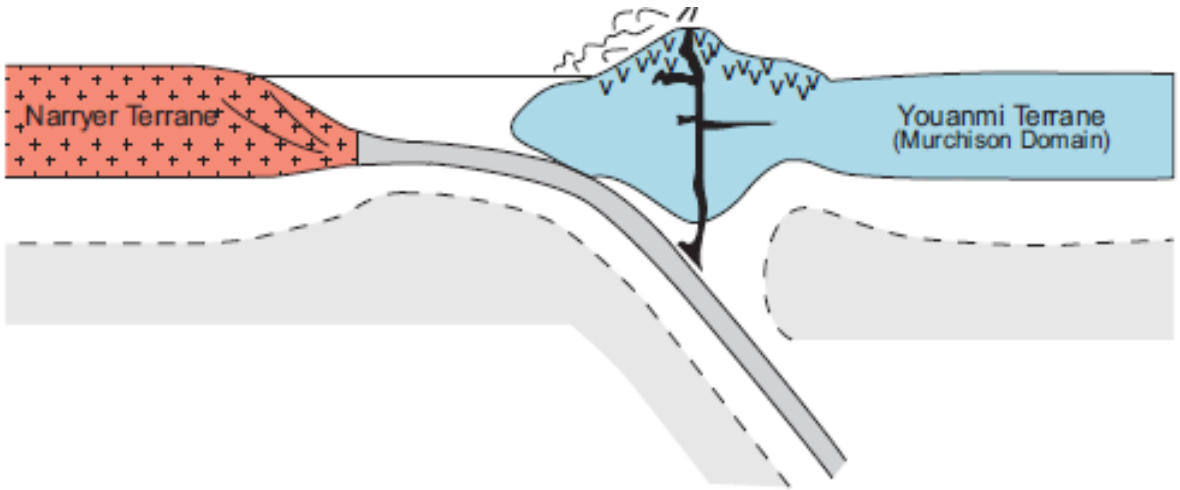
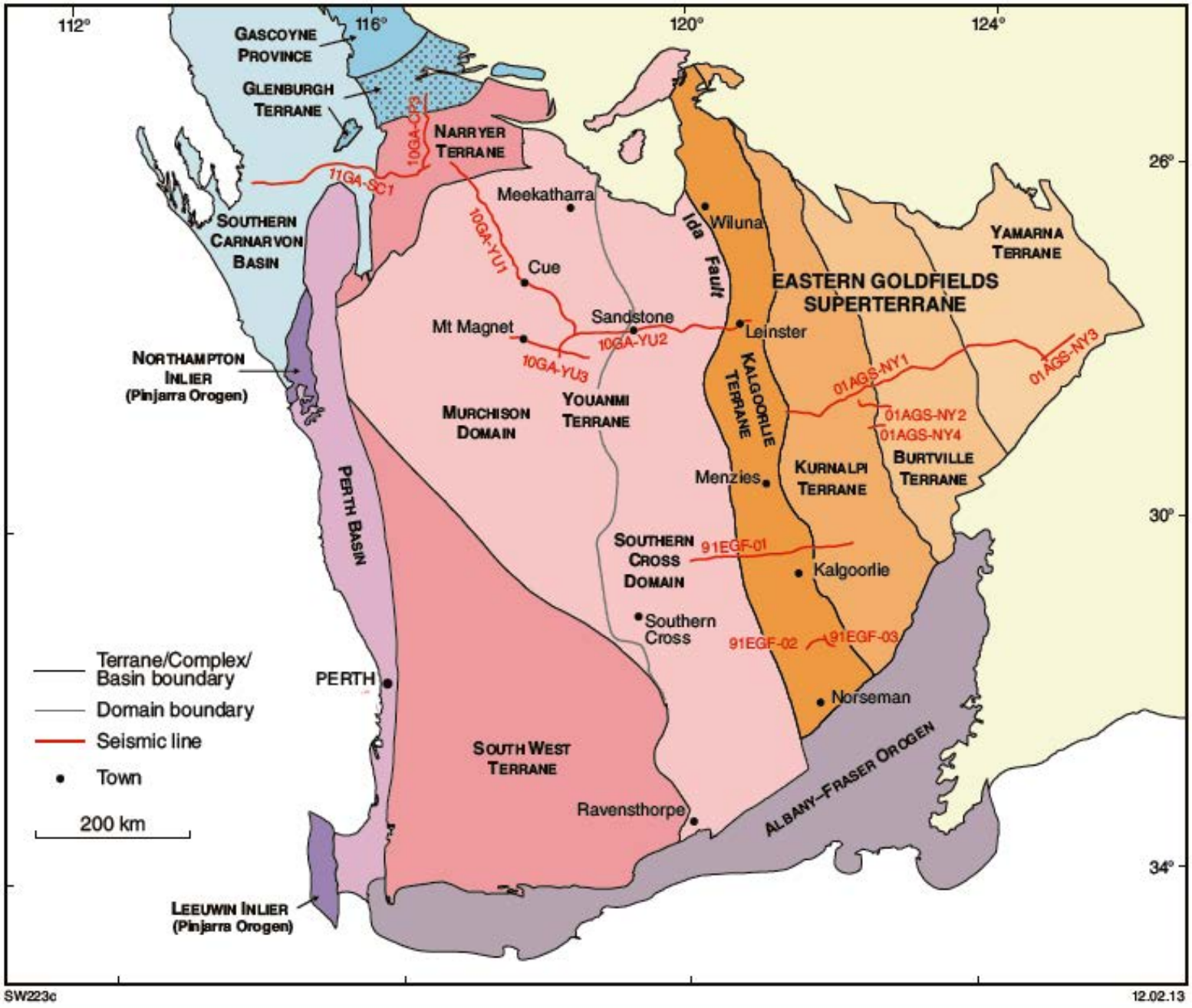
Geodynamic implications of the Youanmi and Southern Carnarvon deep seismic surveys

Russell Korsch, R Blewett, S Wyche, I Zibra, T Ivanic, M Doublier, S Romano, M Pawley, S Johnson, M Van Kranendonk, L Jones, N Kositcin, K Gessner, C Hall, S Chen, N Patison, B Kennett, T Jones, J Goodwin, P Milligan & R Costelloe



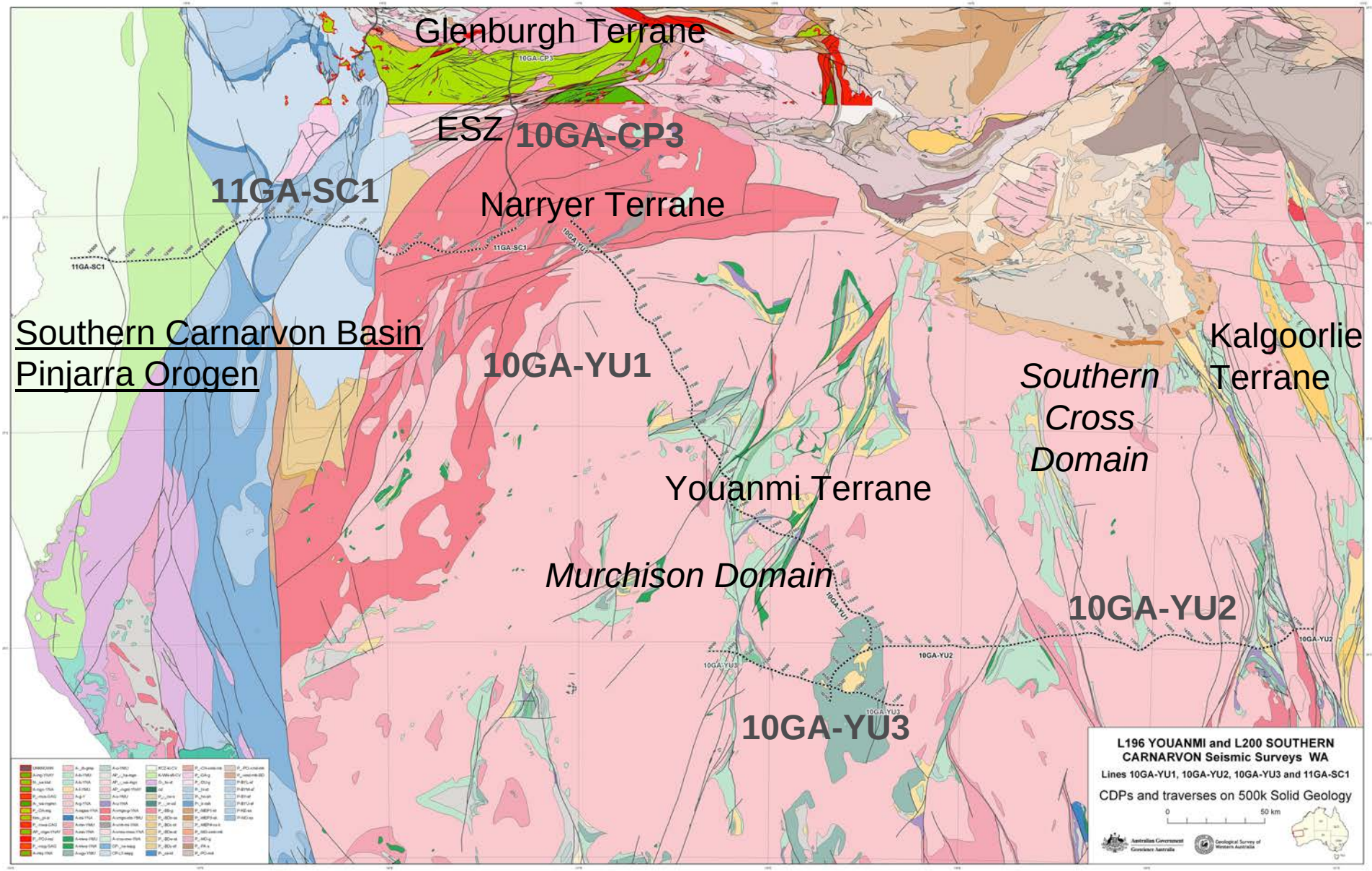


AIMS

Crustal Architecture

Geodynamic Speculations

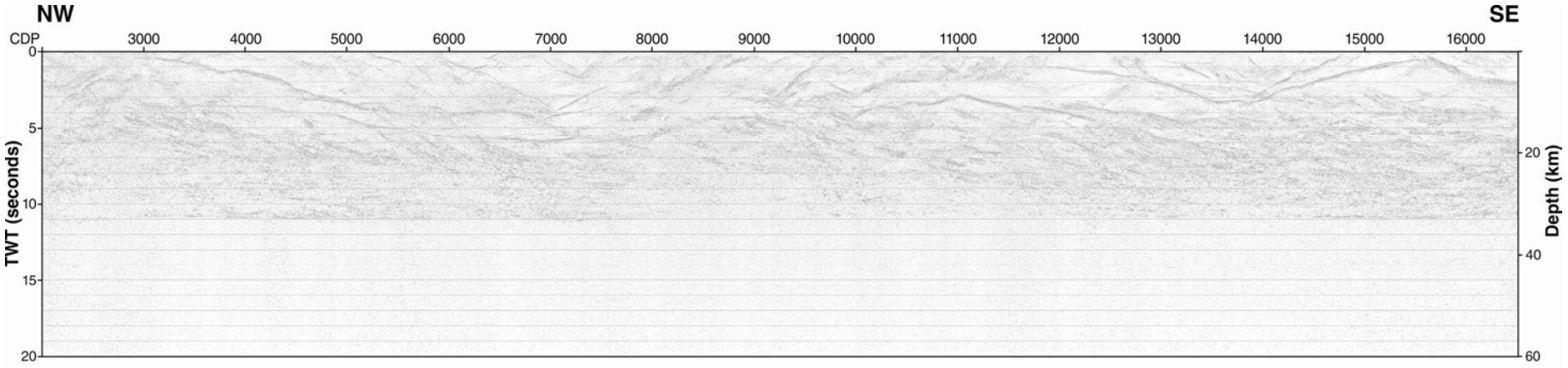
Link with previous seismic lines



Basement Terranes

ESZ = Errabiddy Shear Zone

Crustal architecture -10GA-YU1



Note: V = H (assuming average crustal velocity = 6000 ms-1)

Moho – very well defined

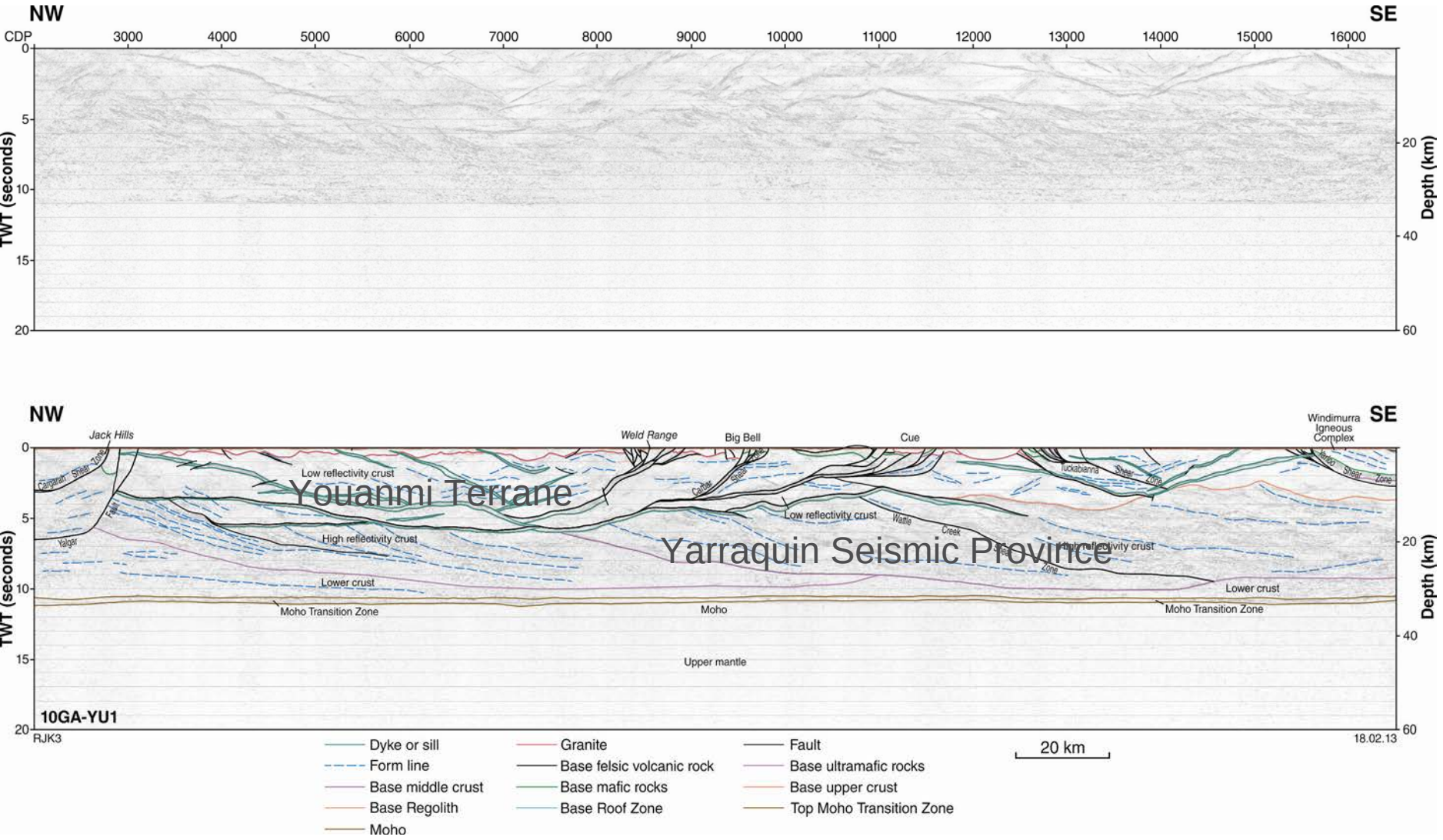
- interpreted at ~11 s TWT (~33 km depth)

- thin transition zone between lower crust and upper mantle

- 3-layer crust

- upper, weakly to moderately reflective
- middle, strongly reflective, listric to SE
- lower, moderately to strongly reflective, subhorizontal

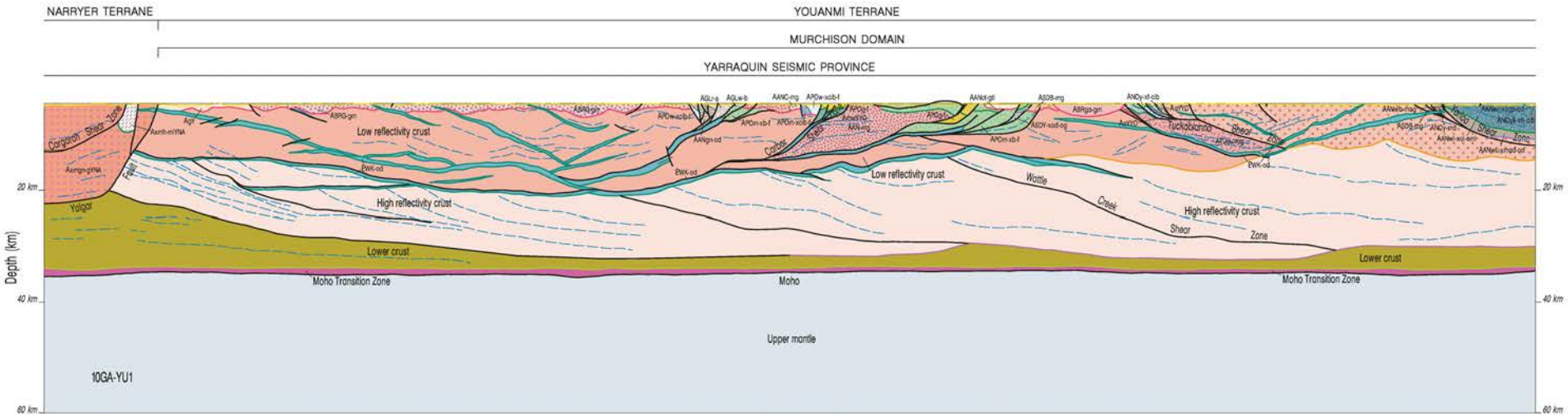
Crustal architecture -10GA-YU1



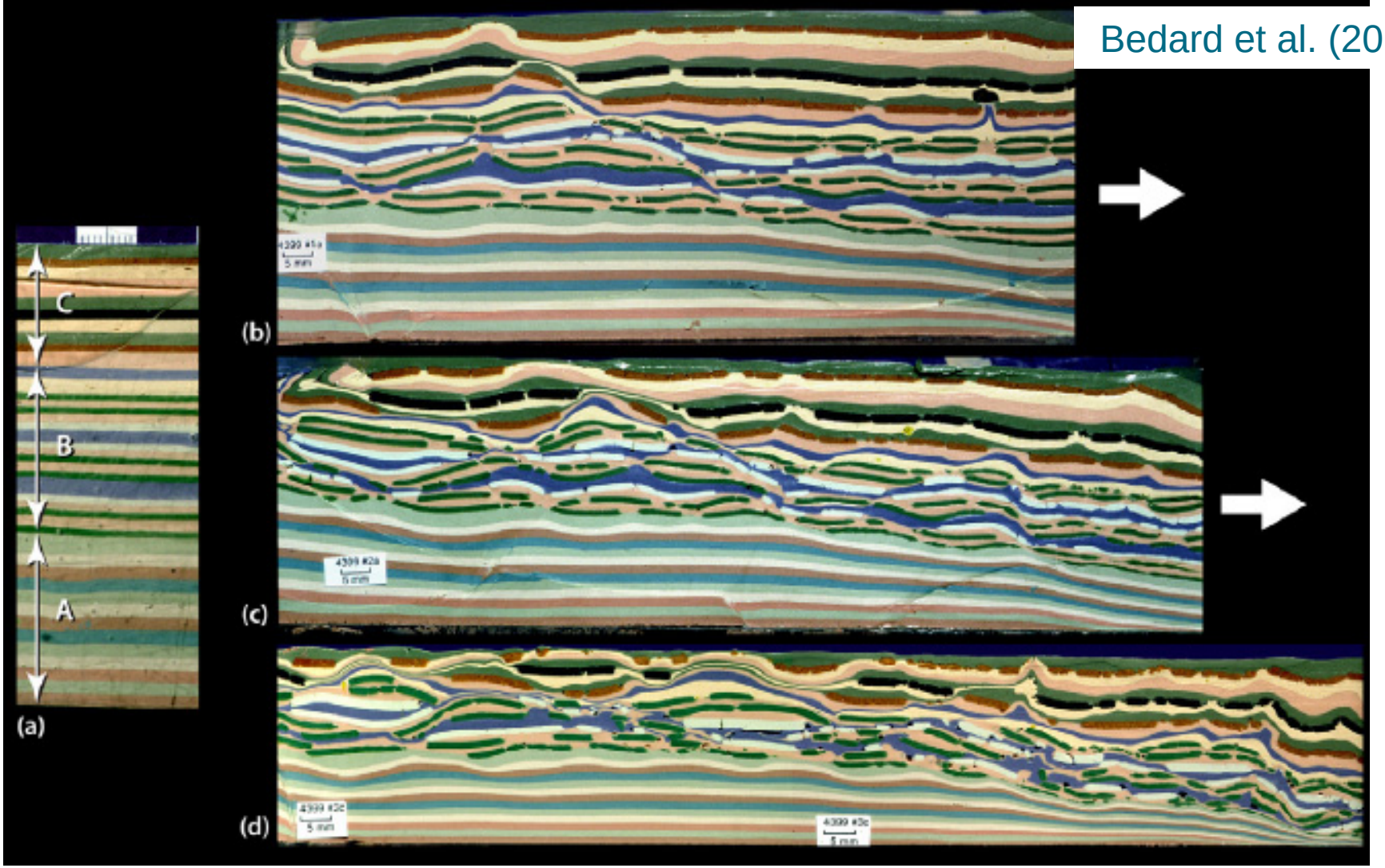
Youanmi Terrane – confined to weakly to moderately reflective upper crust

Yarraquin Seismic Province* - middle and lower crust combined

Crustal architecture -10GA-YU1

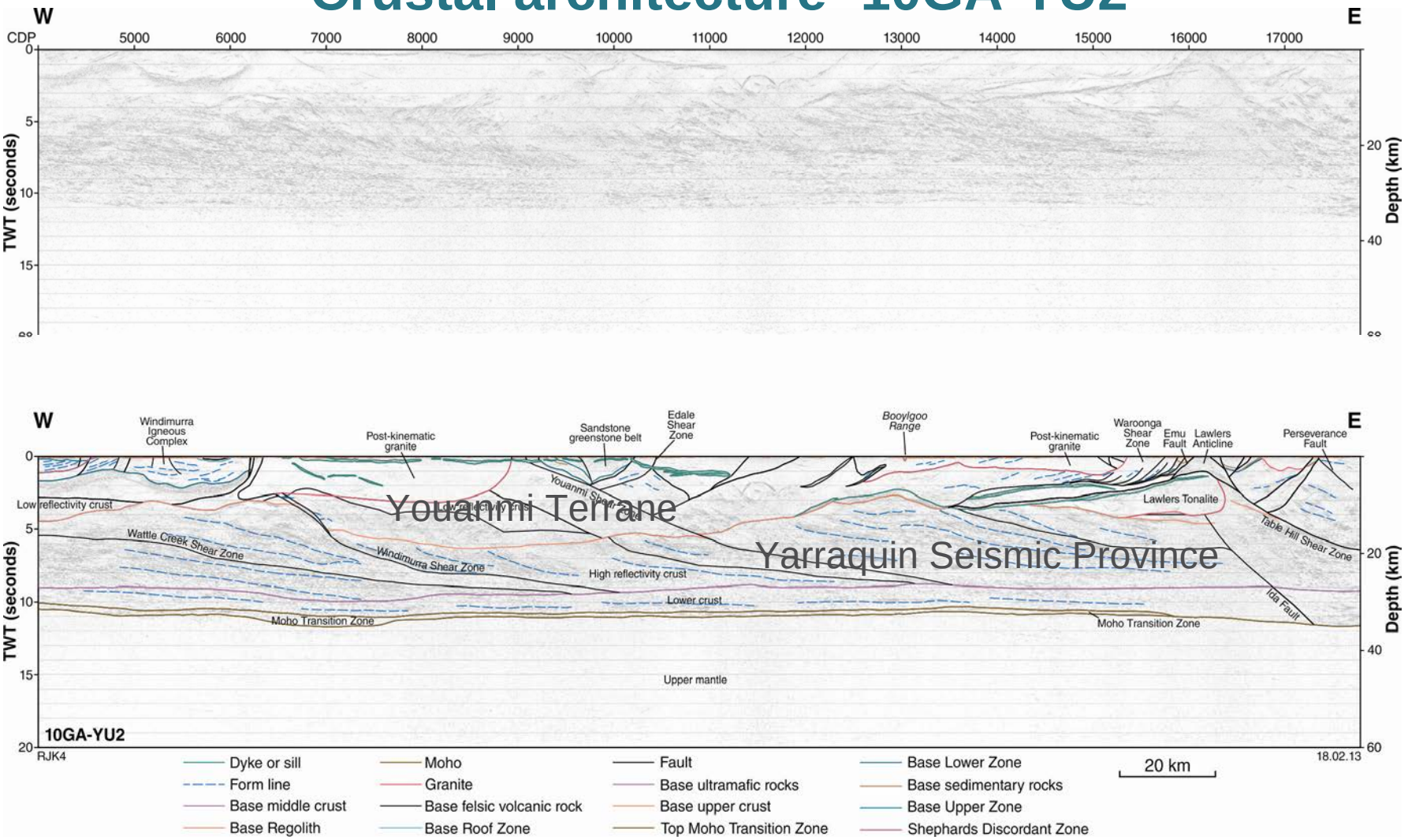


Bedard et al. (2012)



Could the fabric of the Yarraquin Seismic Province be due to crustal scale extension?
Analogue model – but crust now thinned to 25 km would have been originally 65 km
Possible solution – extension followed by later contraction to thicken crust

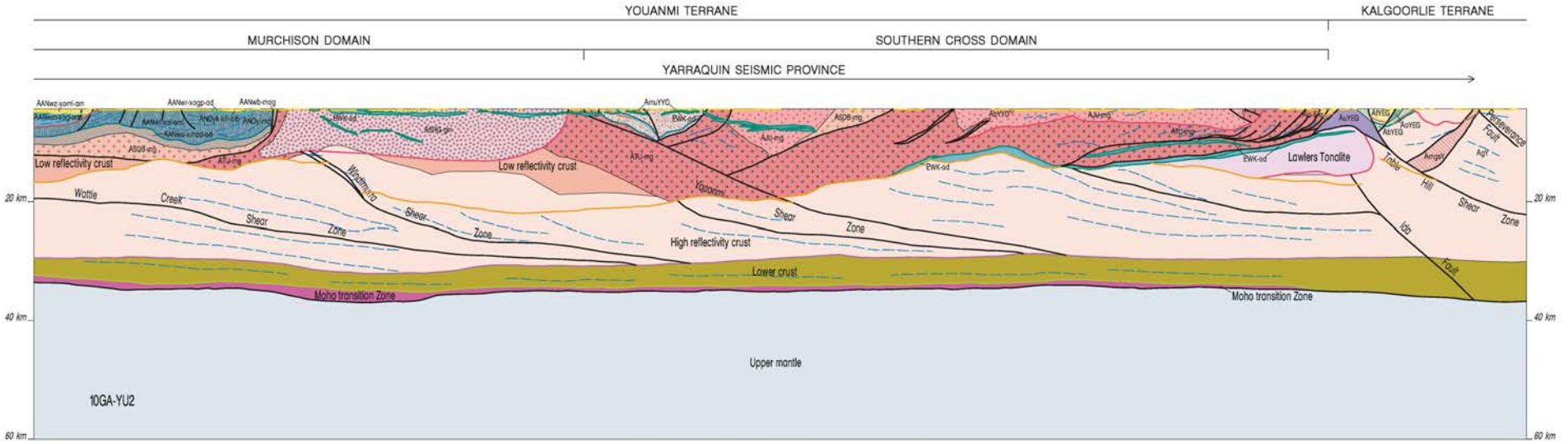
Crustal architecture -10GA-YU2



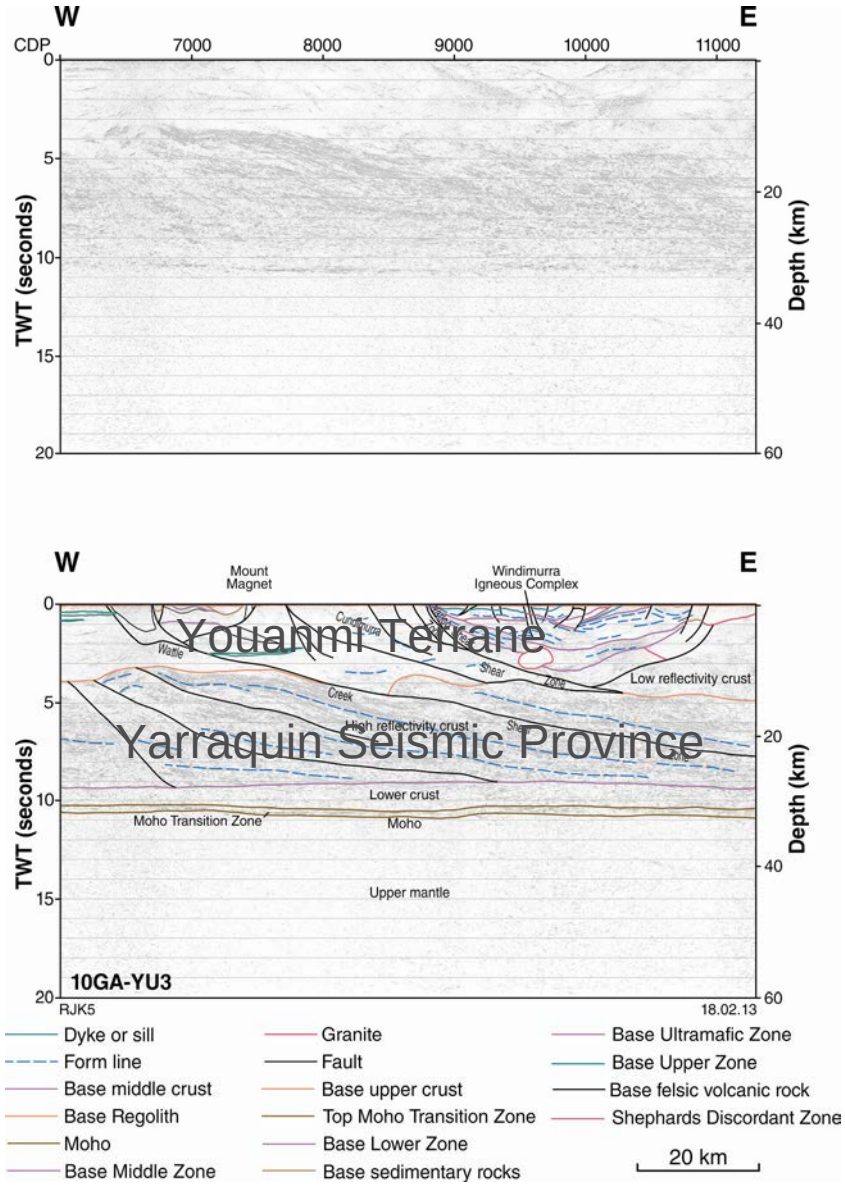
Same 3-layer crust as 10GA-YU1 (except for easternmost end)

Note: Murchison and Southern Cross Domains have same seismic character

Crustal architecture -10GA-YU2

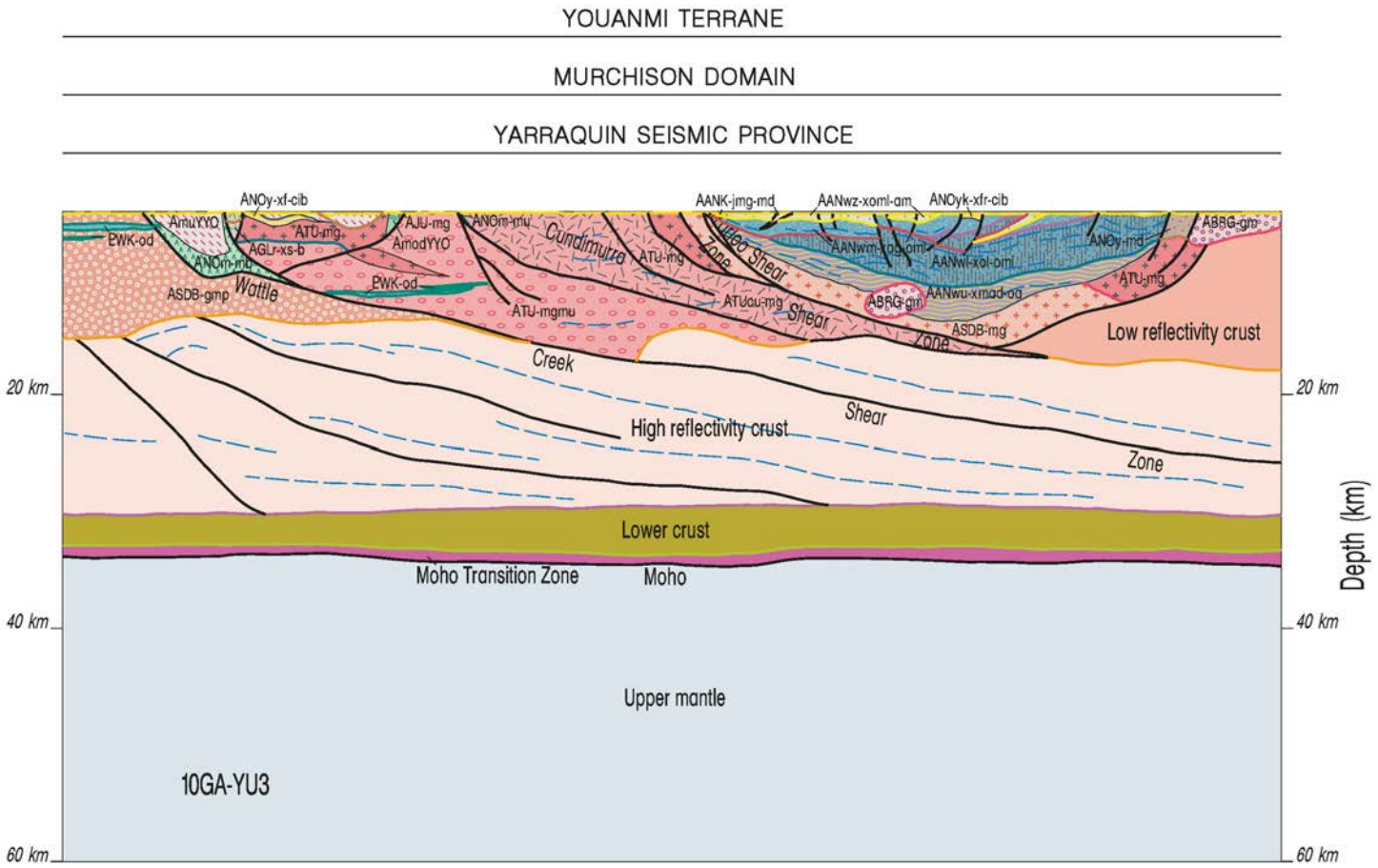


Crustal architecture -10GA-YU3

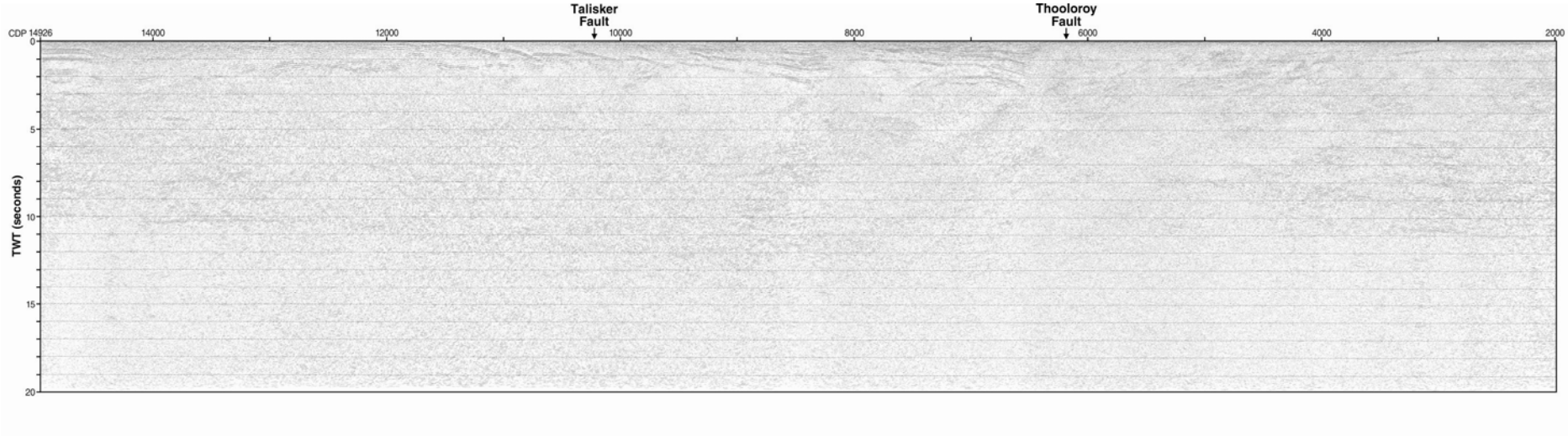


Same 3-layer crust as 10GA-YU1 & 10GA-YU2

Crustal architecture -10GA-YU3



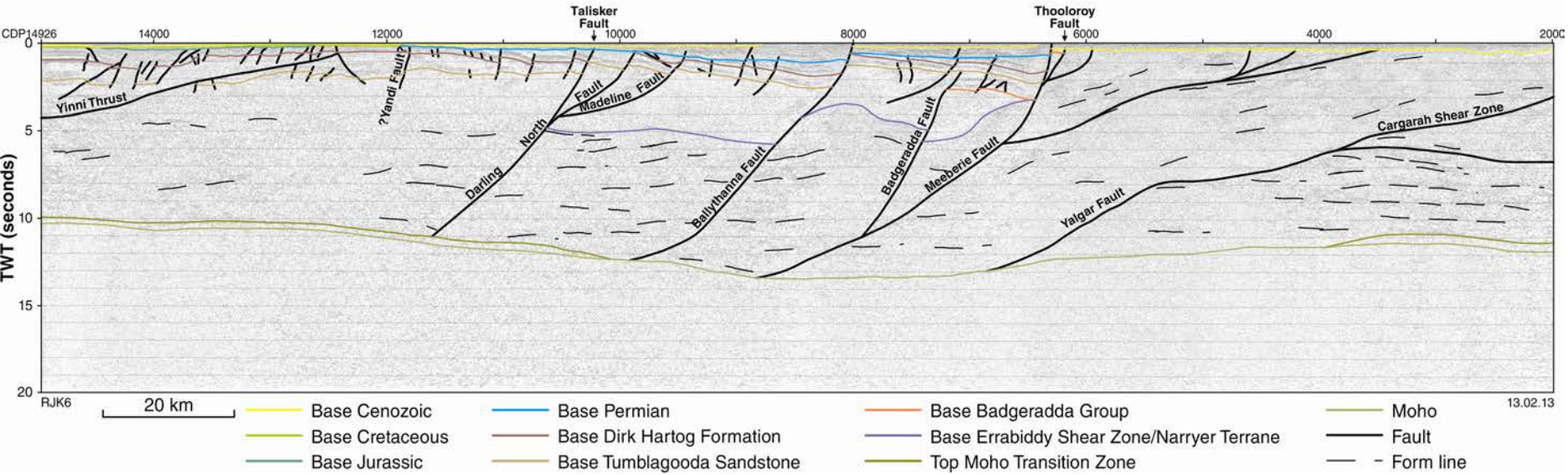
Crustal architecture -11GA-SC1

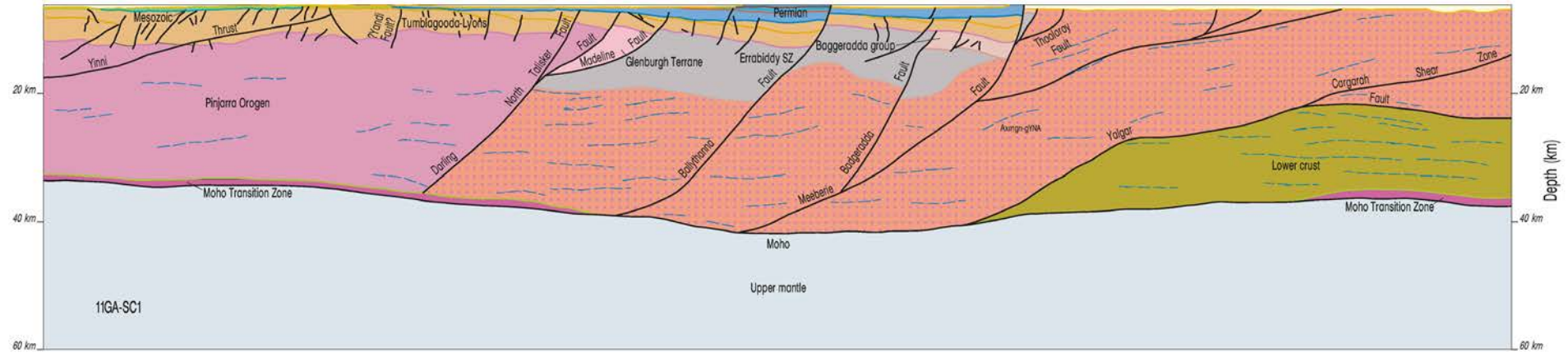


Moho – poorly defined (except in west and east)
- undulating
- 10 s TWT (~30 km depth) in west
- >13 s TWT (nearly 40 km depth) in centre

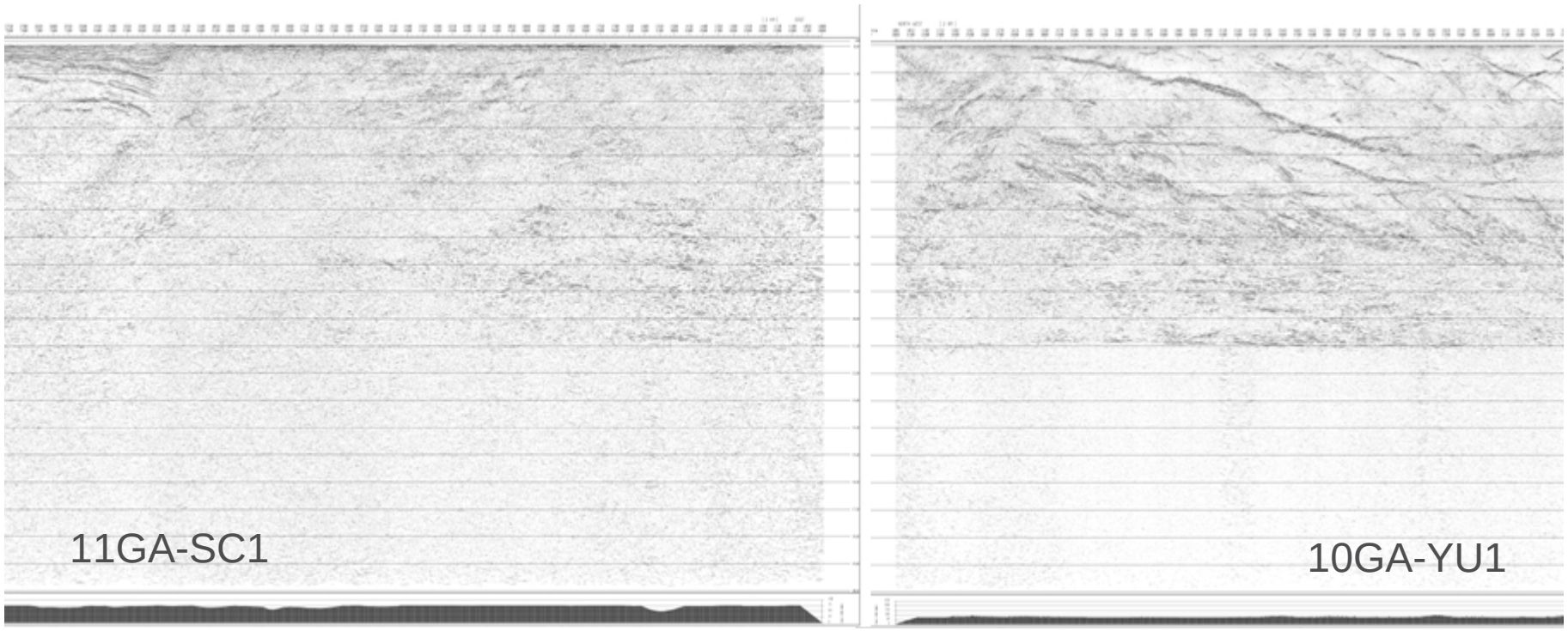
Crust – only weakly to moderately reflective
- very different to architecture of Youanmi seismic lines

Crustal architecture -11GA-SC1

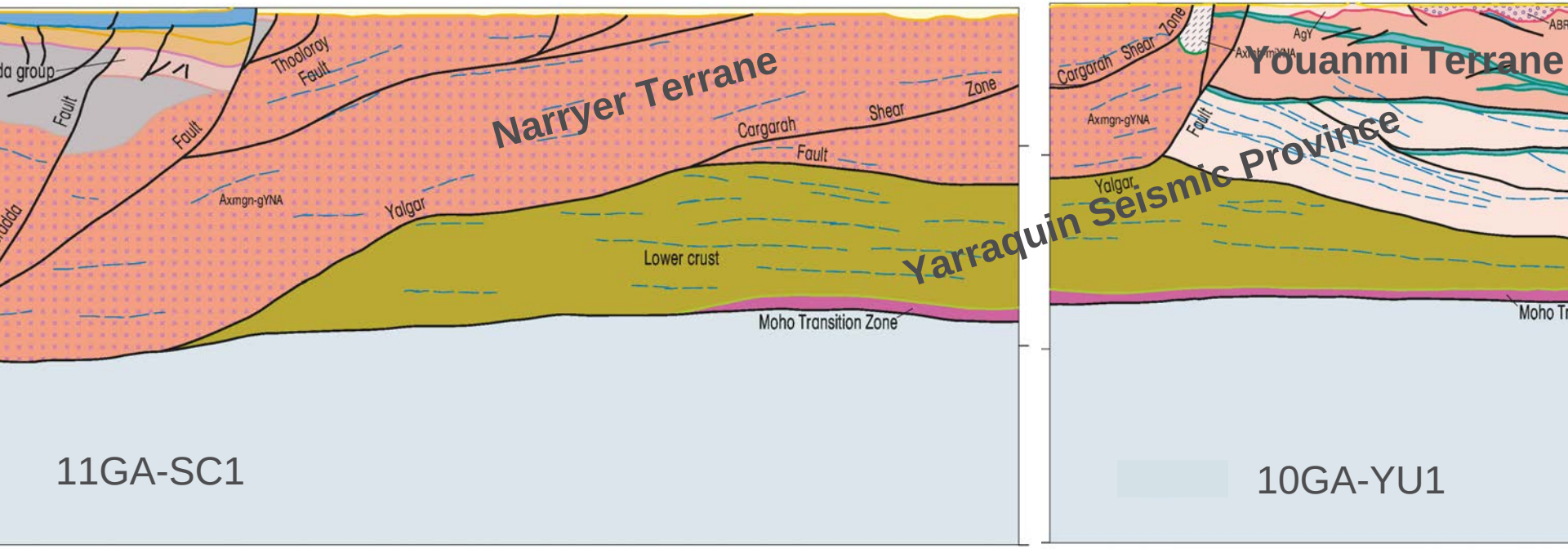




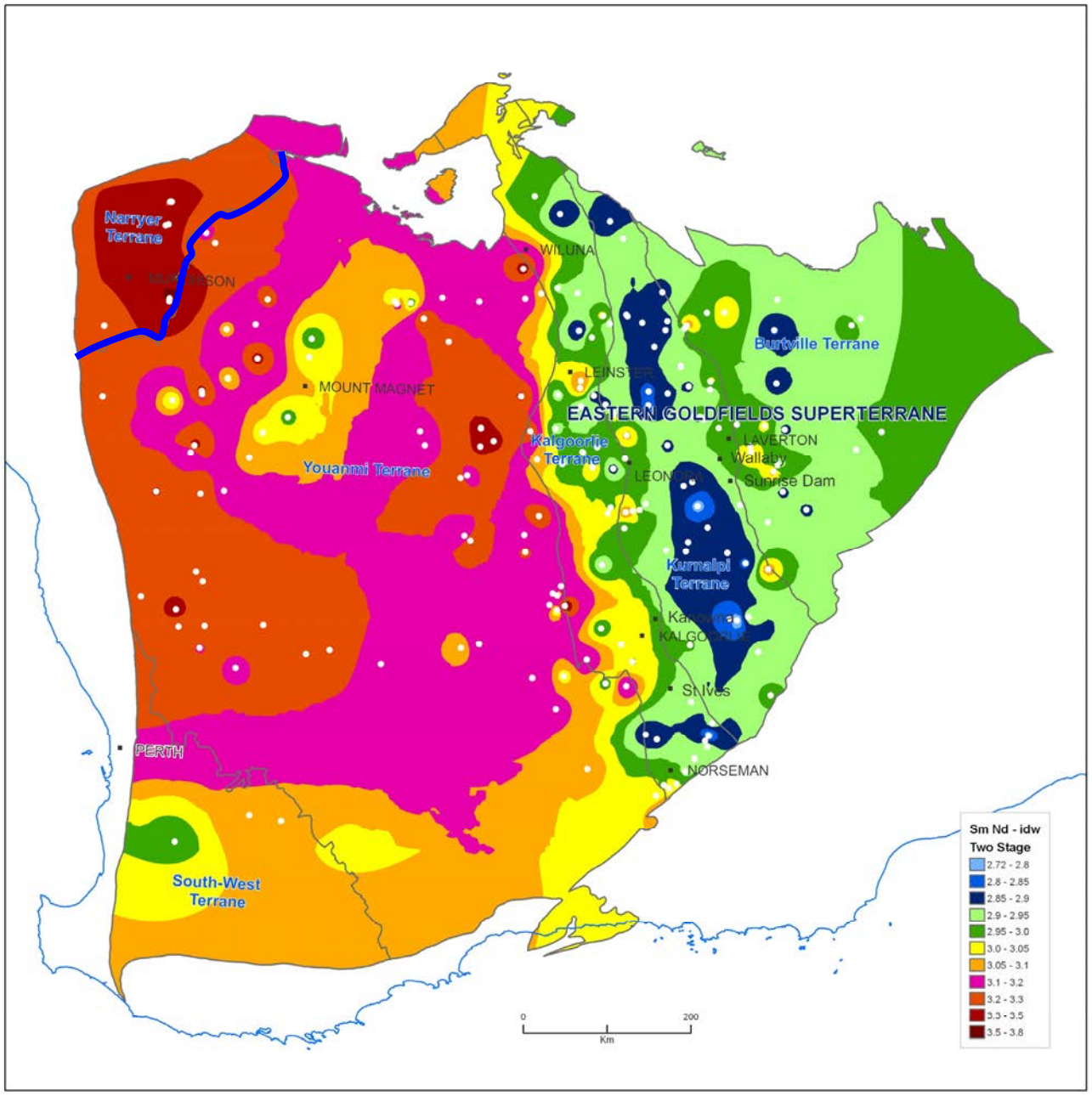
Relationship between Narryer Terrane & Youanmi Terrane
Combined 11GA-SC1 and 10GA-YU1



Relationship between Narryer Terrane & Youanmi Terrane Combined 11GA-SC1 and 10GA-YU1



Does the Yalgar Fault represent the site of a suture zone?

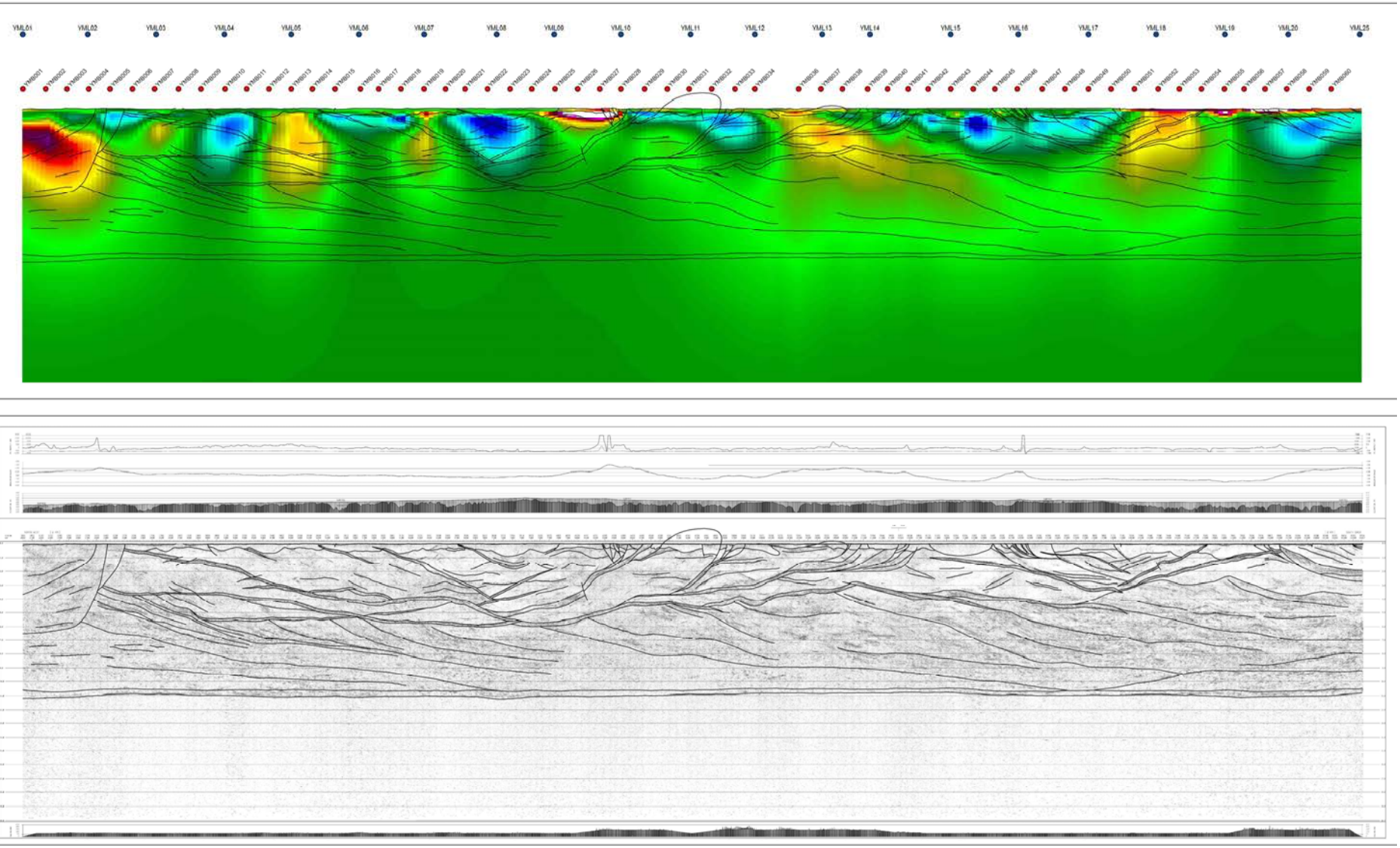


Nd model ages for granites - Champion & Cassidy (2007)

Distinctive pattern between terranes, but coherent pattern within terranes

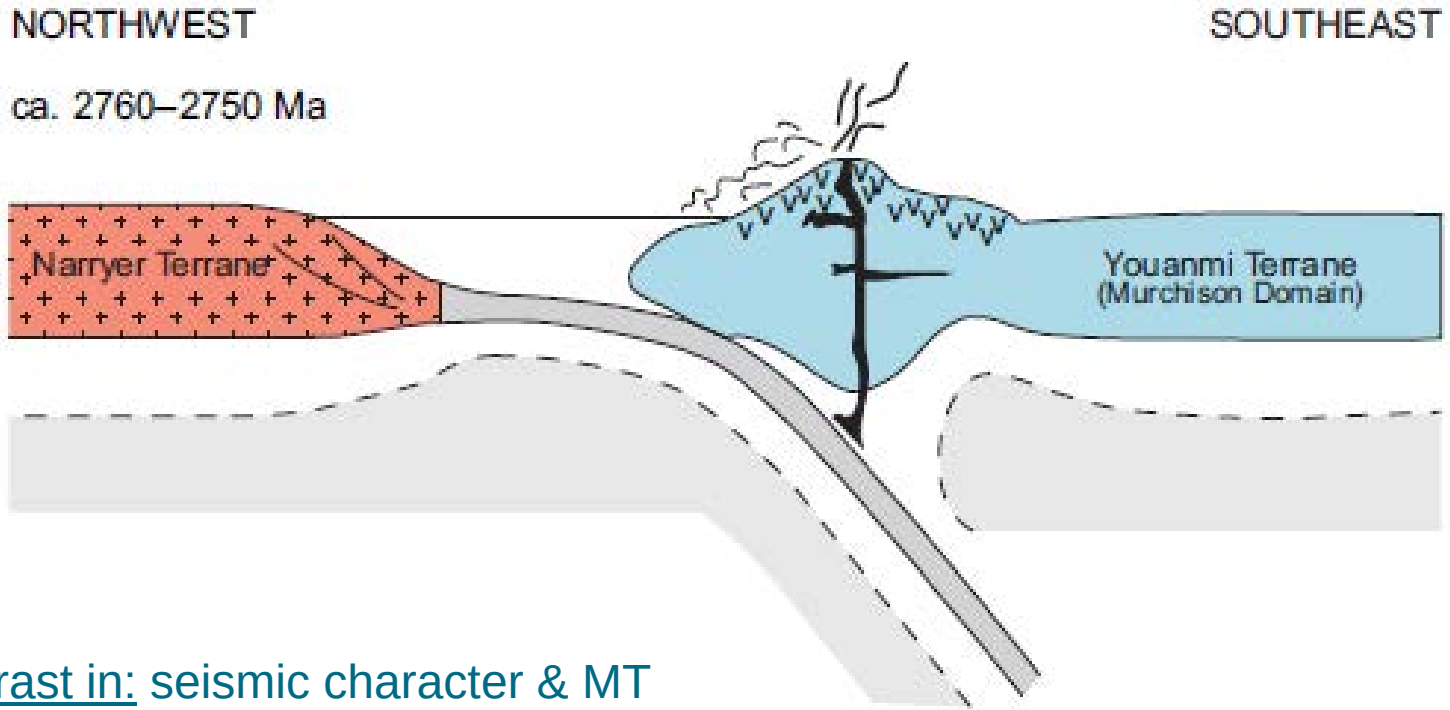
Note difference between Narryer and Youanmi terranes

10GA-YU1 – seismic interpretation & MT



NOTE: Contrast in MT across the Yalgar Fault

Collision between Narryer Terrane and Youanmi Terrane?



Contrast in: seismic character & MT
Nd model ages (older in Narryer Terrane)

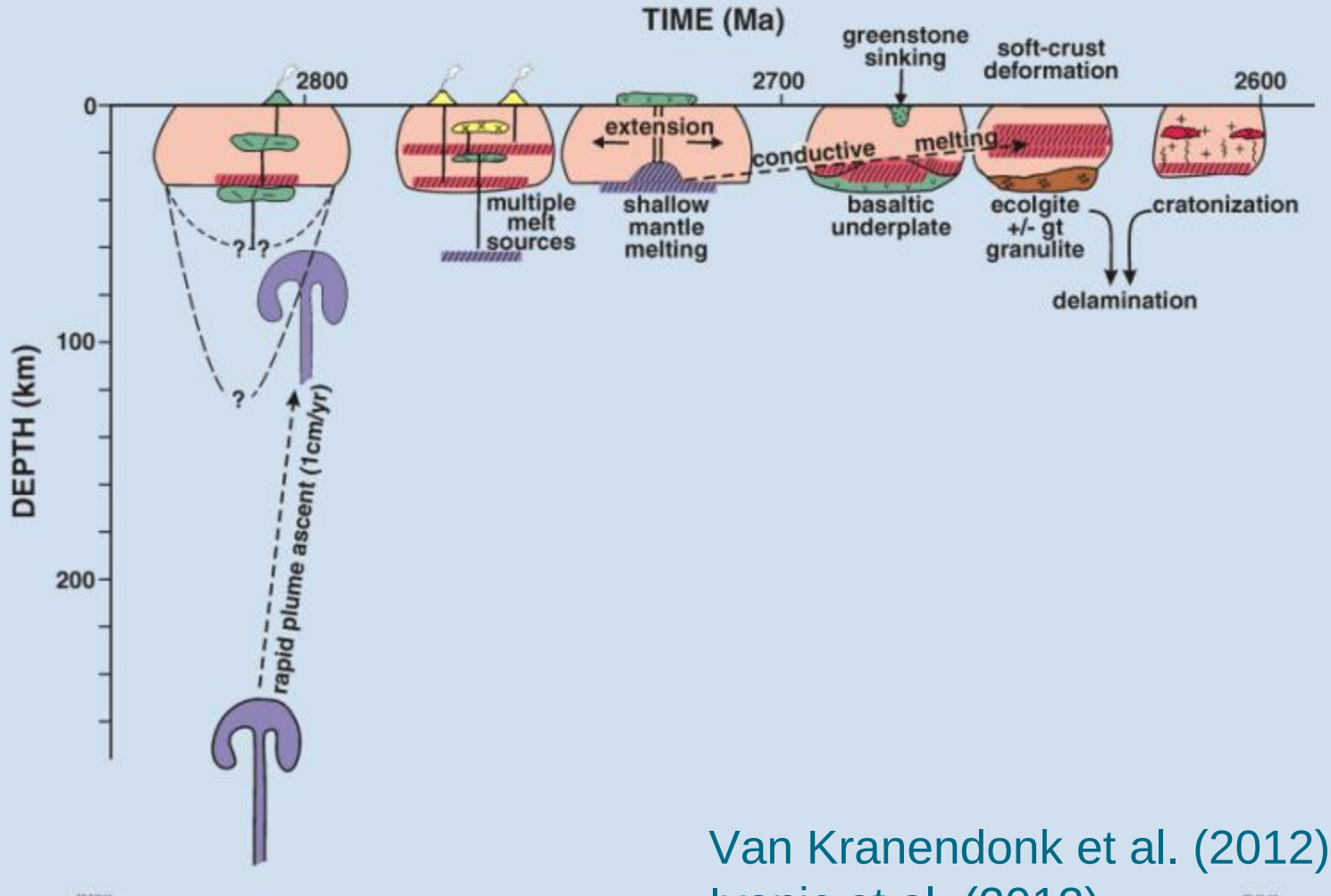
Timing – Northern Murchison Domain contains sanukitoid-like rocks (Champion et al. 2002) and boninites (Wyman & Kerrich 2012), both ca. 2780-2740 Ma – arc-forearc setting?

Polarity of subduction – arc-related rocks on upper plate are in Youanmi Terrane

Yalgar Fault – suture possibly represents collision-related opposite polarity

Stitching plutons – 2750-2620 Ma (Spaggiari et al. (2007)

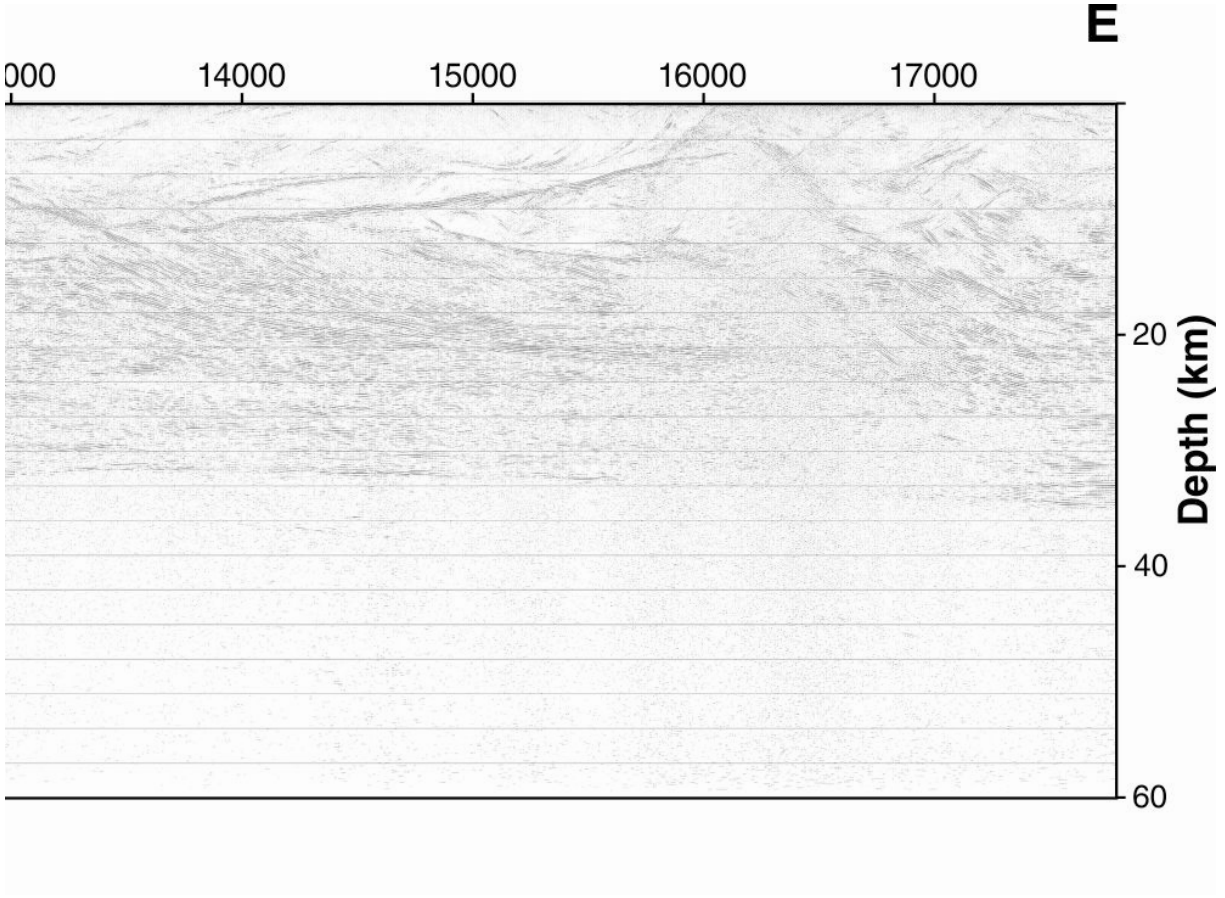
Alternative model for Murchison Domain – plume-driven autochthonous setting



Van Kranendonk et al. (2012)
Ivanic et al. (2012)

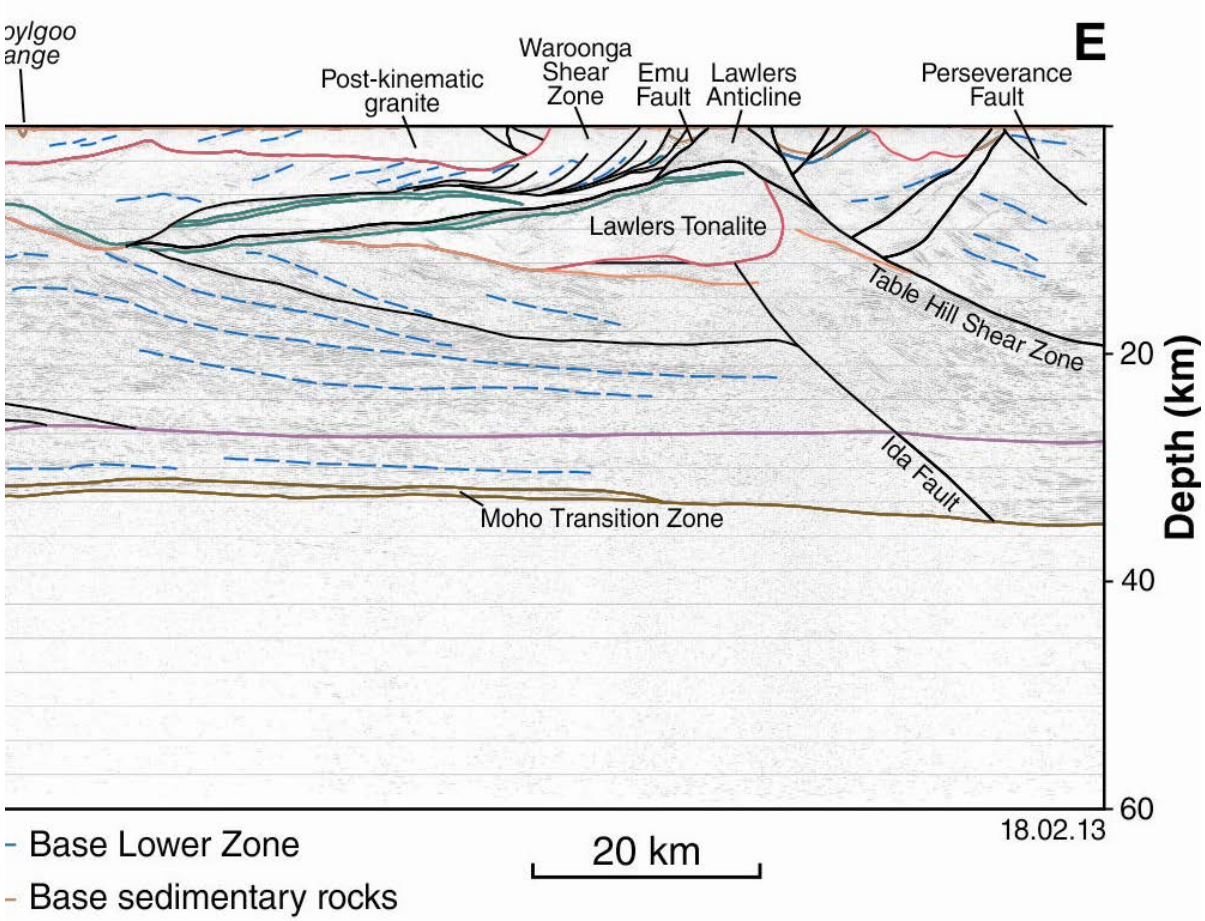
Relationship Between Youanmi Terrane & Kalgoorlie Terrane

Eastern end of 10GA-YU2

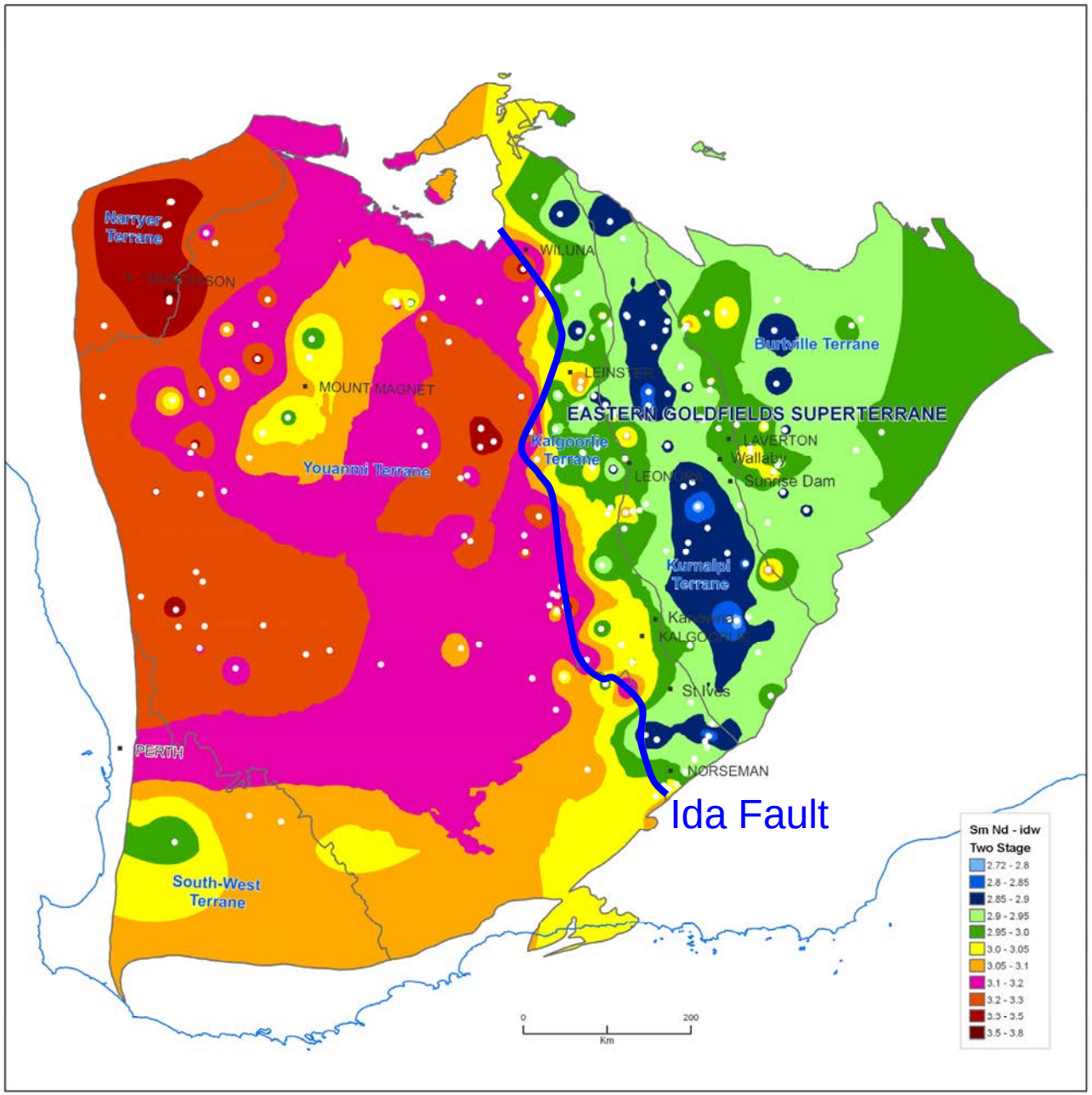


Relationship Between Youanmi Terrane & Kalgoorlie Terrane

Eastern end of 10GA-YU2



Does the Ida Fault represent the site of a suture zone?

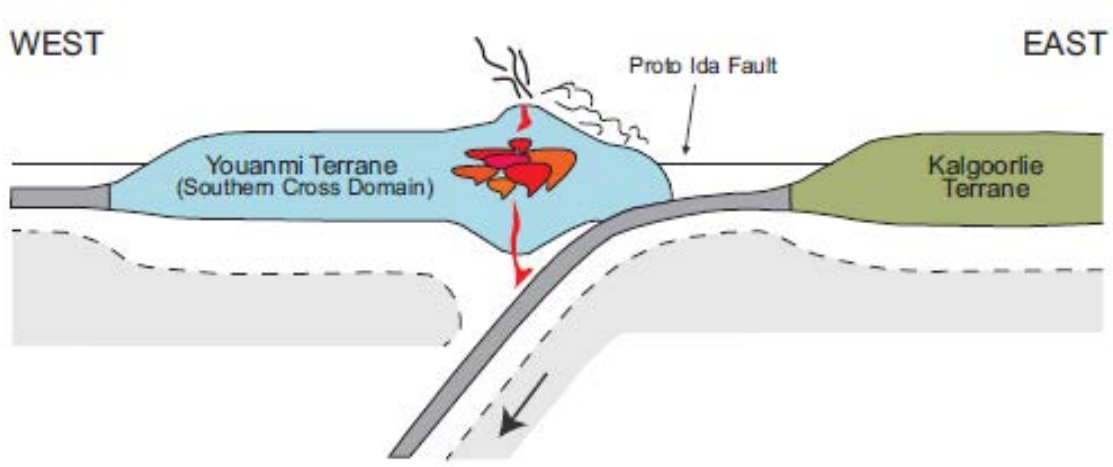


Nd model ages for granites - Champion & Cassidy (2007)

Distinctive pattern between terranes, but coherent pattern within terranes

Note big difference between Youanmi and Kalgoorlie terranes

Collision between Youanmi Terrane and Kalgoorlie Terrane?



Contrast in: seismic character
Nd model ages (older in Youanmi Terrane)

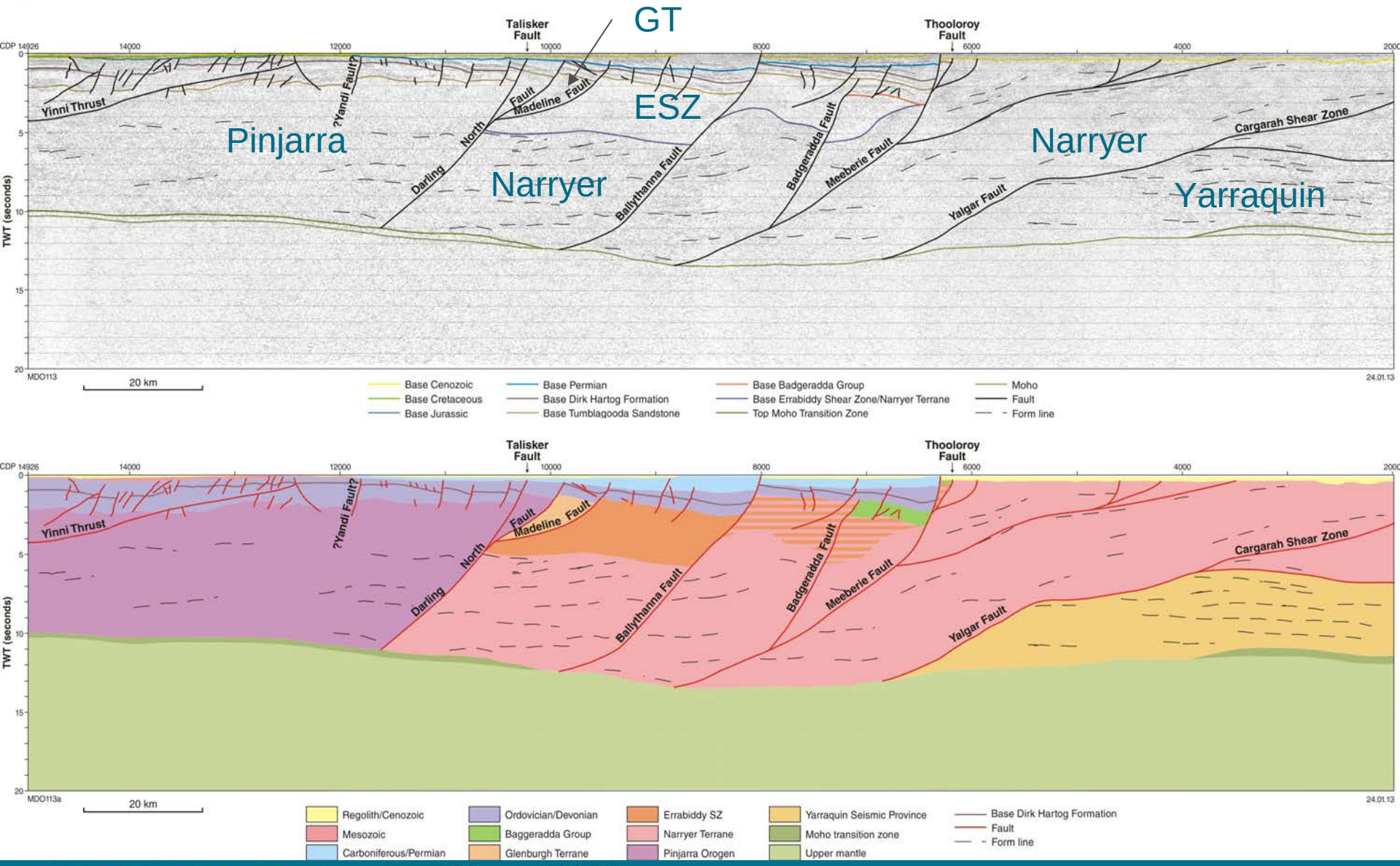
Timing – Southern Cross Domain contains boninites (Angerer et al. 2013)
– interpreted as intraoceanic arc

Age – not directly dated, possibly ca. 2800 Ma

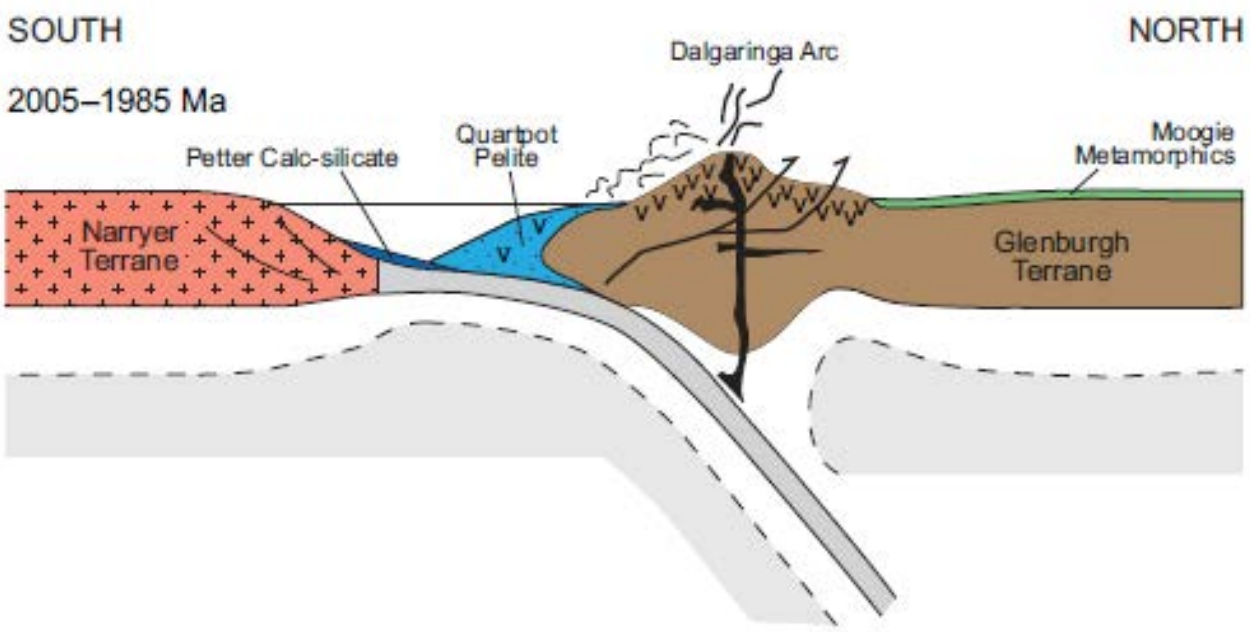
Polarity of subduction – arc-related rocks on upper plate are in Youanmi Terrane

Ida Fault – suture possibly represents collision-related opposite polarity

Relationship between Narryer Terrane and Glenburgh Terrane, and between Narryer Terrane and Pinjarra Orogen



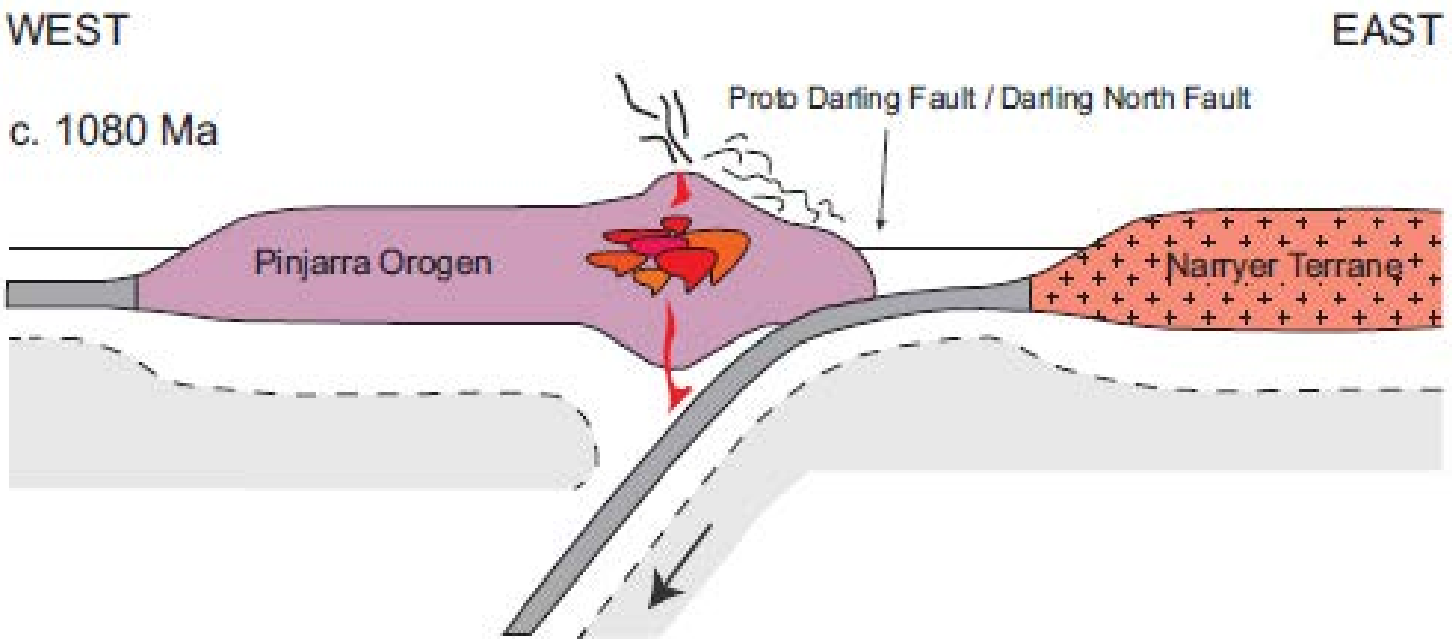
Collision between Glenburgh Terrane and Narryer Terrane



Dalgaringa magmatic arc (2005-1975 Ma) gives polarity of subduction
Collision - 1965-1950 Ma = Glenburgh Orogeny

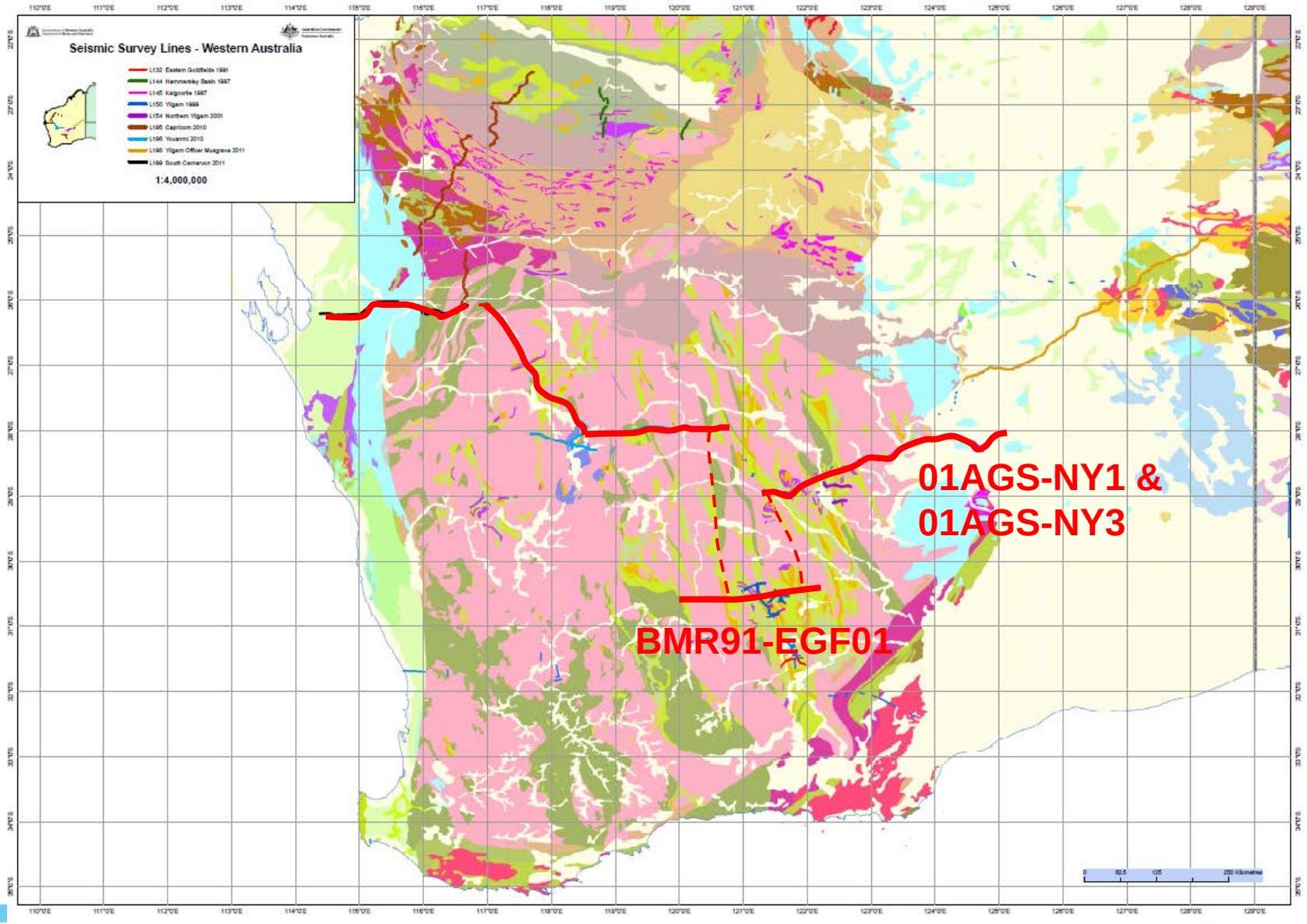
After Johnson et al. (2011); Korsch et al. (2011)

Relationship between Narryer Terrane and Pinjarra Orogen



Contrast in metamorphic and magmatic ages (Archean v Late Mesoproterozoic)
Timing – poorly constrained, but 1080 Ma granulites In Pinjarra Orogen interpreted to be result of collision
Polarity of subduction – poorly constrained, but no Mesoproterozoic magmatic rocks found in Narryer Terrane – suggests west-dipping subduction
Darling Fault & Darling North Fault – possible suture, with Paleozoic extensional reactivation

Link with previous seismic lines in Yilgarn Craton



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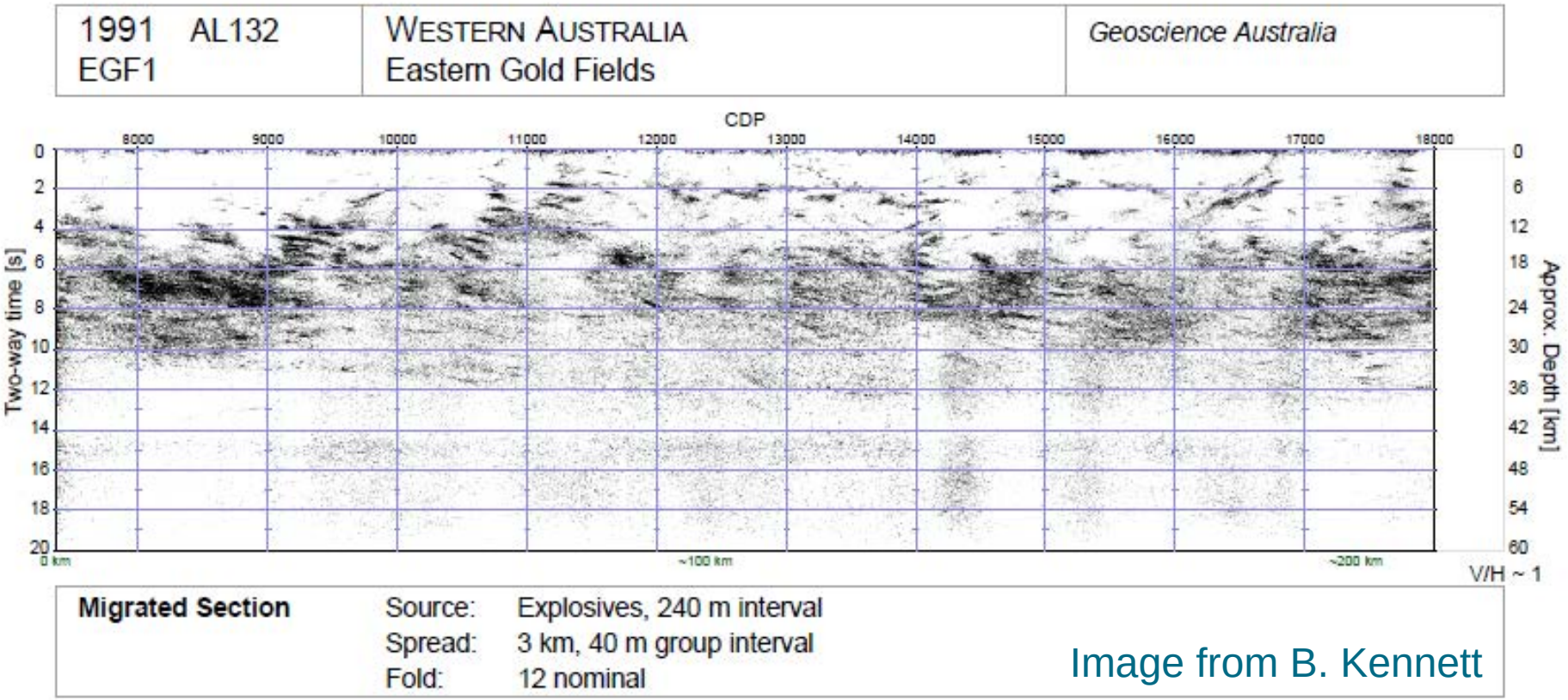


Image from B. Kennett

01AGS-NY1 and 01AGS-NY3

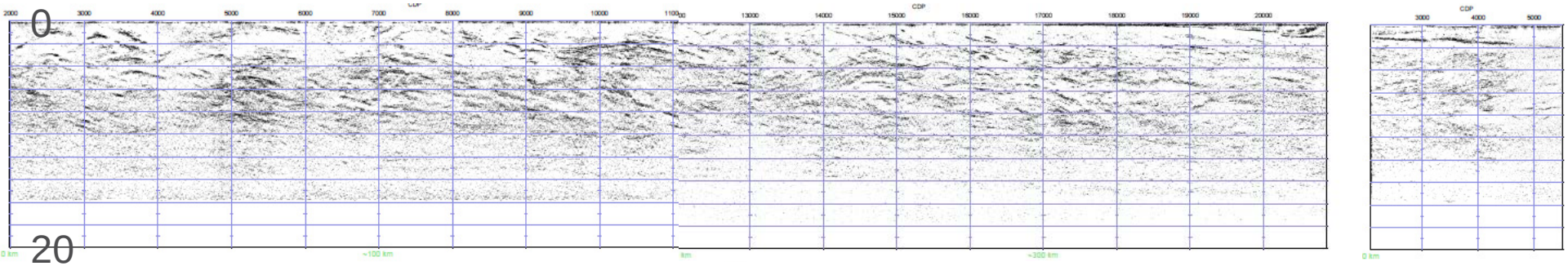
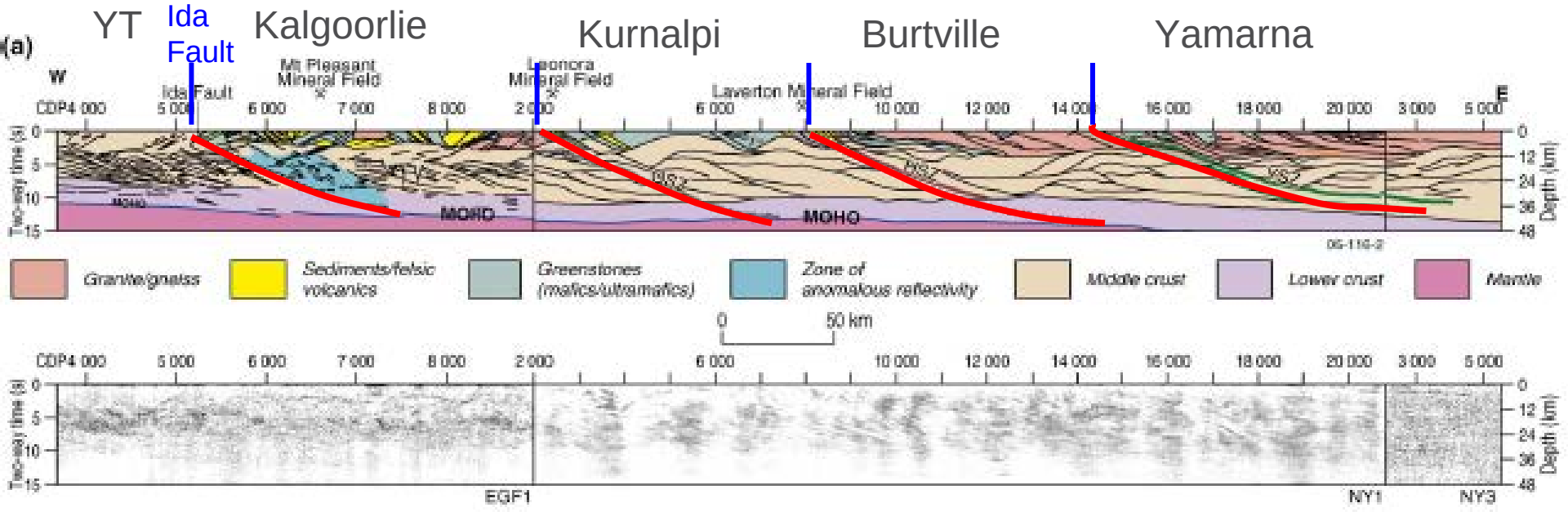


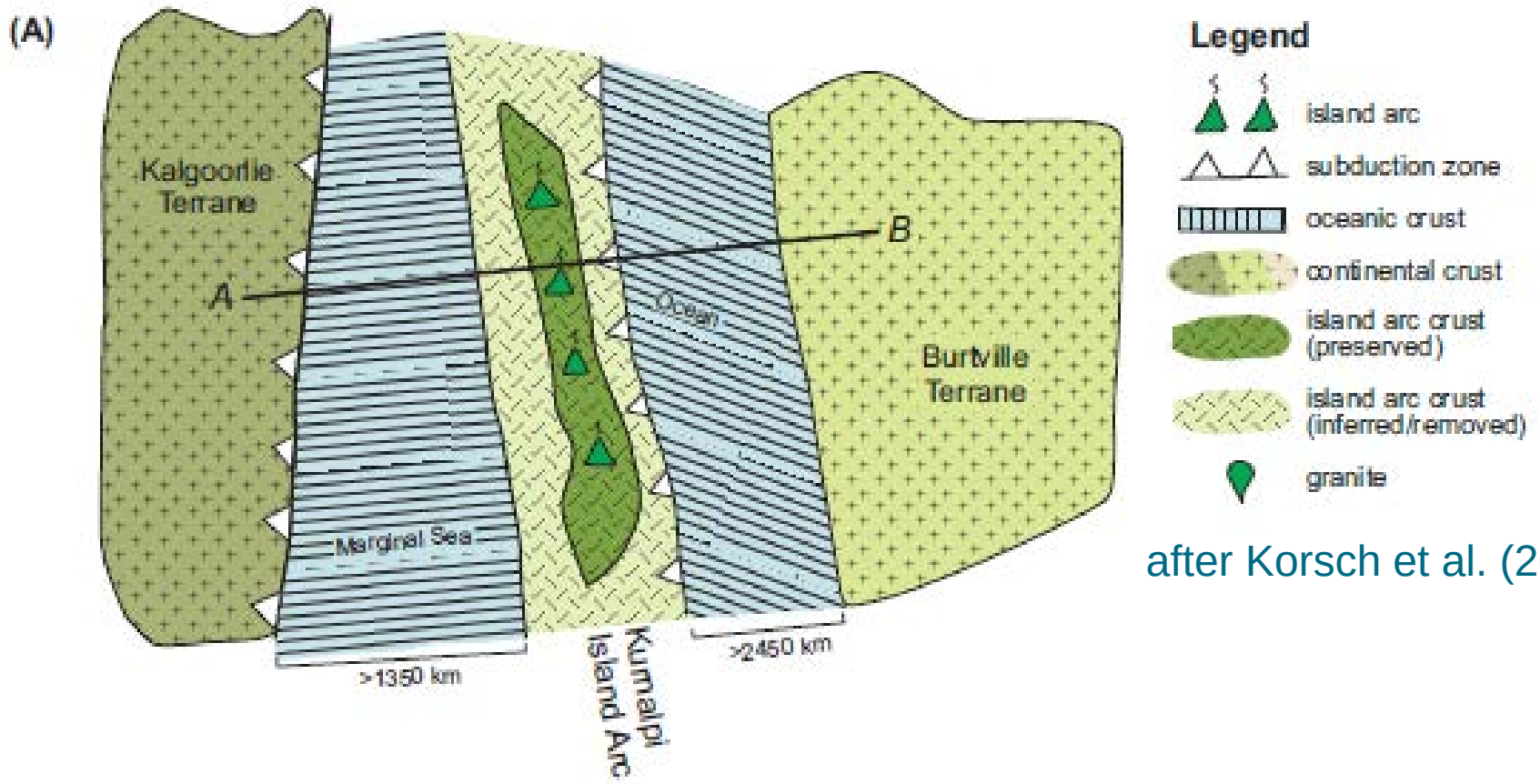
Image from B. Kennett

Combined section – relationship between Youanmi Terrane and terranes in Eastern Goldfields Superterrane



Goleby et al. (2006)

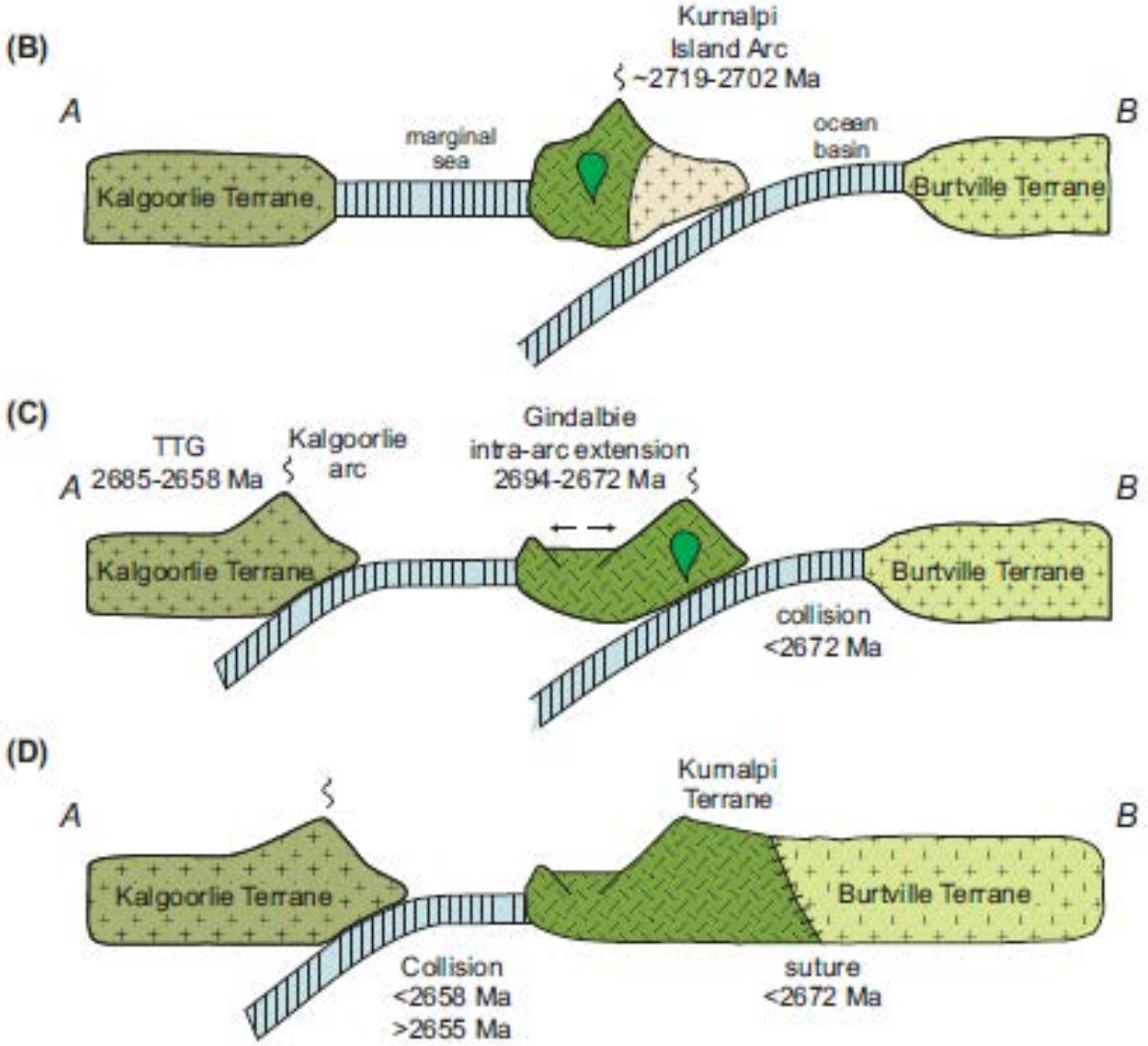
Possible tectonic scenario for formation of Kurnalpi island arc



after Korsch et al. (2011)

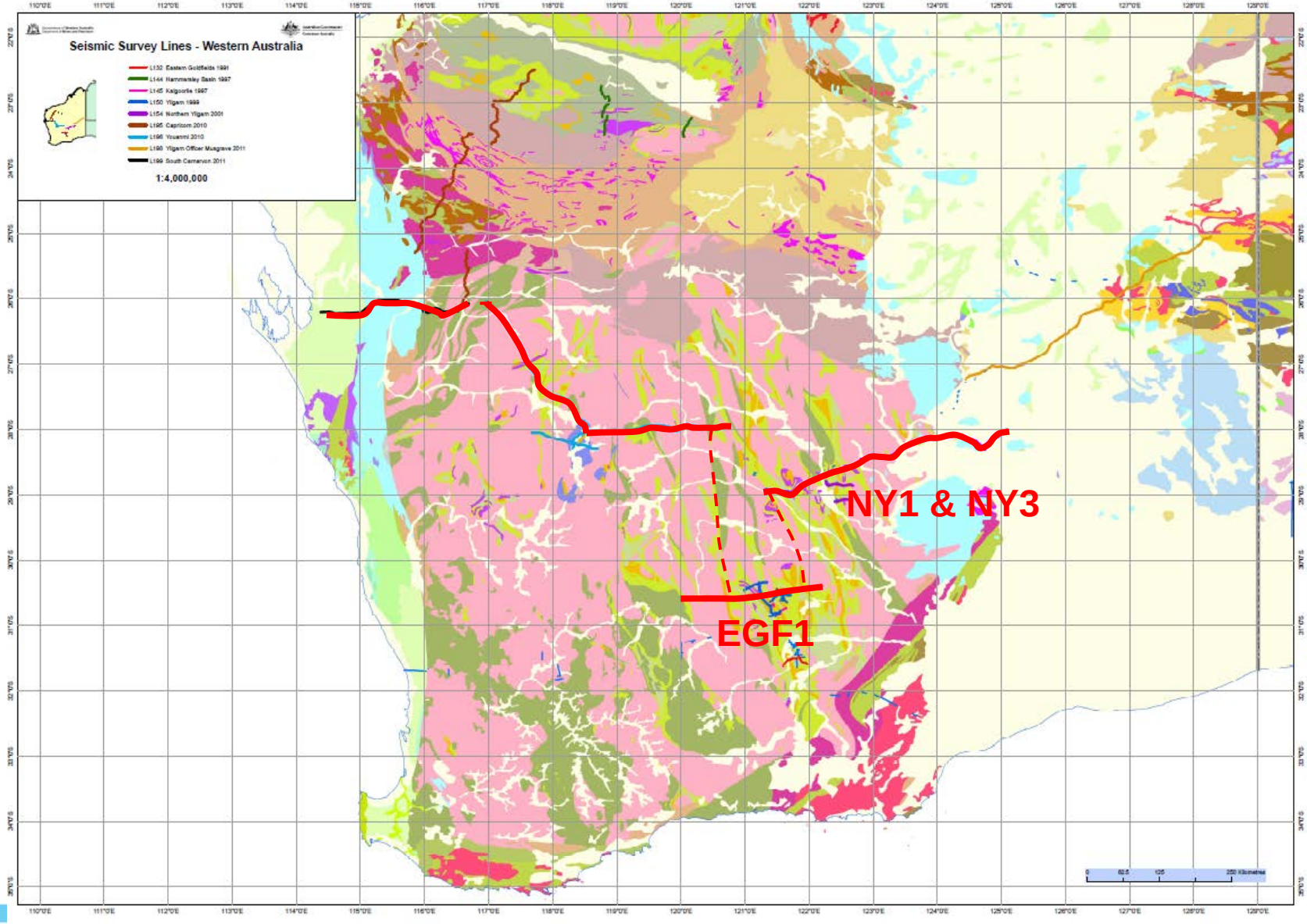
Contrast in: Nd model ages (Kurnalpi Terrane is most juvenile)
Timing – Kurnalpi Terrane volcanic rocks 2719-2702 Ma – interpreted as intraoceanic arc (Barley et al. 2008; Kositcin et al. 2008)

Schematic cross sections for accretion of eastern Yilgarn terranes

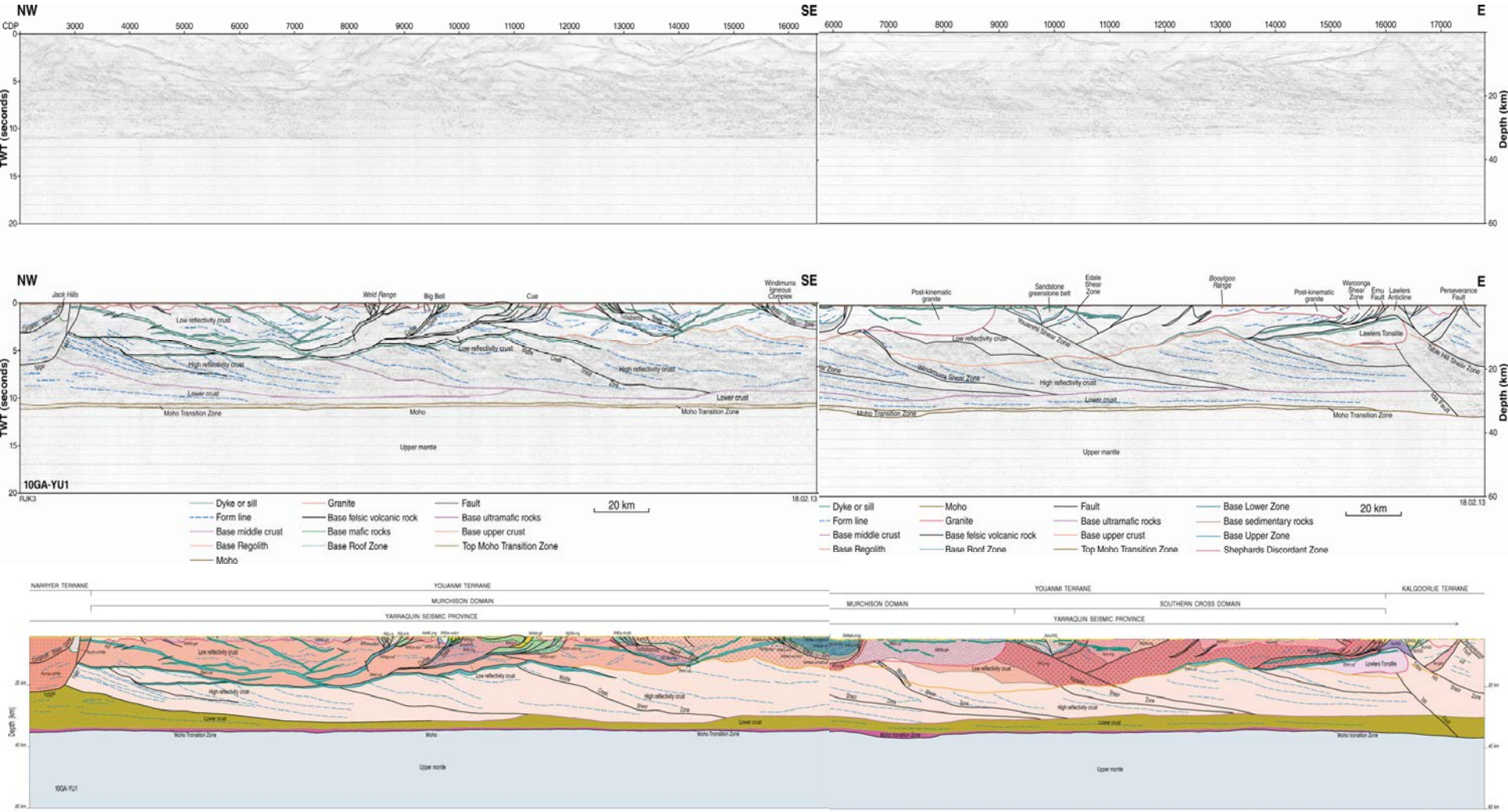


after Korsch et al. (2011)

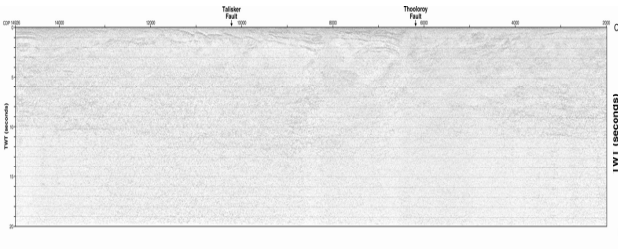
Transect from Pinjarra orogen to eastern Yilgarn Craton

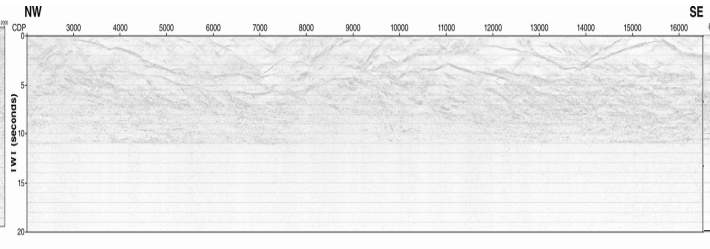


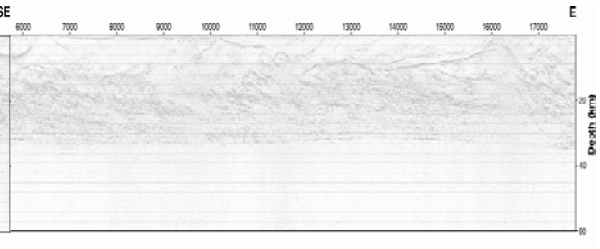
Composite section - Youanmi Terrane

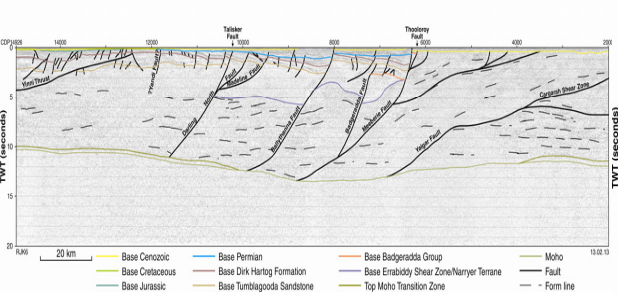


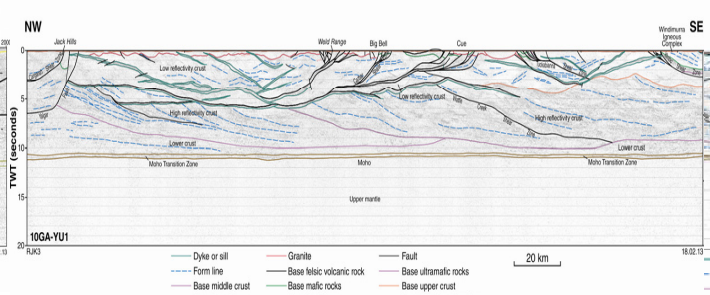
Pinjarra Orogen - Narryer Terrane – Youanmi Terrane

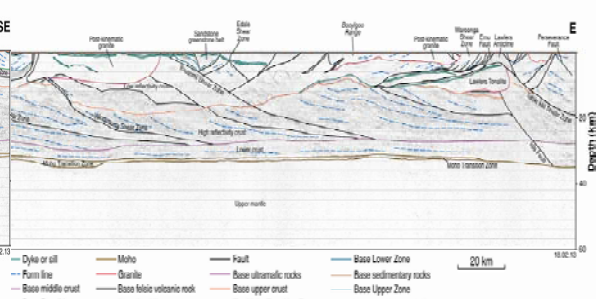


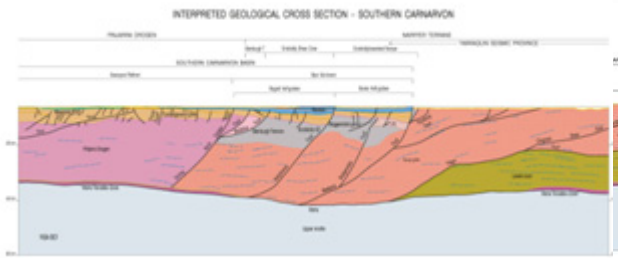


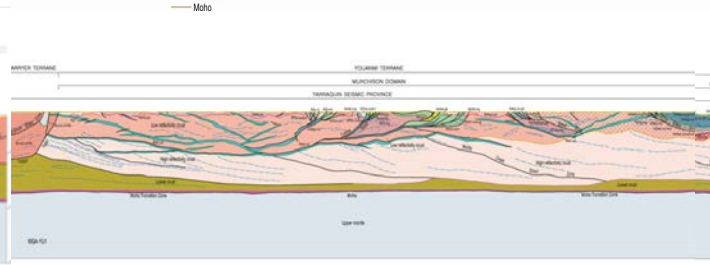


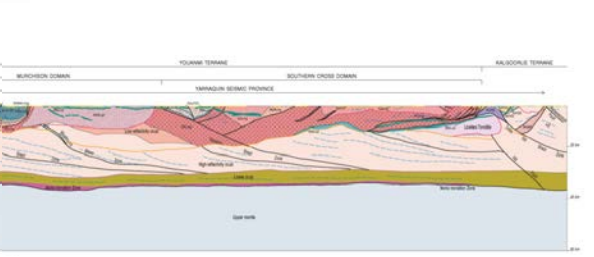






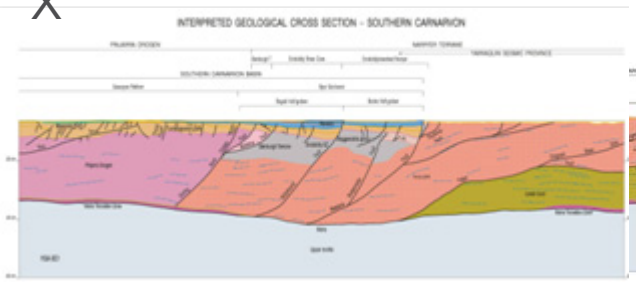






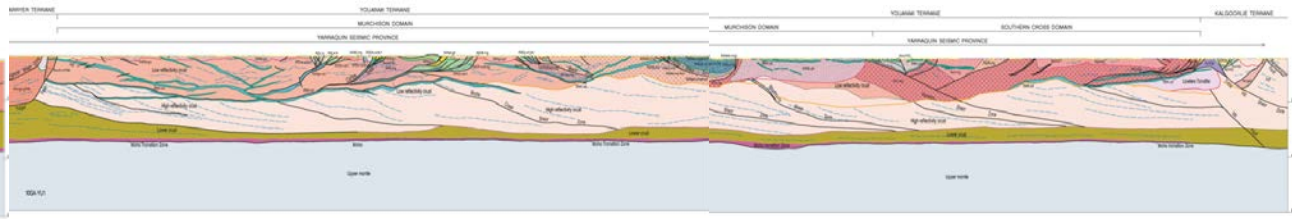
Composite section from Pinjarra orogen to eastern Yilgarn Orogen

X



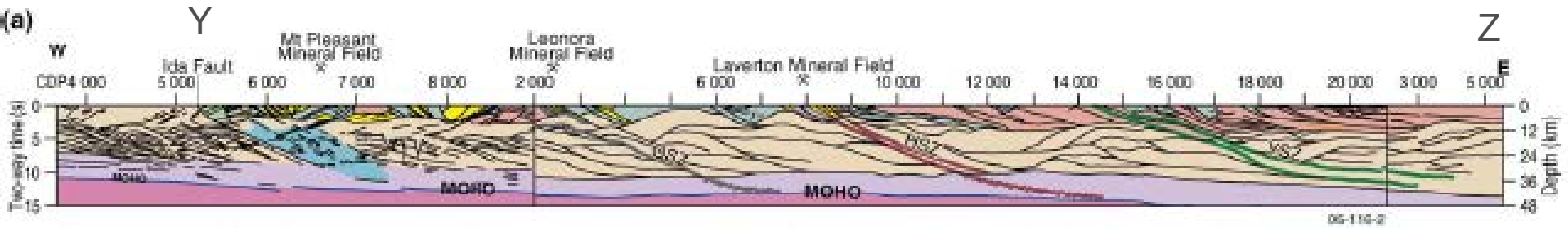
11GA-SC1

Y



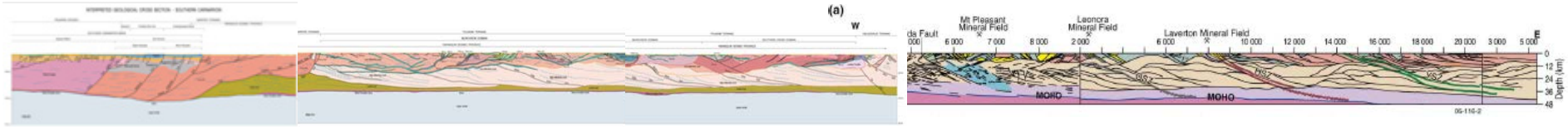
10GA-YU1 10GA-YU2

(a) Y Z

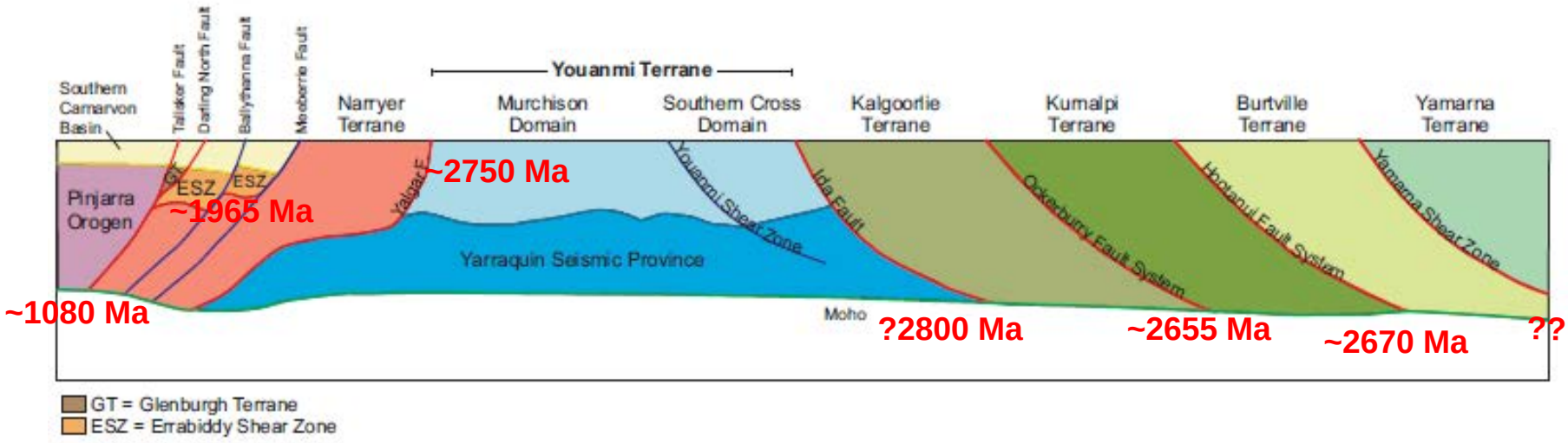


BMR91-EGF01 01AGS-NY1 01AGS-NY3

Composite section from Pinjarra orogen to eastern Yilgarn Orogen



Cartoon cross section (not to scale) showing present day relationships between the crustal terranes

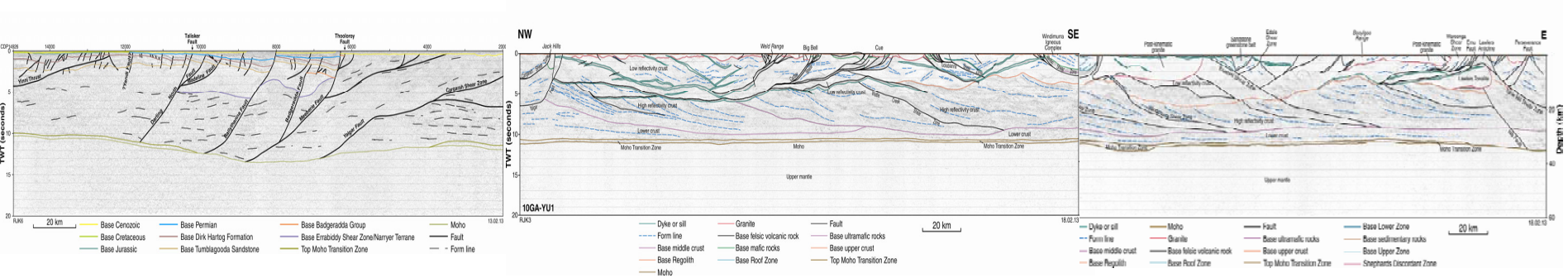


Youanmi Terrane + Yarraquin Seismic Province form a central nucleus, or protocraton of Yilgarn Craton

Narryer Terrane sutured to protocraton in northwest

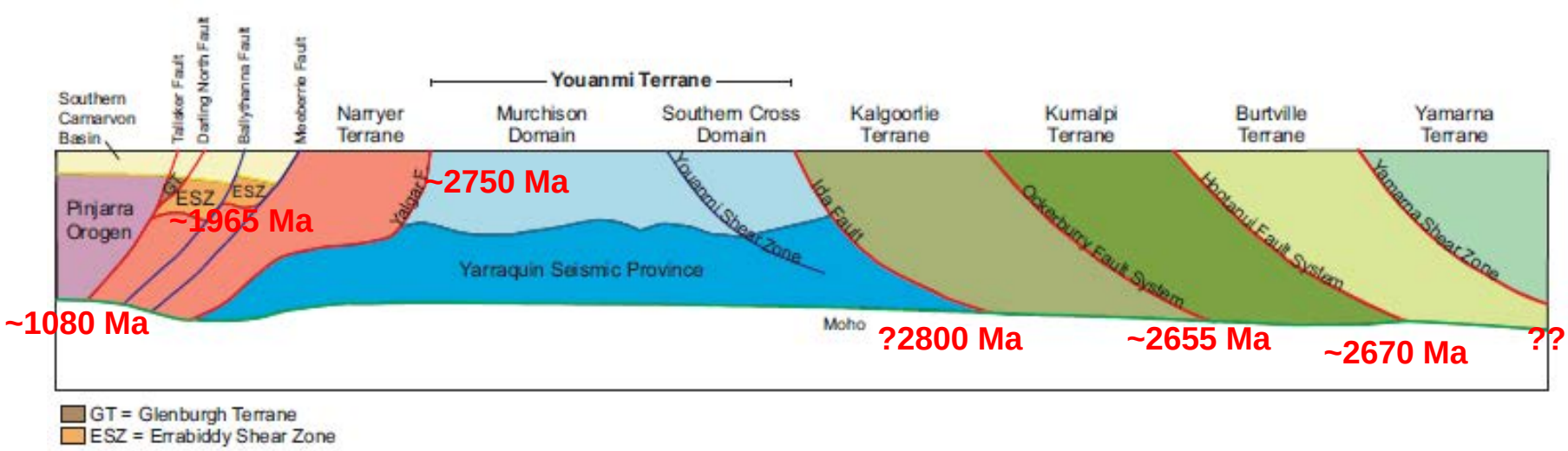
Terranes of Eastern Goldfields Superterrane in east accreted to protocraton, to form part of the West Australian Craton

Summary 1
Crustal architecture of Pinjarra Orogen to Ida Fault



- First holistic view of the crustal architecture of the region (954 line km of new seismic data, 695 km of new MT)
- Several crustal-scale terranes
  - Including newly recognised seismic province
- Youanmi Terrane + Yarraquin SP = 3 layer crust
- Narryer Terrane – different seismic reflectivity & MT

Summary 2
Assembly of part of West Australian Craton



- **Several probable sutures recognised**
- **Progressive accretion of continental slivers onto protocraton (ie Youanmi Terrane and Yarraquin Seismic Province)**

Coming soon: Transect across southern Western Australia

YOM (484 km)
19 June 2013

Albany-Fraser &
Tropicana
(672 km)
March 2014

Australian Government
Geoscience Australia

Seismic data and interpretations can be downloaded from:

http://www.ga.gov.au/minerals/projects/current-projects/seismic-acquisition-processing.html

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