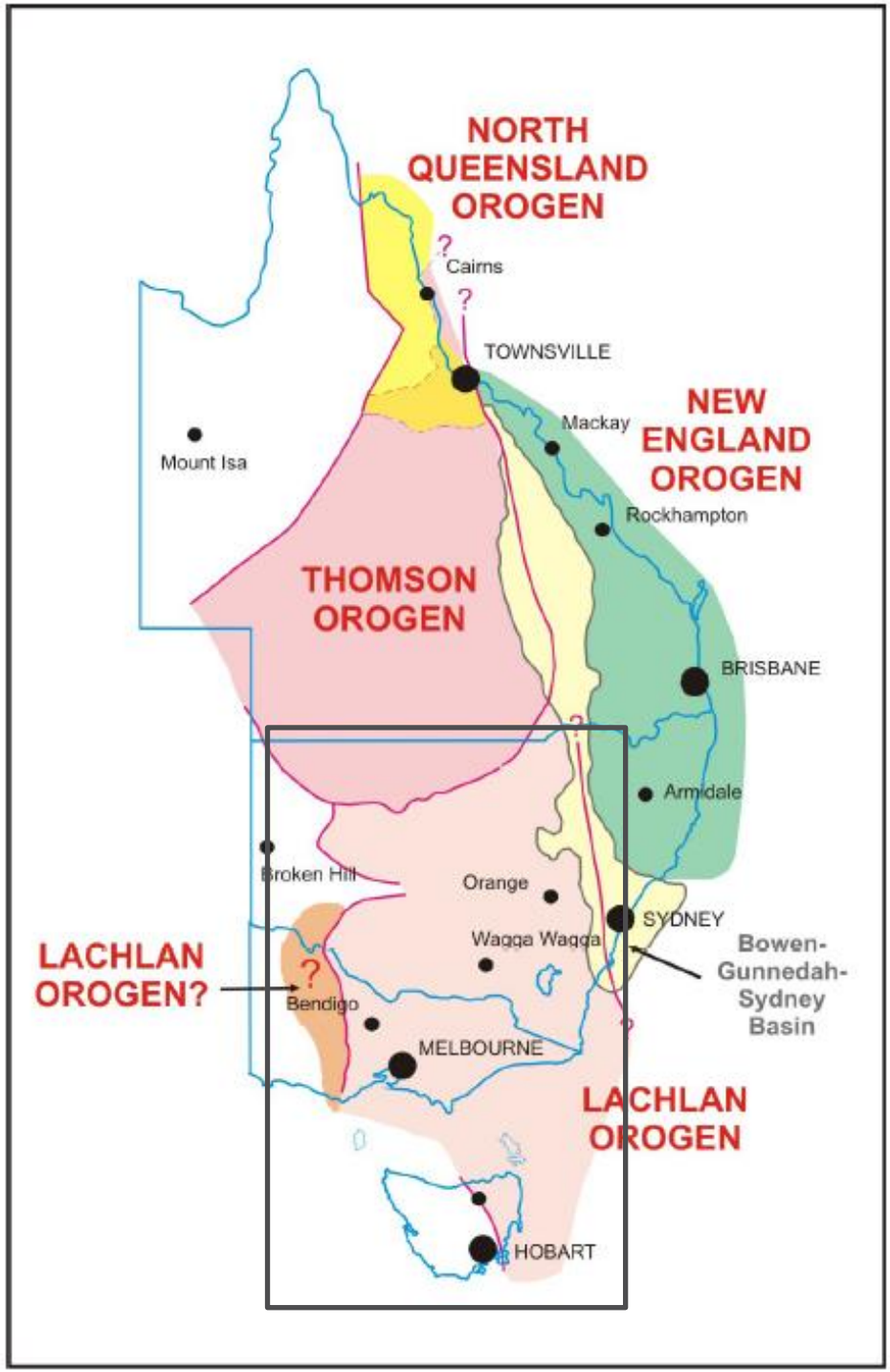
Australian Government
Geoscience Australia

Metallogenesis of the Lachlan Orocline: how much of the mineral wealth of southeast Australia is due to a collision with VanDieland?

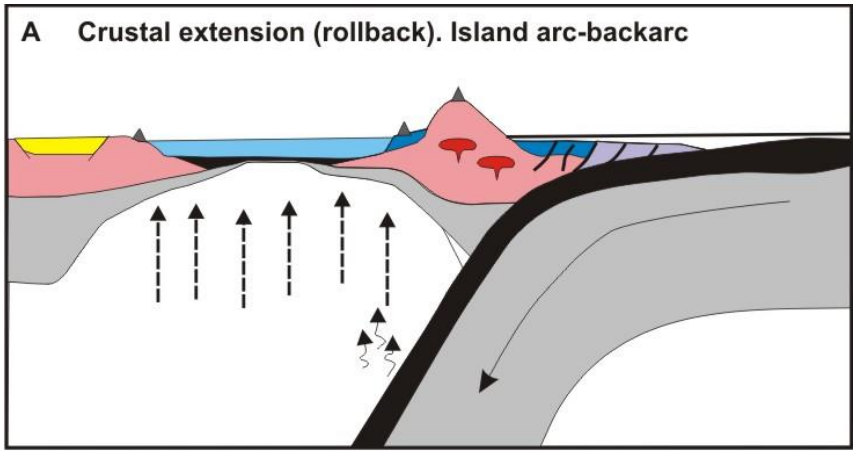
OR: It's all Tassie's fault!

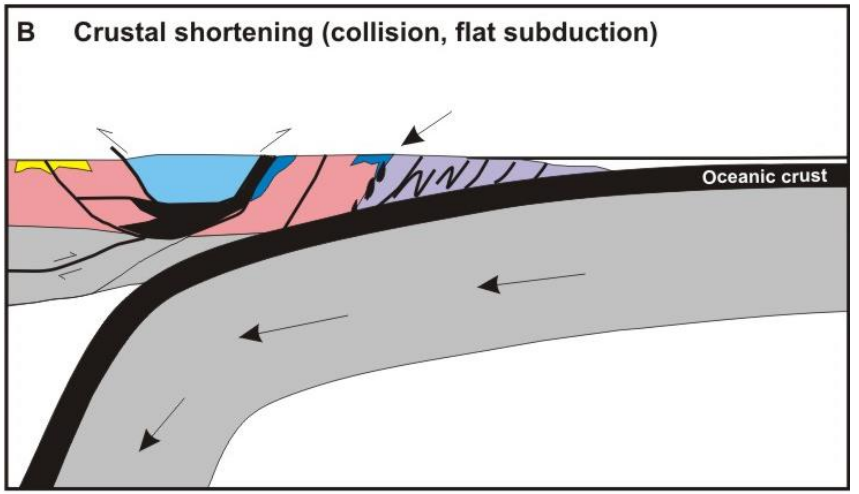
David L Huston, Ross Cayley and David C Champion

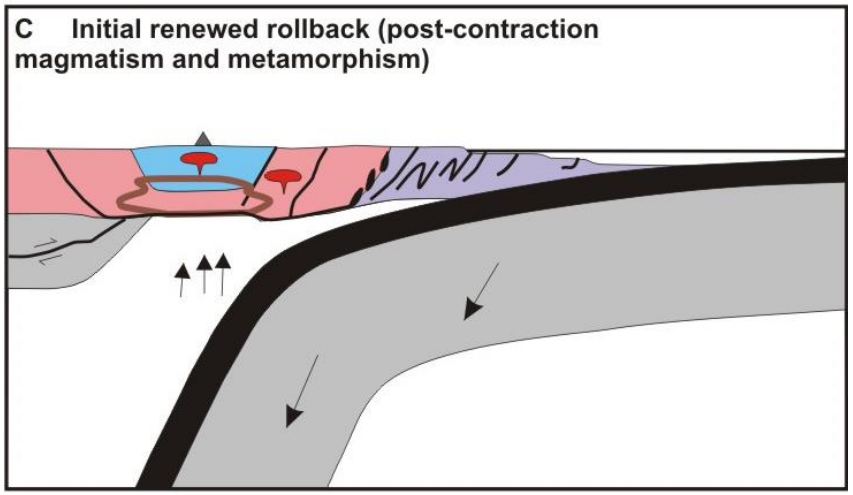


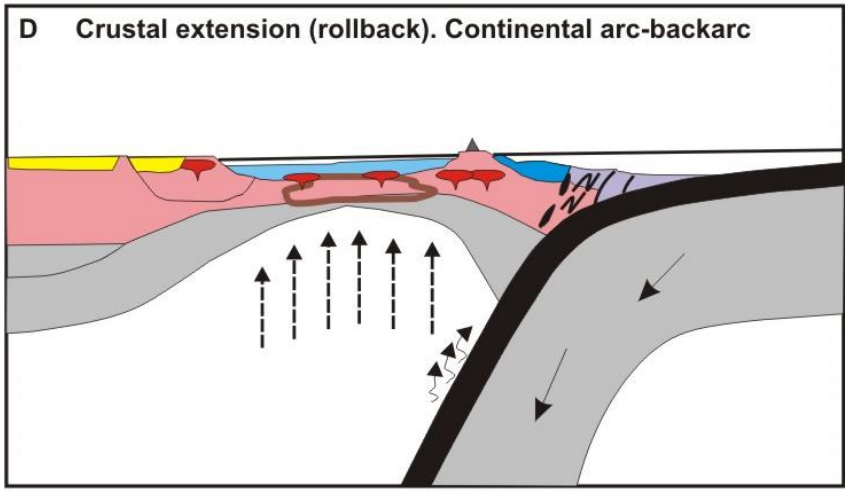
WHY this talk

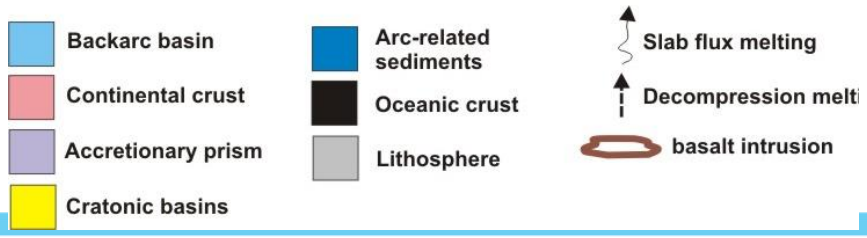
- Development of Cayley-Musgrave orocline model
- Modelling by Moresi et al. (2014)
- GA's continued interest in Tasmanides
  - Update of Phanerozoic synthesis (in review)
  - GA's regional drilling programs (Stavely and southern Thomson)
- Concept of "tectono-metallogenic" systems











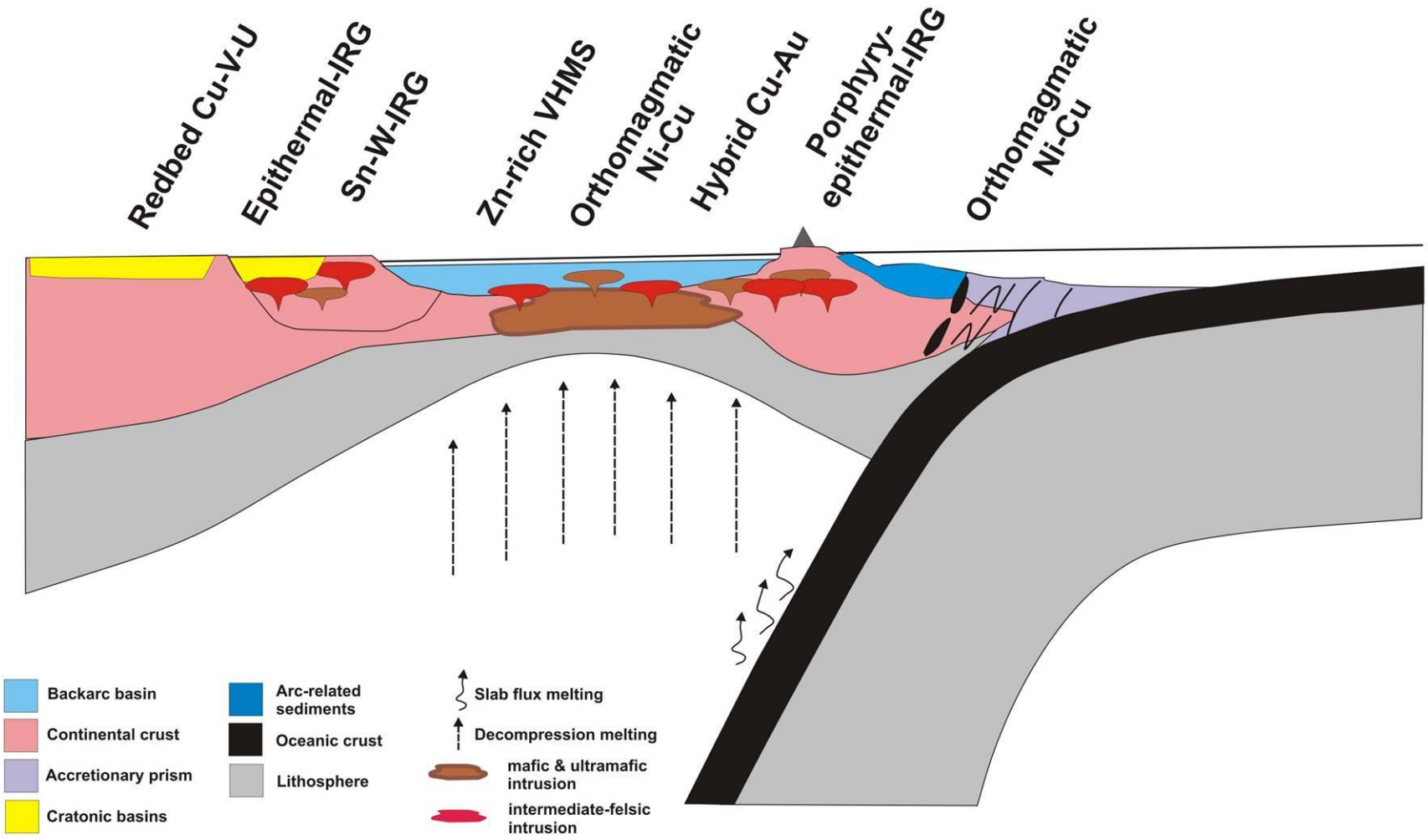
Tectonic synthesis – Cycles

(e.g., Collins and Richards, 2008)

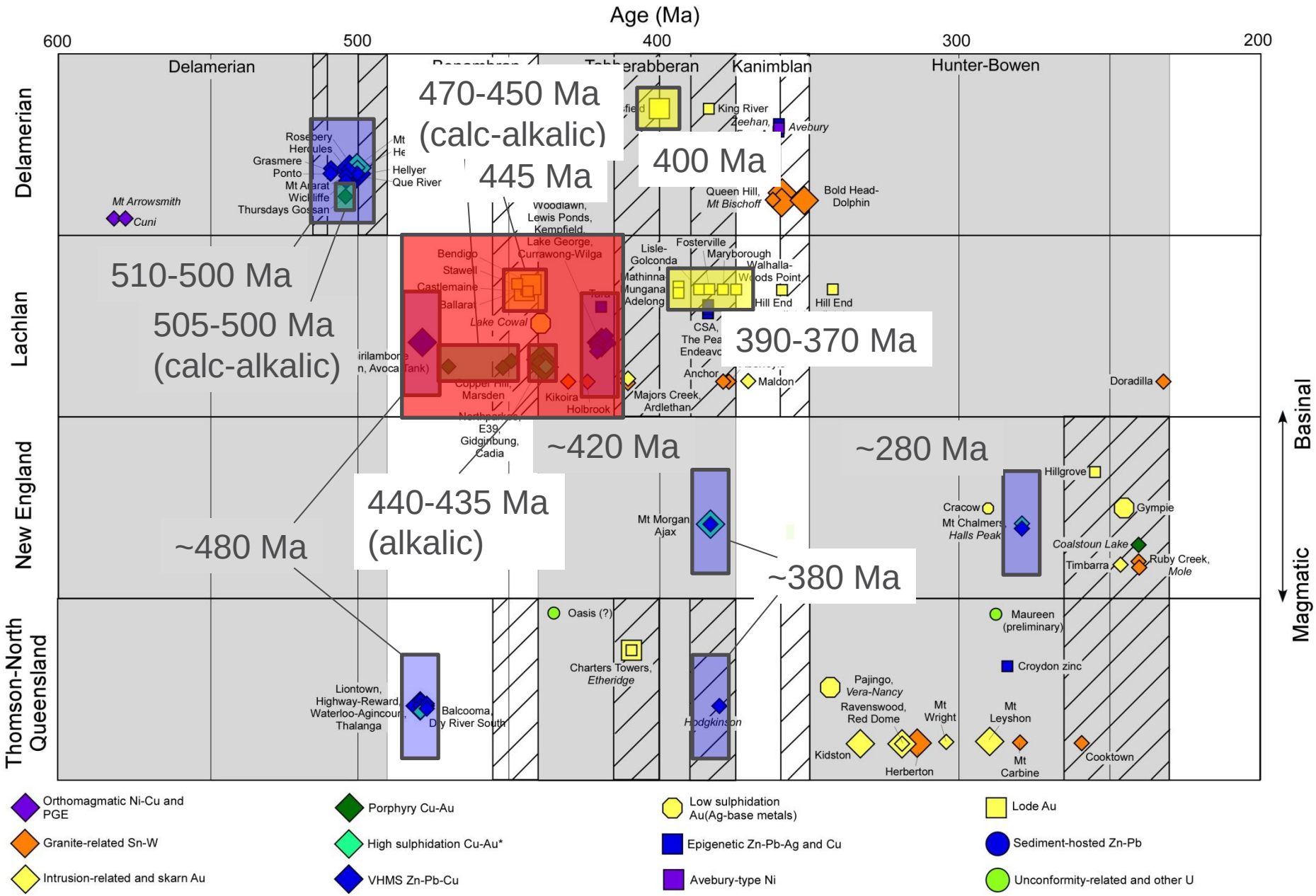
Tectonic cycles of the Lachlan Orogen
(following Glen, 2005; Gray and Foster, 2004)

Cycle	Age (Ma)
Delamerian	600-490
Benambran	490-430
Tabberabberan (includes Bindian)	430-380
Kanimblan	380-350
Hunter-Bowen	350-230

Spatial relationship of deposits in convergent margin

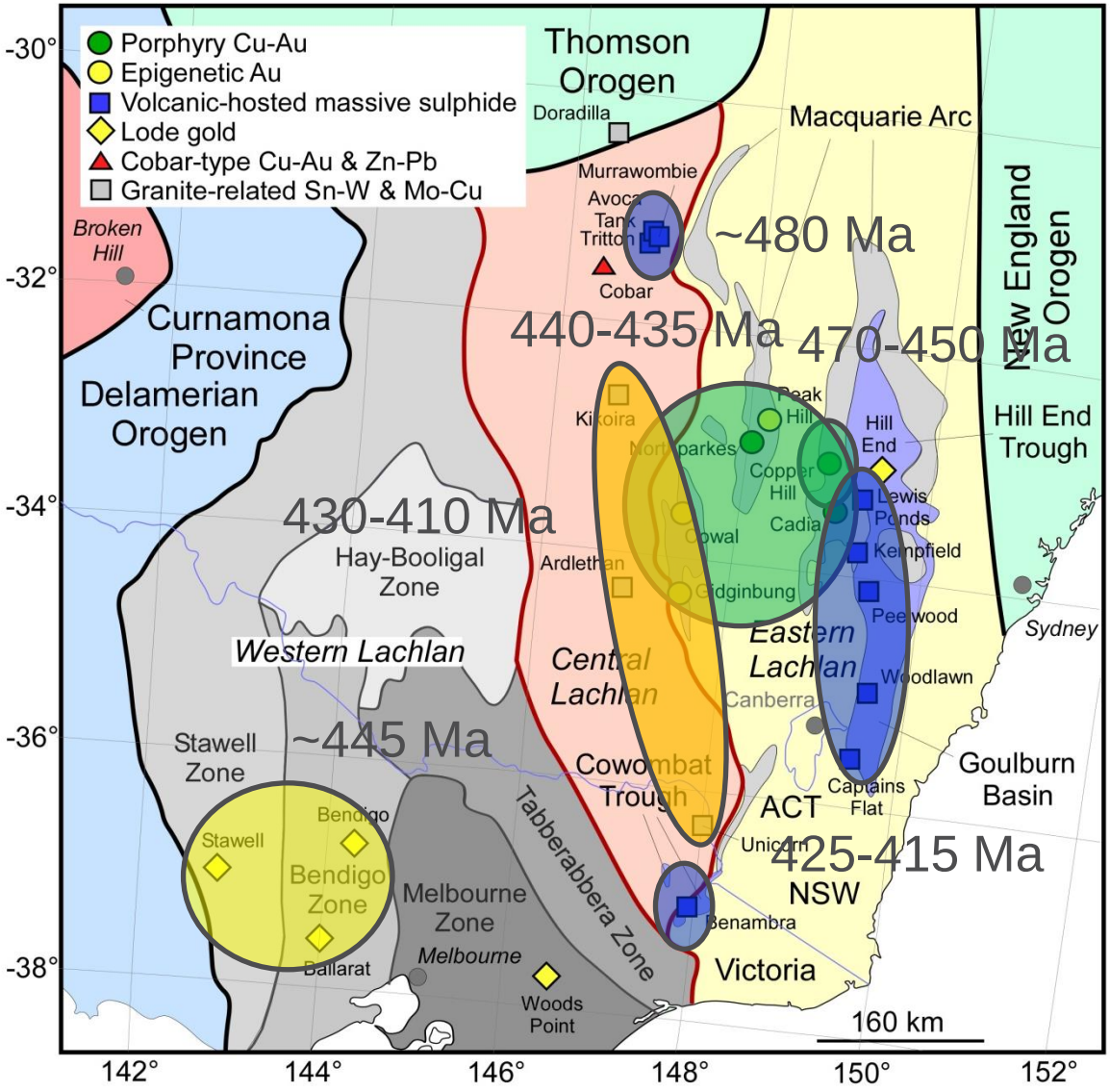


Base after Collins and Richards (2008)



*Includes high sulphidation epithermal and VHMS deposits. Size of symbol indicates relative size of deposit. Normal text indicates well constrained ages; itallics indicate ages inferred from geological framework. Hatching indicates spatial and temporal distribution of major contractional deformation events.

Mineral deposits of the Lachlan Orogen

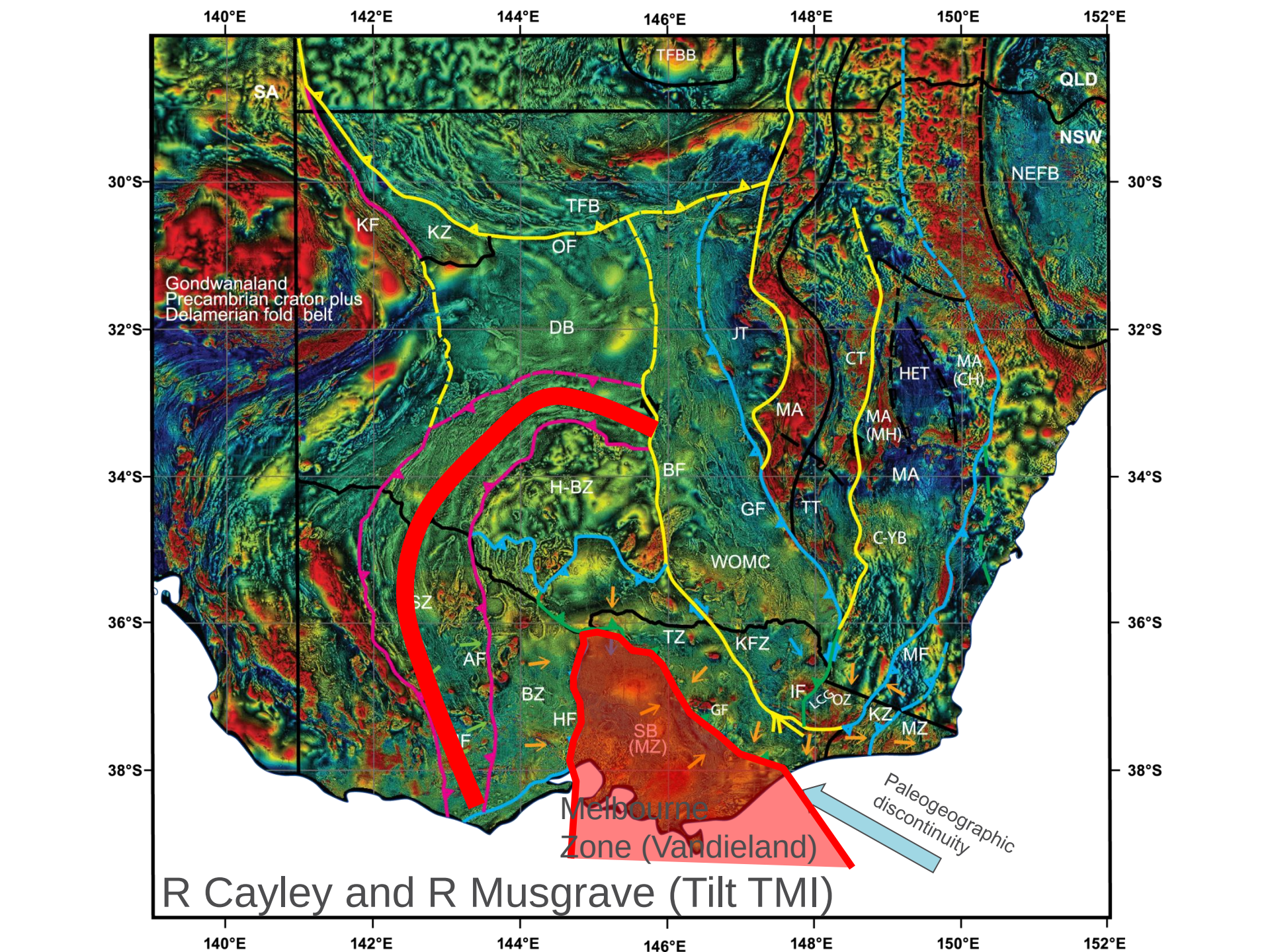


Why do we care?

	Value ($B)*	Value (%)
Pangea-Gondwana assembly	558	100
Tasman Element	500	90
Southeast Australia (TAS, VIC and NSW)	373	67
480-410 Ma period	261	47

70% of southeast Australia's mineral wealth formed between 480 Ma and 410 Ma

* Value base on production, resources and prices at 31 December 2011


140°E
142°E
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152°E
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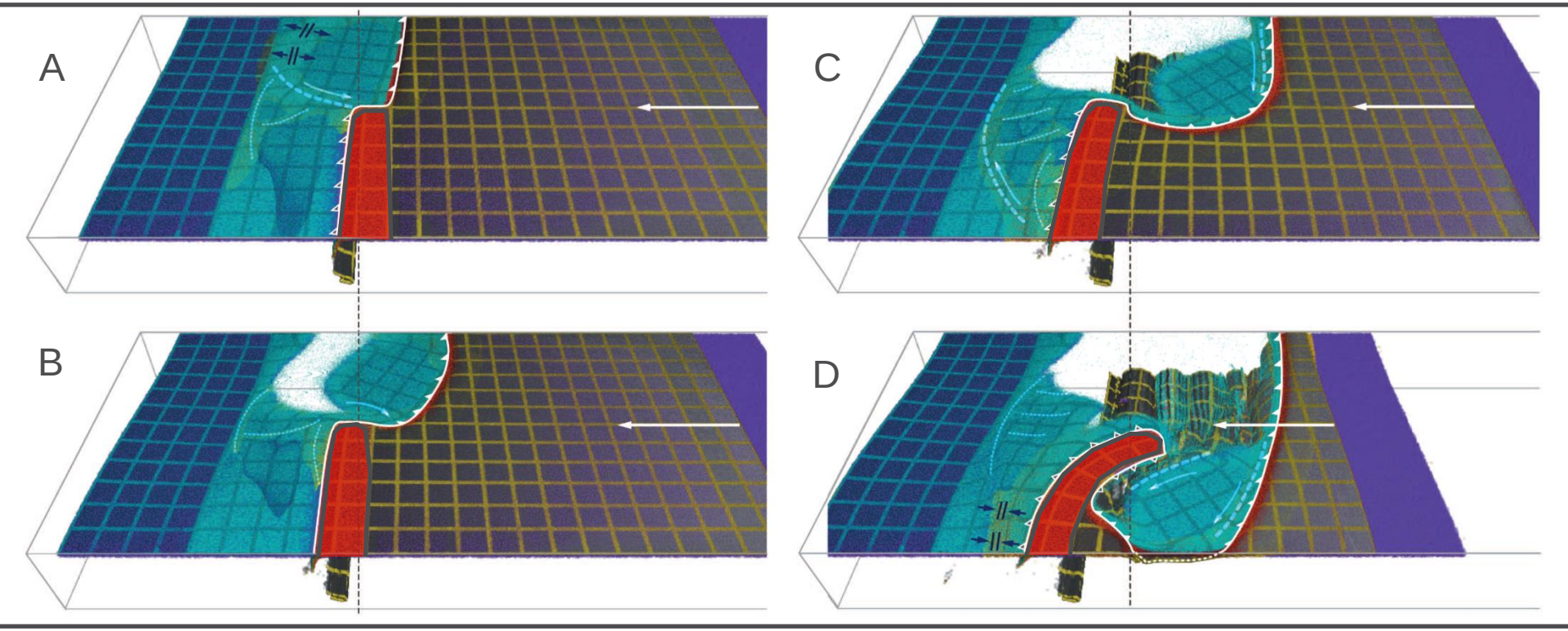
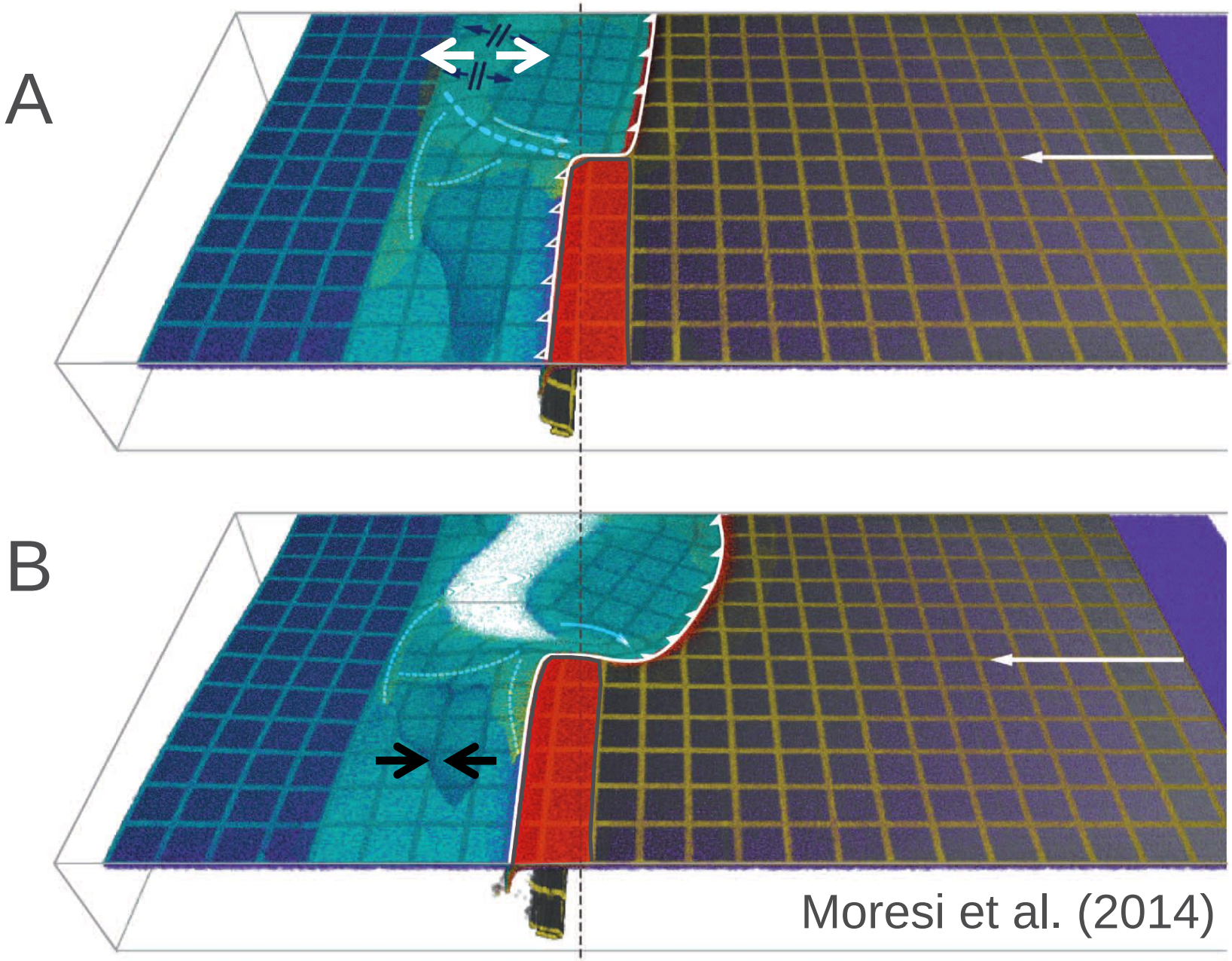
32°S
34°S
36°S
38°S
SA
QLD
NSW
TFBB
NEFB
TFB
KF
KZ
OF
Gondwanaland
Precambrian craton plus
Delamerian fold belt
DB
JT
CT
HET
MA
(CH)
MA
MA
(MH)
BF
H-BZ
GF
TT
C-YB
WOMC
TZ
KFZ
MF
AF
BZ
IF
LCCOZ
KZ
MZ
HF
GF
SB
(MZ)
Melbourne
Zone (Vandieland)
Paleogeographic
discontinuity
R Cayley and R Musgrave (Tilt TMI)

Benambran Cycle - the Lachlan Orocline

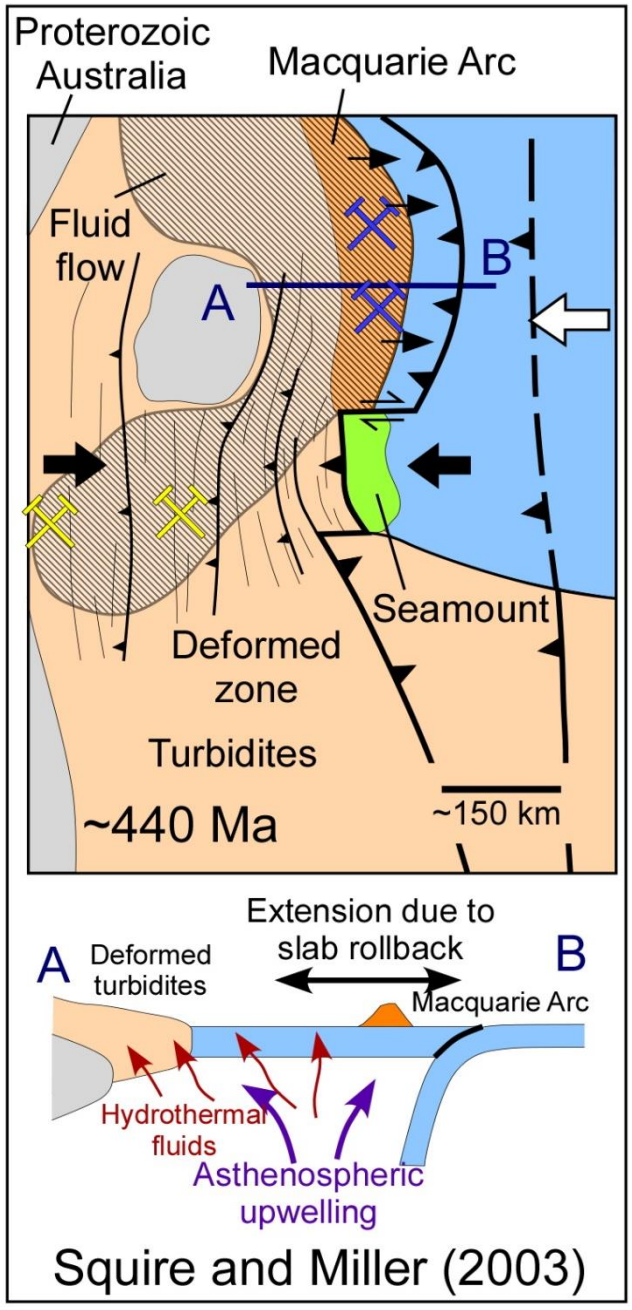
(after original concept by Ross Cayley (GSV) and Robert Musgrave (GSNSW))



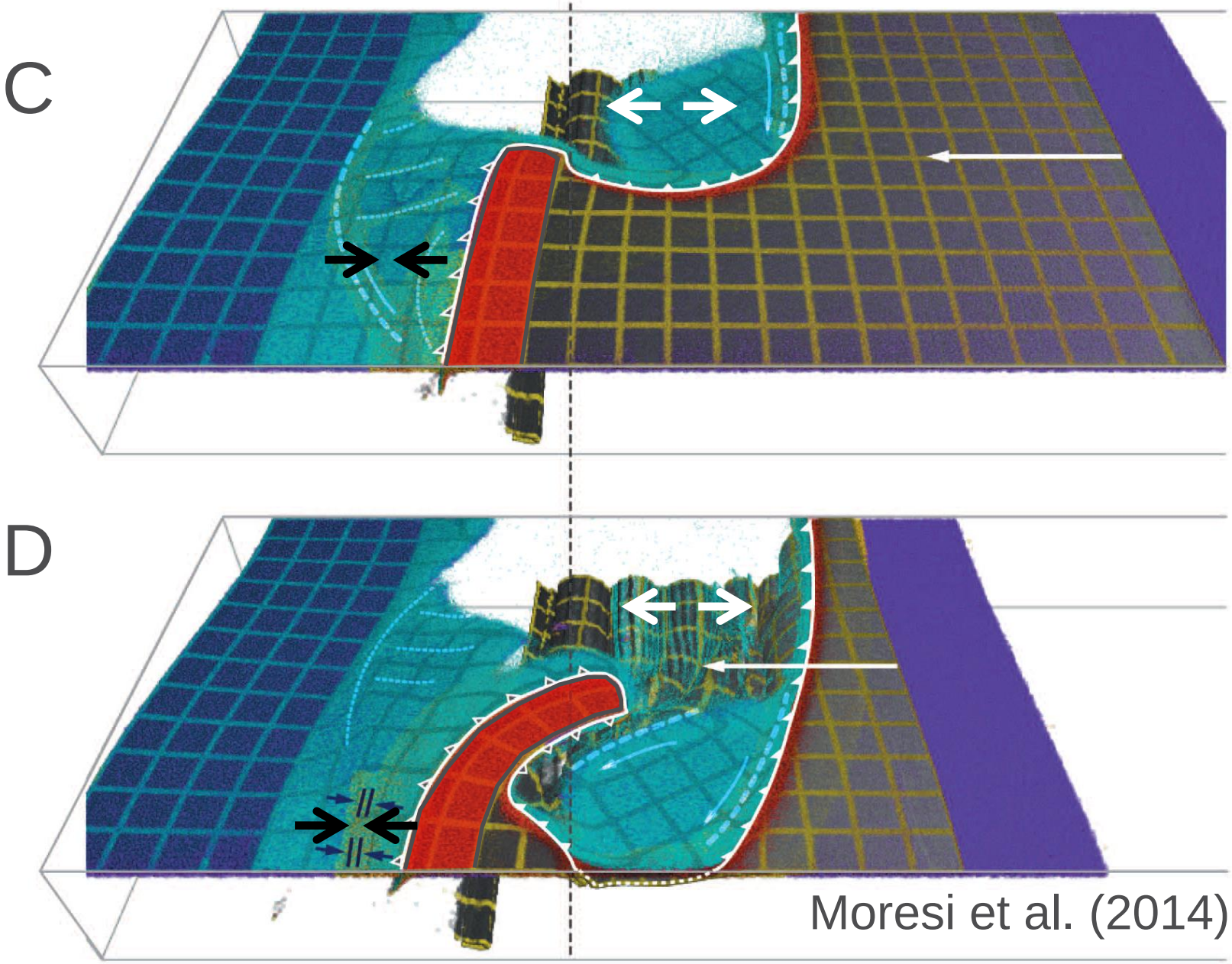
Moresi et al. (2014)



Squire and Miller (2003) – accretion of seamount

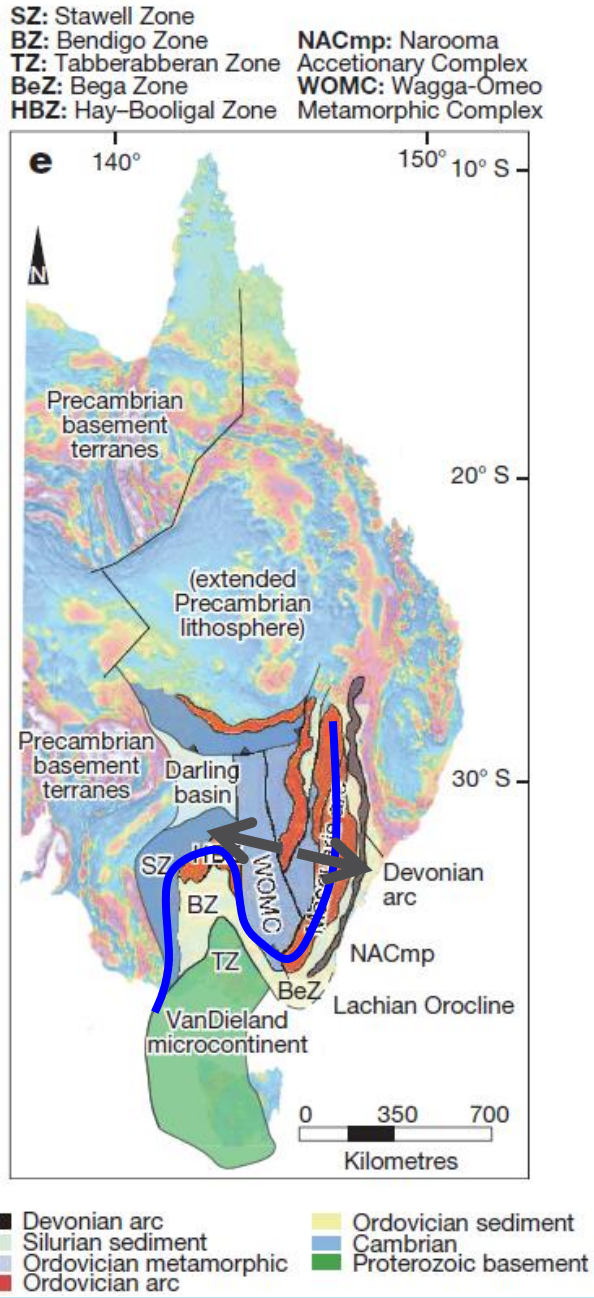


- ~440 Ma (Benambran Orogeny)
- Coeval orogenic gold and porphyry copper deposits
- Orogenic gold in hinterland of impactor
- Porphyry copper in arc system to north

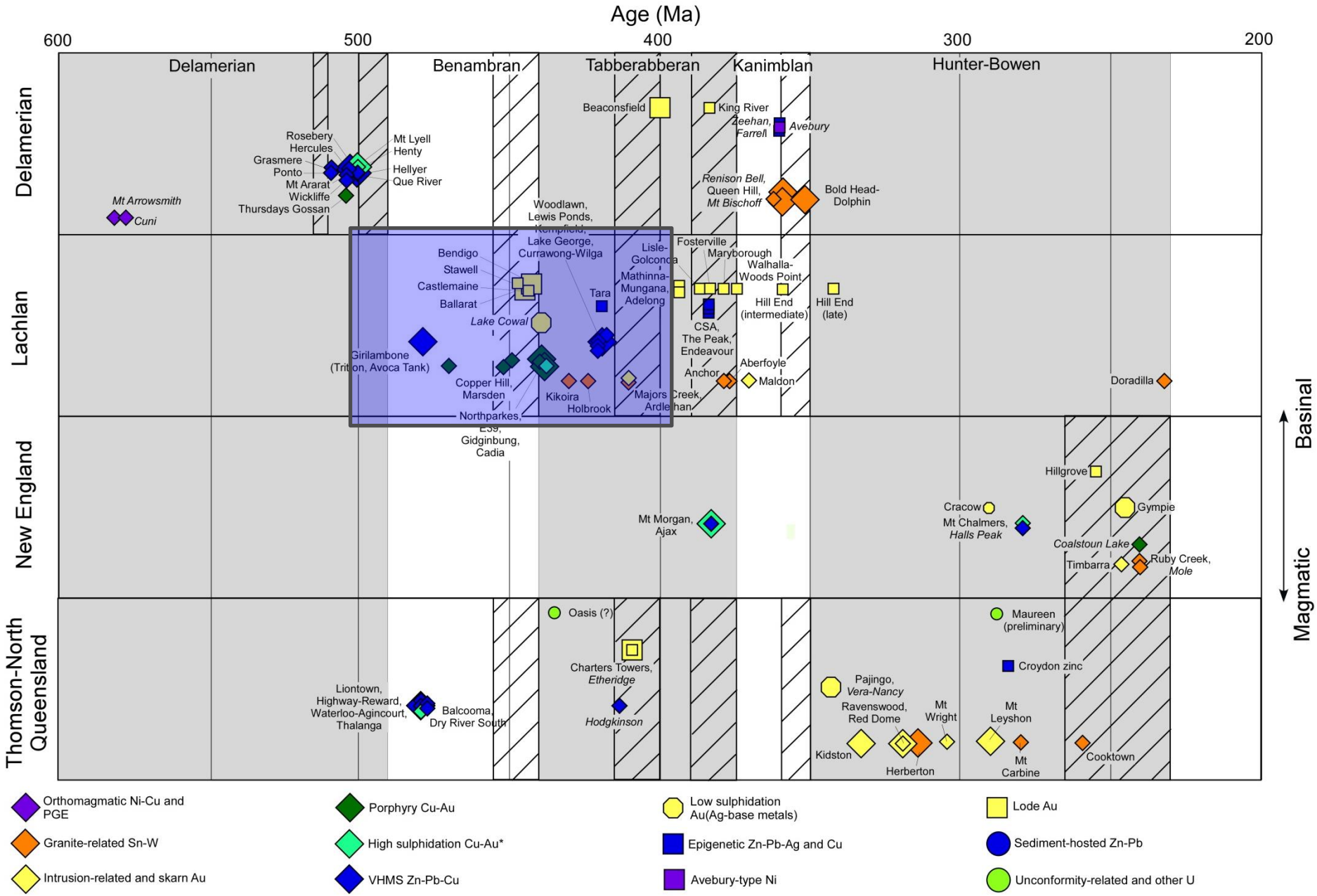


Moresi et al. (2014)

Cayley and Musgrave (2015) – Lachlan Orocline model



- Southeastern Australian geophysics (and geology) wraps around VanDieland
- Accretion of VanDieland at ~445 Ma (Benambran Orogeny)
- Extension in eastern NSW at 440-410 Ma



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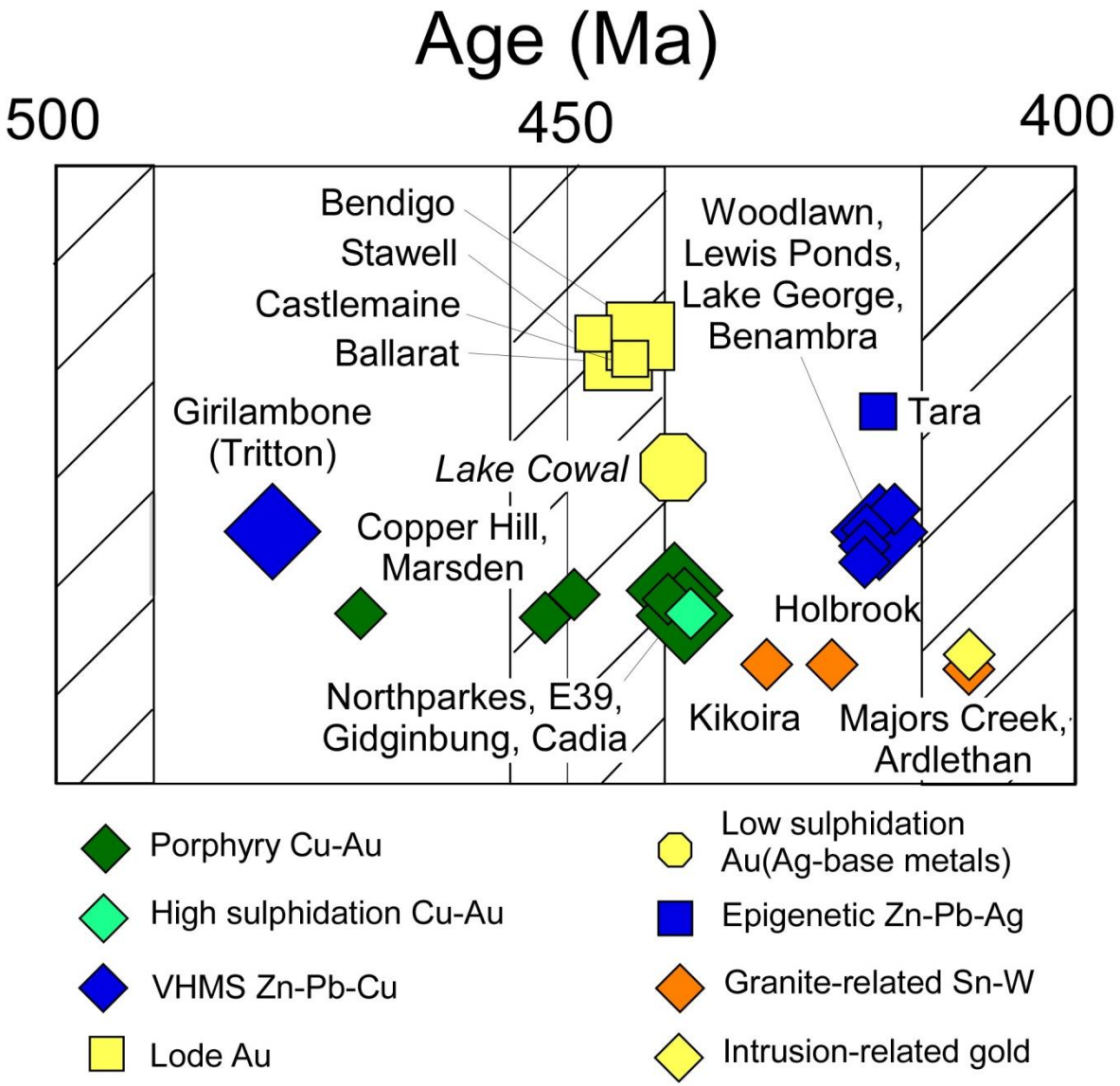
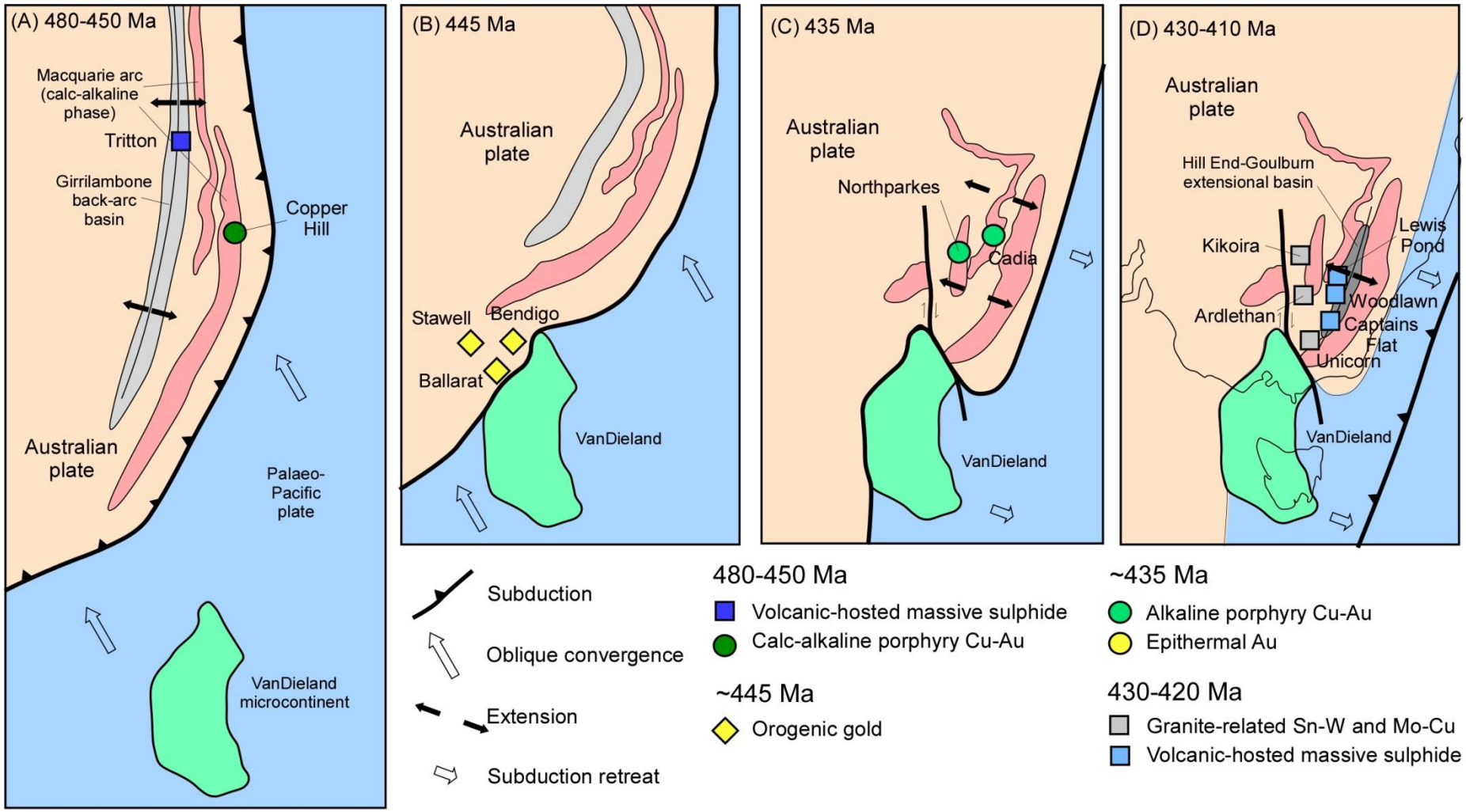
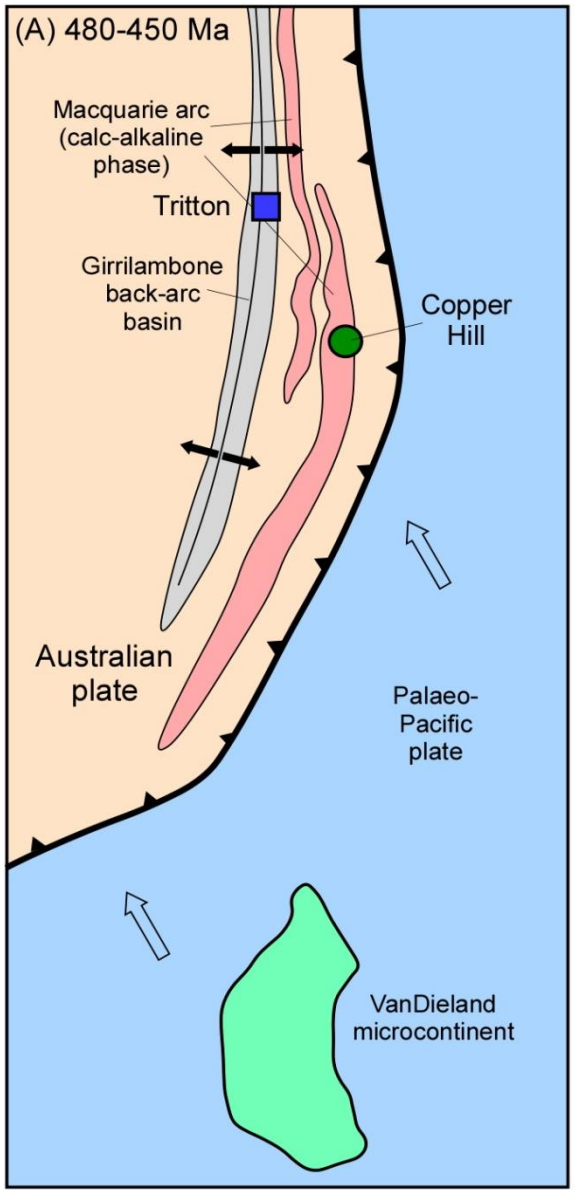
Mineralising events – Lachlan Orocline



Metallogenic evolution of the Lachlan Orocline



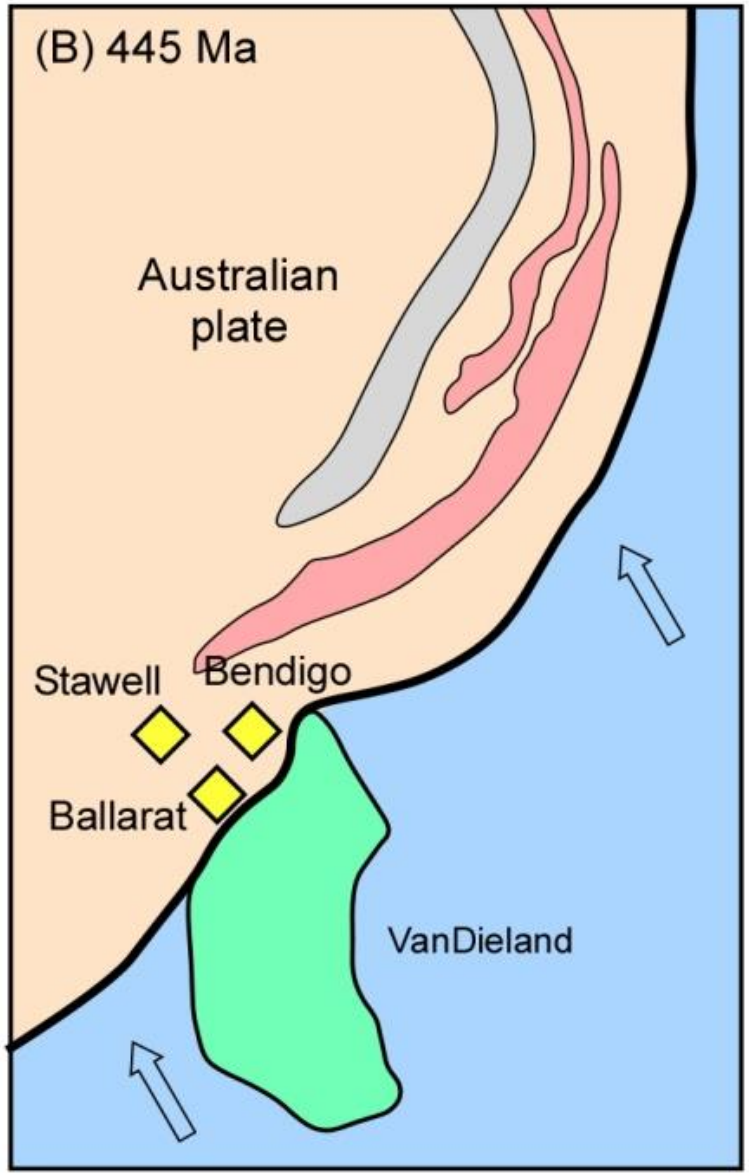
Evolution of the Lachlan Orocline – Stage 1



- 480-450 Ma: NW-directed subduction; formation of arc and back-arc basin
- Calc-alkaline magmatism and associated porphyry copper-gold in Macquarie Arc (Marston and Copper Hill)
- Tholeiitic magmatism in back-arc and associated pelitic-mafic (Besshi-type) VHMS deposits (Tritton)

BUSINESS AS USUAL
(no perturbations, smallish deposits)

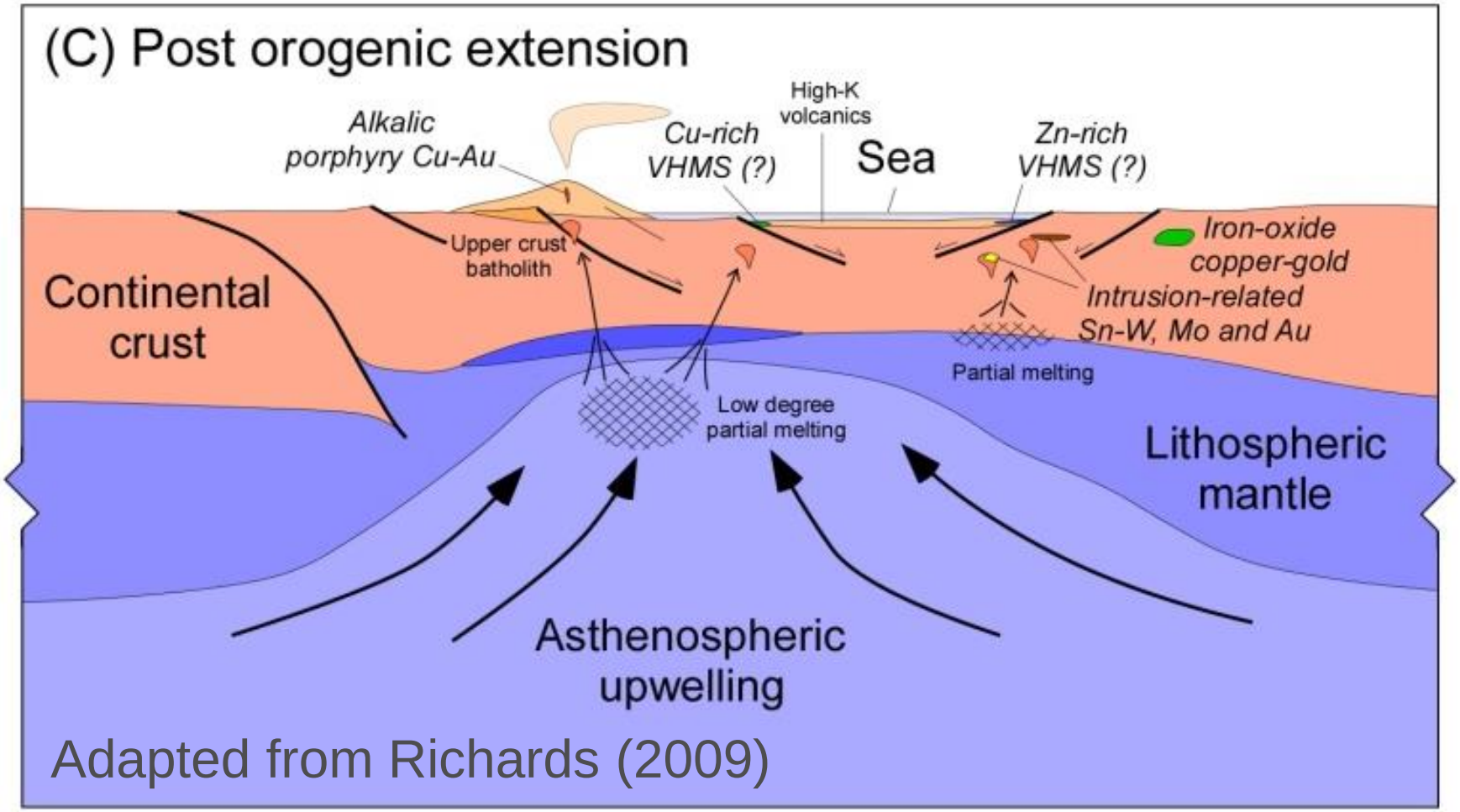
Evolution of the Lachlan Orocline – Stage 2



- ~445 Ma: Accretion of VanDieland; Benambran Orogeny
- Orogenic gold in hinterland (most of Victorian goldfields)
- No mineralisation outside of western Victoria

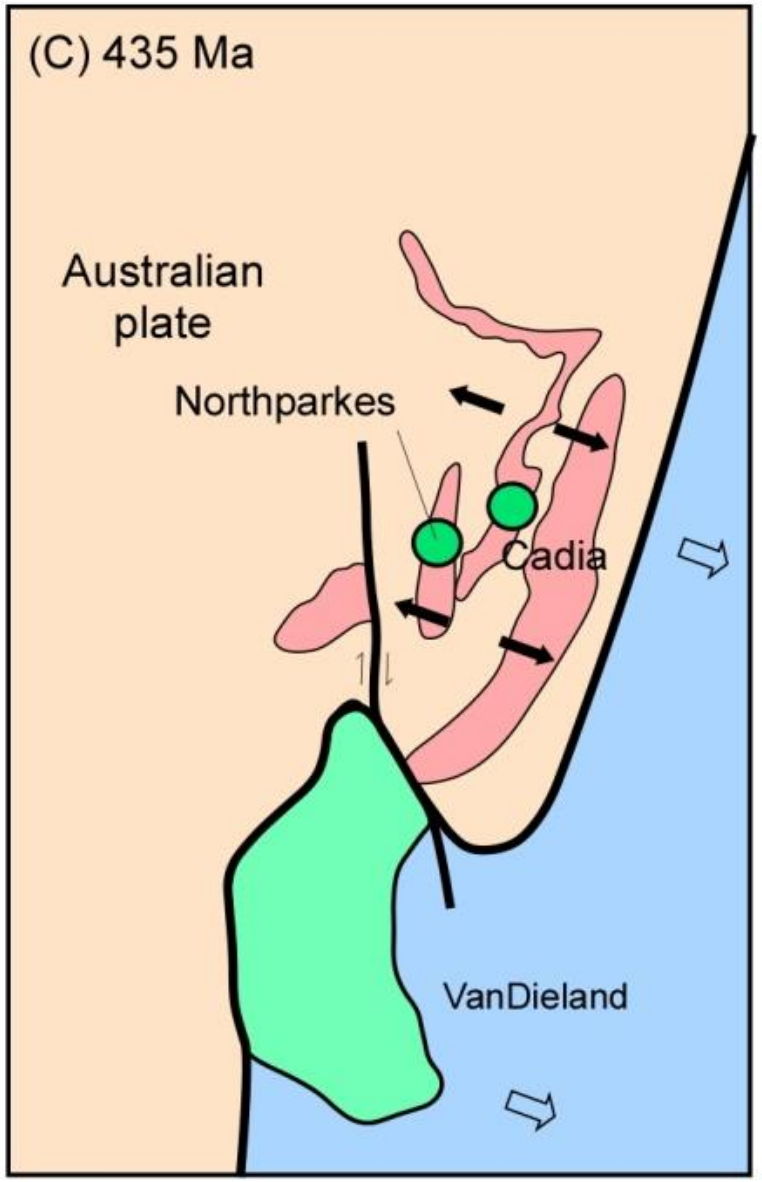
ACCRETION
(big perturbation, big deposits)

Mineralisation associated with post-orogenic extension



Adapted from Richards (2009)

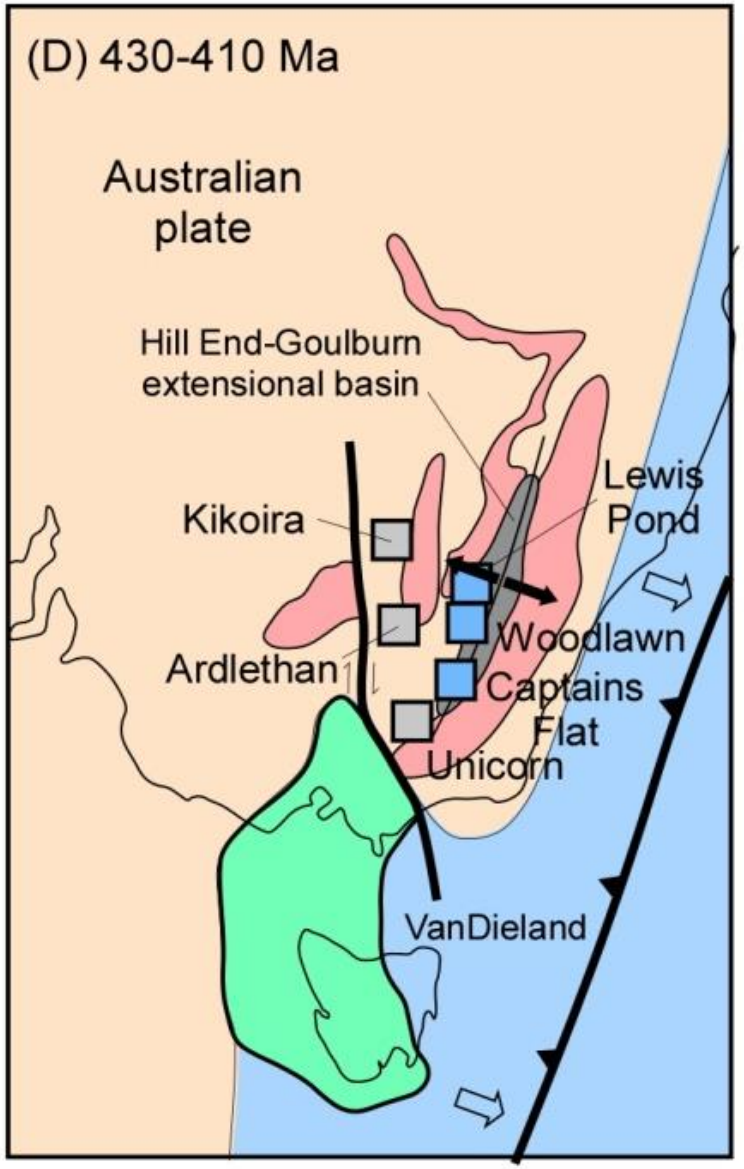
Evolution of the Lachlan Orocline – Stage 3



- ~435 Ma: (Post-orogenic) extension in eastern NSW
- Alkaline magmatism and associated porphyry copper-gold deposits in Macquarie "arc"
- No mineralisation SW of Baragwanath transfer zone

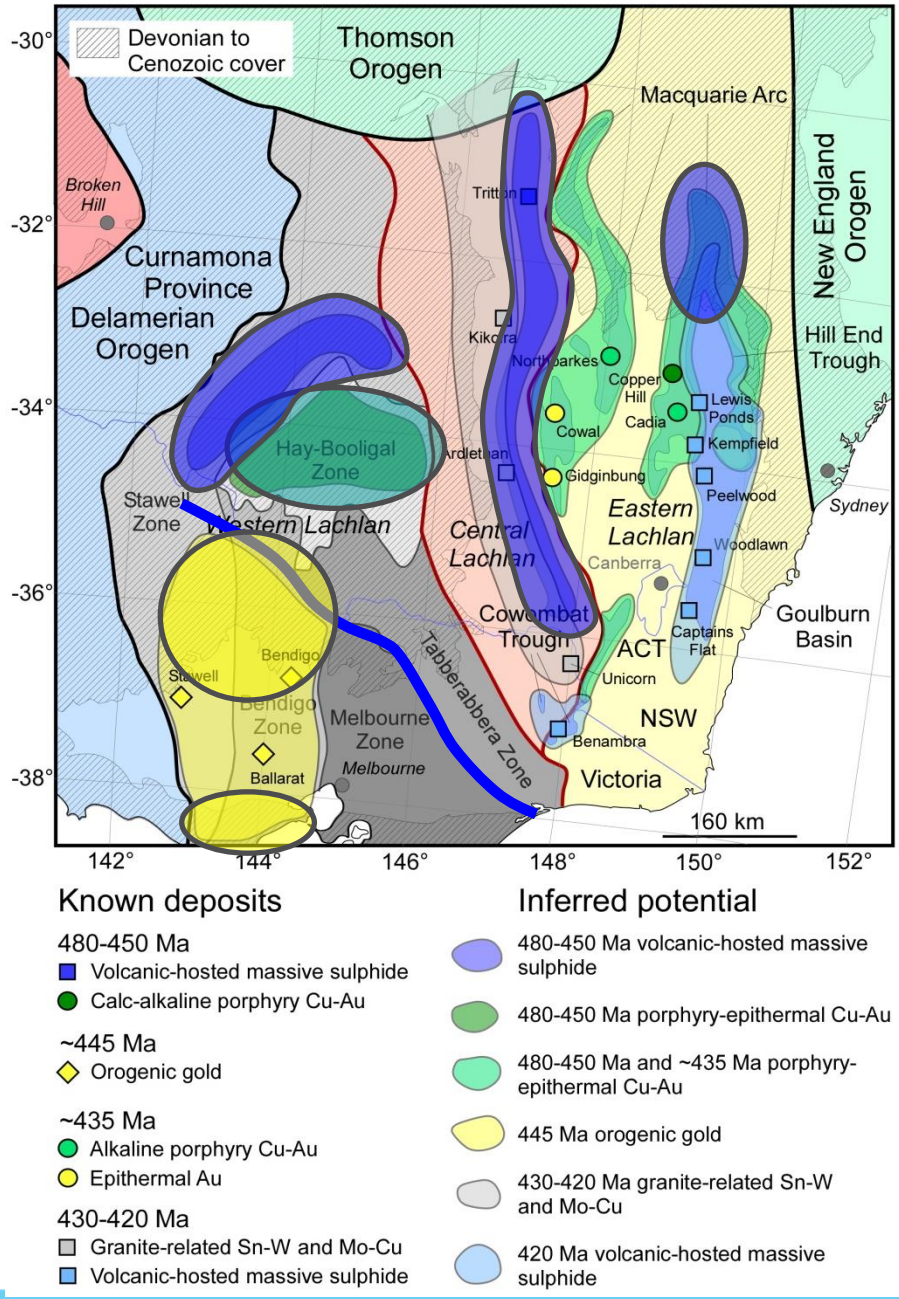
OROCLINE
(big perturbation, big deposits)

Evolution of the Lachlan Orocline – Stage 4



- 430-410 Ma: Continued extension in eastern NSW
- Re-establishment of west-directed subduction
- VHMS mineralisation in extensional basins (Goulburn, Hill End and Cowombat troughs: 420 Ma; northward younging?)
- Granite-related Sn, Mo and Au mineralisation (430-410 Ma)
- No mineralisation SW of Baragwanath transfer zone

Mineral potential?



- Lachlan Orocline model explains metallogeny of Lachlan Orogen well
- Boundary between Melbourne and Tabberabbera zone is a fundamental metallogenic boundary
- ~445 Ma orogenic gold potential extends undercover to north and south of Victorian goldfields
- 480-450 Ma calc-alkaline porphyry copper-gold potential in undercover Hay-Booligal Zone
- ~480 Ma VHMS potential along eastern margin of Central Lachlan and north of Hay-Booligal Zone
- Undercover ~420 Ma VHMS potential north of Hill End Trough?

Conclusions

- Mineralisation in eastern Australia is linked to tectonic cycles that developed episodically during the evolution of the Tasman Element
- The style of mineralisation is related to both spatial and temporal location within tectonic cycles
- Accretion of VanDieland (western 2/3^{rds} of Tasmania + Melbourne Zone) triggered development of Lachlan Orocline
- Much mineralisation in southeast Australia can be linked to the evolution of the Lachlan Orocline, particularly the world-class Victorian goldfields and Macquarie Cu-Au province
- Big deposits are linked to big tectonic disturbances

Where to next?

Testing the orocline model

- Prediction: eastern Tasmania is a wrap-around from the Lachlan;
  Tests: lead isotope characteristics, lithological comparisons
- Prediction: extensions of 480-450 Ma arc-backarc system along eastern margin of Central Lachlan;
  Tests: drilling Hay-Booligal Zone, igneous geochemistry and geochronology

Better understanding of the fourth dimension – time

- Dating different mineral systems using same isotopic system (Re-Os, Ar-Ar): are differences in timing real?
- Spatial-temporal changes in deposit types (temporal changes in Silurian VHMS ages? granite-related ages?)

Relationships with other tectonic elements

- Proterozoic Australia
- Thomson and Delamerian orogens

Take home points

- The Cayley-Musgrave Lachlan Orocline model explains the metallogenesis of southeast Australia well
- Local researchers can provide critical data to further develop this concept
  - Marc Norman (ANU) – Re-Os and cassiterite U-Pb geochronology
  - Sebastien Meffre (UniTas-MacquarieUni-UniMel ARC Linkage) – geochemistry, ore genesis, geochronology, tectonics

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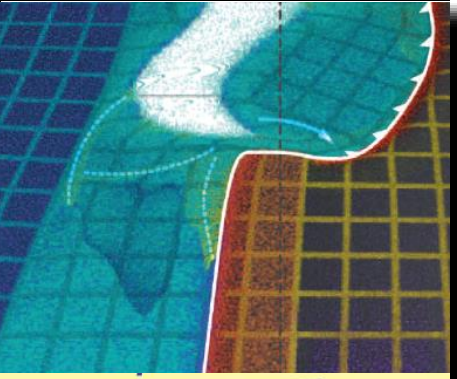

Plate tectonic and ore deposit evolution of SE Australia

An Australian Research Council Linkage proposal 2016-2019

Collaboration between universities, industry and surveys

Aims:

- Address some of the key remaining problems within the Lachlan Orogen geology.
- Apply new geochemical and geophysical tools to evaluate ore deposit genesis and prospectivity.
- Evaluate new tectonic models and their implications for ore deposit distribution.

Multidisciplinary team:

- Expertise in geochemistry, ore deposit geology, geochronology, tectonic reconstruction, geophysics and geo-statistics
  - Sebastien Meffre, David Cooke, Matt Cracknell, Jo Whittaker (UTas)
  - Elena Belousova (Macquarie Univ.) and Roland Mass (Univ. of Melbourne)

CODES ARC CENTRE OF EXCELLENCE IN ORE DEPOSITS

CCFS

THE UNIVERSITY OF MELBOURNE

More details from Sebastien.Meffre@utas.edu.au or David.Cooke@utas.edu.au