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# Geodynamic implications of the 2012 Albany–Fraser deep seismic reflection survey: a transect from the Yilgarn Craton across the Albany–Fraser Orogen to the Madura Province

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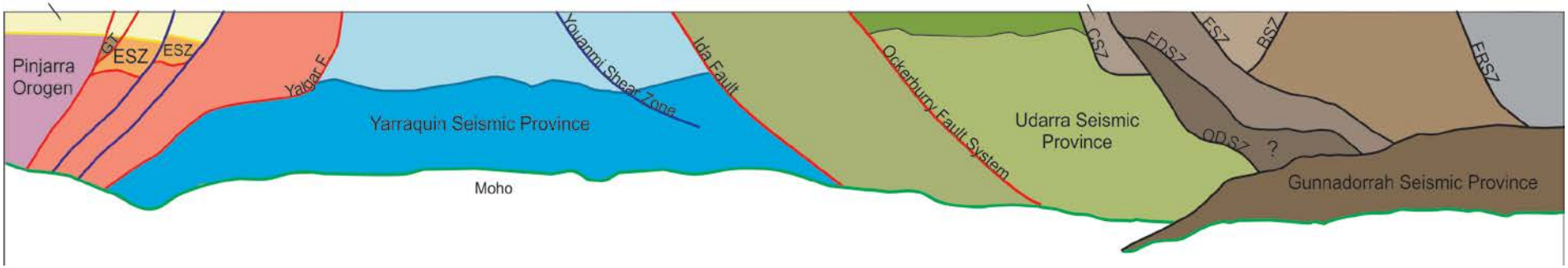


# Project Partners

Government of **Western Australia**
Department of **Mines and Petroleum**

**Australian Government**
**Geoscience Australia**

AngloGold Ashanti

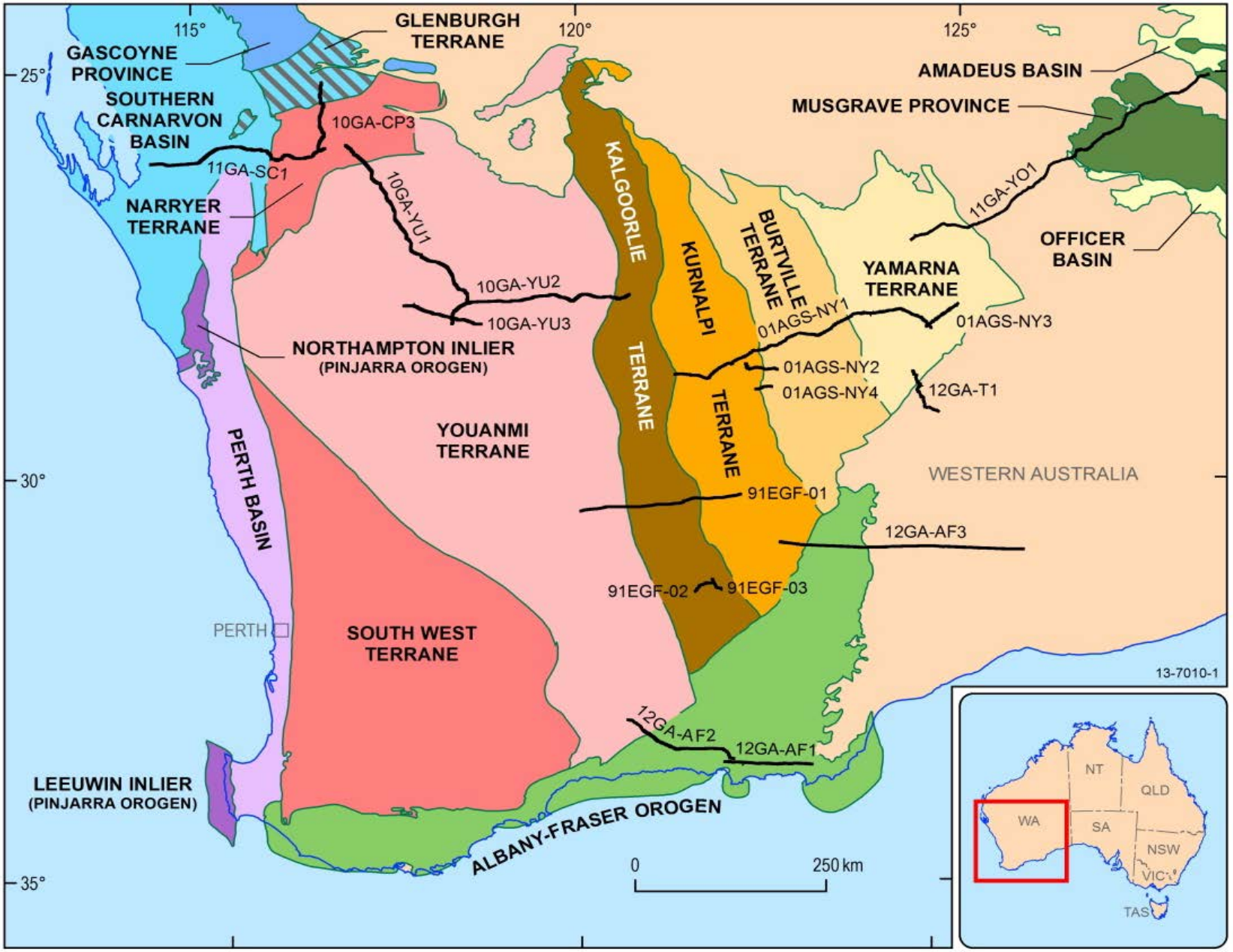
Independence Group

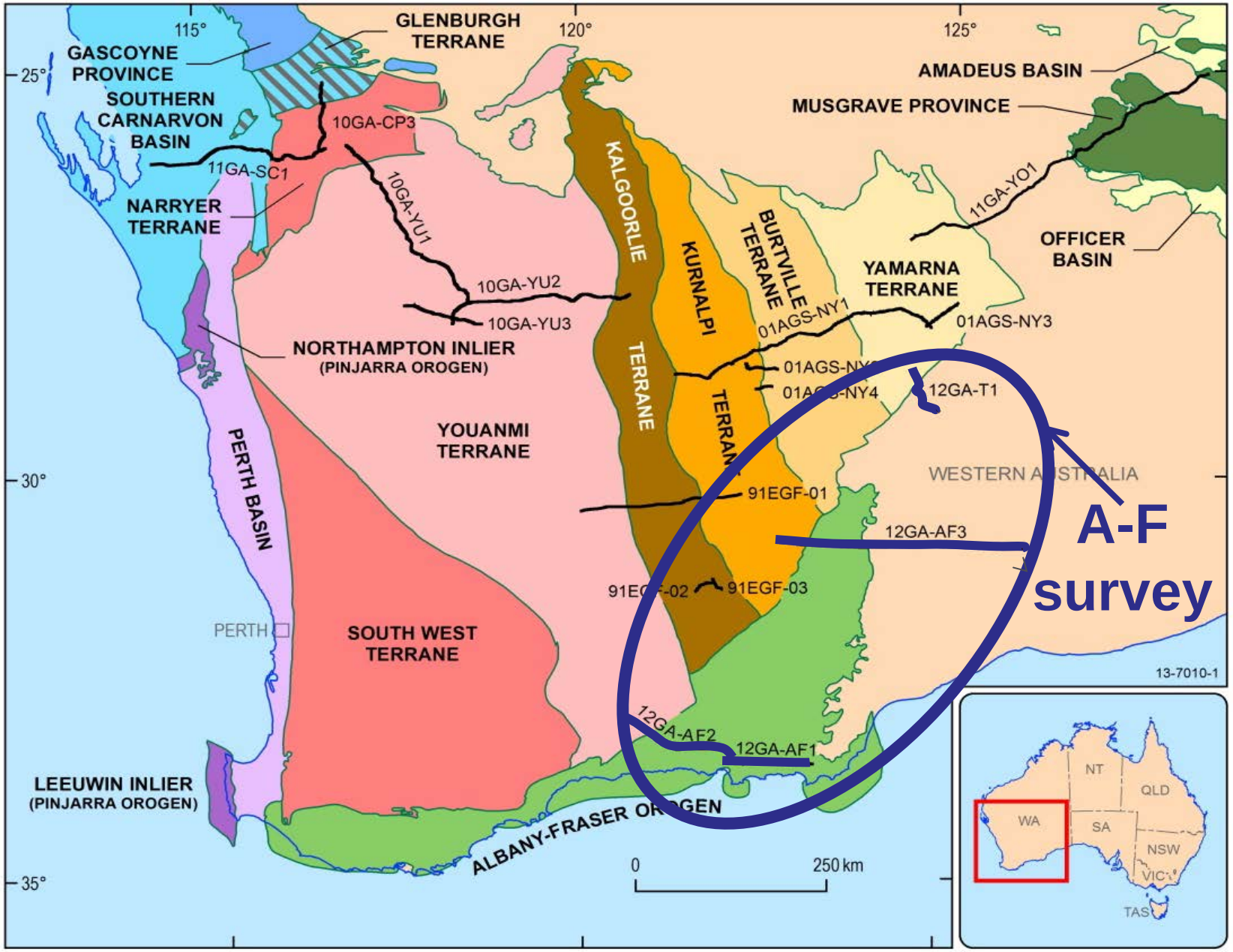
Geological Survey of Western Australia

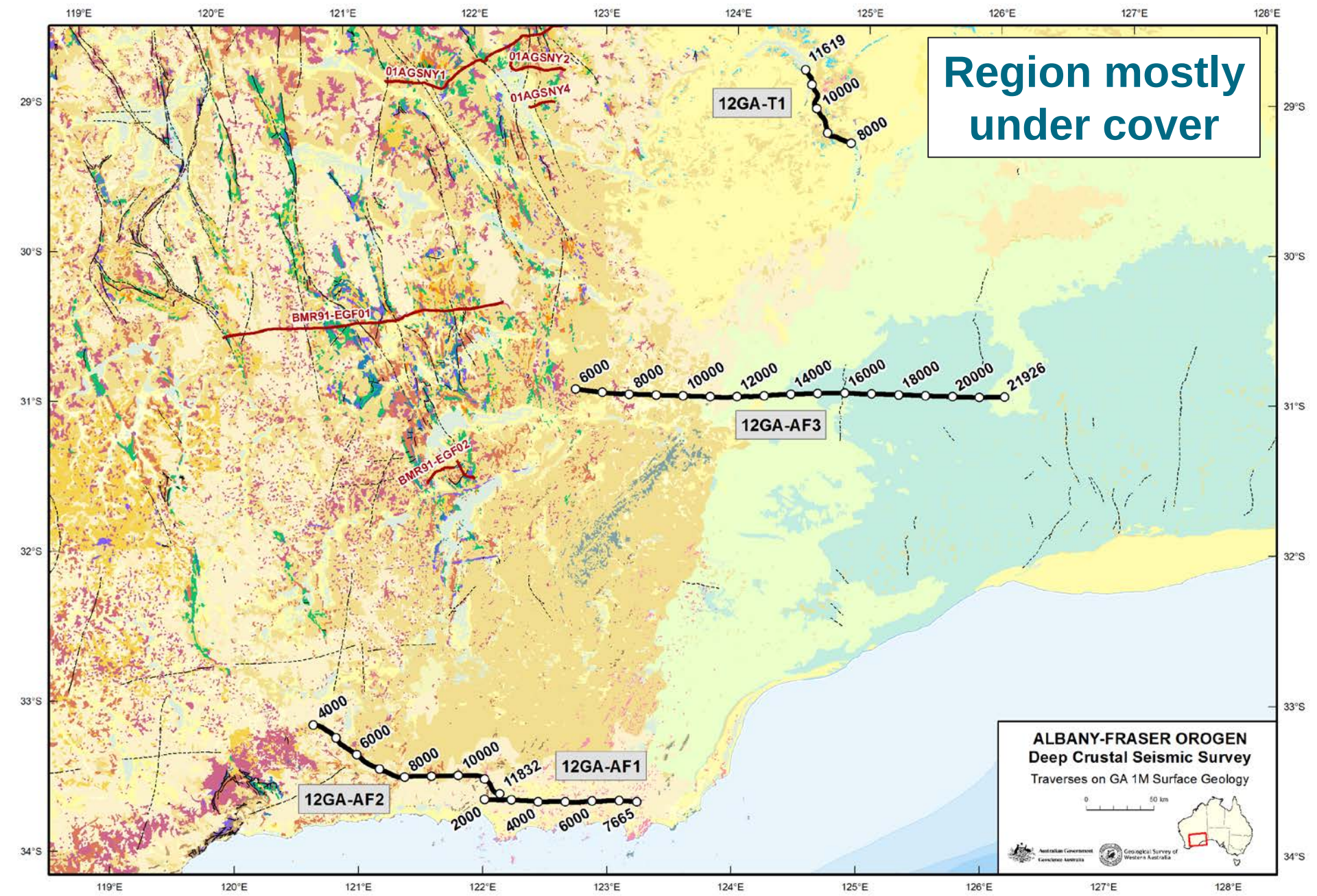
ROYALTIES FOR REGIONS
EXPLORATION INCENTIVE SCHEME

## Contributors

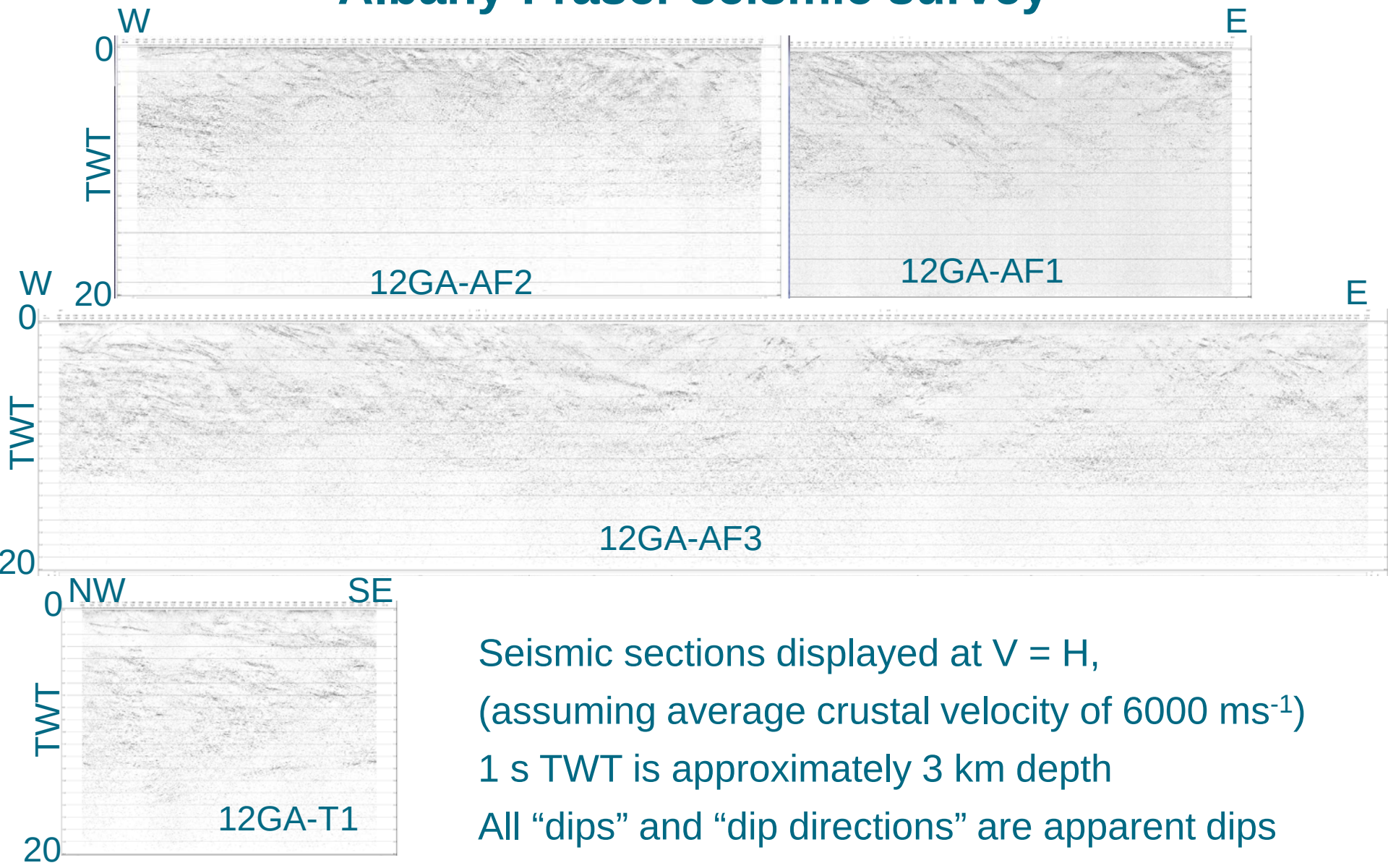
RSES, Australian National University
CET, University of Western Australia
GEMOC, Macquarie University







# Albany-Fraser seismic survey



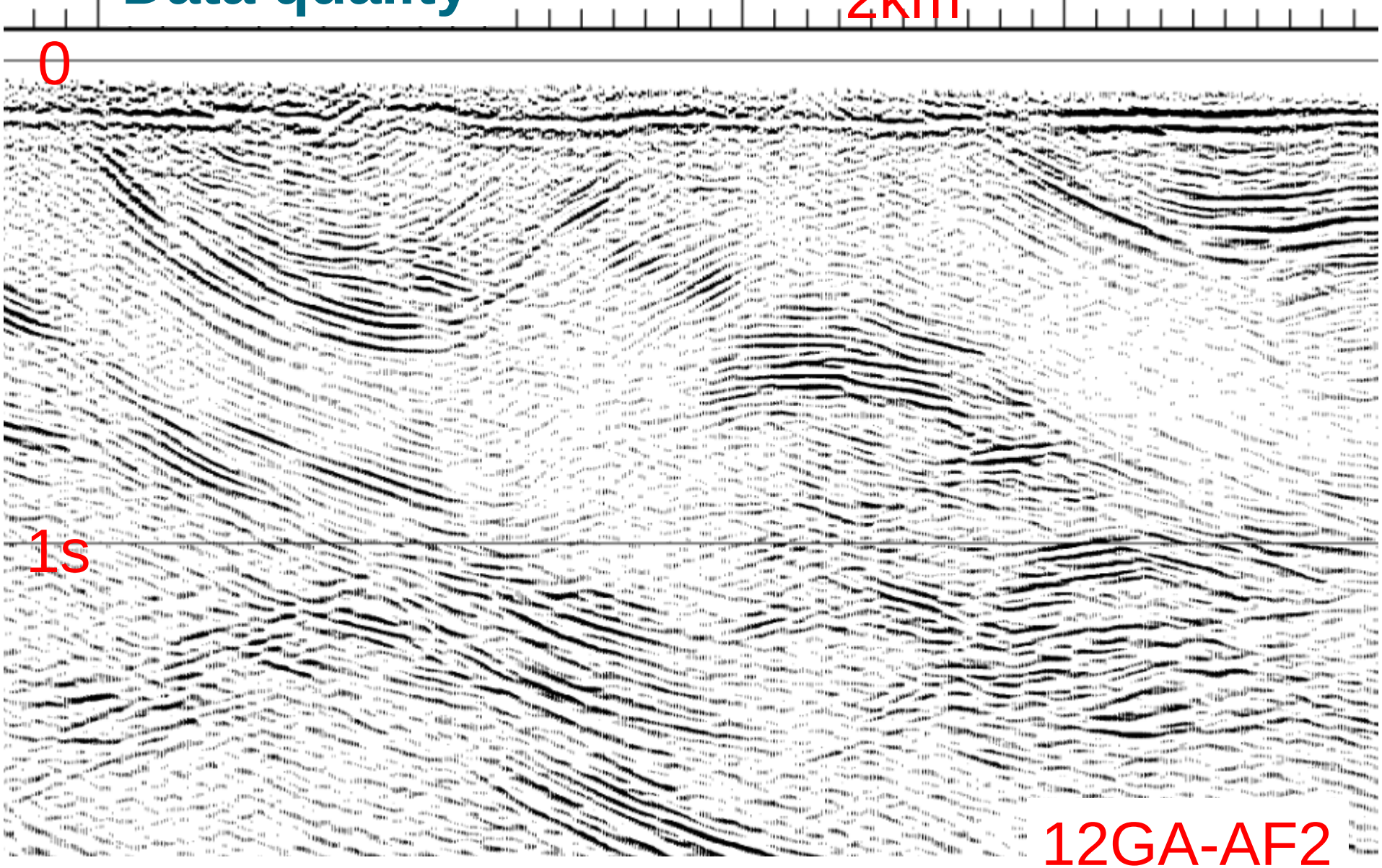

Seismic sections displayed at V = H,

(assuming average crustal velocity of 6000 $ms^{-1}$)

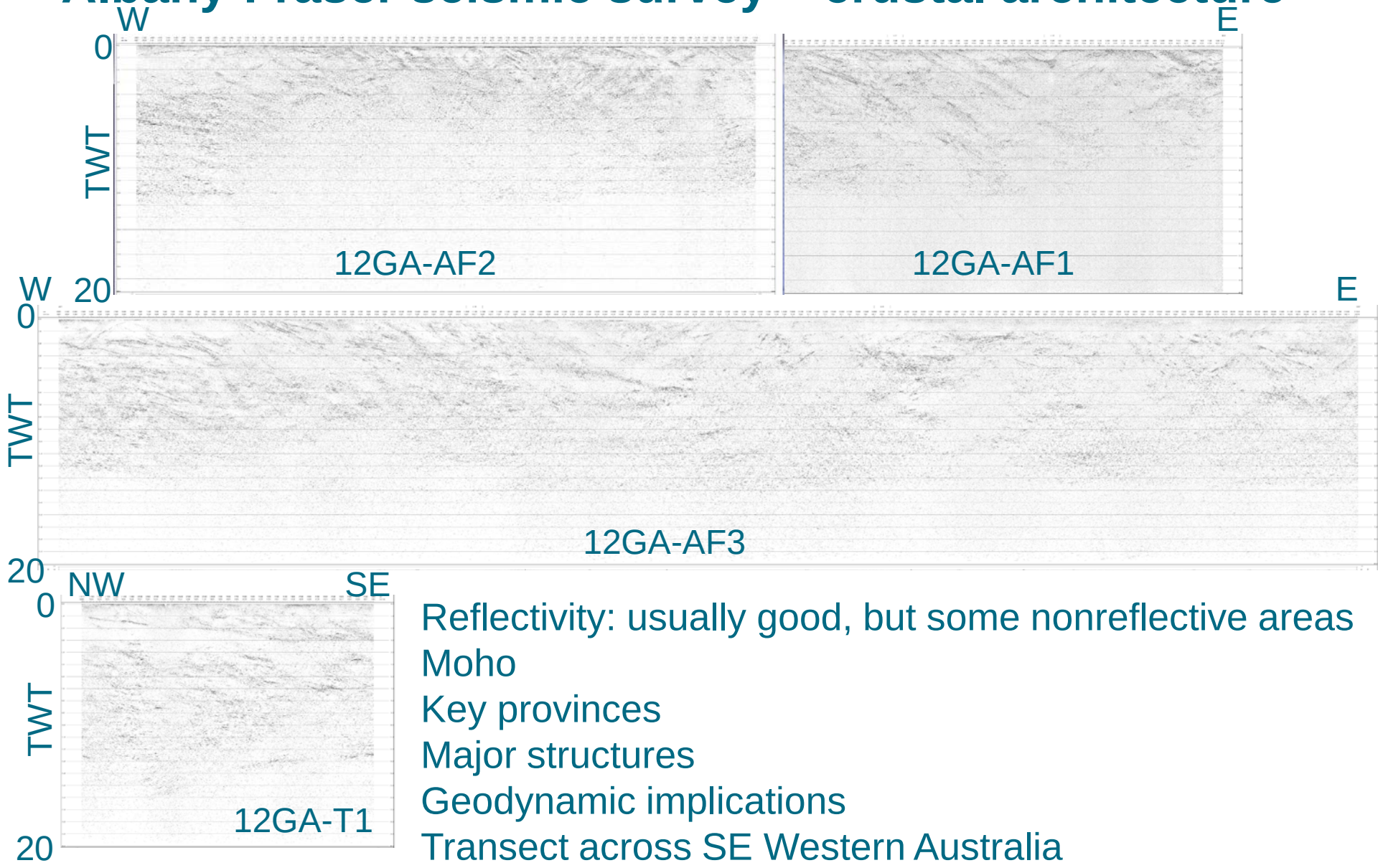
1 s TWT is approximately 3 km depth

All “dips” and “dip directions” are apparent dips

# Data quality

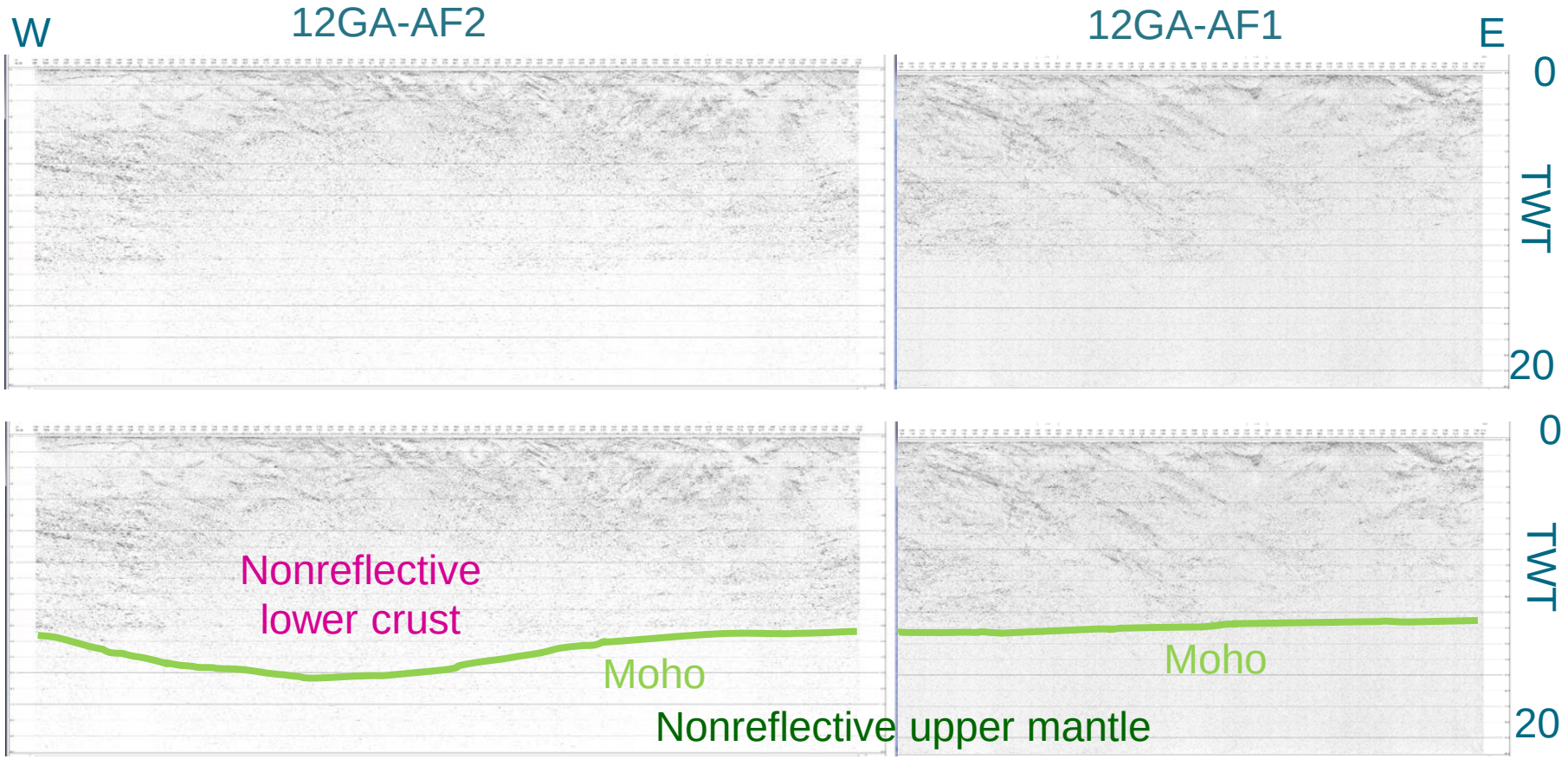


# Albany-Fraser seismic survey – crustal architecture



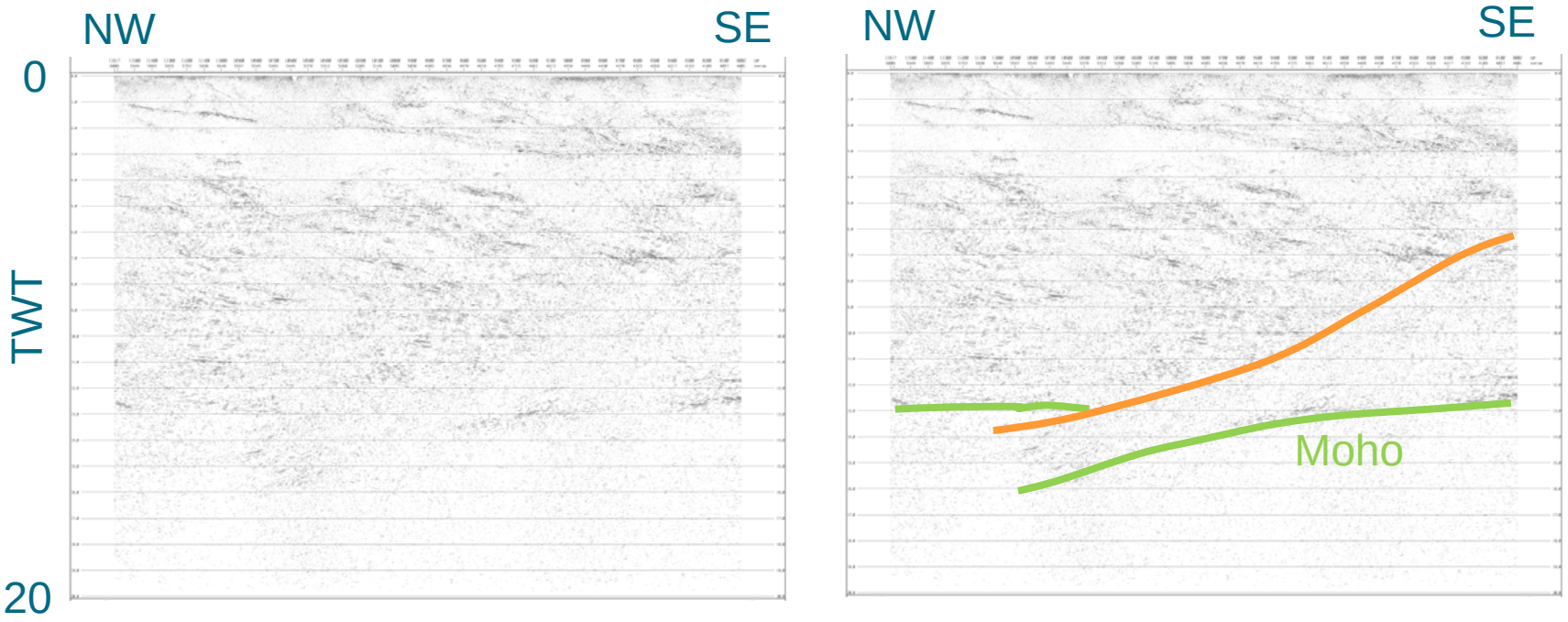

Reflectivity: usually good, but some nonreflective areas
Moho
Key provinces
Major structures
Geodynamic implications
Transect across SE Western Australia

# Structure of the Moho – 12GA-AF1 and 12GA-AF2



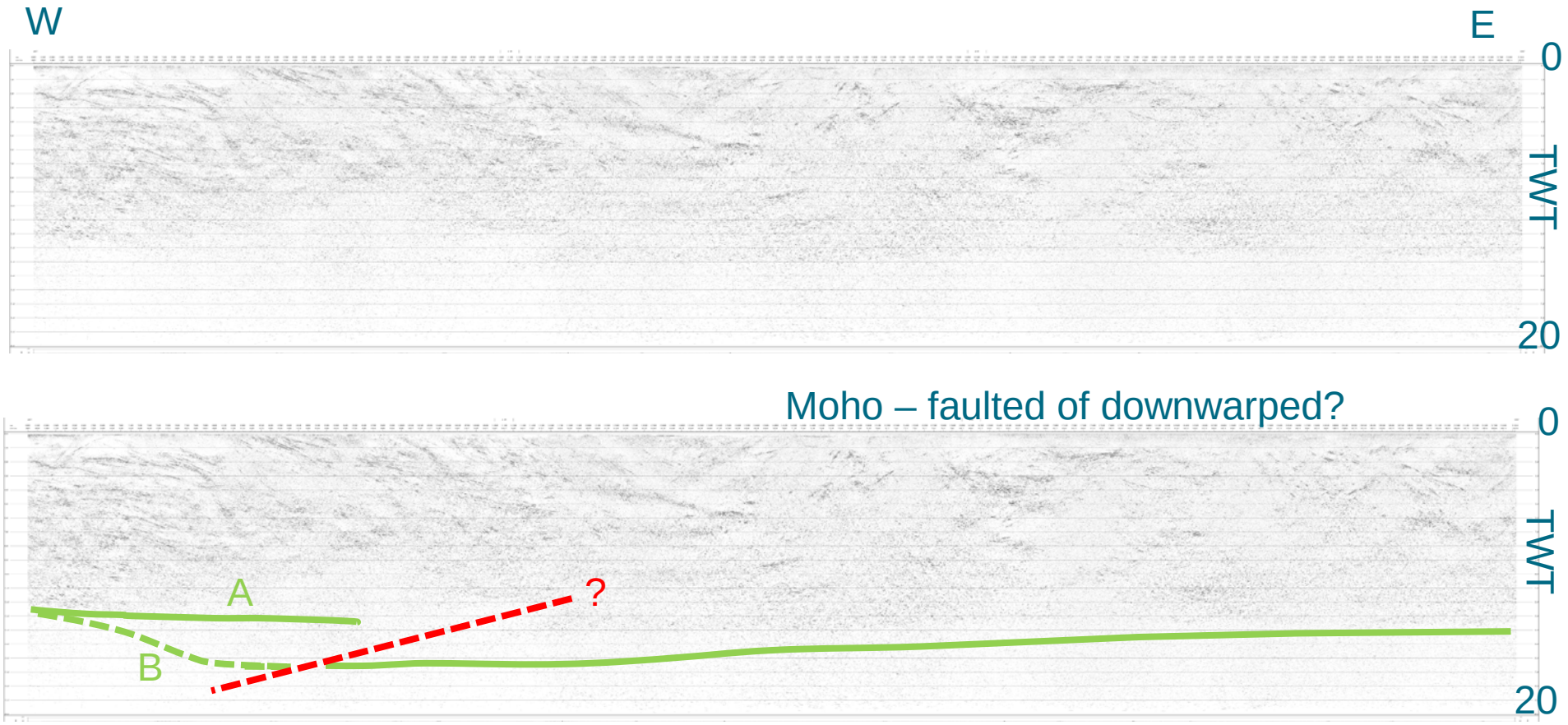

Moho strongly to weakly reflective
Crust ~35-46 km thick
Crust thicker beneath nonreflective region

# Structure of the Moho – 12GA-T1



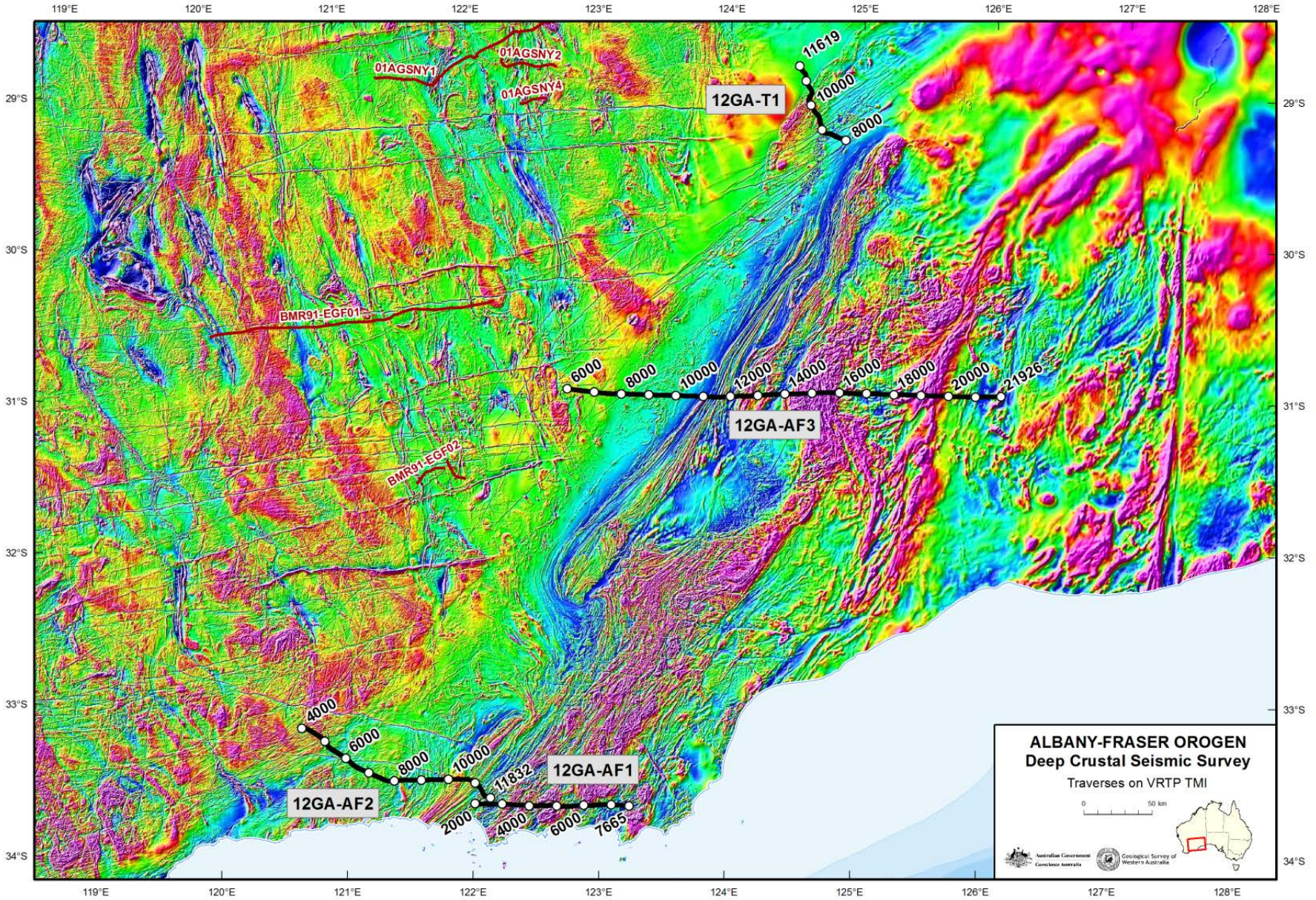

Moho moderately reflective
Moho possibly faulted on seismic line 12GA-T1
Crust 39-49 km thick

# Structure of the Moho – 12GA-AF3

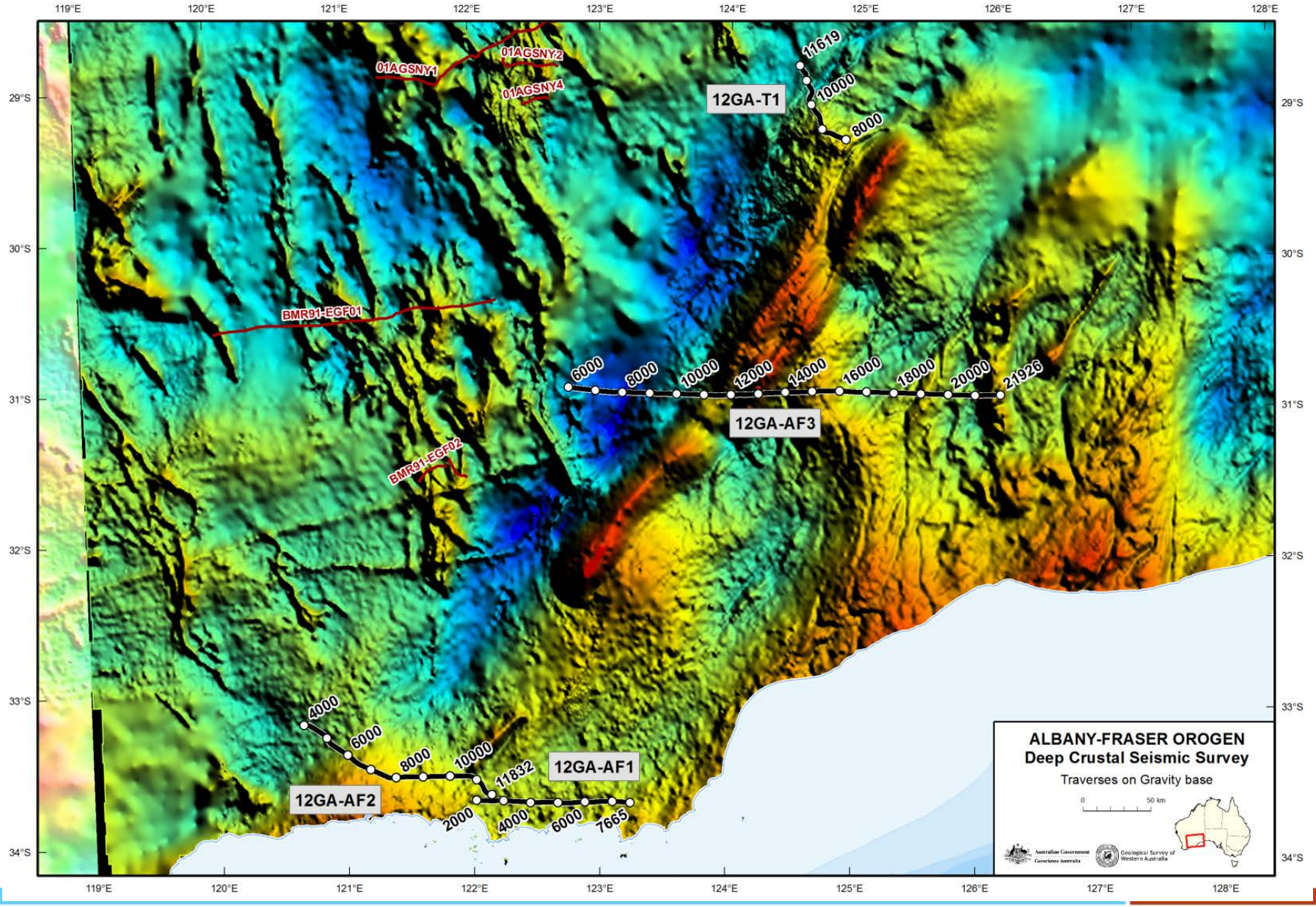



Moho moderately to weakly reflective
Moho faulted (A) or downwarped (B)?
Crust 39-49 km thick

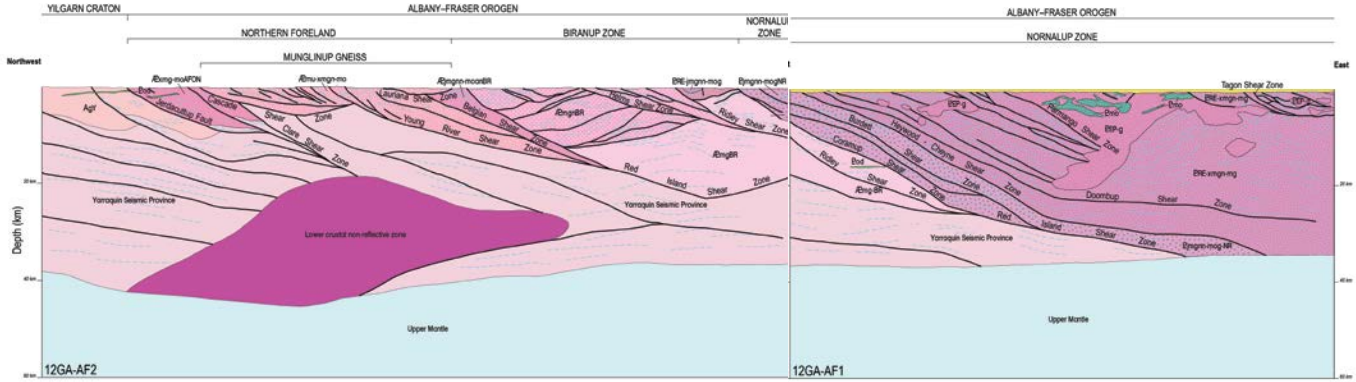
# Albany-Fraser seismic survey – key crustal provinces

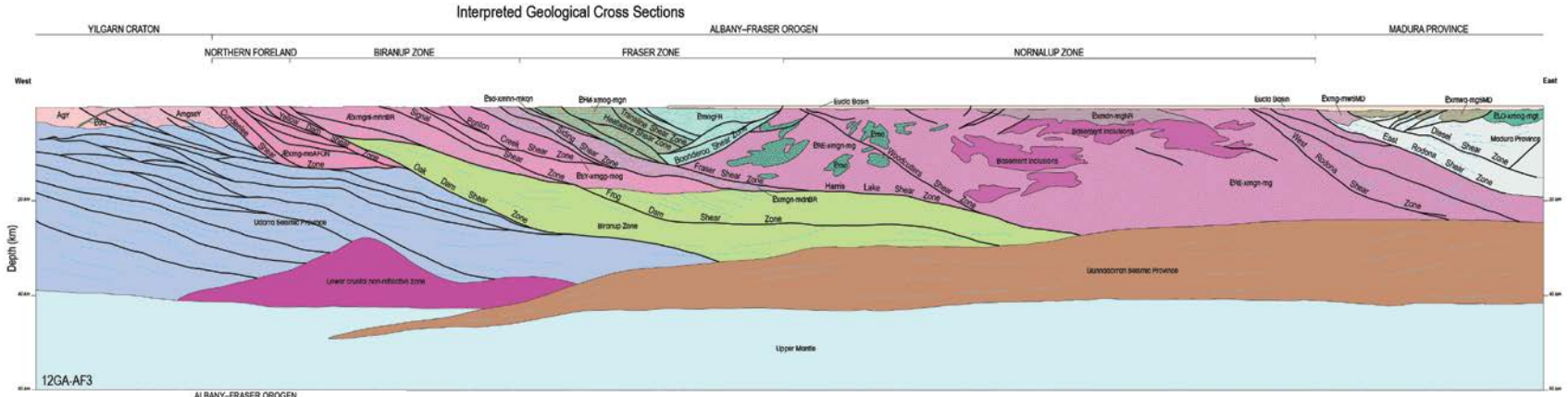


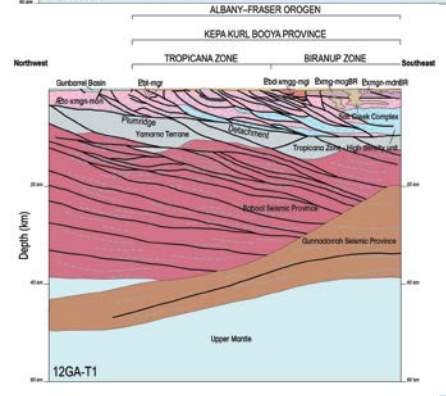
# Albany-Fraser seismic survey – key crustal provinces



# Albany-Fraser seismic survey – key crustal provinces

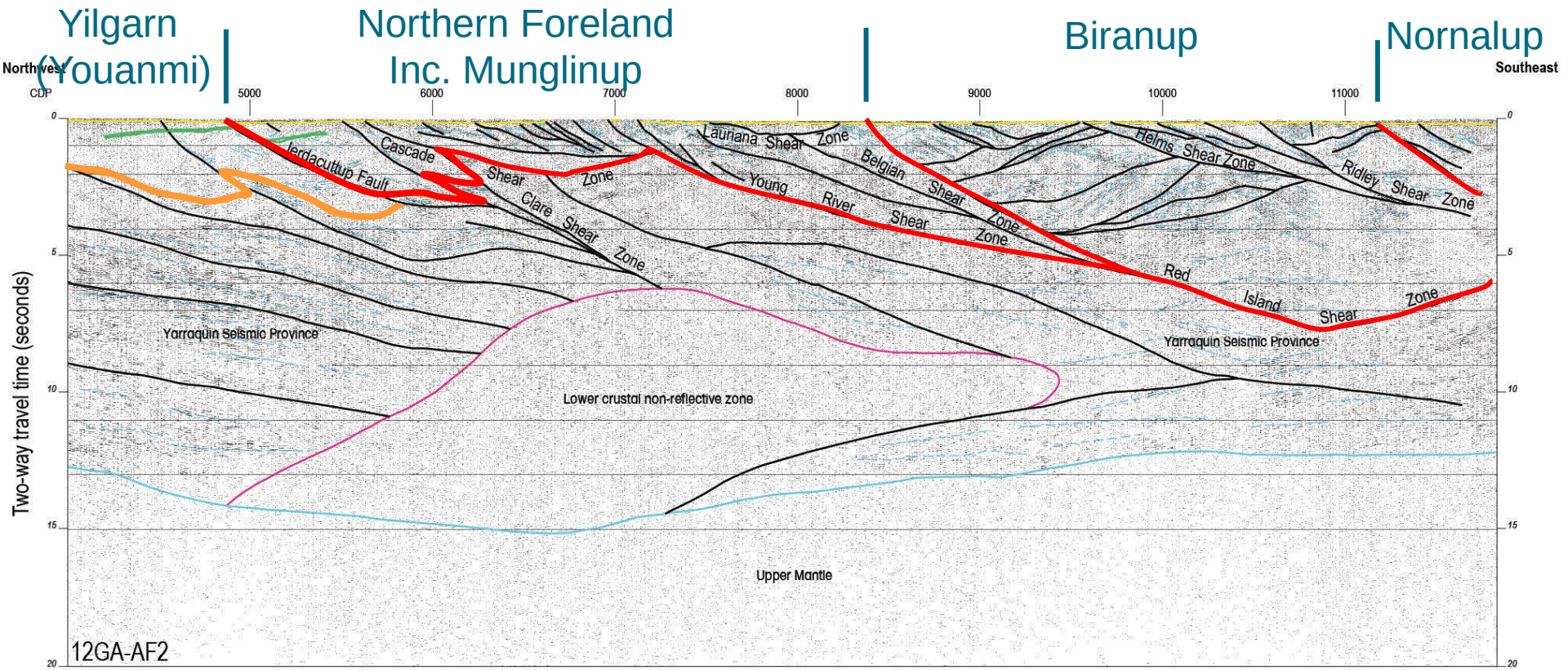


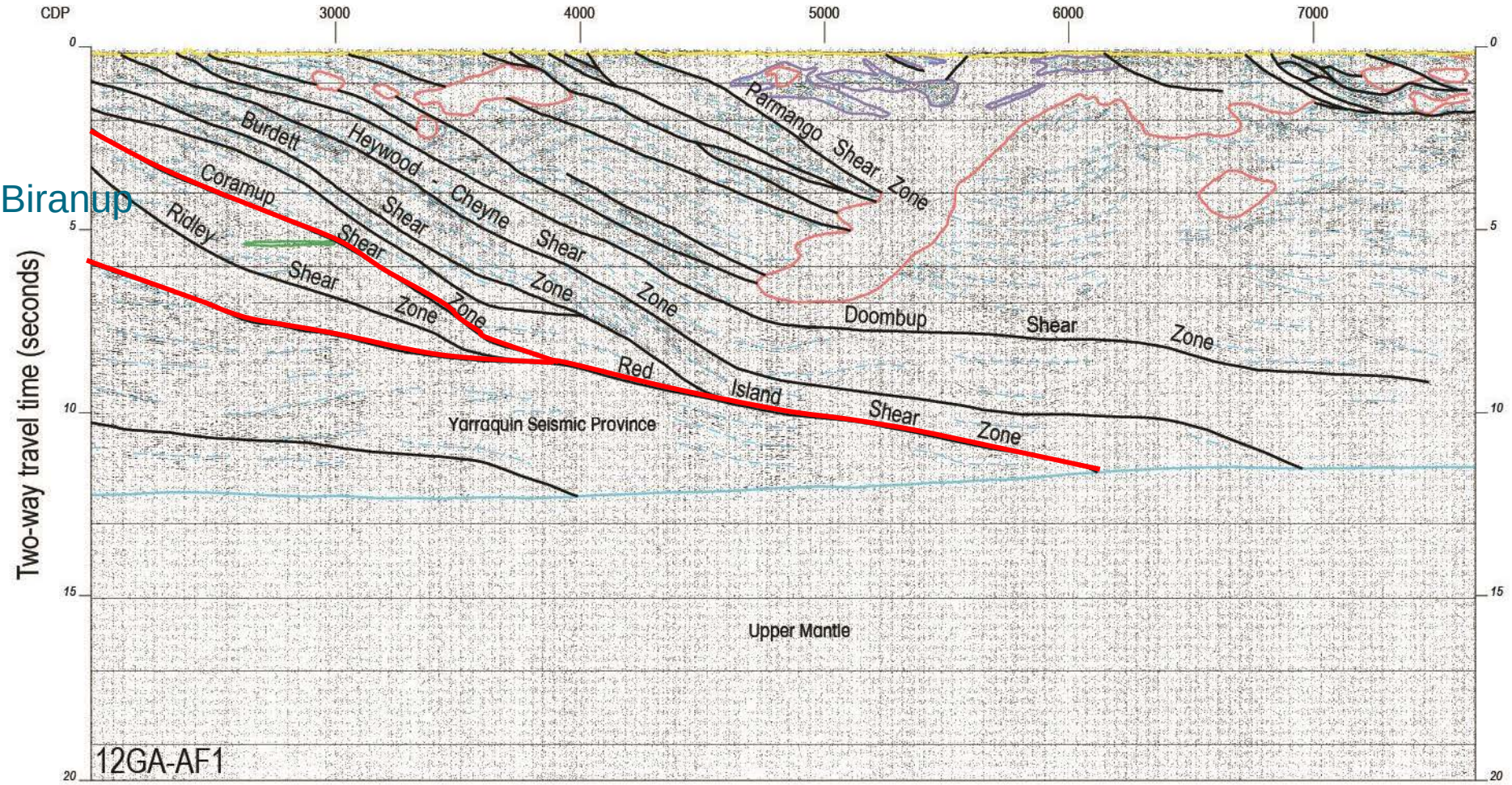




Yilgarn – Youanmi, Kurnalpi, Yamarna
Albany-Fraser – Northern Foreland, Tropicana
Albany-Fraser – Biranup, Fraser, Nornalup
Madura Province
Lower crustal SPs - Yarraquin, Udarra, Babool
Gunnadorrah Seismic Province

# Major crustal boundaries – 12GA-AF2

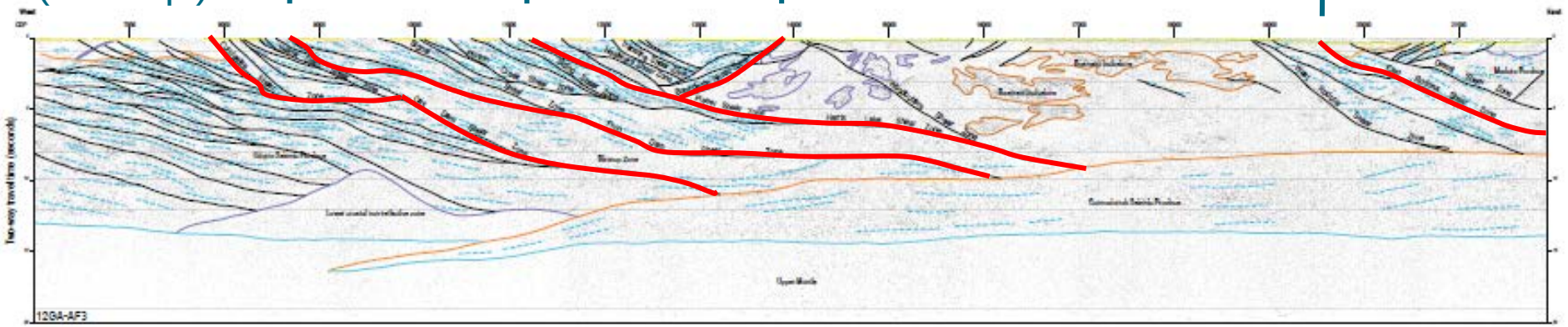


# Major crustal boundaries – 12GA-AF1

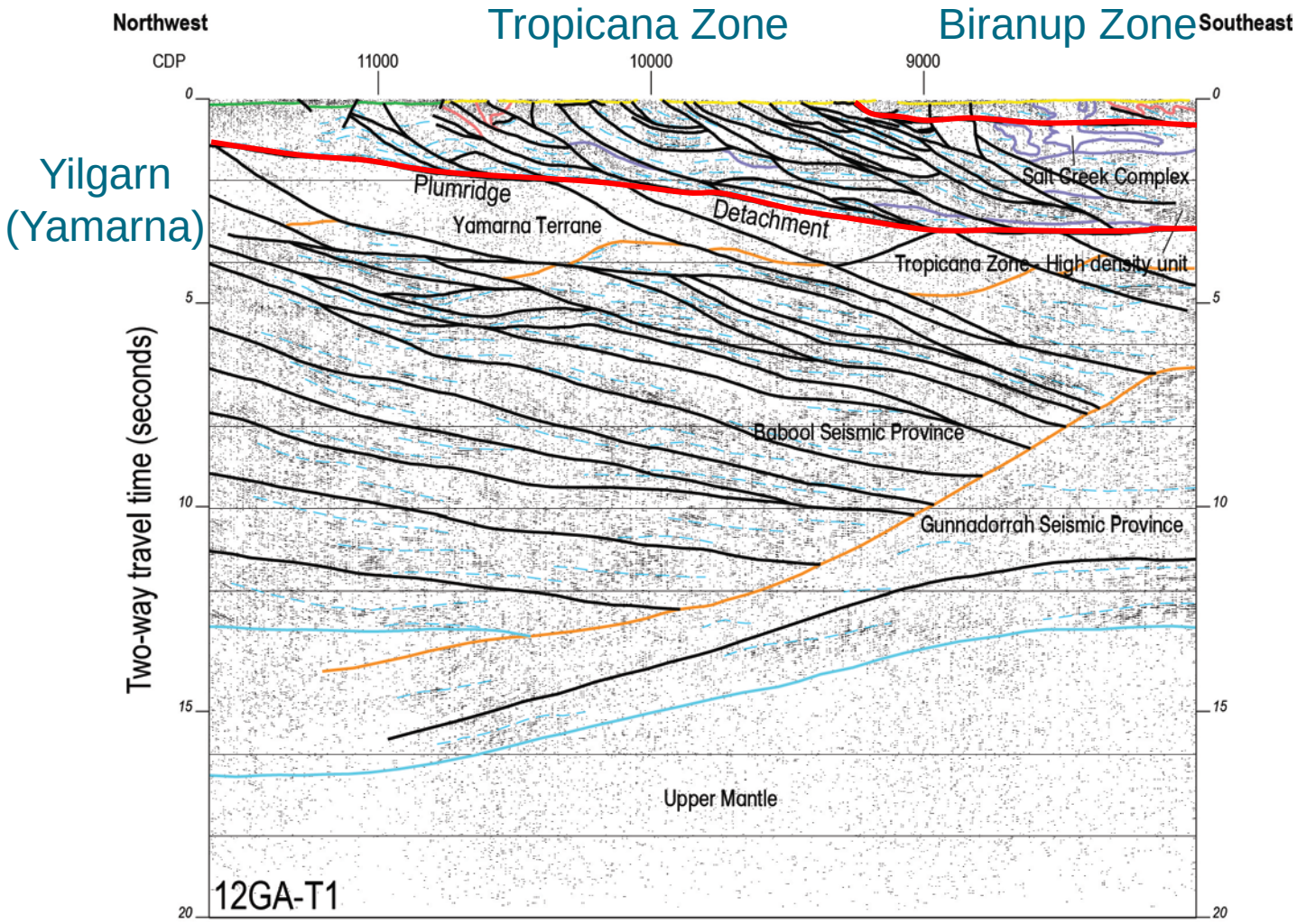


# Major crustal boundaries – 12GA-AF3

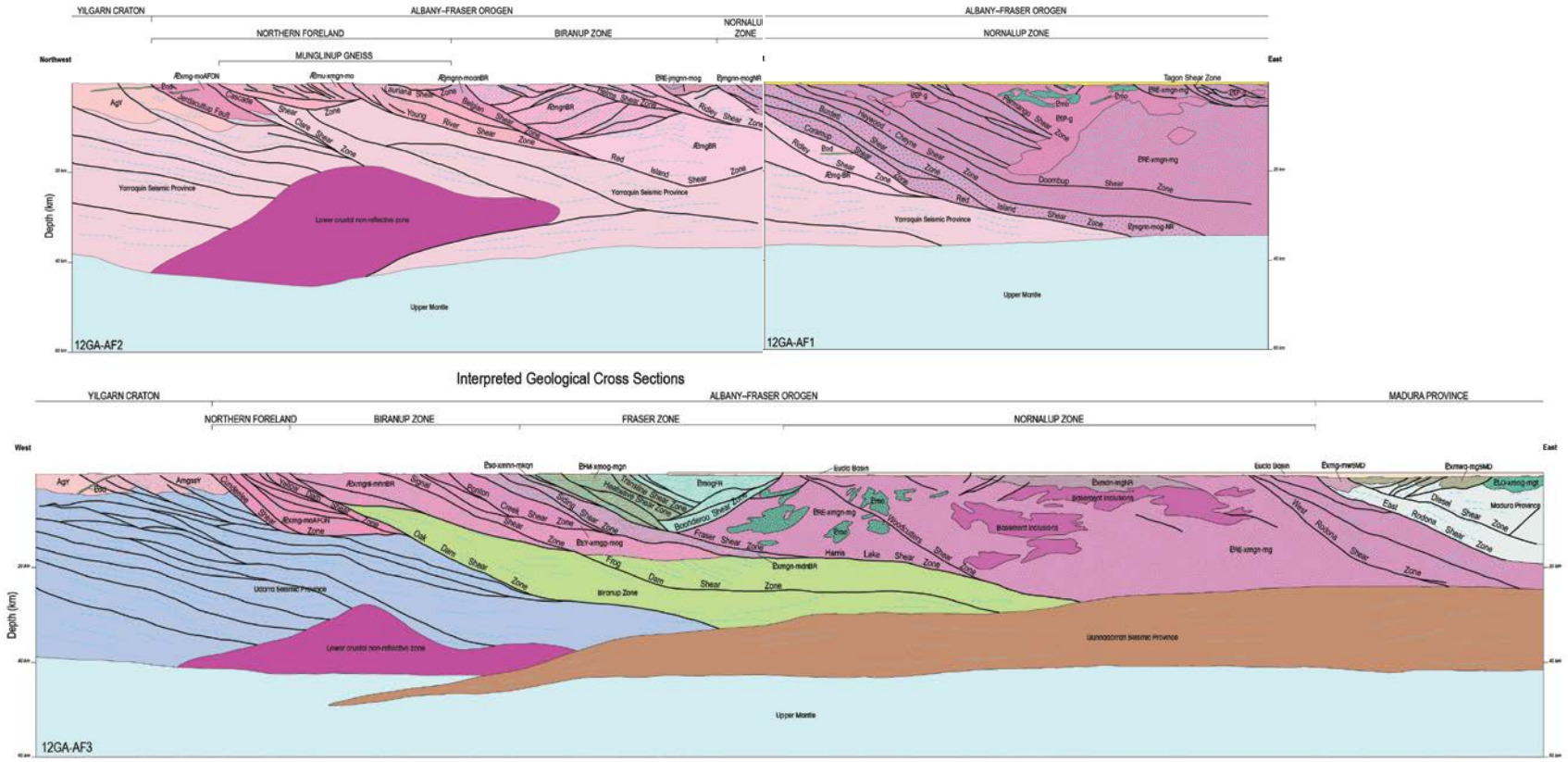
Yilgarn (Kurnalpi) | NF | Biranup | Fraser | Nornalup | Madura



# Major crustal boundaries – 12GA-T1



# Crustal deformation




Seismic sections are images of present-day crustal architecture

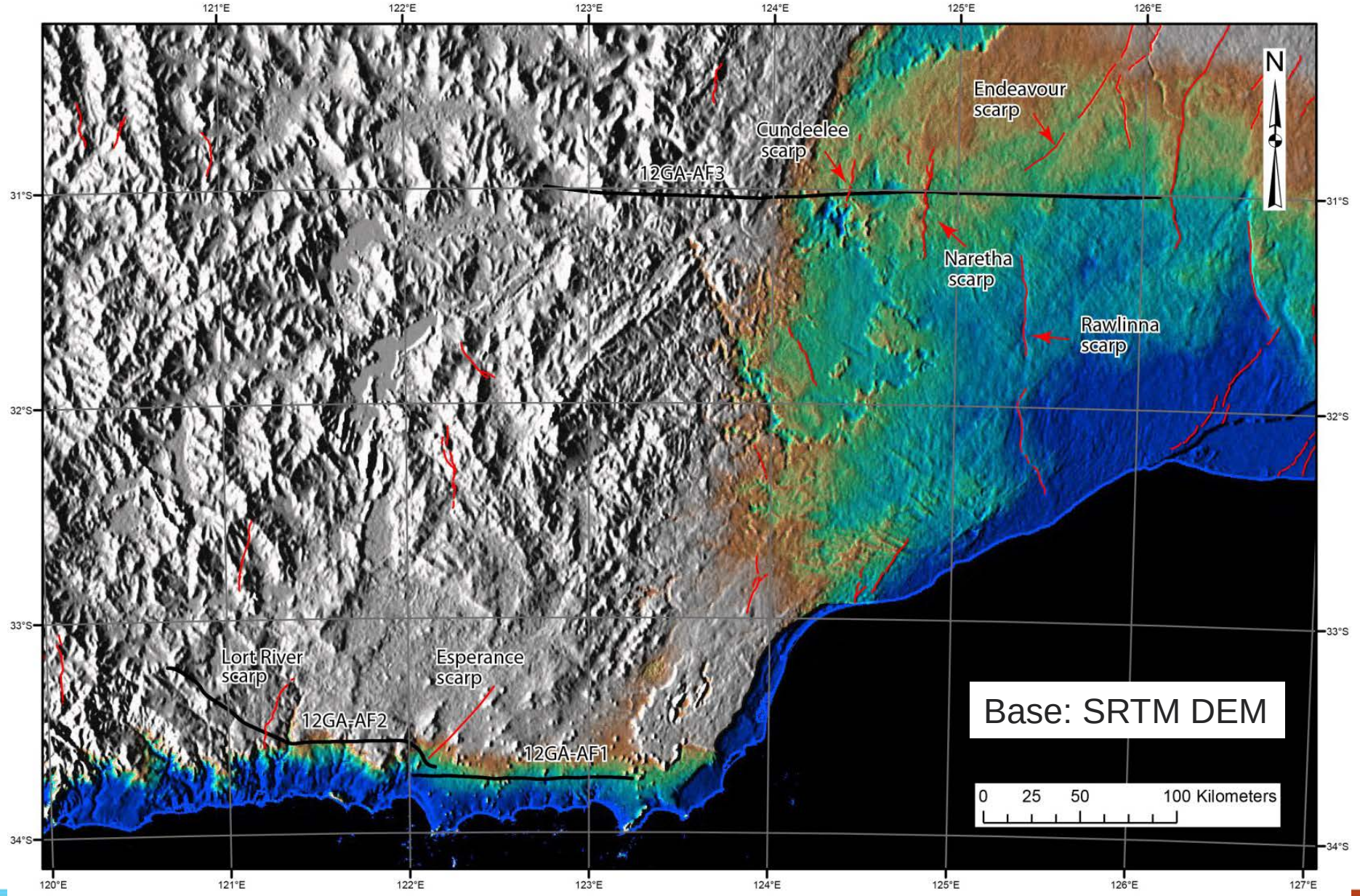
End result of numerous geological events

Structures suggest west-directed shortening was dominant

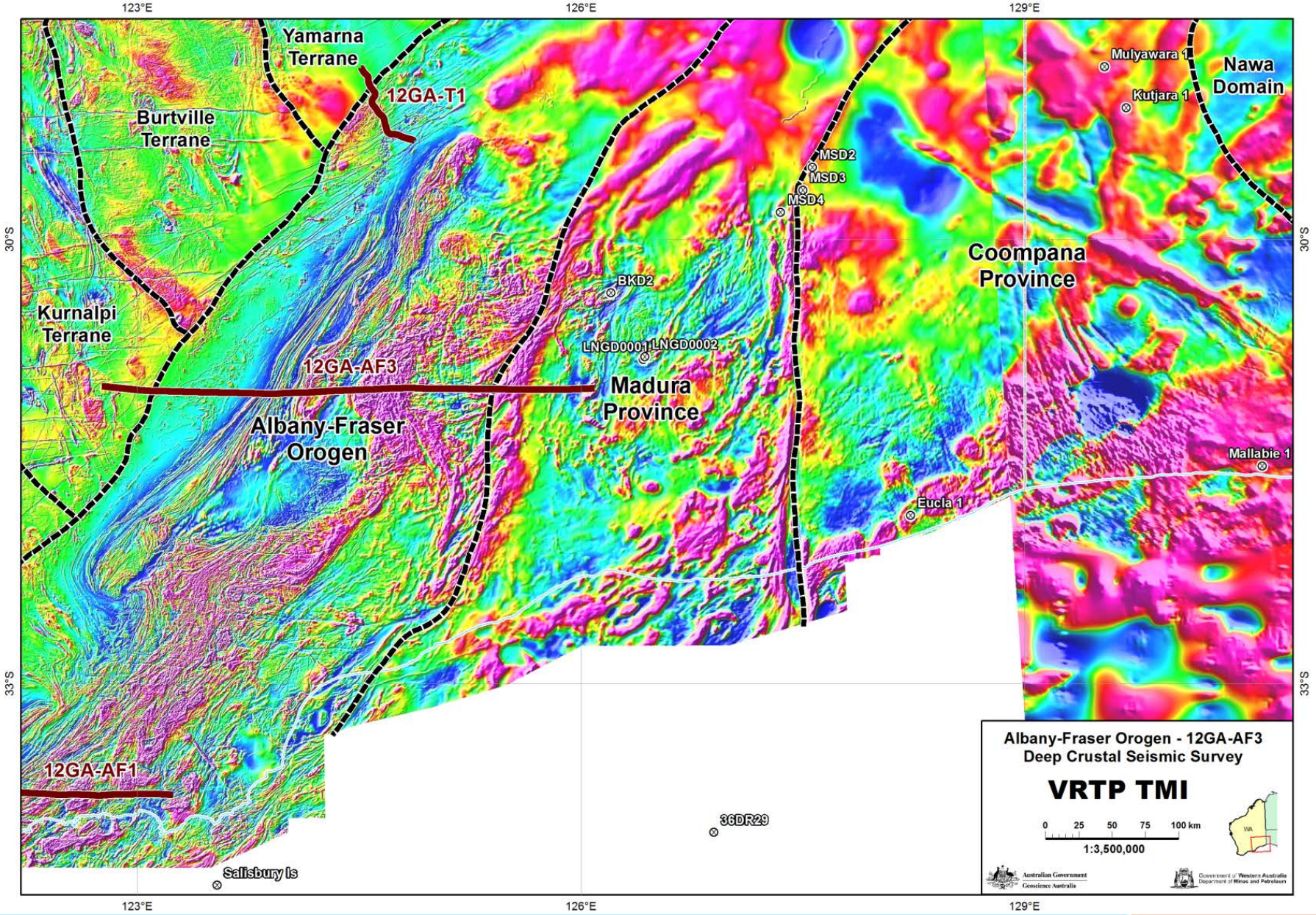
Structures formed during Albany-Fraser Orogeny Stages I & II

Plus older structures reworked during AFO

# Cenozoic structures

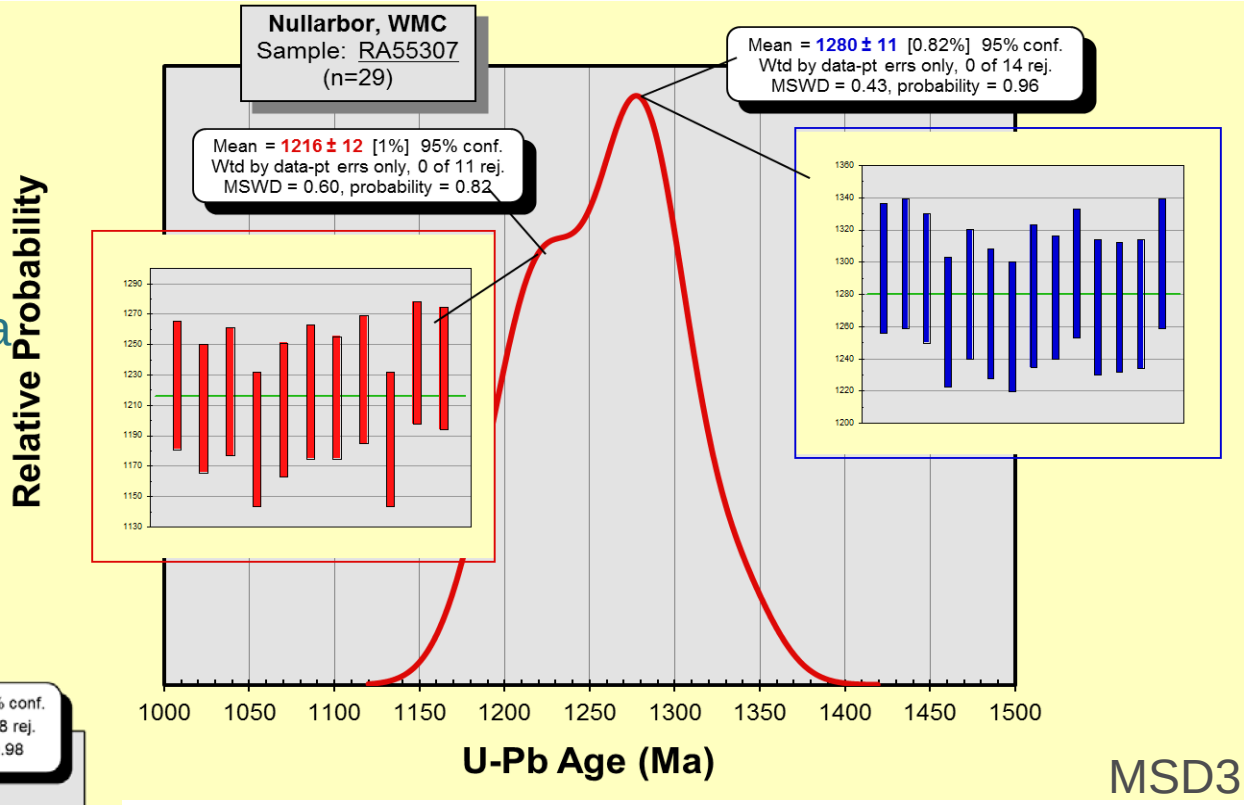


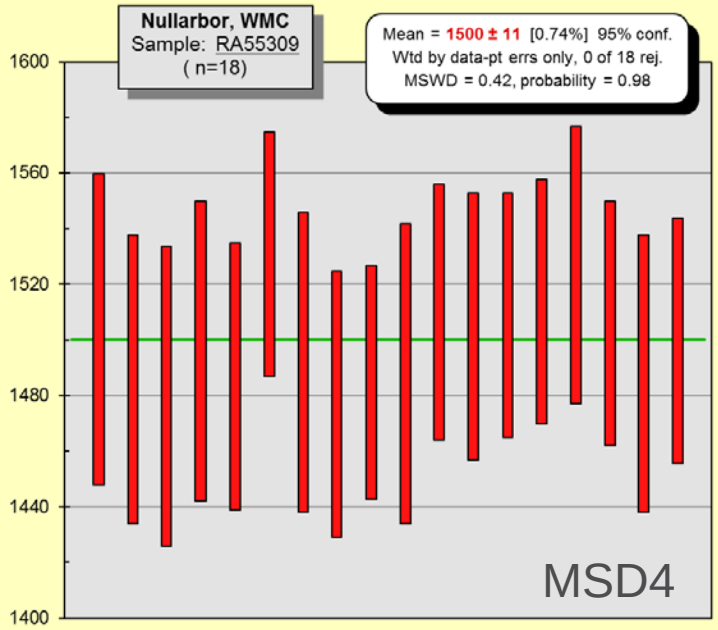
# Regional setting – new geochronology



## MSD3

Coompana Province
granite
Magmatism 1280 ± 11 Ma
Metamorphism 1216 ± 12 Ma



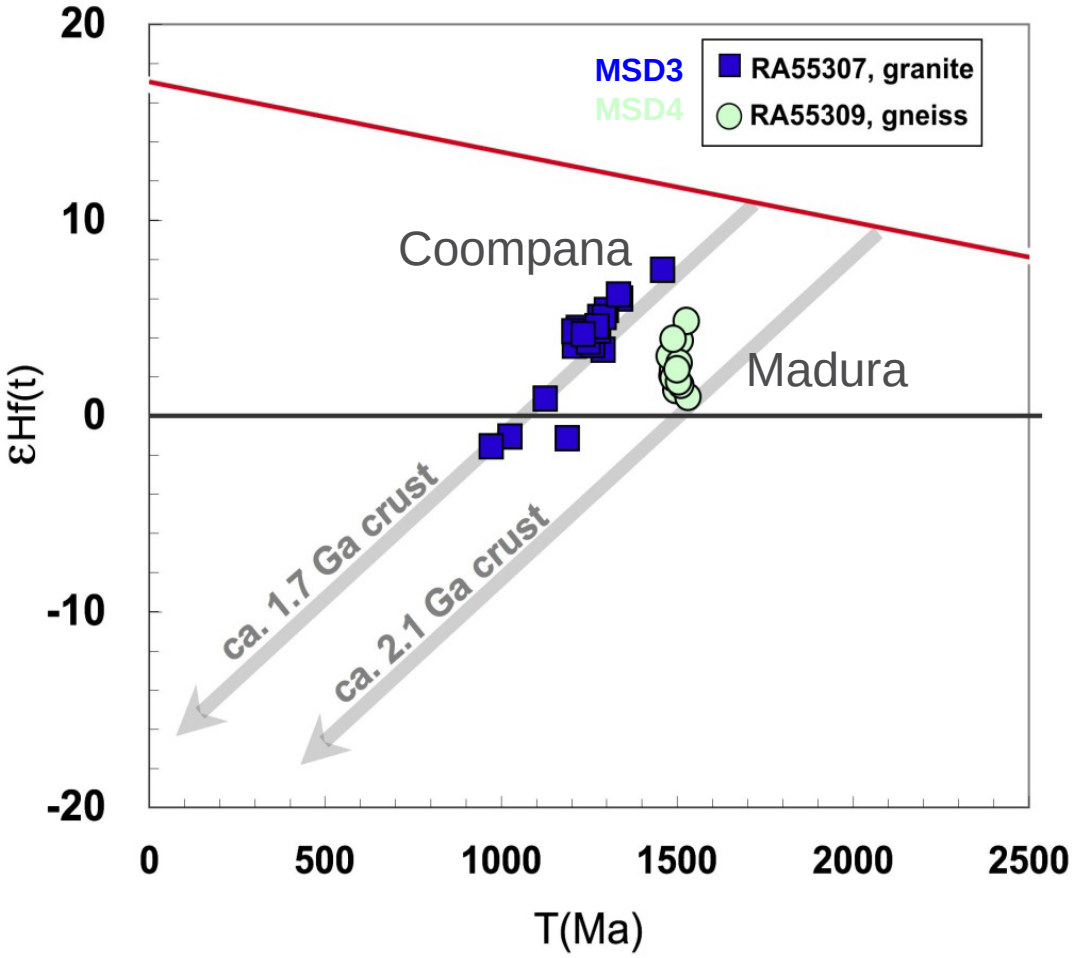




## MSD4

Madura Province
Granitic gneiss
Magmatism 1500 ± 11 Ma

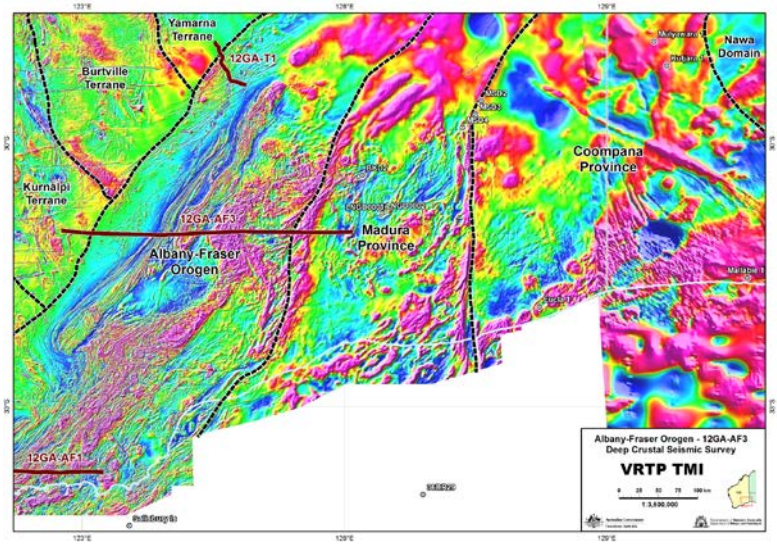
Drilling by WMC Resources Ltd
Analyses by GEMOC, Macquarie University

# Hf results from MSD3 and MSD4

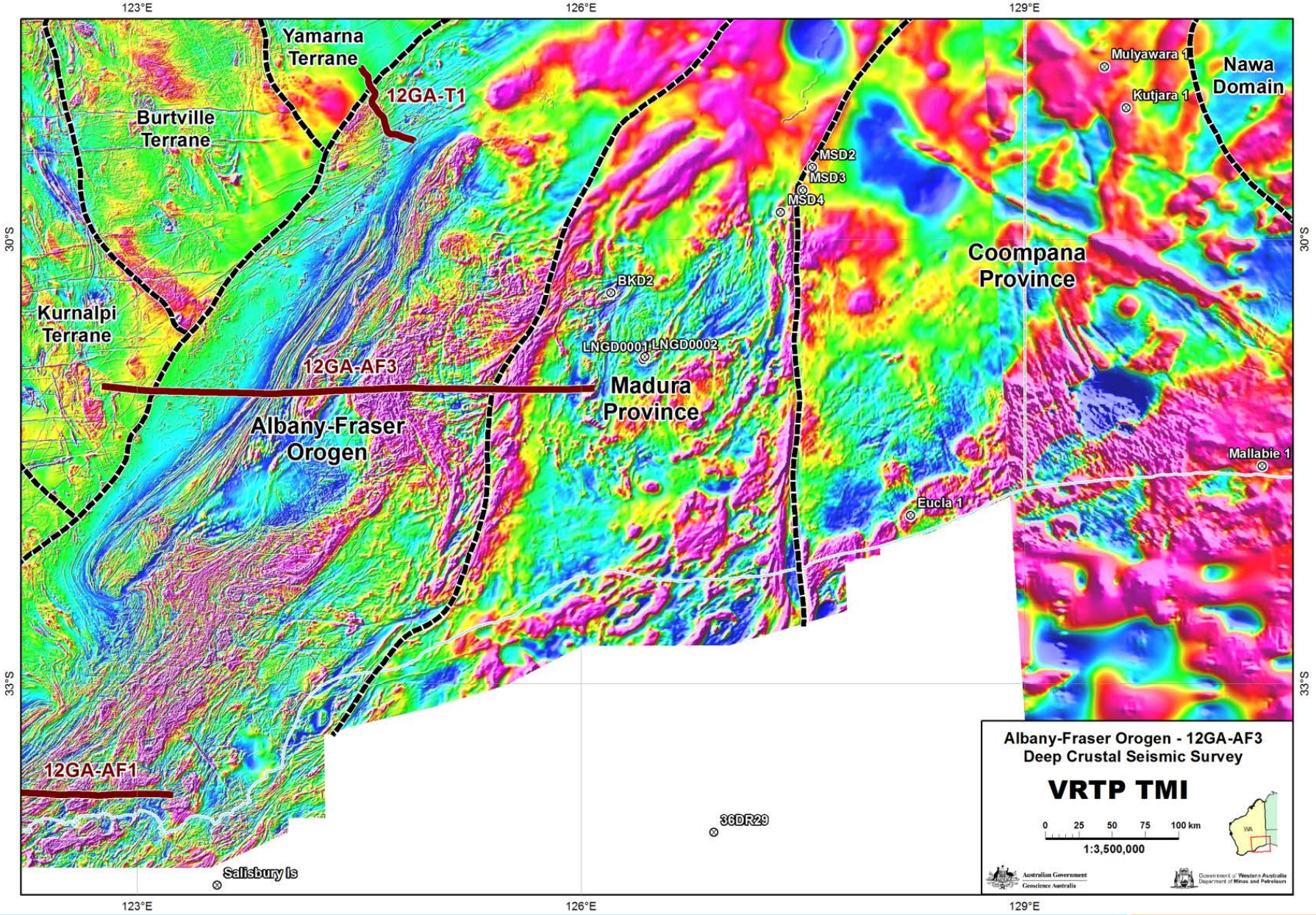



Hf model ages suggest different protolith for the two samples

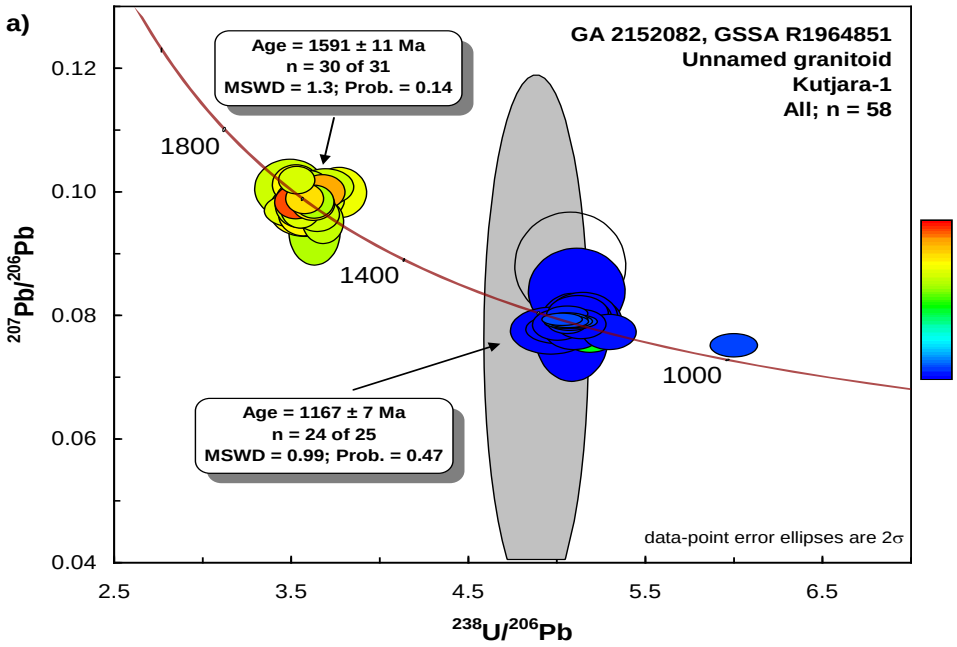
?Significance of Mundrabilla Shear Zone

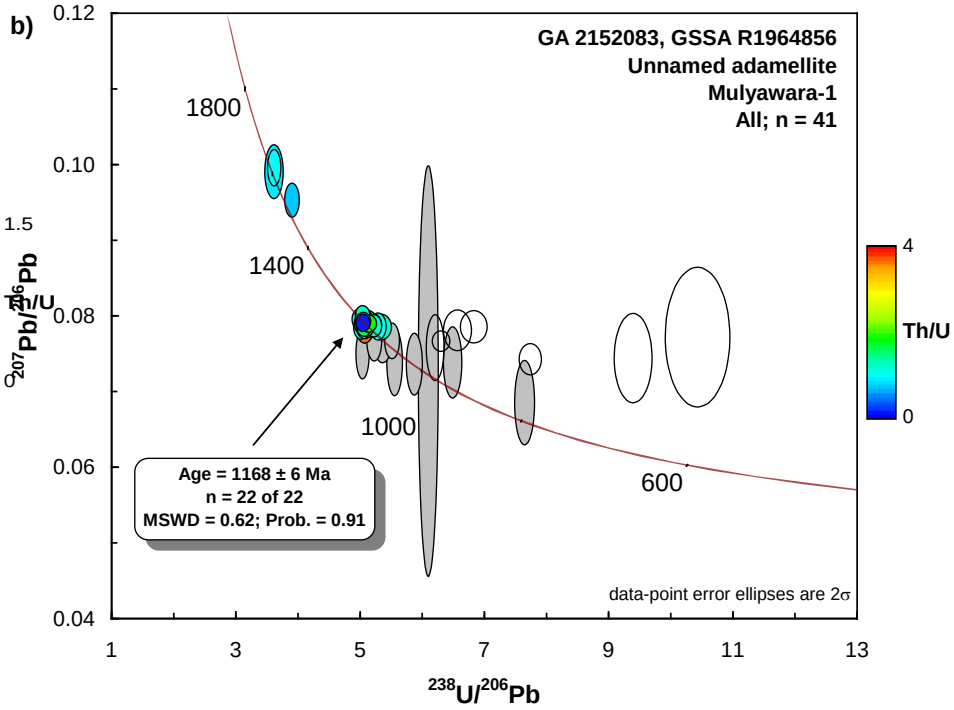


# Regional setting – new geochronology



# Coompana Province




## Kutjara 1

Magmatism 1591 ± 11 Ma

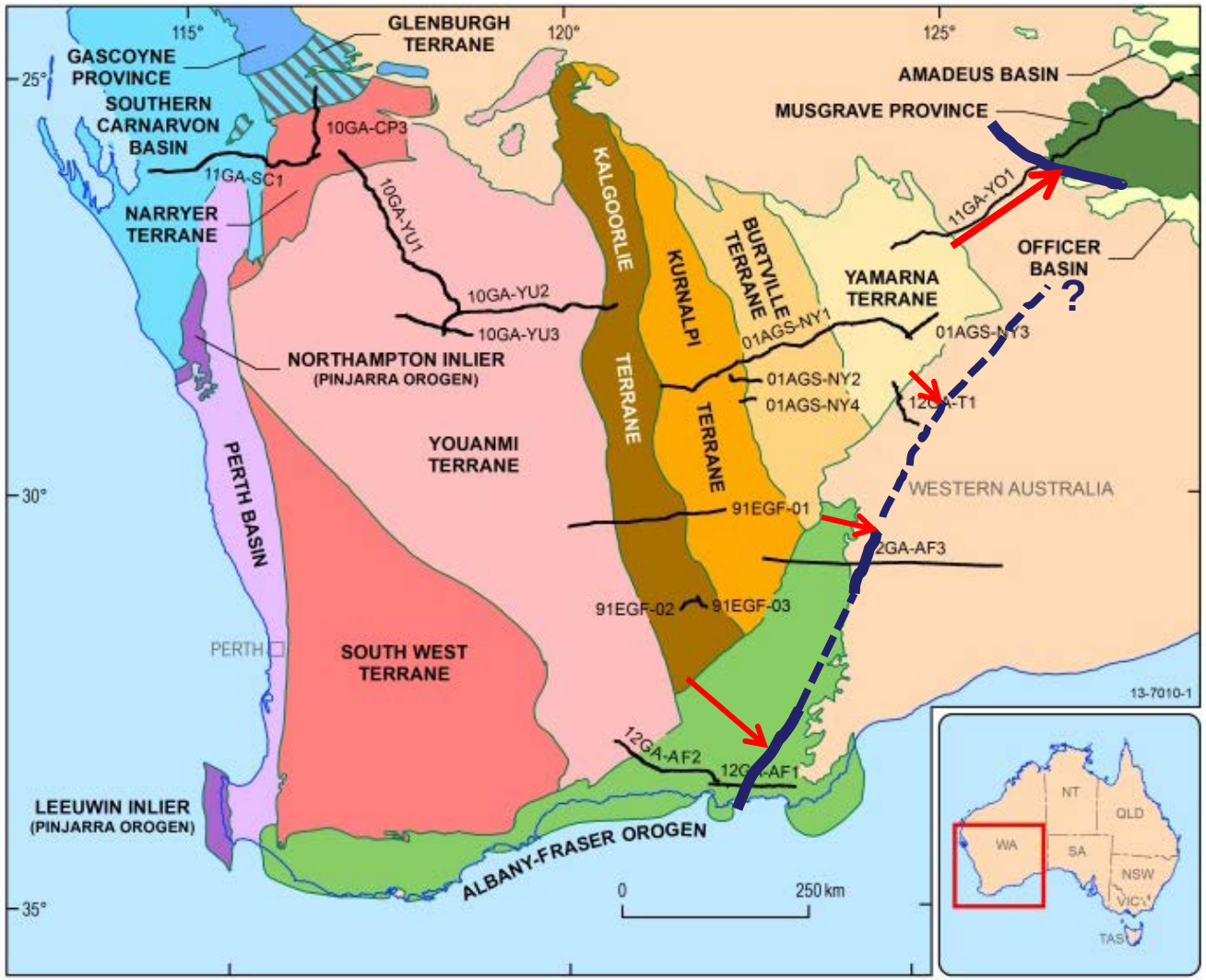
Metamorphism 1167 ± 7 Ma

## Mulyawara 1

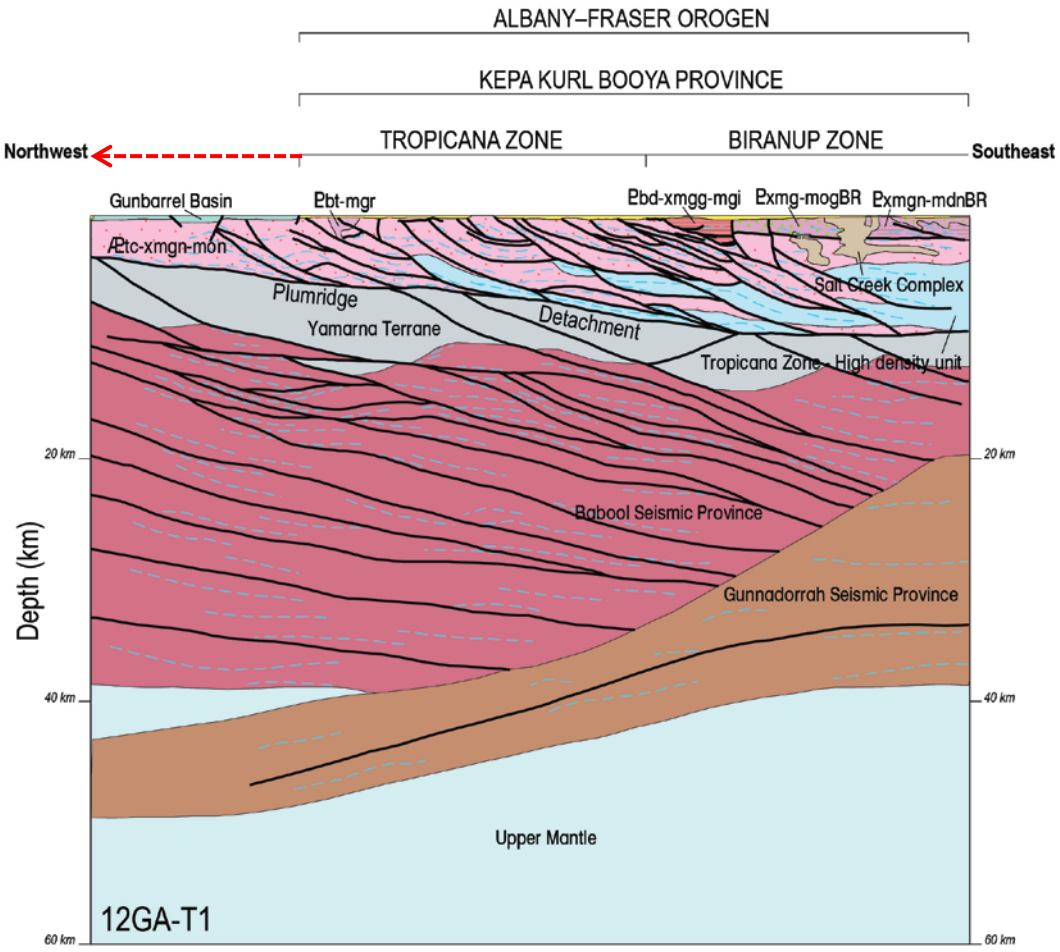
Magmatism 1168 ± 6 Ma

Sampling with permission from Rodinia Oil (Australia) Pty Ltd

# Revised extent of Yilgarn Craton (including the subsurface)



# Significance of Tropicana Zone



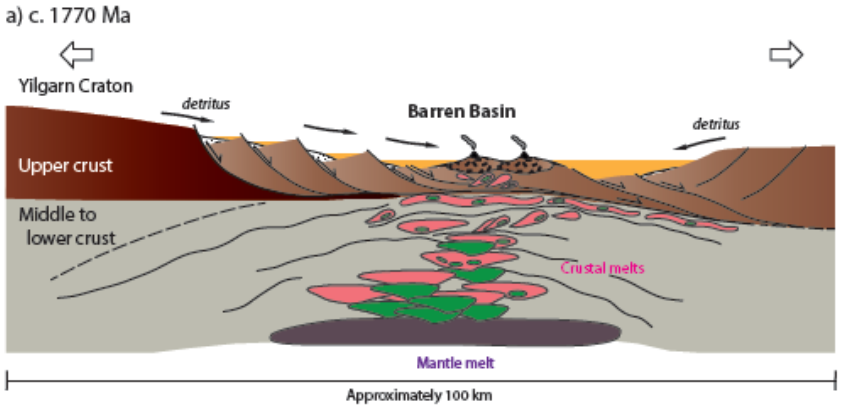

Different architecture and history to Yilgarn Craton and rest of Albany-Fraser Orogen

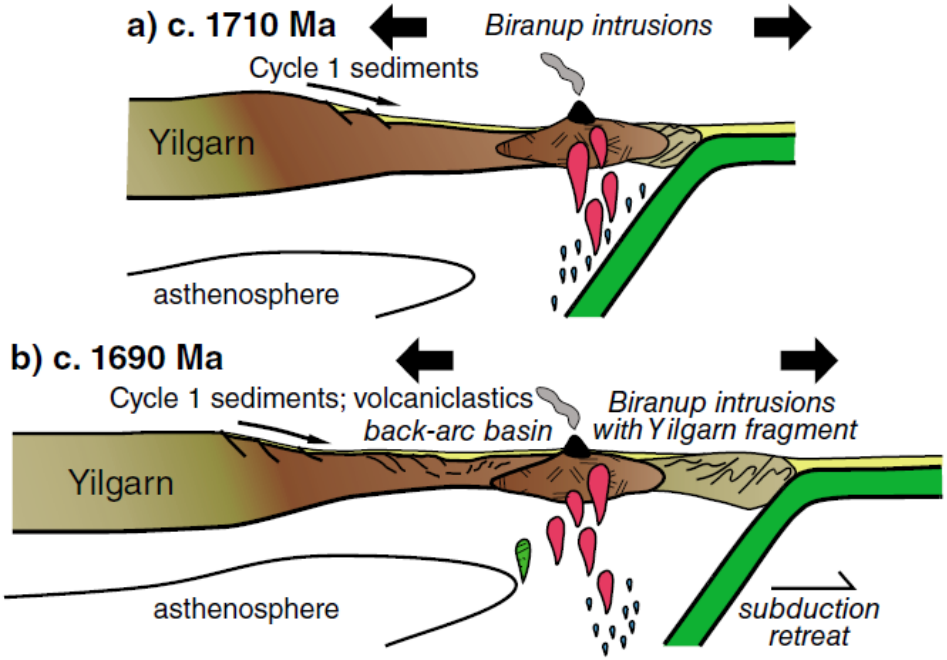
Hard-linked system of listric faults sole onto Plumridge (basal) Detachment

~2520-2515 Ma Tropicana Event not recognised elsewhere - thrust sheet derived from deeper level in SE

Yilgarn Craton extended prior to emplacement of Tropicana thrust sheet

# Proterozoic extension and contraction

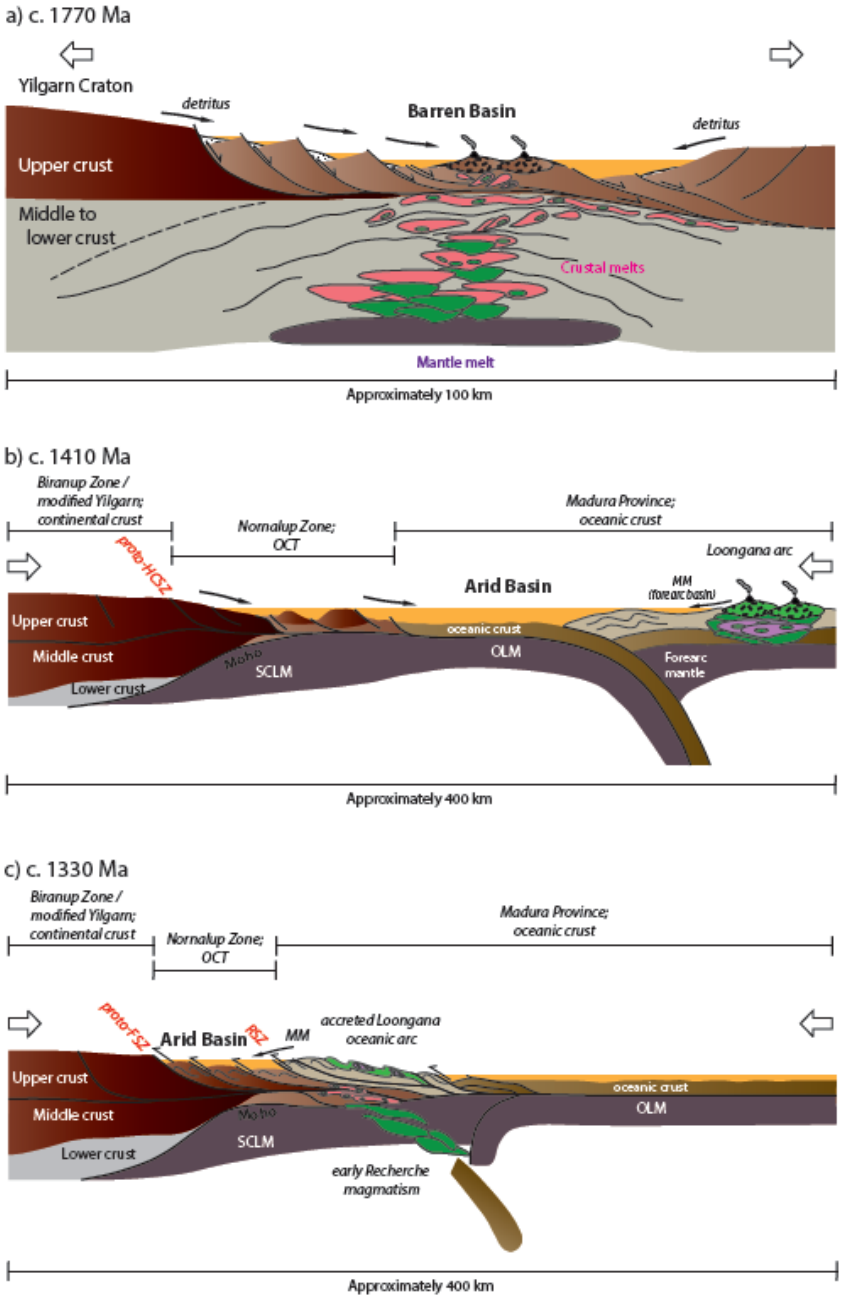



- Extensional (rift) basins
- Intracontinental or distal backarc setting
- Any subduction was well to east

From Kirkland et al. (2011),Spaggiari et al. (2014)

# Proterozoic extension and contraction



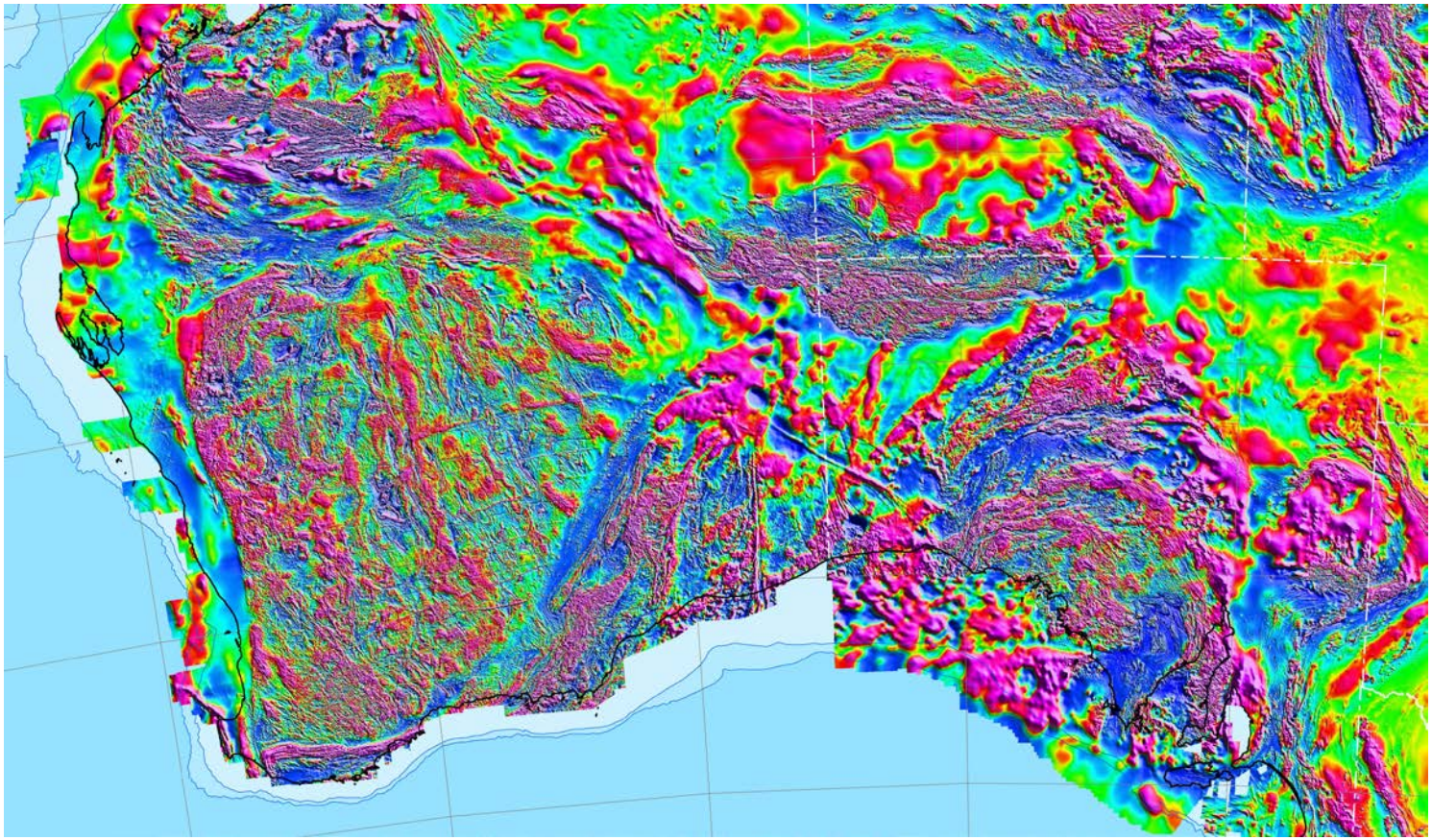

Extensional displacements on shear zones are rarely observed in the seismic

Hangingwall (ramp) anticlines common – thrusts

Probable reactivation/inversion of extensional faults as thrusts during later contractional deformations

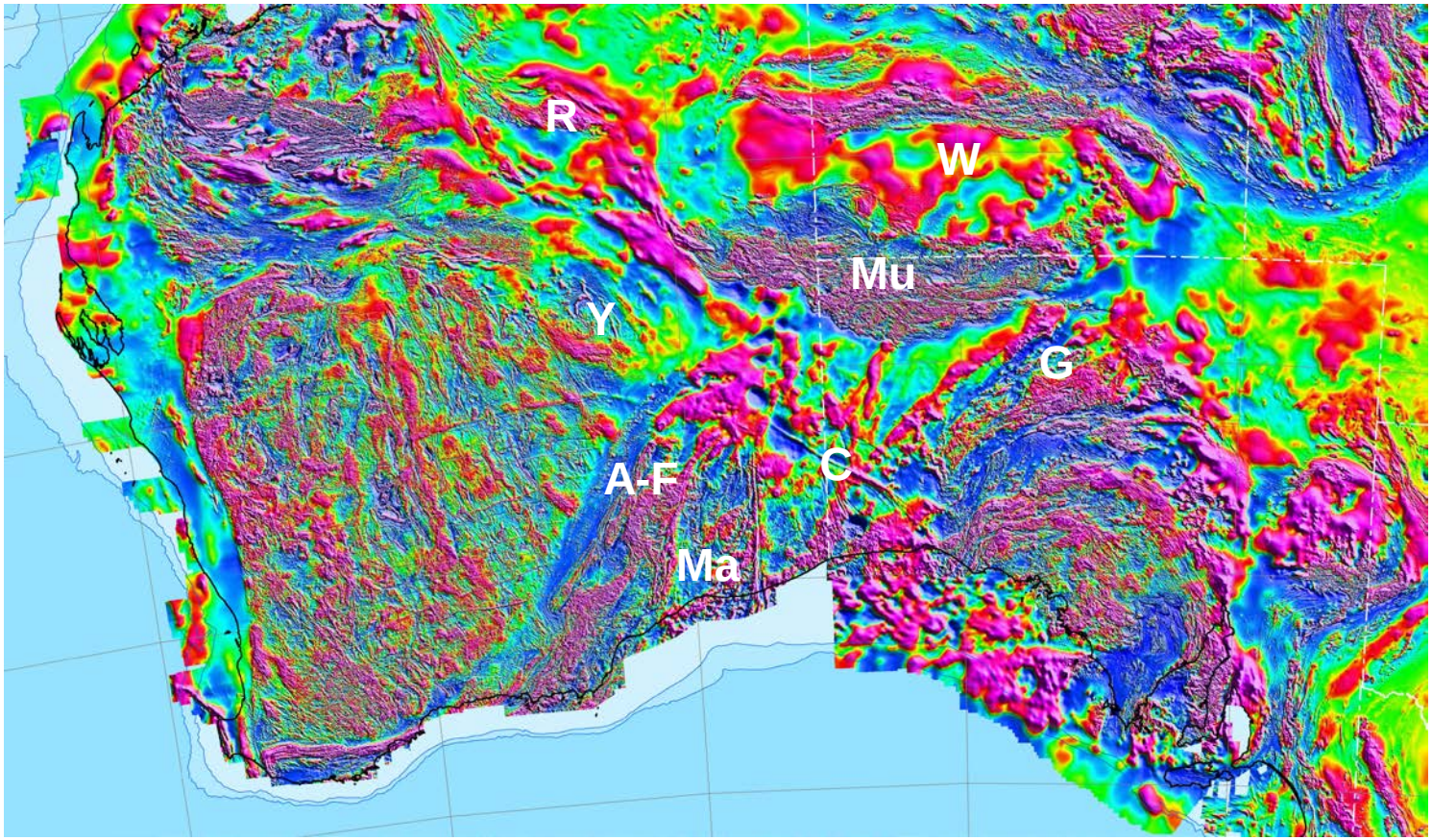
From Spaggiari et al. (2014)

# Questions about geodynamics in Southeast WA



? Links with surrounding provinces

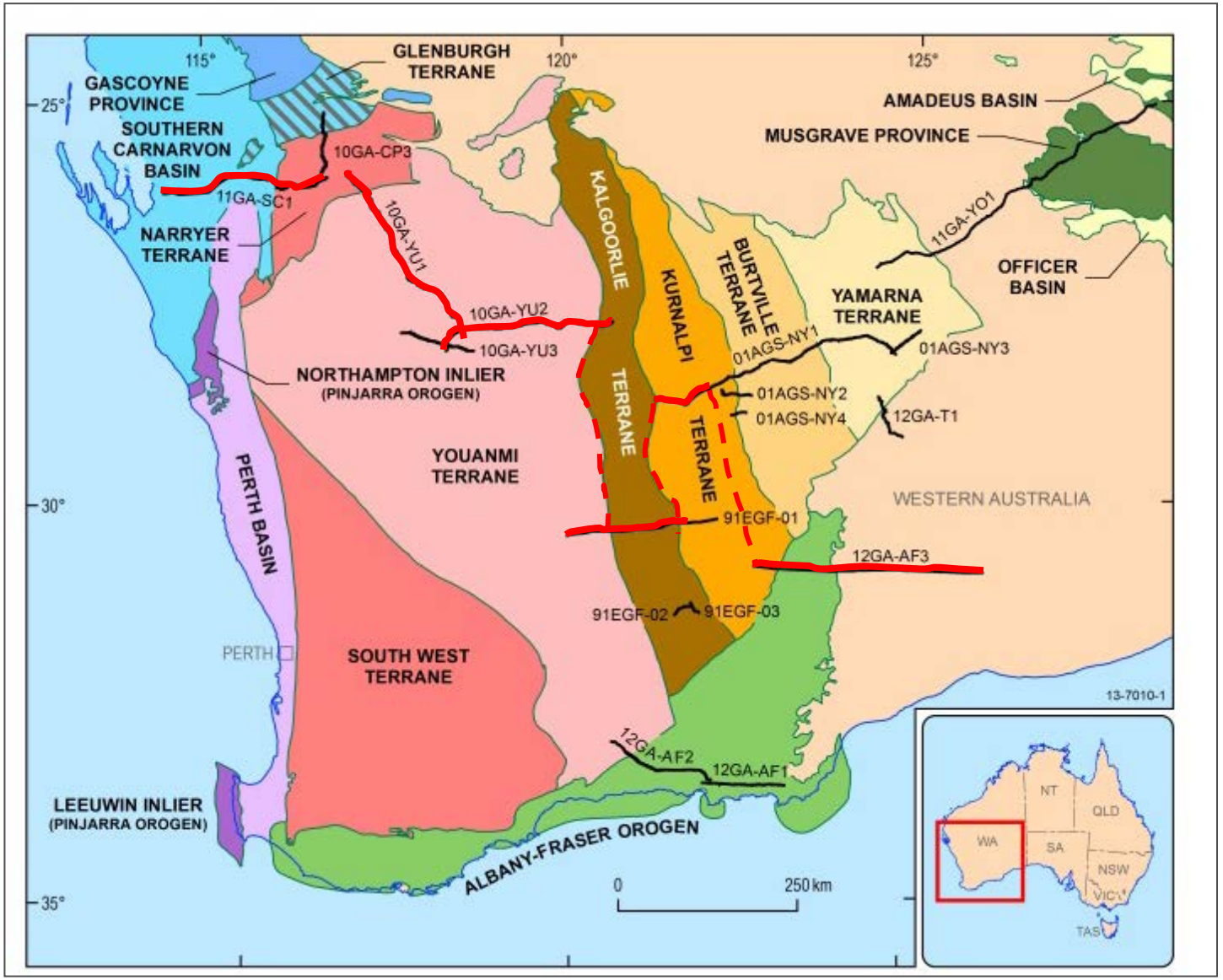
# Questions about geodynamics in Southeast WA




Musgrave Province – keystone block in central Australia between WAC, NAC and SAC

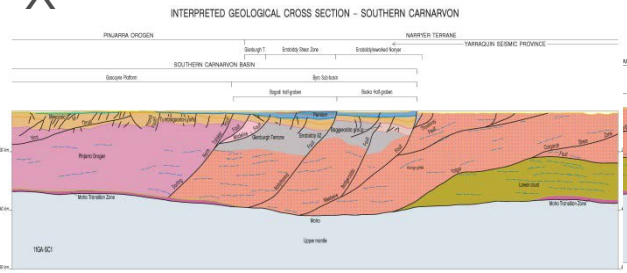
Albany-Fraser Orogen, Madura Province and Coompana Province link the WAC and SAC

# Transect across southern Western Australia



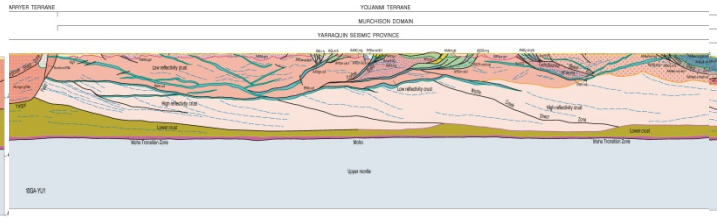
# Composite section from Pinjarra Orogen to Madura Province

X

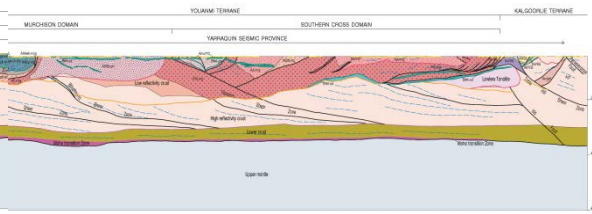



11GA-SC1

Y

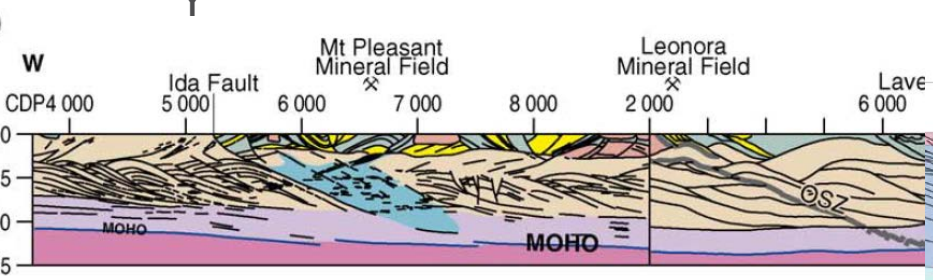



10GA-YU1




10GA-YU2

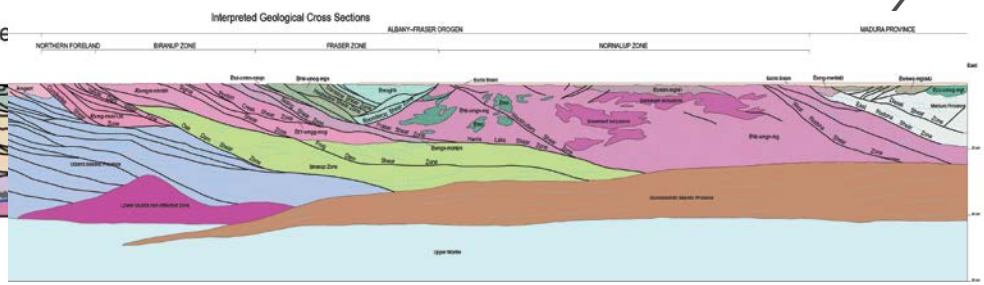
Y




BMR91-EGF01

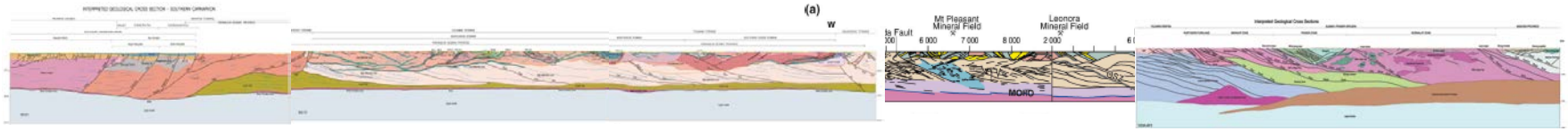
01AGS-NY1

7

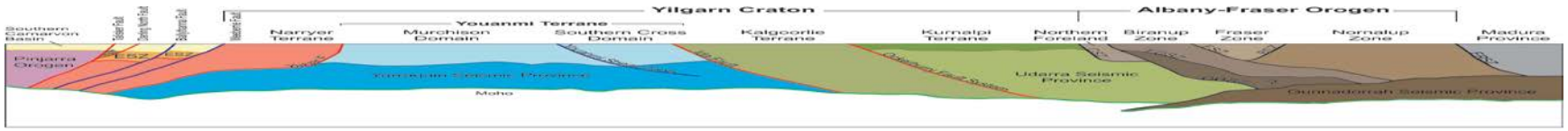



12GA-AF3

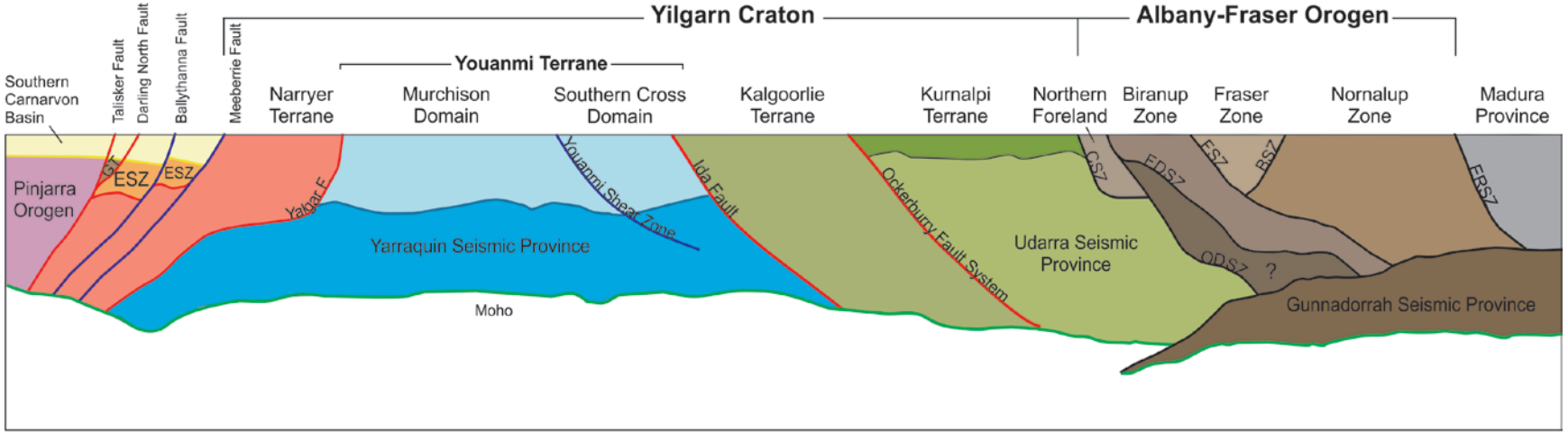
# Cross section showing present day relationships between the crustal provinces



SC1 YU1 YU2 EGF1 NY1 AF3

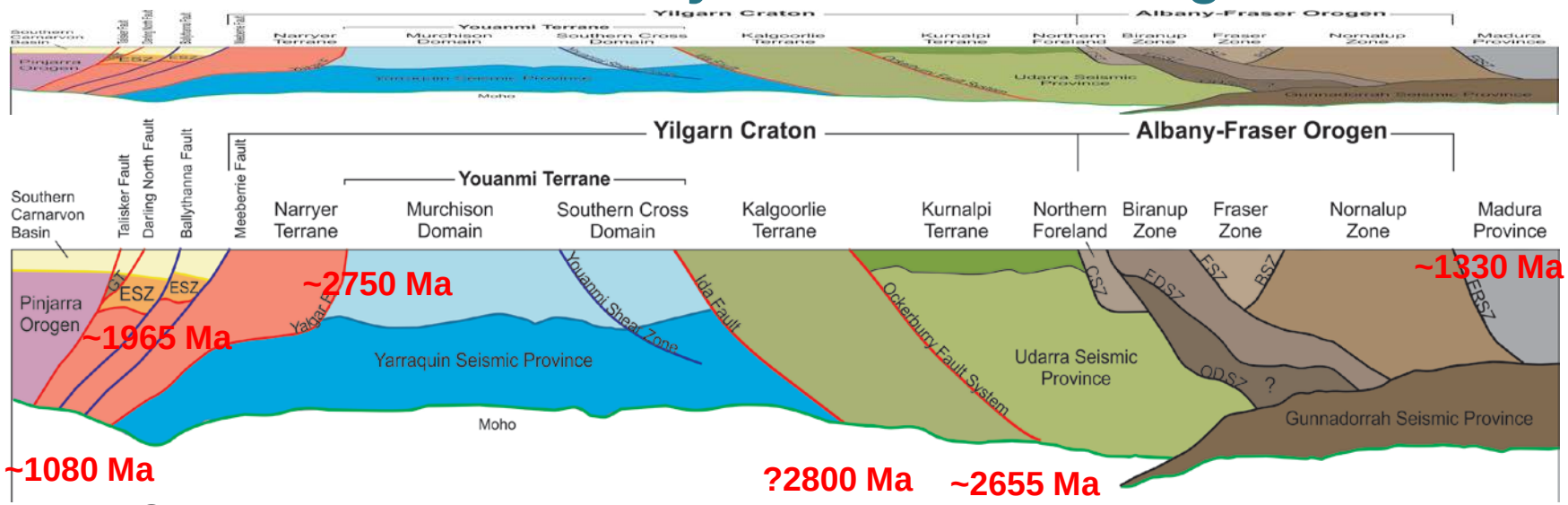



VE x ~1




VE x ~3.5

# Transect across Western Australia
## 2 billion years in the making




VE x ~3.5

**Youanmi Terrane + Yarraquin Seismic Province form a central nucleus, or protocraton of Yilgarn Craton**

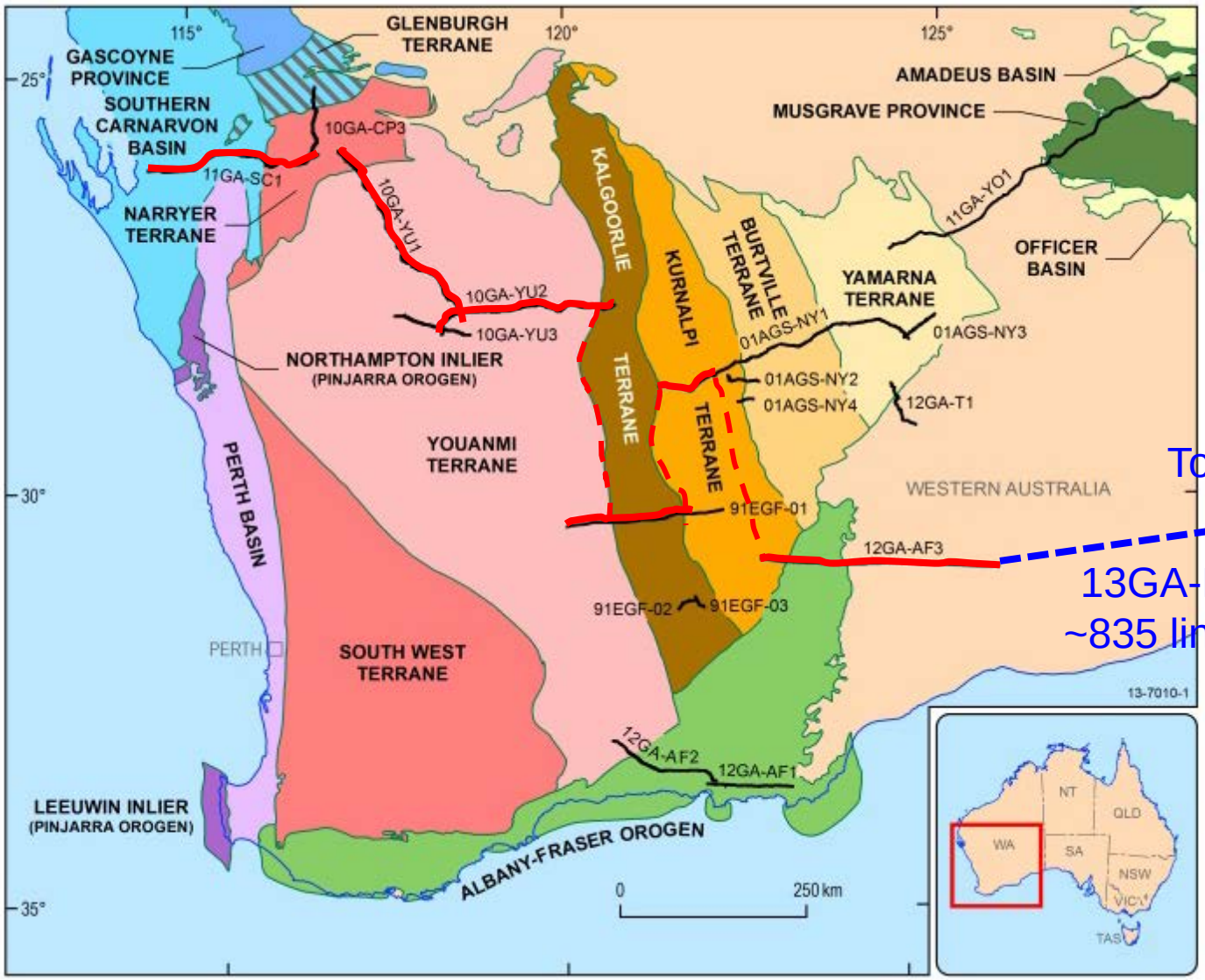
**Narryer Terrane sutured to protocraton in northwest**

**Terranes of Eastern Goldfields Superterrane in east accreted to protocraton, to form entire Yilgarn Craton**

**Glenburgh Terrane sutured in NW to form part of West Australian Craton (WAC)**

**Madura Province and Pinjarra Orogen sutured to WAC → present architecture**

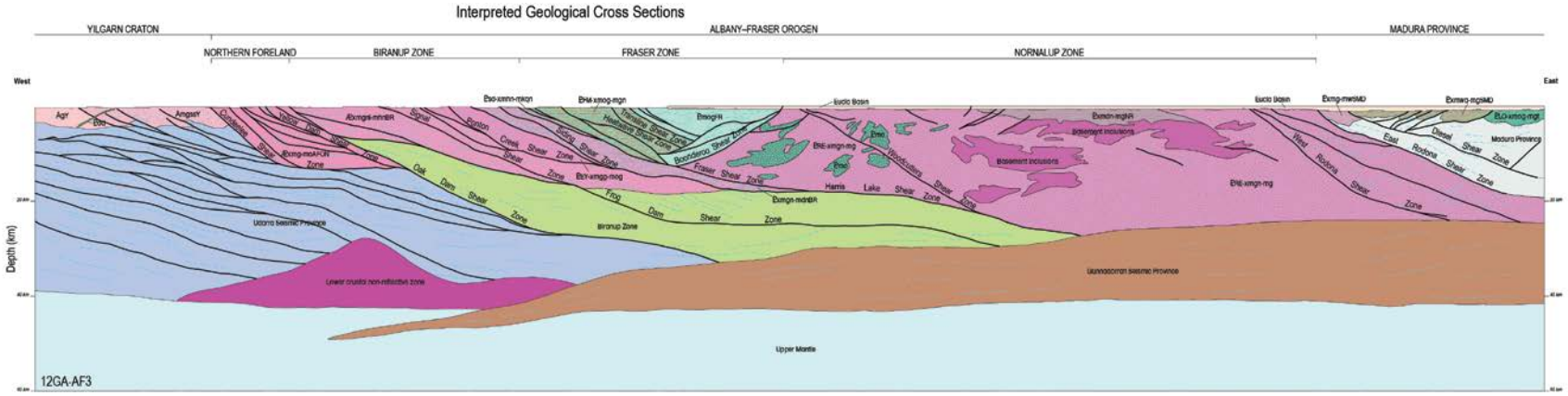
# To be continued !
# new Eucla-Gawler seismic line




To Tarcoola

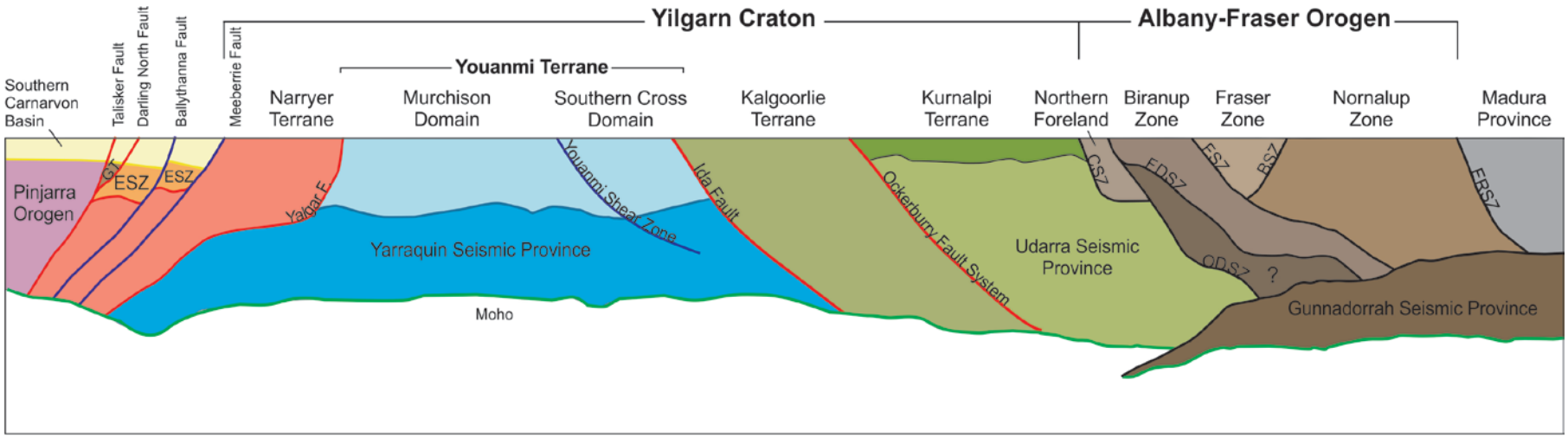
13GA-EG1
~835 line km

# Albany-Fraser Survey - Summary 1
## Crustal architecture of SE Yilgarn Craton to Madura Province




- First holistic view of the crustal architecture of this poorly-exposed region (672 line km of new seismic data)
- Crosses several crustal-scale provinces
  - Including cross section across Albany-Fraser Orogen
  - Tropicana Zone imaged
- Yilgarn Craton extends well to the east beneath the Albany-Fraser Zone

# Albany-Fraser Survey - Summary 2
## Assembly of southern Western Australia




- Several probable sutures recognised previously
- Progressive accretion of continental slivers onto protocraton (Youanmi Terrane and Yarraquin Seismic Province)
- Archean, Paleoproterozoic and Mesoproterozoic accretion events, including Madura Province

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# THANK YOU

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