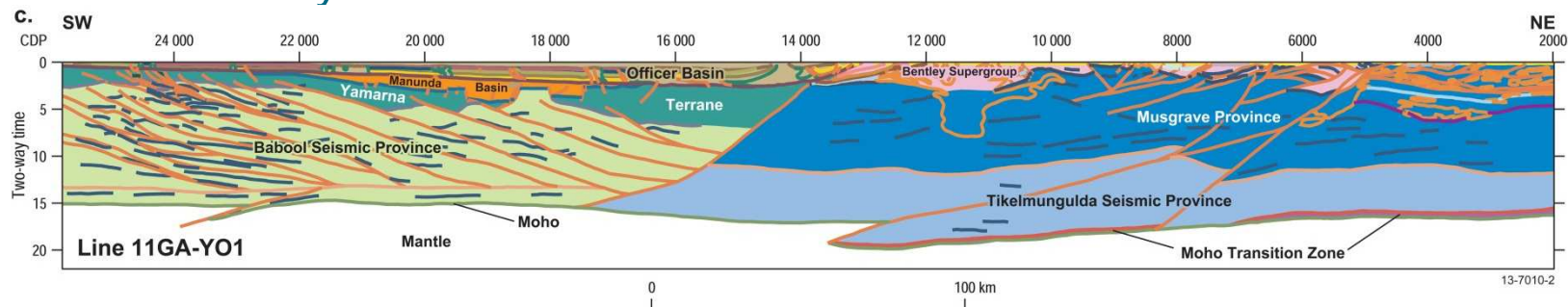


# Geodynamic implications of the Yilgarn-Officer-Musgrave (YOM) deep seismic reflection survey: part of a ~1800 km transect across Western Australia from the Pinjarra Orogen to the Musgrave Province

[Russell Korsch](#), R Blewett, H Smithies, R Quentin de Gromard, H Howard, M Pawley, L Carr, R Hocking, N Neumann, BLN Kennett, ARA Aitken, J Holzschuh, J Duan, J Goodwin, T Jones, K Gessner and W Gorczyk



# Project Partners



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



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

**Australian Government**  
**Onshore Energy Security Program**



**Geological Survey of**  
**Western Australia**

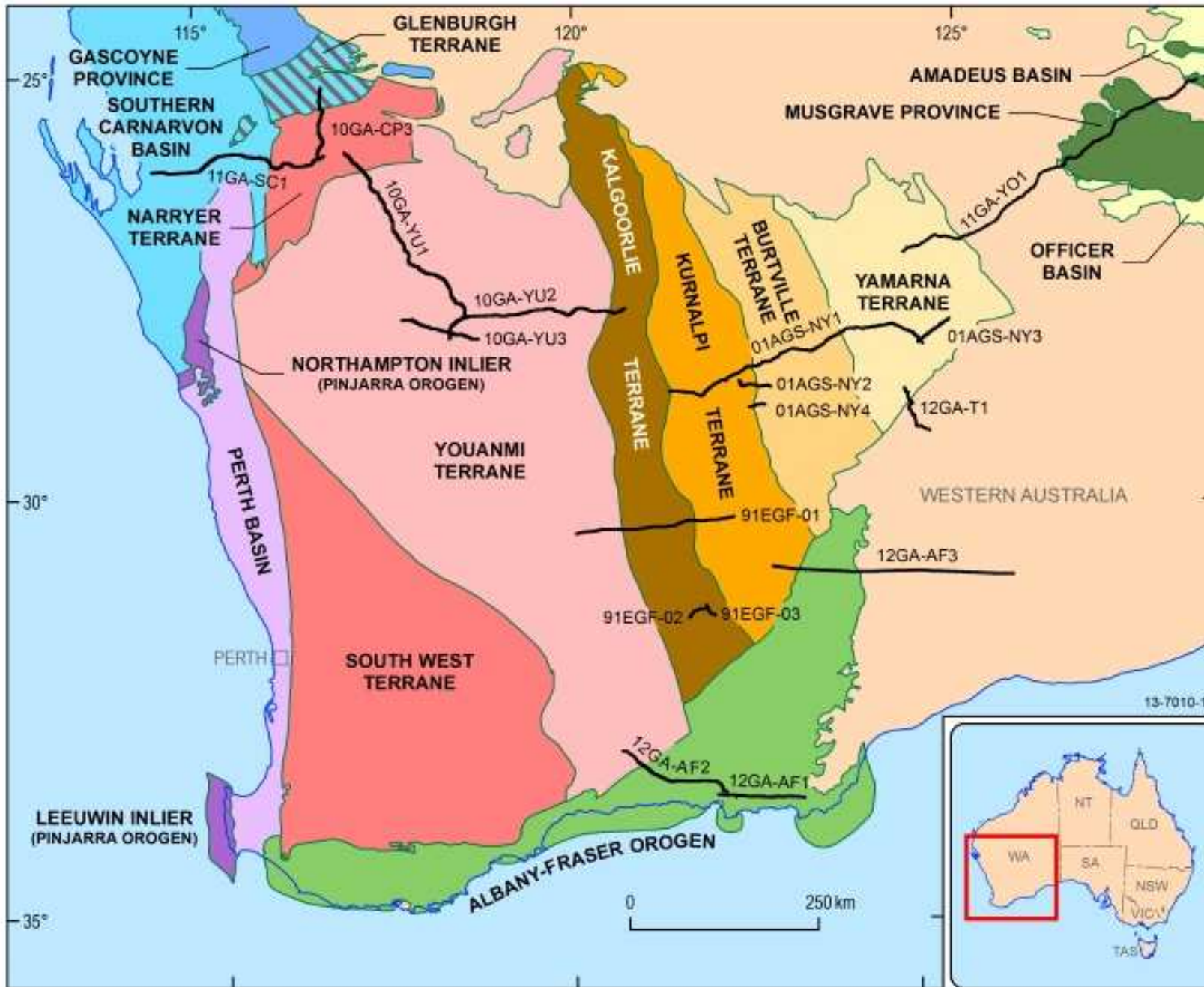


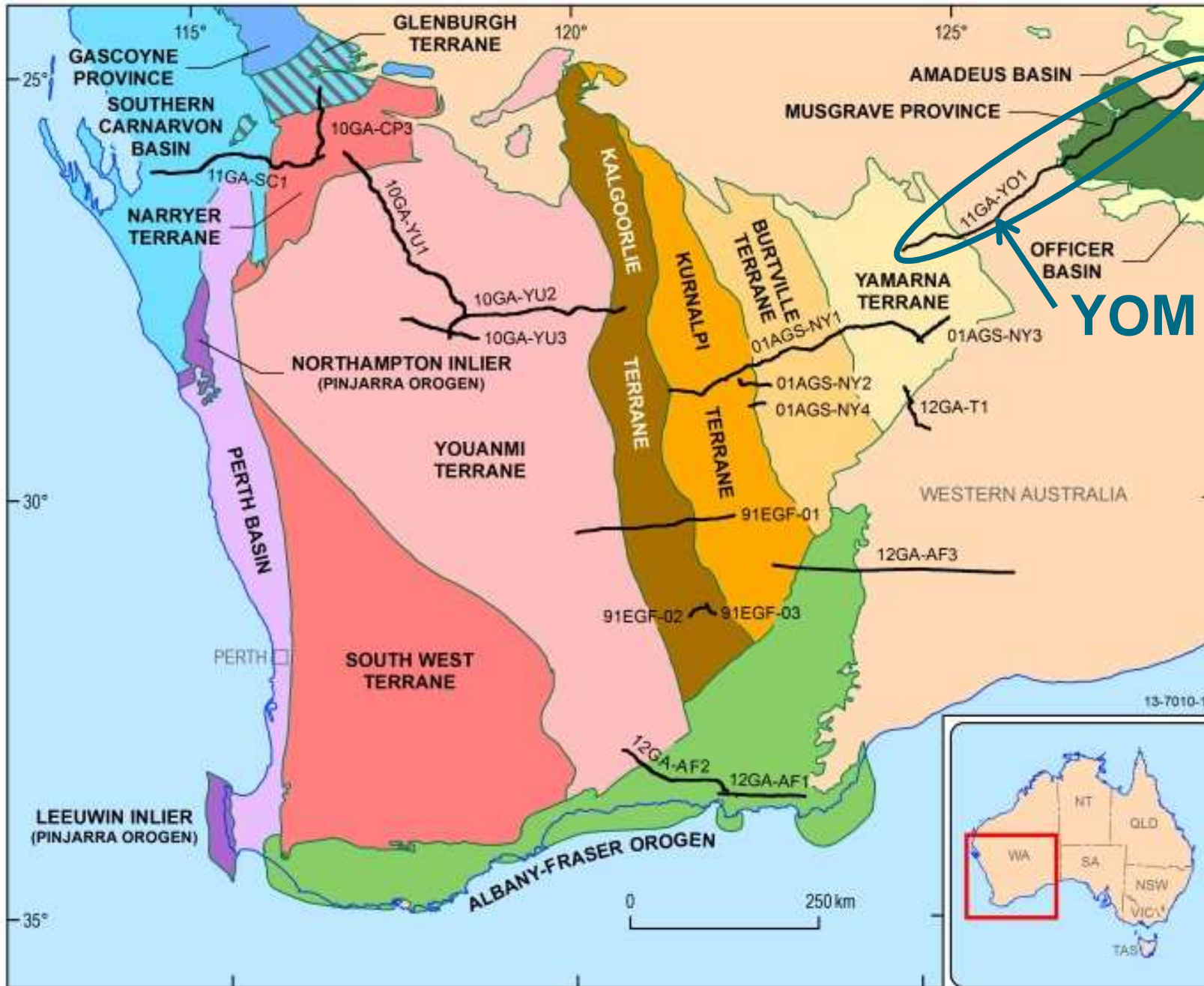
**ROYALTIES**  
**FOR REGIONS**

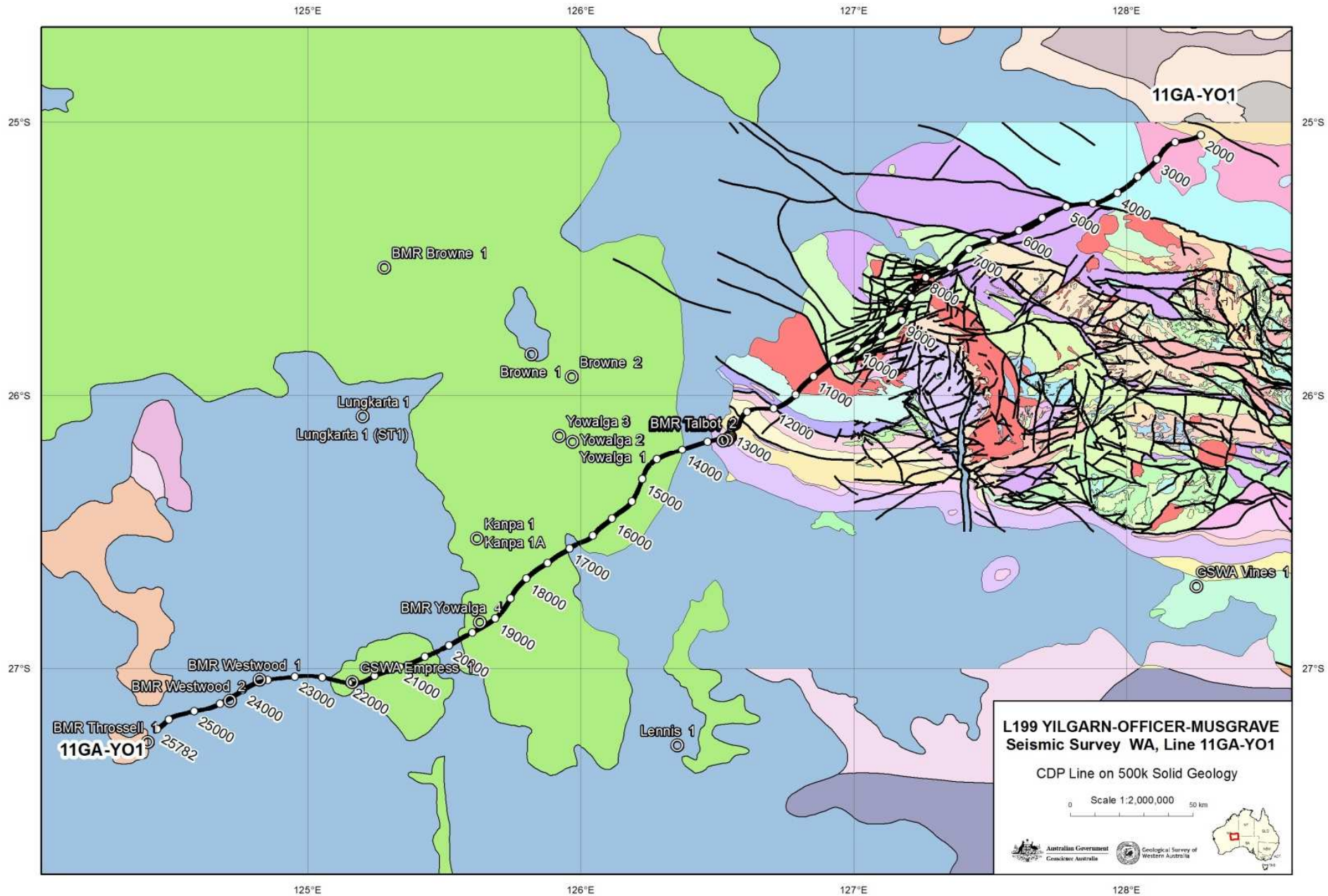
**EXPLORATION INCENTIVE SCHEME**

## **Contributors**

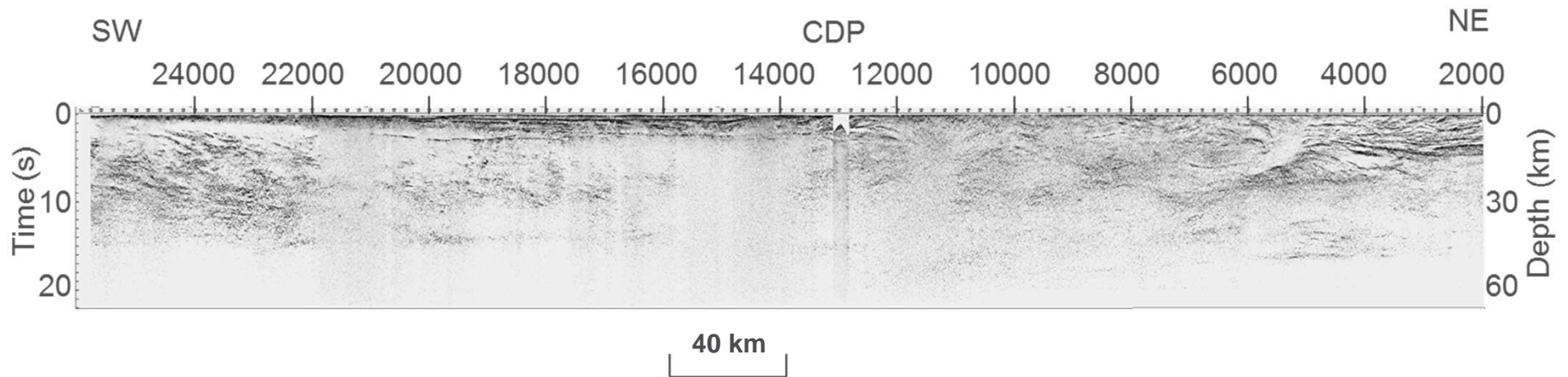
Geological Survey of South Australia  
RSES, Australian National University  
CET, University of Western Australia







# YOM crustal architecture



**Note:  $V = H$  (assuming average crustal velocity = 6000 ms<sup>-1</sup>)**

Image of entire line (484 km long, to a depth of 66 km)

Moho

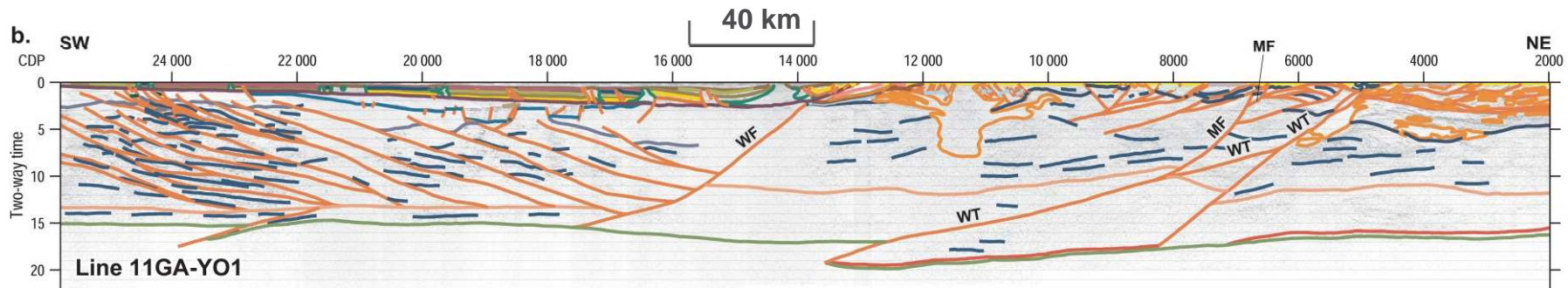
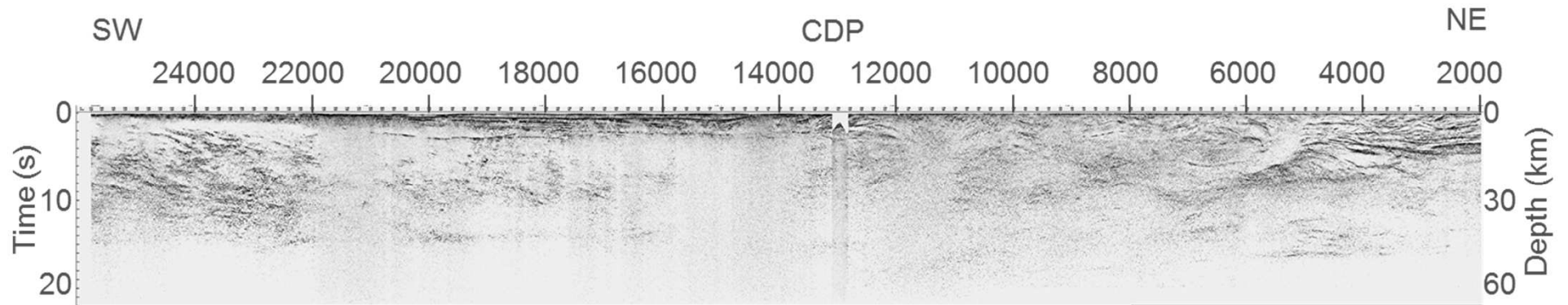
Key provinces (crust in SW versus crust in NE)

Major structures

Geodynamic implications

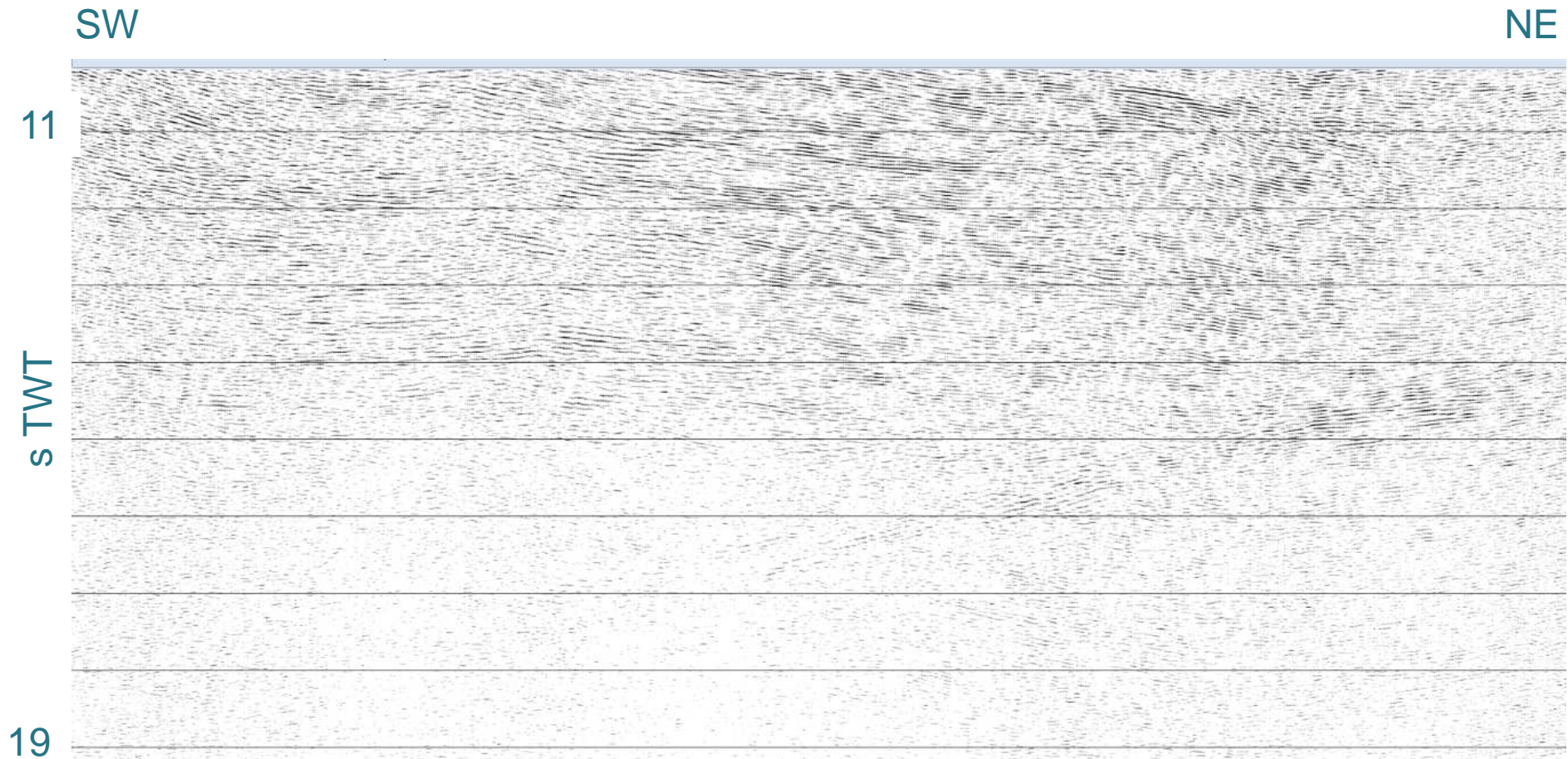
Transect across Western Australia

# YOM crustal architecture - Moho



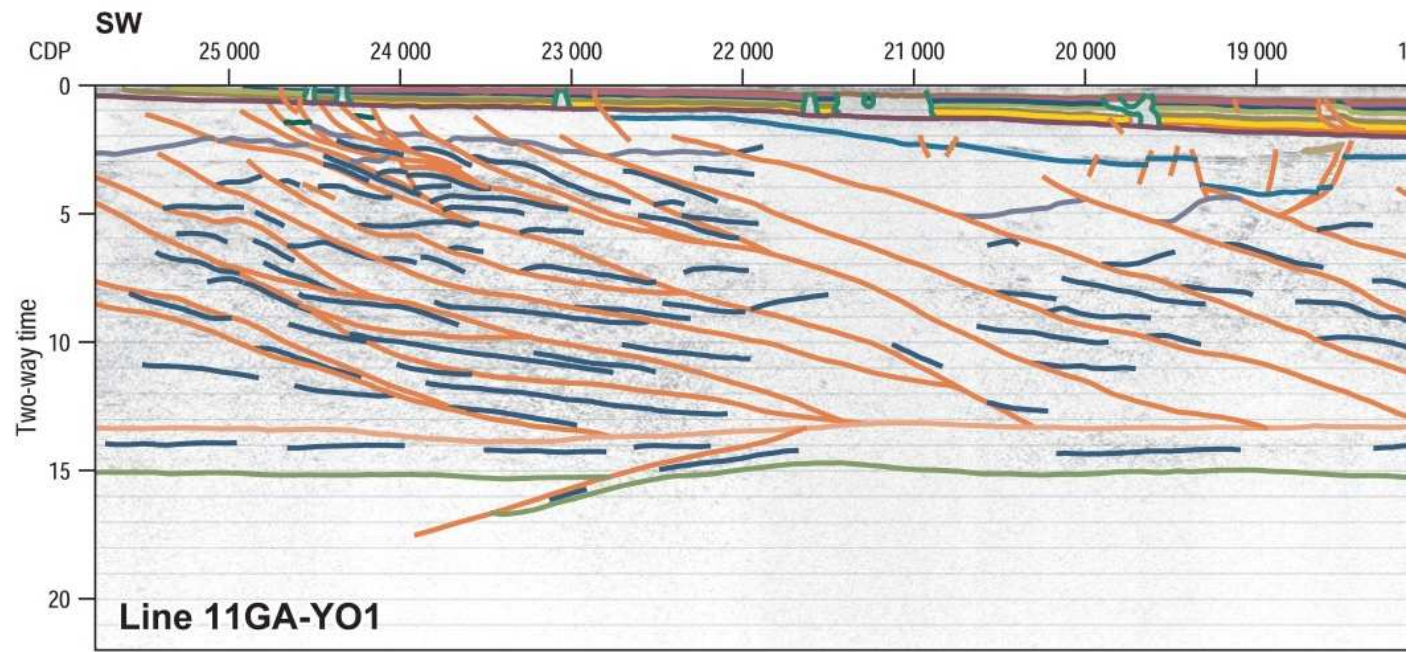
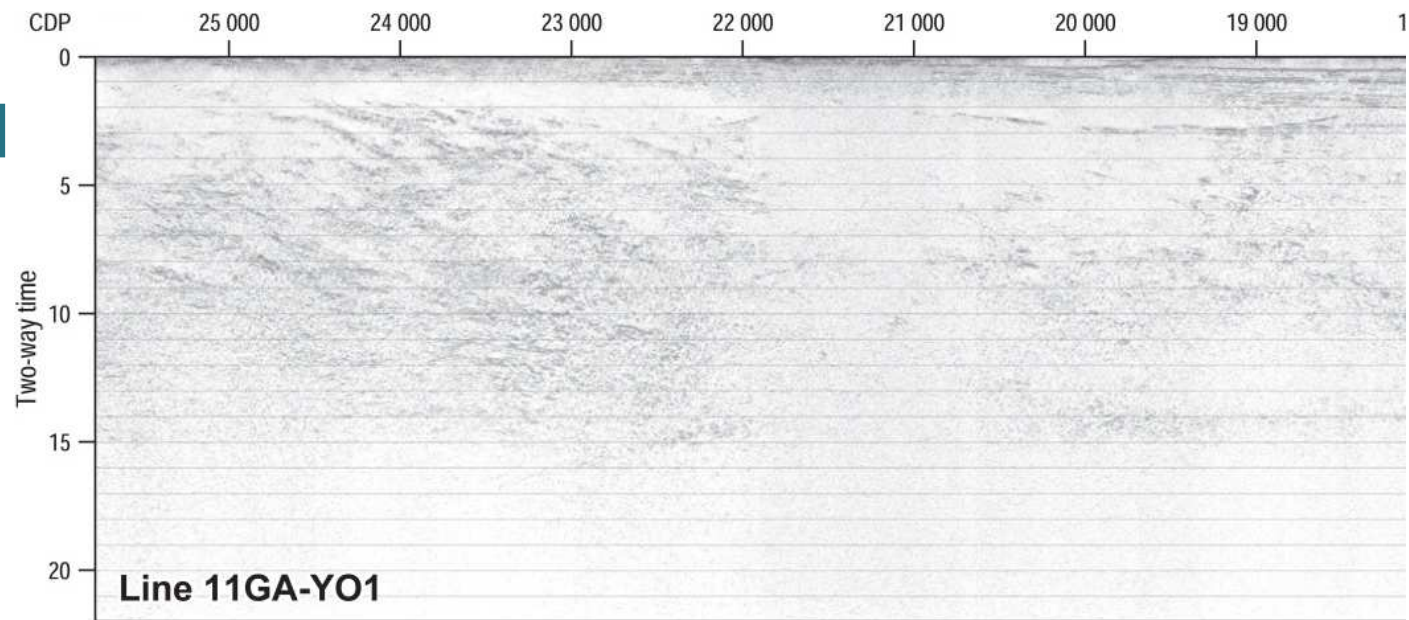
- Moho**
- very well to very poorly defined
  - ~15 s TWT (~45 km depth) in southwest
  - ~16.2 s TWT (~49 km depth) at northeast end
  - thickens to SW to ~19.8 s TWT (~59 km depth)
  - Overall, Musgrave crust is thicker than Yilgarn crust
  - Moho possibly faulted by Woodroffe Thrust

# Faulted Moho?

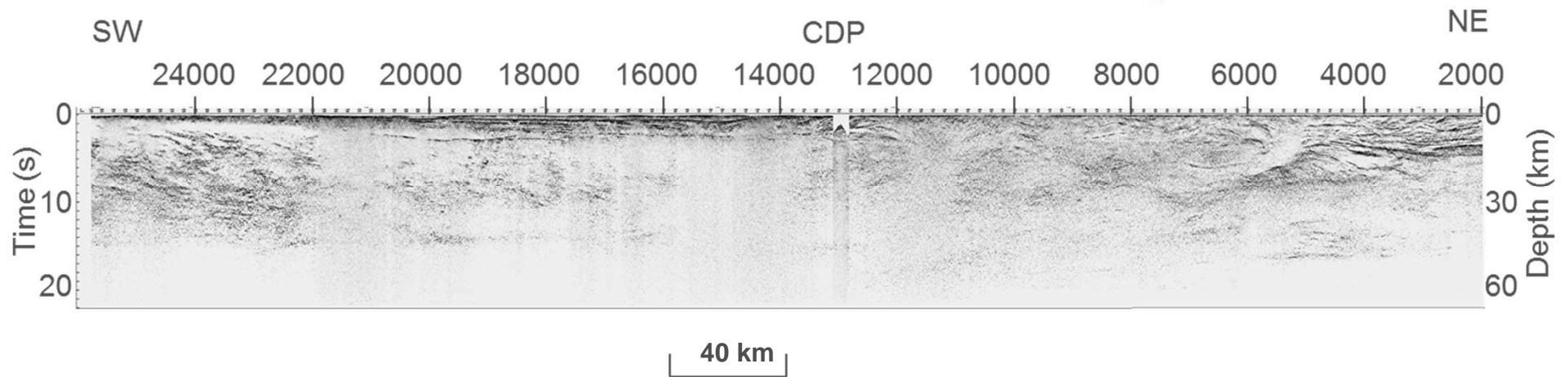




# Faulted Moho?



# YOM crustal architecture – crustal provinces



Crustal reflectivity very different between SW and NE parts of section

SW

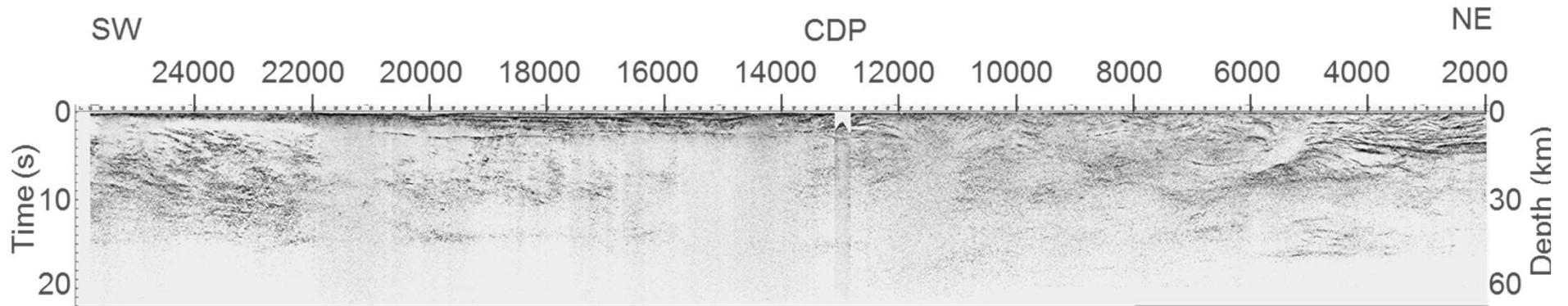
Upper crust – weakly reflective  
Middle & lower crust - highly reflective

NE

Upper & middle crust – highly reflective  
Lower crust - weakly reflective

Two different pieces of crust which have been juxtaposed

# YOM crustal architecture – crustal provinces



40 km

SW

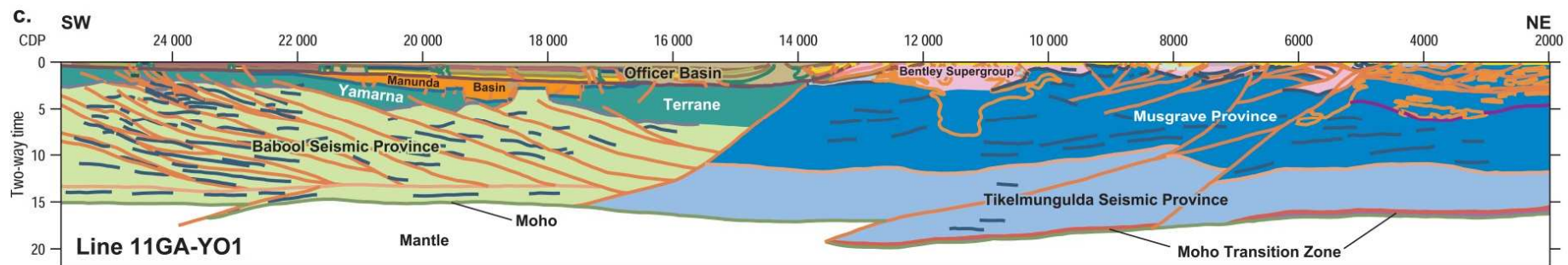
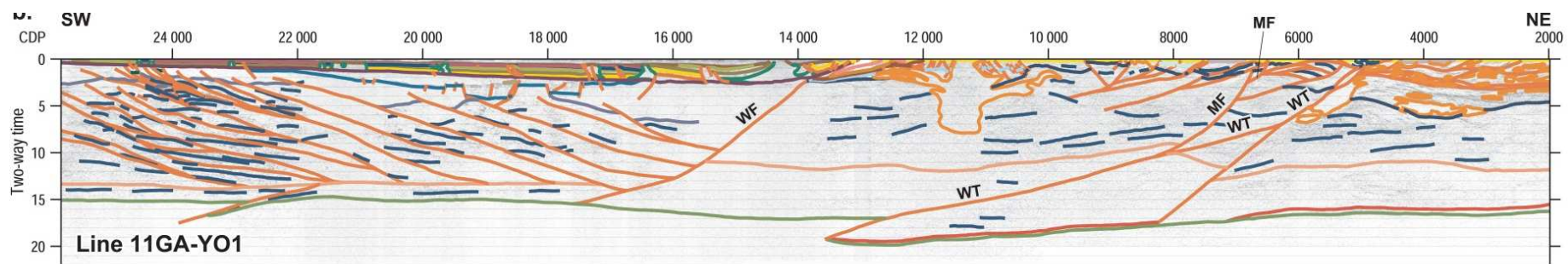
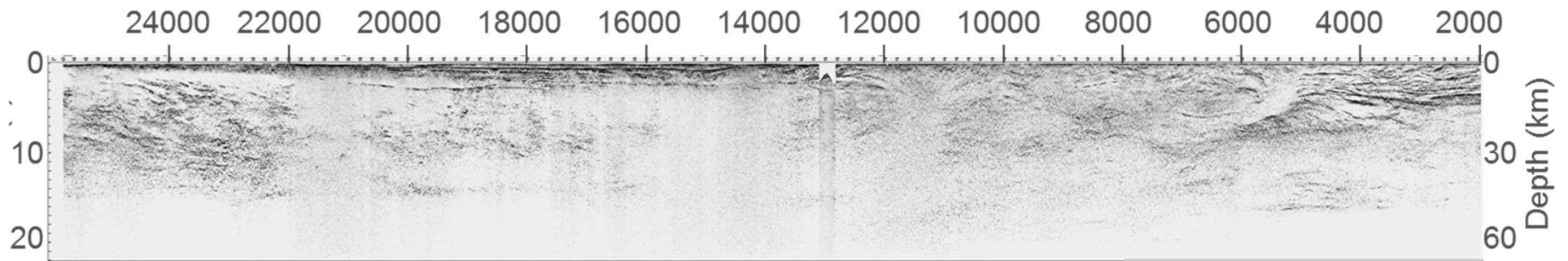
NE

Officer Basin  
 Manunda Basin  
 Yamarna Terrane  
 Babool Seismic Province

*Winduldarra Fault*

(Bentley Supergroup)  
 Musgrave Province  
 Tikelmungulda Seismic Province

# YOM crustal architecture – crustal provinces



### Officer Basic Seismic Horizon Colours

- Base Cenozoic
- Base Lennis Sandstone
- Base Table Hill Volcanics
- Base Wahlgu Formation
- Base Steptoe Formation
- Base Kanpa Formation
- Base Hussar Formation
- Intra Browne Formation 2
- Intra Browne Formation 1
- Base Officer Basin
- Salt
- Base Mesoproterozoic metasedimentary rocks

### Musgrave Province

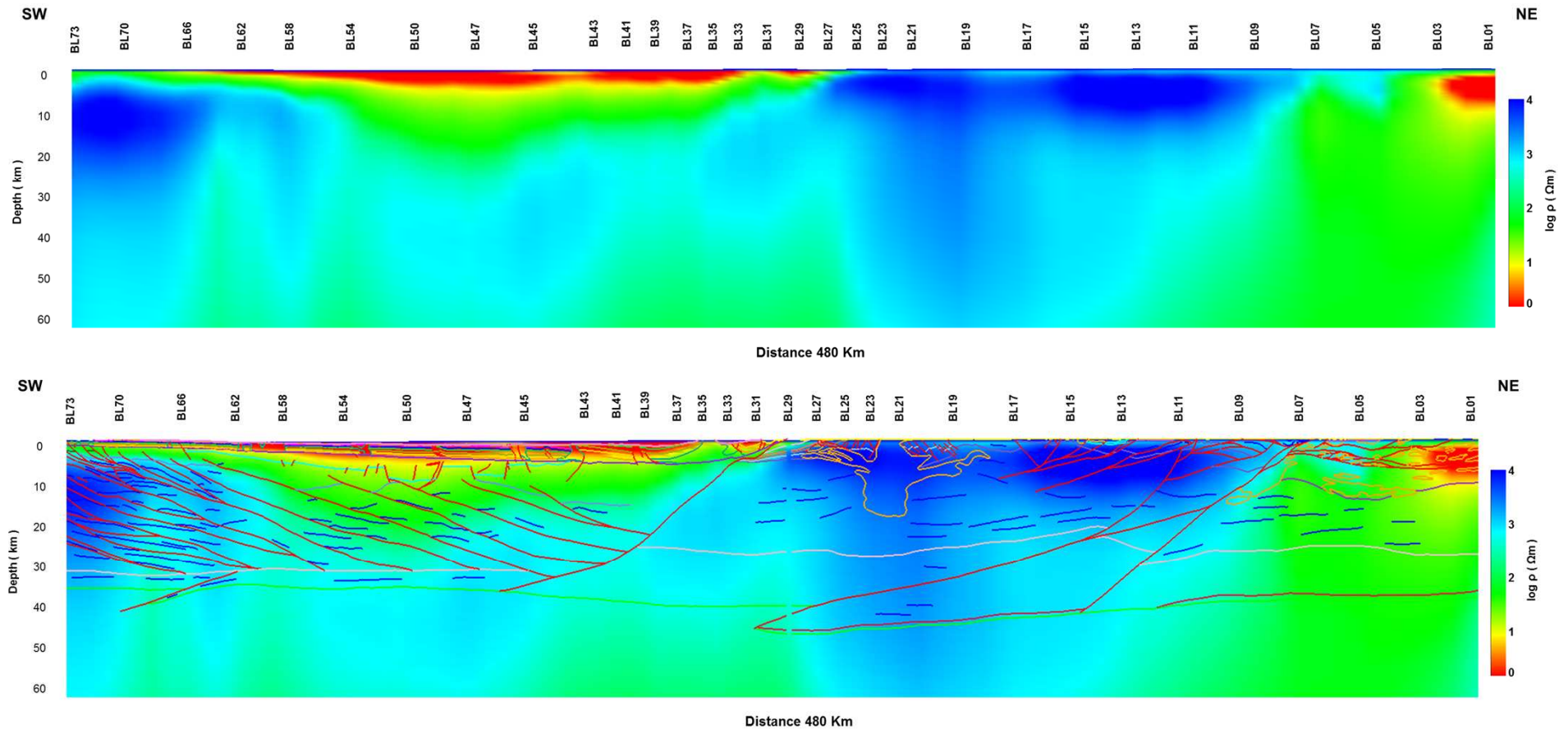
- Base Permian or Cambrian sedimentary rocks
- Base Mission Group
- Base Cassidy Group
- Base Pussy Cat Group
- Base Palgrave Group and equivalents

- Base Bentley Supergroup
  - Layered intrusion
- Fault**
- WF** Windularra Fault
  - MF** Mitika Fault
  - WT** Woodroffe Thrust

### General

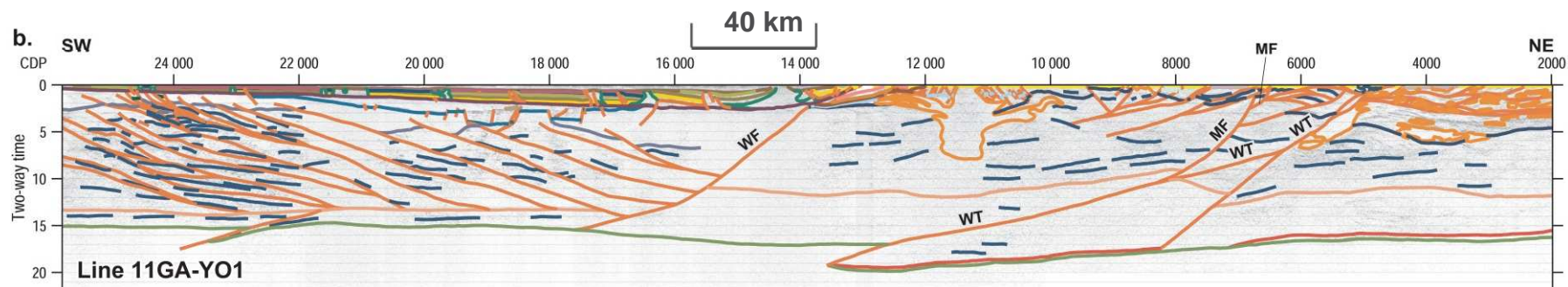
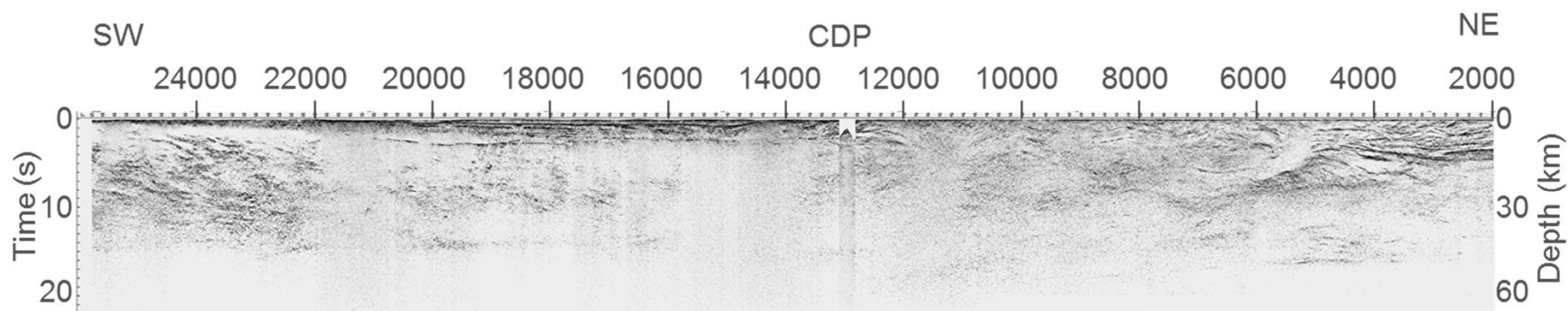
- Base Cenozoic/regolith
- Base mafic rocks
- Base nonreflective upper crust in Yilgarn Craton
- Base upper crust
- Base middle crust
- Top Moho transition zone
- Moho
- Fault
- Granite
- Dyke/sill
- Form line

# YOM crustal architecture – crustal provinces



Magnetotellurics confirms difference in crust between SW and NE parts  
But, also shows two distinct MT regions within Musgrave Province

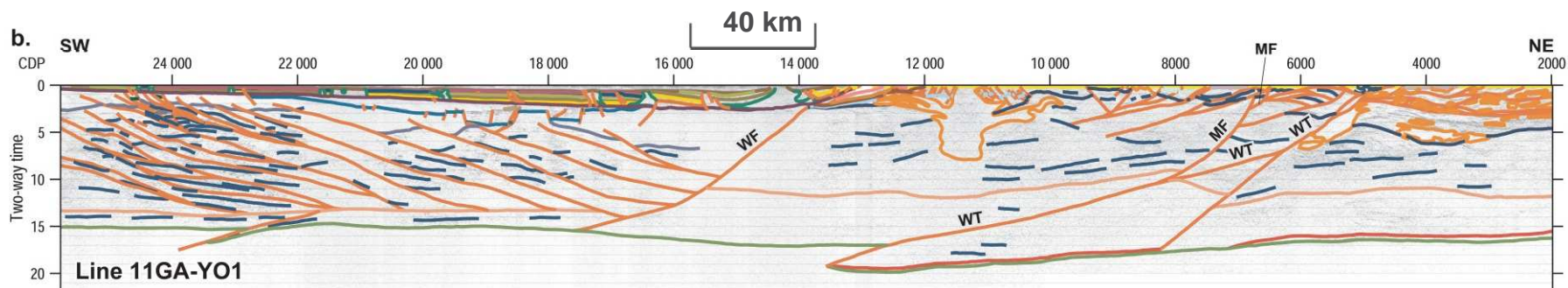
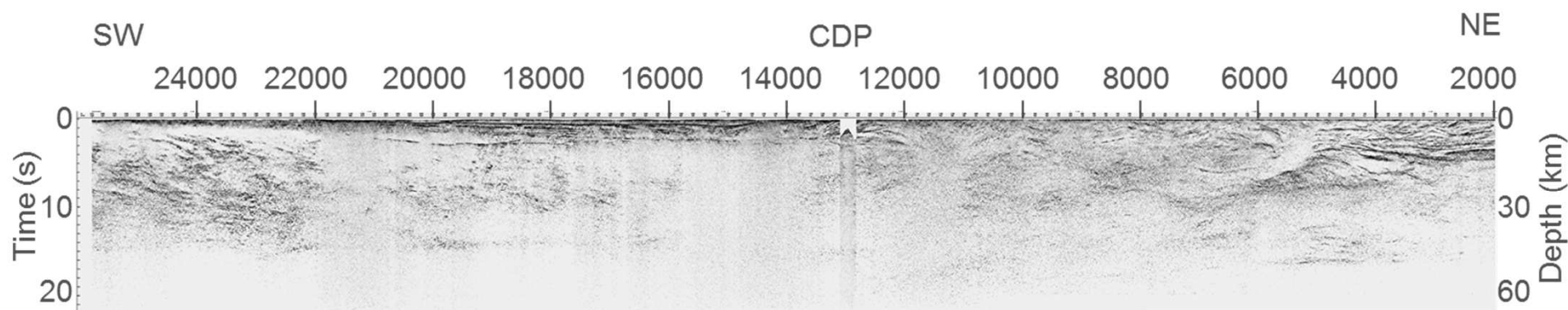
# YOM crustal architecture – major structures



Significance of the:

- Winduldarra Fault (WF)
- Mitika Fault (MF)
- Woodroffe Thrust (WT)

# Winduldarra Fault



NE extent of Yilgarn crust

Nonreflective zone

SW extent of Musgrave crust

Moho faulted by Woodroffe Thrust

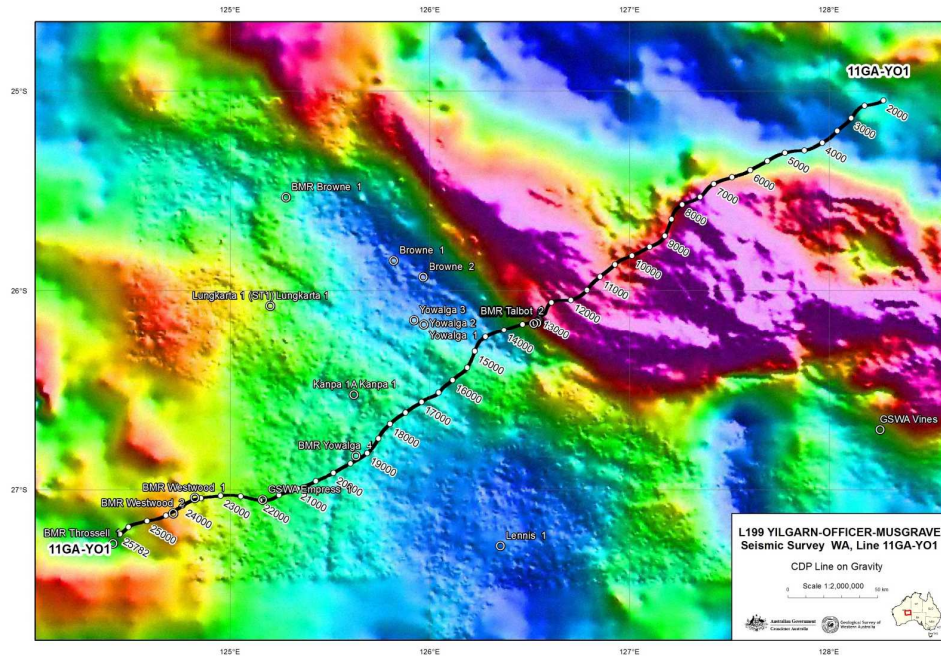
MT

Gravity gradient (gravity worms indicate dip to SW)

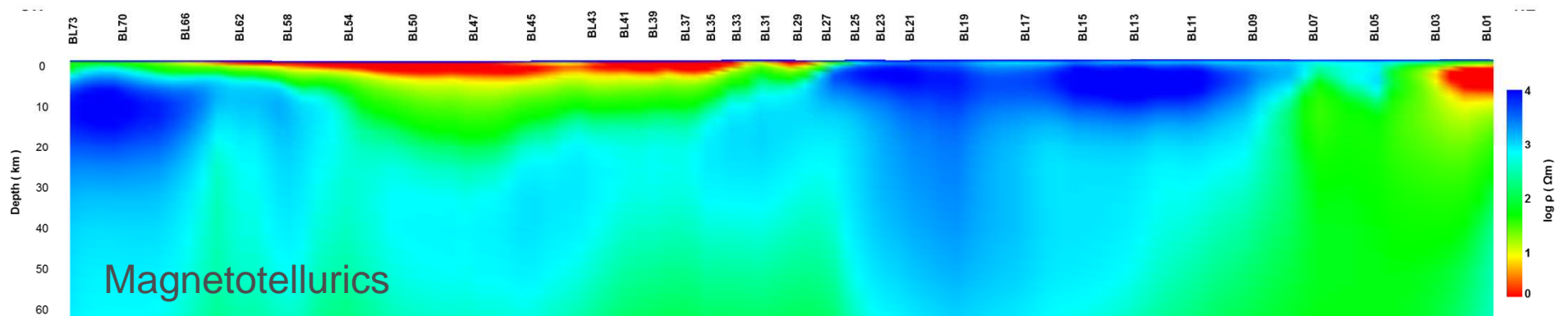
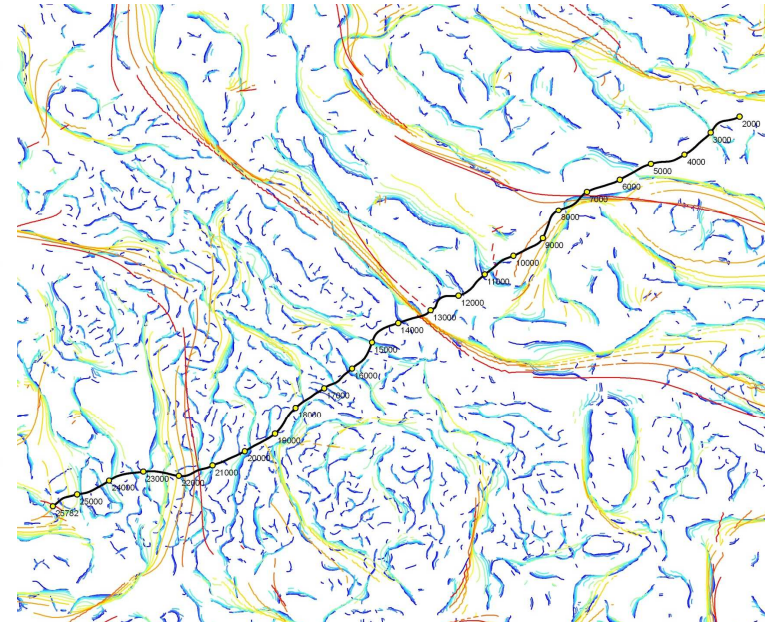
? Linkage of crustal scale structure to surface structure (uplifted Townsend Quartzite)

# Winduldarra Fault

## Gravity



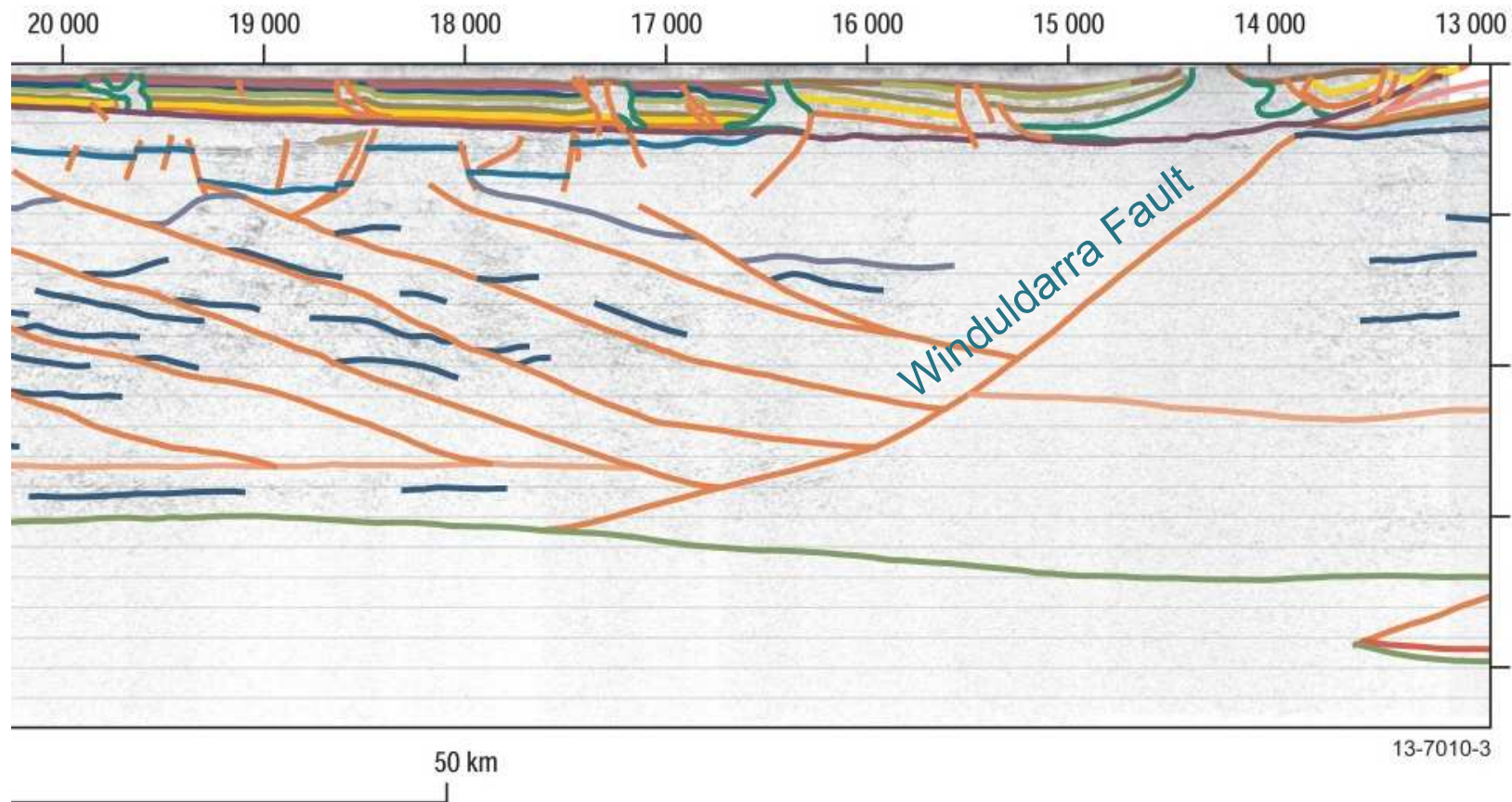
## Gravity worms



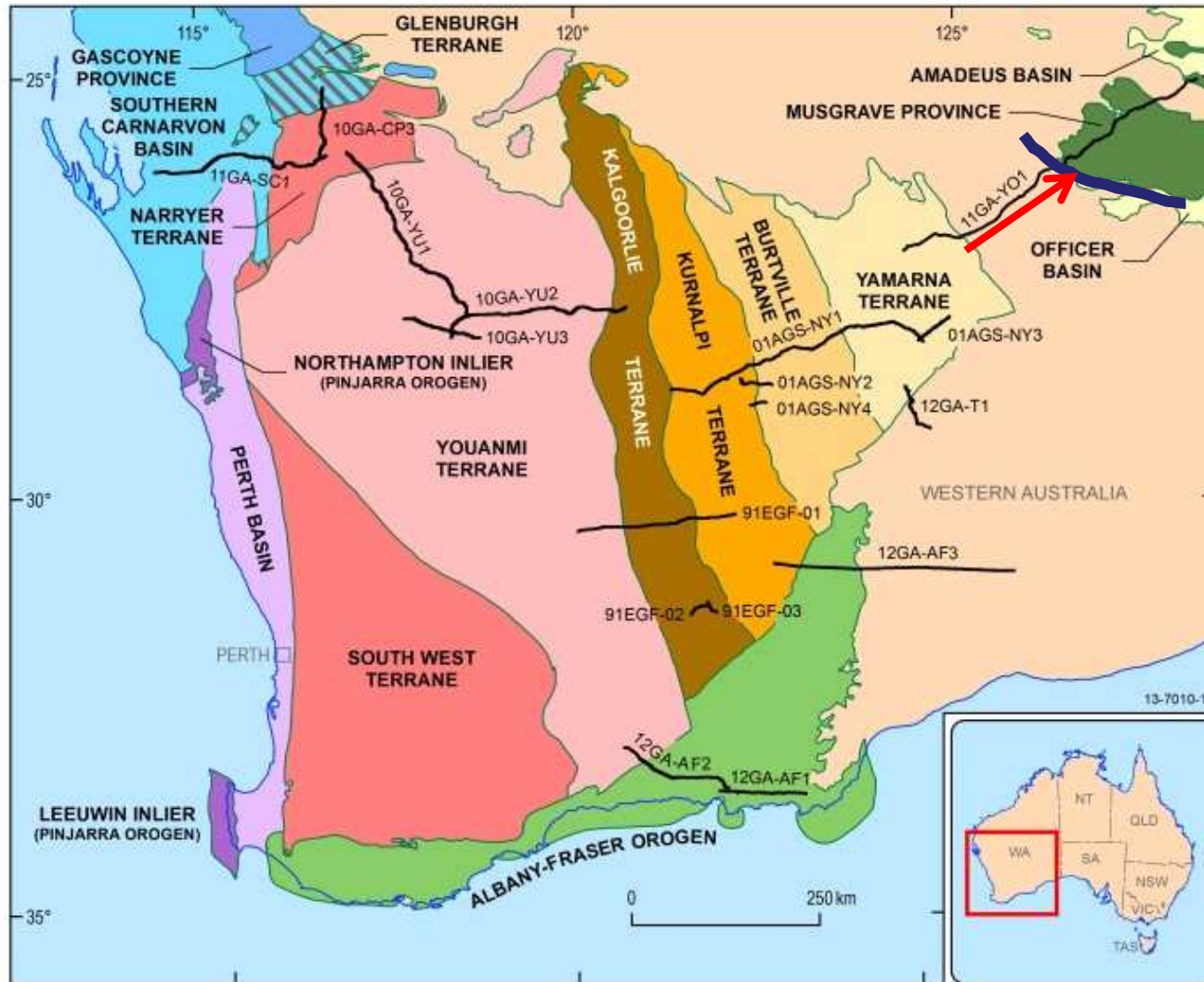


# Winduldarra Fault

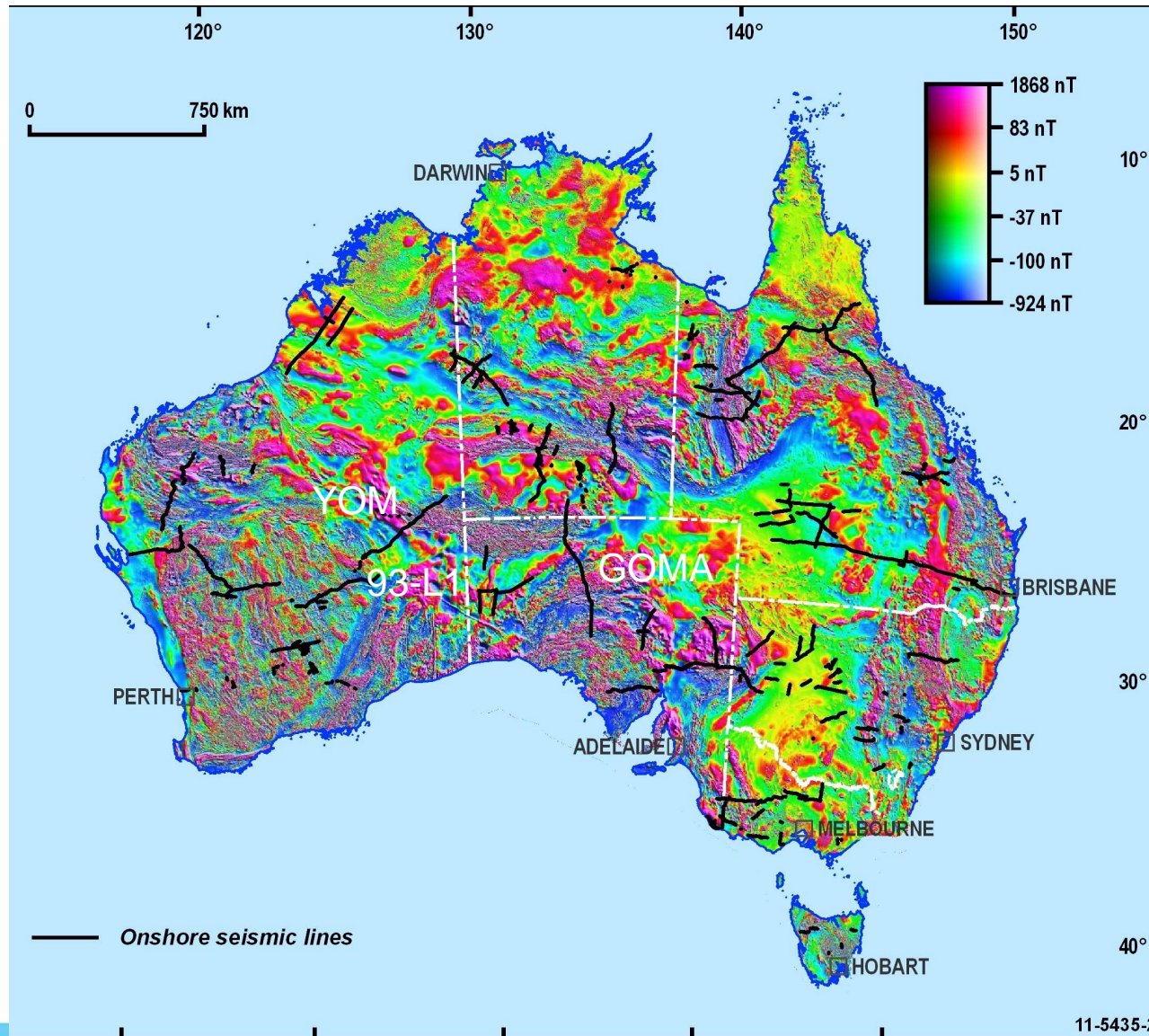
Terrane boundary between Yilgarn Craton and Musgrave Province



# Revised extent of Yilgarn Craton

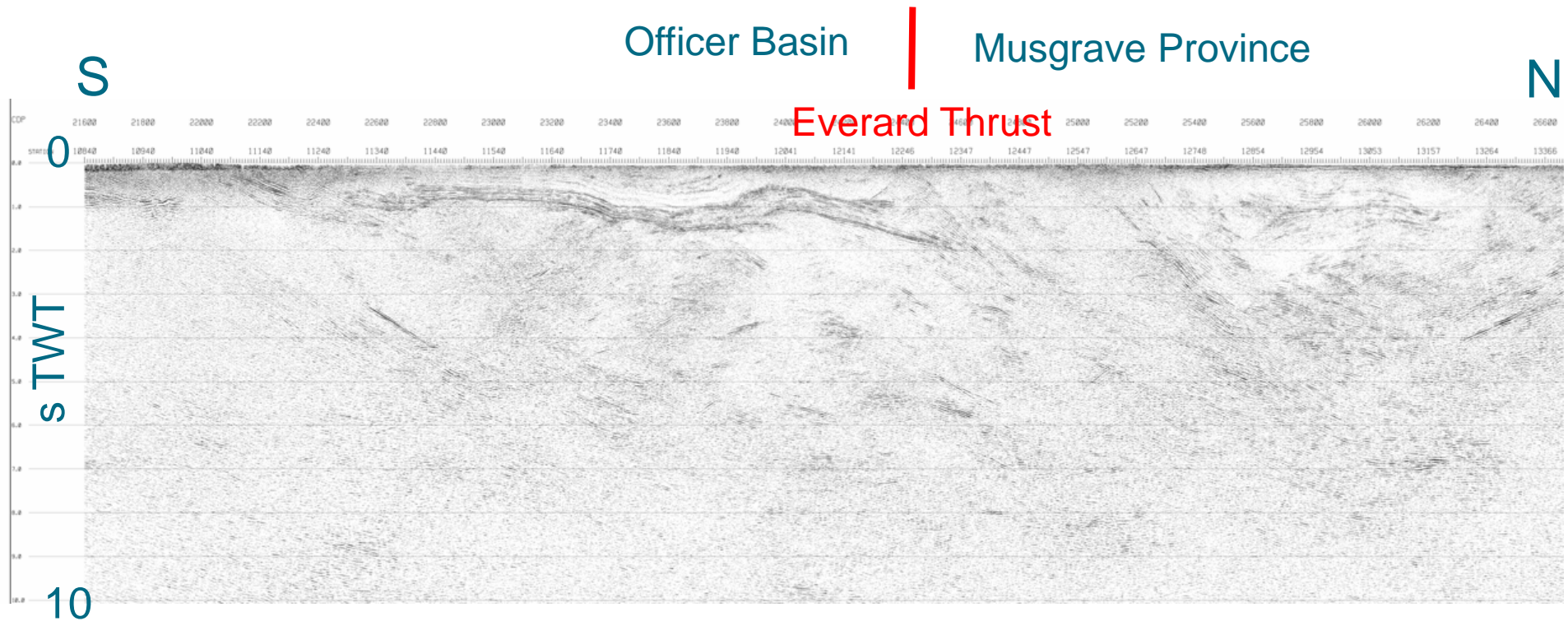


# Compare Winduldarra Fault with other seismic lines across contact between Officer Basin and Musgrave Province



# GOMA seismic line

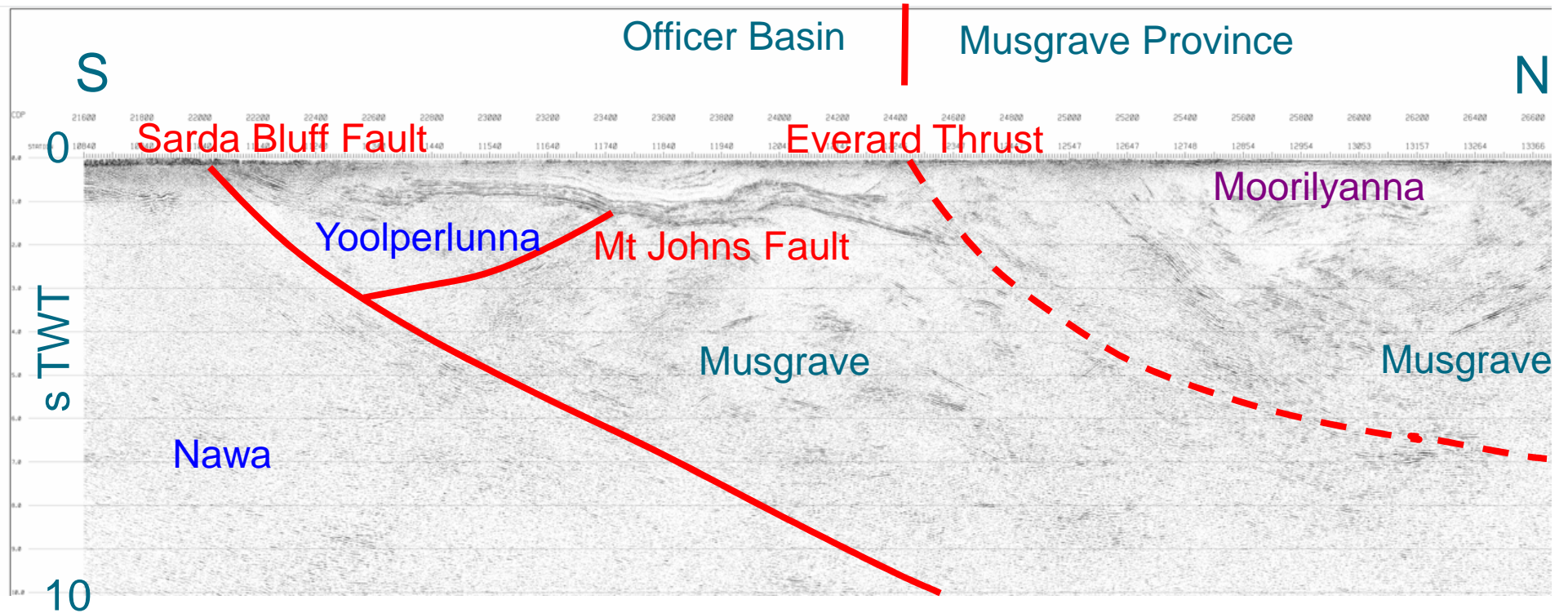
## Nawa Domain (Gawler Craton) to Musgrave Province



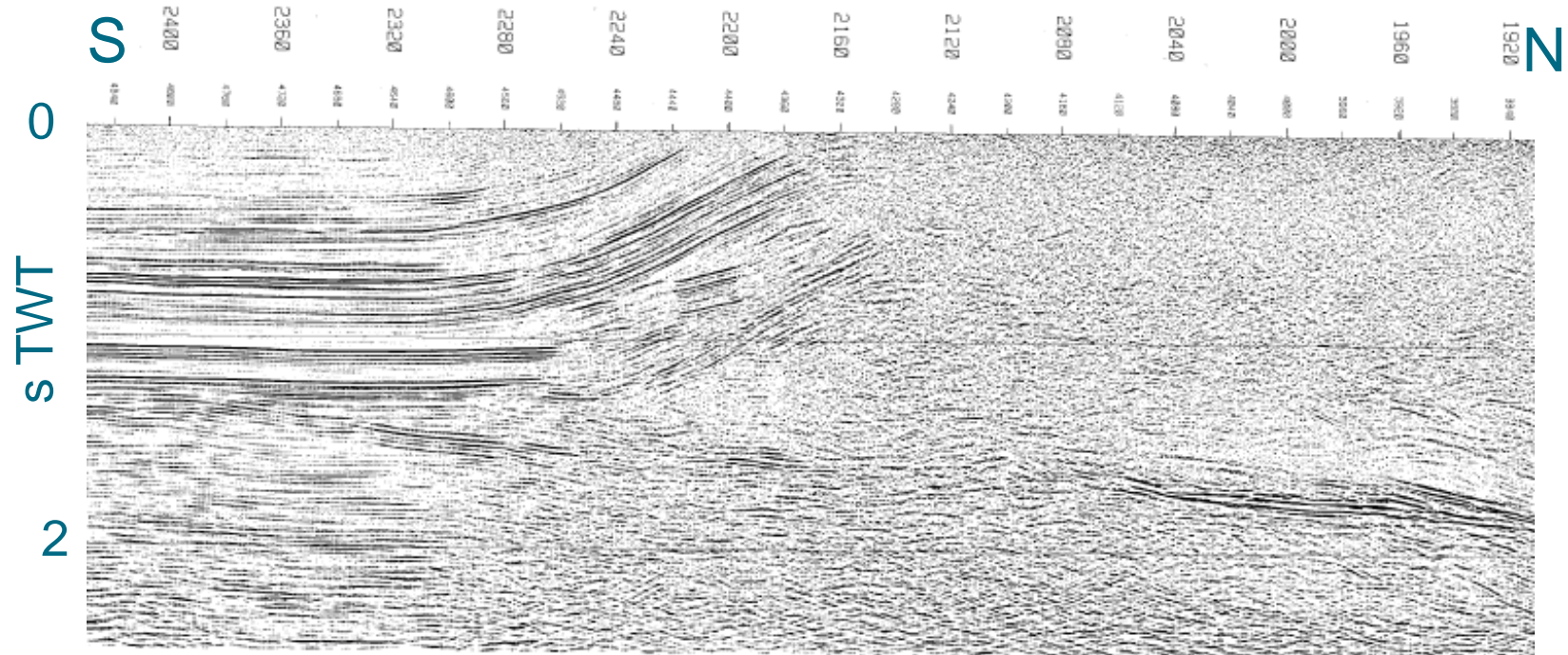
Everard Thrust – surface boundary  
Subsurface extent of Musgrave Province

# GOMA seismic line

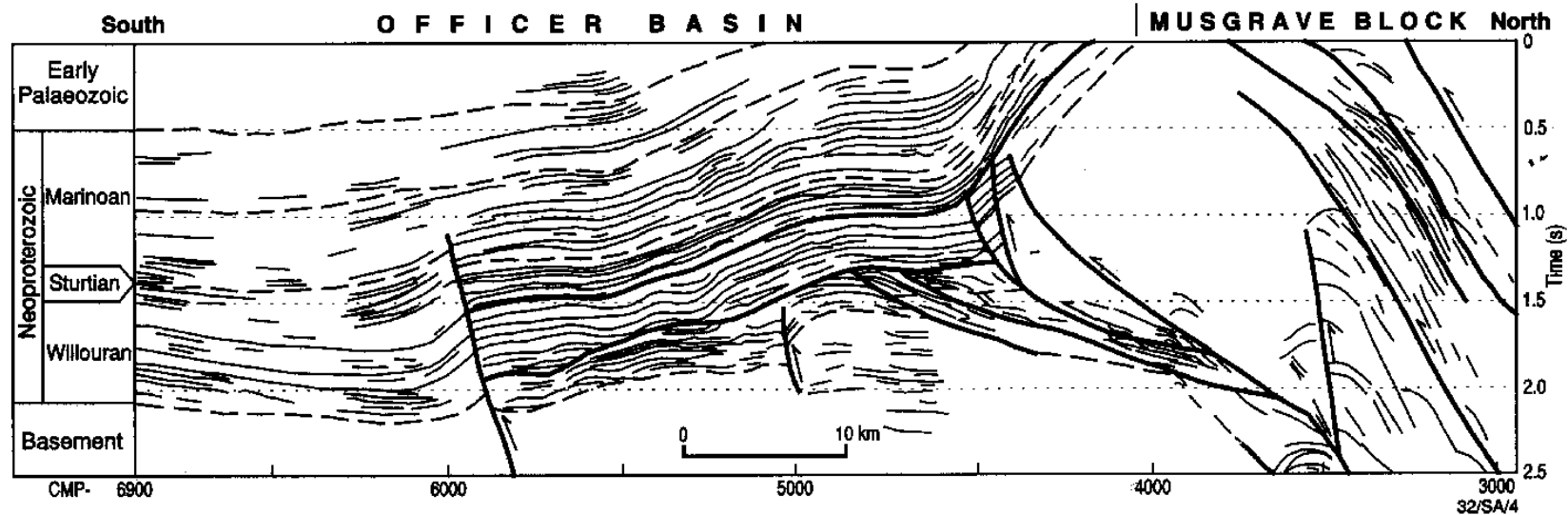
## Nawa Domain (Gawler Craton) to Musgrave Province



# Officer Basin seismic line 93AGS-L1



# Officer Basin seismic line 93AGS-L1

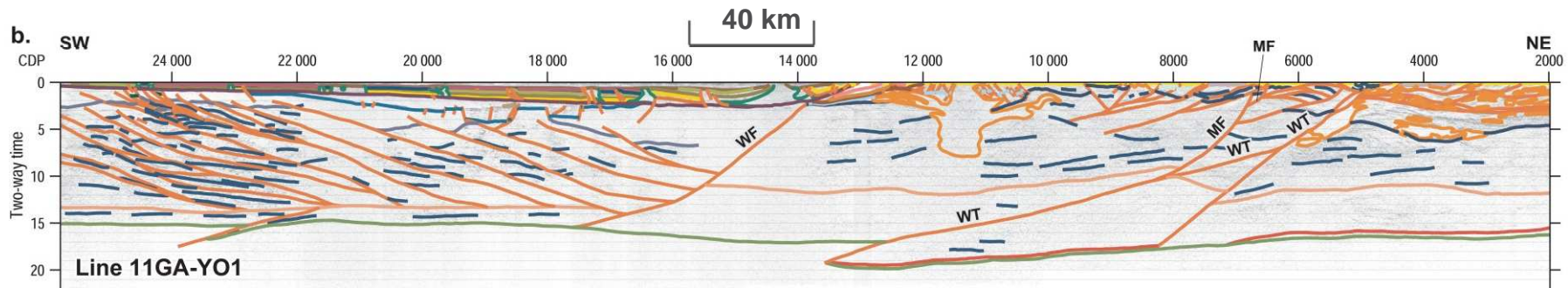
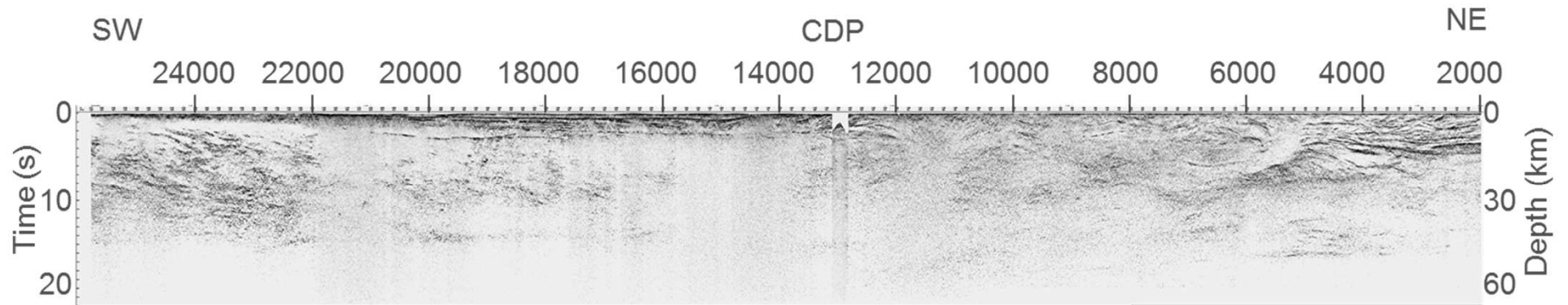


From Lindsay & Leven ( 1996, Basin Research)

Southern margin of Musgrave Province against Officer Basin:

- very complicated
- different geometries along strike
- Musgrave Province extends some distance to south under Officer Basin

# Woodroffe Thrust and Mitika Fault



MT

Gravity gradient (gravity worms indicate dip to SW)

Moho faulted by Woodroffe Thrust

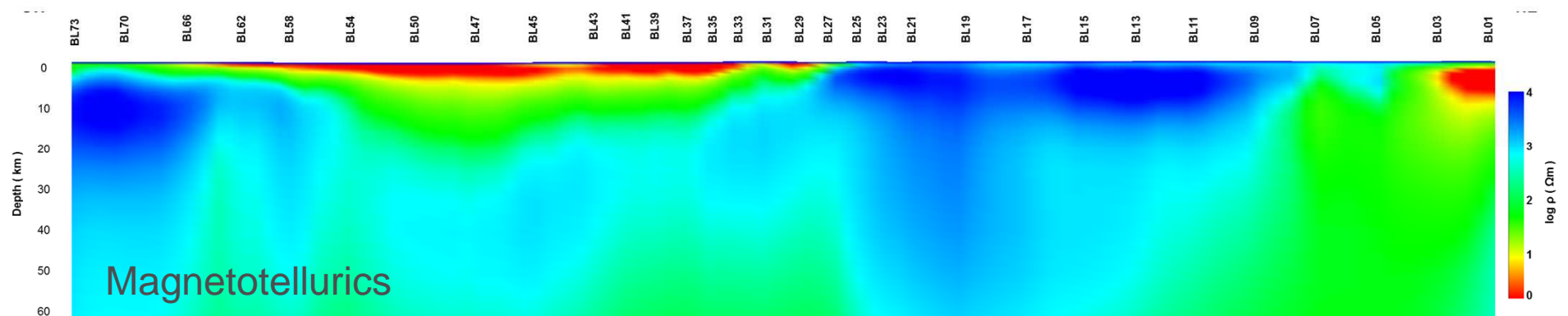
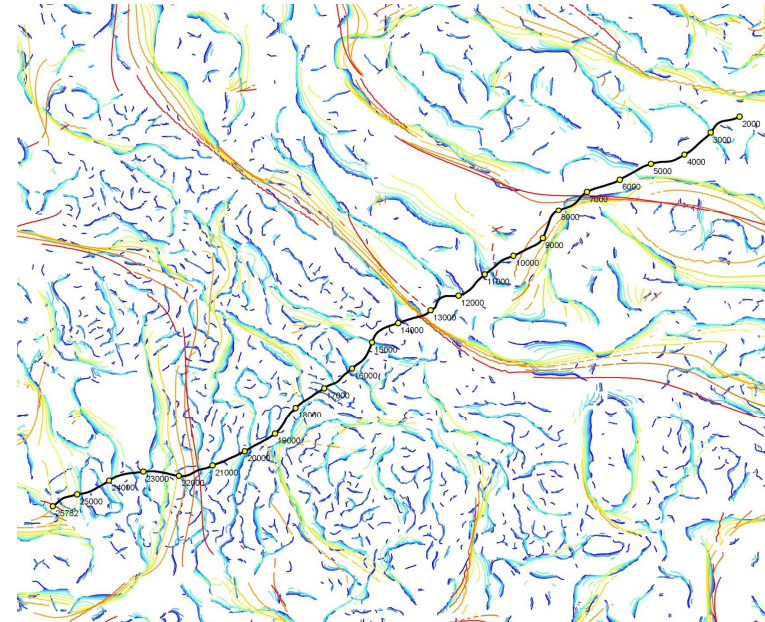
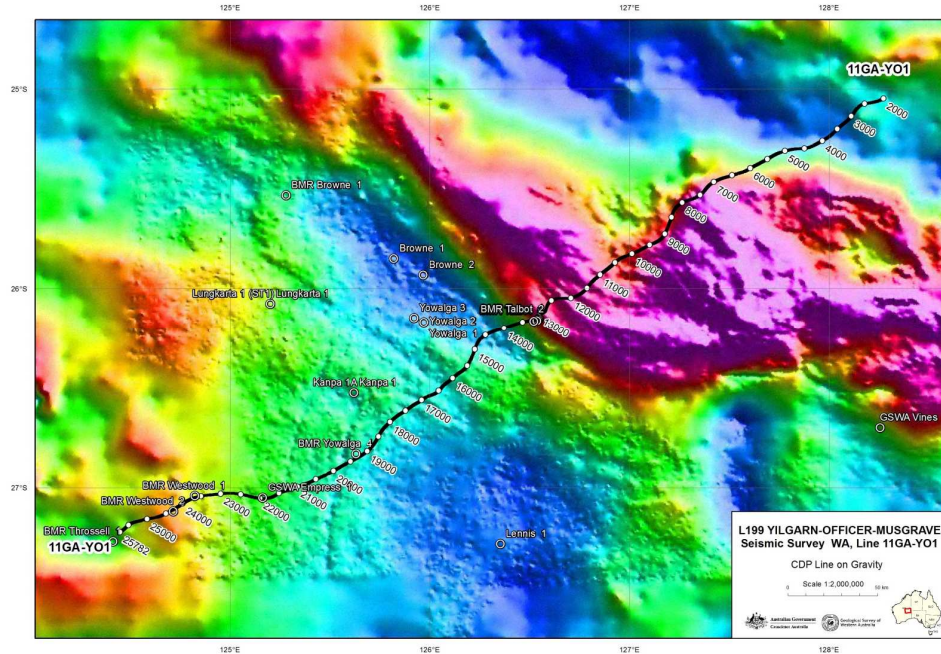
Mitika Fault soles onto Woodroffe Thrust in mid crust



# Woodroffe Thrust and Mitika Fault

## Gravity

## Gravity worms

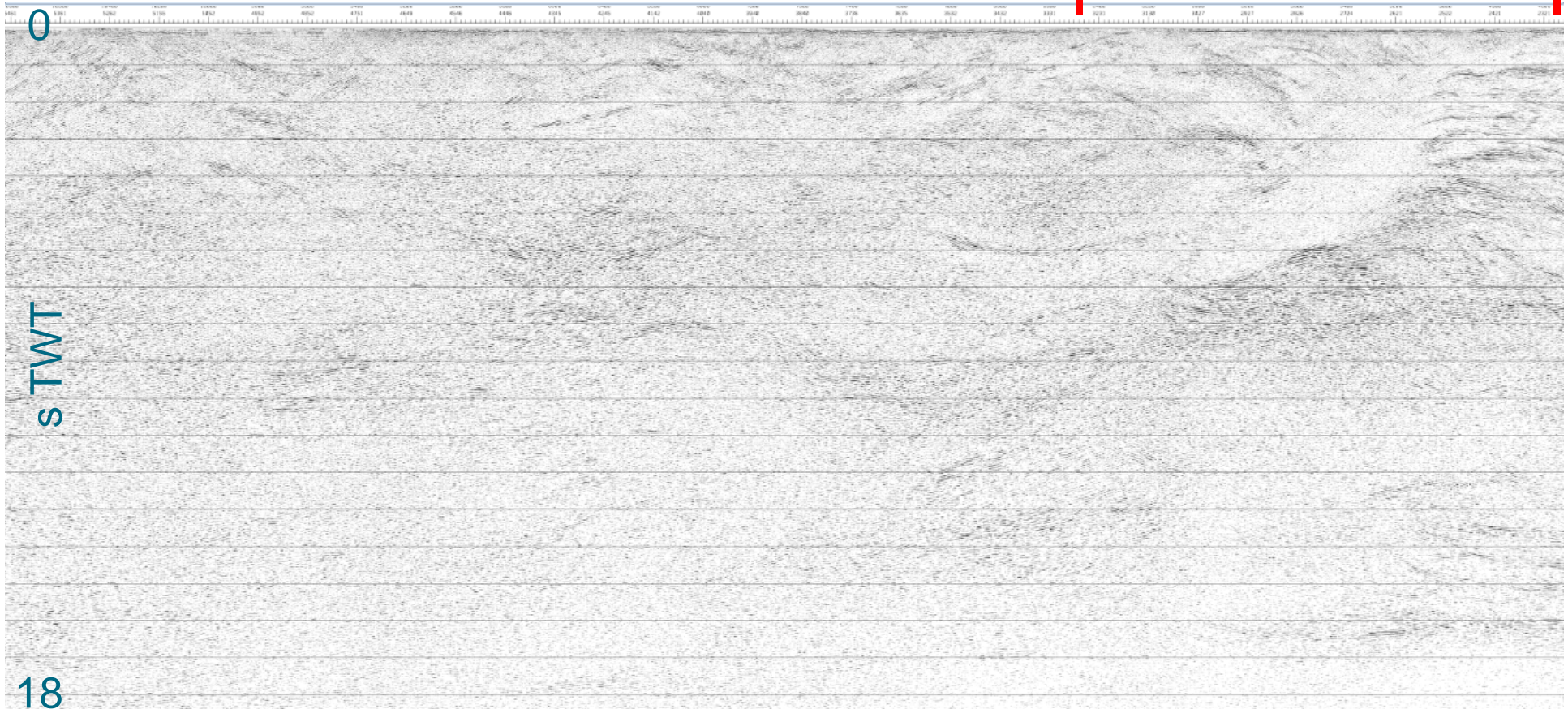


# Woodroffe Thrust and Mitika Fault

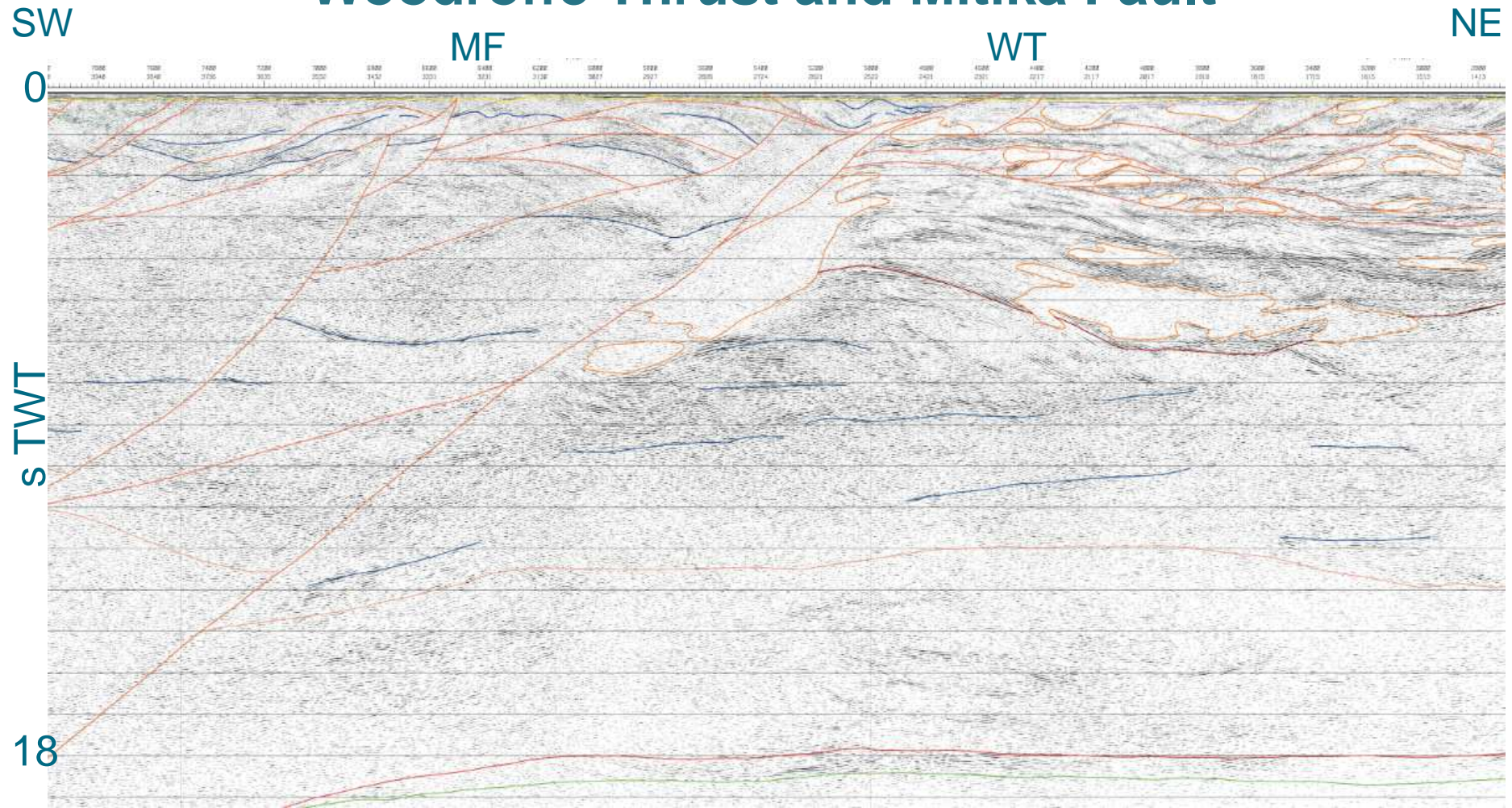
SW

NE  
WT

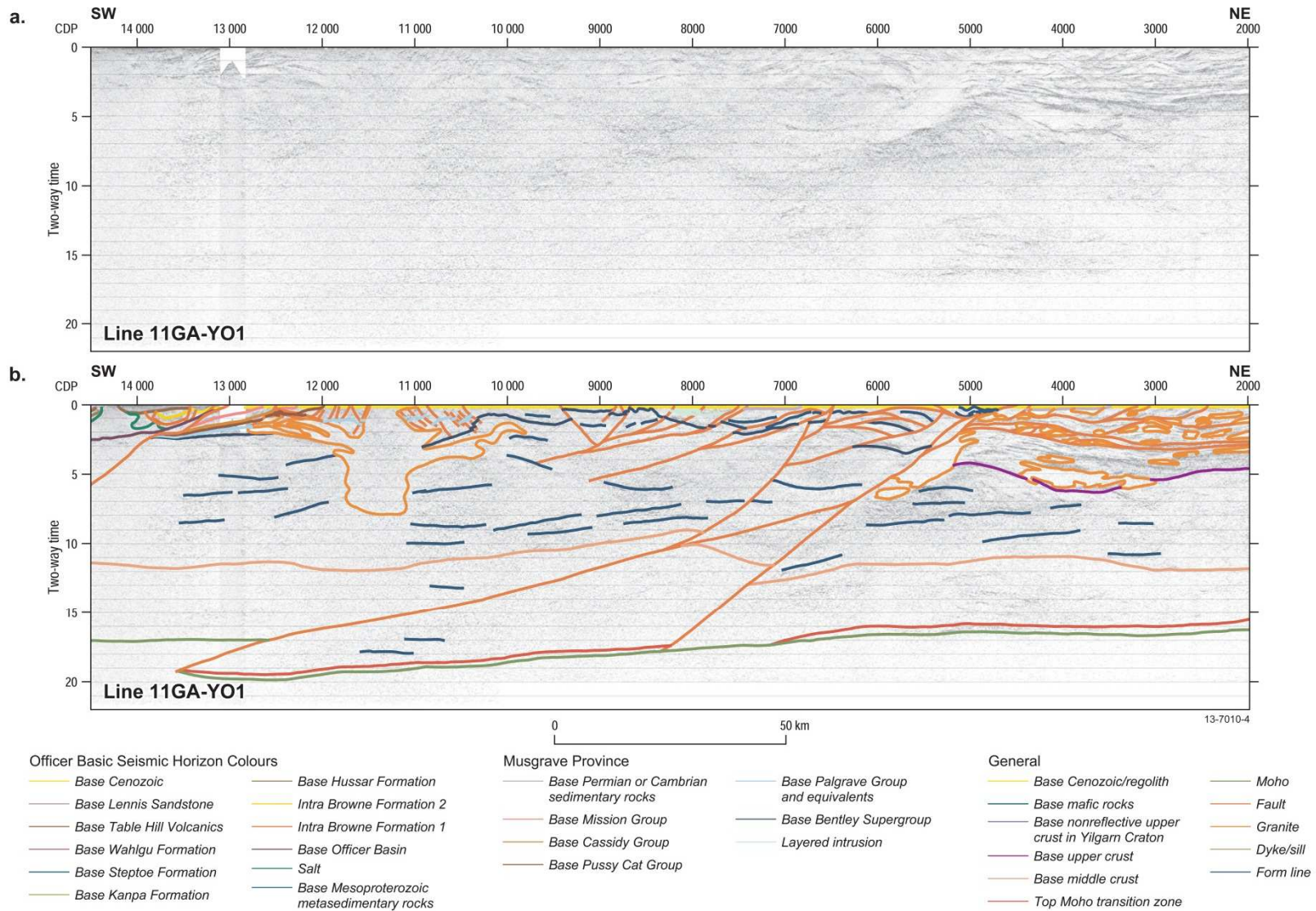
MF



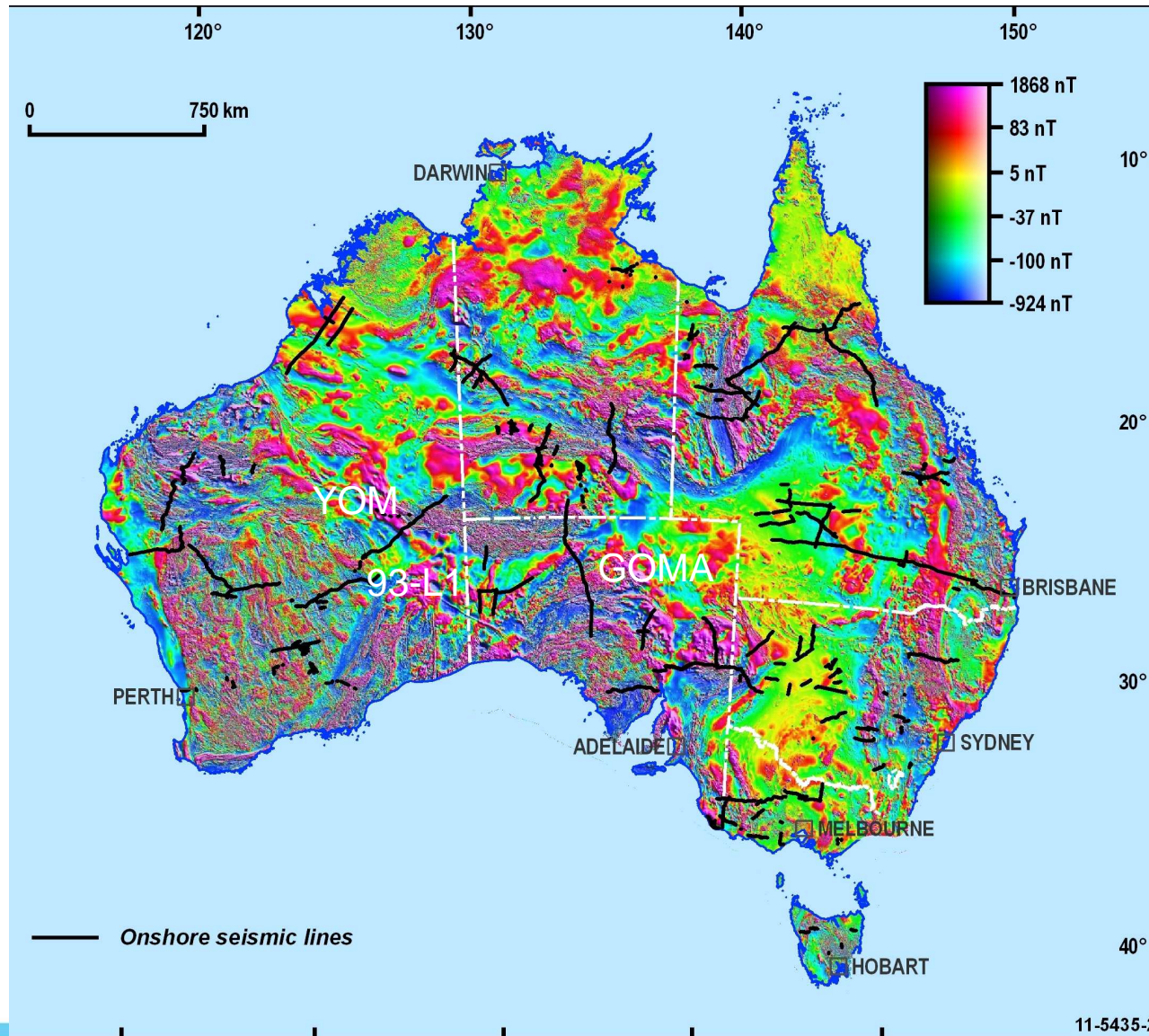
# Woodroffe Thrust and Mitika Fault



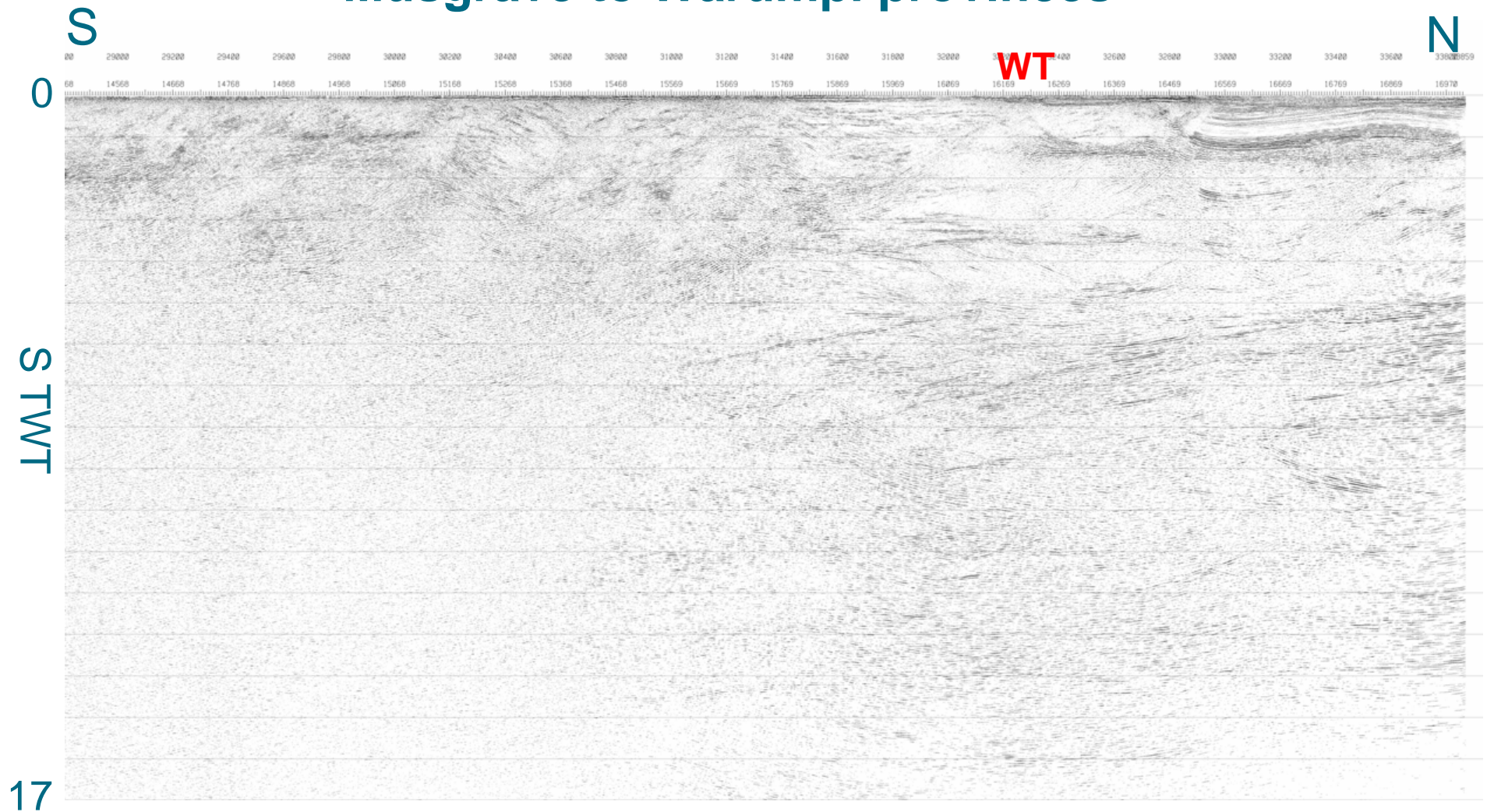
# Woodroffe Thrust and Mitika Fault



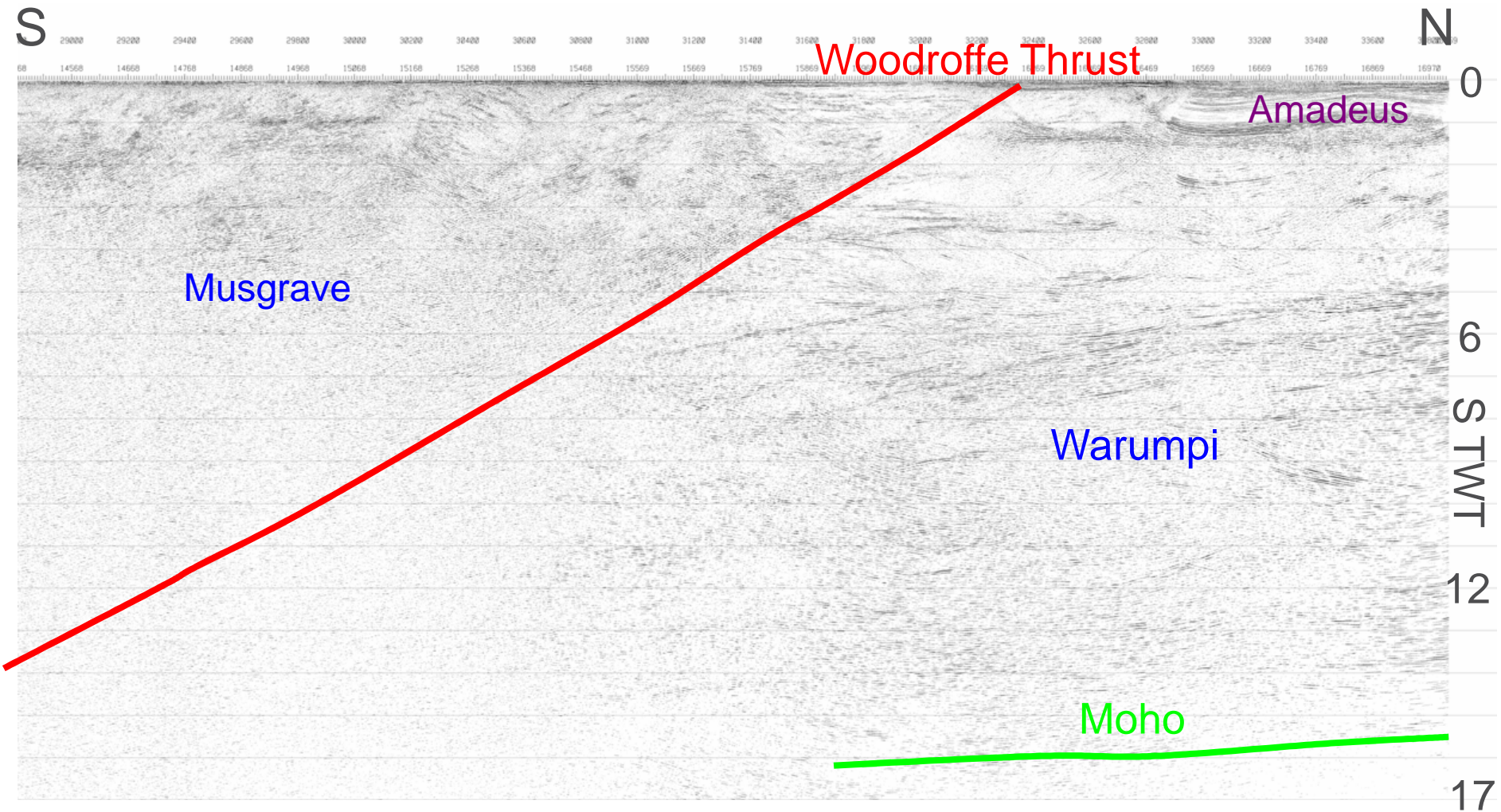
# Woodroffe Thrust imaged in GOMA seismic line



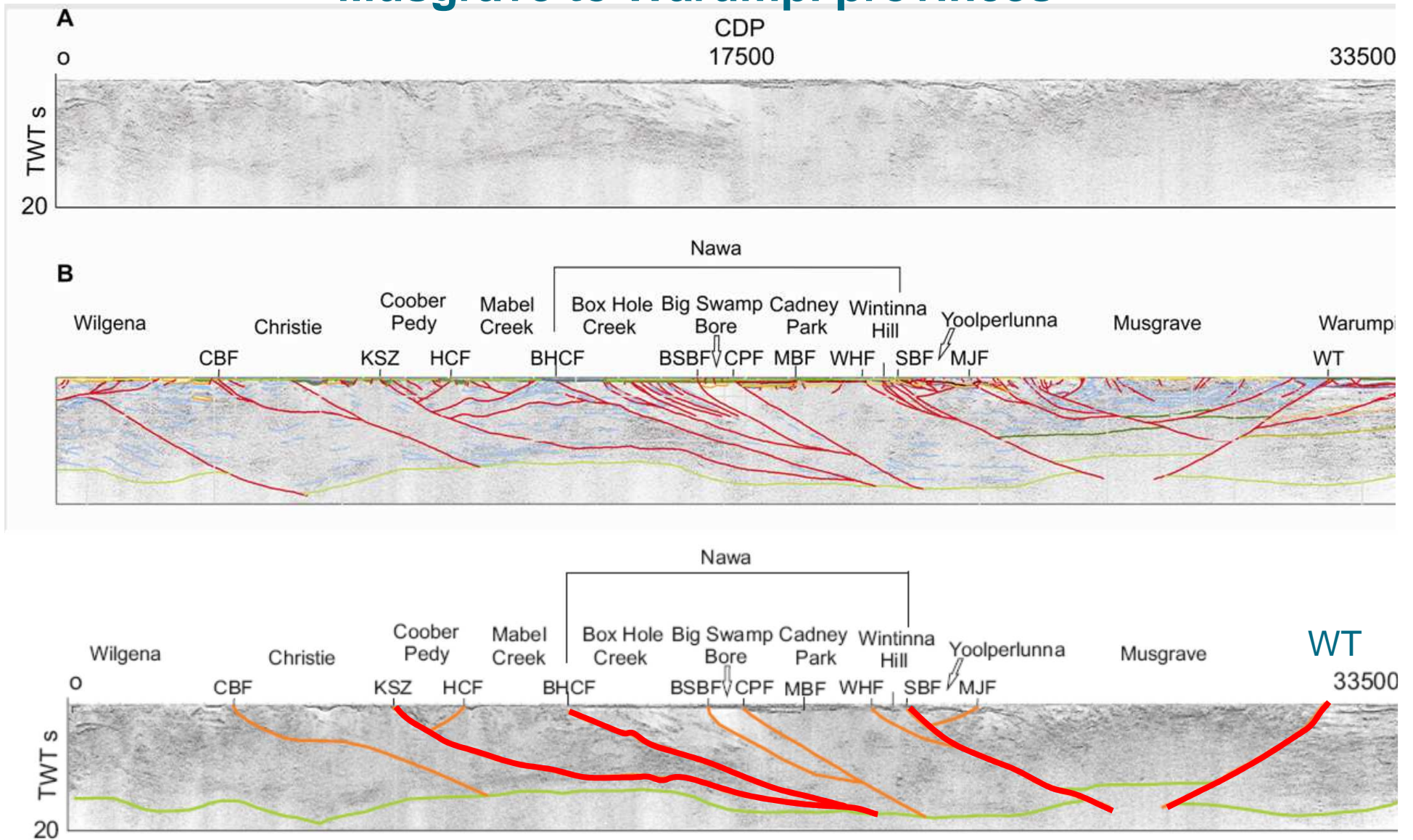
# GOMA seismic line Musgrave to Warumpi provinces



# GOMA seismic line Musgrave to Warumpi provinces



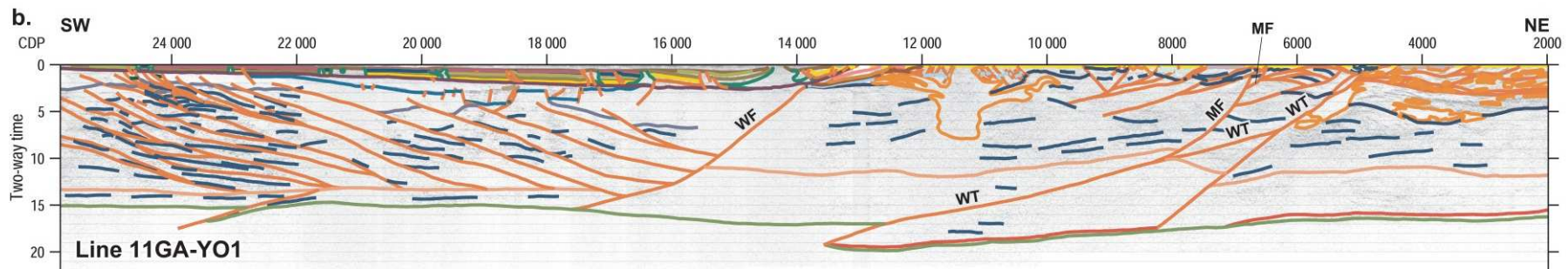
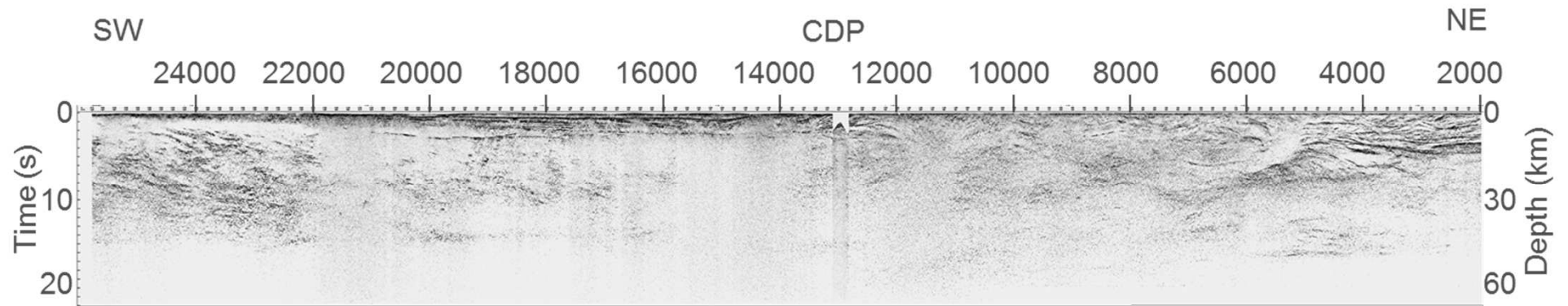
# GOMA seismic line Musgrave to Warumpi provinces





# Geodynamic implications

## Relationship between Yamarna Terrane & Musgrave Province



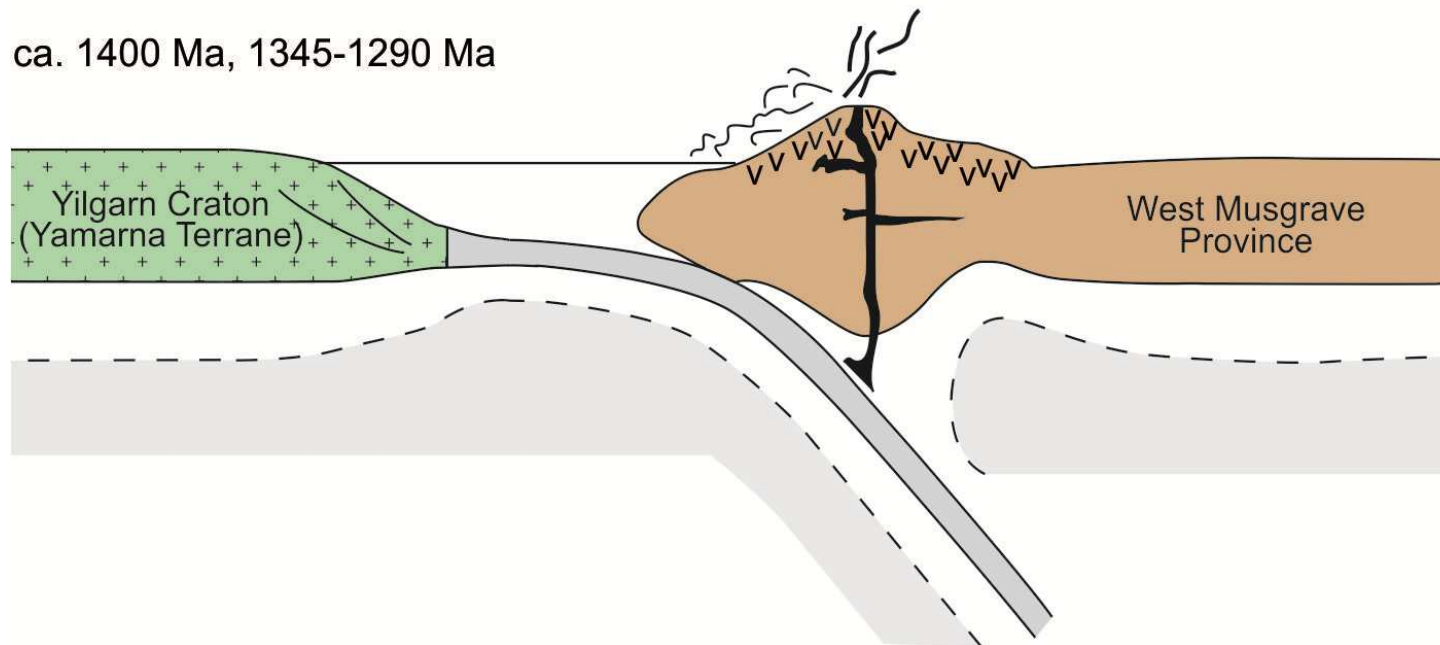
Two seismically different crustal blocks  
Significance of Winduldarra Fault

# Collision between Yamarna Terrane and Musgrave Province?

SOUTHWEST

NORTHEAST

ca. 1400 Ma, 1345-1290 Ma



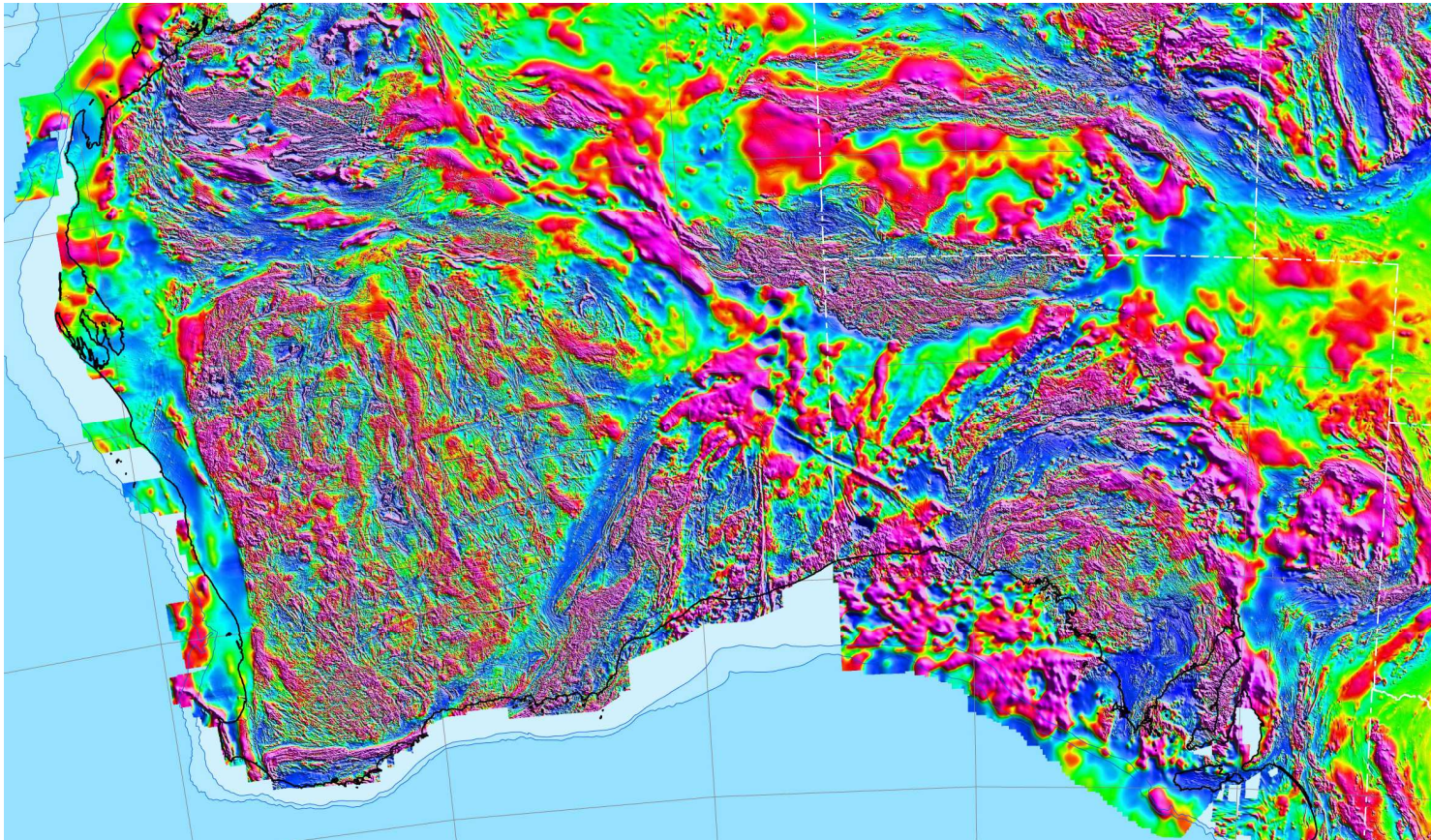
## Contrast in: seismic character & MT

Timing – west Musgrave Province contains subduction-related calcalkaline suites (1400 Ma Palulankutja Supersuite and 1345-1293 Wankanki Supersuite): arc-forearc setting?

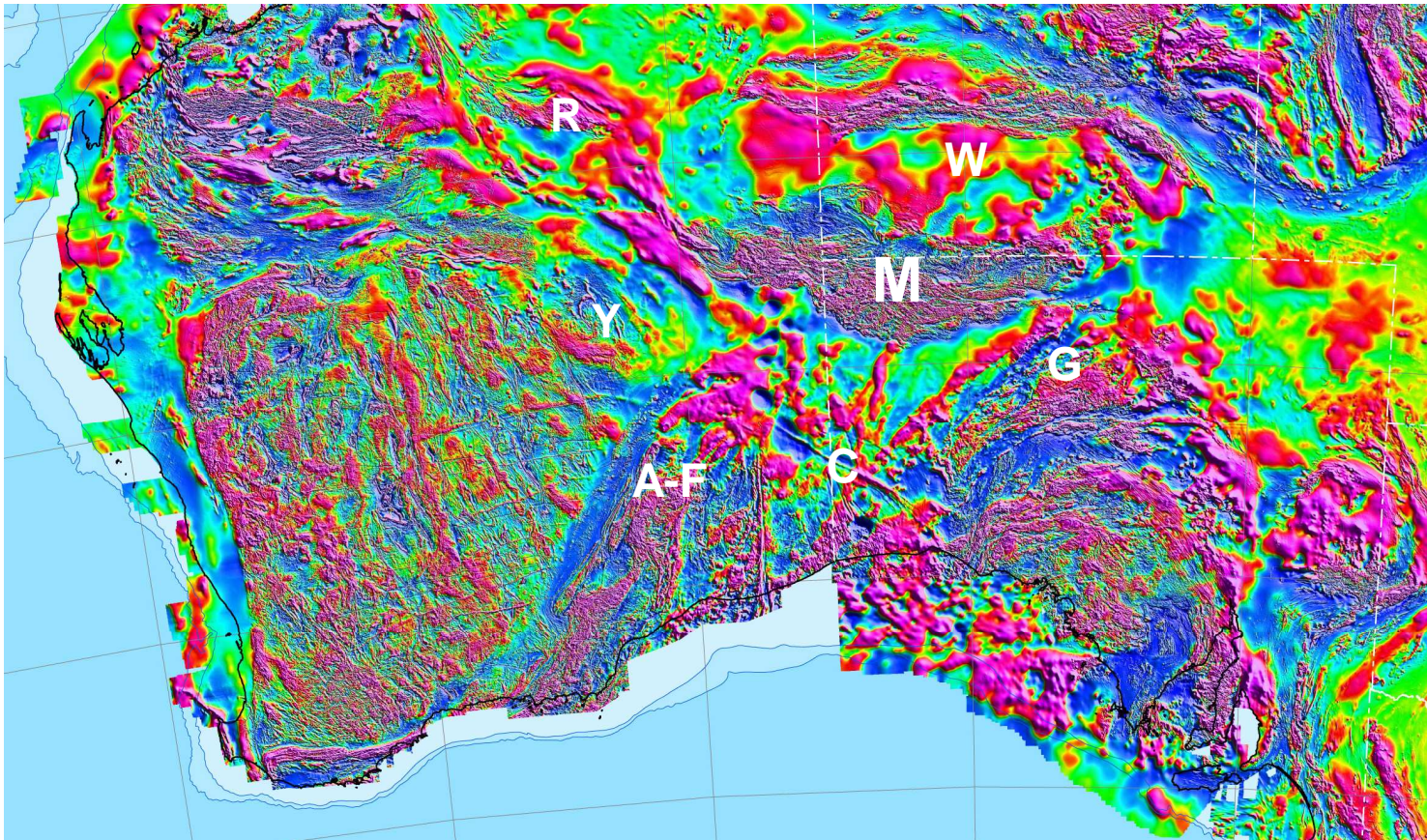
Polarity of subduction – arc-related rocks on upper plate are in Musgrave Province

Winduldarra Fault – suture possibly represents collision-related opposite polarity: obduction?

# Questions about geodynamics in Southeast WA

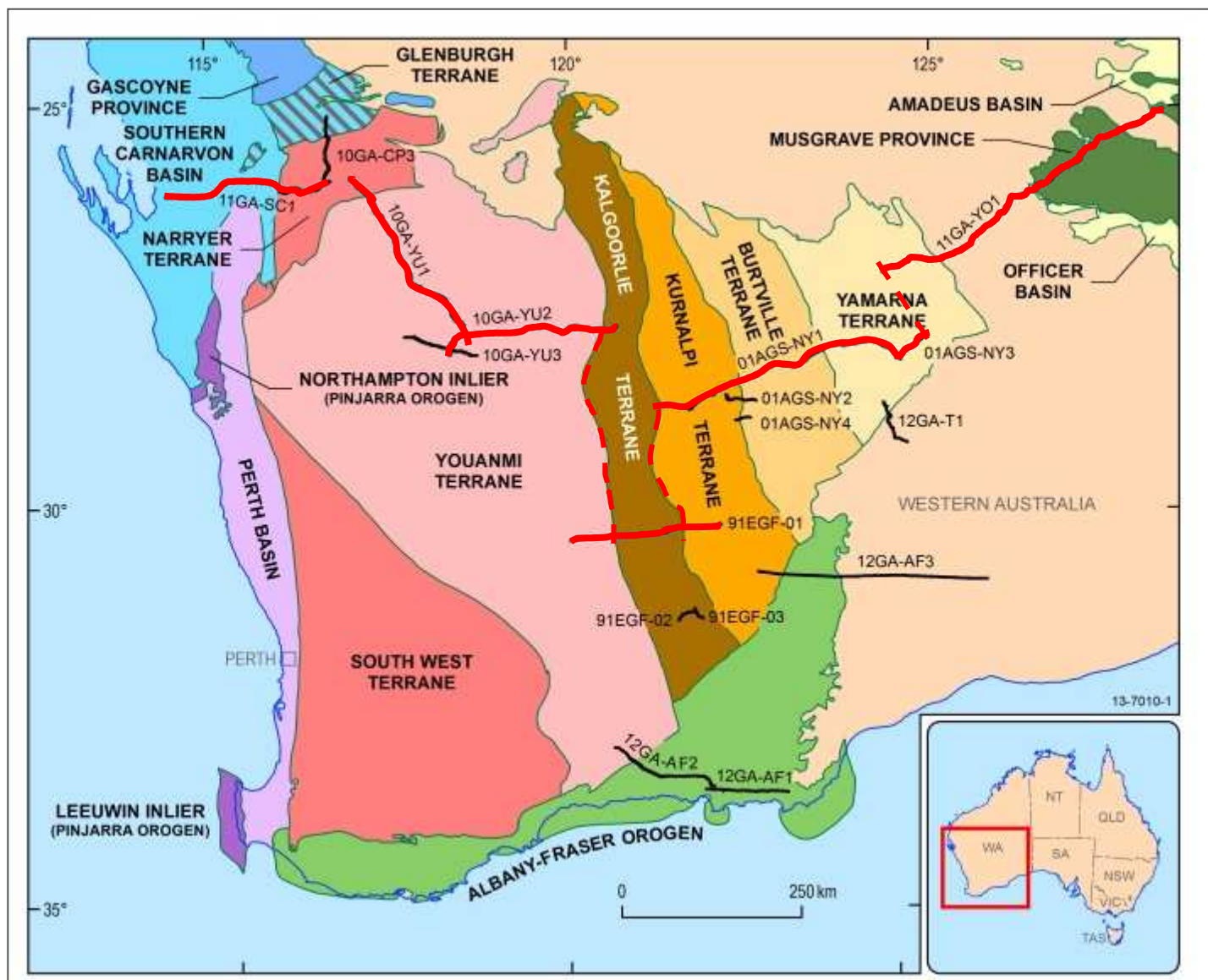


# Questions about geodynamics in Southeast WA

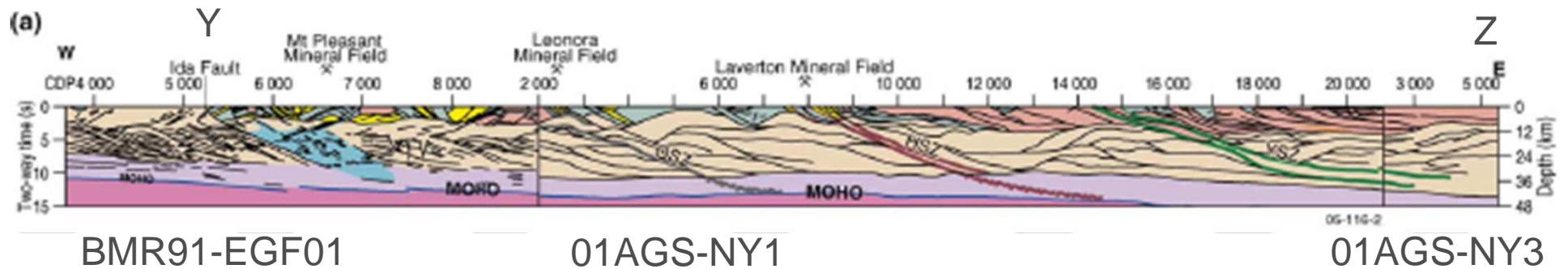
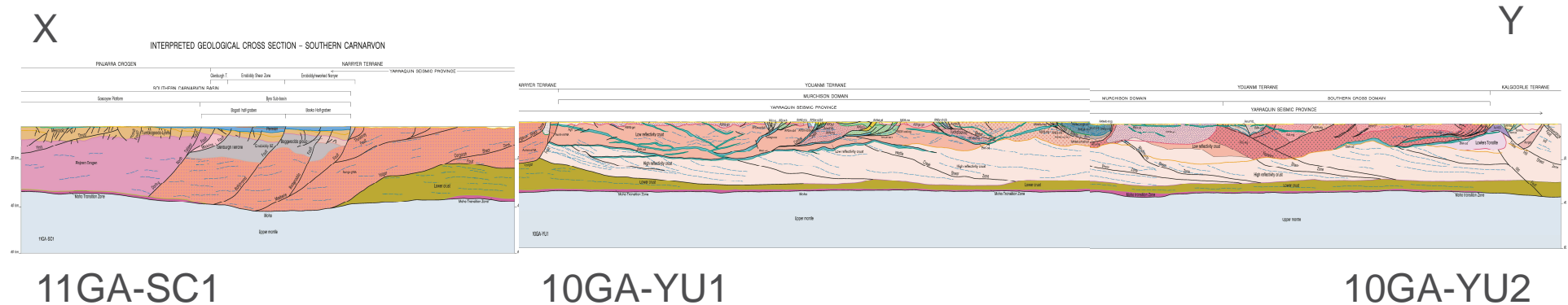


Musgrave Province – keystone block in central Australia  
Between WAC, NAC and SAC

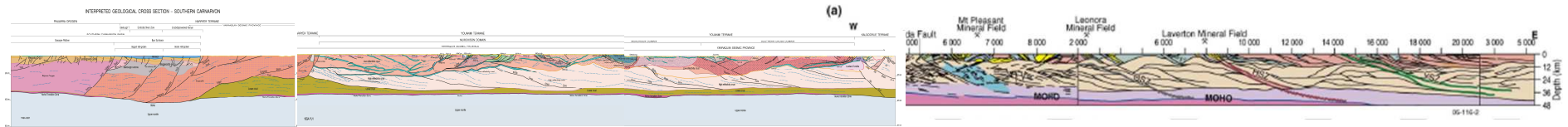
# Transect across Western Australia



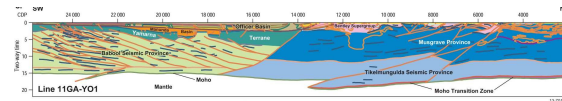
# Composite section from Pinjarra Orogen to eastern Yilgarn Orogen



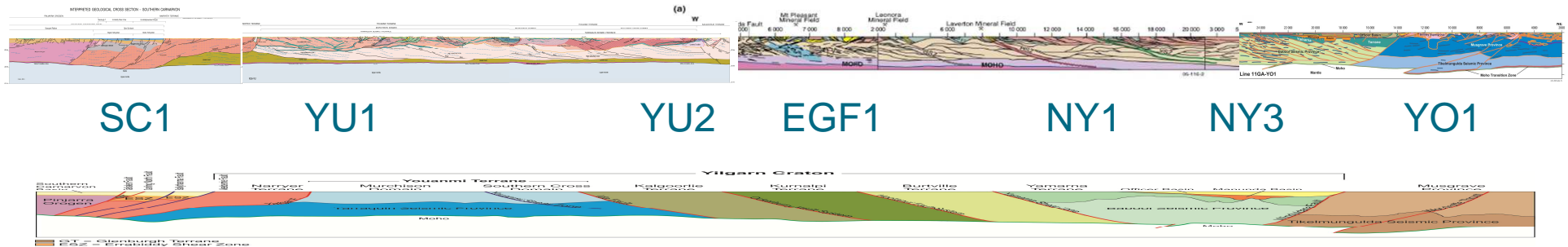
# Composite section from Pinjarra Orogen to eastern Yilgarn Craton



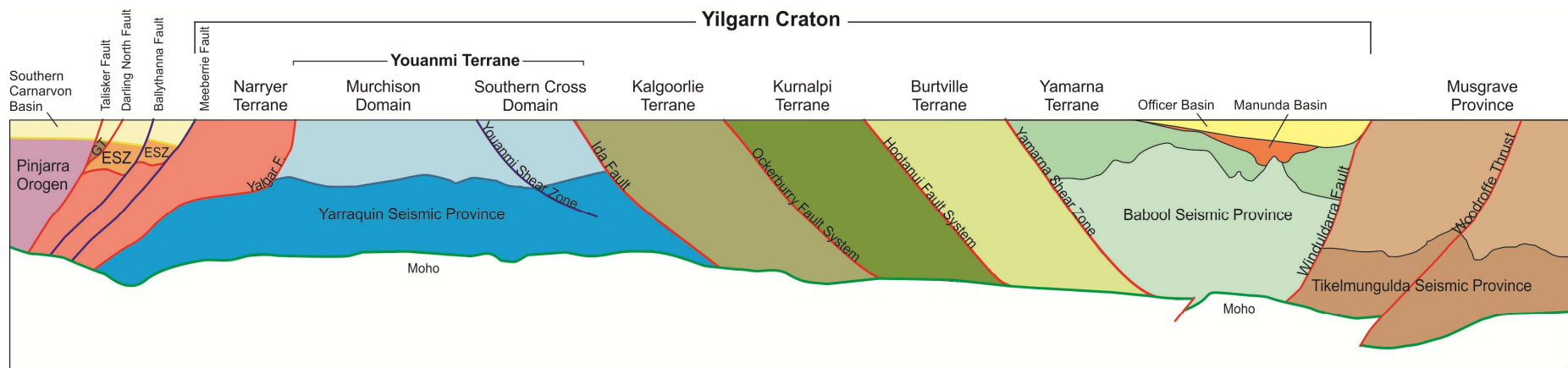
# Cross section from eastern Yilgarn Craton to west Musgrave Province



# Cross section showing present day relationships between the crustal terranes



VE x 1

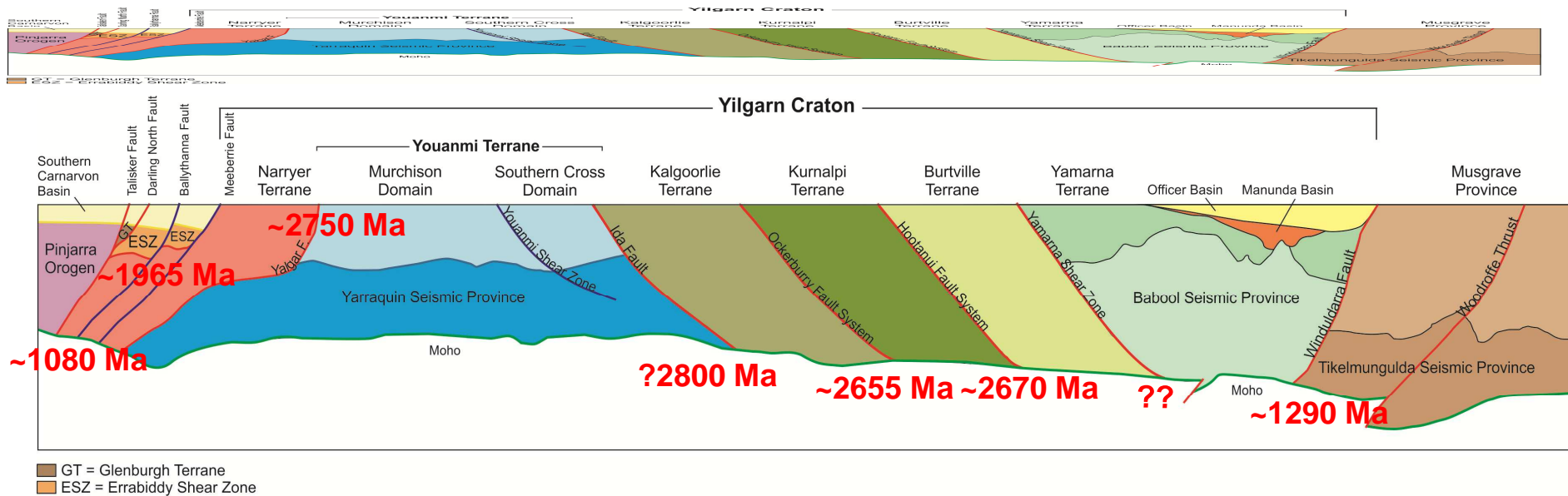


GT = Glenburgh Terrane  
ESZ = Errabiddy Shear Zone

VE x ~3.5



# Transect across Western Australia 2 billion years in the making



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

**Narryer Terrane sutured to protocraton in northwest**

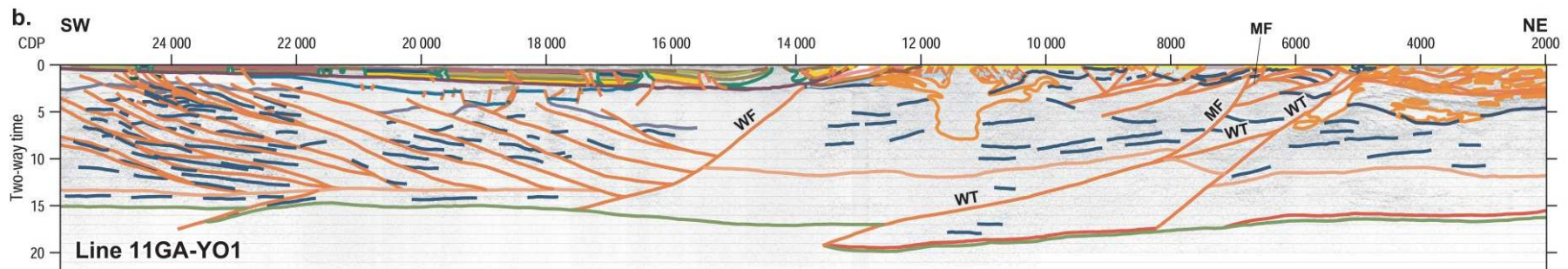
**Terranes of Eastern Goldfields Superterrane in east accreted to protocraton, to form entire Yilgarn Craton**

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

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

# Summary 1

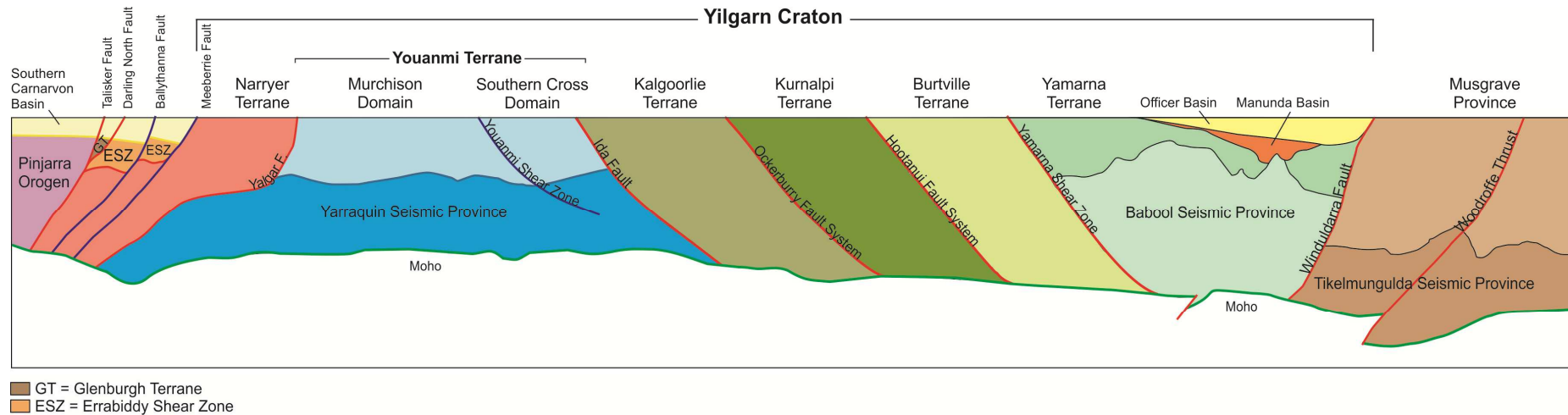
## Crustal architecture of NE Yilgarn Craton to west Musgrave Province



- **First holistic view of the crustal architecture of the region (484 line km of new seismic data, 480 km of new MT)**
- **Several crustal-scale terranes and basins**
  - Including two newly recognised seismic provinces
  - Manunda Basin imaged
- **Yamarna Terrane + Babool SP very different seismically and MT to west Musgrave Province and Tikelmungulda SP**

# Summary 2

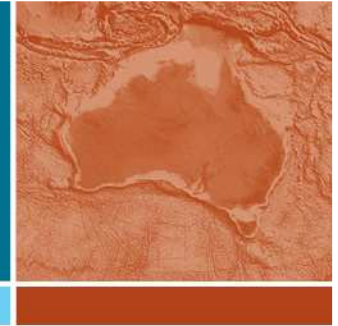
## Assembly of southern Western Australia



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



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



# THANK YOU

Seismic & MT data, maps and interpretations can be downloaded from:  
<http://www.ga.gov.au/minerals/projects/current-projects/seismic-acquisition-processing/table-1-oesp-deep-crustal-seismic-programs.html>

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