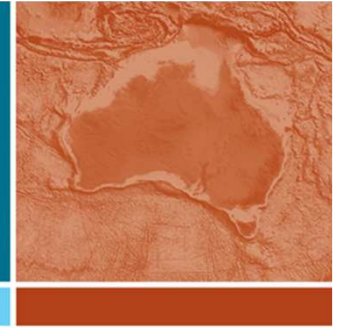




Australian Government  
Geoscience Australia



# Geological setting and interpretation of the southwest half of deep seismic reflection line 11GA–YO1: Yamarna Terrane of the Yilgarn Craton and the western Officer Basin

Russell Korsch, R Blewett, M Pawley, L Carr, R Hocking, N Neumann, H Smithies, R Quentin de Gromard, H Howard, 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**

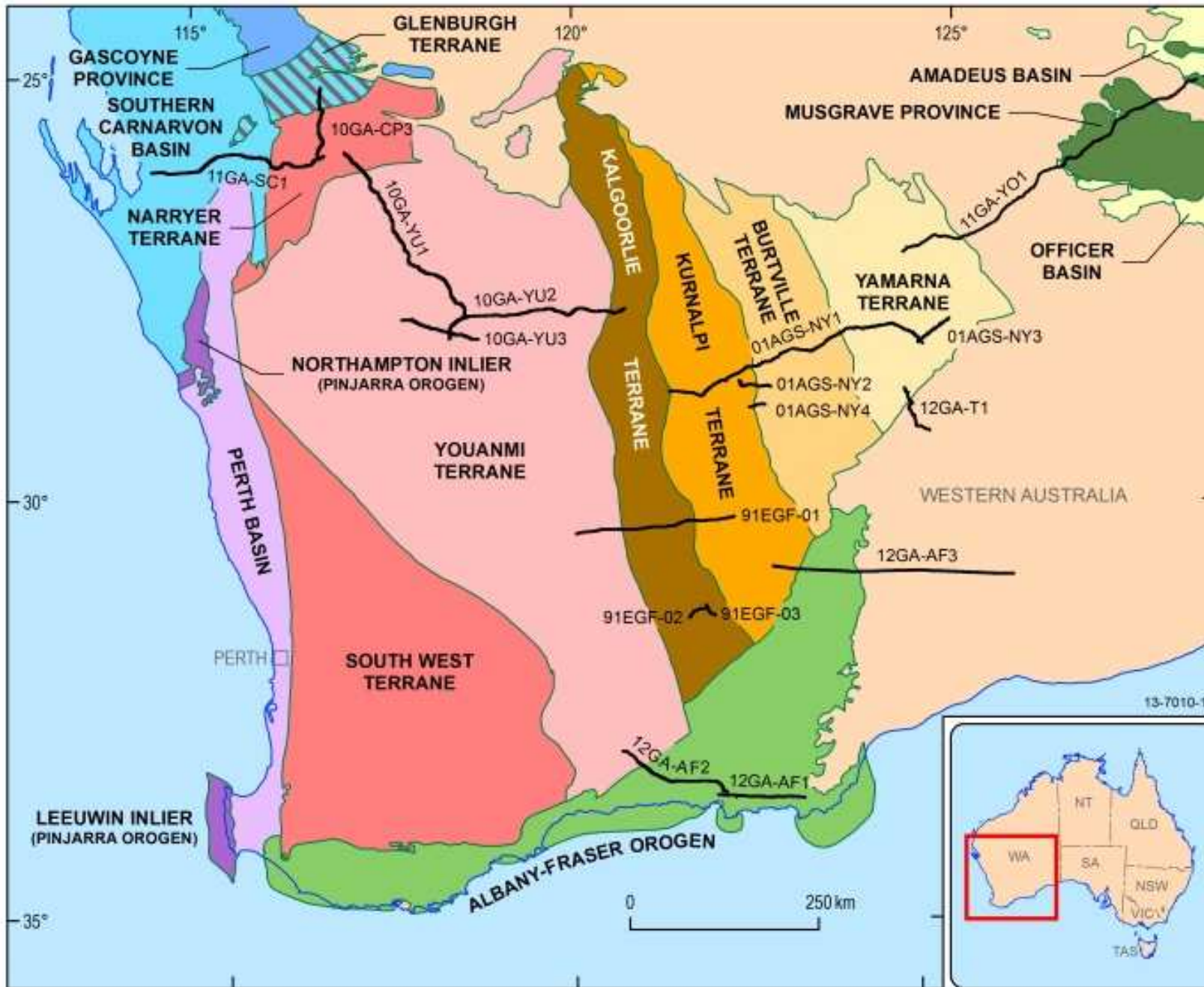


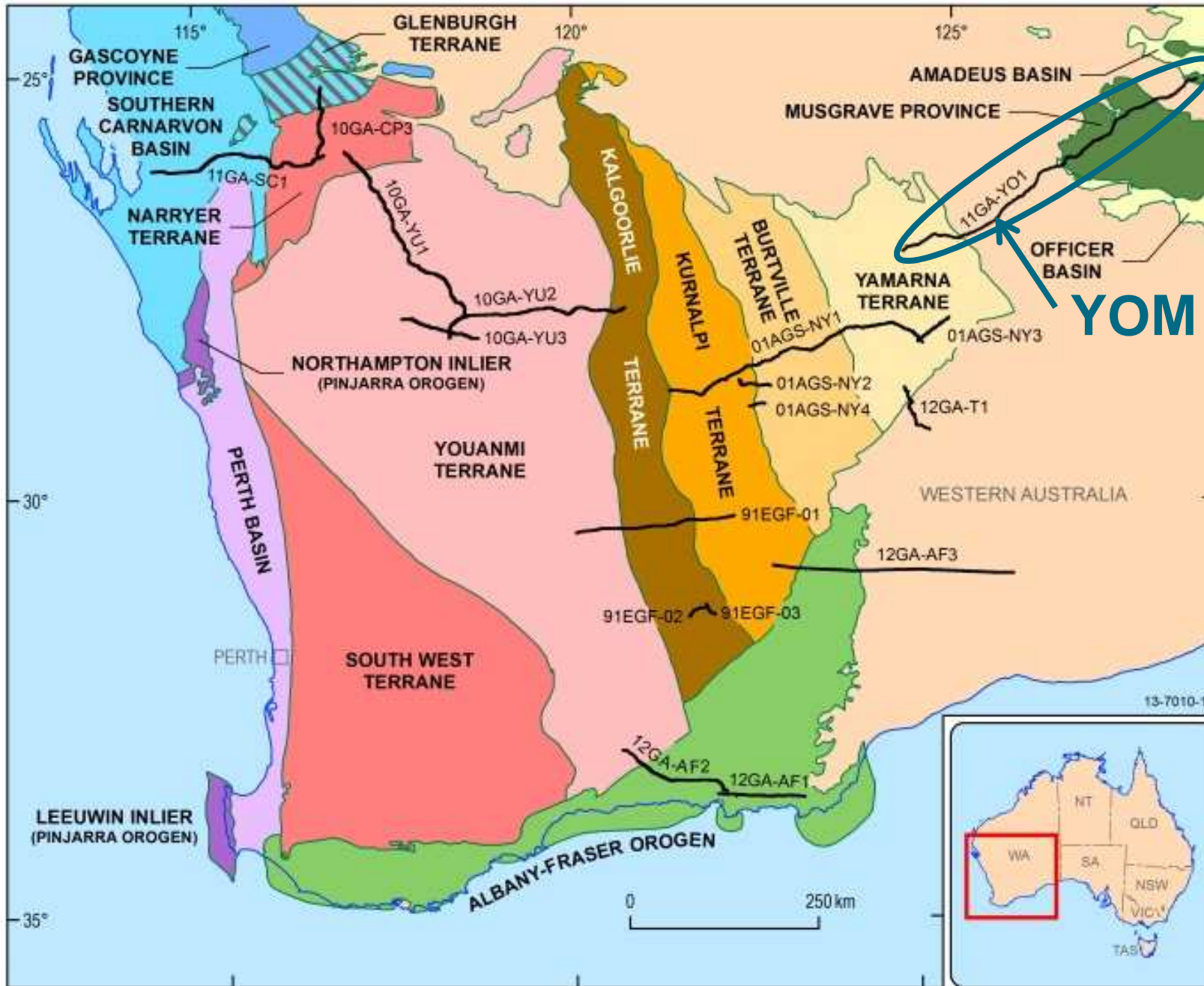
**ROYALTIES**  
**FOR REGIONS**

**EXPLORATION INCENTIVE SCHEME**

## Contributors

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



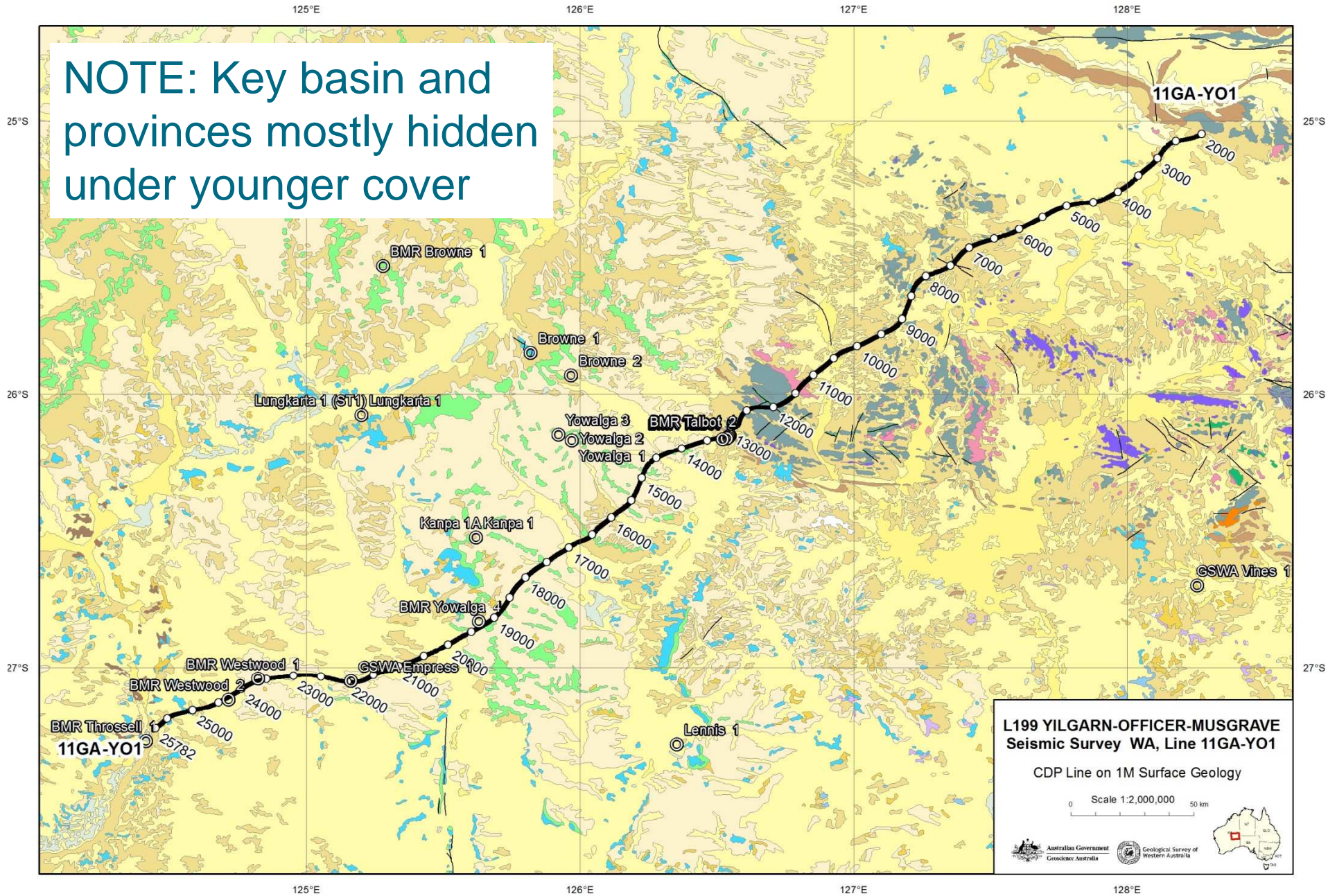


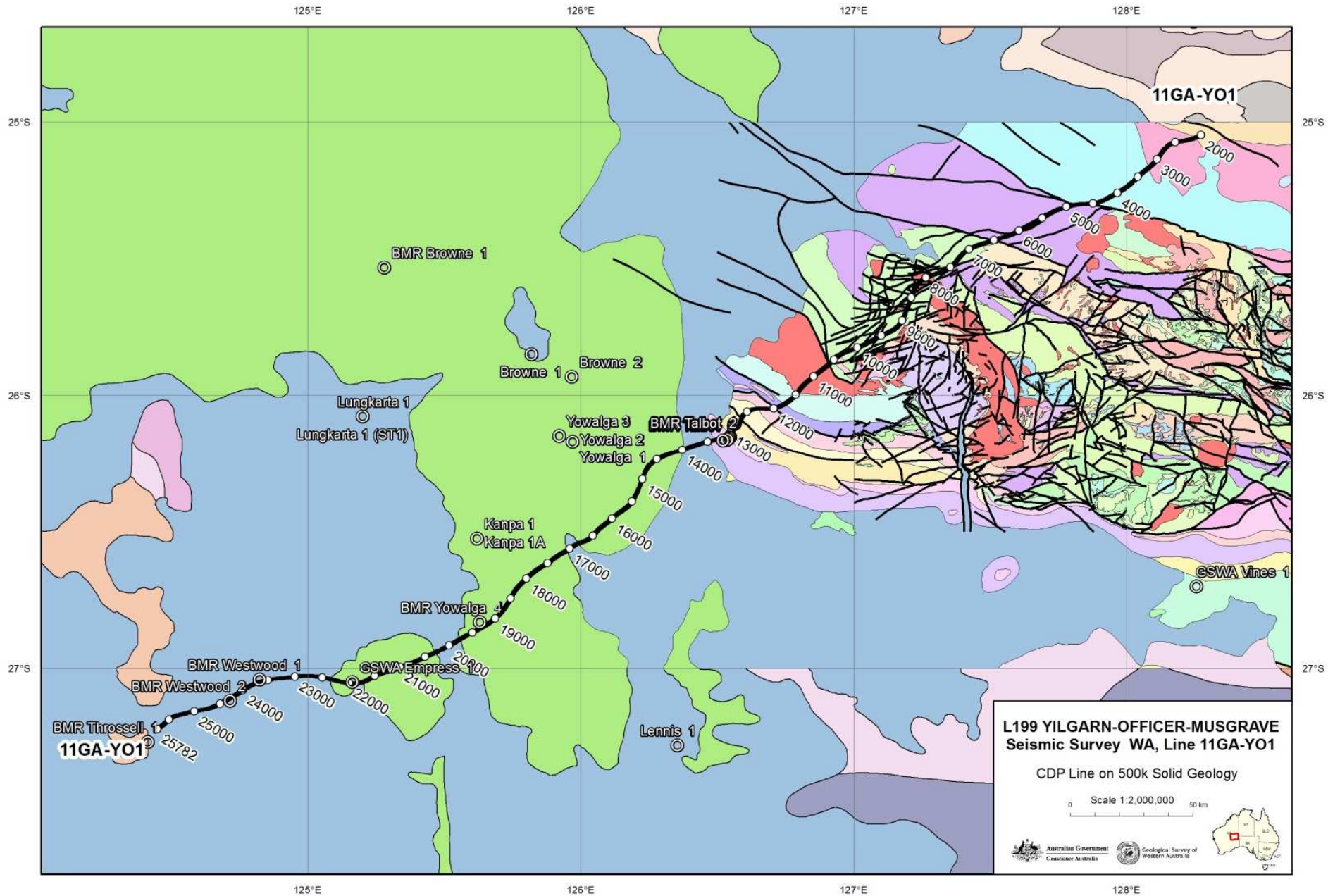
# Aims of the Yilgarn-Officer-Musgrave (YOM) seismic survey

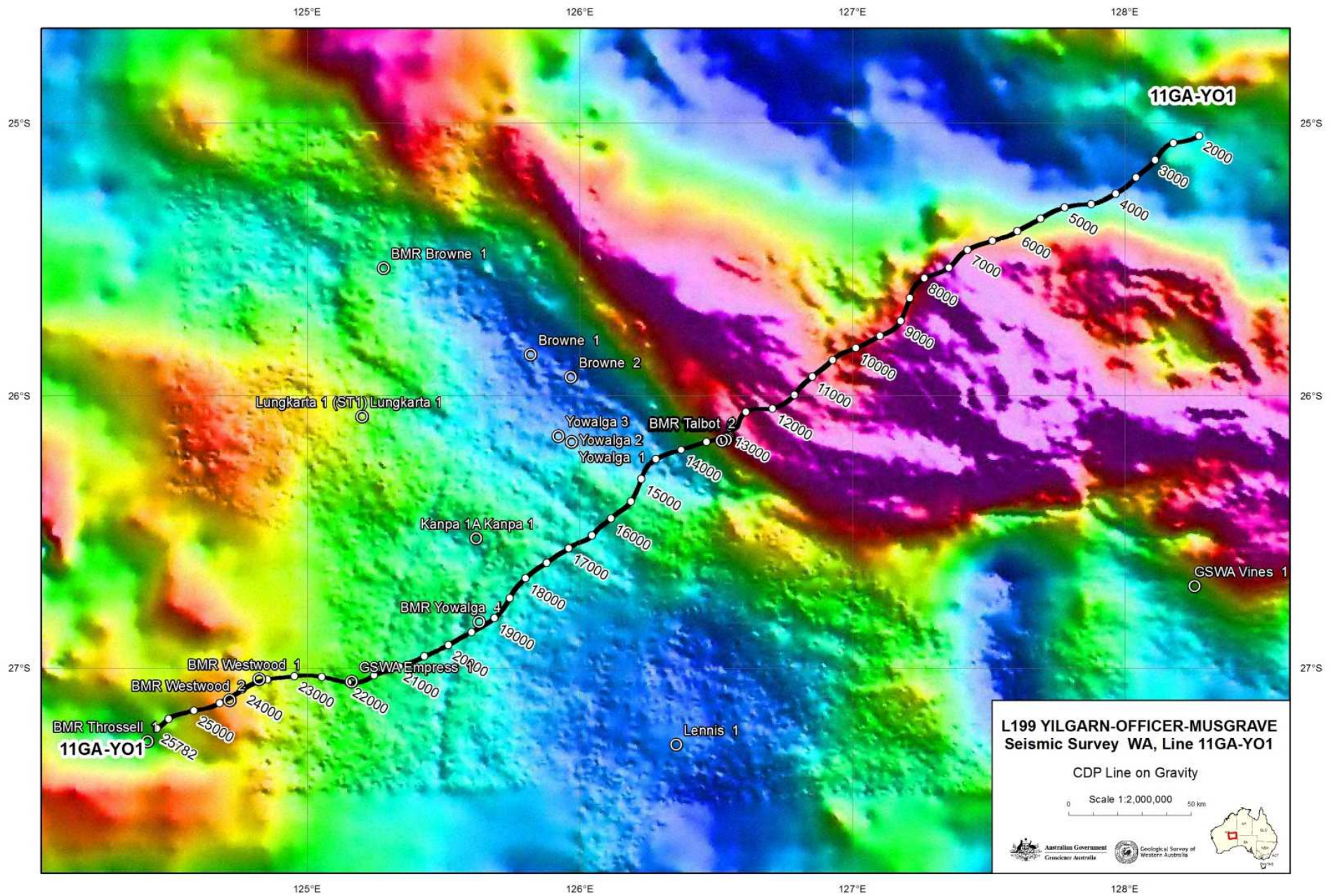
1. Produce a high quality seismic section across western Officer Basin, one of Australia's underexplored frontier sedimentary basins
2. Architecture and deep structure of Archean Yamarna Terrane, in northeastern Yilgarn Craton
3. Architecture and deep structure of the Mesoproterozoic west Musgrave Province
4. Relationship between the Yamarna Terrane and west Musgrave Province

**NOTE:** Key basin and provinces mostly hidden under younger cover

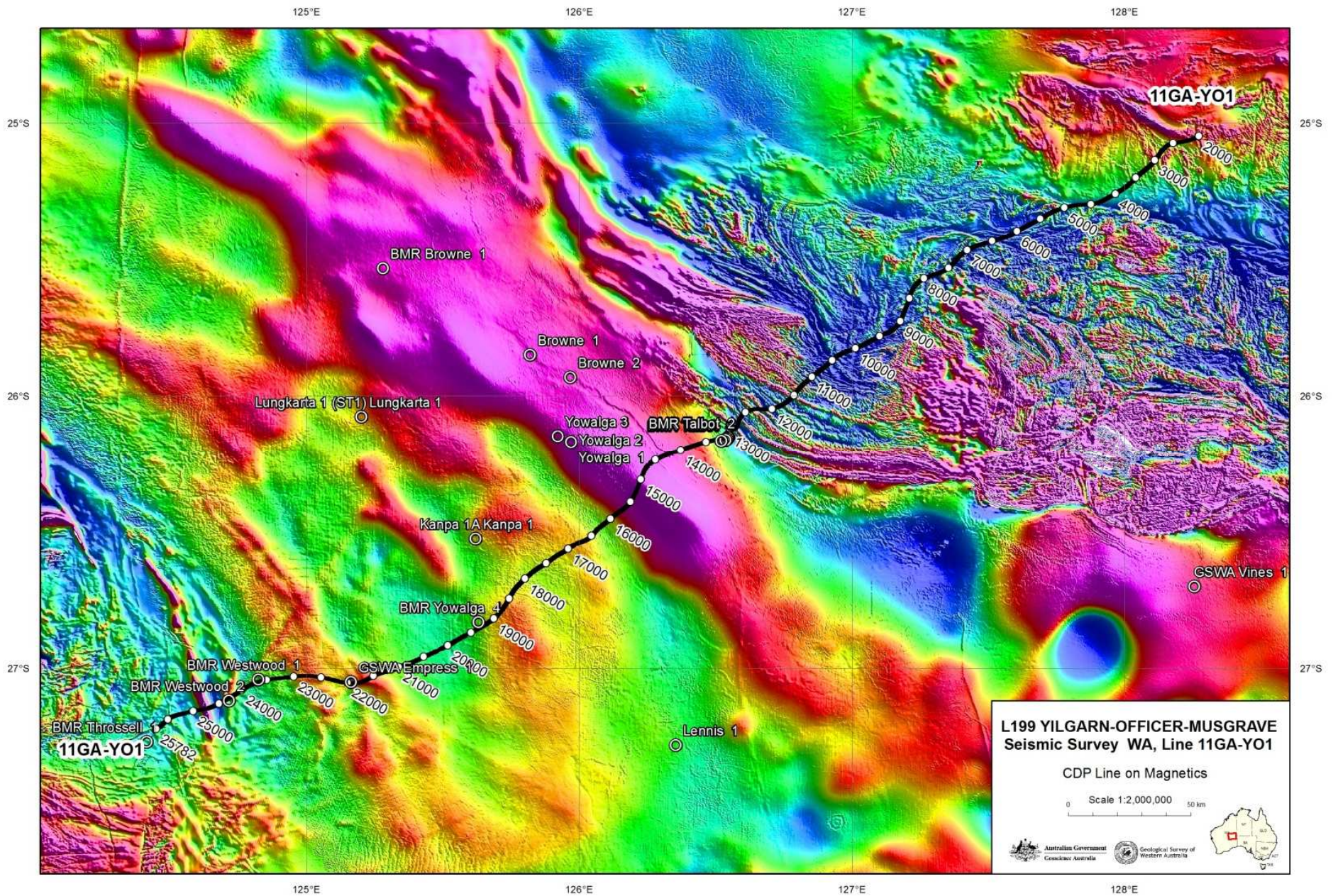
**NOTE: Key basin and provinces mostly hidden under younger cover**

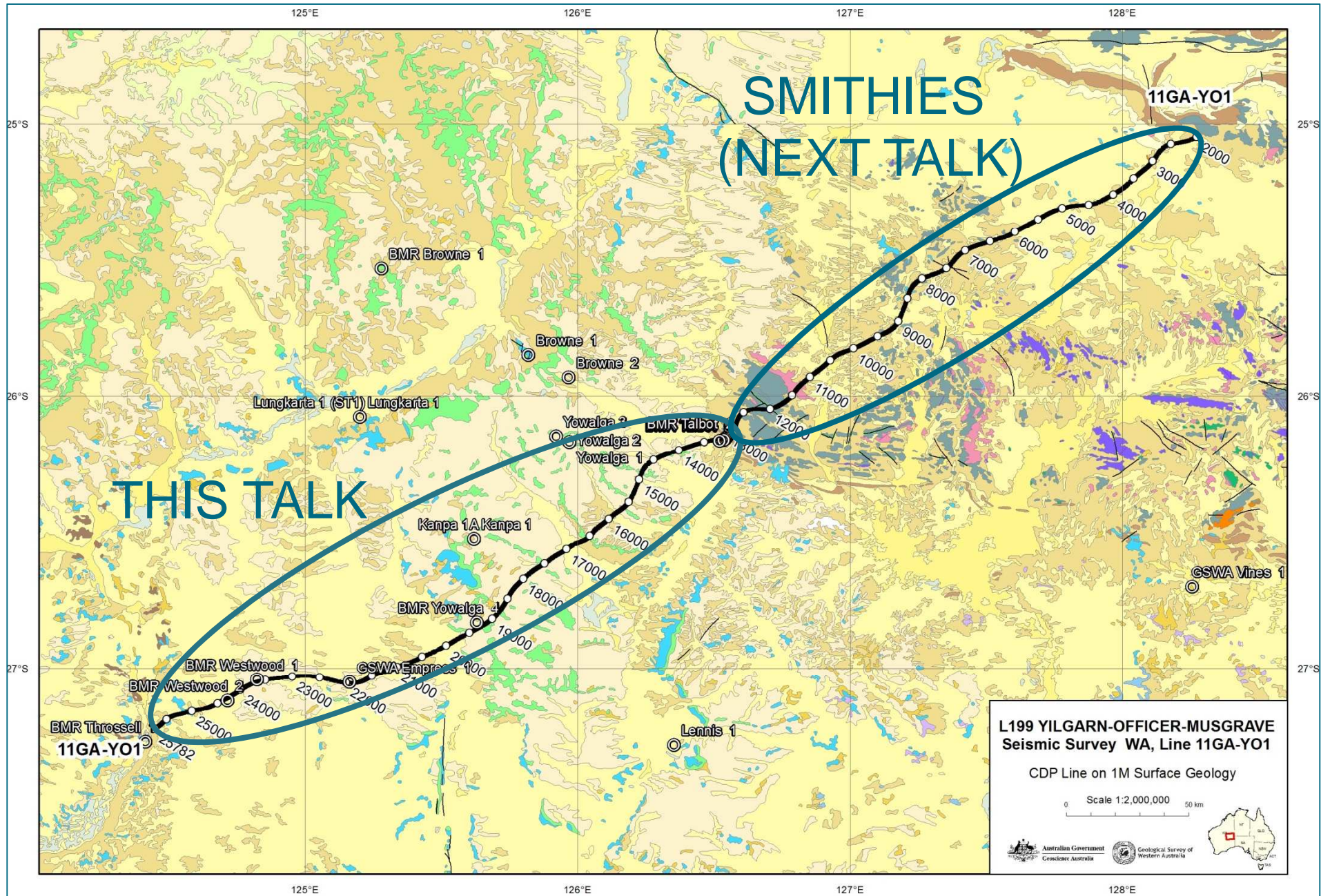












# Southwest half of YOM seismic line - Key Provinces

## **SURFACE**

Cenozoic to Permian sediments

Officer Basin – Neoproterozoic - ?Devonian

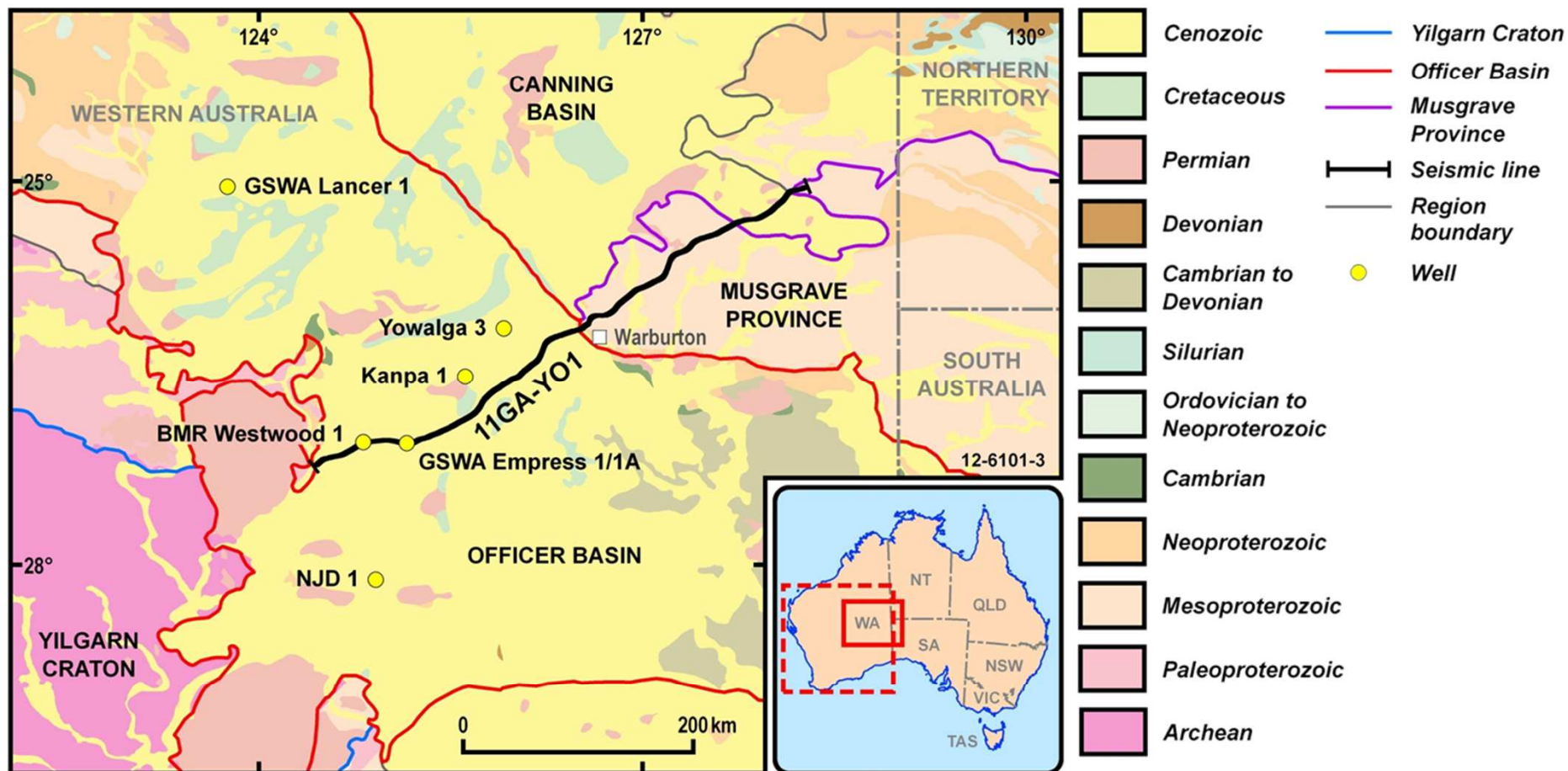
Manunda Basin (new name) – Mesoproterozoic

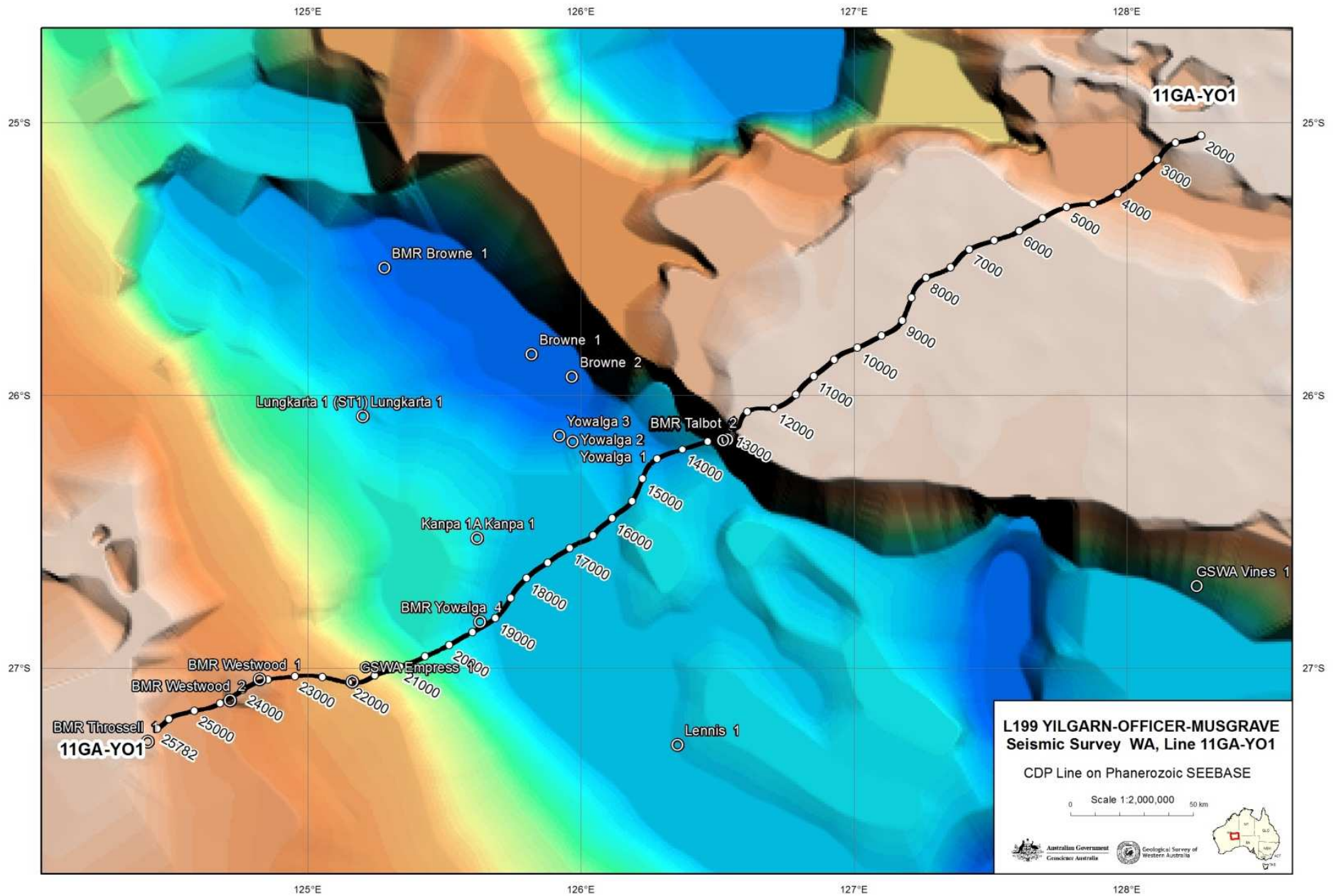
Yamarna Terrane (Yilgarn Craton) – Neoproterozoic

Babool Seismic Province (new) – age unknown

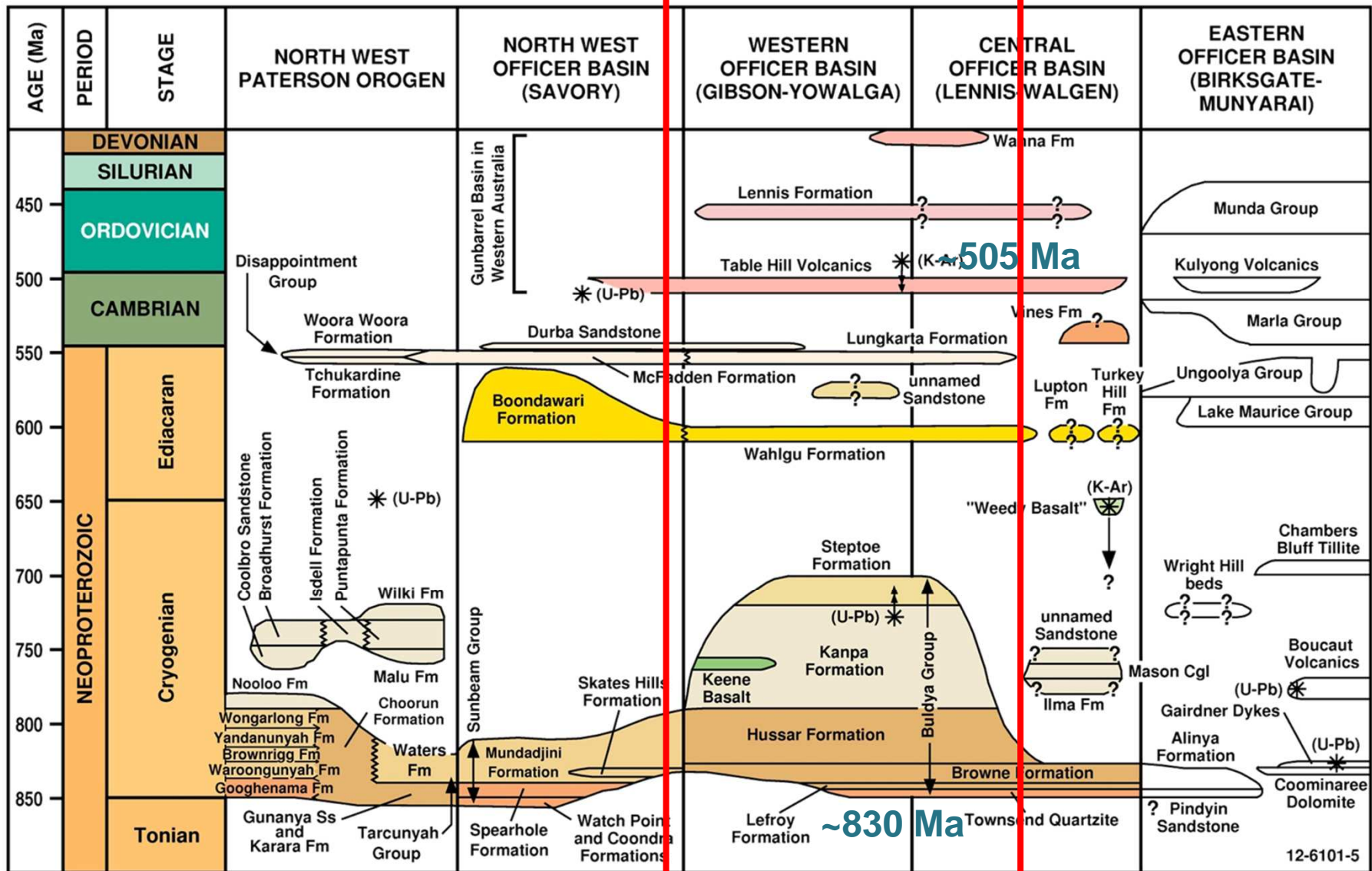
## **MOHO**

# Seismic line 11GA-YO1 (YOM) across Officer Basin



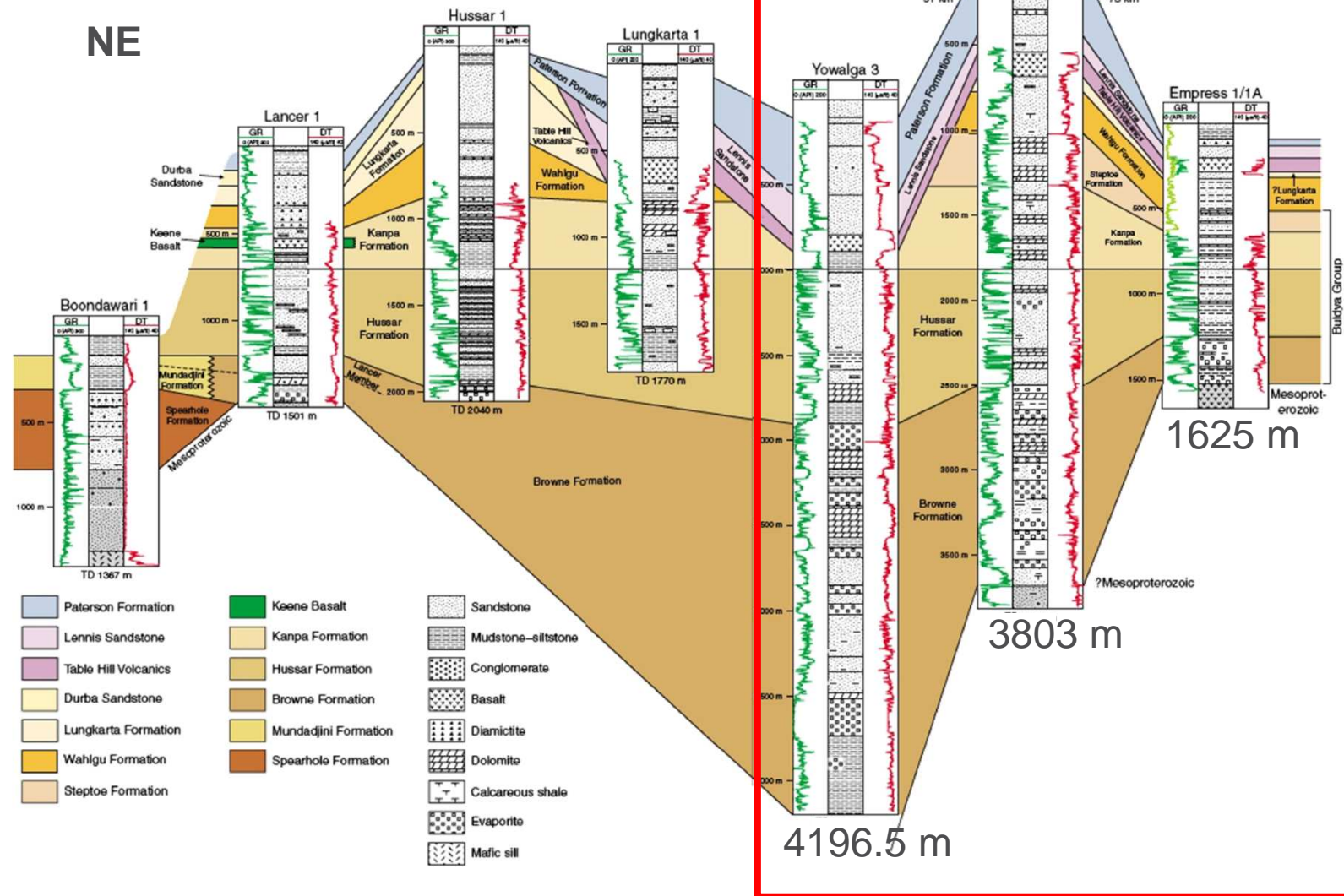


# Officer Basin - stratigraphy



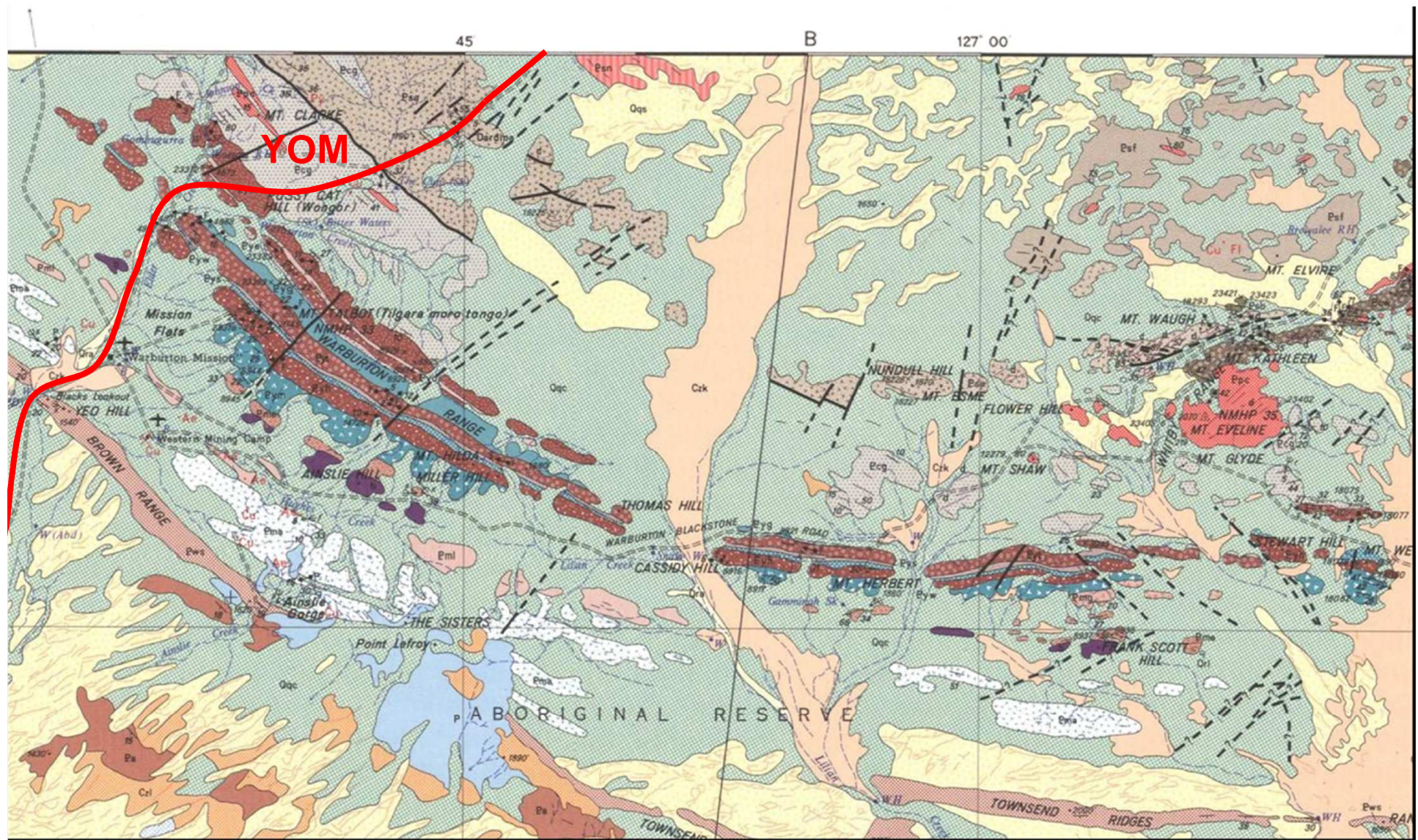
From Grey et al. (2005)

# Officer Basin - well control



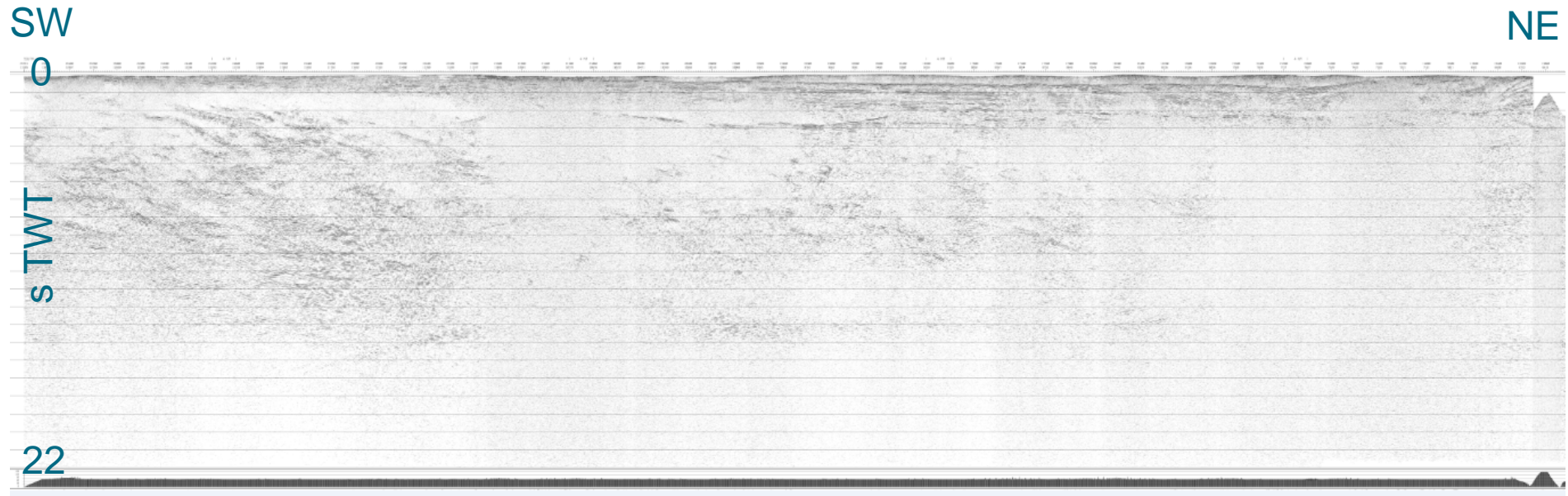
From Grey et al. (2005)

# Surface control - TALBOT map sheet SG52-9





# Officer Basin – standard seismic section

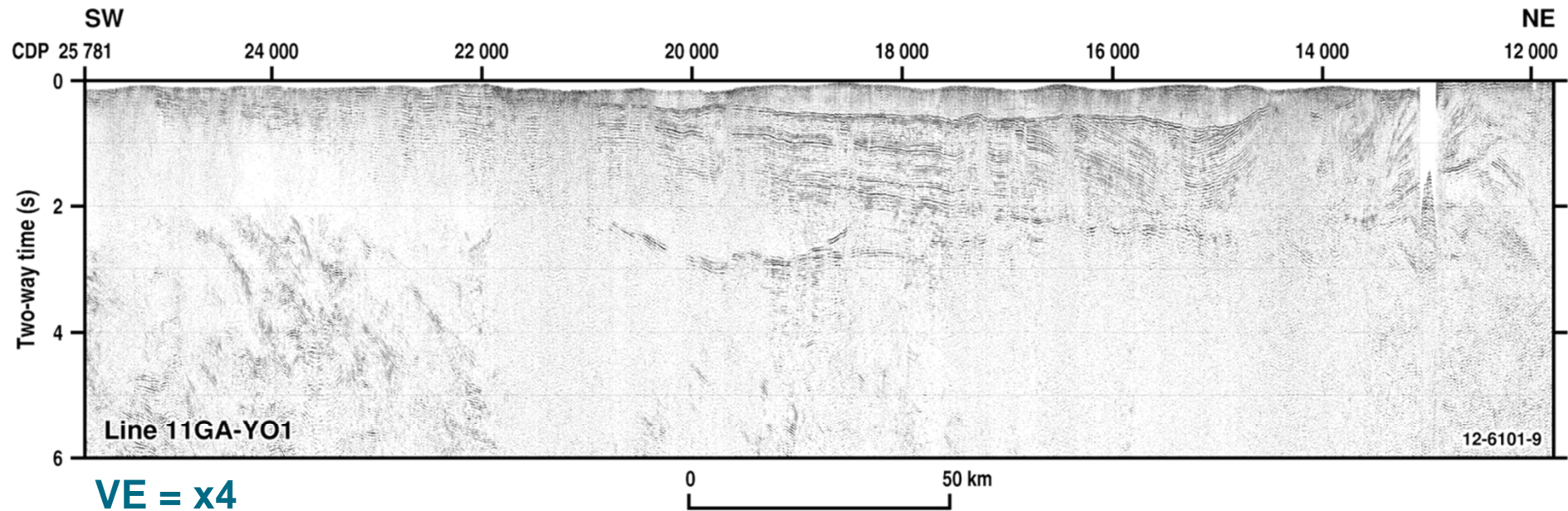


**V:H = ~1:1**

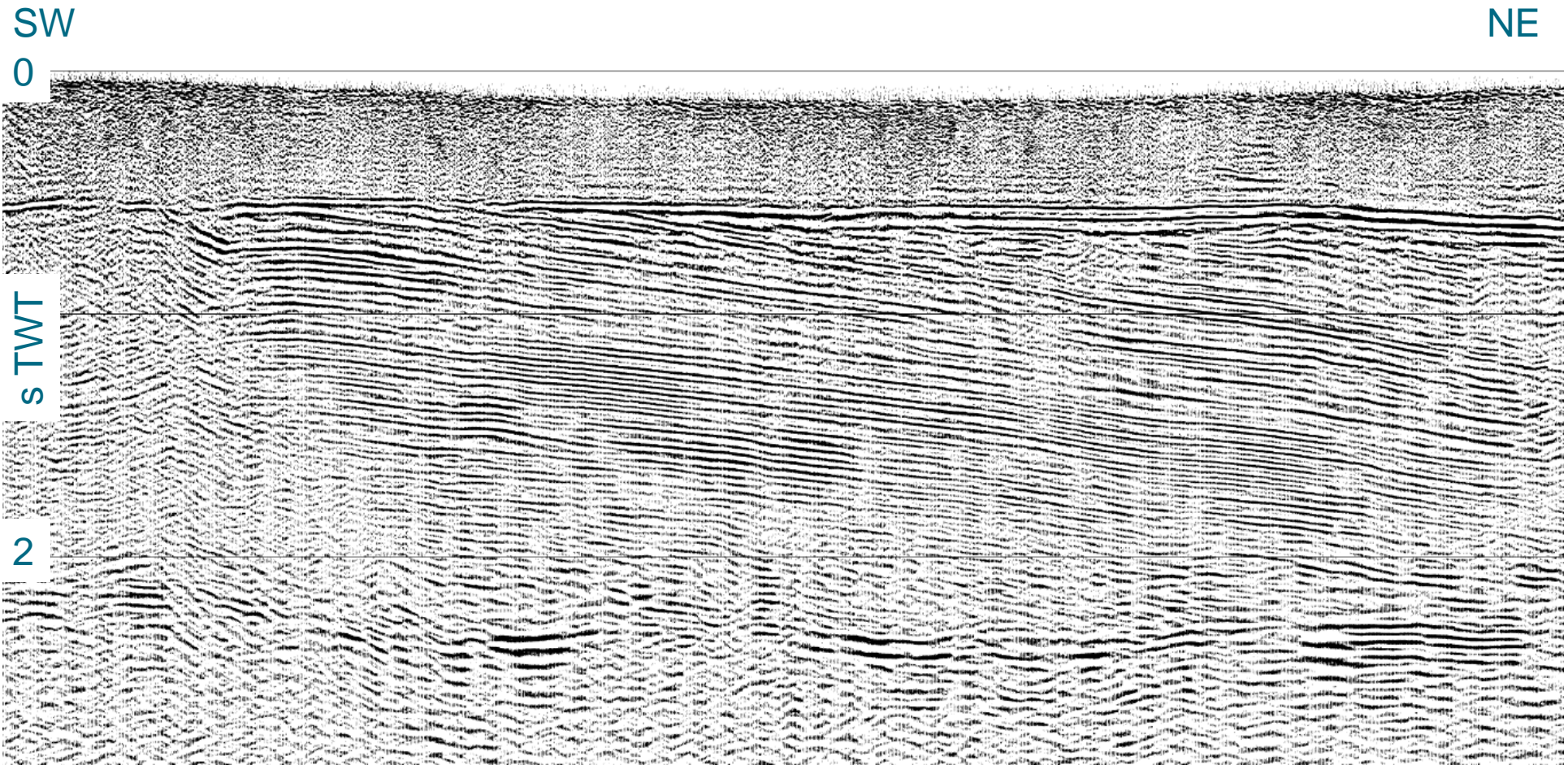
(for whole of crust)

NOTE: Unless otherwise stated, all seismic sections are displayed at V:H = ~1:1, assuming assuming an average crustal velocity of  $6000 \text{ ms}^{-1}$ . Thus, 1 s TWT is ~3 km depth.

# Officer Basin – vertical exaggeration = x4



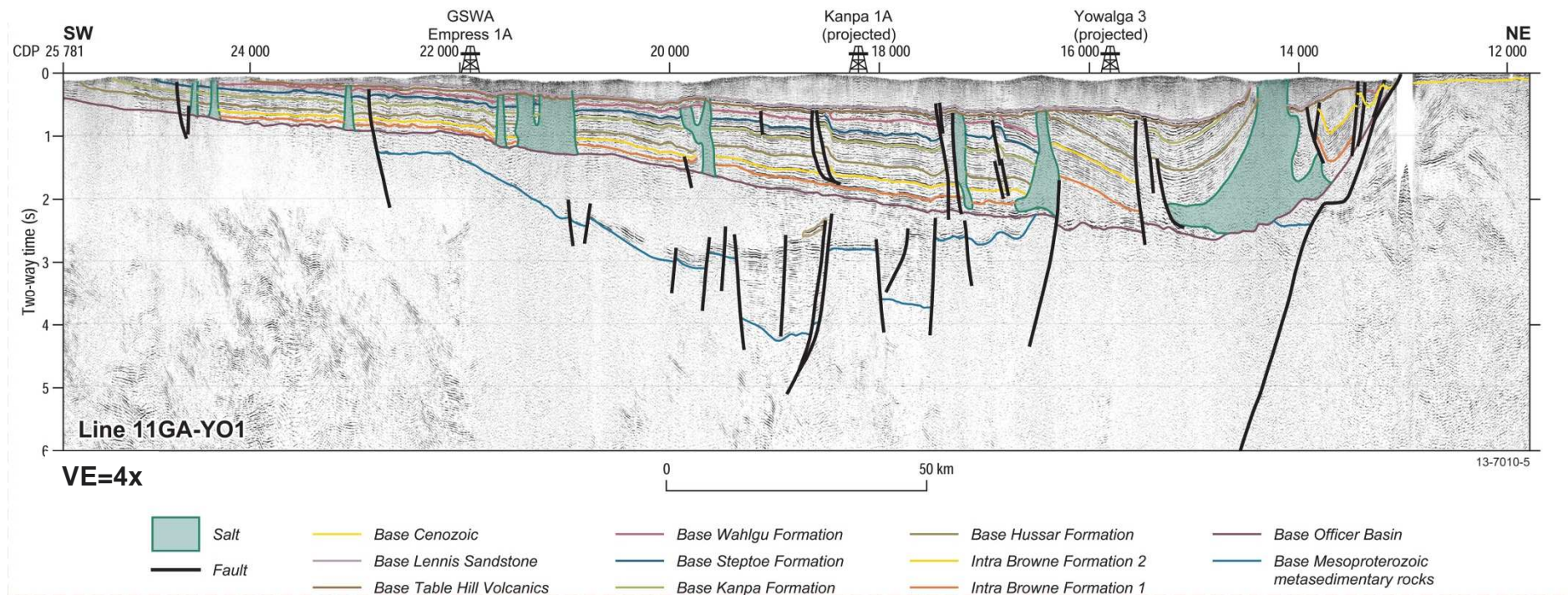
# Officer Basin – seismic detail



V:H = ~1:1

~5 km

# Officer Basin – interpreted YOM section



Basin – thickens to NE → initial extensional basin

Basin bounding fault to NE? (original basin margin destroyed)

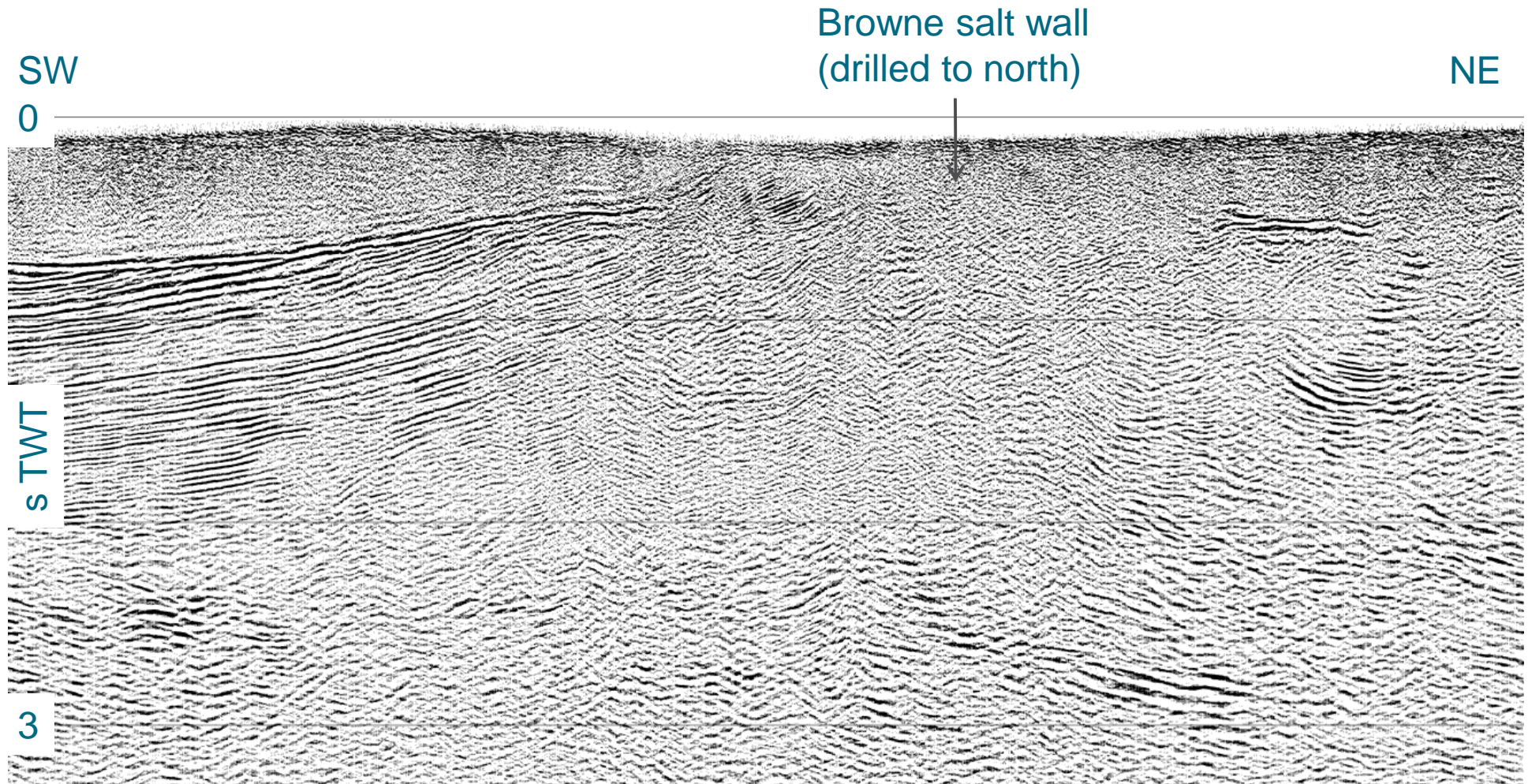
Sedimentary succession - ~480 m preserved in SW to >5200 m in NE

Unconformities – e.g. below Cambrian Table Hill Volcanics

Structure – SW-directed thrust faults, hangingwall anticlines

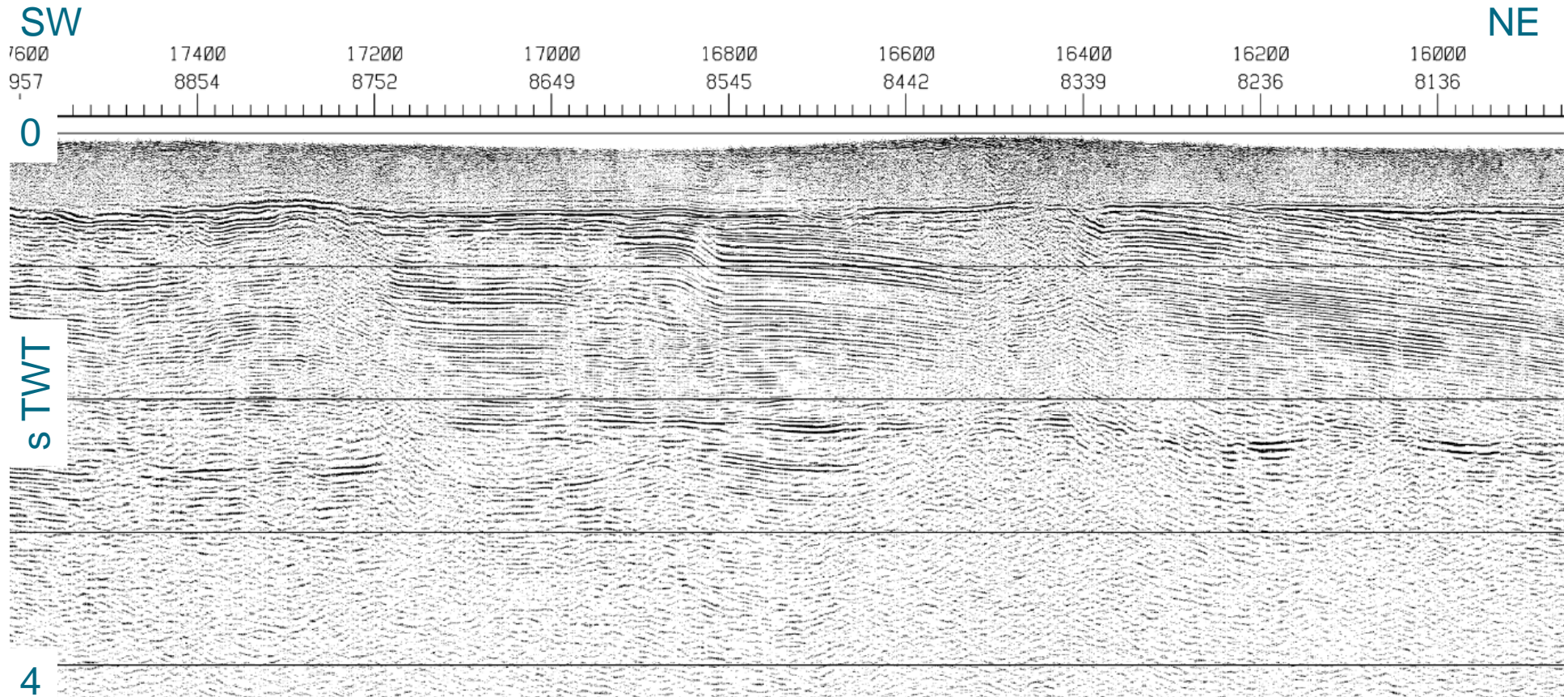
Salt Tectonics – several salt intrusions interpreted

# Officer Basin – salt tectonics



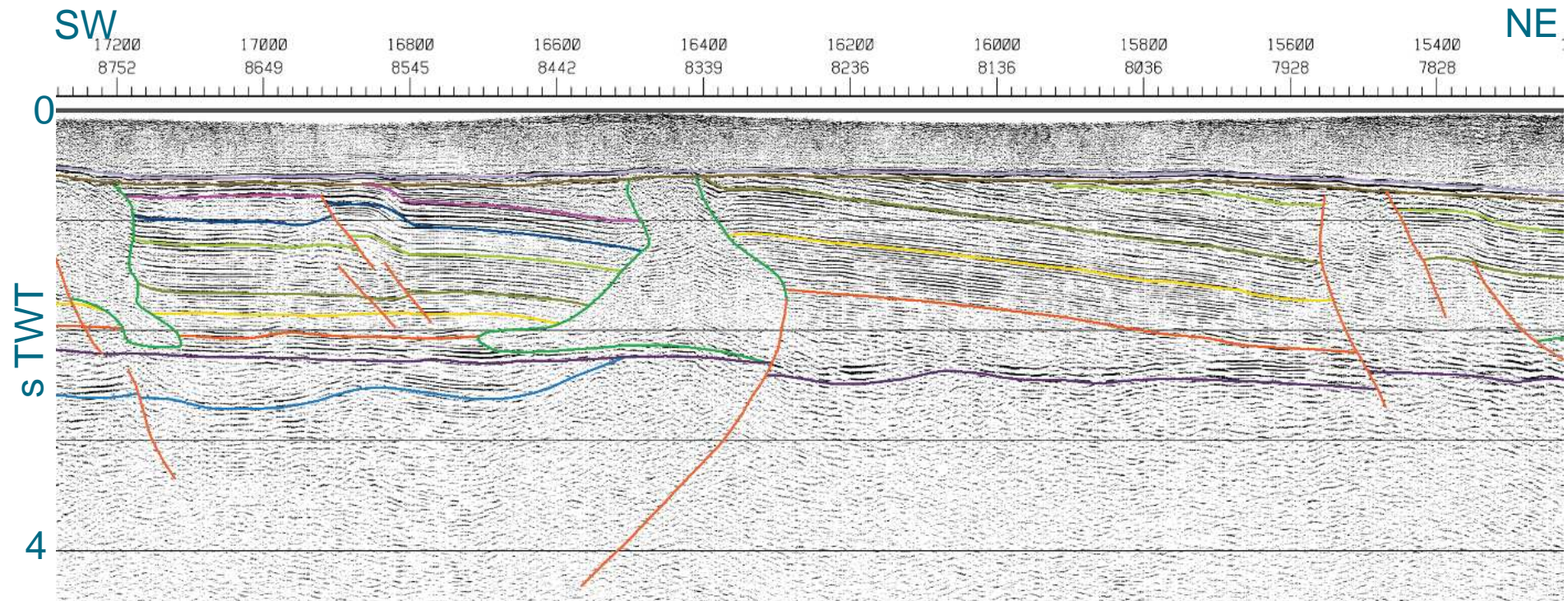
Salt = nonreflective zone

# Officer Basin – salt tectonics

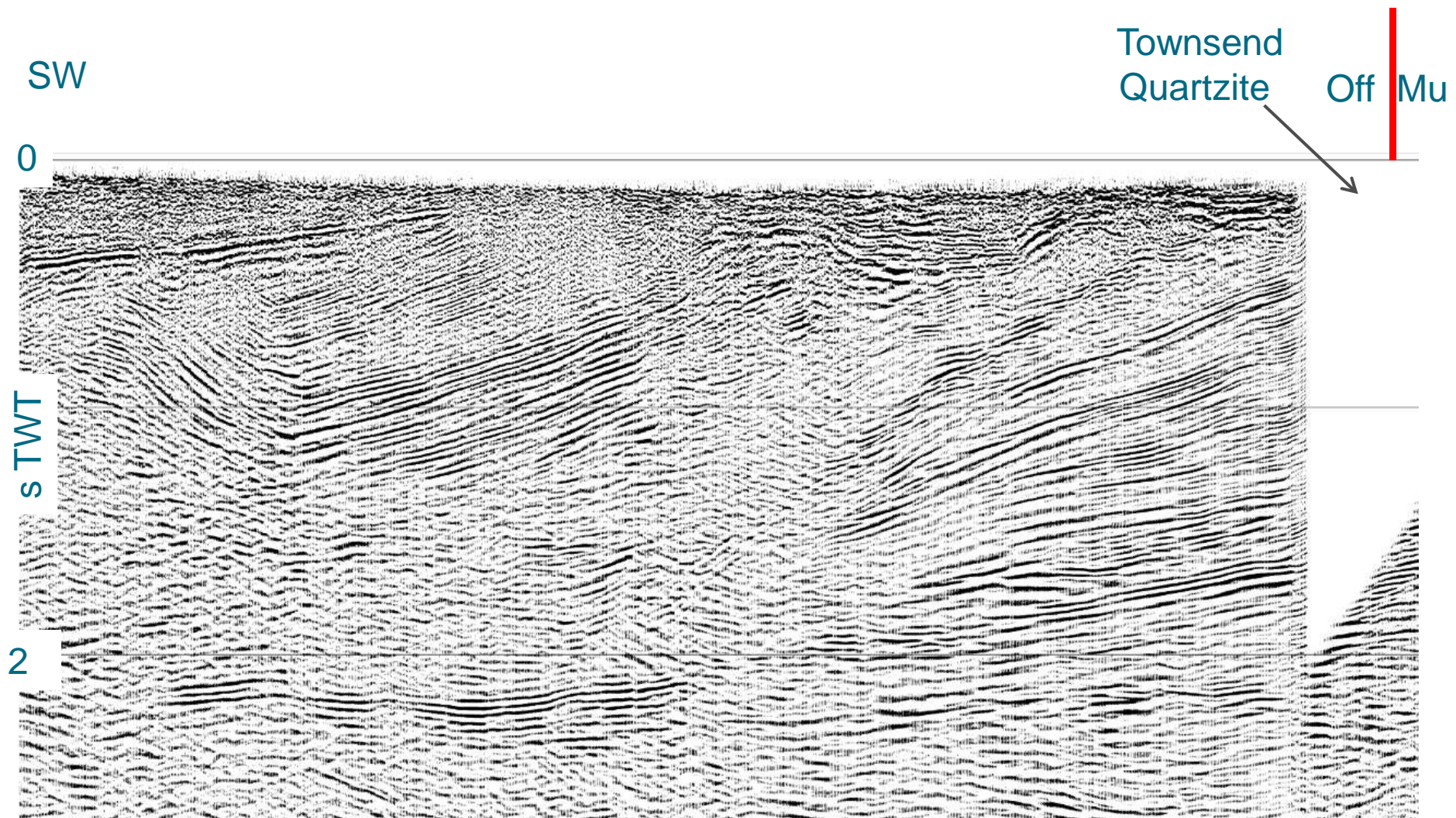


Nonreflective zones interpreted to be salt

# Officer Basin – salt tectonics

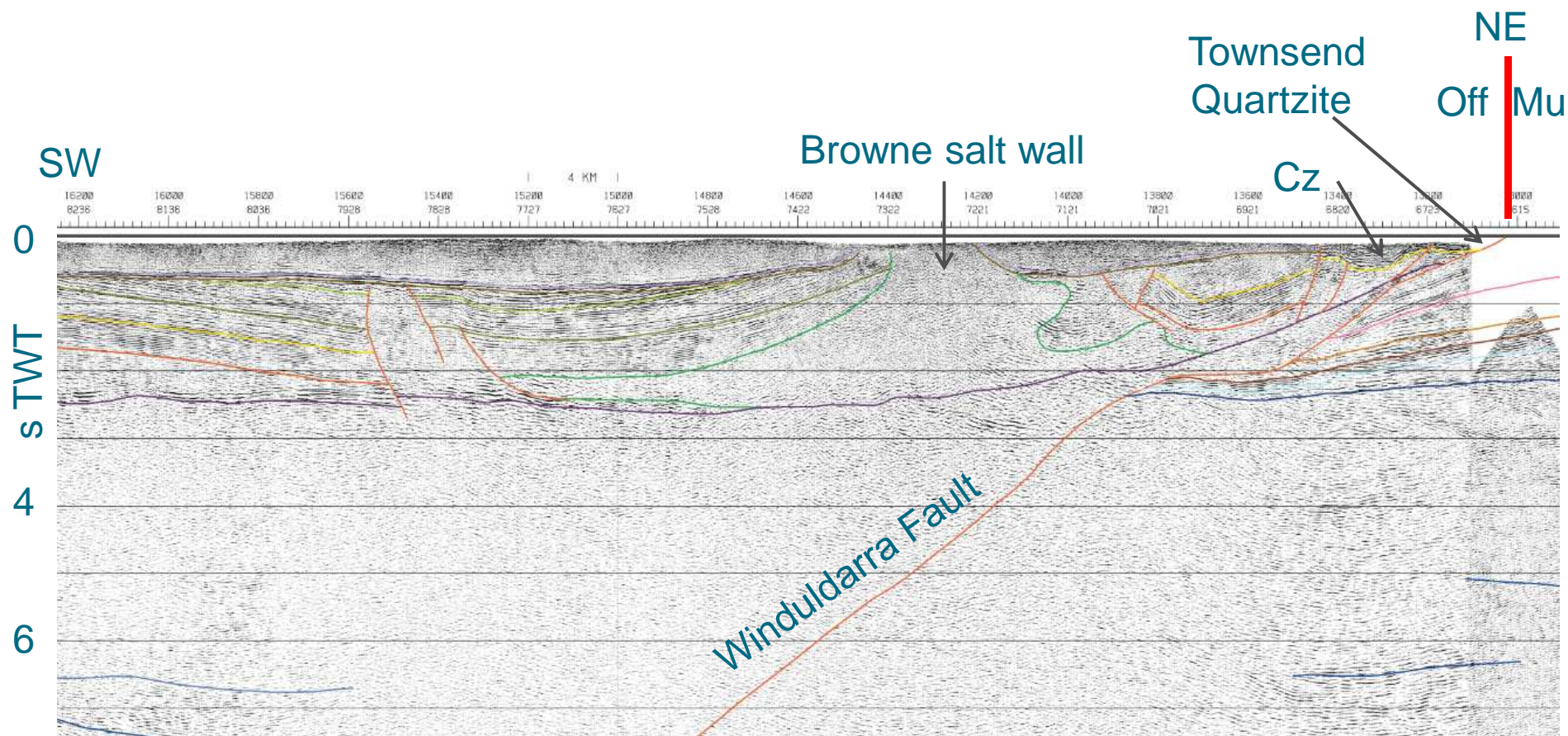


# Officer Basin – margin with Musgrave Province



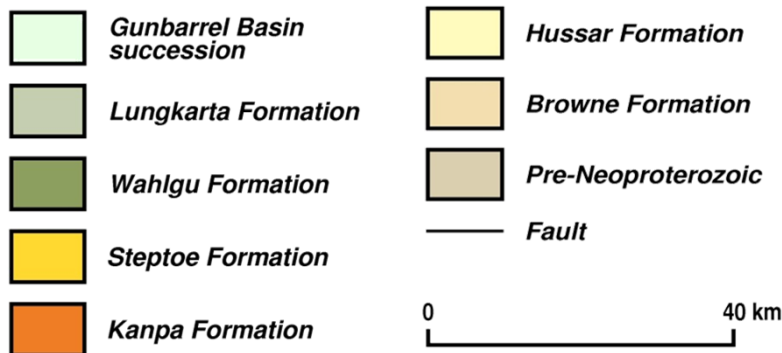
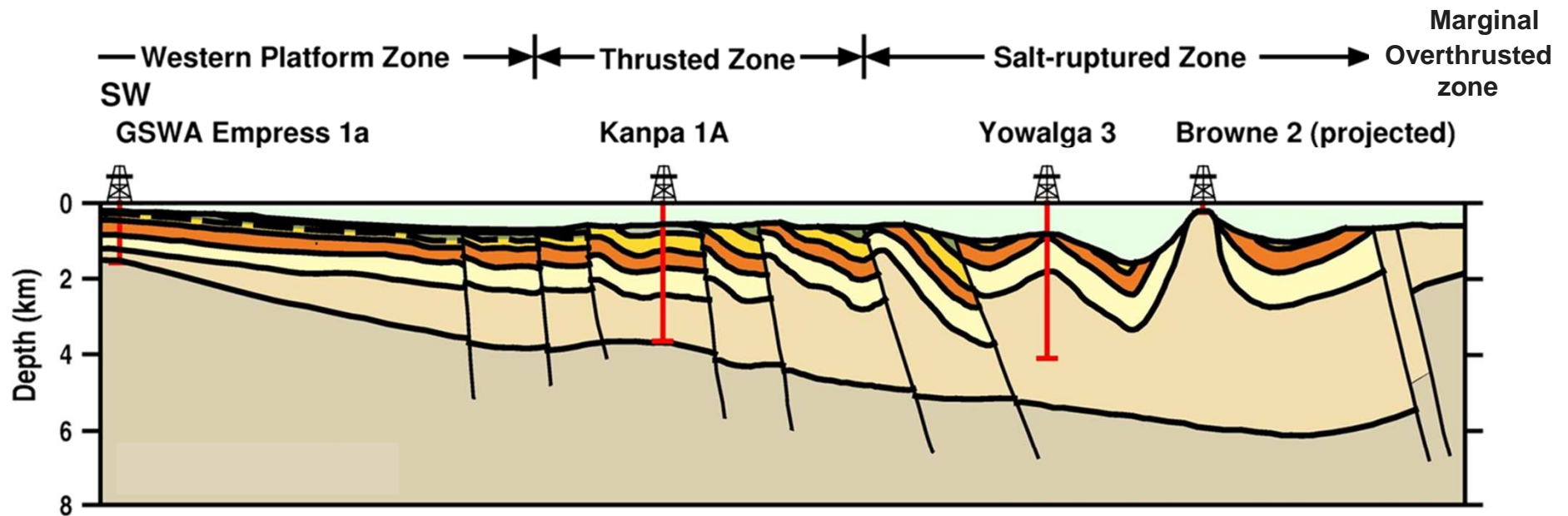


# Officer Basin – margin with Musgrave Province



Winduldarra Fault = inversion of older extensional fault OR new thrust fault?

# Comparative cross section (2005)



YOM seismic line suggests:

- Salt intrusions more extensive to the SW
- Thrust faults not as significant

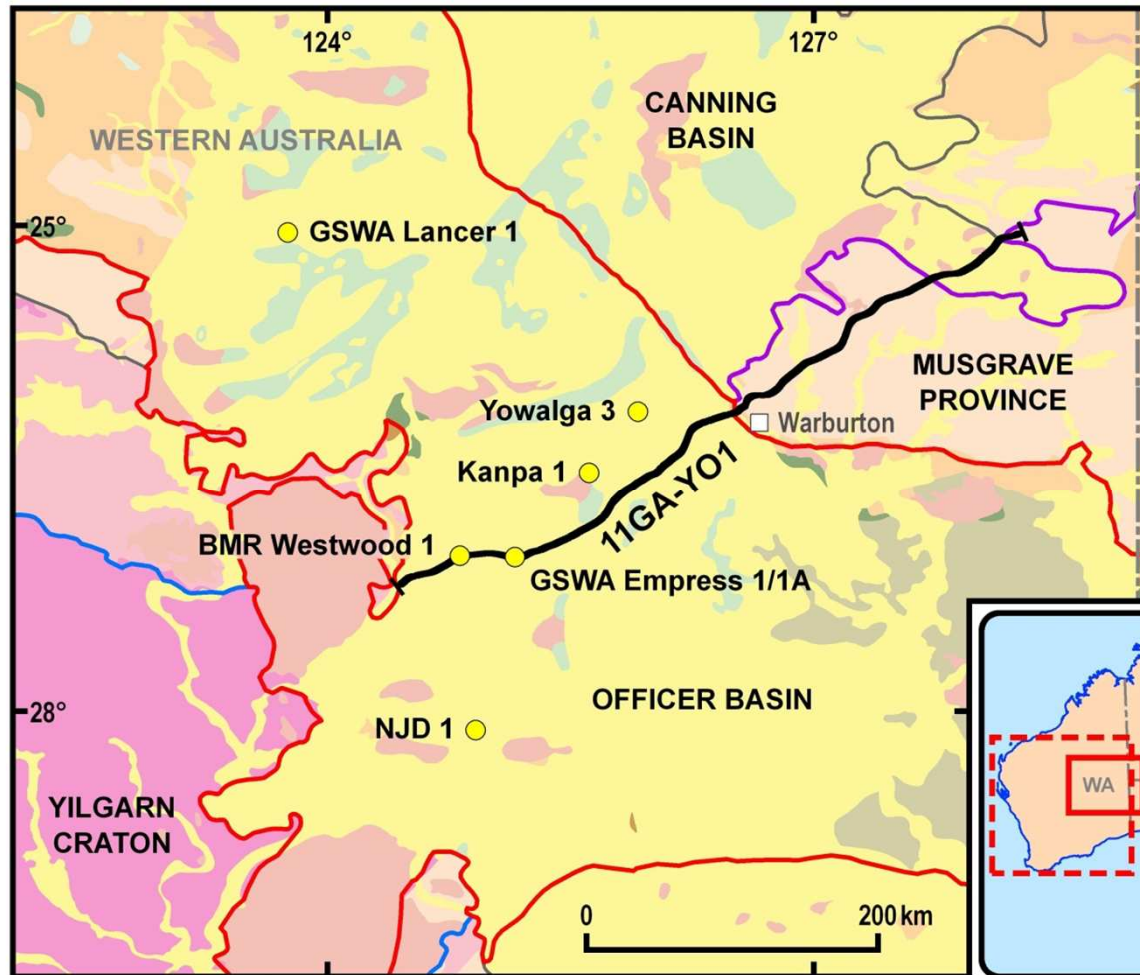
From Simeonova and Iasky (2005)

# Manunda Basin (new name)

Sedimentary succession below Officer Basin:

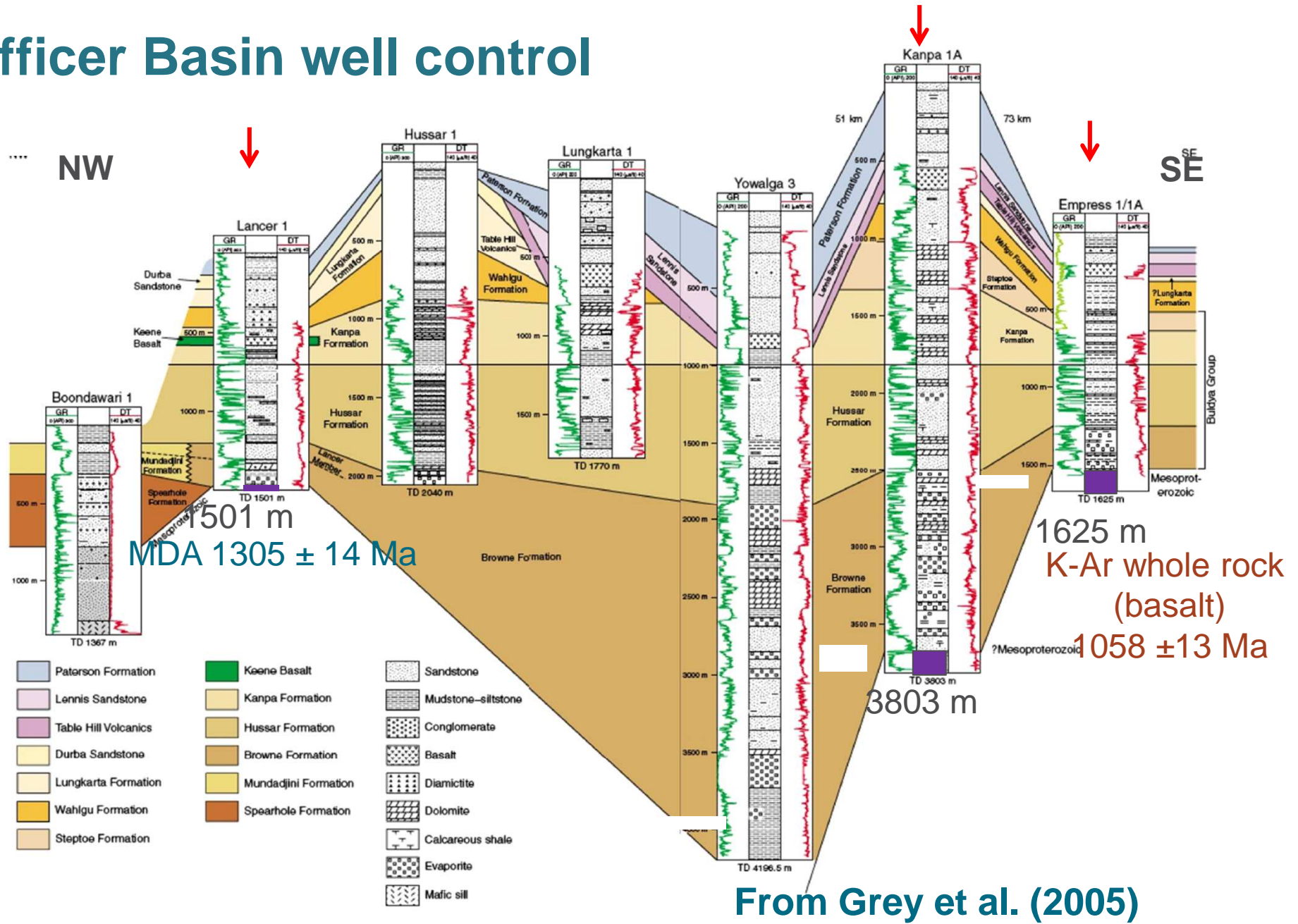
- Identified on some previous seismic profiles
- Intersected in drillholes
- Not yet identified in outcrop near YOM seismic line

# Manunda Basin – sampled in drill holes



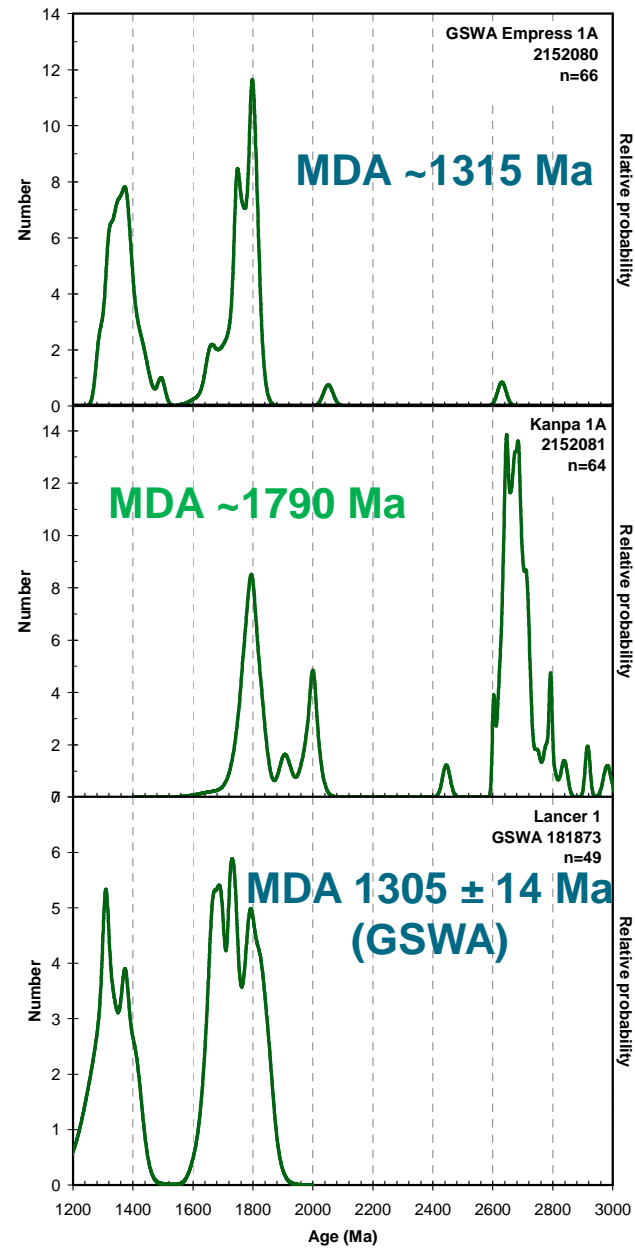
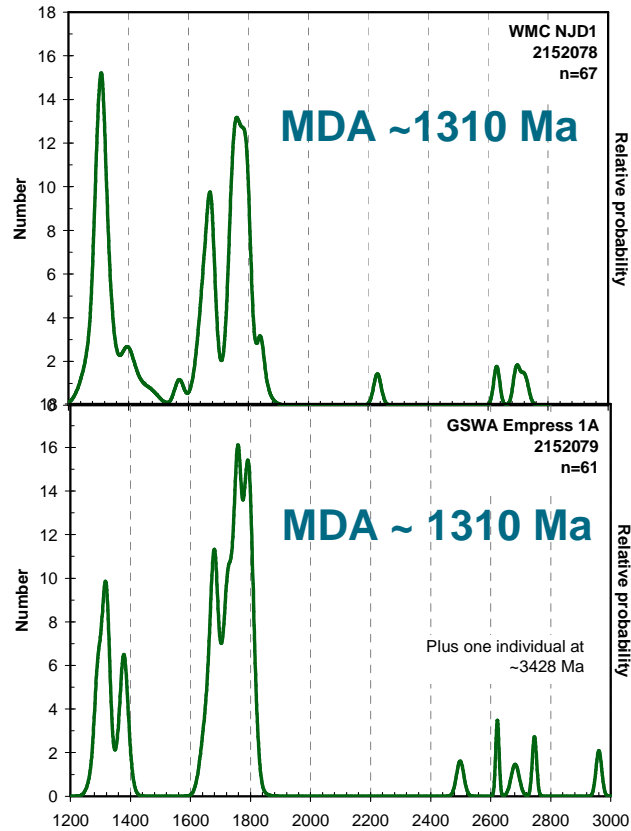
GSWA Lancer 1 >1479 m  
Kanpa 1 >3671 m  
GSWA Empress 1A >1522 m  
NJD 1 >377 m

# Officer Basin well control

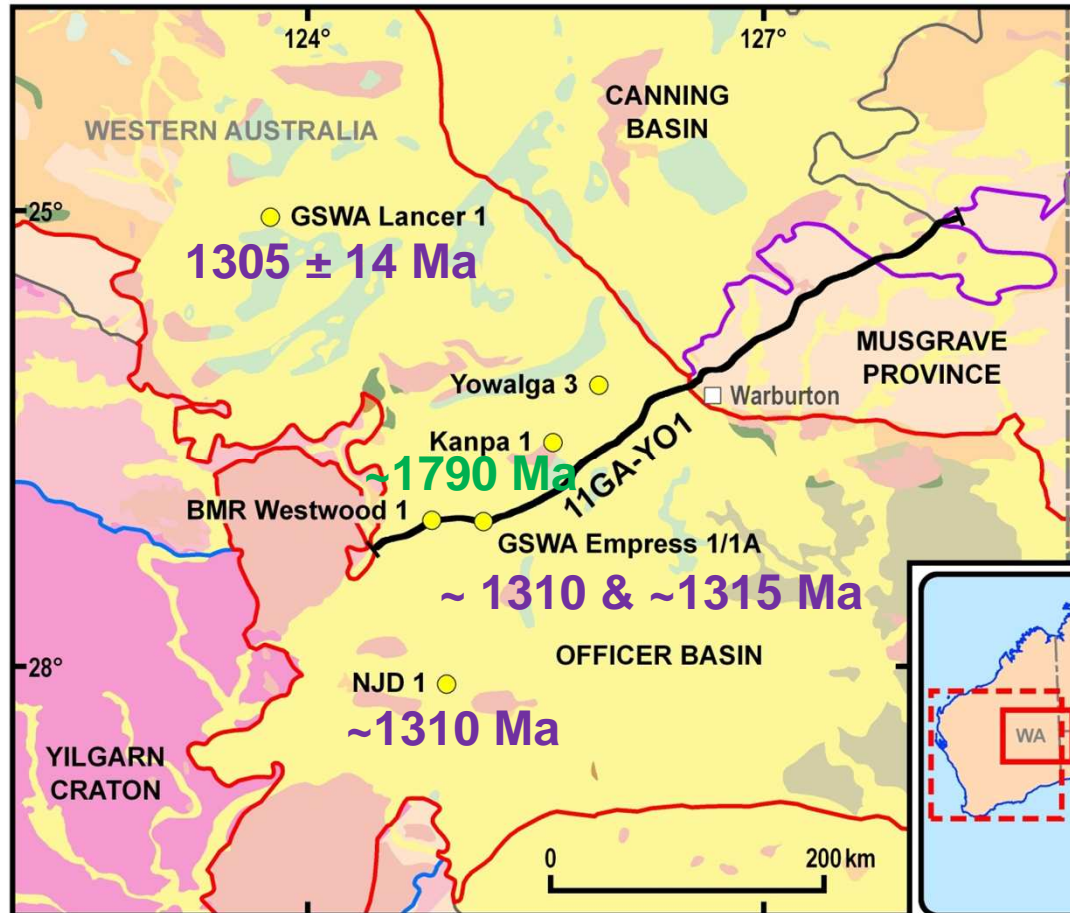


From Grey et al. (2005)

# New SHRIMP geochronology - detrital zircons



# Manunda Basin – geochronology from drill hole core



## Sample depths

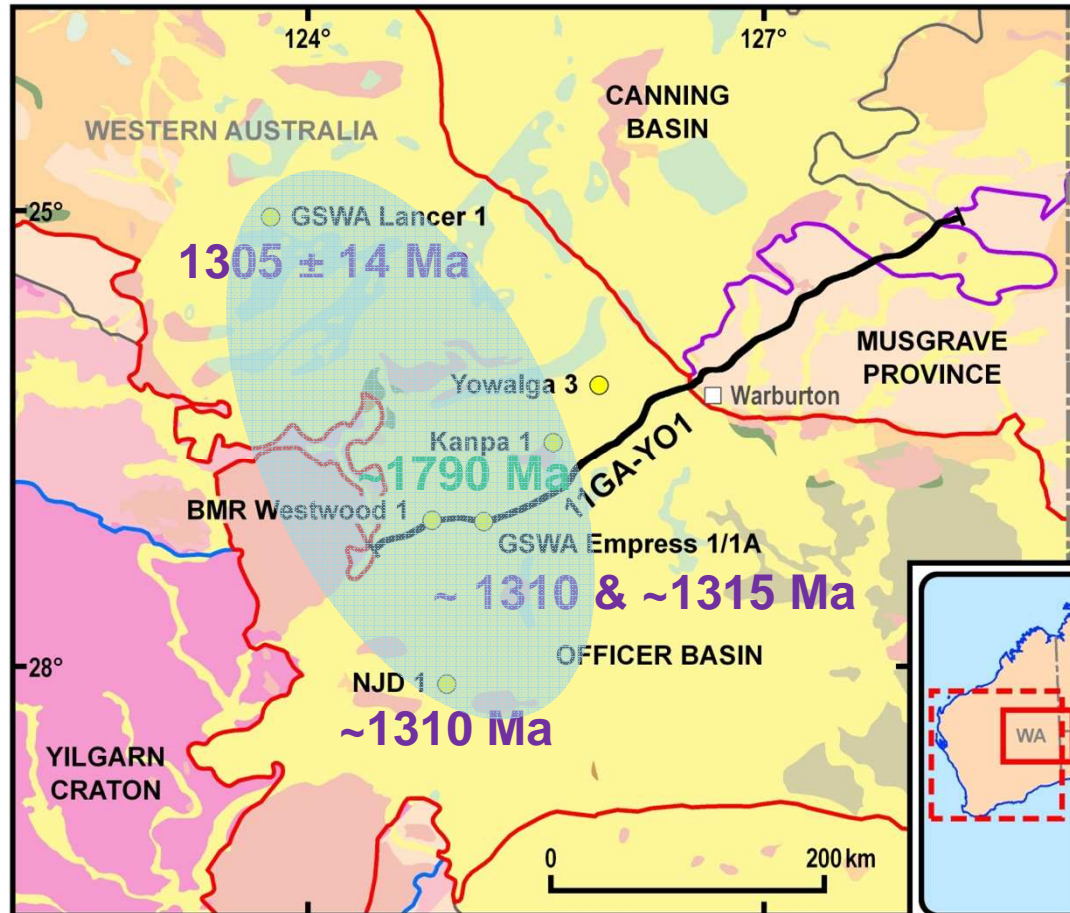
GSWA Lancer 1 - 1490 m

Kanpa 1 - 3773-3803 m (cuttings)

GSWA Empress 1A - 1539 m,  
1546 m

NJD 1 - 504-511 m

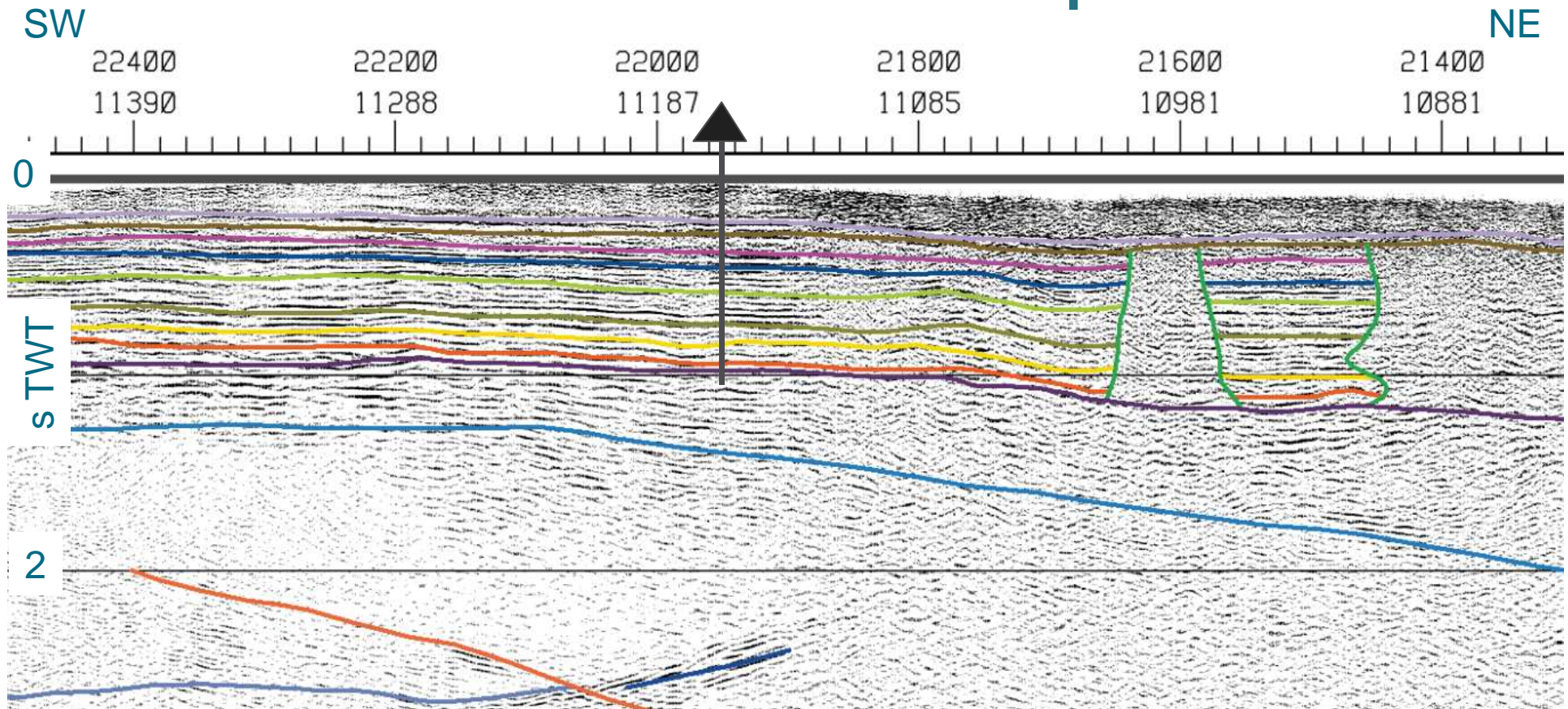
# Manunda Basin – geochronology from drill holes



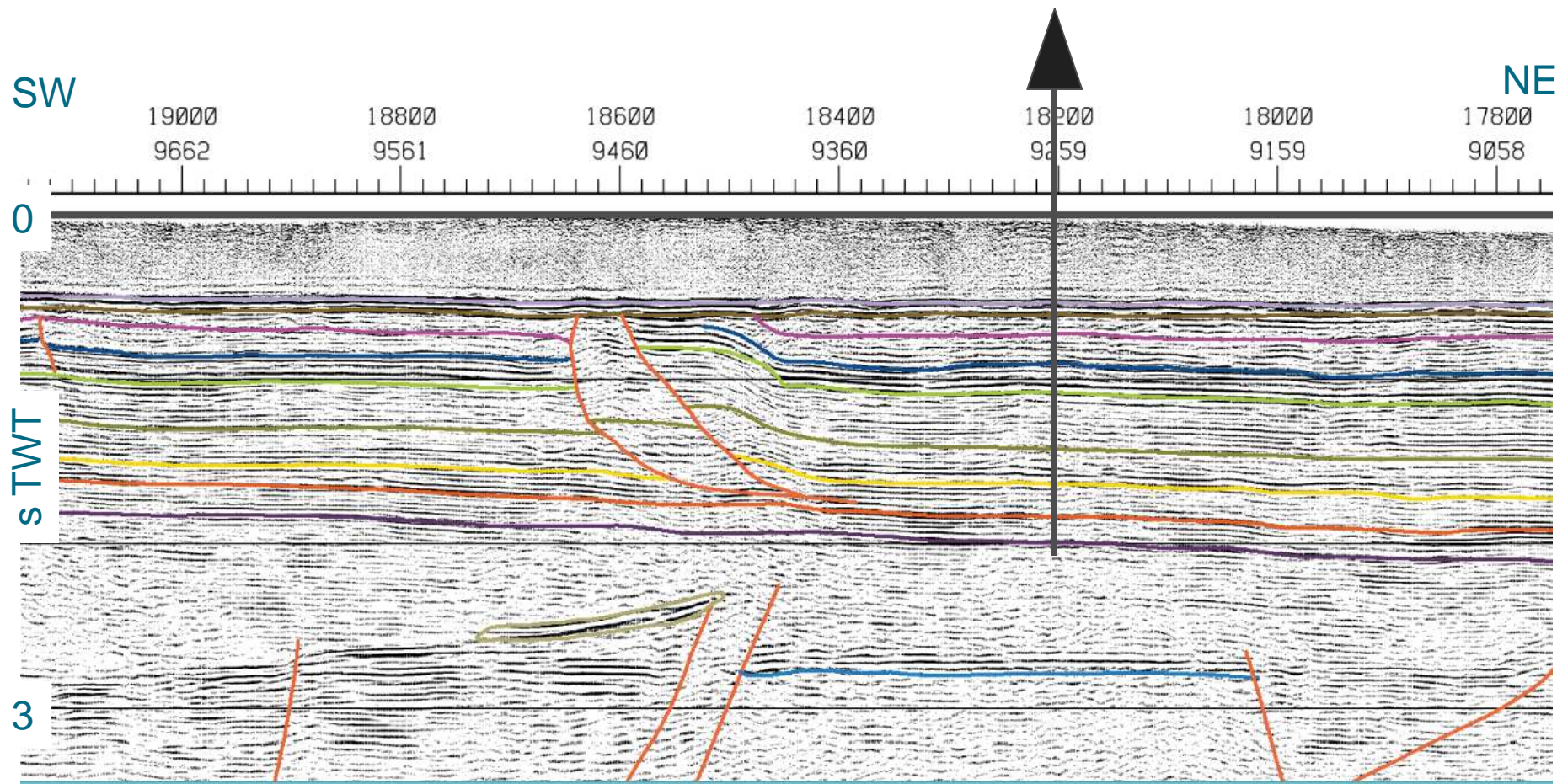
Large subsurface basin  
extending for over 400 km



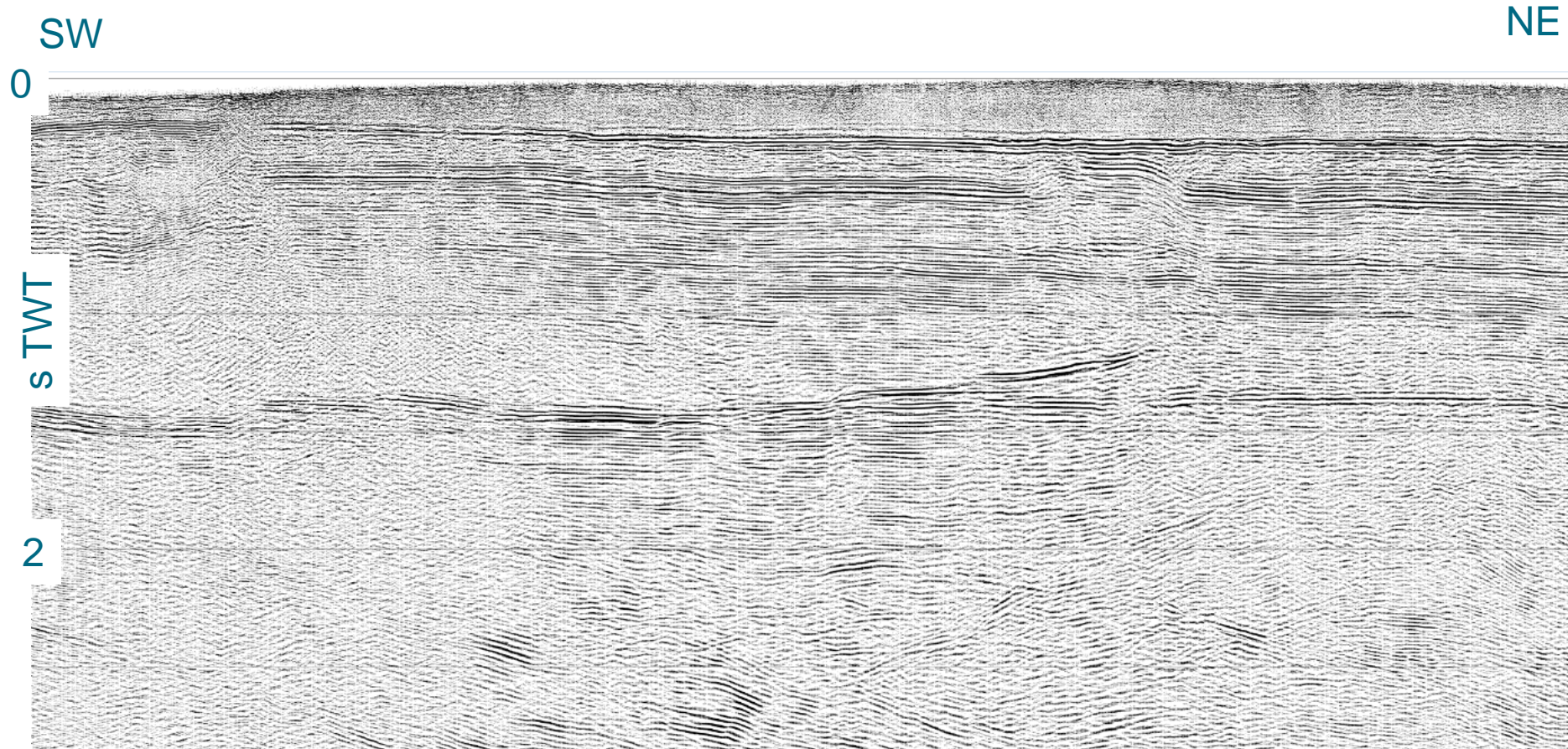
# Manunda Basin – GSWA Empress 1A



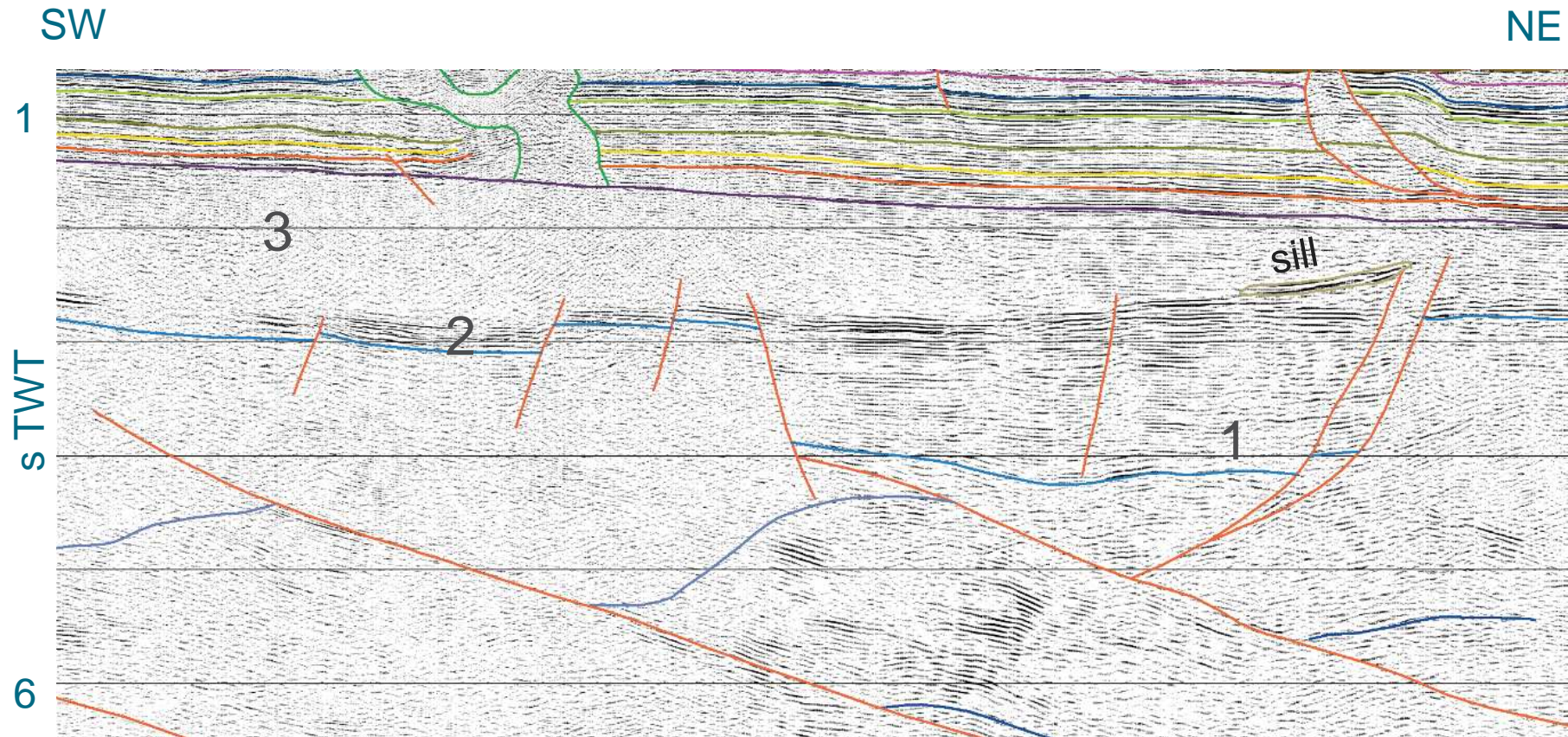
# Manunda Basin – Kanpa 1 (projected)



# Manunda Basin – YOM seismic section

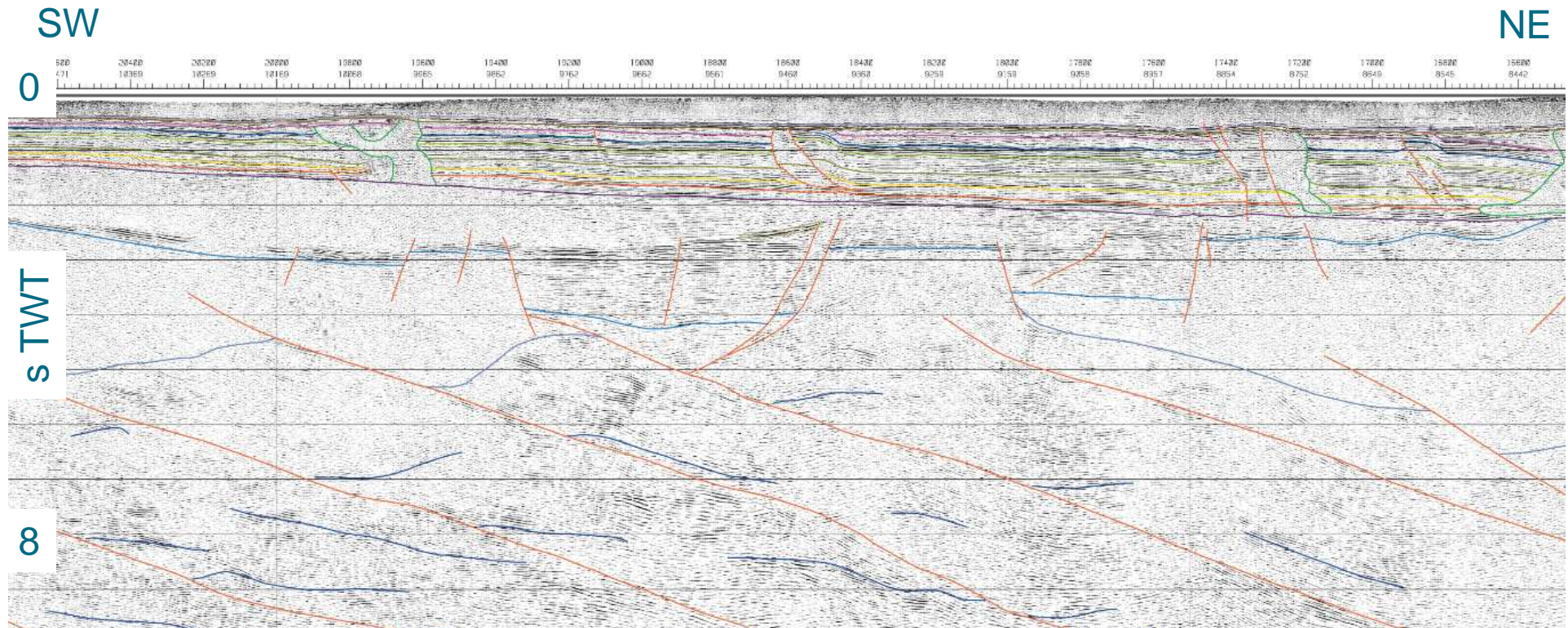


# Manunda Basin – seismic sequences



Basin architecture – graben with thinner platforms – classic steer's head basin  
Mechanical extension, followed by thermal relaxation  
At least 3 seismic sequences

# Manunda Basin – basin architecture



>400 km long  
~125 km wide in vicinity of YOM seismic line

# Yamarna Terrane

Eastern Goldfields Superterrane – consists of several discrete terranes in eastern Yilgarn Craton

Yamarna Terrane - easternmost terrane of Yilgarn Craton

Mostly hidden under younger cover

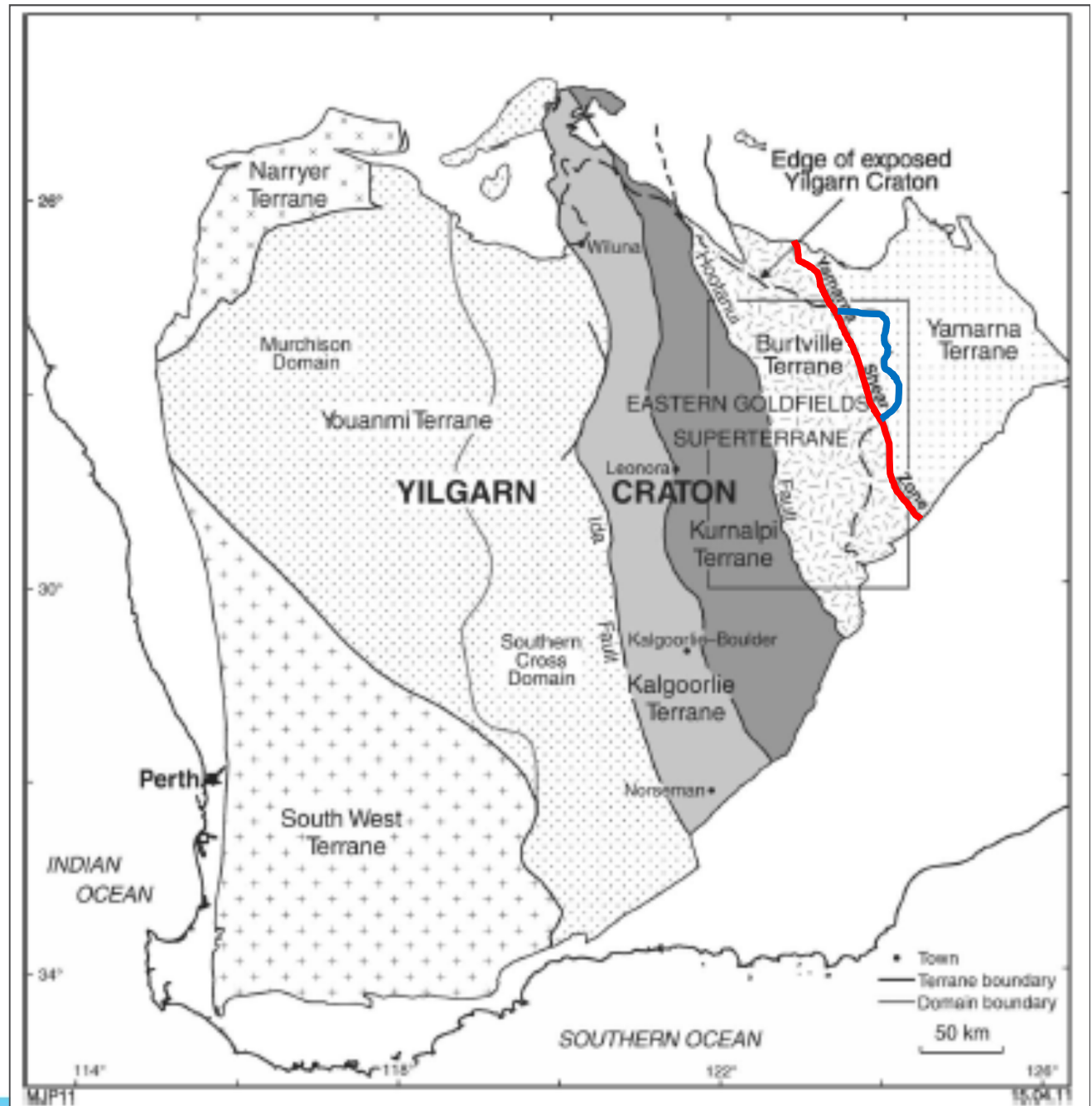
Typical Yilgarn granite-greenstone terrane

Closest outcrop about 85 km to SW of YOM seismic line

Closest drill holes about 70 km to NW of YOM seismic line

# Yamarna Terrane

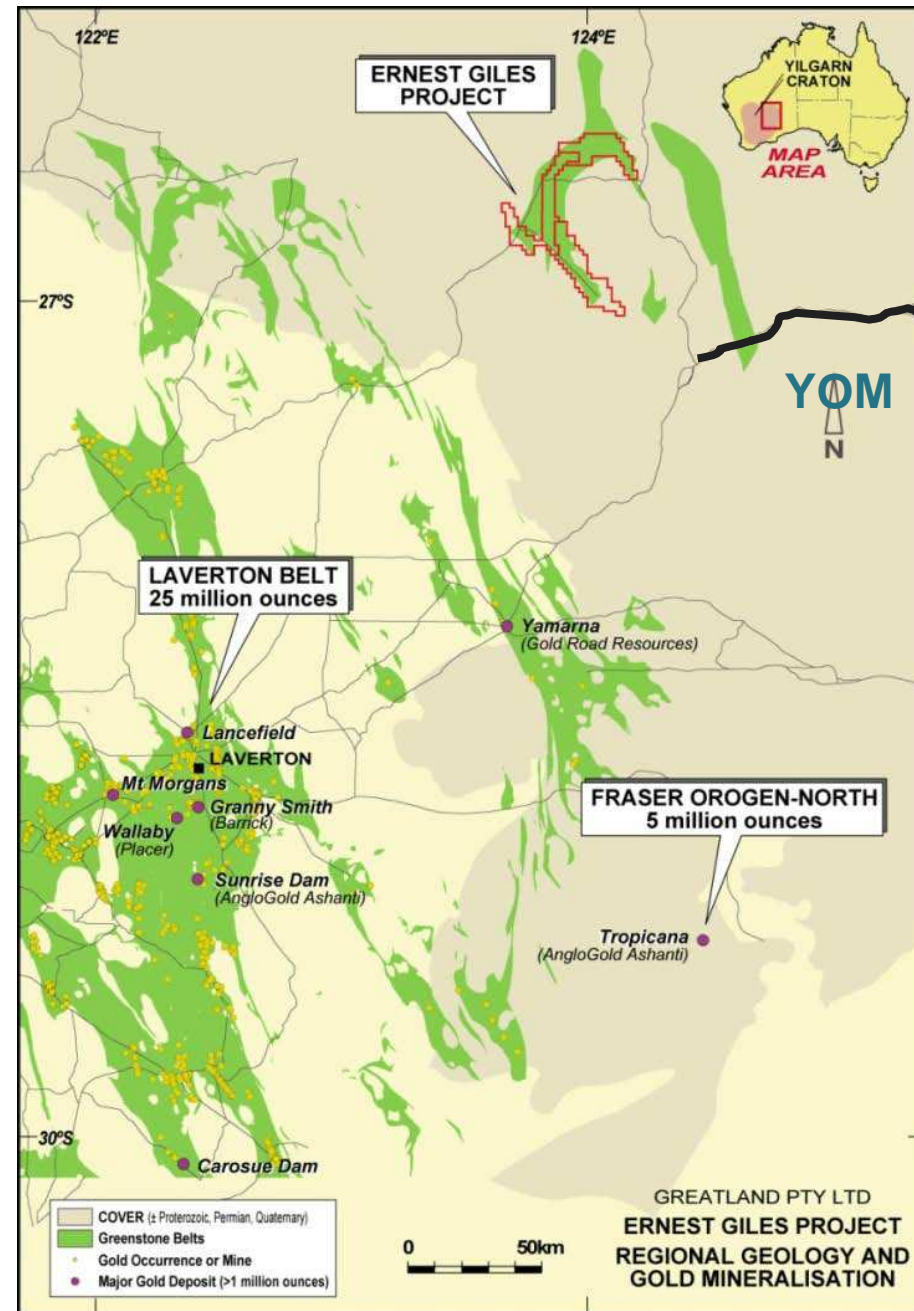
Mostly under cover -  
Hence most poorly  
understood terrane  
in Yilgarn Craton



## Closest drill holes:

Ernest Giles Range ~70 km to NW of end of YOM

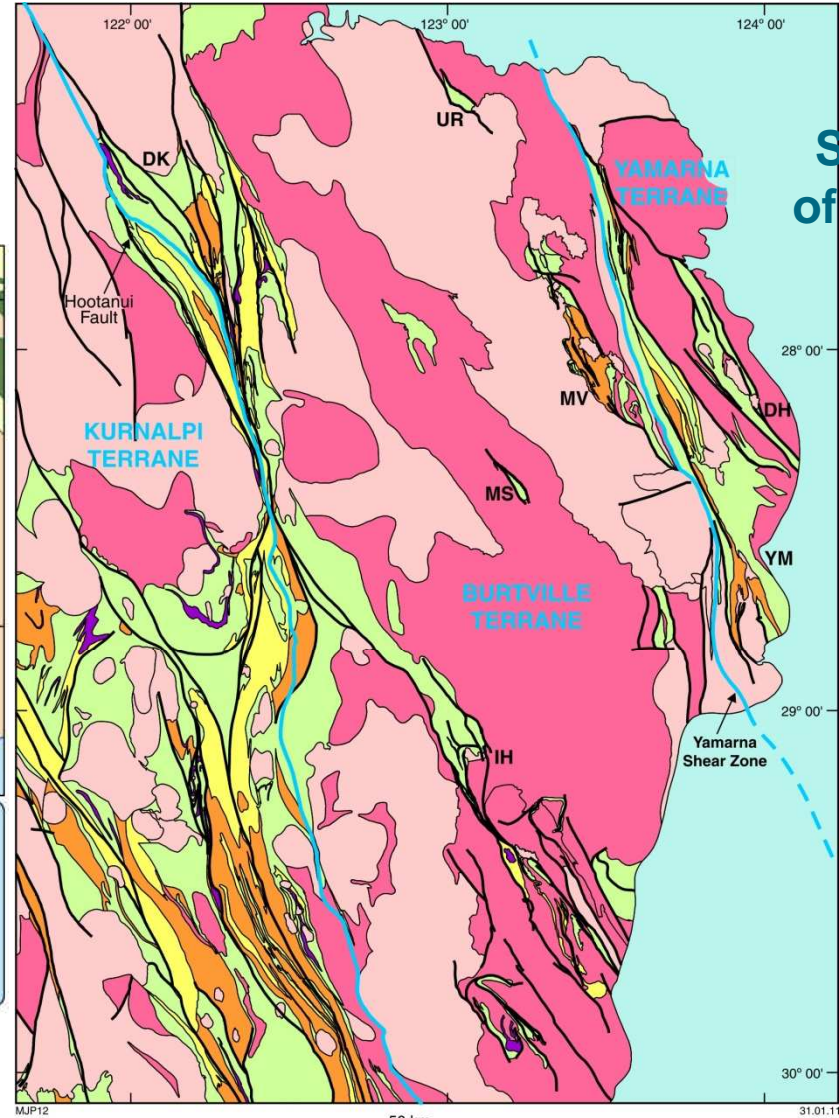
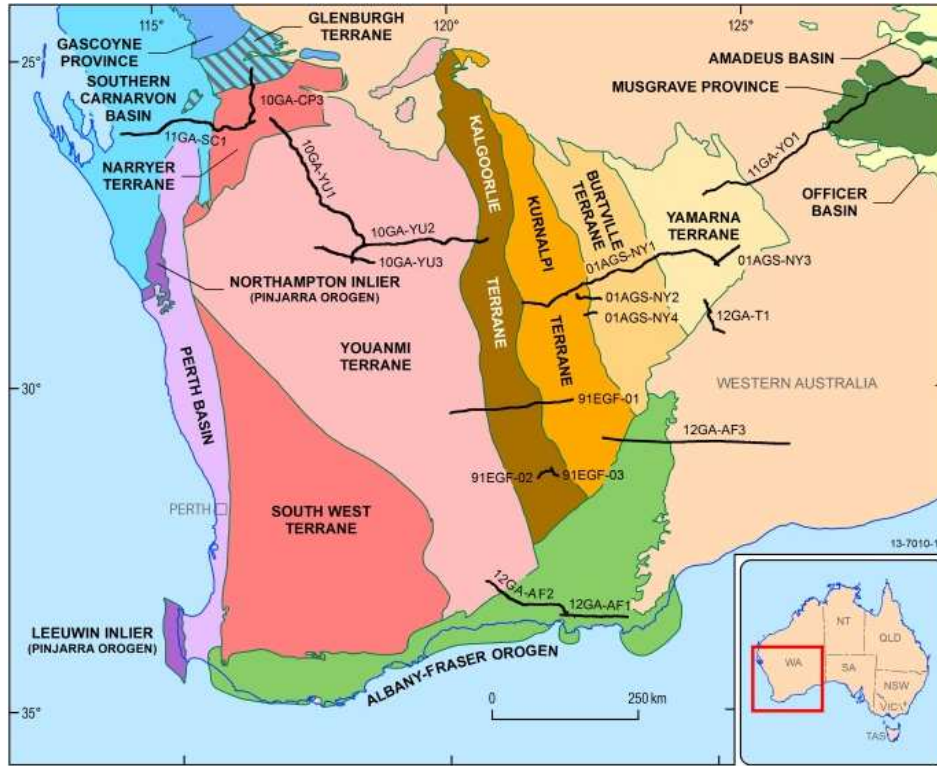
Archean greenstone and BIF intersected at 140-270 m depth



From Greatland Gold (2012)



# Northeast Yilgarn Craton



Start of YOM

- |  |   |   |  |
|--|---|---|--|
| <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: #e0f2f1; border: 1px solid black; margin-right: 5px;"></span> Younger basins</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: #ffe0b2; border: 1px solid black; margin-right: 5px;"></span> Granite</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: #ffb74d; border: 1px solid black; margin-right: 5px;"></span> Metagranitic rocks</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: #fff9c4; border: 1px solid black; margin-right: 5px;"></span> Sedimentary rocks</li> </ul> | <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: #ffccbc; border: 1px solid black; margin-right: 5px;"></span> Felsic volcanic rocks</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: #c8e6c9; border: 1px solid black; margin-right: 5px;"></span> Mafic rocks</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: #bbdefb; border: 1px solid black; margin-right: 5px;"></span> Ultramafic rocks</li> </ul> | <p><b>Greenstone belts</b></p> <ul style="list-style-type: none"> <li><b>UR</b> Ulrich Range</li> <li><b>MV</b> Mount Venn</li> <li><b>MS</b> Mount Sefton</li> <li><b>DK</b> Duketon</li> <li><b>IH</b> Irwin Hills–Stella Range</li> <li><b>YM</b> Yamarna–Mount Gill</li> <li><b>DH</b> Dorothy Hills</li> </ul> | <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; border-bottom: 1px solid black; margin-right: 5px;"></span> Boundary</li> <li><span style="display: inline-block; width: 15px; border-bottom: 1px dashed black; margin-right: 5px;"></span> Fault</li> <li><span style="display: inline-block; width: 15px; border-bottom: 1px solid blue; margin-right: 5px;"></span> Terrane boundary</li> <li><span style="display: inline-block; width: 15px; border-bottom: 1px dashed blue; margin-right: 5px;"></span> Terrane boundary, concealed</li> </ul> |
|--|---|---|--|

# Northeast Yilgarn geology

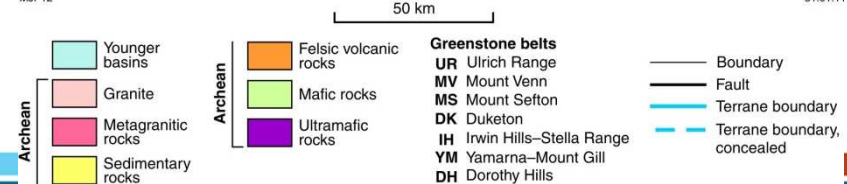
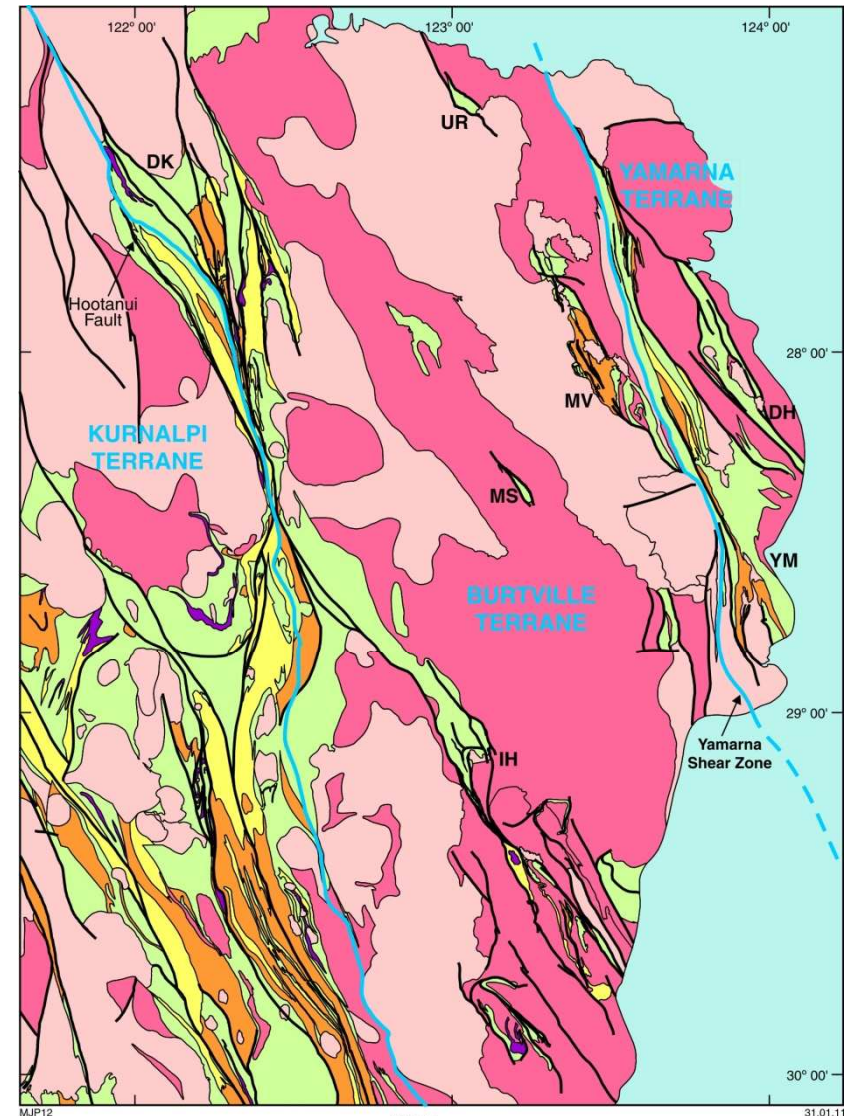
New mapping and geochronology by GSWA indicates two terranes in the northeast Yilgarn Craton

## Burtville Terrane between Hootanui Fault and Yamarna Shear Zone

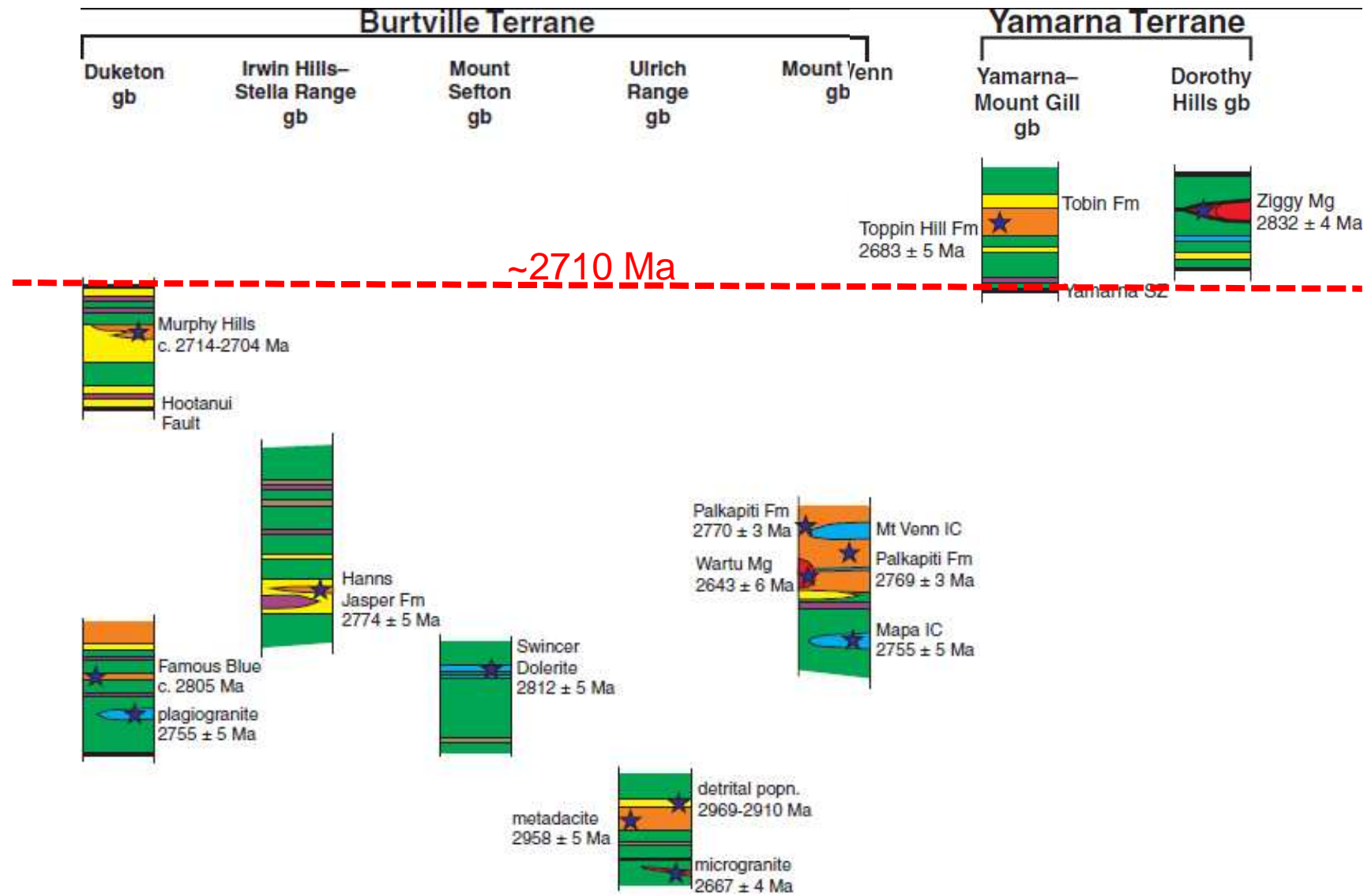
- Greenstones are older than c. 2735 Ma

## Yamarna Terrane to east of Yamarna Shear Zone

- Greenstones are younger than c. 2710 Ma

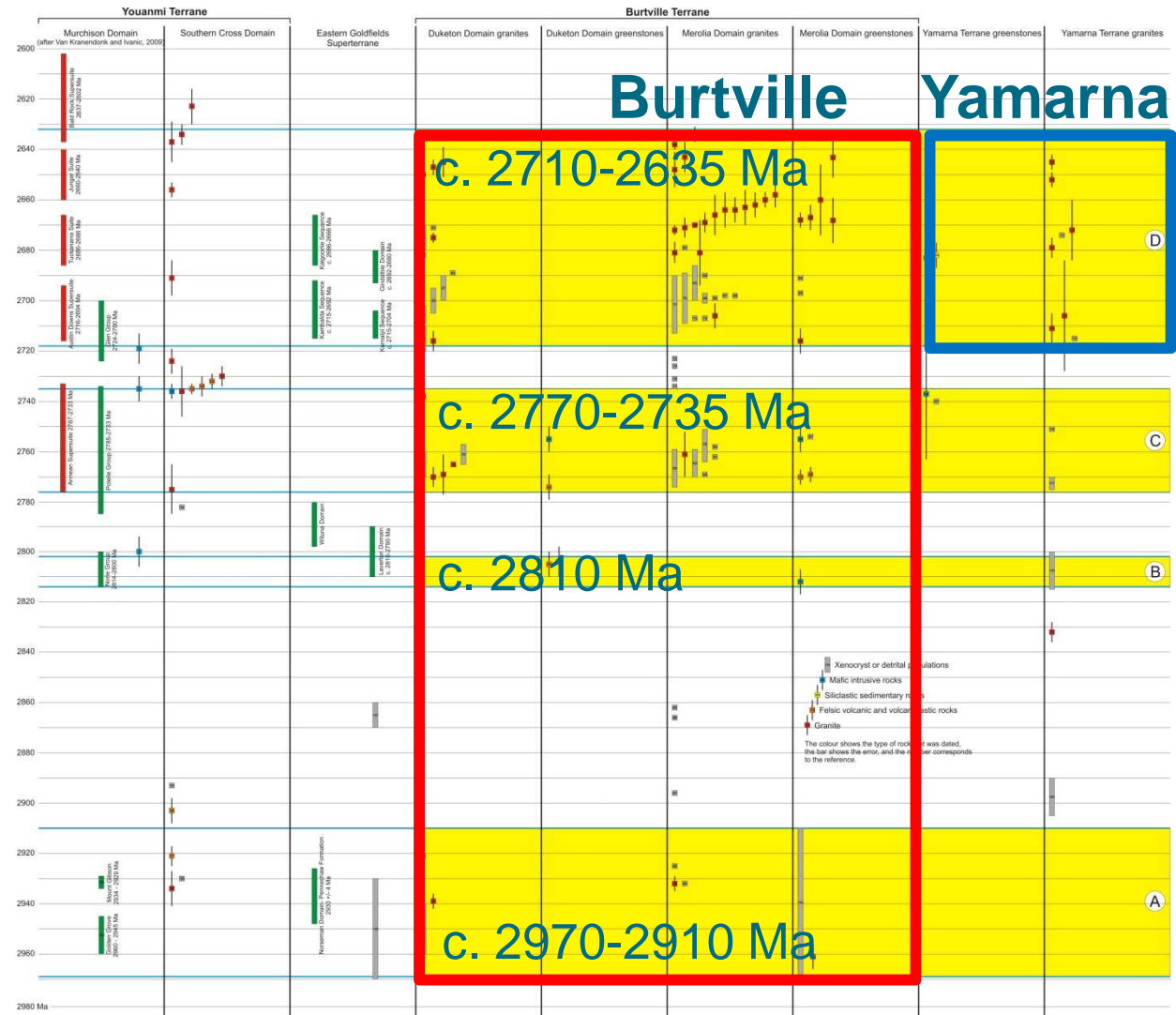
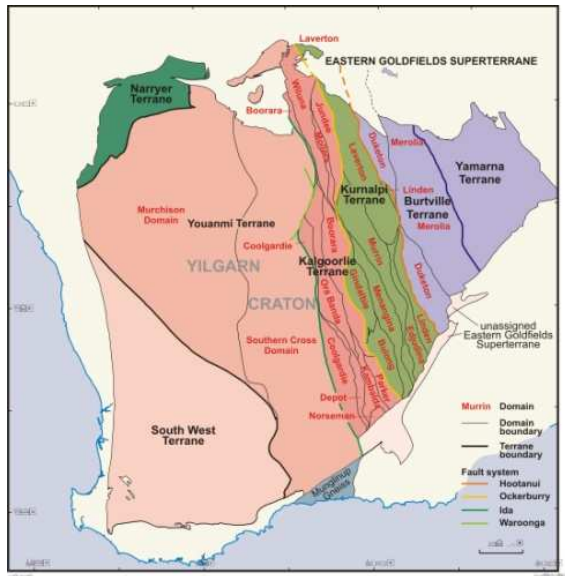


# Yamarna Terrane - greenstone stratigraphy

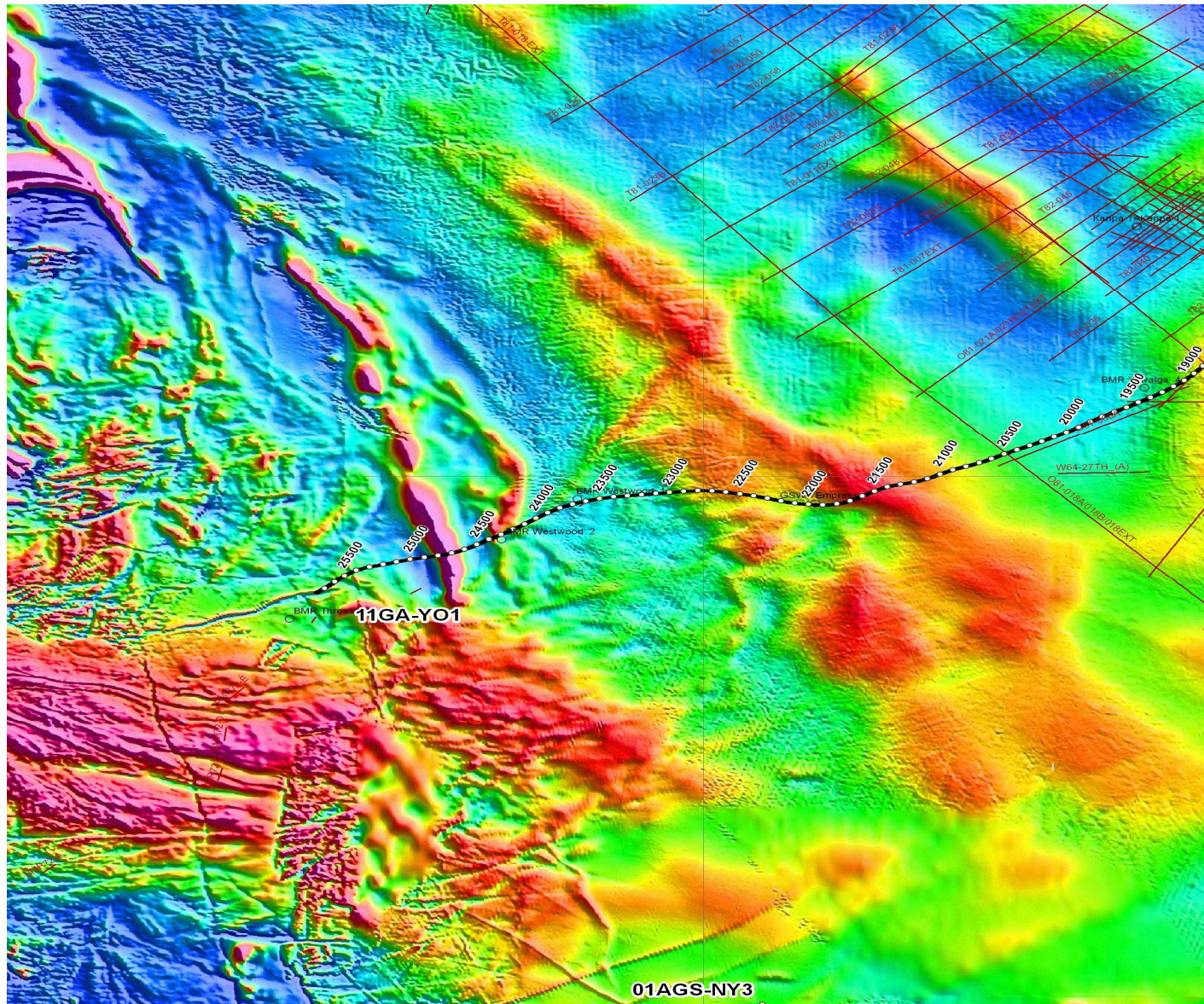


# Yamarna Terrane - granitic magmatic events

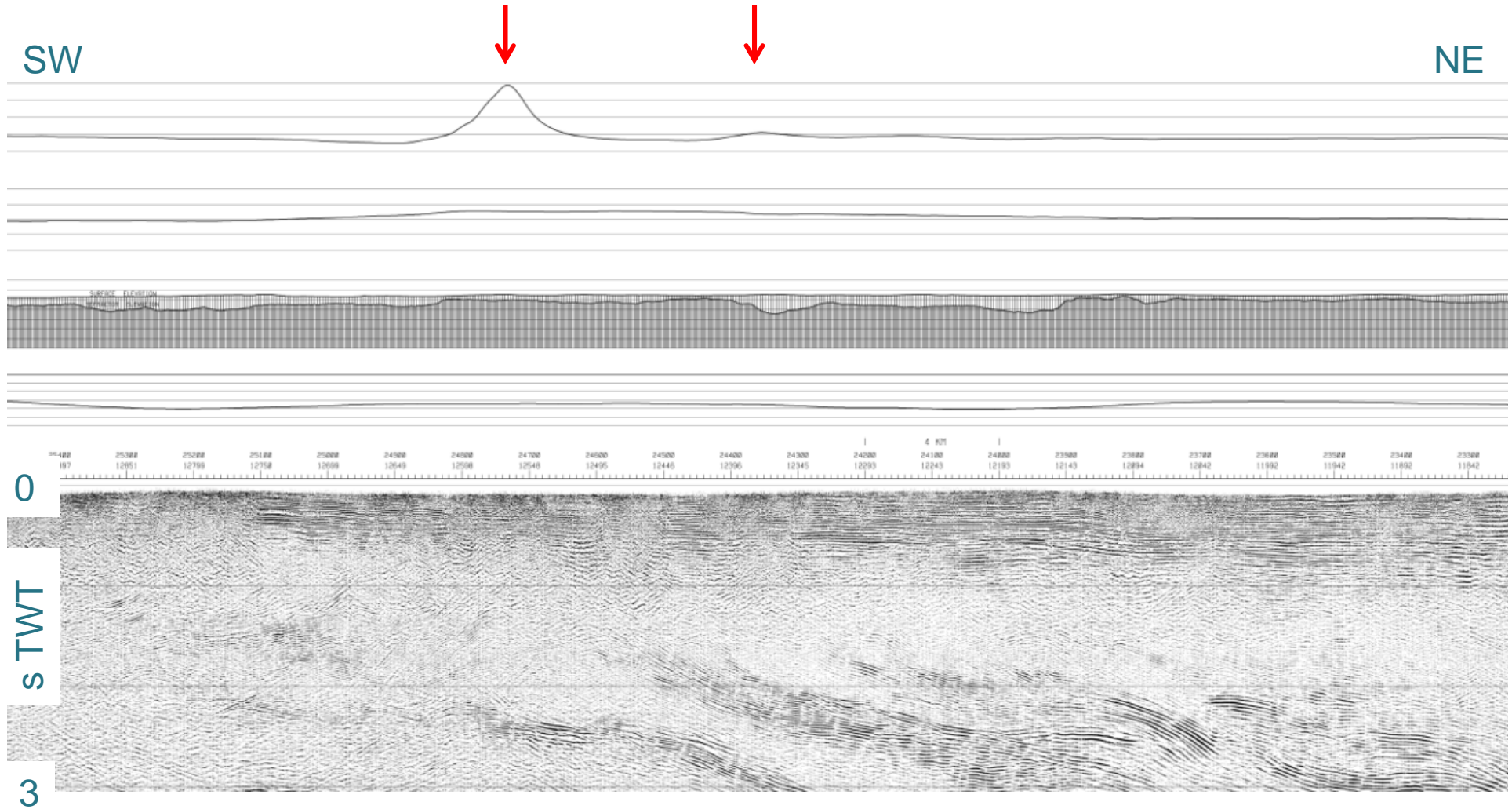
- 4 main magmatic events recognised
- Only youngest event found in Yamarna Terrane



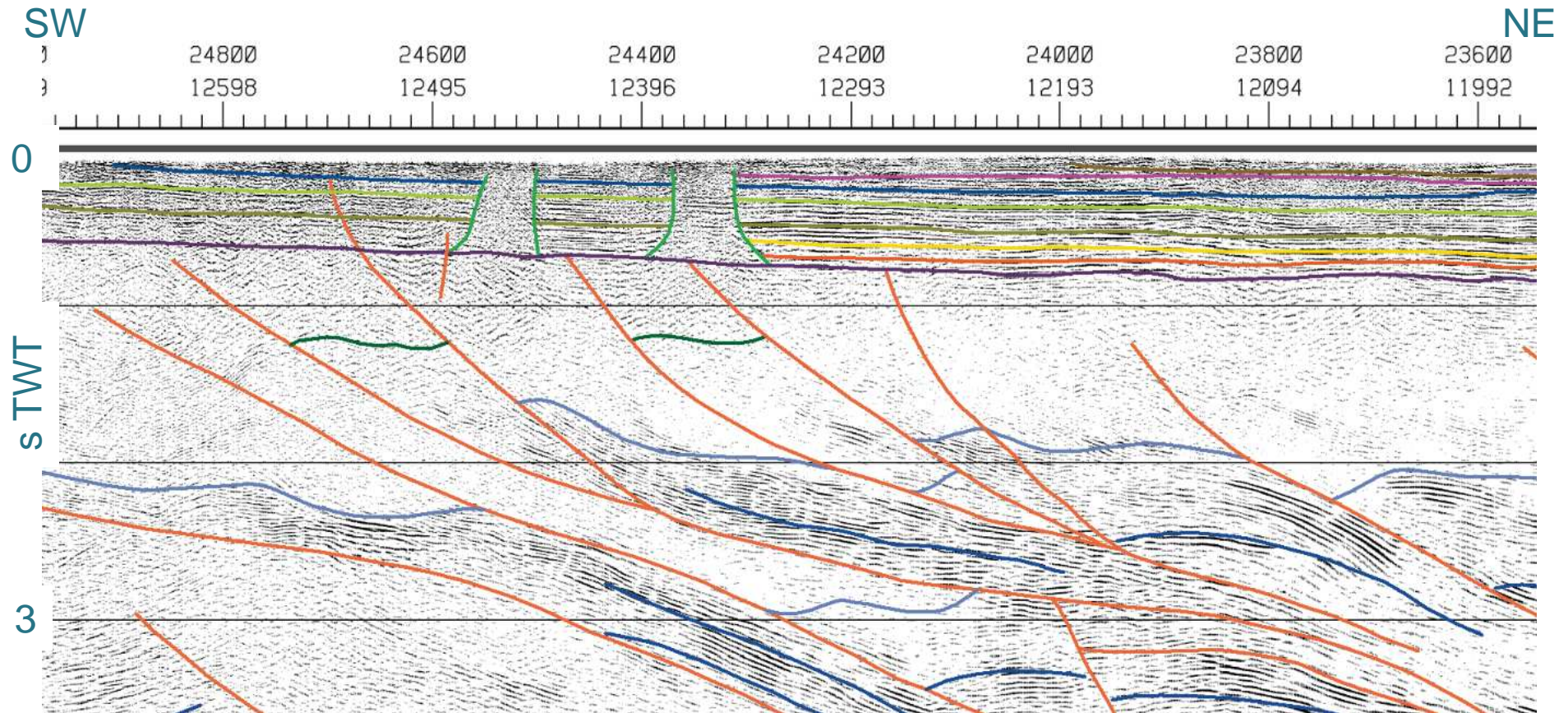
# Yamarna Terrane – magnetic anomalies



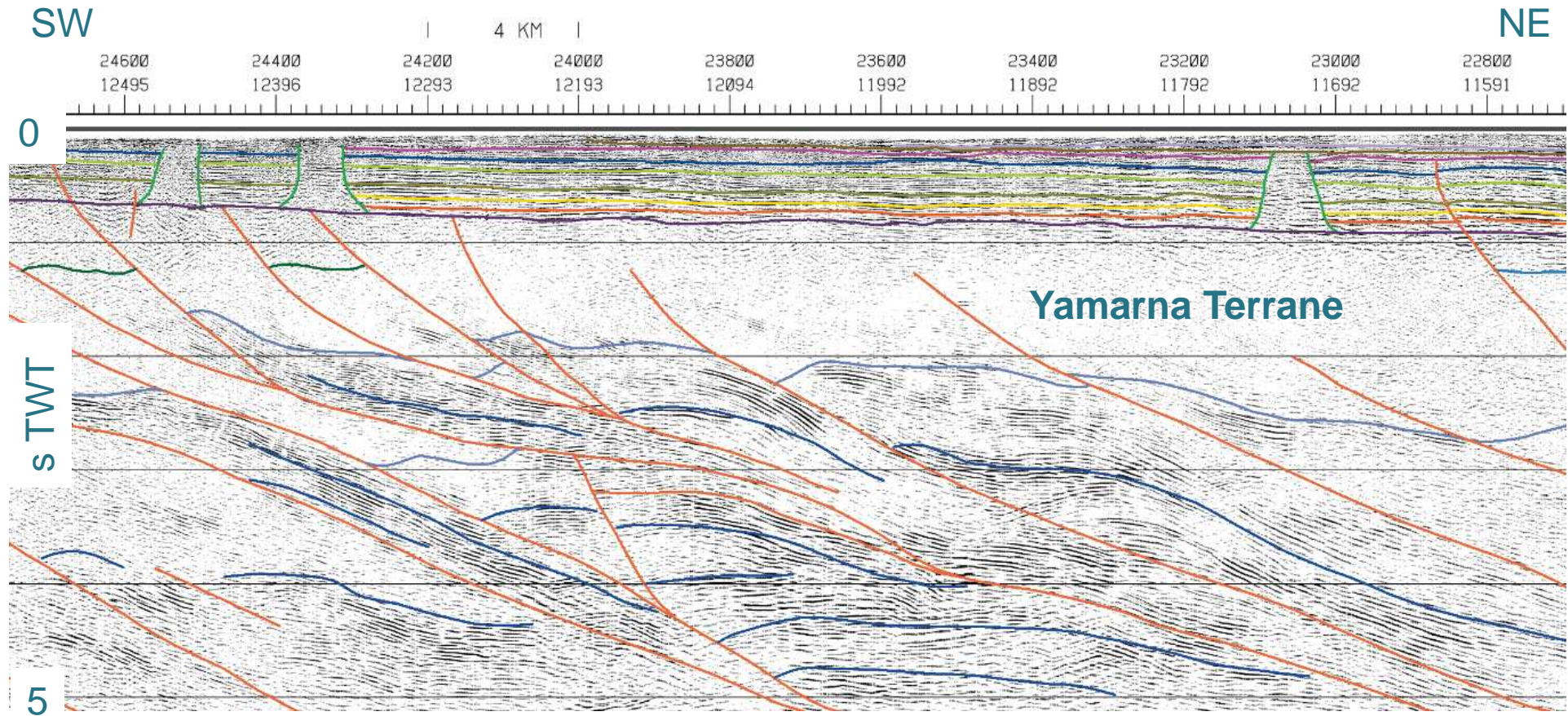
# Yamarna Terrane – magnetic anomalies



# Yamarna Terrane – seismic interpretation

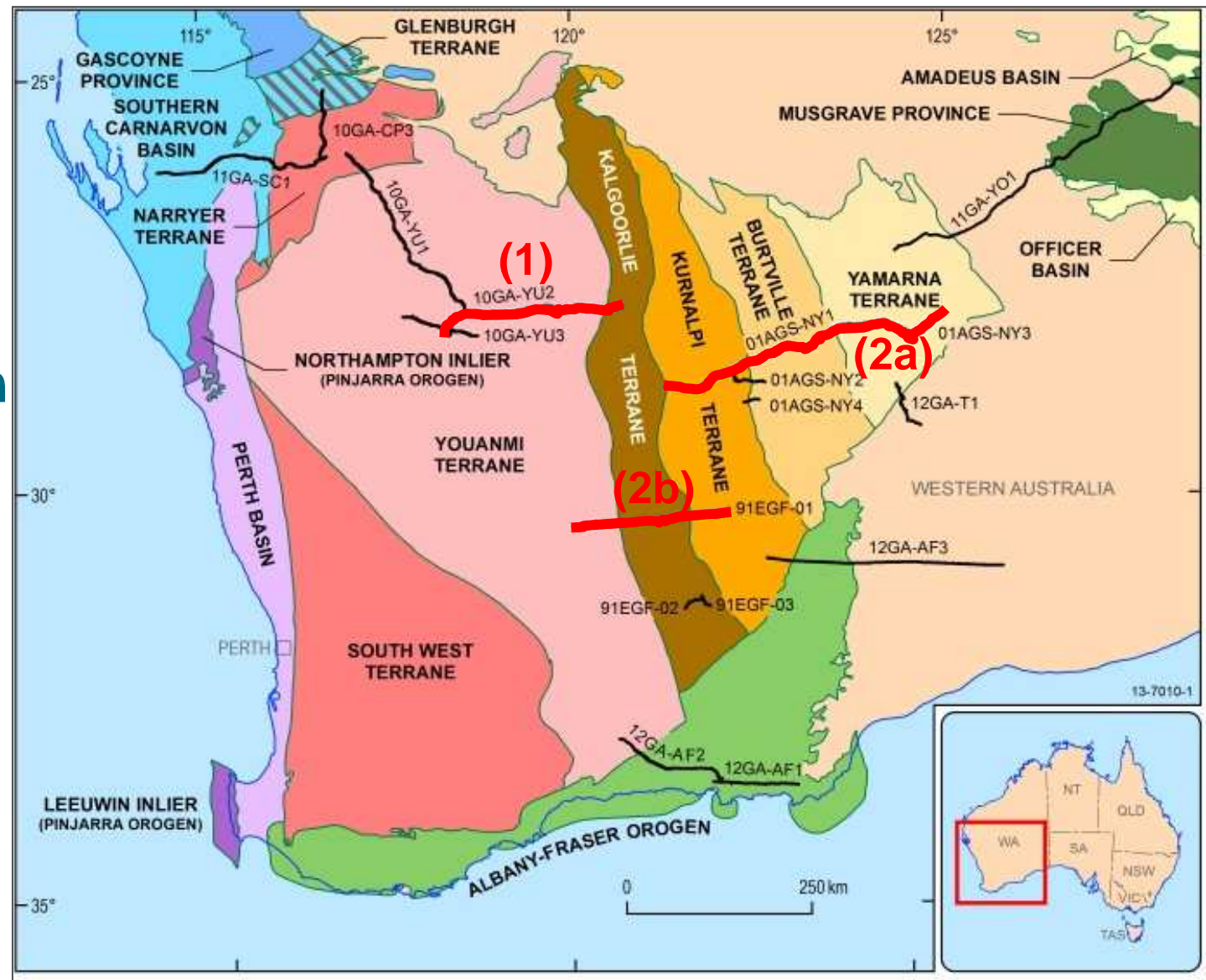


# Yamarna Terrane – essentially nonreflective

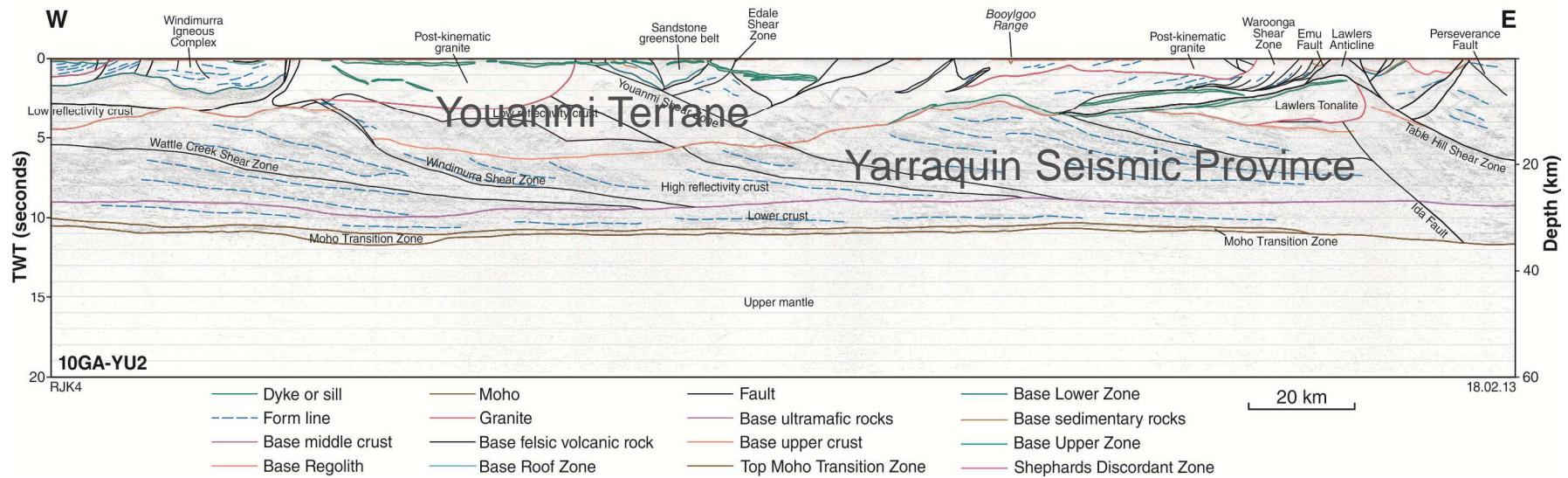
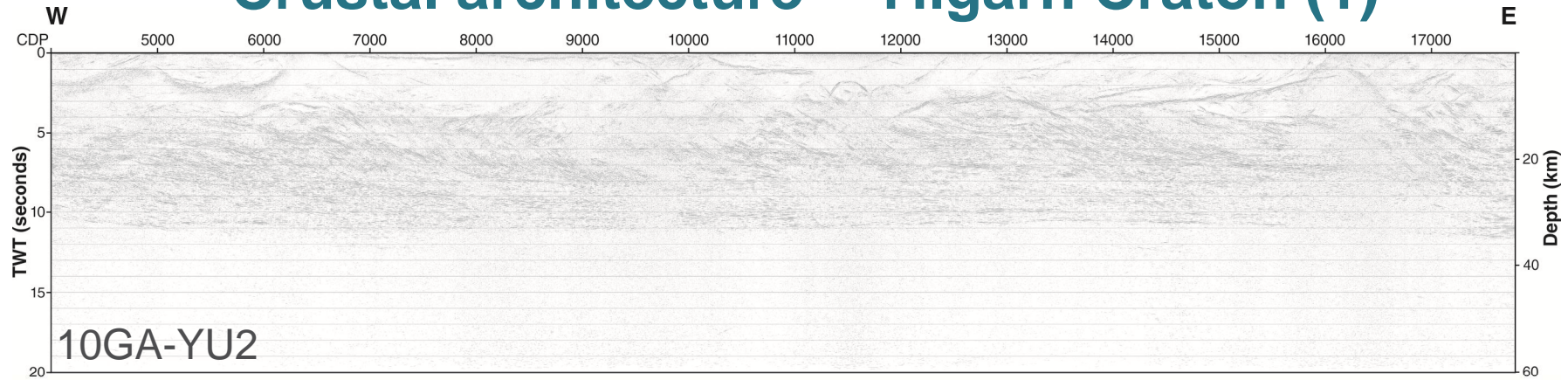




# Comparison with deep seismic lines in Yilgarn Craton

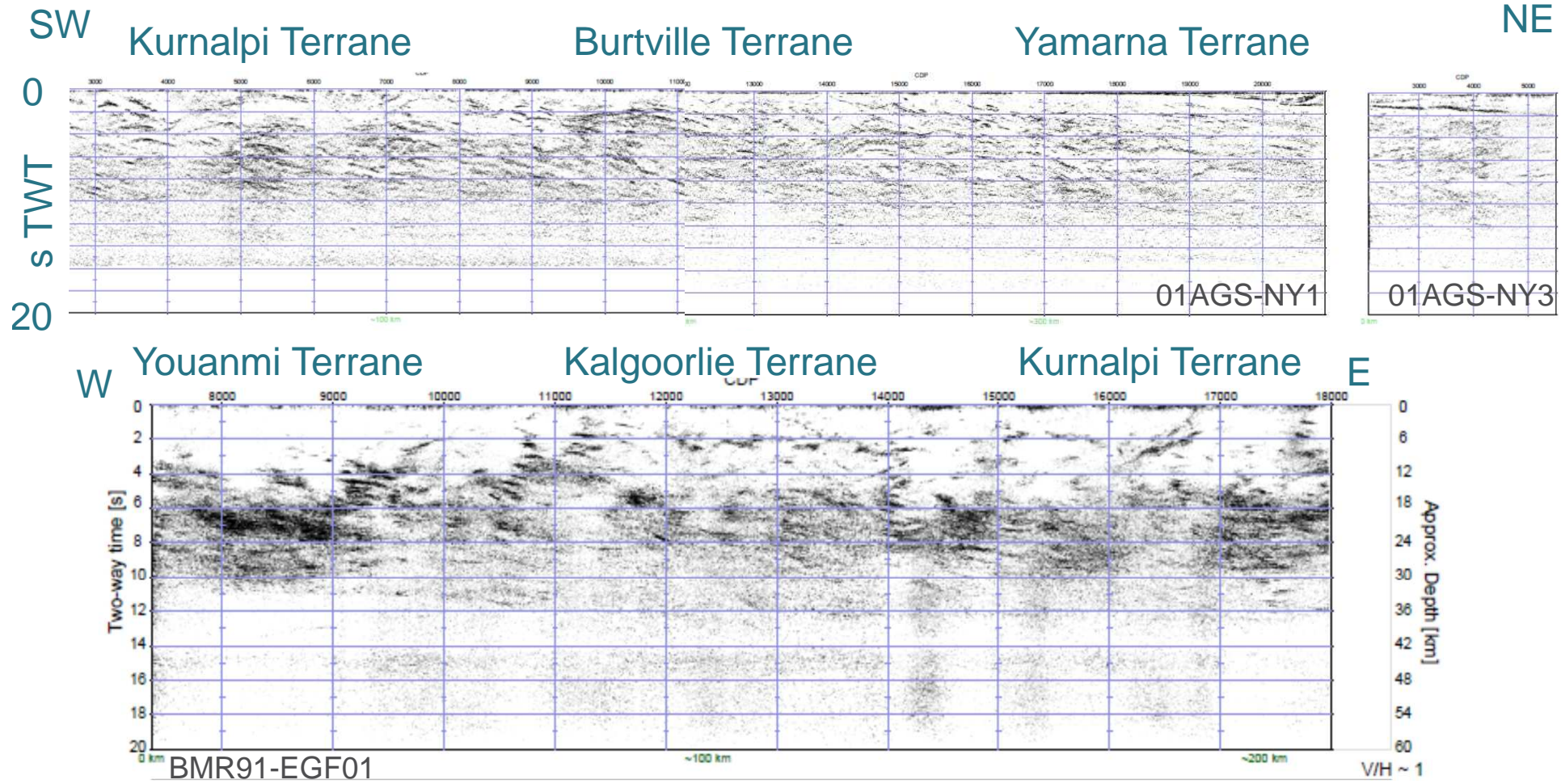


# Crustal architecture – Yilgarn Craton (1)



Upper crust – weakly reflective  
Middle and lower crust – strongly reflective

# Crustal architecture – Yilgarn Craton (2)



Typical seismic reflection signature for Yilgarn Craton:  
 Upper crust – weakly reflective  
 Middle and lower crust – strongly reflective

Images from B. Kennett

# Southwest YOM seismic line - whole of crust section



Crustal seismic reflection signature typical for Yilgarn Craton:

Upper crust – weakly reflective

Middle and lower crust – strongly reflective

Cannot track highly reflective unit to (near) surface

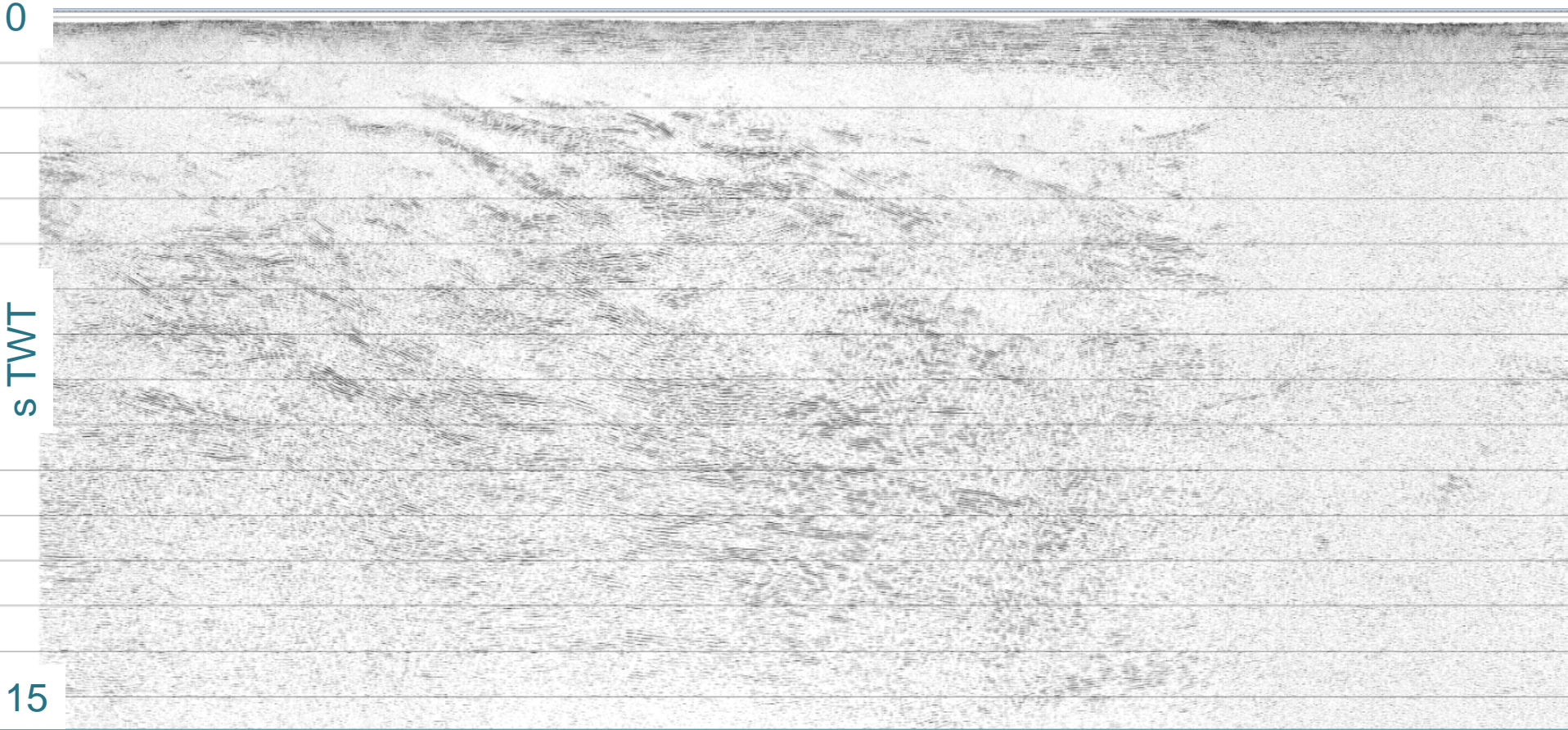
Cannot demonstrate that highly reflective unit is Yamarna Terrane:

**Middle and lower crust = Babool Seismic Province**

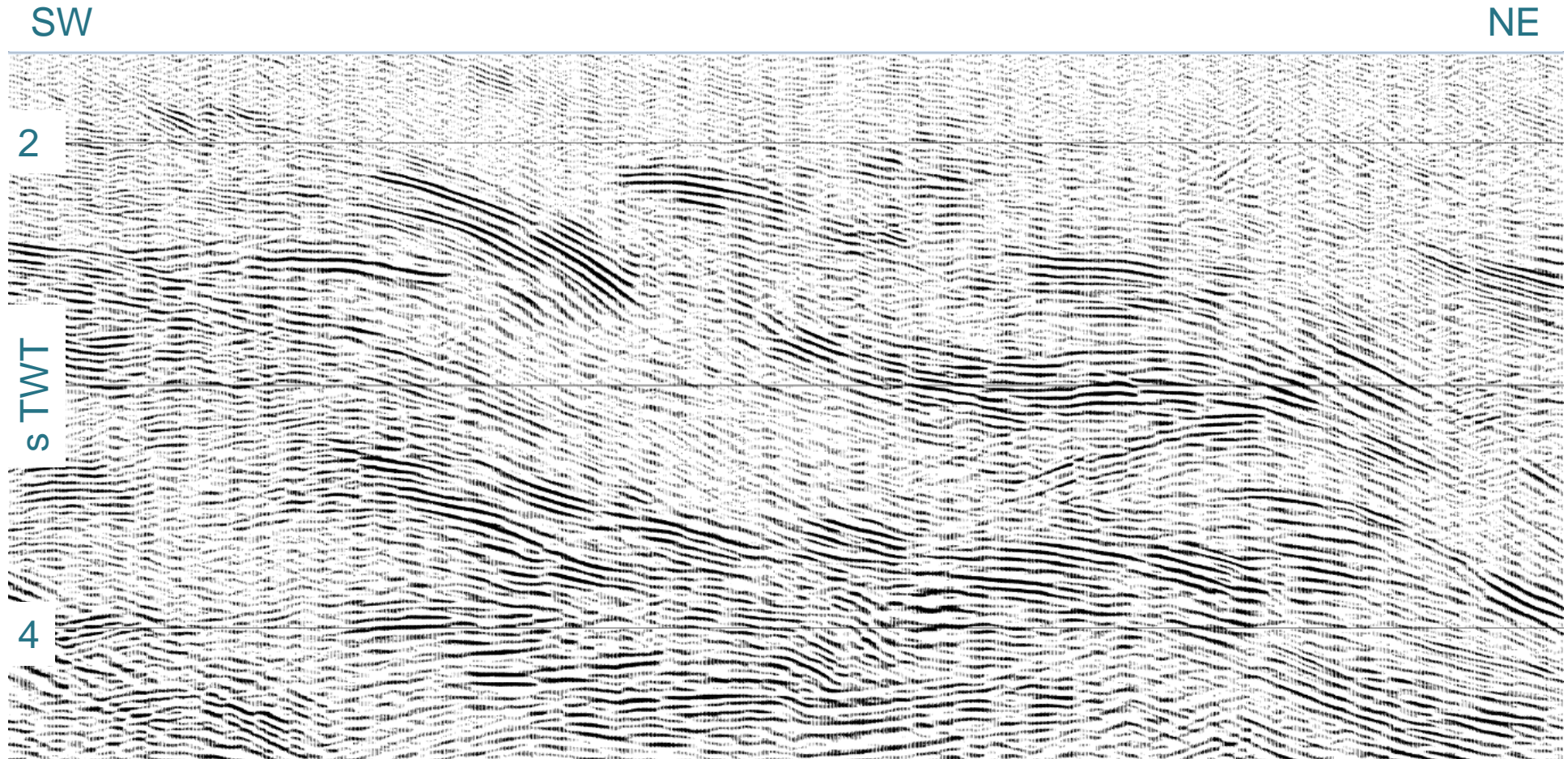
# Babool Seismic Province

SW

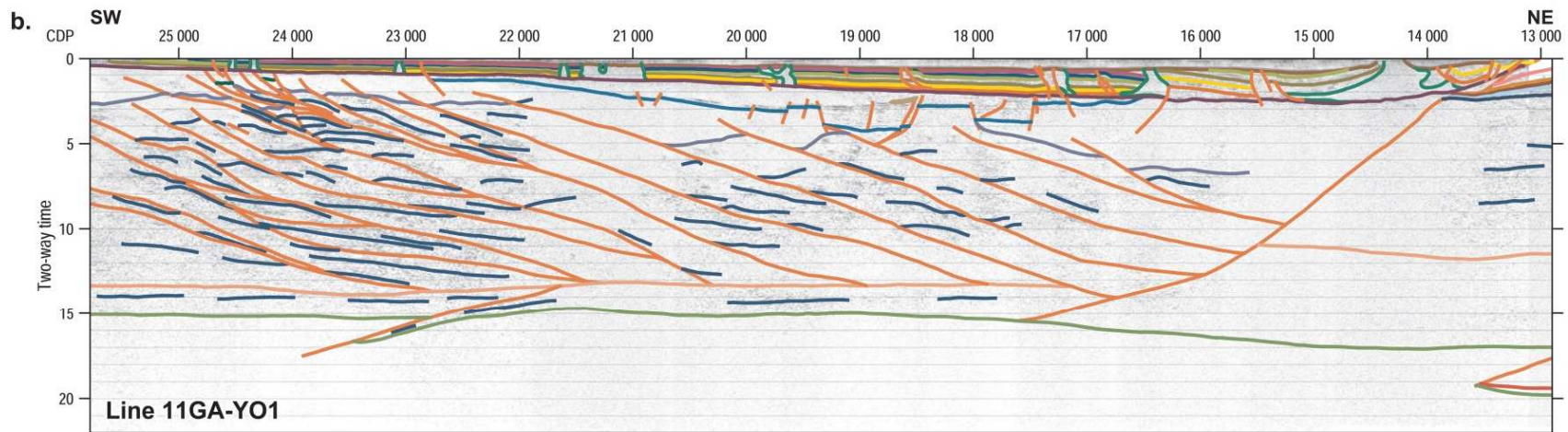
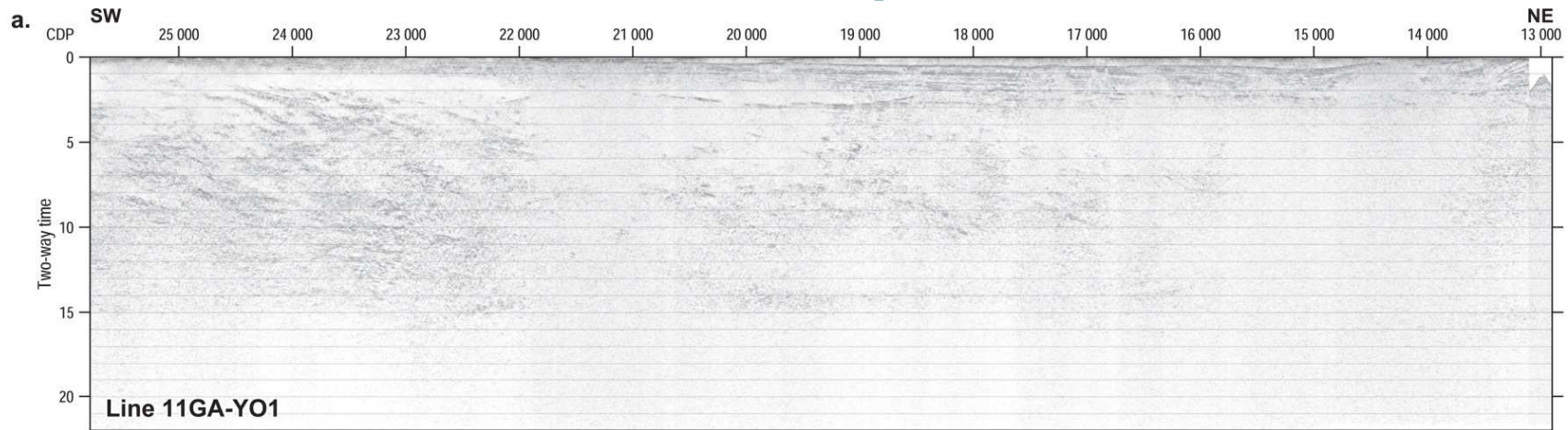
NE



# Babool Seismic Province - detail



# Southwest YOM deep seismic section



0 50 km

13-7010-3

## 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

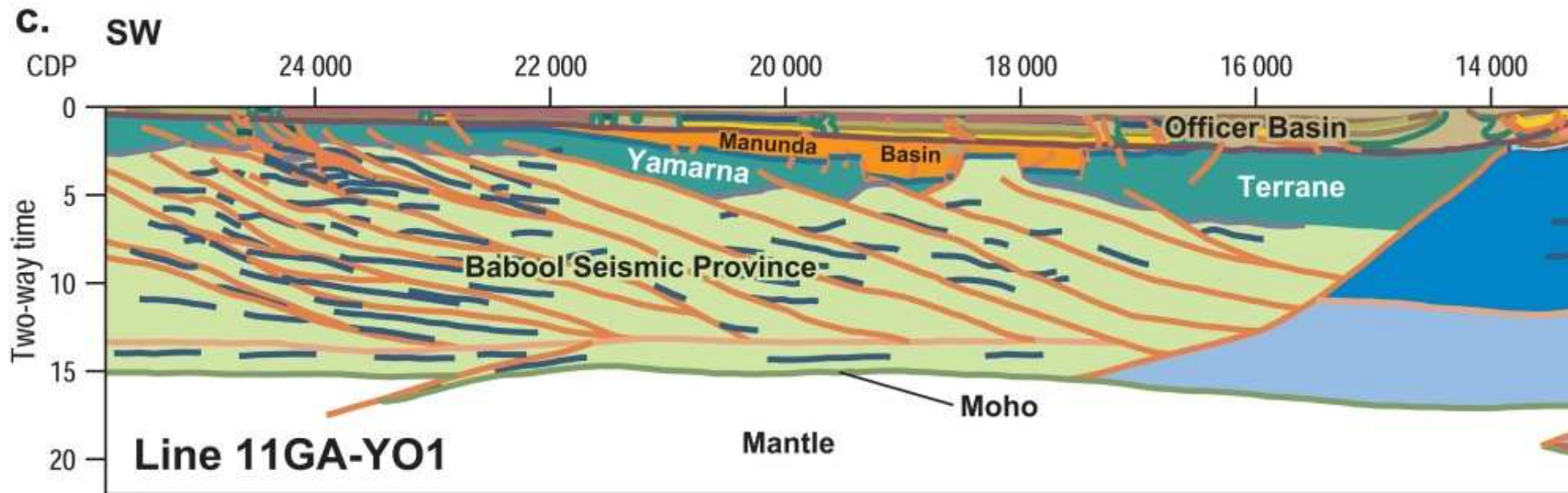
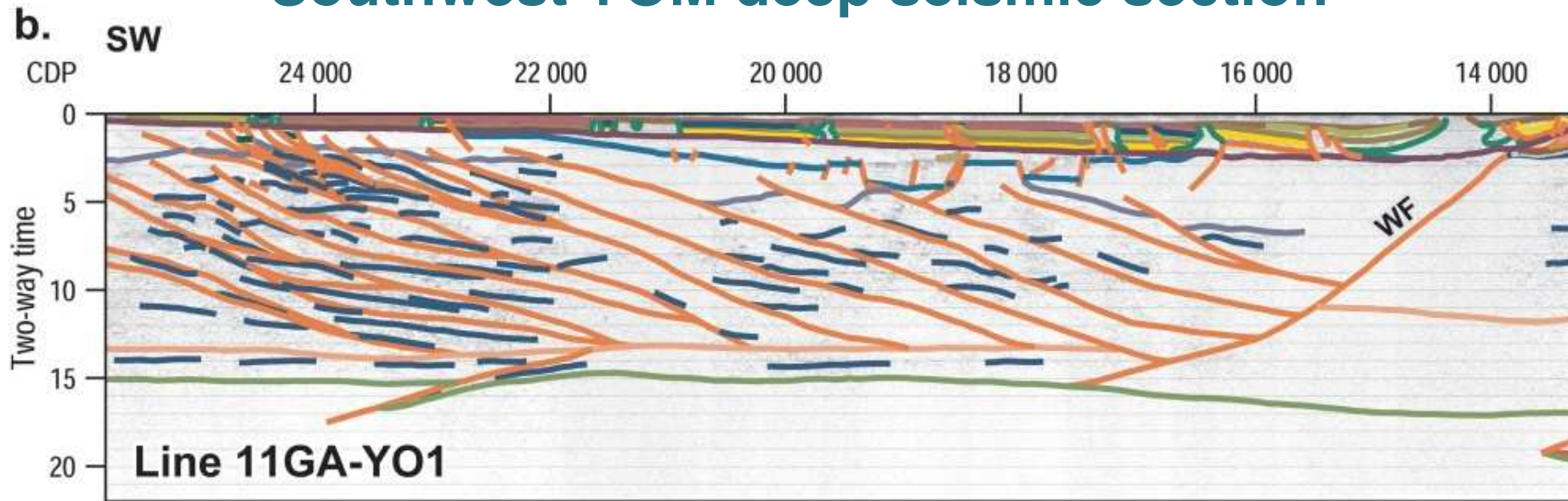
## Musgrave Province

- 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

## General

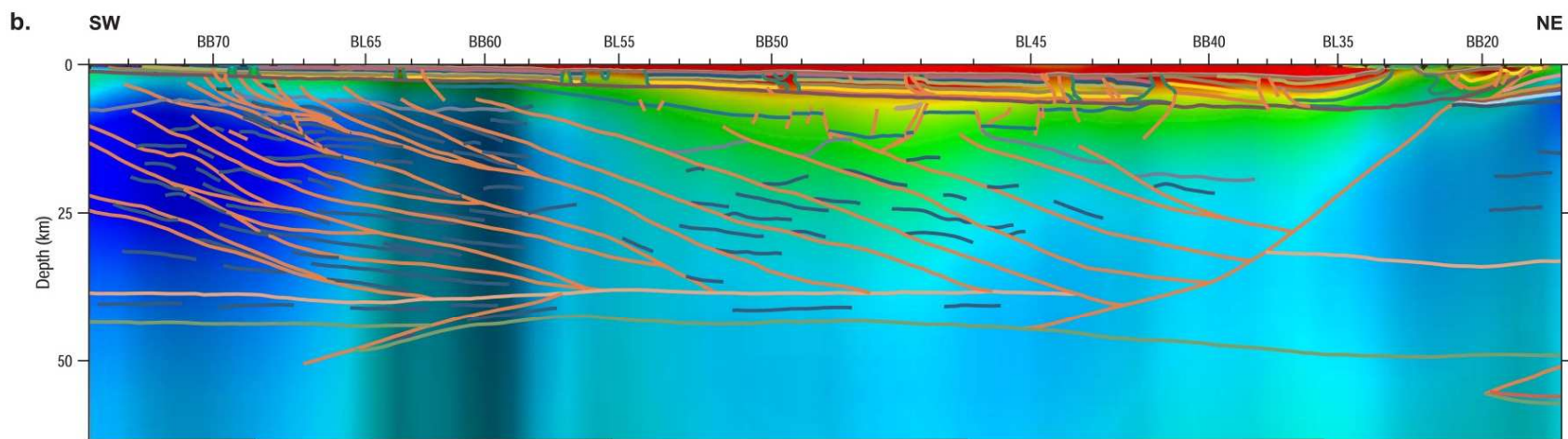
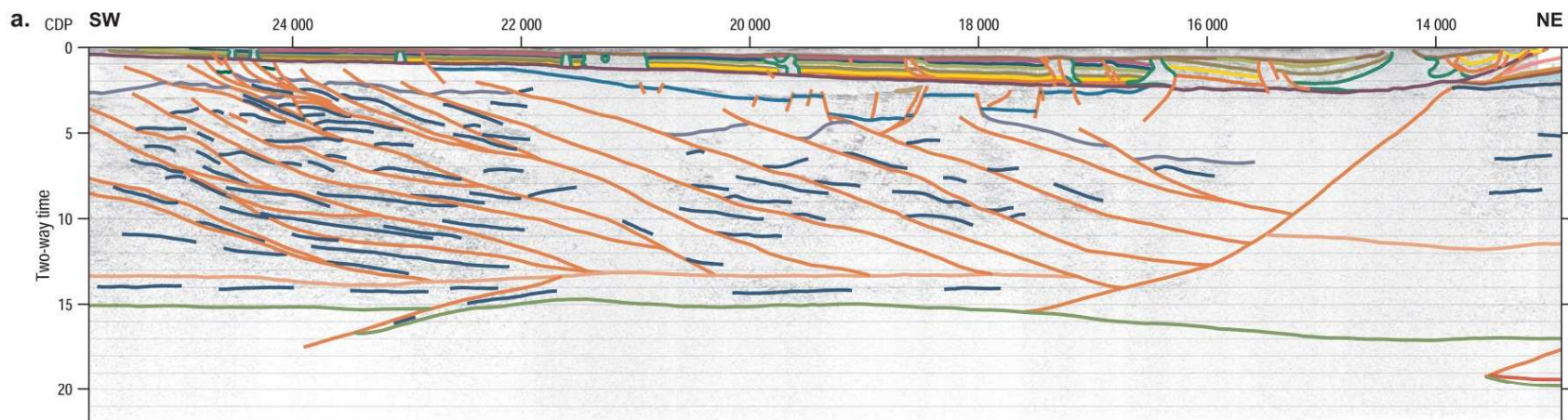
- Base Cenozoic/regolith
- Base mafic rocks
- Base nonreflective upper crust in Yilgarn Craton
- Base upper crust
- Base middle crust
- Top moho transition zone
- Moho
- Fault
- Granite
- Dyke/sill
- Form line

# Southwest YOM deep seismic section





# Southwest YOM - magnetotellurics



0 50 km

13-7010-7

**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

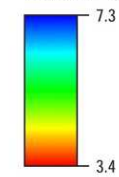
**Musgrave Province**

- 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

**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

**Natural Log**



# Summary

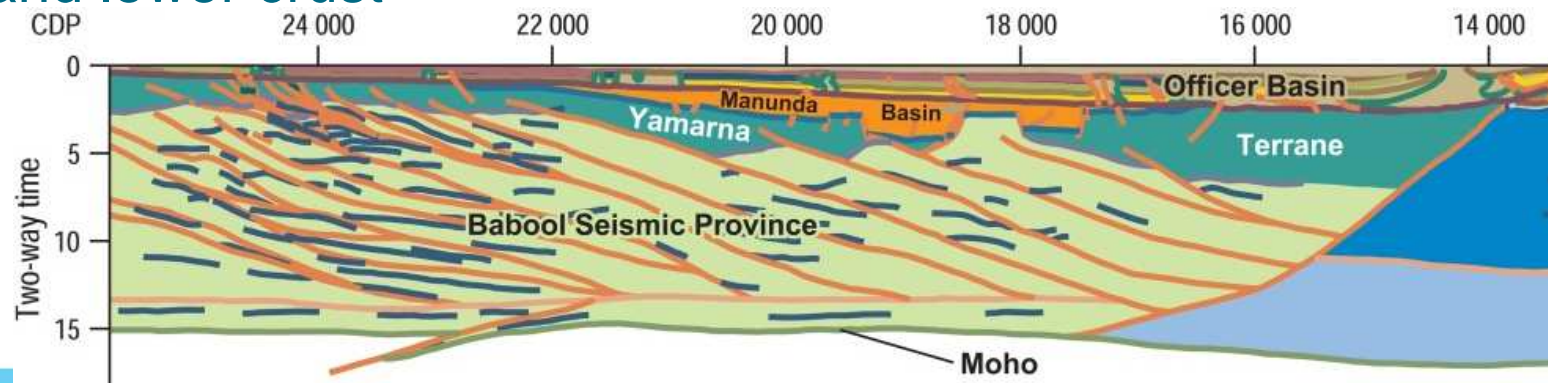
YOM provides NE-SW image of entire crust of northeastern Yilgarn Craton and overlying Officer Basin in area of no outcrop

Officer Basin – thickens to NE, originally extensional, disrupted in places by thrust faults and salt diapirs

Manunda Basin (new name) – Mesoproterozoic (MDA ~1310 Ma) extensional, steer's head basin, up to 6 km thick

Yamarna Terrane of Yilgarn Craton – weakly reflective, extends in subsurface further to north than previously interpreted

Babool Seismic Province (new name) – highly reflective middle and lower crust





**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>

**Phone:** +61 2 6249 9111

**Web:** [www.ga.gov.au](http://www.ga.gov.au)

**Email:** [Russell.Korsch@ga.gov.au](mailto:Russell.Korsch@ga.gov.au)

**Address:** Cnr Jerrabomberra Avenue and Hindmarsh Drive, Symonston ACT 2609

**Postal Address:** GPO Box 378, Canberra ACT 2601