

Applying an energy system approach to unravel sedimentary-hosted mineral deposits in the world-class Olympic IOCG province of South Australia

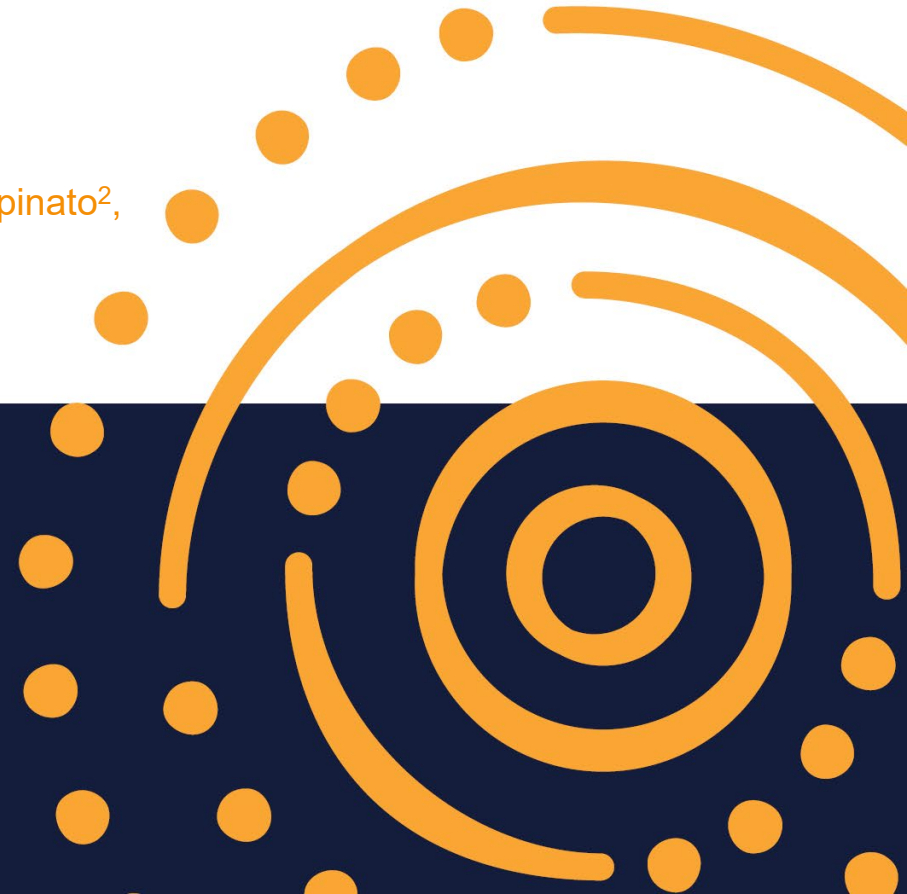
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Geological Survey of South Australia, Department for Energy and Mining

with contributions by:

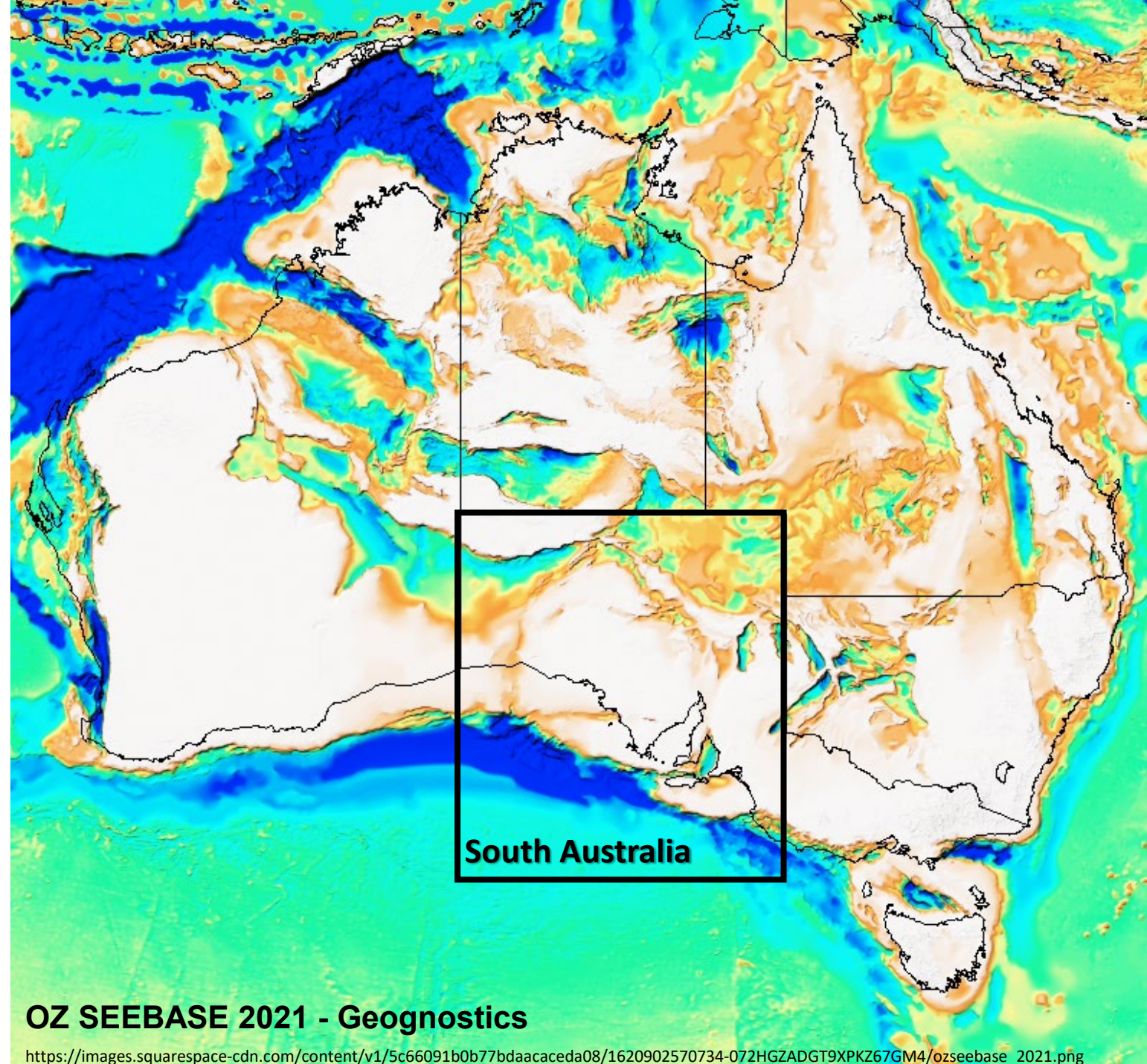
Susanne Schmid², Vincent Crombez², Marcus Kunzmann³, George Gouthas¹, Giovanni Spampinato², Alan Collins⁴, Morgan Blades⁴, Darwin Subarkah⁴, Jarred Lloyd⁴, Wolfgang Preiss^{1&4}

¹Geological Survey of South Australia, ²CSIRO, ³FMG, ⁴The University of Adelaide



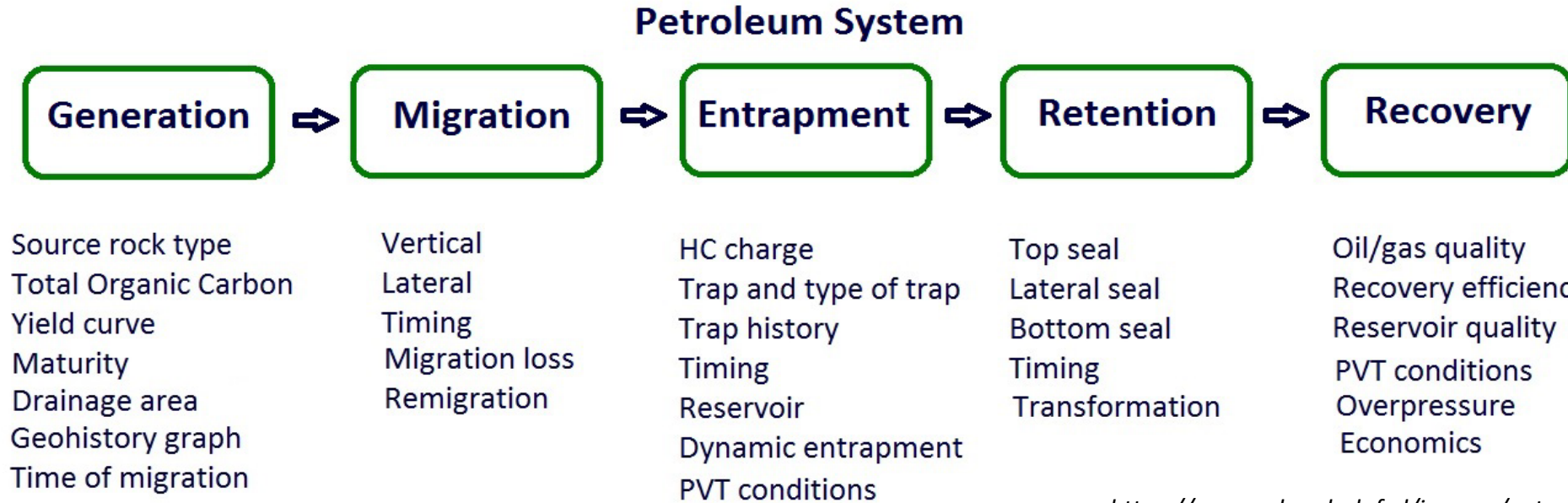
Background

- Australia has lots of basins of various ages that host base metal mineralisation
- **proven mineral provinces with mature and active frontier exploration**
- wide range of basin styles, clastic and carbonates, black shales and redbeds
- many are relatively undeformed, outcrop or shallow under cover
- but many are also very deformed and intruded, mineralised, deeply eroded and buried under regolith/cover
- **using approaches commonly used in the energy industry has the potential to provide new insights for exploration mineral targets within these basins**



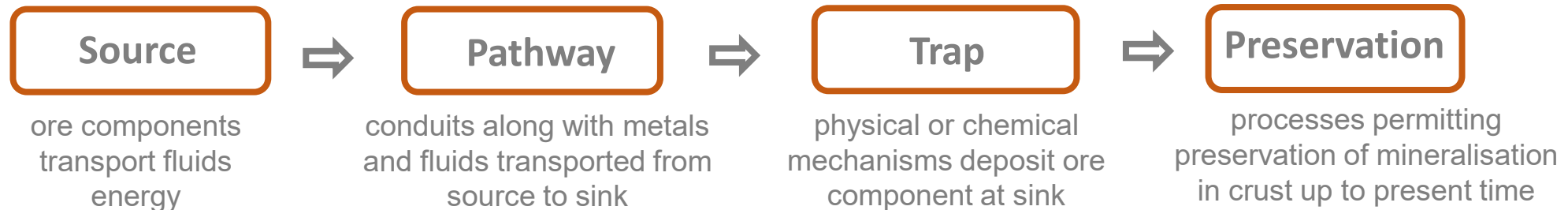
Petroleum System Approach

Many concepts are similar for **Mineral Systems**, but different terms used and extra processes present (magmatic, hydrothermal...)

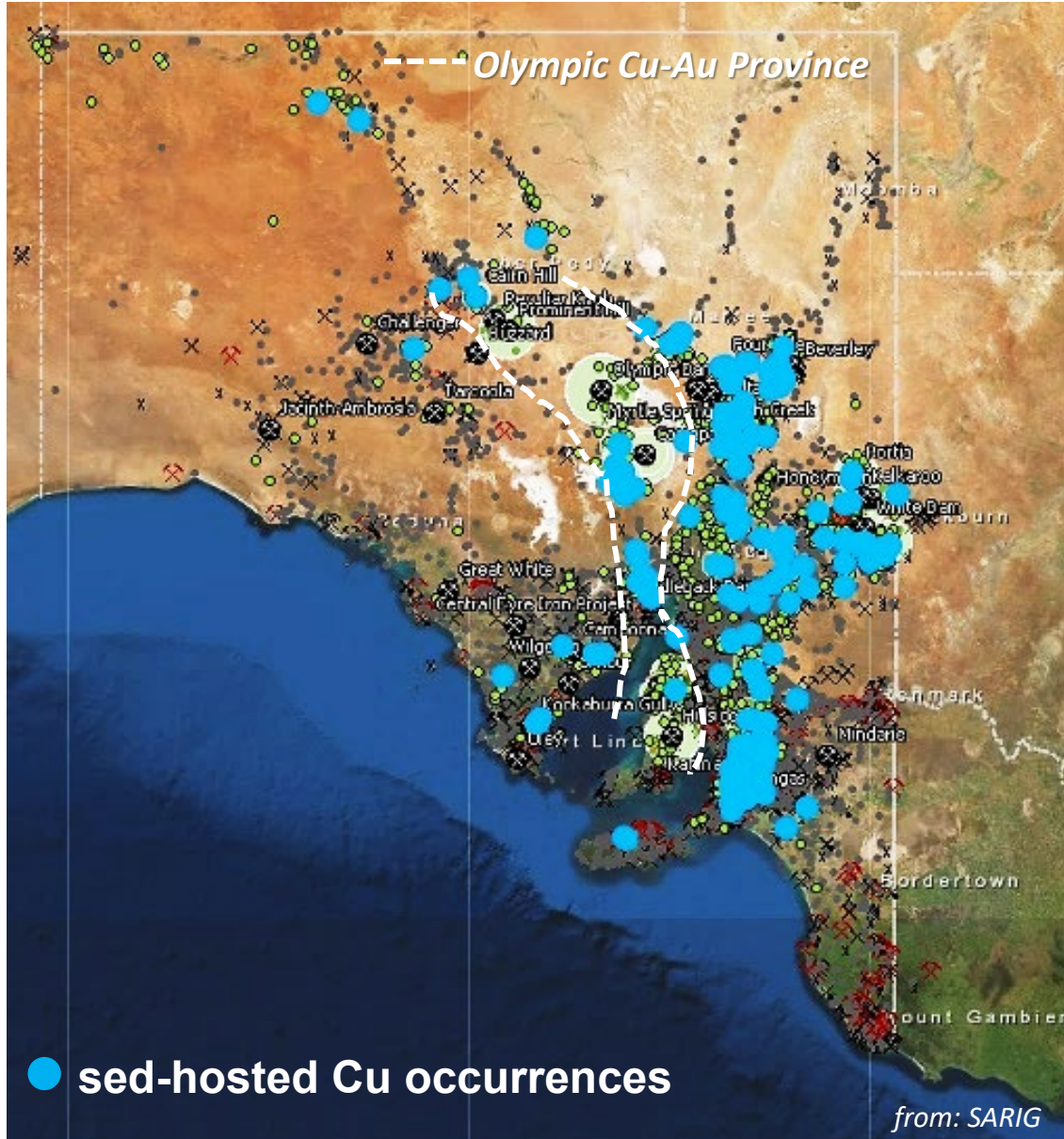


<https://www.mhnederlof.nl/images/petroleumsystem.jpg>

Mineral System



Sediment-hosted copper in South Australia



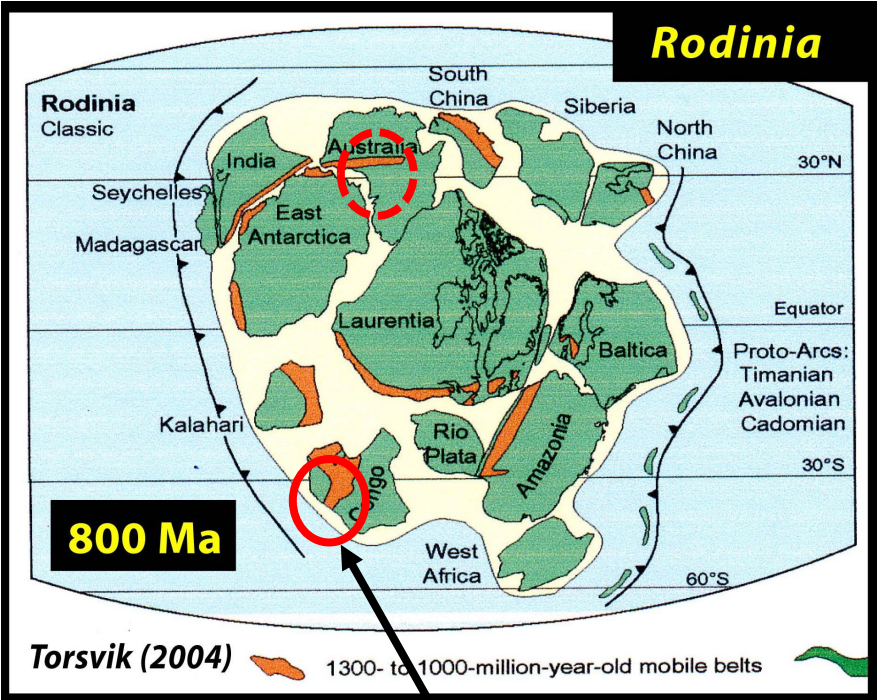
~40% of copper occurrences in South Australia are sediment-hosted

Deposit	Ore (Mt)	Cu (%)	Cu (kt)	Co (%)	Past production (Cu - kt)
Emmie Bluff	40.2	1.27	511	0.06	-
Windabout	17.65	0.77		0.05	-
MG14	1.83	1.24		0.033	-
Gully	0.9	0.9	8.1	0.01	-
Sweet Nell	0.35	1.2	4.2		Neg
Cattlegrid	15	0.67	100	0.01	>156
Main Open Cut	3.3	0.51	17		16
Kapunda	3.7	1.2	47		14
Mountain of Light	1.2	0.82	10		0.6
Blinman	20.21	>3.5-15			9.9
Burra	2.7	3.3			90

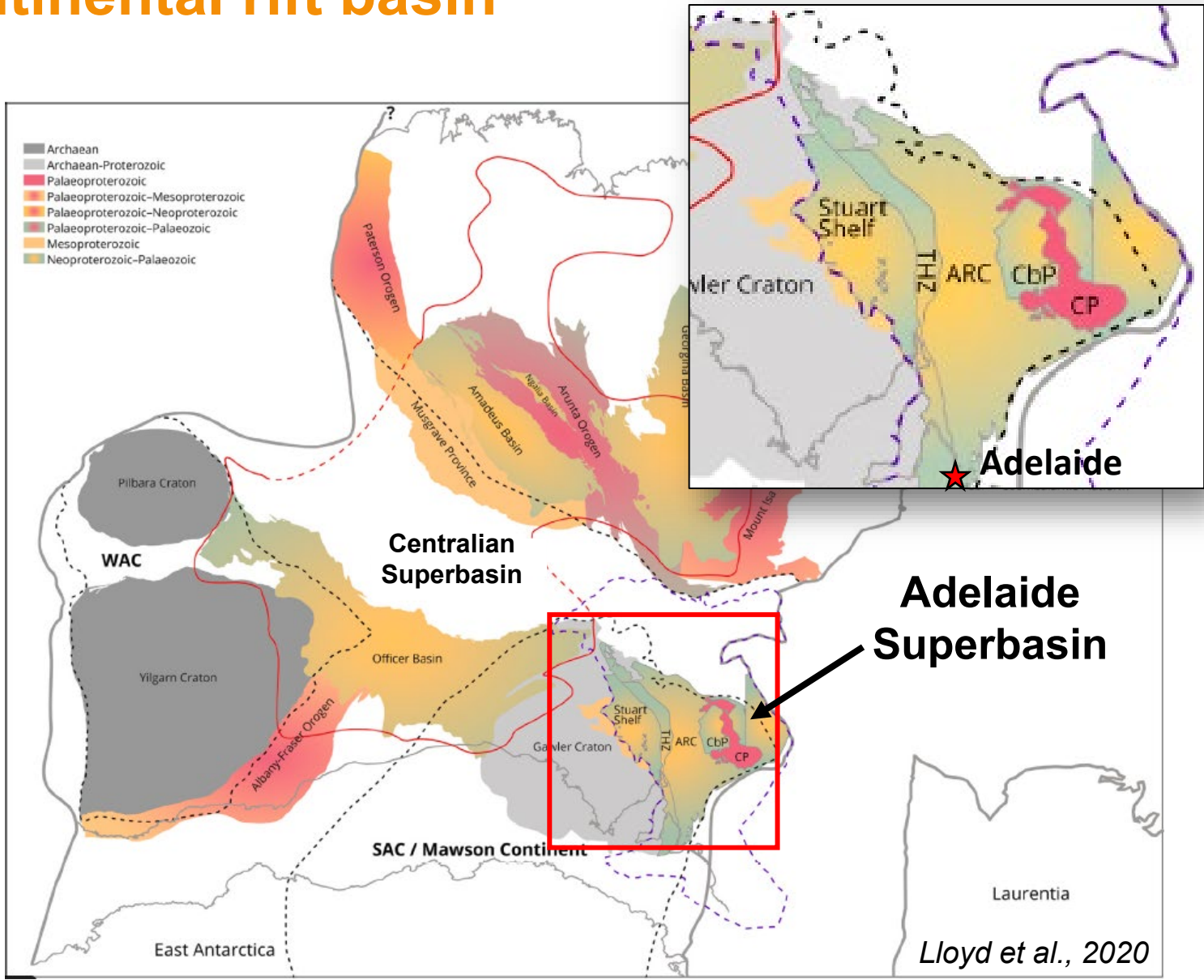
→ just how prospective is South Australia for sediment-hosted Cu deposits and where are the 'giant' ones?

Comparison Central African Copperbelt (CACB) - South Australia

Tectonic setting → intracontinental rift basin



Katanga Basin



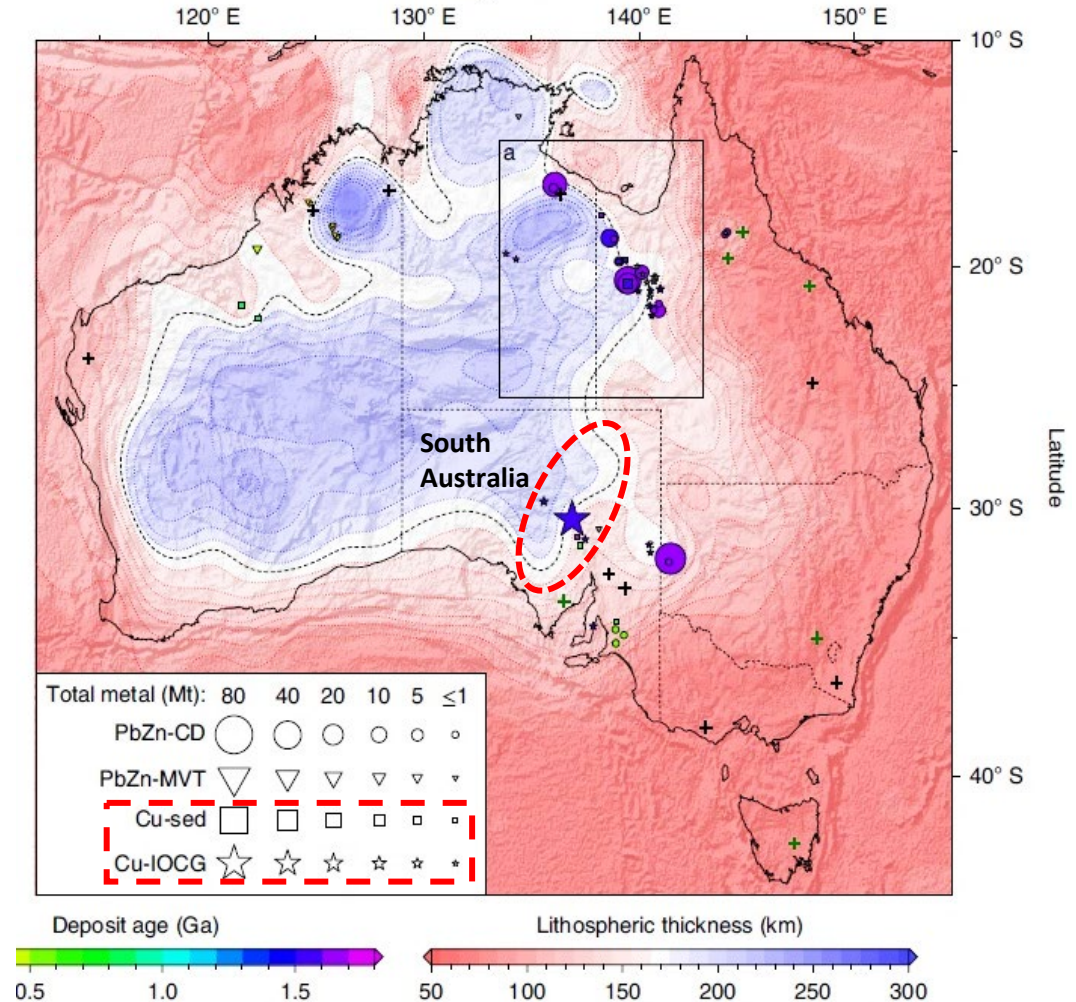
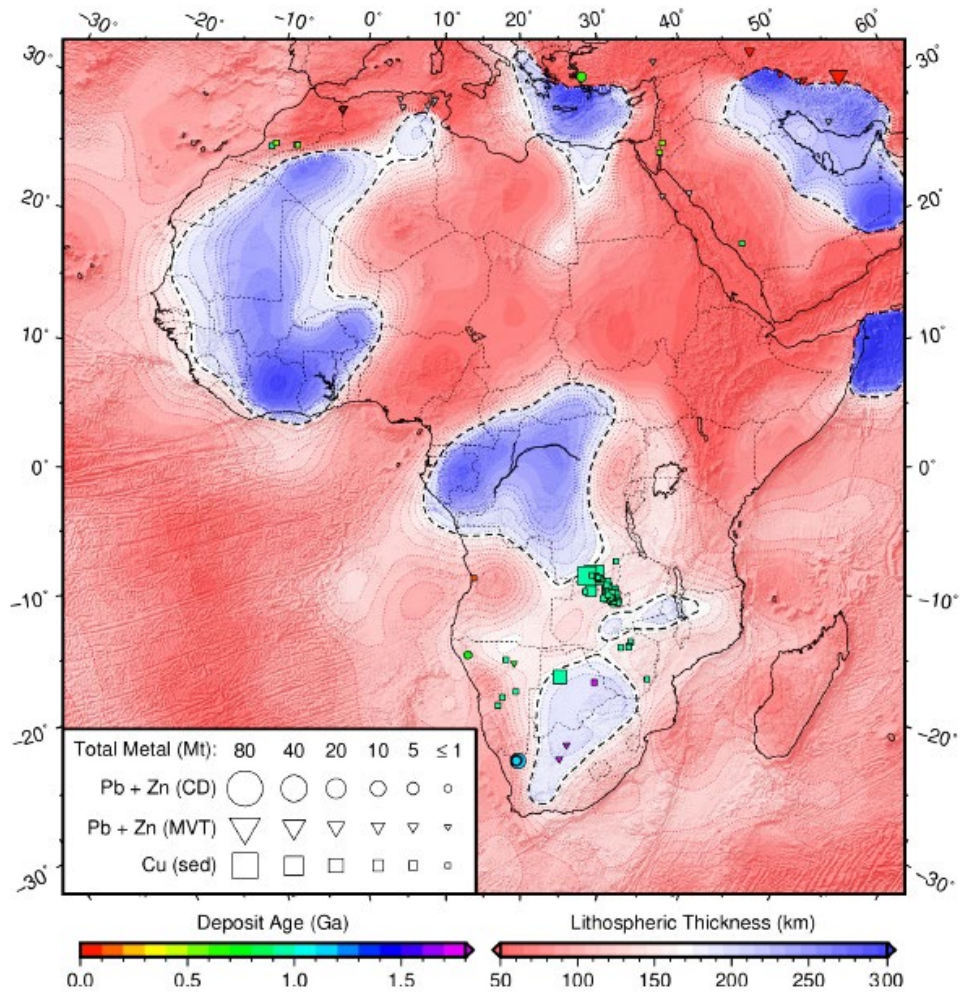
Adelaide Superbasin

Lloyd et al., 2020

Comparison Central African Copperbelt (CACB) - South Australia

Continental margins - lithosphere thickness model (Hoggard et al., 2020)

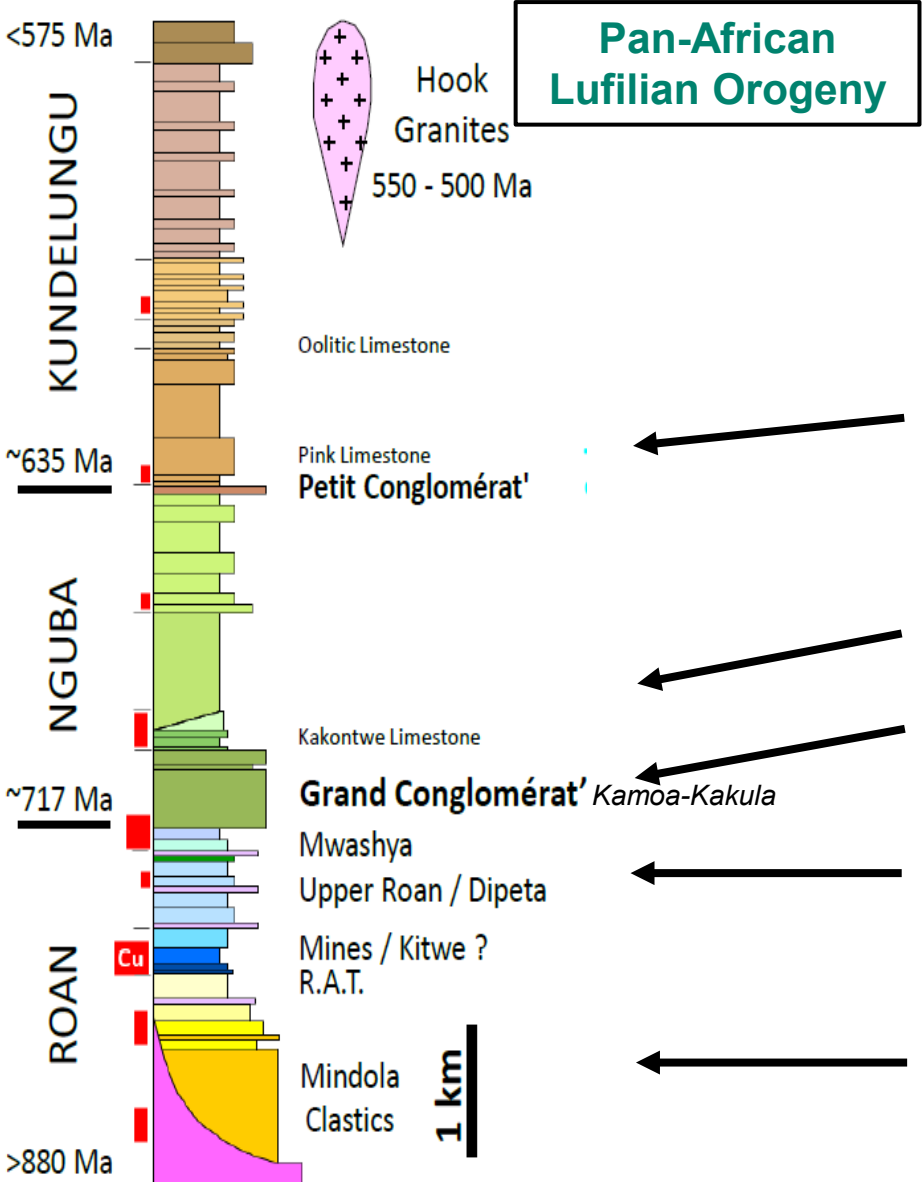
→ both have enriched sub-continental lithospheric mantle (SCLM)



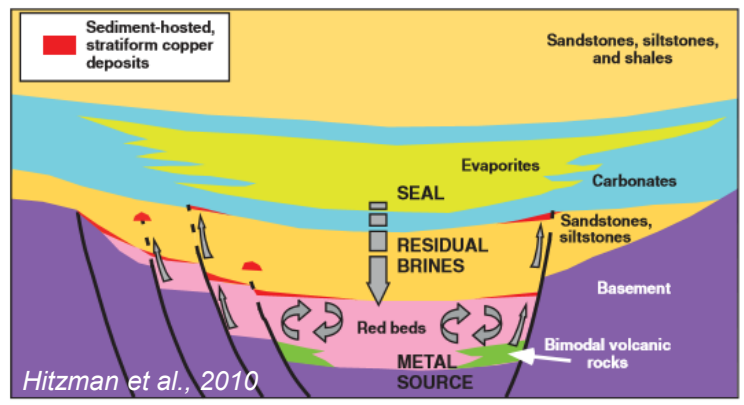
Basin evolution

Katangan Supergroup

Adelaide Superbasin



Woodhead, 2020



Delamerian Orogeny

Cap carbonate
post-Marinoan glaciation



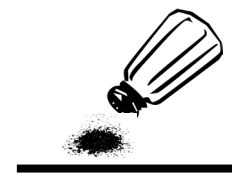
Seal/trap
→ carbonate



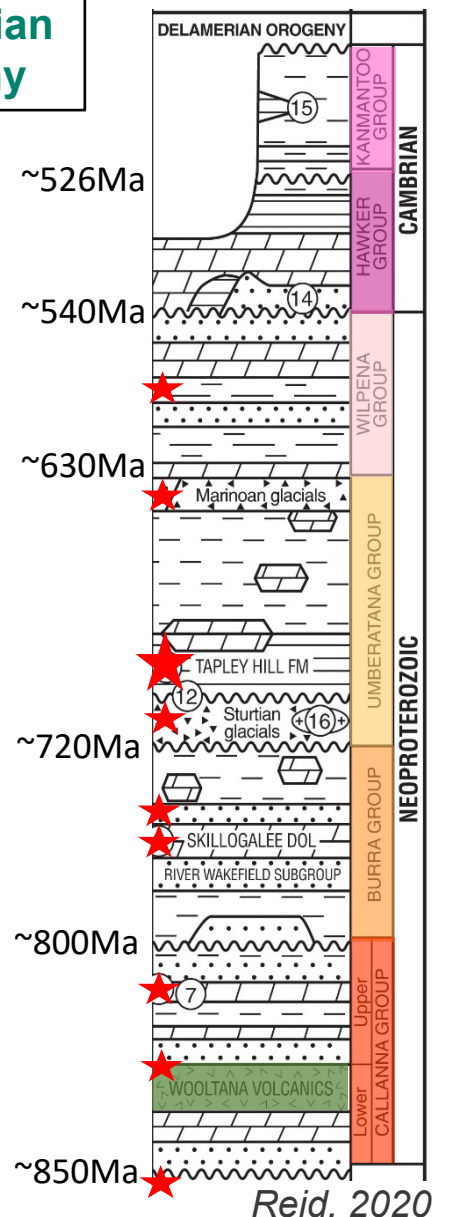
Sturtian glacials

Renewed extension
→ finer-grained clastics and carbonates

Rift phase
→ coarse clastics, evaporites, carbonates, mafic igneous rocks



★ Cu

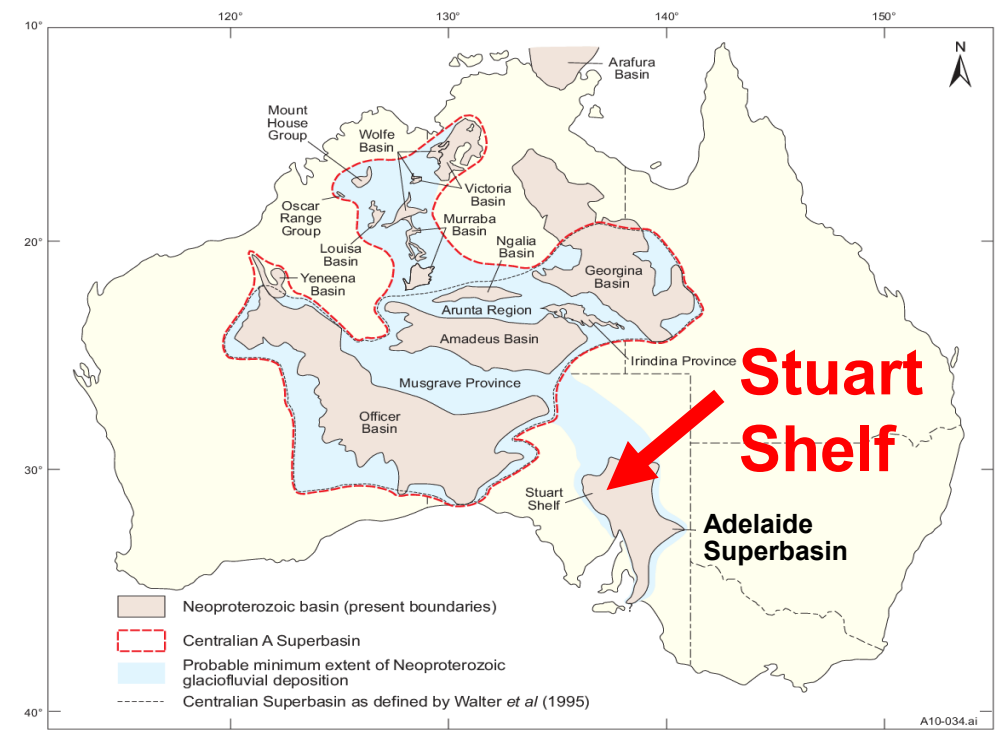


Why the Stuart Shelf?

- renewed and increased exploration interest
- known sediment-hosted Cu (Co-Pb-Zn) deposits
- similarities to Central African Copper Belt
- overlies world-class Olympic IOCG Province

Mineralisation:

- Neoproterozoic Tapley Hill Fm (mainly at base)
- permafrost breccia at contact between Mesoproterozoic redbeds of Pandurra Fm and Neoproterozoic aeolian sandstones of Whyalla Sandstone
- palaeo-basement highs (e.g. Pernatty High)

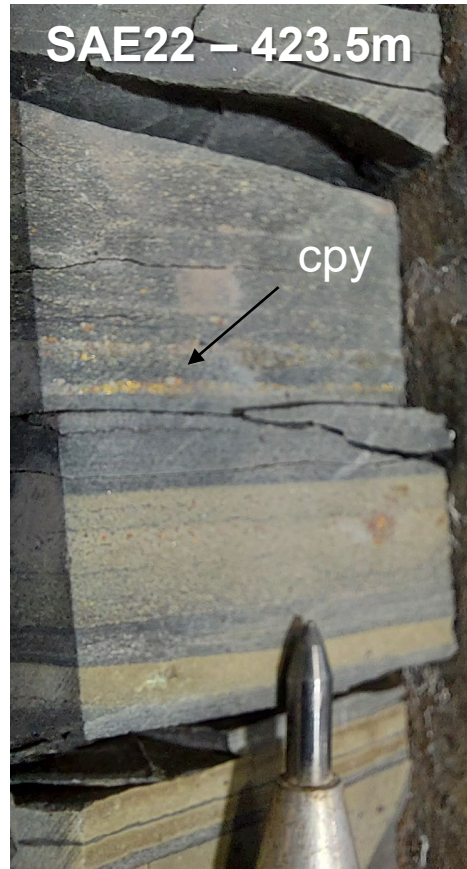


Cattlegrid Pit Mount Gunson

Sed-Cu mineralisation Stuart Shelf

Ore textures

replacement (laminae, clasts), cements, veins

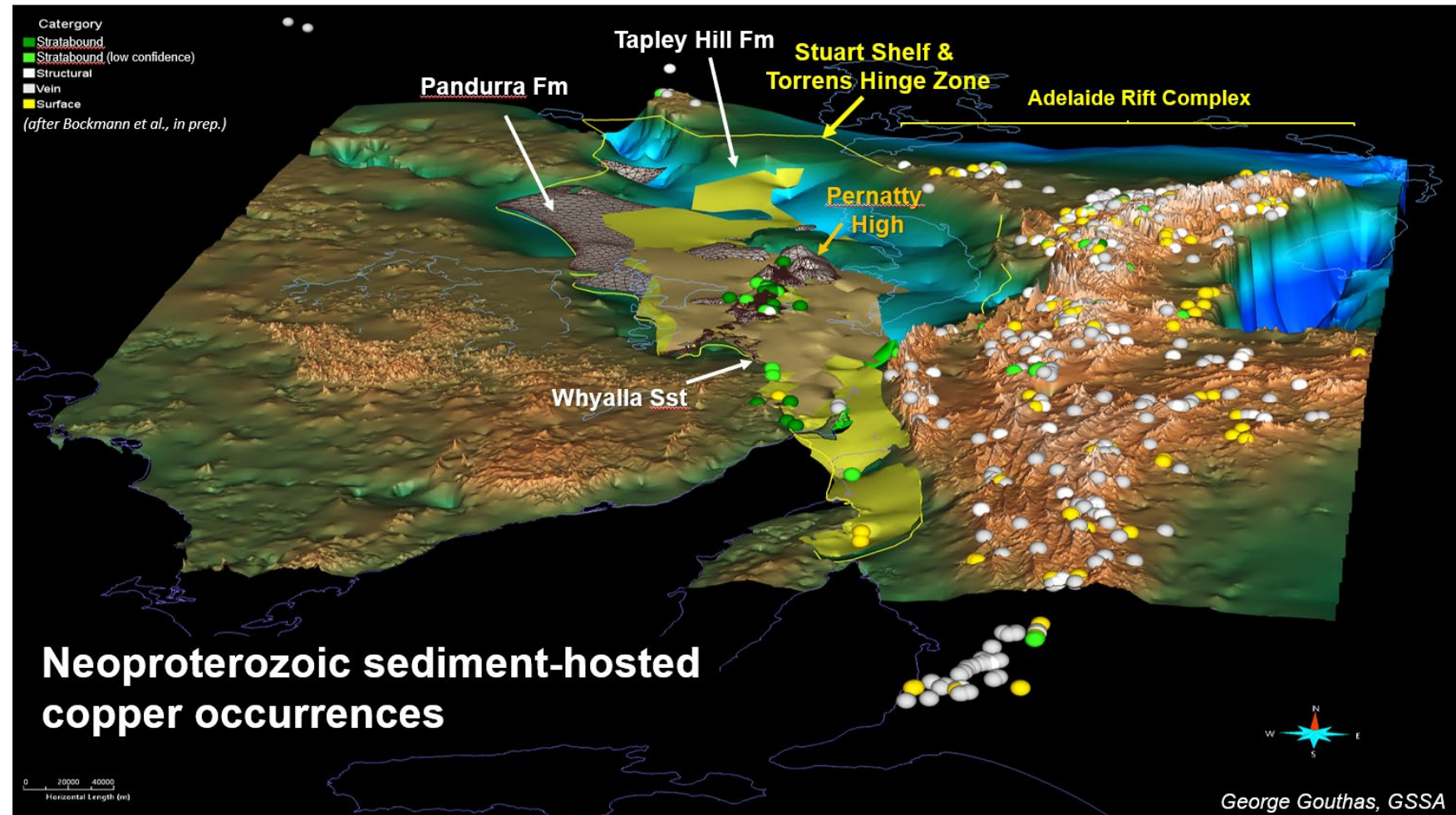


Emmie Bluff – clast and matrix cpy, replacement textures

Cattlegrid/Mt Gunson - permafrost breccia

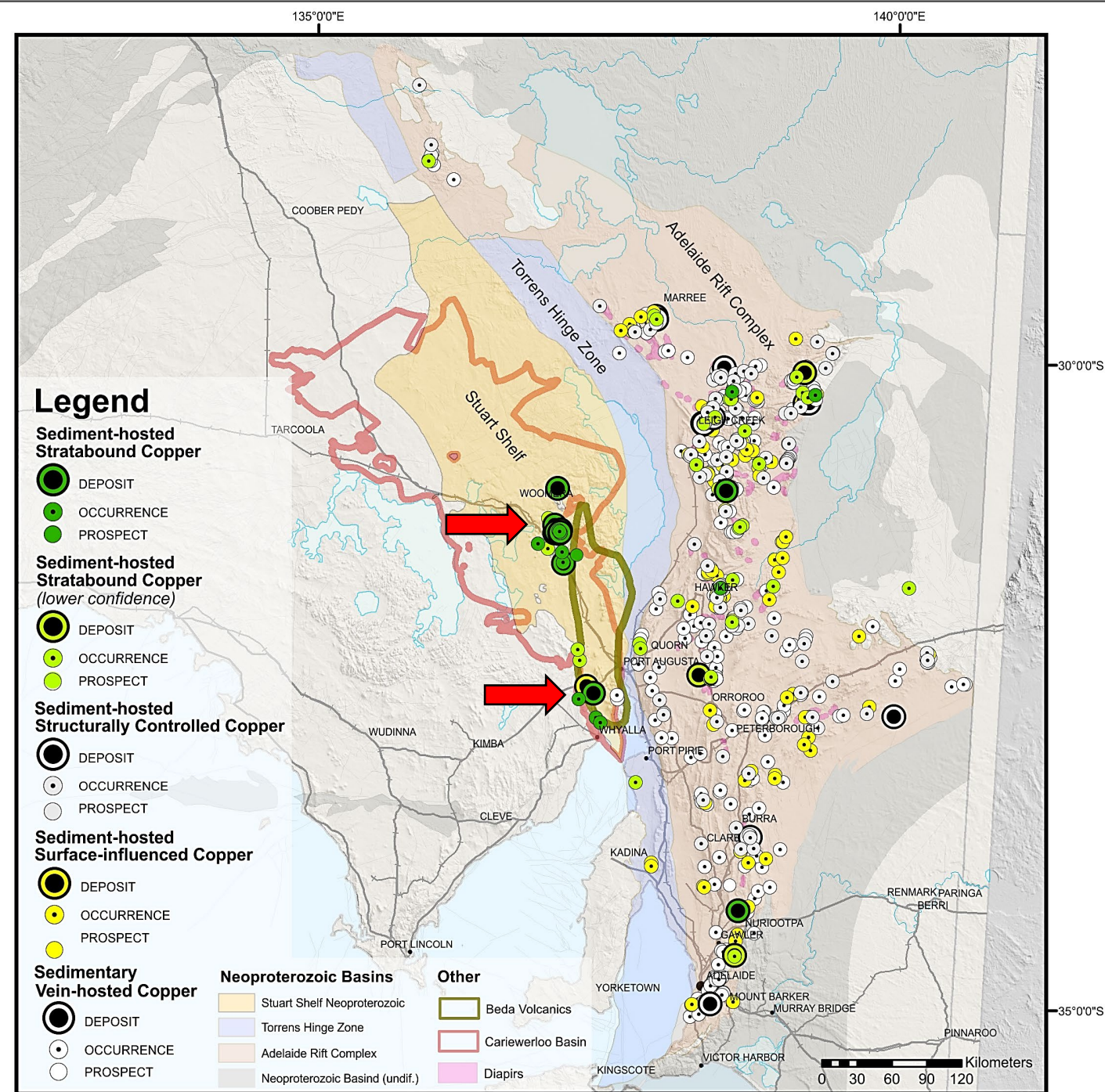
Mineral systems components SedCu on Stuart Shelf

- ✓ Geological setting
- ✓ Chronostratigraphy
- ✓ Prolonged depositional history
- ✓ Evaporites
- ✓ Host rocks
- ✓ Source rocks
- ✓ Structural traps
- ✓ Basement endowment
- ✓ Demonstrated Cu enrichment



Stuart Shelf emerging patterns

- dominantly hosted in Tapley Hill Fm and permafrost breccia developed at contact Mesoproterozoic Pandurra Fm and Neoproterozoic Whyalla Sandstone
- around Pernatty High (basement high)
- along western margin of Beda Volcanics
- within extend of underlying Cariewerloo Basin (Pandurra Fm)

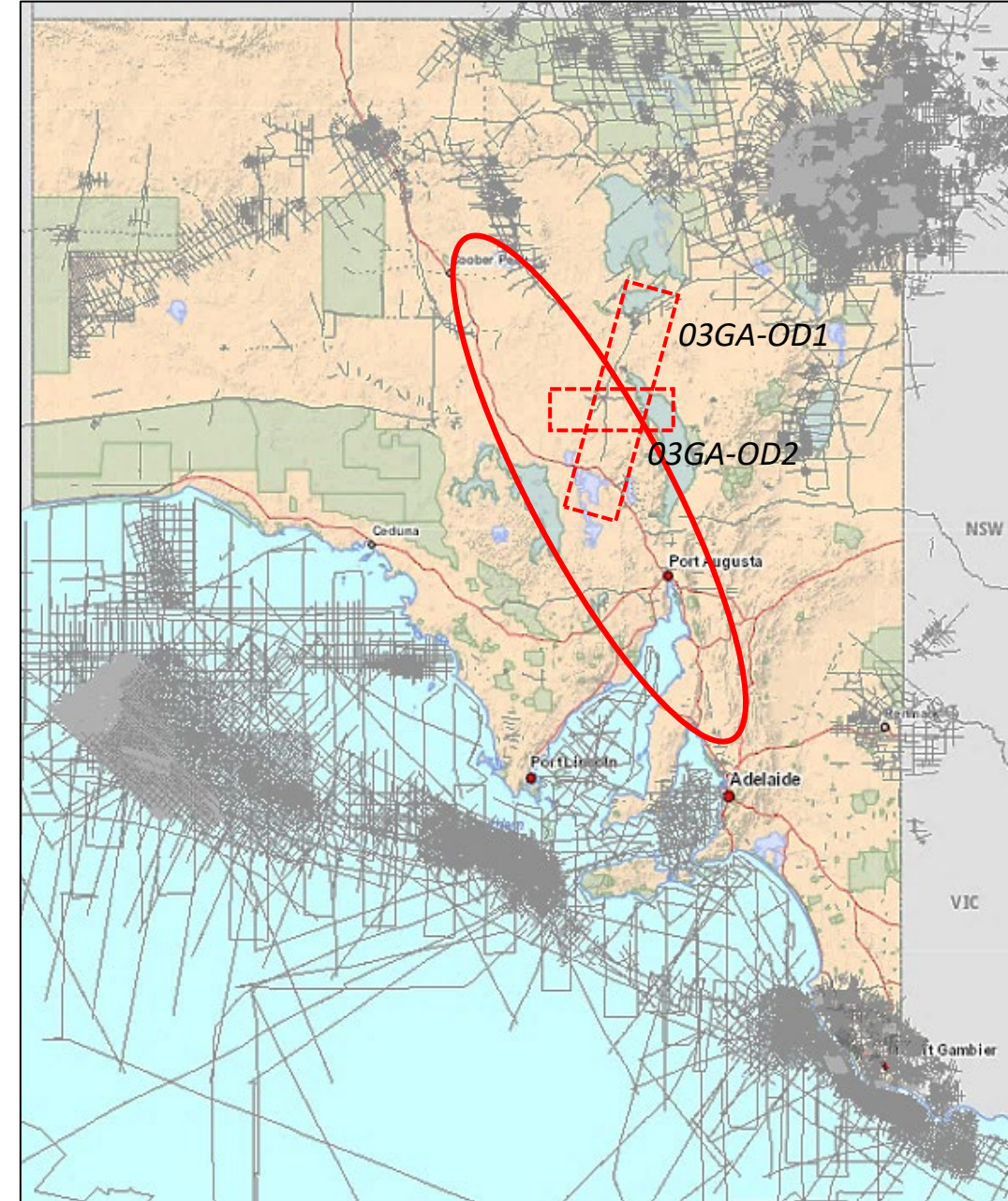
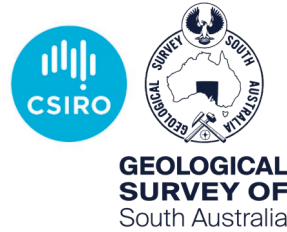


Stuart Shelf sediment-hosted mineral potential

→ Applying an energy system approach to unravel sedimentary-hosted mineral deposits in the world-class Olympic IOCG province of South Australia

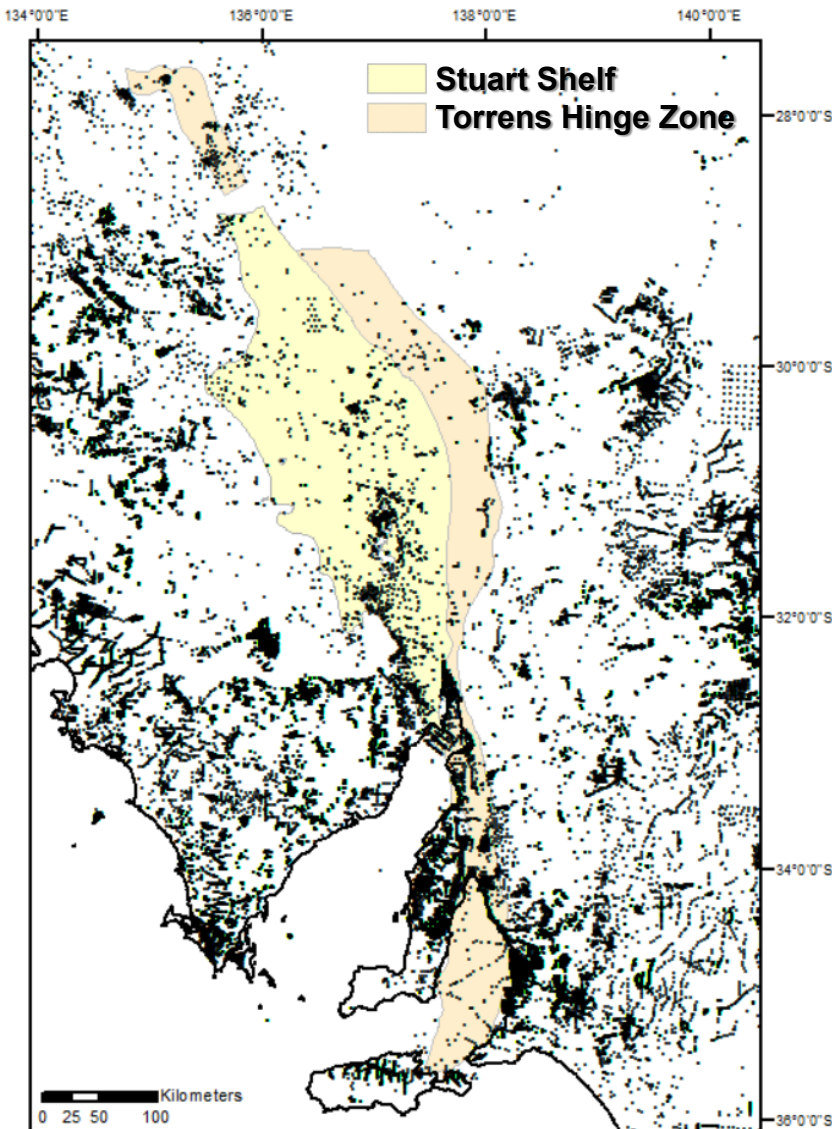
GSSA/CSIRO Sedimentary Cu project

with a strong focus on basin evolution & architecture using a litho- and sequence stratigraphic approach

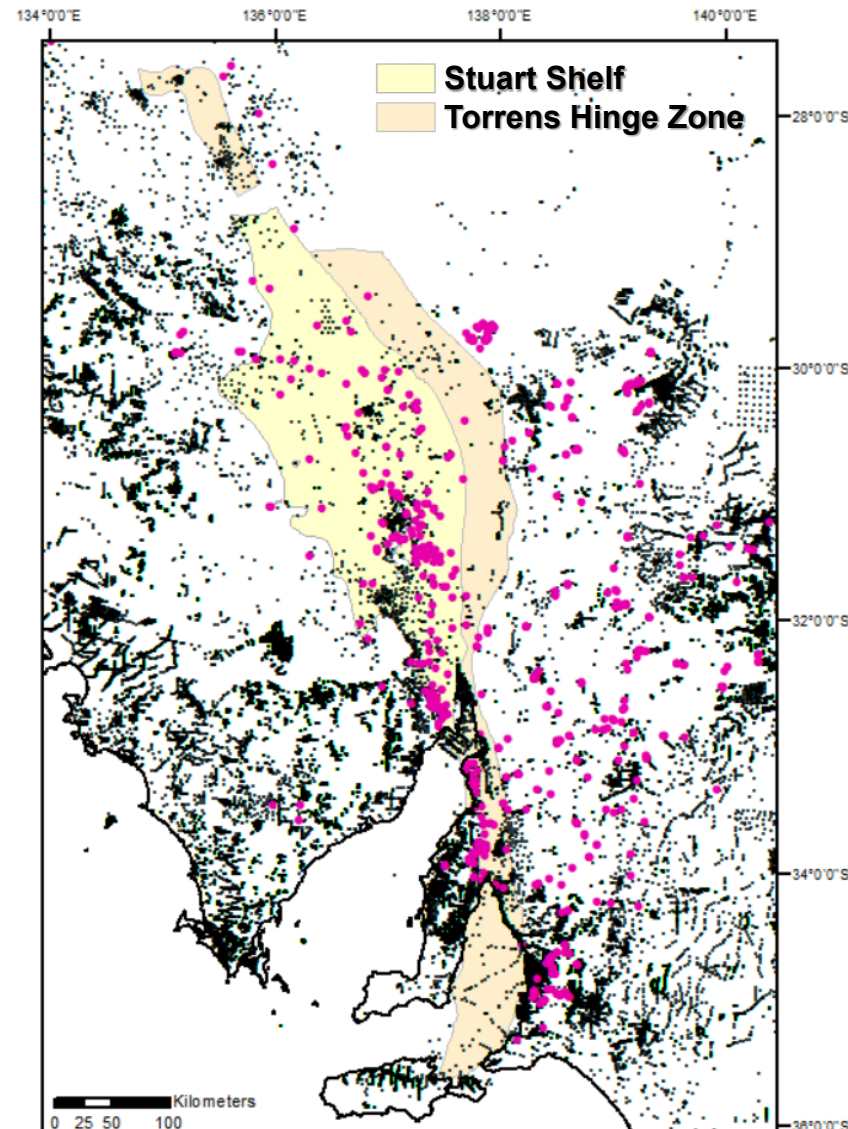


Stuart Shelf data availability – drillholes

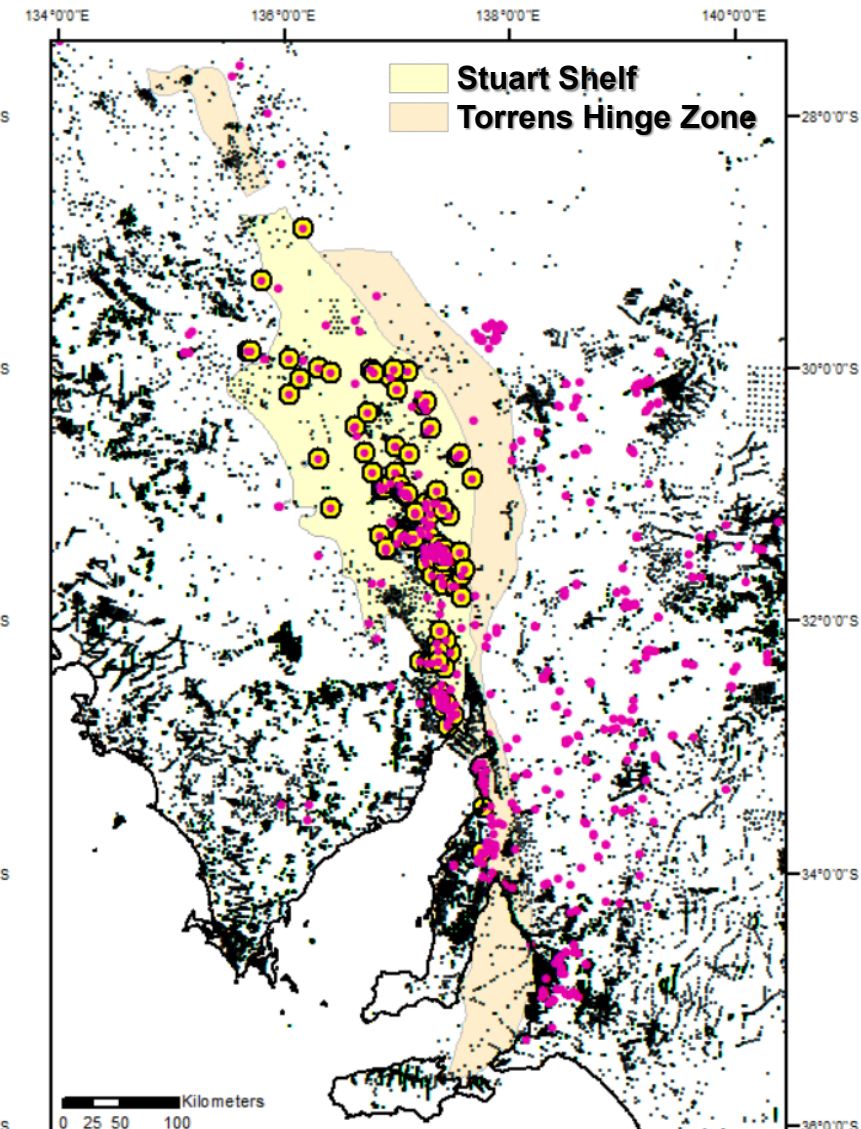
• all mineral drillholes

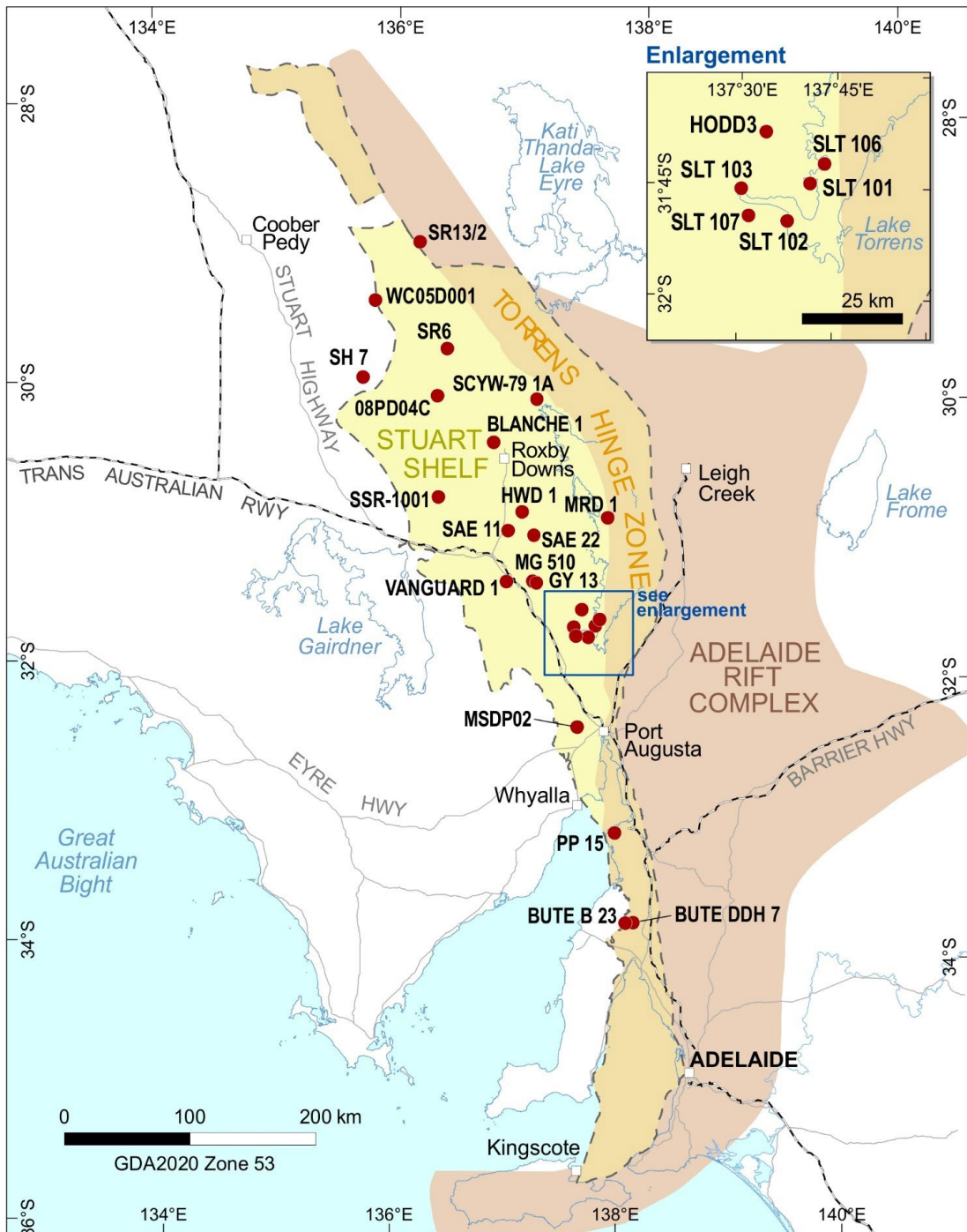


• drillholes with drill core (Neoprot.)



• drillholes with HyLogged™ core (Neoprot.)





New data collection included:

25 drillholes logged & HyLogged™

→ 10,570 m of core relogged

→ 9,245 gamma data, 4,711 pXRF data (including standards)

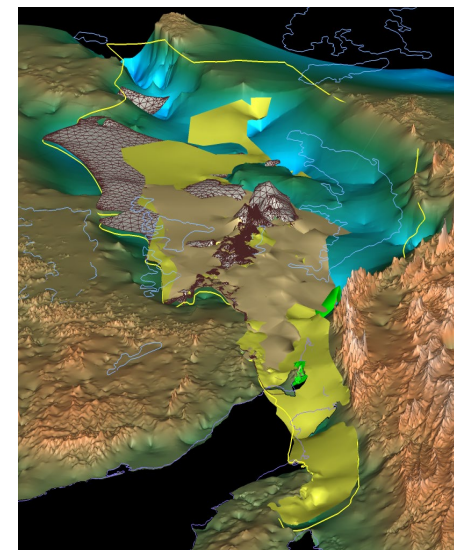
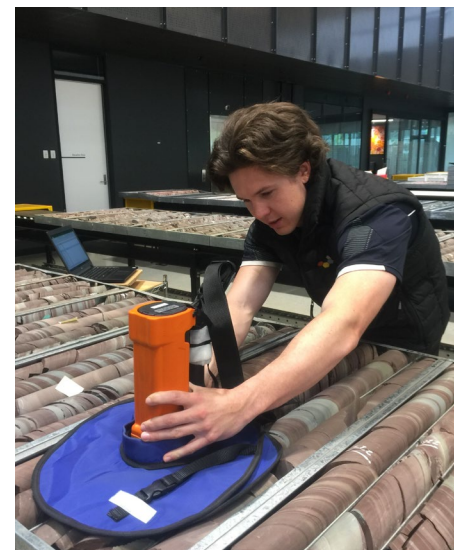
→ 120 samples for carbon isotope, 8 samples for Rb-Sr dating

→ 20 thin sections for diagenesis study

→ 3,450 detailed core photographs

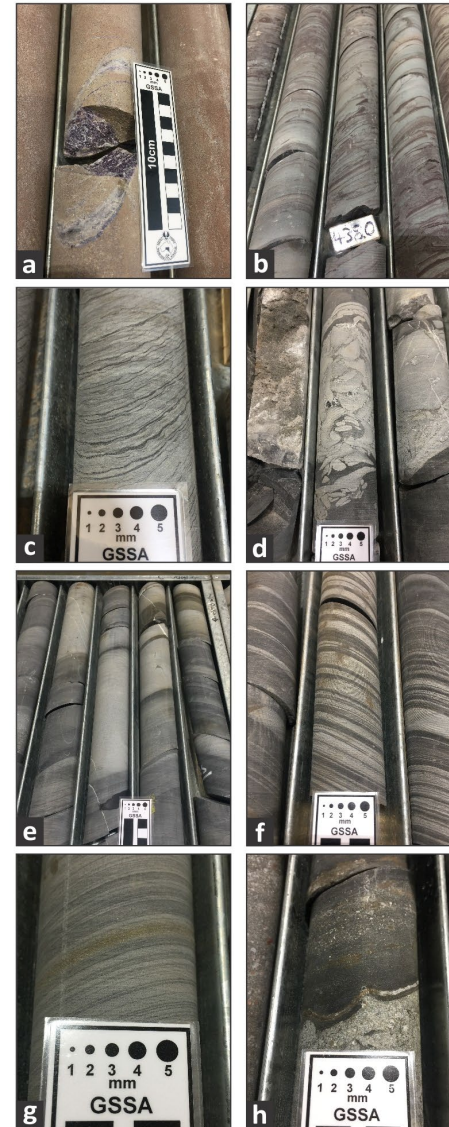
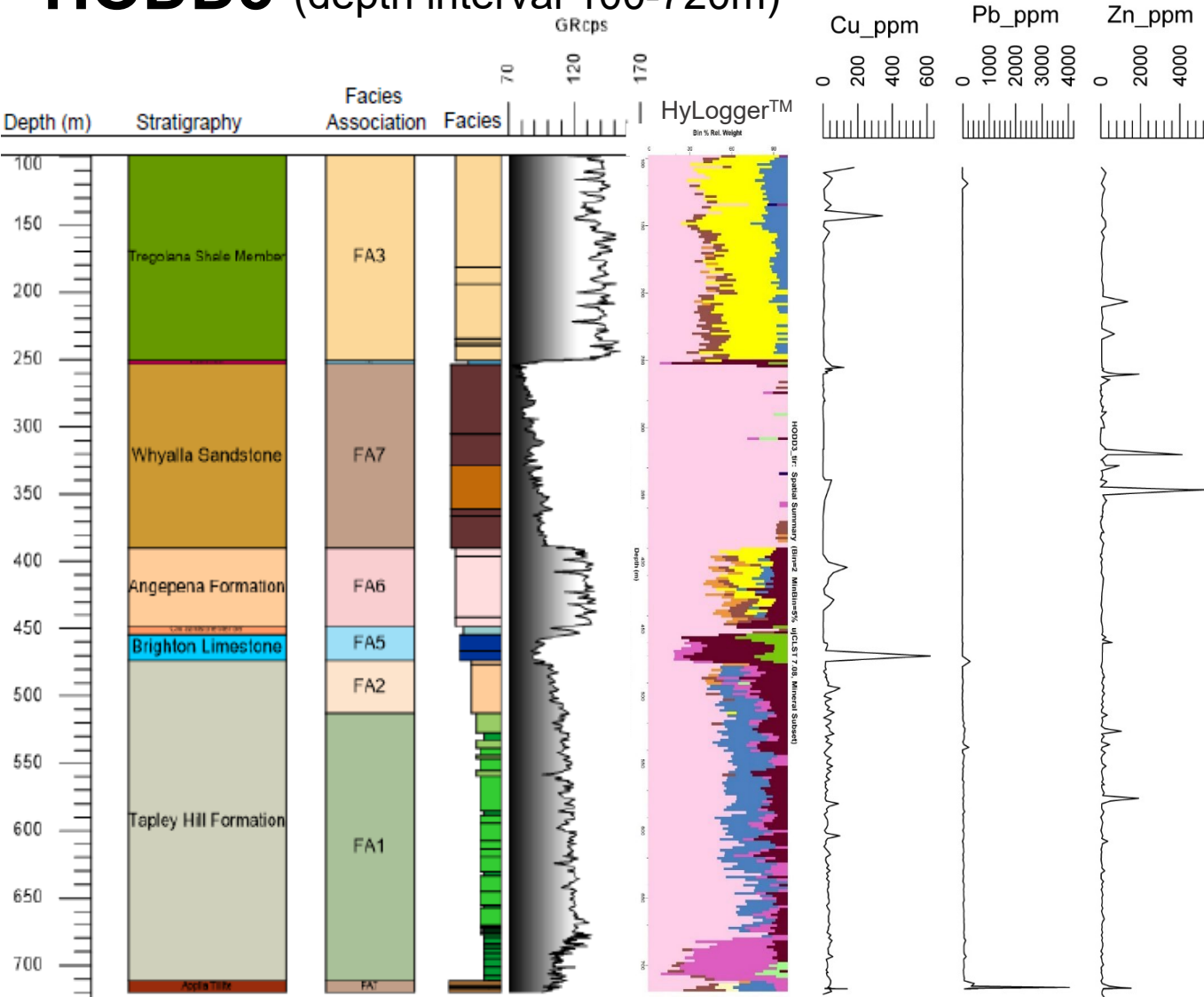
→ 3D surfaces Top Pandurra Fm, Beda Basalt & Tapley Hill Fm,
Base Whyalla Sst

→ 18 lithofacies, 7 facies association

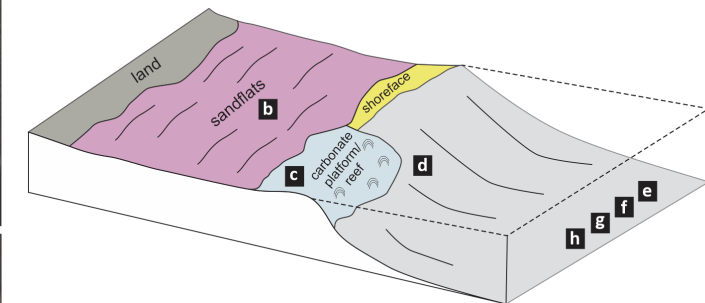


Drillhole review and data collection - example

HODD3 (depth interval 100-720m)



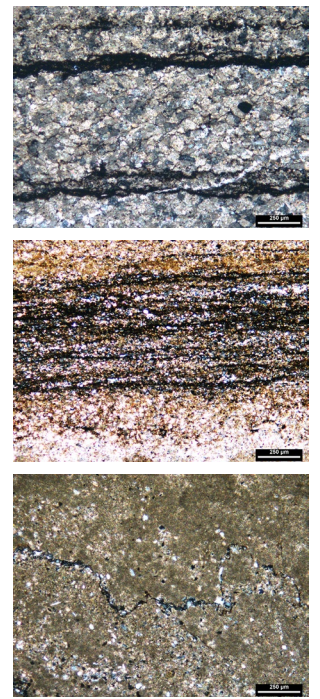
Depositional Environments

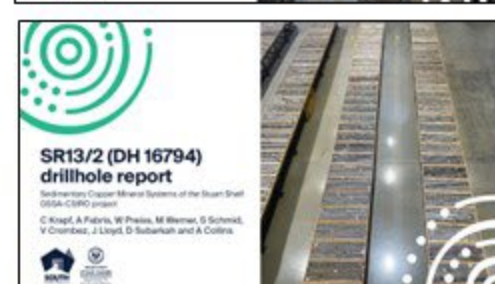
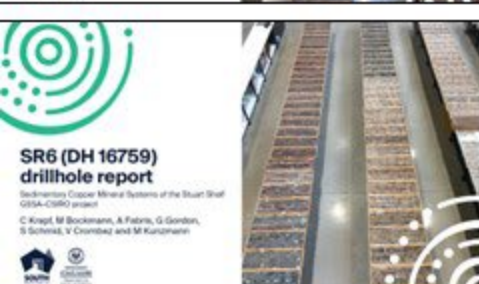
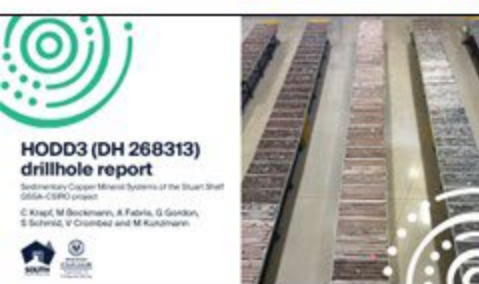


Facies Association (FA)

- FA1: offshore
- FA2: offshore transition
- FA3: lower shoreface - prodelta
- FA4: shoreface to delta front
- FA5: shallow subtidal to subtidal
- FA6: intertidal to supratidal
- FA7: glacial to fluvio-glacial

Thin sections



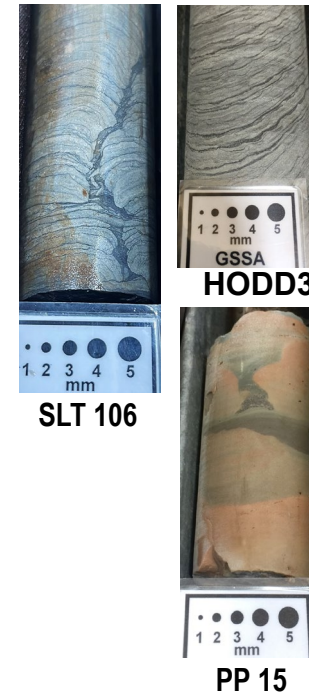


Facies analysis

18 lithofacies → 7 facies associations (FA)

distinguished based on compositional and textural properties, and the occurrence of distinct sedimentary structures

FA 1 offshore	FA 2 offshore transition	FA 3 lower shoreface - prodelta	FA 4 shoreface to delta front	FA 5 shallow subtidal to subtidal	FA 6 intertidal to supratidal	FA 7 glacial to fluvio-glacial
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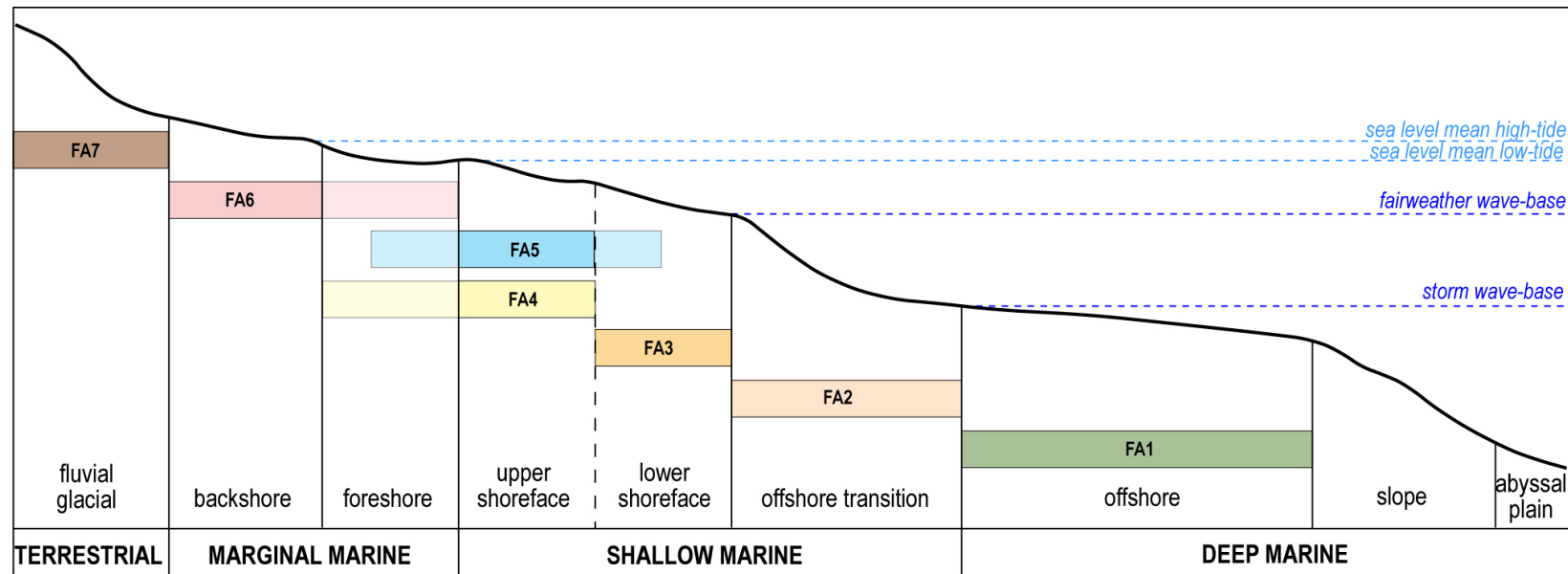


Facies analysis

18 lithofacies → 7 facies associations (FA)

in parts these are aligned closely with existing stratigraphic units

FA 1 offshore	FA 2 offshore transition	FA 3 lower shoreface - prodelta	FA 4 shoreface to delta front	FA 5 shallow subtidal to subtidal	FA 6 intertidal to supratidal	FA 7 glacial to fluvio-glacial
Tapley Hill Fm (basal)	Tapley Hill Fm (above BSFR)	Tregolana Shale Mbr	Corraberra Sst Mbr Simmens Qtz Mbr	Brighton Lst Nuccaleena Fm	Angepena Fm Cox Sandstone Mb	Whyalla Sandstone Appila Tillite Wilmington Fm



Correlative surfaces mapped from facies

black mudrock
maximum flooding surface

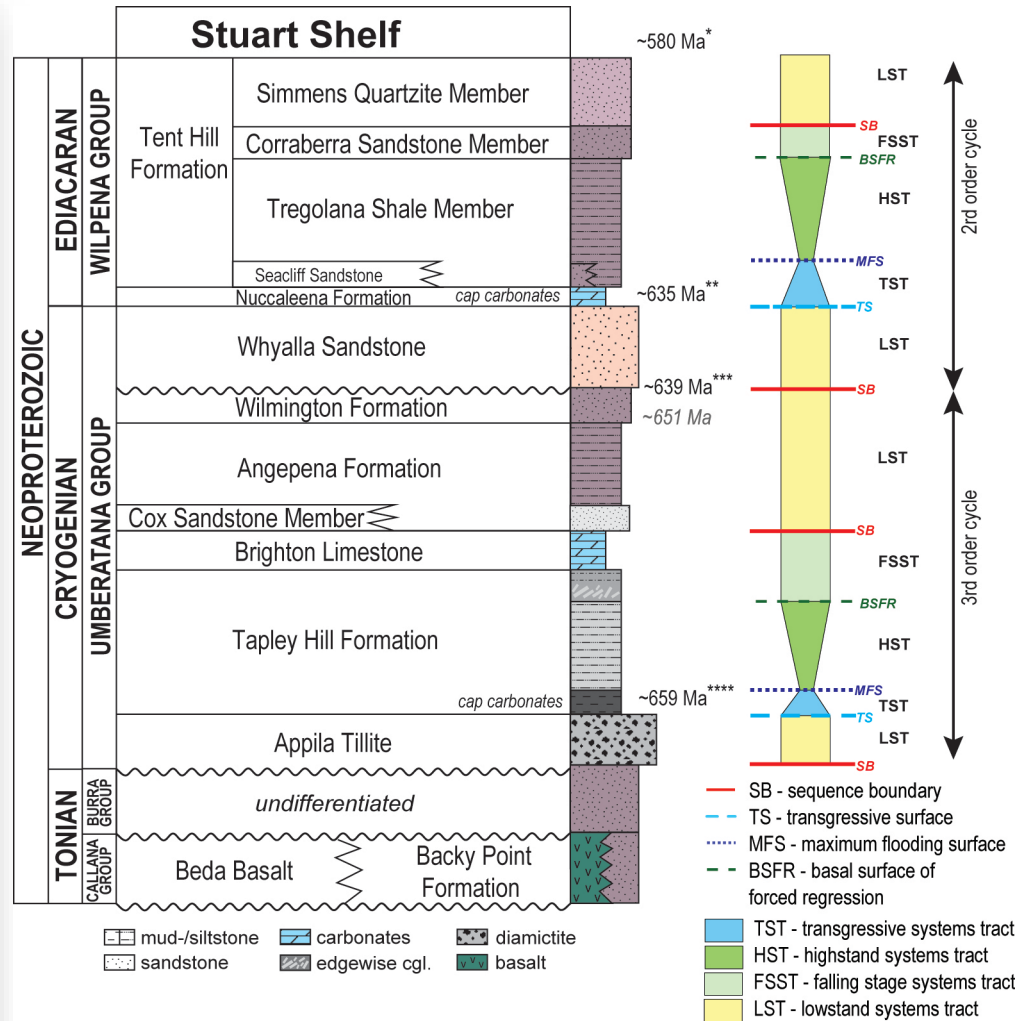


SLT 102

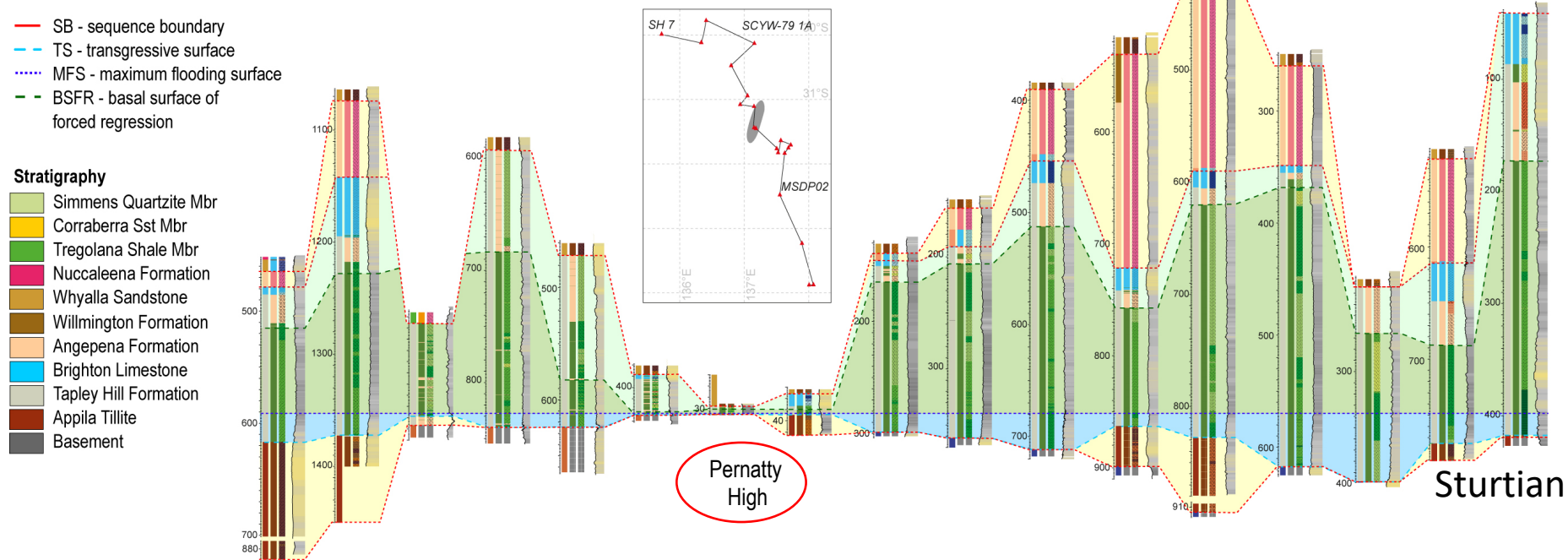
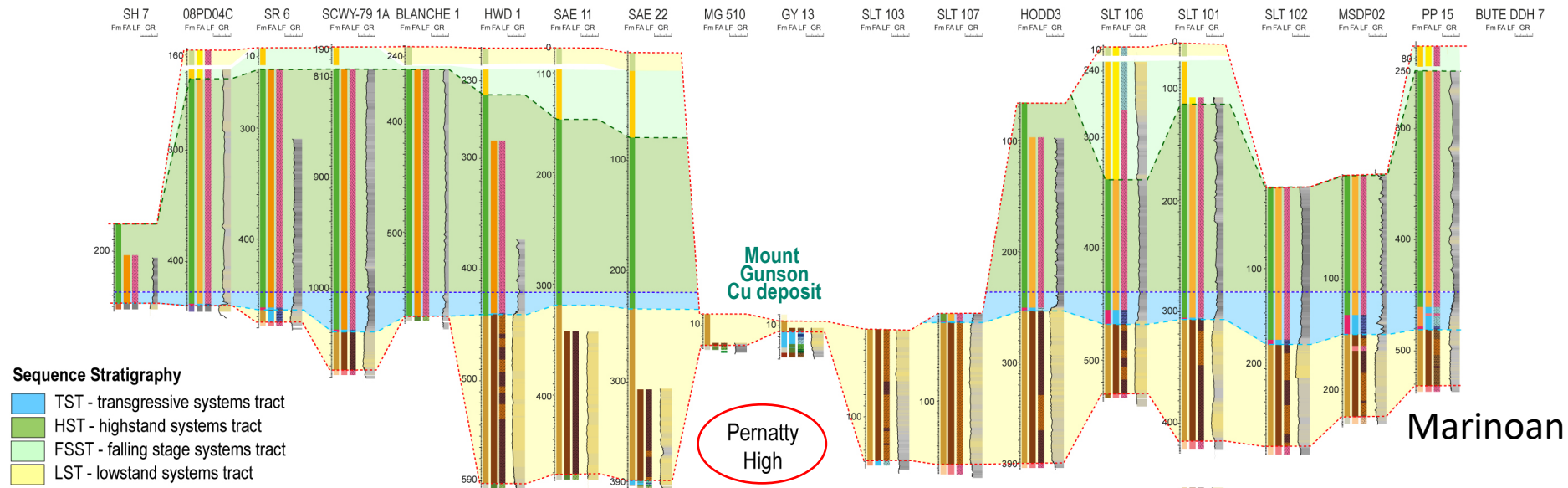
edgewise conglomerate
basal surface of forced regression (BSFR)



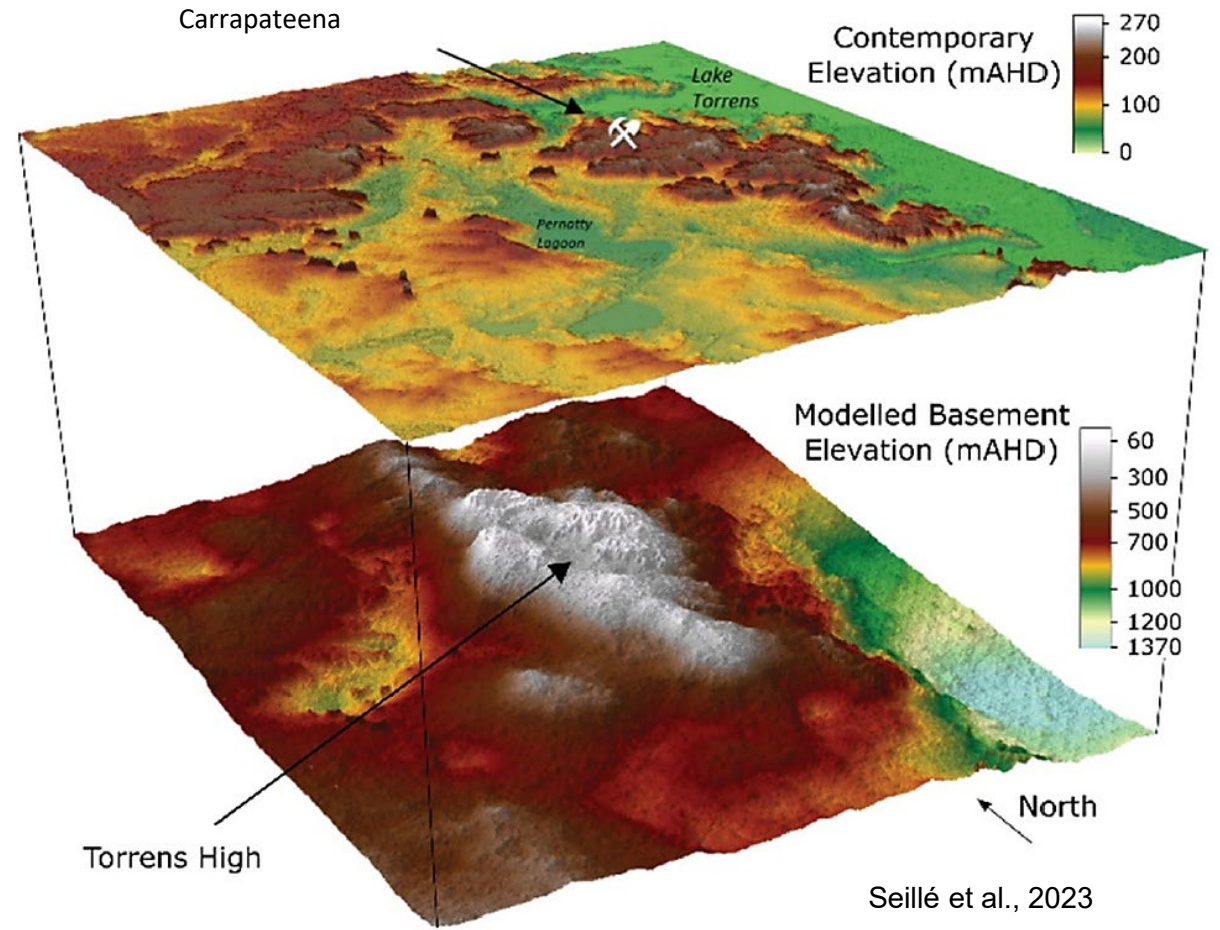
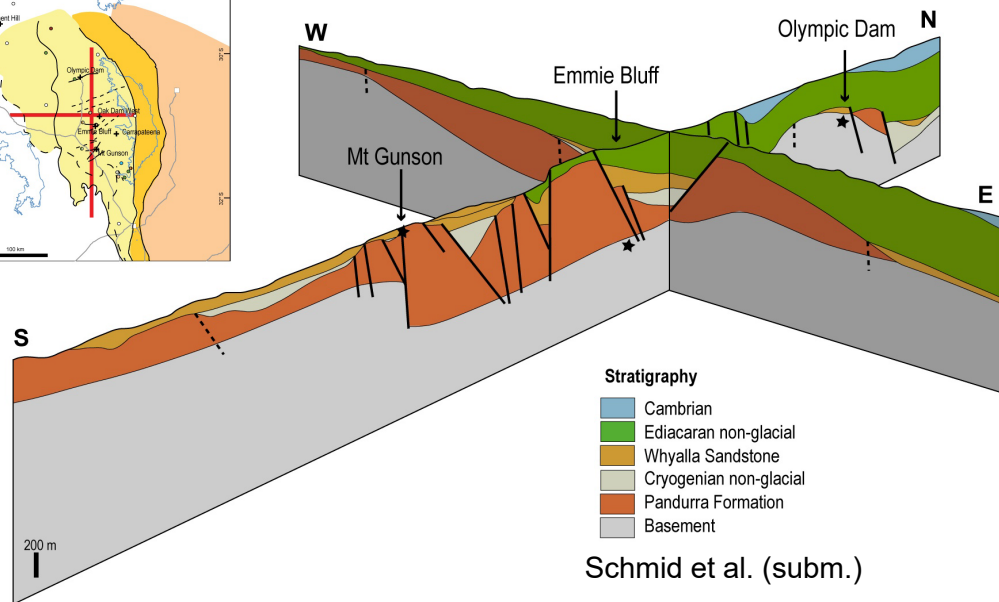
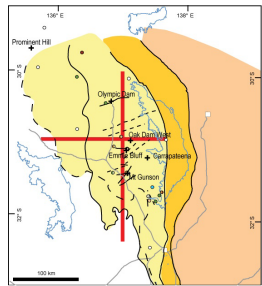
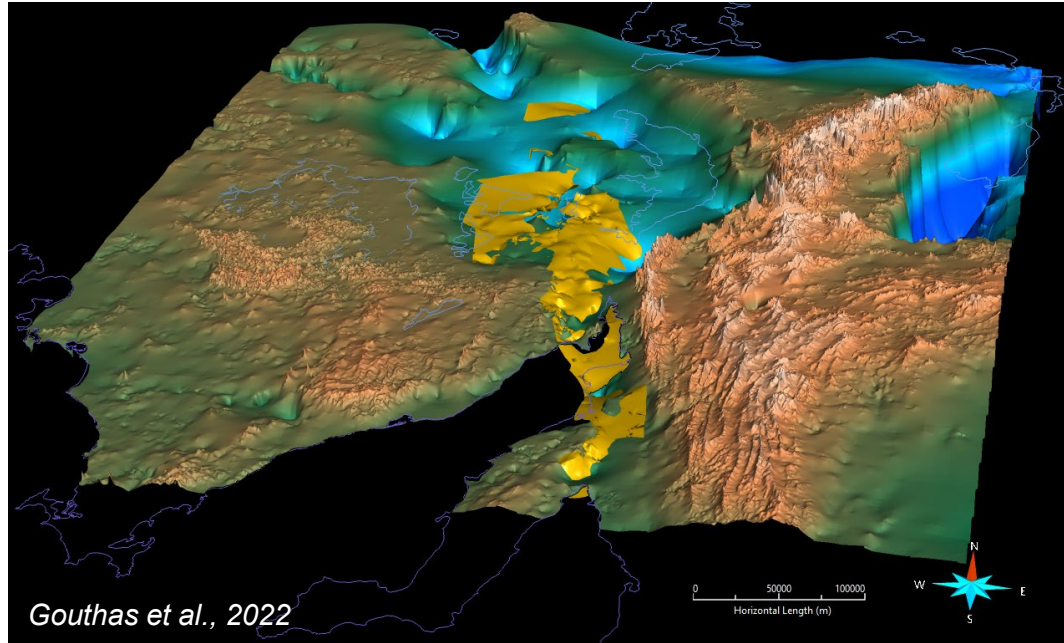
HODD 3



Sequence Stratigraphic framework of the Stuart Shelf



Basin architecture framework of the Stuart Shelf



Summary

Applying a petroleum systems approach to the Neoproterozoic succession of the Stuart Shelf in South Australia resulted in:

- updated stratigraphy and recognition of basin-wide correlatable facies
 - basin-wide sequence stratigraphic framework
 - modelling of multiple 3D surfaces and unit thickness
 - construction of 2D cross section across known basement highs
 - uncover of the 'Torrens High' basement high
- facilitates the re-evaluation of sediment-hosted copper potential across Stuart Shelf
- new search space and revisiting of brownfield areas with a better understanding
- ?role of underlying IOCG deposits vs. classical basin-hosted stratabound model?**

SedCu opportunities beyond the Stuart Shelf

Torrens Hinge Zone

- Does THZ contain significant deposits at explorable depths?

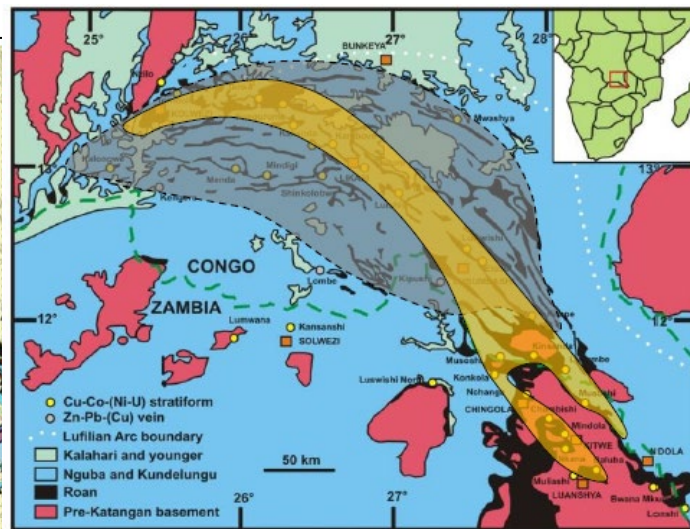
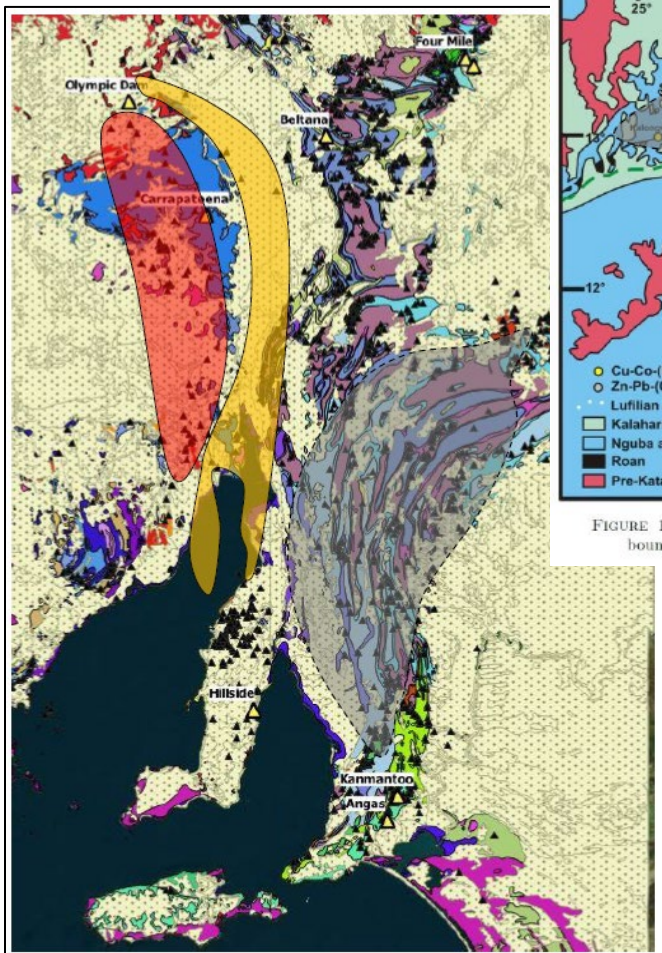


FIGURE 1.3: Geological map of the Central African Copperbelt, with geographic boundaries and ore deposits marked. (Adapted from Cailteux et al., 2005a).

“You could hide the main mineralised segment of the CACB in Torrens Hinge Zone”

Stuart Bull, 2020 Mwale Symposium

Adelaide Rift Complex

- With <1% of Dh’s in ARC drilled to >100m, could some of those small occurrences at surface be pointing to something bigger at depth?
- Diapirs – REE potential (e.g., Taruga’s Mount Craig project)



Worrumba Anticline, Flinders Ranges

Contacts

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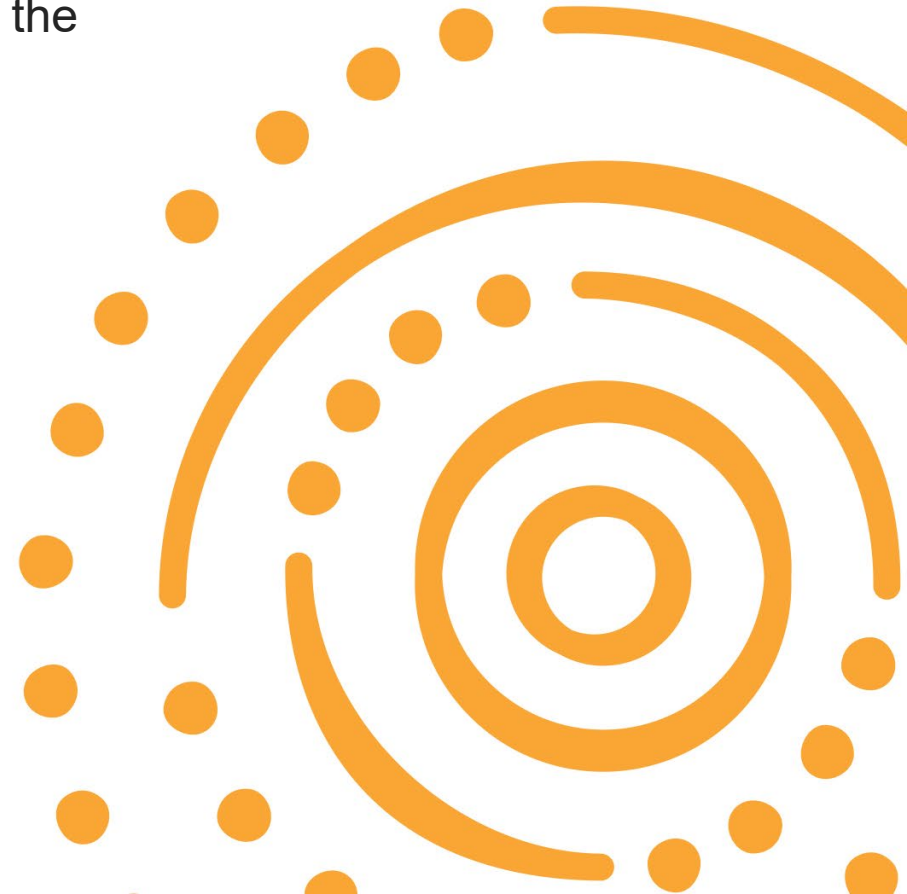
Email: Carmen.Krapf@sa.gov.au



Acknowledgement of Country

As guests on Aboriginal land, the Department for Energy and Mining (DEM) acknowledges everything this department does impacts on Aboriginal country, the sea, the sky, its people, and the spiritual and cultural connections which have existed since the first sunrise. Our responsibility is to share our collective knowledge, recognise a difficult history, respect the relationships made over time, and create a stronger future.

We are ready to walk, learn and work together.



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