



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

Geology of the Gascoyne Province and preliminary interpretation of deep seismic reflection lines 10GA–CP2 and 10GA–CP3: crustal architecture of the Gascoyne Province

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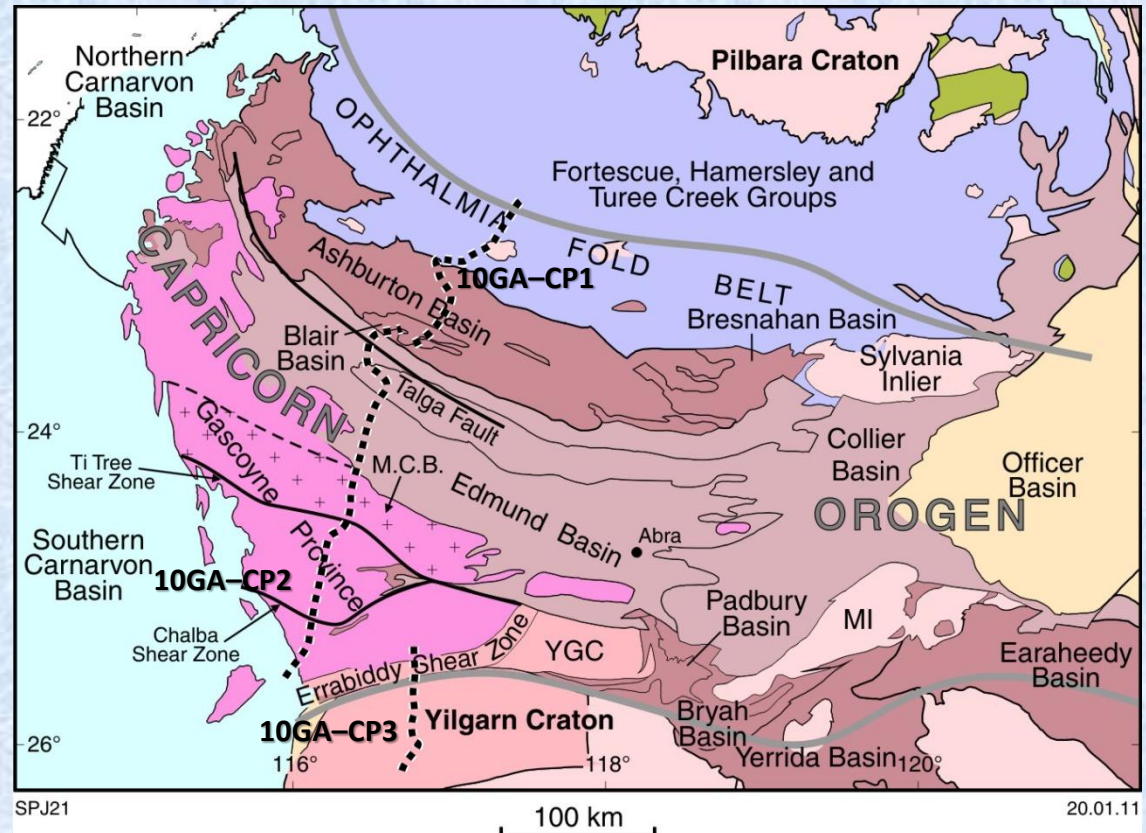
Capricorn Orogen



Records the collision of the Archean Pilbara and Yilgarn Cratons to form the **West Australian Craton**

Capricorn Orogen includes:

- deformed craton margins
- granitic and medium- to high-grade metamorphic rocks of the Gascoyne Province
- variably deformed Proterozoic sedimentary basins

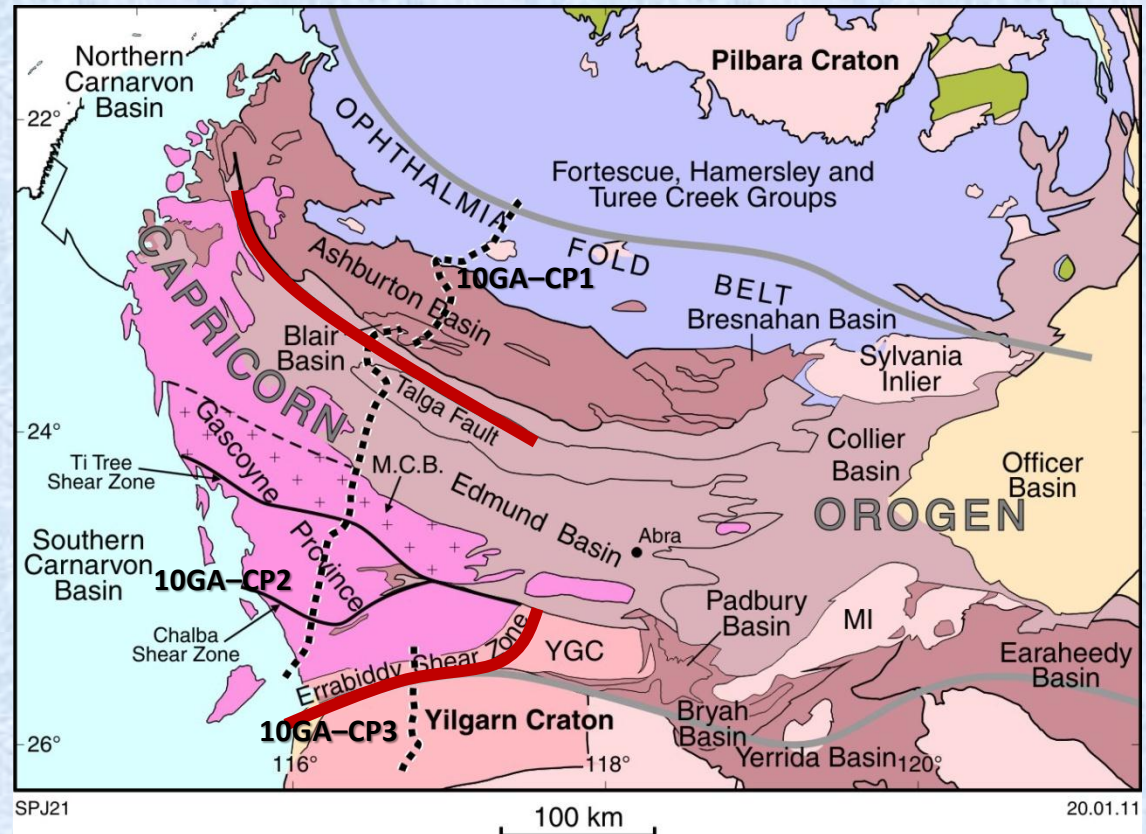


West Australian Craton



Assembled during two distinct and separate events. Three blocks, two collisions and therefore two suture zones.

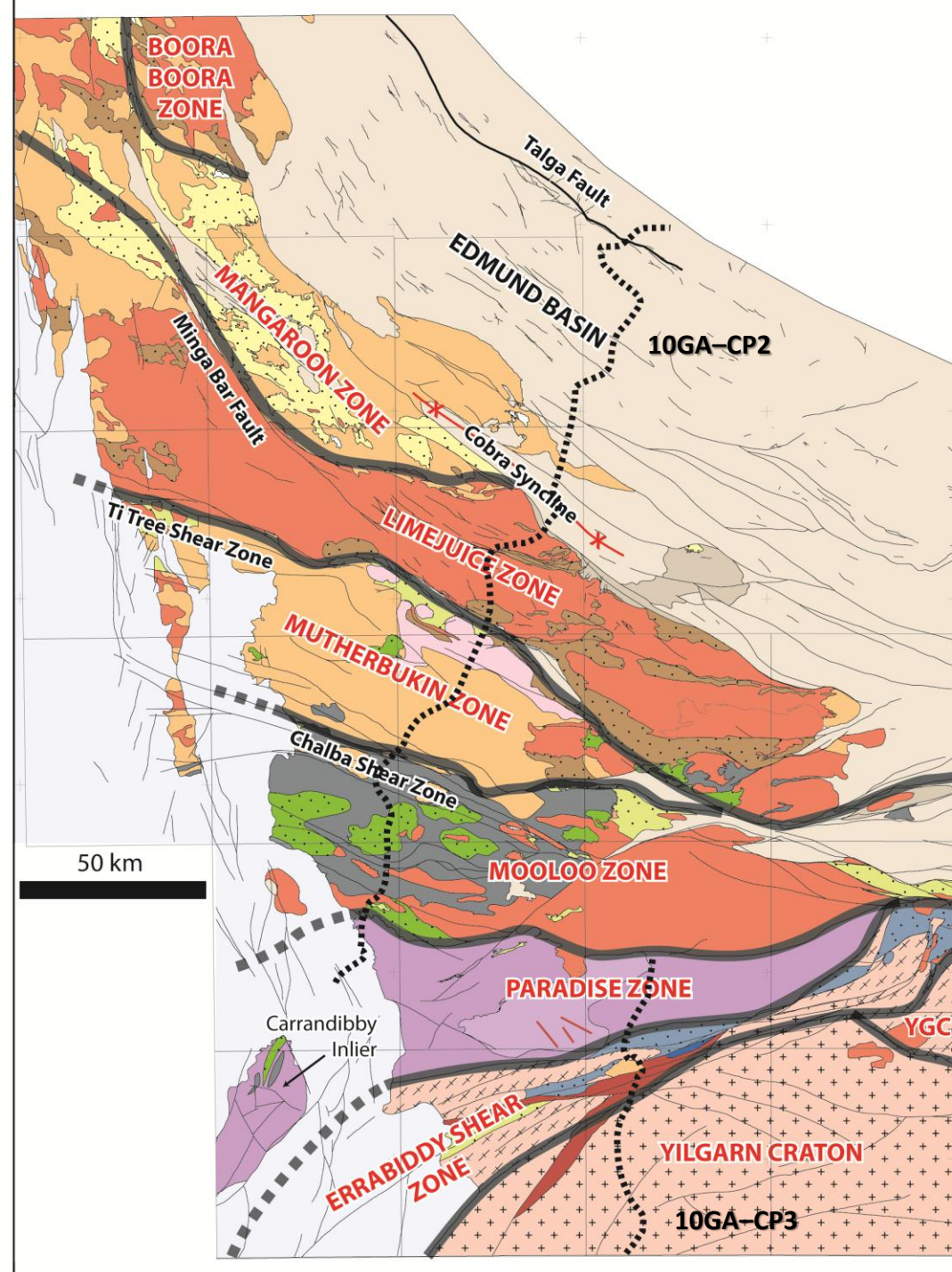
- Collision of the Pilbara Craton with the oldest part of the Gascoyne Province (Glenburgh Terrane) during the 2215–2145 Ma Ophthalmian Orogeny. **Suture is unexposed – Talga Fault?**



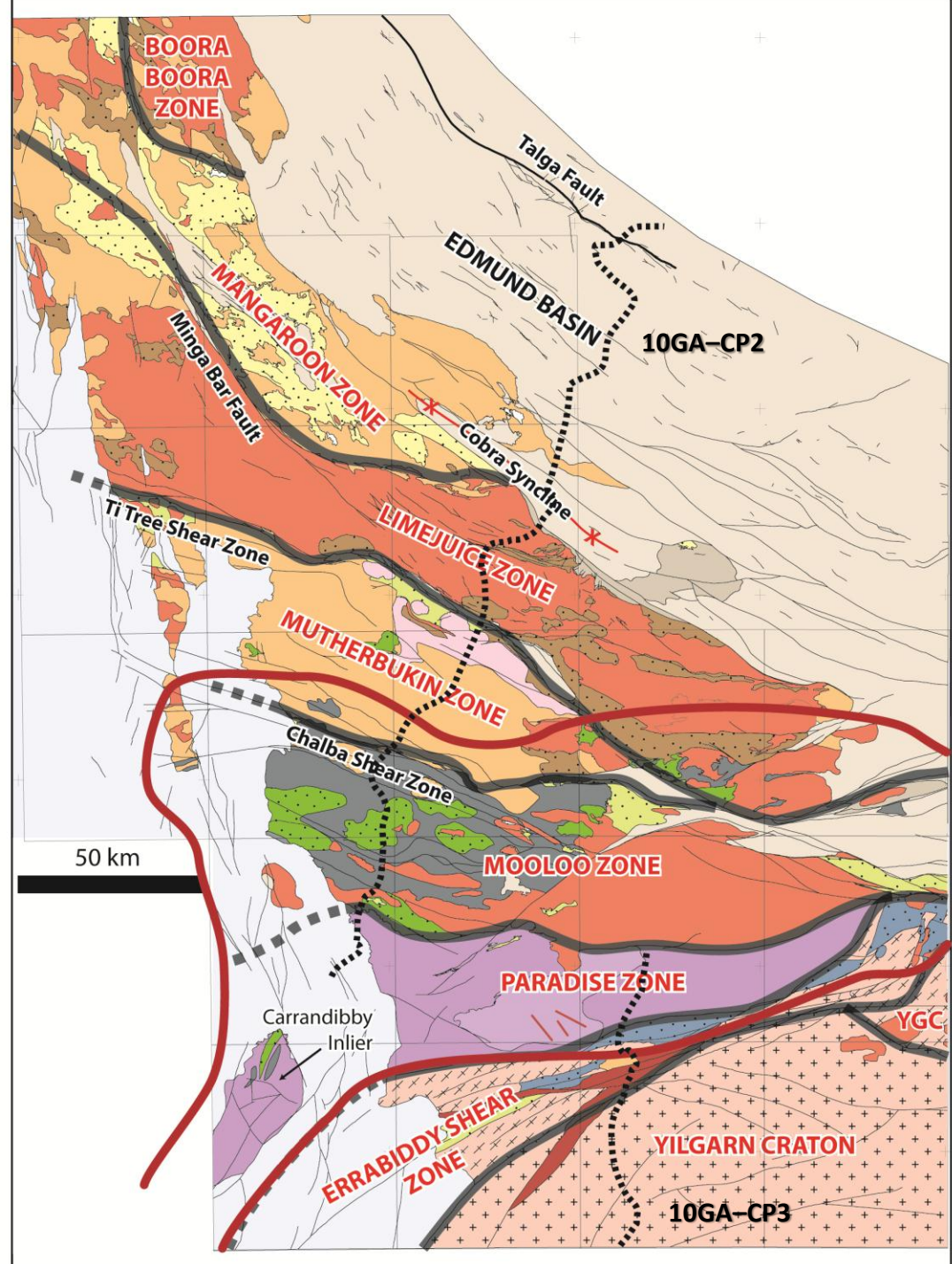
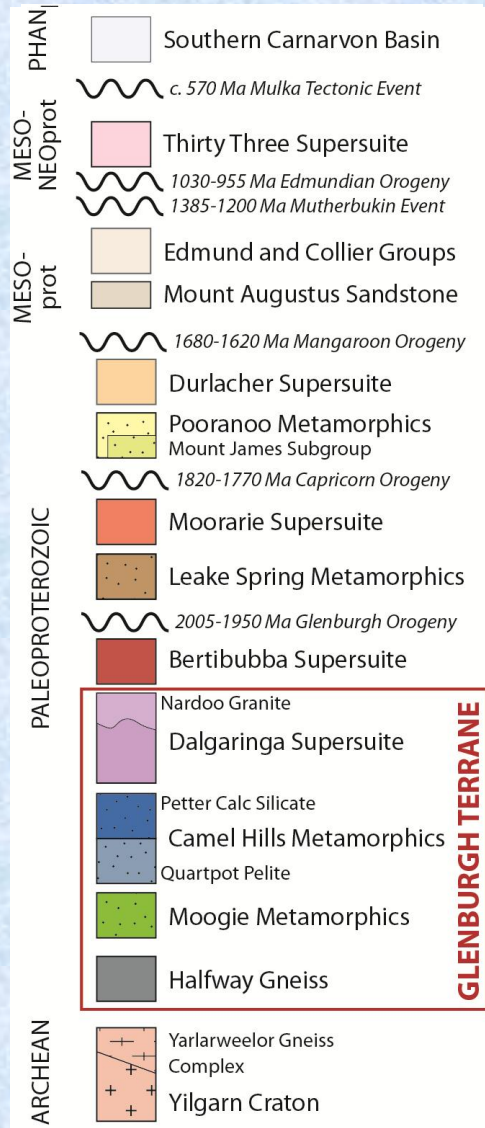
- Collision of a combined Pilbara Craton – Glenburgh Terrane with the Yilgarn Craton during the 2005–1950 Ma Glenburgh Orogeny. **Suture at the Errabiddy Shear Zone**

Gascoyne Province

- Following these collisions, the Gascoyne Province was subject to over one billion years of intracontinental reworking, including deformation, metamorphism and magmatism
- Series of fault or shear zone bounded structural – metamorphic – magmatic corridors

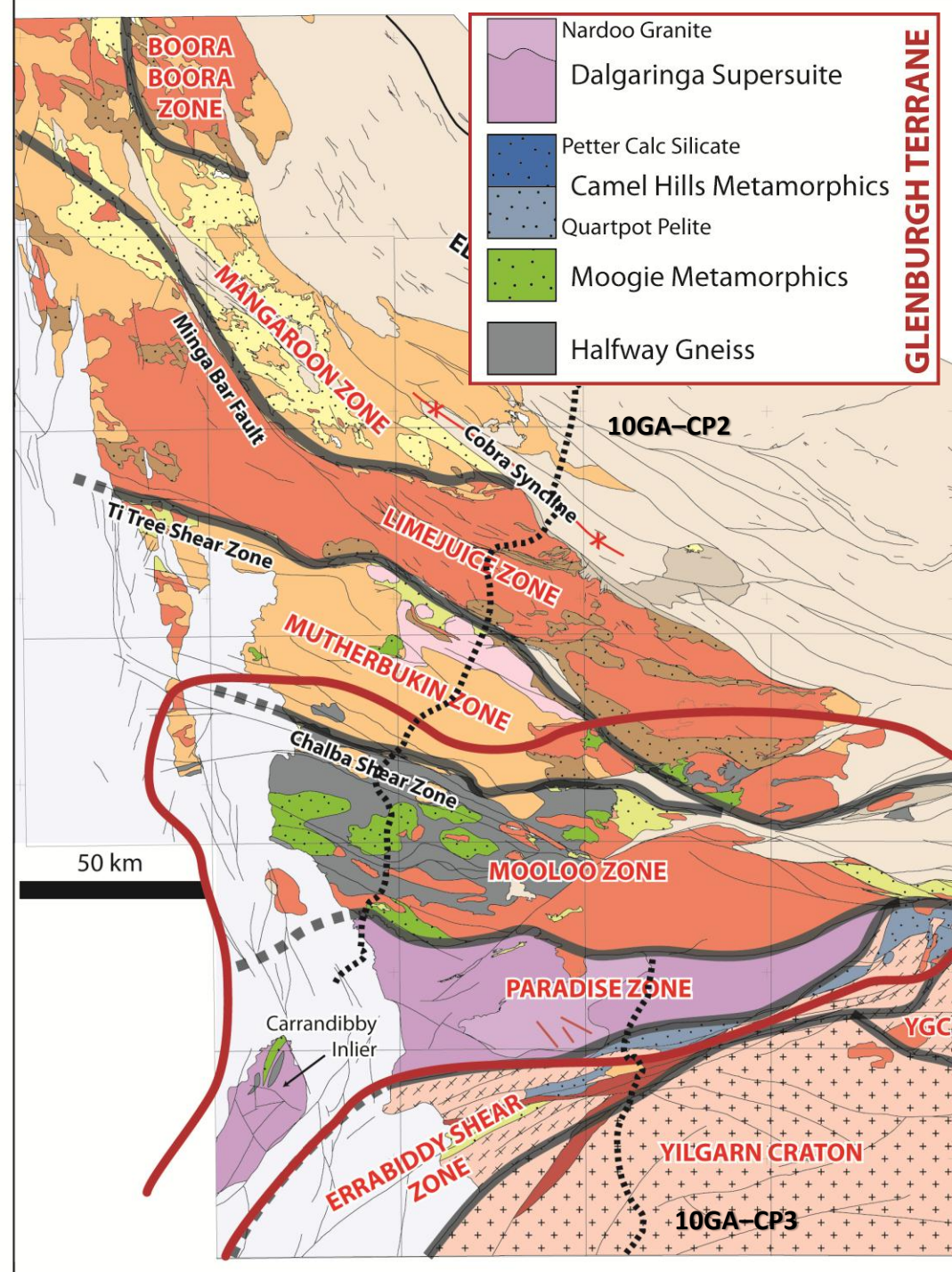


Glenburgh Terrane



Glenburgh Terrane

- Heterogeneous granitic gneisses (Halfway Gneiss) that predate both collisions, and which are exotic to the Pilbara and Yilgarn Cratons
- Siliclastic metasedimentary rocks of various age
 - Moogie Metamorphics
 - Camel Hills Metamorphics
- Intermediate to felsic granitic batholith that formed in a continental margin arc leading up to the collision of the Pilbara Craton – Glenburgh Terrane with the Yilgarn Craton (Dalgaringa Supersuite)

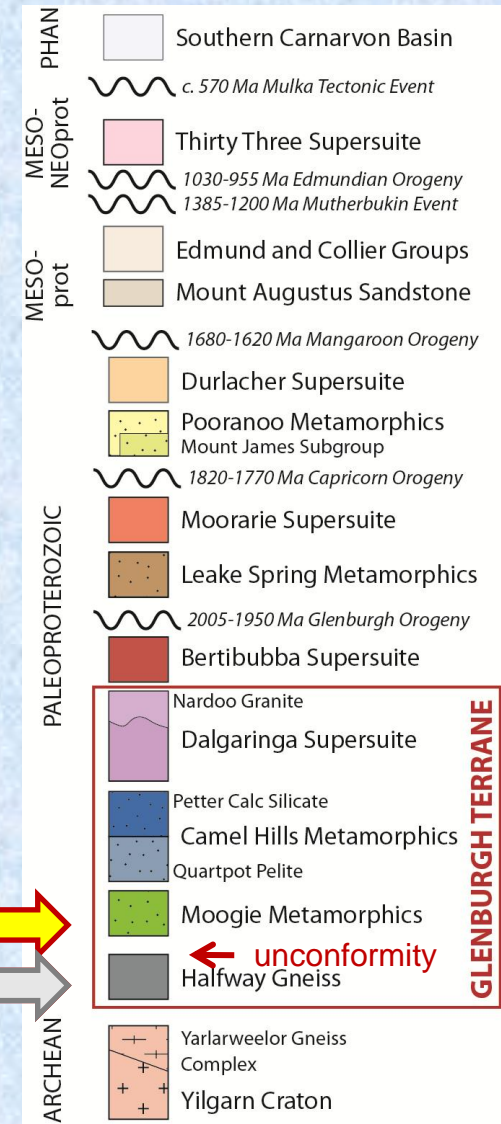
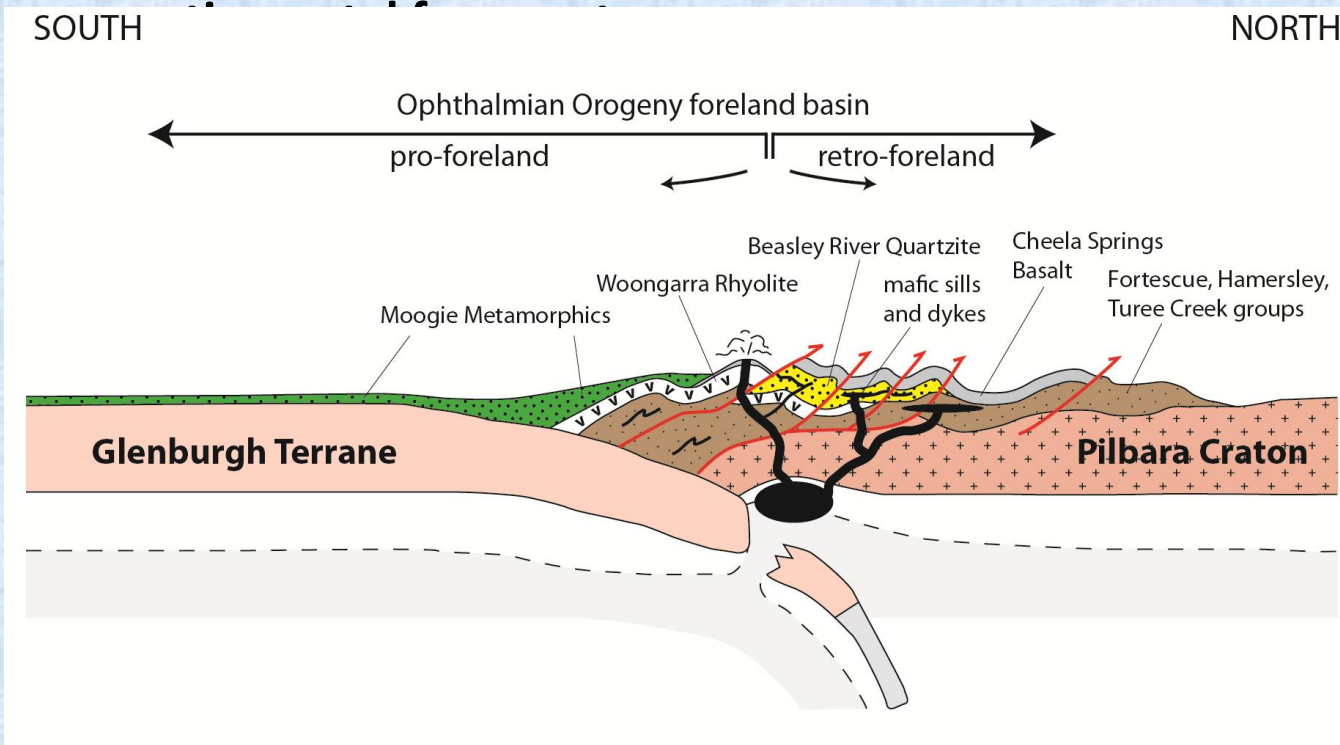


Glenburgh Terrane: an exotic crustal fragment



Halfway Gneiss

- Heterogeneous granitic gneisses (2555–2430 Ma)
- Inherited zircon and Hf-zircon model ages indicate an older crustal history as old as 3700 Ma
- Isotopic evolution different to the Pilbara and Yilgarn Cratons

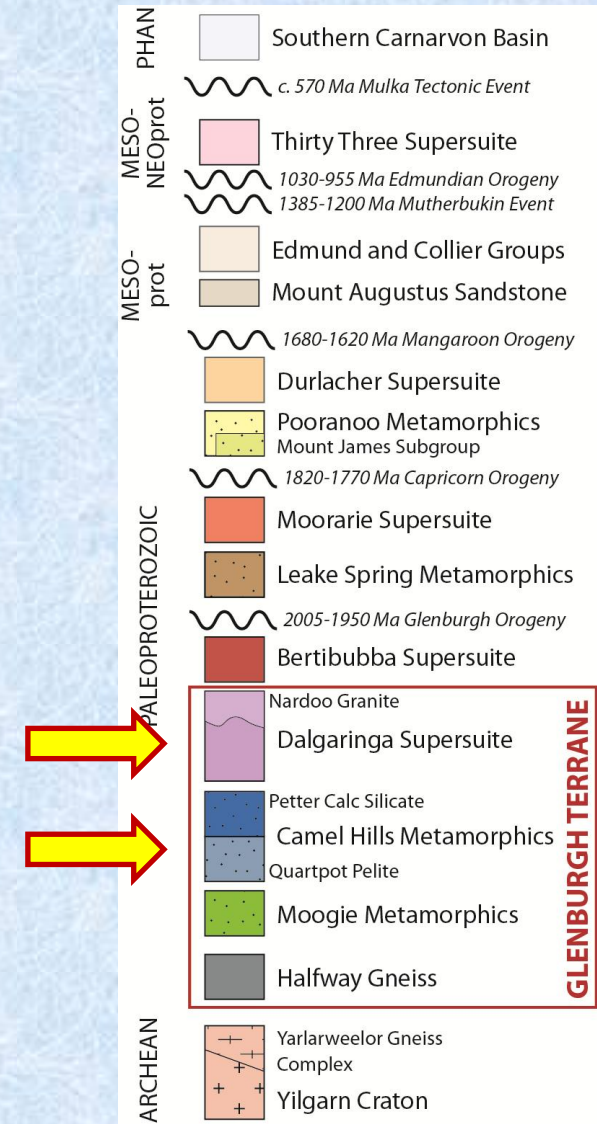


GLENBURGH TERRANE

Glenburgh Terrane – Yilgarn Craton collision



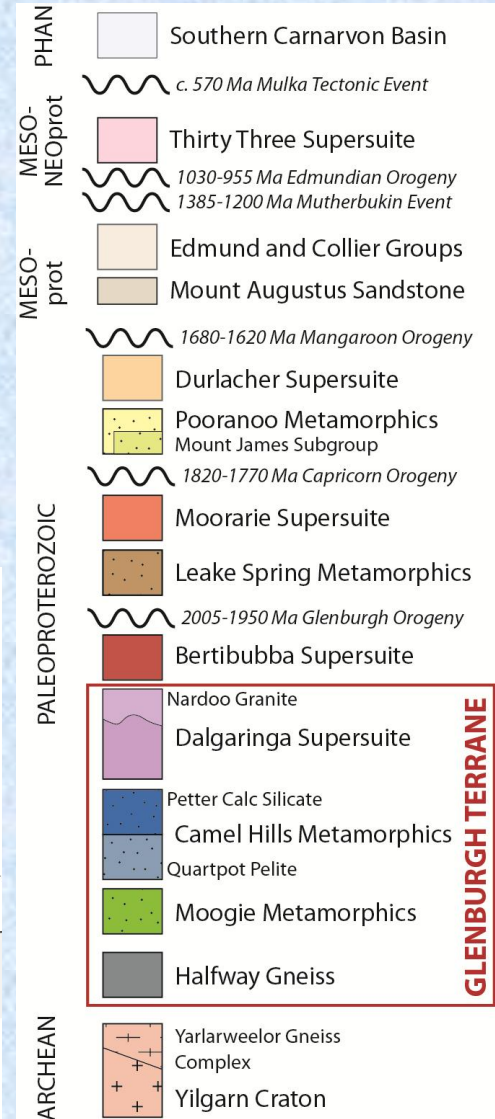
- Mid- to upper-crustal continental margin arc system that was active leading up to the final suturing of the Glenburgh Terrane with the Yilgarn Craton
- The 2005–1970 Ma Dalgaringa Supersuite are strongly deformed gneisses and granites with continental margin arc affinity
- The Camel Hills Metamorphics are syn-arc siliclastic (meta)sediments derived from the erosion of older parts of the arc



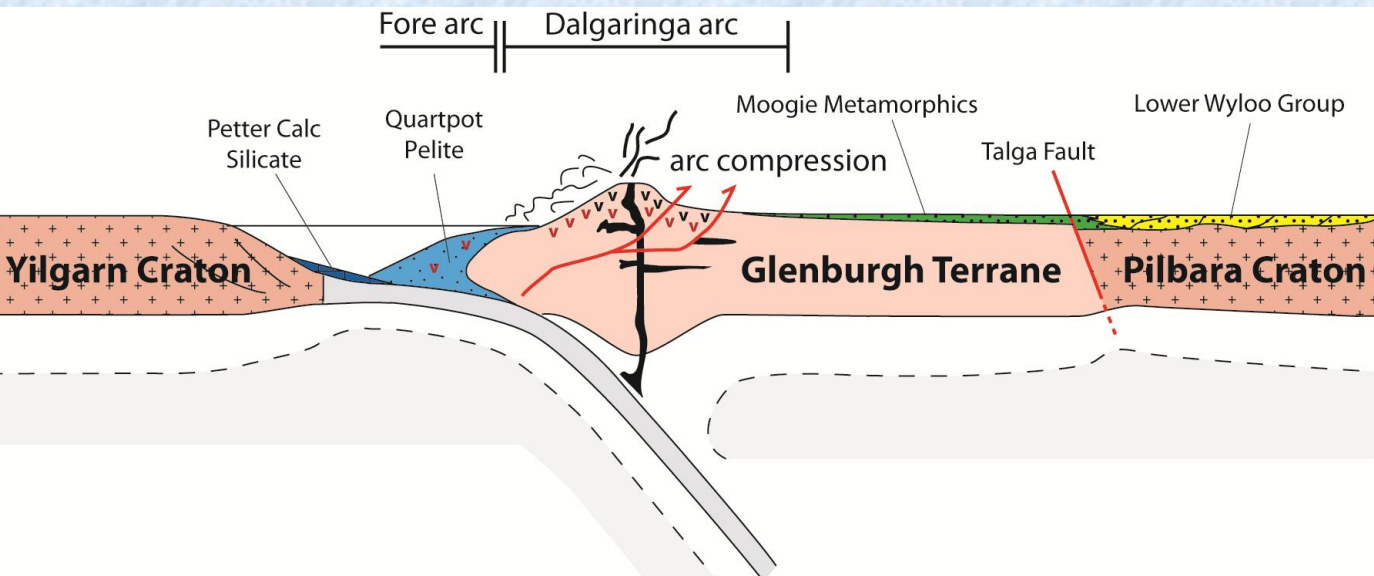
The Dalgaringa continental margin arc



- Dalgaringa Supersuite intrudes and is tectonically interleaved with the Halfway Gneiss and Moogie Metamorphics
- No intrusions of Dalgaringa age have been identified in the Yilgarn Craton
- Northward subduction under the Glenburgh Terrane



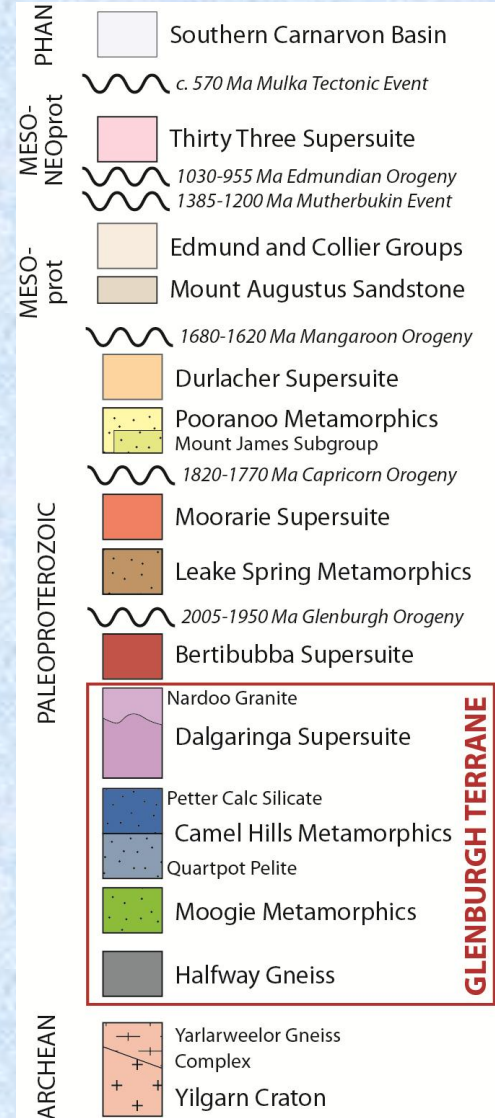
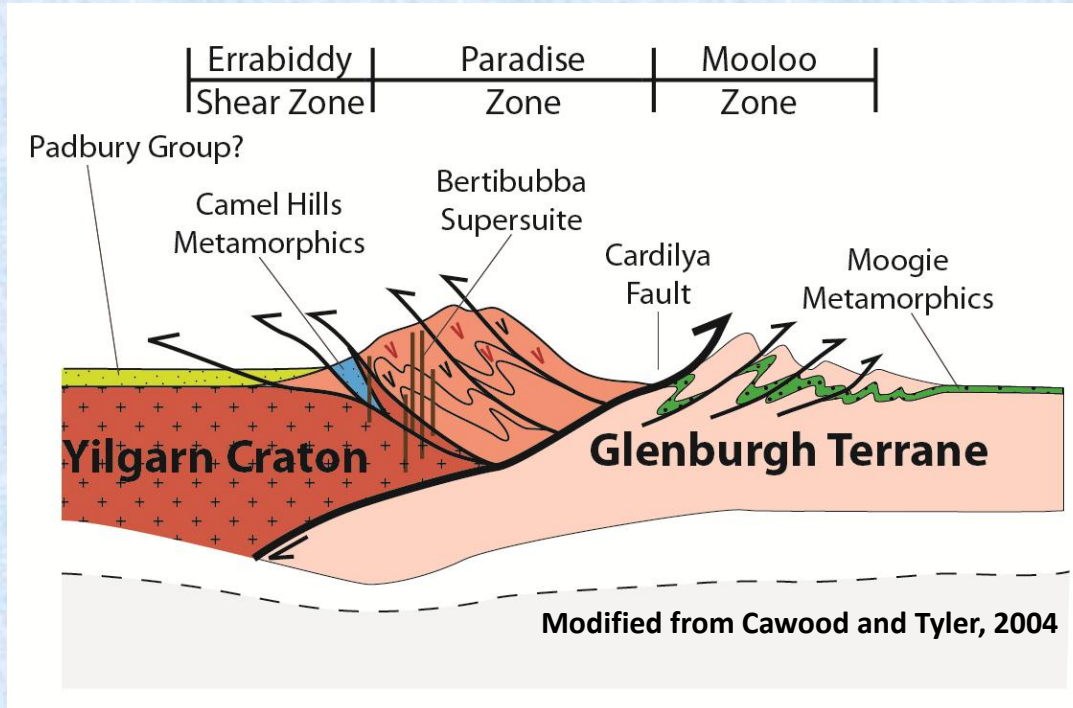
GLENBURGH TERRANE



Collision during the Glenburgh Orogeny



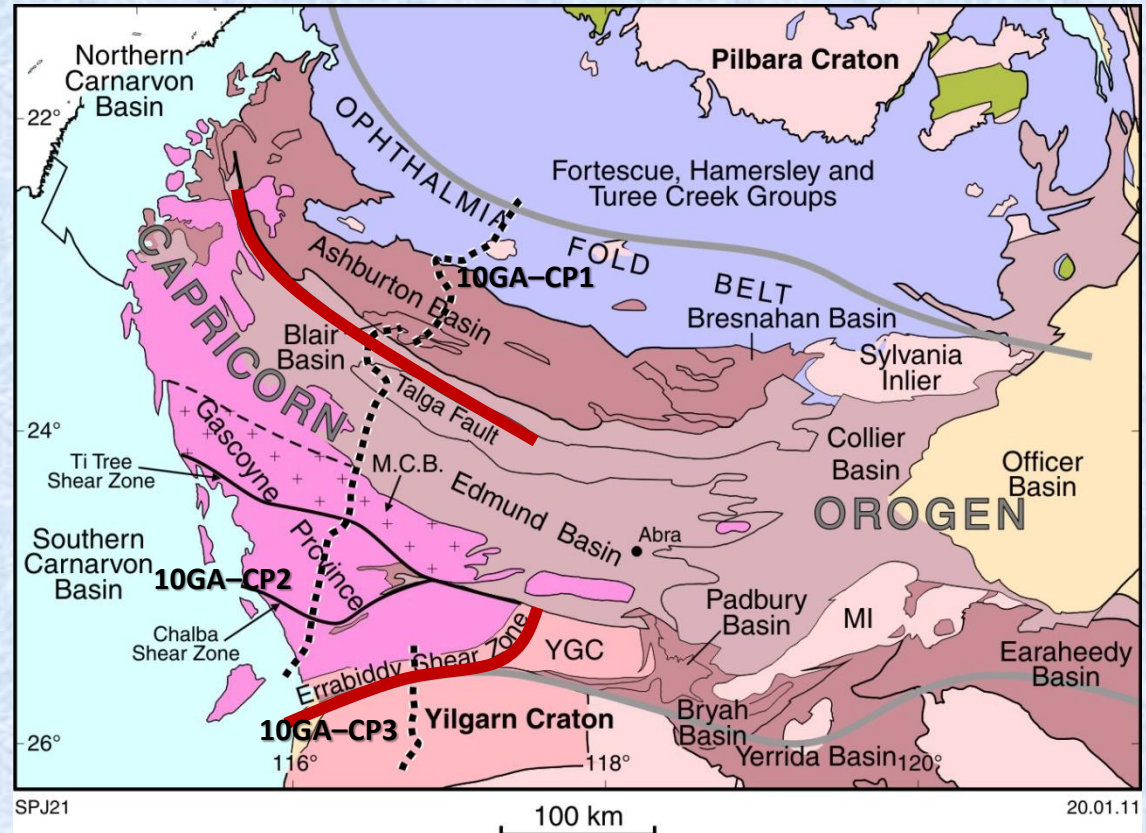
- Constrained by the dating of metamorphic zircon and monazite at **1965–1950 Ma** from high-grade metasedimentary rocks in the collision zone



Principal sutures of the West Australian Craton



- **Pilbara Craton — Glenburgh Terrane suture** is unexposed. MT survey (Selway et al., 2009) and tomography of Abdullah (2010) suggest it is coincident with the Talga Fault. Steep north-dipping structure



- **Glenburgh Terrane — Yilgarn Craton suture** located at the Errabiddy Shear Zone. MT survey (Selway et al., 2009) suggests moderate south dipping under the Yilgarn Craton

Intracratonic orogenies and tectonic events



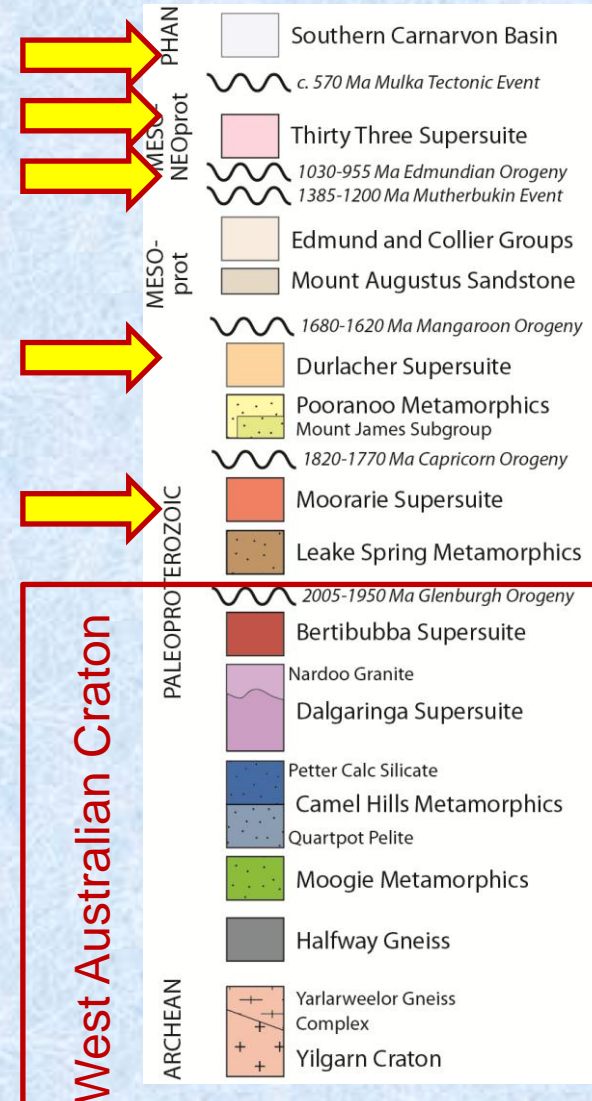
c. 570 Ma Mulka Tectonic Event
 brittle-ductile reworking

1030–955 Ma Edmondian Orogeny
 Thirty Three Supersuite
 greenschist to amphibolite facies modT-LP

1385–1210 Ma Mutherbukin Tectonic Event
 Sub-greenschist to amphibolite facies modT-LP

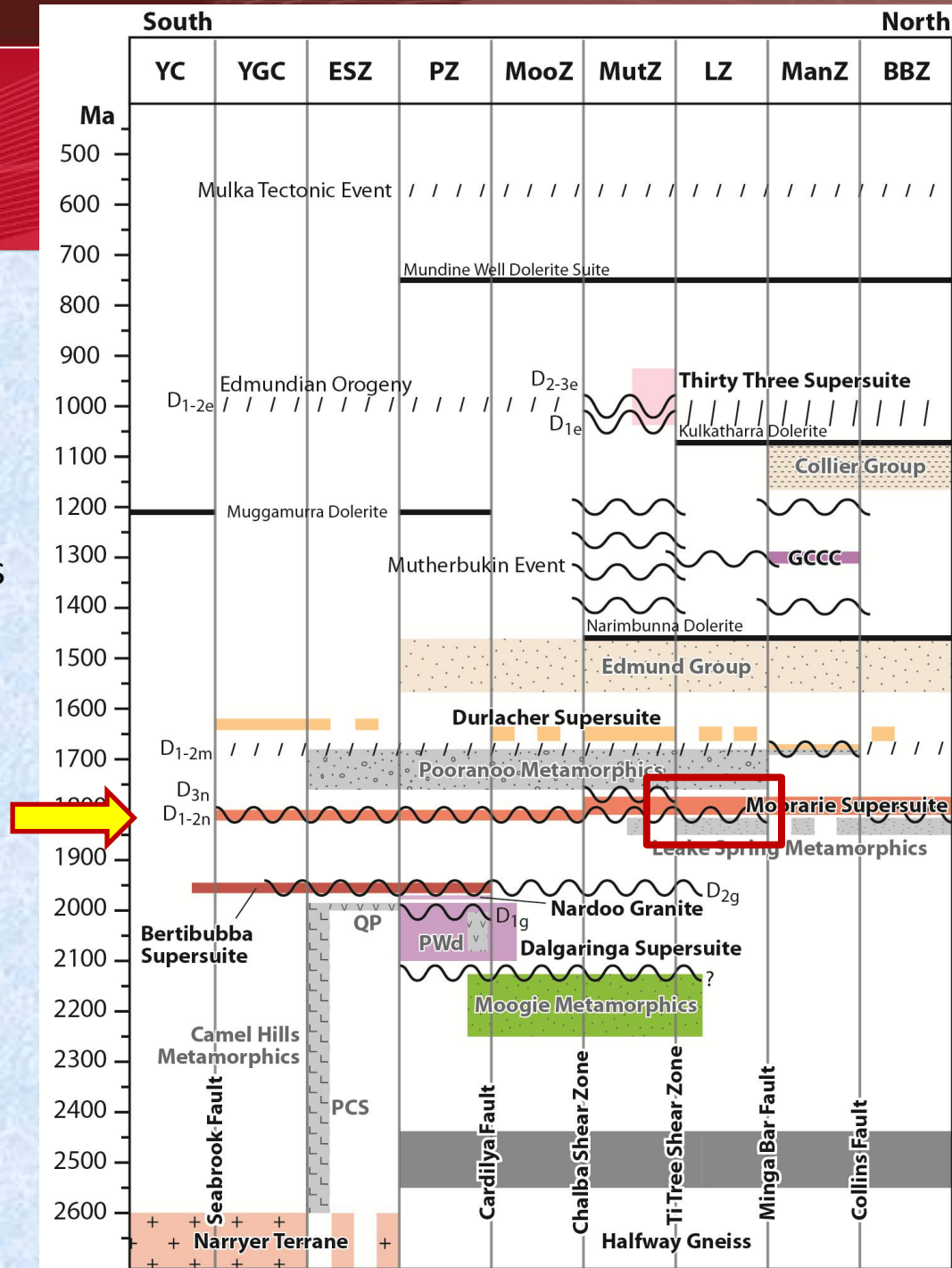
1680–1620 Mangaroon Orogeny
 Durlacher Supersuite
 amphibolite to granulite facies HT-LP

1820–1770 Ma Capricorn Orogeny
 Moorarie Supersuite
 greenschist to upper amphibolite HT-LP



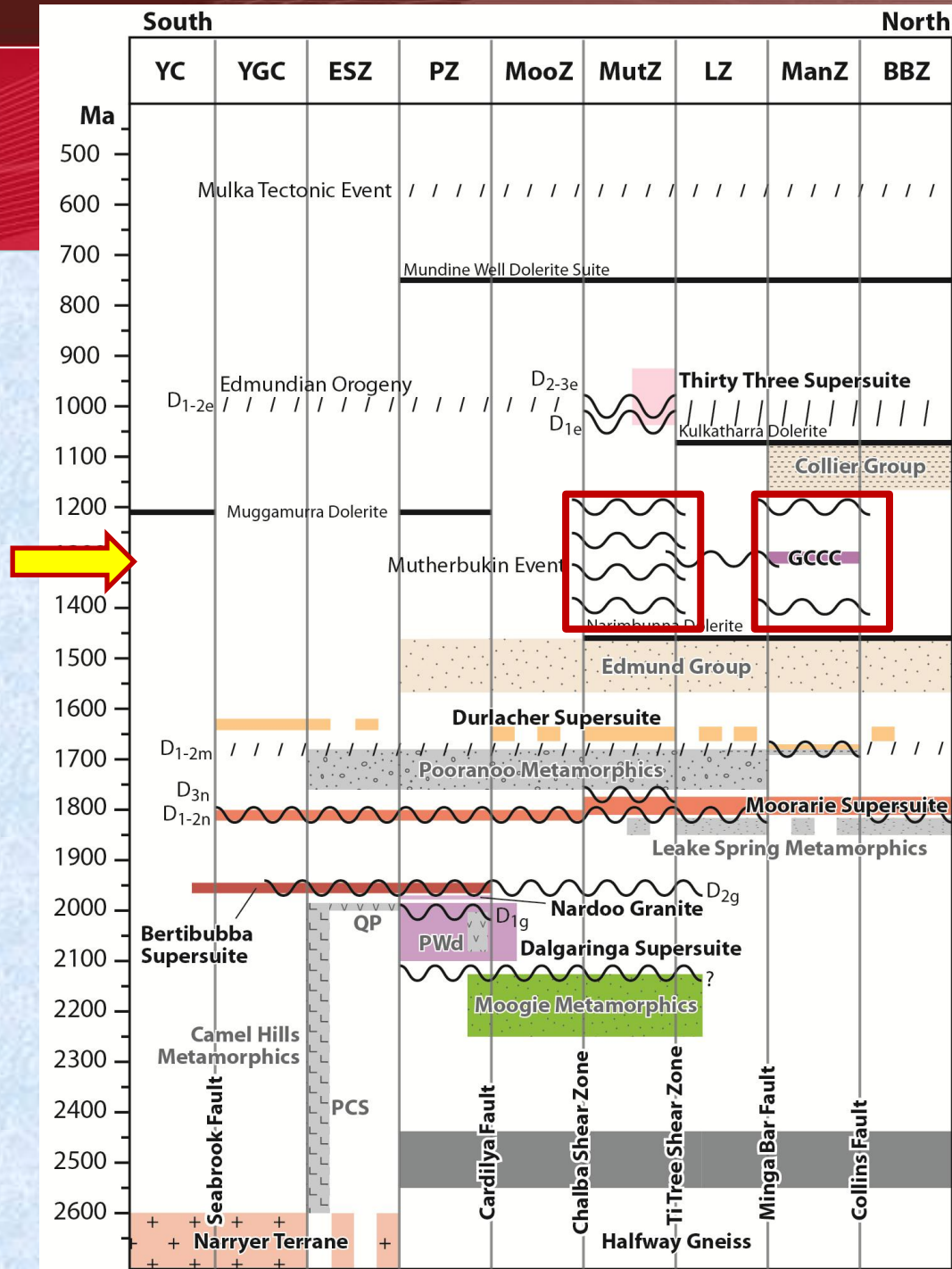
1820–1770 Ma Capricorn Orogeny

- Gascoyne Province-wide orogeny with granitic stocks and intrusions across the entire province
- Metamorphism related thermal effects of granite magmas. Deformation includes compression, folding and faulting
- However, voluminous magmatism was focussed within the Limejuice Zone producing the Minnie Creek batholith
 - gabbro-monzogranite
 - S-type granites although oxygen isotopes of zircon indicate mantle derived component
 - **Shape of batholith at depth?**



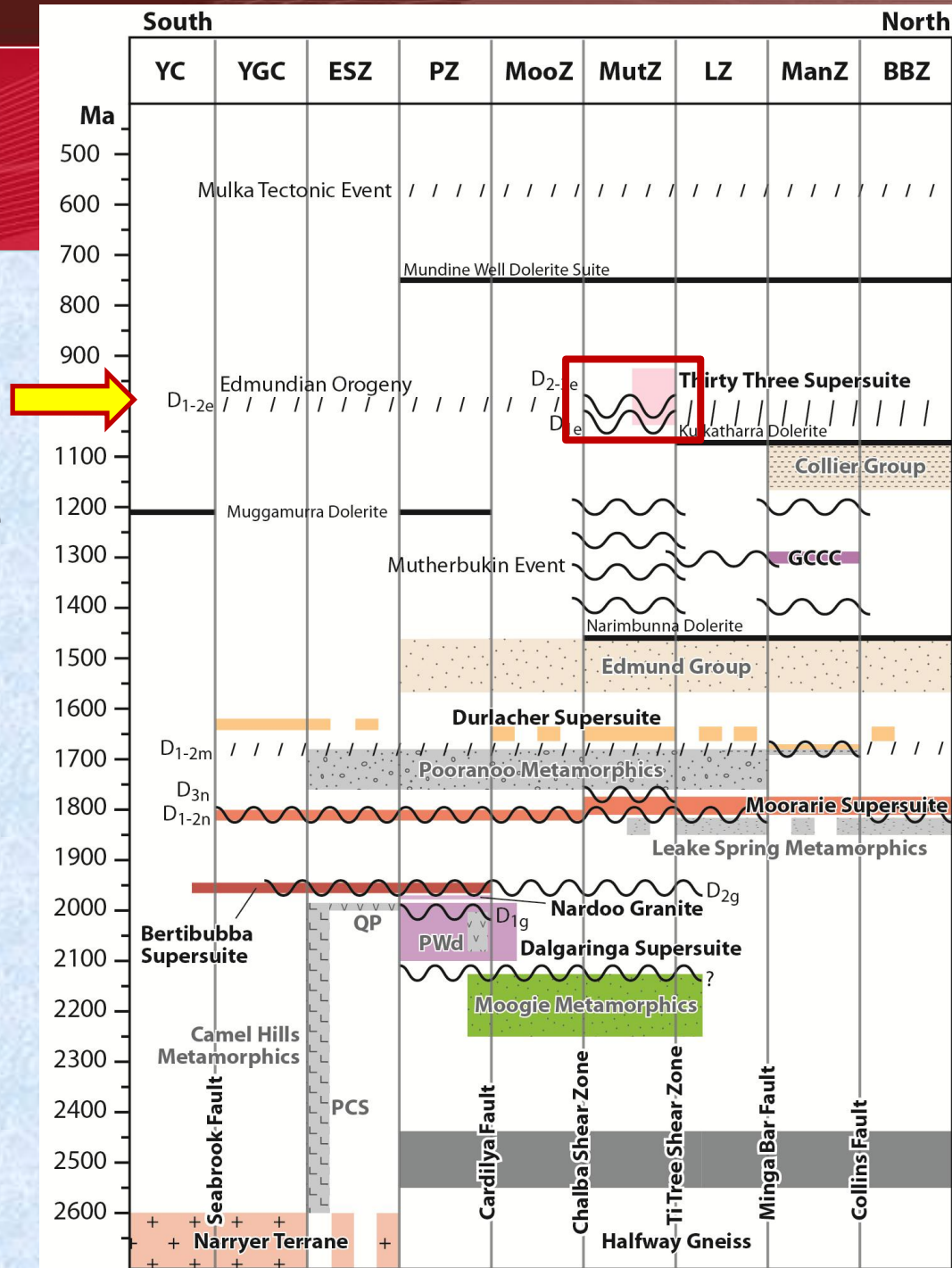
1385–1200 Ma Mutherbukin T Event

- Deformation, metamorphism and hydrothermal alteration in Gascoyne Province and Edmund Basin
- Mod-T, low-P oblique strike slip with crustal-scale sheath folds
- Intrusion of the Gifford Creek Carbonatite Suite – significant mantle input
- Basement structures extend into the upper crustal Edmund Group as faults
 - Extensive hydrothermal fluid flow
 - Polymetallic Abra deposit
- Mantle-tapping structures? Minga Bar-Minnie Creek-Lyons River Fault?



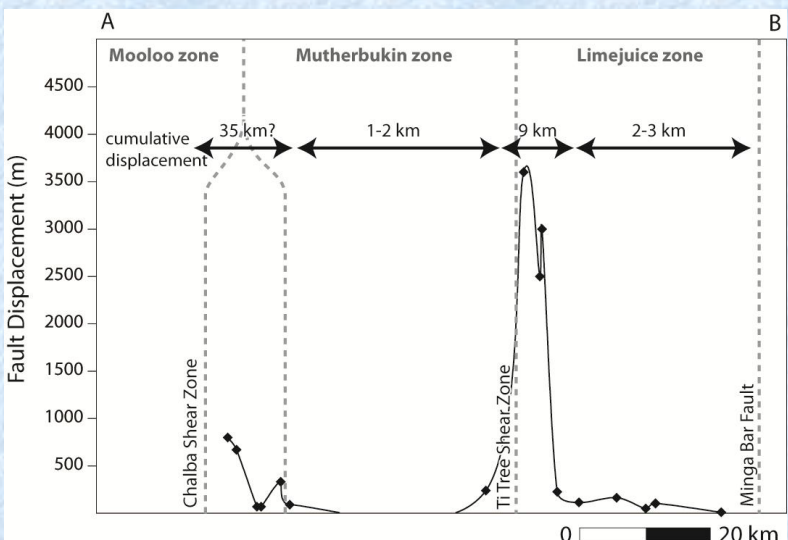
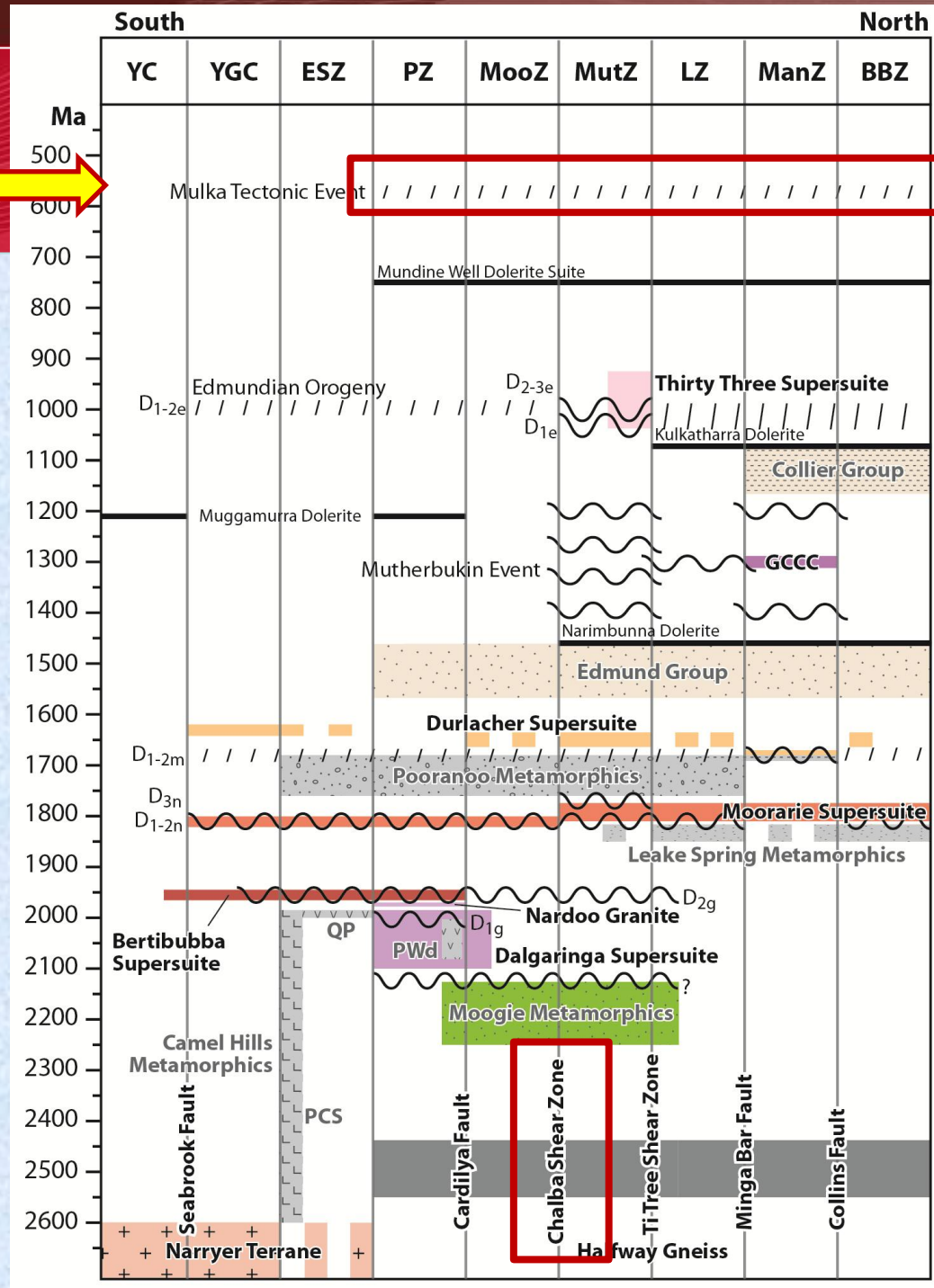
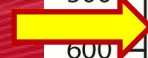
1030–955 Ma Edmundian Orogeny

- Deformation in both the Gascoyne Province and Edmund and Collier Basins
- Mod-T, Mod-P metamorphism within a 10–20 km wide corridor along the Ti Tree Shear Zone.
 - Leucocratic tourmaline-granites and REE-bearing pegmatites in the basement (Thirty Three Supersuite)
- Major period of open to tight folding, plus faulting in both the Edmund and Collier Basins
- Crustal thickening with basement – cover detachment ?



c. 570 Ma Mulka Tectonic Event

- Network of anastomosing shear zones and brittle-ductile faults
- Dextral strike slip with offsets 10-100m
 - Some faults may have large offsets up to 4km
- Concentrated into discrete corridors such as the Chalba Shear Zone (5–10 km wide)
- Reactivation of older structures

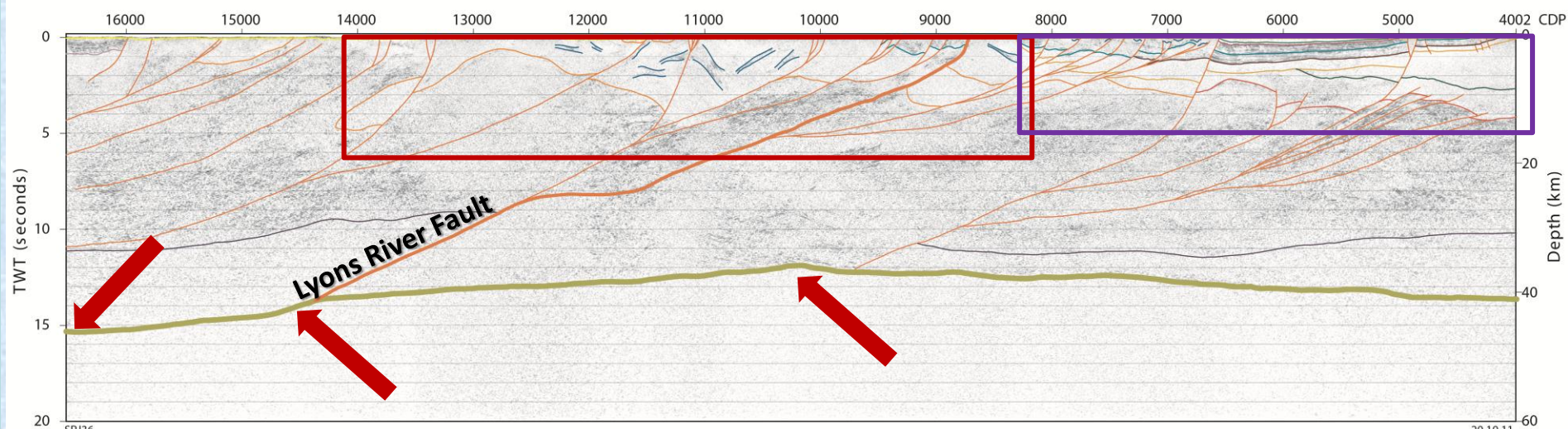
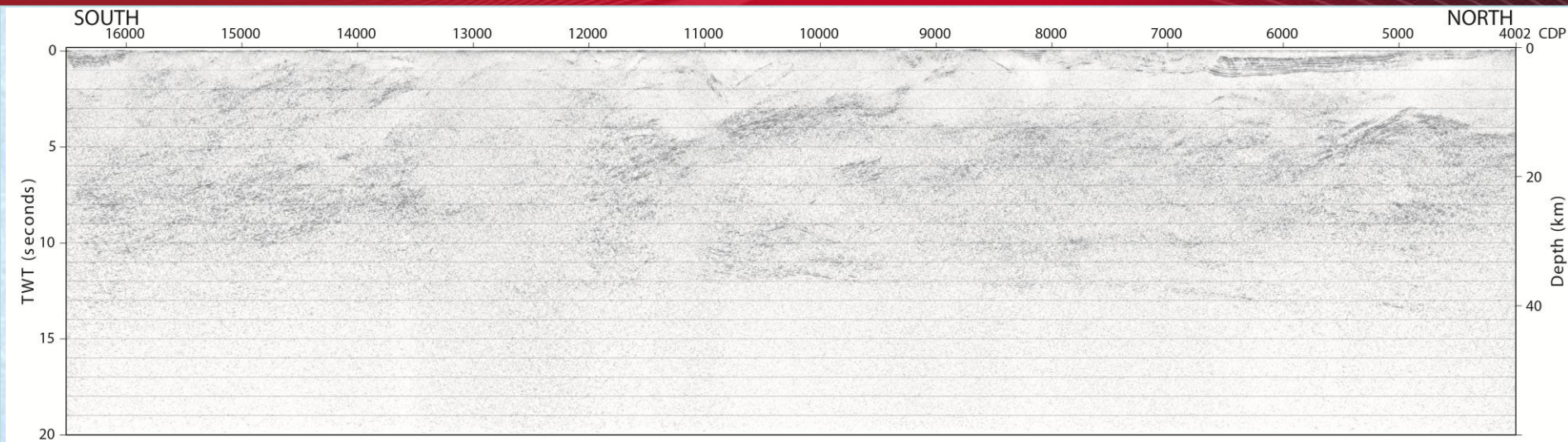


Preliminary interpretation of seismic lines 10GA–CP2 and 10GA–CP3



- Location and orientation of major terrane-bounding faults, including any potential suture zones
- The depth and shape of the Minnie Creek batholith, and other Proterozoic granite intrusions
- The deep crustal structure of the Edmund and Collier Basins
- Better refine the crustal architecture of the Gascoyne Province

Preliminary interpretation of seismic line 10GA-CP2



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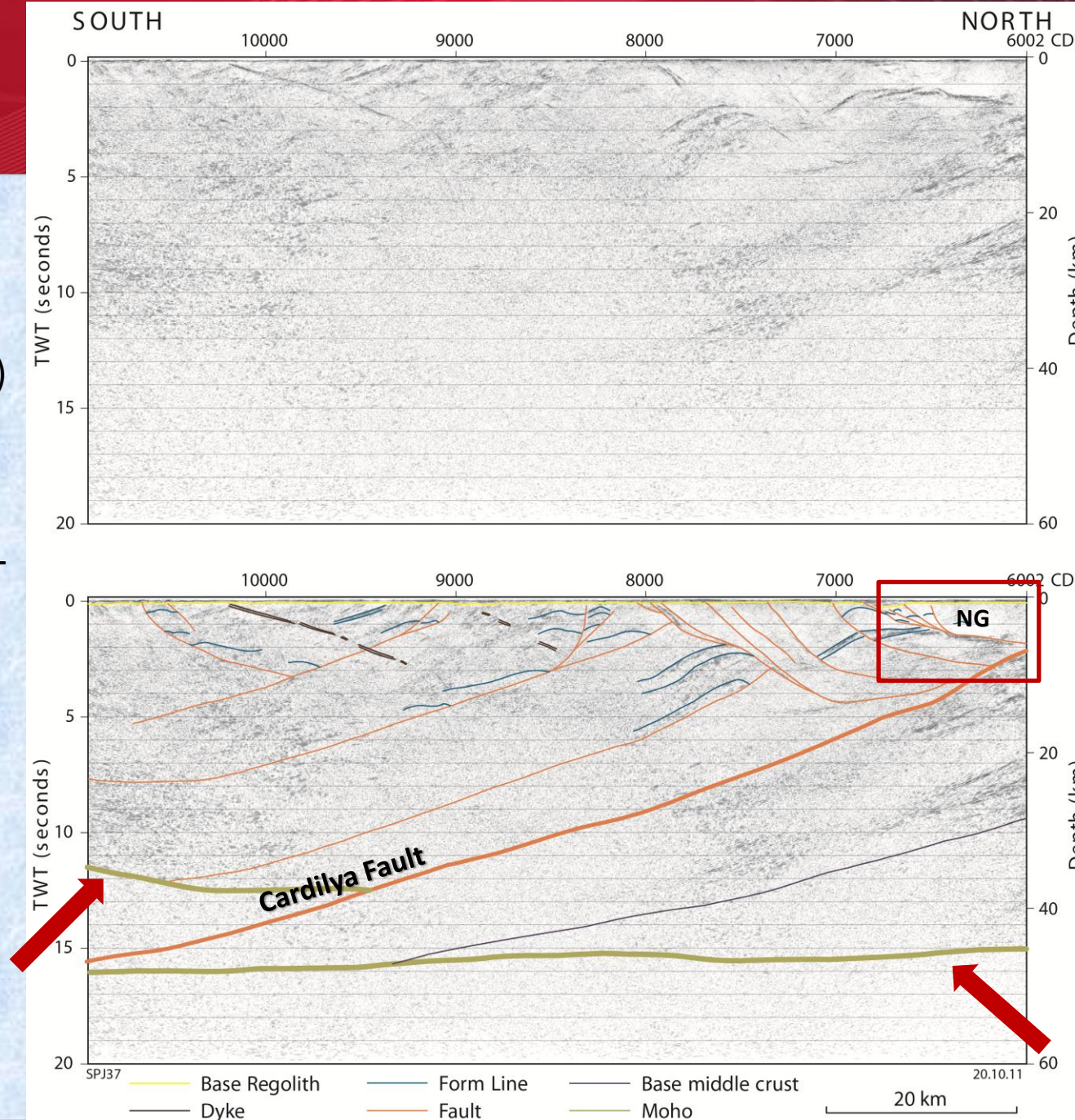
- | | | | |
|-------------------------|------------------------------|--------------------------|---------------------|
| — Base Regolith | — Base Edmund Package 3 | — Base Upper Wyloo Group | — Fault |
| — Base Carnarvon Basin | — Base Edmund Package 2 | — Base Lower Wyloo Group | — Base middle crust |
| — Base Collier Basin | — Base Edmund Package 1 | — Form Line | — Moho |
| — Base Edmund Package 4 | — Base Mt Augustus Sandstone | — Granite | |

20 km

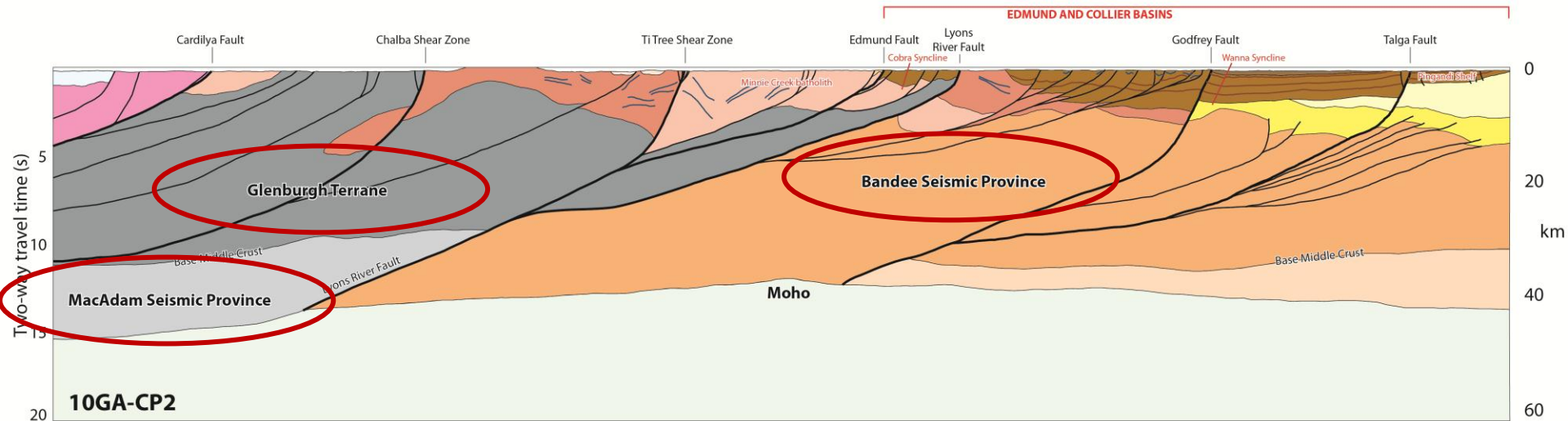
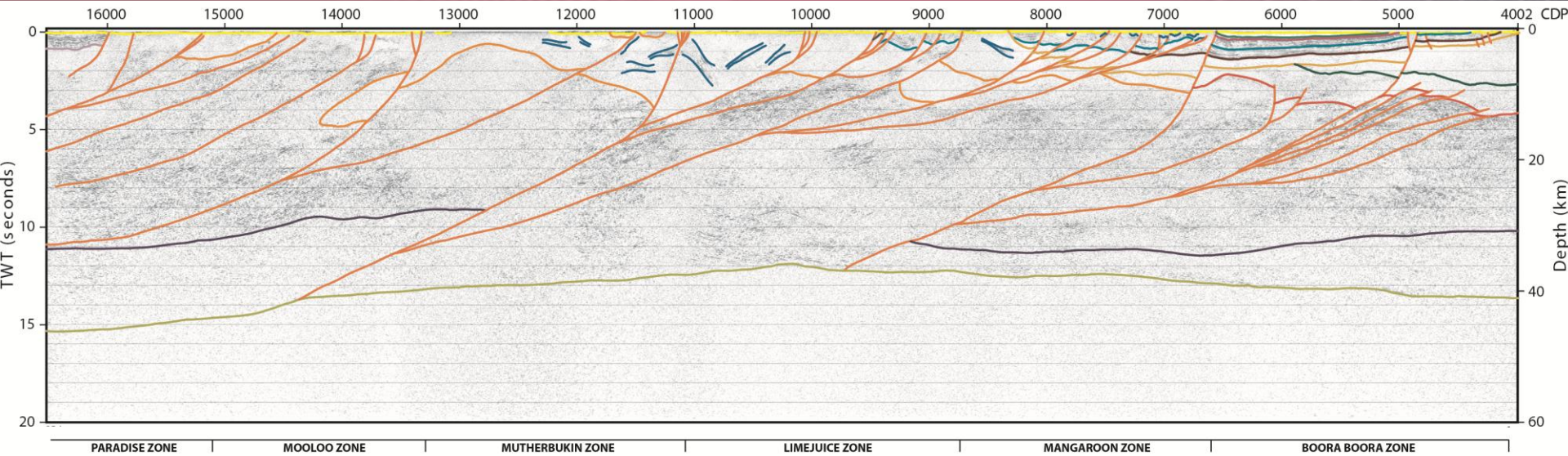
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10GA-CP3

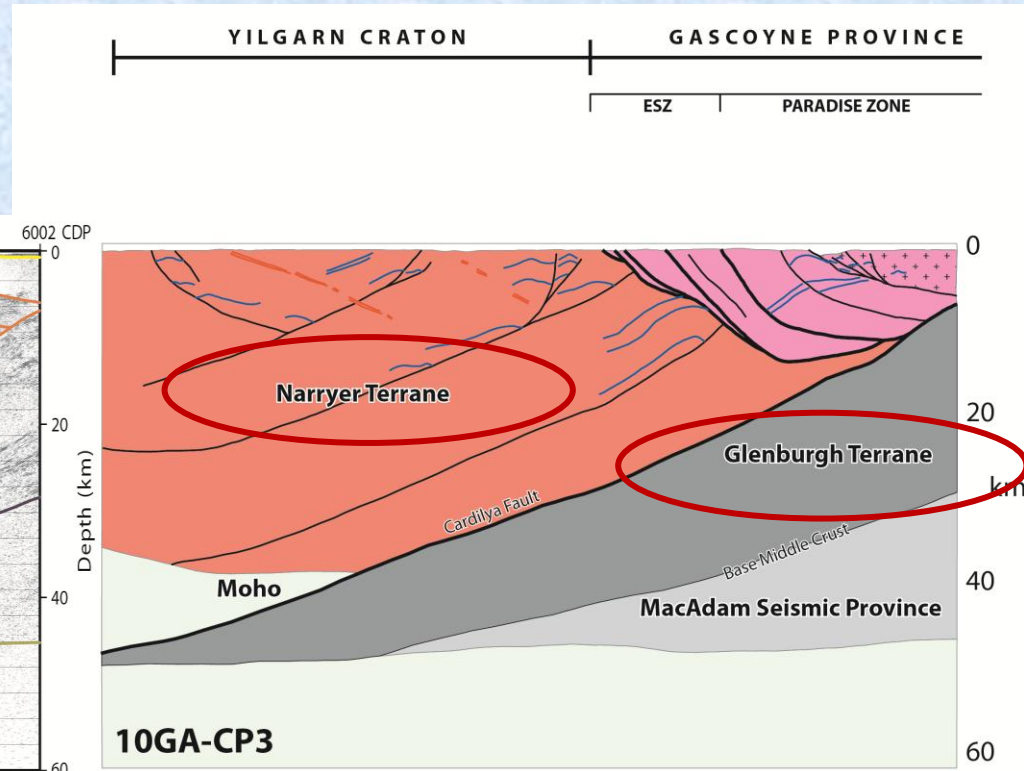
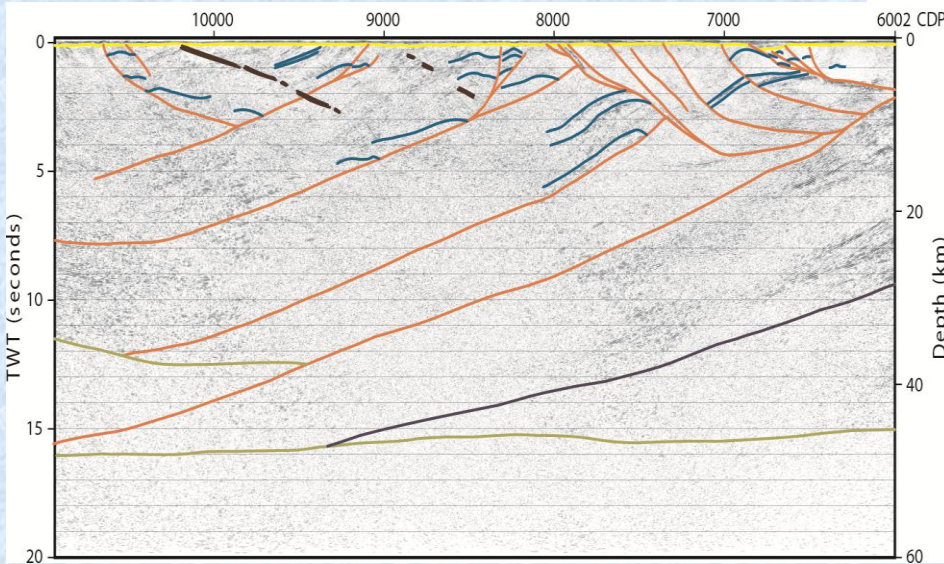
- Moho poorly imaged
- Deep under the Glenburgh Terrane (15.5 s TWT ~ 47 km) – tied to line 10GA-CP2
- Shallow under the Narryer Terrane (11 s TWT ~ 33 km) – tied to lines 10GA-YU1 and 11GA-SC1
- Duplication of Moho by underthrusting
- No resolution of upper crustal units apart from the Nardoo Granite



Crustal terranes and seismic provinces



Crustal terranes and seismic provinces



Suture zones revisited

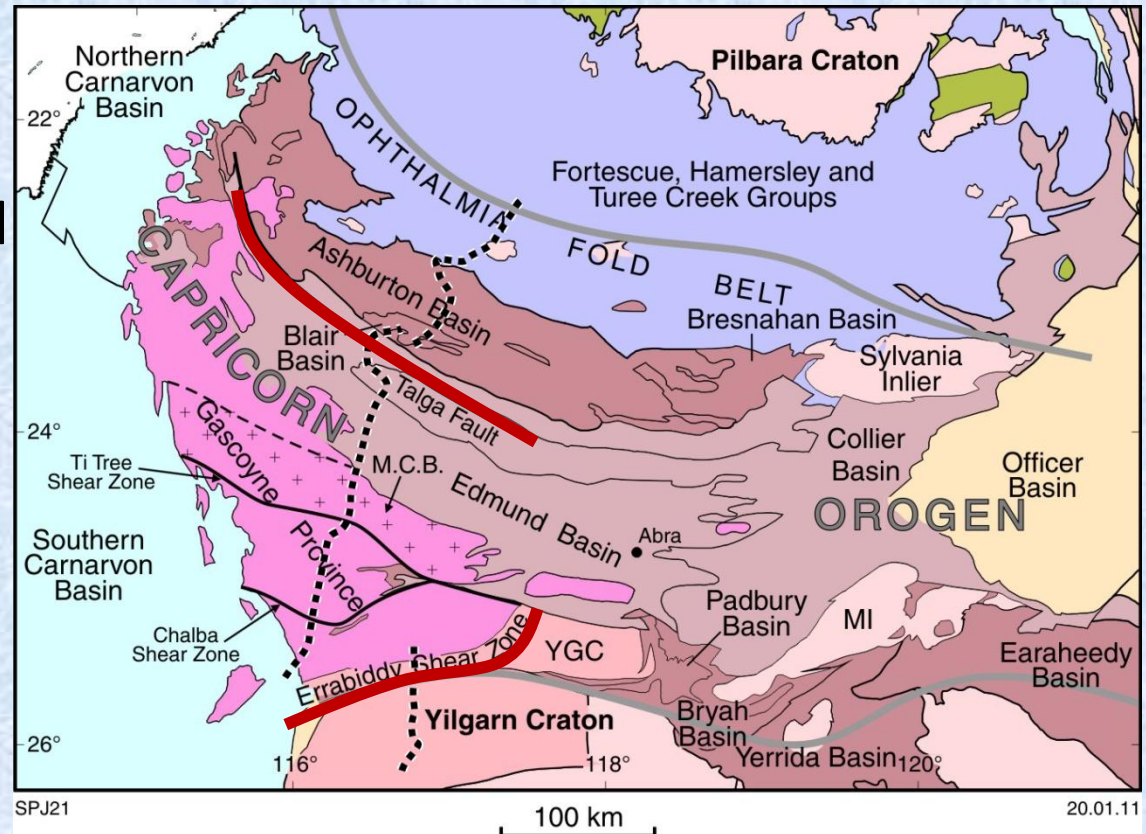
Assembled during two distinct and separate events. Two collisions and two sutures

- Collision/accretion of the Pilbara Craton with the oldest part of the Gascoyne Province (Glenburgh Terrane) during the 2215–2145 Ma Ophthalmian Orogeny

• TALGA FAULT

- Collision of a combined Pilbara Craton – Glenburgh Terrane with the Yilgarn Craton during the 2005–1950 Ma Glenburgh Orogeny

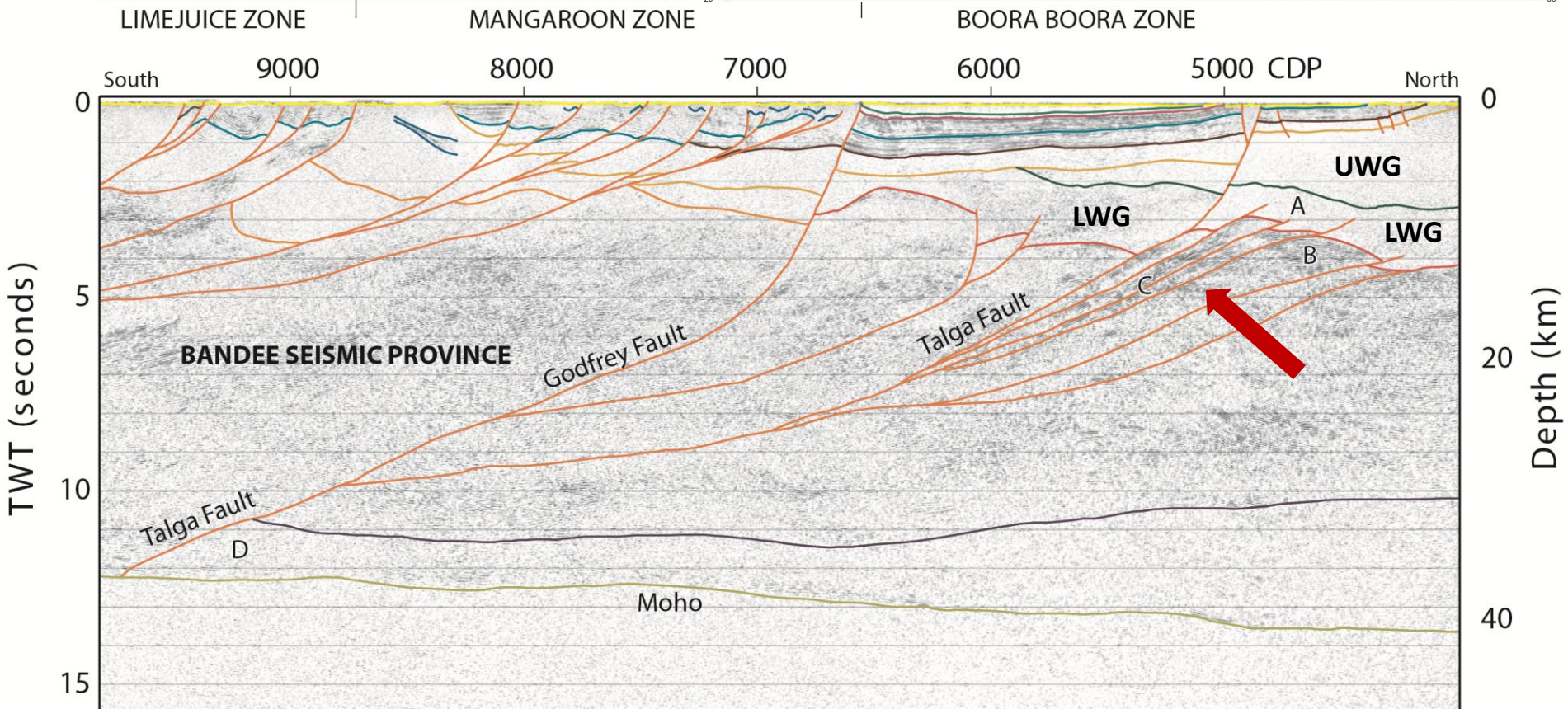
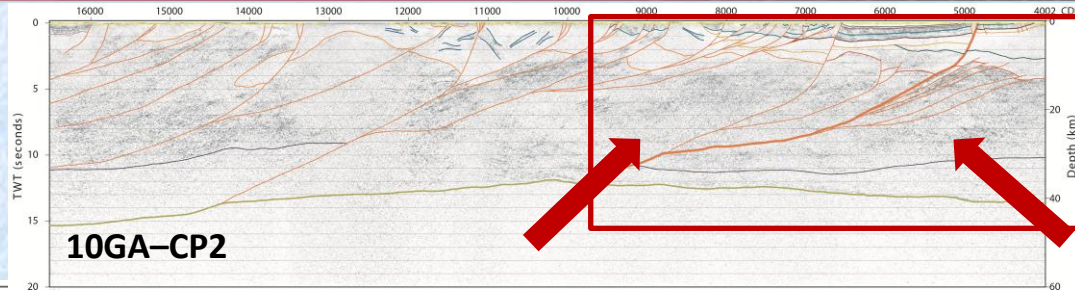
• ERRABIDY SHEAR ZONE



Pilbara Craton – Glenburgh Terrane suture



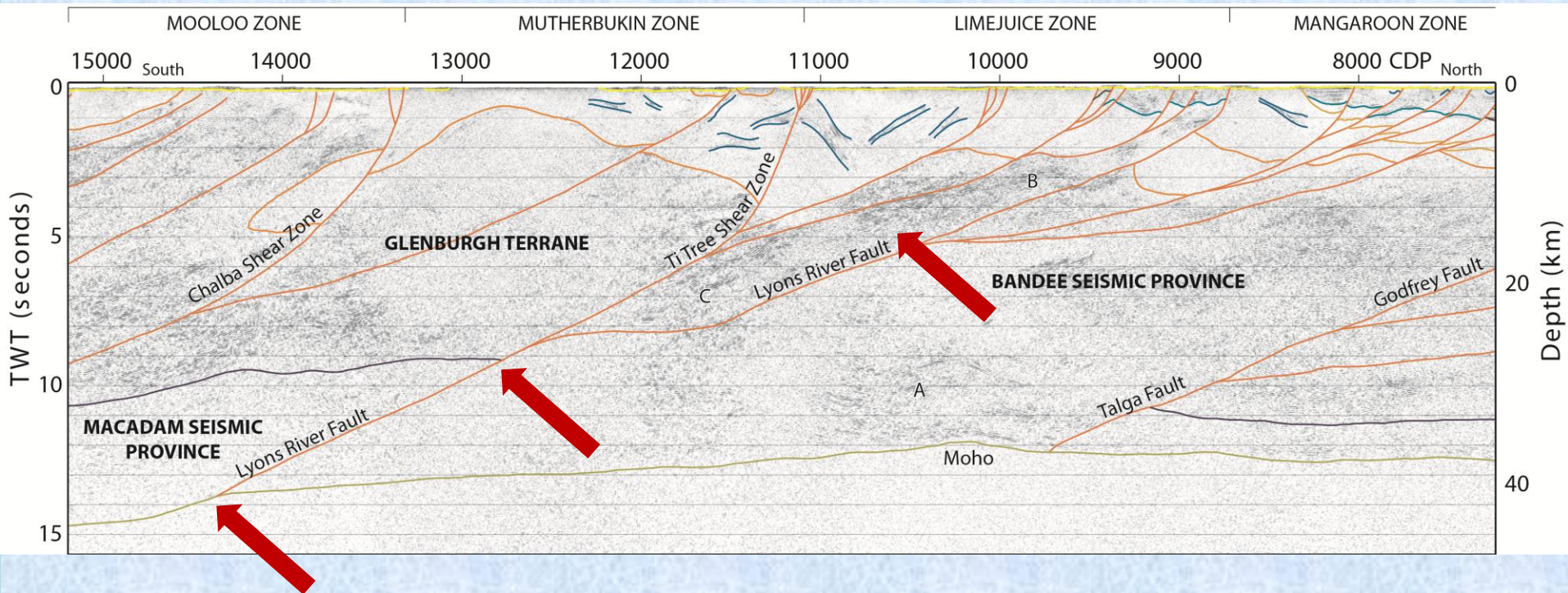
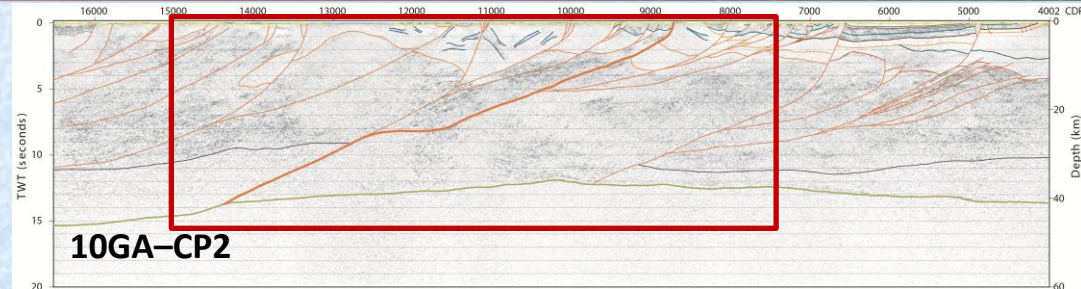
The Talga Fault



Pilbara Craton – Glenburgh Terrane suture



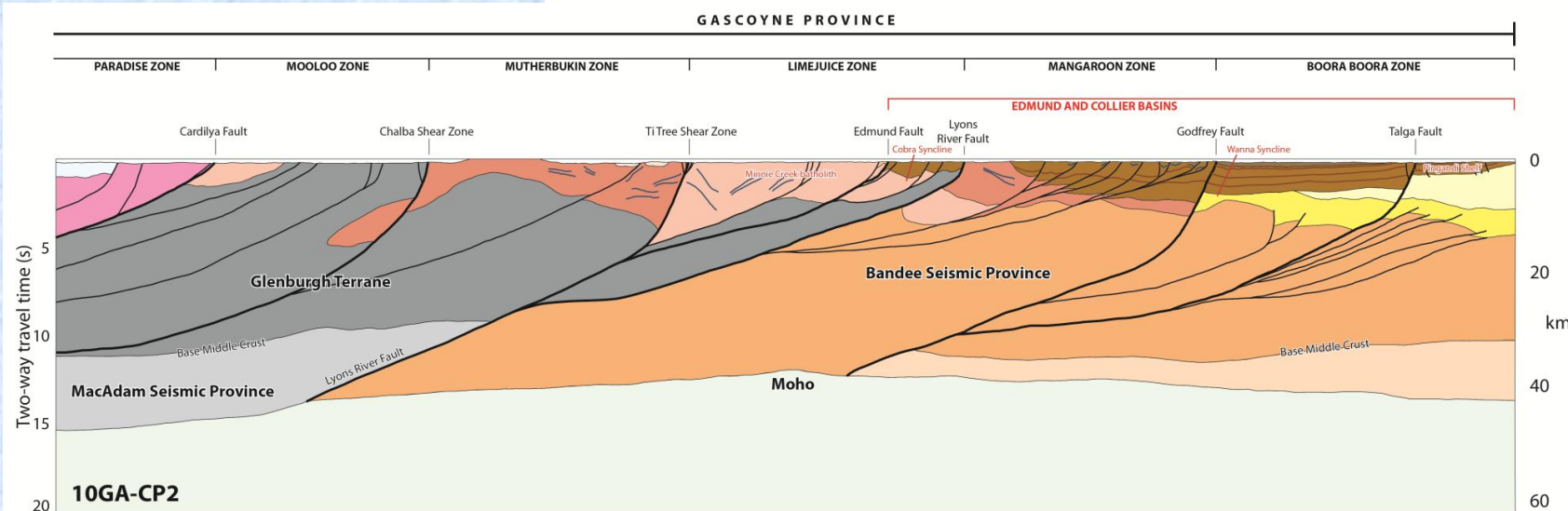
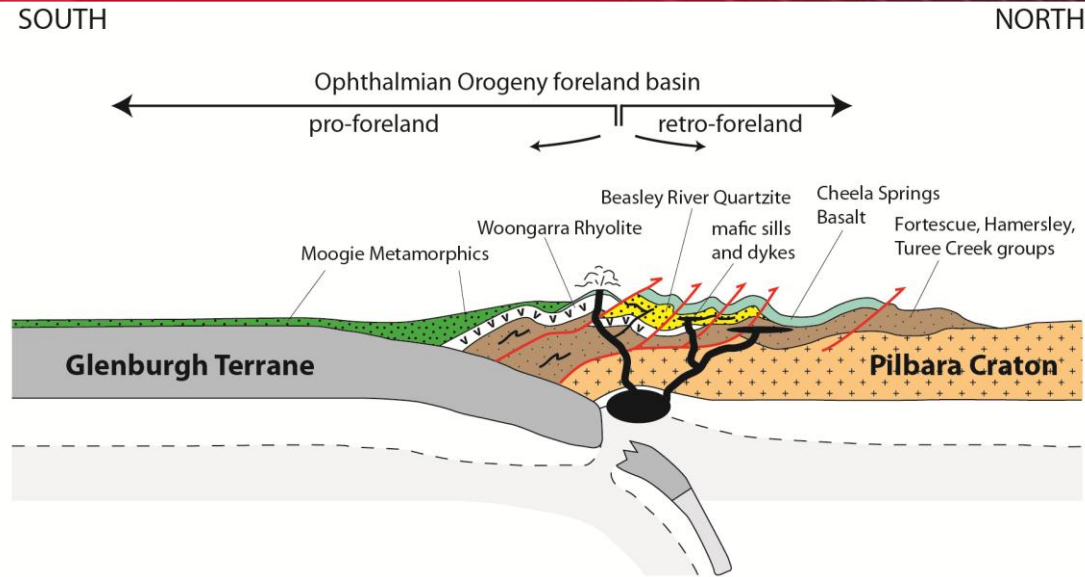
The Lyons River Fault



Implications for the 2215–2145 Ma Ophthalmian Orogeny



- Original geodynamic model is potentially incorrect – southward-directed subduction
- Reasonably assume some form of magmatic arc leading up to the collision
- Not evident in the southern Pilbara
- Need to be looking in the Glenburgh Terrane

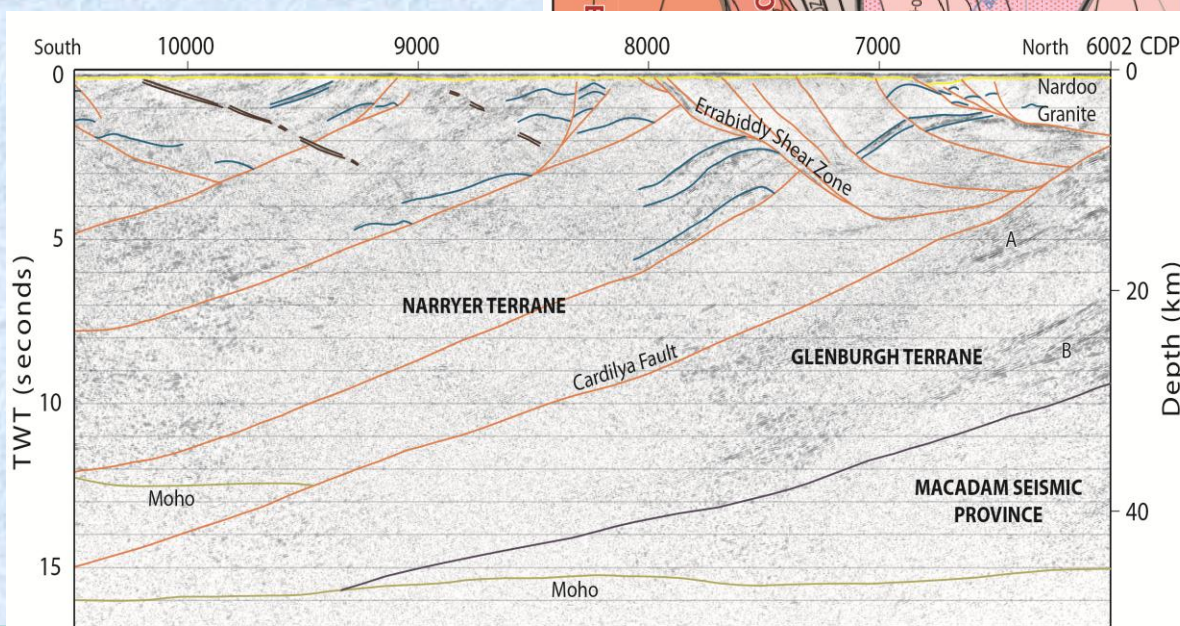
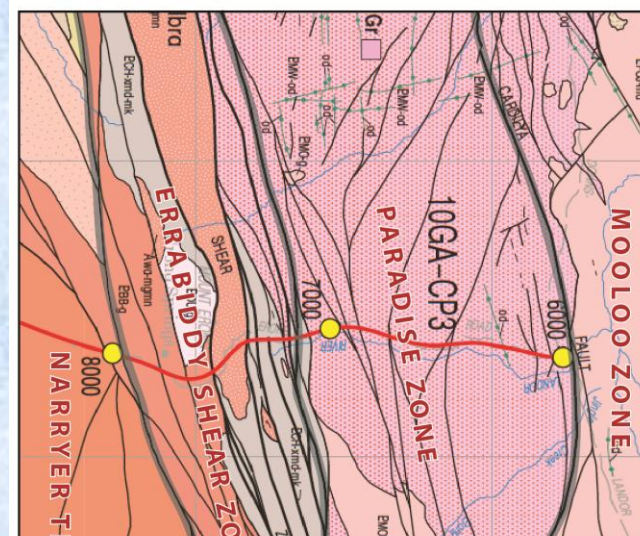


Glenburgh Terrane – Yilgarn Craton suture



The Errabiddy Shear Zone

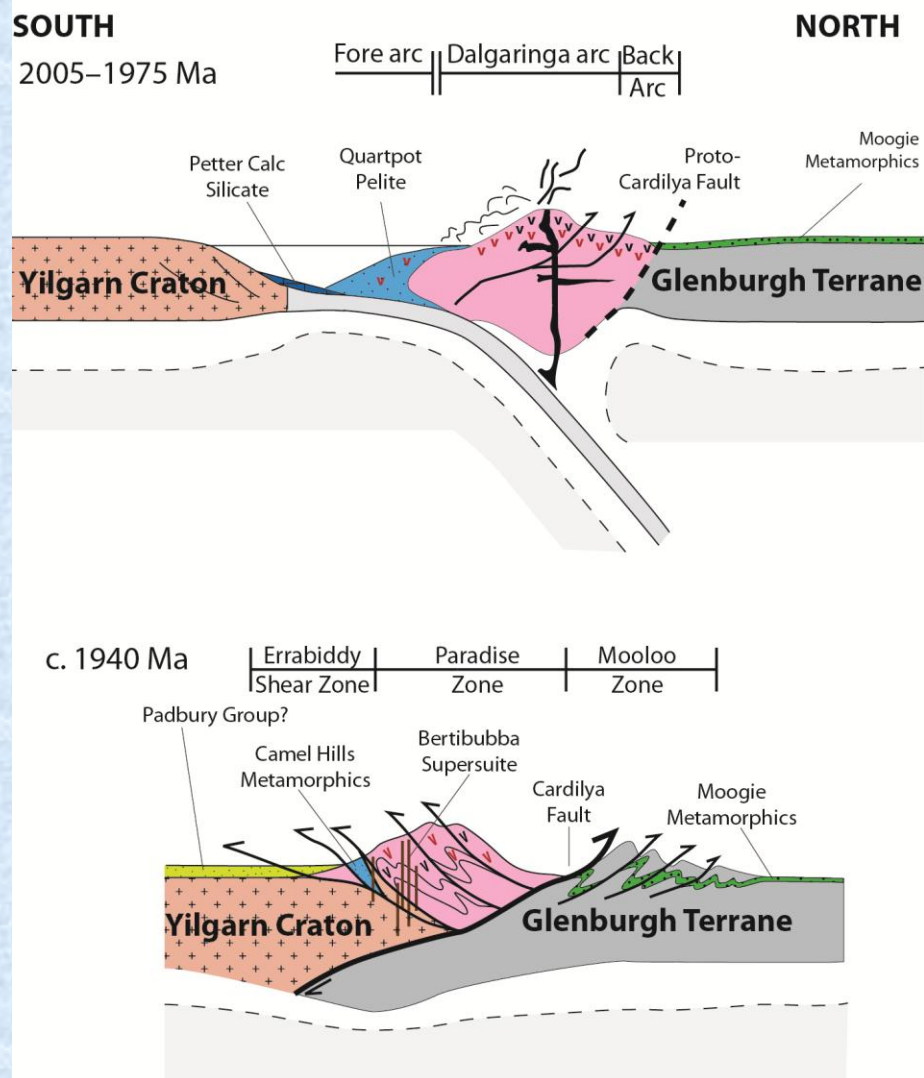
- Moderately north-dipping imbricate zone
- Intersects the moderately south-dipping Cardilya Fault at 4 s TWT (~12 km)
- Cardilya Fault transects the entire crust, duplicating the Moho
- Strong reflections in the GT indicate high strain zone



Errabiddy Shear Zone and Cardilya Fault



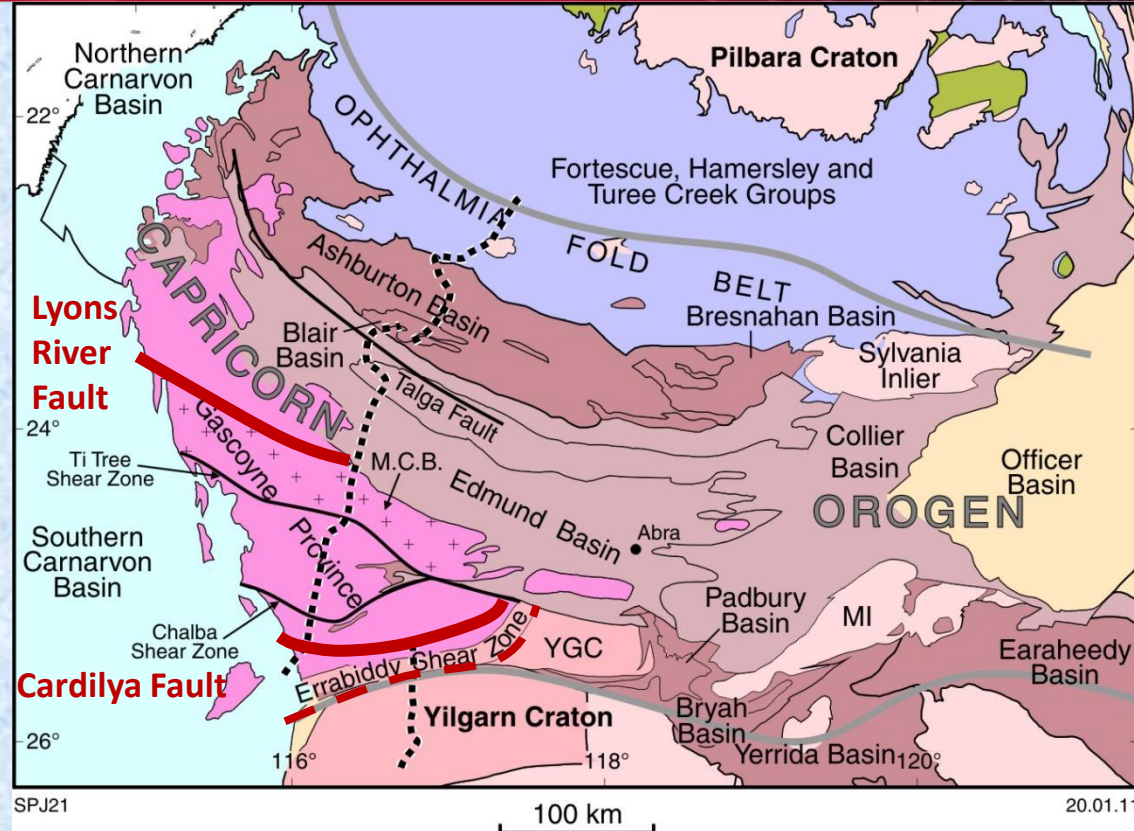
- Errabiddy Shear Zone is the principal suture between the Glenburgh Terrane and the Yilgarn Craton
- Cut by the Cardilya Fault
- Both related to the collision during the Glenburgh Orogeny
- Proto-Cardilya Fault may have formed in thinned crust in the back arc of the Dalgaringa Arc



Suture Zones - conclusions

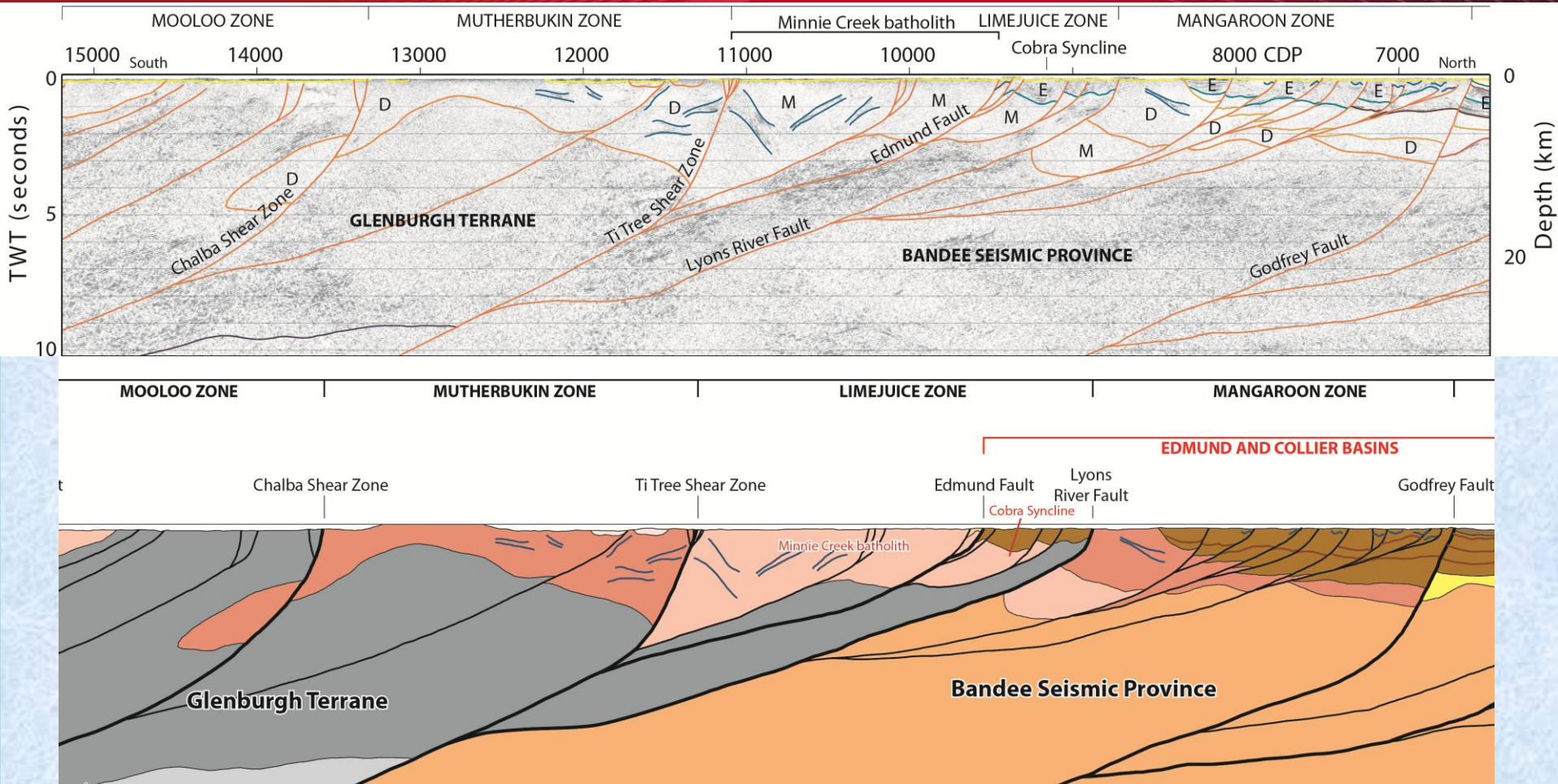


- Three crustal blocks and two suture zones
- Lyons River Fault – Minga Bar Fault – Minnie Creek Fault represent the northern suture between the Pilbara Craton (Banded SP) and the Glenburgh Terrane

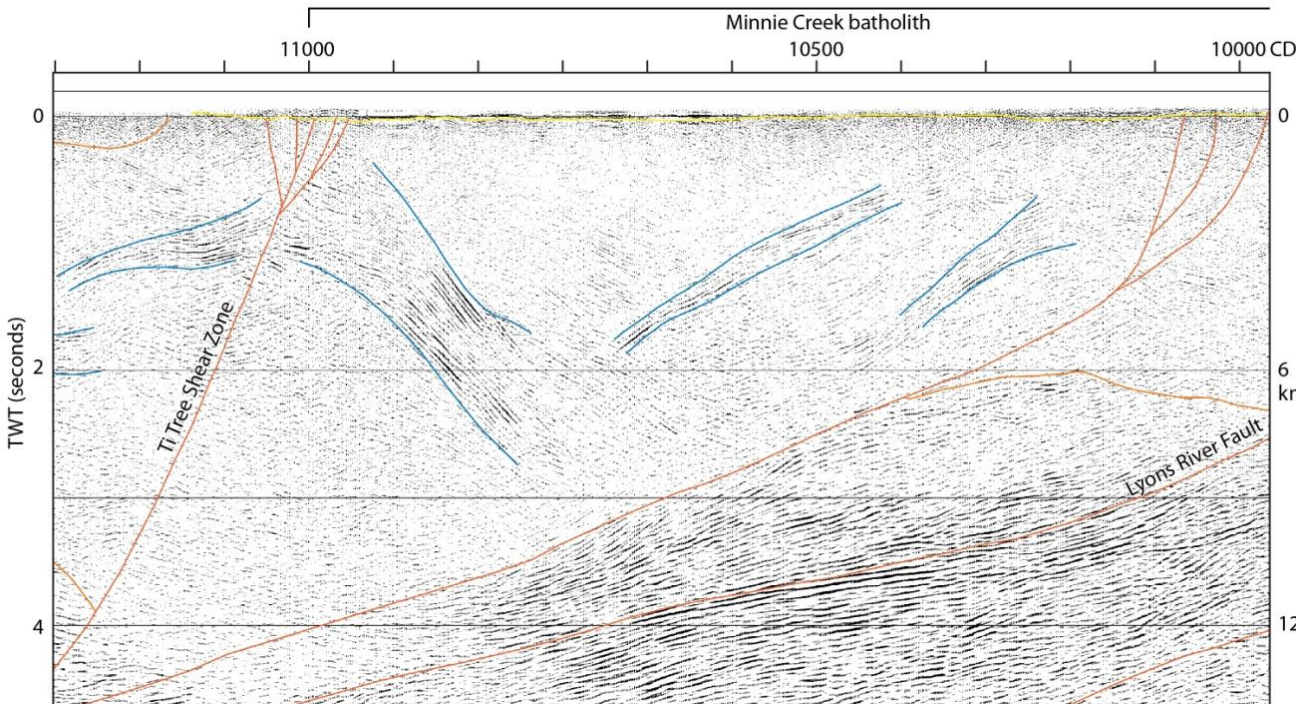
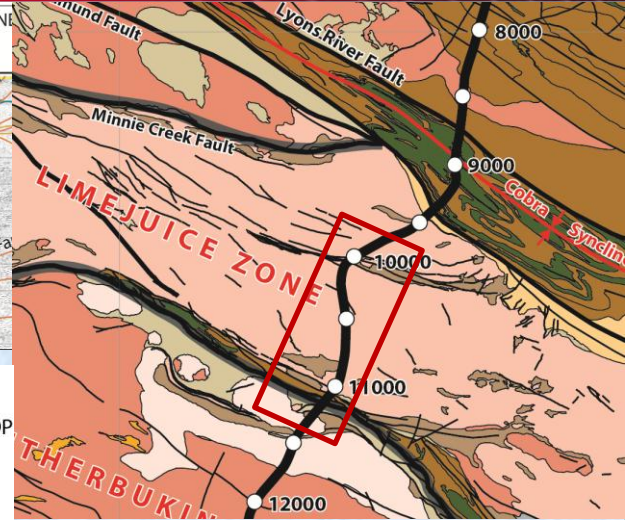
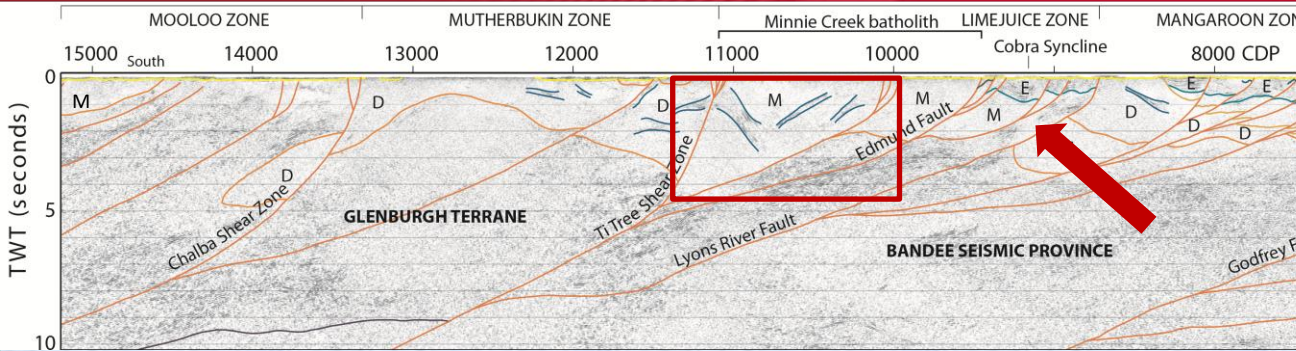


- Although the Errabiddy Shear Zone **IS** the principal suture zone between the Glenburgh Terrane and Yilgarn Craton, the Cardilya Fault is the main crustal structure that separates the two

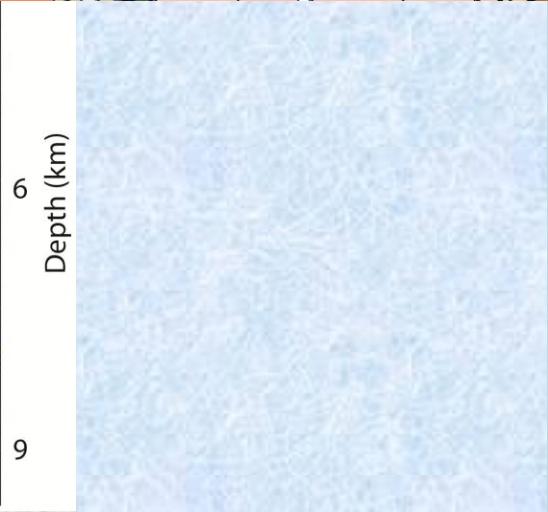
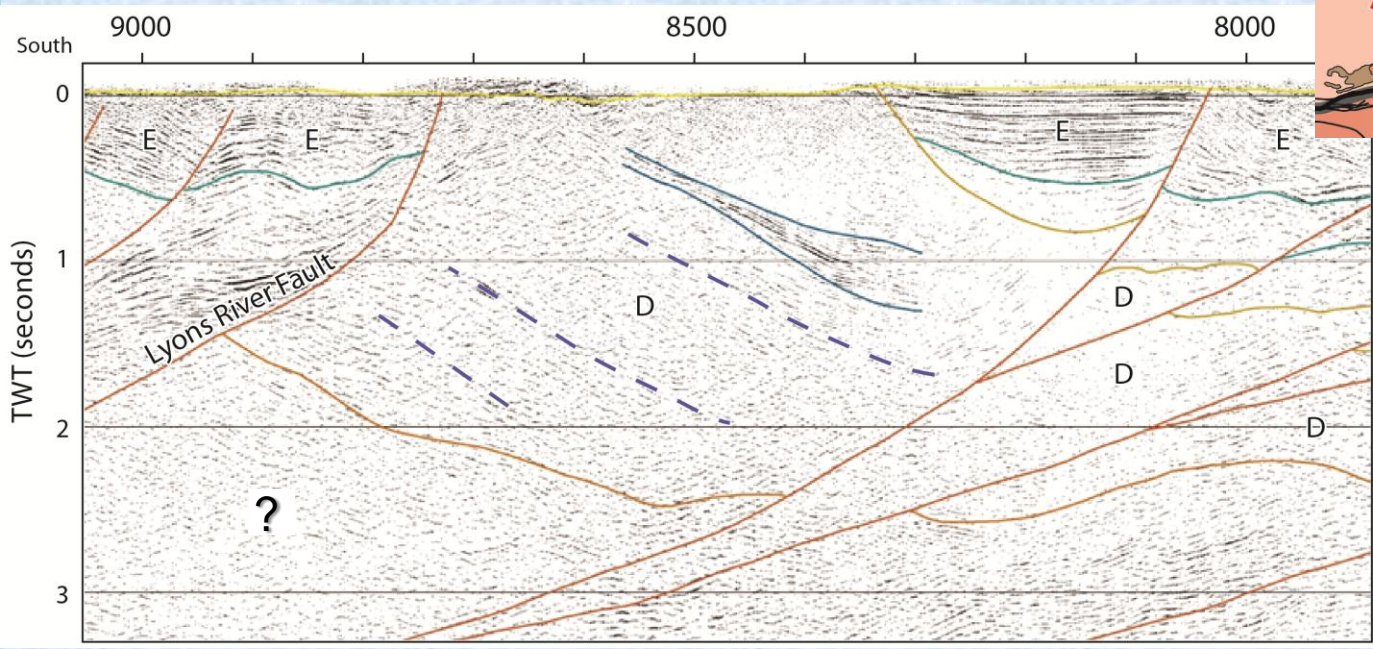
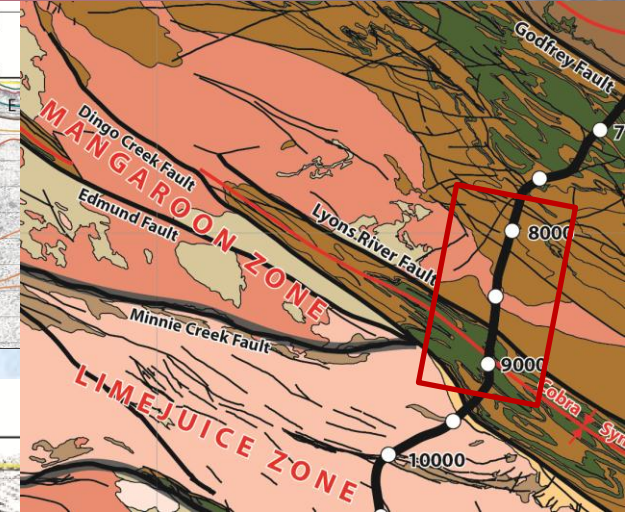
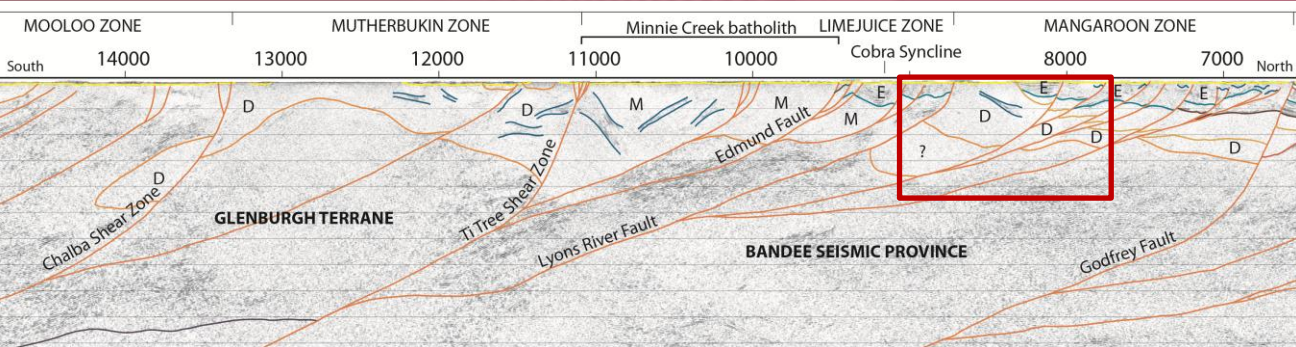
Batholiths and granite intrusions



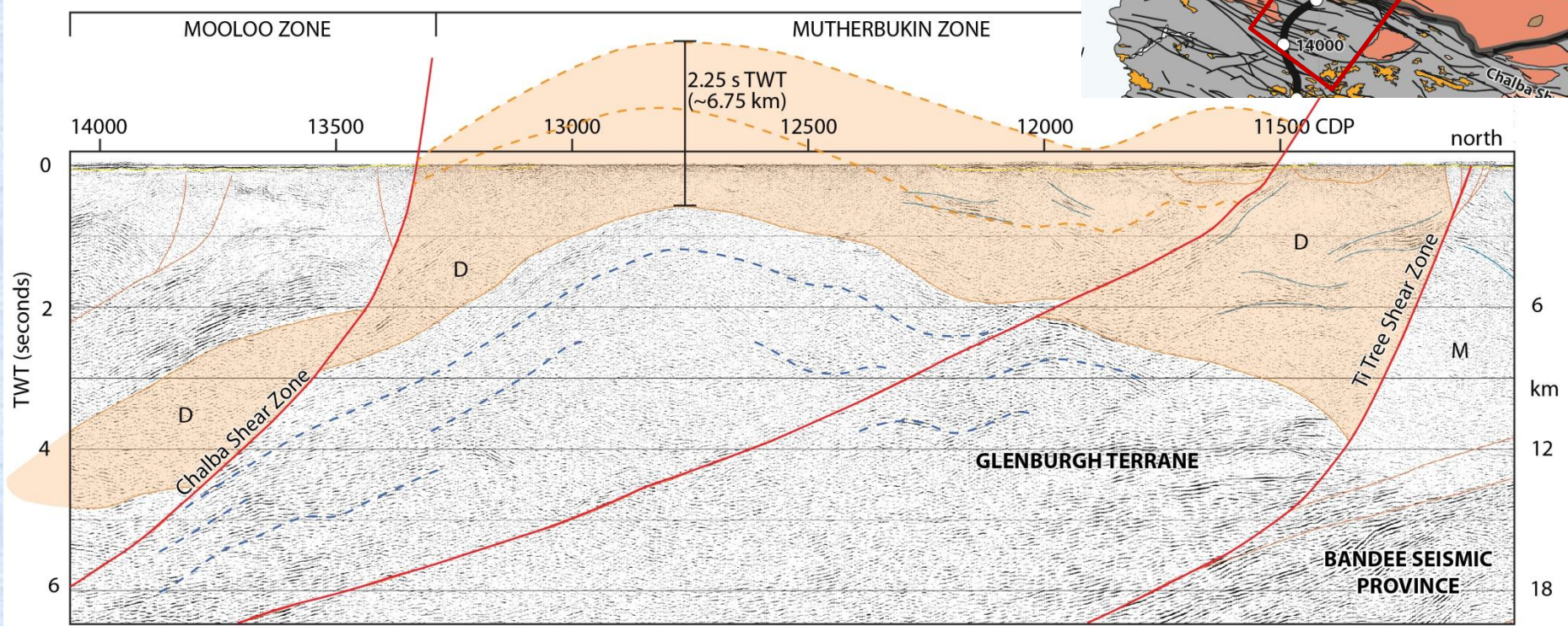
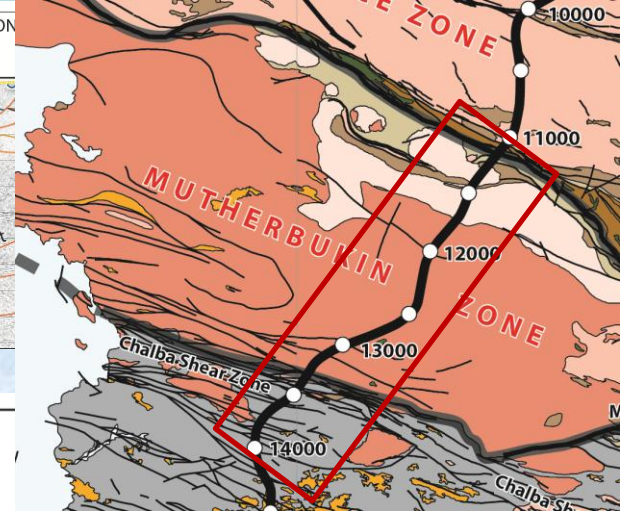
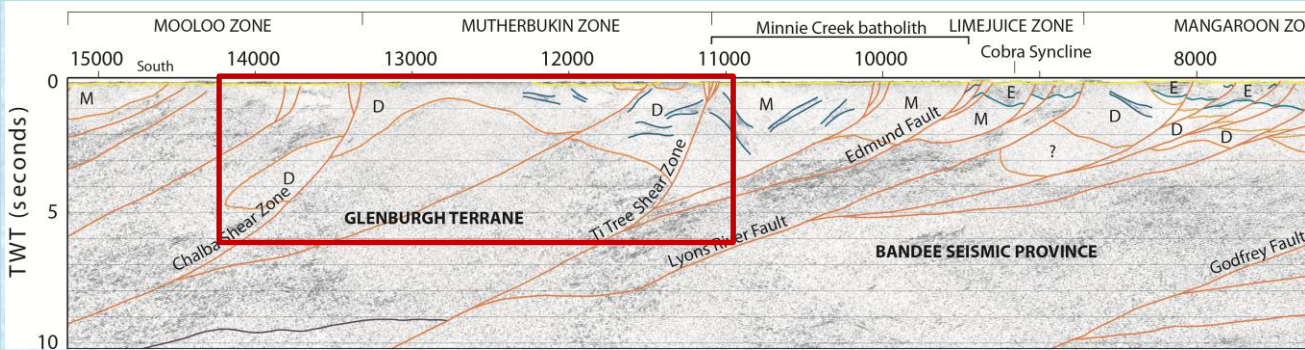
Capricorn Orogeny and Moorarie Supersuite – Minnie Creek batholith



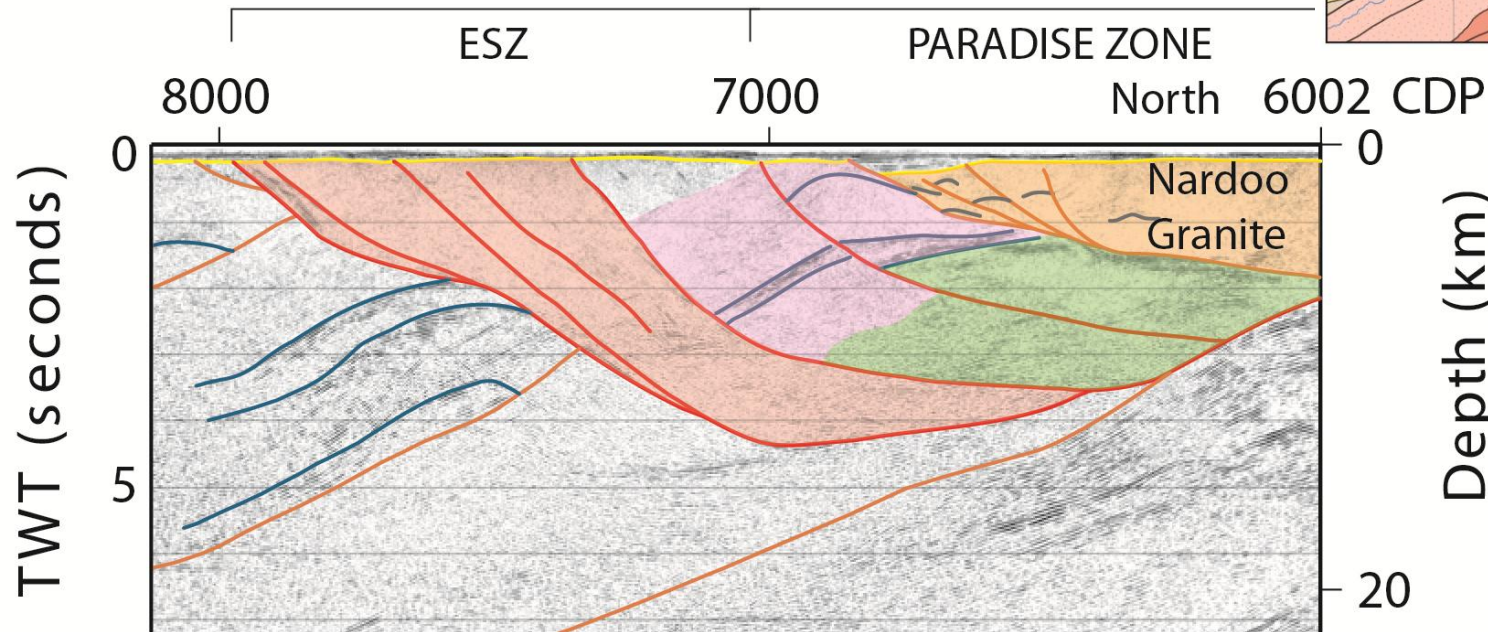
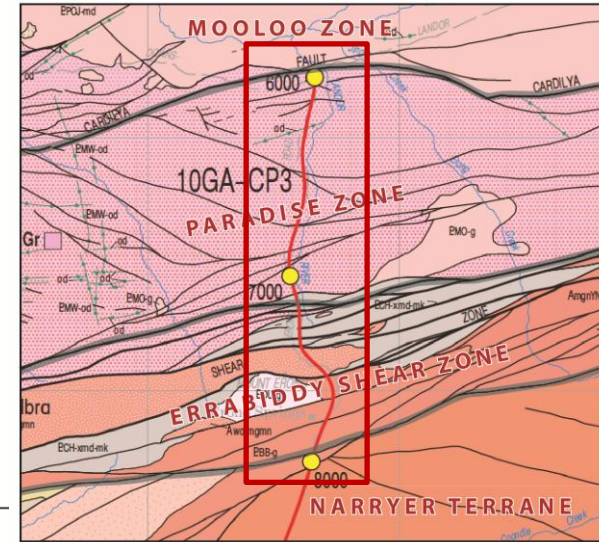
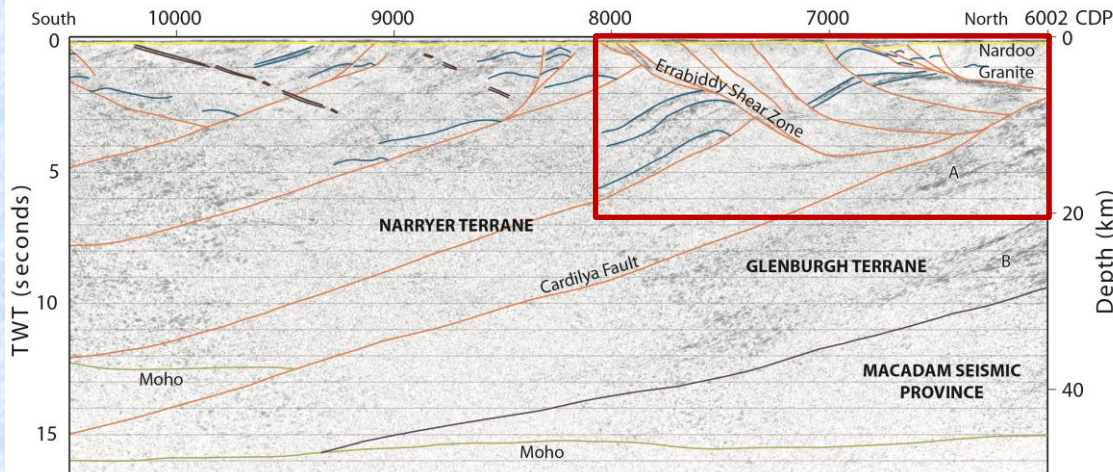
Mangaroon Orogeny and Durlacher Supersuite – Mangaroon Zone



Mangaroon Orogeny and Durlacher Supersuite – Mutherbukin Zone



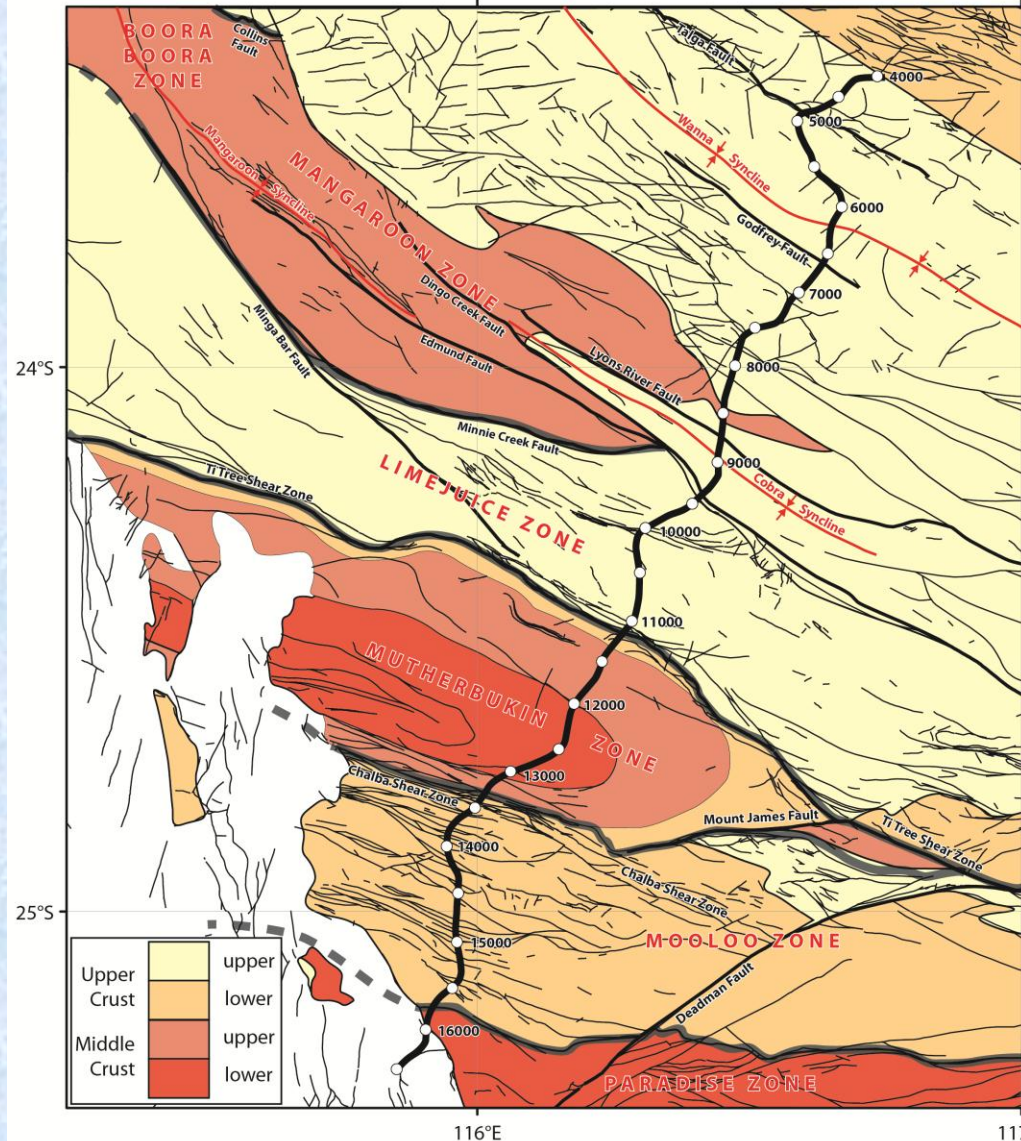
Glenburgh Orogeny and Dalgaringa Supersuite



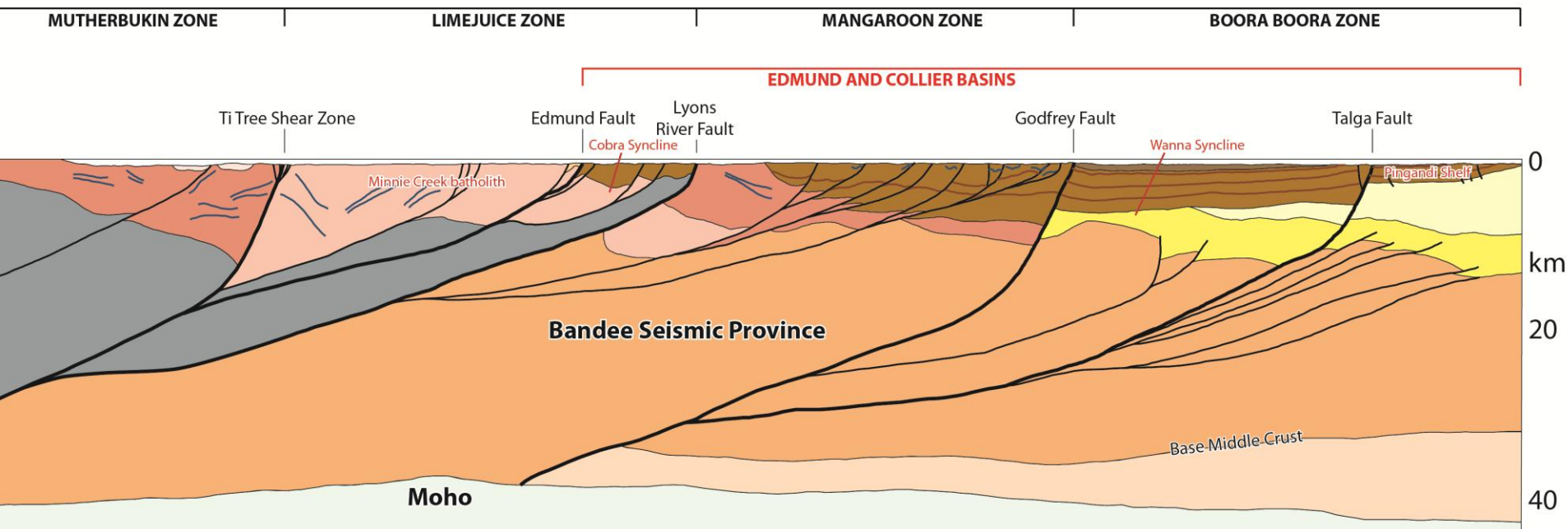
Fault reactivation and crustal reworking



- Gascoyne Province zone boundaries are all major crustal-scale faults or shear zones
- Juxtapose rocks from different crustal levels
- To accommodate deformation and metamorphism during punctuated crustal reworking, these faults must have been multiply reactivated



Fault reactivation and crustal reworking



Talga Fault – Ophthalmian thrust (c. 2200 Ma), Edmund Basin extensional fault (c. 1450 Ma).

Godfrey Fault – Edmund Basin extensional Fault (c. 1465 Ma), Mutherbukin thrust fault (c. 1200 Ma).

Lyons River Fault – Ophthalmian suture zone (c. 2200 Ma), Mangaroon reactivation (c. 1680 Ma), Edmund Basin extensional Fault (c. 1465 Ma), Edmundian/Mutherbukin reactivation (c. 1200 or c. 1000 Ma).

Crustal architecture



- All major faults and shear zones are principal crustal structures related to the assembly of the West Australian Craton during the Ophthalmian and Glenburgh Orogenies
- Reactivation of these structures during over one billion years of repeated crustal reworking, has controlled the partitioning of tectonometamorphism, granite magmatism and sedimentation into discrete tectonic corridors
- The present-day architecture and post 1950 Ma geological history of the Gascoyne Province has ultimately been influenced by events that took place some 2200 to 1950 million years ago

Summary



- The seismic lines have added significant knowledge and understanding of the tectonic evolution of this part of the Capricorn Orogen
- Determined the location and orientation of the major suture zones and crustal structures
- Better understanding of the depth and shape of the Minnie Creek batholith and other Proterozoic intrusions
- Overall, a much more precise understanding of the crustal architecture of the region