The Penong Complex: a new unit with big implications for the Nuyts Domain

Mark Pawley | 27th November 2025

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GEOLOGICAL SURVEY OF South Australia

DISCOVERY DAY

Nuyts Domain introduction

Shear-bounded domain in the southwest Gawler Craton.

Poorly exposed.

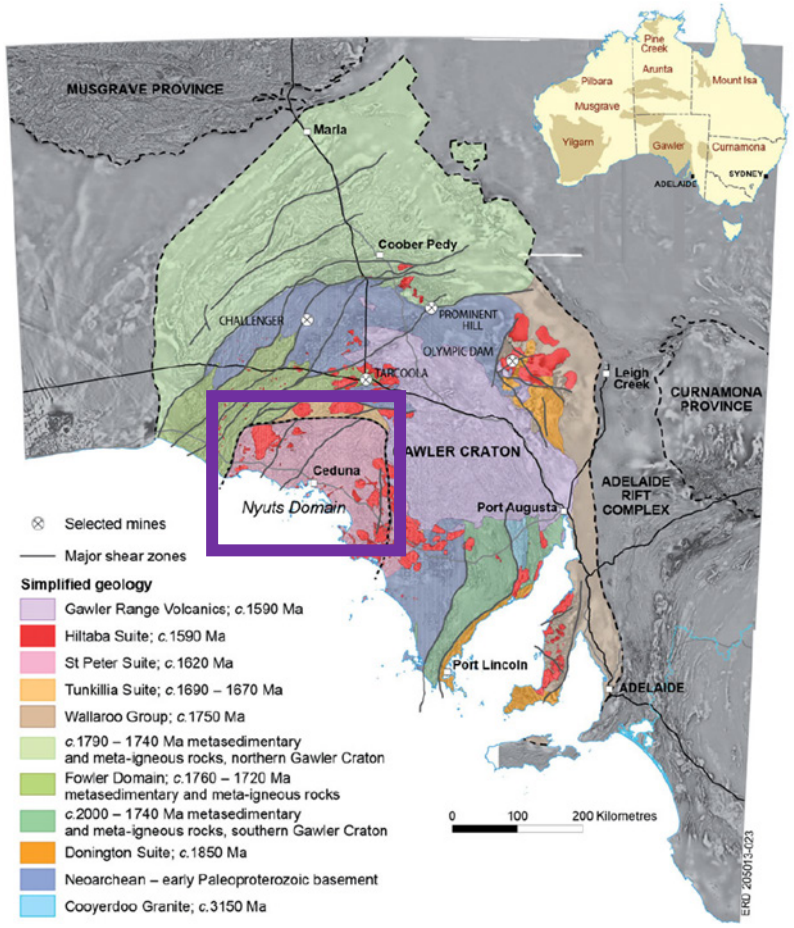
Few basement intersecting drillholes (relative to rest of Gawler Craton).

Magnetically complex (and interesting!).

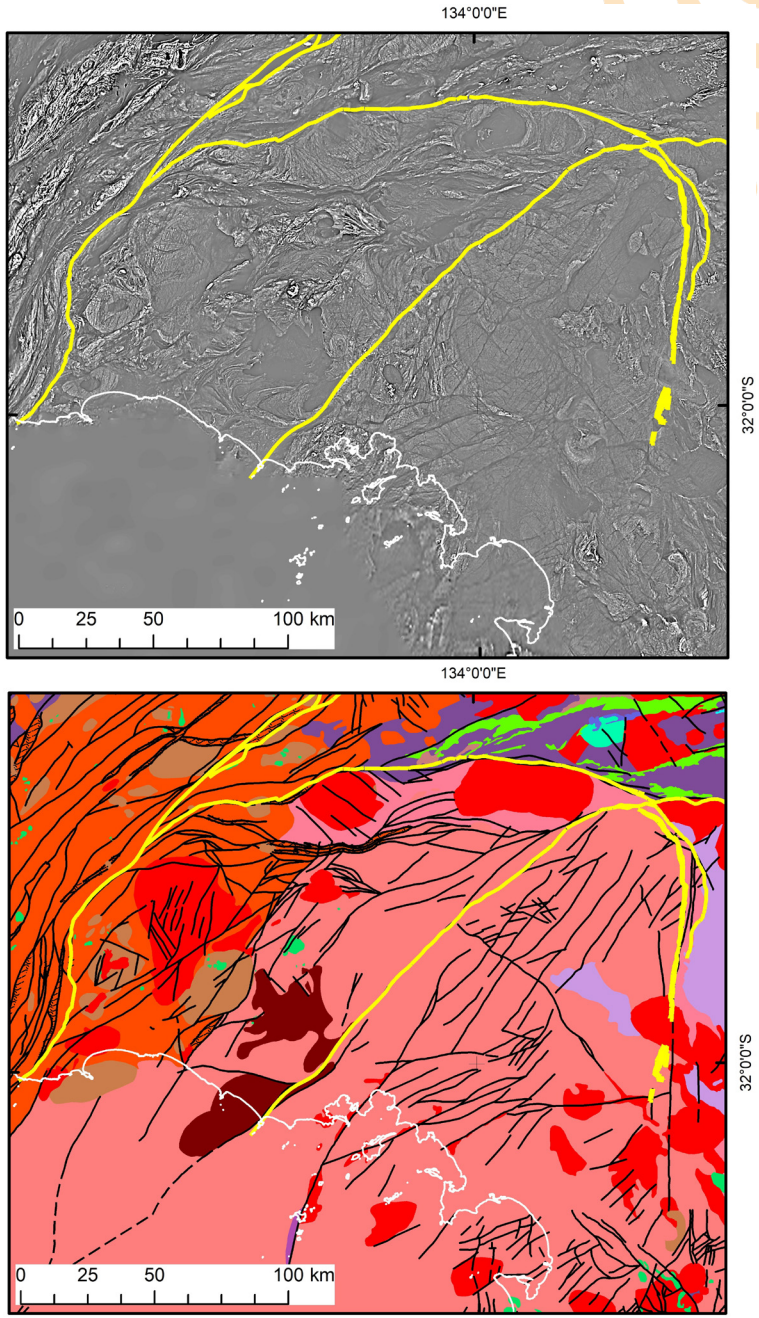
Previously interpreted to be dominated by < c. 1750 Ma magmatic rocks.

But metasediments are present, poorly understood, and important!

They make up the Penong Complex…



(Reid et al. 2019)



GSSA DISCOVERY DAY

Munjeela Suite and metasediments

S-type leucocratic granites of the c. 1591-1577 Ma Munjeela Suite are exposed along the coast and at Munjeela Rock Hole.

Payne (2008) interpreted that:

- The granite magmas were generated through muscovite-dehydration melting of sedimentary rocks.
- Metasedimentary xenoliths in the granite represent the sedimentary source rock of the granite.
- Xenoliths have max. dep. ages of c. 1678-1623 Ma, were metamorphosed at 21-12 km deep, and multiply deformed.
- This means the sediments were buried to >20 km between 1623 and 1591 Ma.
- Garnet compositions indicate that the granite magma was generated and started to crystallise at depths of ~18-20 km.
- The range of P-T conditions in the xenoliths suggests the ascending magma sampled a thick metasedimentary pile.
- The xenoliths have no detrital zircons older than c. 1900 Ma.

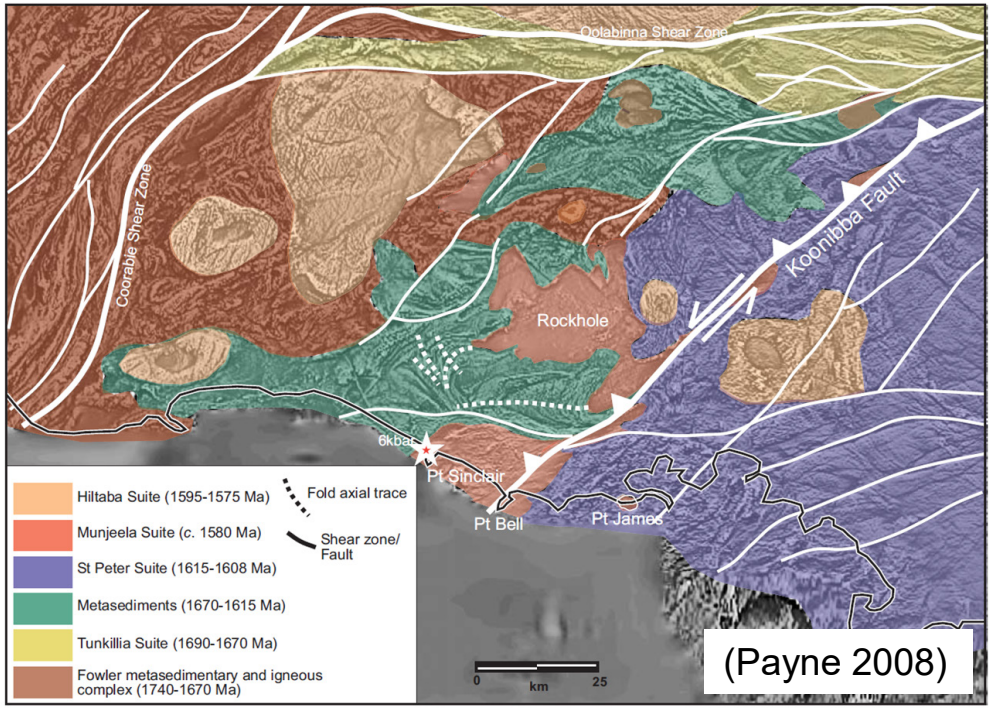


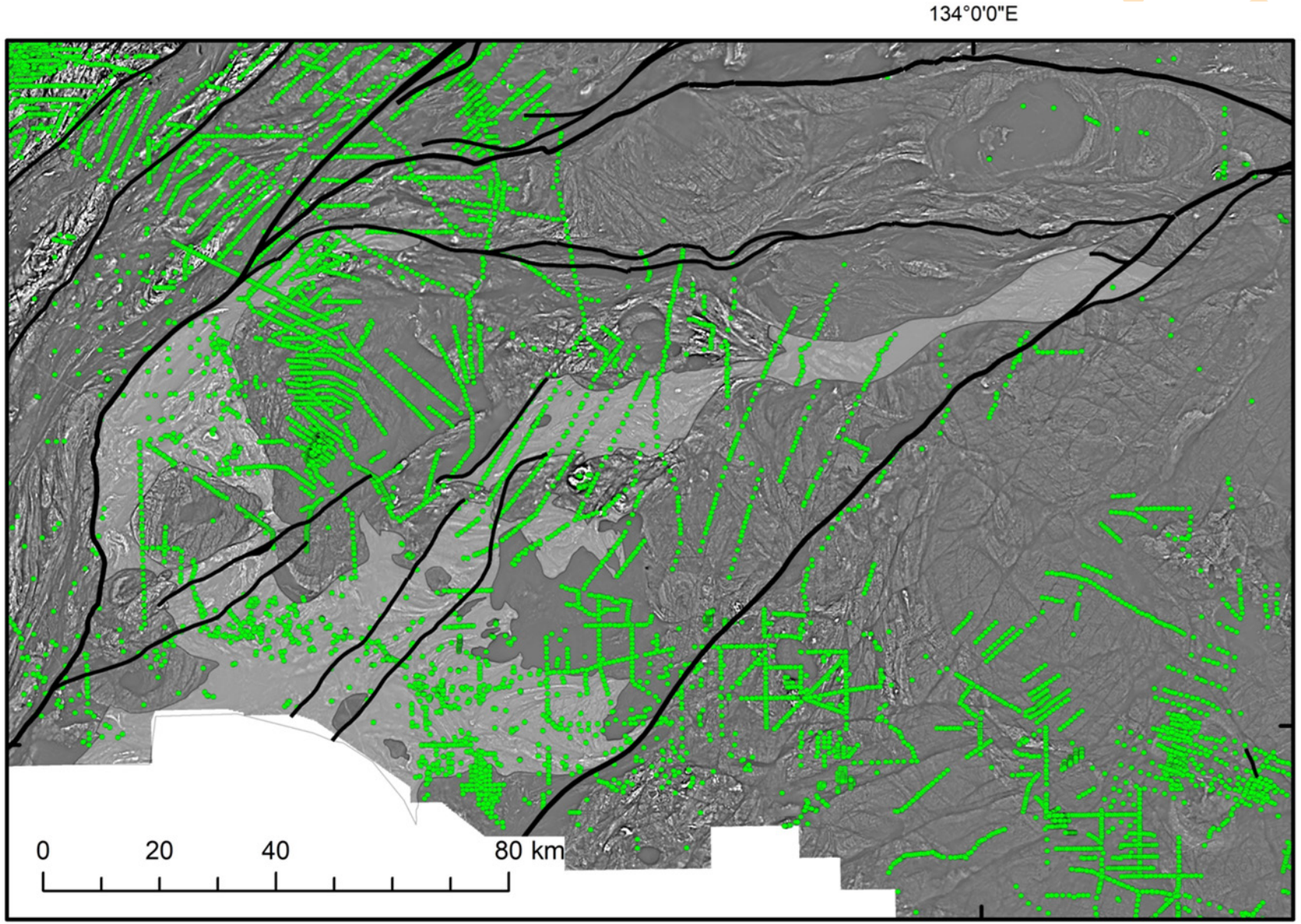
Figure 6.2 - Total Magnetic Intensity map of the south-western Gawler Craton displaying locations of Munjeela Suite intrusions and field sampling localities. Intepretation of M. Hand, modified after Fairclough et al. (2004).

Nuyts Domain drillholes

Lots of drillholes, but few intersect the basement.

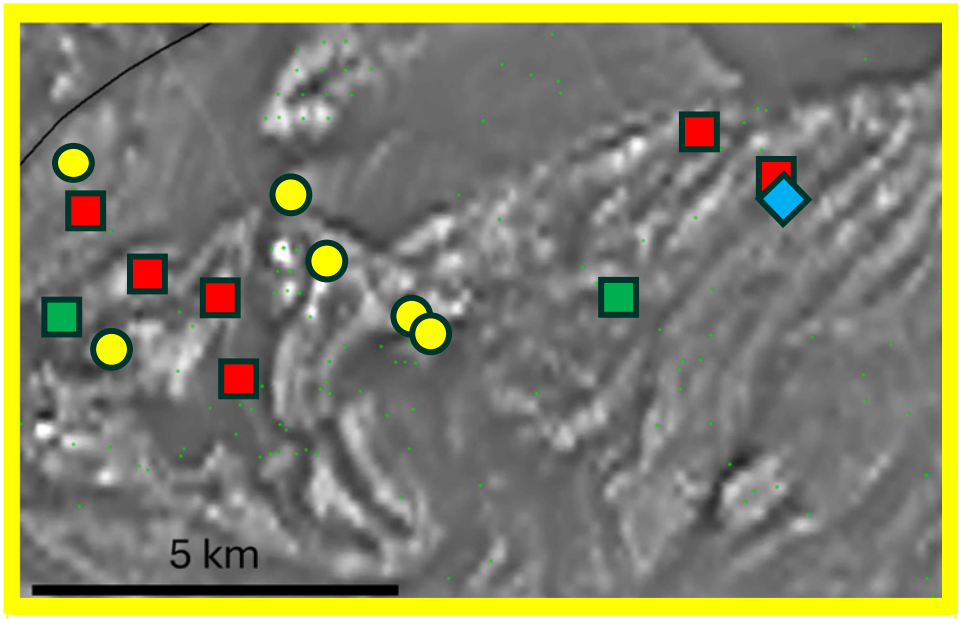
Less have lithological/protolith information, with the majority of core and chips logged as ‘schist’ or ‘gneiss’.

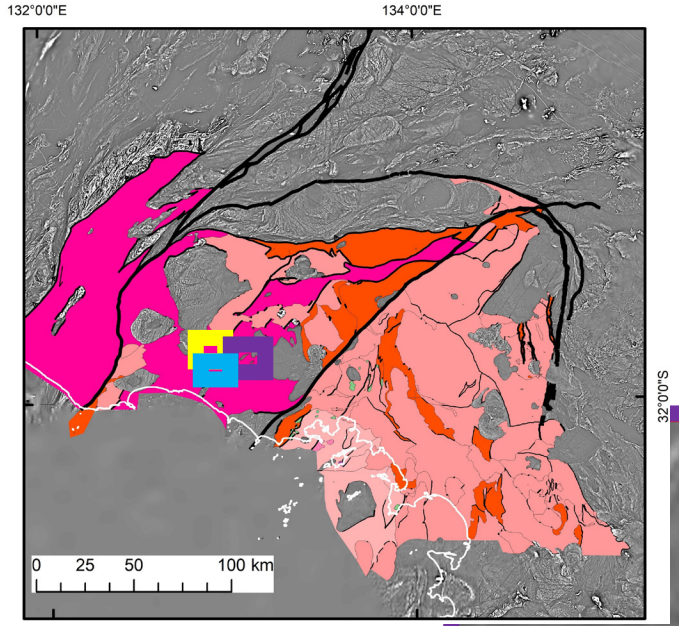
The drillholes indicate the basement is generally < 50 m.

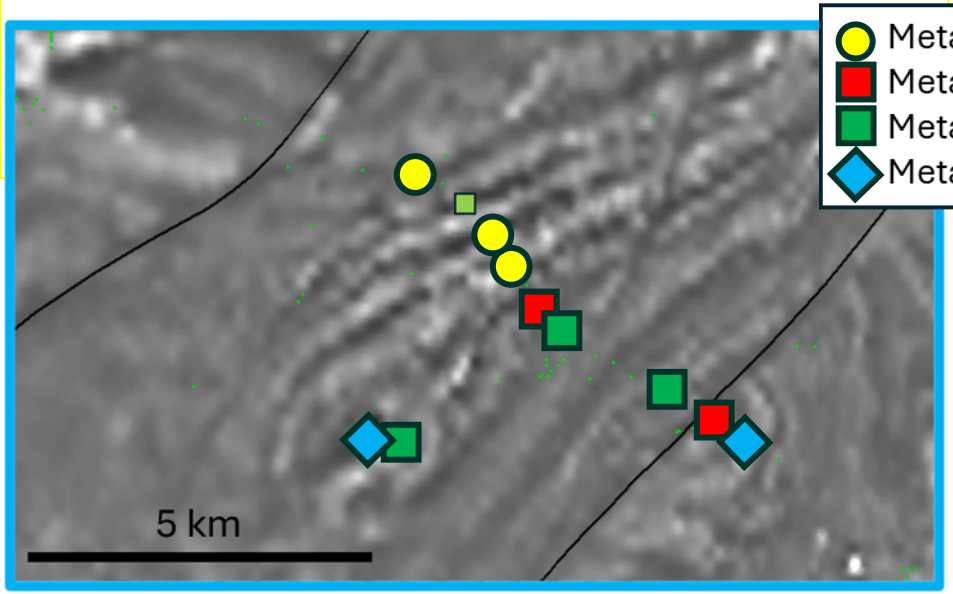


GSSA
DISCOVERY DAY

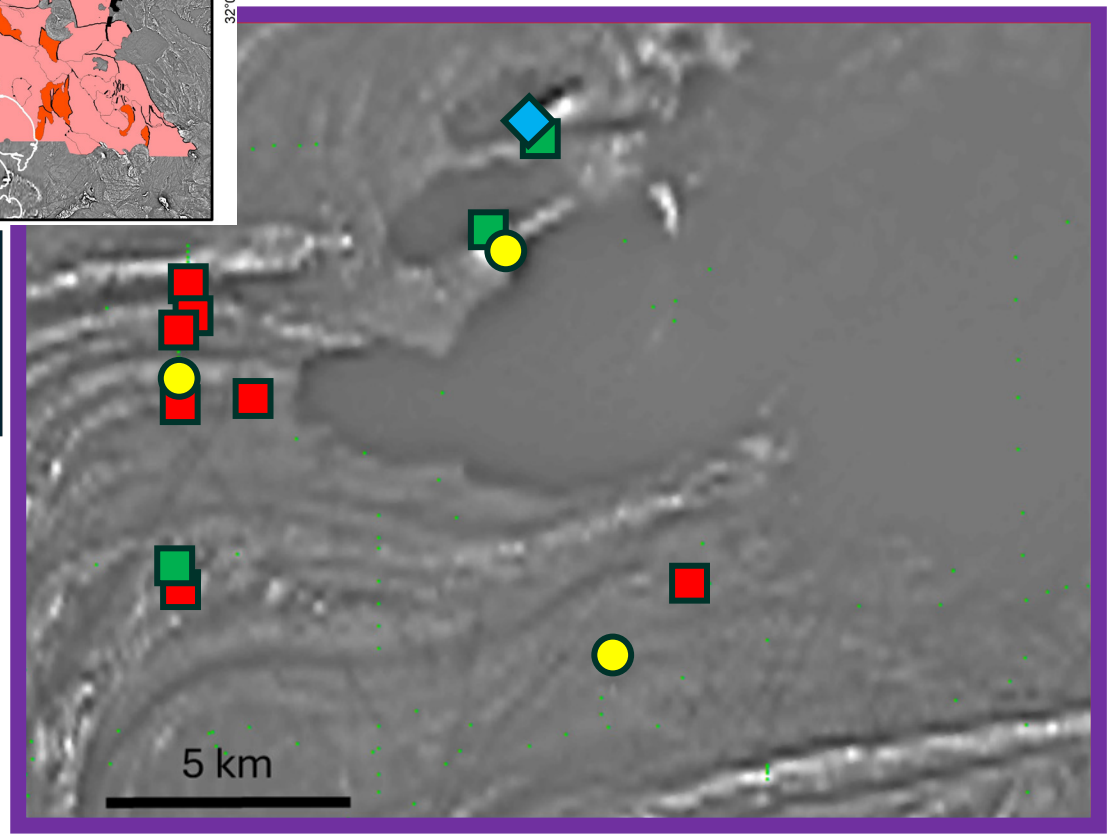
Penong Complex drillholes







Metasedimentary rocks
Metafelsic igneous rocks
Metamafic igneous rocks
Meta-ultramafic igneous rocks



A range of protoliths were intersected in the drillholes.

Few metasediments, but this may reflect exploration targeting bias.

Drillhole data indicates there is a sedimentary package intruded by bimodal igneous rocks.

Formally defined as the Penong Complex.

Penong Complex geochronology

Payne (2008) interpreted the metasediments to be 1670-1615 Ma.

GSSA were unsuccessful in dating the metasediments, dated felsic and mafic rocks within the Penong Complex interpreted to be sill-like intrusions into the sedimentary pile (Brown et. al. 2025).

Similar magmatic ages. Mafic rocks have two metamorphic ages!

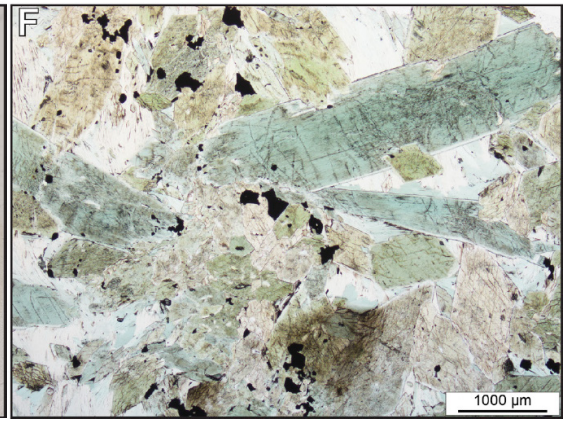
Mafic rocks had MORB-like compositions.

Chl-amph mafic schist (4466964, KW112, 75.80-79.90 m)

1658.7 ± 6.9 Ma mag. age (zircon U–Pb LA-ICP-MS)

1621.0 ± 20.0 Ma meta. age (apatite U–Pb LA-ICP-MS)

1614.0 ± 37.1 Ma meta. age (apatite Lu–Hf LA-ICP-MS)



Ga-musc S-type porphyritic granite (4466968, KW112, 75.8-79.9 m)

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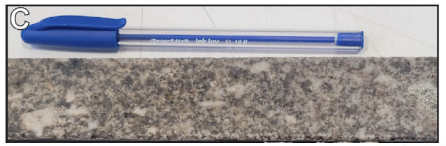

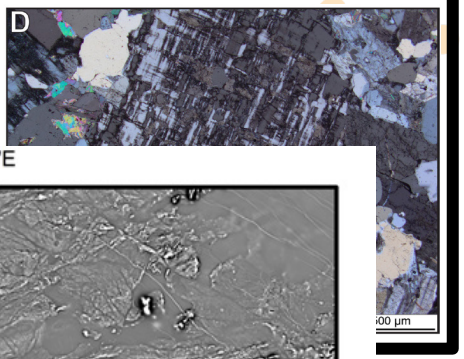

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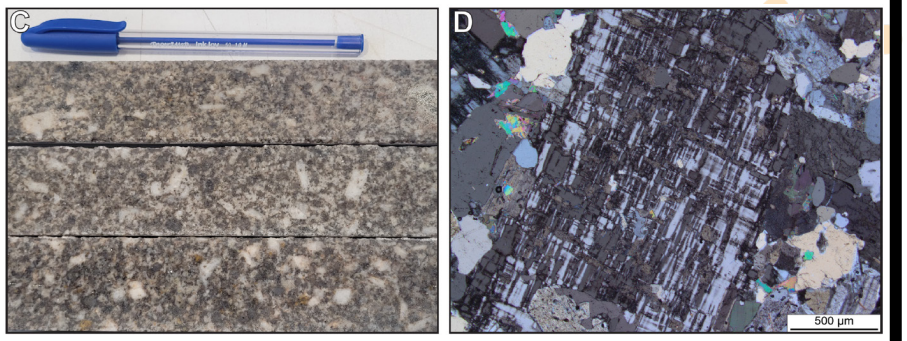

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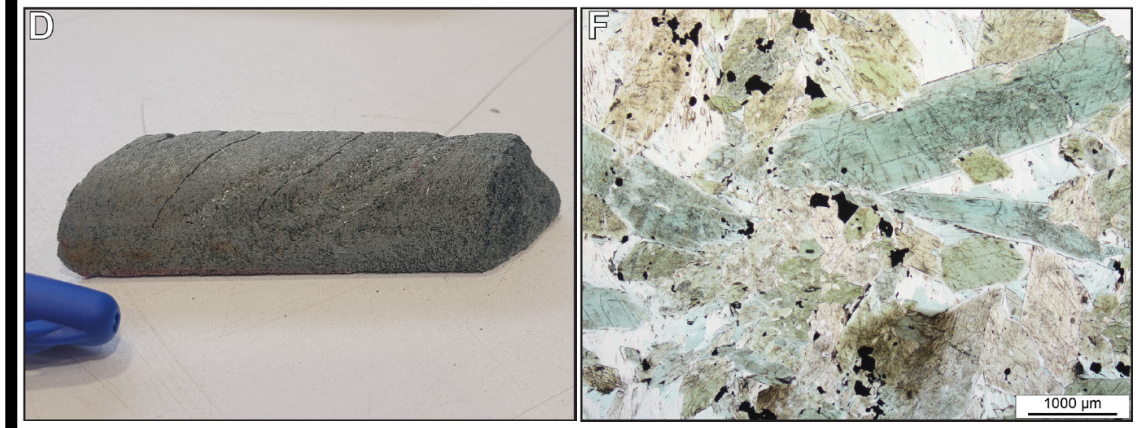
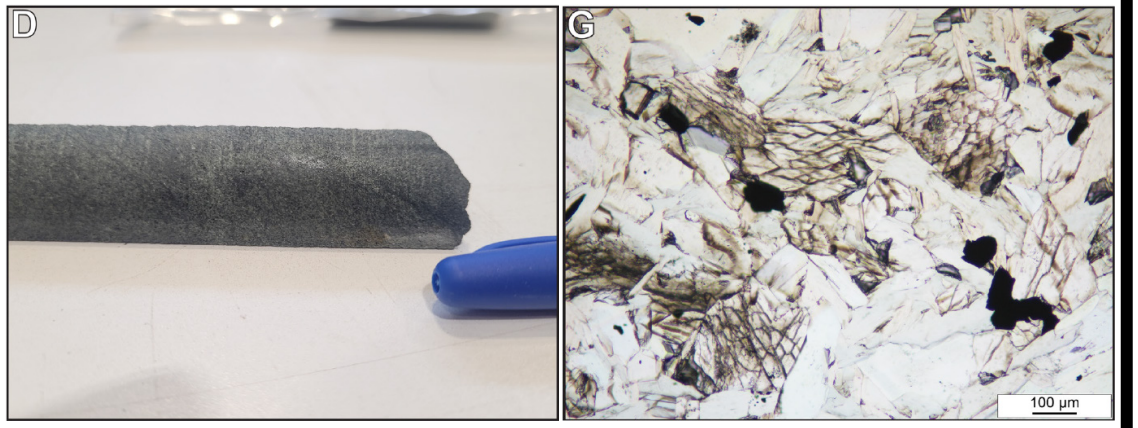


Chl-amph mafic schist (4466965, KW112, 91.90-92.90 m)

1657.5 ± 6.5 Ma mag. age (zircon U–Pb LA-ICP-MS)

1631.0 ± 36.7 Ma meta. age (apatite Lu–Hf LA-ICP-MS)

1610.0 ± 14.0 Ma meta. age (apatite U–Pb LA-ICP-MS)

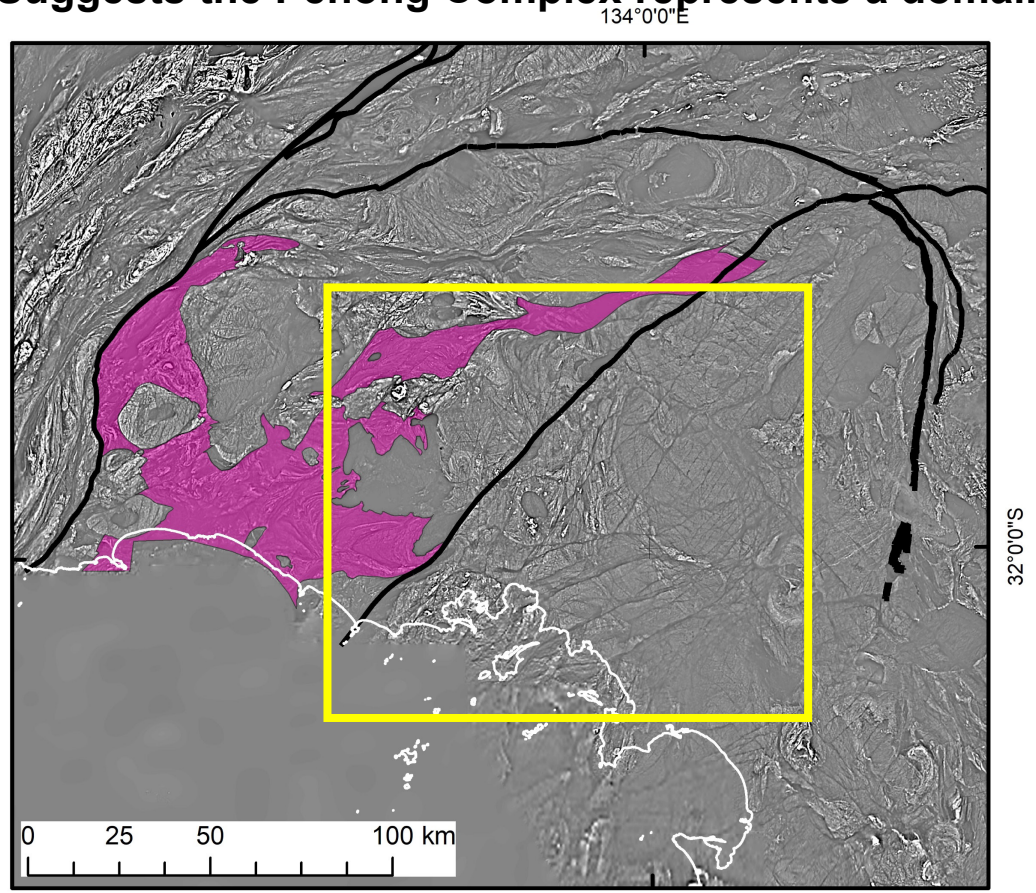


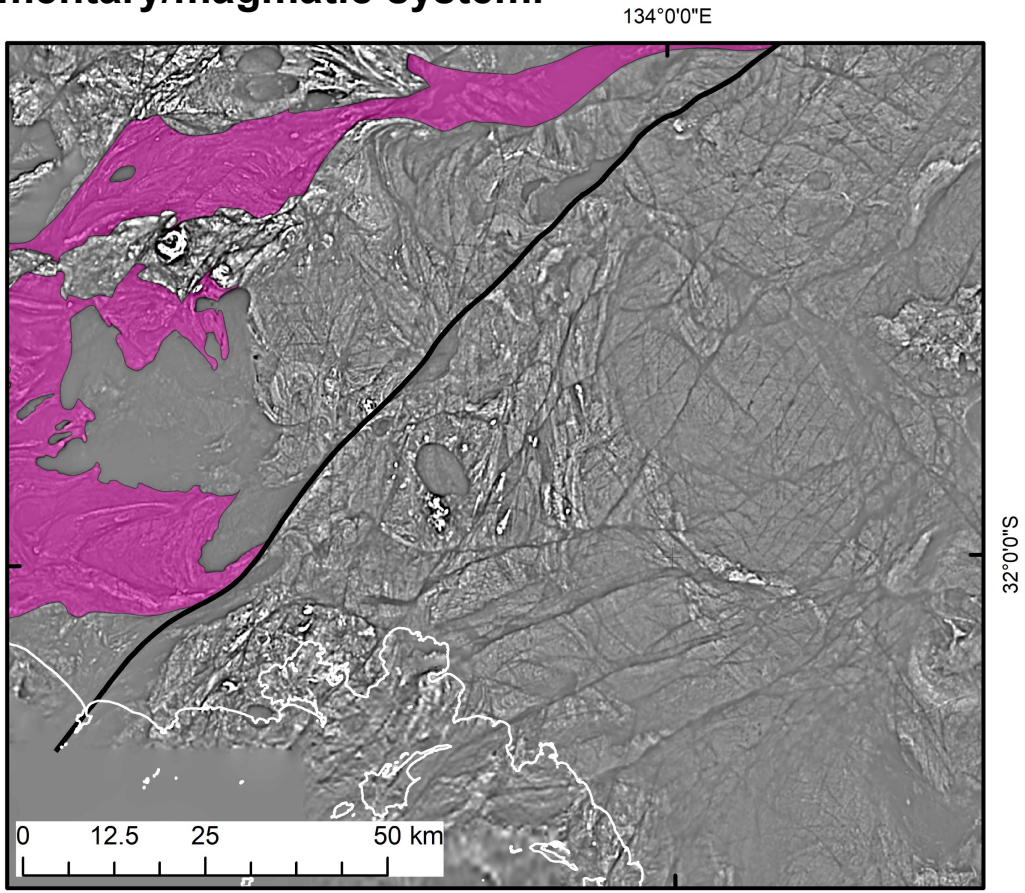
Distribution of the Penong Complex

Extensive unit in the western Nuyts Domain.

The distribution of S-type Munjeela Suite rocks suggests the Penong Complex extends into the eastern Nuyts Domain.

Suggests the Penong Complex represents a domain-scale sedimentary/magmatic system.





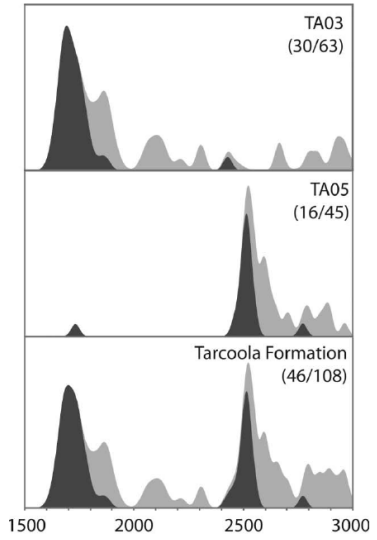
Implications for previous models

Previous models are generally arc-related, either as an arc or back-arc.

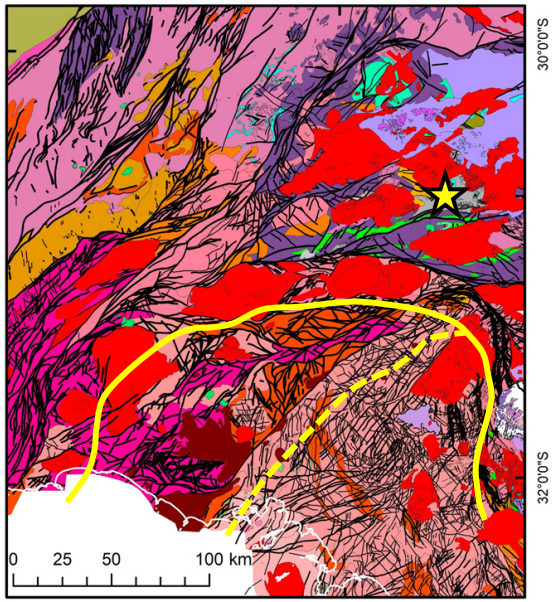
Recent work indicated the igneous rock compositions were not unique to an arc-proposed extension.

A widespread sedimentary-magmatic package has implications for the previous models.

- The geometry of the Nuyts Domain makes it difficult to fit in an arc itself.
- If the Nuyts Domain was a back-arc basin, sedimentation would be derived from the surrounding domains of largely Neoarchaean to earliest Paleoproterozoic rocks. C.f. Tarcoola Formation to north.
- But no zircons older than c. 1900 Ma have been found in the Penong Complex.

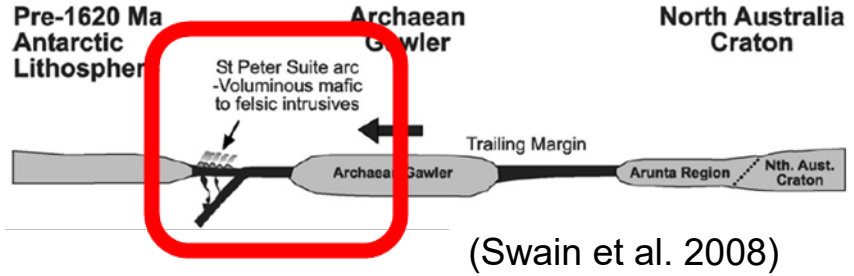


(Howard et al. 2011)

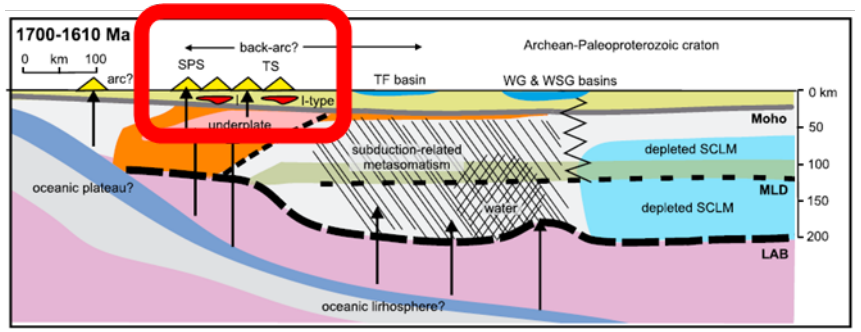


(a) ca.1620 - 1608 Ma

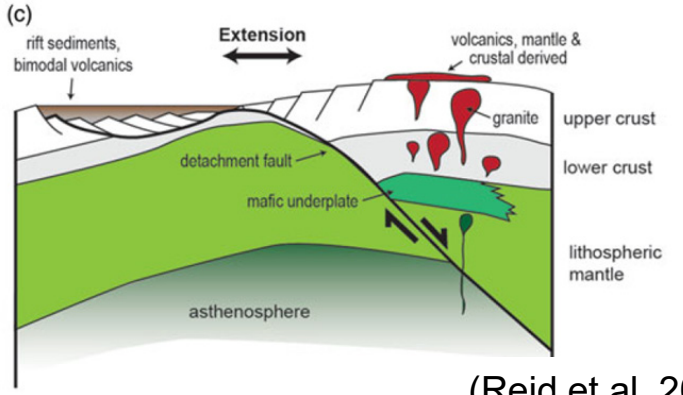
St Peter Suite
- Development of arc magmatism south of Archaean Gawler
- South-dipping subduction
- Collision of Archaean Gawler at ca. 1608 Ma



(Swain et al. 2008)



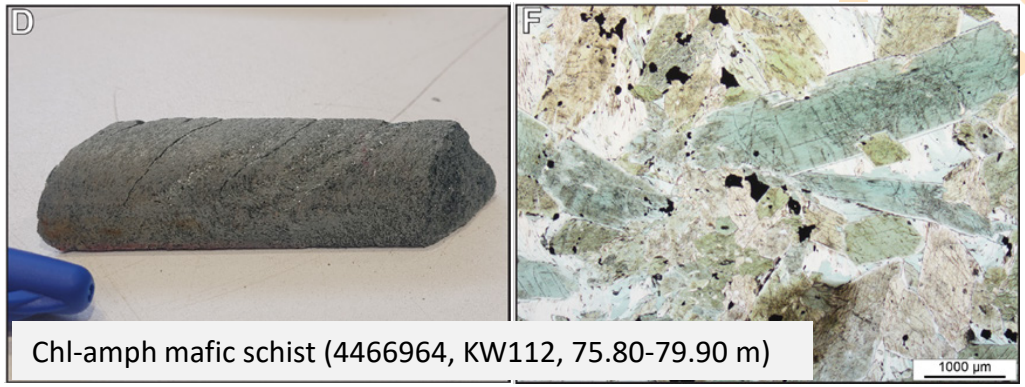
(Skirrow et al. 2018)



(Reid et al. 2020)

Key observations for alternative tectonic models

1. C. 1690-1670 Ma Tunkillia Suite are ‘late- to post-tectonic’ with respect to the c. 1730-1690 Ma Kimban Event (Payne et al. 2010).
2. C. 1660 Ma mafic sheets in Penong Complex have MORB-like composition (associated with rifting or extension).
3. There are no zircons in Penong Complex recycled from surrounding Archean crust, as seen in the similarly-aged Tarcoola Formation? What does this mean for basin development?
4. C. 1650-1605 Ma St Peter Suite could be extensional.



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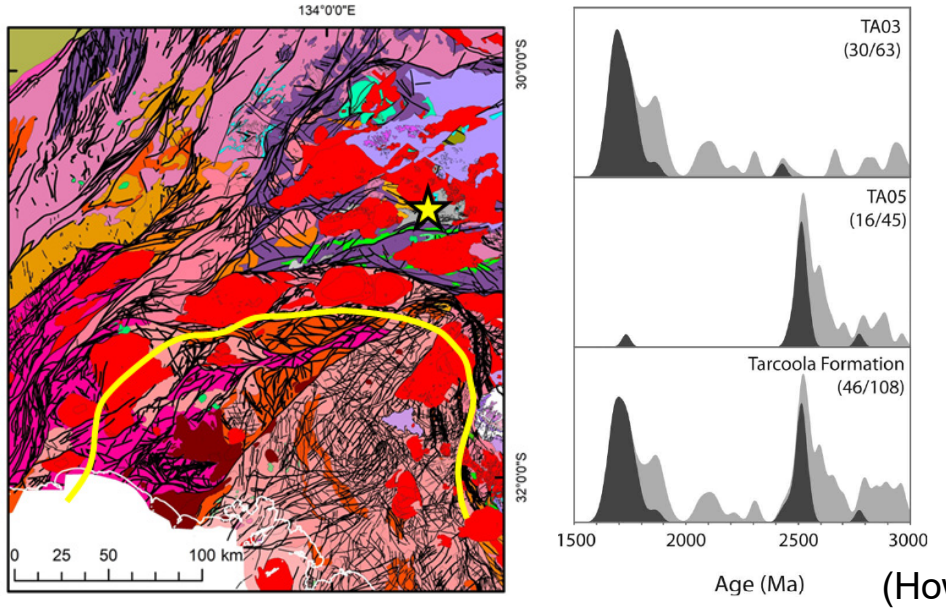

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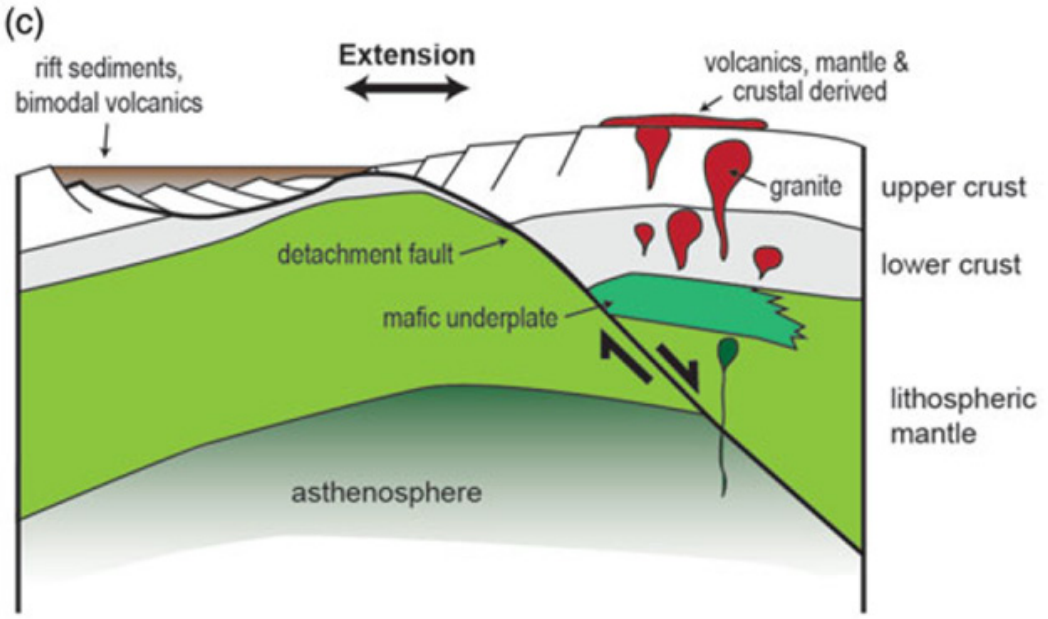


(Reid et al. 2020)

What setting fits the observations?

Could there be delamination involving a 3-stage process?

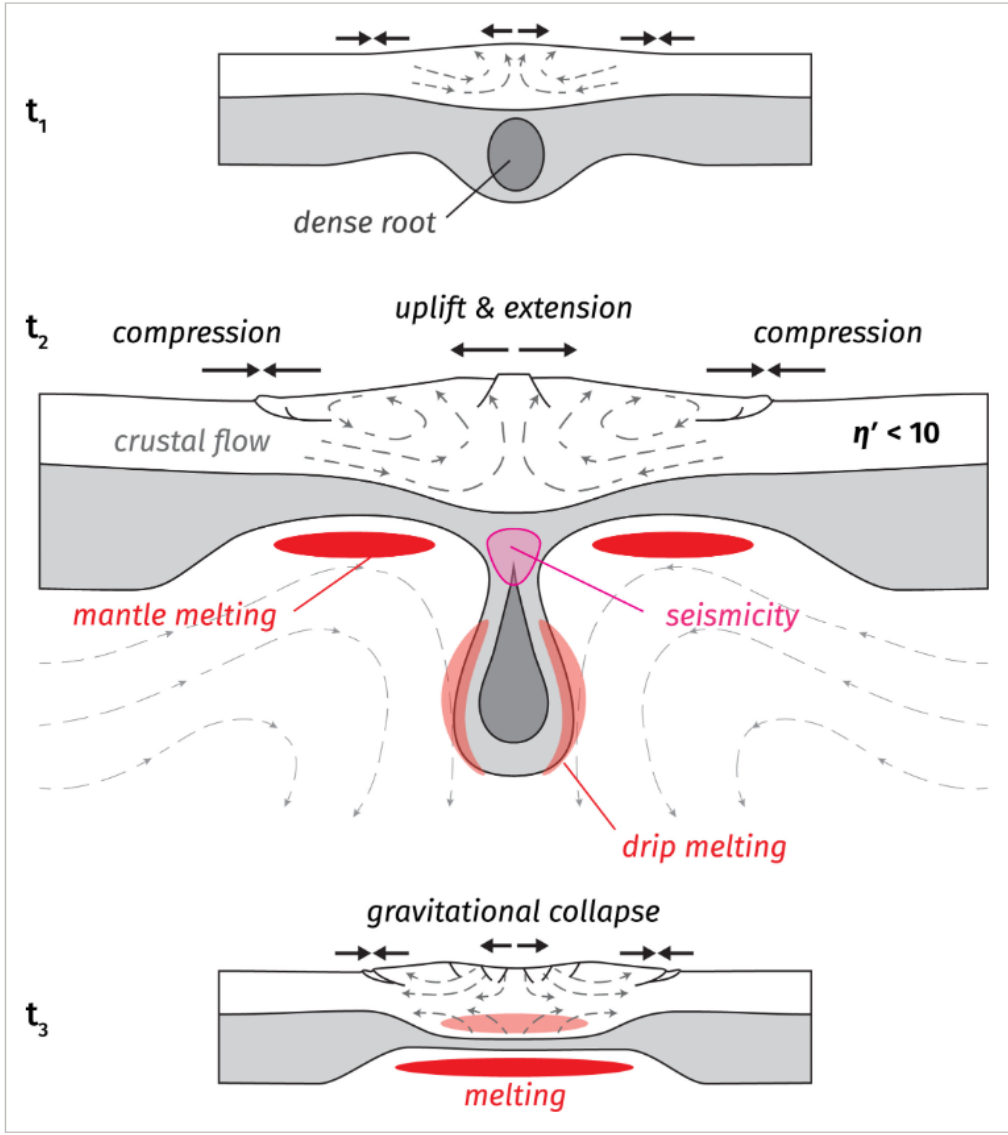
1. Crustal thickening during the c. 1730-1690 Ma Kimban Event.

2. c. 1690-1670 Ma delamination leads to high heat flow and uplift, resulting in:

- Regional high-K, magnesian magmatism (i.e. Tunkillia Suite).
- Uplift and exhumation that exposes and erodes the intrusive rocks.

3. Local extension and subsidence occurs in the Nuyts Domain, due to upwelling mantle material, results in:

- c. 1670-1625 Ma deposition in an internally sourced basin, with detritus locally derived from the exhumed magmatic rocks.
- Extension produces the c. 1660 Ma MORB-like mafic magmatism.
- Extension also results in c. 1650-1605 Ma St Peter Suite (extensional?) magmatism.



(McMillan and Schoenbohm 2023- GGG)

Mineral potential of the Penong Complex

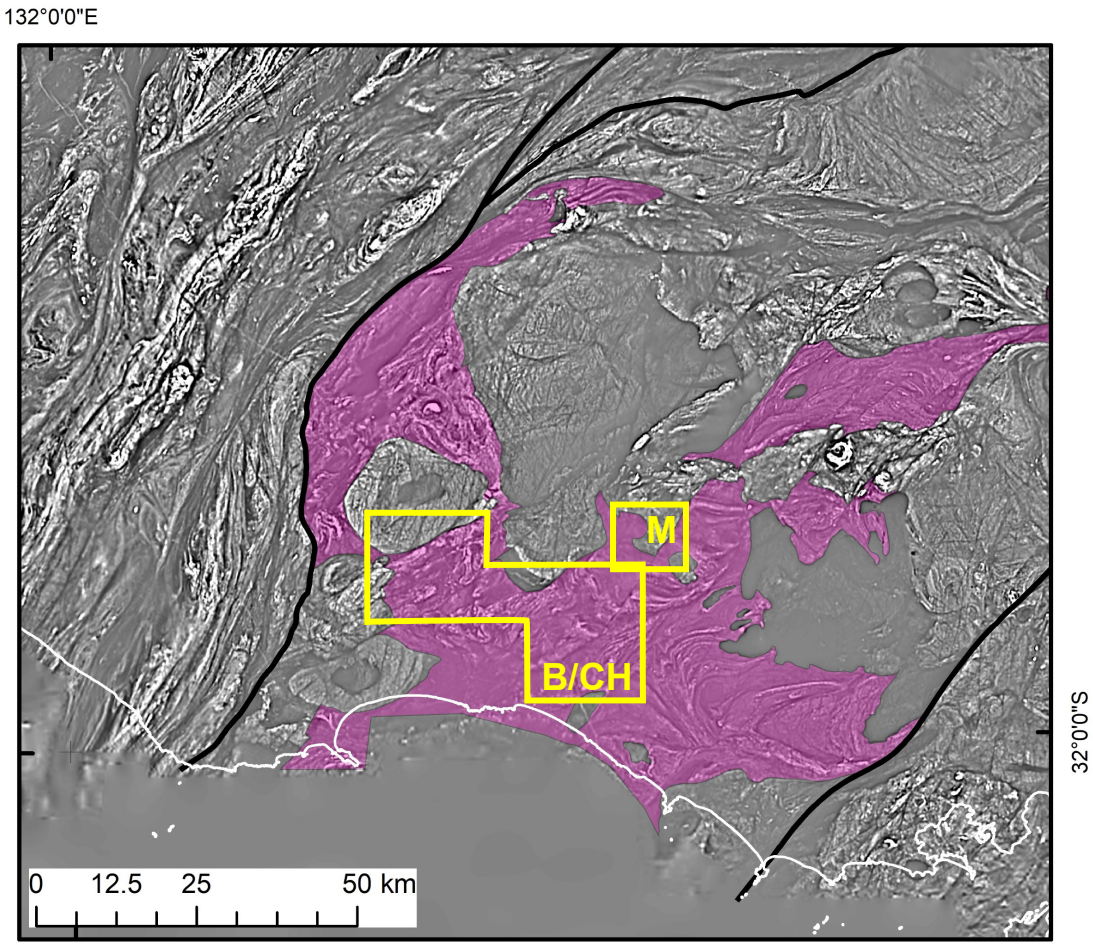
There has been very little exploration in the Penong Complex…

Moornaba

- In the 1980s, CRA Exploration looked for IOCG and BH-type deposits in a proposed caldera. Intersected interlayered mafic and felsic gneiss, with meta-ultramafics and metasediments with anomalous Cu ± Zn-Co-Mn (ENV5010).

Bookabie/Cooper Hill

- In the late-90s, Pasminco/PIMA found elevated Ni-Cr in ultramafic rocks, and elevated Au in NE-trending shears (ENV08983).
- In the 2000s, Mithril Resources looked for Voisey's Bay type deposits. They found anomalous Ni-Cu-Pt-Pd associated with a large mafic/ultramafic complex near Cooper Hill (ENV11055).



The rocks of the Penong Complex appear to be prospective for a range of mineral systems.

Plus, cover is generally < 50 m.

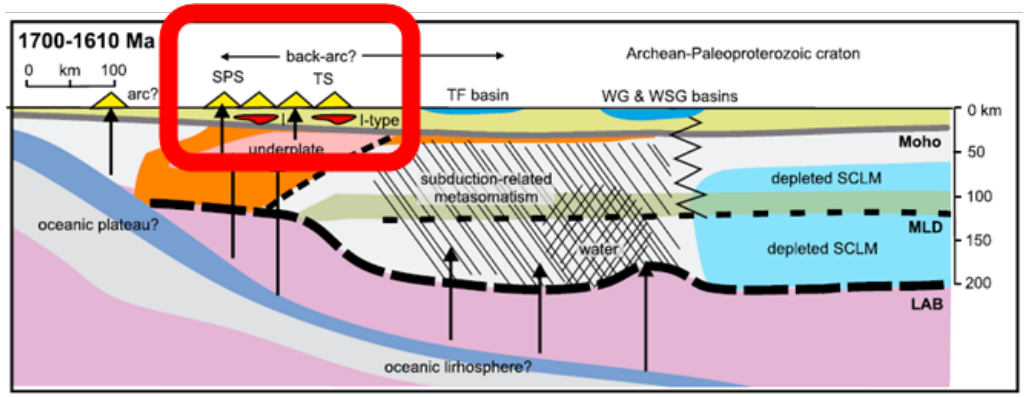
Mineral potential of the Penong Complex

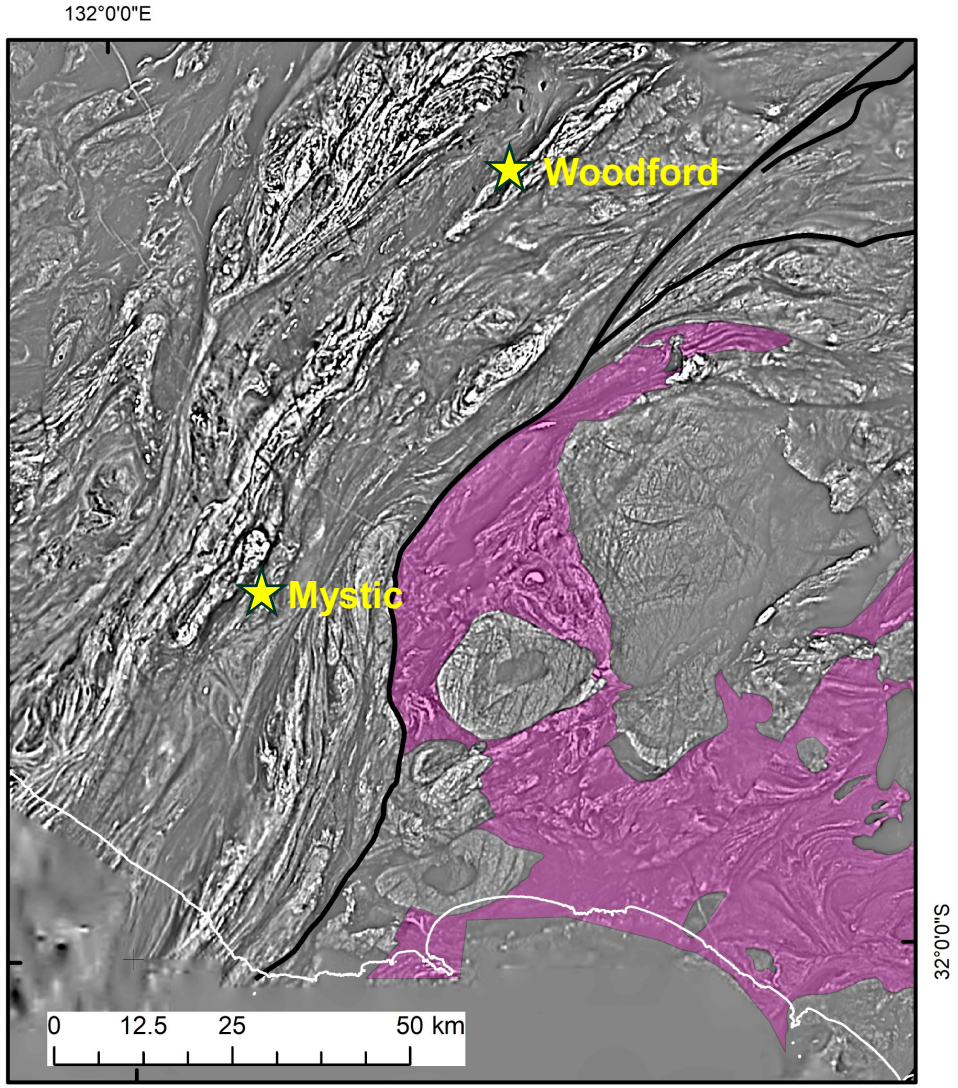
The western Nuyts Domain has a similar package of magmatic and sedimentary rocks as that seen in the eastern Fowler Domain (Reid 2019).

- The main difference appears to be greater shearing and transposition of the lithologies and structures in the Fowler Domain.
- Does this mean that exploration models for orthomagmatic Ni-Cu systems in Proterozoic belts can be applied in the Penong Complex?

Finally, an alternative tectonic setting for the Nuyts Domain without subduction has flow on effects for the models proposed for the Hiltaba Suite-related mineralisation that occurs after c. 1600 Ma.

Is post-Kimban Orogeny subduction necessary to prime the Gawler Craton for the IOCG event (e.g. Skirrow et al. 2018)?





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