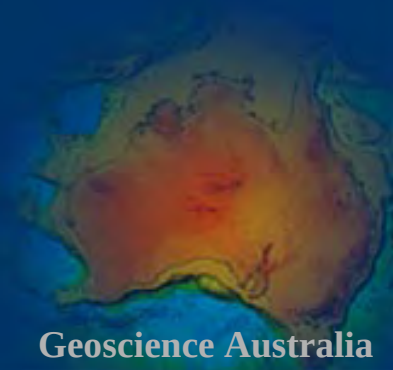
Australian Government

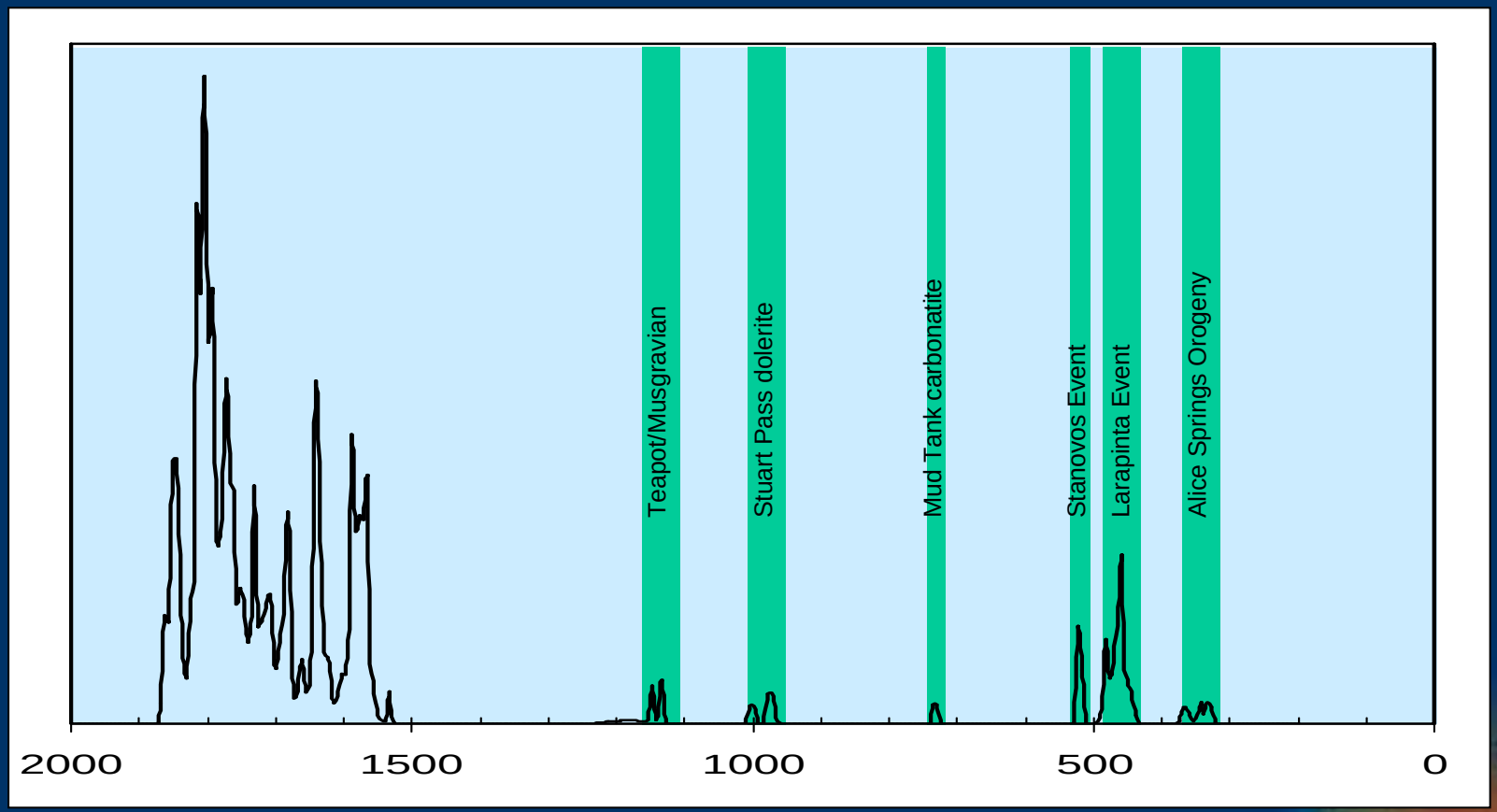
Geoscience Australia

Post-1550 Ma tectonism in the North Australian Craton

David Maidment

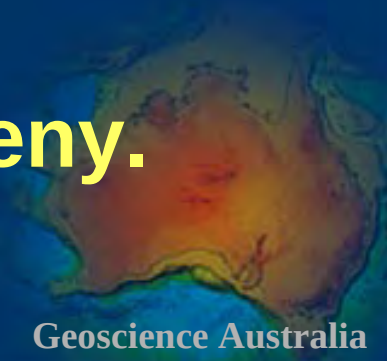


Post-1550 Ma tectonism



Overview of post-1550 Ma tectonism

- 1135 Ma – Teapot Event.
- 850 Ma – Initiation of Centralian Superbasin.
- 732 Ma – Minor alkaline intrusions.
- 560-530 Ma Petermann/King Leopold orogenies.
- 520 Ma – Stanovos Event.
- 480-460 Ma – Larapinta Event.
- 450-300 Ma – Alice Springs Orogeny.

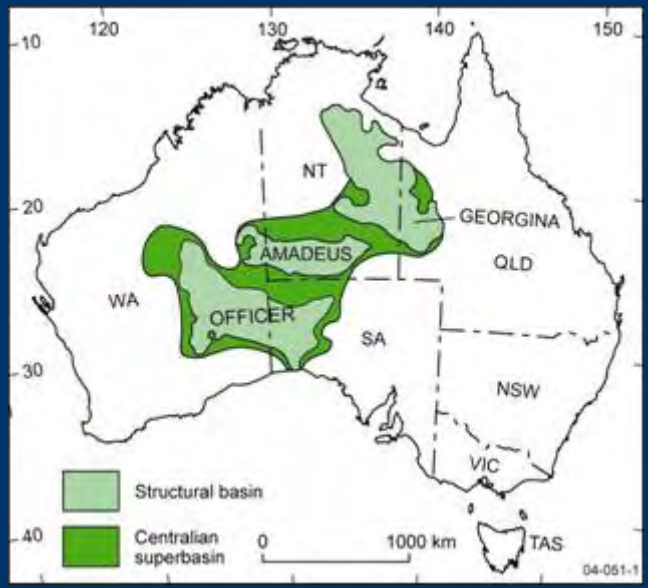


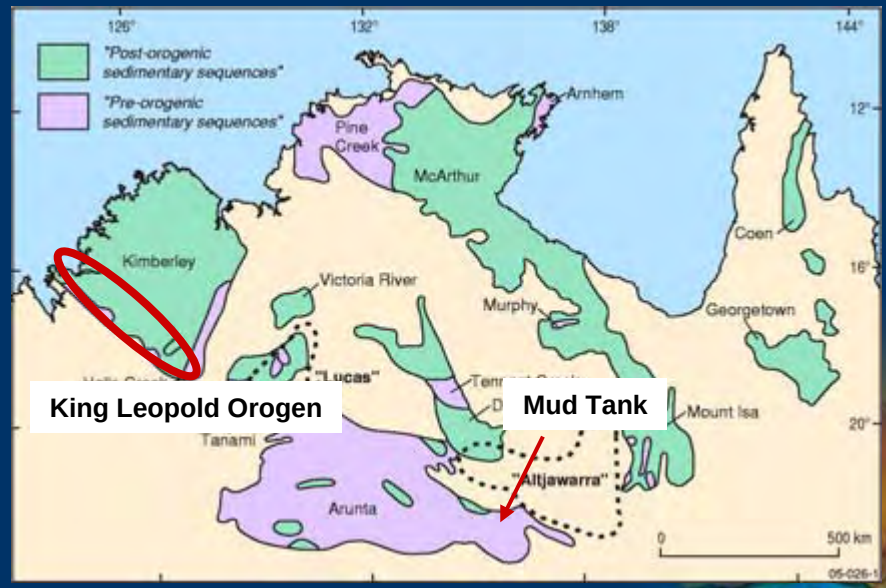
Teapot Event (~1135 Ma)

- Minor magmatism at ~1135 Ma in southern Arunta Region.
- Coeval with widespread felsic magmatism in Musgrave Block.

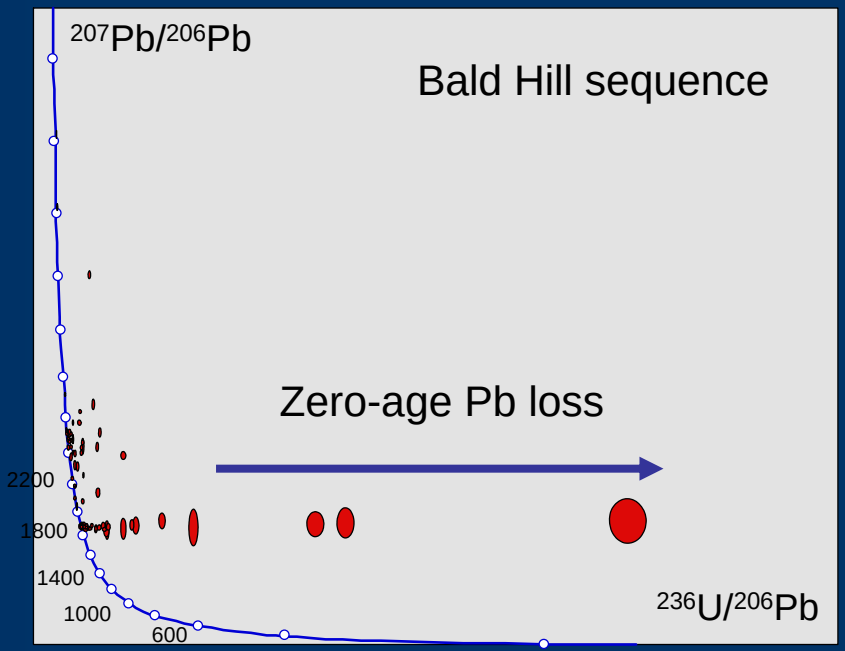
Neoproterozoic events

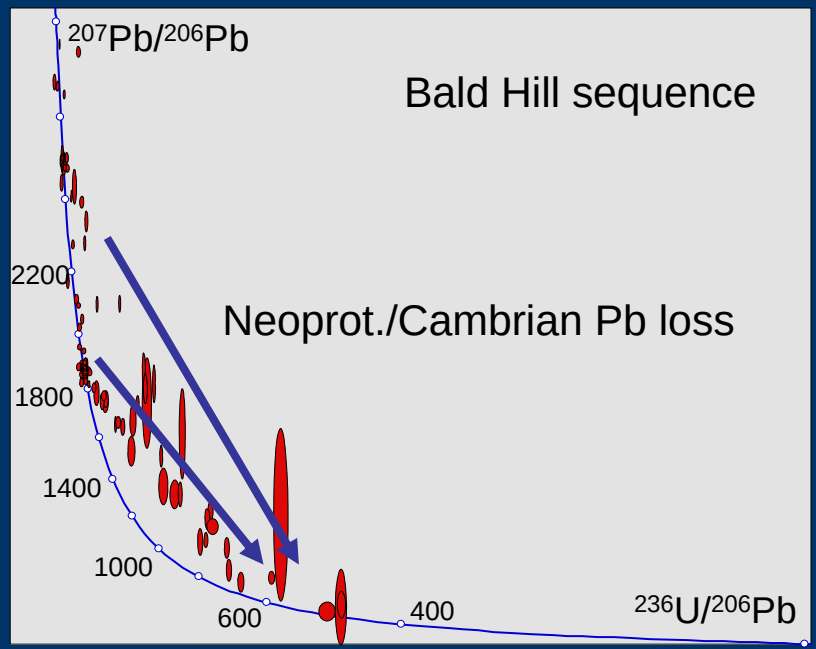
- **~850 Ma - Initiation of Centralian Superbasin.**
- **732 ± 5 Ma - Intrusion of minor alkaline intrusives in eastern Arunta Region.**
- **560-530 Ma dextral transpression on NW-SE, E-W shear zones (Petermann-King Leopold orogenies).**





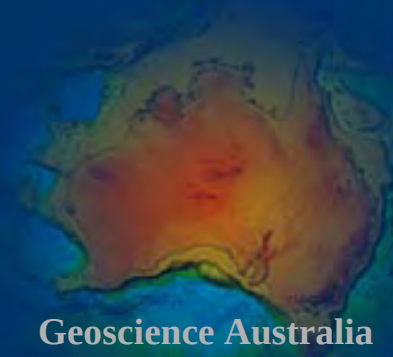
Late Neoproterozoic isotopic disturbance





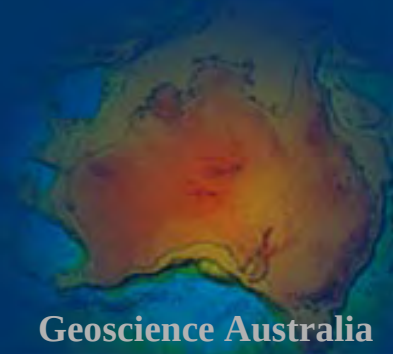
King Leopold Orogen

W. Tanami

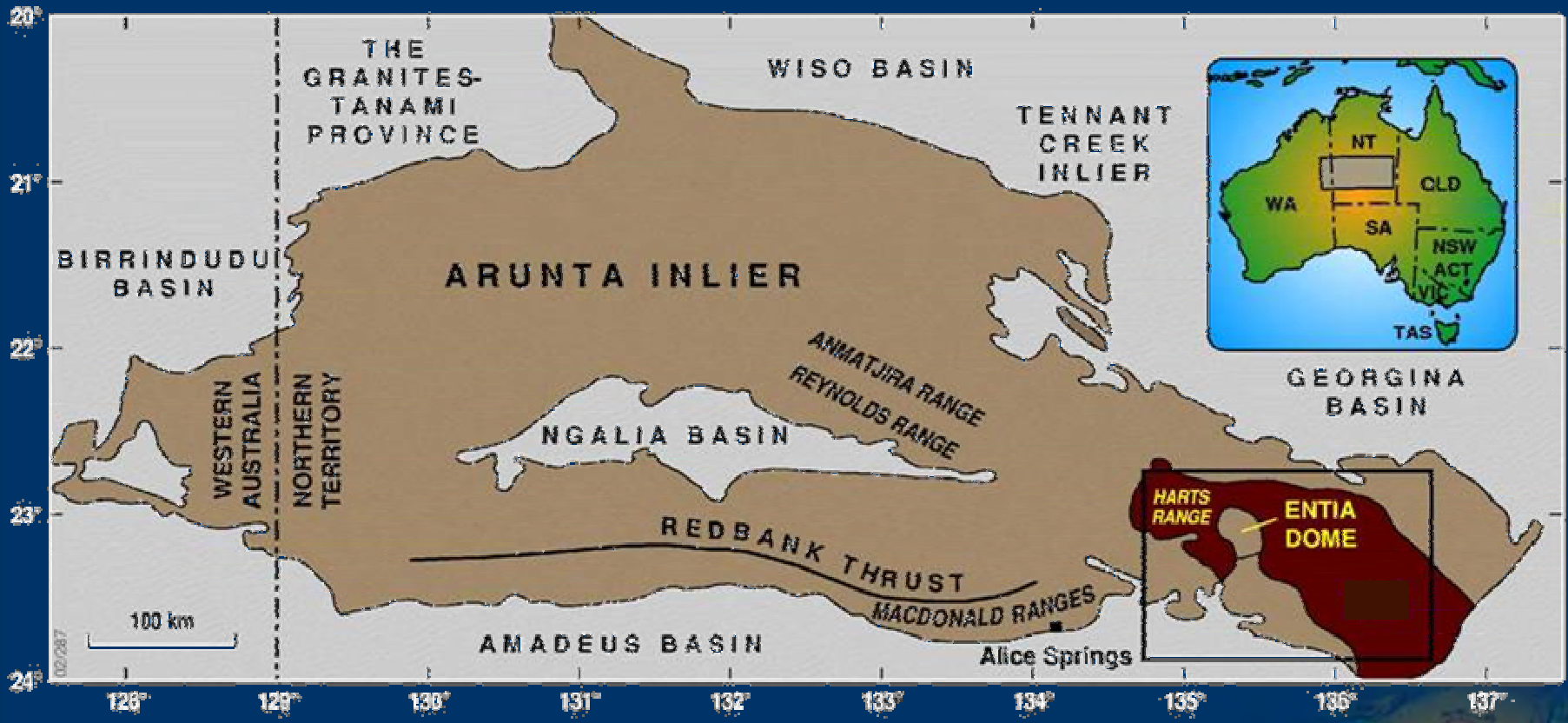


Palaeozoic tectonism

- **High-grade metamorphism and partial melting between 520 Ma and 300 Ma.**
  - **520 Ma Stanovos Event (extension)**
  - **480-460 Ma Larapinta Event (extension)**
  - **450-300 Ma Alice Springs Orogeny**
- **Expressed at highest grade in southeast Arunta Region (Harts Range Metamorphic Complex).**

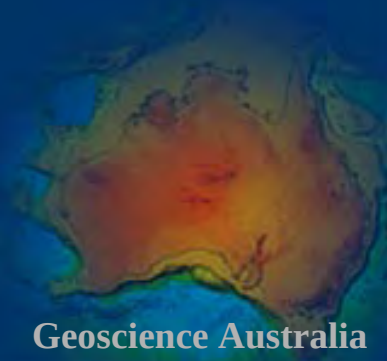


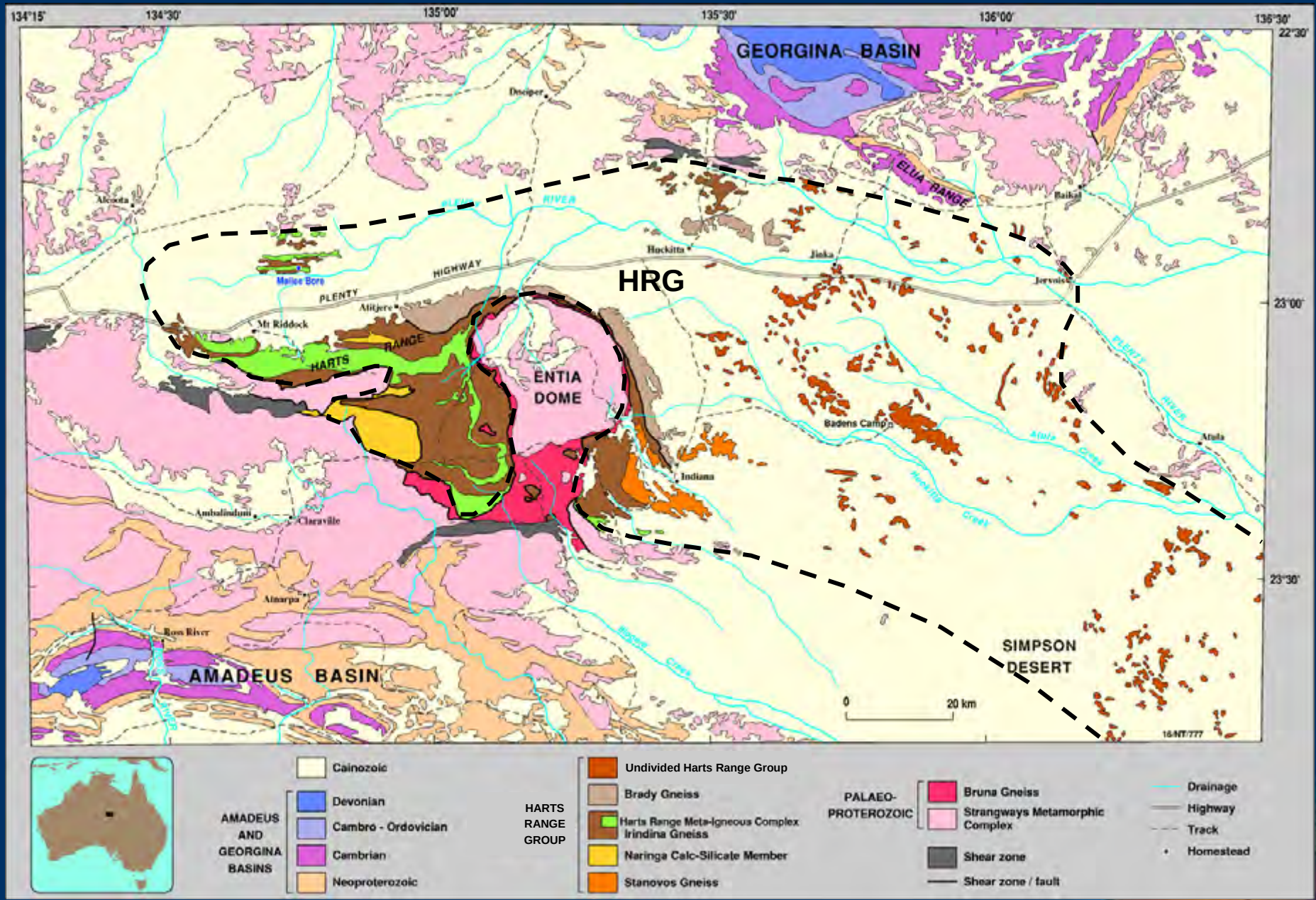
Harts Range Metamorphic Complex



Harts Range Metamorphic Complex

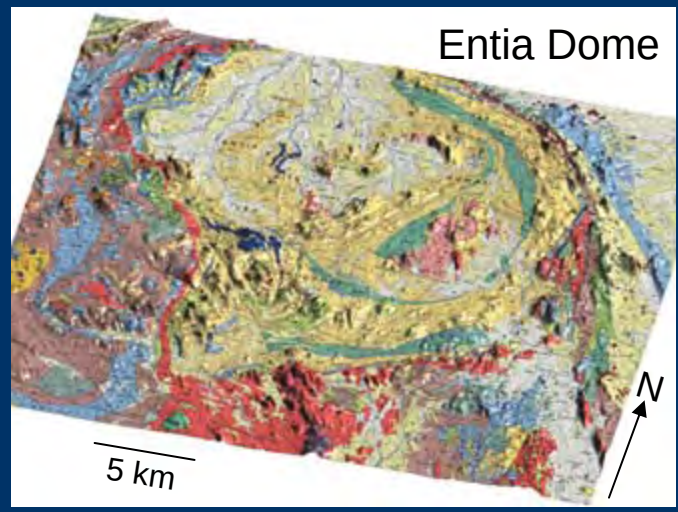
- High-grade metamorphic rocks (Harts Range Group) similar to adjacent and underlying Palaeoproterozoic metamorphics.
- HRG contains remnant detrital zircons as young as ~500 Ma.
- Age of protoliths similar to that of surrounding unmetamorphosed sedimentary successions.




134°15'
134°30'
135°00'
135°30'
136°00'
136°30'
22°30'
23°00'
23°30'
GEORGINA BASIN
HRG
ENTIA DOME
HARTS RANGE
ELUA RANGE
PLENTY RIVER
HIGHWAY
Alcoota
Mallee Bore
Mt Riddock
Alitjere
Hockitta
Jinka
Jervois
Baikal
Badens Camp
Indiana
Ambalindum
Claraville
Atnarpa
Ross River
AMADEUS BASIN
SIMPSON DESERT
0
20 km
16-NT/777
Cainozoic
Devonian
Cambro - Ordovician
Cambrian
Neoproterozoic
AMADEUS AND GEORGINA BASINS
Undivided Harts Range Group
Brady Gneiss
Harts Range Meta-Igneous Complex
Irindina Gneiss
Naringa Calc-Silicate Member
Stanovos Gneiss
HARTS RANGE GROUP
Bruna Gneiss
Strangways Metamorphic Complex
PALAEO-PROTEROZOIC
Shear zone
Shear zone / fault
Drainage
Highway
Track
Homestead

Entia Gneiss Complex (1800-1700 Ma)

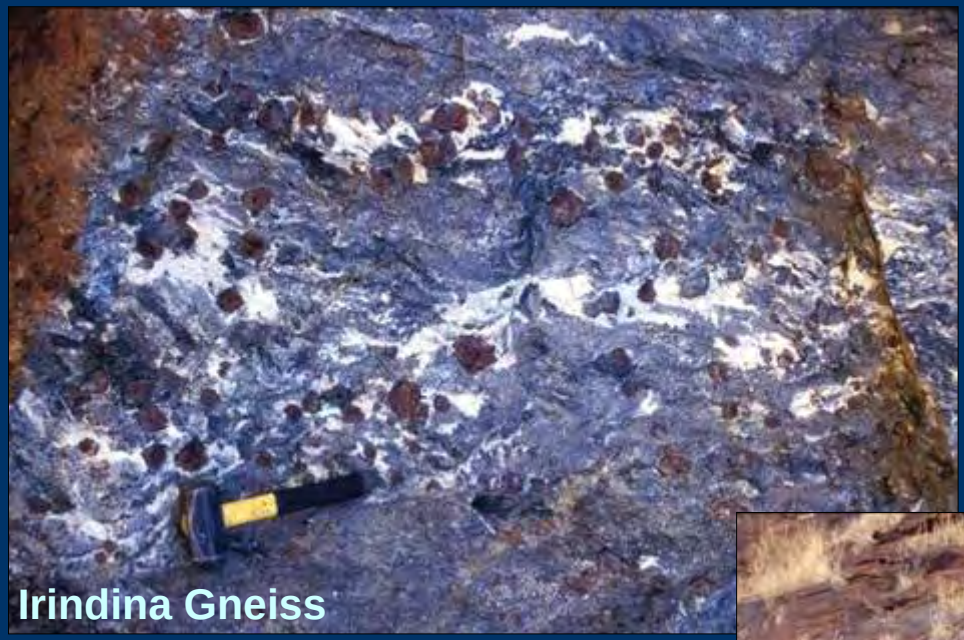
Felsic and mafic gneiss

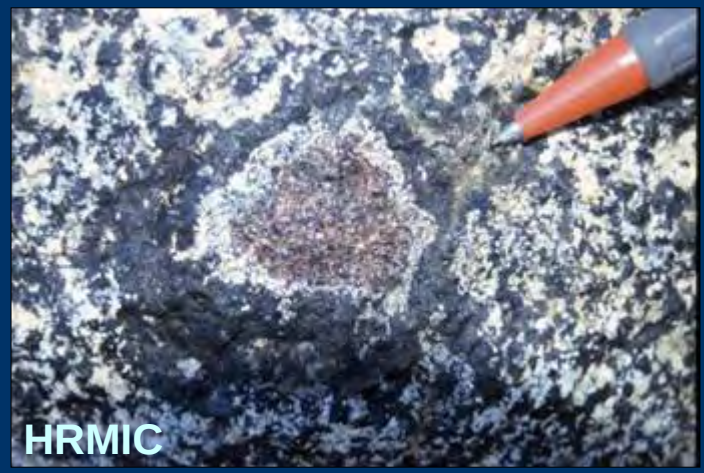


Garnet marble

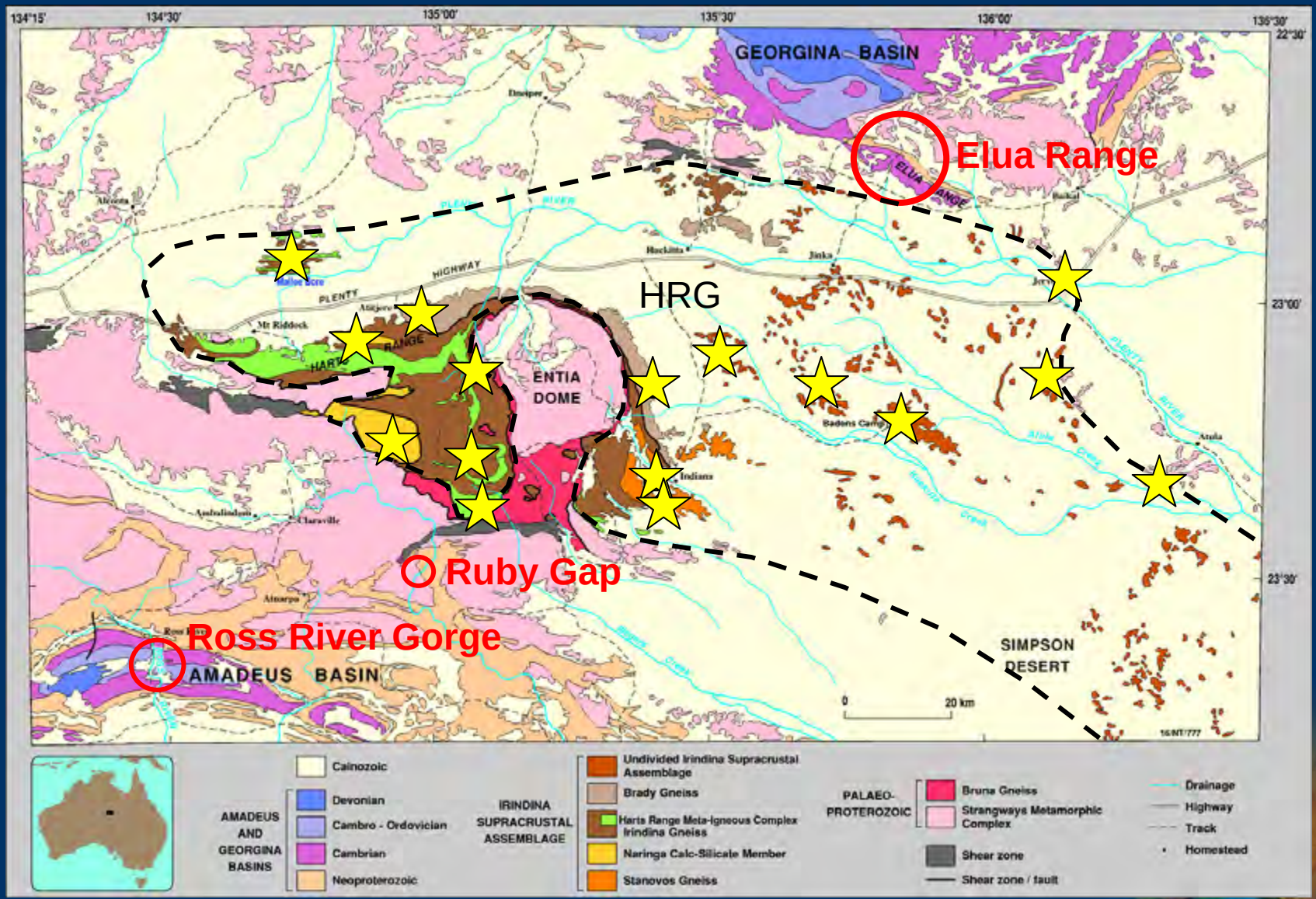
Palaeoproterozoic basement-cored gneiss dome

Harts Range Group





Harts Range area detrital zircon sampling



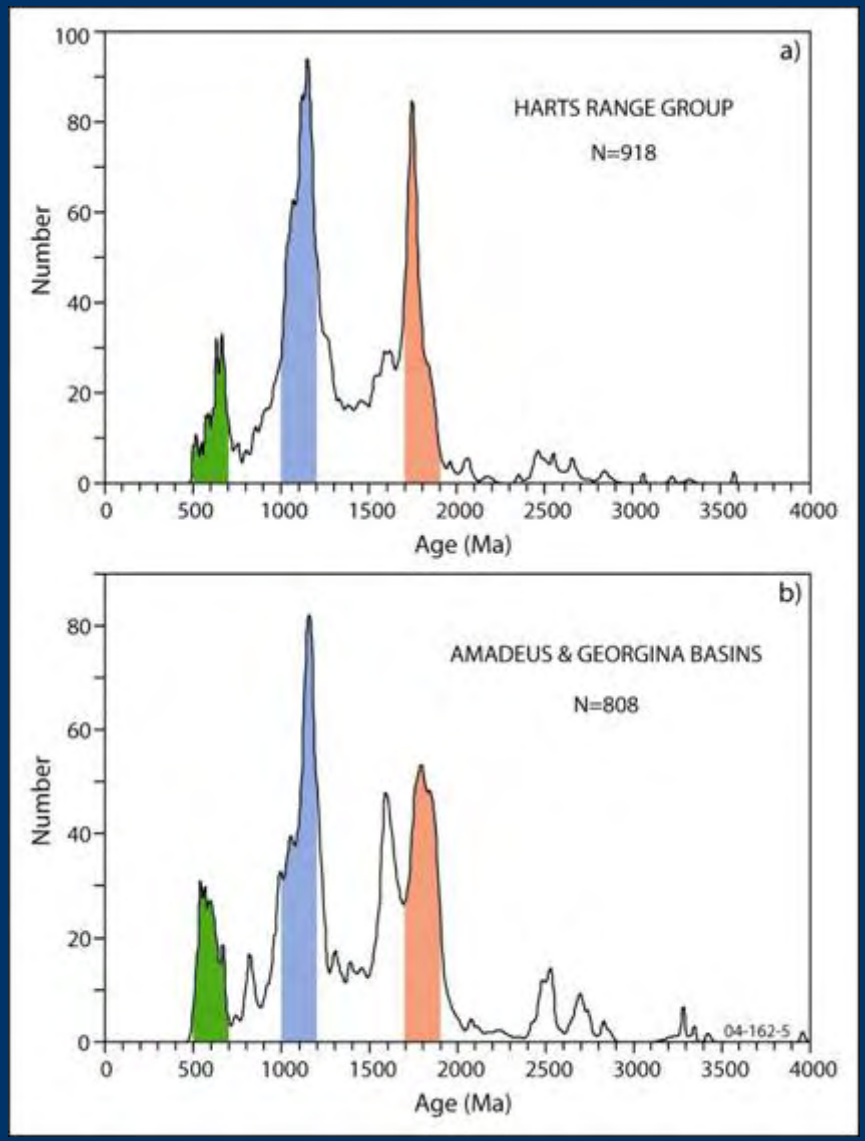
Amadeus Basin – Ross River Gorge


Arumbera Sandstone


Pacoota Sandstone

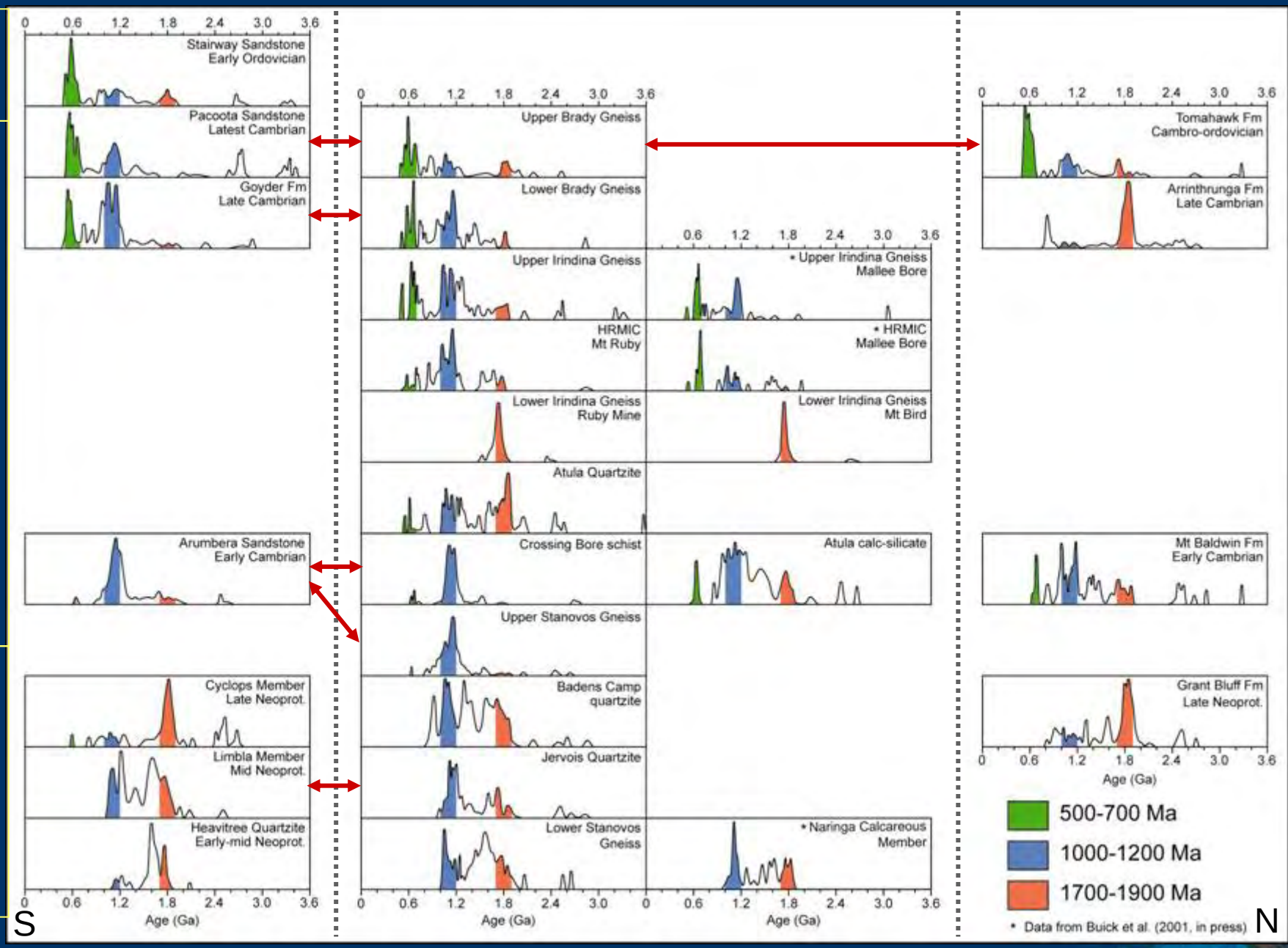

Giles Ck Dolomite

Detrital zircon geochronology



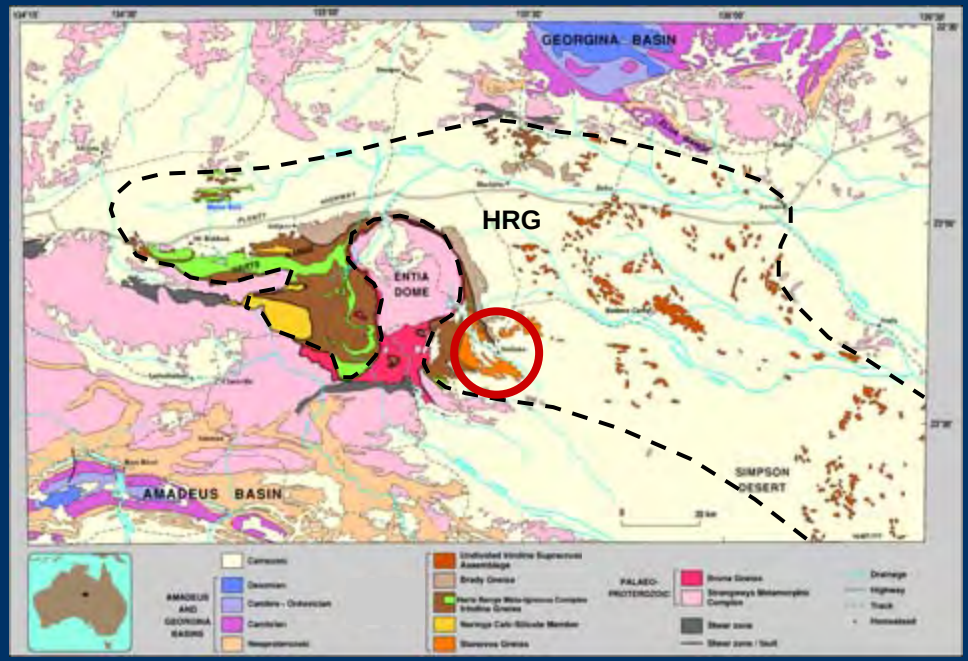
Harts Range Group

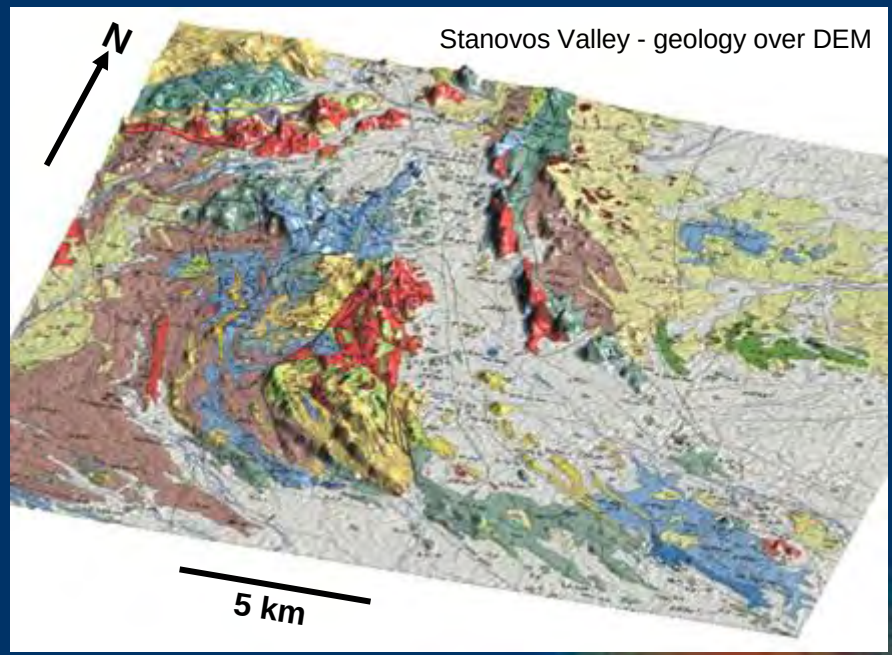
Amadeus & Georgina basins


AMADEUS BASIN
HARTS RANGE GROUP
GEORGINA BASIN
ORDOV.
CAMBRIAN
NEOPROTEROZOIC
Stairway Sandstone
Early Ordovician
Pacoota Sandstone
Latest Cambrian
Goyder Fm
Late Cambrian
Arumbera Sandstone
Early Cambrian
Cyclops Member
Late Neoprot.
Limbla Member
Mid Neoprot.
Heavitree Quartzite
Early-mid Neoprot.
Upper Brady Gneiss
Lower Brady Gneiss
Upper Irindina Gneiss
HRMIC
Mt Ruby
Lower Irindina Gneiss
Ruby Mine
Atula Quartzite
Crossing Bore schist
Upper Stanovos Gneiss
Badens Camp
quartzite
Jervois Quartzite
Lower Stanovos
Gneiss
• Upper Irindina Gneiss
Mallee Bore
• HRMIC
Mallee Bore
Lower Irindina Gneiss
Mt Bird
Atula calc-silicate
• Naringa Calcareous
Member
Tomahawk Fm
Cambro-ordovician
Arrinthrunga Fm
Late Cambrian
Mt Baldwin Fm
Early Cambrian
Grant Bluff Fm
Late Neoprot.
0 0.6 1.2 1.8 2.4 3.0 3.6
Age (Ga)
500-700 Ma
1000-1200 Ma
1700-1900 Ma
• Data from Buick et al. (2001, in press)
S
N

Stanovos Event (520 Ma)

Partial melting of late Neoproterozoic to Cambrian sedimentary rocks at ~520 Ma.

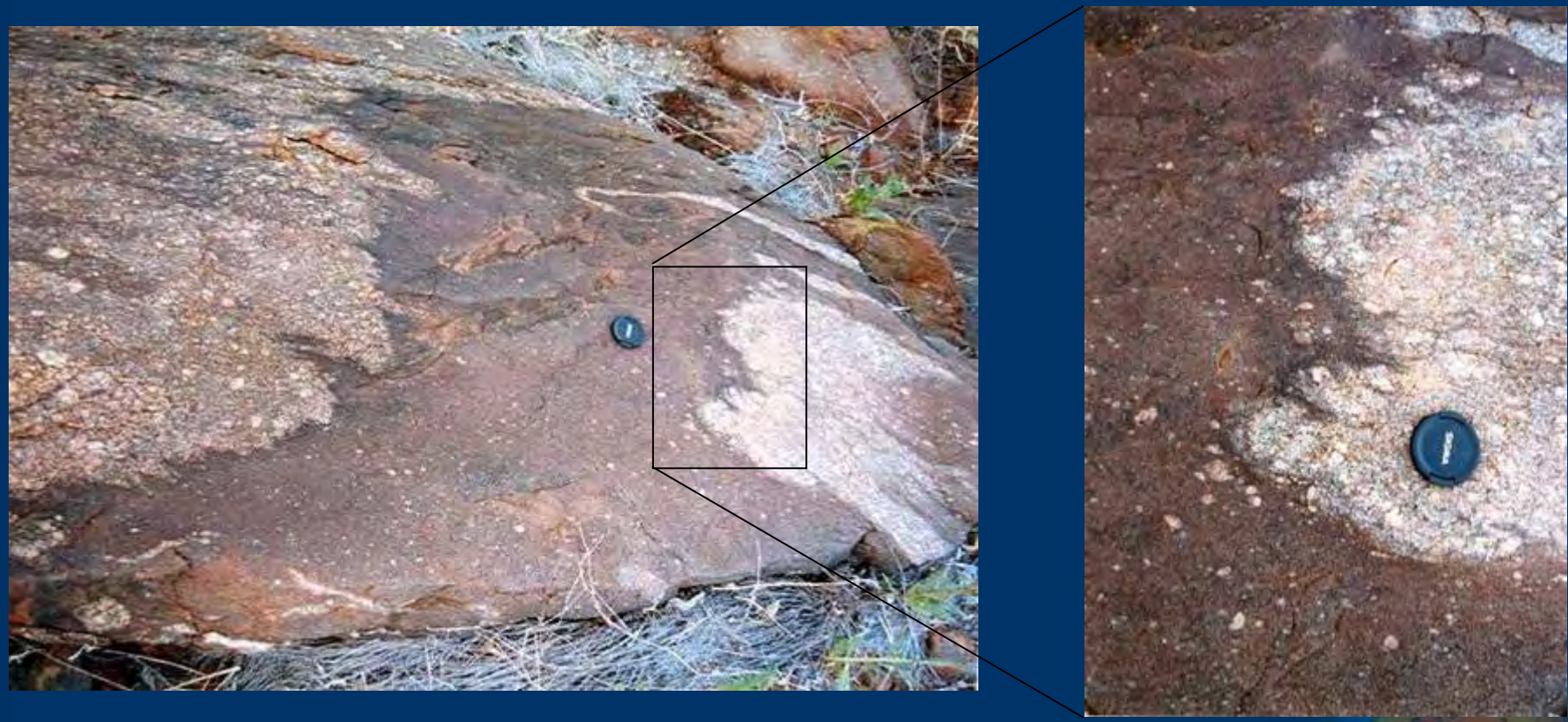




520 Ma Indiana Walls Granite

520 Ma migmatite – Stanovos Gneiss

520 Ma bimodal magmatism



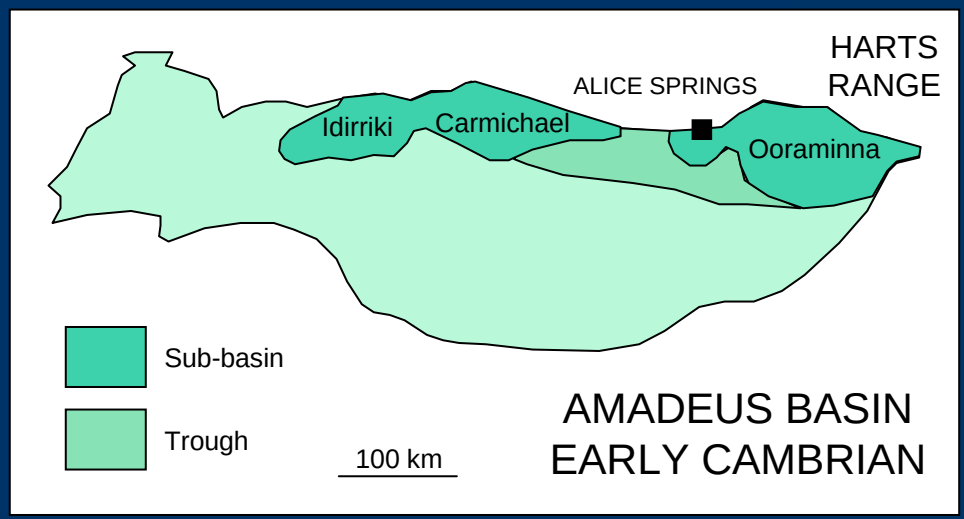
Mafic intruding felsic

520 Ma bimodal magmatism

Felsic intruding mafic

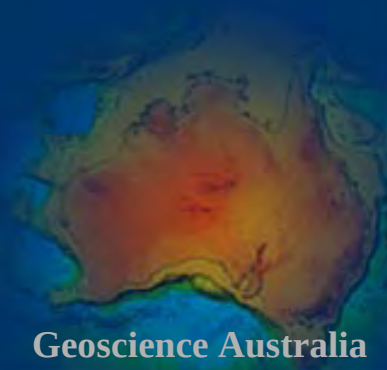
Stanovos Event – tectonic setting

- **Inferred extensional setting based on:**
  - **Sub-basin development and marine transgression in late Cambrian.**
  - **Deeper-water sediments in Harts Range.**
  - **Bimodal magmatism.**

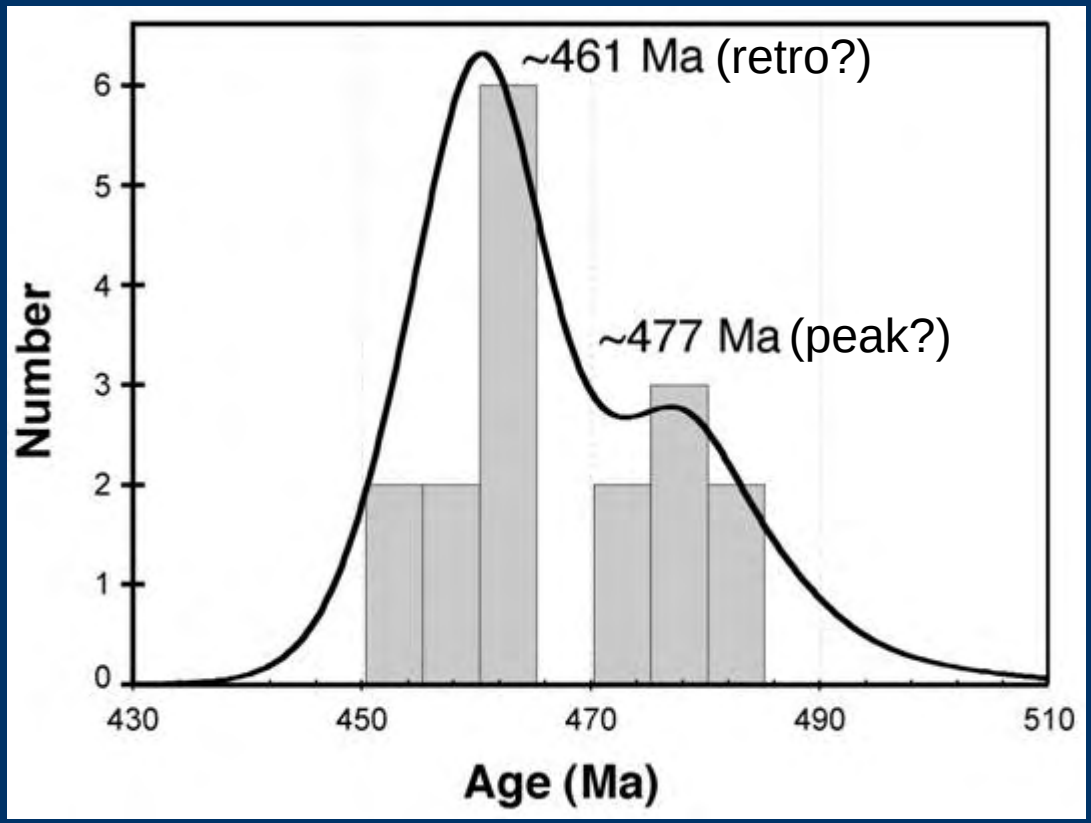


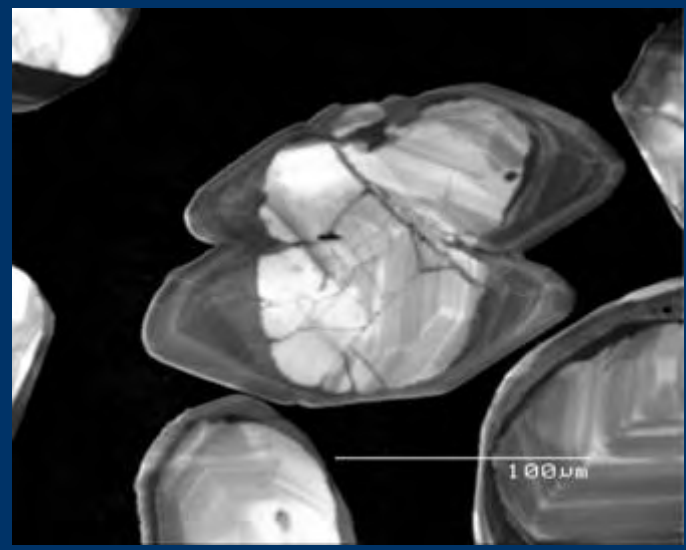
Larapinta Event (480-460 Ma)

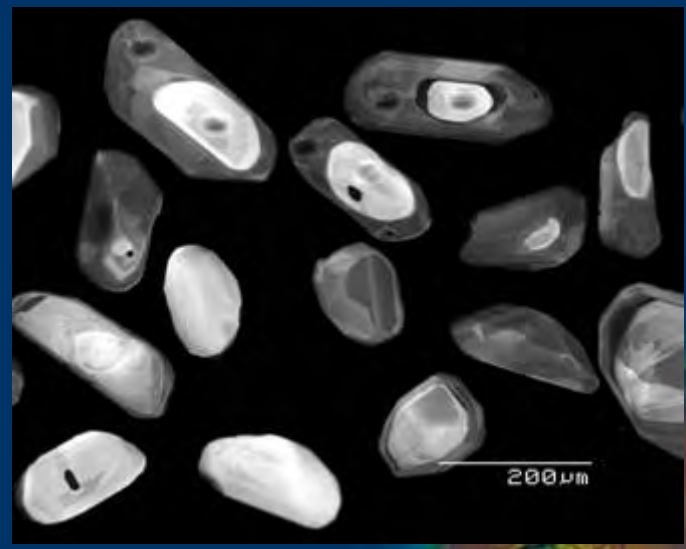
- Amphibolite- to granulite-facies metamorphism of HRG (peak: 800 ºC, 1.0-1.2 Gpa; retrograde: 700 ºC, 0.7 Gpa).
- Regional flat-lying foliation, N-S lineation, no macro-scale folding.
- Adjacent Palaeoproterozoic rocks largely unaffected.



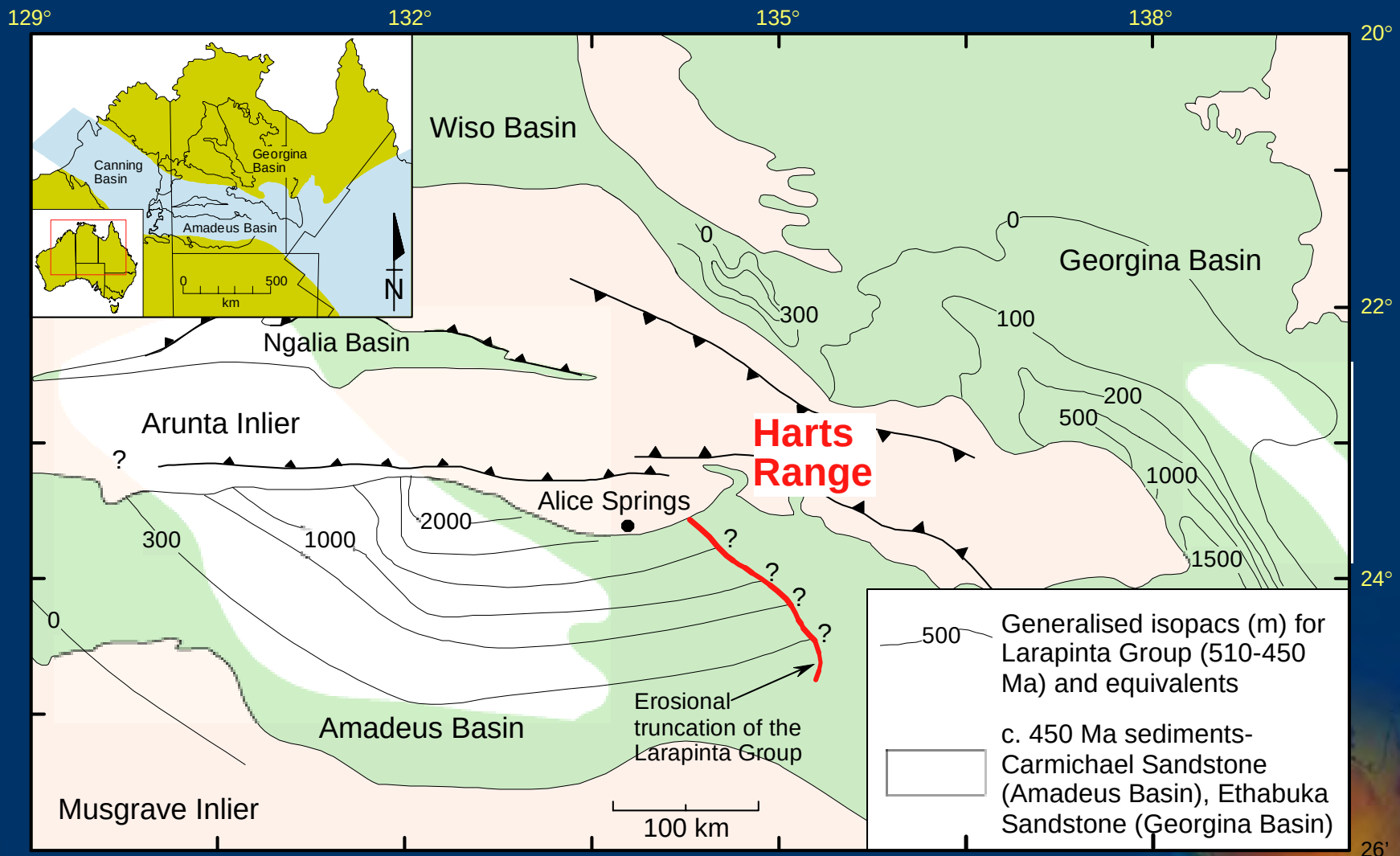
HRG metamorphic zircon ages







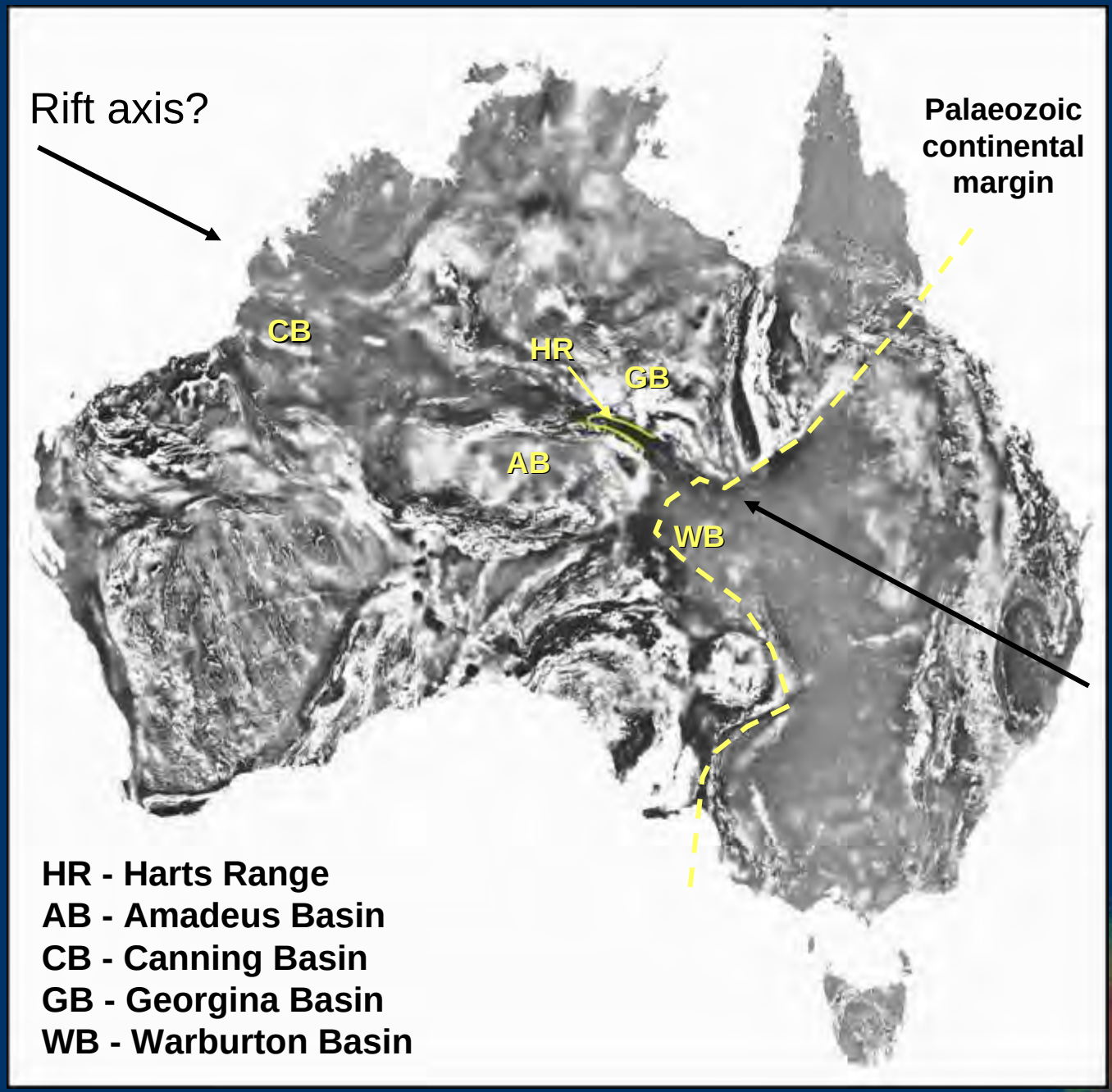
Palaeogeographic setting



From Mawby (2000)

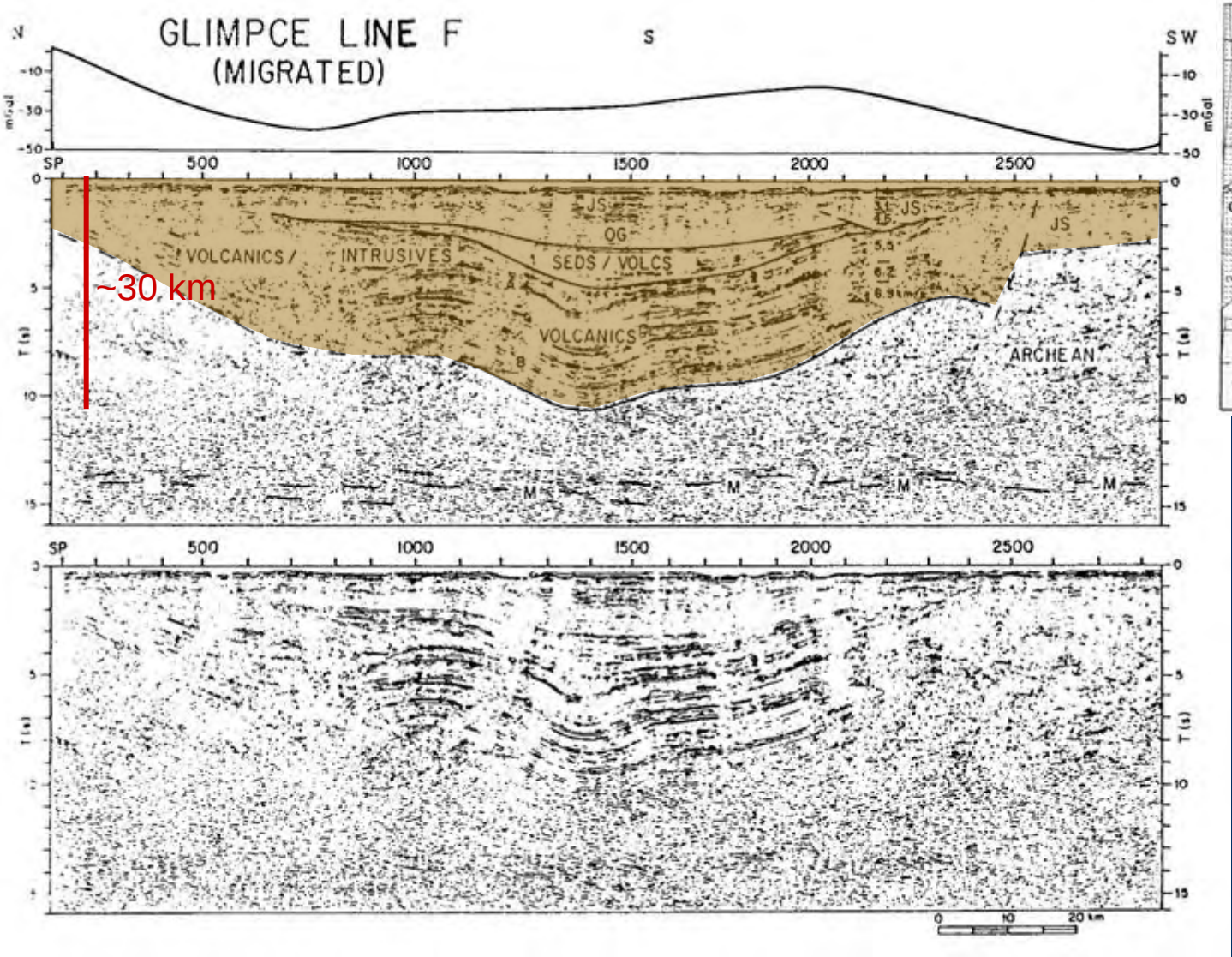
Evidence for extension

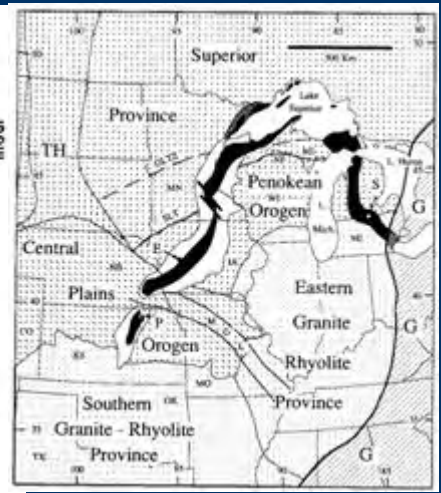
- **Flat-lying foliation in the lower crust, with no large-scale folding.**
- **Depocentre above metamorphism at depth.**
- **Detrital ages and sedimentation styles inconsistent with mountain building.**
- **Syn-tectonic mafic dykes.**



TMI – Reduced to pole

Midcontinent Rift System, USA



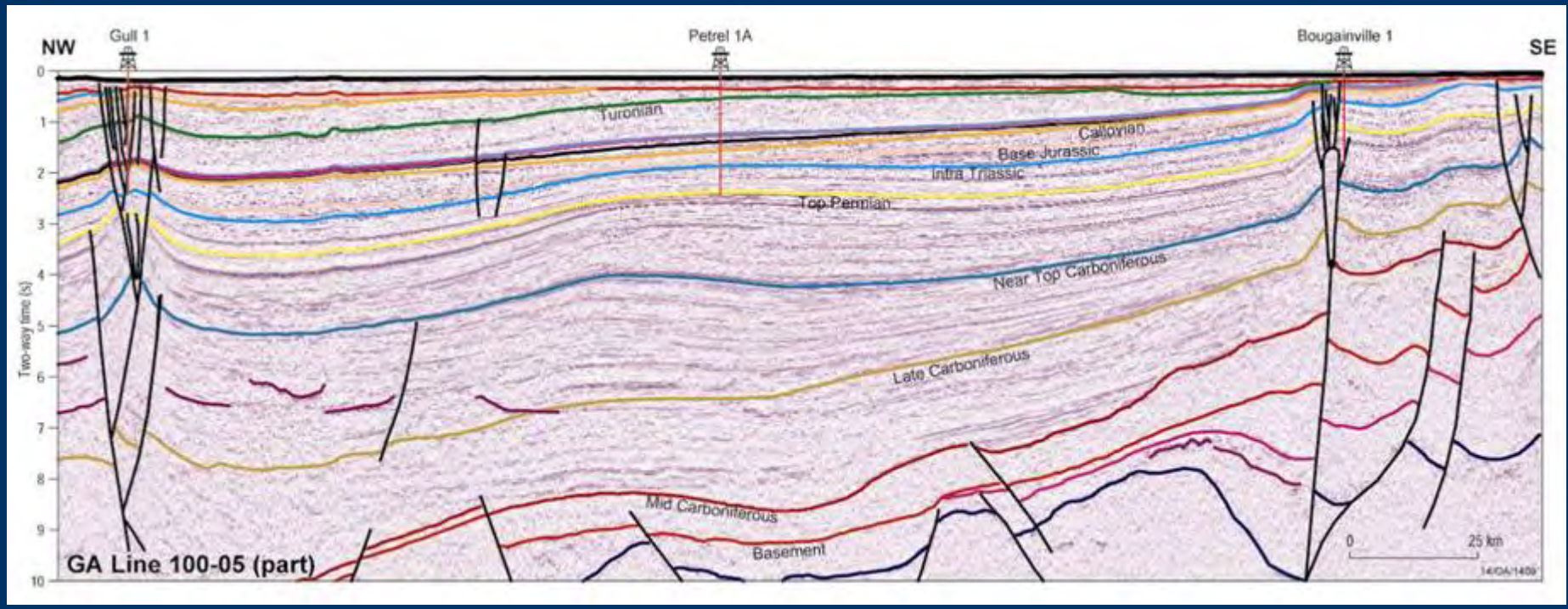


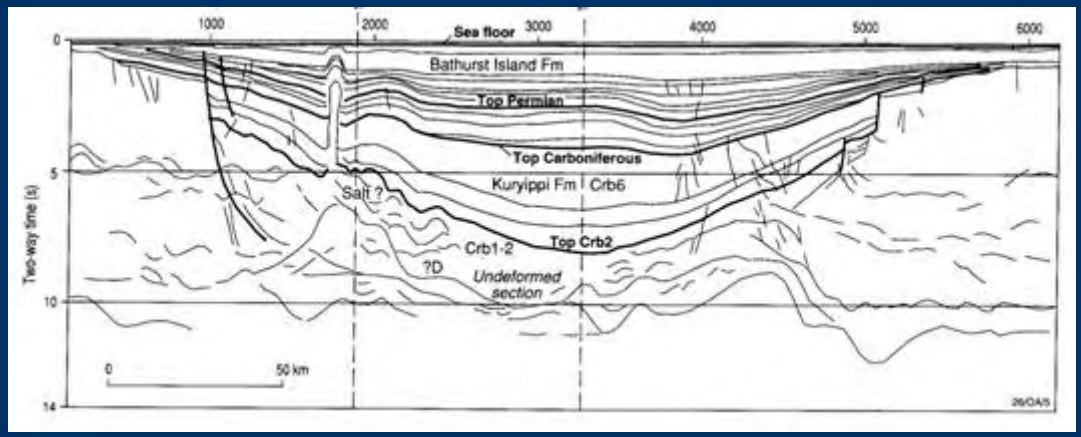
Hinze et al. (1992)

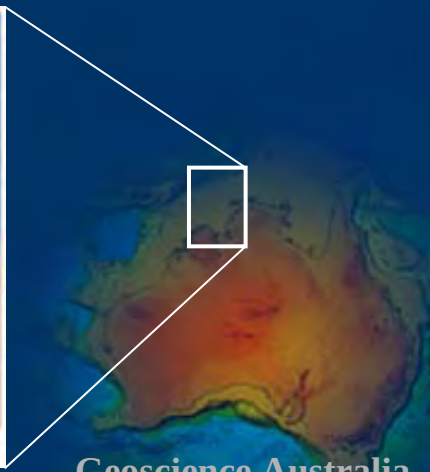
~1100 Ma

$$\frac{V}{H} = 1$$

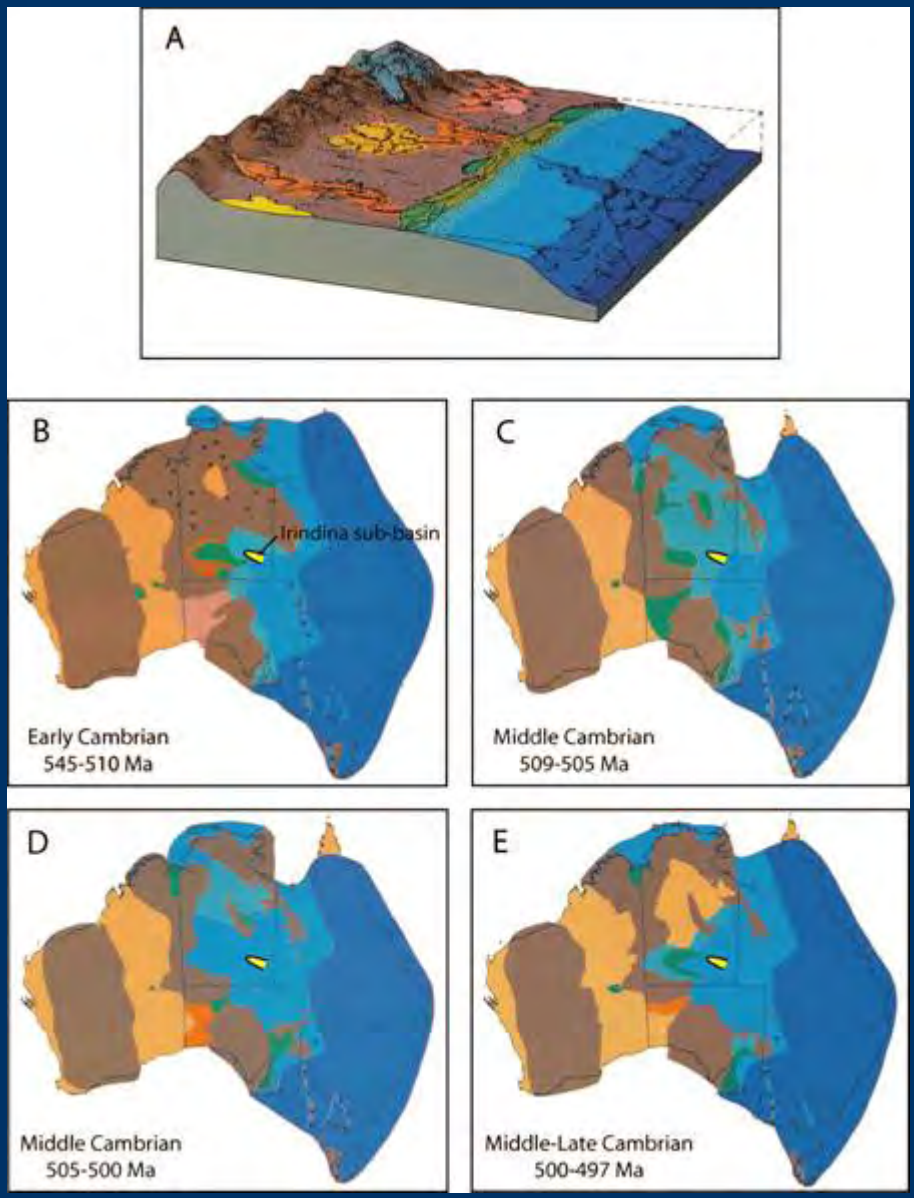
Petrel Sub-basin, NW shelf

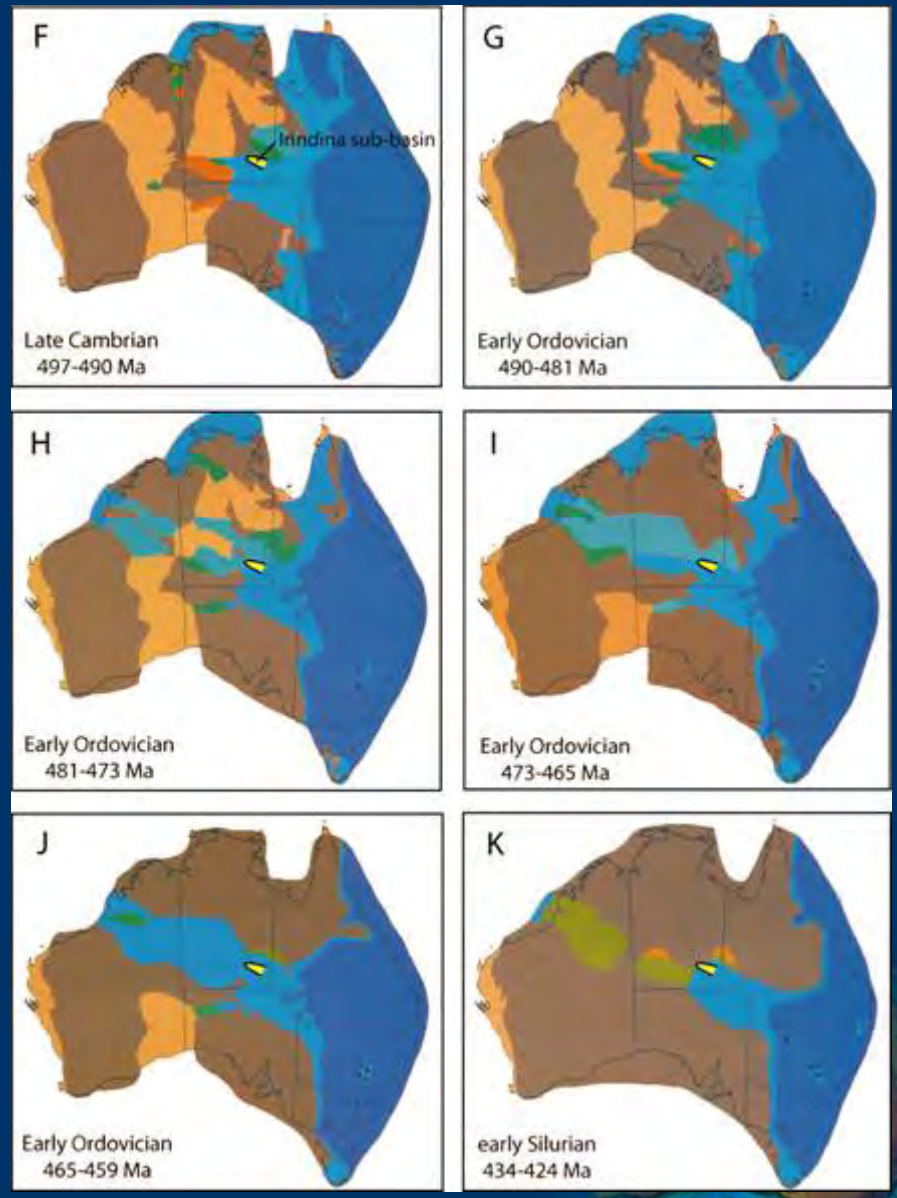






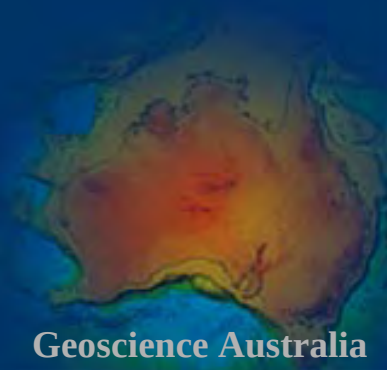
Cambrian to Silurian palaeogeography





Alice Springs Orogeny (ASO)

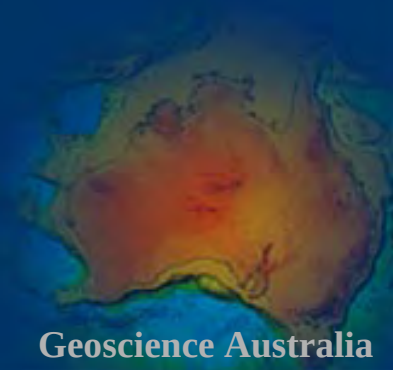
- **N-S to NE-SW shortening in central Australia between ~450 and ~300 Ma.**
- **Recognised by:**
  - **K-Ar, ^{40}Ar-^{39}Ar and Rb-Sr cooling ages in the Arunta Region.**
  - **Style and distribution of sedimentation in basins adjacent to orogen.**



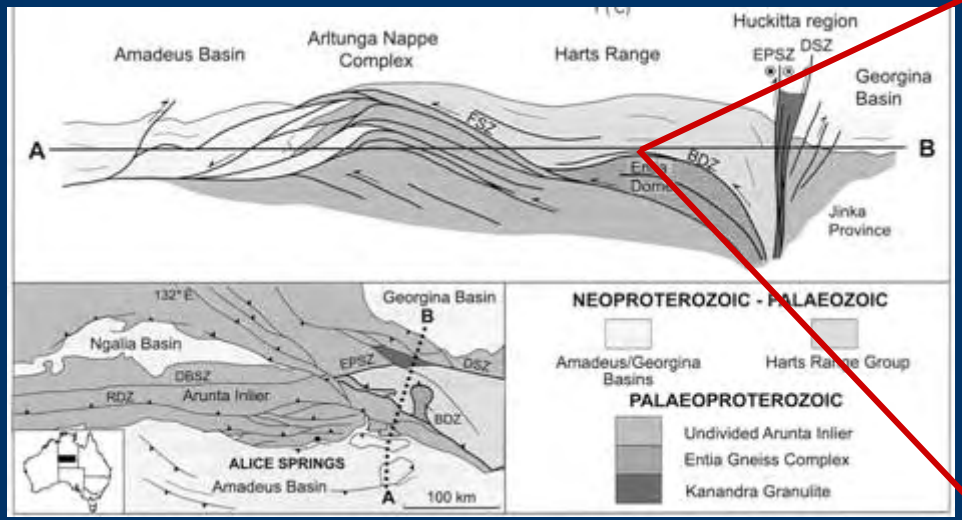
Effects and character of ASO

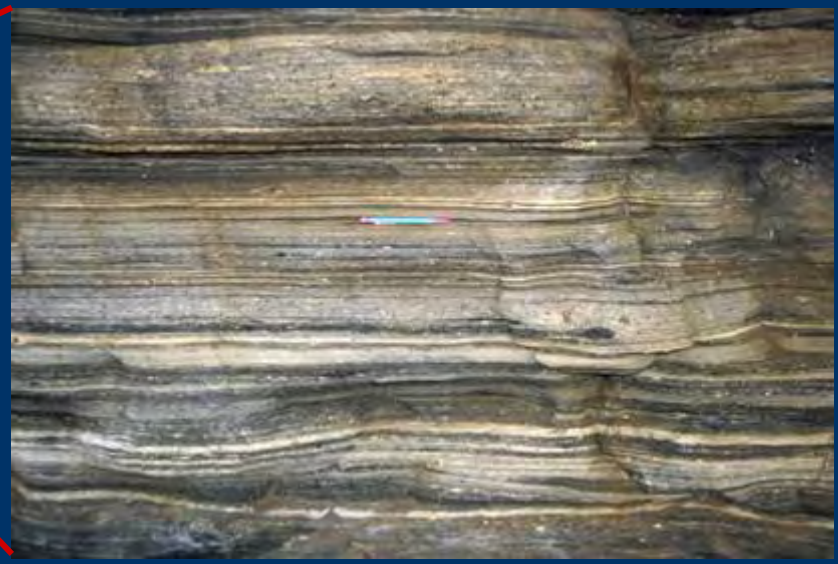
Episodic deformation, consisting of 4 major ‘movements’:

450 Ma	Rodingan
400-380 Ma	Pertnjara
370-360 Ma	Brewer
330-320 Ma	Mt Eclipse



Rodingan Movement (450 Ma)



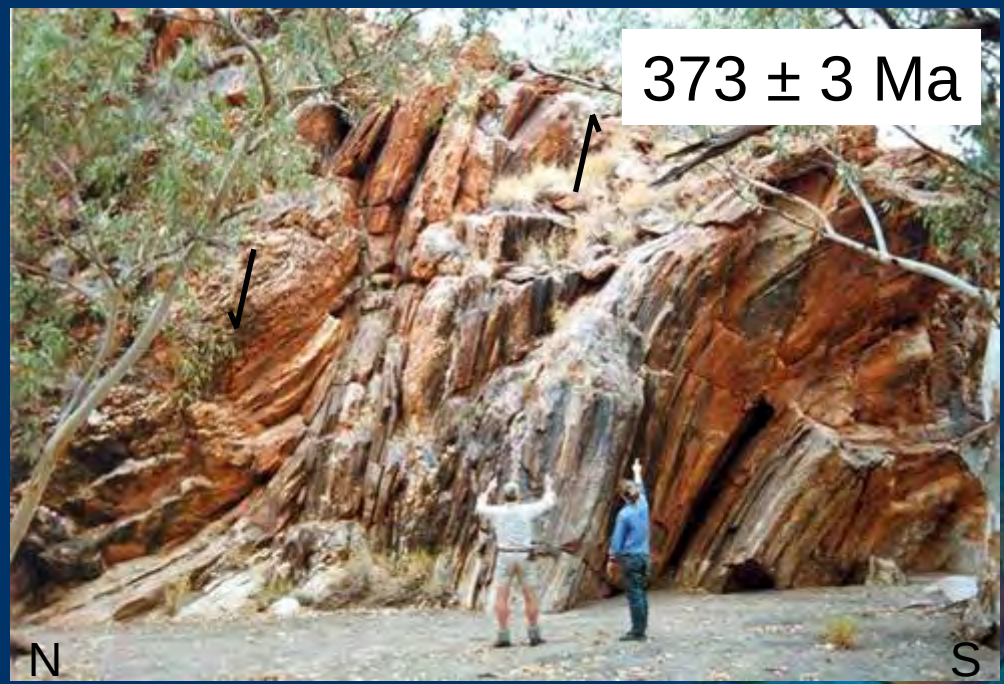


Scrimgeour & Raith (2001)

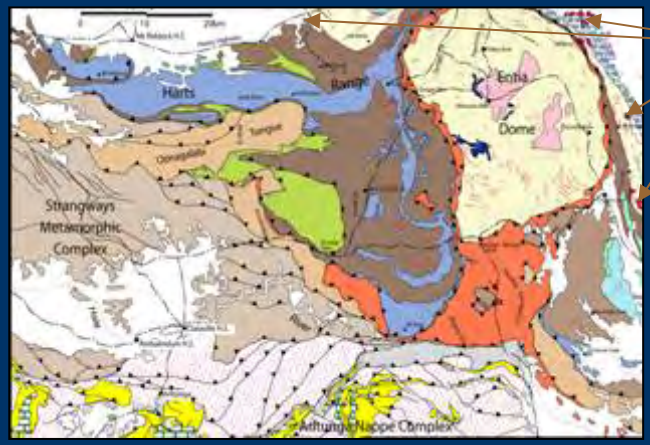
- **Uplift of eastern Arunta.**
- **South-directed thrusting of HRG over basement along mid-crustal detachment.**

Pertnjara Movement (400-380 Ma)

- N-S shortening.
- E-W trending amphibolite-facies shear zones in SMC, HRMC.
- Late extension?

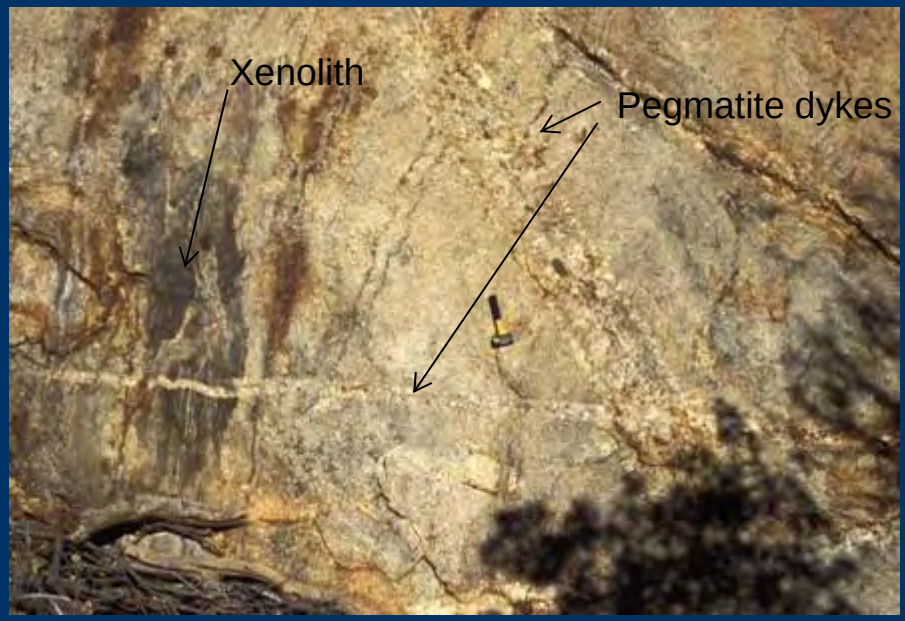


Brewer Movement (360 Ma)



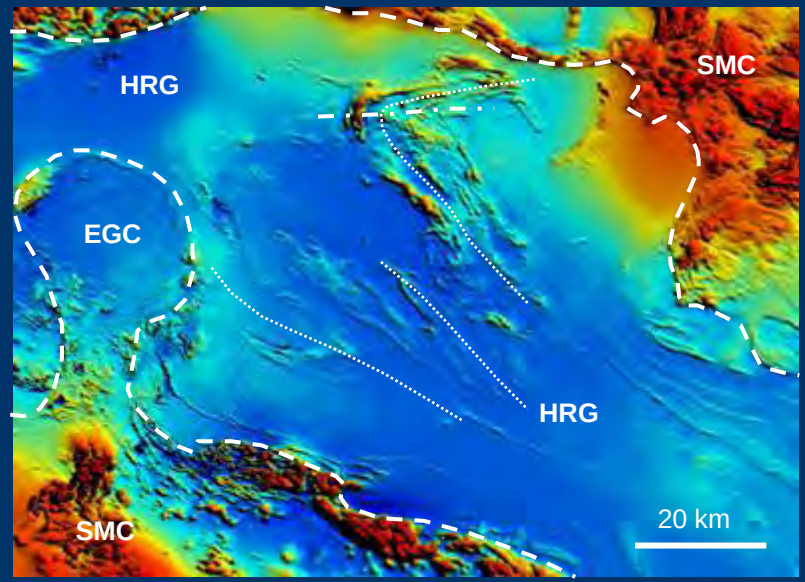
361 ± 3 Ma
Granite intrusion

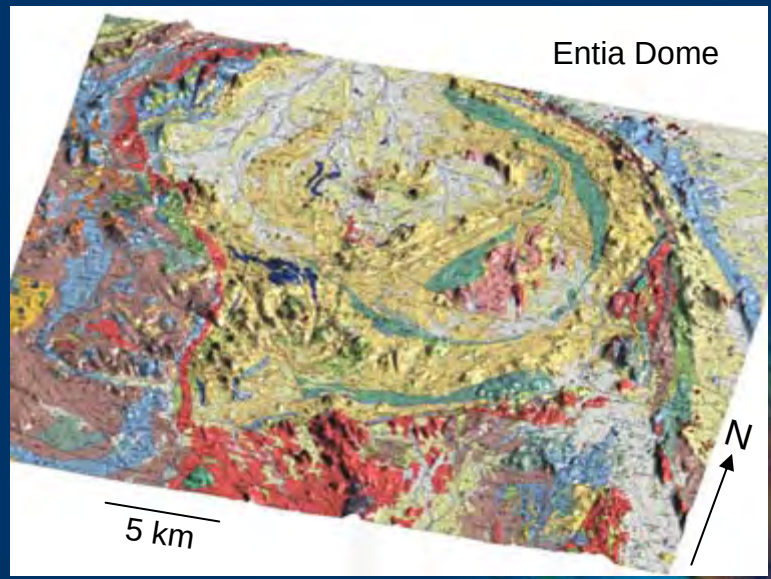
Pegmatite dykes,
metamorphism



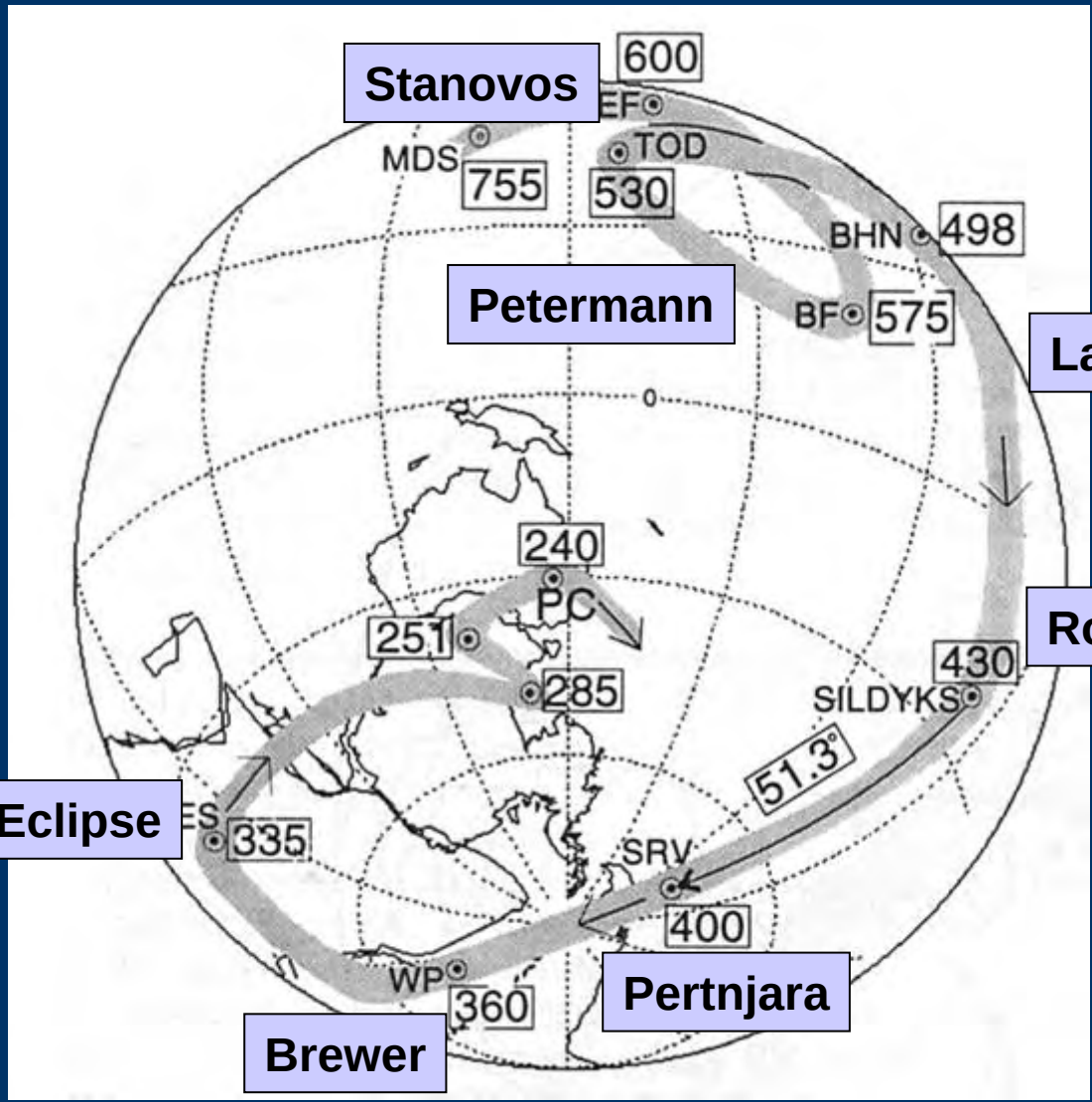
Mount Eclipse Movement (~330 Ma)

- SSW-SW vergent thrusting in Reynolds Range, ?Harts Range.
- Kyanite-grade, shallowly dipping foliation at 336 ± 3 Ma.
- Met^{m} in EGC 332 ± 3 Ma.
- Late doming and exhumation.





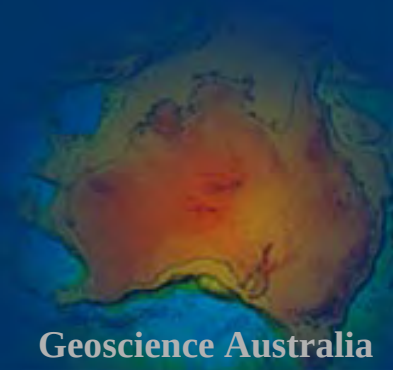
Apparent Polar Wander Path



Schmidt & Clarke (2000)

Post-1550 Ma mineralisation

- Mordor (PGE-Cu-Au-Ni) – 1132 ± 5 Ma
- Mud Tank (vermiculite) – 732 ± 5 Ma
- Nolans Bore (REE) – 400-300 Ma?
- Arltunga (Au) – 300-290 Ma
- Harts Range mineral sands (grt, hbl), Recent



Harts Range vs Broken Hill

Feature	Broken Hill	Harts Range
Lower migmatitic quartzofeldspathic package	Y	Y
Middle sill-grt metapelite package with calc-silicate	Y	Y
Fe-rich metatholeiite sills/volcanics	Y	Y
Upper lower-grade metapelite lacking amphibolite	Y	Y
Early layer-parallel foliation, lineation	Y	Y
Granite intrusion ~20 m.y. after deposition	Y	Y
Upper amphibolite to granulite facies	Y	Y
Low magnetisation, structurally controlled anomalies	Y	Y
Inferred extensional setting	Y	Y
High-T, low-P	Y	Mod-P
Albitites/lower oxidised package	Y	N
Banded iron formation	Y	N

Summary

- Post-1550 Ma tectonism in the NAC largely restricted to intracratonic events in the south and east.
- High-grade metamorphism of Stanovos (520 Ma) and Larapinta (480-460 Ma) events associated with formation of deep intracratonic rift.
- 450-300 Ma Alice Springs Orogeny focussed on thermally weakened crust.
- Potential for base metal mineralisation (BHT?) in eastern Arunta.