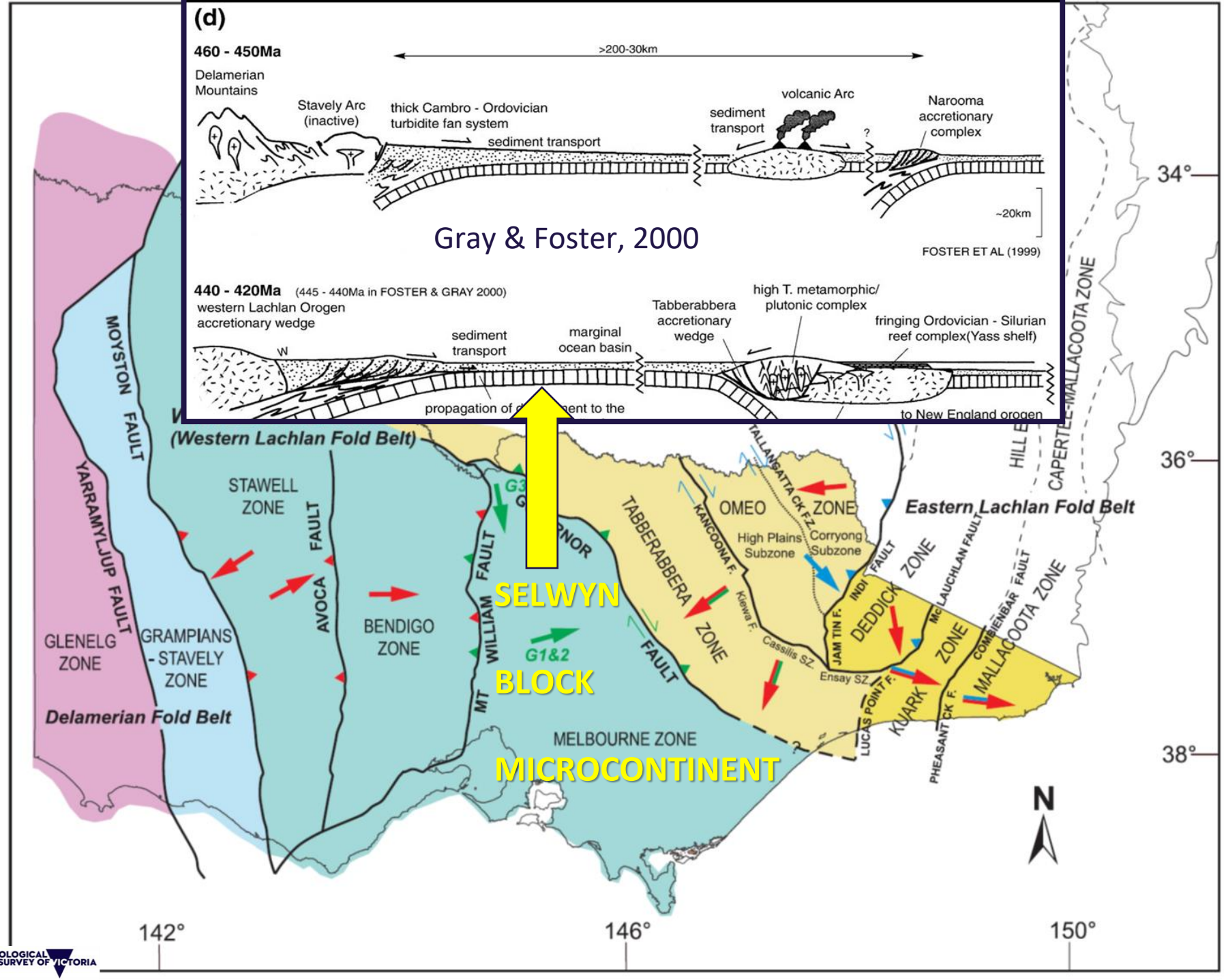
Lachlan Fold Belt



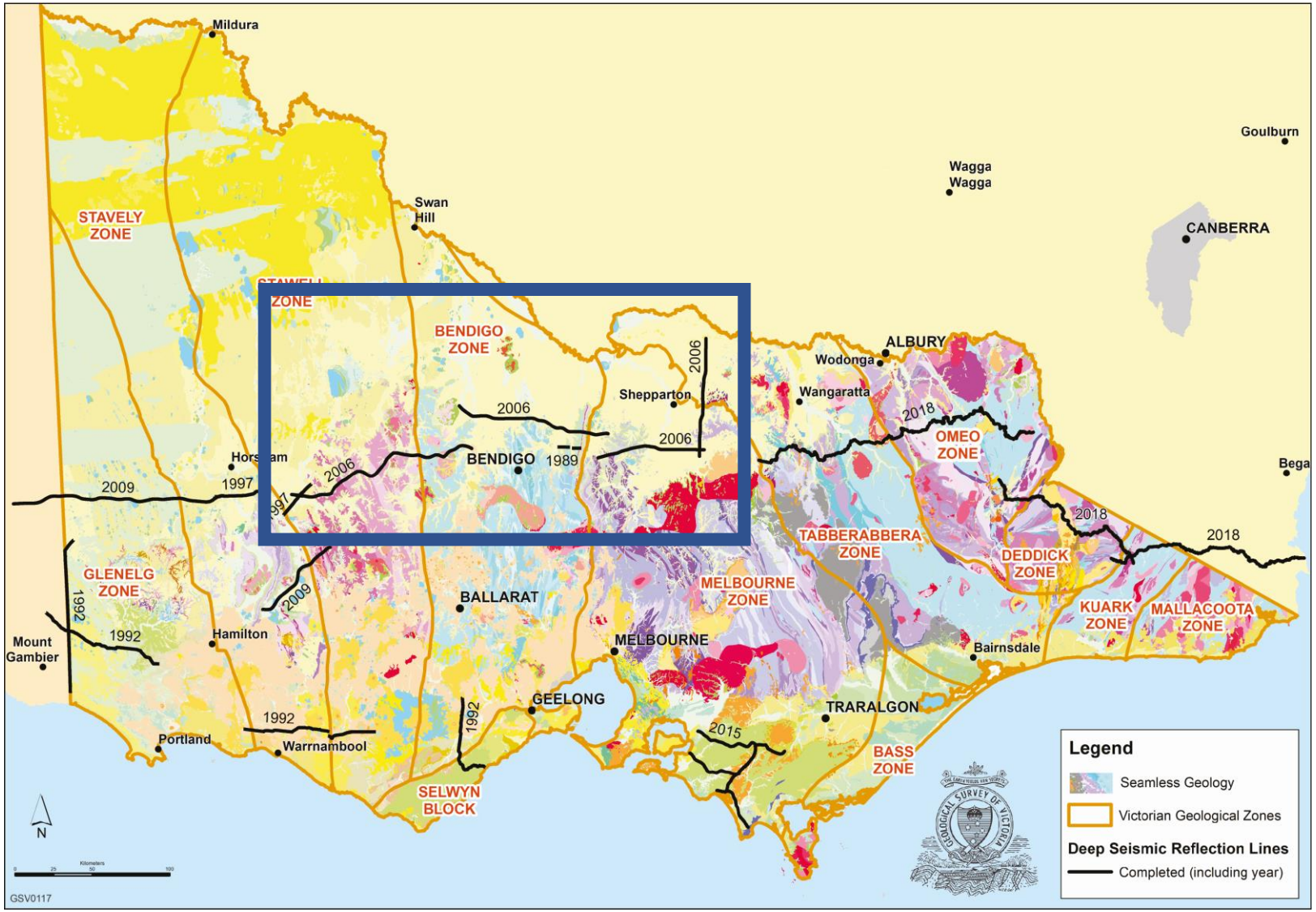

# Time-space plot : Victoria

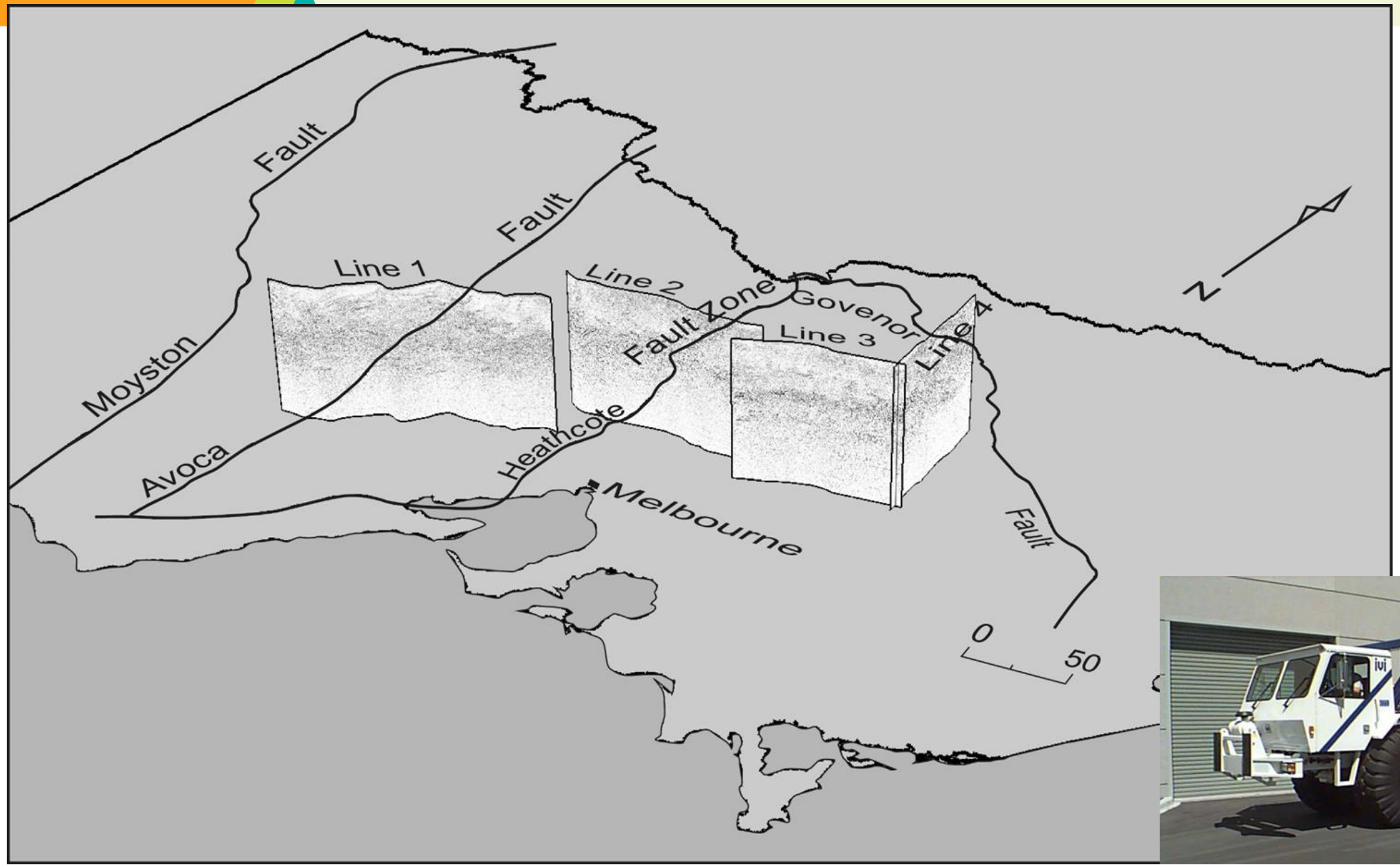
Cayley & Musgrave, in prep




The Selwyn Block model – alternative explanation for some observed changes in Lachlan Fold Belt sedimentation and deformation timing (particularly overlying Melbourne Zone)

# Deep Seismic Reflection





Fault
Fault
Line 1
Line 2
Fault Zone
Govenor
Line 3
Line 4
Moyston
Avoca
Heathcote
Melbourne
Fault
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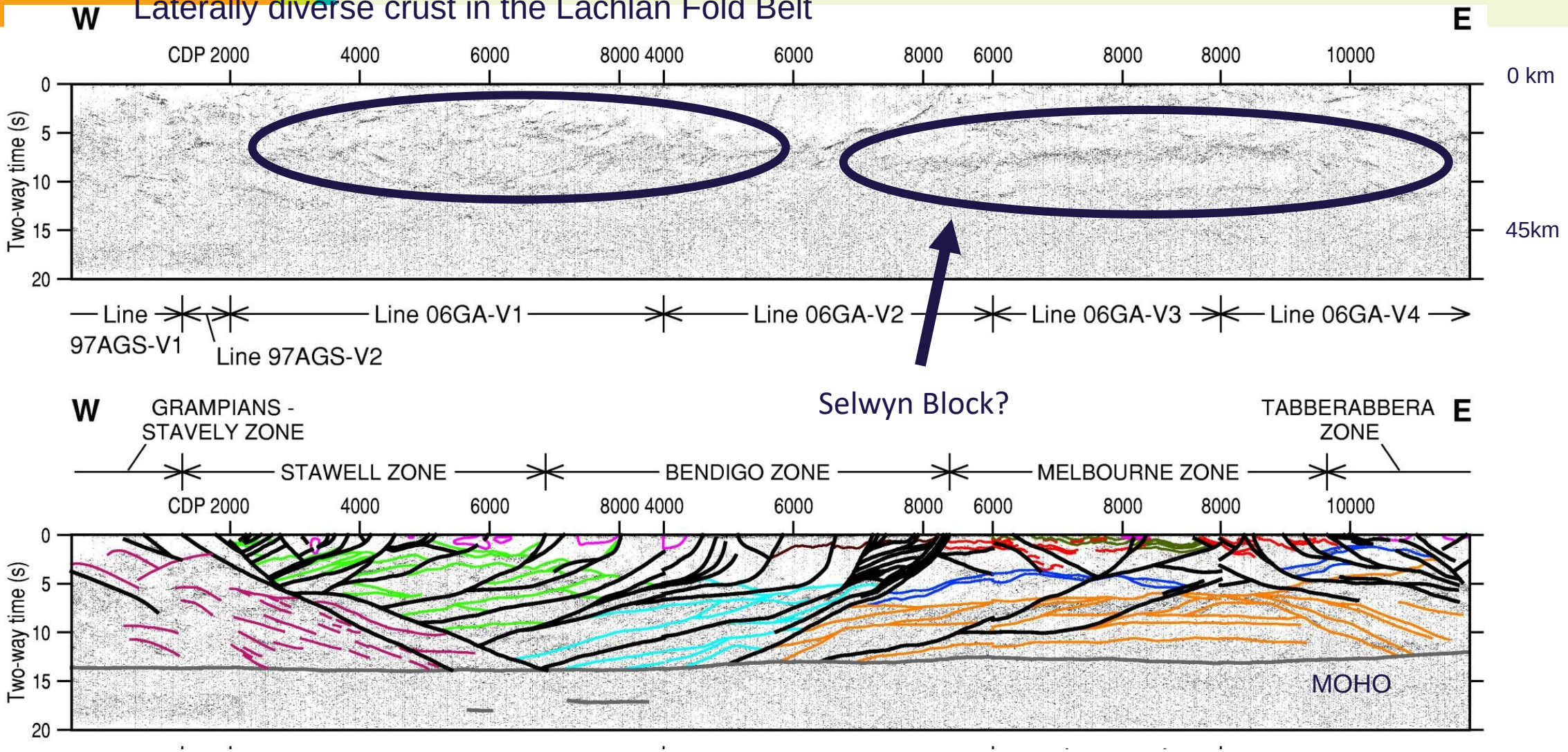
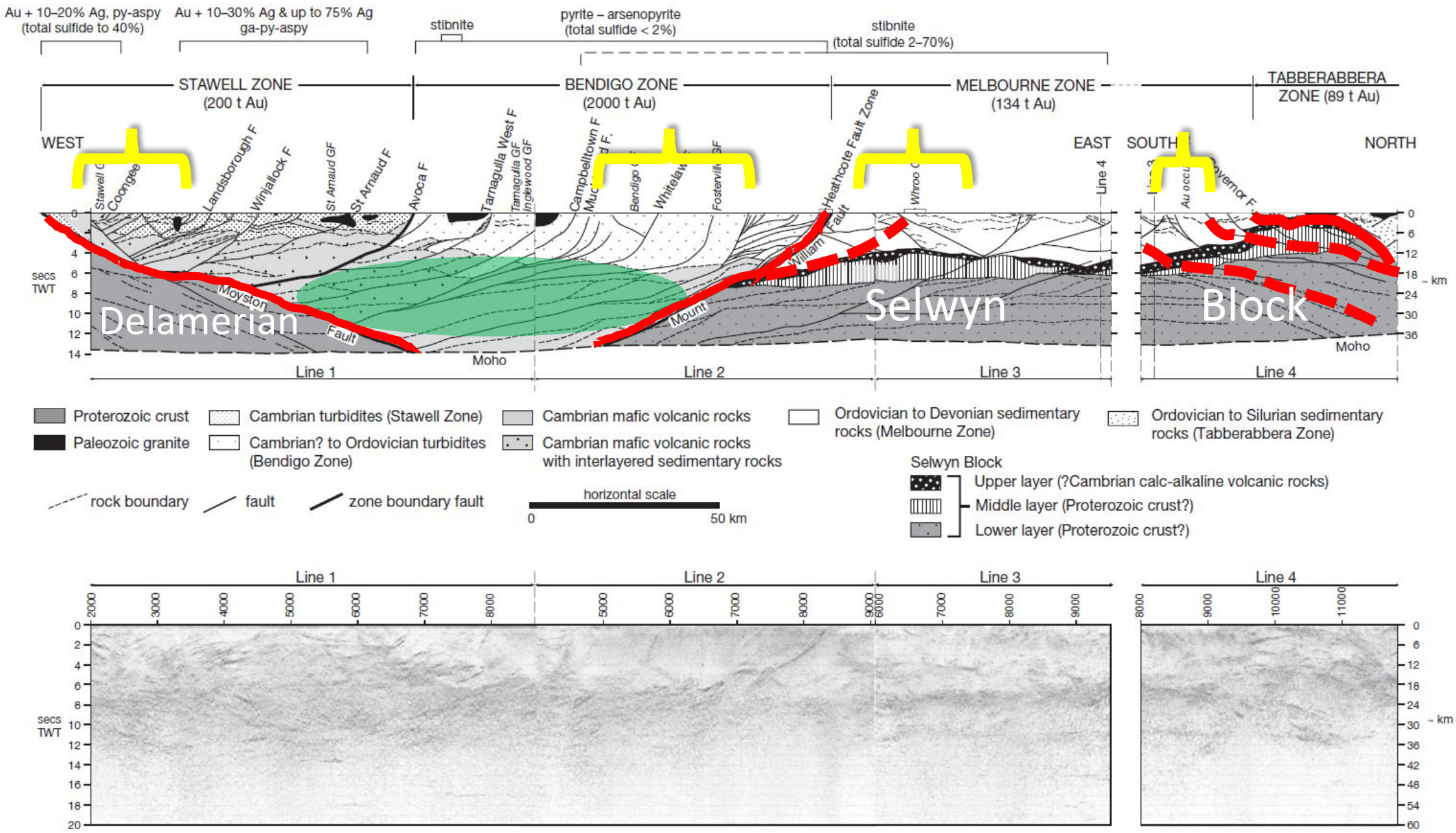
# Laterally diverse crust in the Lachlan Fold Belt




Cayley et al., 2011



GEOLOGICAL SURVEY OF VICTORIA

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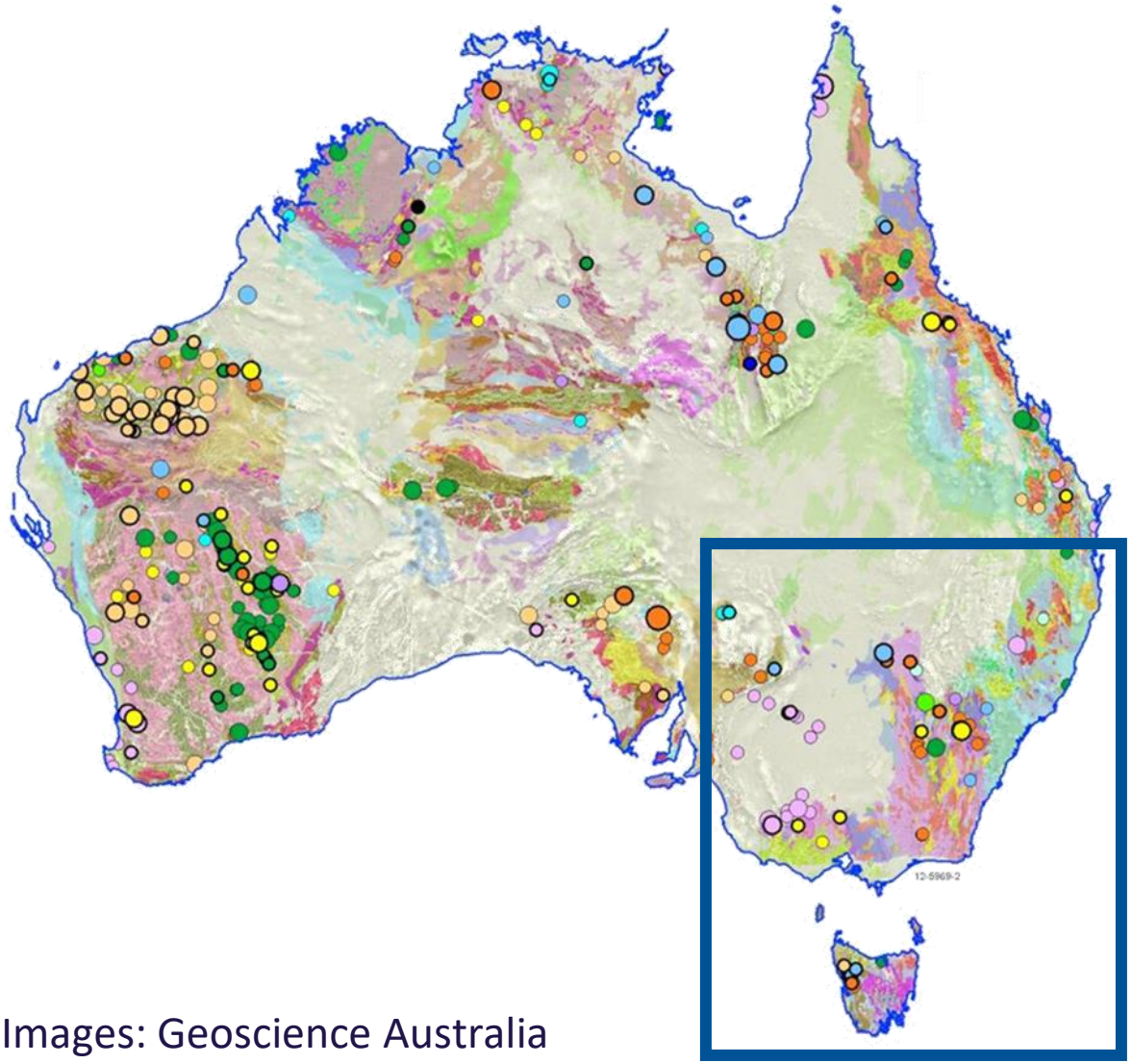
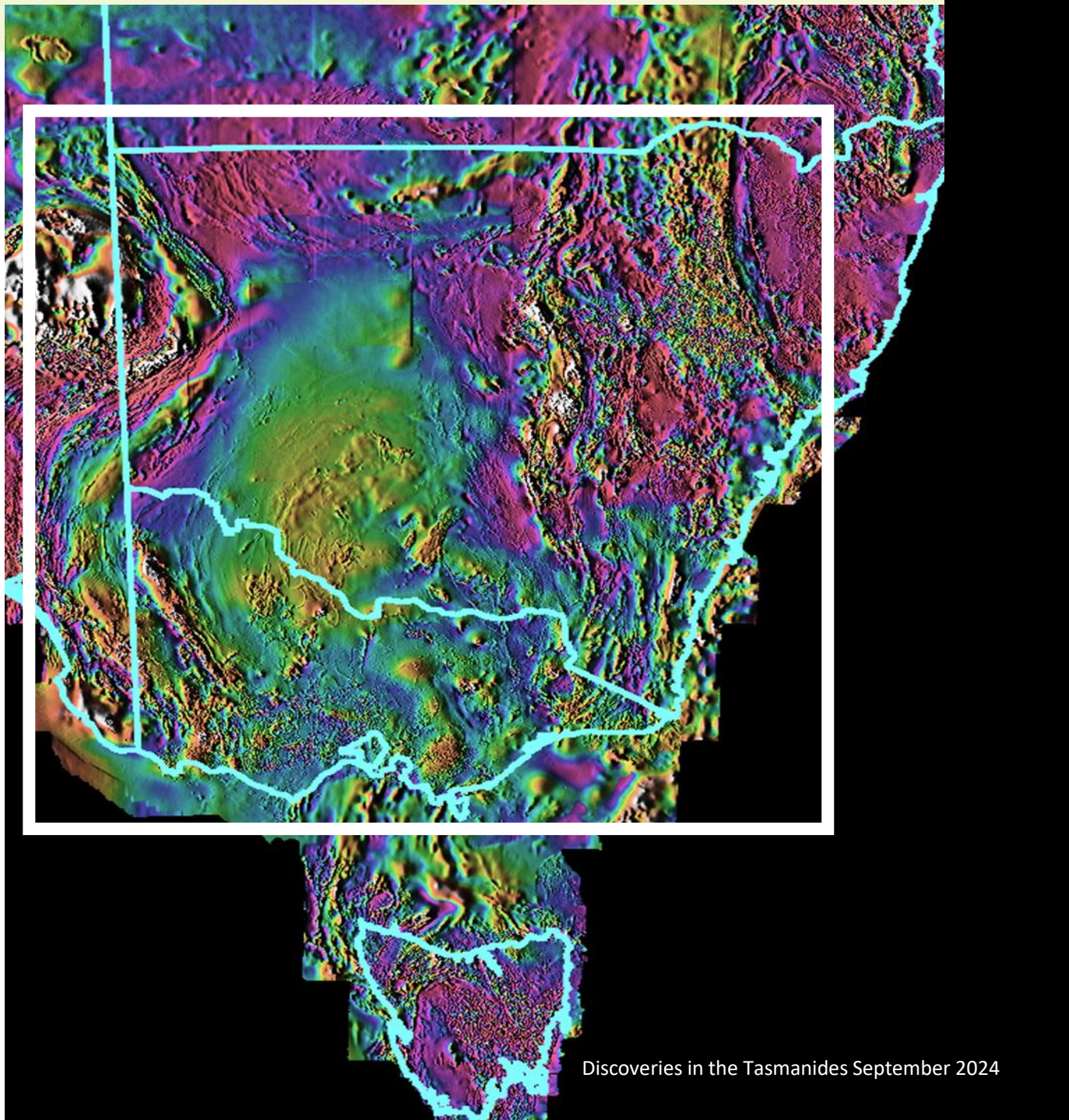
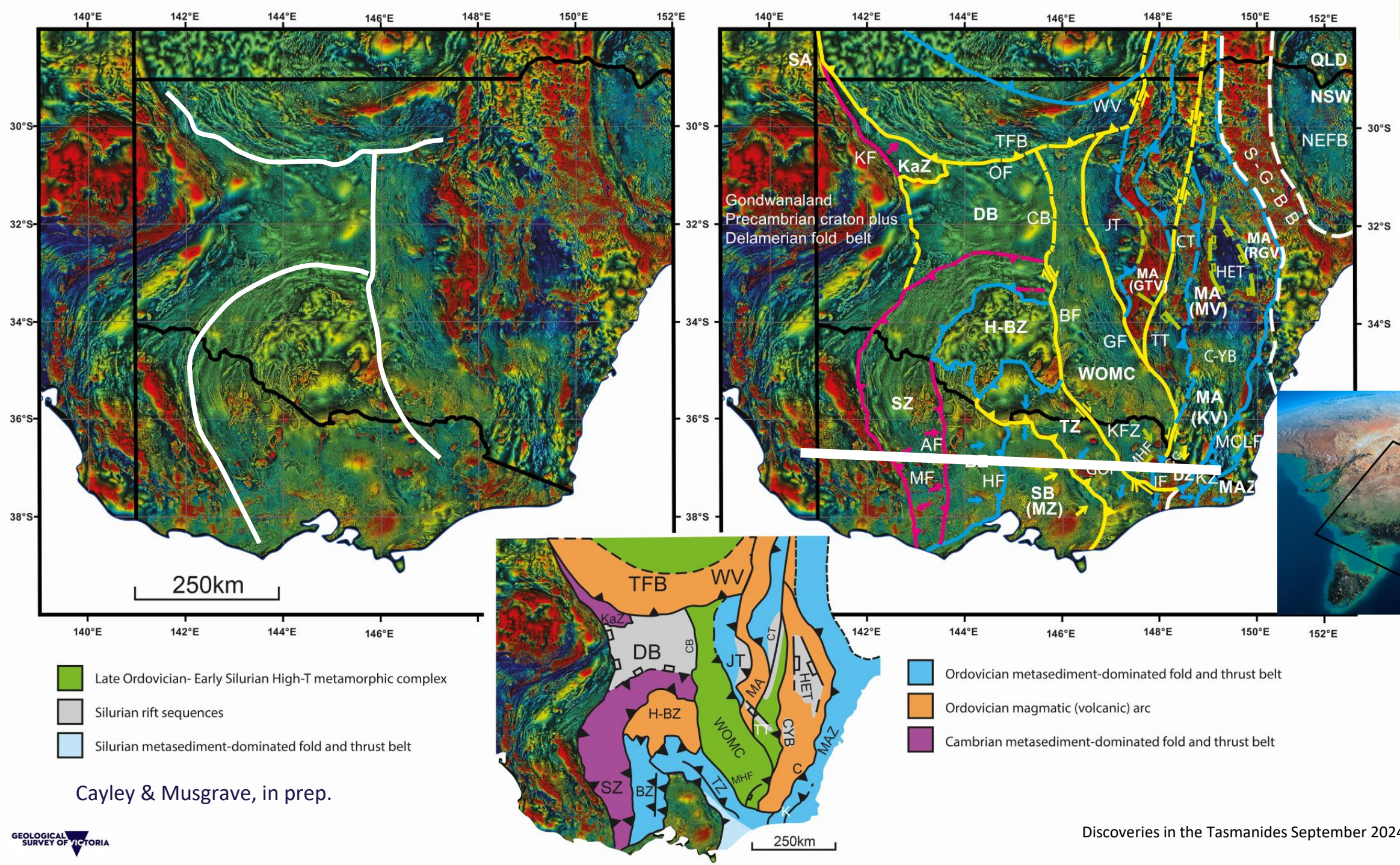


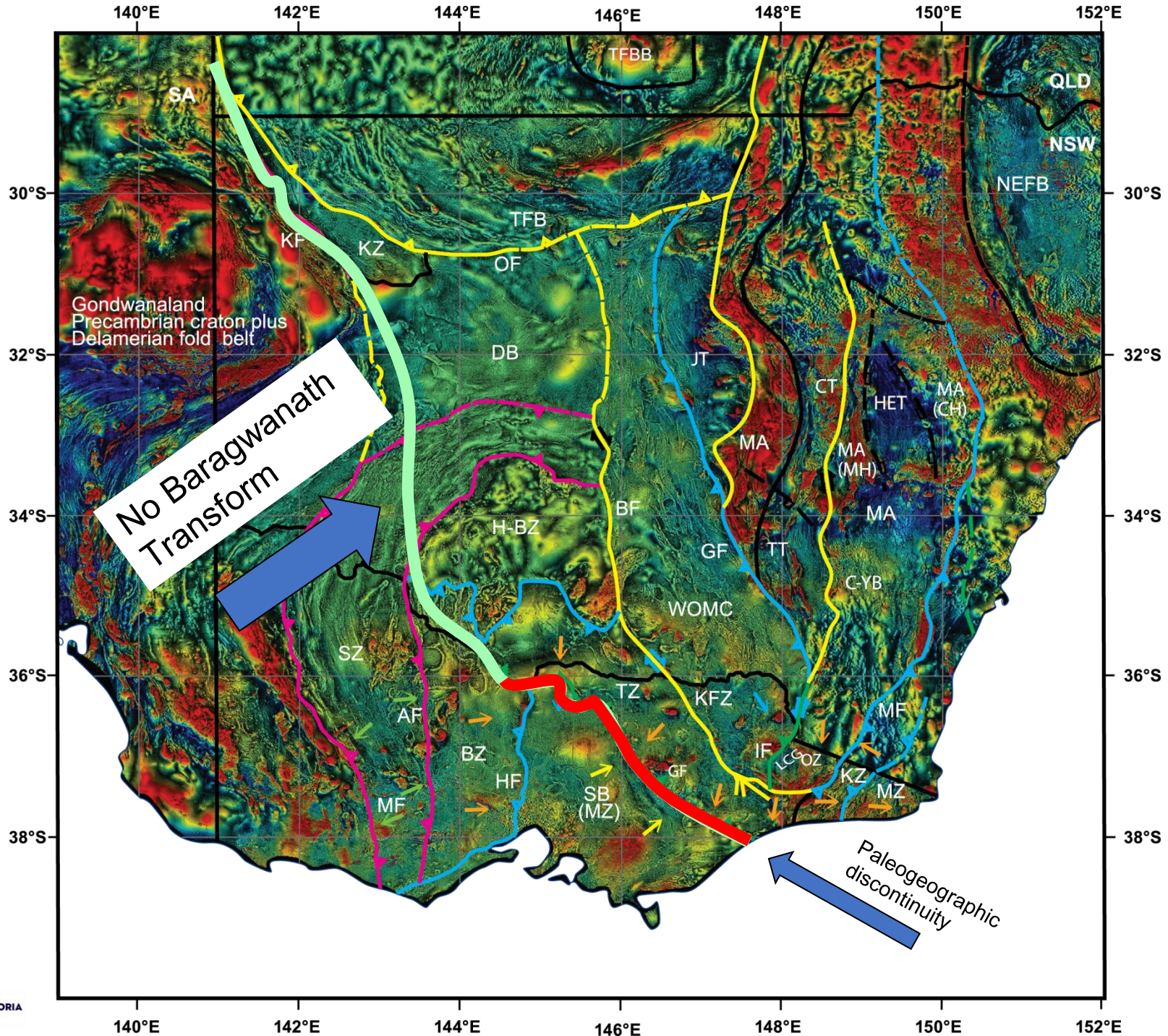
Images: Geoscience Australia

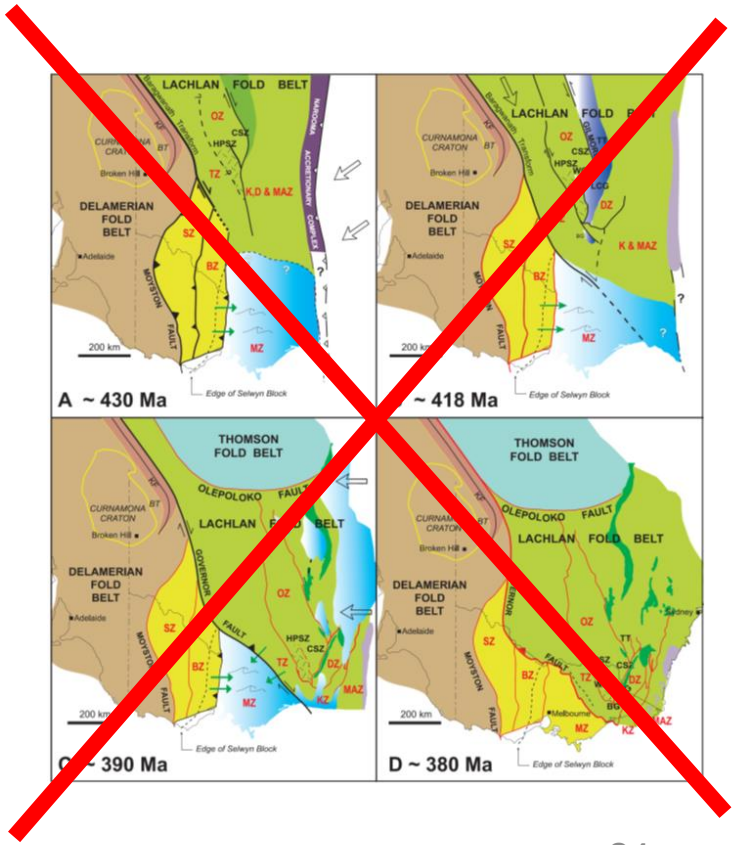


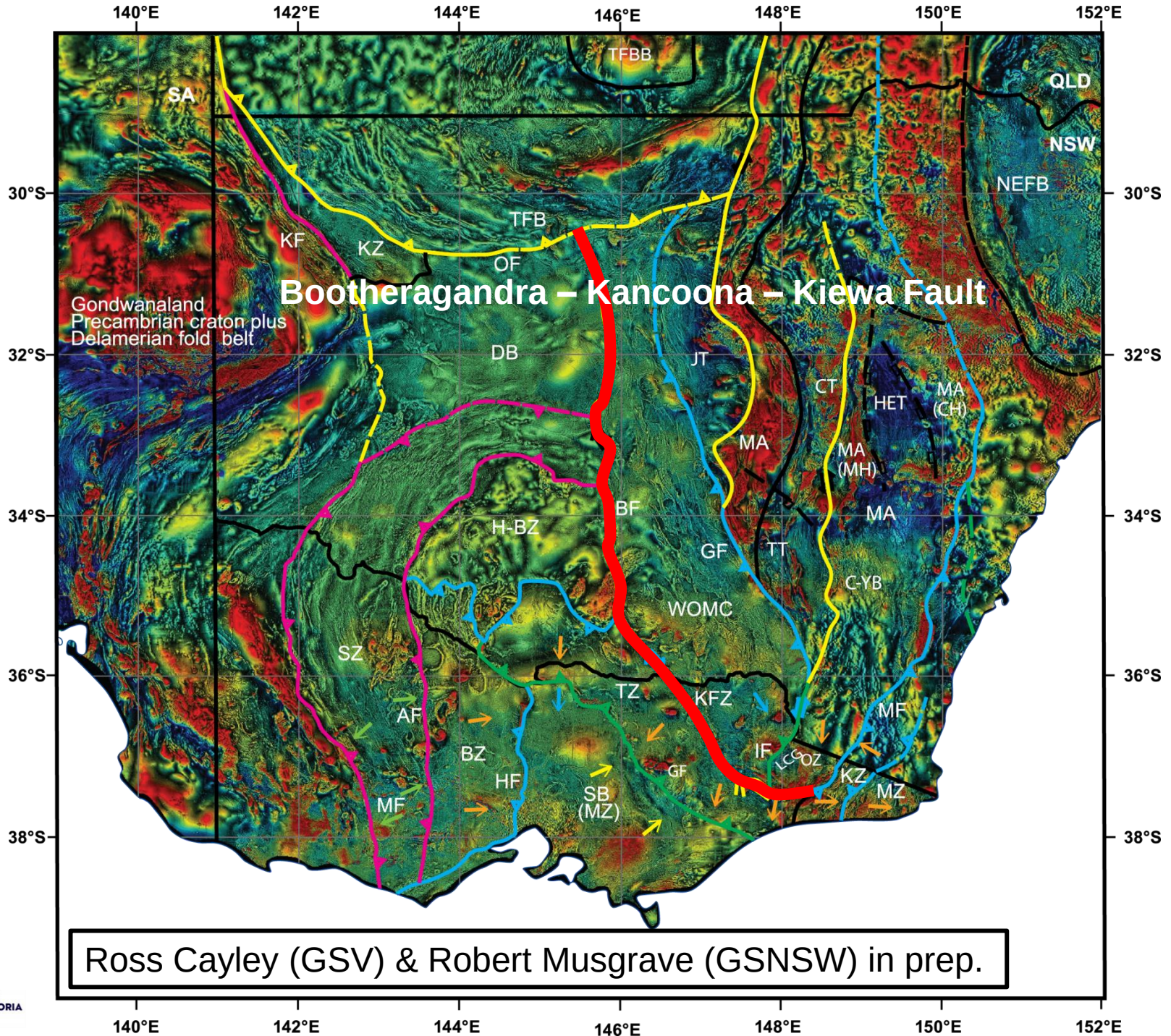
Discoveries in the Tasmanides September 2024



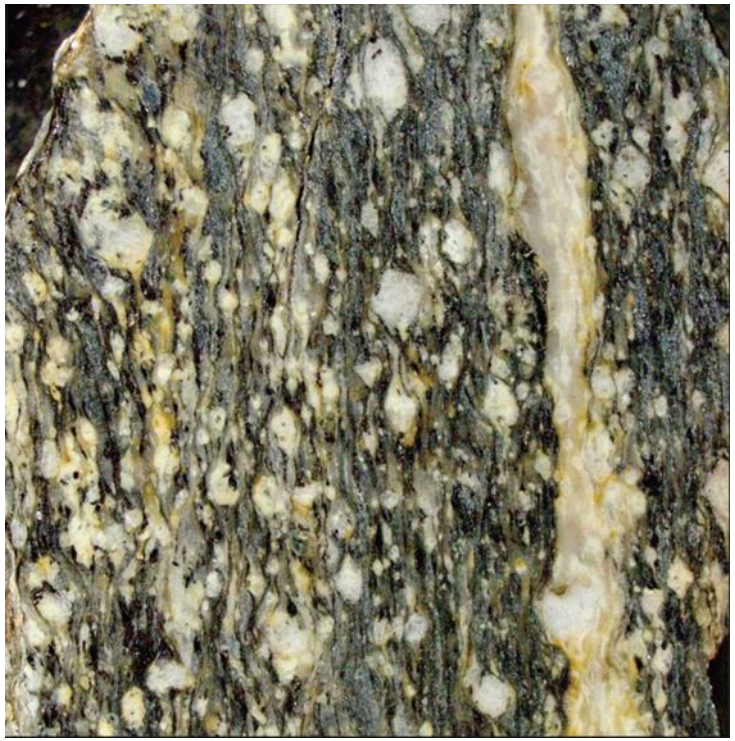

Cayley & Musgrave, in prep.


140°E
142°E
144°E
146°E
148°E
150°E
152°E
30°S
32°S
34°S
36°S
38°S
SA
QLD
NSW
NEFB
TFBB
TFB
OF
KF
KZ
Gondwanaland
Precambrian craton plus
Delamerian fold belt
No Baragwanath
Transform
DB
JT
CT
HET
MA
(CH)
MA
MA
(MH)
MA
BF
H-BZ
GF
TT
C-YB
WOMC
SZ
AF
BZ
HF
MF
TZ
KFZ
SB
(MZ)
GF
IF
LCC
OZ
KZ
MZ
MF
Paleogeographic
discontinuity

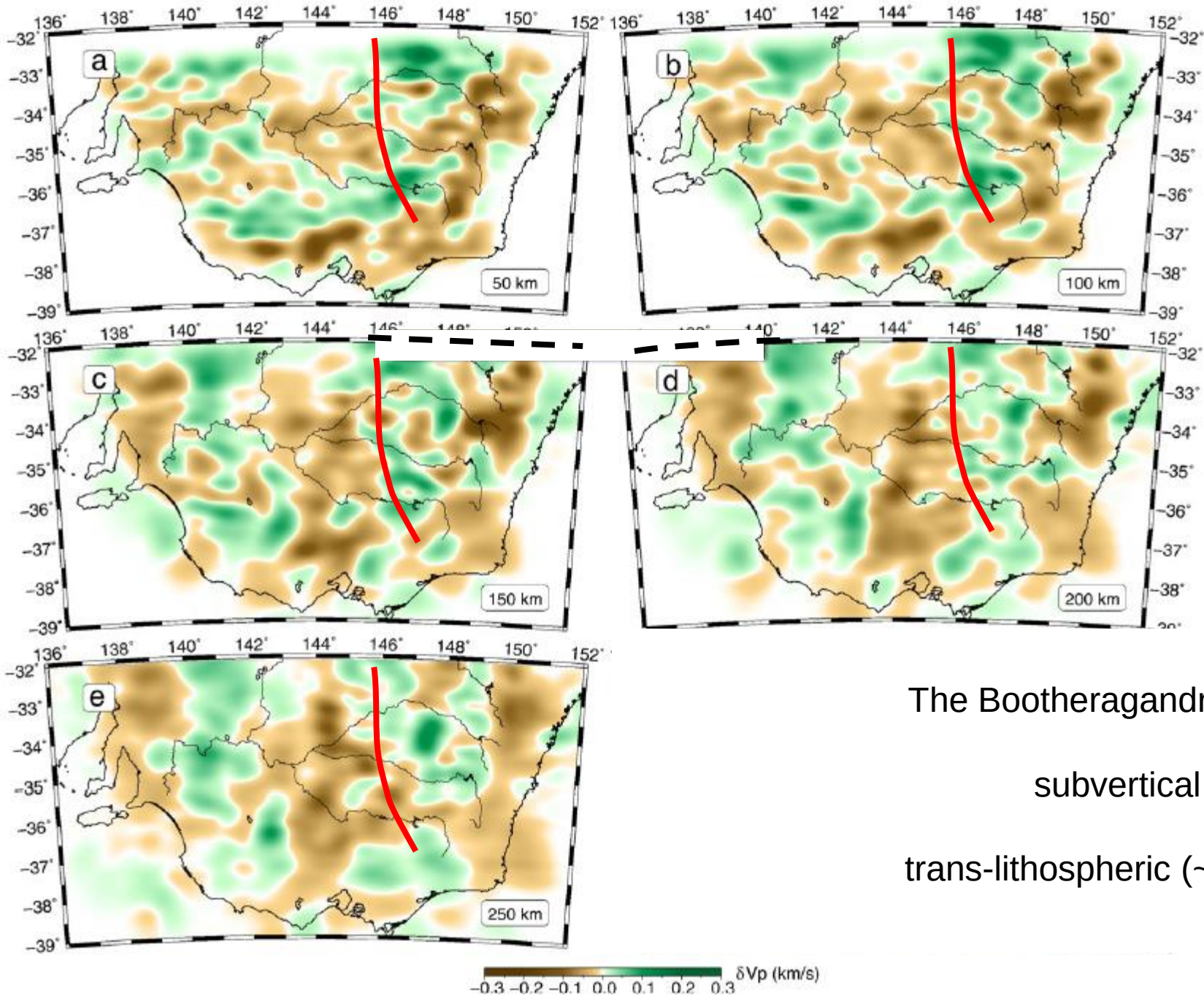

LACHLAN FOLD BELT
DELAMERIAN FOLD BELT
A ~ 430 Ma
~ 418 Ma
THOMSON FOLD BELT
OLEPOLOKO FAULT
~ 390 Ma
D ~ 380 Ma




Ross Cayley (GSV) & Robert Musgrave (GSNSW) in prep.



Mylonite in granite,
Kiewa Shear Zone

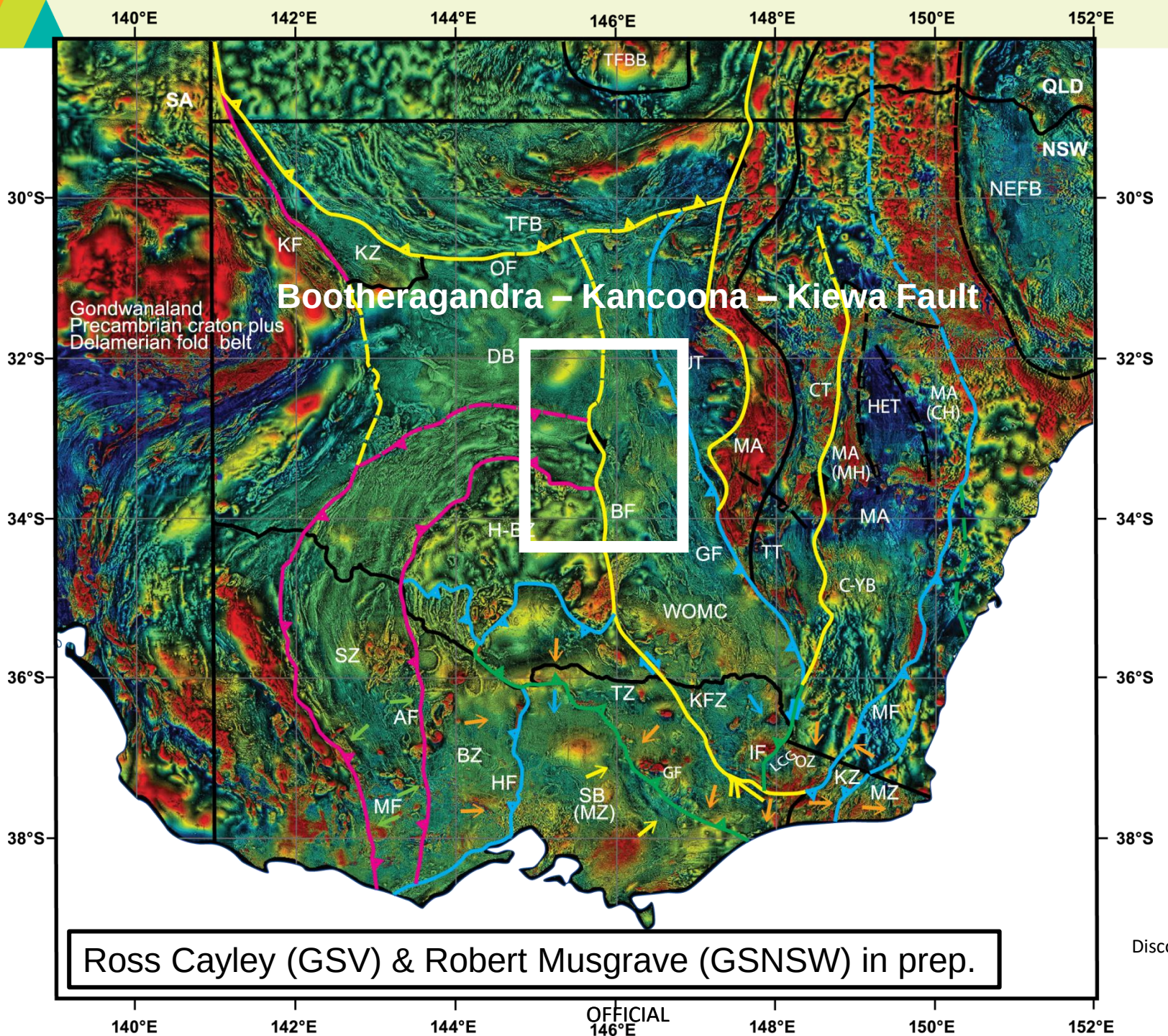



WOMBAT passive seismic experiment:
time arrival residuals
(Rawlinson, et al, GR, 2011)

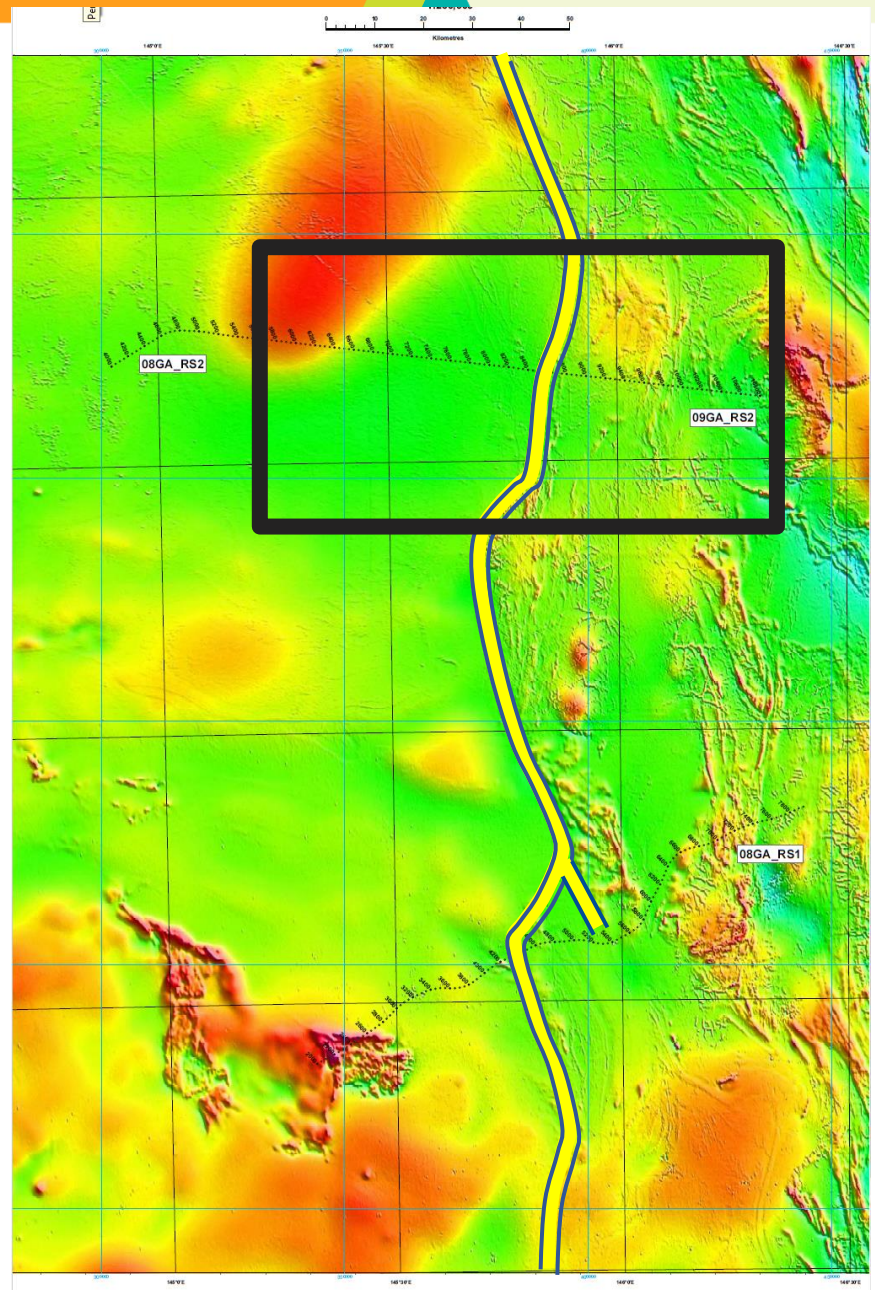
The Bootheragandra Fault:

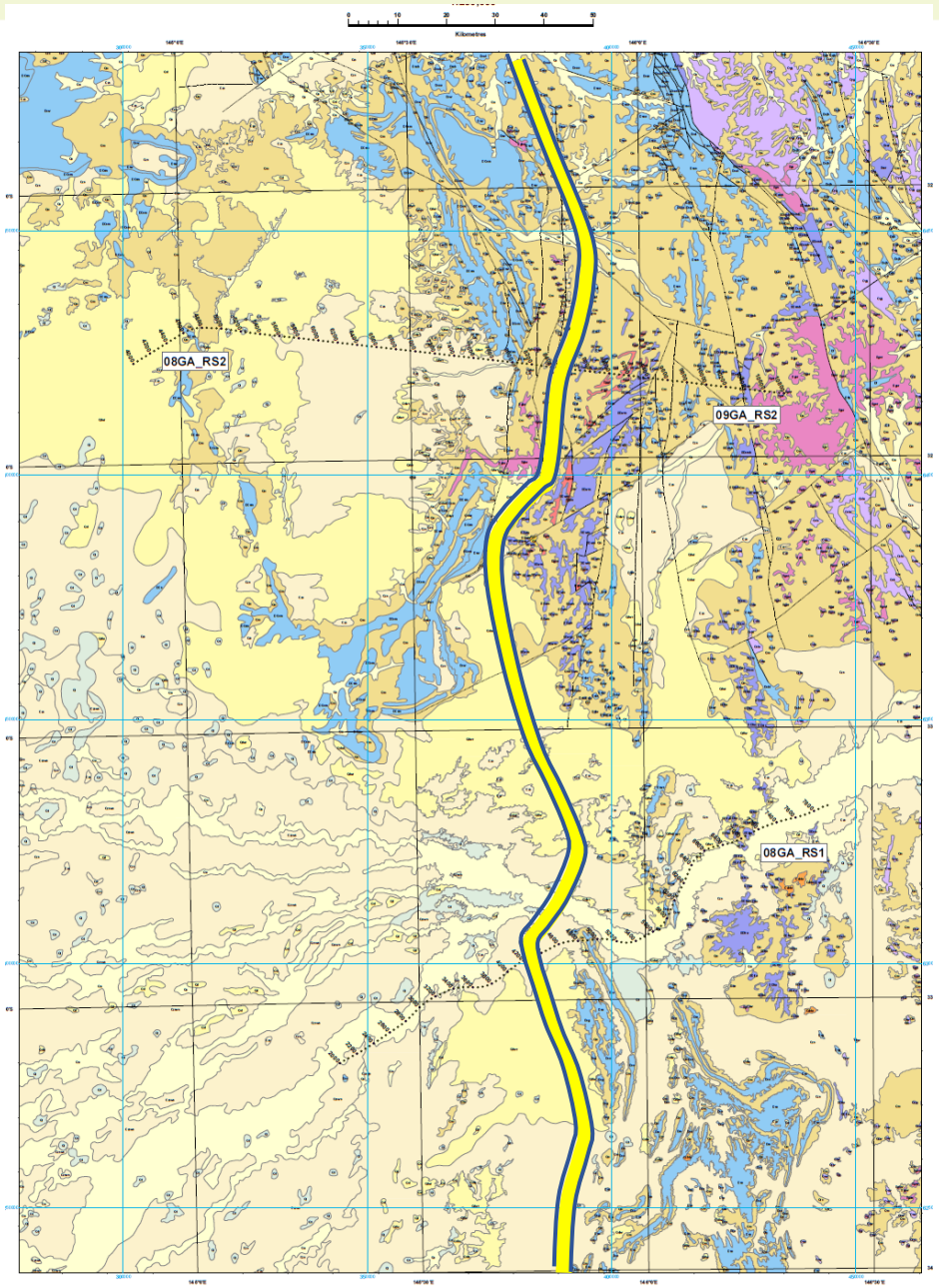
subvertical

trans-lithospheric (~200km)

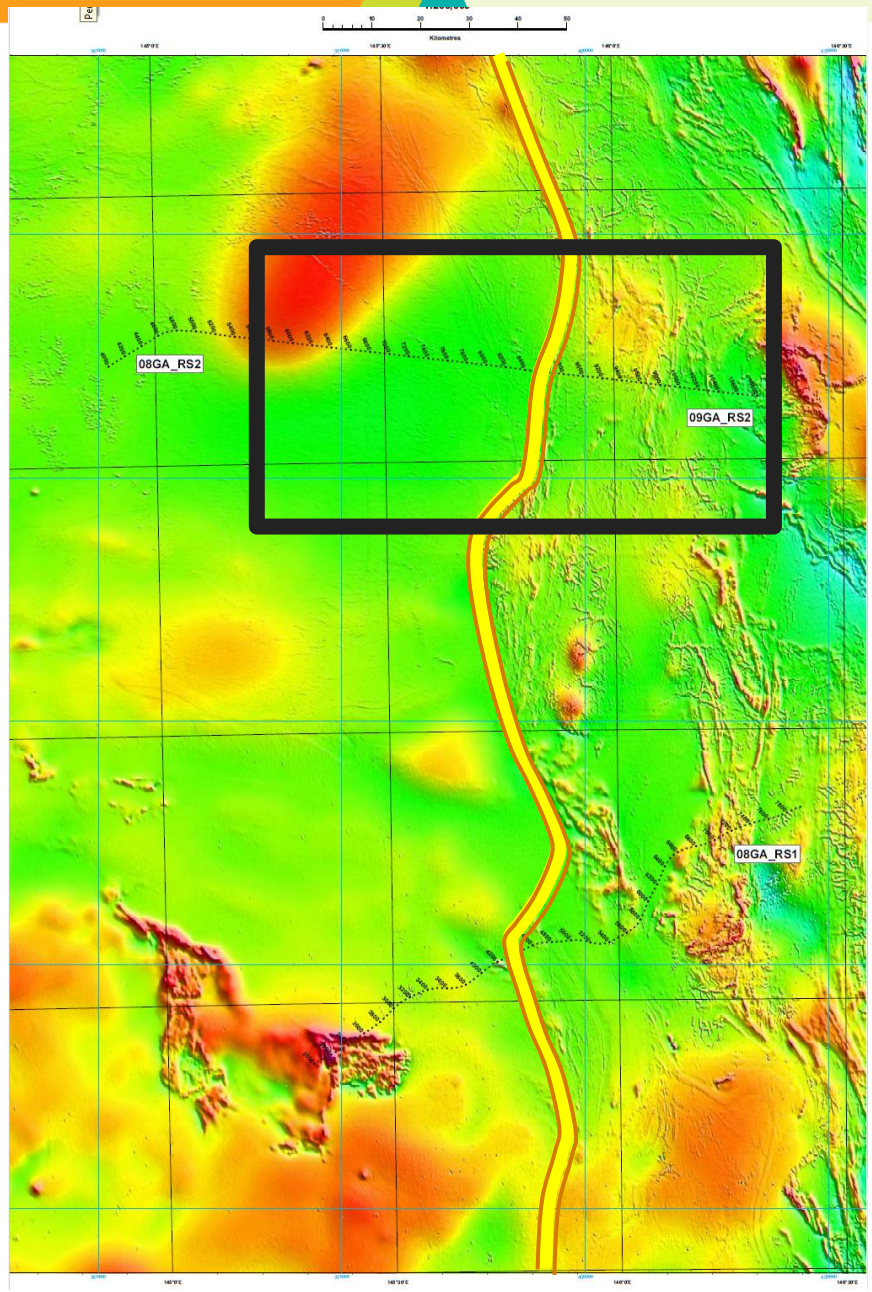


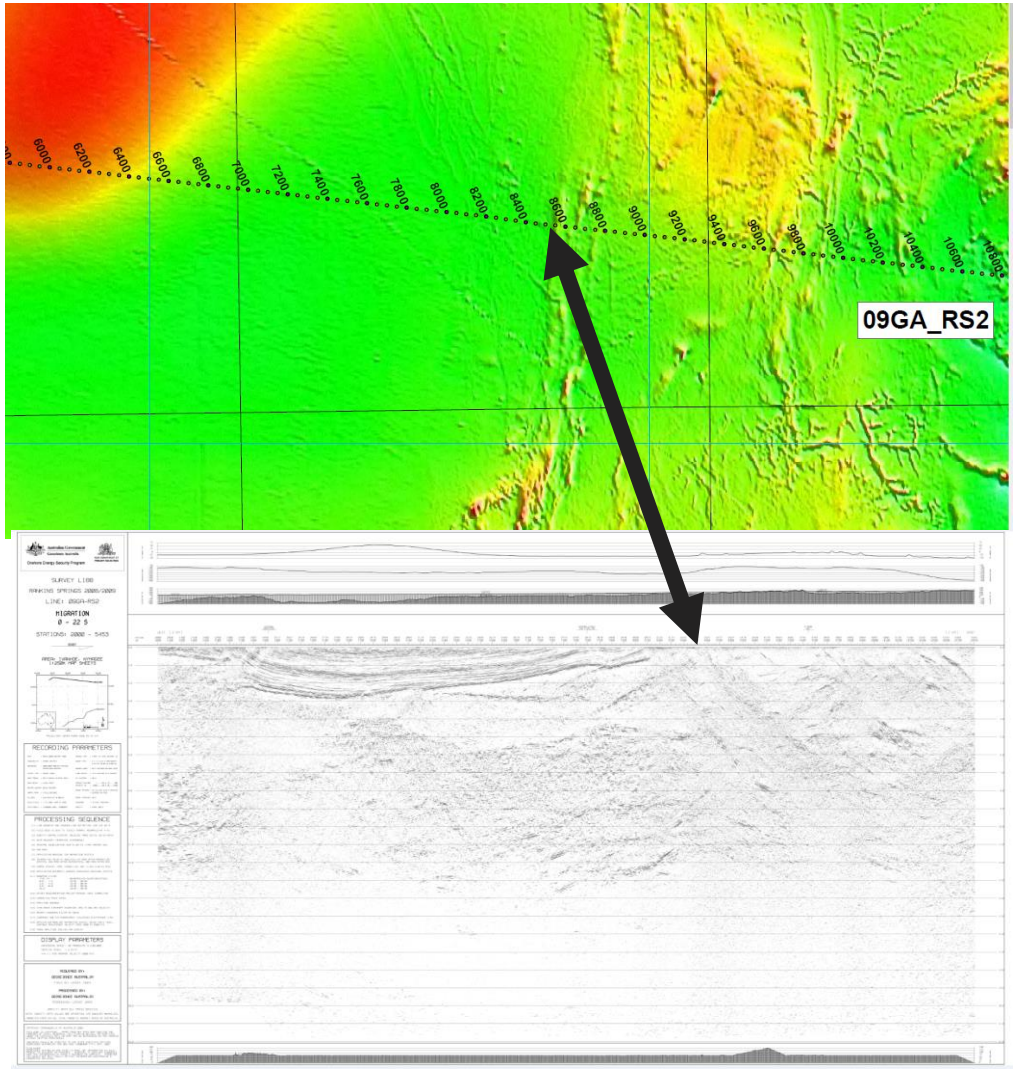

Ross Cayley (GSV) & Robert Musgrave (GSNSW) in prep.



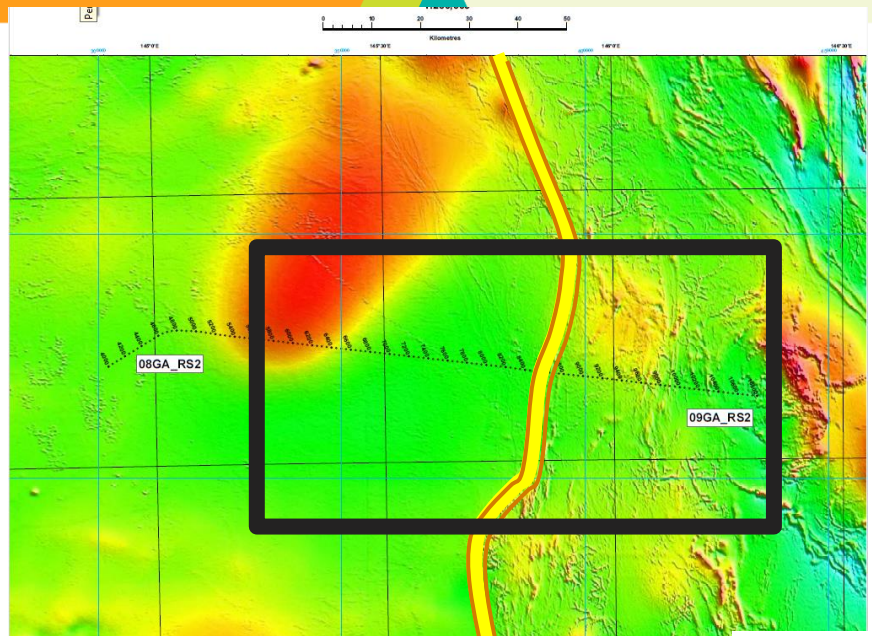

L188 Rankins Springs seismic survey NSW 2008-2009 (GA, 2018)

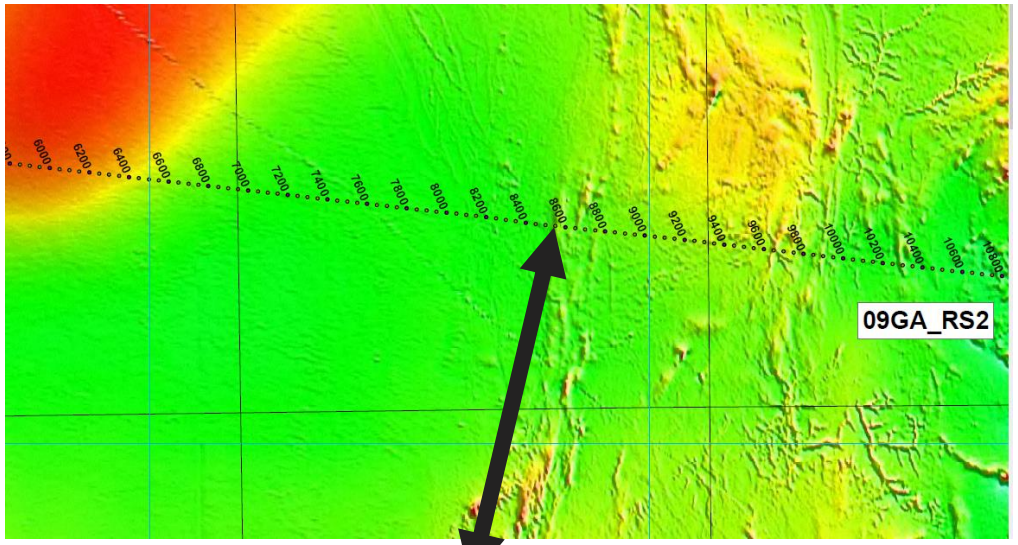


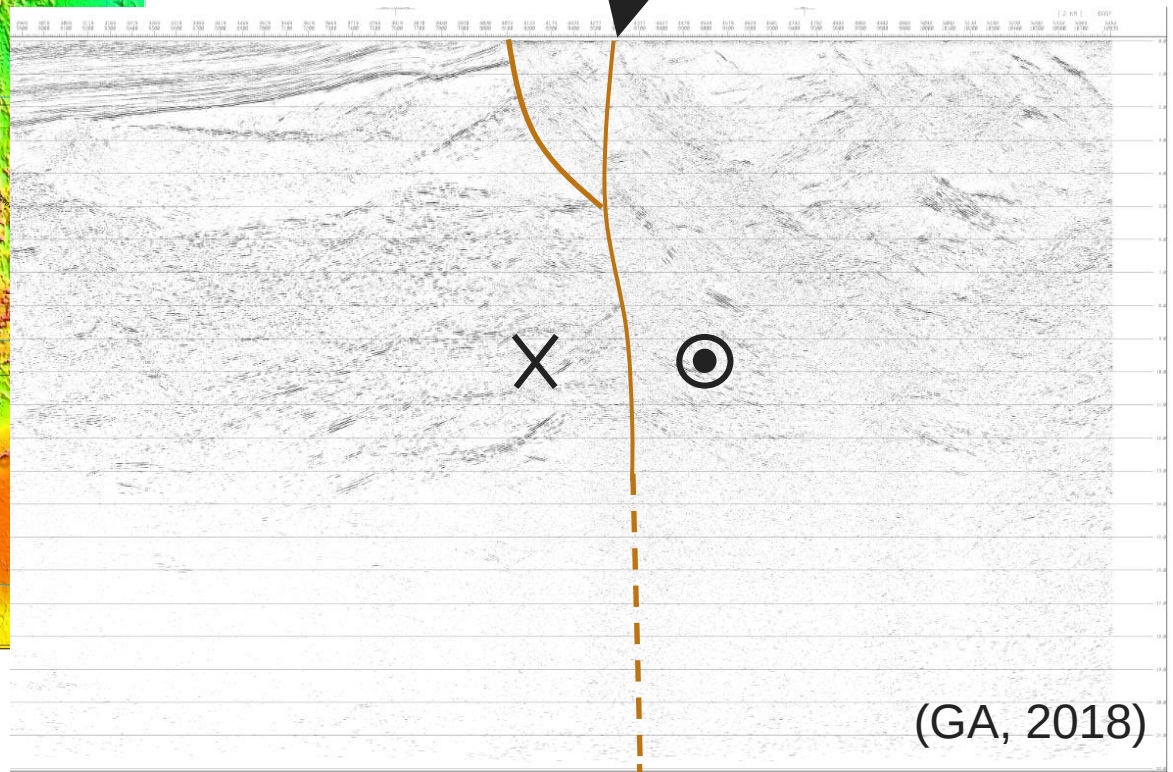




L188 Rankins Springs seismic survey NSW 2008-2009

(GA, 2018)

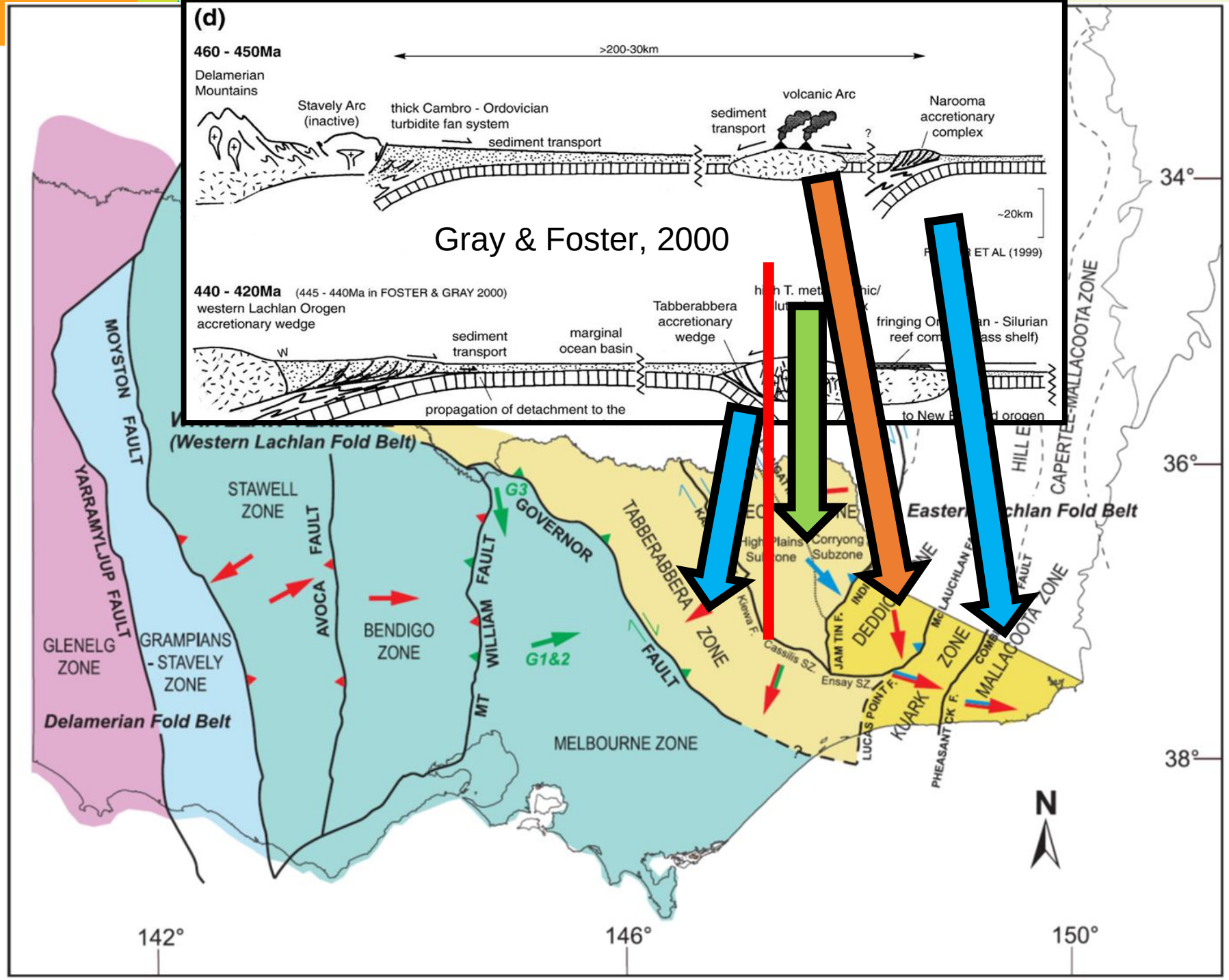



L188 Rankins Springs seismic survey NSW 2008-2009

reinterpretation from Cayley & Musgrave (in prep)




This strike slip fault is big enough to explain the bits of Victorian geology that don't make sense in their current positions..

# Talk outline

- Geological Systems Analysis – a logical way to categorize tectonic ambiguity / complexity
- Competing tectonic models for Lachlan Fold Belt development – confusing for mineral explorers
- Palaeogeography – a key constraint for Lachlan Fold Belt retrodeformation
- Fundamental Constraints – the Delamerian, Benambran, Quidongan, Bindian and Tabberabberan (and Kanimblan) Orogenies. Where are they? Where **AREN'T** they?
- Structural / stratigraphic mapping + potential field and seismic reflection geophysics – taking understanding to crustal scale
- **A constrained retrodeformation scenario for the Ordovician-Silurian Lachlan Fold Belt - the Lachlan Orocline**
- Towards a Unifying Theory for predicting the locations of Eastern Australian Early Palaeozoic geology and mineral systems (especially buried ones)

# Convergent margin key elements and systematics

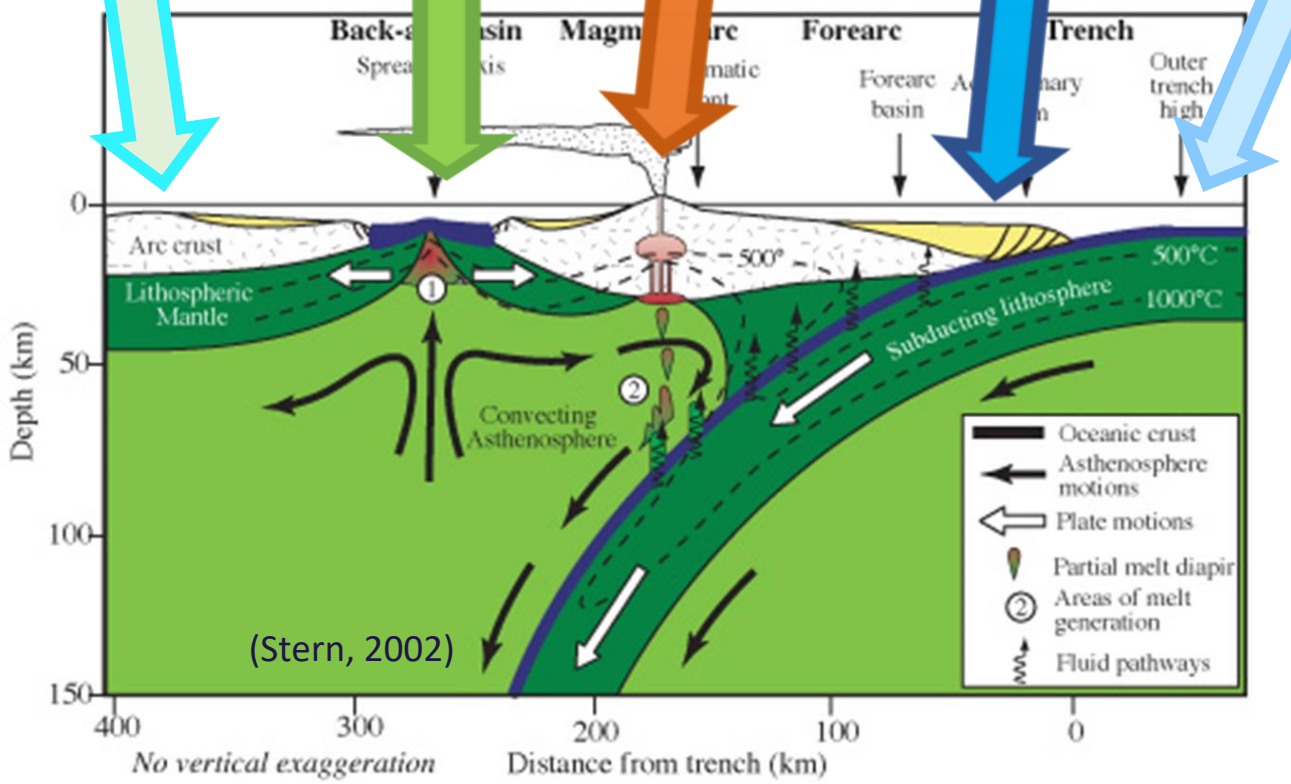
Distal back-arc: transition to intraplate

Back-arc basin: hot, syn-sediment magmatism, extension weak/strong deformation

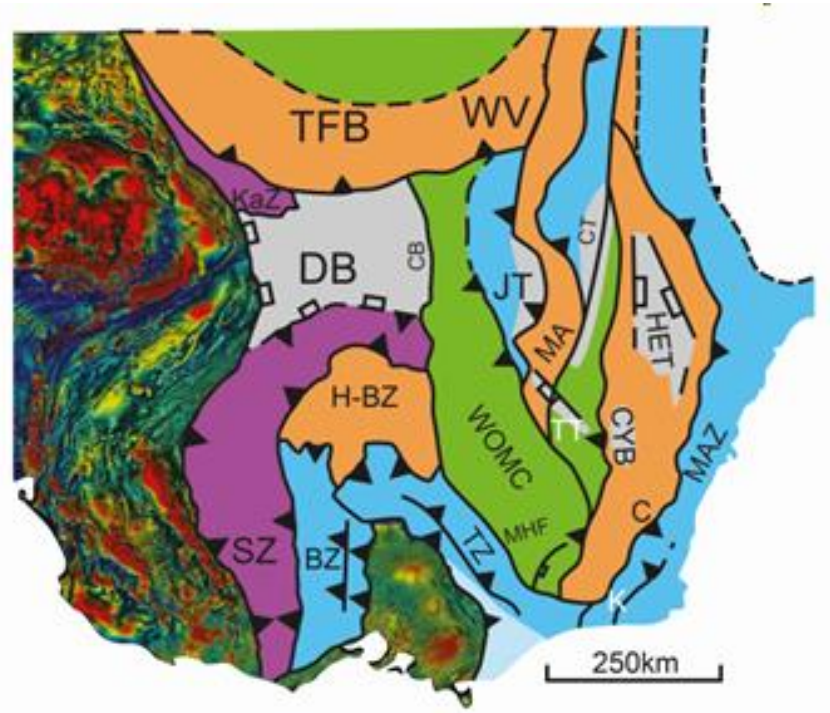
Magmatic arc: hot, igneous-dominated

Accretionary wedge: cold, inherent strong syn-sedimentary shortening deformation, amagmatic (thickening crust)

Intraplate: cold, undeformed, amagmatic

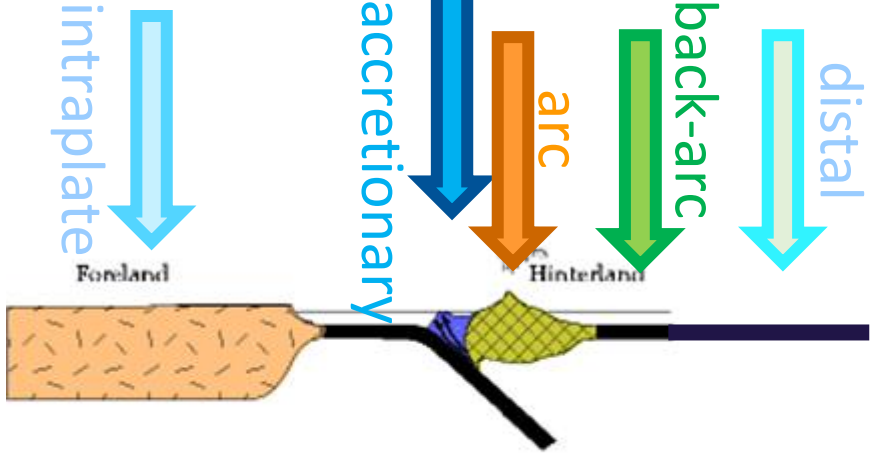



(Stern, 2002)

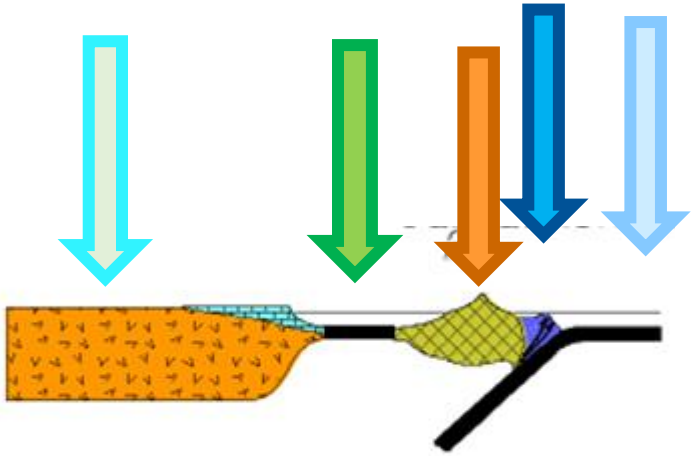




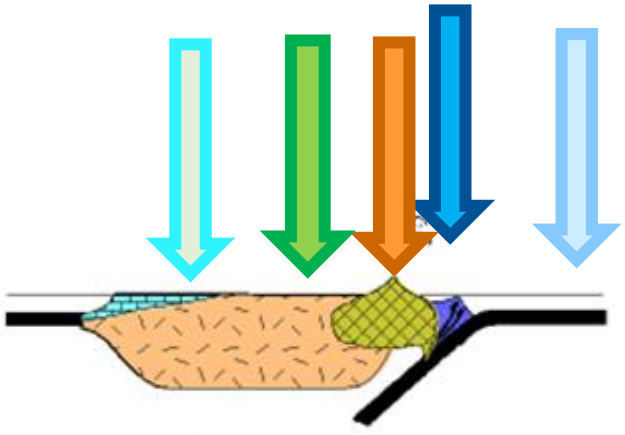

GEOLOGICAL SURVEY OF VICTORIA



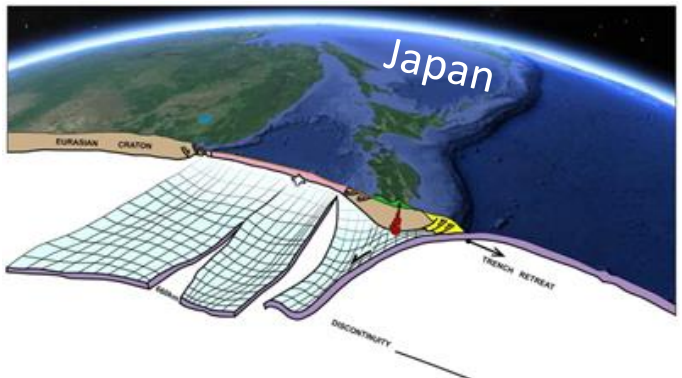

Continent-Island Arc Collision

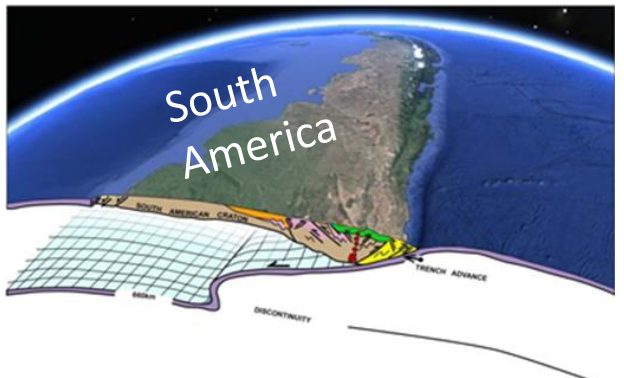



Island Arc

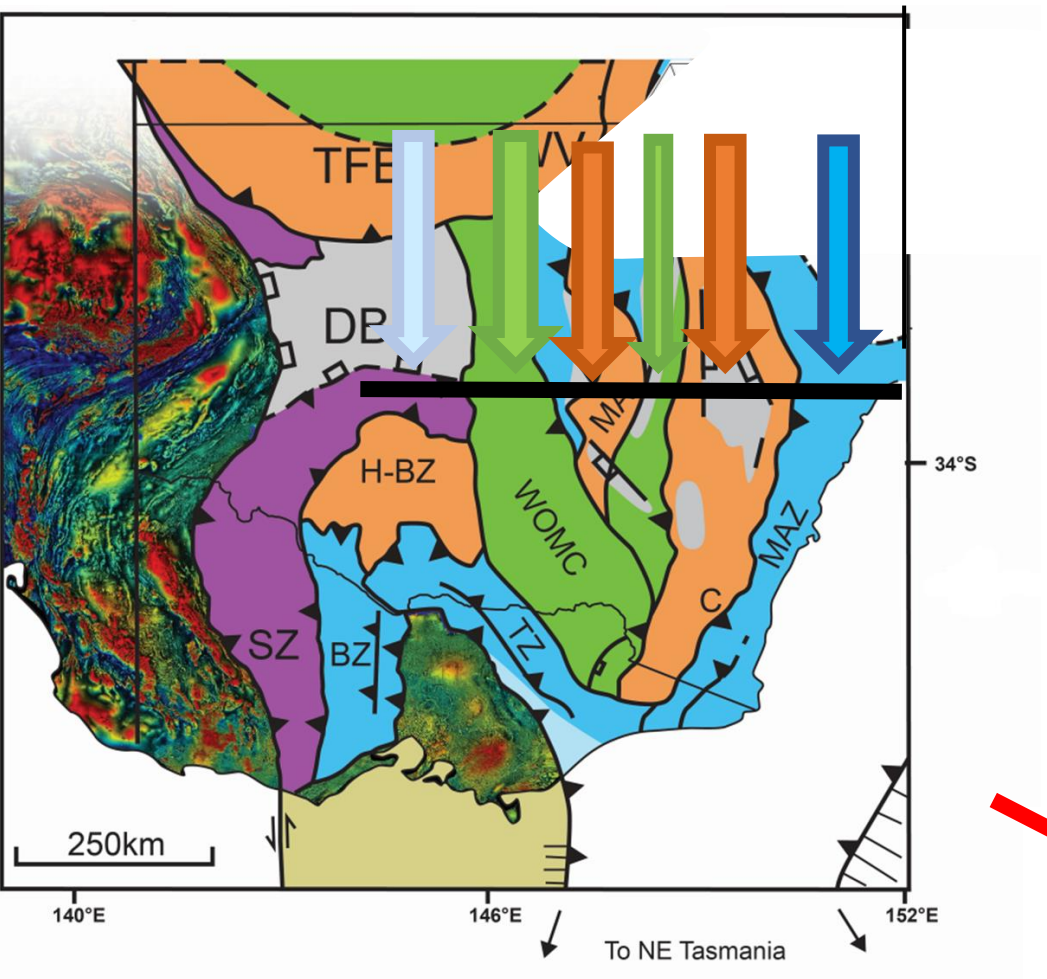


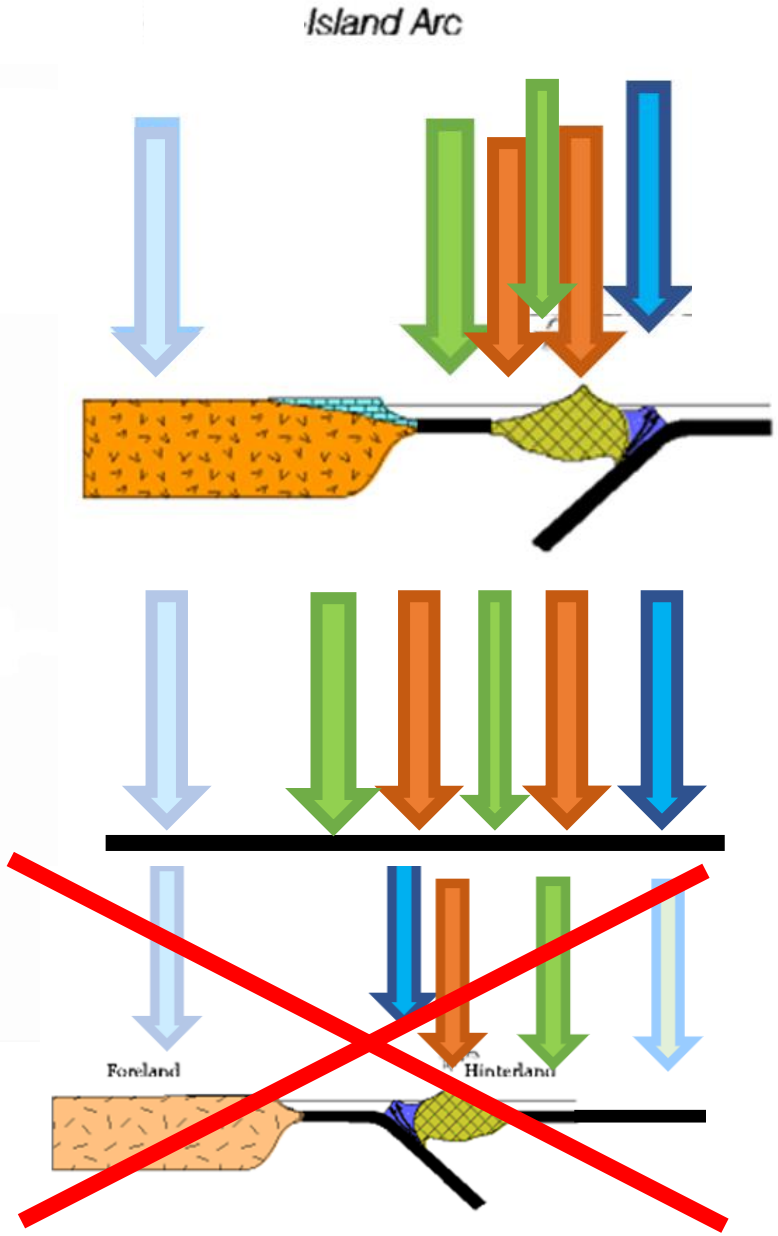
Cordilleran

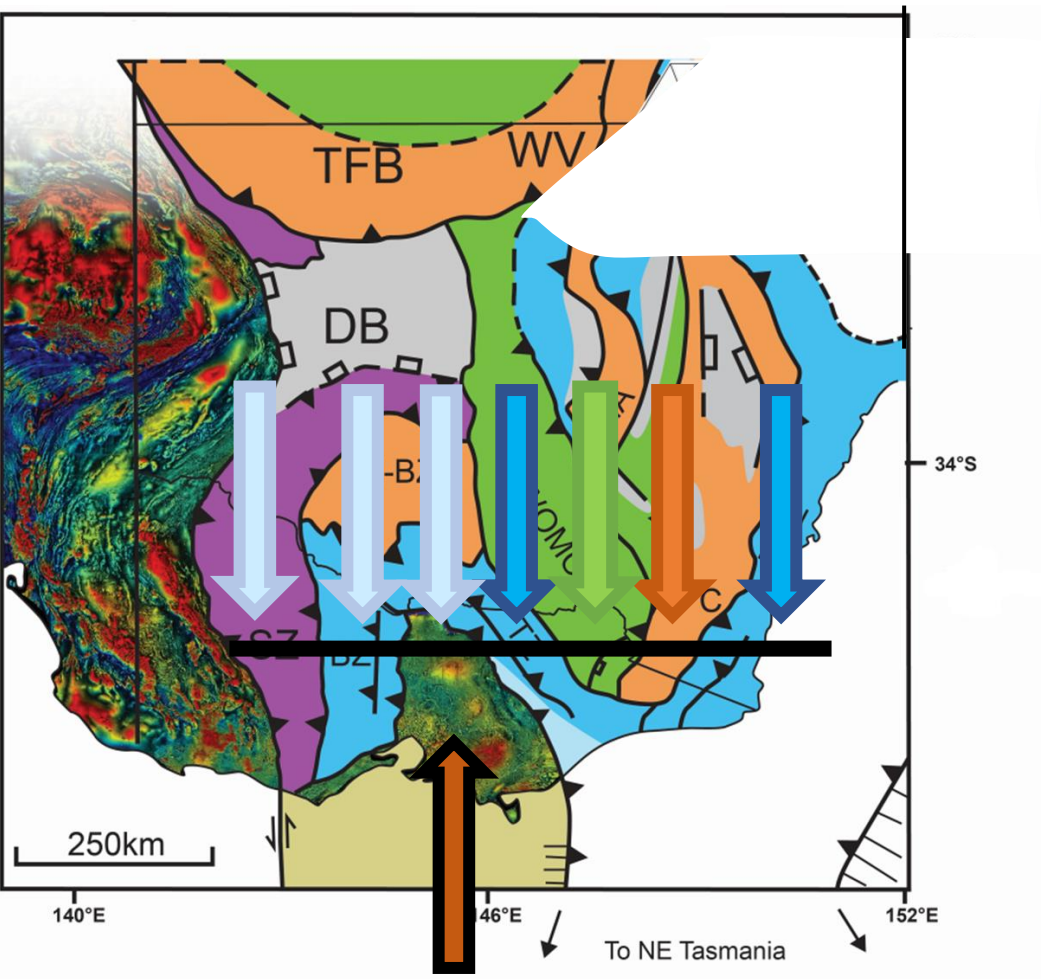


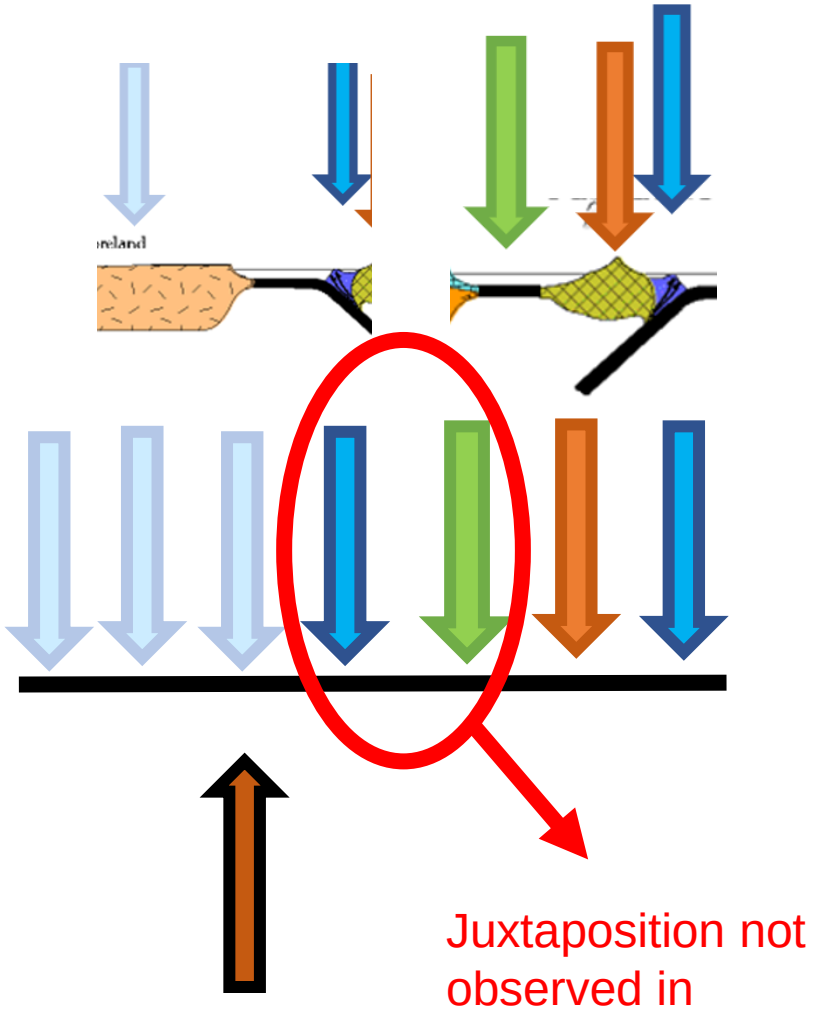




# Benchmarking against modern systems


TFE
DB
H-BZ
WOMC
MA
C
MAZ
SZ
BZ
TZ
34°S
250km
140°E
146°E
152°E
To NE Tasmania


Island Arc
Foreland
Hinterland

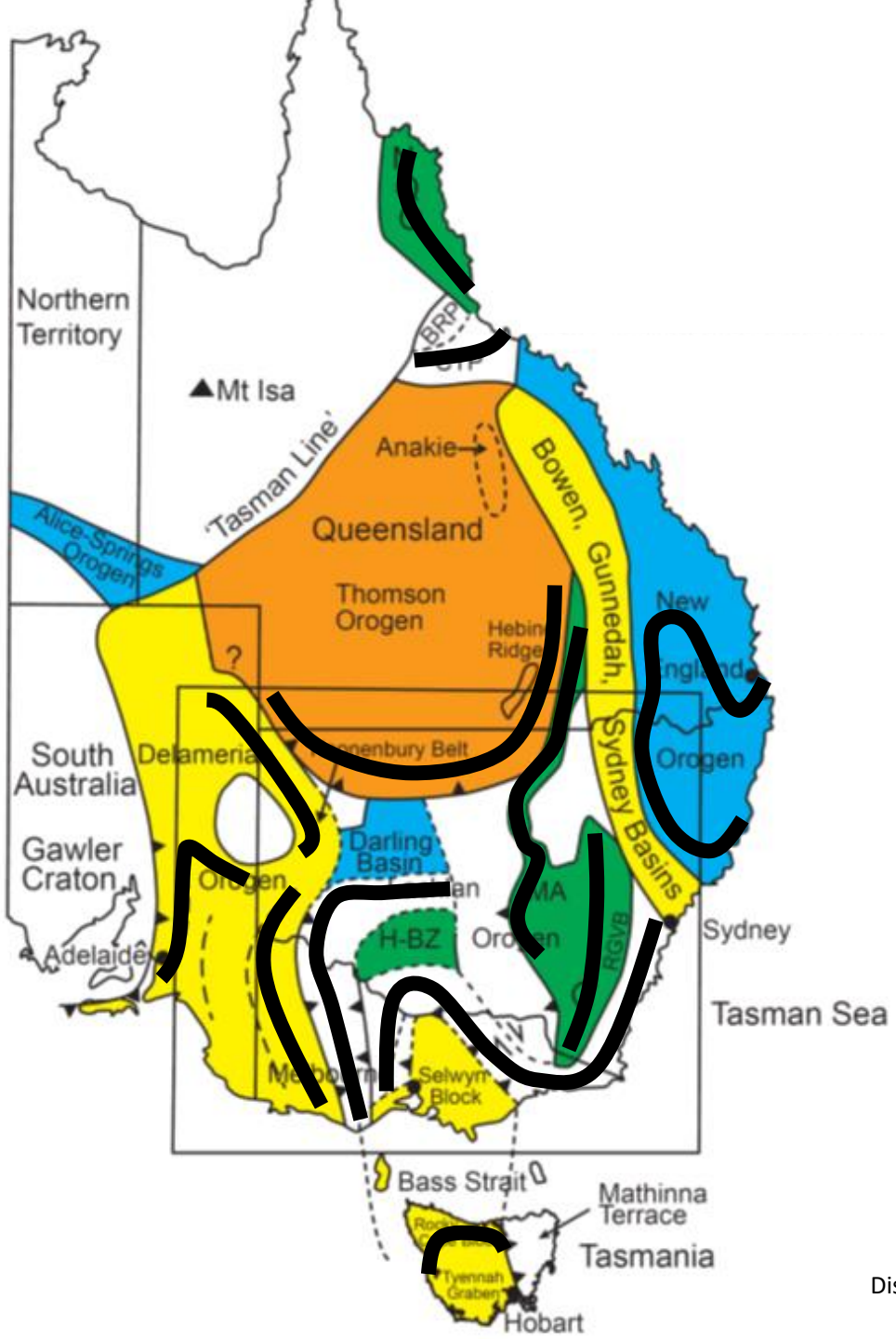


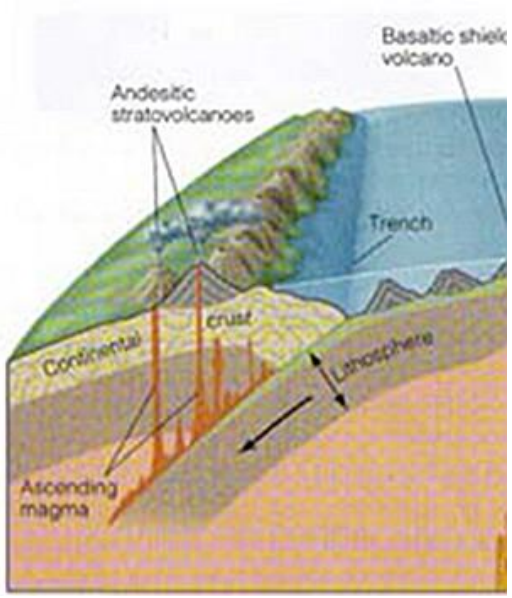
Juxtaposition not observed in active systems

Eastern Australian Tasmanides geology…

…all screwed up….



# …not like a ‘textbook’ accretionary system……




‘textbook’ accretionary systems are often depicted in ‘pseudo-3D’ – which is 2D projected to distance.

Any cross-section through it will look the same……

# Analogue modelling…


Early Palaeozoic east-Australia as a rock ‘warehouse’……

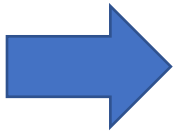
lots of familiar stores,
but pretty messy…..

bits and pieces piled up
all over the place…

…hard to understand….

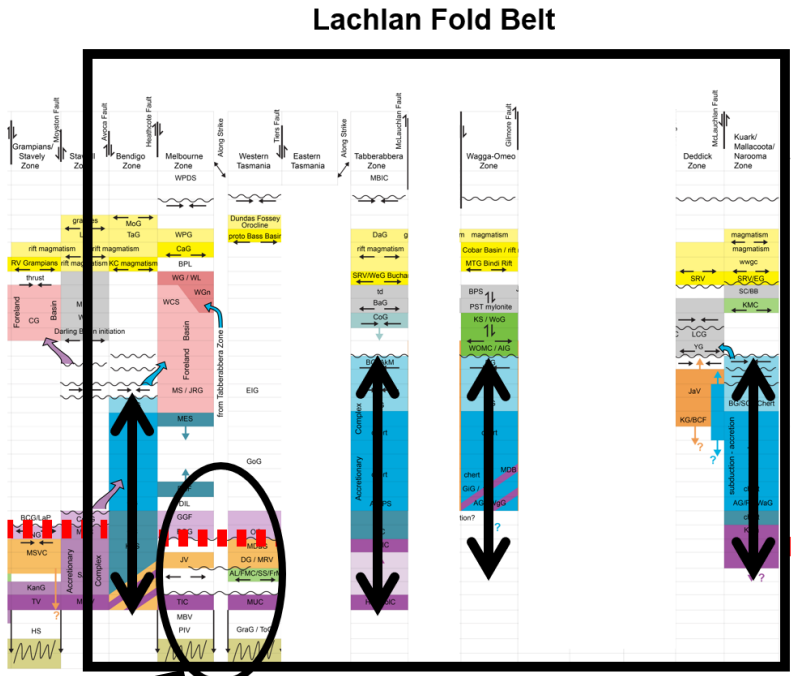
# …not like the ‘textbook’ warehouse…..

# The difference?……

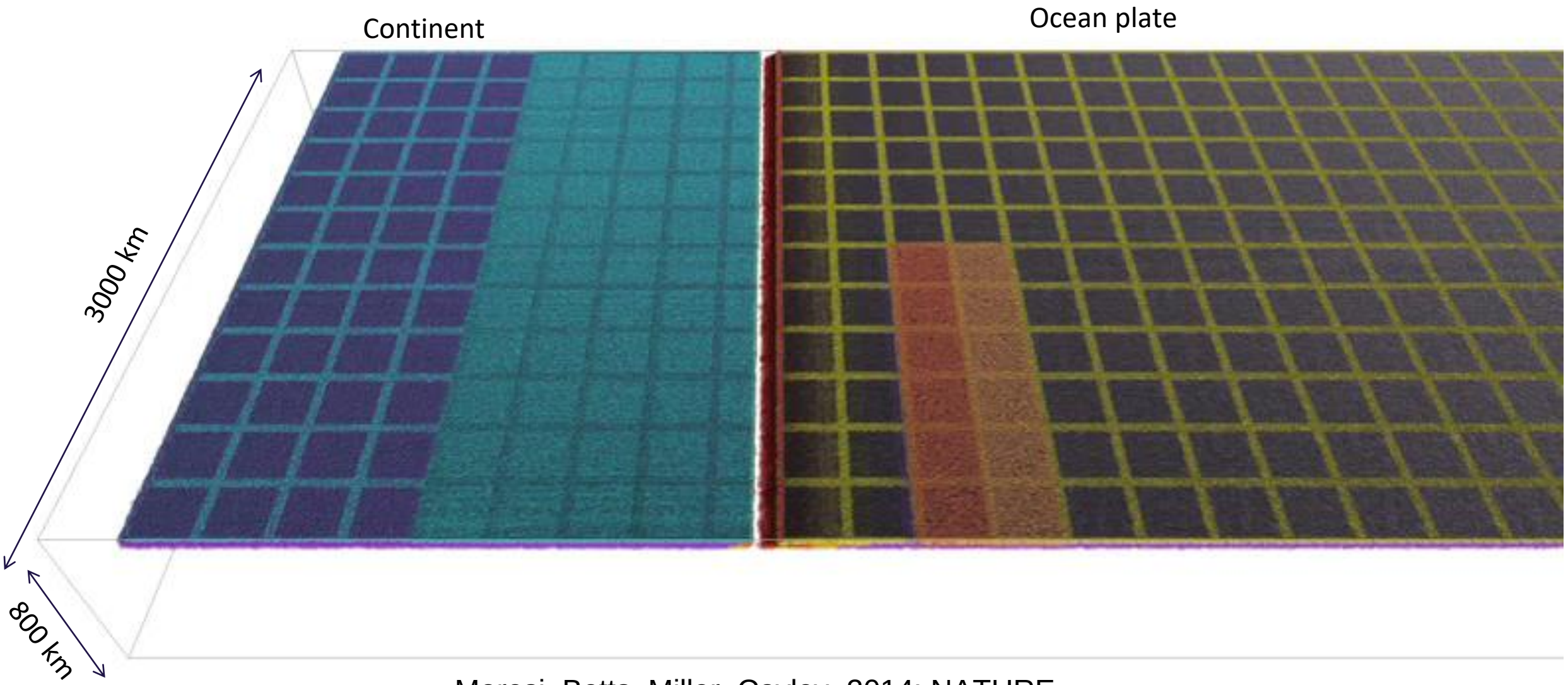

Appreciation of the **huge potential** of small colliders introduced into large, organised, but gravitationally meta-stable system
to trigger a cascade……and the rapid rate of that change…

The Lachlan Fold Belt has a potential major ‘collider’ – Vandieland
(western Tasmania / Selwyn Block)

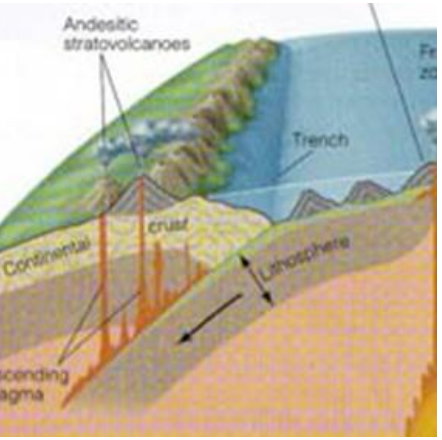


# Geodynamics of congested subduction zones

Model run time = 60 Million years

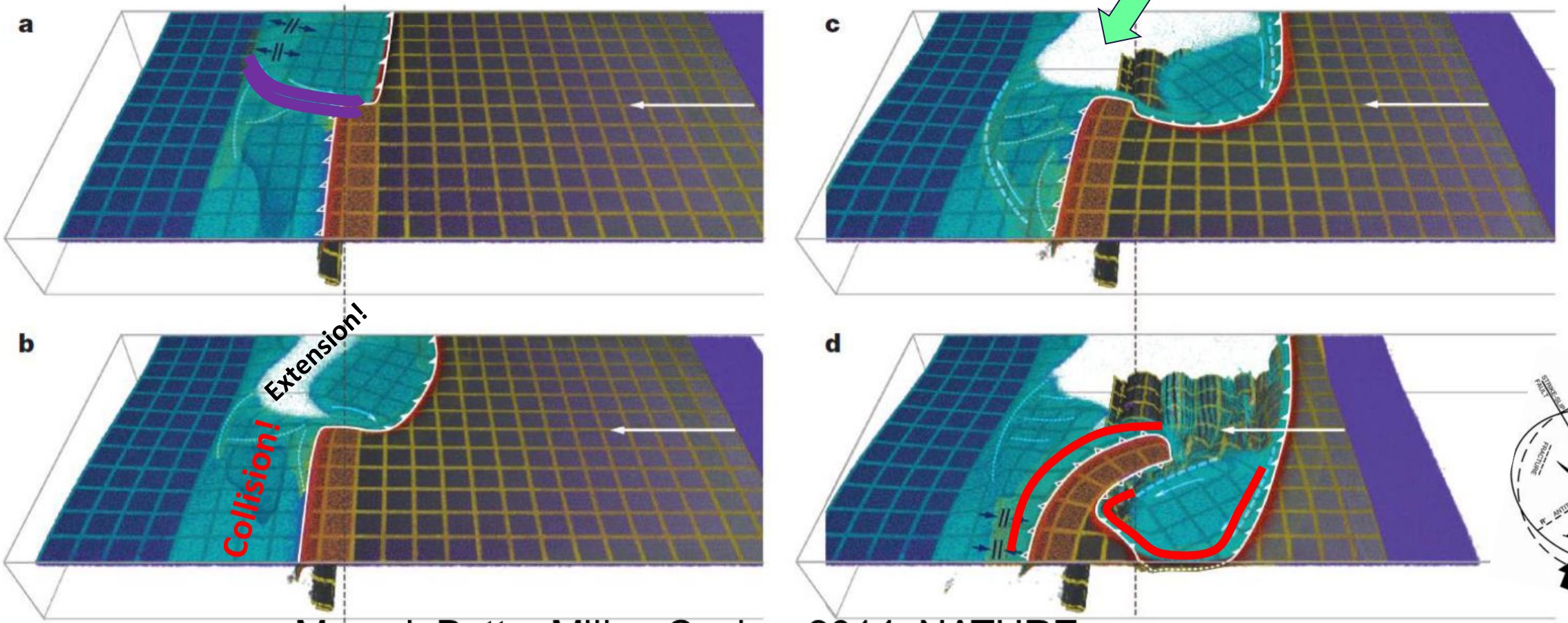


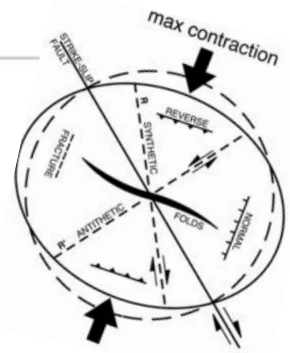

Moresi, Betts, Miller, Cayley, 2014: NATURE



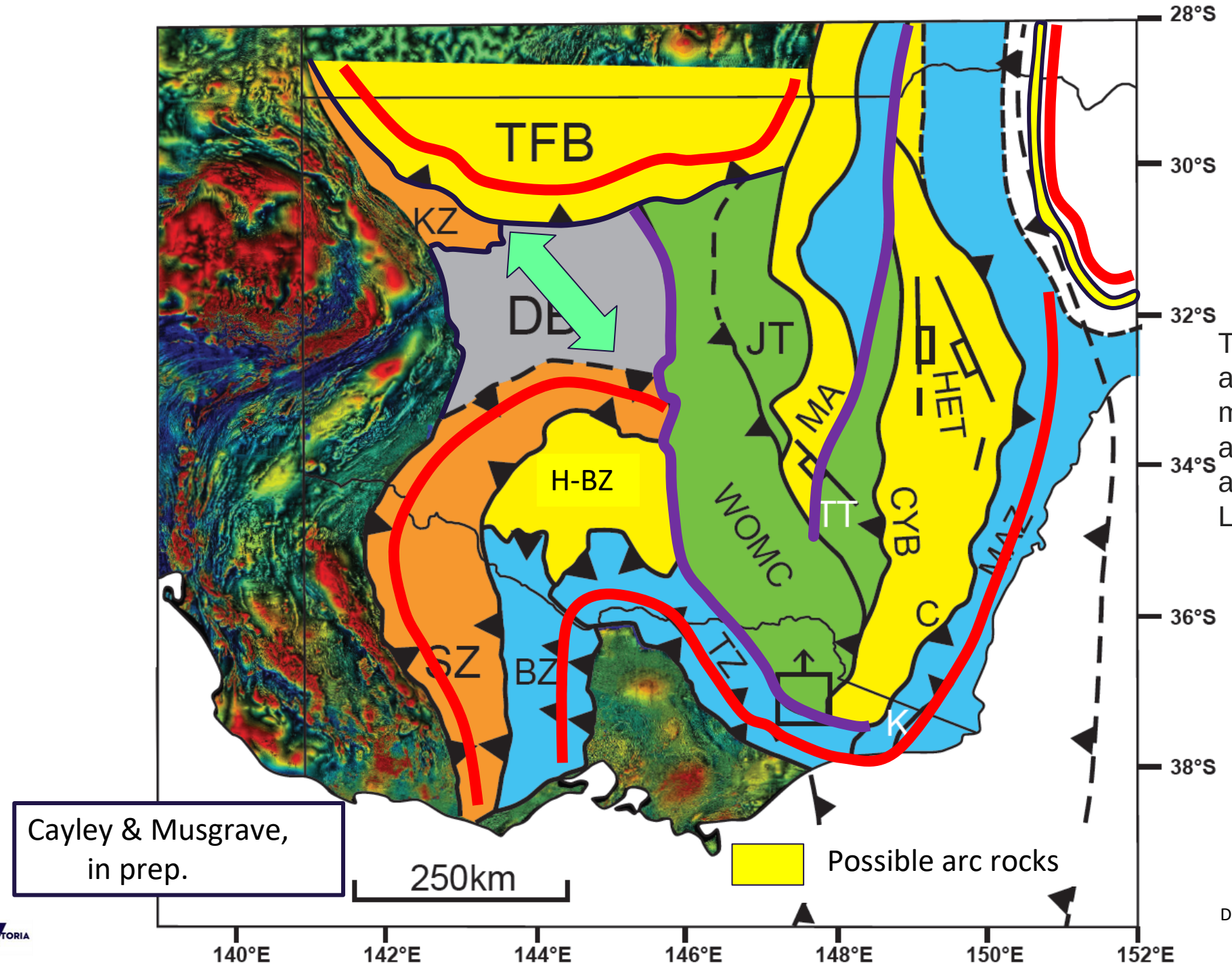

# Geodynamics of congested subduction zones

Rifting / basins




Moresi, Betts, Miller, Cayley, 2014: NATURE

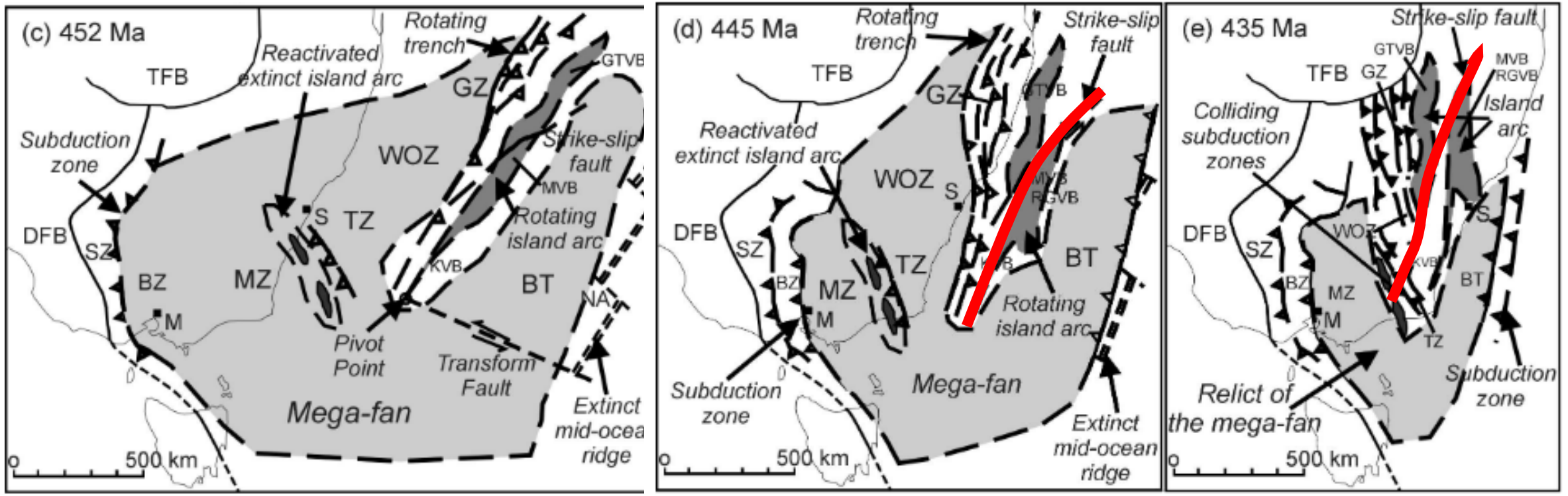



Cayley & Musgrave, in prep.

The distinctive patterns of asymmetric transtensional modification of crust, driven by asymmetric slab rollback can all be recognised in the Lachlan Fold Belt

..the Lachlan Orocline model provides overarching geodynamic context for previous models proposed to explain strange geological juxtapositions within the Lachlan Fold Belt in NSW…..

# Models that suggest strike-slip repetition of Macquarie Arc segments:




Packham, 1987 (AGU Geodynamics Series 19); Fergusson, 2009 (AJES)

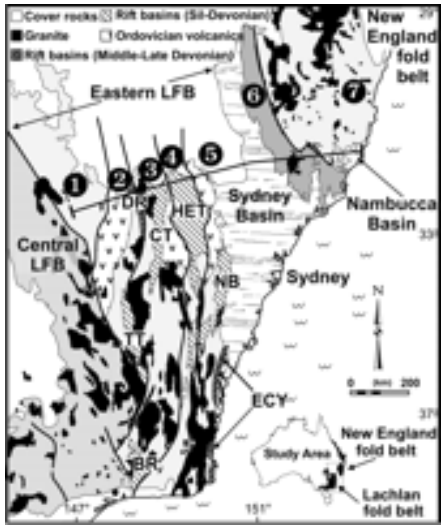
# New ideas for LFB geodynamics…

..the Lachlan Orocline model fits geodynamic context proposed in previous models to explain magmatic evolution in NSW…..

Recognition of the critical role of roll-back in LFB evolution….

Tectonic switching and roll-back in the LFB

Collins, 2002 (Geology)



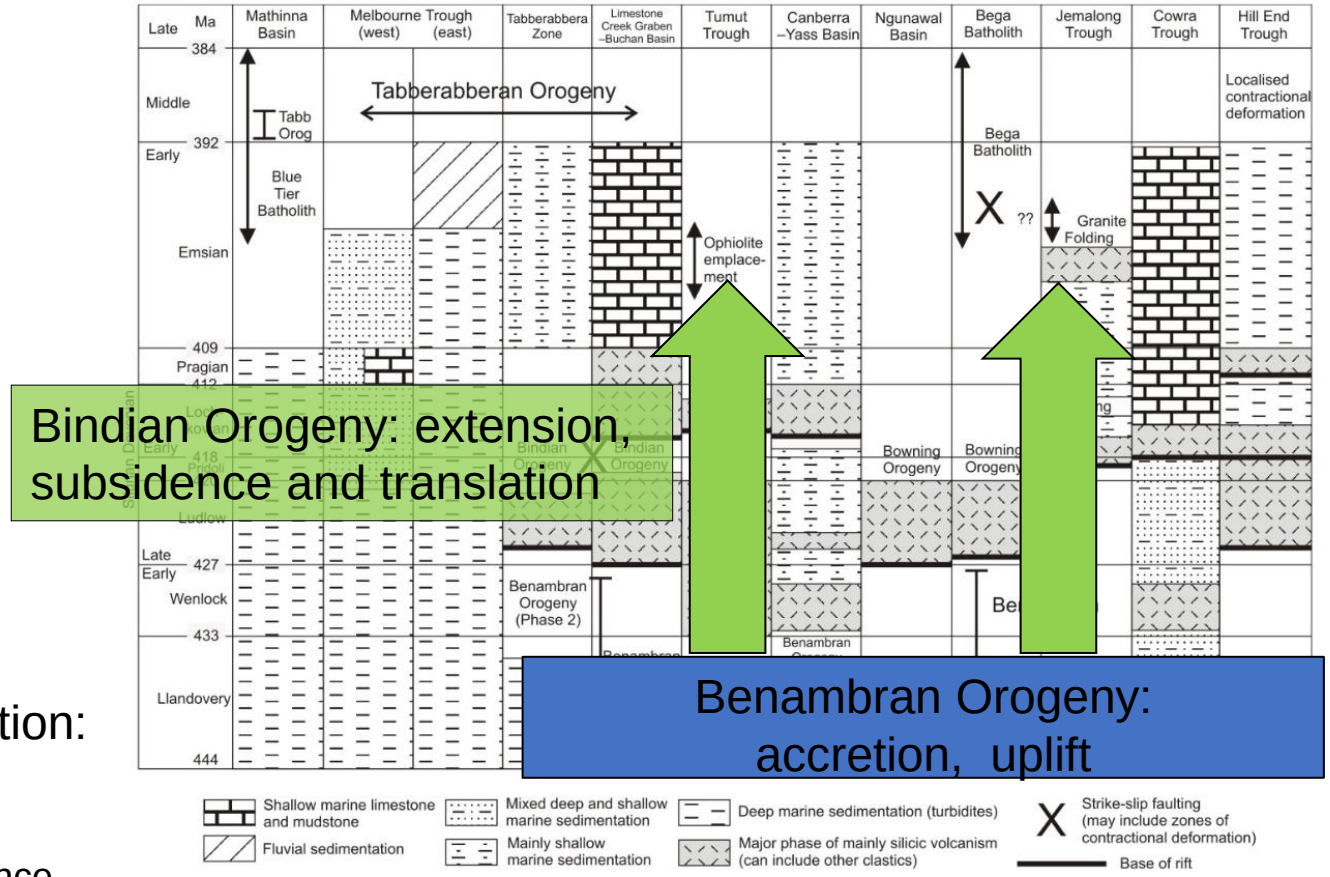

Extension and the tripartite association:

S-type granites, arcs and back-arc basins

Collins and Richards, 2008 (Geology)

# Models that link extension to sedimentation in the Lachlan Fold Belt:

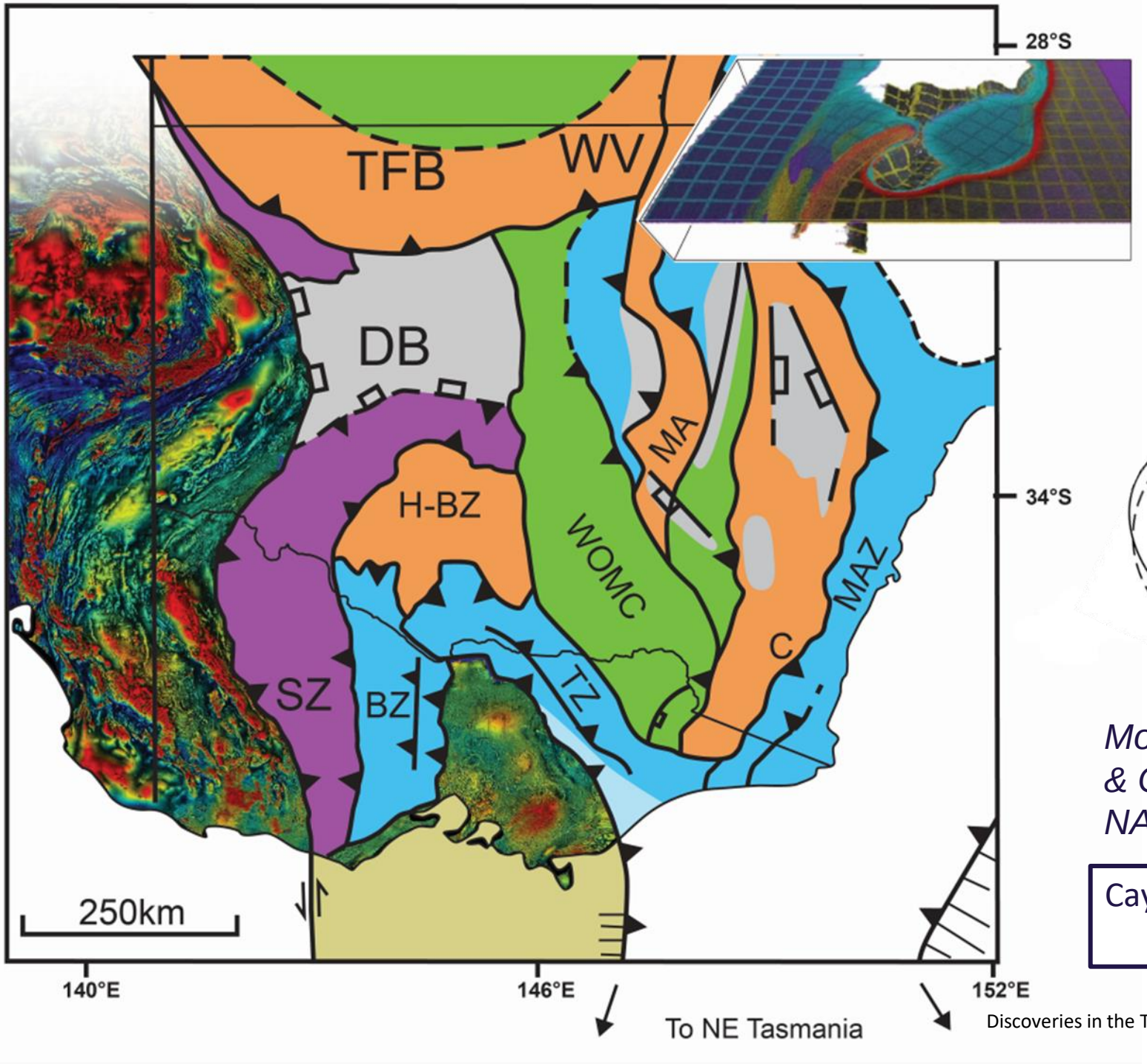
..the Lachlan Orocline model provides overarching geodynamic context for observations of Late Ordovician uplift followed by Silurian widespread subsidence and basin-formation…..



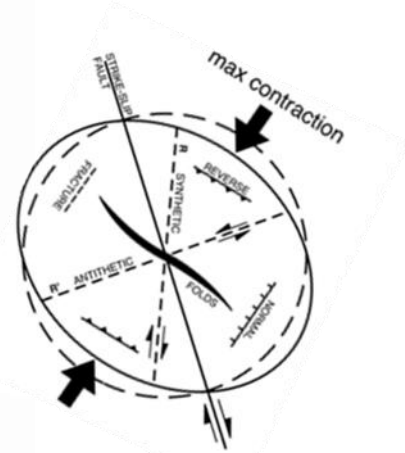

Fergusson, 2010: AJES:

Lachlan Fold Belt sedimentation:

Late Silurian-Middle Devonian
plate-driven extension and convergence

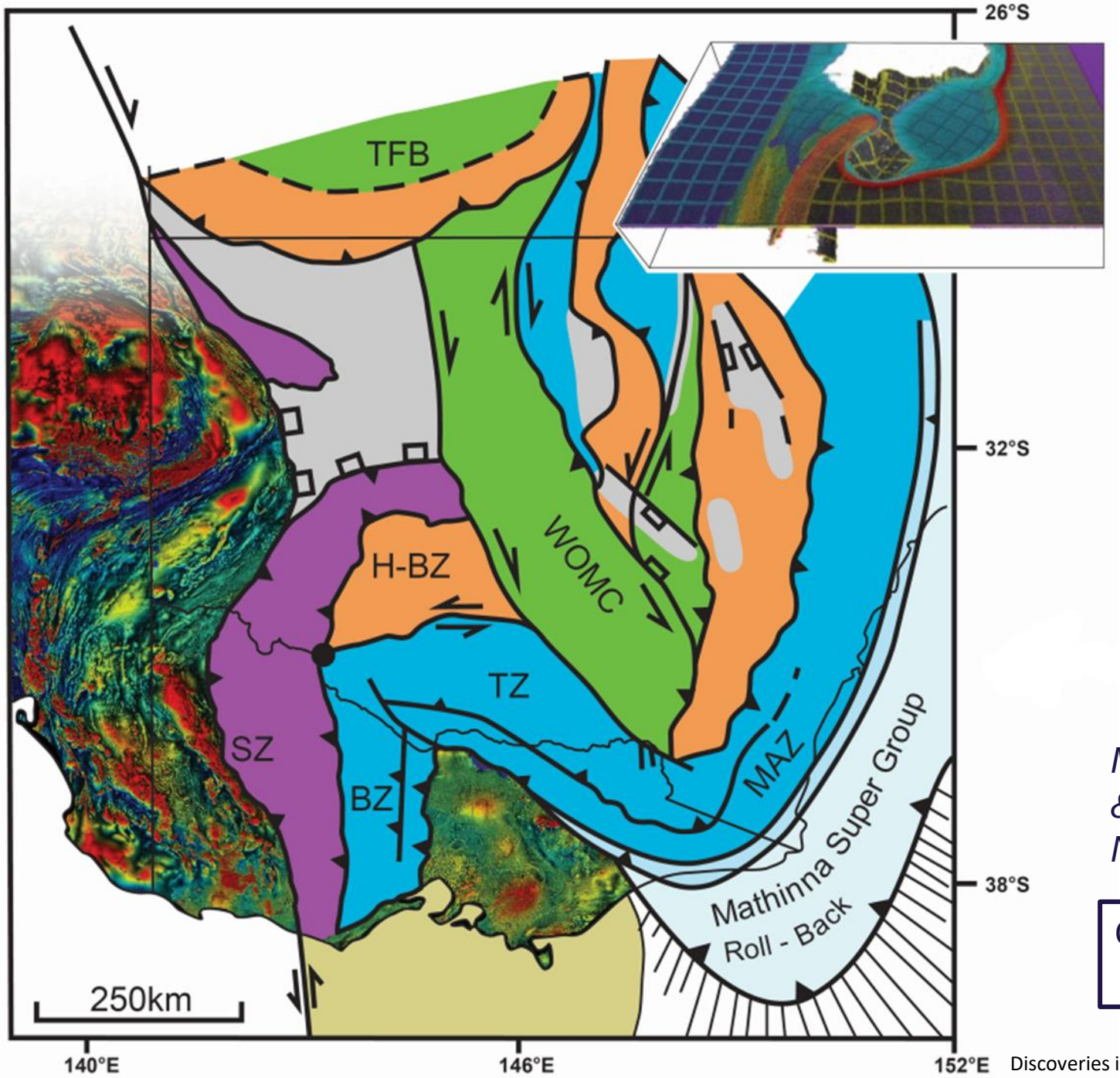



Retrodeforming the Victorian-NSW Lachlan Fold Belt from ~390Ma to ~440 Ma using constraints from Victorian and NSW geology and potential file data:




*Moresi, Betts, Miller & Cayley 2014, NATURE.*

Cayley & Musgrave, in review

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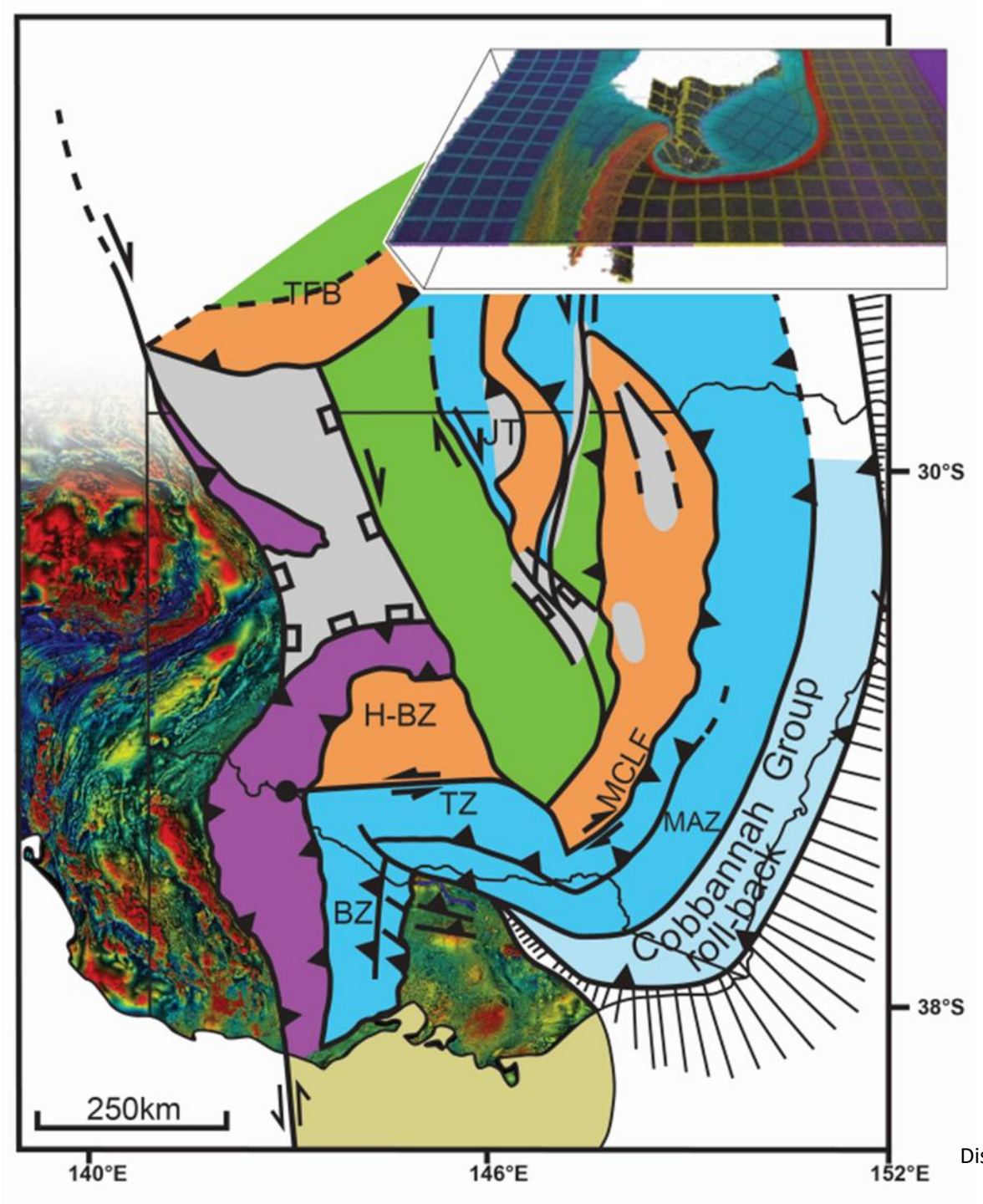
Cayley & Musgrave, in review

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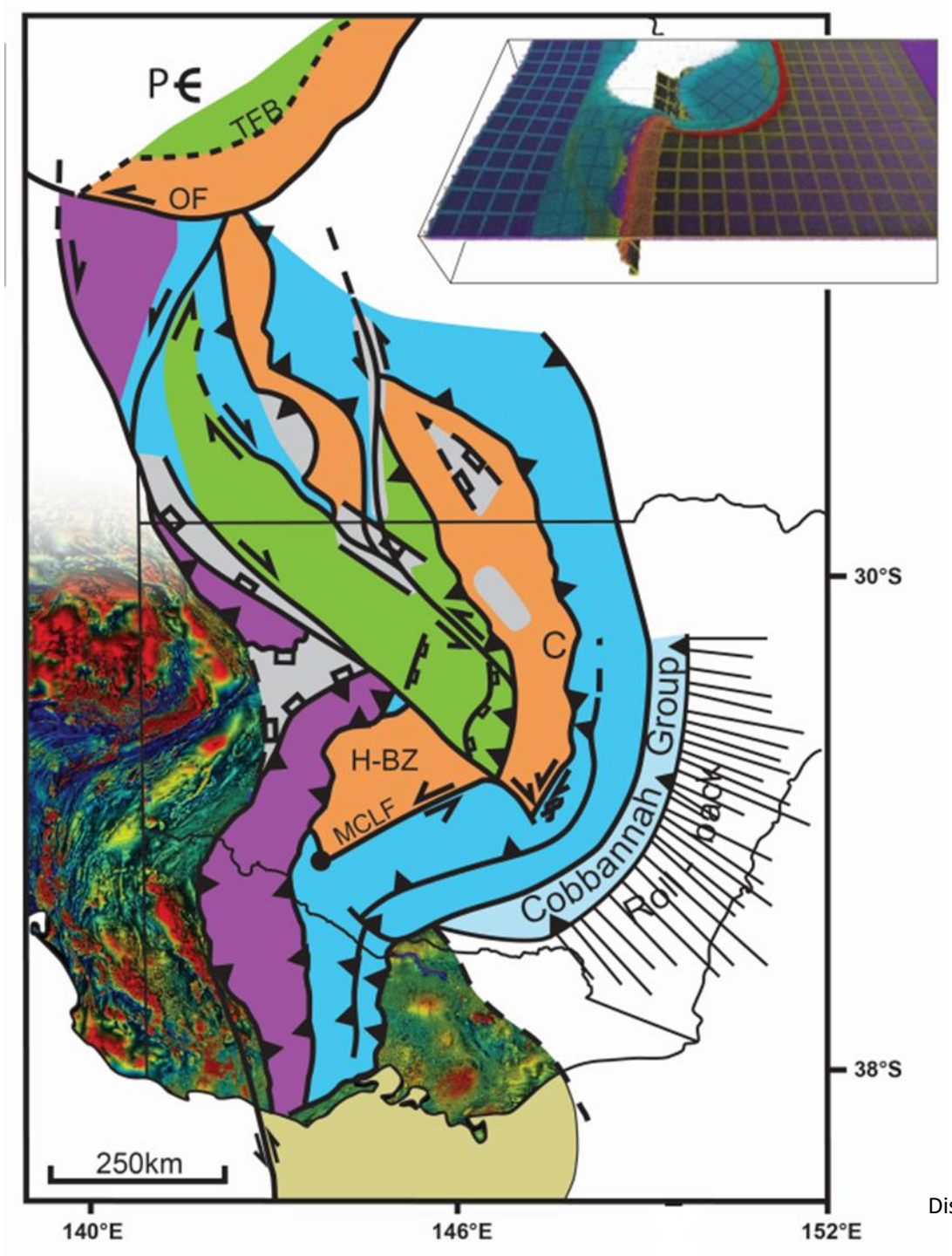
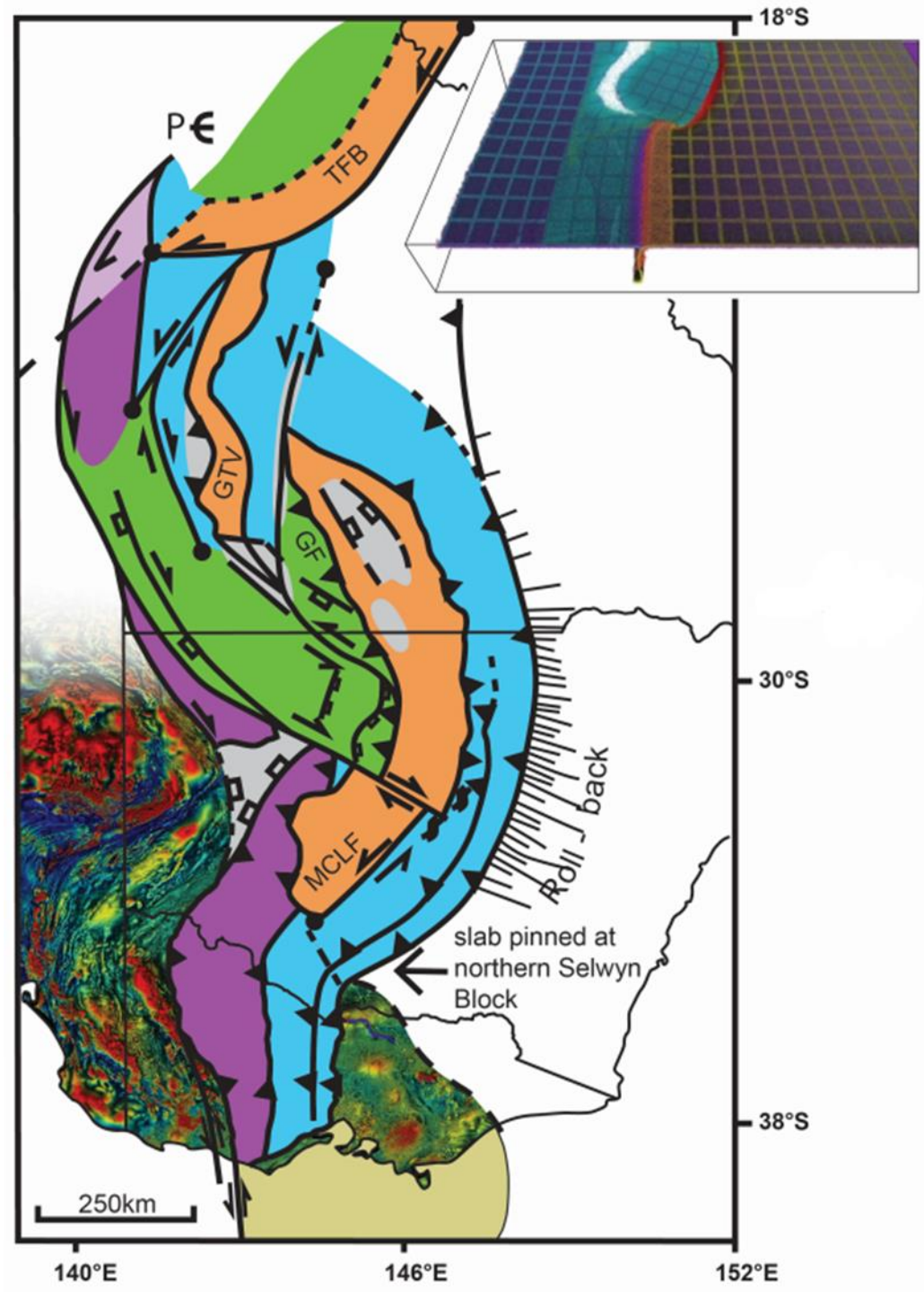
Cayley & Musgrave, in review



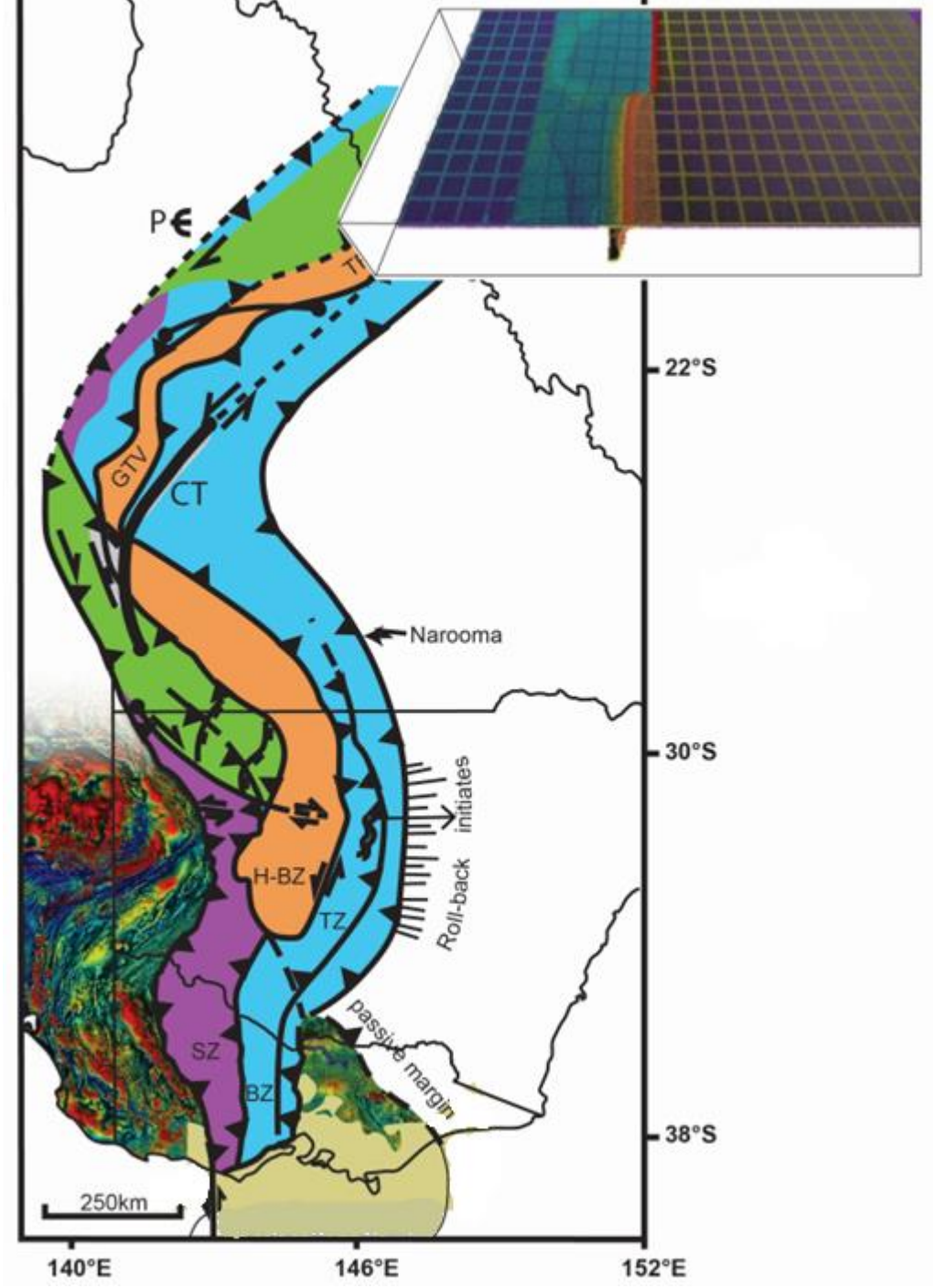

*Moresi, Betts, Miller & Cayley 2014, NATURE.*

Cayley & Musgrave, in review



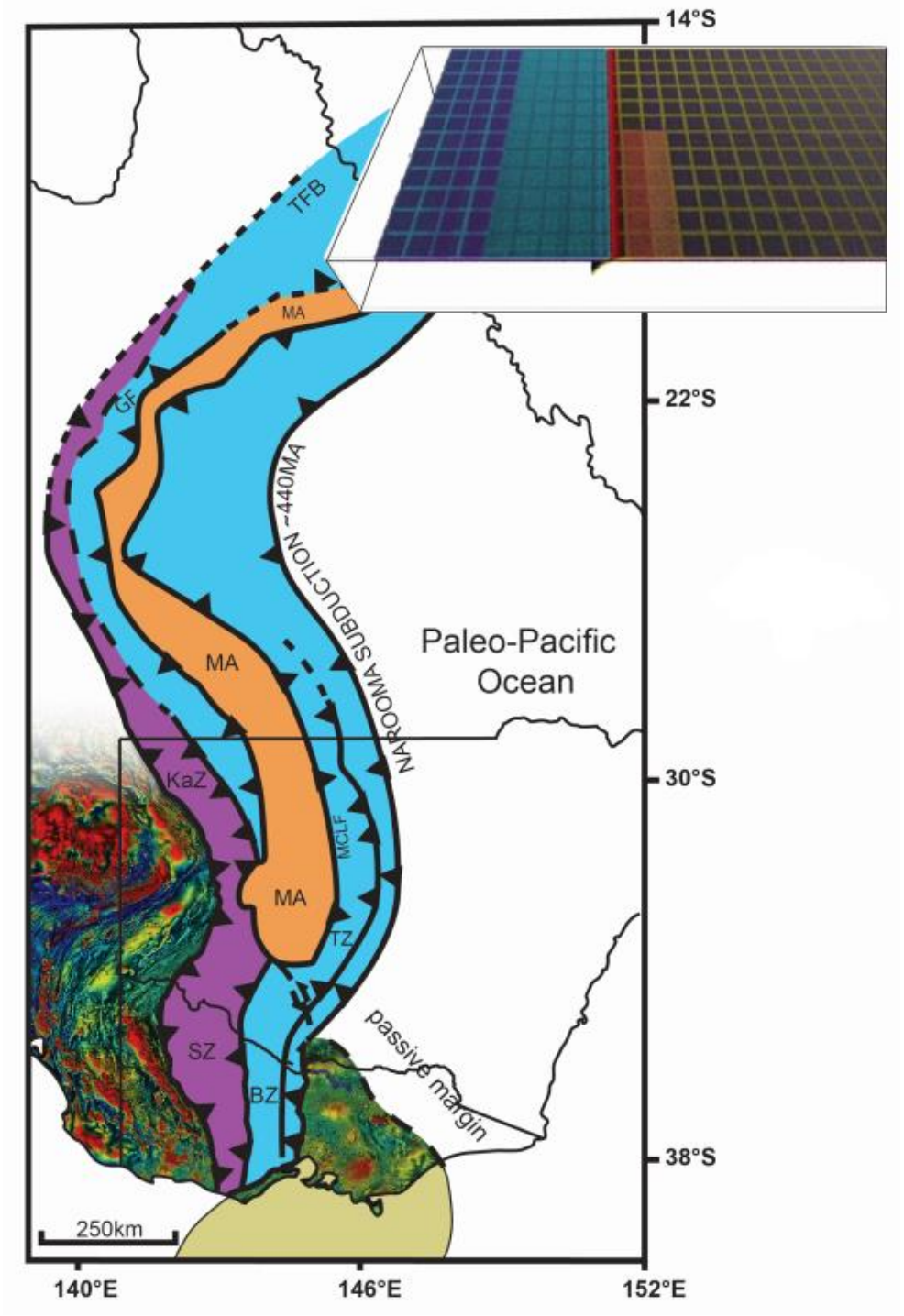

*Moresi, Betts, Miller & Cayley 2014, NATURE.*

Cayley & Musgrave, in review



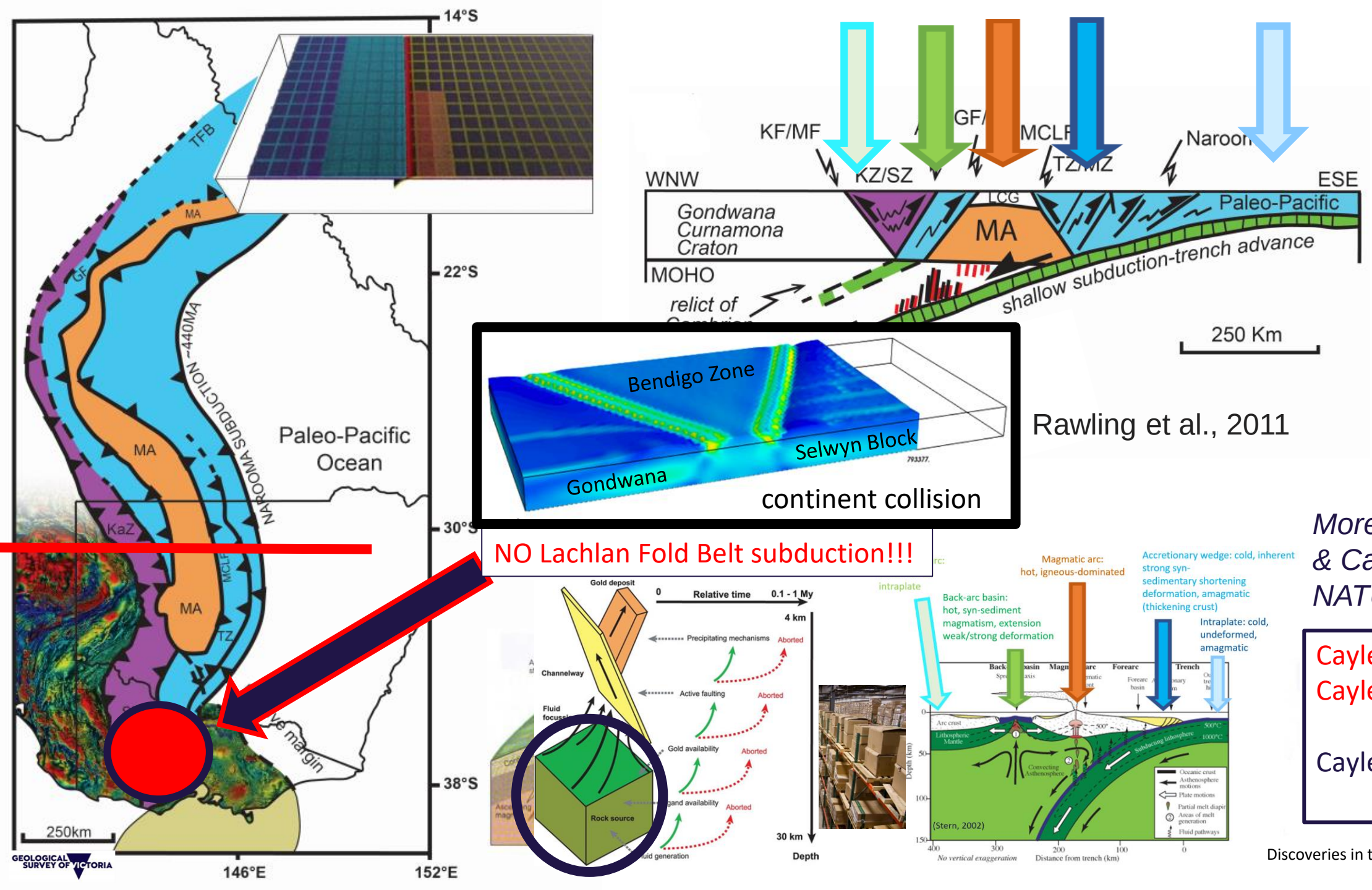

*Moresi, Betts, Miller & Cayley 2014, NATURE.*

Cayley & Musgrave, in review




*Moresi, Betts, Miller & Cayley 2014, NATURE.*

Cayley & Musgrave, in review










Rawling et al., 2011

NO Lachlan Fold Belt subduction!!!





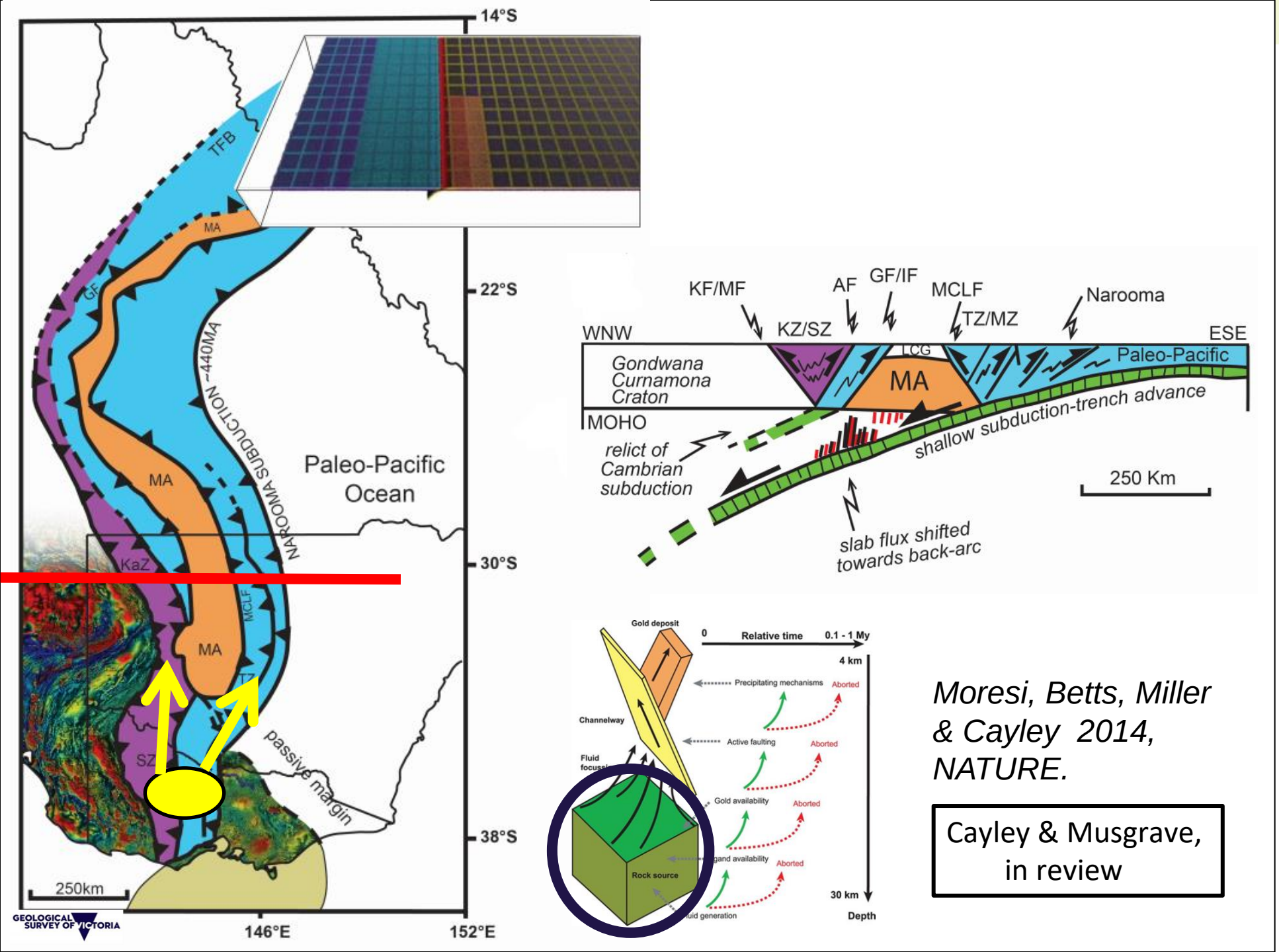




*Moresi, Betts, Miller & Cayley 2014, NATURE.*

Cayley et al., 2011, Cayley 2011

Cayley & Musgrave, in review





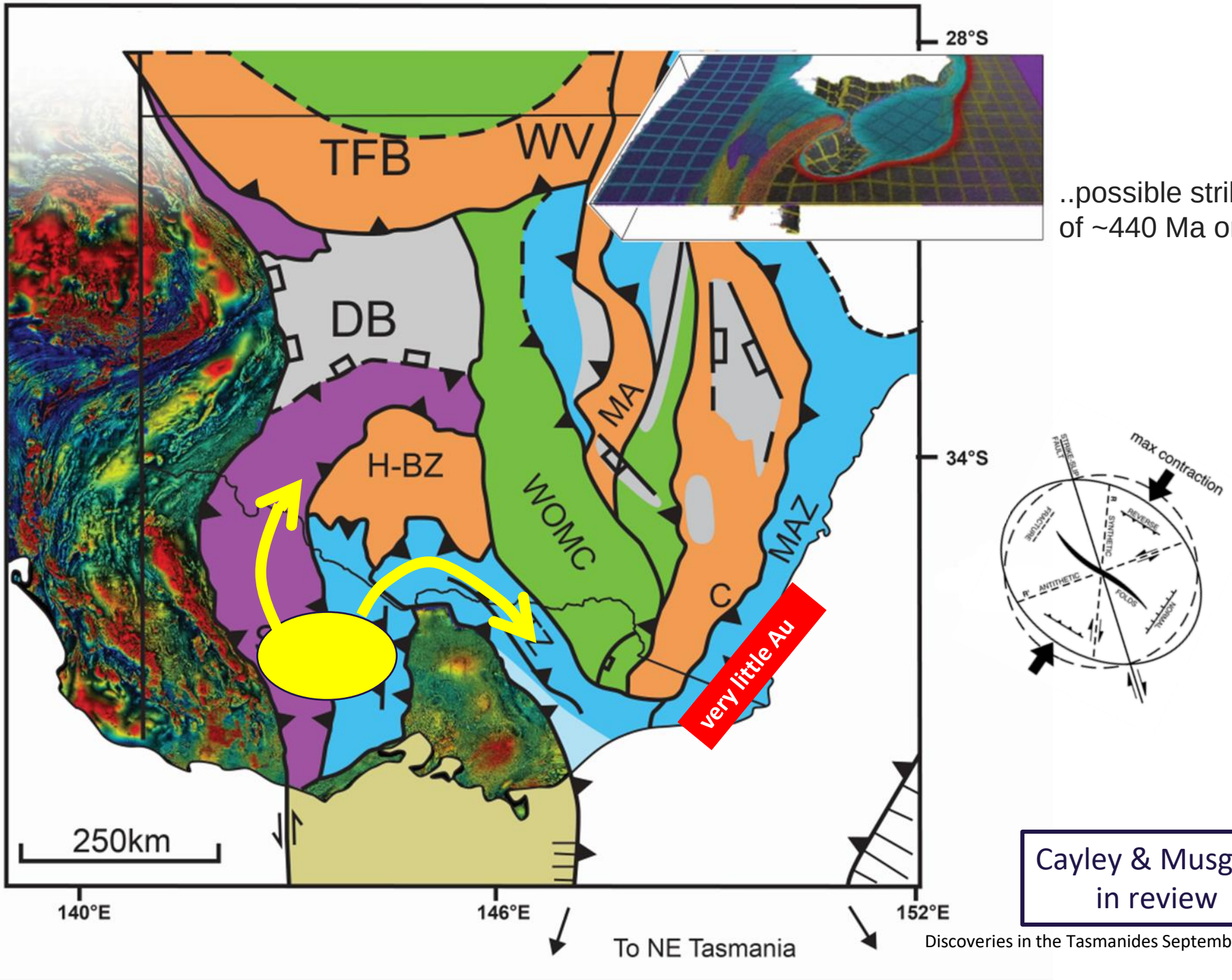





*Moresi, Betts, Miller & Cayley 2014, NATURE.*

Cayley & Musgrave, in review

..possible strike-extensions of ~440 Ma orogenic gold



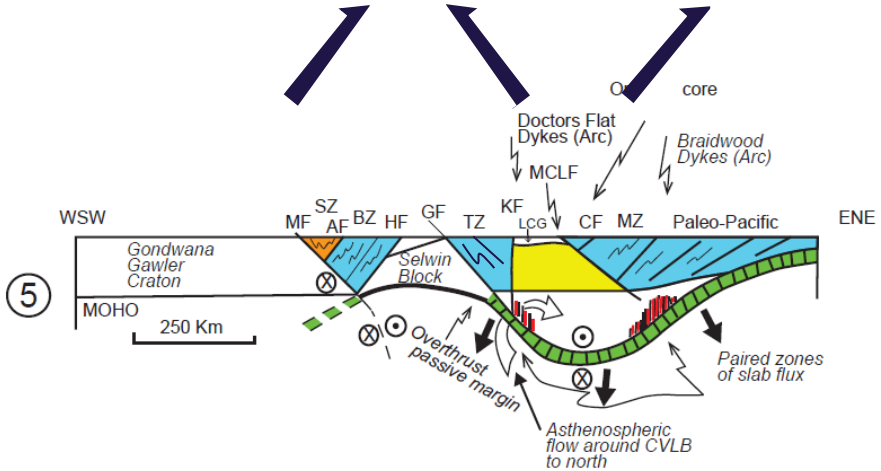

..possible strike-extensions of ~440 Ma orogenic gold

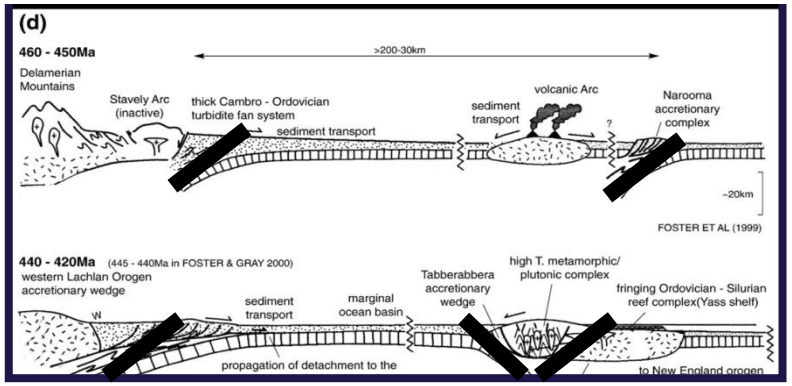


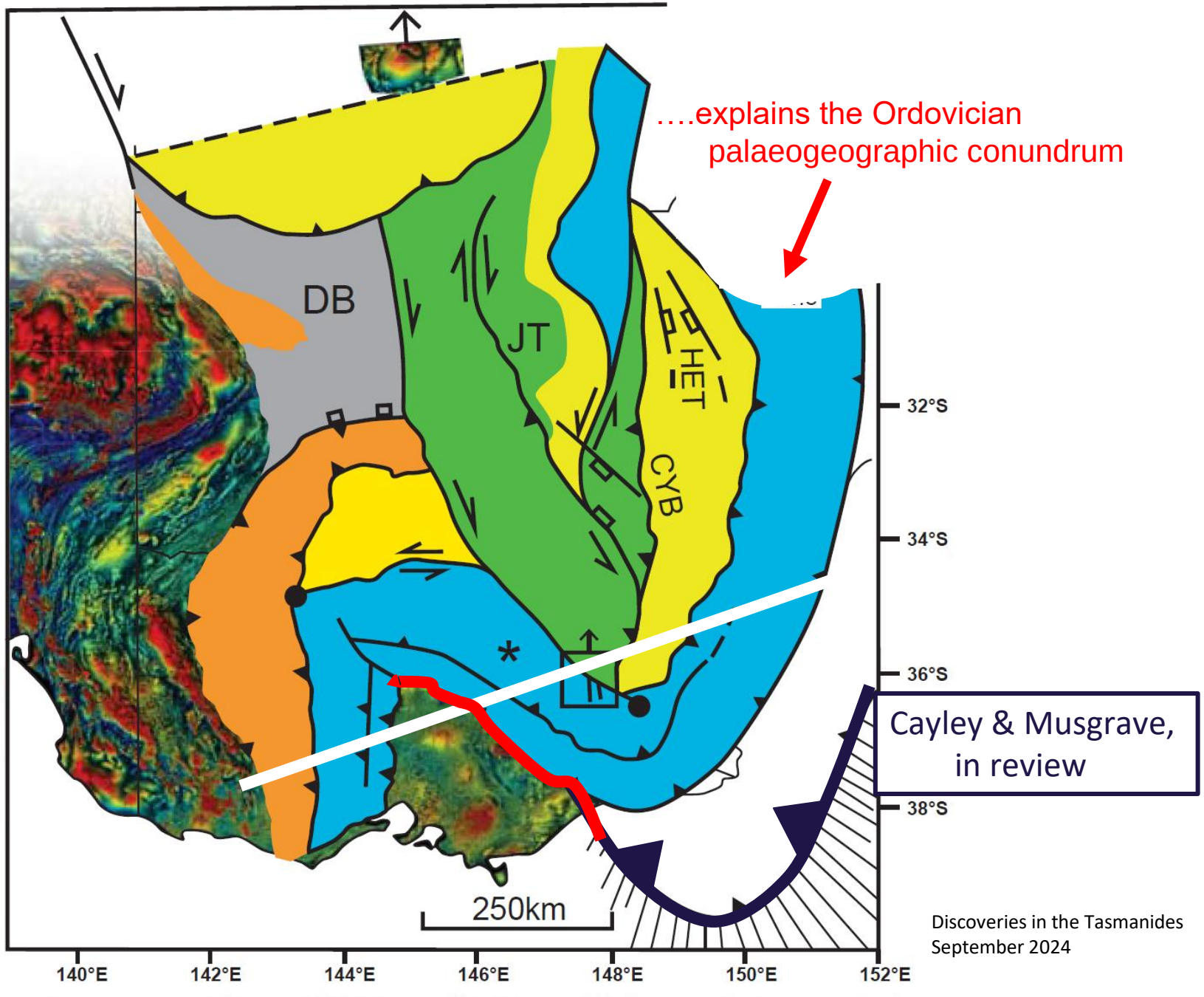

Cayley & Musgrave, in review

The Lachlan Orocline:

an alternative explanation of apparent vergence reversals in Ordovician LFB:



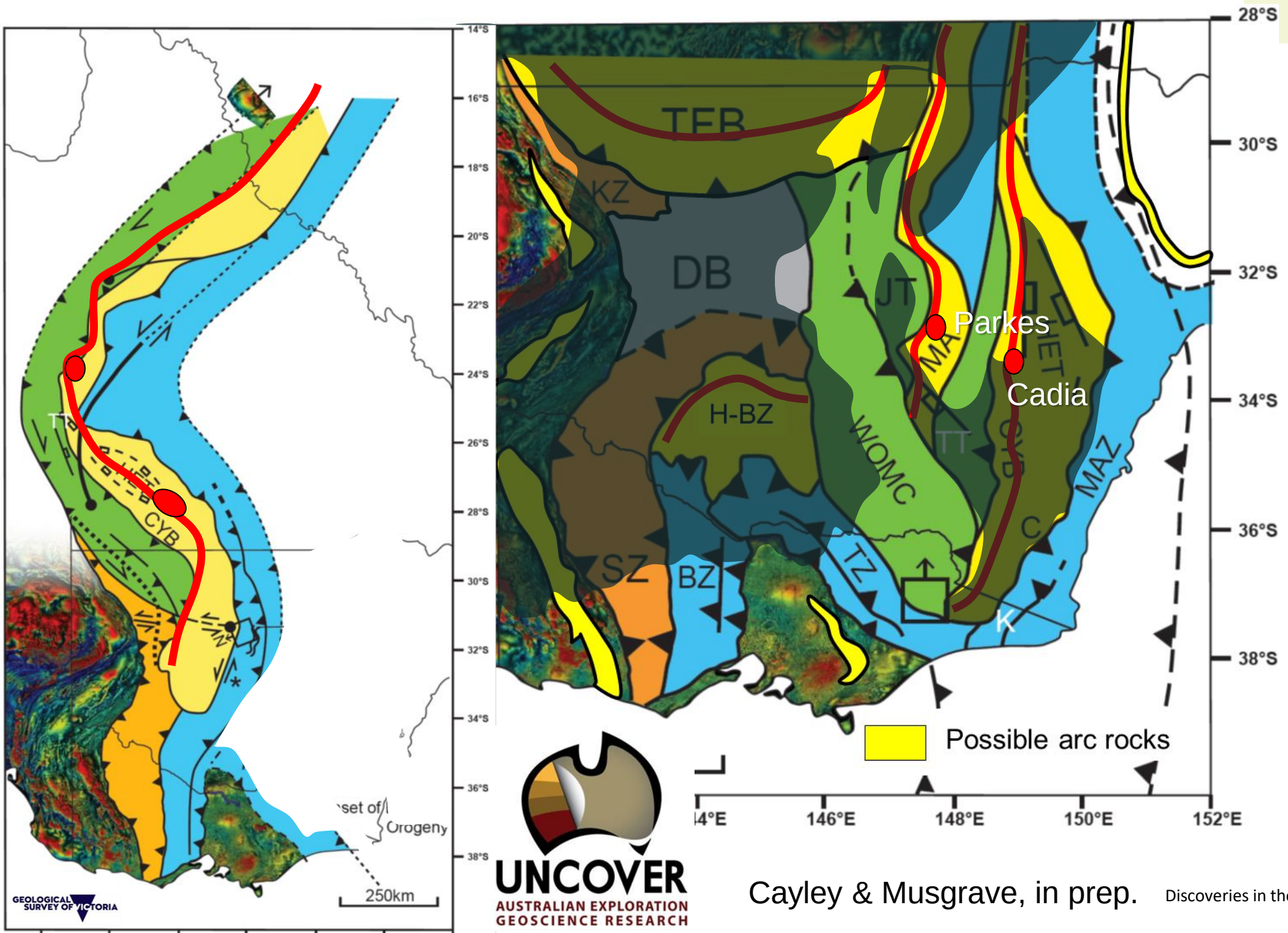




….explains the Ordovician palaeogeographic conundrum

Cayley & Musgrave, in review

Discoveries in the Tasmanides
September 2024



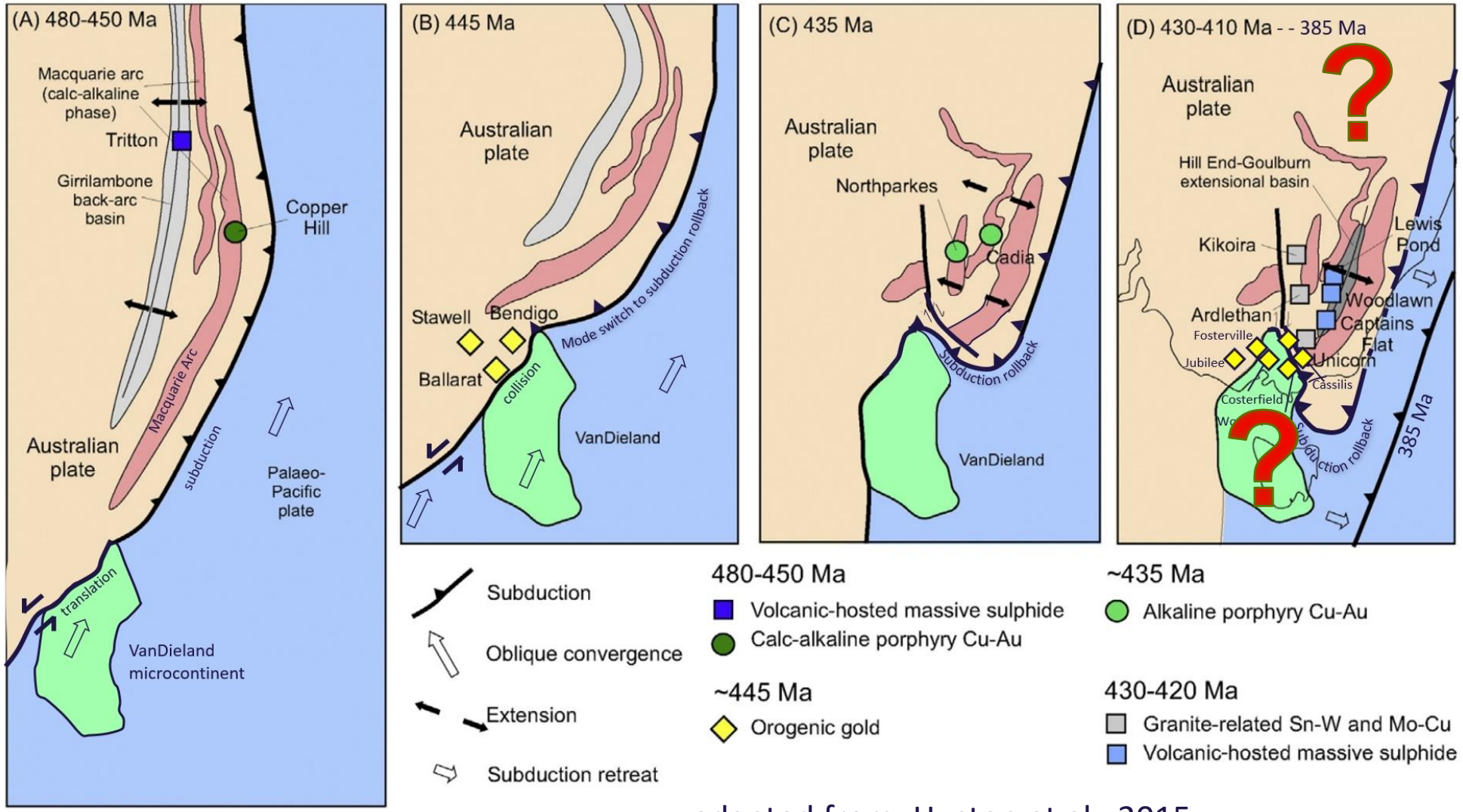

The major Macquarie Arc mineral systems formed prior to Lachlan Orocline formation

They have been segmented and redistributed by the Lachlan Orocline

Most of this crust lies concealed under Murray-Darling Basin cover

UNCOVER
AUSTRALIAN EXPLORATION GEOSCIENCE RESEARCH

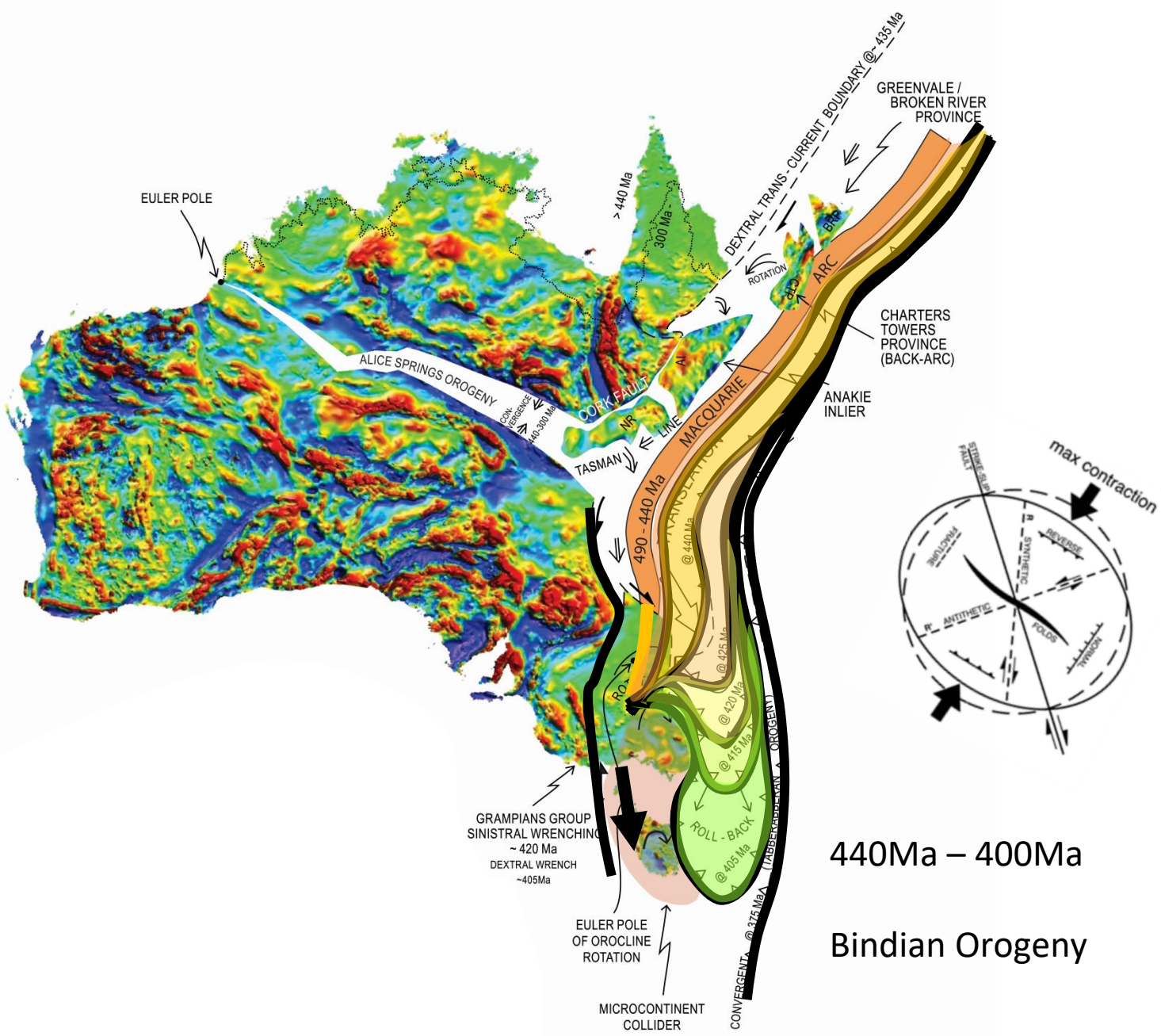
Cayley & Musgrave, in prep.




adapted from: Huston et al., 2015

# Talk outline

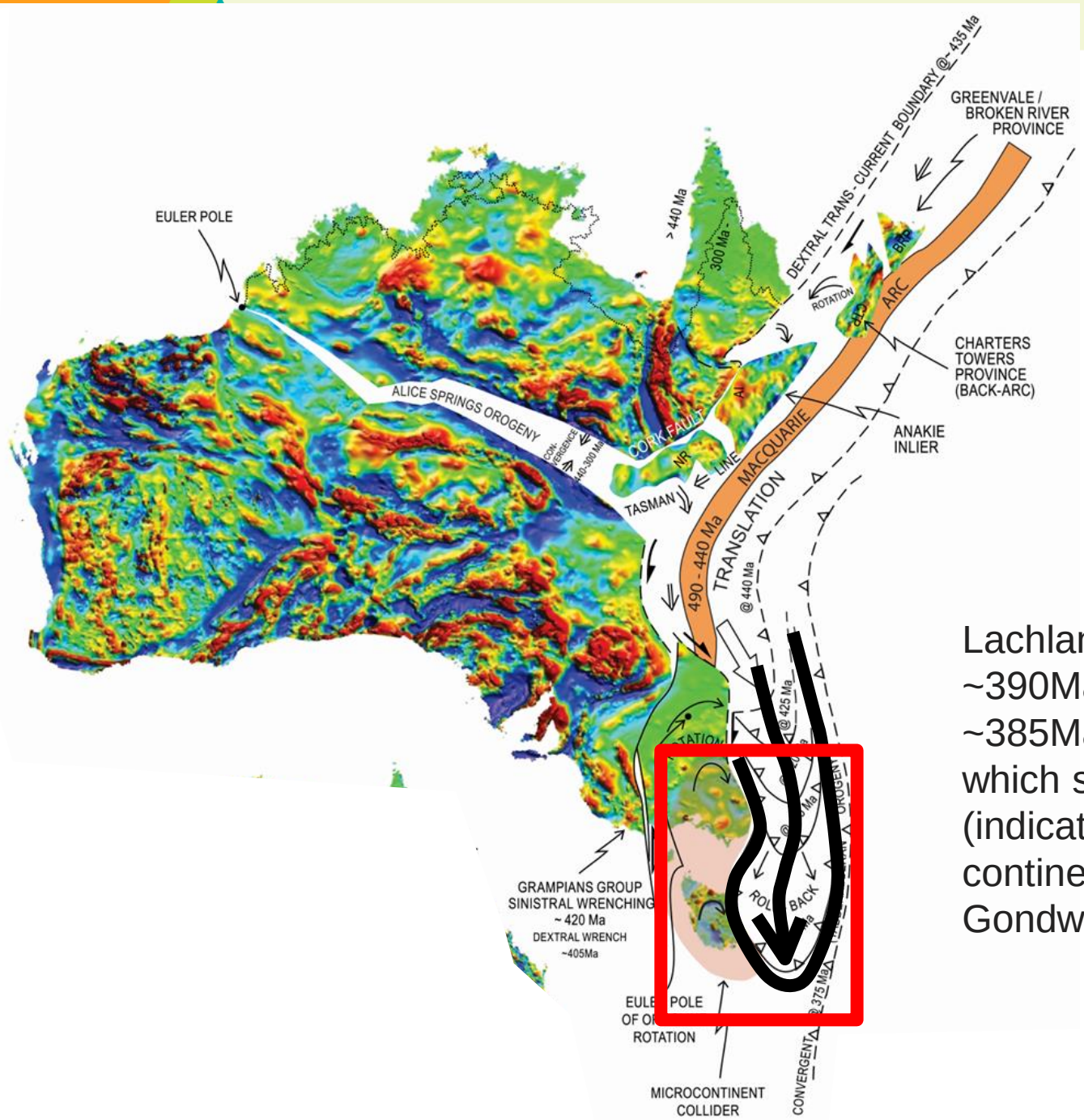
- Geological Systems Analysis – a logical way to categorize tectonic ambiguity / complexity
- Competing tectonic models for Lachlan Fold Belt development – confusing for mineral explorers
- Palaeogeography – a key constraint for Lachlan Fold Belt retrodeformation
- Fundamental Constraints – the Delamerian, Benambran, Quidongan, Bindian and Tabberabberan (and Kanimblan) Orogenies. Where are they? Where **AREN'T** they?
- Structural / stratigraphic mapping + potential field and seismic reflection geophysics – taking understanding to crustal scale
- A constrained retrodeformation scenario for the Ordovician-Silurian Lachlan Fold Belt - the Lachlan Orocline
- **Towards a Unifying Theory for predicting the locations of Eastern Australian Early Palaeozoic geology and mineral systems (especially buried ones)**




440Ma – 400Ma

Bindian Orogeny

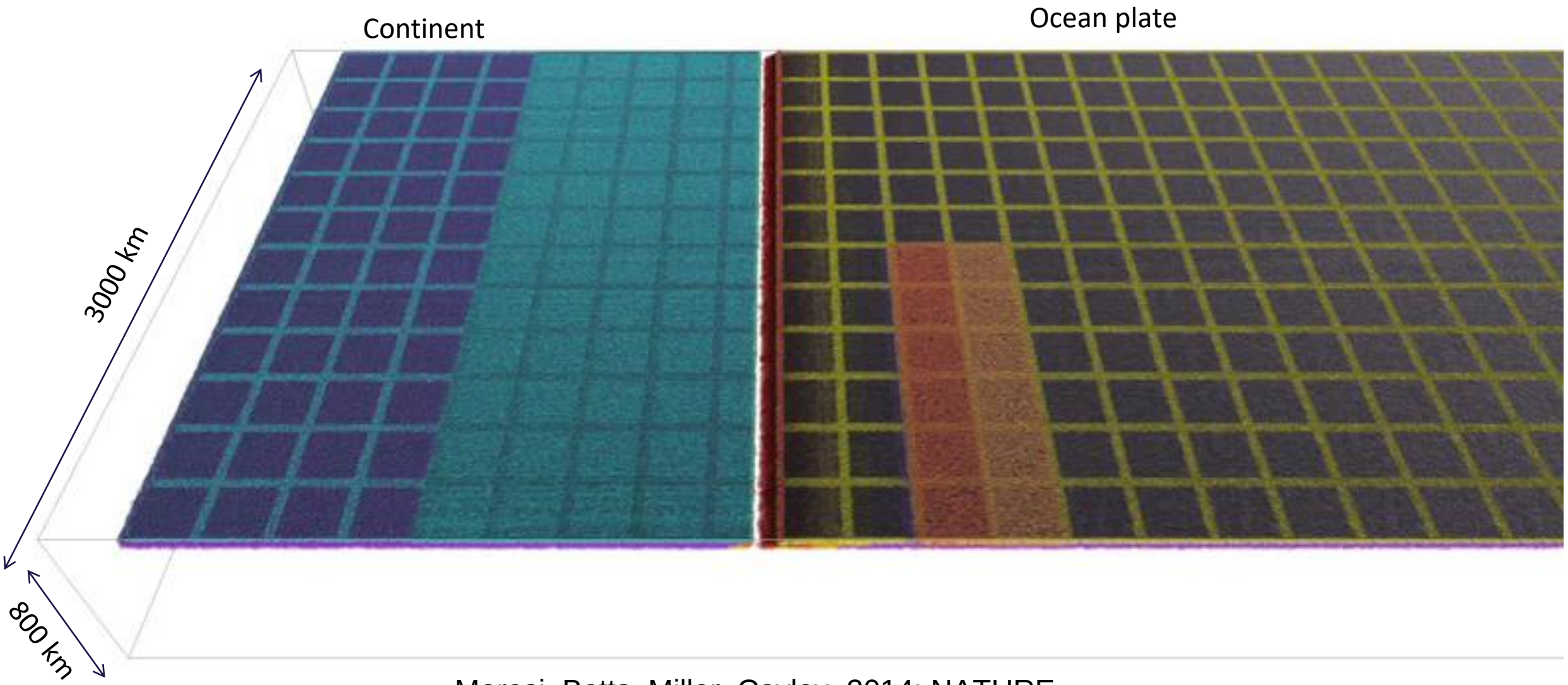
Cayley & Musgrave, in review




Lachlan Orocline folded-slab resolution by ~390Ma is indicated by the ~385Ma Tabberabberan Orogeny, which similarly affected all of eastern Australia (indicating re-establishment of a single, simple, continent-dipping slab along the Gondwana – paleopacific margin by that time)

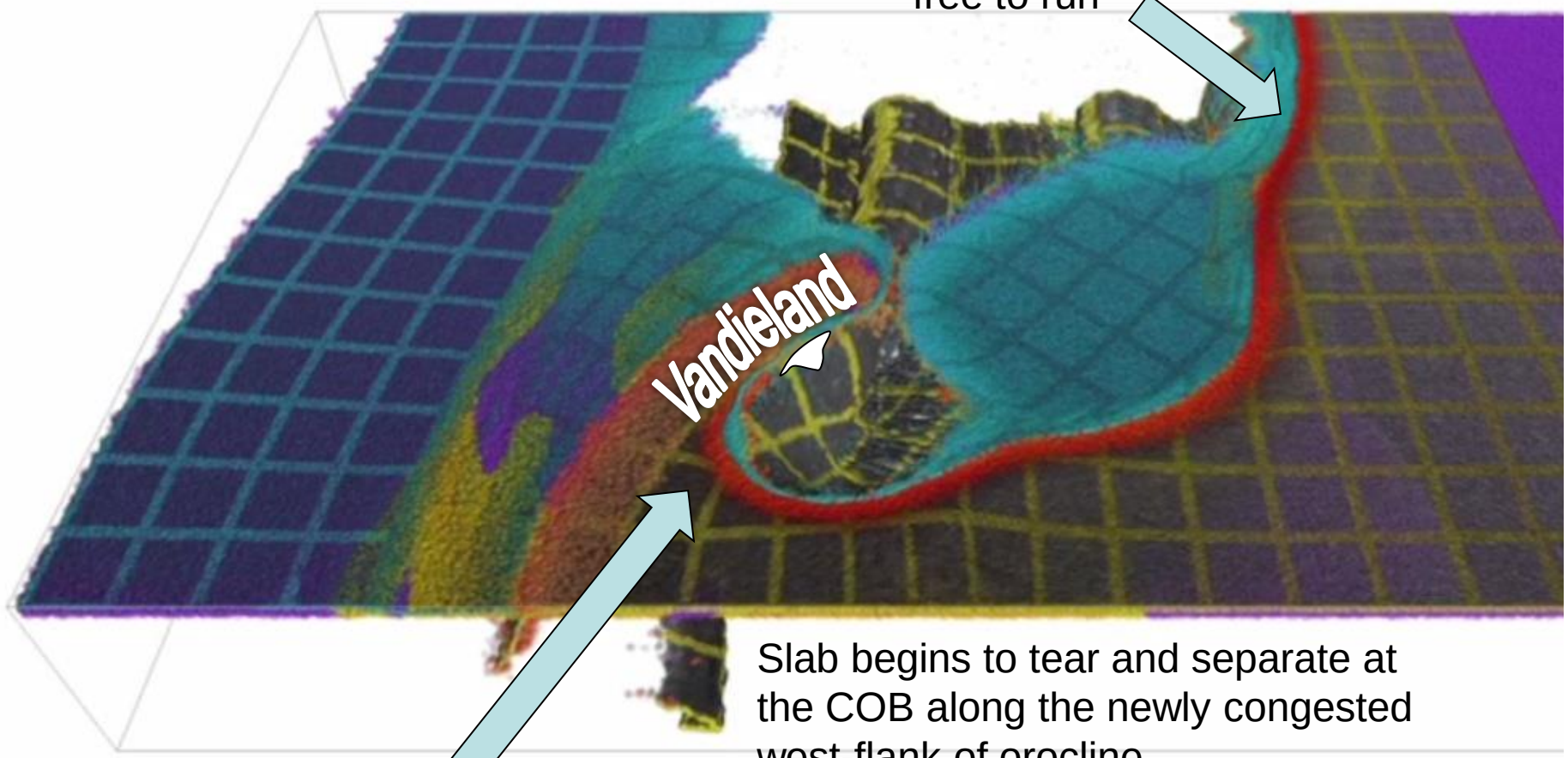
# Geodynamics of congested subduction zones

Model run time = 60 Million years




Moresi, Betts, Miller, Cayley, 2014: NATURE

East flank facing open ocean – free to run

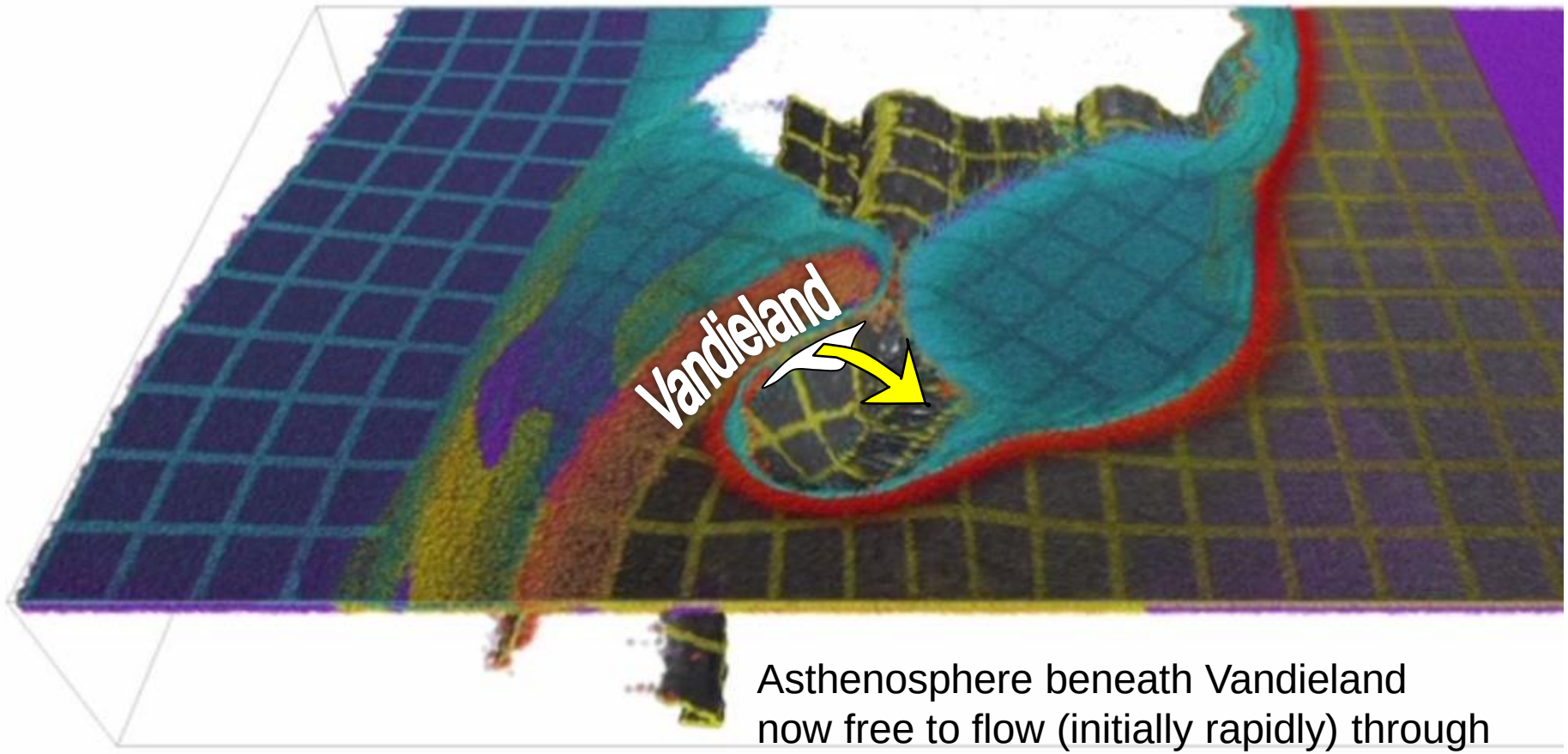



West flank becoming progressively congested

Slab begins to tear and separate at the COB along the newly congested west-flank of orocline
– for the LFB this was
a window-tear, not a zip-tear

…marks beginning of final transfer of Vandieland onto the upper plate (of the remaining active east flank of the subduction zone)

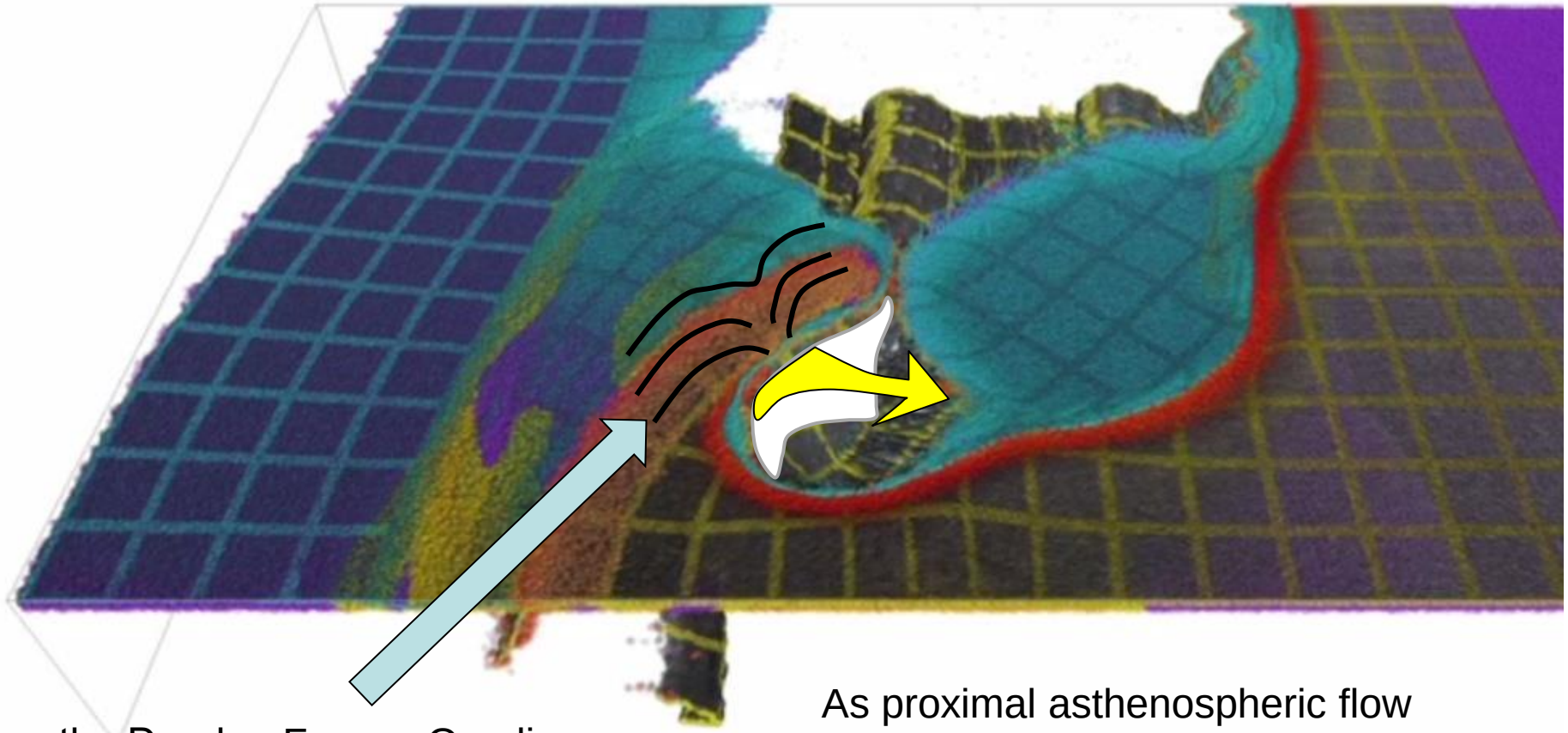
*Moresi, Betts, Miller & Cayley 2014, NATURE.*




Asthenosphere beneath Vandieland
now free to flow (initially rapidly) through
slab window, and directly into
the site of ongoing slab-foundering

(for the first time since it's initial accretion…..
40 million years earlier)

*Moresi, Betts, Miller & Cayley 2014, NATURE.*



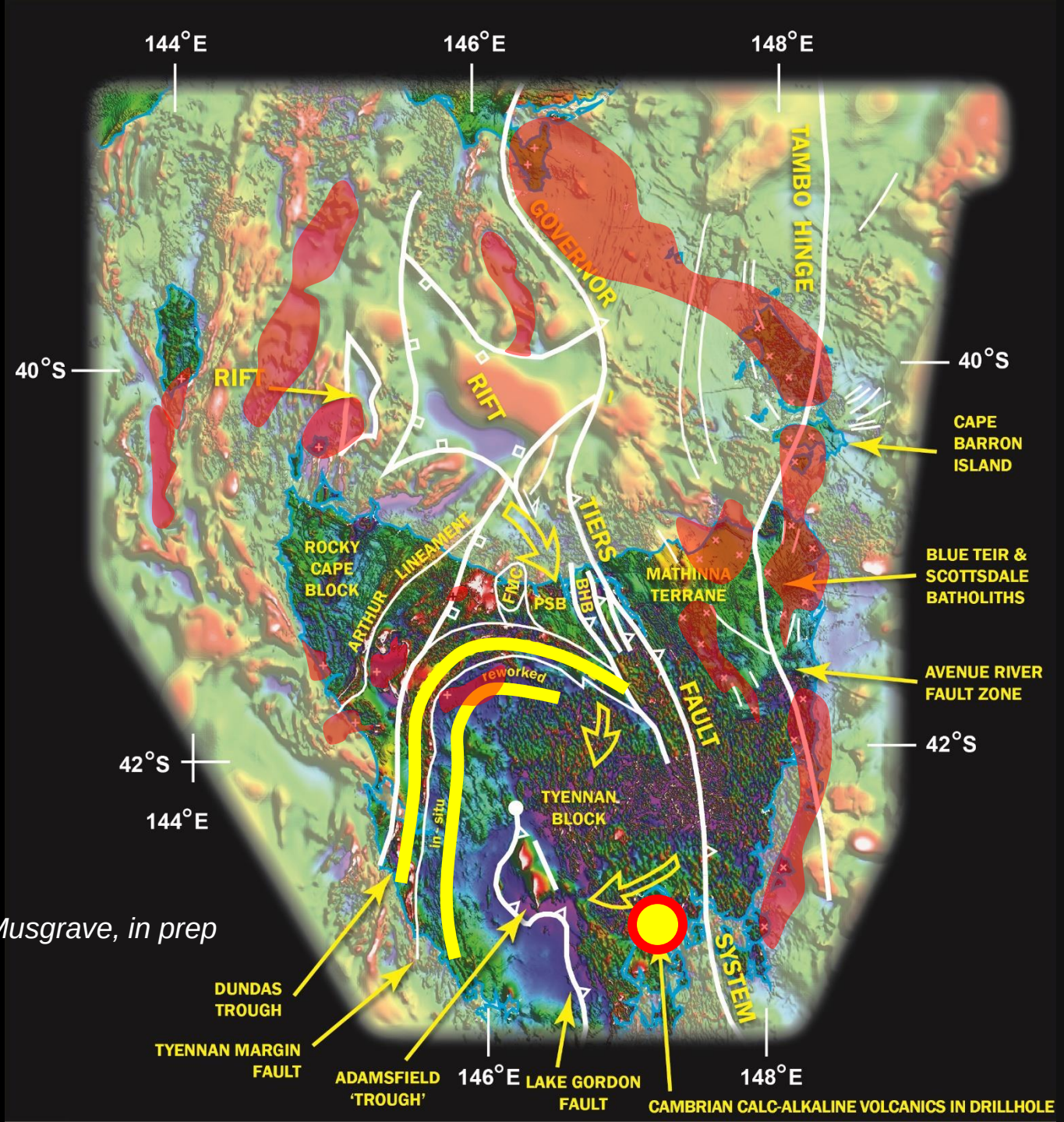
…the Dundas-Fossey Orocline

As proximal asthenospheric flow gathers momentum, the resulting flow-gradient drives extension in the overlying lithosphere –

it's thinned (Bass Strait),

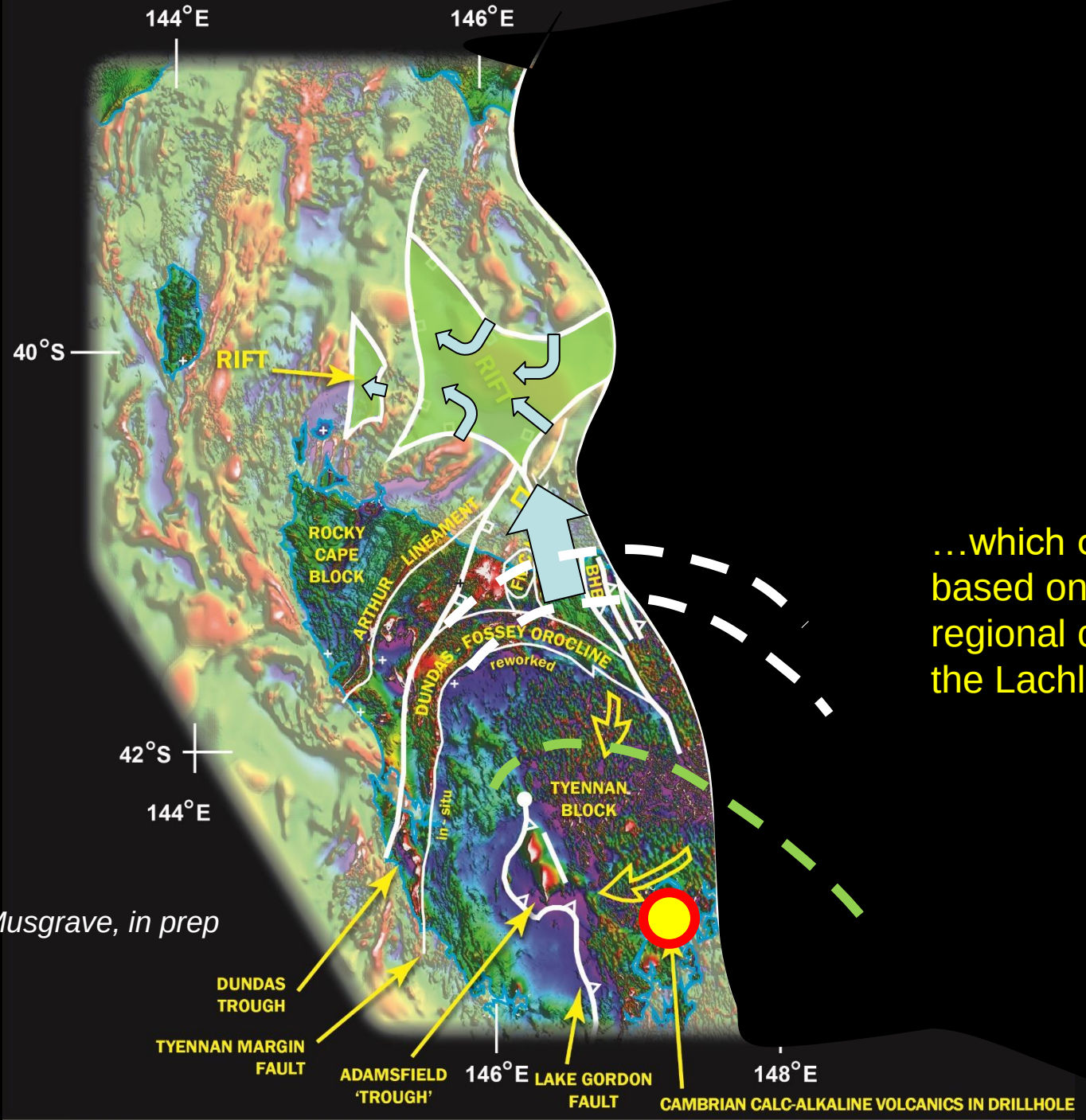
and rafted along for the ride (orocline)…

*Cayley & Musgrave, in prep*




*Cayley & Musgrave, in prep*

An explanation for the origin of:
the Dundas-Fossey Orocline,
and Devonian magmatism in Tasmania

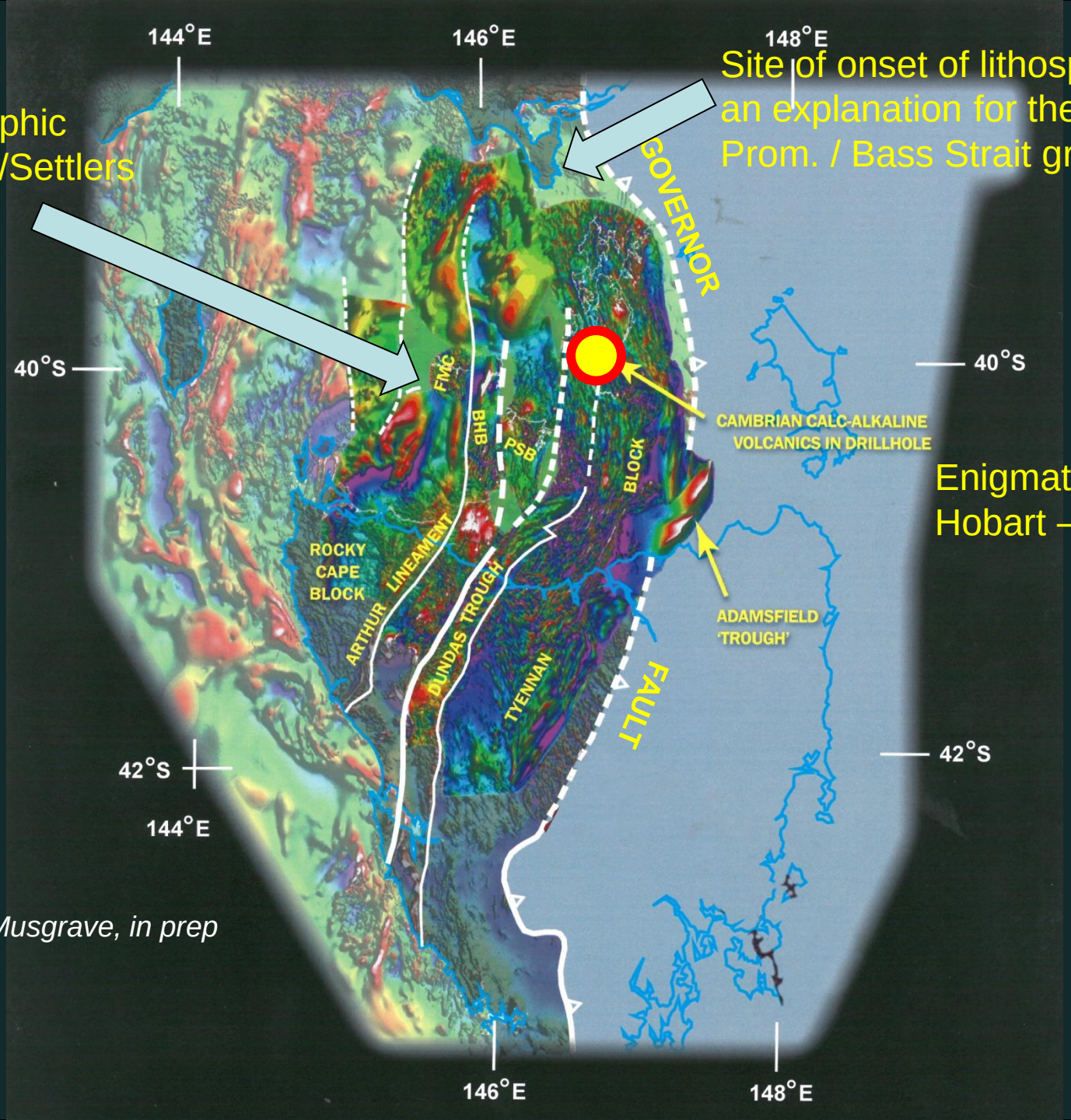



*Cayley & Musgrave, in prep*

…which can be retrodeformed based on new insights and regional context provided by the Lachlan Orocline hypothesis….

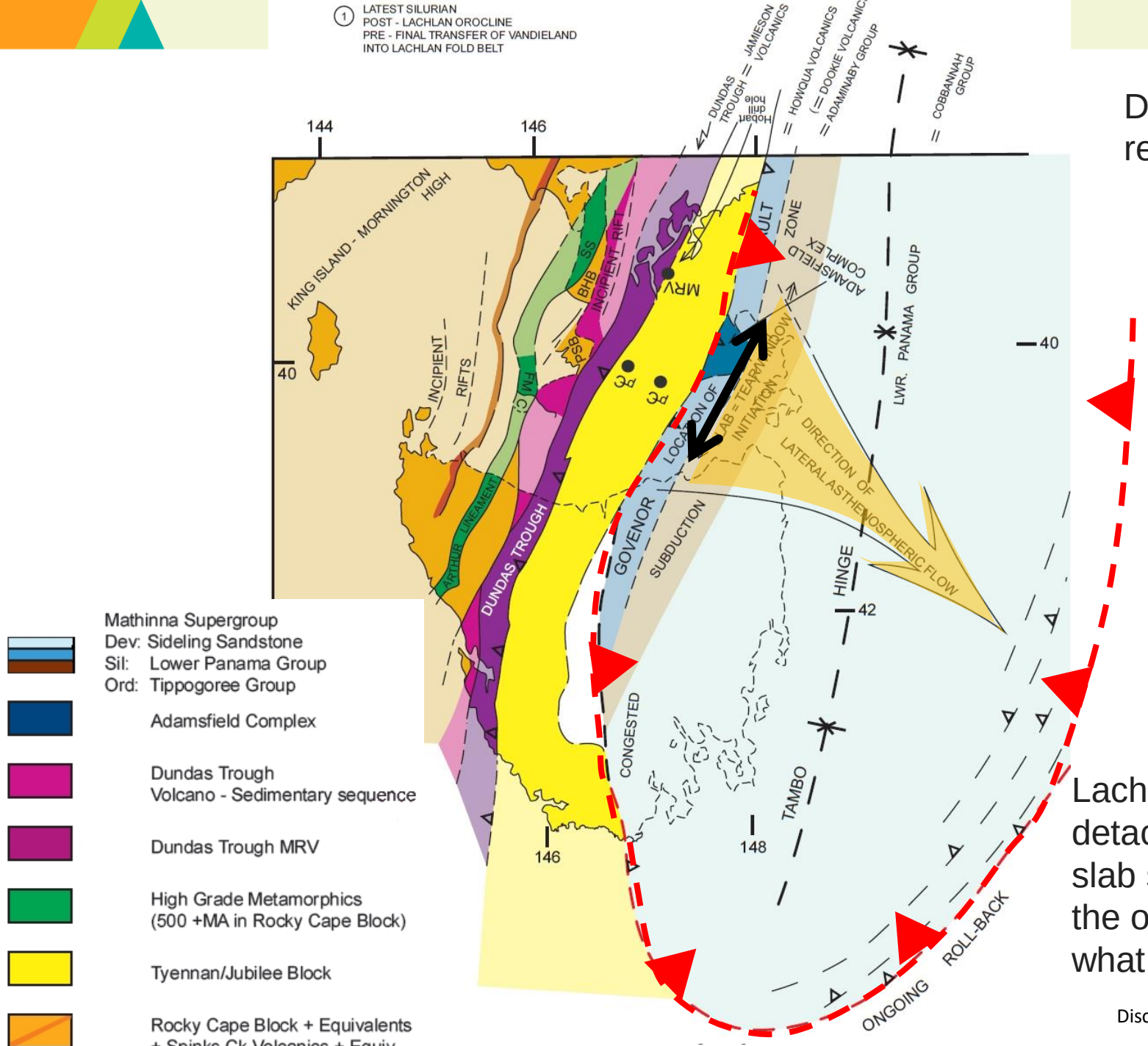
Forth Metamorphic Complex/Settlers Schist – reunited with AL

Site of onset of lithospheric tearing: an explanation for the origin and timing of the vast Wilsons Prom. / Bass Strait granite complex




Enigmatic Cambrian andesites beneath Hobart – restored to the Dundas 'Trough'

*Cayley & Musgrave, in prep*

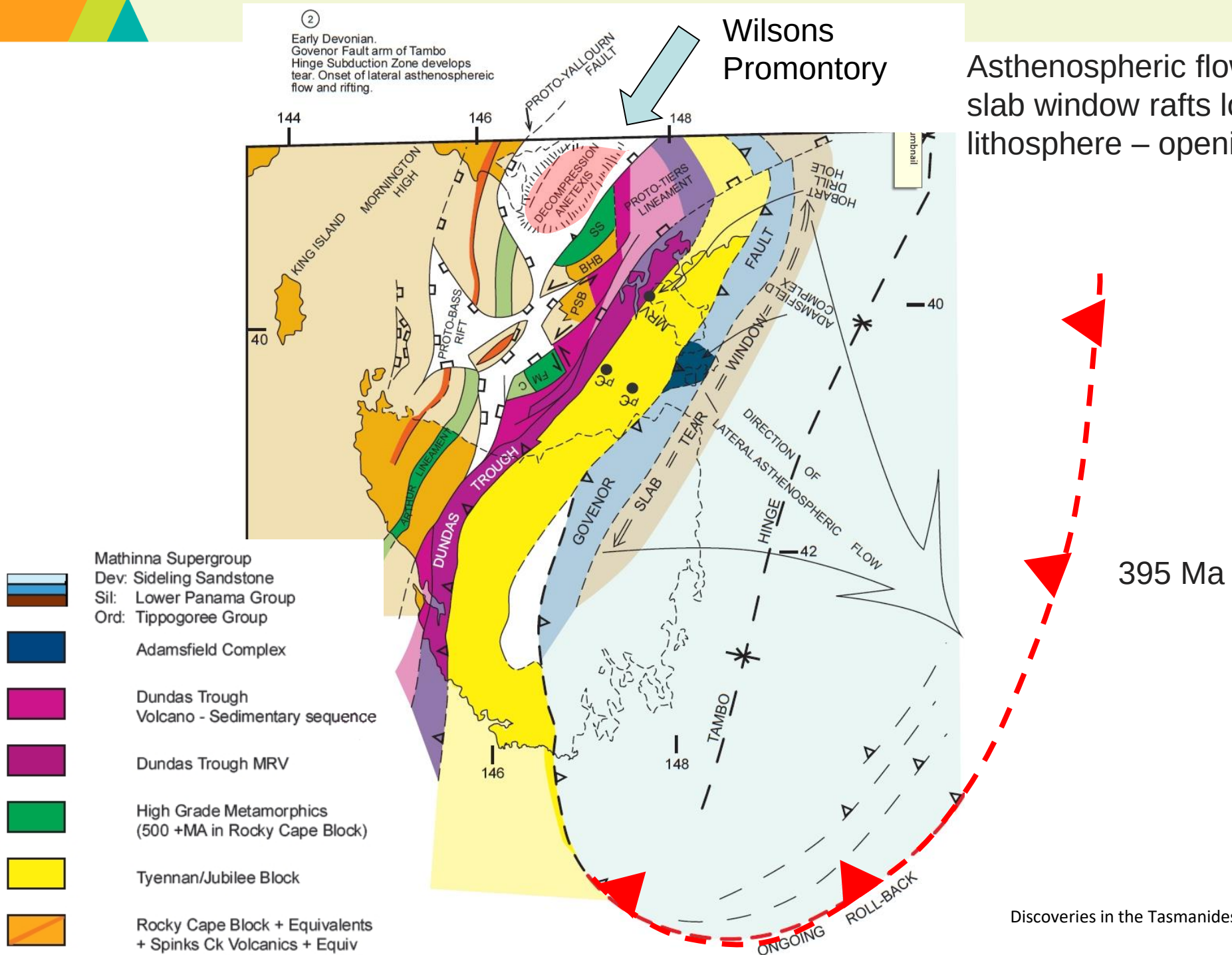



Detailed Tasmania-Bass Strait retrodeformation sequence:

stepped forward in time

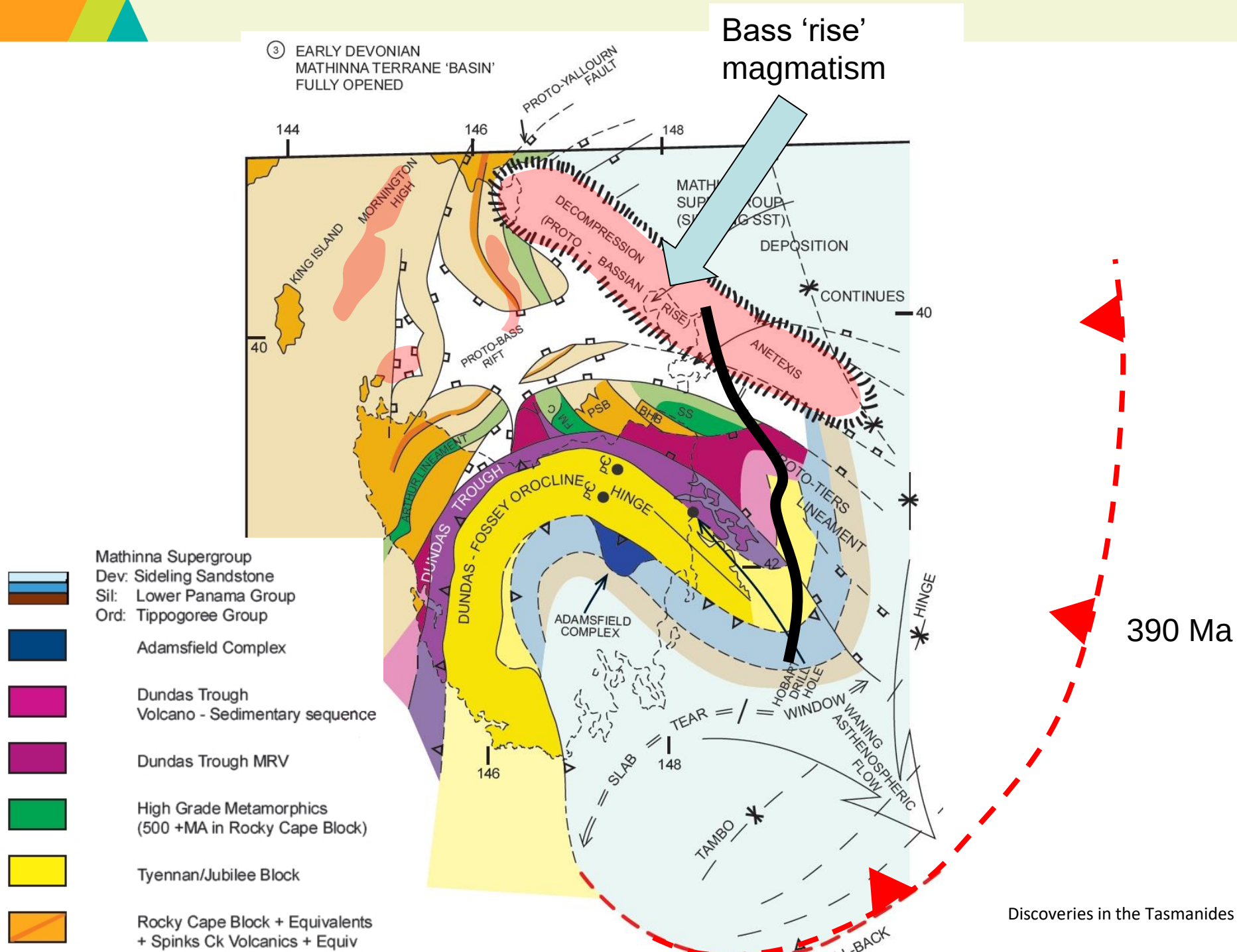
400 Ma

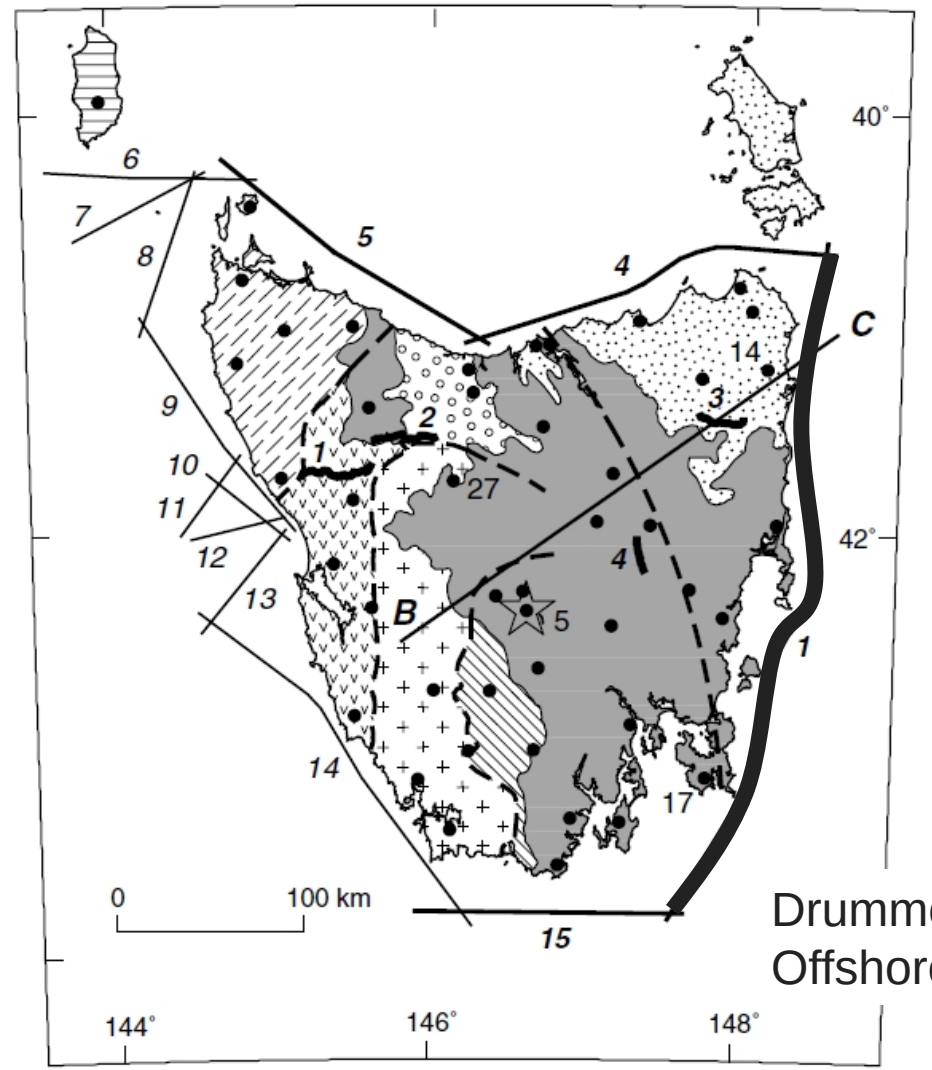
Lachlan Orocline resolution:
detachment of the folded congested slab segment, beginning with the opening of a slab window beneath what today is Bass Strait at ~405Ma

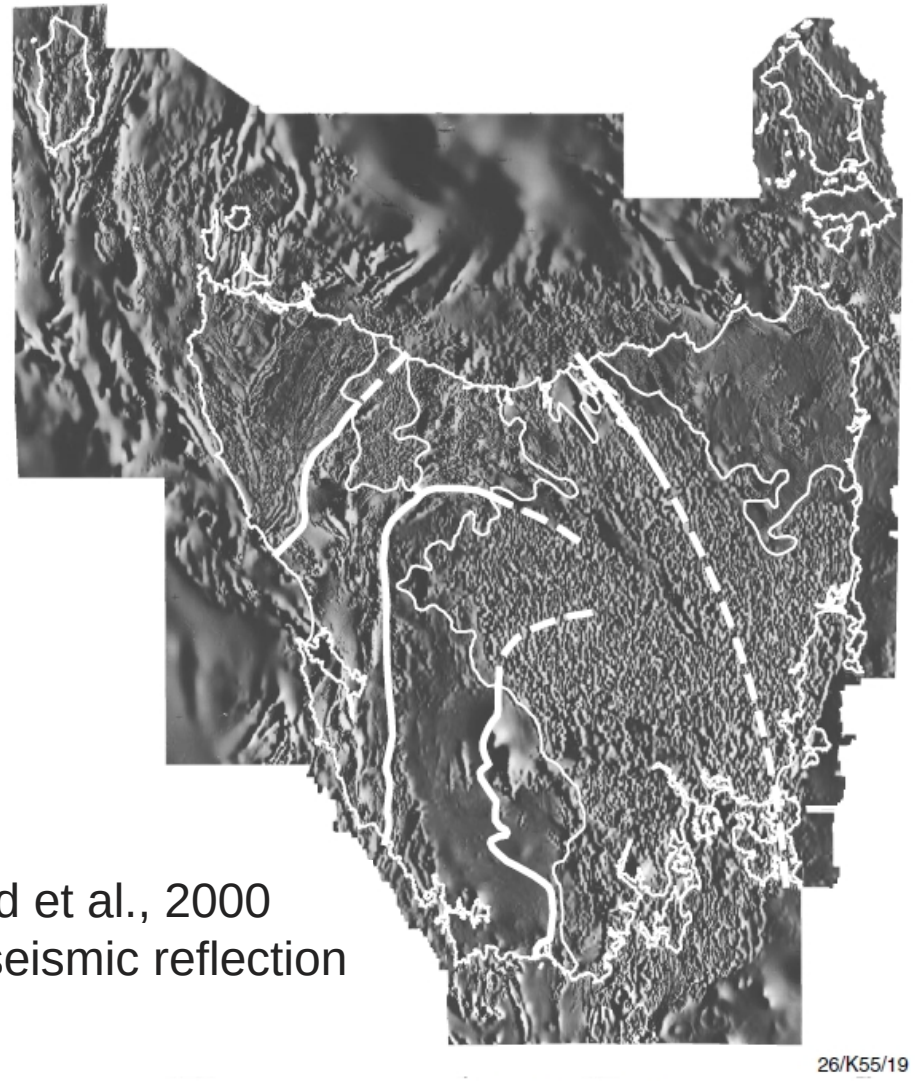



Asthenospheric flow through the slab window rafts locally overlying lithosphere – opening asymmetric rifts

395 Ma


Bass ‘rise’ magmatism
③ EARLY DEVONIAN
MATHINNA TERRANE ‘BASIN’
FULLY OPENED
PROTO-YALLOURN FAULT
144
146
148
MORNINGTON HIGH
KING ISLAND
DECOMPRESSION (PROTO - BASSIAN RISE)
DEPOSITION
CONTINUES
40
PROTO-BASS RIFT
ANETEXIS
PSB
BHB
SS
ARTHUR LINEAMENT
DUNDAS TROUGH
DUNDAS - FOSSEY OROCLINE
HINGE
PROTO-TIERS LINEAMENT
ADAMSFIELD COMPLEX
HOBART DRILL HOLE
WINDOW
TEAR
SLAB
WANING ASTHENOSPHERIC FLOW
TAMBO
Mathinna Supergroup
Dev: Sideling Sandstone
Sil: Lower Panama Group
Ord: Tippogoree Group
Adamsfield Complex
Dundas Trough
Volcano - Sedimentary sequence
Dundas Trough MRV
High Grade Metamorphics
(500 +MA in Rocky Cape Block)
Tyennan/Jubilee Block
Rocky Cape Block + Equivalents
+ Spinks Ck Volcanics + Equiv
390 Ma




Drummond et al., 2000
Offshore seismic reflection

King Island
Dundas Element
Tyennan Element
Northeast Tasmania Element
Rocky Cape Element
Sheffield Element
Adamsfield - Jubilee Element
Tasmania Basin and younger cover sequence
Element boundary
4 Onshore Seismic line
15 / 14 Offshore Seismic line
17 Station number

Drummond et al, 2000: interpreted highly extended Precambrian continental margin beneath Mathinna Terrane

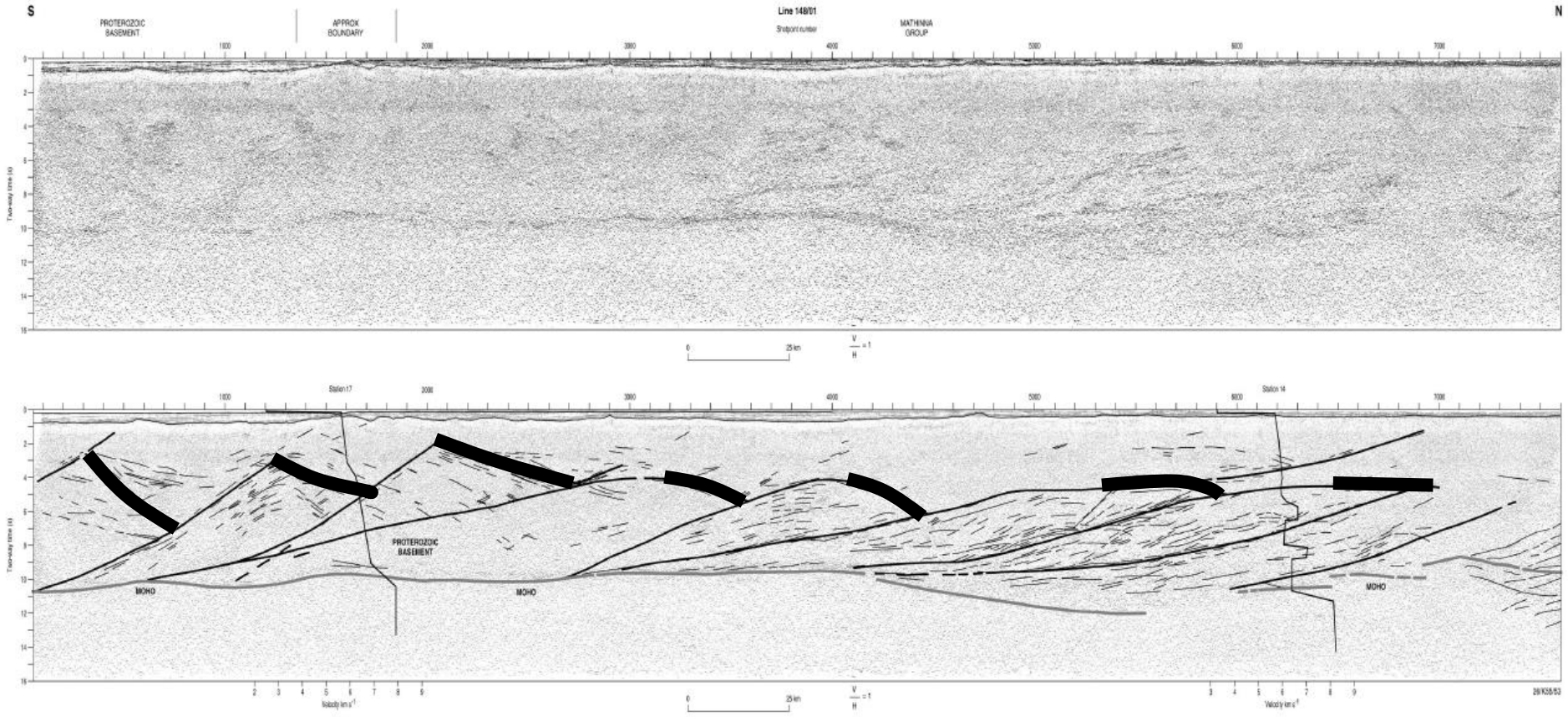
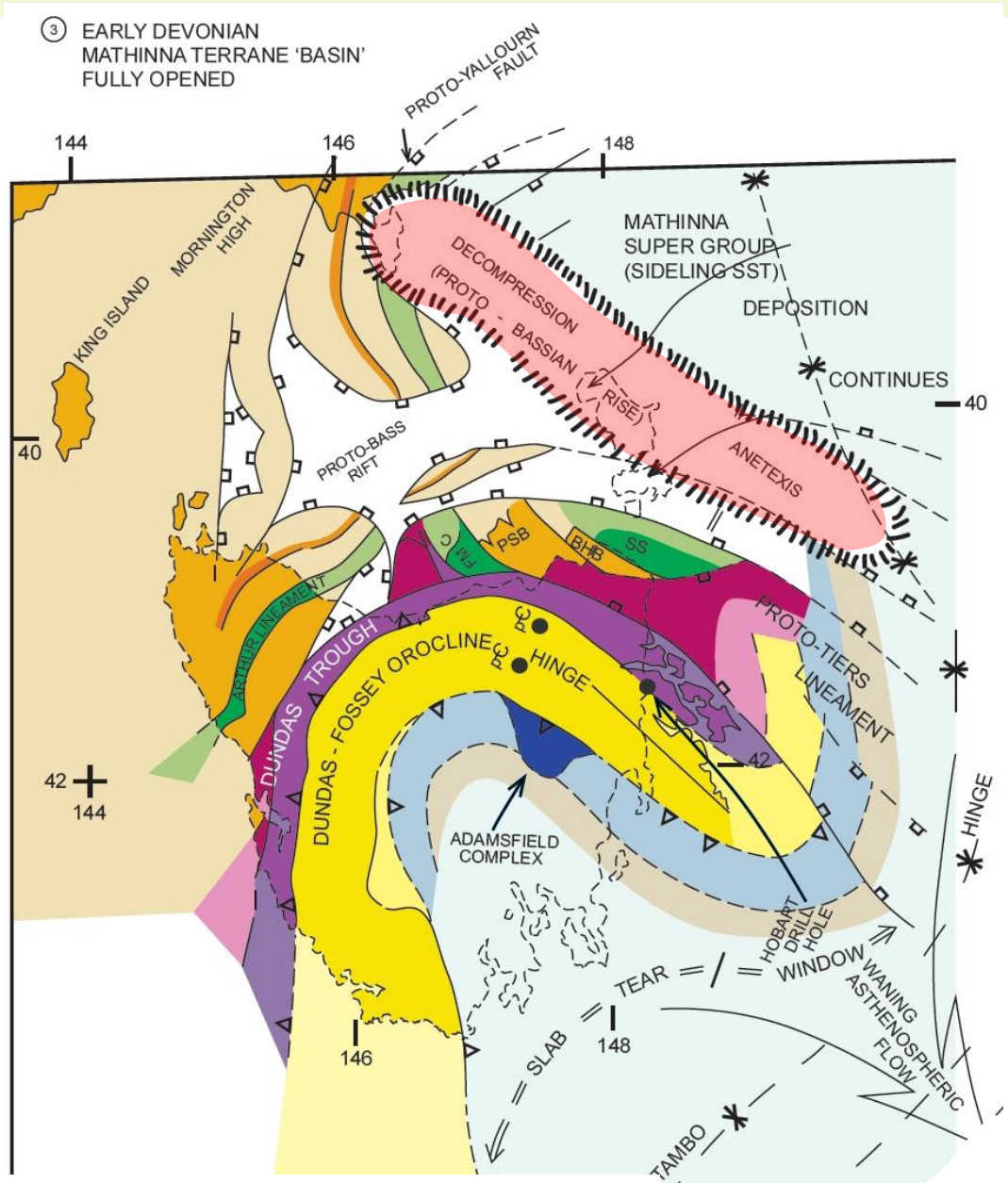


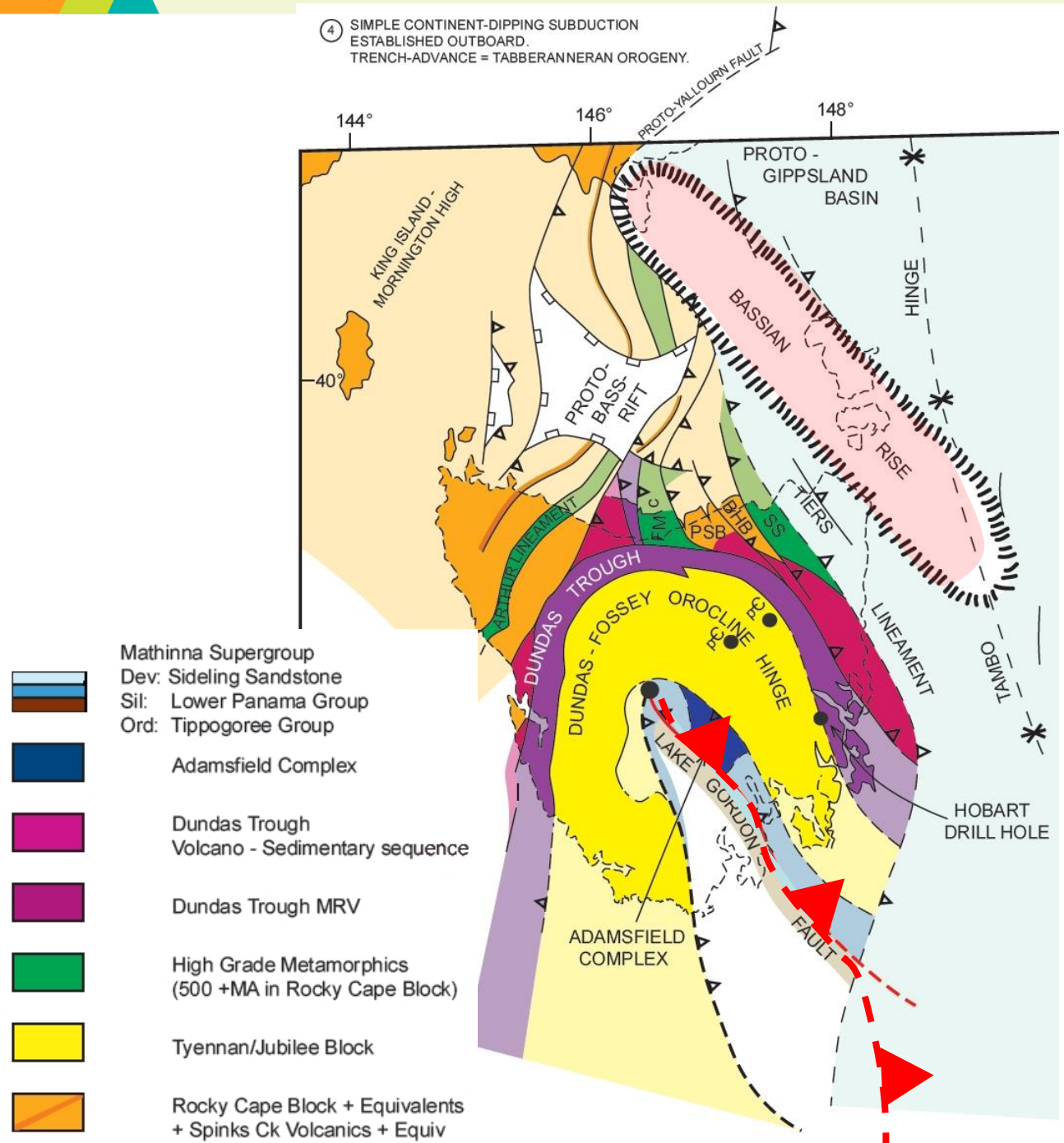

Fig. 3. (a) Seismic reflection data from offshore Line 1. Data are post stack wave equation migrated. $V/H = 1$ (assuming a seismic velocity of 6.0 km $s^{-1}$). (b) Interpreted reflection section. 1D models of velocity vs two-way-travel time were derived for the data in Fig. 2.

How extended? 80-90%. Equates to lithospheric thinning of 40-45%




390 Ma

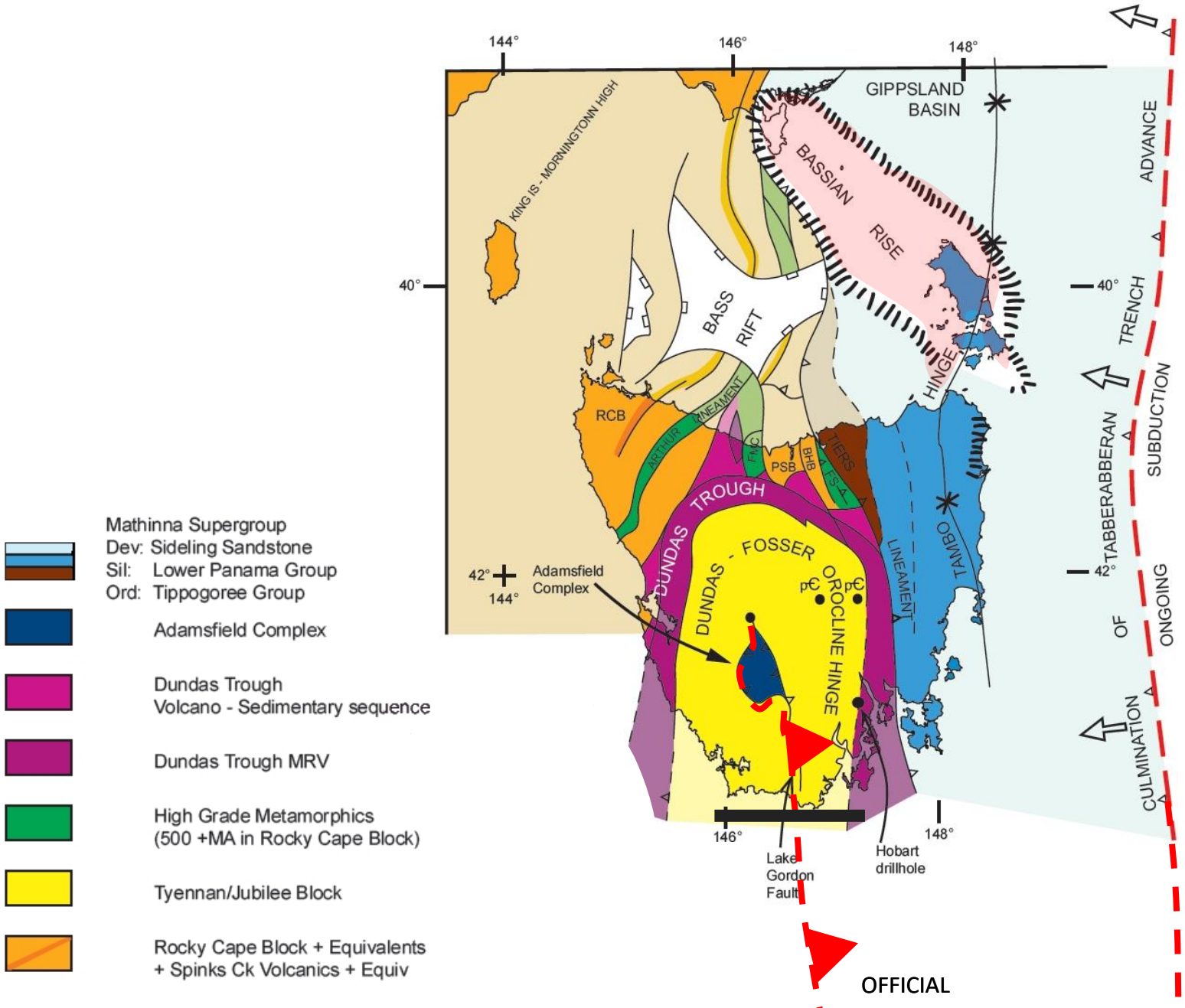
Single continent-dipping subduction zone re-established outboard……..




advance

Onset of Tabberabberan Orogeny ~380 Ma

Trench




Culmination of Tabberabberan Orogeny ~375 Ma

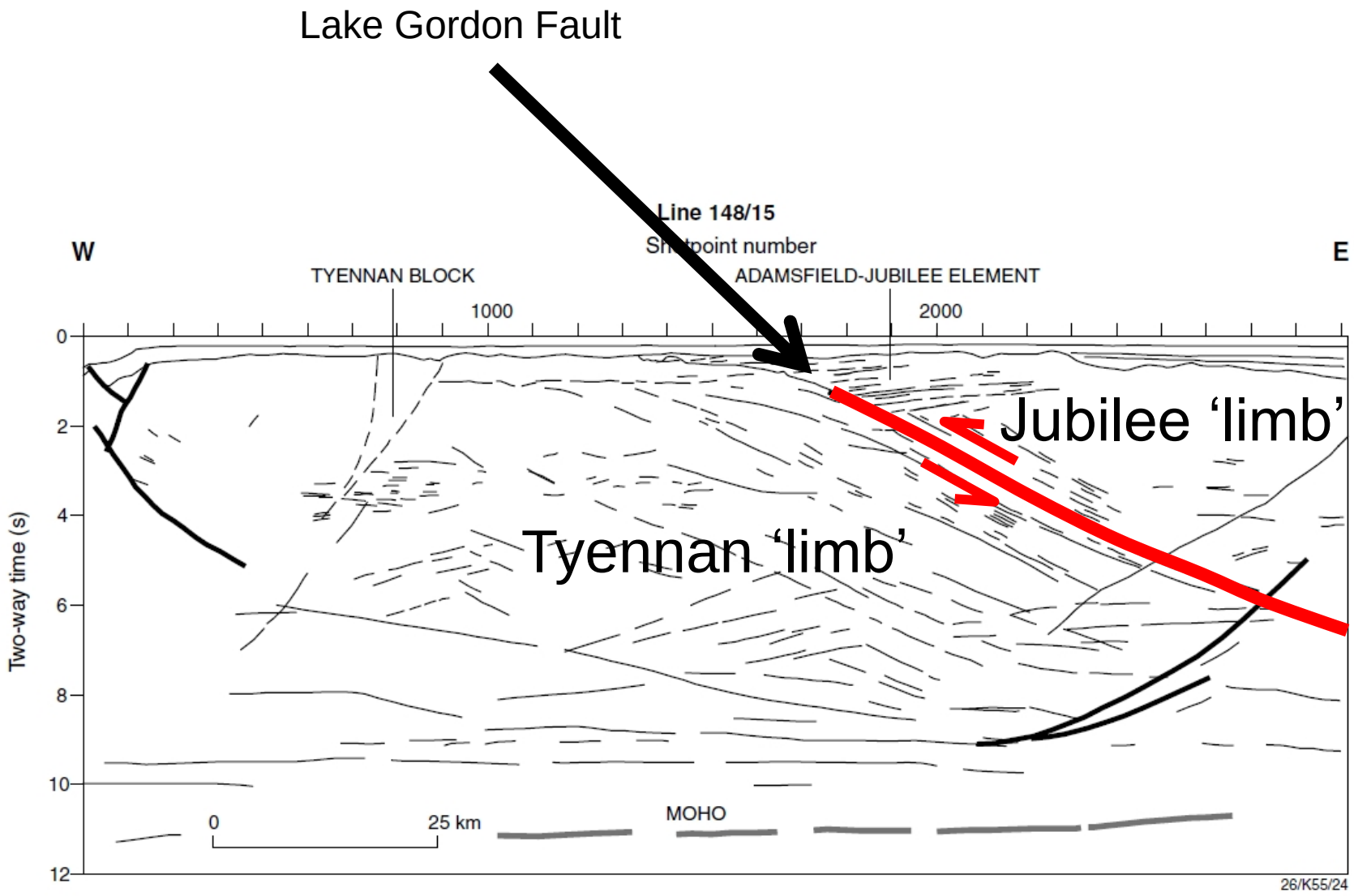
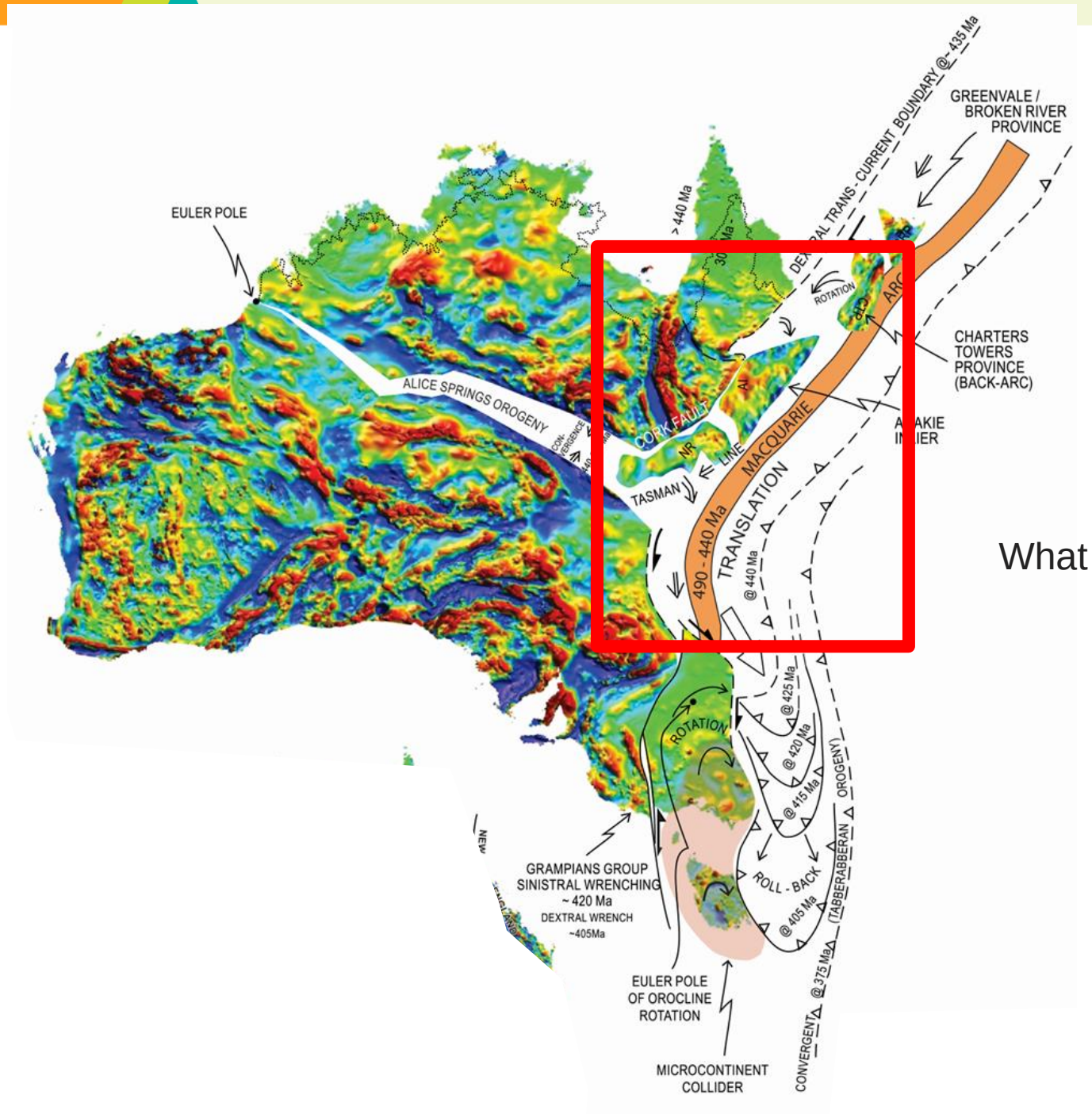


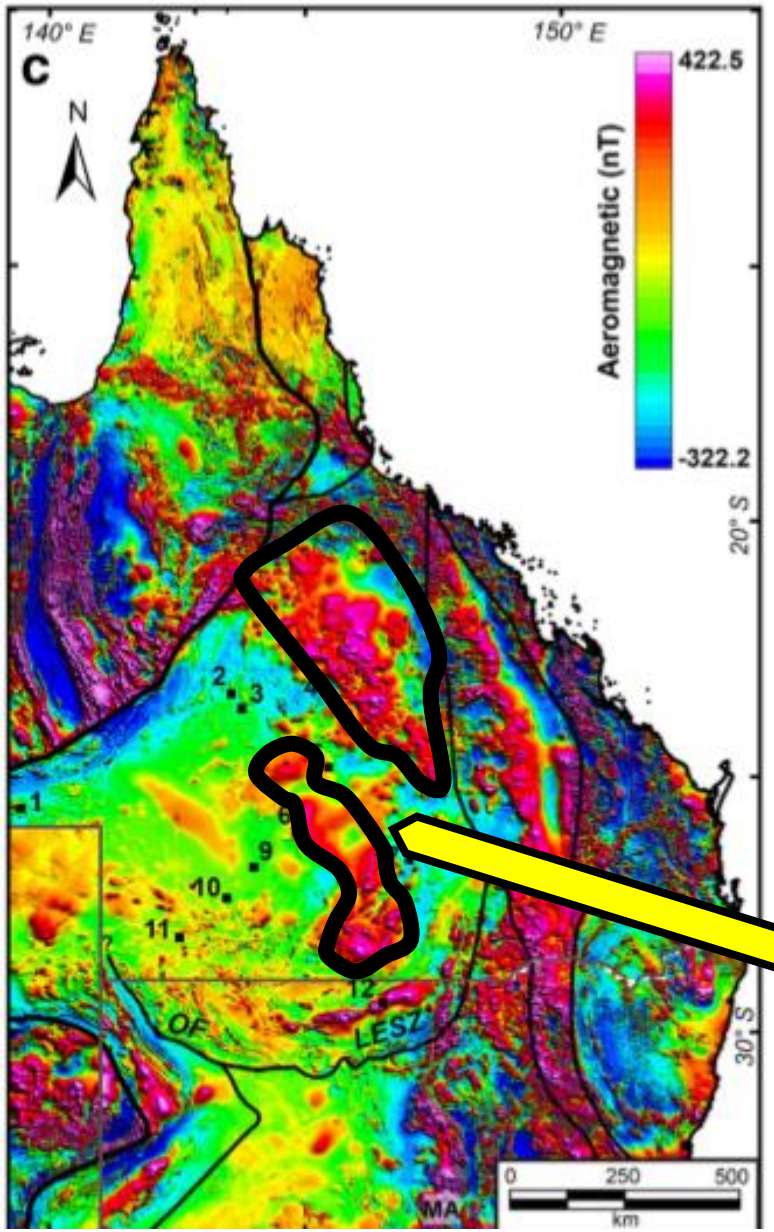

Fig. 8. Line diagram of offshore Line 15 along the southern coastline.

Drummond et al, 2000

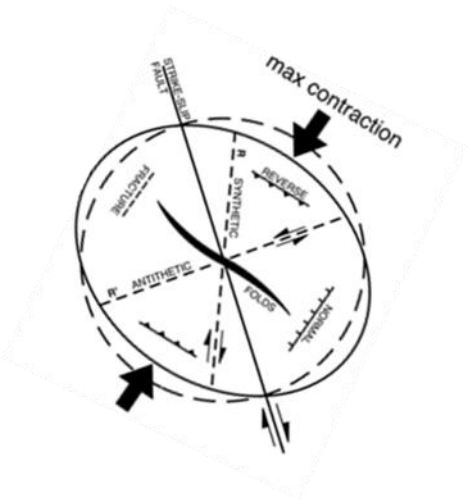


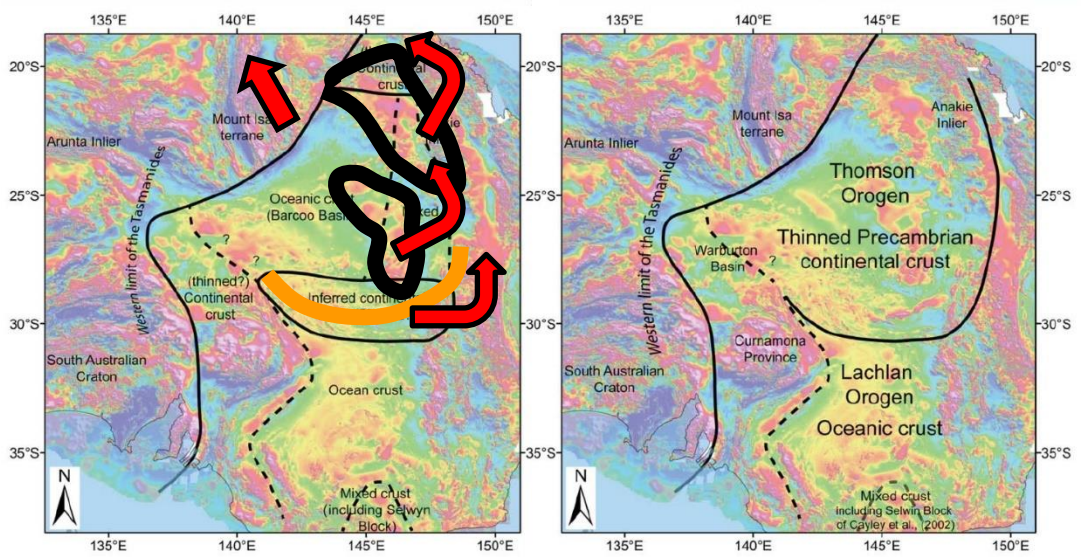

What about the northern parts of the system?

# The Lachlan Orocline hypothesis provides context for retrodeformation:




Abdullah & Rosenbaum, 2017




Glen, 2013

Spampinato et al, 2015

Nebine ridge basement –
displaced Mount Isa Province fragment?

Unmagnetic zone - a displaced fragment of the Kalkadoon-Leichhardt Domain (Mt Isa)?)

Cayley & Musgrave, in review

## Thomson Fold Belt as part of the Lachlan Fold Belt system is permissible:

- Delamerian, Benambran Orogeny, Anakie Inlier (Fergusson et al., 2013): rifted part of margin?

- Upper Nebine Ridge contains Cambrian sediments (520 +/- 10 Ma; Kositcin et al, 2015)
  - could be equivalent to Koonenberry / Kanmantoo Group: rifted part of margin?

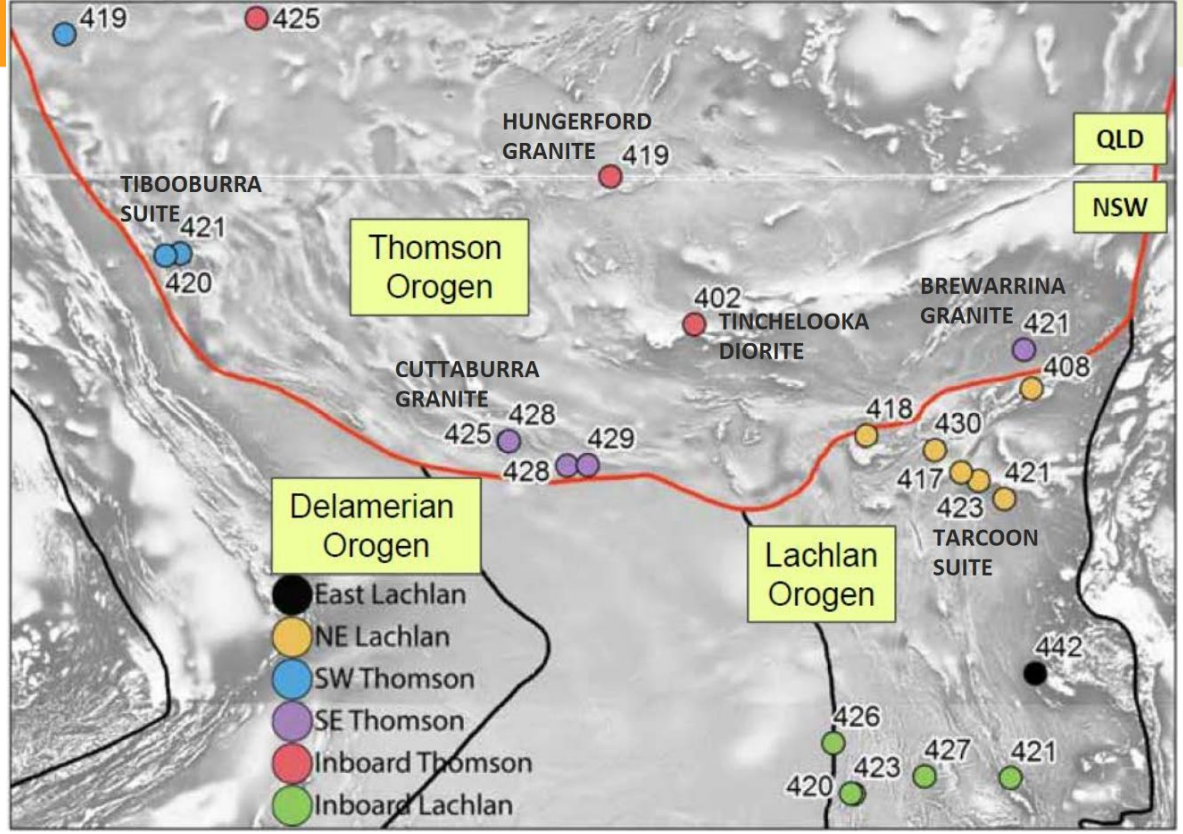
- Thomson Beds / Warratta Group: limited Delamerian Orogeny (Purdy et al, 2016):
  Lachlan Fold Belt correlate (Bendigo Zone)?

- Warraweena Volcanics:
  Calc-alkaline / shoshinite composition (Gilmore et al, 2017), likely Ordovician age
  (Phase 4 of Macquarie Arc; Hack et al., 2017): Lachlan Fold Belt correlate? **Or not?**
  some 'WV' now dated at ~417Ma! (Hack et al, in press) (also Fork Lagoon Beds, NE TFB)

- Tibooburra region – clear Benambran Orogeny and LFB magmatic history
  (Thalhammer et al., 1998): Lachlan Fold Belt correlate?

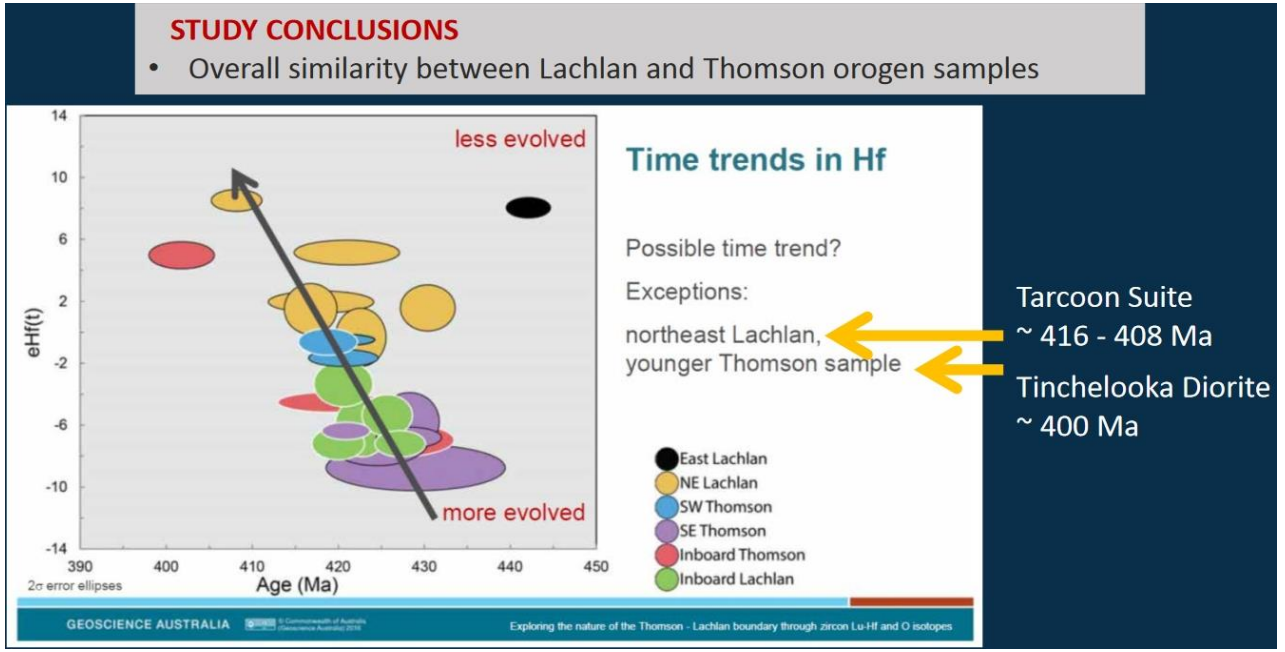
- Silurian – S-type and I-type granitic complexes abundant in TFB (eg. Collins et al, 2017)
  = evidence of Silurian decompression melting = evidence of Bindian transtension/rifting

- Thomson Fold Belt region (Barcoo Basin) links to Larapinta Seaway –
  South-directed Alice Springs Orogeny continues post-Lachlan Orocline resolution:
  a far-field legacy of the Siluro-Devonian LO geodynamics.



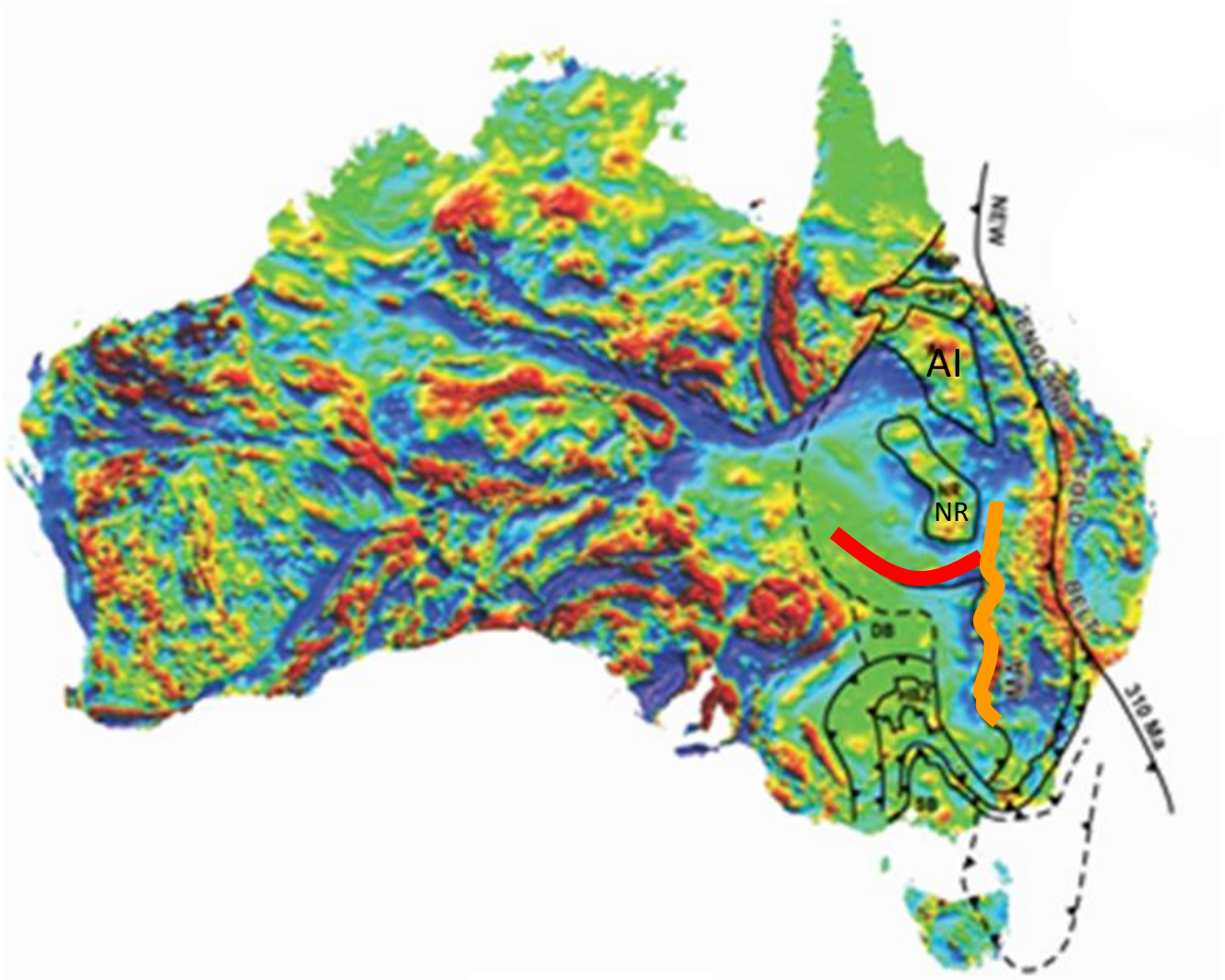

Waltenberg et al., 2016

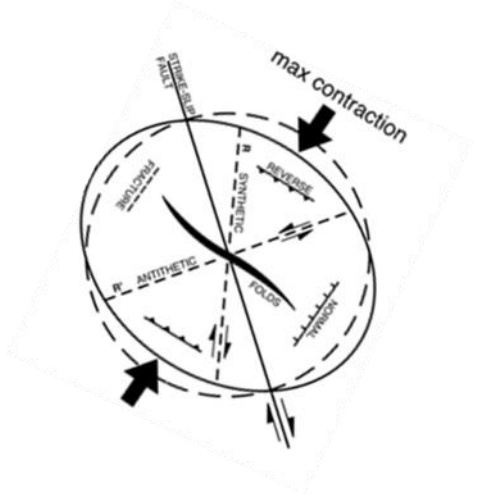
Lots of magmatism in the ~430-410 Ma interval:
The time window of Lachlan Orocline formation



**Lachlan Orocline retrodeformaton supplies boundary constraints to TFB retrodeformation: and a structural template for internal TFB retrodeformation**

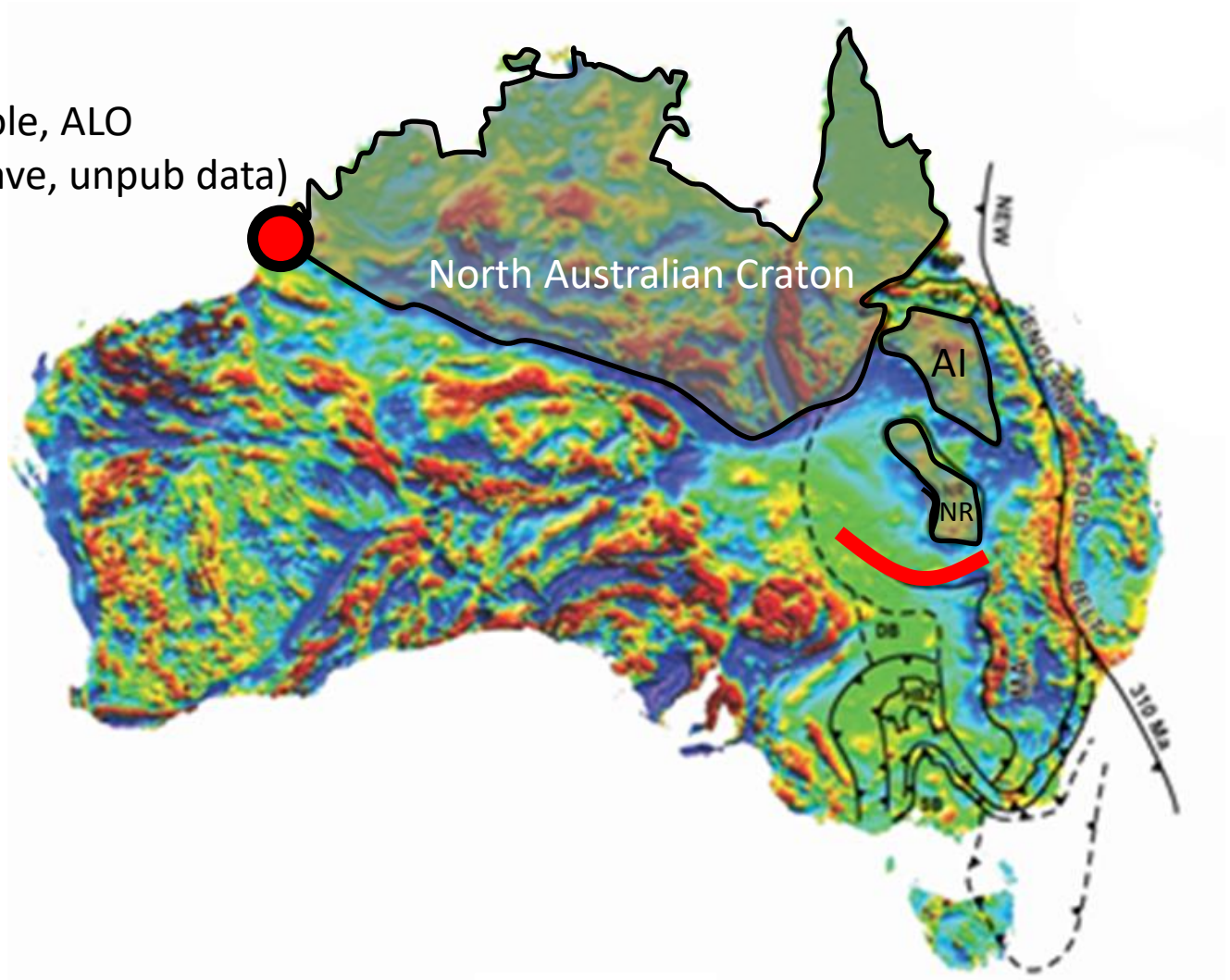
- Scissor-closure of Alice Springs Orogen: clockwise rotation for North Australian Craton from the Early Silurian onwards
- Restored Maquarie Arc trench position shows a back-arc setting for TFB interior (also arc, since Macquarie Arc fragments occur in the eastern, northern and southern TFB)
- Retreating plate boundary must lie east of the Macquarie Arc
- Northeast-trend of Diamantina Lineament lies in a releasing bend configuration for Lachlan Orocline Silurian dextral transtension: (expected to have acted as an extensional fault initially – then strike-slip)
- Clockwise rotations, southward translations expected within the TFB interior
- Microcontinental blocks within TFB expected to include passive rift fragments (eg. Nebine Ridge, Anakie Inlier)

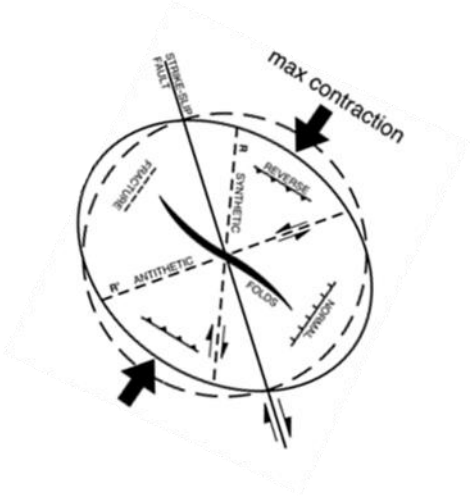

AI
NR
NEW
ENGLAND
310 Ma


max contraction
STRIKE-SLIP FAULT
FRACTURE
SYNTHETIC
REVERSE
R
ANTITHETIC
R'
FOLDS
NORMAL

Today

Euler pole, ALO
(Musgrave, unpub data)

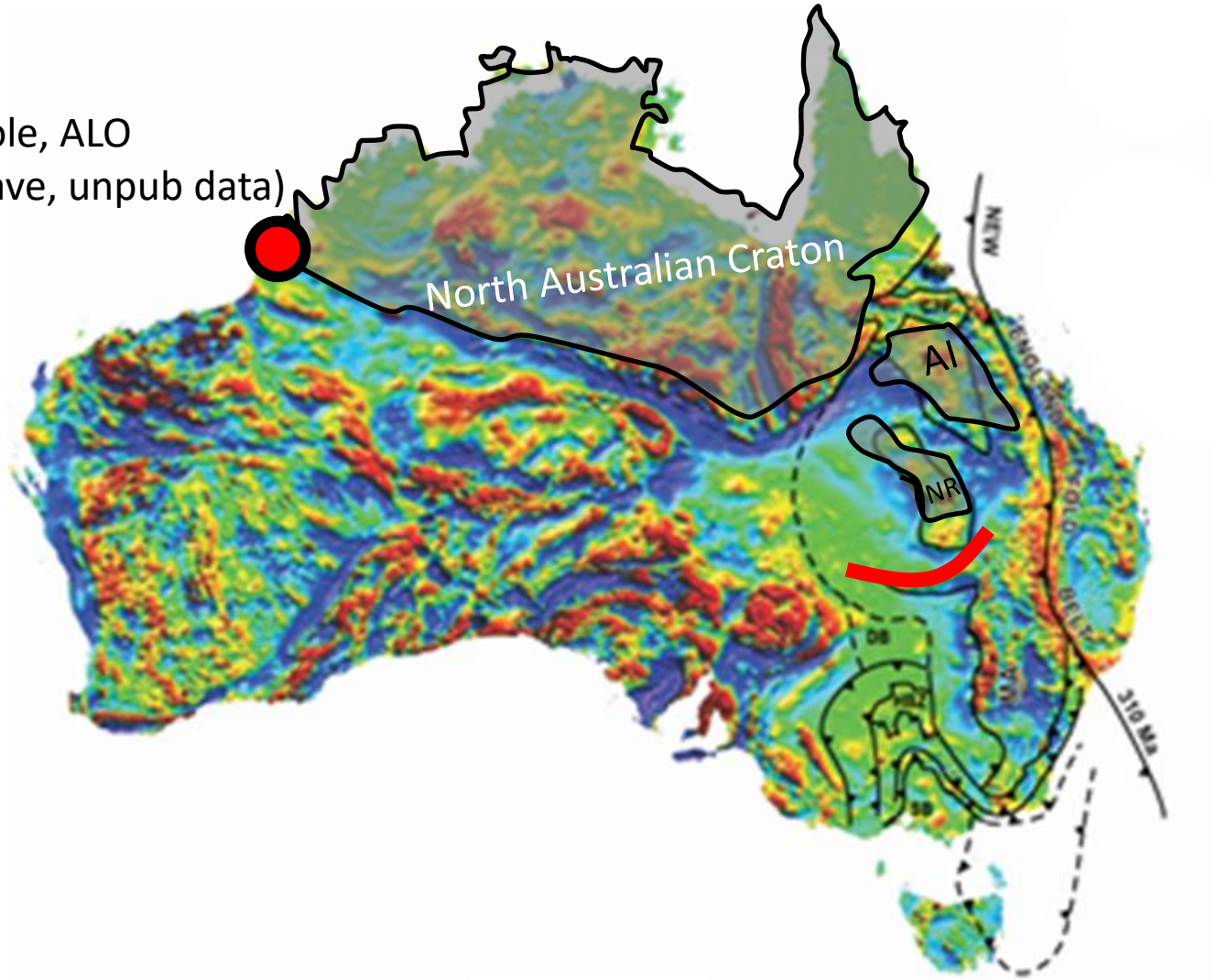


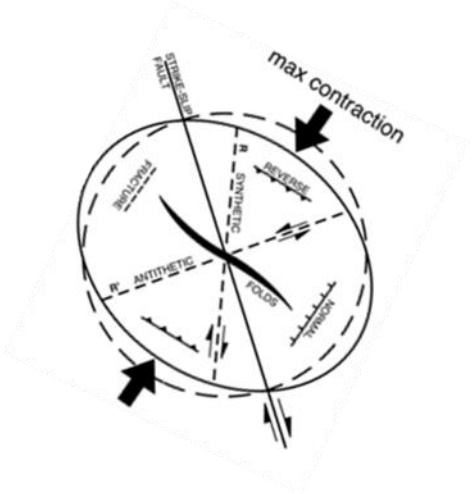




~350 Ma onwards

(post- Alice Springs Orogeny)

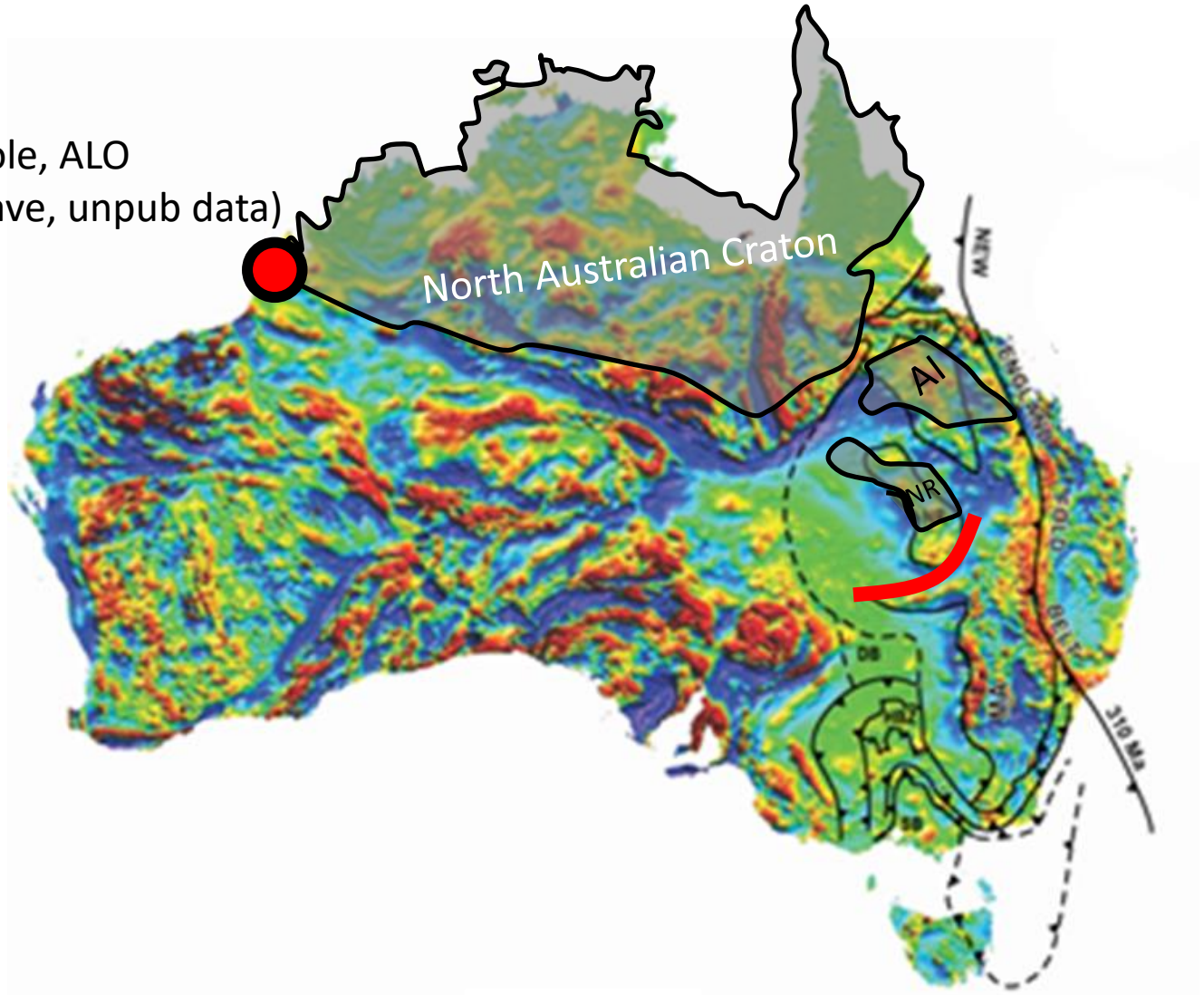
Euler pole, ALO
(Musgrave, unpub data)

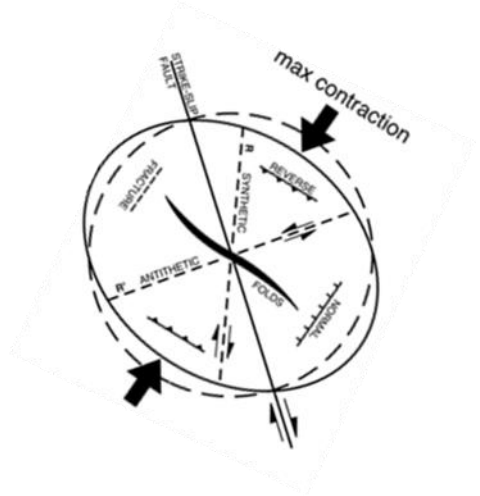



~390 Ma

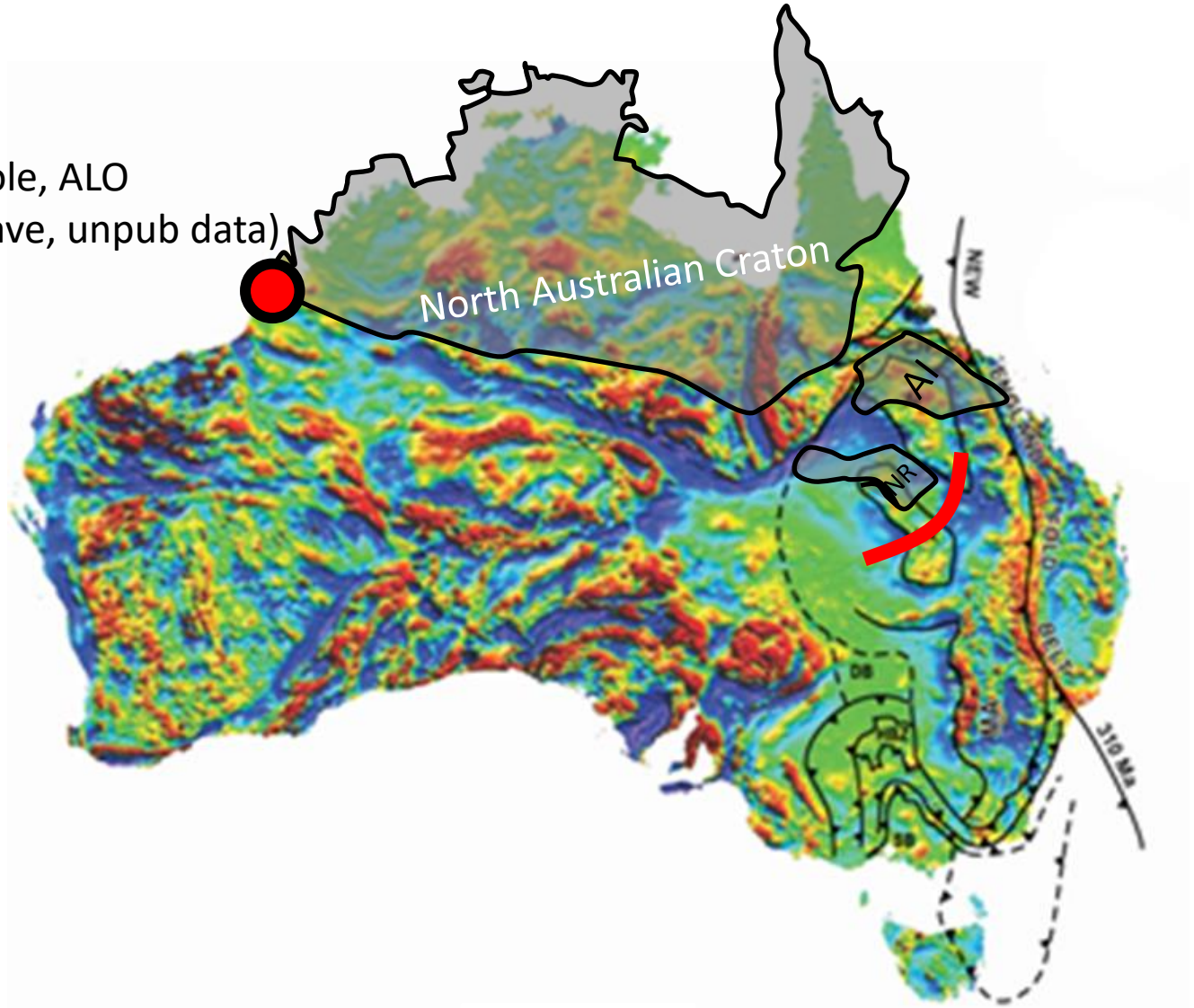
Euler pole, ALO
(Musgrave, unpub data)

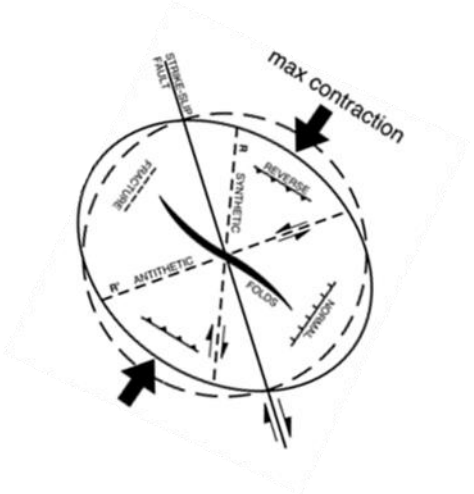



~410 Ma

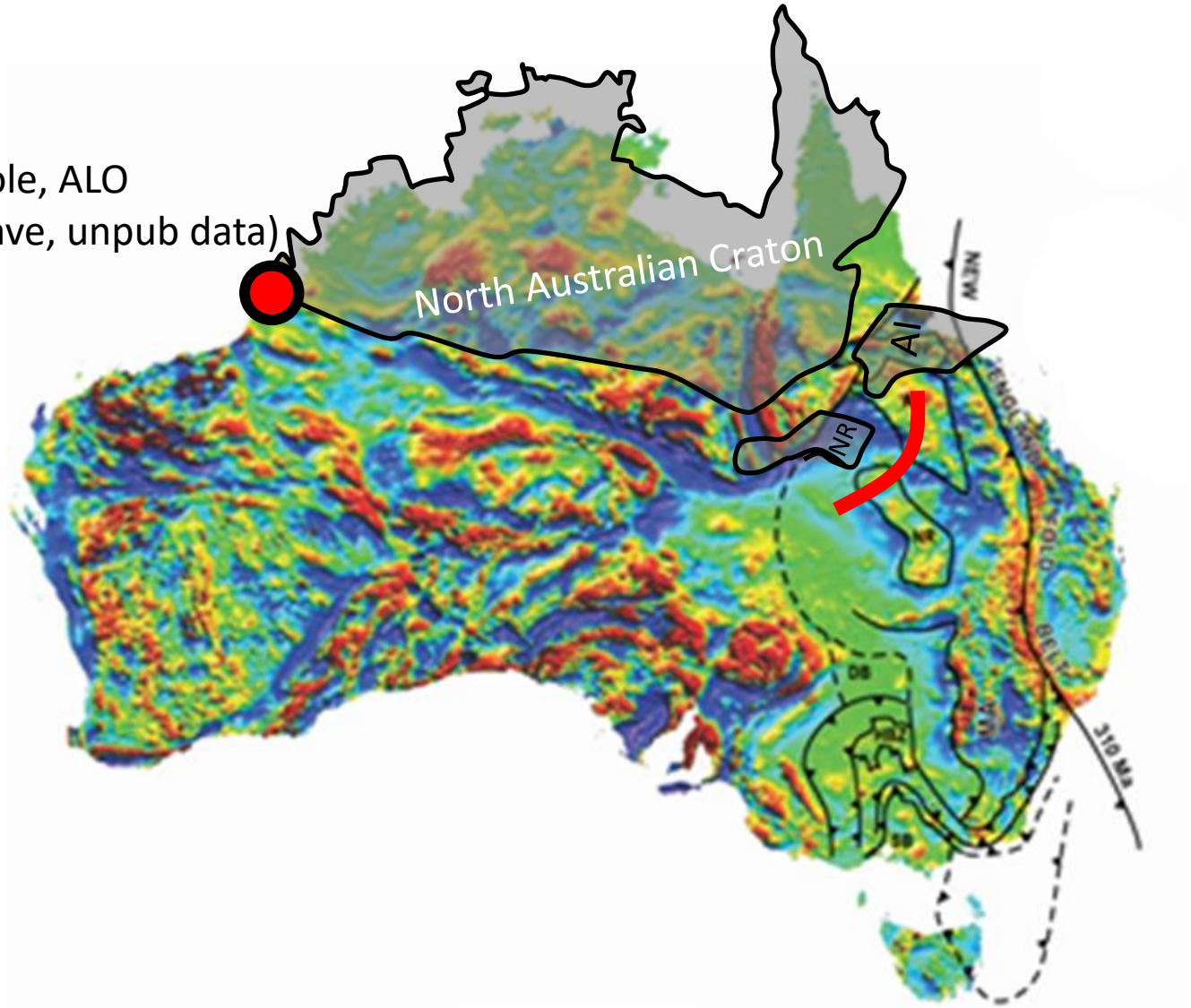
Euler pole, ALO
(Musgrave, unpub data)

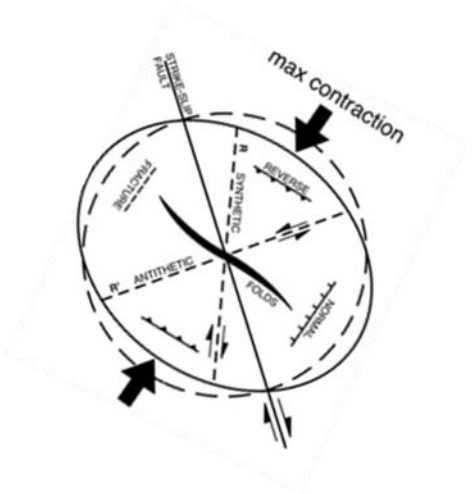



~420 Ma

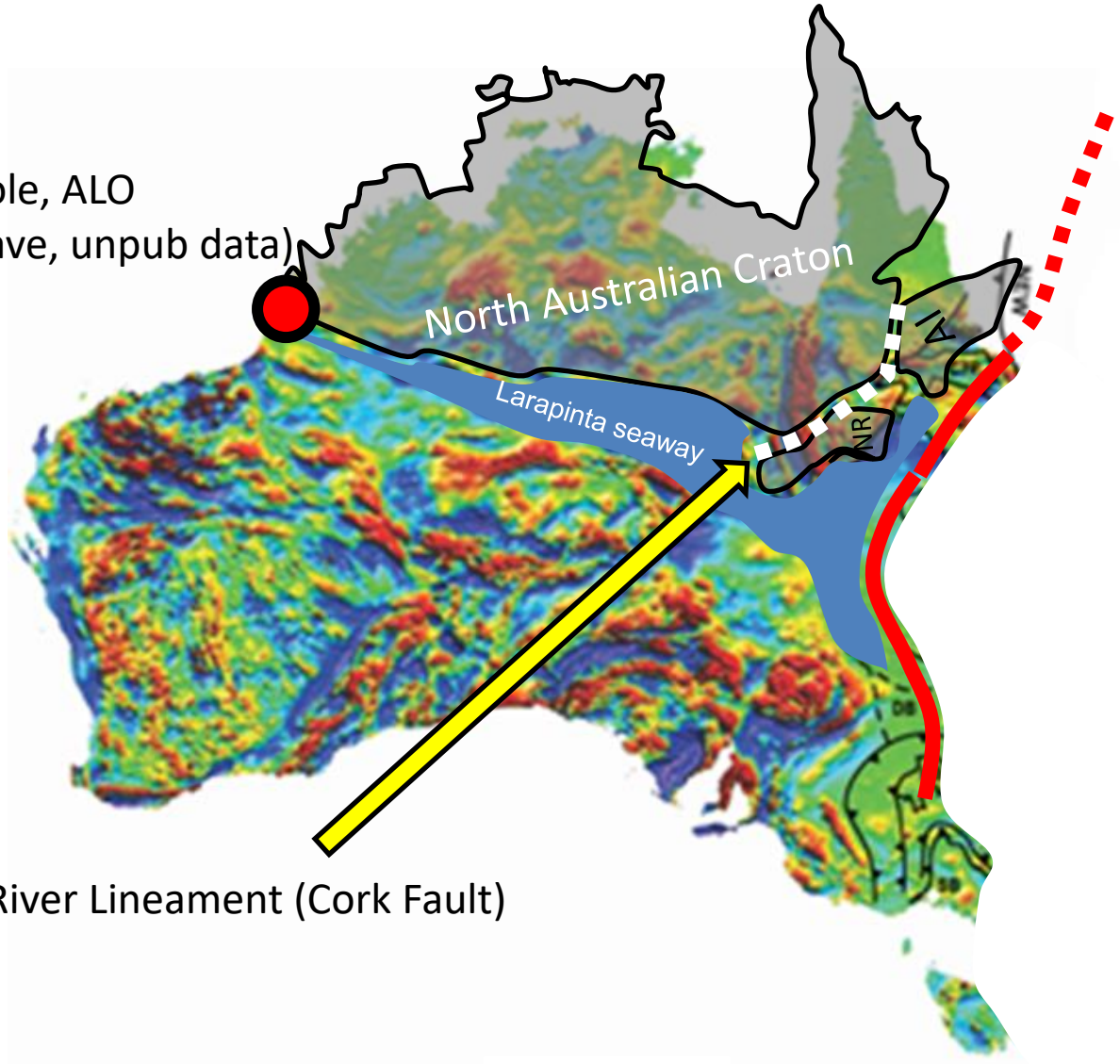
Euler pole, ALO
(Musgrave, unpub data)



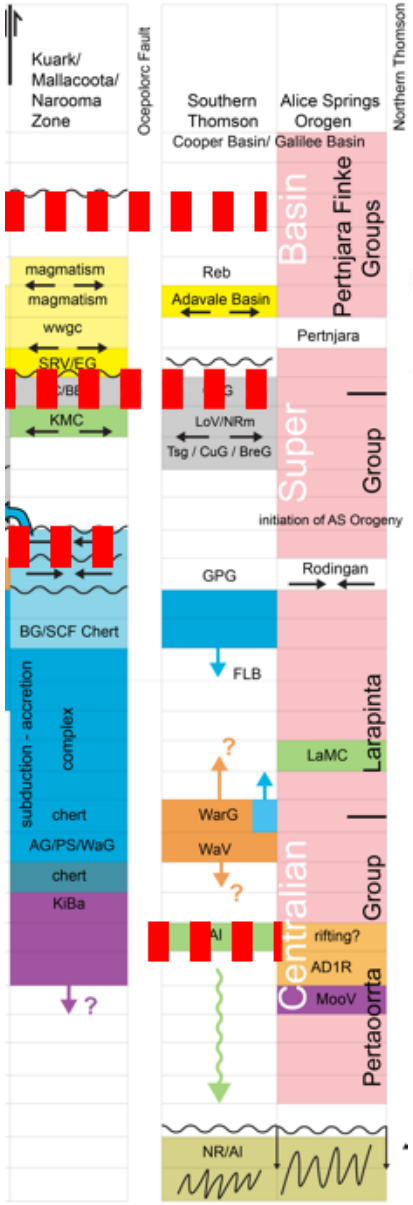



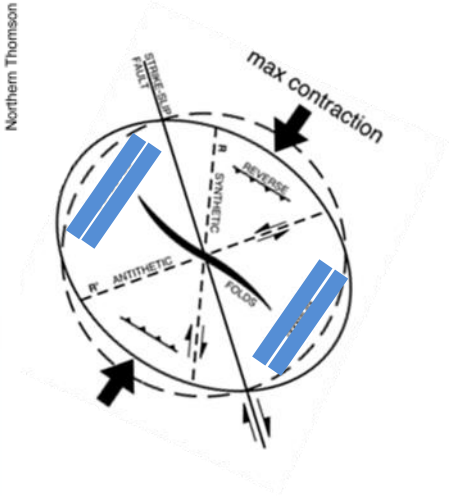

~430 Ma

Euler pole, ALO
(Musgrave, unpub data)

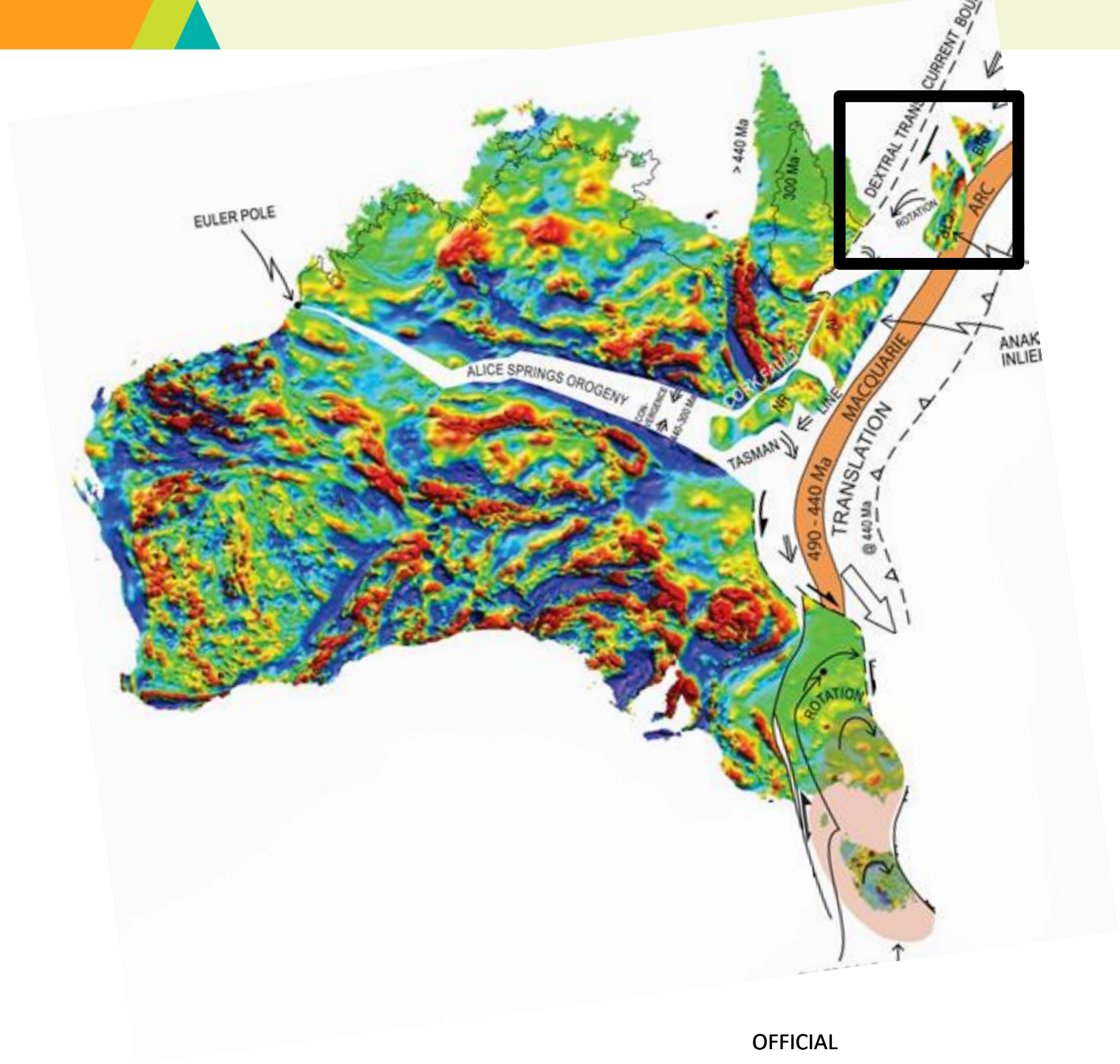


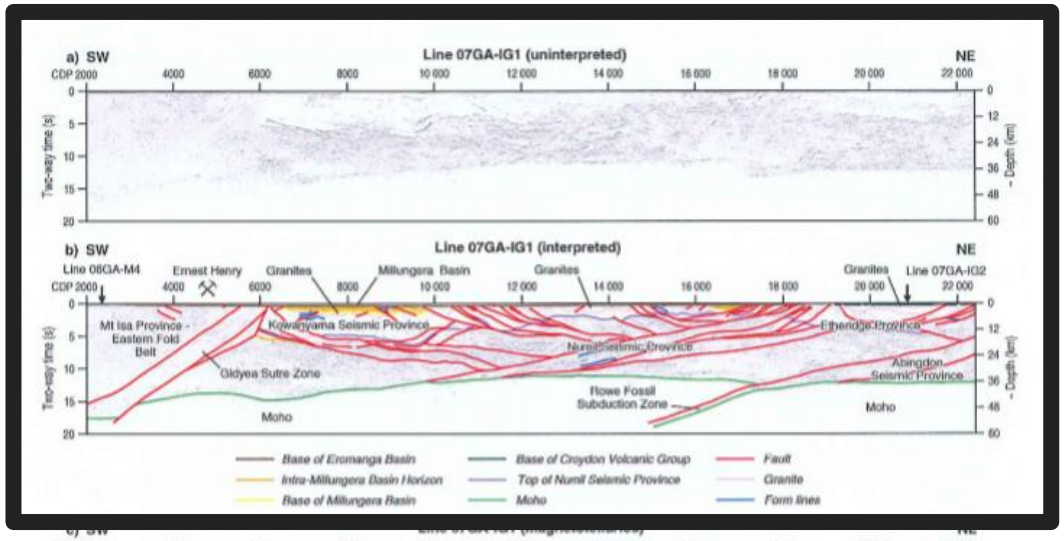

Diamantina River Lineament (Cork Fault)

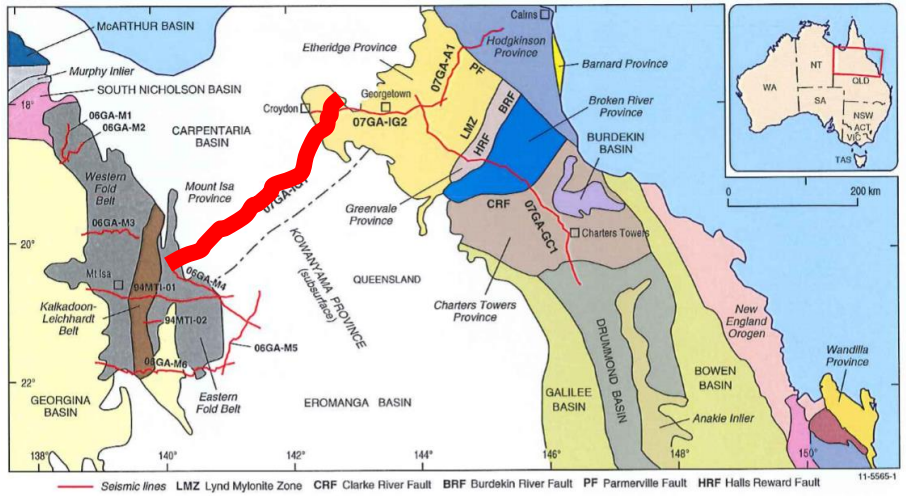


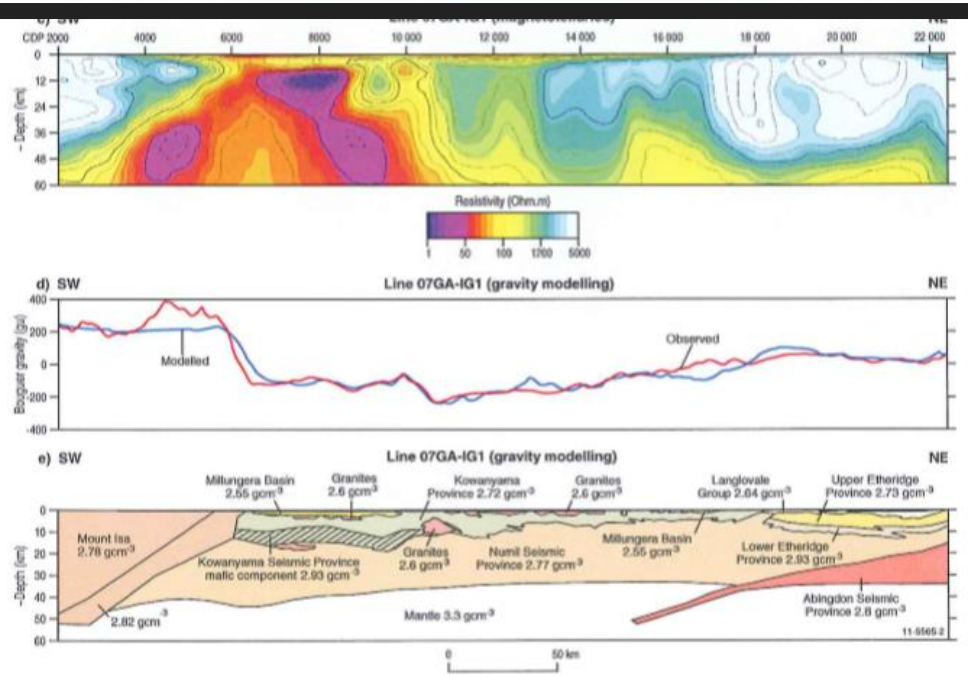



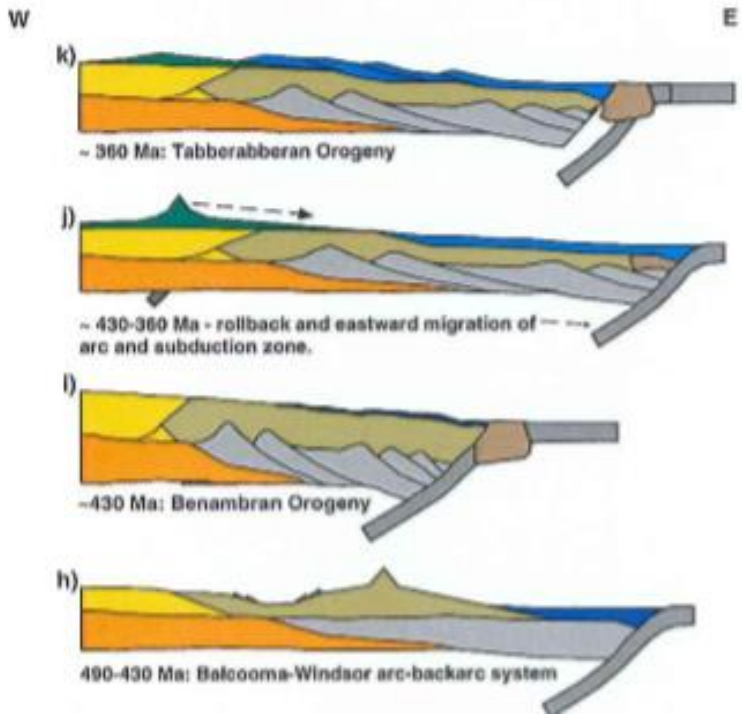

Pre- ~440 Ma


EULER POLE
ALICE SPRINGS OROGENY
TASMAN
LINE
> 440 Ma
300 Ma -
DEXTRAL TRANS
CURRENT BOU
ROTATION
ARC
ANAK
INLIE
MACQUARIE
TRANSLATION
490 - 440 Ma
@ 440 Ma
ROTATION

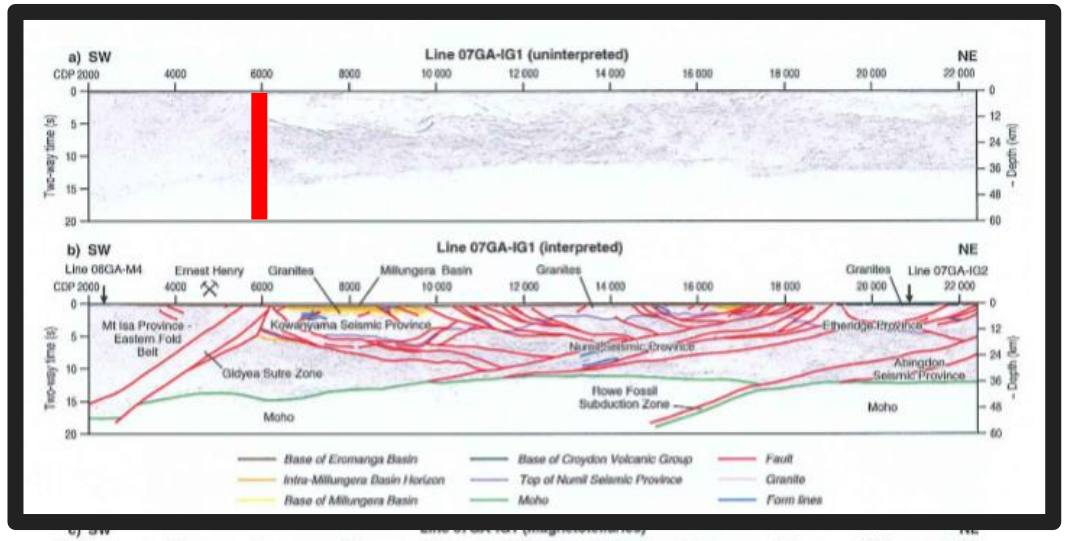


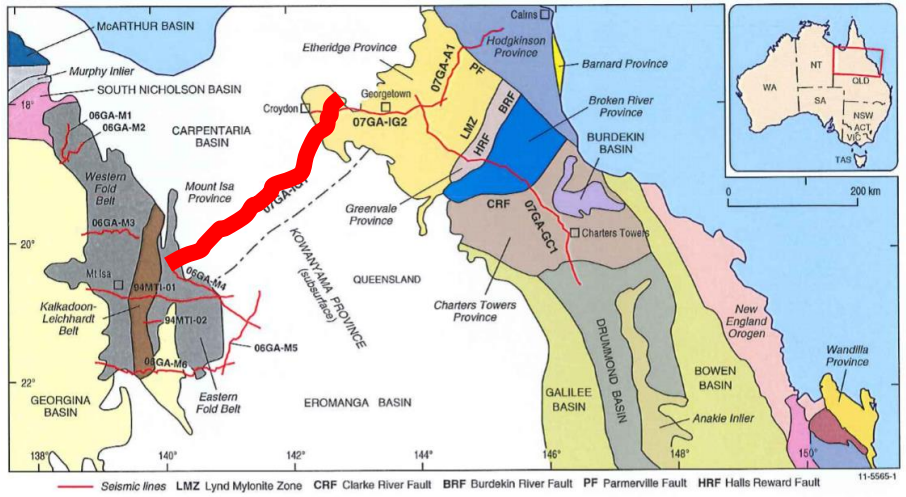



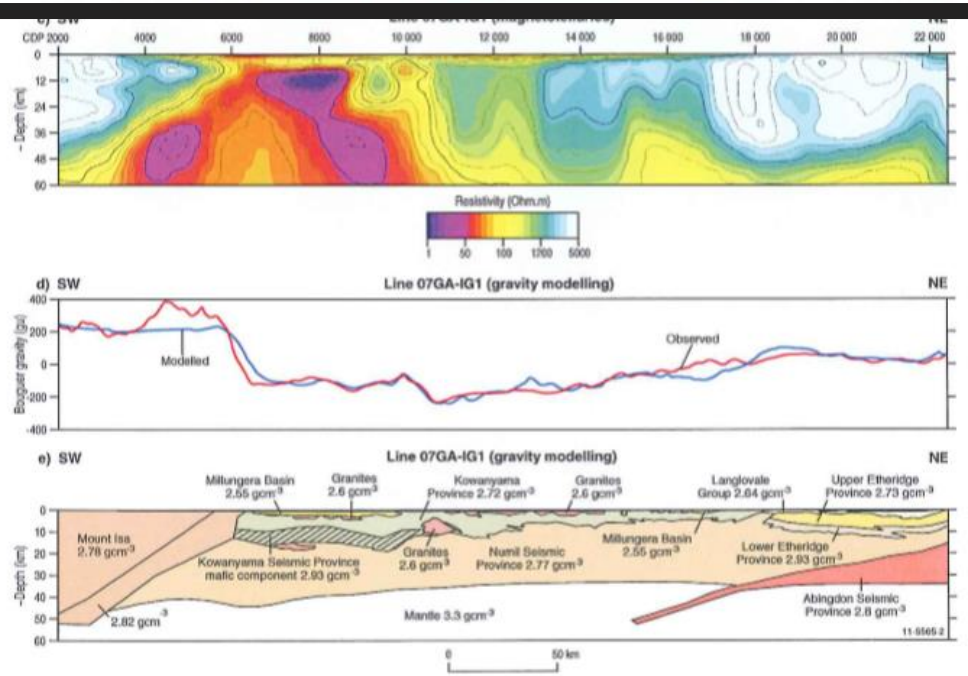



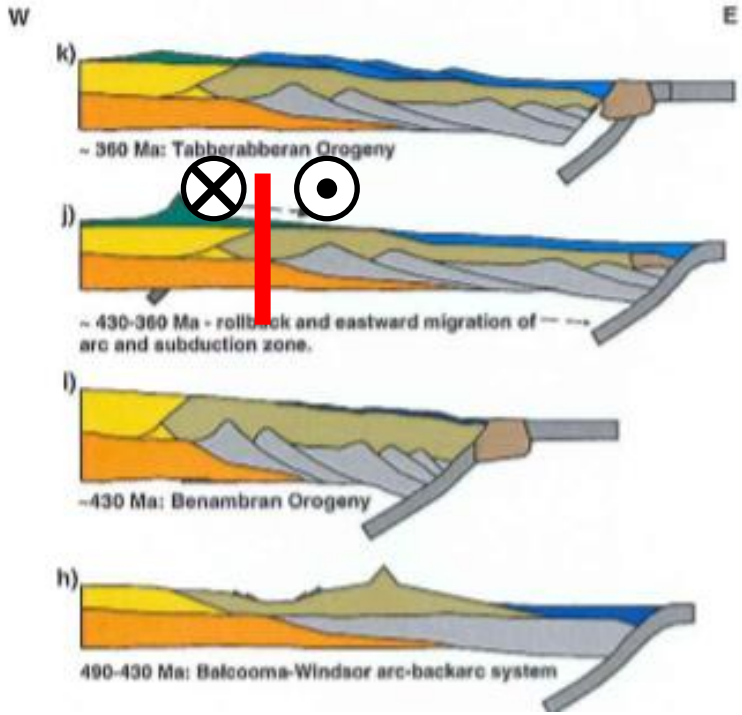




Korsch et al., 2012



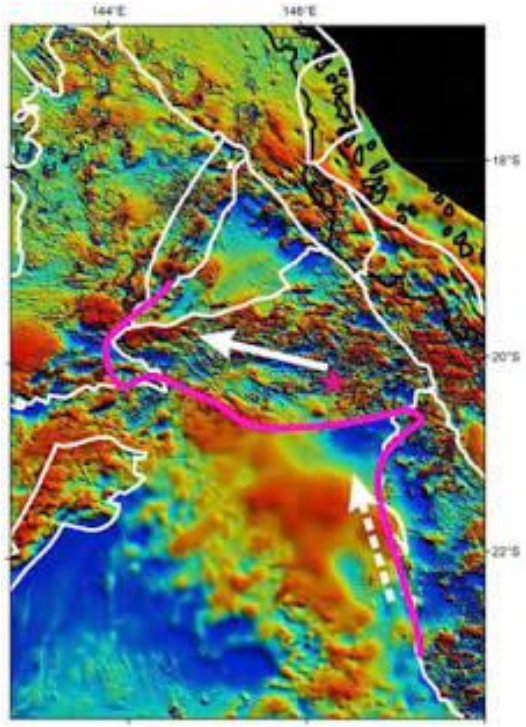



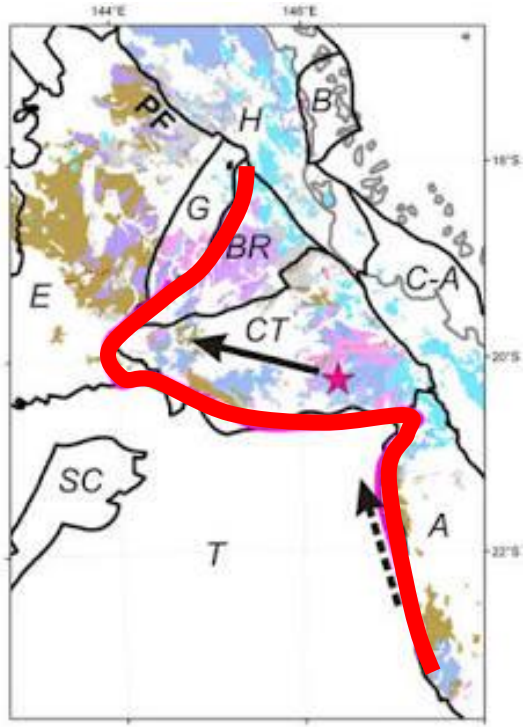

I reinterpret the western major boundaries as subvertical strike-slip faults (in red)

Korsch et al., 2012

# Charters Towers (Big Bend) Orocline

Limited paleomag data consistent with the idea
that the Charters Towers Orocline (Big Bend Orocline; Bell, 1980)
is real… (Musgrave, 2015)






BUT:

Age is constrained to post-Silurian the Alice-Springs Orogeny culmination or Hunter-Bowen Orogeny – too young to be part of the transtensional phase of Lachlan Orocline development in the Silurian.

Also has buckle morphology = consequence of N-S shortening with subhorizontal sigma3.

Still fits (and is predicted by) legacy Lachlan Orocline geodynamics – ie formed towards ALO culmination (the Olepeloko Fault reactivated as a south-directed thrust)

# Conclusions:

Collision of the Western Tasmania (Vandieland) microcontinent into an otherwise simple continent-fringing and continent-dipping convergent margin system caused Lachlan Orocline formation, and a lot of mayhem!

Pre-Silurian mineral systems fragmented, translated and reoriented by this deformation

Resolution of the folded subduction system is preserved in Tasmania as a secondary orocline and as persistent lithospheric thinning (Bass Strait)

The Thomson Fold Belt: part of the Lachlan Fold Belt, with entrained North Australia Craton fragments? Likely shares a lot of LFB prospectivity.

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# Thanks for listening.
# Have a great conference everyone!

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