Exposing the Eucla basement: what separates the Albany–Fraser Orogen and the Gawler Craton?

Part 1

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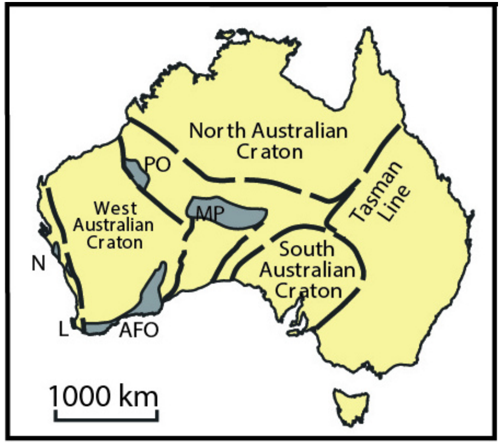
EXPLORATION INCENTIVE SCHEME

Introduction

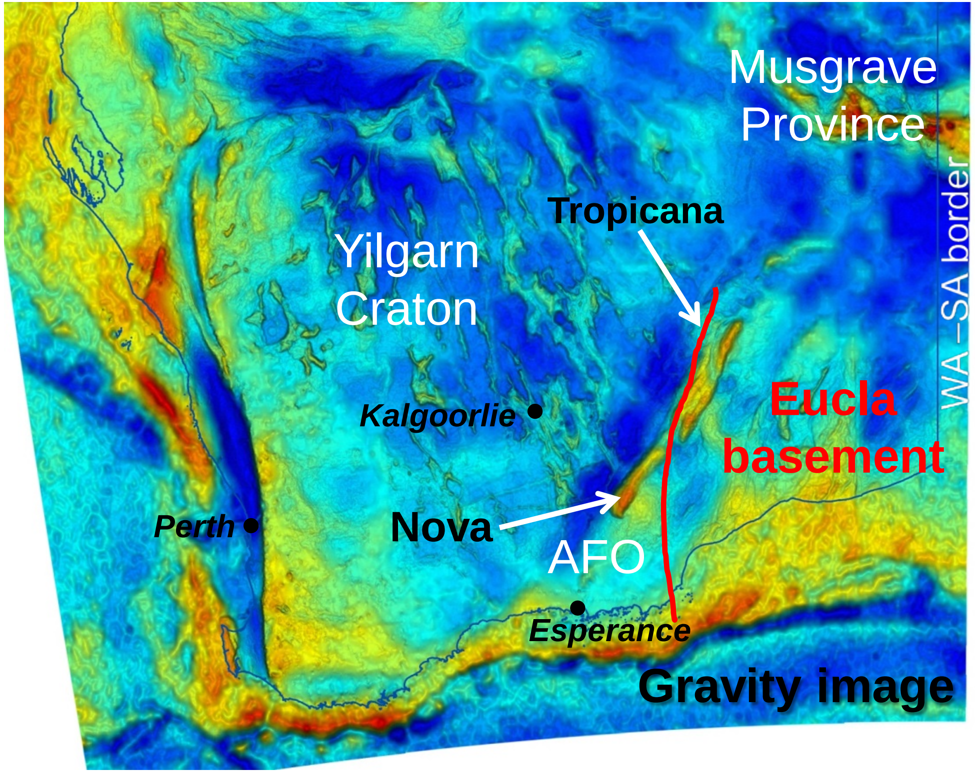
The problem: a vast area of unknown Precambrian crust entirely under cover – missing links in Proterozoic Australia assembly

The answer: The Eucla basement stratigraphic drilling program – new information, encourage greenfields exploration



EXPLORATION INCENTIVE SCHEME

Eucla basement – what lies between



Basement completely hidden – drill cores and geophysics only

Figure 2. a) Typical limestone core from the Wilson's Bluff Limestone. b) Typical black shale core from the Madura Formation. c) Typical micaceous siltstone core from the Madura Formation. d) Unconsolidated sand interlayered with dark siltstone from the Loongana Formation.

The cover

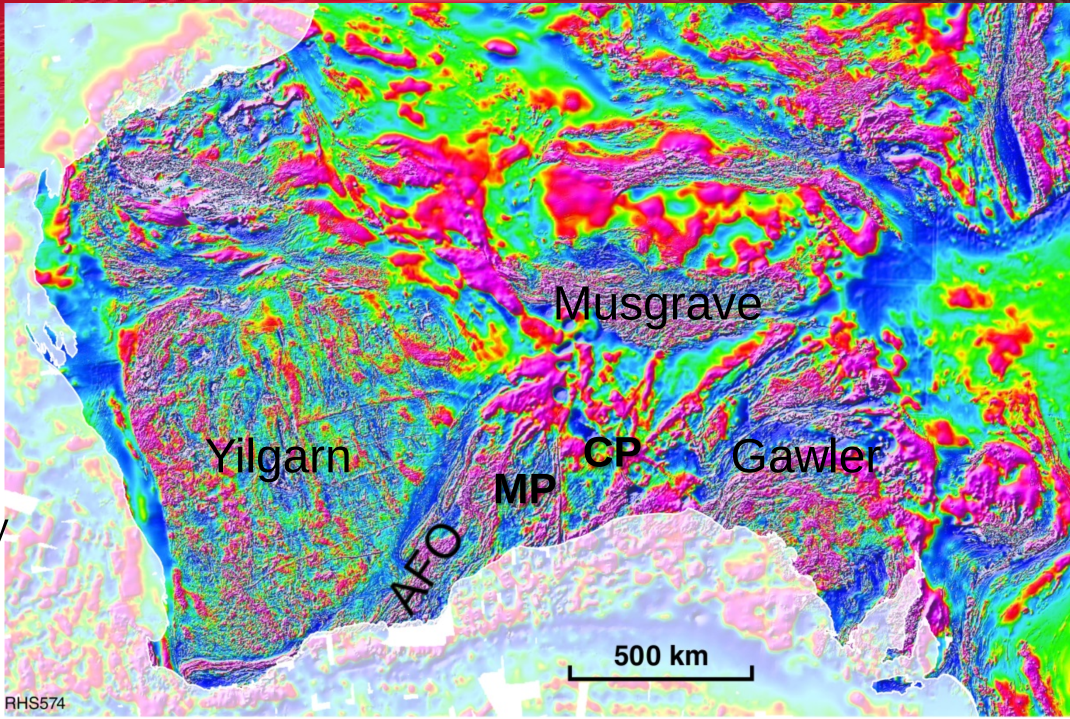
- Basement drill cores (i.e. the rocks) = what, and how
- Geophysical data = where (mostly, and how)

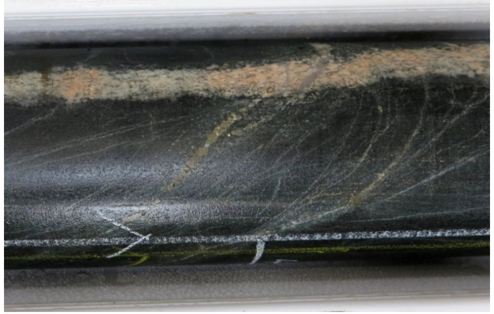
Two distinct, but related, provinces

Evolution (and prospectivity) of two craton margins:

- Western Gawler Craton (SAC/Mawson) and Coompana Province
- Albany–Fraser Orogen (AFO; Yilgarn Craton/WAC) and Madura Province

Observation: Large crustal mass of dominantly oceanic heritage between AFO and Gawler
Conclusion: No continental collision



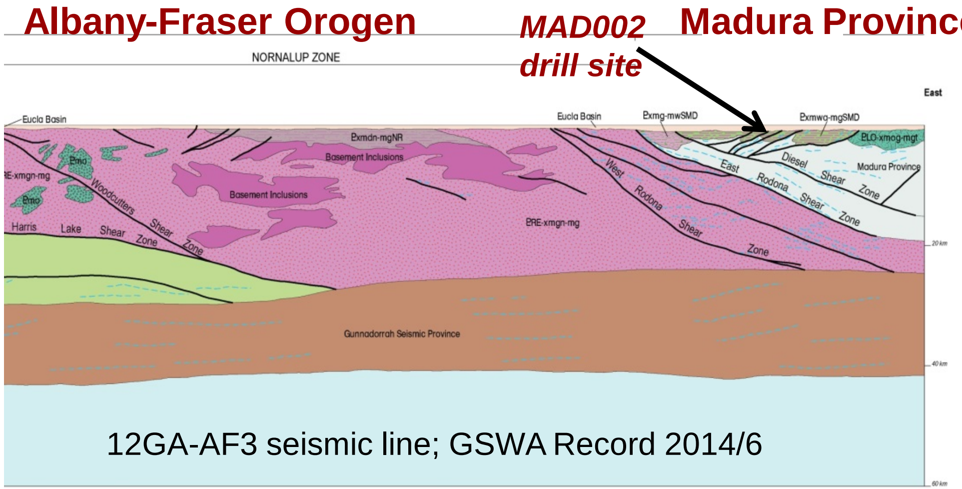


Prospectivity (see GSWA Record 2015/10):

- Cu theme in both provinces (Cu in sulfides in most cores)
- VMS, IOCG, subduction or arc-related, intrusion-related (shoshonites)

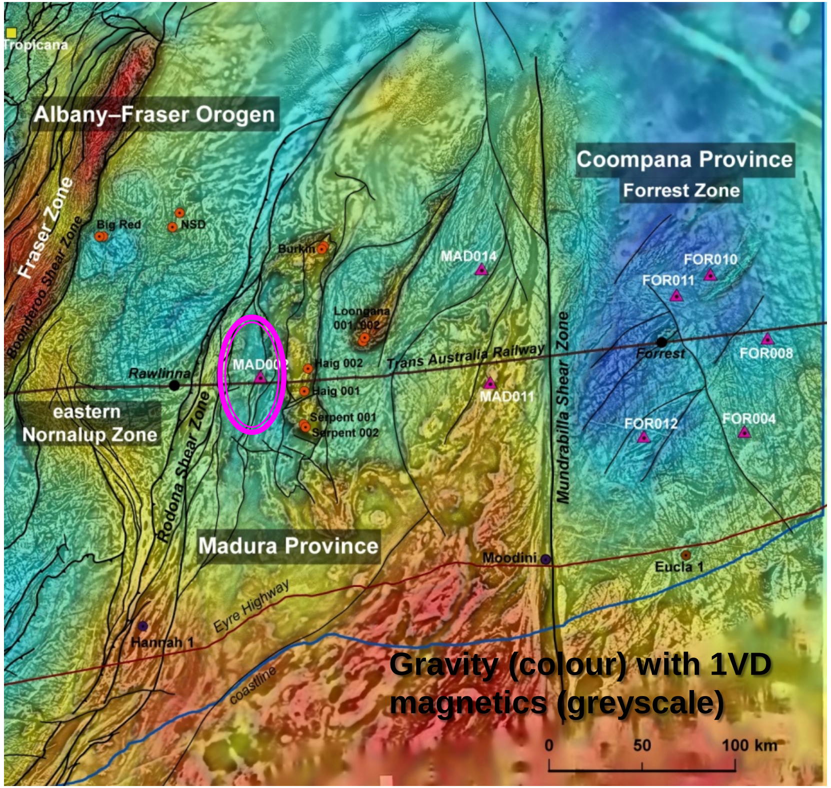
Madura Province

- Madura Province bound by Rodona and Mundrabilla Shear Zones
- Three stratigraphic cores drilled to complement existing company cores
- Sites selected to map geophysical domains



12GA-AF3 seismic line; GSWA Record 2014/6

GSWA stratigraphic drill hole
EIS co-funded drill hole
Company donated core site

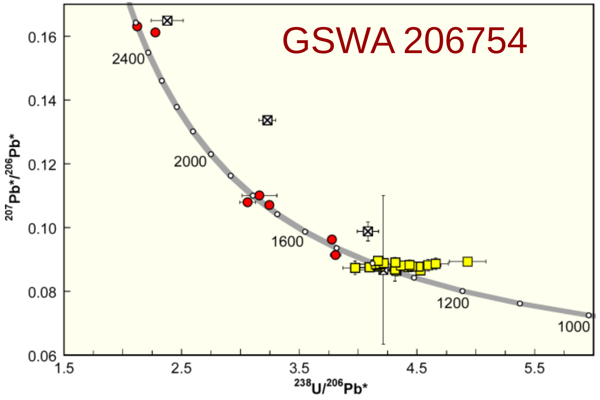


Gravity (colour) with 1VD magnetics (greyscale)

Madura Province: MAD002 drill core, basement at 390 m

Two main units:

- Fine-grained, laminated (blue-green hbl-plag-biotite-epidote-quartz-titanite) mafic schist (Pinto Basalt; E-MORB/OIB)
- Estimated lower amphibolite facies peak metamorphism
- Intruded by medium-grained plagiogranite (plag-qtz-biotite-hbl) (Haig Cave Supersuite; adakite)



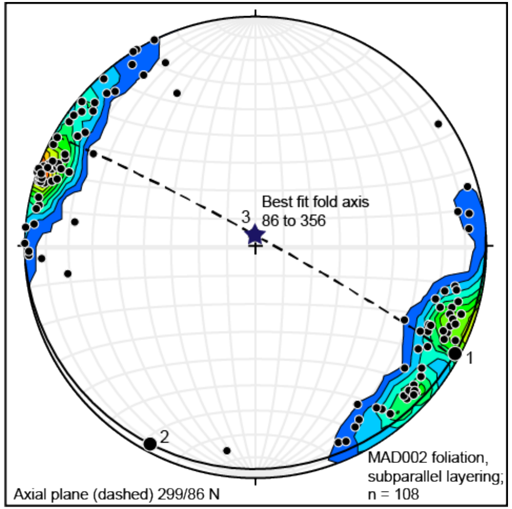
Adakite crystallization: 1389 ± 7 Ma

Photographed dry

Madura Province: MAD002 drill core, basement at 390 m

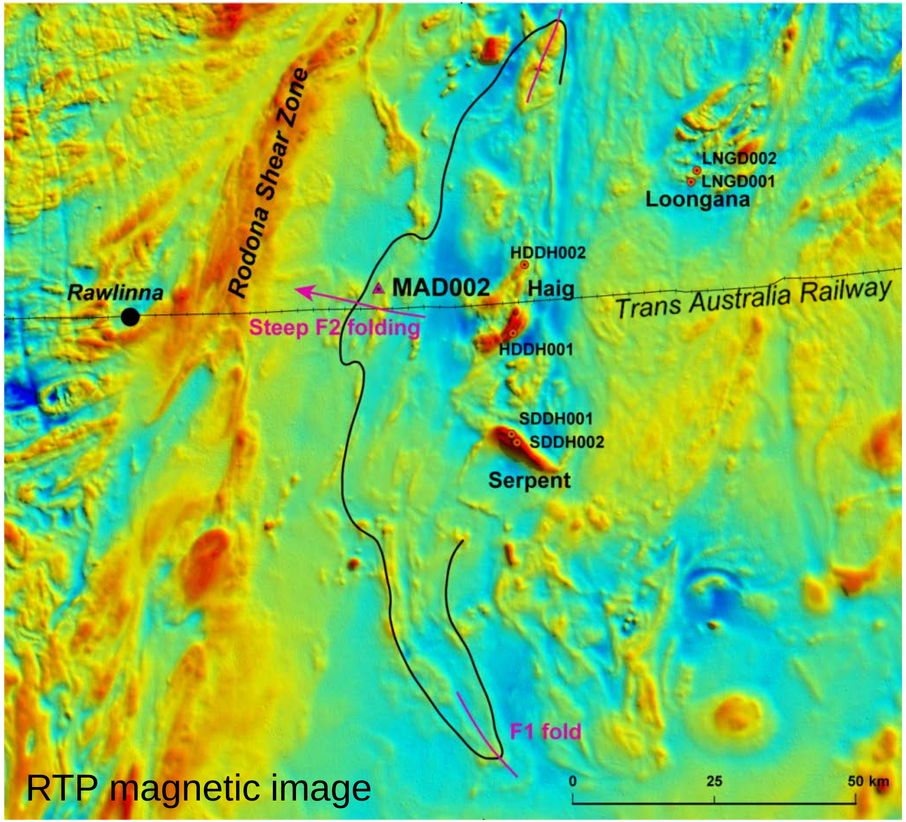
Structural relationships:

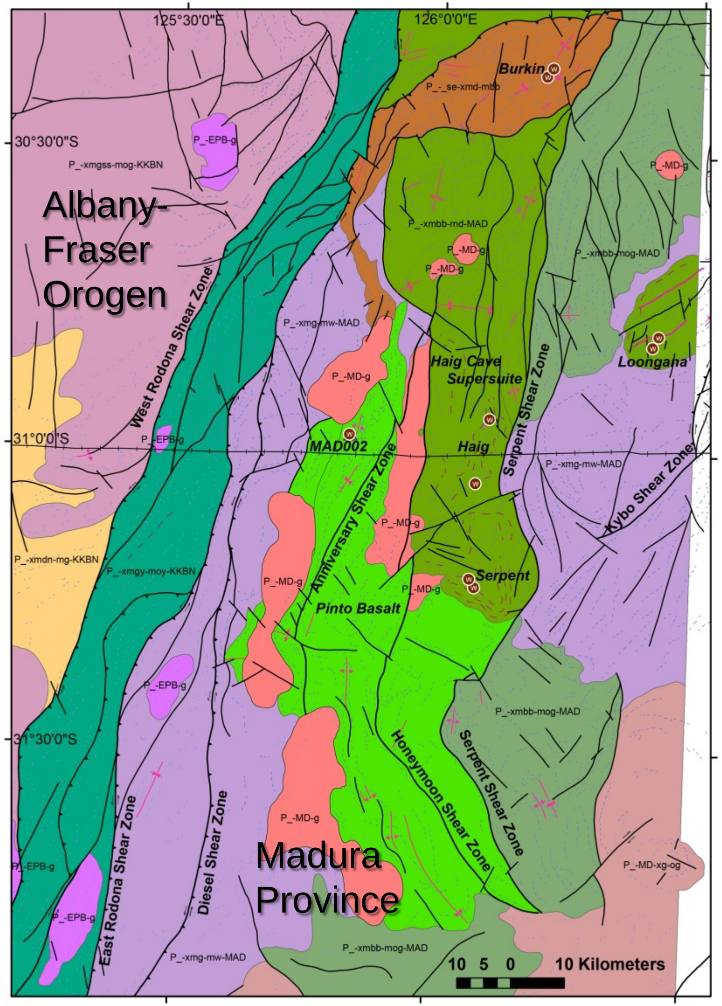
- Sub-vertically plunging, F2 folds of the layering in the metabasalt and the plagiogranite veins; S- and Z-folds
- Hbl-bearing axial planar foliation (S2) in the metabasalt
- Folded plagiogranite veins, but also locally transgress the folds $\Rightarrow$ c. 1389 Ma intrusion pre- to syn-folding



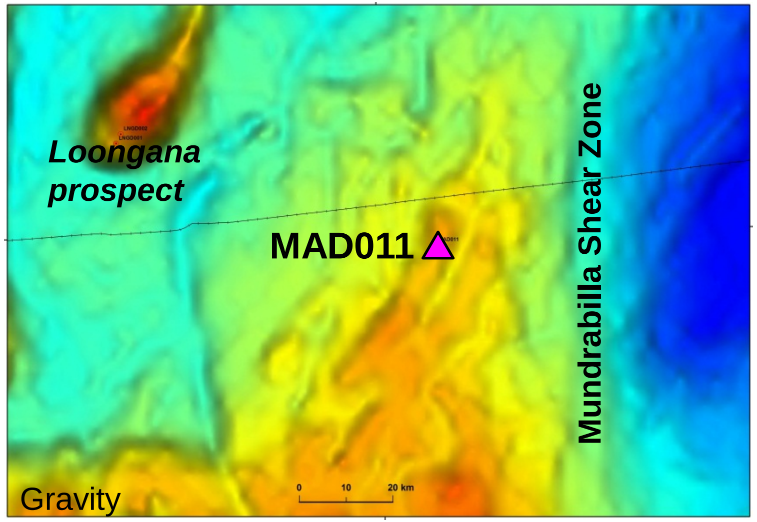
Photographed wet

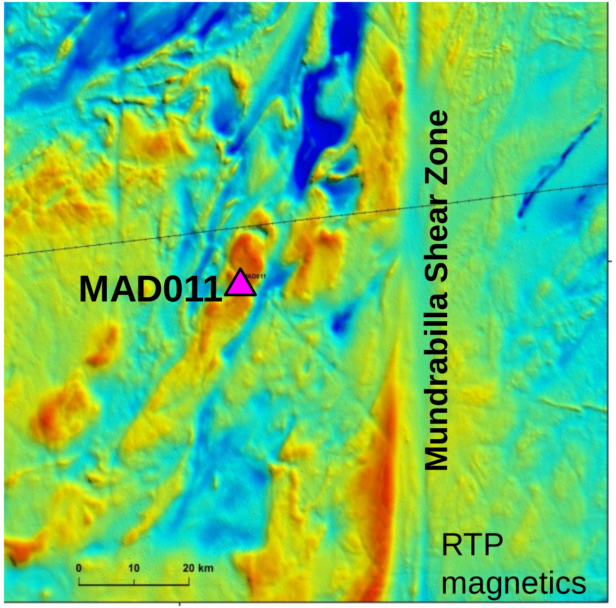
Madura Province: structural and geophysical interpretation

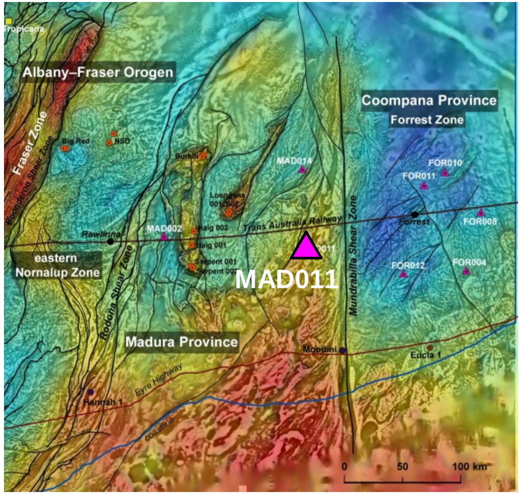




Madura Province: MAD011 drill core, basement at 435 m







Gravity (colour) with 1VD magnetics (greyscale)

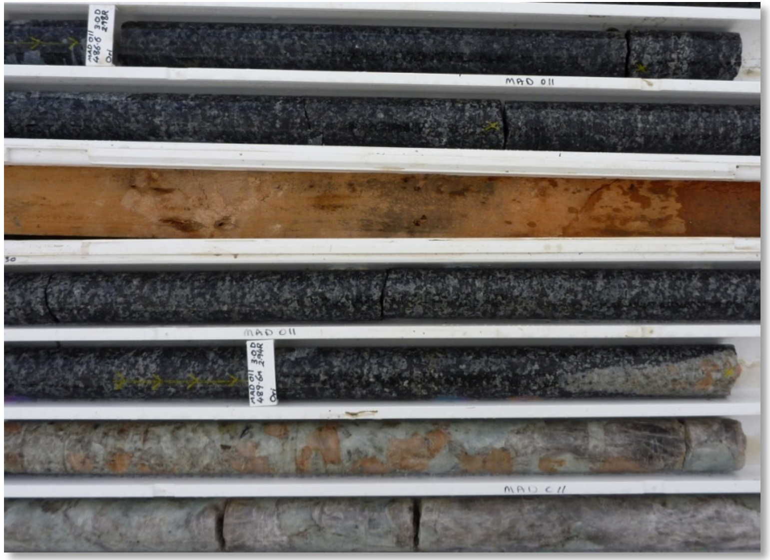
MAD011 maps strong magnetic and gravity features drawn into the Mundrabilla Shear Zone

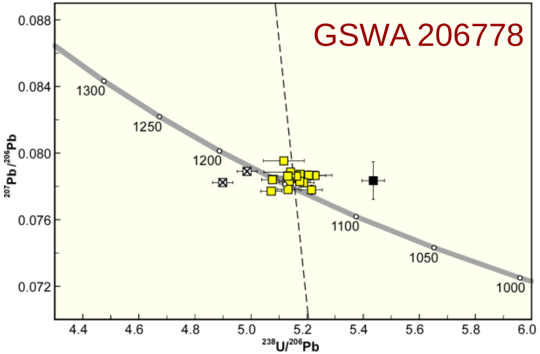
Madura Province: MAD011 drill core, basement at 435 m

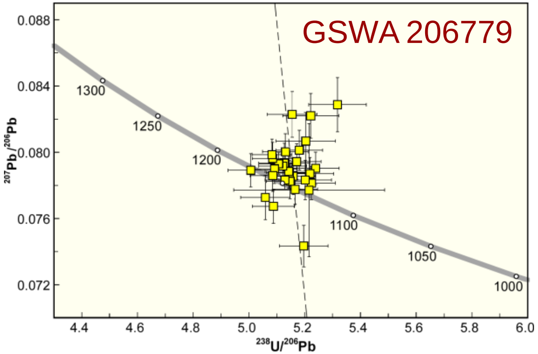
Two main rock types:

1. Medium- to coarse-grained ferro-monzogabbro, grades to a coarse plagioclase-rich leucogabbro (Kestral Cavern Gabbro; High-KFe series Moodini Supersuite)

- Typical assemblage of plag-qtz-mafic clots (hbl-bt)-magnetite, locally opx (retrogressed to cummingtonite)-cpx







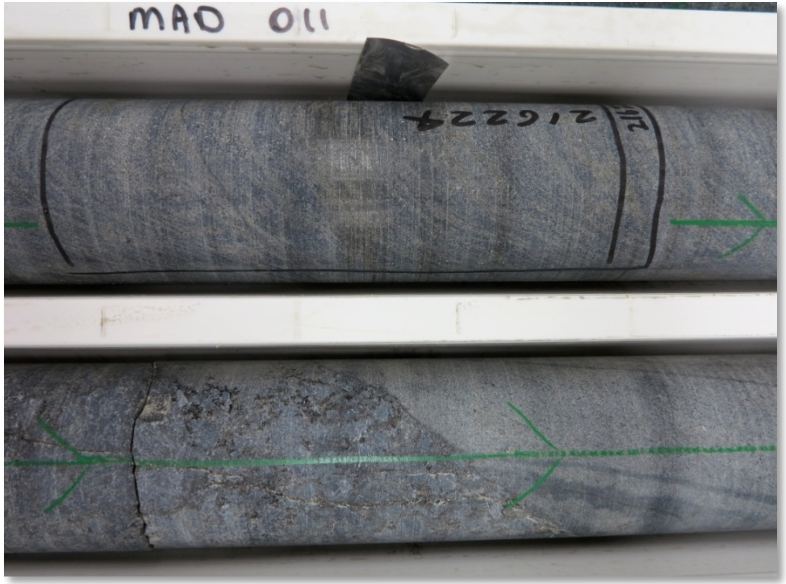
Kestral Cavern Gabbro (Moodini Supersuite) monzogabbro crystallization: 1143 ± 5 Ma; 1144 ± 7 Ma

Photographed wet

Madura Province: MAD011 drill core, basement at 435 m

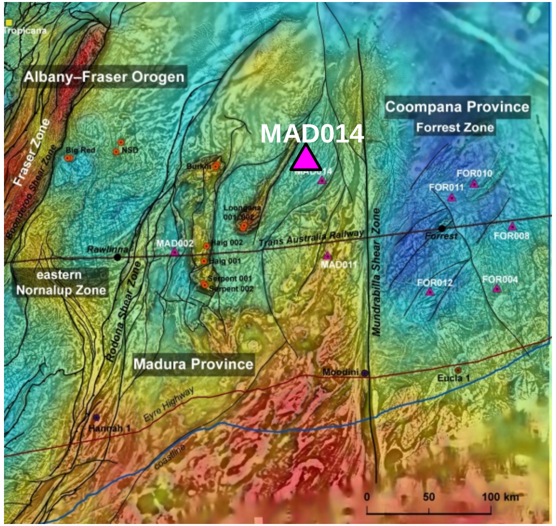
Two main rock types:

2. Rafts or xenoliths of fine-grained, thinly layered and foliated mafic amphibolite:
Typical assemblage of opx-cpx-hbl-plag-ilmenite, locally magnetite and bt; possibly hornfels due to gabbro intrusion (subduction-modified N-MORB, fore-arc or backarc metabasalt)



Photographed dry

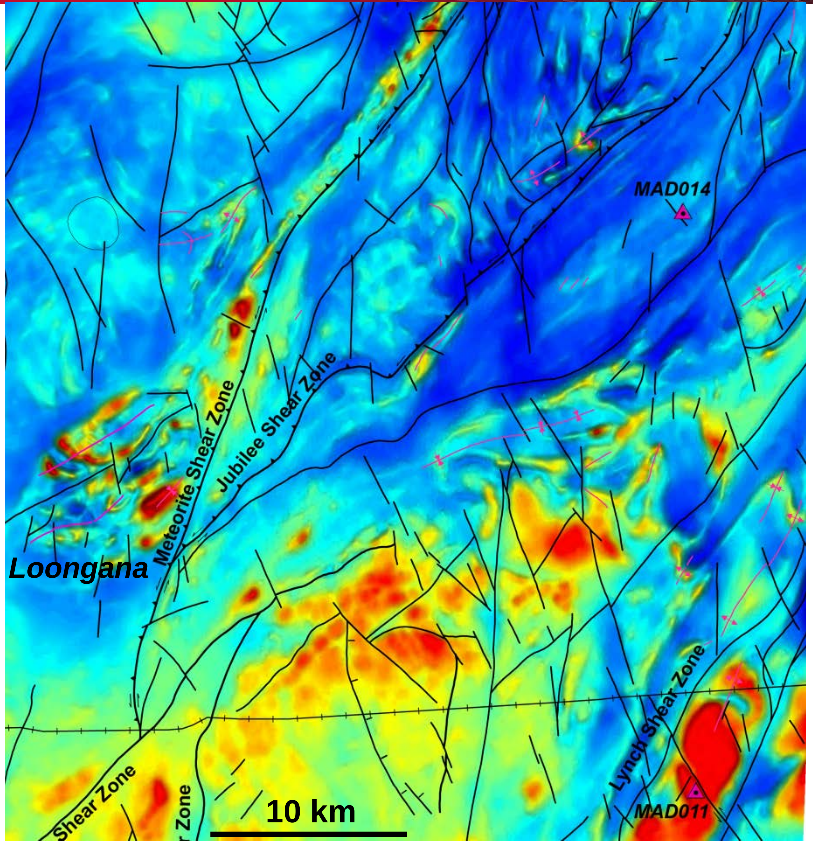
Madura Province: MAD014 drill core, basement at 250 m



MAD014 maps moderately magnetic Moodini Supersuite, which intrudes complexly folded rocks – probable metabasalt and associated metasedimentary rocks, and metagabbro and plagiogranites of the Haig Cave Supersuite

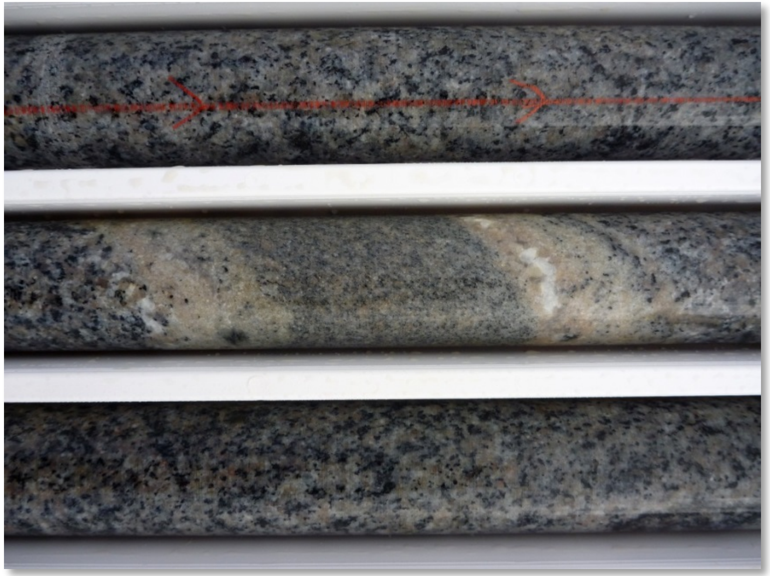
MAD011 and MAD014 show that Moodini Supersuite intrusions are extensive in the Madura Province

RTP magnetics

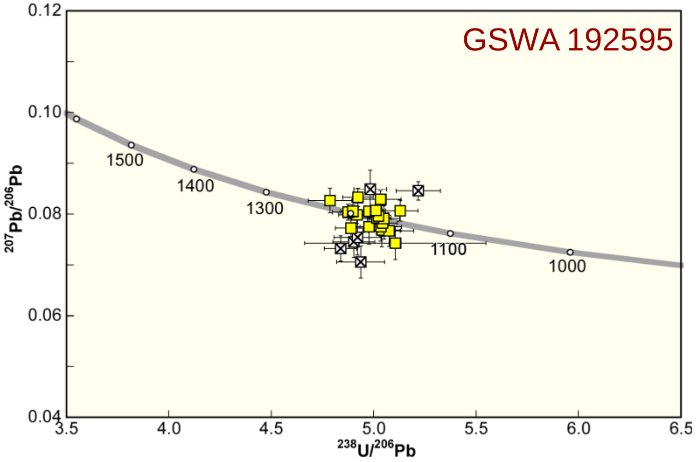


Madura Province: MAD014 drill core, basement at 250 m

High-KFe series, high Th, Moodini Supersuite):
Medium- to coarse-grained, unfoliated mesocratic granodiorite to monzogranite.
Intruded by veins of fine-grained, unfoliated equigranular monzogranite to syenogranite, typically with pegmatitic margins



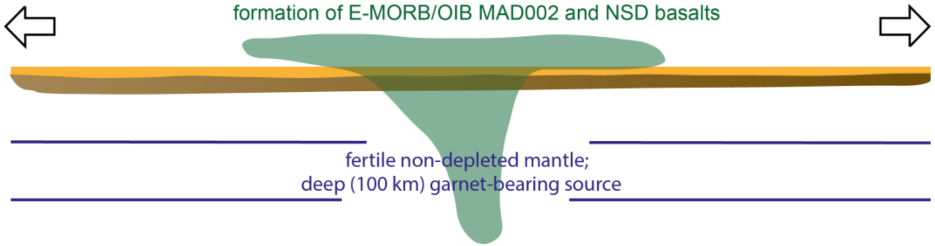
Crystallization of granodiorite:
1181 ± 7 Ma



Madura Province tectonic evolution

Madura Province and eastern Nornalup Zone (AFO):

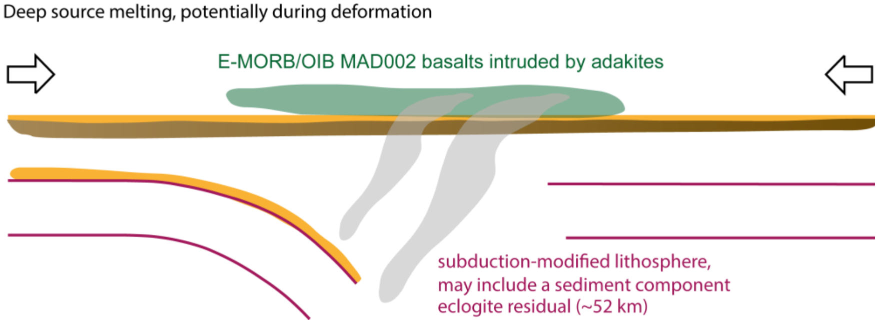
1. Lithospheric extension (Barren Basin/AFO), ocean-continent transition, formation of Arid Basin



Potential for VMS-style or exhalative deposits

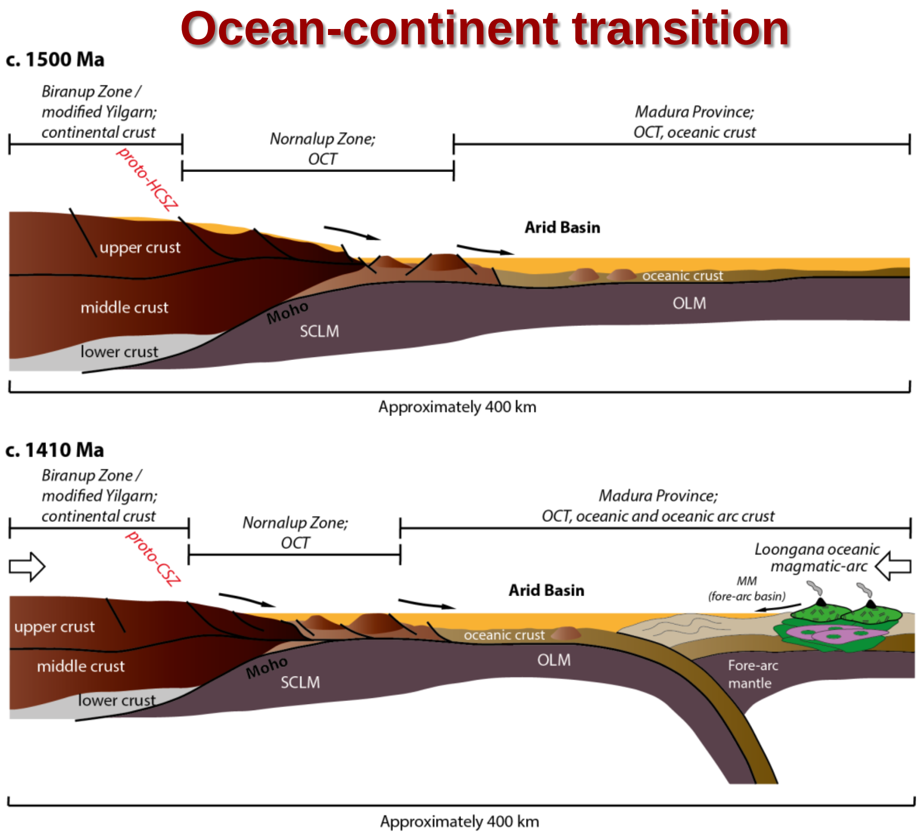
- Paleoproterozoic rift setting constrained by basin analysis and sediment provenance of the Barren Basin, and associated magmatism (GSWA Reports 133, 150).
- Rift develops into an ocean-continent transition – Arid Basin
- Eastern Nornalup Zone crust is attenuated, weak, and shows greater modification by orogenic processes than the rest of the AFO

2. Change to convergent setting and, much later, but certainly by 1410 Ma, develop the Loongana oceanic arc and adakites (not melts of E-MORB)



Potential for subduction-related deposits, PGEs and Ni

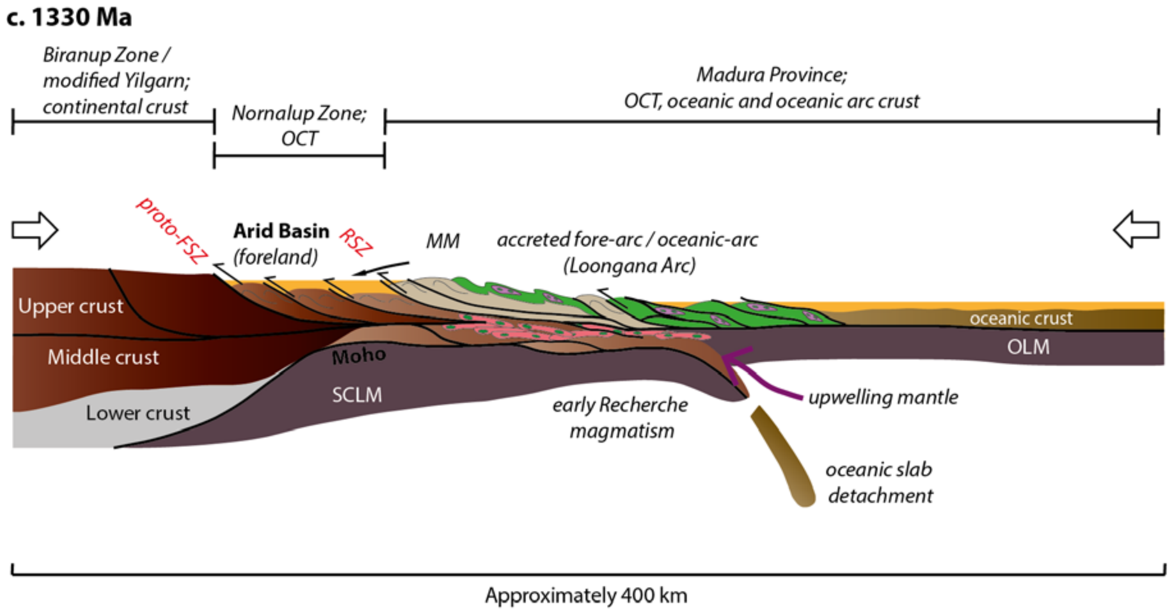
Albany–Fraser — Madura connections

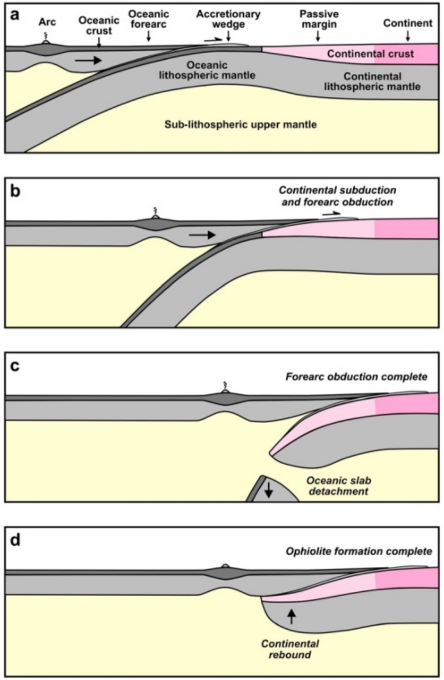


Malcolm Metamorphics (Point Malcolm) are interpreted fore-arc basin sediments of the Arid Basin, interlayered with subduction-modified N-MORB basalt; similar to Burkin prospect.

Albany–Fraser Madura connections

Accretion of oceanic material onto continental margin – the Arubiddy Ophiolite



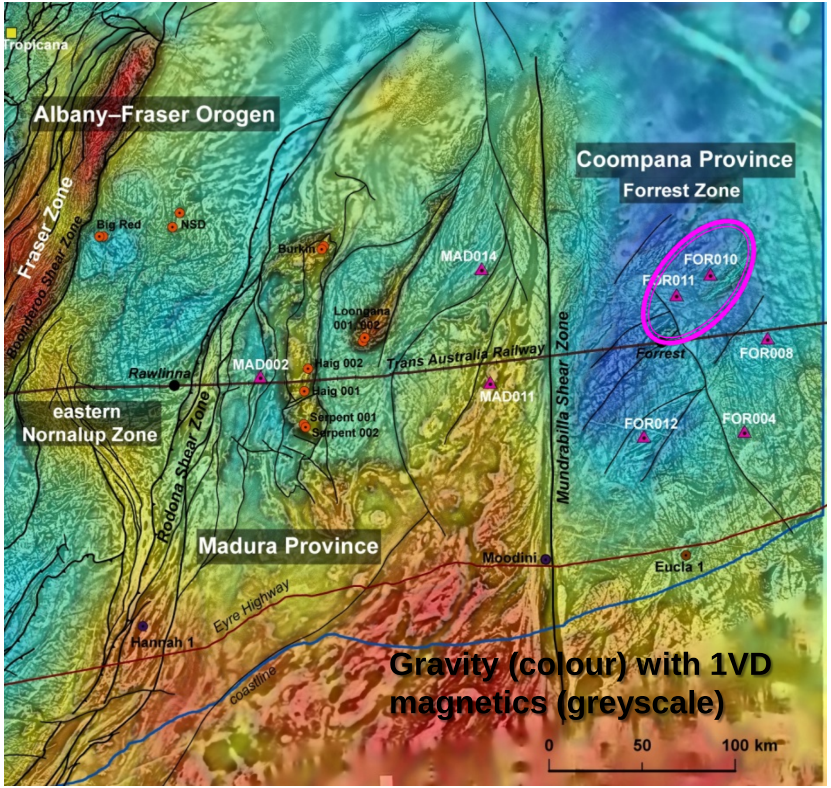


Modelling from Edwards et al., 2015, Tectonics, v. 34, p. 1494–1515.

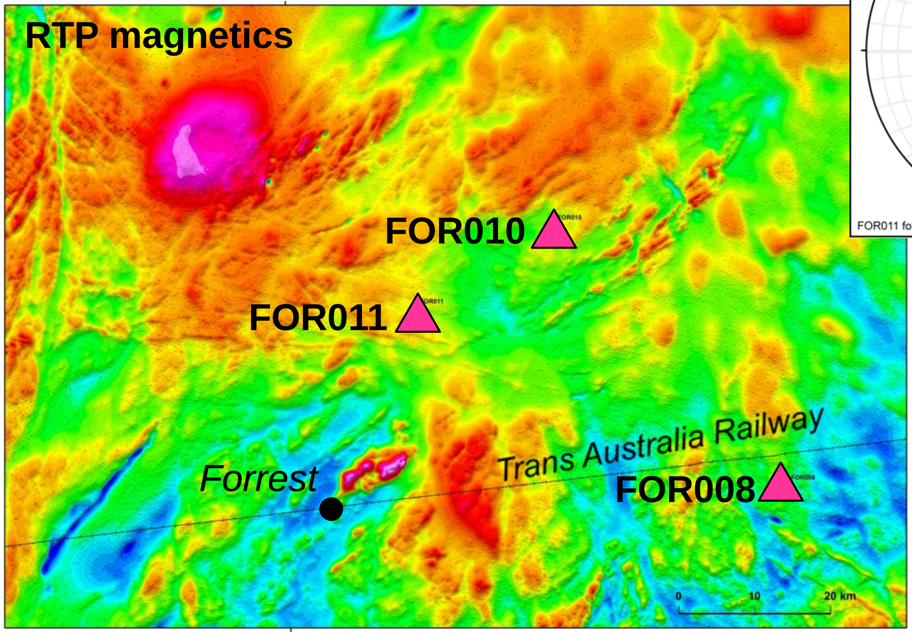
Coompana Province – Forrest Zone

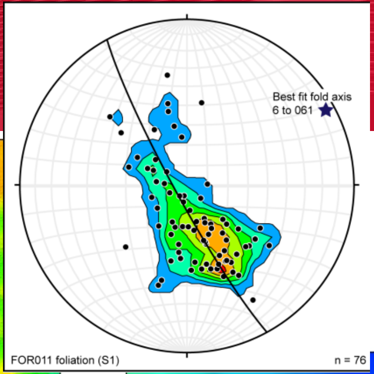
GSWA stratigraphic drill hole
EIS co-funded drill hole
Company donated core site

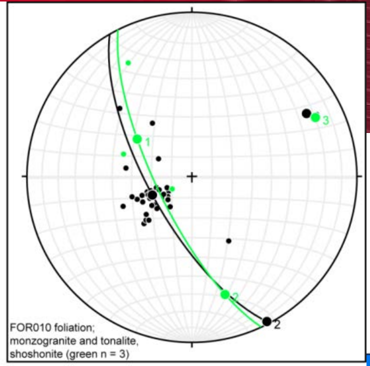
- Forrest Zone is the western part of the Coompana Province
- Separated from the Madura Province by the Mundrabilla Shear Zone
- Five stratigraphic cores drilled; first diamond cores



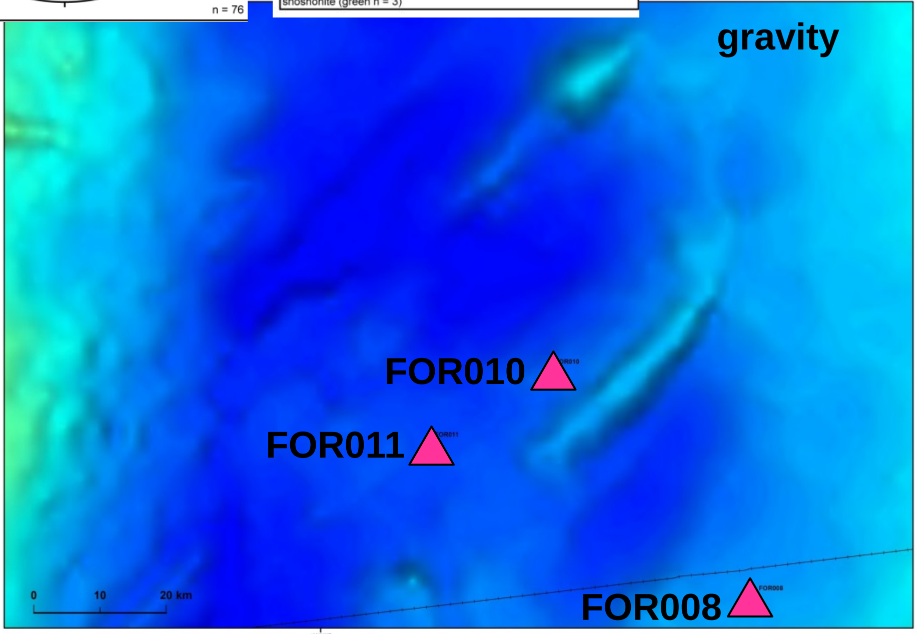
Drill cores FOR010 and FOR011







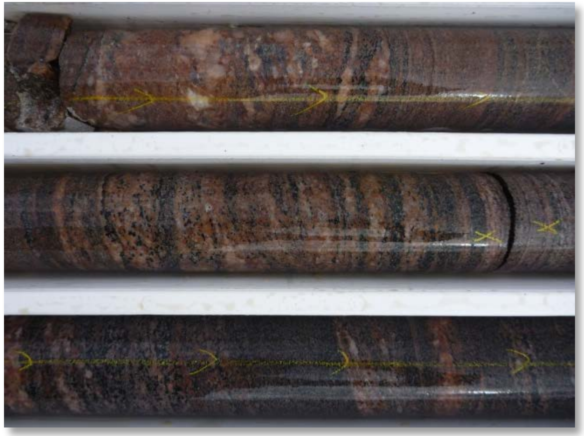
Drill core measurements define a NE-trending belt of shallowly NE-plunging folds – includes shoshonites

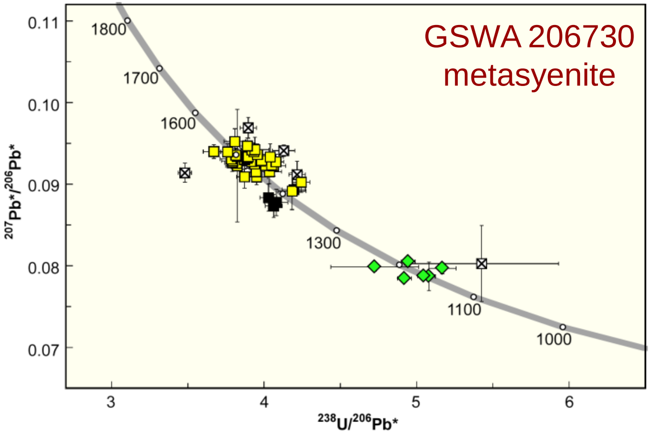


Coompana Province – Forrest Zone; FOR011 drill core; basement at 285 m

Oldest rock types:

- Interlayered fine- to medium-grained, red, equigranular to seriate-textured metasyenite (Undawidgi Supersuite); undated metamonzodiorite to metagranodiorite;
- Undated fine-grained metagabbro (probable Toolgana Supersuite country rock)





- Crystallization: 1488 ± 7 Ma
- Metamorphism: 1174 ± 12 Ma
- Cross-cutting granite veins dated at c. 1189 Ma

Coompana Province – Forrest Zone; FOR010 drill core; basement at 358 m

Complex core, five rock types identified.

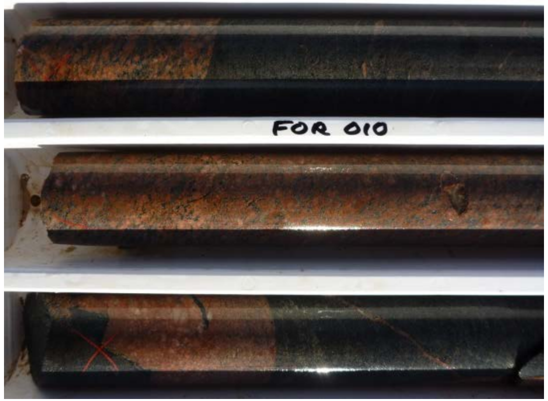
Oldest rock types (c. 1490 Ma Undawidgi Supersuite):

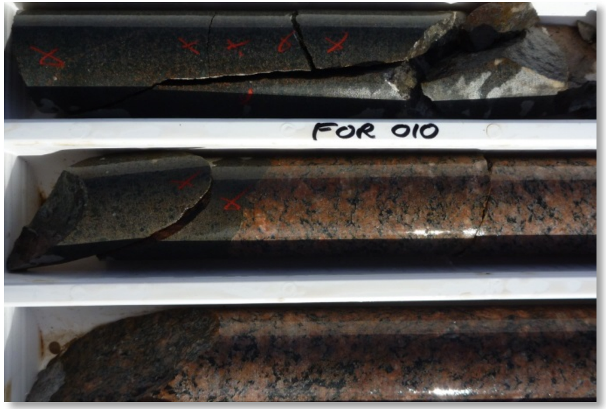
- Interlayered porphyritic biotite monzogranite gneiss (magnesian, alkali high-K) and tonalitic metagranite (magnesian, calcic-calc-alkalic)

Coompana Province – Forrest Zone; both FOR011 and FOR010 drill cores

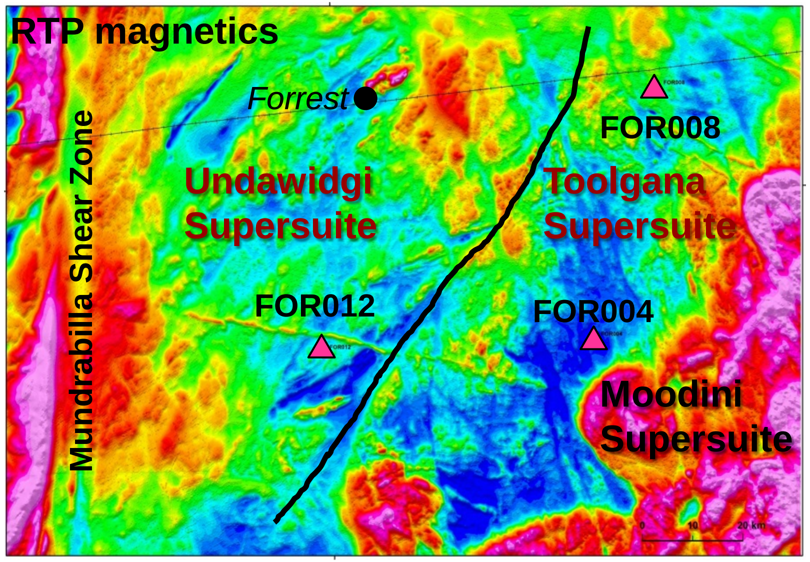
Bottle Corner Shoshonite; intrudes Undawidgi Supersuite

- c. 1180 Ma; part of Moodini Supersuite
- Mafic to intermediate, fine- to medium-grained metagranite
- Typical assemblage plagioclase-K-feldspar-dark biotite-dark green hornblende phenocrysts-quartz-titanite
- Upper greenschist to low amphibolite facies; cut by Si-rich shoshonitic syenogranite
- Commonly altered / contain pyrite, chalcopyrite, rare galena



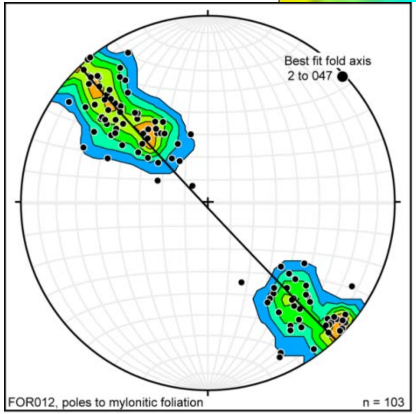


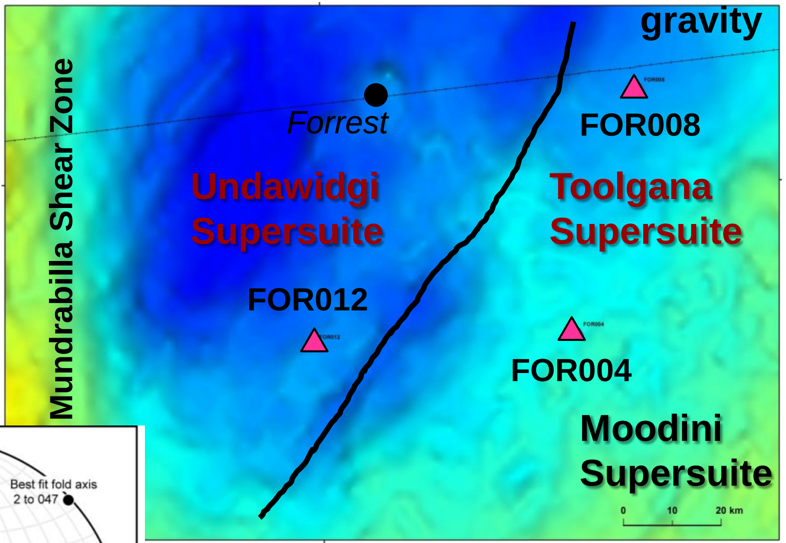
Coompana Province – Forrest Zone; FOR012 drill core; basement at 310 m



Wedge-shaped structure at FOR012:

- Shallowly inclined to subhorizontal folding
- Core intersects an upper limb dipping northwest and a lower limb dipping to the southeast
- Fold closure to the northwest





Significant structure between Undawidgi and Toolgana Supersuites

FOR012

Coompana Province – Forrest Zone; FOR012 drill core; basement at 310 m

Undawidgi Supersuite (c. 1490 Ma; magnesian to ferroan, alkali-calcic, high-K – rift-related):

- Mylonitic to ultramylonitic fine- to medium-grained, locally thinly layered metagranite (high-level intrusion?)
- Mafic to intermediate, micaceous schist; wispy carbonate veins
- Intensely foliated to mylonitic, fine-grained, grey to dark grey schist; felsic metavolcanic or high level metagranite; wispy carbonate veins
- Upper greenschist facies; locally with disseminated pyrite and chalcopyrite, associated with magnetite

Coompana Province – Forrest Zone; FOR008 drill core; basement at 380 m

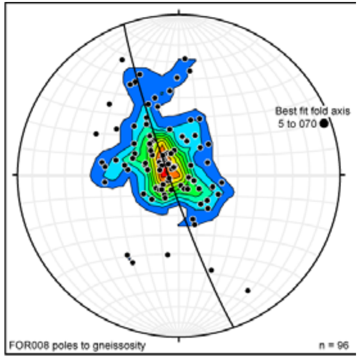
Toolgana Supersuite (c. 1610 Ma; magnesian, calc-alkalic, high-K – oceanic arc-related; equivalent to St Peter Suite in the Gawler):

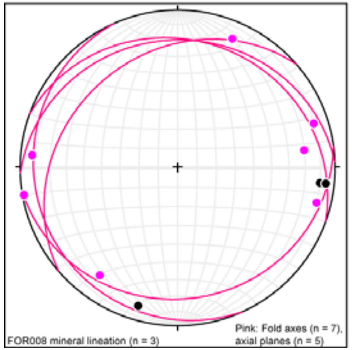
- Medium- to locally coarse-grained, red to grey, seriate-textured to porphyritic (up to 4 cm), biotite-rich, locally hornblende-bearing, migmatitic, granodiorite to monzogranite gneiss; localised leucosome veins and patches (melt)
- Interlayered with medium-grained, monzodiorite gneiss (high-K, calc-alkalic)
- Zones of chlorite-epidote-hematite greenschist facies alteration
- Locally stockwork veins; carbonate veins; fluorite

Coompana Province – Forrest Zone; FOR008 drill core; basement at 380 m

- Chalcopyrite veinlets in stringers with abundant magnetite altered to hematite
- Coarse-grained porphyritic granite gneiss contains 1154 ppm Cu (GSWA 219012) – patchy chlorite (from biotite) and sericite (from plagioclase) alteration; hematite staining

Structural relationships:





Southeast side of significant structure:

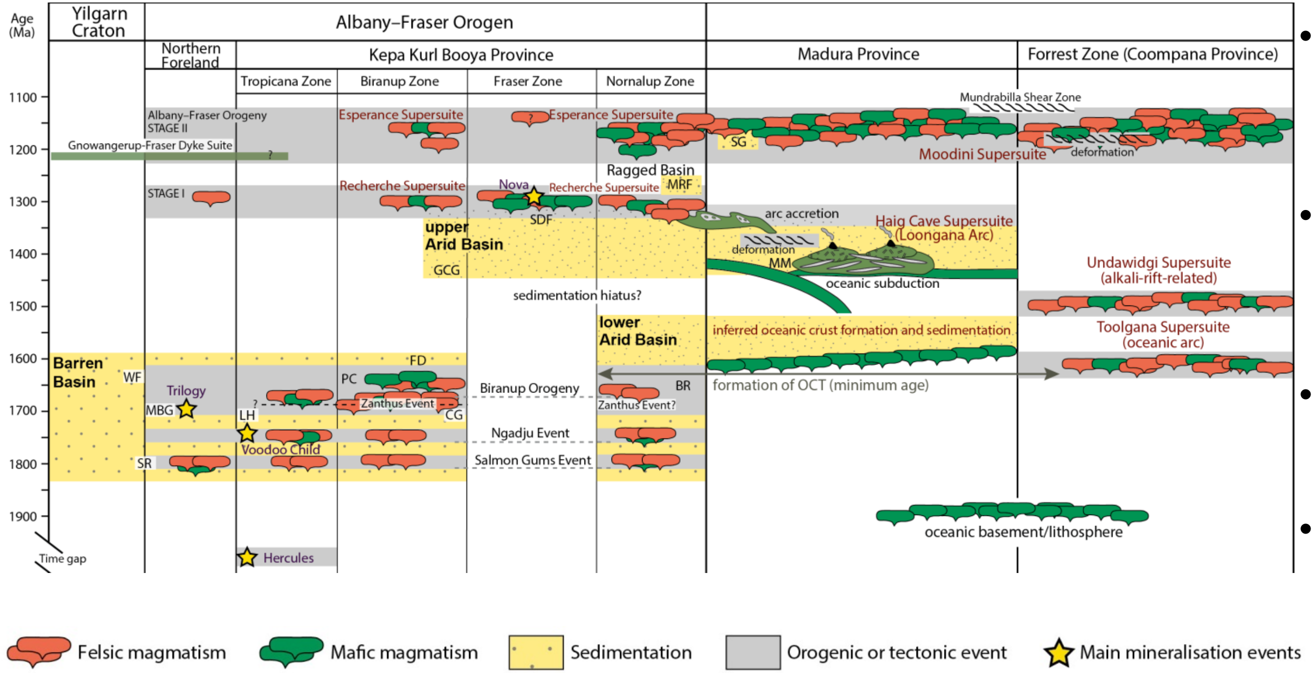
- Dominantly shallowly dipping gneissocity
- Subhorizontal mineral lineation
- Top NW shear sense (porphyroclasts, kinks) prior to or during migmatization
- Flat-lying, small-scale Z-folds and curvilinear folds
- Pre-dates greenschist alteration

Coompana Province – Forrest Zone; FOR004 drill core; basement at 390 m

Toolgana Supersuite (c. 1610 Ma; magnesian, calc-alkalic, medium- to high-K – oceanic arc-related; equivalent to St Peter Suite in the Gawler):

- Medium-grained, mesocratic, mostly equigranular, granodioritic to monzogranitic gneiss
- Intruded by fine- to medium-grained, equigranular to seriate-textured, biotite leucogranite, which includes wisps and schleiren of fine-grained metadiorite and metagranodiorite
- Retrograde alteration: biotite to chlorite-sericite, plagioclase to sericite; sericite–carbonate–albite–chlorite alteration
- Sparse chalcopyrite and rare bornite

Albany–Fraser — Madura — Coompana connections



- Common, c. 1.9–1.7 Ga oceanic substrate in both Madura and Coompana Provinces
- Relationship between c. 1610 Ma arc formation (Toolgana SS) and rifting to the west?
- c. 1500 Ma rifting in the Coompana related to OCT development in the west?
- Arc accretion to WAC margin by 1330 Ma; Stage I AFO – confined to the west