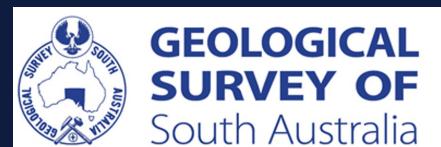


Applying basin analysis to unravel the sedimentary-hosted mineral potential of the Stuart Shelf, South Australia

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with contributions by M. Kunzmann³, G. Gouthas¹, G. Gordon¹, A. Caruso¹,
A. Collins⁴, M. Blades⁴, D. Subarkah⁴, J. Lloyd⁴ & W. Preiss^{1&4}

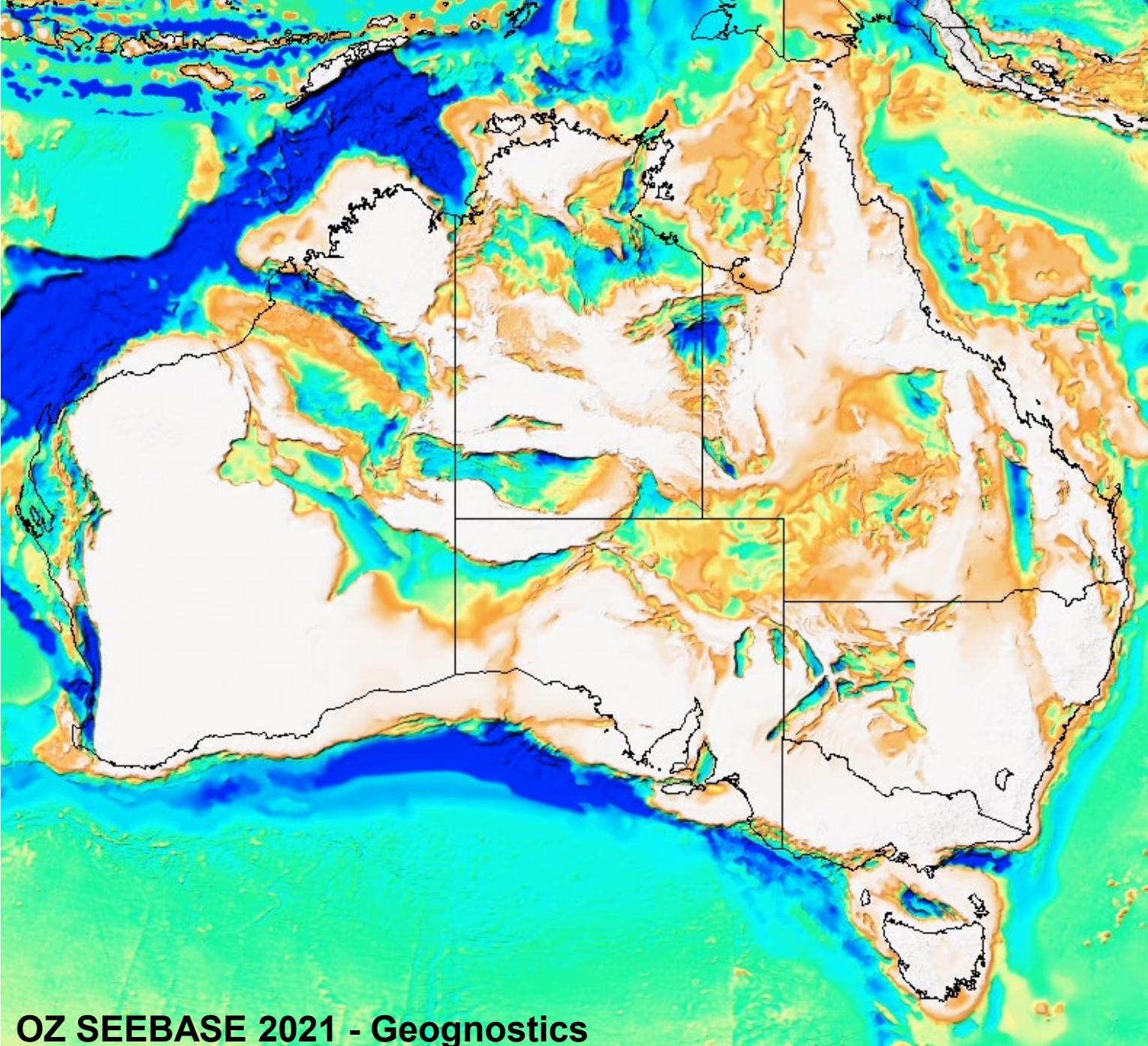
¹Geological Survey of South Australia, ²CSIRO, ³FMG, ⁴The University of Adelaide



CABS IV Symposium
29th - 30th August 2022

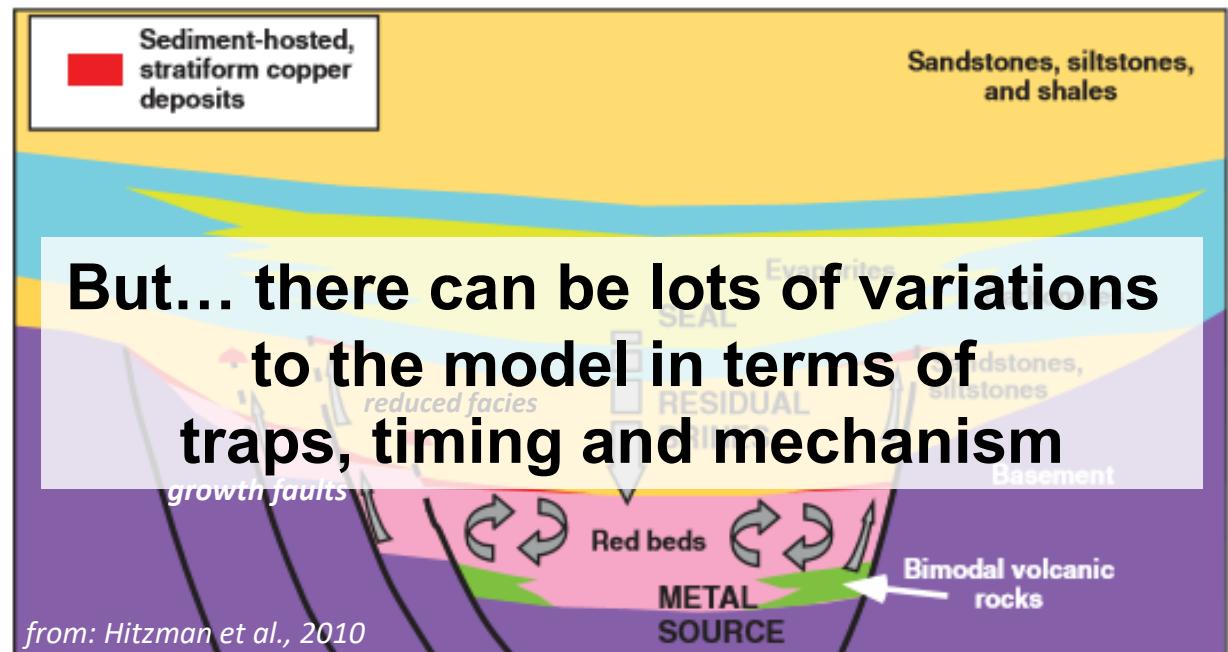
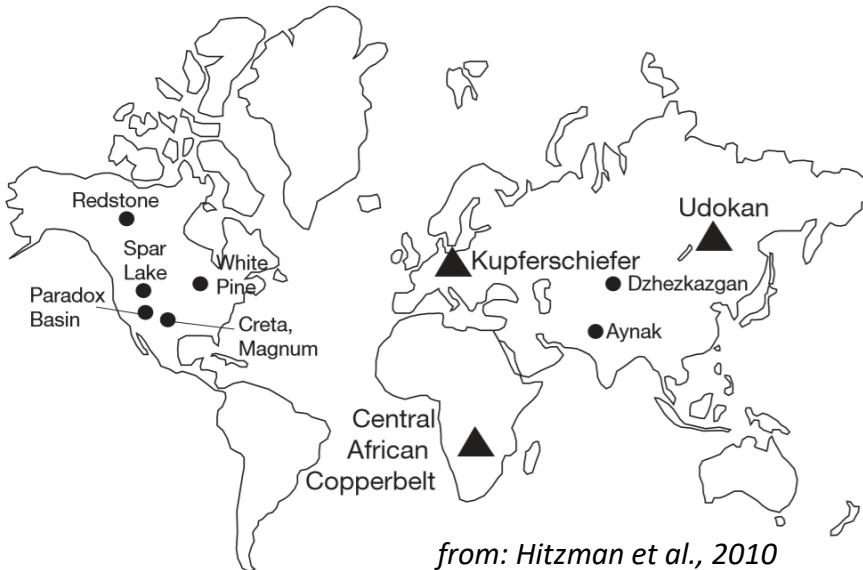
Background

- Australia has a lot 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
- many are very deformed and intruded, mineralised, deeply eroded and buried under regolith/cover
- **using approaches commonly used by petroleum industry has the potential to provide new insights for exploration mineral targets within those basins**



Sediment-hosted stratabound Cu deposits

- Characterised by disseminations, cements and veinlet-hosted copper minerals that are peneconformable with their sedimentary or metasedimentary host rocks
- Deposits are typically thin (<50 m) but laterally extensive (several kilometres) with copper grades of about 1–3%
- Orebodies are commonly hosted in sandstone, siltstone, shale and dolomite mainly in intracratonic sedimentary basins
- Ore genesis involves circulation of sedimentary basin-derived **brines** that dissolves and transports copper, which precipitate ore minerals at **redox boundaries** within either **primary or secondary reduced strata**

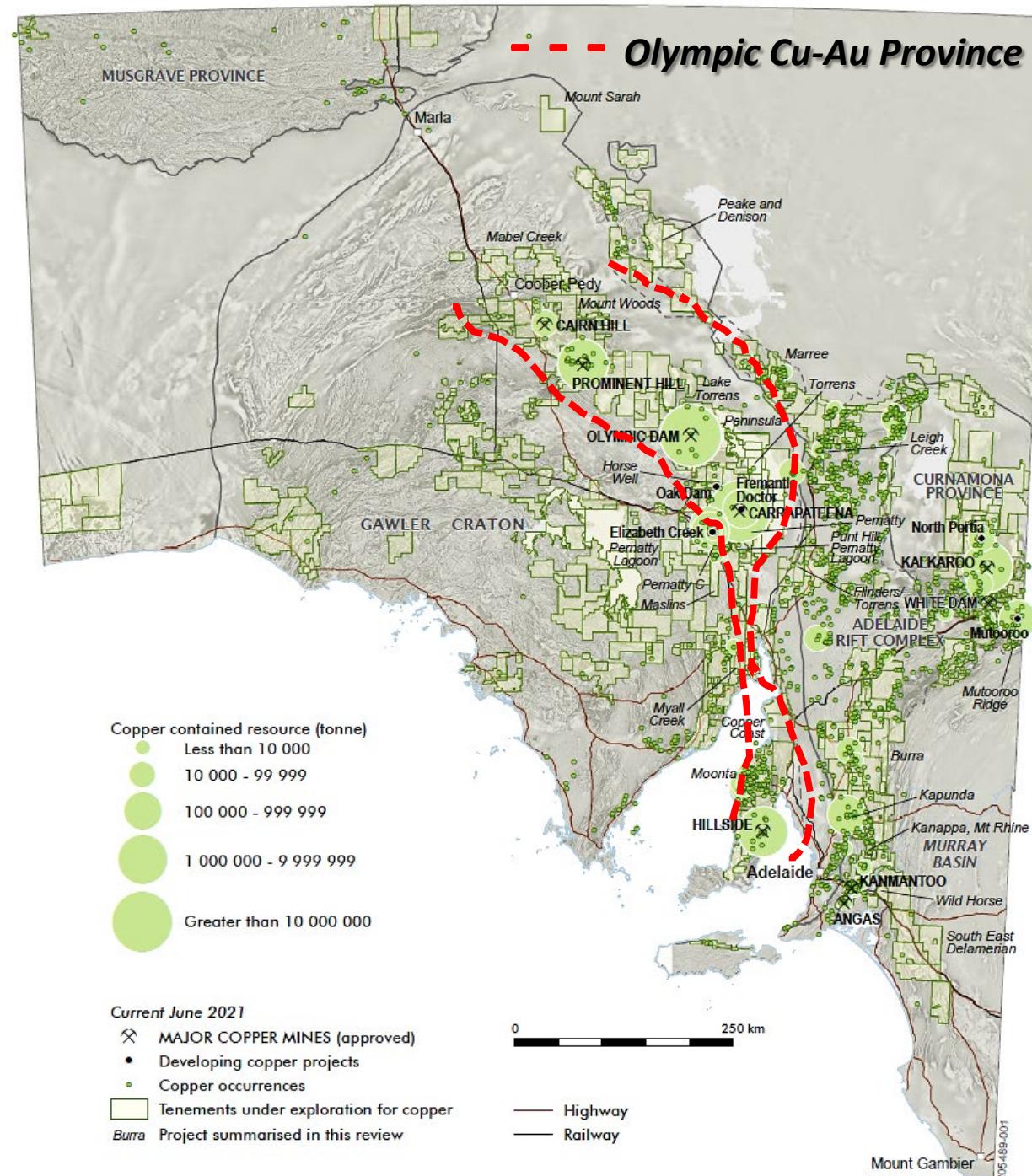


Copper occurrences in SA

→ ~40% SedCu

Mineral systems components

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

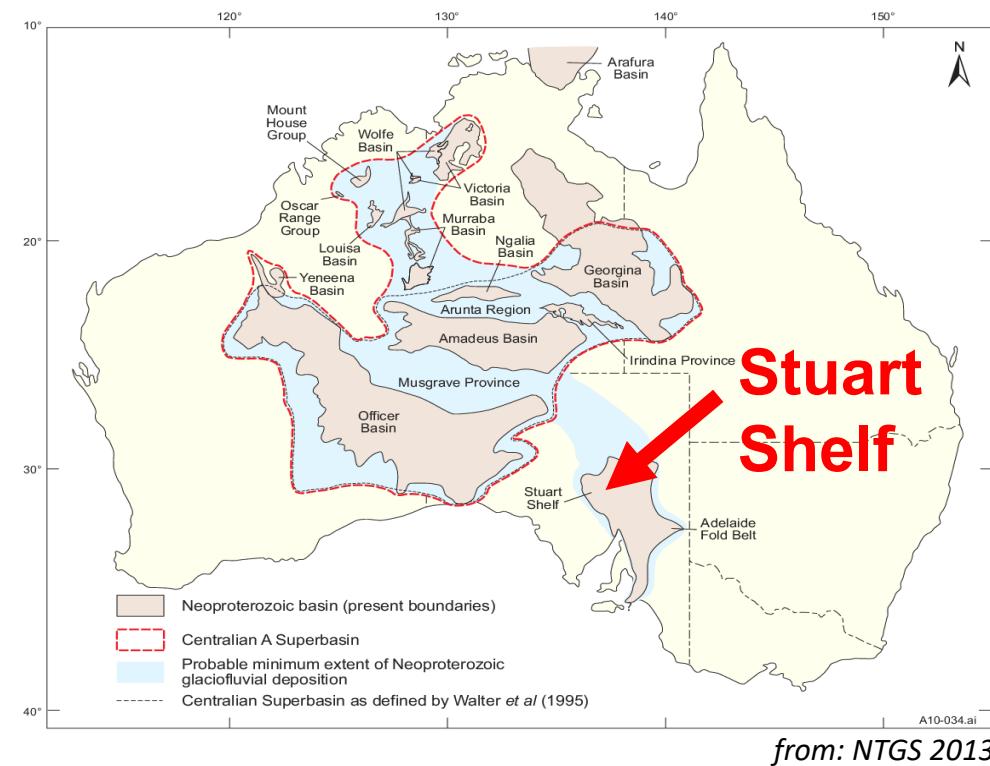


Why the Stuart Shelf?

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

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)

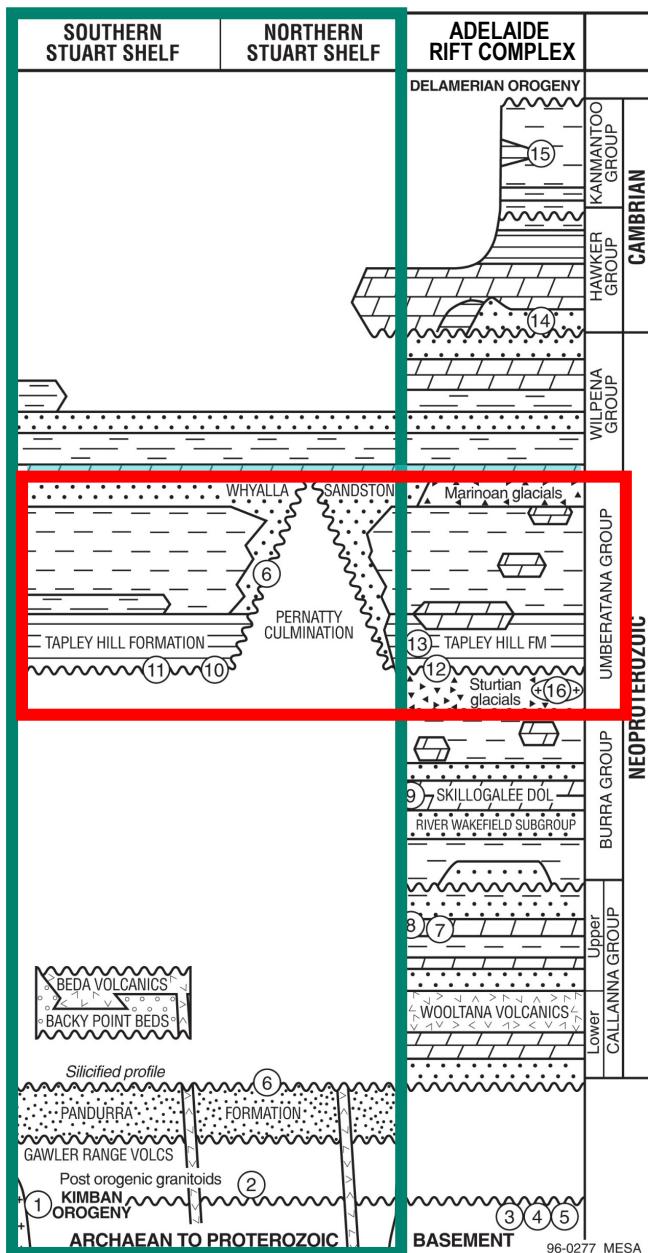


from: NTGS 2013



Cattlegrid Pit Mount Gunson

Stratigraphy of the Stuart Shelf

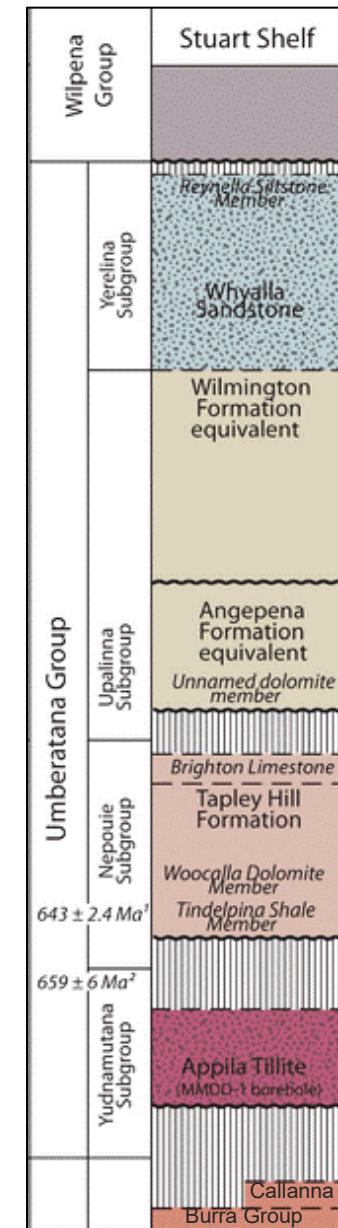


Umberatana Group

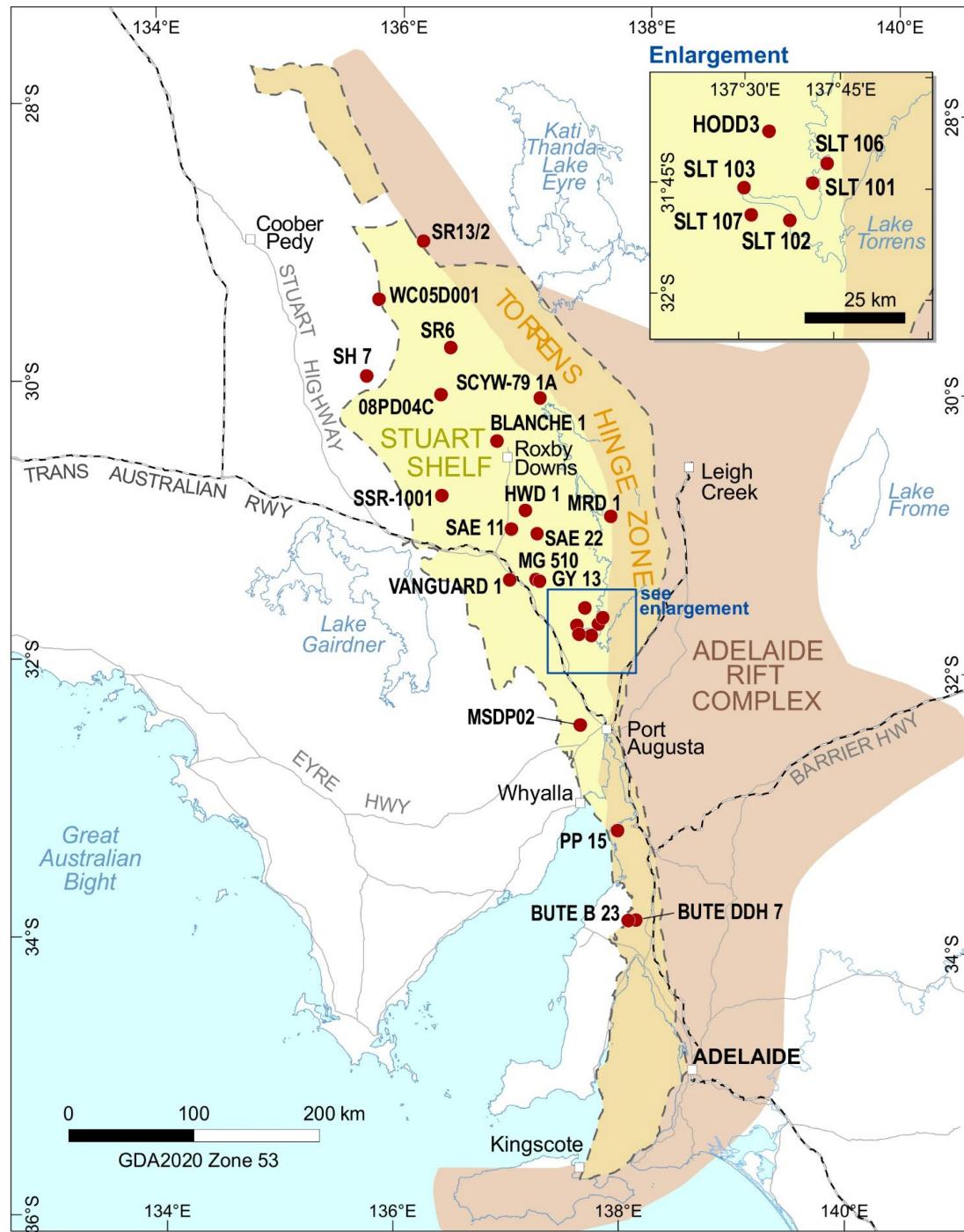
- mudstones, siltstones, sandstones and carbonates
 - includes Sturtian and Marinoan glacials
 - Tapley Hill Formation – reductant

Wainwright 1914	Dickinson 1942	Johns et al. 1964	Tonkin 1966	Thomson and Johnson 1968	Tonkin 1974a, b	Thomson c. 1974	Mason 1978	Preiss 1987
'Leaching sands'	'Upper white sandstone' 'Upper red sandstones and grit'	Pernatty Grit	'Lithic sandstone'	Tent Hill Formation Whylla Sandstone Member	Whylla Sandstone 'Yudnapinna beds'	Whylla Sandstone 'Cattle Grid Formation'	Whylla Sandstone 'Yudnapinna beds' 'Augusta shale'	Whylla Sandstone ? (=Wilmington Formation) ? (=Angepena Formation)
	'Dolomitic limestone'	Pernatty Grit	Woocalla Dolomite Member	Woocalla Dolomite Member	Woocalla Dolomite Member	Tapley Hill Formation	Tapley Hill Formation	Brighton Limestone Member Tapley Hill Formation Woocalla Dolomite Member
'Hard red quartzite'	'Lower red sandstone'		'Red quartzite'	Pernatty Grit	Pandurra Formation	Pandurra Formation	Pandurra Formation	Pandurra Formation

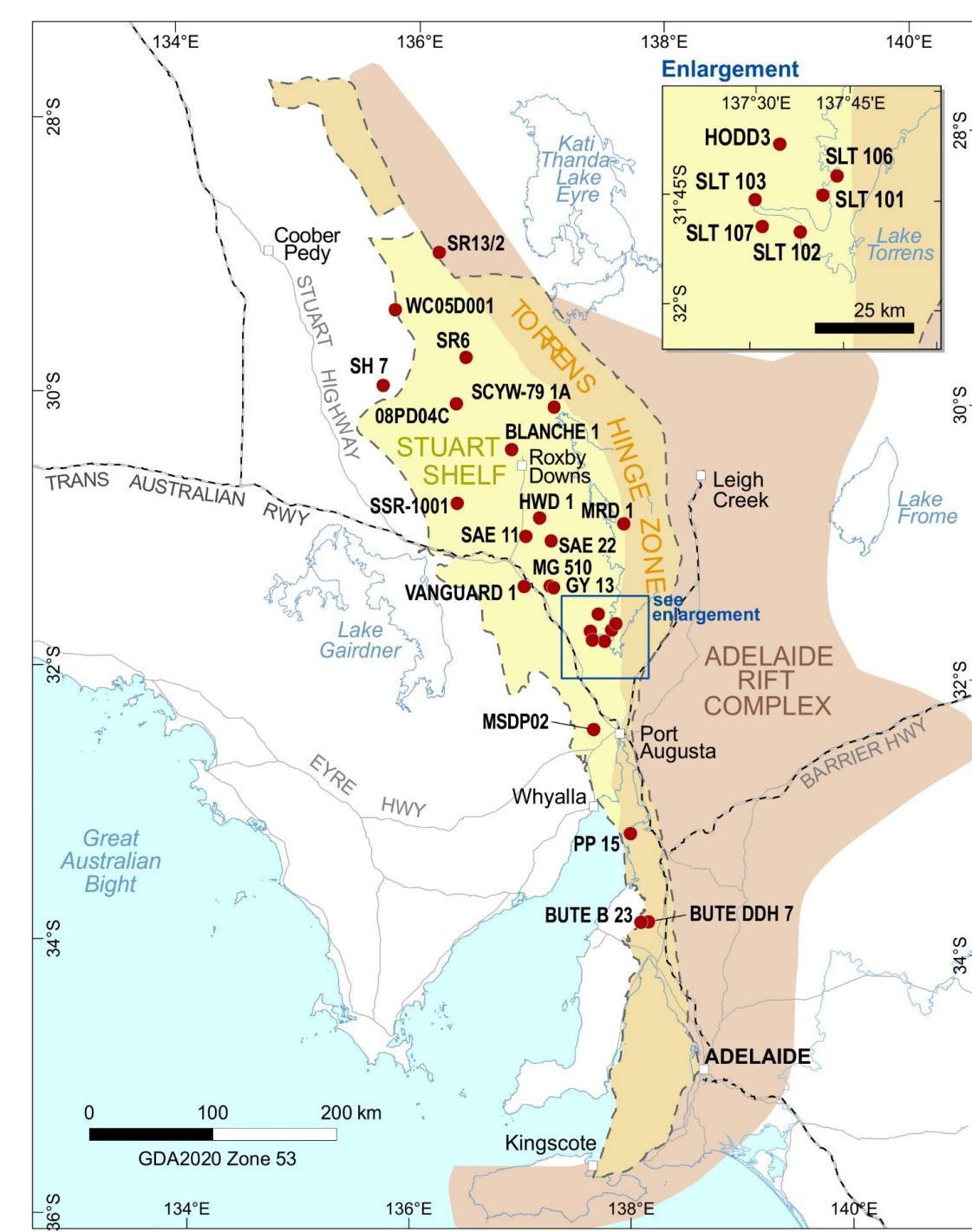
Stratigraphic correlation chart of the southern Stuart Shelf (from: Tonkin, 2019)



GSSA/CSIRO Sedimentary Cu project



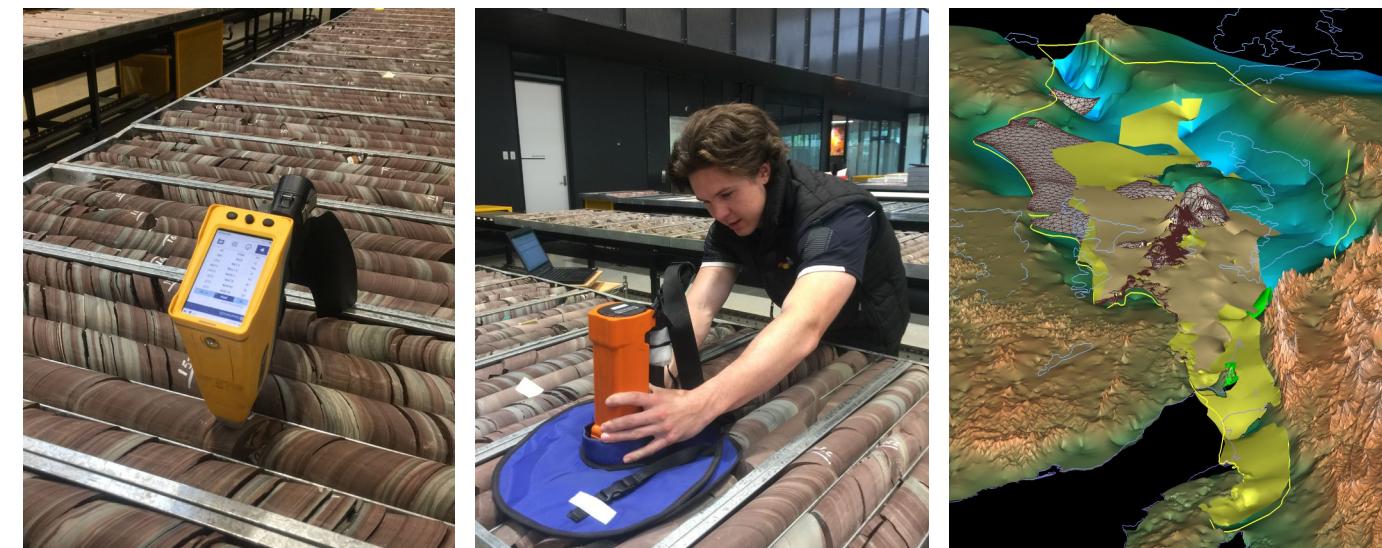
- Re-log key drillholes with a focus on detailed characterisation of **facies, lithology, sedimentary structure, depositional environment** and **redox**
- **Stratigraphic correlation** of the Stuart Shelf to understand **basin structure** and **evolution** to identify areas most likely to host sedimentary copper mineralisation
- **Basin architecture** (unit extents, thicknesses, depth to key horizons, faults) to be mapped using geophysics (magnetics, gravity, seismic and EM where available) and through selected drillhole logging by using a **litho- and sequence stratigraphic approach**
- **Downhole data collection:** pXRF, gamma, C/O and Pb isotopes, pyrite chemistry to be collected from selected drillholes



New data collection included

- 25 out of 25 drillholes logged & HyLogged™
 - 10570 m of core
 - 9245 gamma data, 4711 pXRF data (including standards)
 - 120 samples for carbon isotope, 8 samples for Rb-Sr dating
 - 20 thin sections for diagenesis study
 - 3450 detailed core photographs
 - 3D surfaces Top Pandurra Fm, Beda Basalt & Tapley Hill Fm, Base Whyalla Sst
 - 18 lithofacies, 5 facies association

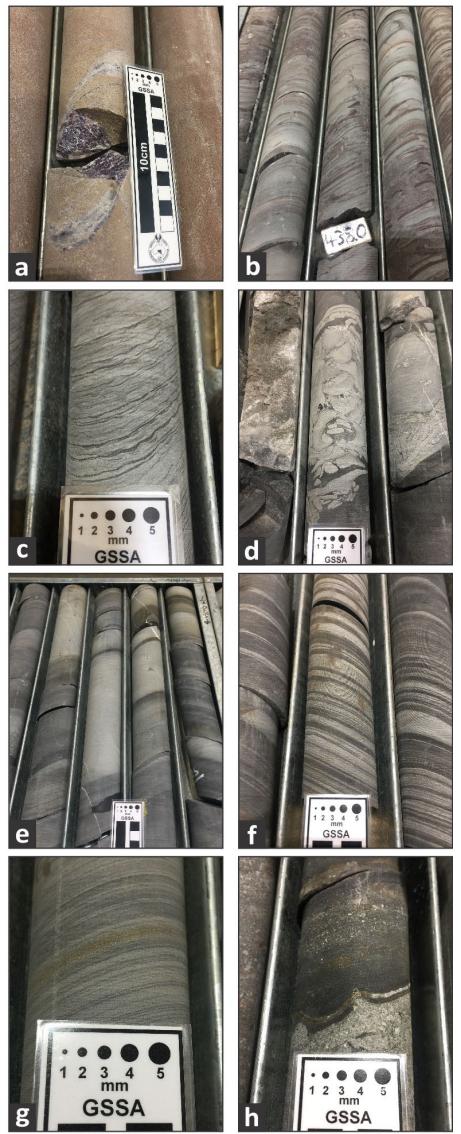
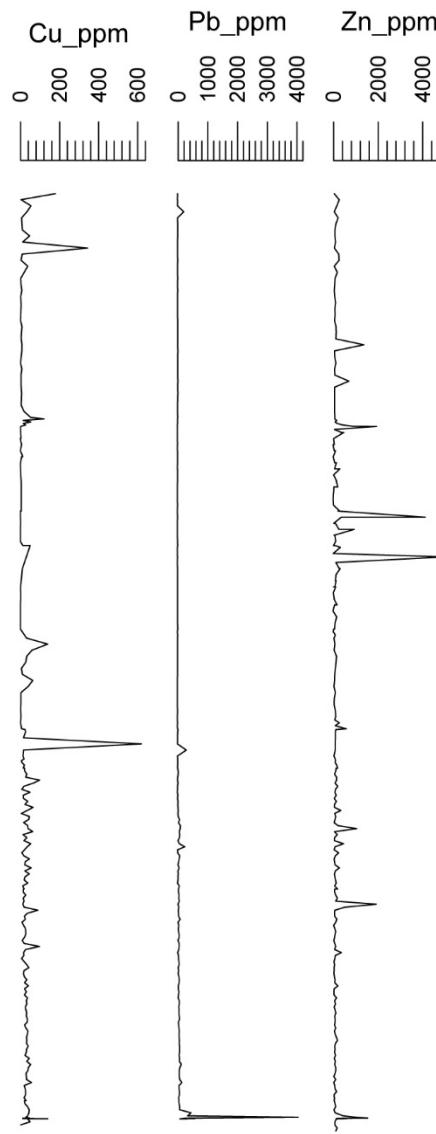
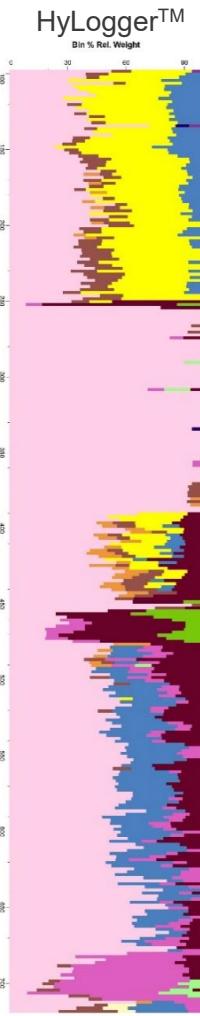
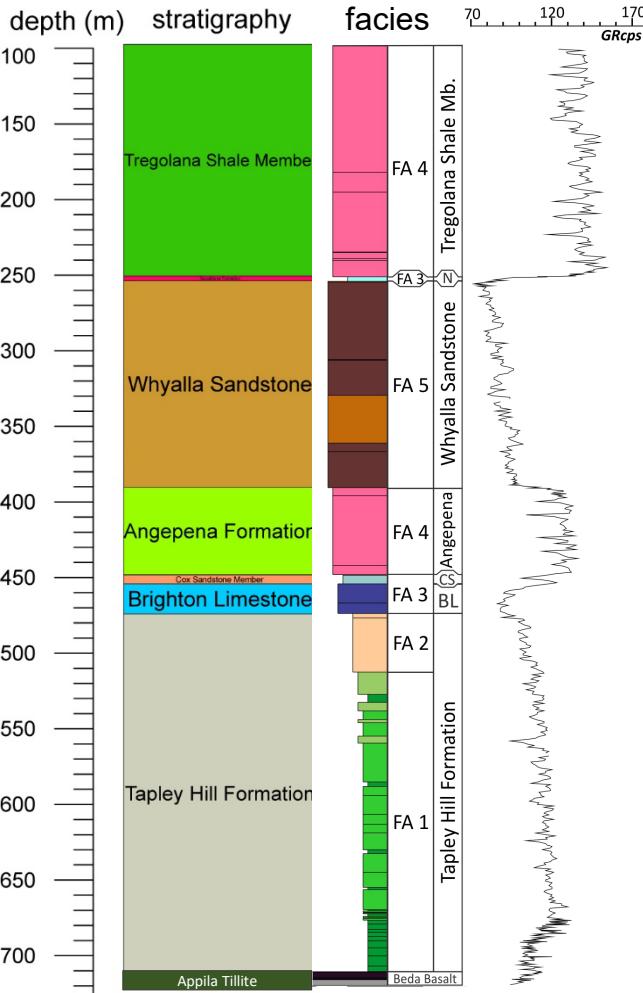
FA 1: offshore (basin floor)	FA 2: offshore transition (slope)	FA 3: shallow subtidal to shoreface (platform)	FA 4: intertidal to supratidal (sandflat, sabkha)	FA 5: continental (glacial, fluvio-glacial)
LF→5	LF→4	LF→5	LF→1	LF→3



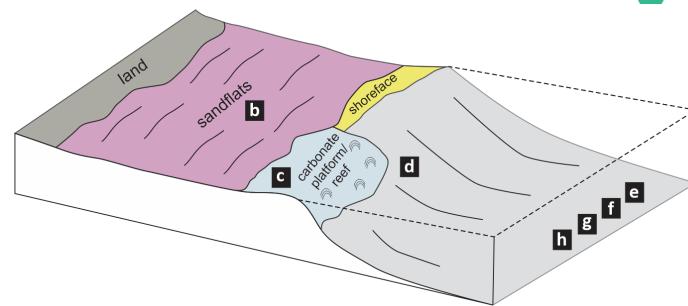
How does this look in one representative drillhole?



HODD 3



Depositional Environments



Facies and Facies Associations

FA1	black mudrock
	lam silt
	zebra
	grainflow
	silic sst
FA2	ewc
	slump
	rip
	debrige
FA3	strom
	m dolo
	lam dolo
	sst shore
	mbl
FA4	ic silt-sst
FA5	diamictite
	b sst
	m sst

Thin sections



Facies analysis

18 lithofacies (LF) → 5 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: shallow subtidal to shoreface	FA 4: intertidal to supratidal	FA 5: continental
5 LF	4 LF	5 LF	1 LF	3 LF



SKYW-79 1A



SLT 102



HODD 3



MSDP02



SLT 106



SLT 103



PP 15



SAE 22

Facies analysis

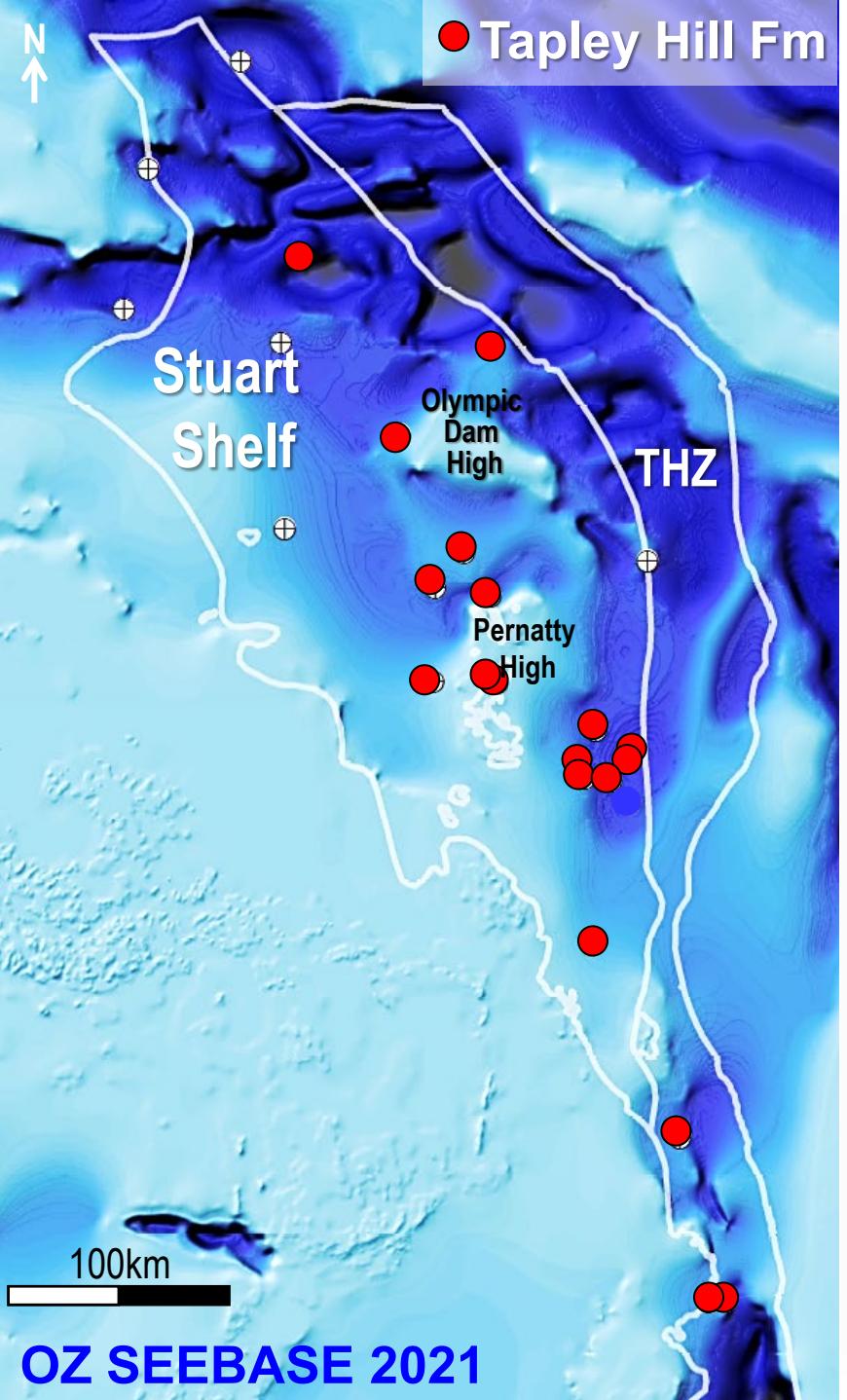
18 lithofacies (LF) → 5 facies associations (FA)

in parts these are aligned closely with existing stratigraphic units

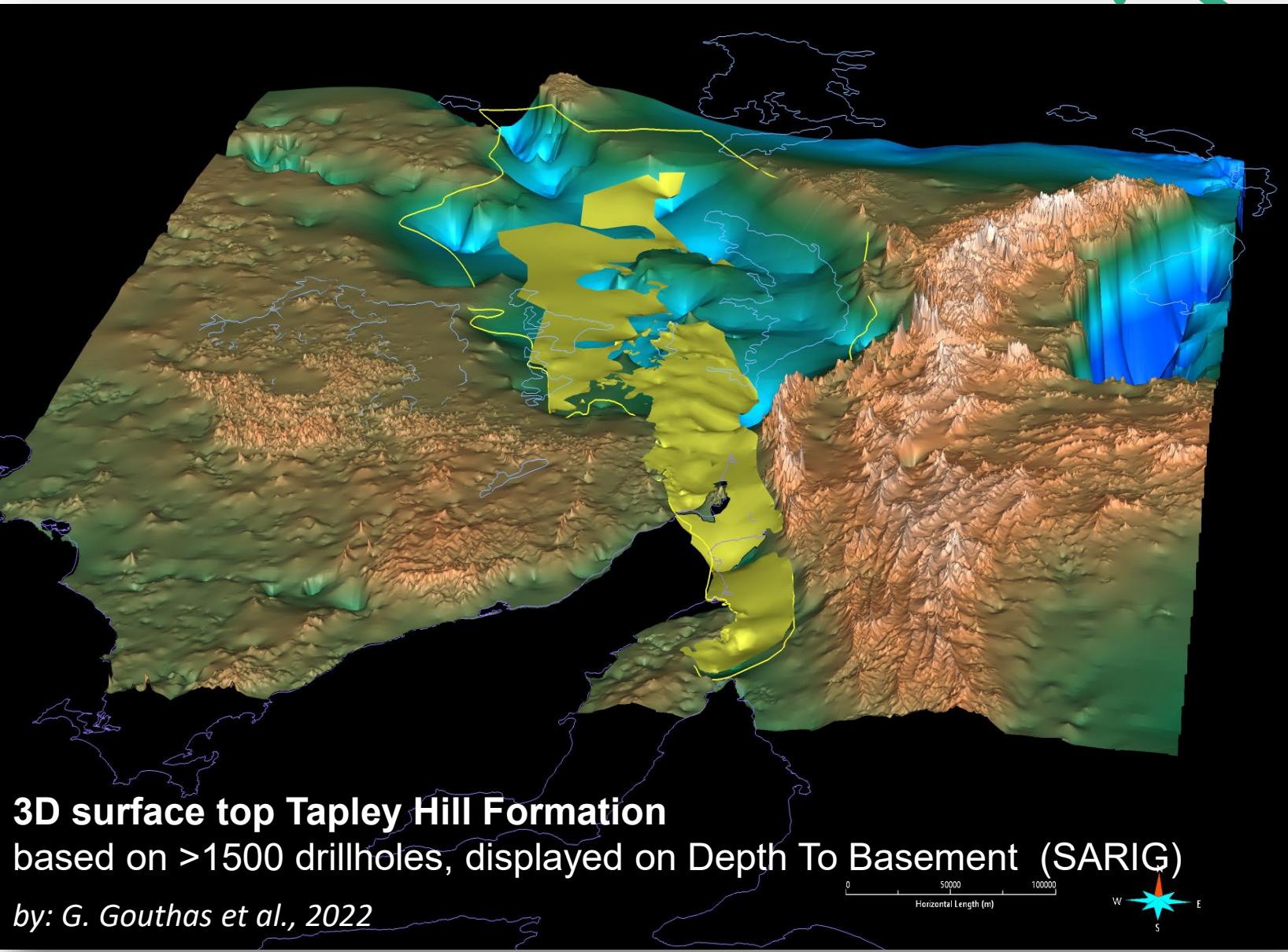
FA 1: offshore	FA 2: offshore transition	FA 3: shallow subtidal to shoreface	FA 4: intertidal to supratidal	FA 5: continental
5 LF	4 LF	5 LF	1 LF	3 LF
Tapley Hill Fm (basal)	Tapley Hill Fm	Tapley Hill Fm Brighton Limestone Nuccaleena Fm Cox Sandstone Mb	Angepena Fm	Whyalla Sandstone Appila Tillite Wilmington Fm

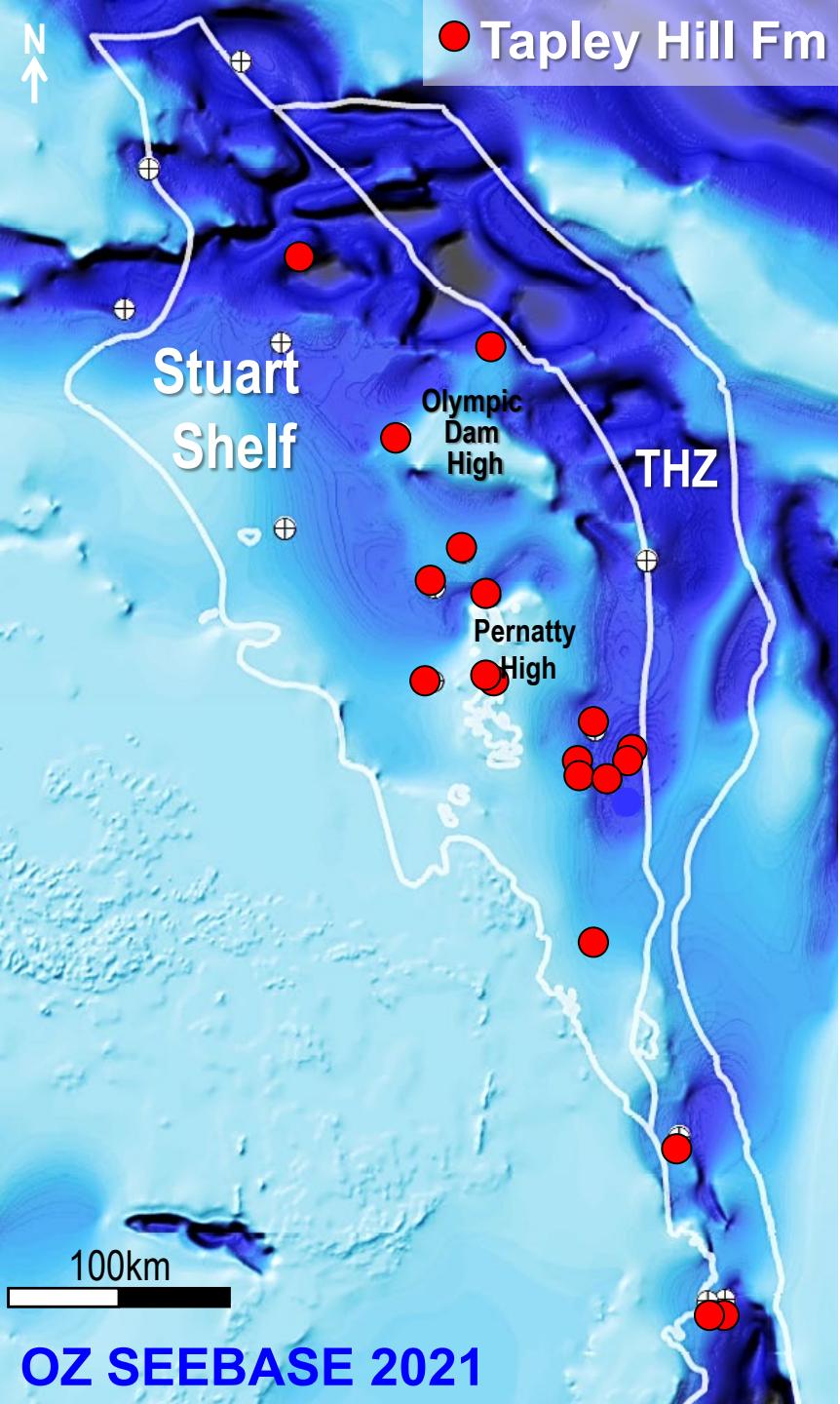
Stratigraphy and facies of the Stuart Shelf based on basin-wide drillhole analysis

		Stuart Shelf	MSDP02	MG510	HWD 1	HODD3	BUTE DDH7	SR6	PP15	GY13	Vanguard 1	BUTE B 23	SAE 11	SAE 22	SLT106	SLT101	SCYW-79 1A	SLT 102	SLT 103	SLT 107	BLANCHE 1	WC05 D001	SSR-1001	MRD 1	SH7	08PD 04C	SR13/2
NEOPROTEROZOIC	MARINOAN	WILPENA GROUP														X	X				X		X	X	X		
		Simmens Quartzite																									
		Corraberra Sandstone Member								X	X						X	X	X			X		X	X	X	
		Tregolana Shale Member	X		X	X		X	X		X						X	X	X	X	X			X	X	X	X
	STURTIAN	Seaciff Sandstone																									
		Nuccaleena Formation	X		x	x		x	x		x						x	x	x	x	x			x	x	x	x
		Whyalla Sandstone	X	X	X	X		X	X		X						X	X	X	X	X			X	X		
		Wilmington Formation																	X								
		Angepena Formation	X			X		X	X									X	X	X	X	X					X
		Cox Sandstone Member				X			X									X		X	X	X					
MESO-PROTEROZOIC	CALLANAPURRA GROUP	Brighton Limestone		X	X	X	X	X	X		X						X	X	X	X	X	X	X	X	X	X	
		Tapley Hill Formation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
		'basal grit'																x	x								
		Appila Tillite			X	X	X	X	X	X							X										
		undifferentiated																									X
PALEO-PROTEROZOIC	CALLANAPURRA GROUP	Beda Basalt/Backy Point Fm. Gairdner Dolerite	X			X	X	X	X								X	X	X	X	X	X	X	X	X	X	
		Pandurra Formation		X	X								X		X	X							X	X	X	X	X
		Gawler Range Volcanics/ Hiltaba Suite			X	X						X		X		X	X					X	X	X	X	X	
		Gawler Craton (undiff.)				X	X					X	X									X		X	X	X	



Tapley Hill Formation





Tapley Hill Formation

FA 3 - shallow subtidal to shoreface

FA 2 - offshore transition

FA 1 - offshore



- in most drillholes the base of the Tapley Hill Fm is characterised by a variety of offshore lithofacies
- black mudstones only occur in the lowermost part of the THF and coincide with the highest gamma values within the THF
 - *maximum flooding surface (MFS)*
- indicative of rapid deepening and flooding across the entire Stuart Shelf after the Sturtian glaciation
- followed by a basin-wide regression

FA1: offshore (below wave storm base)



LF1	LF2	LF3	LF4	LF5
black mudrock	laminated siltstone	intercalated dark and light dolomitic siltstone	grainflow deposit	sandstone - siliciclastic



HODD 3



SKYW-79 1A



SLT 102



HODD 3



SLT 101

Examples from basal part of Tapley Hill Fm



SLT 102



HODD 3



Vanguard 1

FA2: offshore transition (between storm-wave base and fair weather-wave base)

LF6

edgewise conglomerate

LF7

slumps

LF8

rip up beds

LF9

debrite



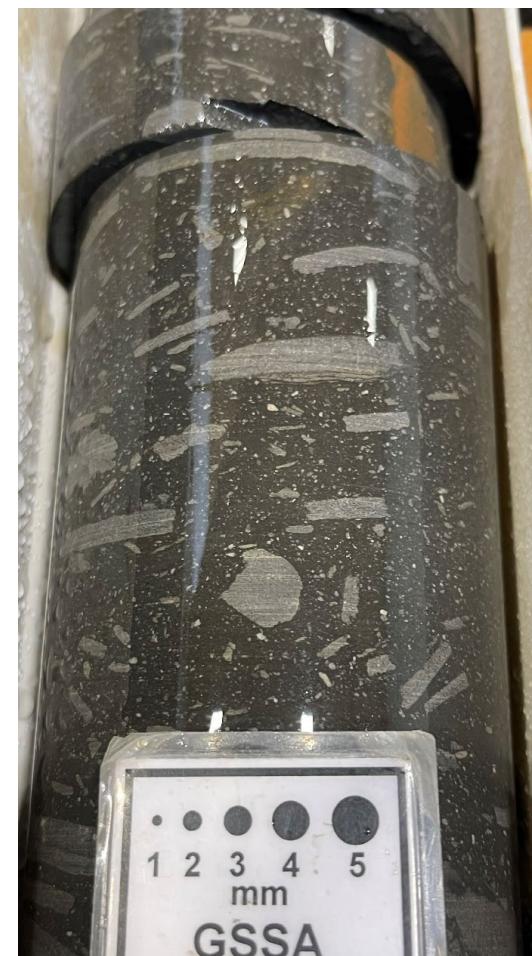
HODD 3



HODD 3



SAE 22



BLANCHE 1

FA2: offshore transition (between storm-wave base and fair weather-wave base)

LF6

edgewise conglomerate



HODD 3

- present in most drillholes with Tapley Hill Fm
 - important marker horizon
- basal surface of forced regression!



BLANCHE 1

SR6

BUTE DDH 7

MSDP02

HWD1

FA3: shallow subtidal to shoreface



LF12

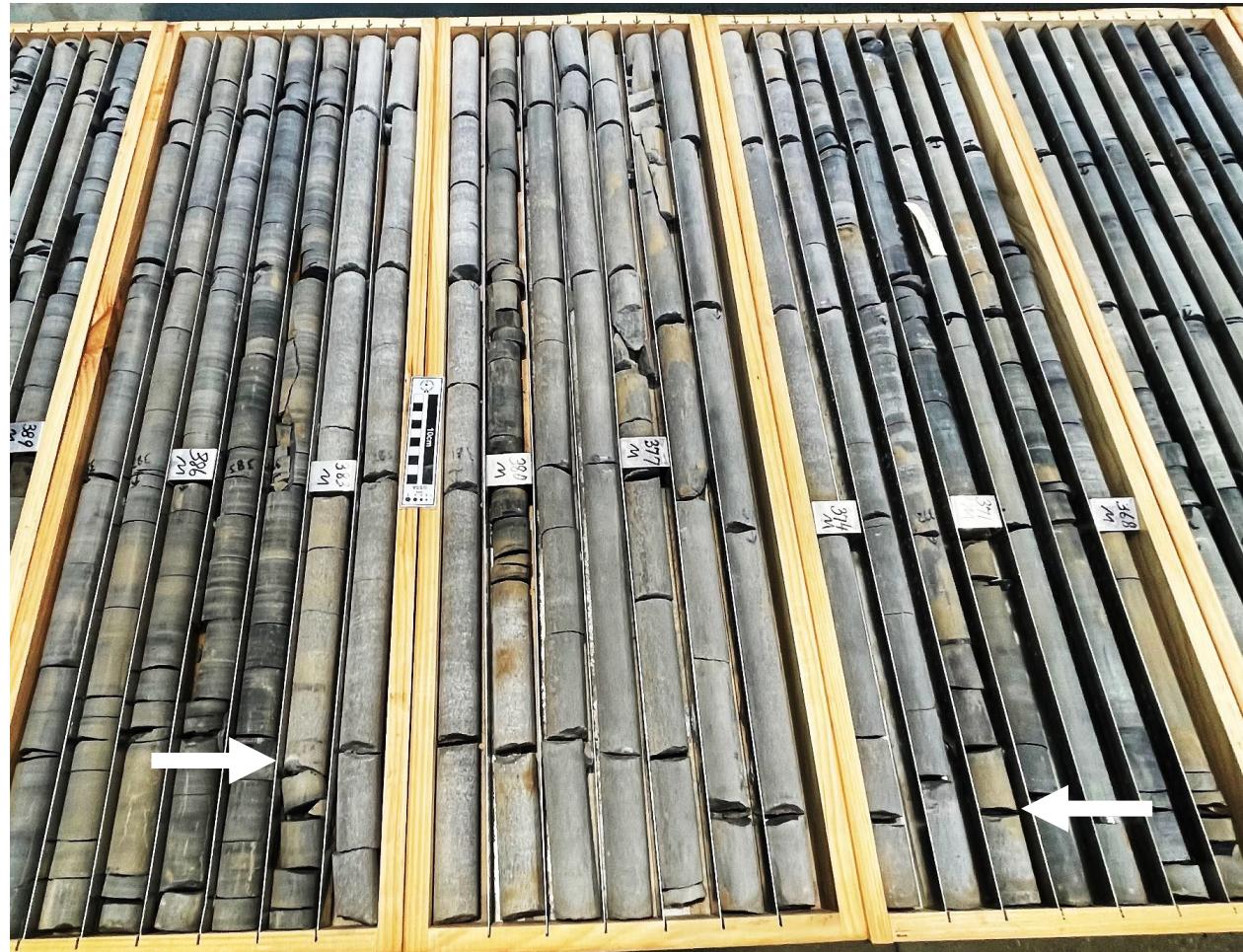
laminated silty dolostone

LF13

sandstone - siliciclastic



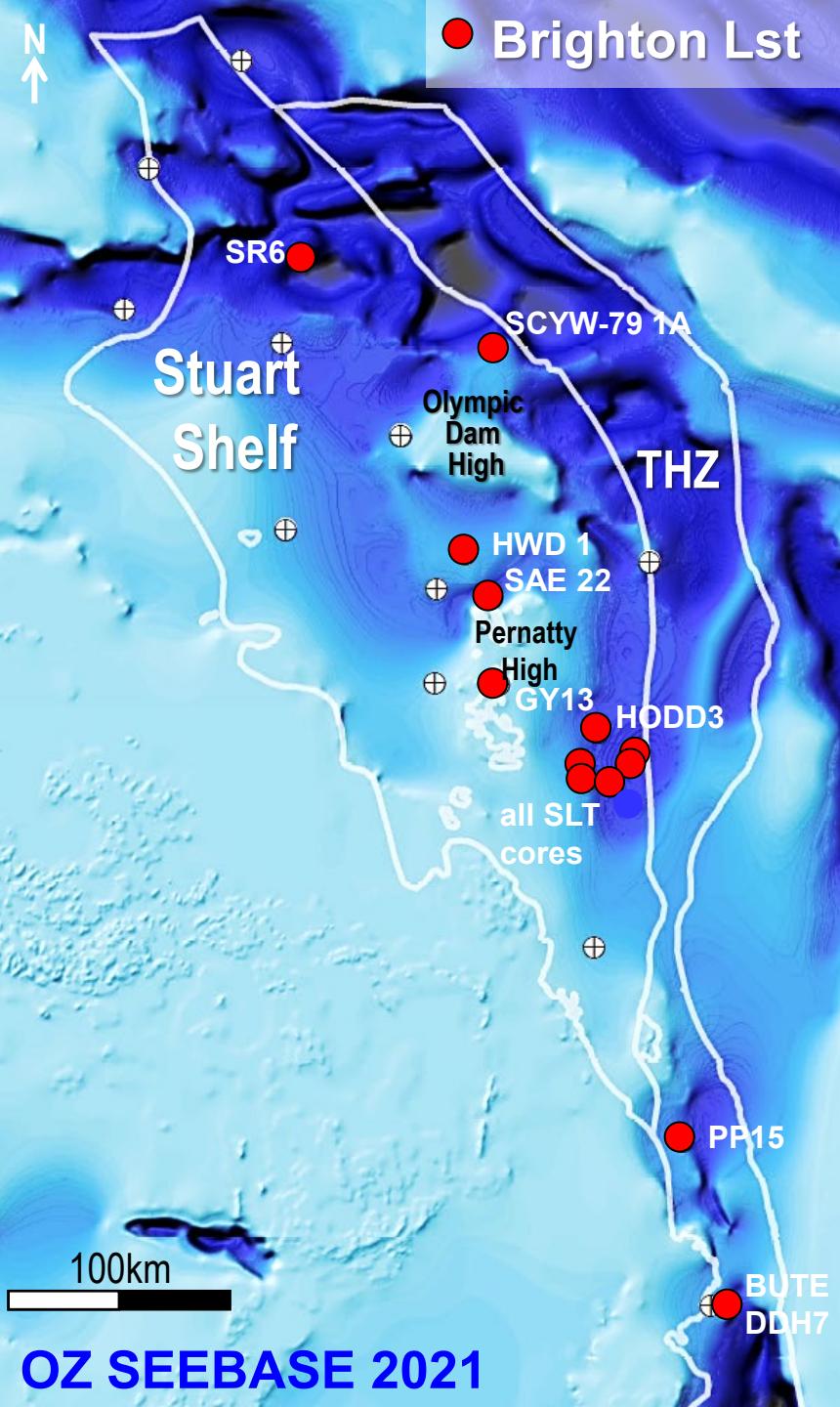
SLT 103



SLT 102



SLT 102



Brighton Limestone

FA 3 - shallow subtidal to shoreface

LF10

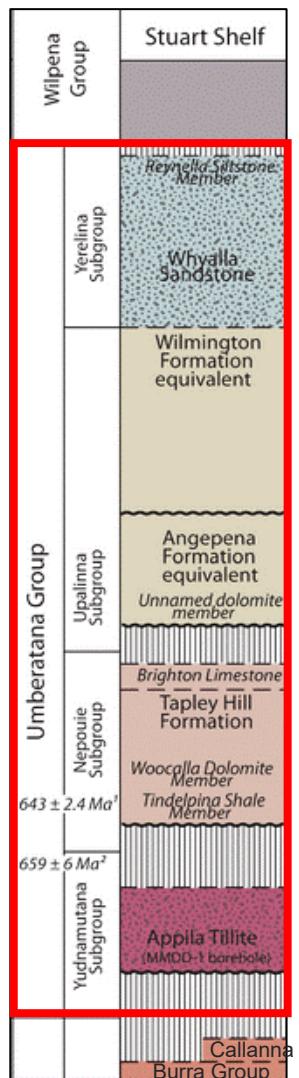
stromatolite

LF14

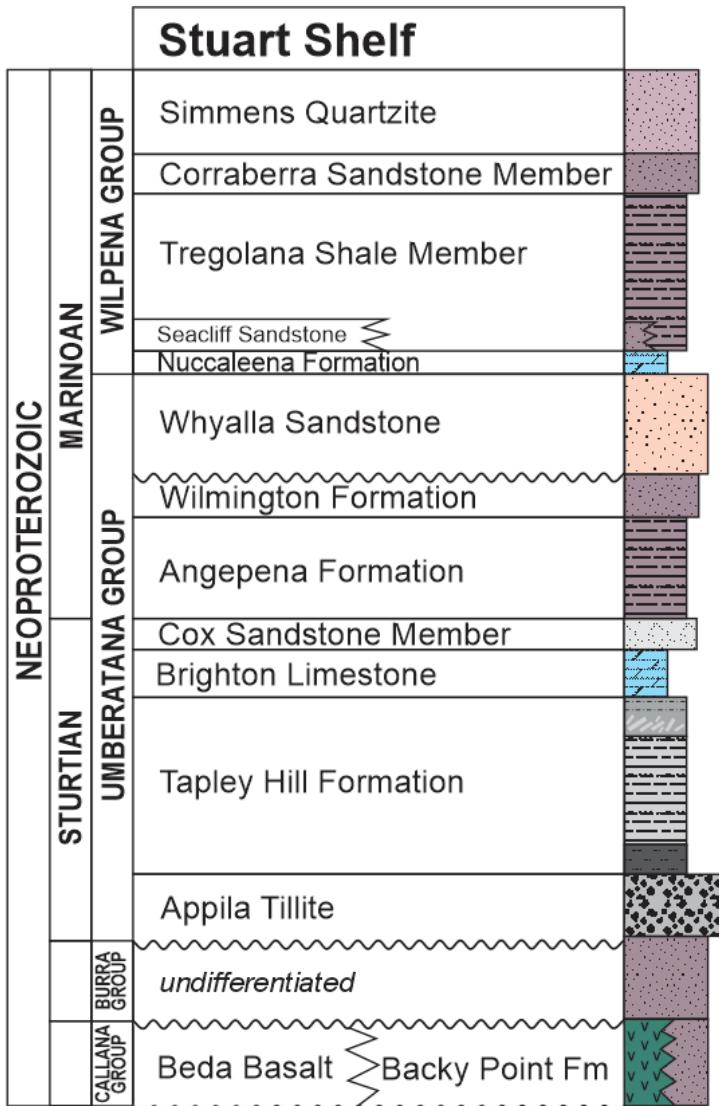
microbiolaminite



Updated stratigraphy of the Stuart Shelf



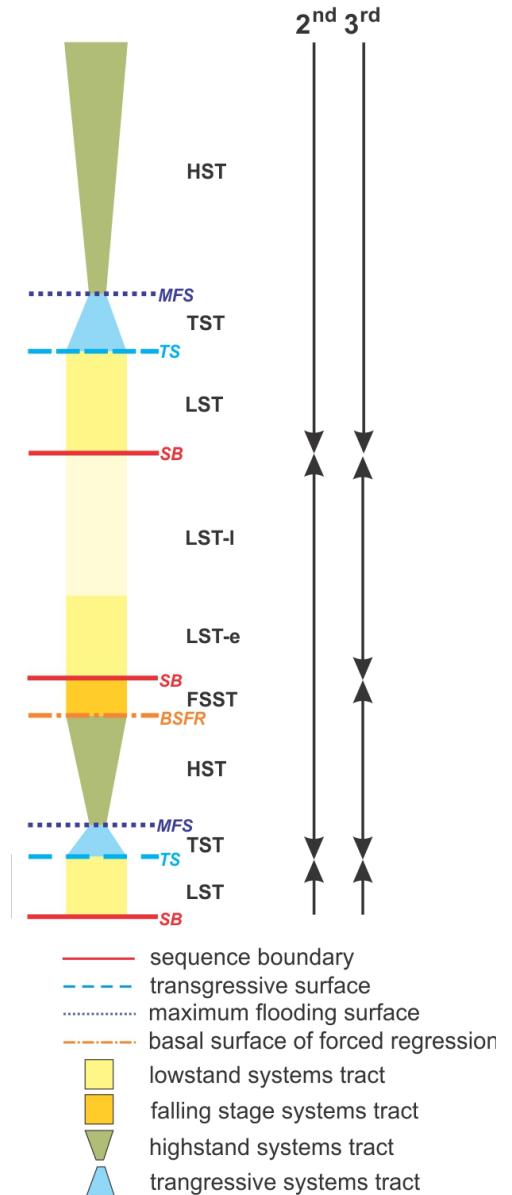
Busfield & LeHeron, 2014



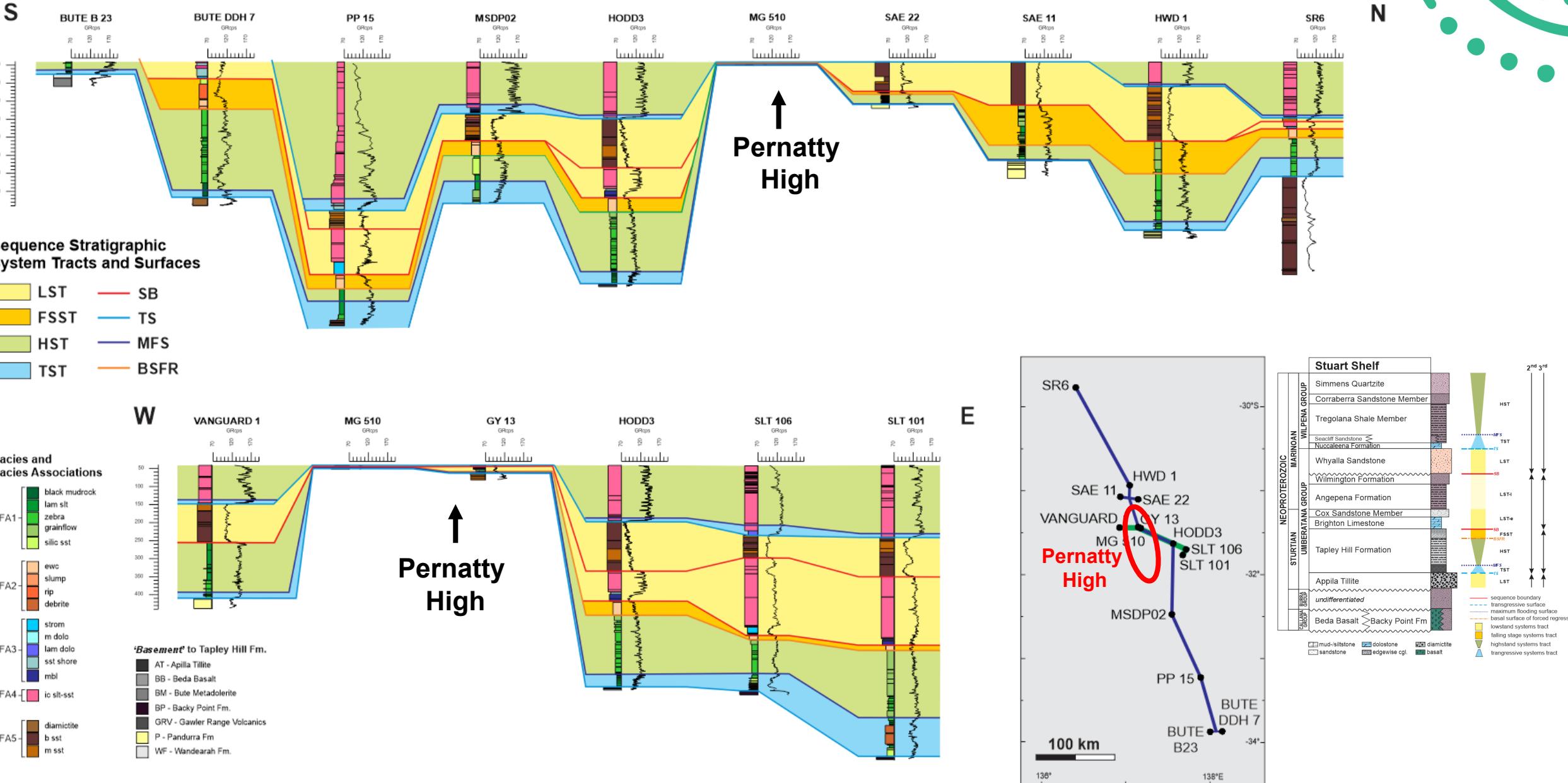
Legend for facies:

- mud-siltstone
- sandstone
- dolostone
- edgewise cgl.
- diamictite
- basalt

new sequence stratigraphy

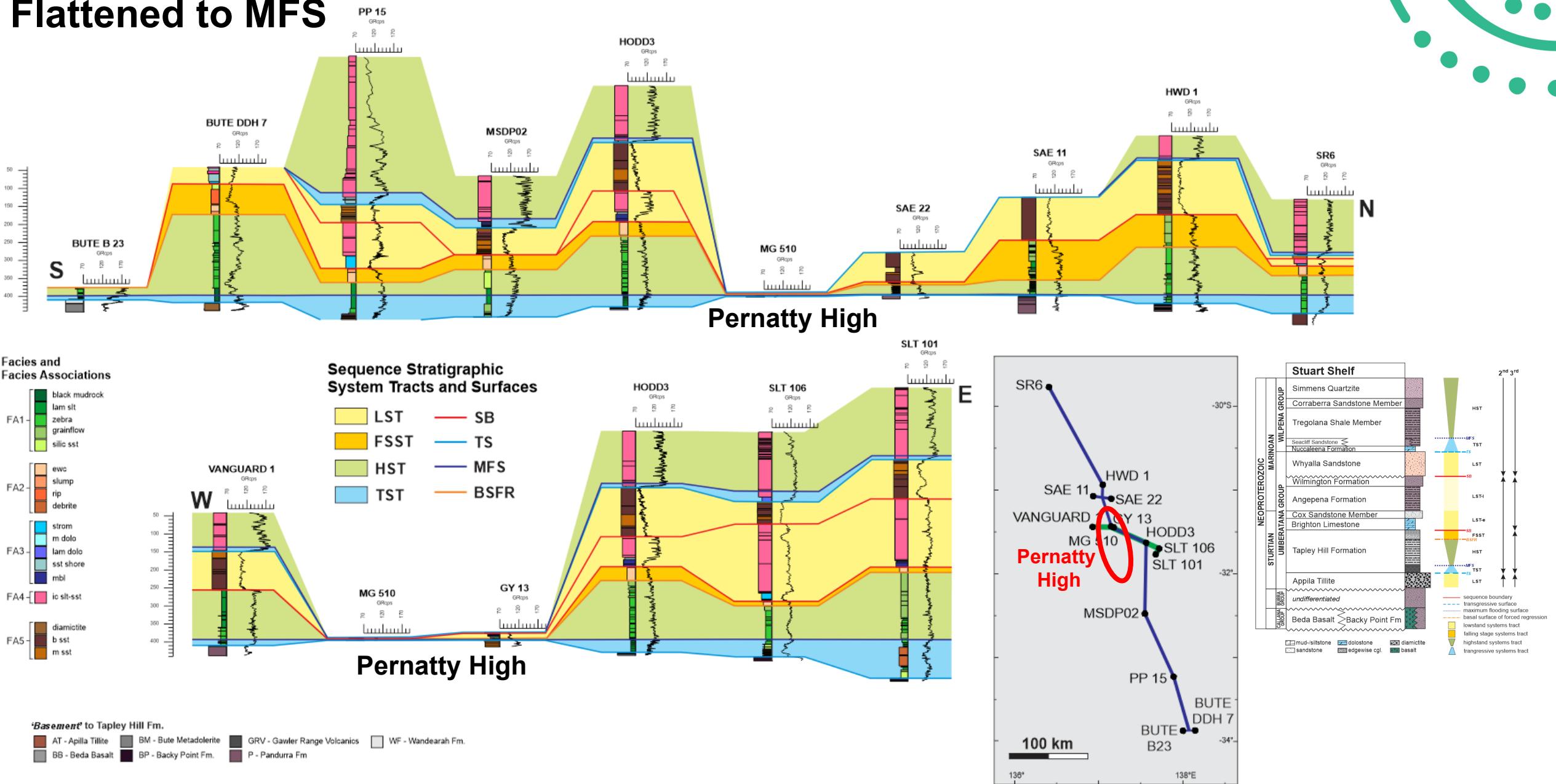


Correlating across the Stuart Shelf



Correlating across the Stuart Shelf

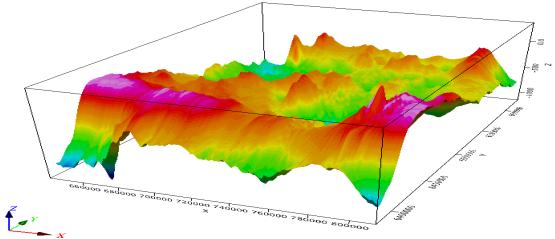
Flattened to MFS



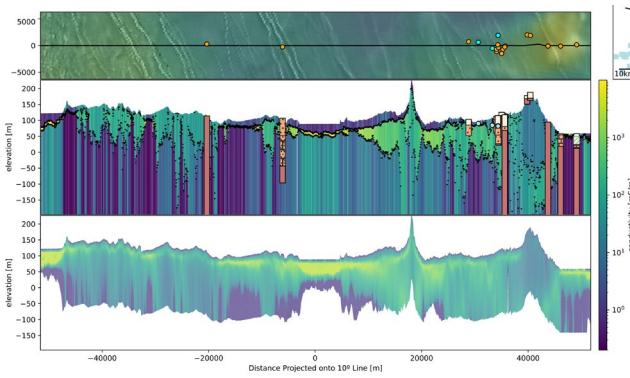
What's next....

Geophysics

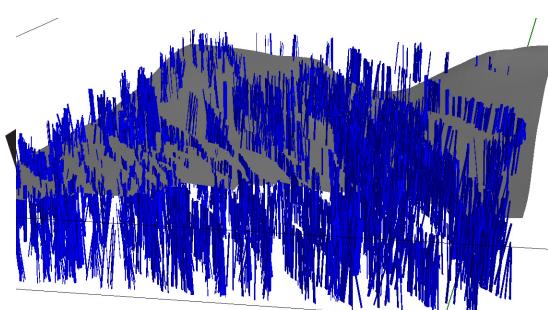
updated basin depth to Pandurra Fm by gravity inversion



AEM advanced processing

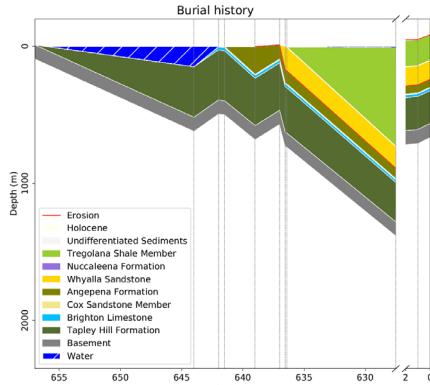


Gairdner Dyke swarm mapping

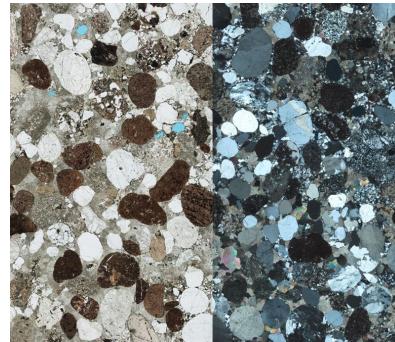


Basin Analysis

1D burial history logs



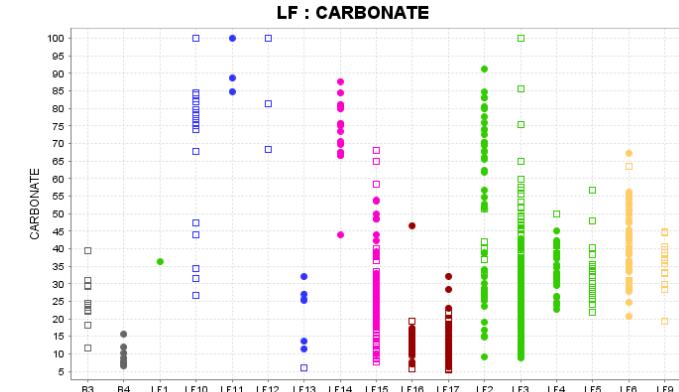
sandstone diagenesis



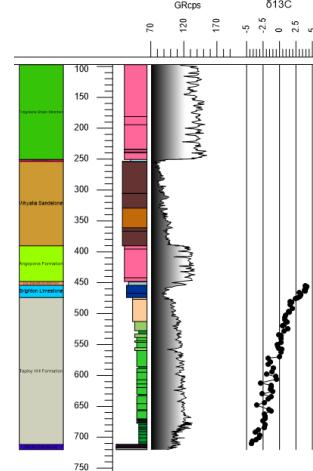
3D basin model including facies maps

Mineralogy & Geochemistry

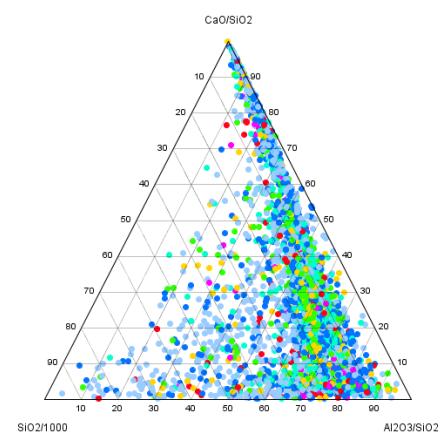
hyperspectral mineralogy by lithofacies



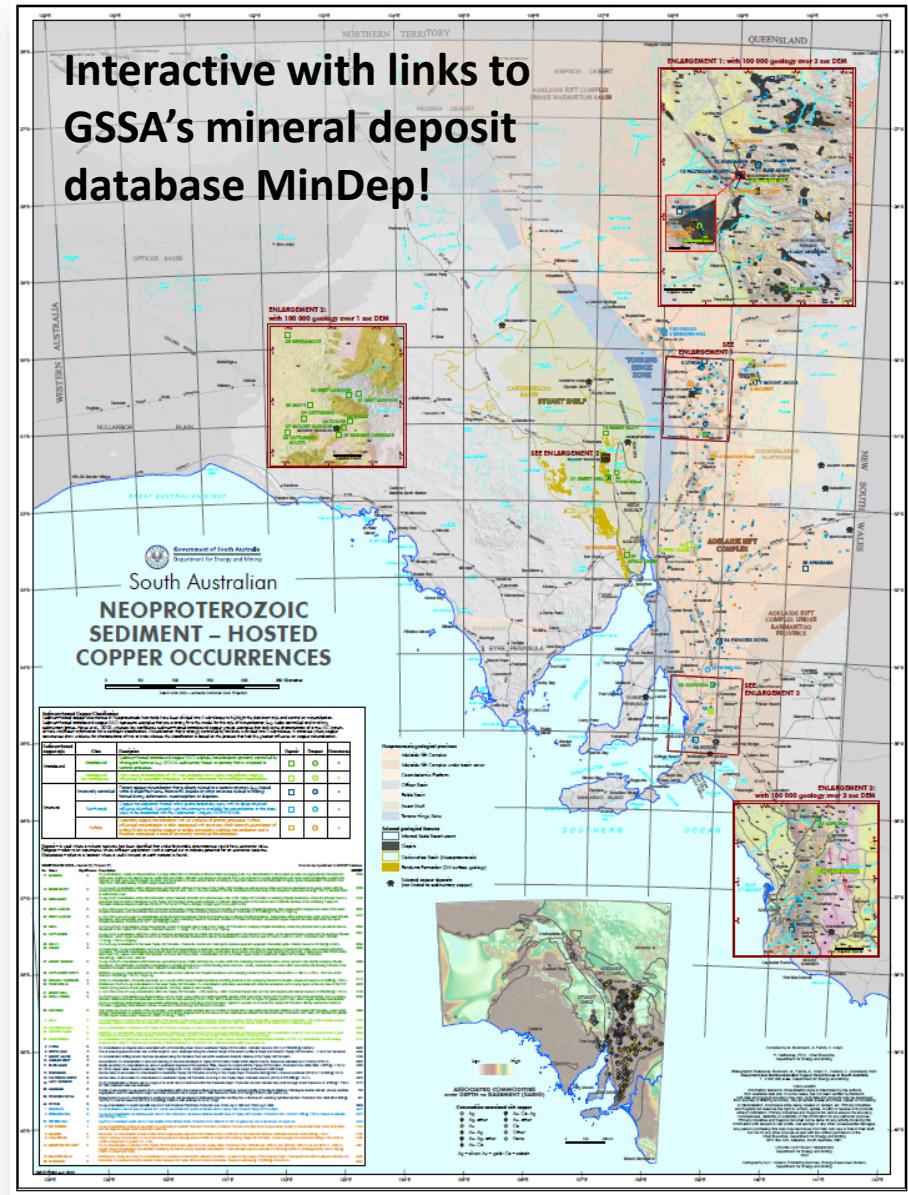
carbon isotopes



pXRF geochemistry



... new data to take home



This screenshot shows the GSSA's mineral deposit database MinDep website. The top navigation bar includes 'Data and products' and 'Search' buttons, and a language selection dropdown set to 'English'. A cookie consent message is displayed, stating: 'This webpage uses cookies. If you continue navigating this page, we will assume you accept this.' with links to 'Accept' or 'Get me out of here'. Below the header, there is a search bar with a 'Back to search' button. The main content area features a section titled 'Stuart Shelf Sedimentary Copper 3D model' with a descriptive text box. This box contains information about sedimentary-hosted copper deposits, the Adelaide Rift Complex, and the Stuart Shelf. It mentions four stratigraphic surfaces: Pandurra Formation, Beda Basalt, Tapley Hill Formation, and Whyalla Sandstone. The text notes that these surfaces were constructed from drillholes and outcrops, and highlights the Tapley Hill Formation as a potential host. A 'Completed' badge is visible in the bottom right corner of this box. To the right, there is an 'Overview' section with a 3D model of the Stuart Shelf area. At the bottom, there is a 'Download and links' section with a 'Download Model' button and a link to the file: <https://dsd-gdp.s3.amazonaws.com/2043140/GDP00121.zip>.

Contacts

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Acknowledgement of Country

We would like to acknowledge this land that we are presenting from today is the traditional lands of the Larrikia people and that we respect their spiritual relationship with their country. We also acknowledge the Larrikia people as the custodians of the Darwin region and that their cultural and heritage beliefs are still as important to the people living here.

The Department for Energy and Mining acknowledges Aboriginal people as the First Nations Peoples of South Australia. We recognise and respect the cultural connections as the traditional owners and occupants of the land and waters of South Australia, and that they continue to make a unique and irreplaceable contribution to the state.

