PACE
Palaeontology, Ancient Climate and Ecosystems

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Geological Survey of Western Australia

Stratigraphic and geochemical analysis of pre-Cenozoic sediments beneath the Nullarbor Plain: implications for basin and margin evolution

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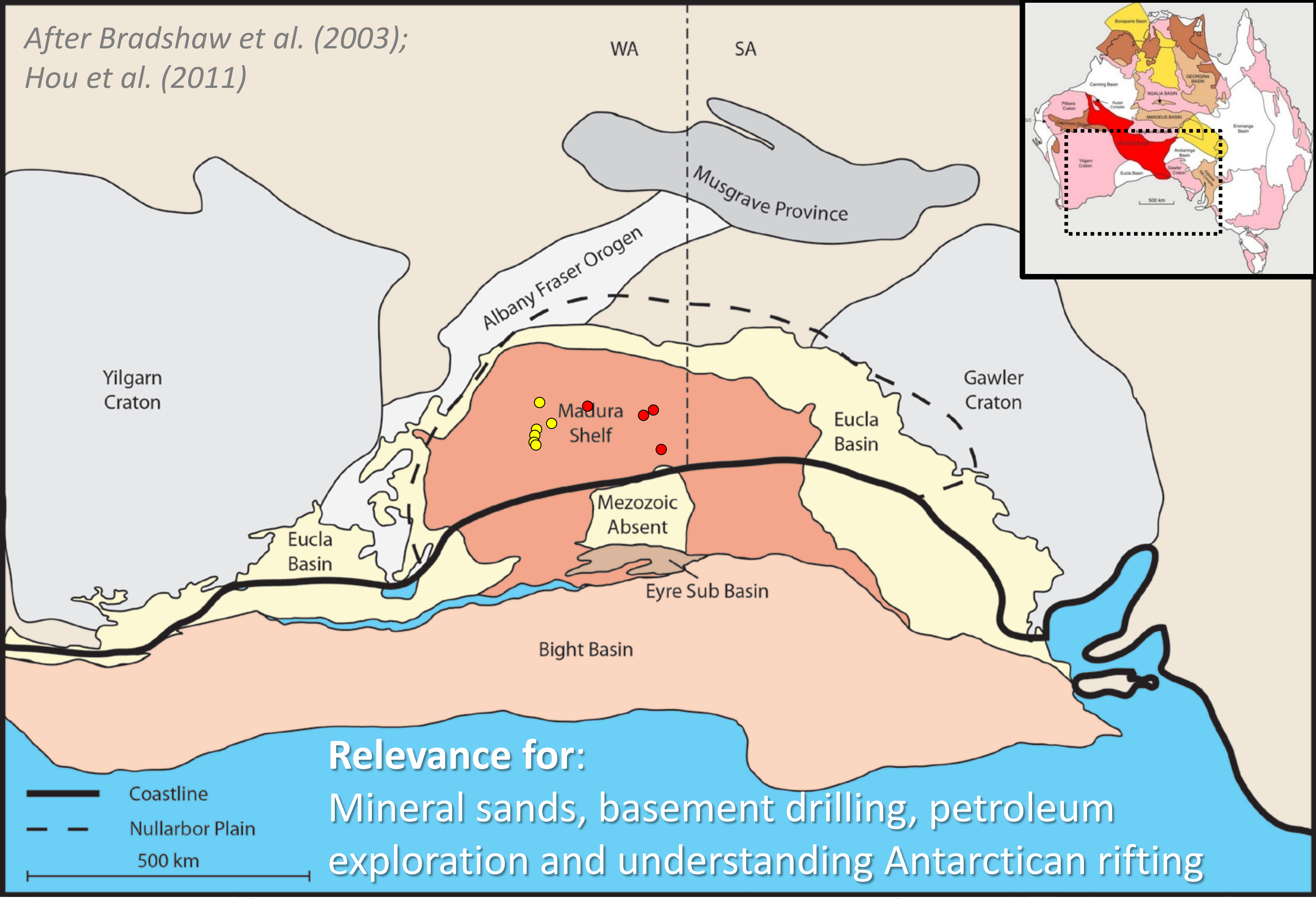
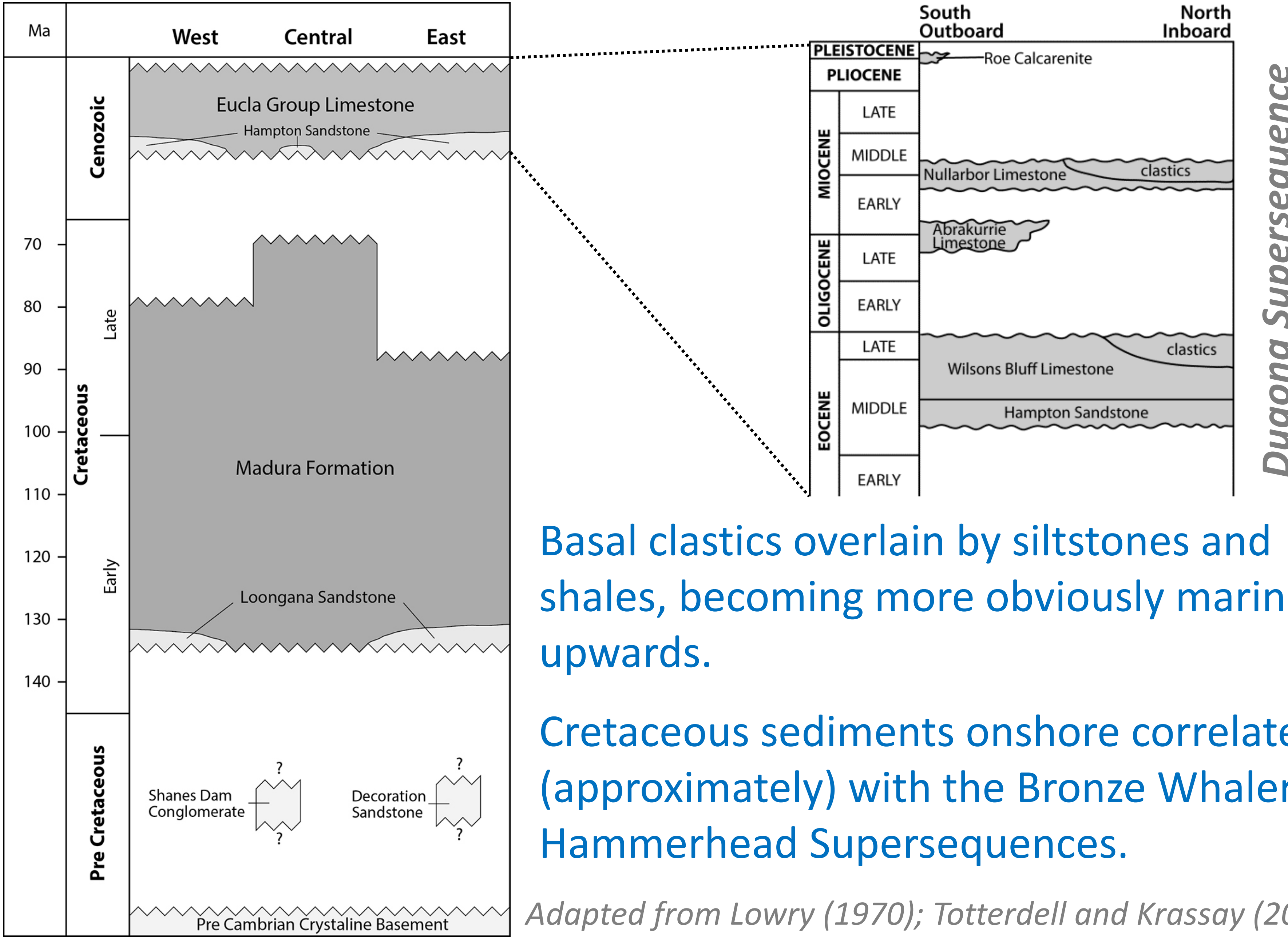


Madura Shelf (thin onshore component of Bight Basin) is flanked by four major basement blocks and disconformably covered by Eucla Basin carbonates.

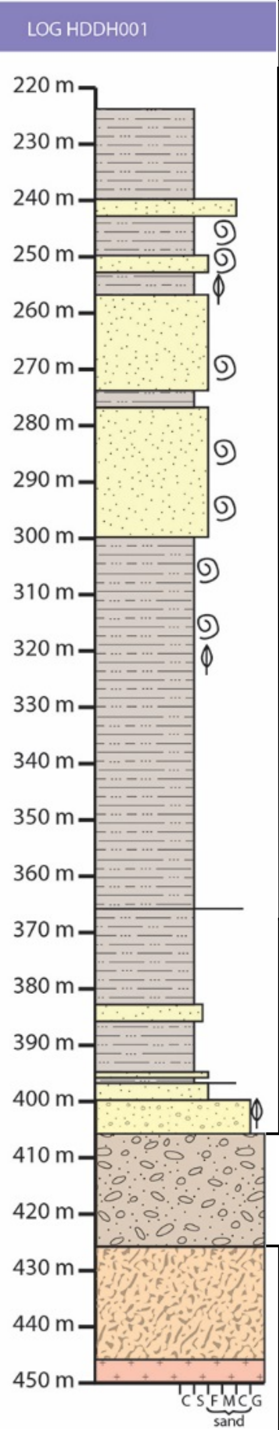
Generalised stratigraphy of region for WA



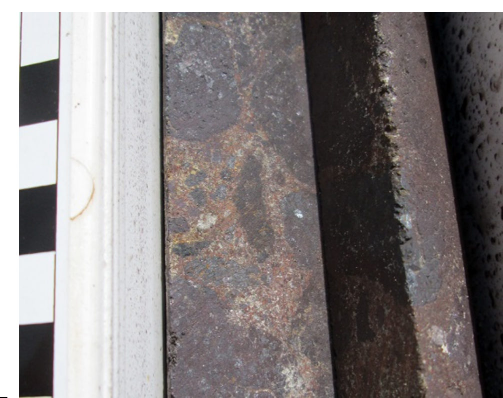
Basal clastics overlain by siltstones and shales, becoming more obviously marine upwards.

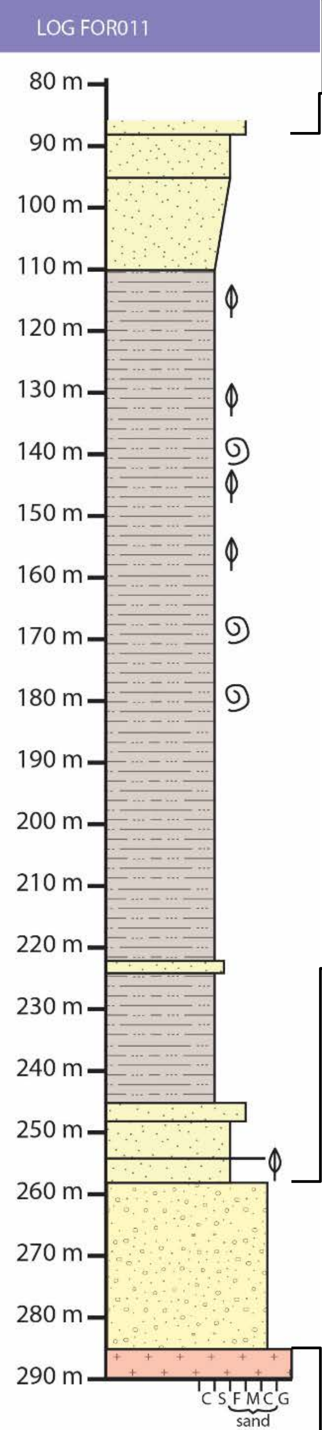
Cretaceous sediments onshore correlate (approximately) with the Bronze Whaler to Hammerhead Supersequences.

Adapted from Lowry (1970); Totterdell and Krassay (2003)



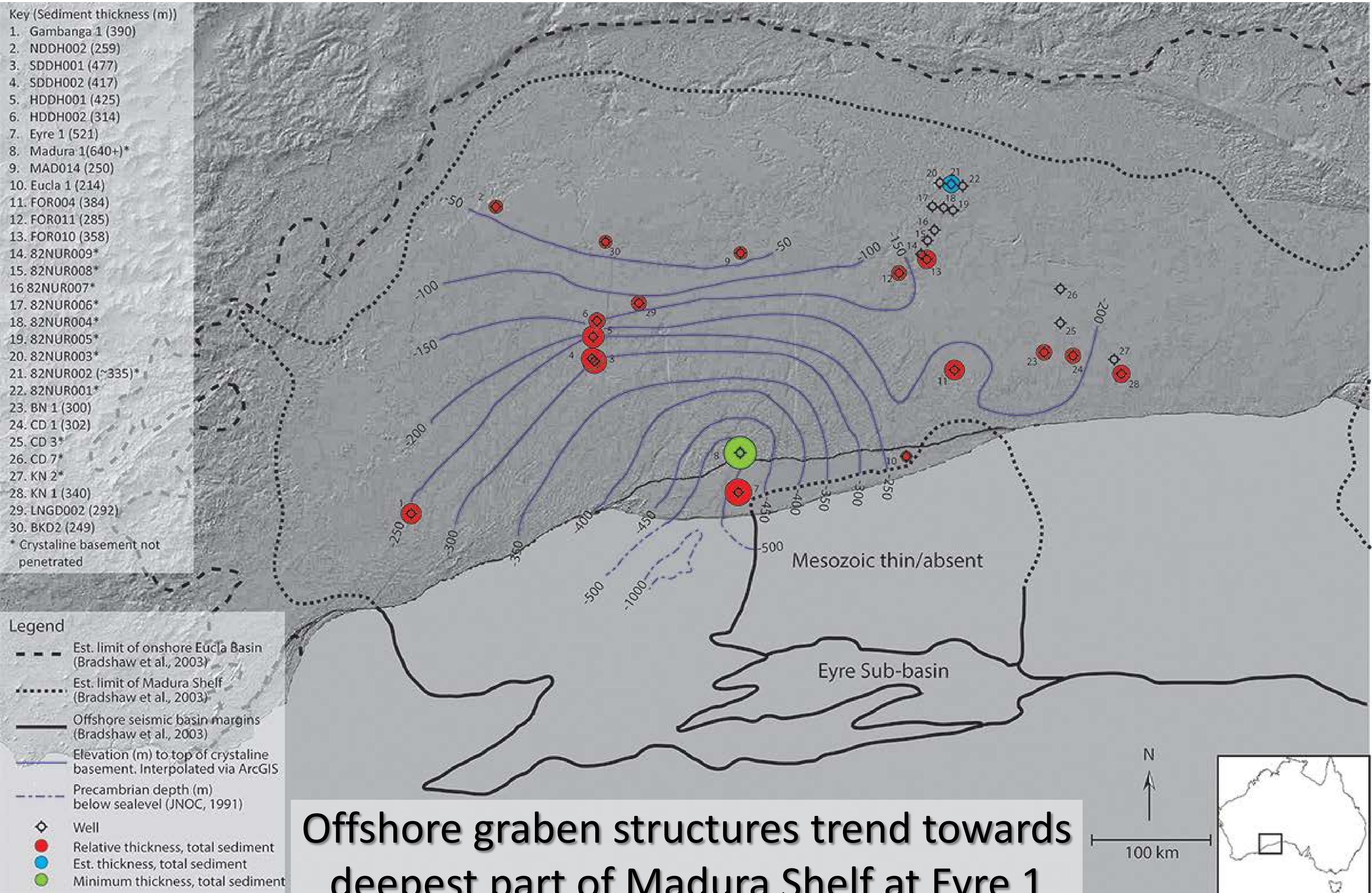
Rock Unit		Sedimentology and biota	GDE
Decoration Sandstone (FOR010 only)	Green/Red Claystone	*Green/Red mst. No macro fossils, barren of palynomorphs.*	Low energy non-marine/ marine?
	Bedded Sandstone	*Interbedded planar, thick fining up and wavy/irregular lam. sst. Qtz-dominated, m-c grained moderately-sorted, well-rounded. Haematite-rich lower half. Conglomeritic base. No macro fossils but bioturbated in parts.*	Aeolian to shallow-marine
Shanes Dam Conglomerate		*Polymict (quartz, sst, mafic and granitic) rounded pebbles-cobbles. Clast-supported, consolidated, variable carbonate cement. Highly magnetic + ferrugenised in places. No macro fossils observed.*	High energy, fluvial/ alluvial





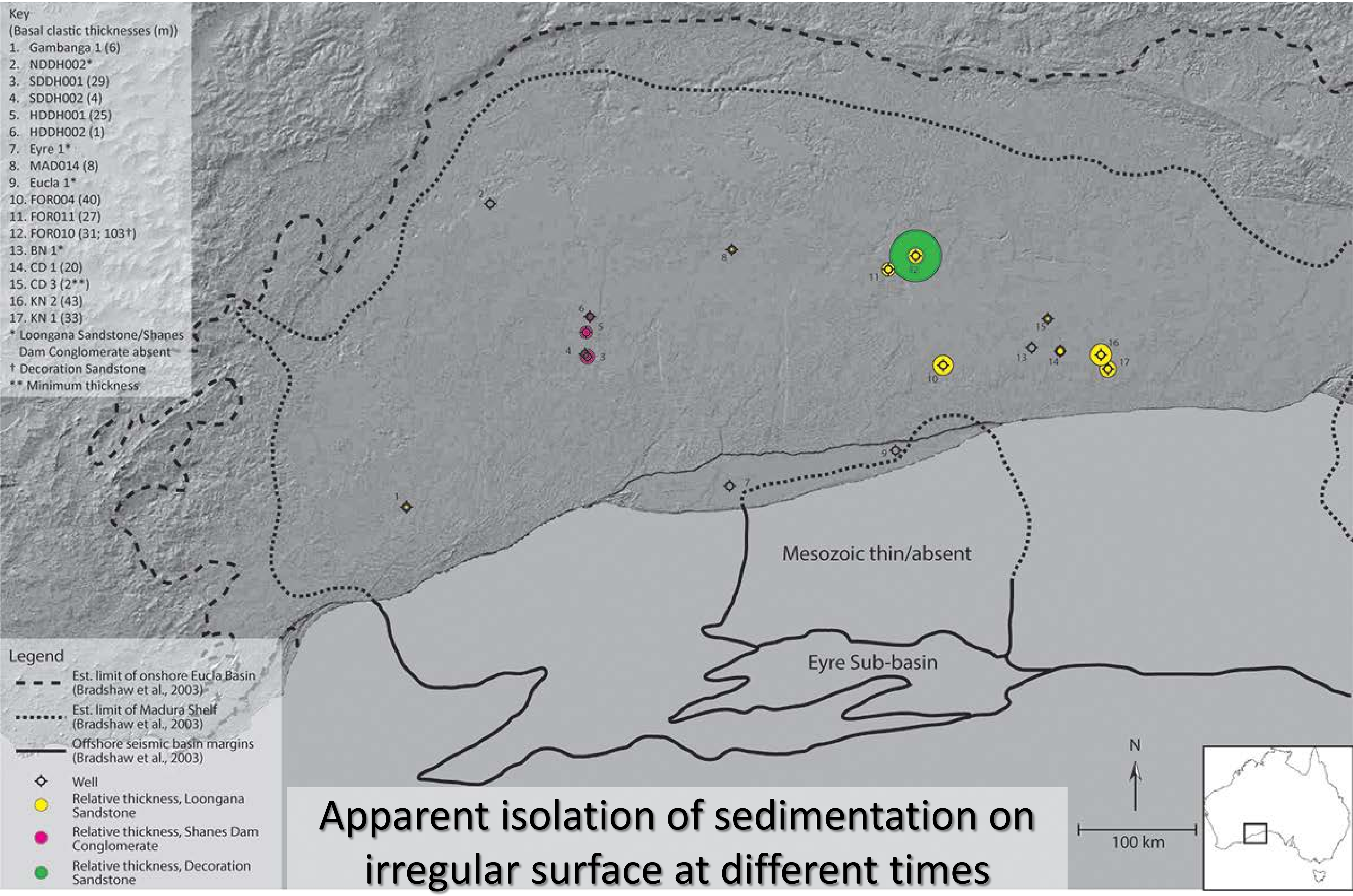
Rock Unit		Sedimentology and biota	GDE
Madura	Marine	*Faint planar lam. slst. and f. sst. Moderately glauconitic. Brachiopods, cephalopods, shelly fossils and charcoal fragments. Abundant dinocysts.*	Low energy, marine
Madura	Non-marine	*Faint planar lam. slst. and f. sst. No macro fossils, irregular horizons of charcoal fragments. Low salinity/fresh water algae.*	Low energy, lacustrine
Loongana Sandstone		*Poorly consolidated qtz-dominated feldspathic m-c sand. Typically angular, poorly sorted. No macro fossils. Low salinity/fresh water algae.*	High energy, fluvial/ lacustrine

Basement elevation and sediment thickness



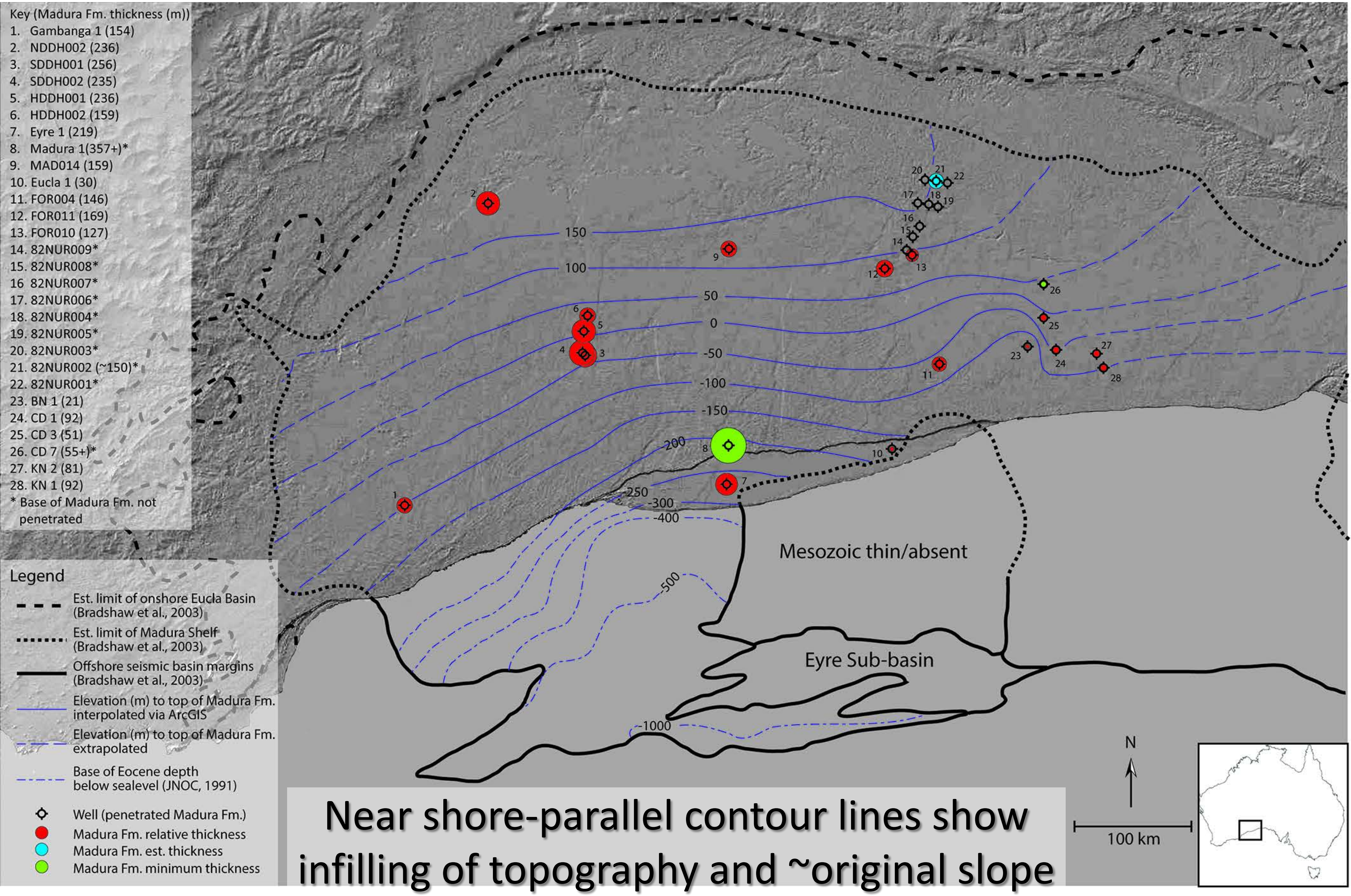
Offshore graben structures trend towards deepest part of Madura Shelf at Eyre 1

Basal clastics – distribution map



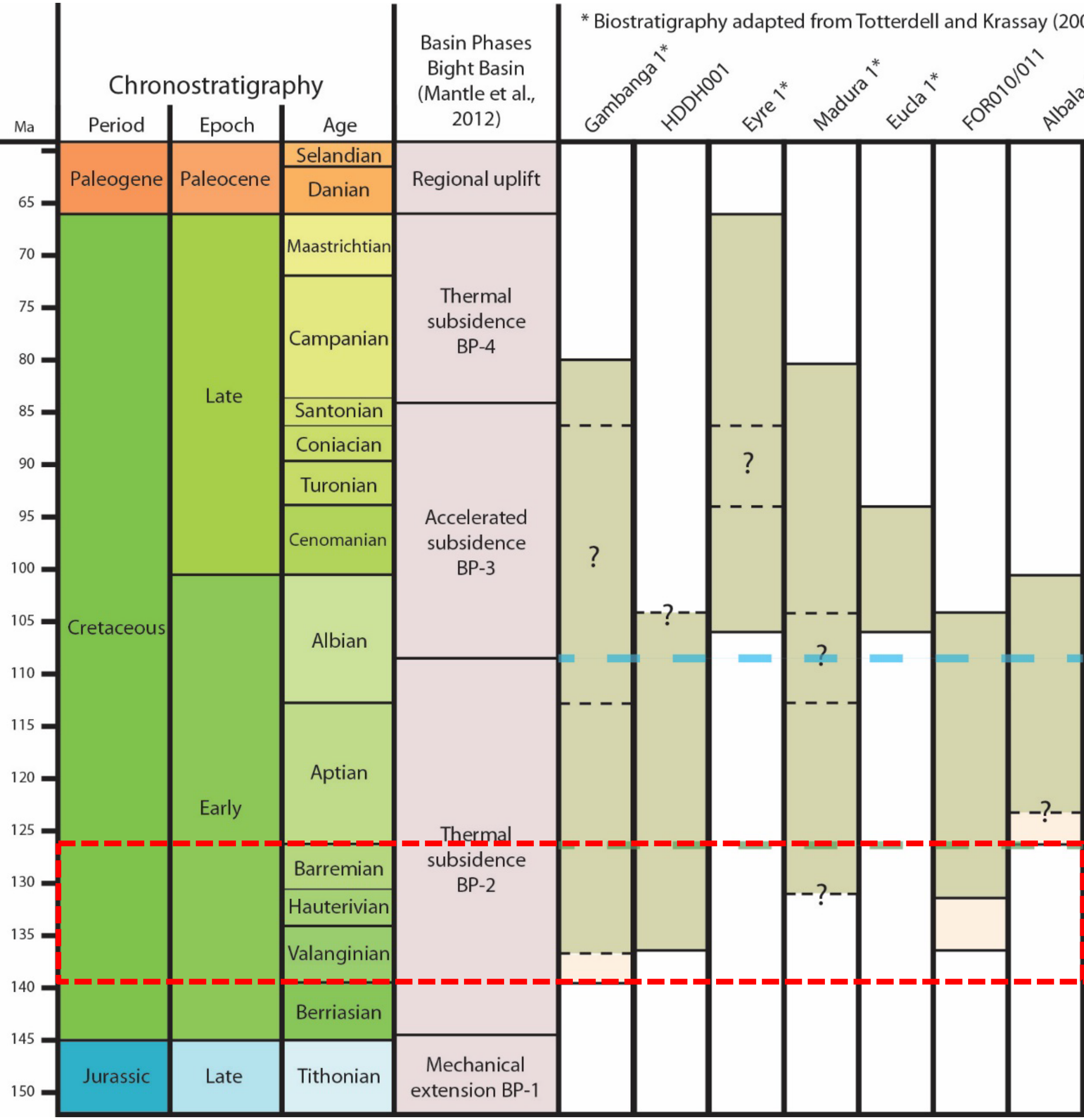
Apparent isolation of sedimentation on irregular surface at different times

Madura Formation development



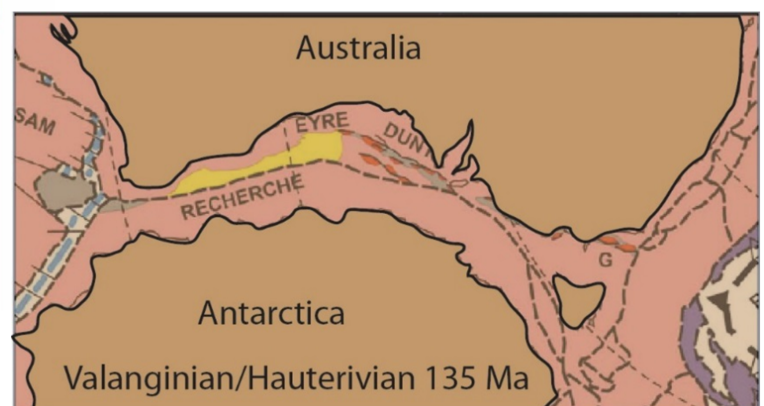
Near shore-parallel contour lines show infilling of topography and ~original slope

Cretaceous of the Madura Shelf – fluvio-lacustrine

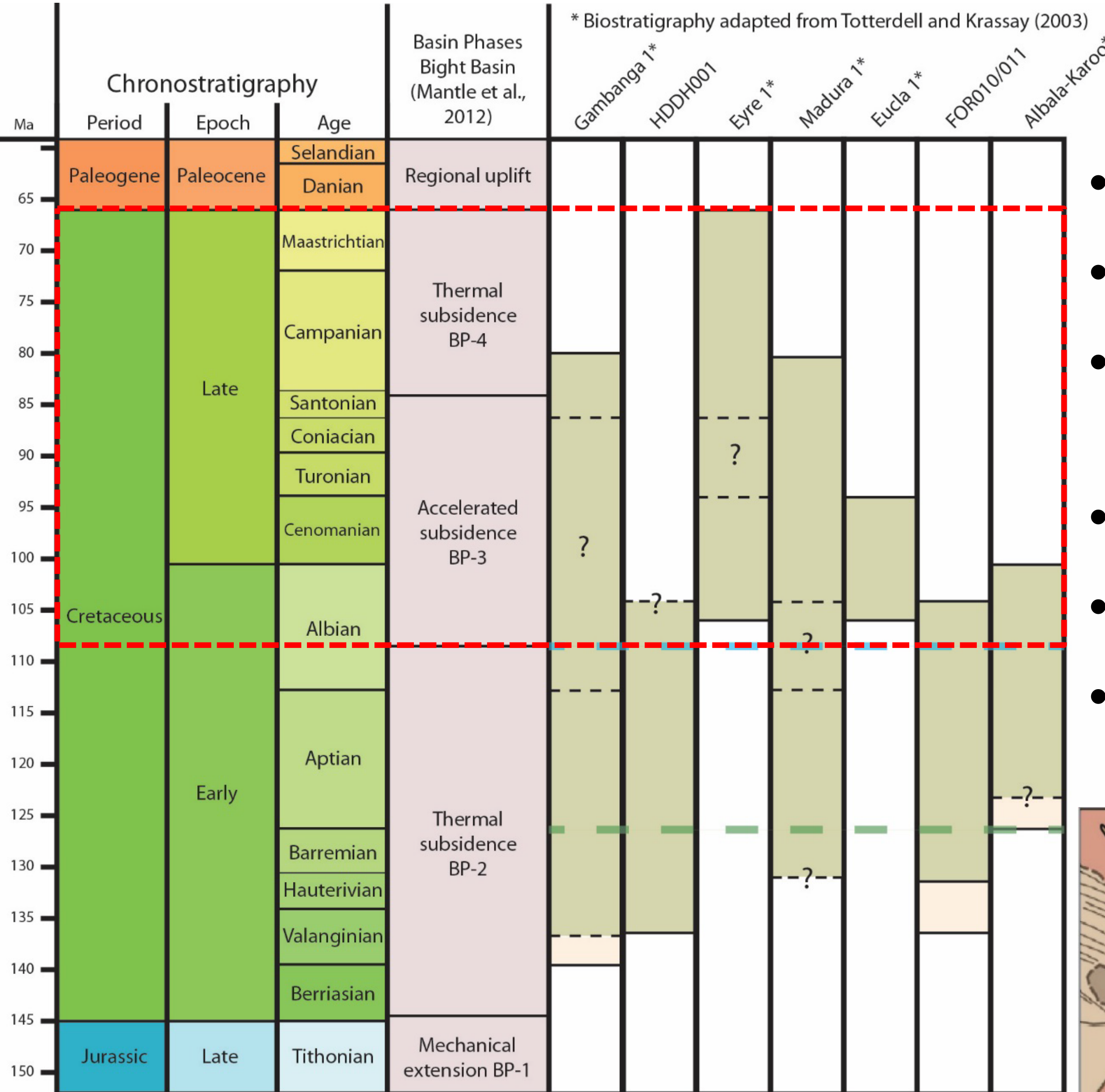


Adapted from Nichols (2011)

- Valanginian-Barremian?
- Widespread deposition in low-lying areas
- Fresh/brackish algae
- Carbonaceous sands and monotonous mudrock

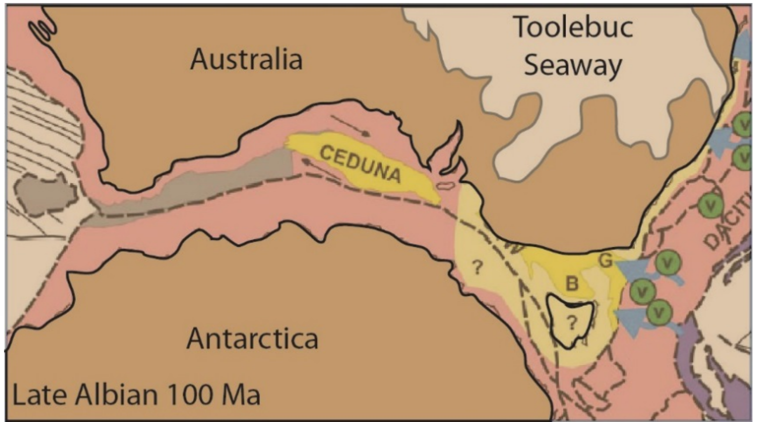


Cretaceous of the Madura Shelf – fully marine

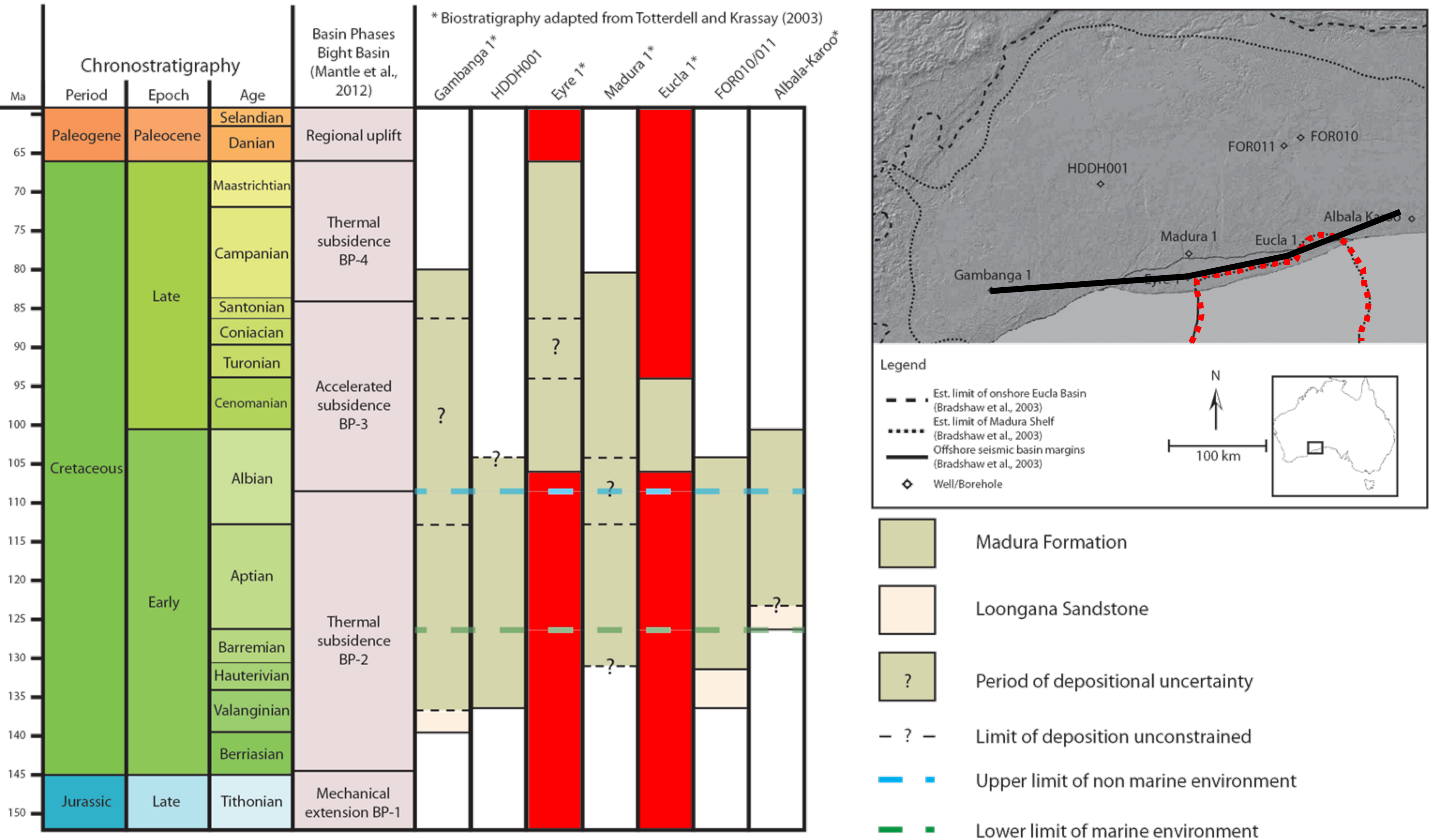


Adapted from Nichols (2011)

- Mid Albian-Maastrichtian
- Accelerated subsidence
- Major mid Cretaceous highstand
- Glauconitic siltstones
- Marine macrofossils
- Abundant dinocysts

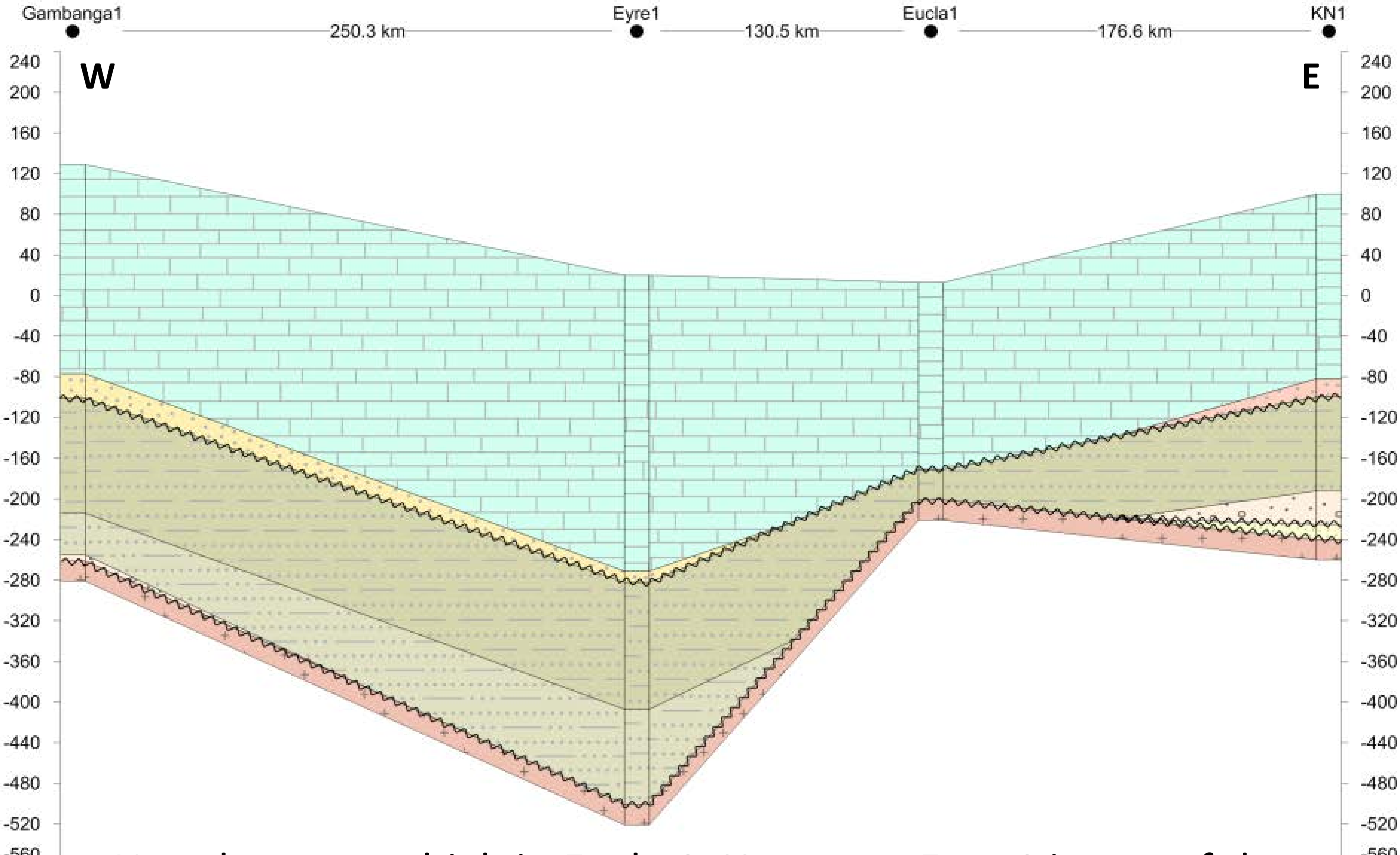


Cretaceous of the Madura Shelf – late faulting



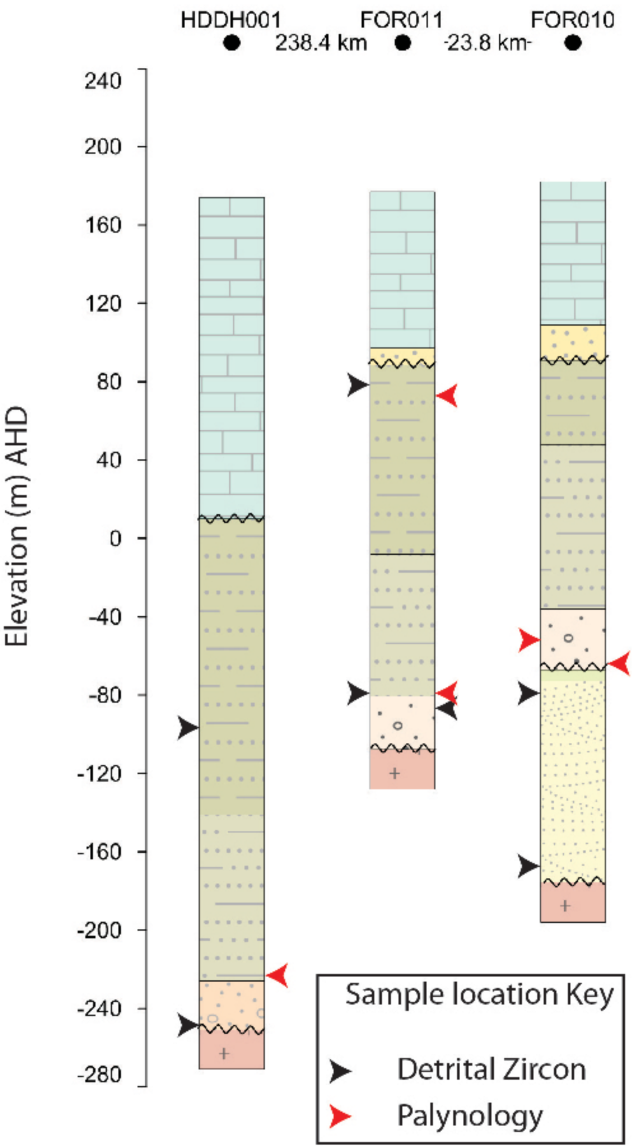
Progressive dominance of marine conditions. However, deposition appears to have commenced later in central regions

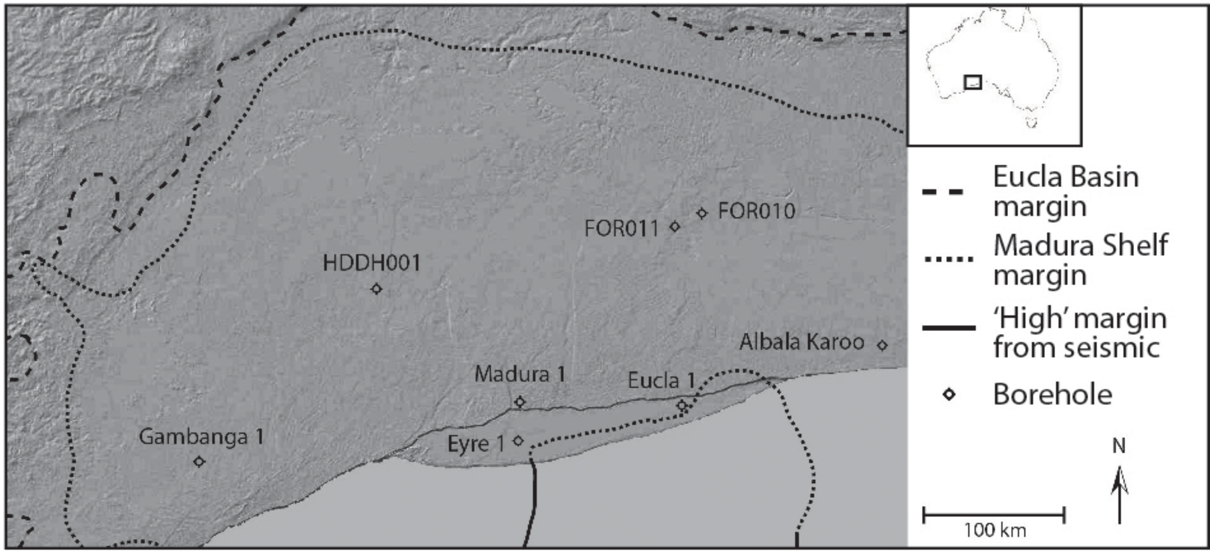
Cretaceous development of the Madura Shelf

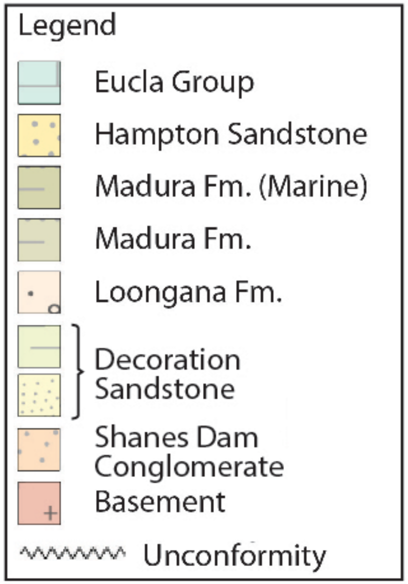


Note basement high in Eucla 1. However, Eyre 1 is one of the deepest → mid-Cretaceous fault movement (*onshore grabens*)?

Sediment age and provenance







Hole ID	Elv. (m)	Depth (m)	Type	GSWA #
HDDH001	-95	269	Detrital zircon	199458
HDDH001	-249	423	Detrital zircon	199456
HDDH001	-224	398	Palynology	
FOR011	79	98	Detrital zircon	199453
FOR011	-80	257	Detrital zircon	199454
FOR011	-90	267	Detrital zircon	199455
FOR011	73	104	Palynology	
FOR011	-80	257	Palynology	
FOR010	-80	262	Detrital zircon	199443
FOR010	-169	351	Detrital zircon	199444
FOR010	-54	236	Palynology	
FOR010	-62	244	Palynology	

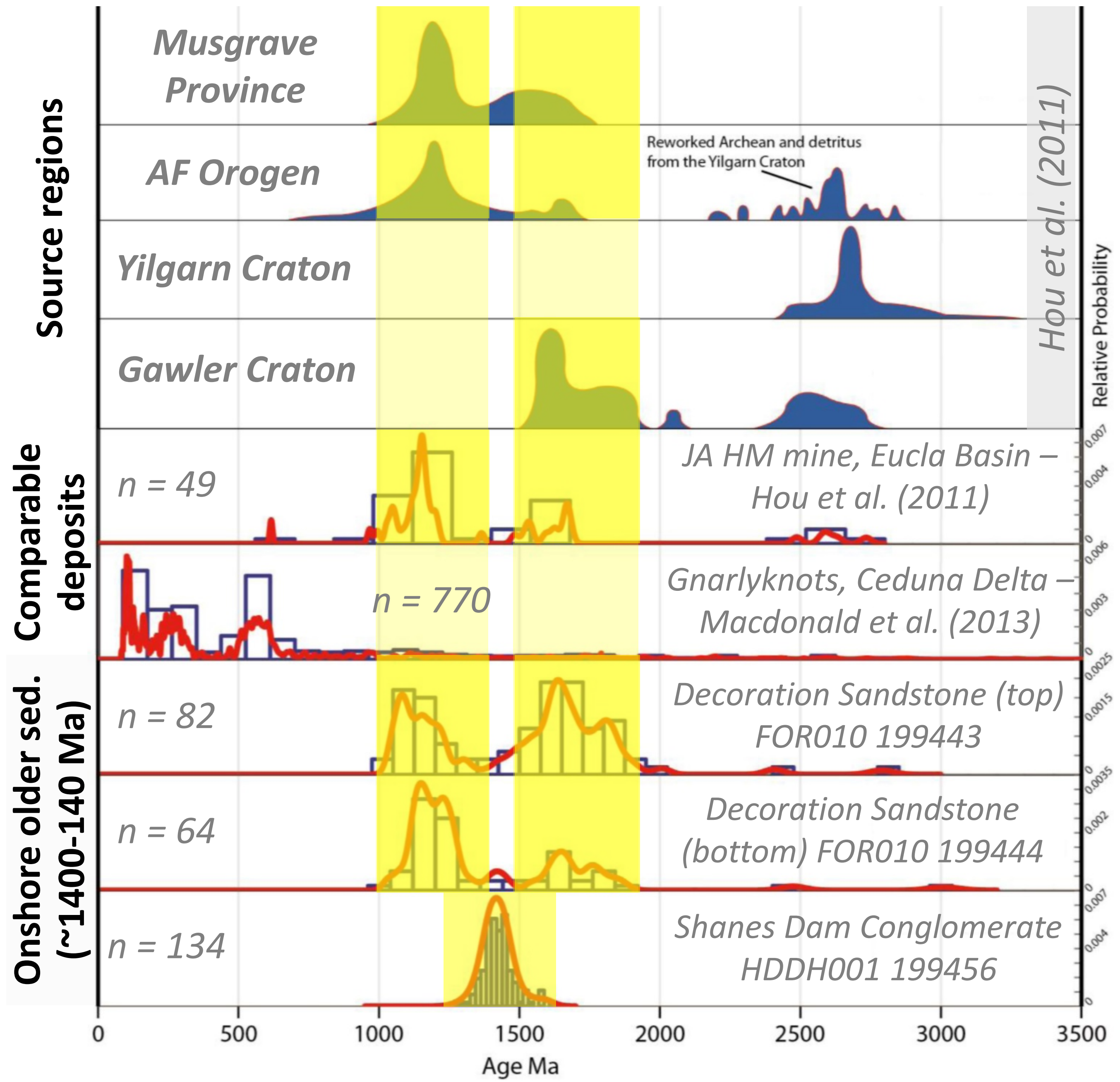
U/Pb detrital zircon age data

Dating zircon populations **constrains sediment age** and enables **correlation to likely source regions**.

Clear Musgrave and AF affinities.

Decoration Sandstone doesn't match Lennis Wanna but similar to other Officer Basin and Cenozoic seds → relatively stable sediment sourcing?

Shanes Dam Conglomerate → local signal related to underlying bedrock

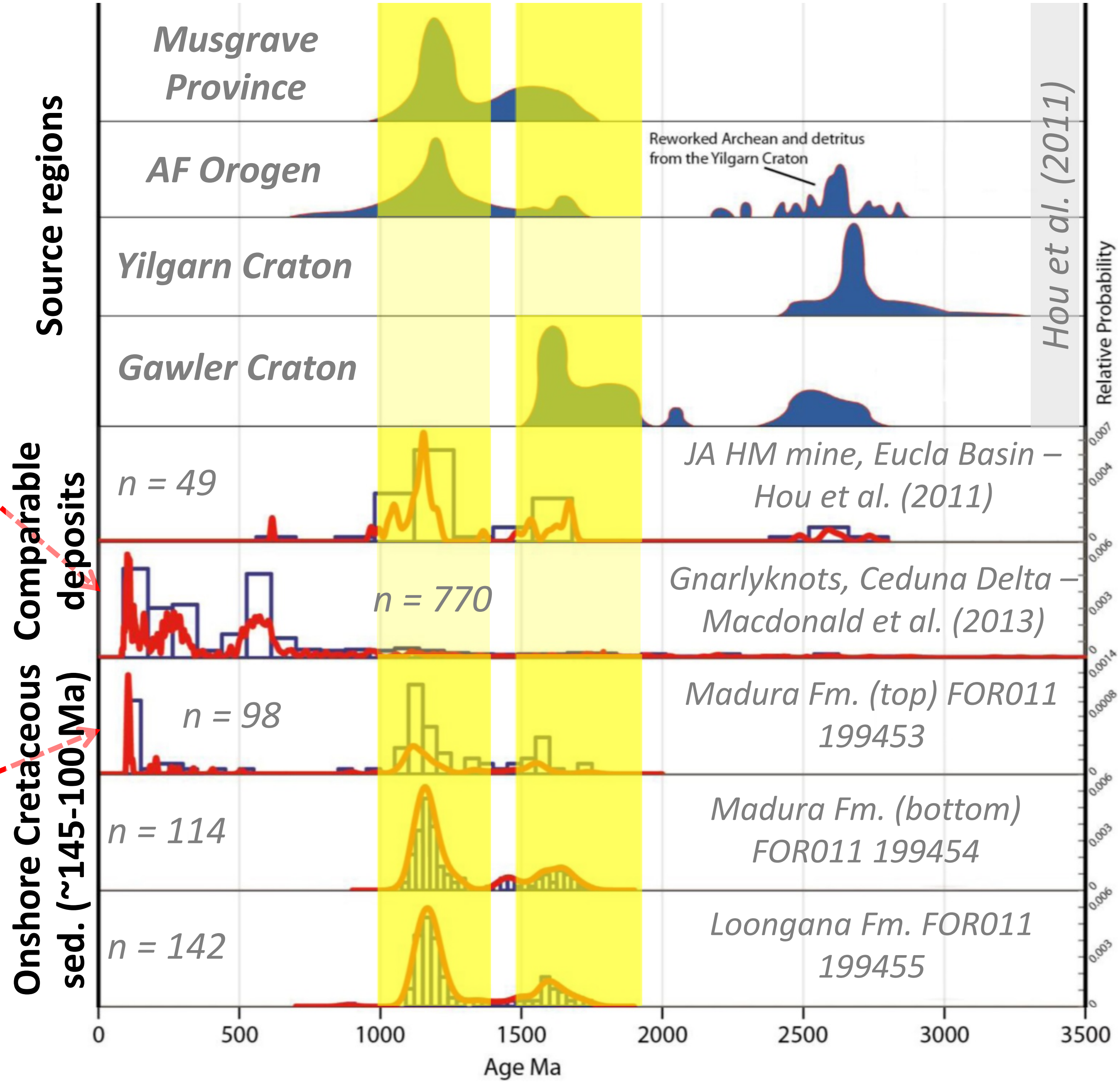


U/Pb detrital zircon age data

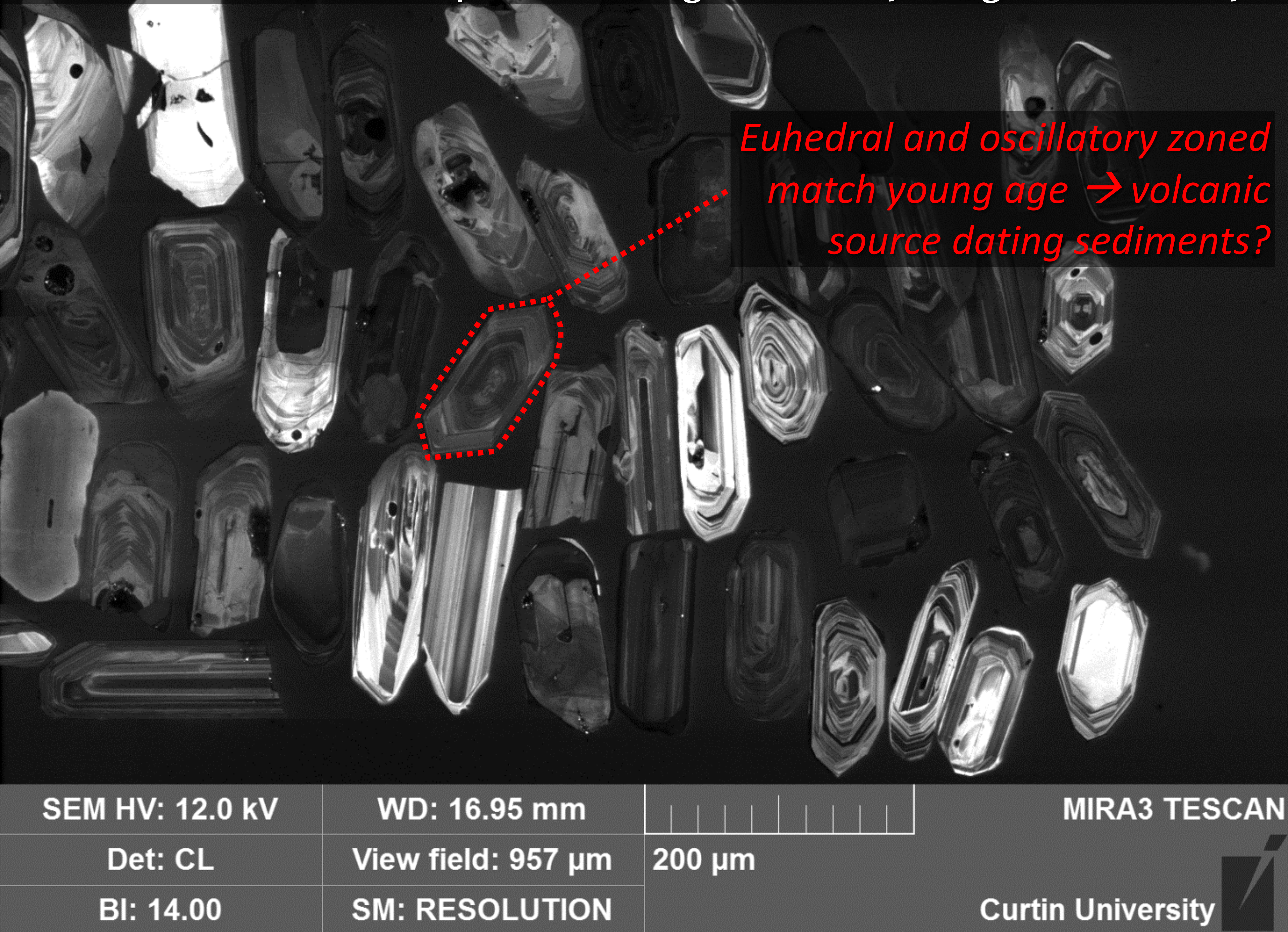
Same AF/Musgrave sediment sources seem stable into more recent times.

East (Gnarlyknots Well) and West (the data here) are disconnected – missing significant Phanerozoic signal.

Very young age matches dates from palynology and suggests contemporaneous volcanic activity



Cathodoluminescence provides insights into crystal growth history



Unrecognised Cretaceous volcanism in the west?

Eyre 1 core

Lapilli fragmental tuff …. **rounded breccia bombs** with cryptocrystalline selvages…. …bedded volcanogenic mafic ash ……quartz chlorite tuff…… ash bed… black ash ….tuff… quartz chlorite tuff…. **green chlorite tuff ….Tuff** …. abundant darker feather-like ash debris (eg 413-413.6) ….. ash tuff …. ash matrix…. **abundant lappilli** …(psuedoporphyblastic fabric)

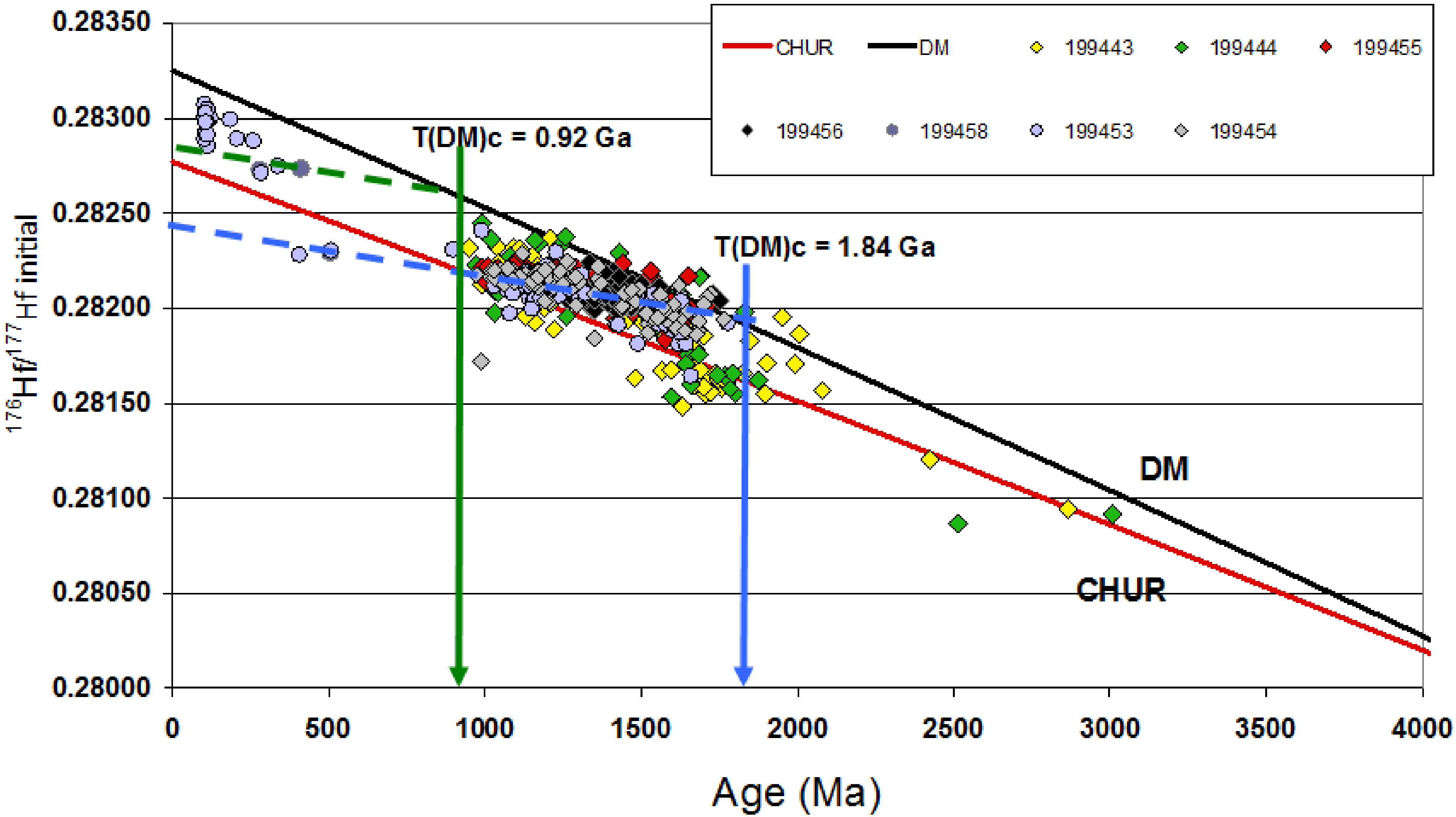
Nope, fanciful interpretation.

So where are they from?

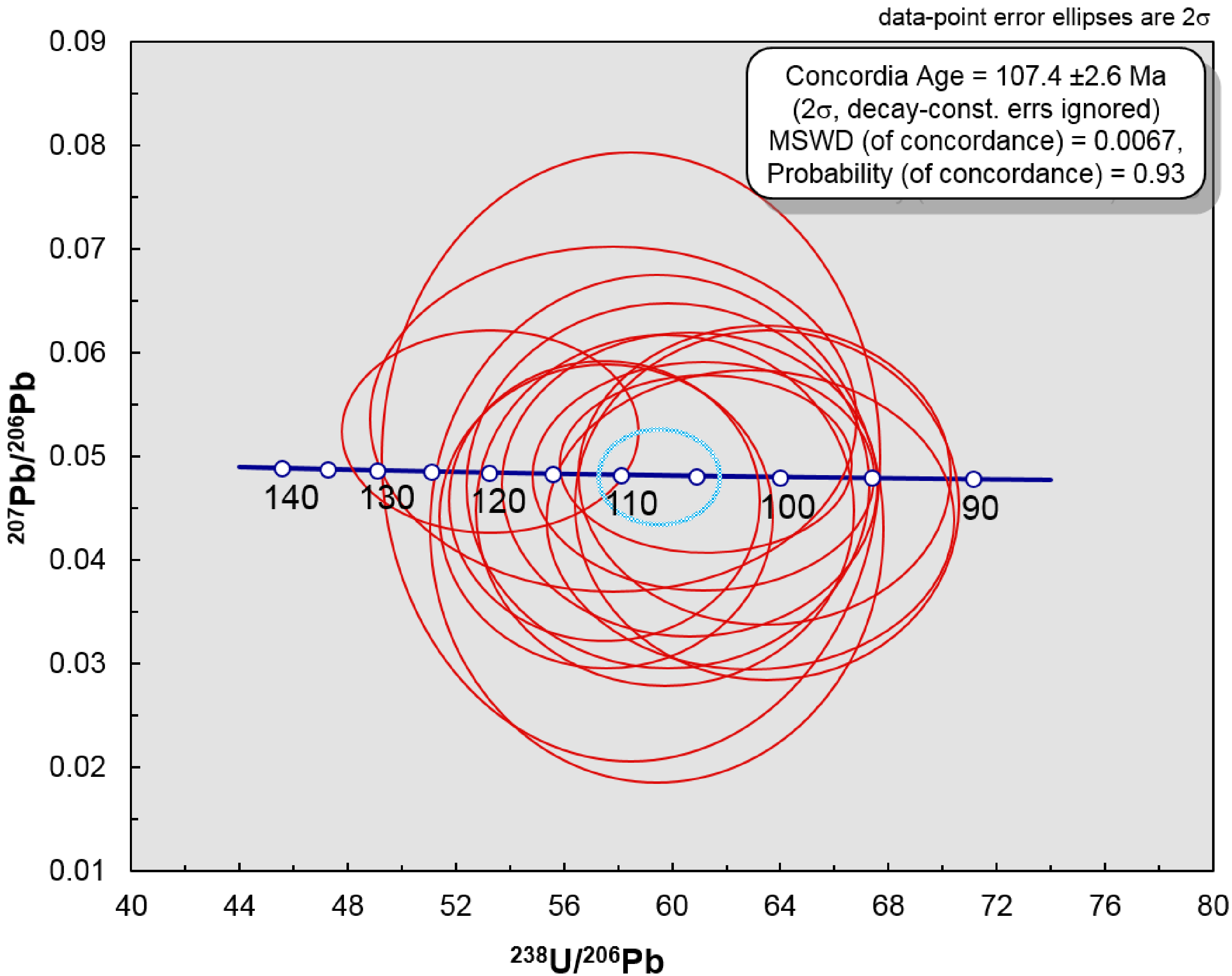
Hf data is key

Zircon Hf isotope data

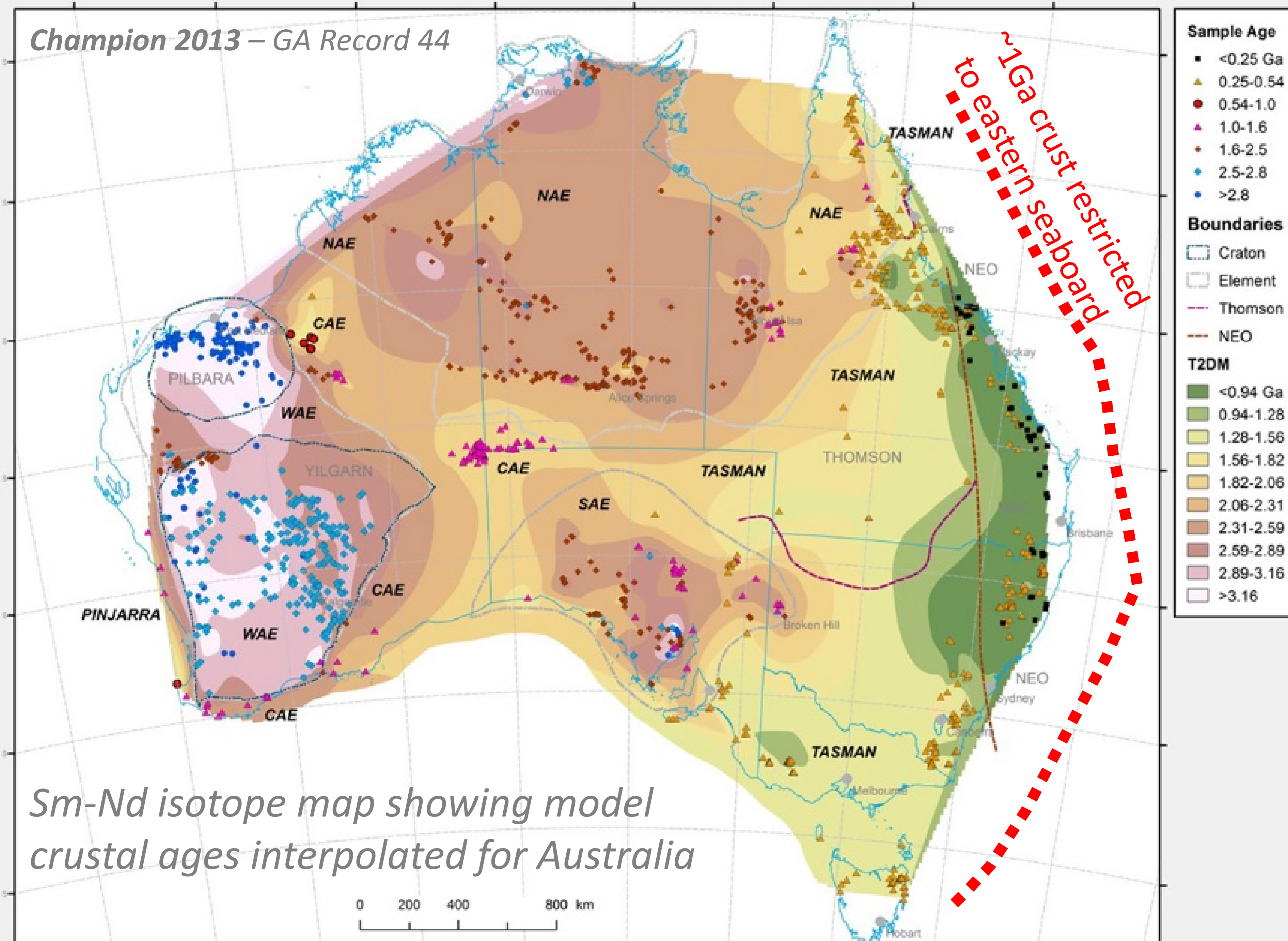
- Juvenile data matching differentiation from DM at ~1.9Ga → **Musgrave Prov.**
- Younger populations appear to derive from a ~0.9Ga DM with successive pulses of mantle input during volcanic episodes.



Volcanic zircons erupted 107Ma (matches Albian paly) **and were associated with ~1Ga crust**



***Champion 2013** – GA Record 44*

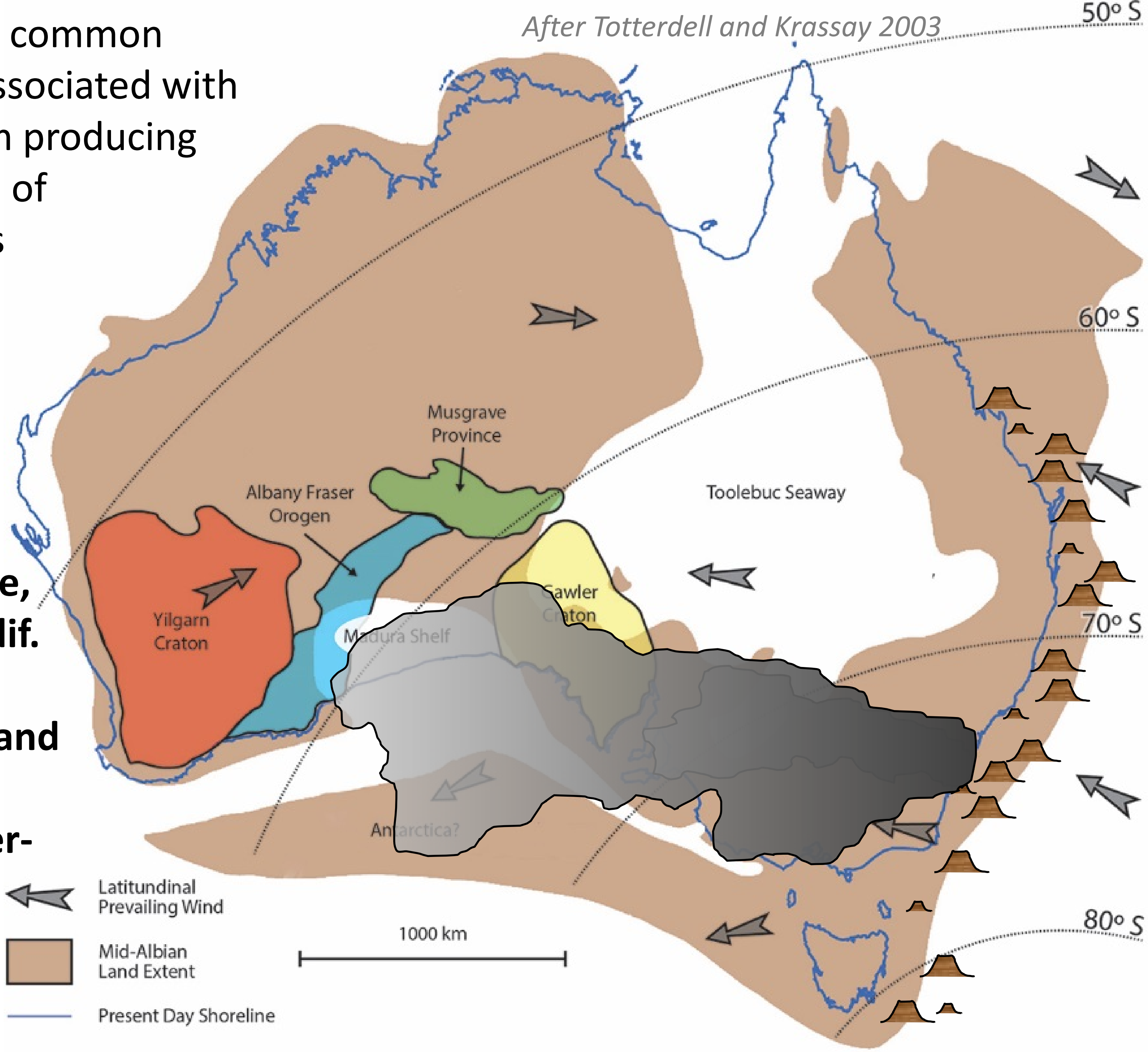


Sm-Nd isotope map showing model crustal ages interpolated for Australia

Albian zircons common component associated with SLIP volcanism producing large volumes of volcaniclastics

No evidence of any closer Antarctican sources

Paly, CL, shape, Hf-isotopes, dif. with other Ceduna data and palaeowind suggests super-eruption.



Conclusions

- Constructing a GIS database of Nullarbor stratigraphic architecture
- Several depocentres pre-date Cretaceous sedimentation beneath Nullarbor
- Mid-Cretaceous highstand inundated the interior of the Madura Shelf
- Mid-Cretaceous fault movement complicates onshore subsidence
- Musgrave Province was the likely sediment source (via multiple cycles) for the Madura Shelf and this routing system was long-lived
- The Madura Shelf and Ceduna Sub-basin operated as distinct sedimentary systems → east-west disconnect
- New ~107 Ma zircon population suggest eastern SLIP super-eruptions
- Are these boreholes representative of the region – or are they unique because of the specific magnetic targets etc.?
- What are the distributions of the older sedimentary packages and when did they form?
- Where is the evidence for prolonged deposition of the Madura Fm. Or the 25-60Ma hiatus and exposure between Cretaceous and Eocene sediments?