Northern Gawler National Drilling Initiative (NDI) Workshop

From Drilling to Discovery

Claire Wade | 09/12/2025

Jack Percival, Laura Morrissey, Tom Wise, Anna Petts, Zara Woolston, Dillon Brown, Liz Jagodzinski, Alicia Caruso, Adrian Fabris

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Acknowledgement of Country

As guests here on Kaurna land, we acknowledge everything this department does impacts on Aboriginal country, the sea, the sky, its people and their spiritual and cultural connection 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.

Ngaityalngadlu taikunthitya yalaka

Yantupinarna Kaurna yartangka, ngadlu tampinthi tupa yaintya pirku wapinthi, wiwunthi yaitya yarta, yarlu, ngayirda, miyurnakuma parnaku tuwila tapa purruna tarraitpayinthi. Muna tirntu parrka-parrka wanti.

Ngadluku taingi ngutu yungkurrinthi, tampinthi yurni ngantanthi pukingka, niipurna pintyathi mankurrititya, taingintya tarrkarri pintyanthi.

Nata ngadlu padnitha, tirkatha Kuma kumangka warpulayi-utha.

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Acknowledgement

We would like to acknowledge the Antakirinja Matu-Yankunytjatjara (AMY) people.

This work is being carried out on the lands of Antakirinja Matu-Yankunytjatjara people with the permission of the AMY Aboriginal Corporation (AMYAC) survey team.

Acknowledgements and Contributions - GSSA

Jack Percival: Geological mapping and interpretation in Nawa Domain

Alicia Caruso: HyLogger – collection, processing and interpretation

Dillon Brown: Geochronology (multi-mineral LA-ICPMS U-Pb and Lu-Hf geochronology)

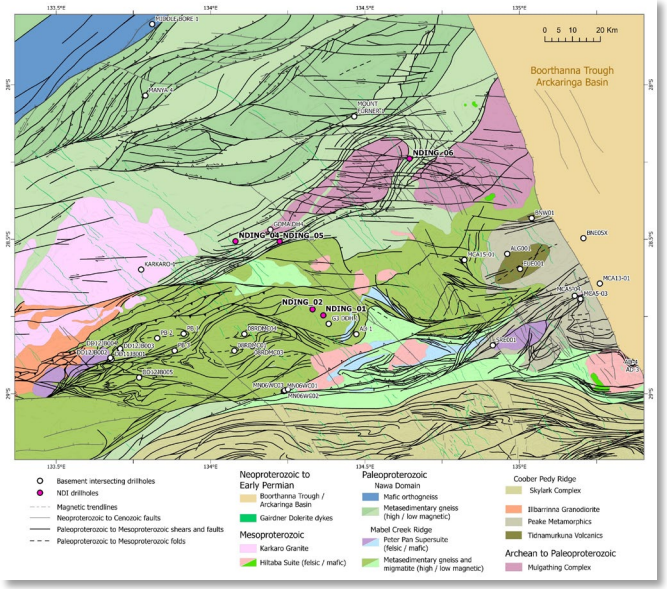
Liz Jagodzinski: SHRIMP geochronology

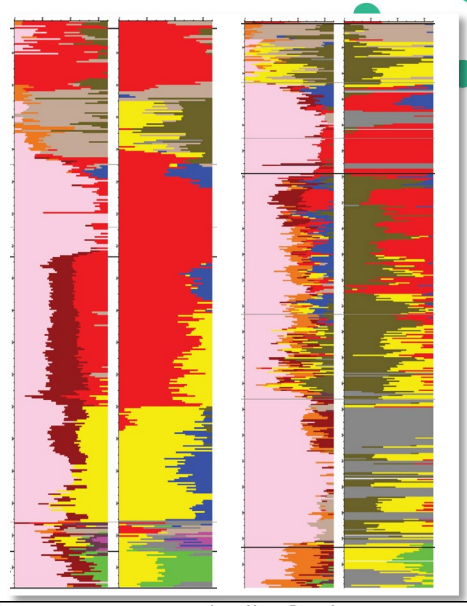
Zara Woolston: pXRF data collection and interpretation

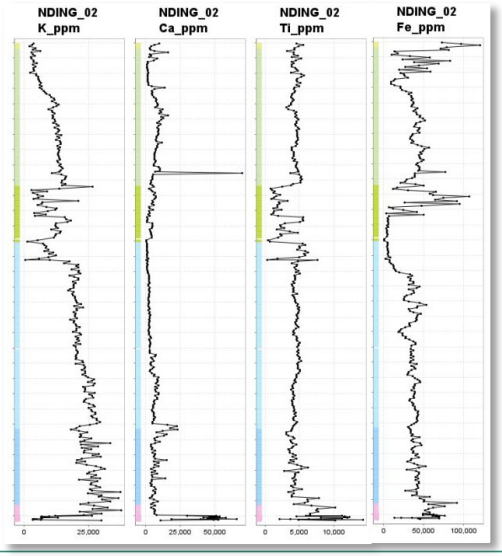
Liliana Stoian: Palynology

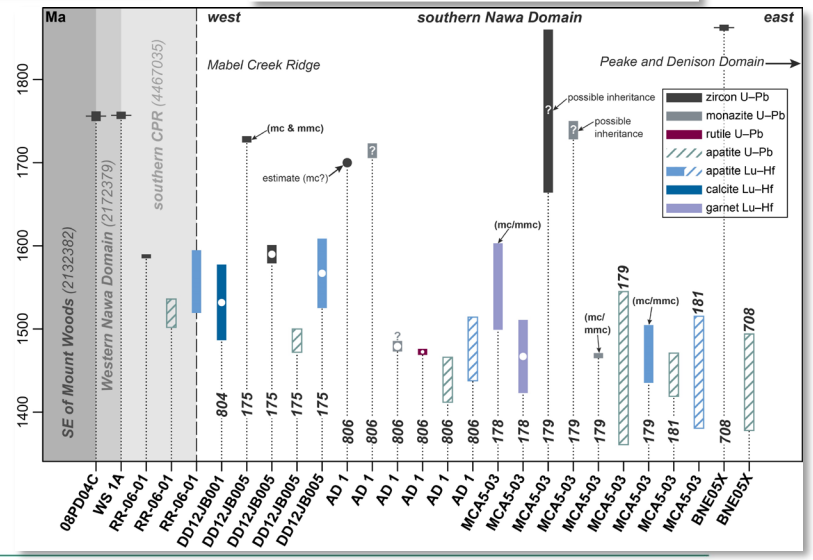
Tom and Claire: Geological logging

Anna: Engagement and logistics









Northern Gawler NDI Workshop – From Drilling to Discovery

Tuesday 9 December

– AGENDA –

COVER	9:00	9:15	Welcome and housekeeping	Claire
	9:15	10:00	Introduction to Northern Gawler NDI and workshop	Claire
	10:00	10:20	NDING Drilling Insights: A palynological Journey Through the Eromanga and Arckaringa Basins	Liliana
	10:20	10:35	Exploring HyLogger data from the Northern Gawler NDI	Alicia
	10:35	11:20	MORNING TEA	
BASEMENT	11:20	11:45	Geochronology of the buried Northern Gawler Craton Basement with highlights from recent NDI drilling	Liz
	11:45	12:00	Remote Mapping of the Nawa Domain: Insights from the Northern Gawler NDI and Discovery Mapping programs	Jack
	12:00	12:20	Connections to the North: Evolution of the buried Northern Gawler Craton Basement	Claire
	12:20	12:30	Regional Implications and mineral prospectivity	Tom
	12:30	12:35	MERS Update	Bronwen
	12:35	1:30	LUNCH	
	1:30	3:00	DISCUSSION AND CORE VIEWING	
	3:00		CLOSE	

NORTHERN GALWER NDI PROJECT AREA

TOTAL MAGNETIC INTENSITY

Current as at November 2025

- Section 15 Gazettal
- Drilled holes
- Basement-intersecting drillholes
- Cover thickness 50m contours

Topographic information

- Major mine
- Mining project
- Locality
- Homestead

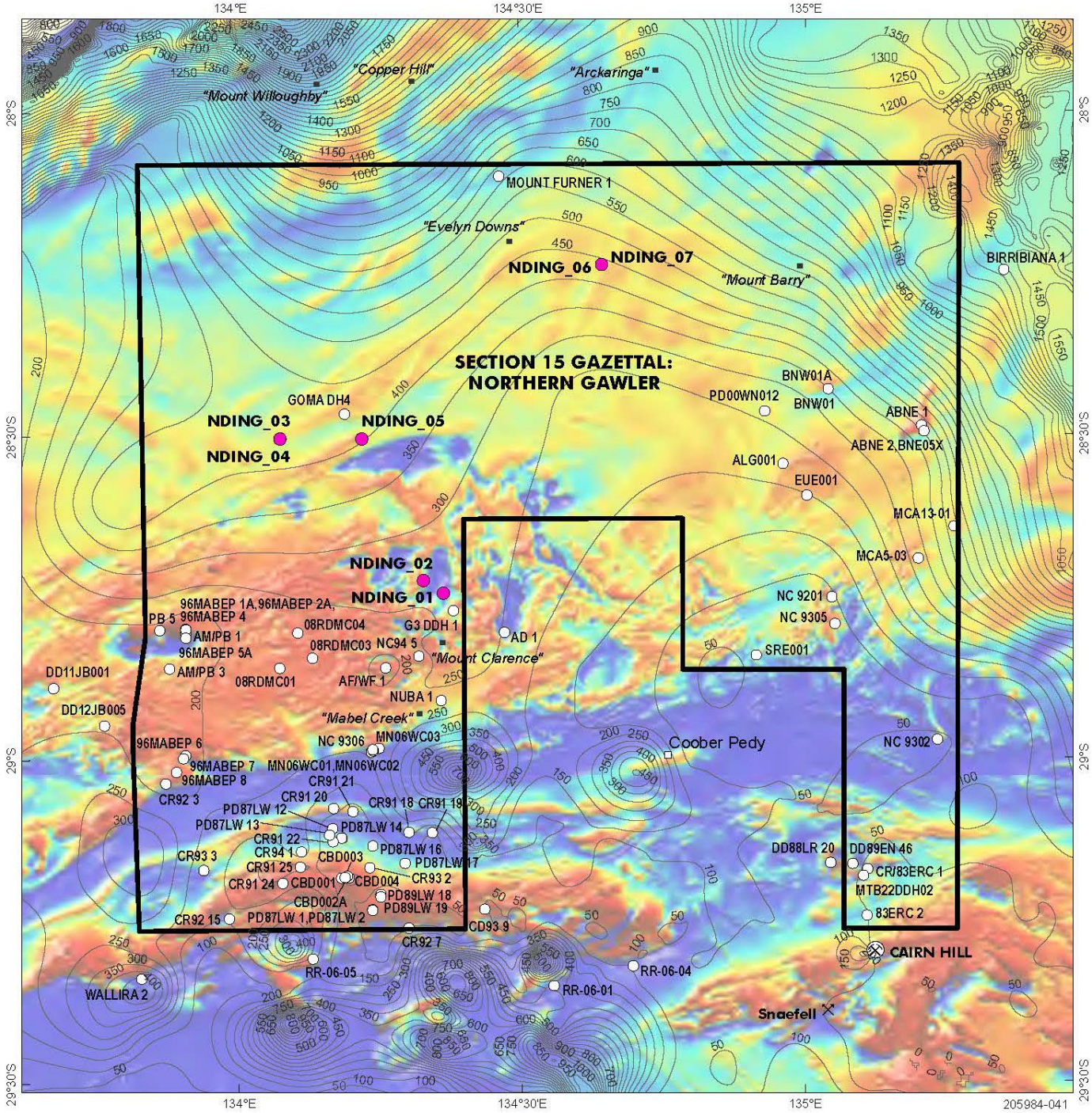
Total Magnetic Intensity (nTesla)

High: 23588.3 Low: -6384.93

0 10 20 30 40 50 km

GDA2020 Projection MGA Zone 53

NORTHERN GAWLER NDI DRILLING PROGRAM TOTAL MAGNETIC INTENSITY with CONTOURS

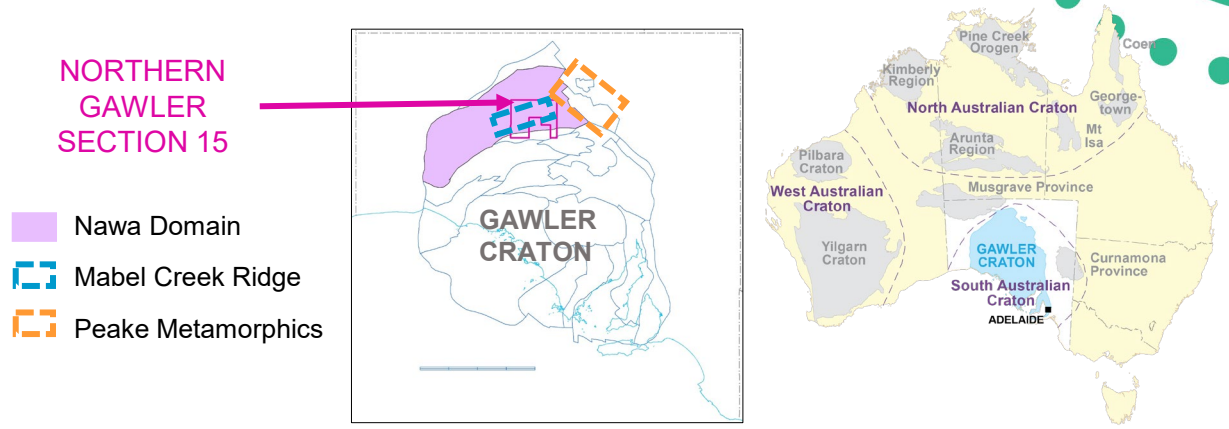


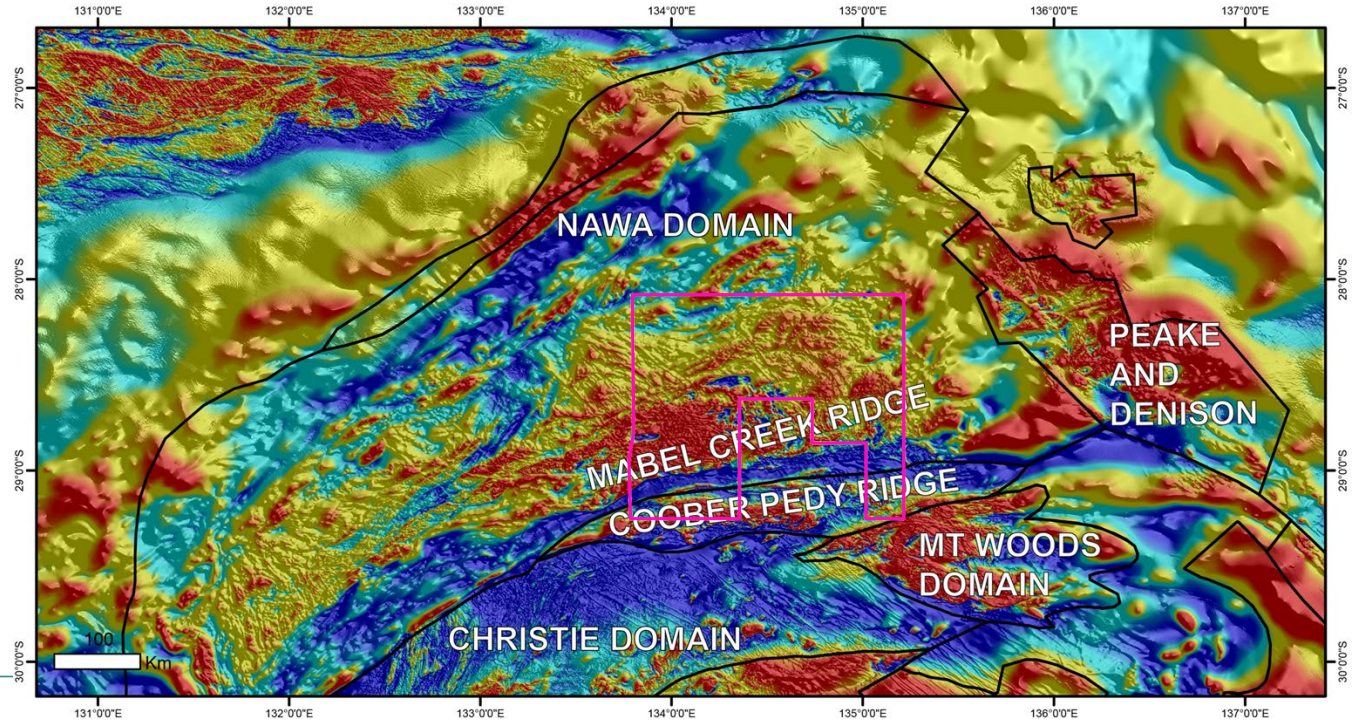
Northern Gawler Craton NDI approach

The Section 15 area encompasses a crucial zone that could aide in understanding the structural architecture of the Northern Gawler Craton

Intersection of three major tectonic domains:

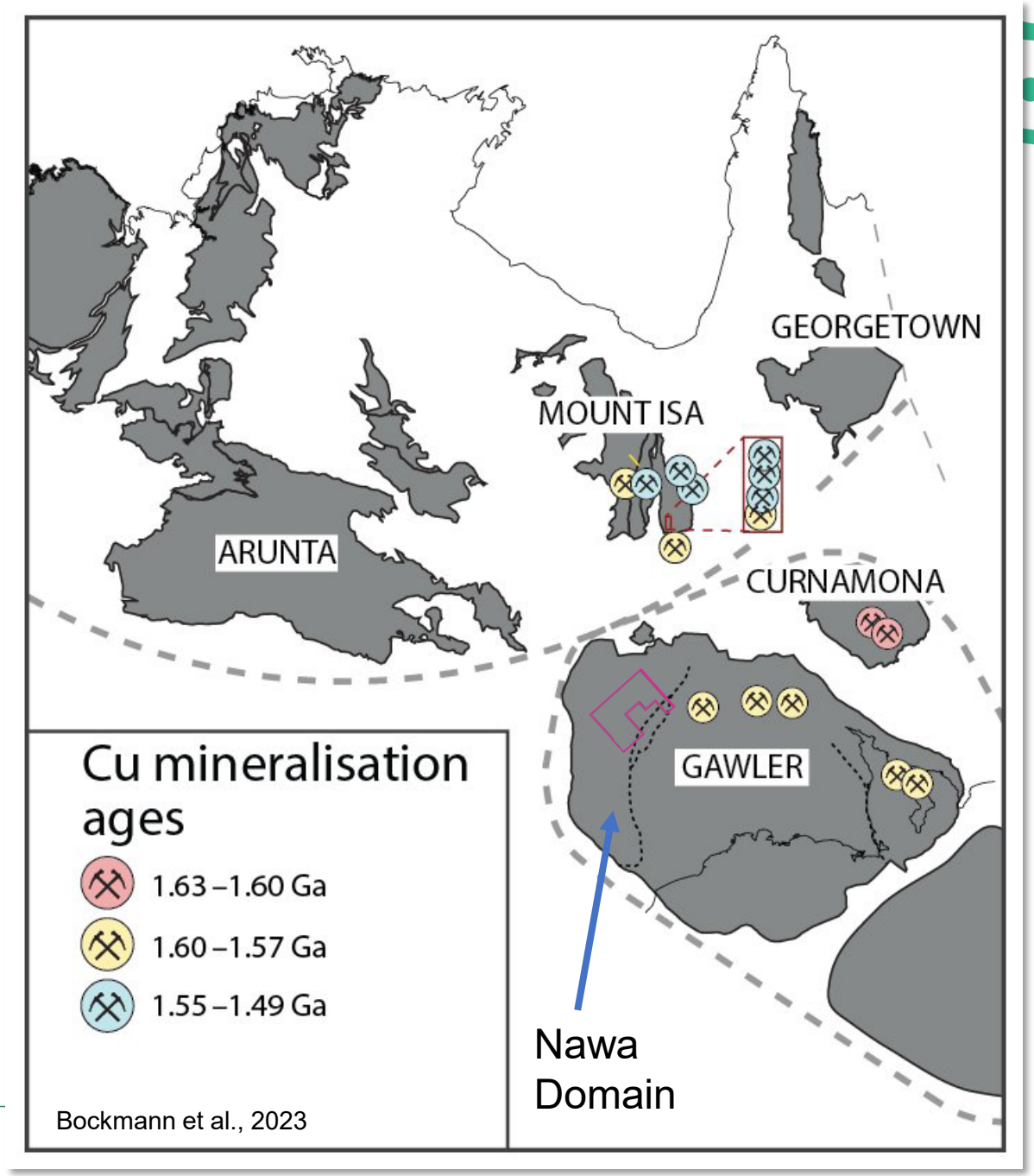
- Nawa Domain
  - Strongly sheared metasedimentary package, with no known Olarian/Kararan (1570–1540 Ma) overprint
- Mabel Creek Ridge
  - Complexly deformed metasedimentary package, with a significant (predominant) Olarian/Kararan overprint
- Peake Metamorphics (Peake and Denison Inliers)
  - Pre-Kimban (pre-1740 Ma) sedimentary package and magmatic intrusives, deformed and metamorphosed during a pre-Kimban event (overprinted during Olarian/Kararan (1570–1540 Ma) and Coorabie (ca. 1450 Ma) events)





Northern Gawler Craton

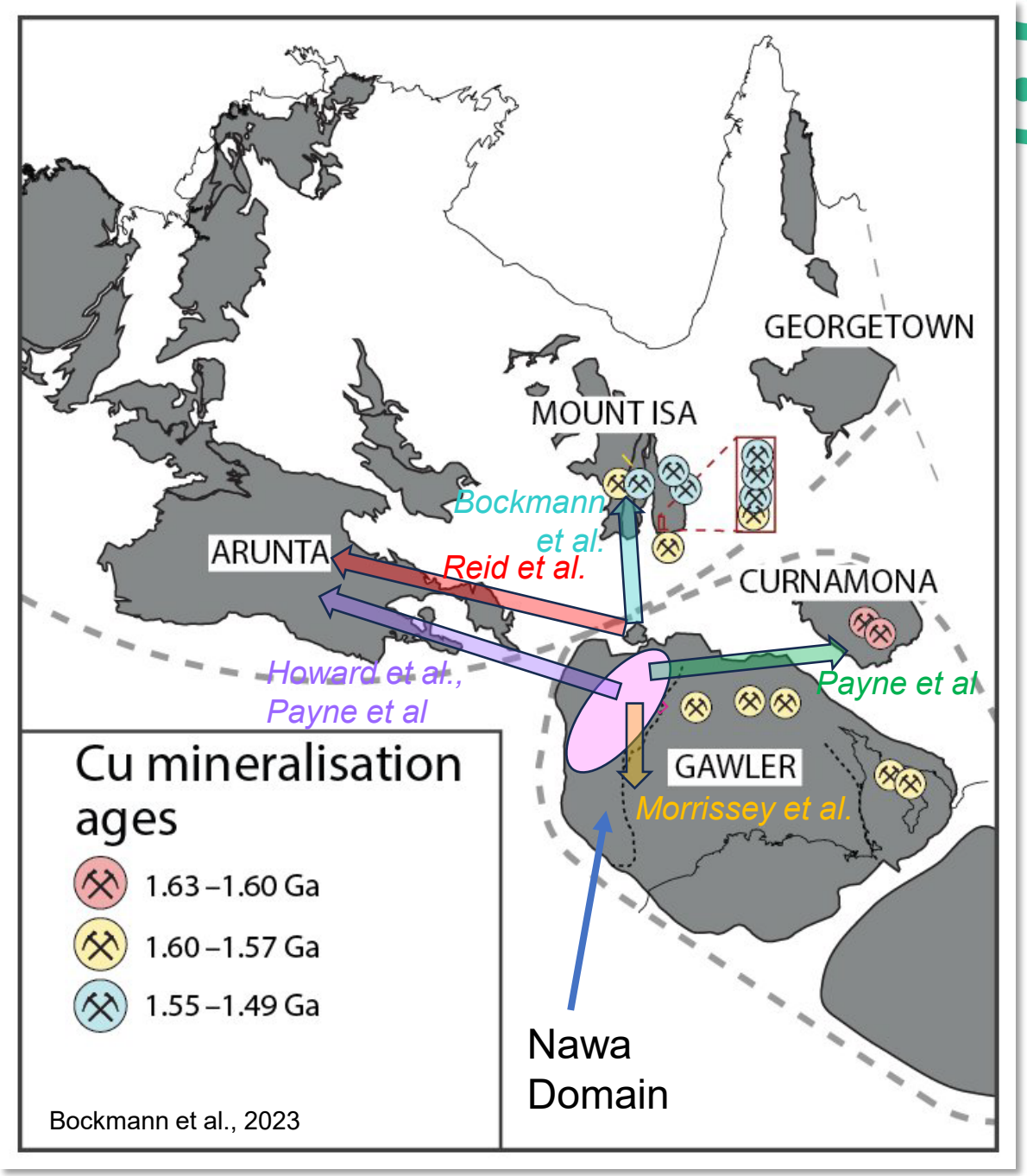
The Northern Gawler Craton also encompasses a crucial zone that can contextualise and strengthen links with the North Australian Craton



Northern Gawler Craton

The Northern Gawler Craton also encompasses a crucial zone that can contextualise and strengthen links with the North Australian Craton

- Explore terrane correlations
  - *How do the bits of the northern Gawler Craton fit together?*
  - *Correlation with north Australia (Aileron/Arunta, Mt Isa) and other parts of South Australia (Peake and Denison, Gawler Craton, Curnamona Province)*
  - *What are the main rock types, protolith, metamorphic and magmatic ages?*



Mapping Northern Gawler

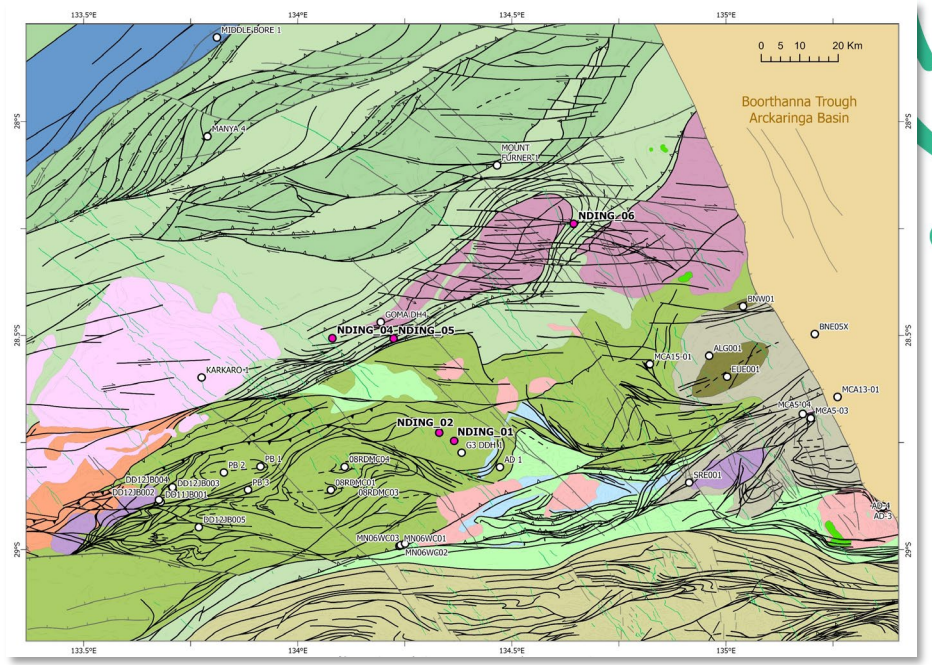
12 drillhole targets* chosen to:

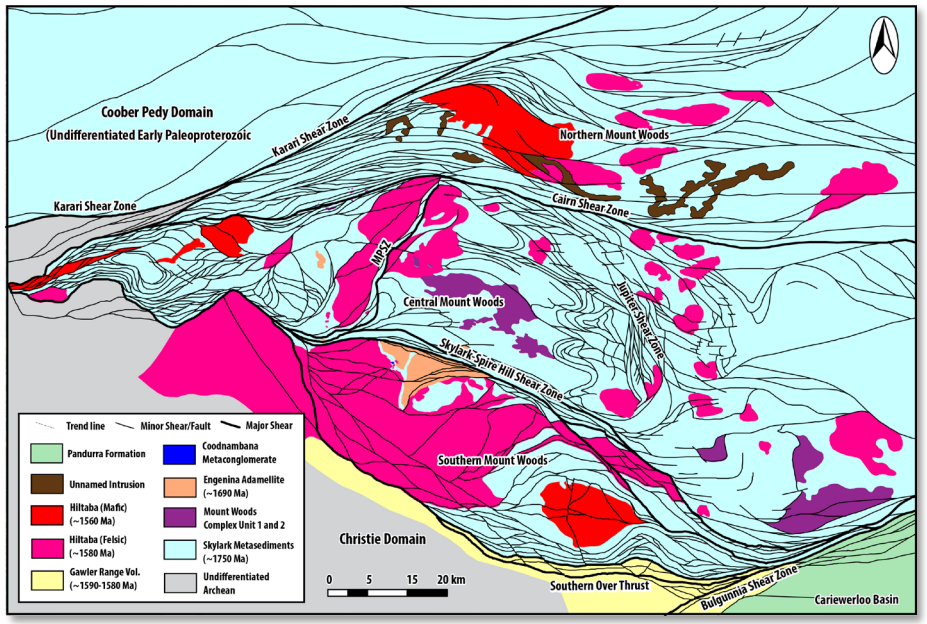
- Characterise different basement rocks and metamorphic history
  - *Filling in the gaps – rock types, protolith ages, metamorphic ages, magmatism*
  - *Context for younger overprinting events*

- Help inform Discovery Mapping project in Northern Gawler Craton (Nawa Domain and Mt Woods Inlier)
  - *Sampling of legacy drillholes in the Northern Gawler Craton – SHRIMP, geochemistry and isotope geochemistry*

- Develop mineral potential in the area (Broken Hill Type (BHT) or sedimentary exhalative (SEDEX) base metals; Cu-Au (IOCG, ISCG), REE)

**Total 5 drillholes completed with basement intersections*





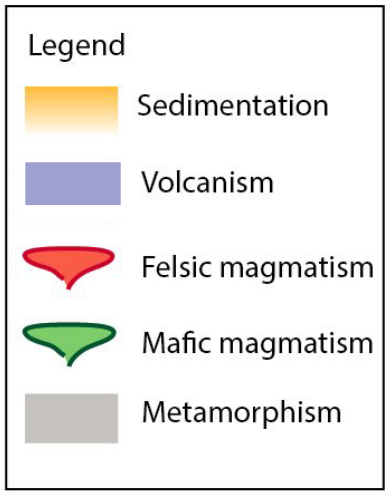
Structural and solid geology interpretation for the Nawa Domain (J. Percival; top) and Mt Woods Inlier, (R. Abdullah; bottom), based on SA 1st Edition Geology.

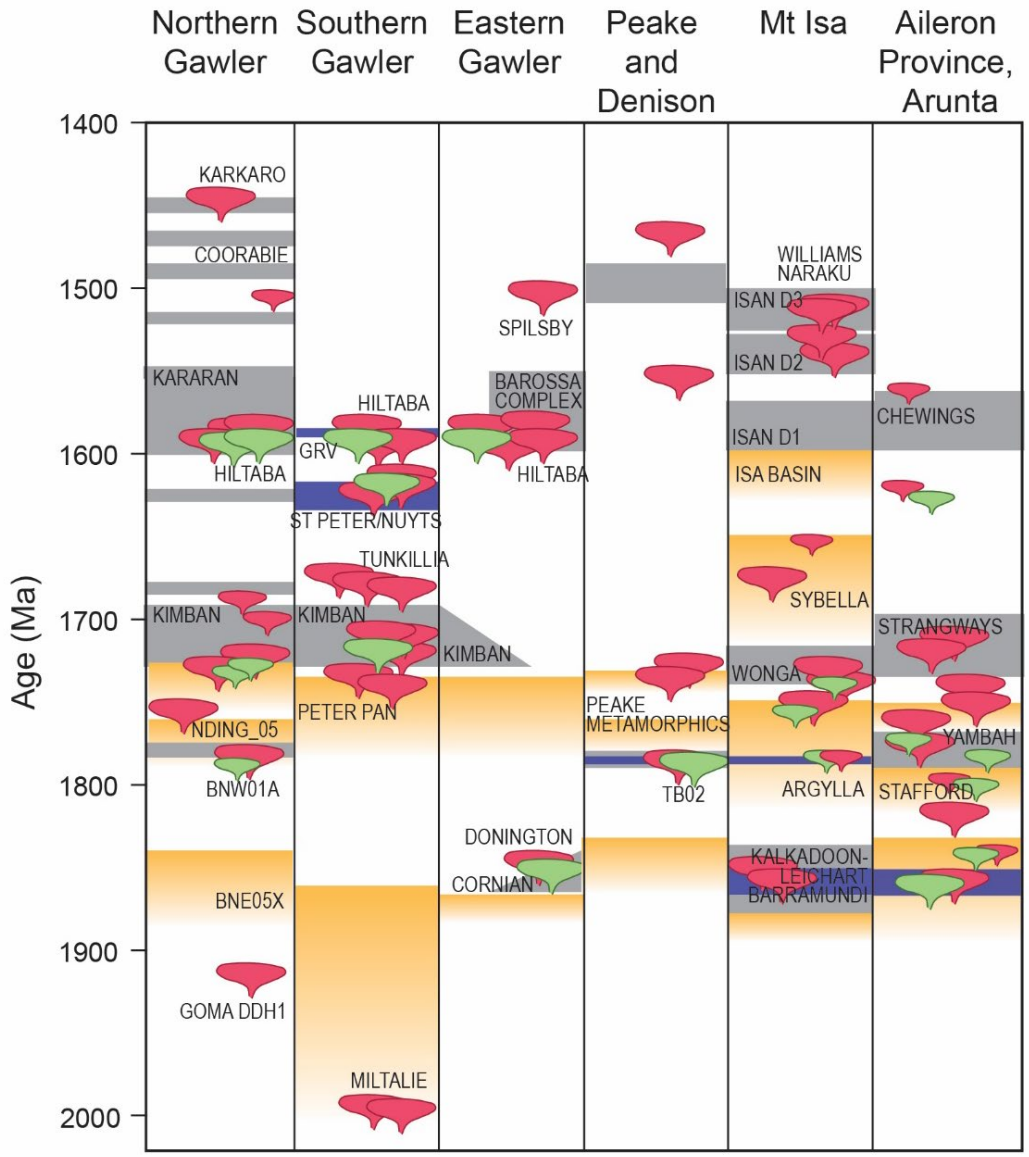
Correlations with adjacent terranes

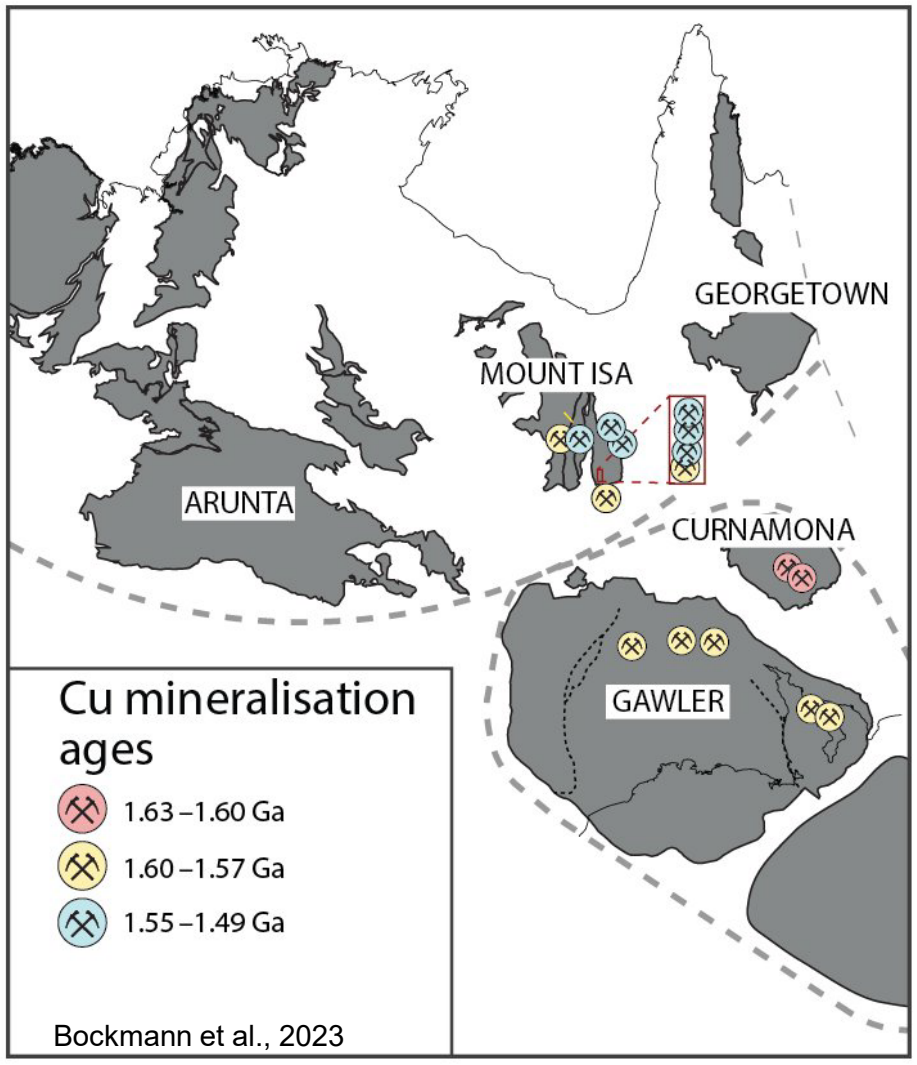
Temporal correlation of geological events between many provinces

No clear shared single history

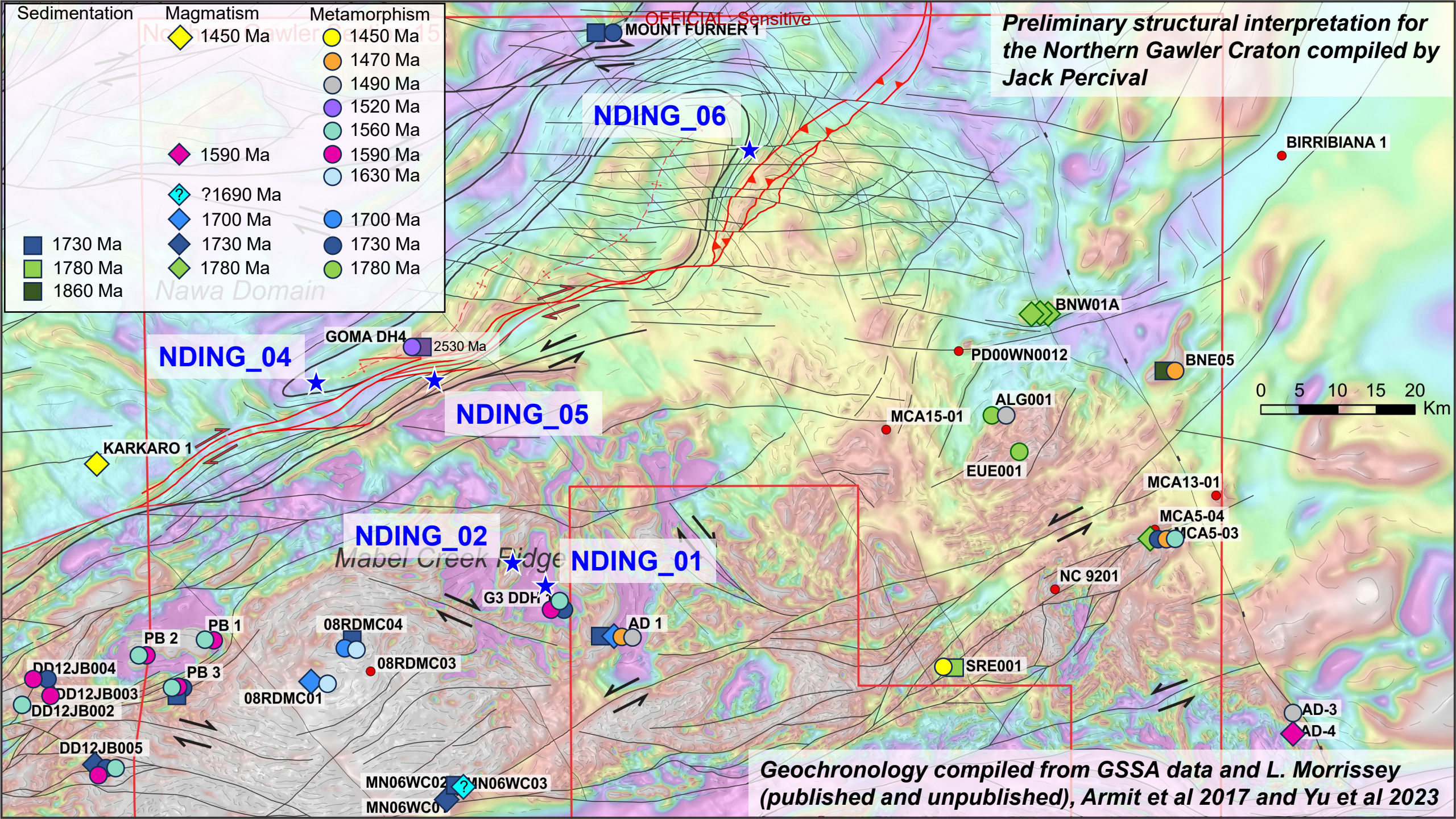
Younger history shared with Mt Isa and Peake and Denison Inliers



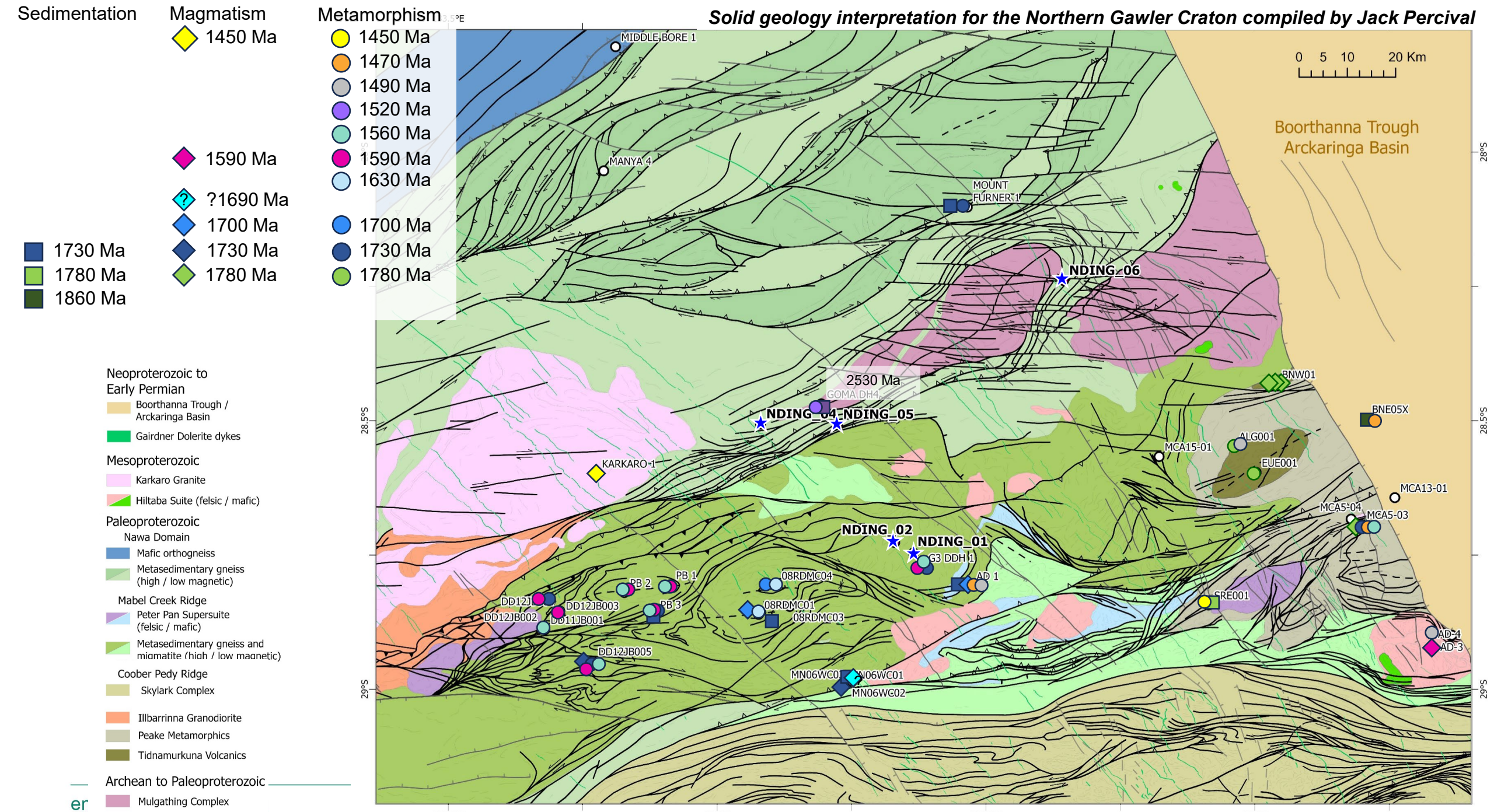




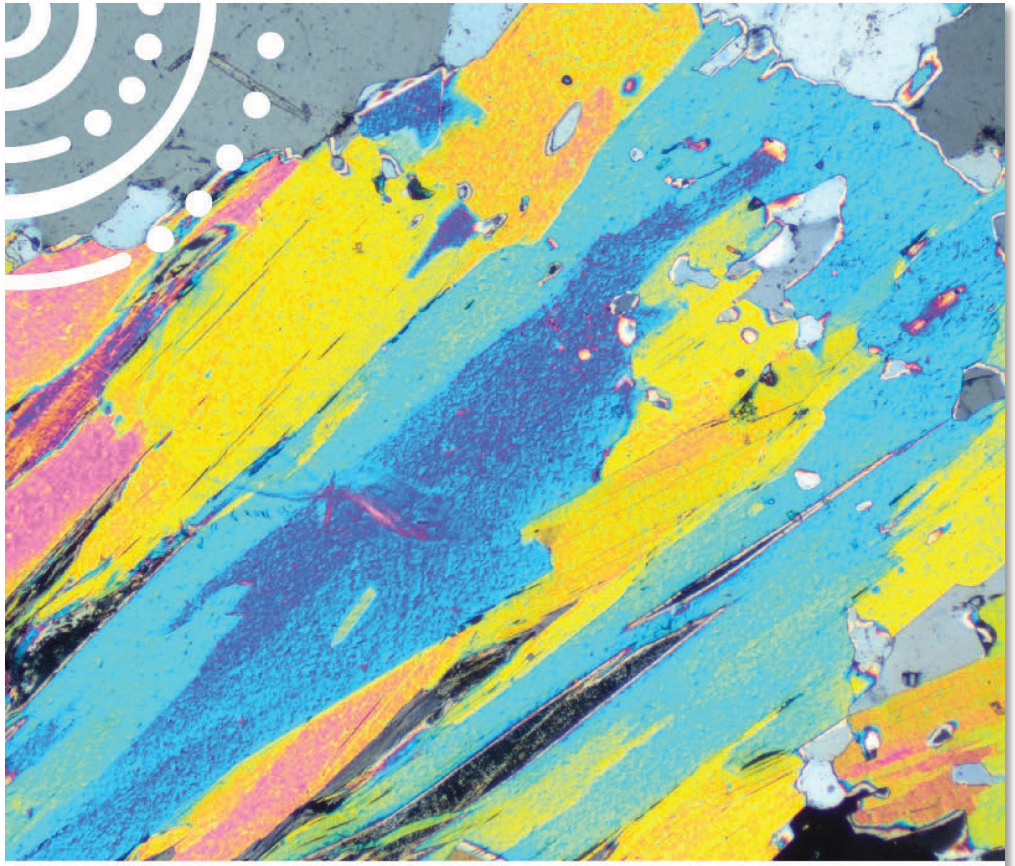
Space-time diagram modified after Payne, Morrissey


OFFICIAL - Sensitive
Preliminary structural interpretation for the Northern Gawler Craton compiled by Jack Percival
Sedimentation
Magmatism
Metamorphism
1450 Ma
1450 Ma
1470 Ma
1490 Ma
1520 Ma
1560 Ma
1590 Ma
1590 Ma
1630 Ma
?1690 Ma
1700 Ma
1700 Ma
1730 Ma
1730 Ma
1730 Ma
1780 Ma
1780 Ma
1780 Ma
1860 Ma
Nawa Domain
NDING_06
NDING_04
NDING_05
NDING_02
NDING_01
Mabel Creek Ridge
MOUNT FURNER 1
BIRRIBIANA 1
BNW01A
PD00WN0012
BNE05
GOMA DH4
2530 Ma
ALG001
MCA15-01
EUE001
KARKARO 1
MCA13-01
MCA5-04
MCA5-03
NC 9201
G3 DDH1
AD 1
SRE001
PB 1
PB 2
PB 3
08RDMC04
08RDMC03
08RDMC01
DD12JB004
DD12JB003
DD12JB002
DD12JB005
AD-3
AD-4
MN06WC02
MN06WC03
MN06WC01
0 5 10 15 20 Km
Geochronology compiled from GSSA data and L. Morrissey (published and unpublished), Armit et al 2017 and Yu et al 2023

Solid geology interpretation for the Northern Gawler Craton compiled by Jack Percival



Geochronology compiled from GSSA data and L. Morrissey (published and unpublished), Armit et al 2017 and Yu et al 2023



Geochronology on the buried northern Gawler Craton

Part 1: Multi-mineral laser-ablation U–Pb–Lu–Hf dating

Dillon Brown, Jack Percival, Tom Wise and Rashed Abdullah

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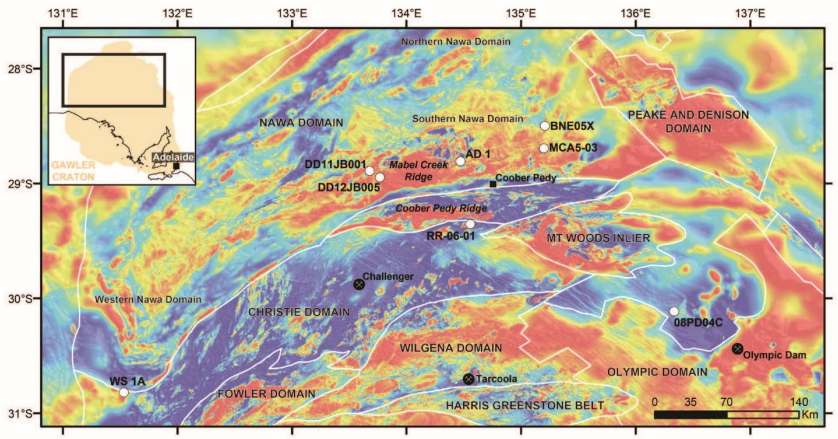
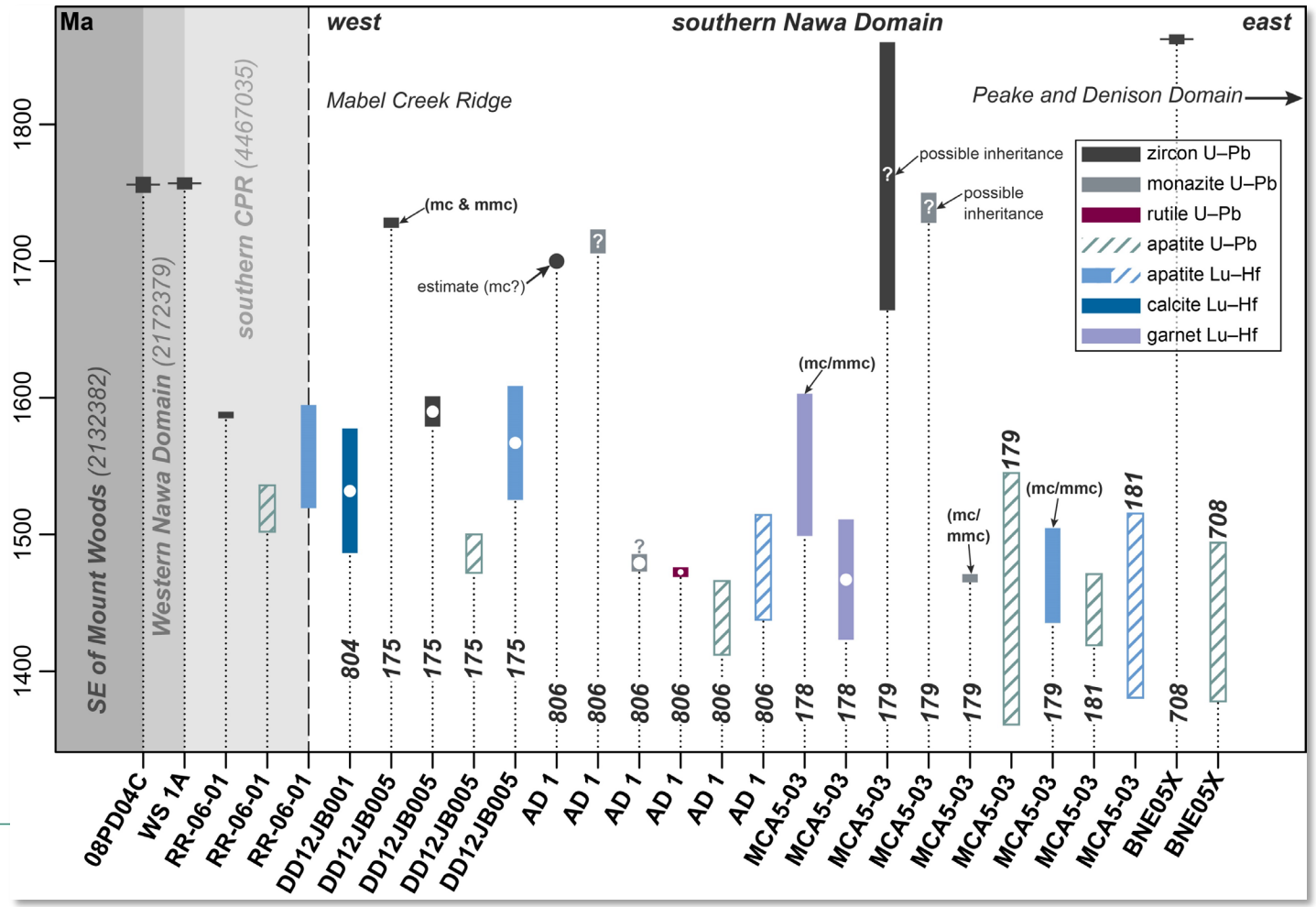
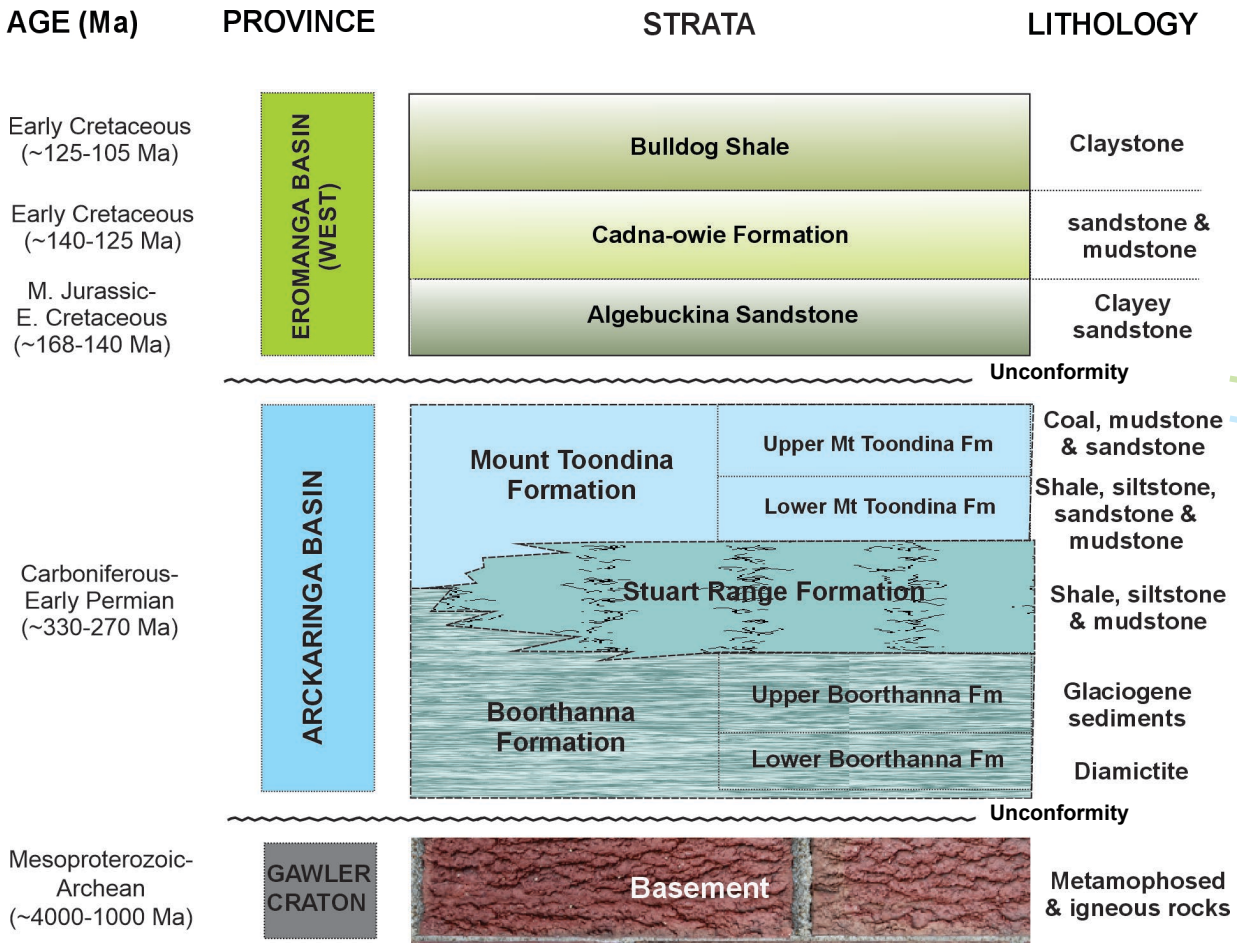
https://catalog.sarig.sa.gov.au/document/mesac1403





Sedimentary basins

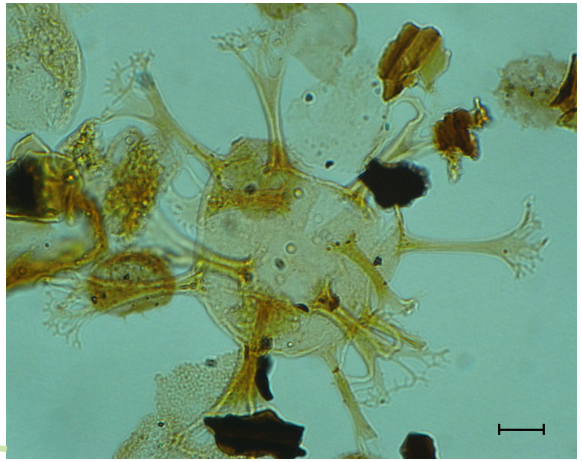
- Refine basin cover thickness (depth to basement) and geological characterisation
- Biostratigraphy and depositional environments in Eromanga Basin and Arckaringa Basin



Strata relationships for Eromanga and Arckaringa basins, modified from Baohong Hou

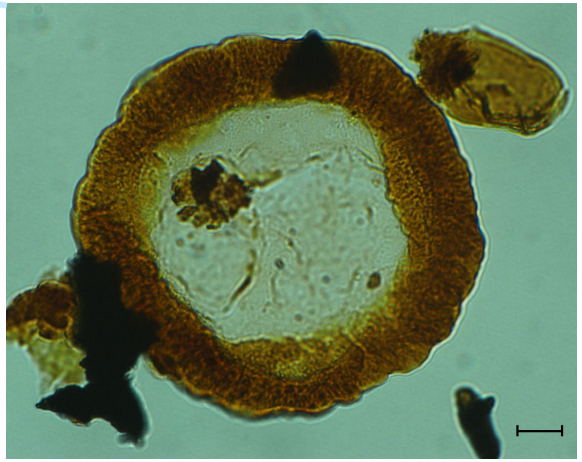
Braided fluvial; non-marine to marginal marine; open marine transgressive.

Cretaceous microplankton Oligosphaeridium pulcherrimum, NDING_06, 21–22 m



Shallow marine-fluvial periglacial; marginal marine; lacustrine, meandering fluvial and back swamp.

Permian spore Cannanoropollis perfectus, NDING_06, 246–247 m



Scale bar 10 µm

NDING_02

NDING_06

AGE (Ma)	PROVINCE	STRATA	LITHOLOGY
Early Cretaceous (~125-105 Ma)	EROMANGA BASIN (WEST)	Bulldog Shale	Claystone
Early Cretaceous (~140-125 Ma)		Cadna-owie Formation	sandstone & mudstone
M. Jurassic-E. Cretaceous (~168-140 Ma)		Algebuckina Sandstone	Clayey sandstone
		Unconformity	
Carboniferous-Early Permian (~330-270 Ma)	ARCKARINGA BASIN	Mount Toondina Formation: Upper Mt Toondina Fm	Coal, mudstone & sandstone
		Mount Toondina Formation: Lower Mt Toondina Fm	Shale, siltstone, sandstone & mudstone
		Stuart Range Formation	Shale, siltstone & mudstone
		Boorthanna Formation: Upper Boorthanna Fm	Glaciogene sediments
		Boorthanna Formation: Lower Boorthanna Fm	Diamictite
		Unconformity	
Mesoproterozoic-Archean (~4000-1000 Ma)	GAWLER CRATON	Basement	Metamophosed & igneous rocks

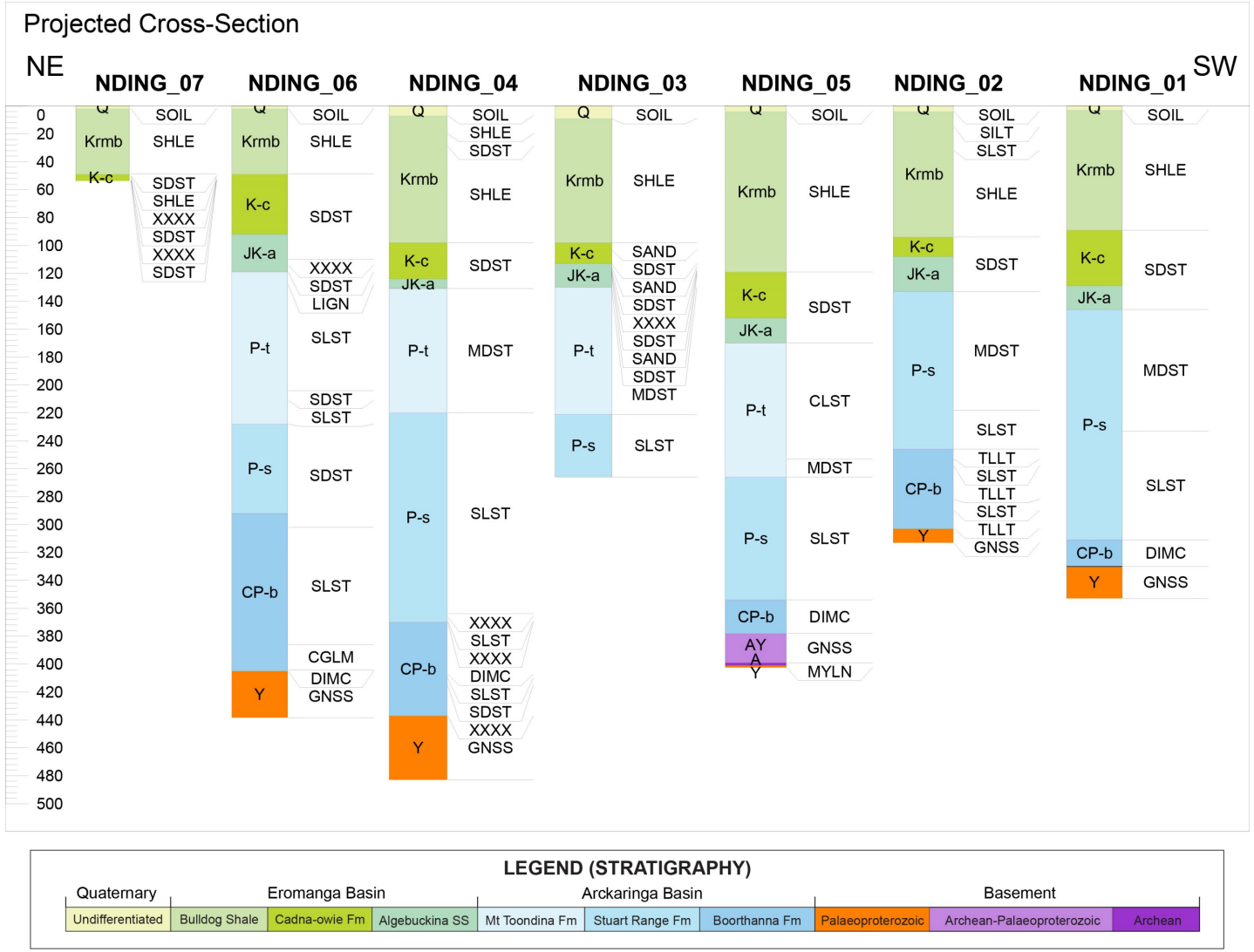
NDI drillholes Depth to Basement

Eromanga Basin relatively consistent stratigraphy and basin thickness (117–166 m) between NDI drillholes.

Arckaringa Basin displays more variation in stratigraphy and basin thickness (170–306 m).

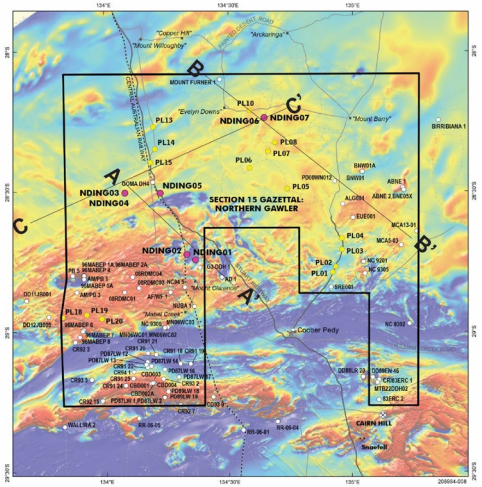
Depth the basement variable (303– 438 m).

Basement lithologies include metasedimentary gneiss, granitic gneiss, intermediate gneiss, migmatitic gneiss and mylonite.



Projected cross section for the Northern Gawler Craton NDI drillholes

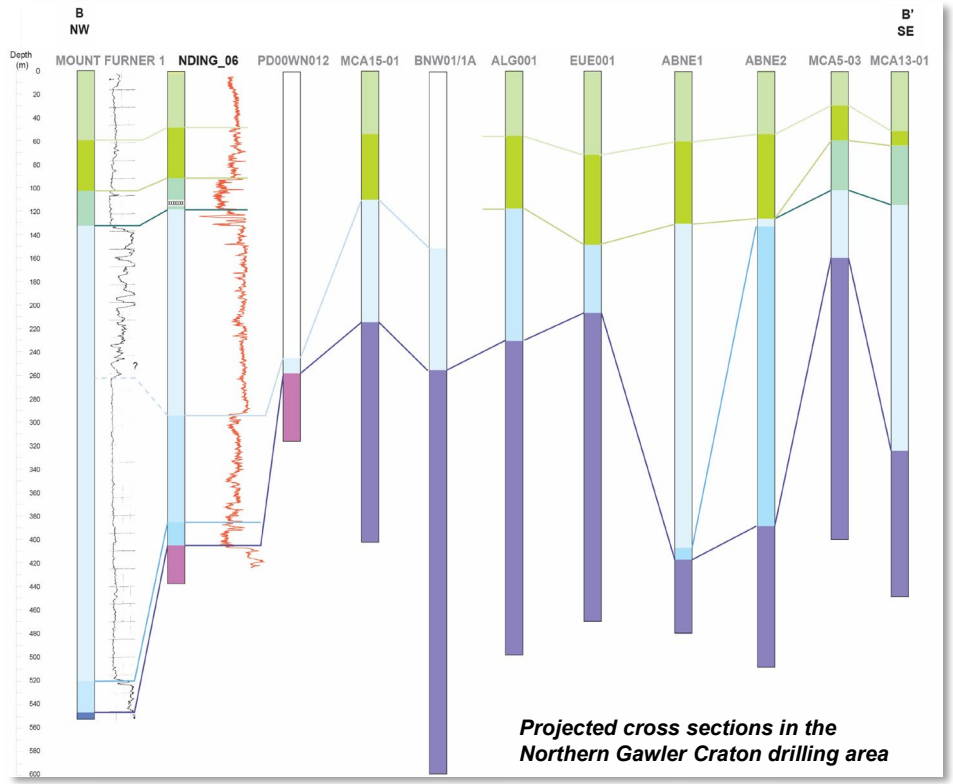
Regional Depth to Basement and basin stratigraphy



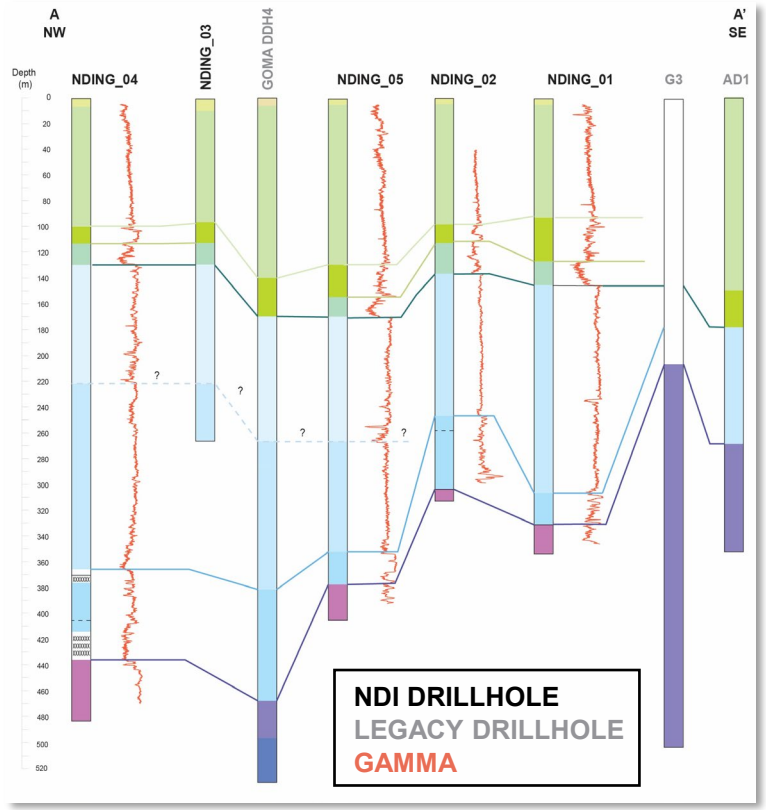
Eromanga Basin relatively consistent stratigraphy and basin thickness across the region.

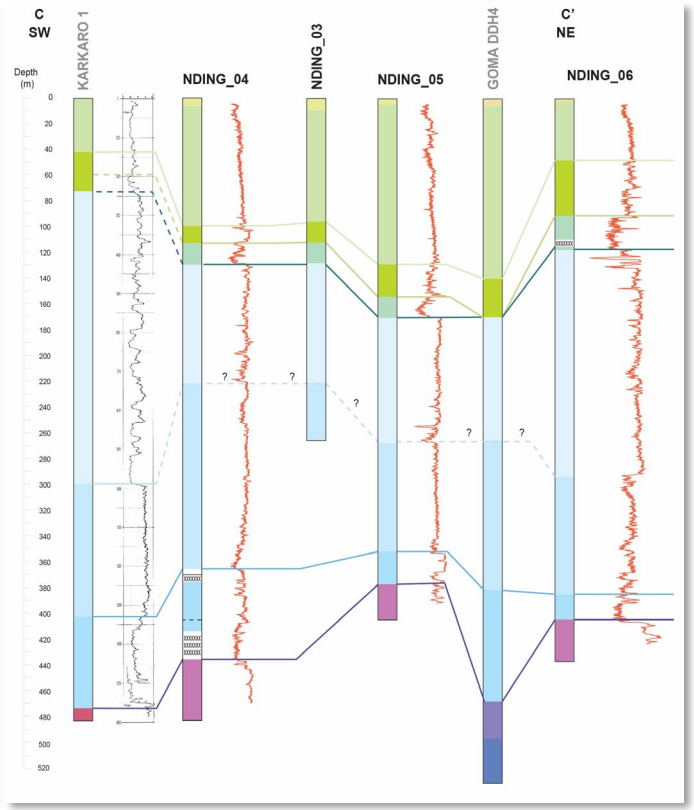
Arckaringa Basin displays more variation in stratigraphy and basin thickness (deepening to the north). NDI drillholes have helped refine presence of Carboniferous-Early Permian units from Arckaringa Basin in regional drillholes.

Depth the basement in Northern Gawler Craton highly variable.

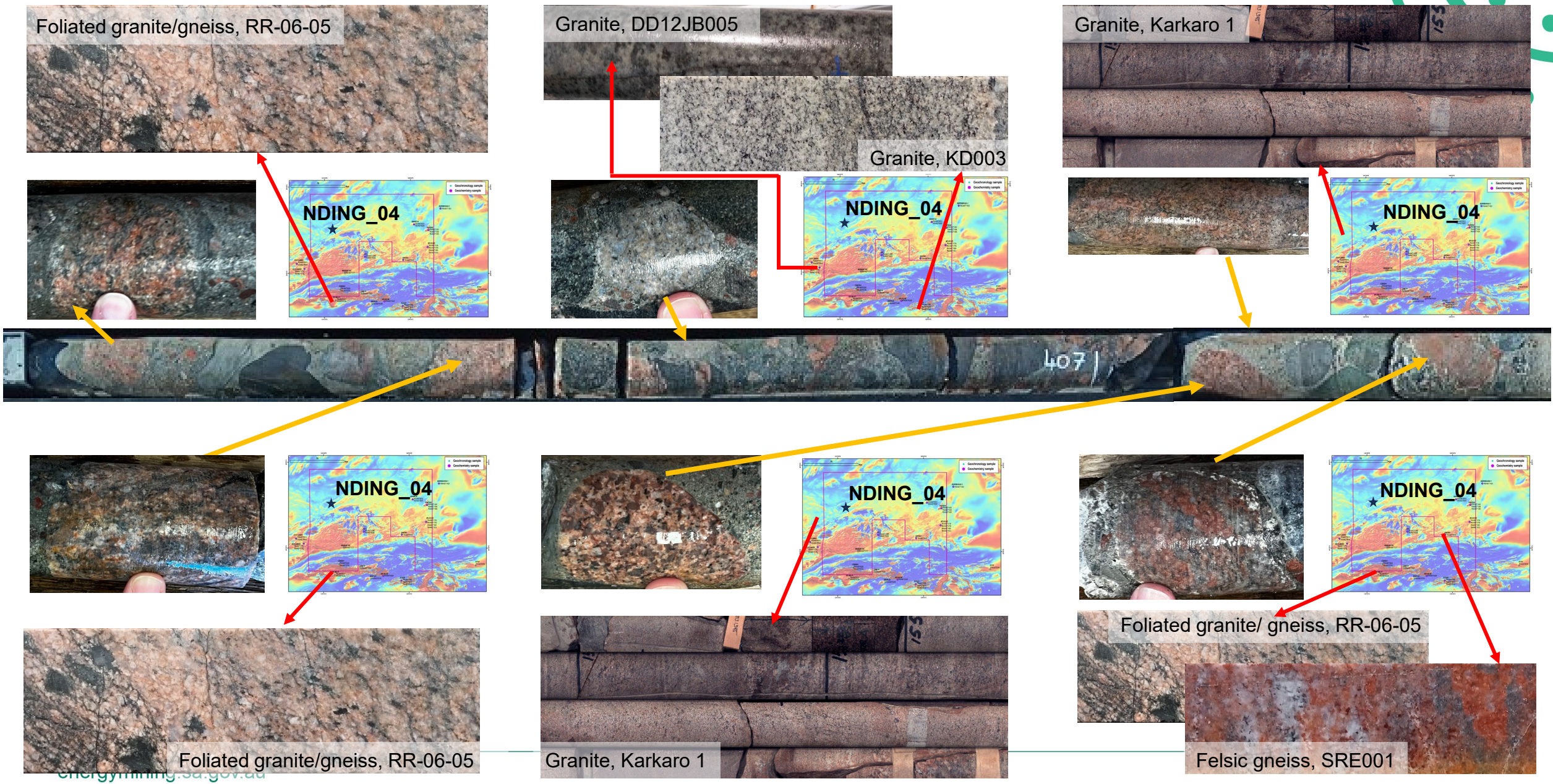


Projected cross sections in the Northern Gawler Craton drilling area

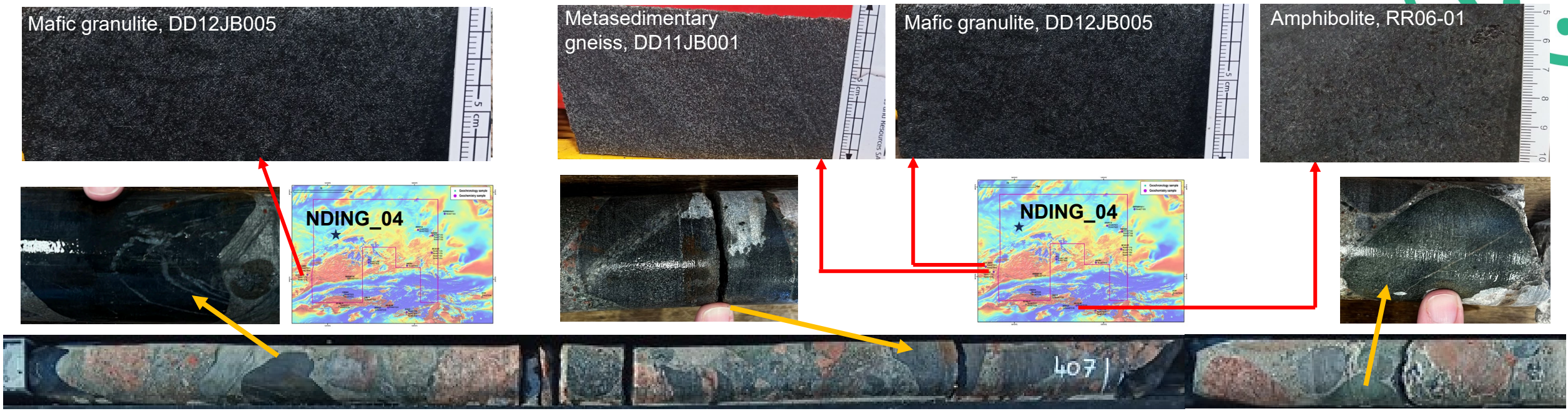




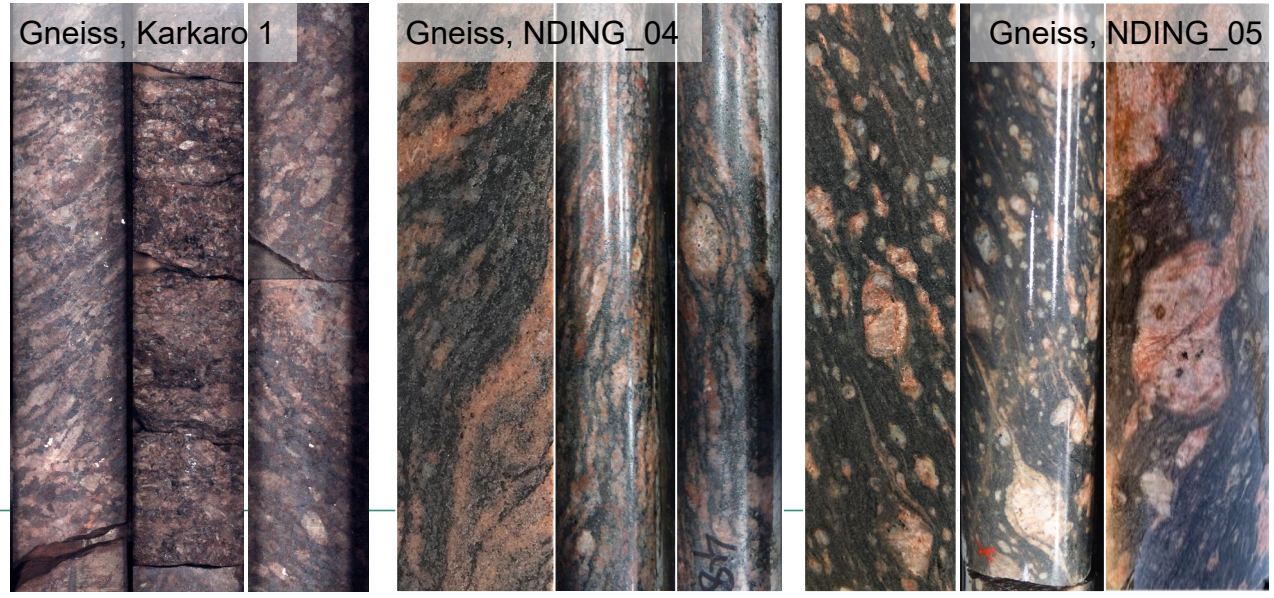
Permian Diamicite – granite clasts



Permian Diamicite – mafic-intermediate clasts



Permian Diamicite – gneissic clast



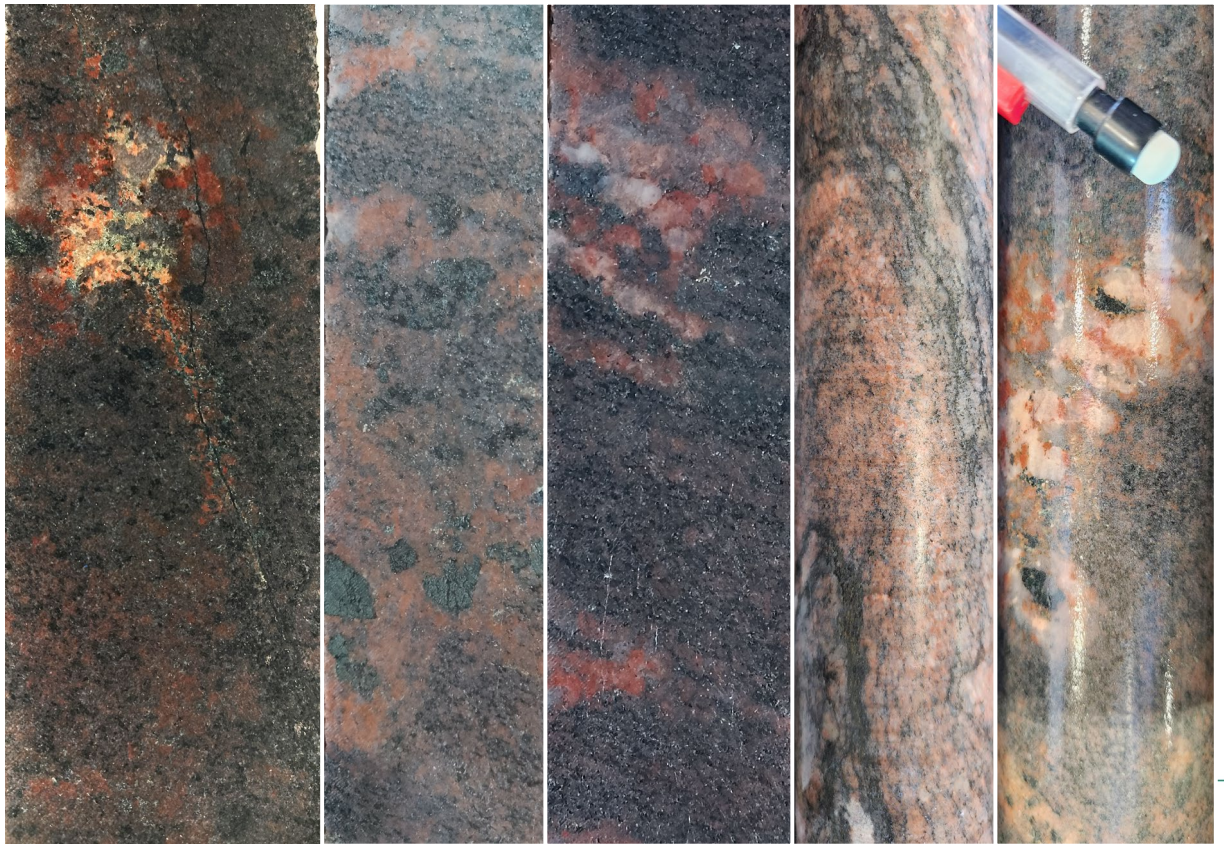
Key questions/areas of research interest for Northern Gawler NDI

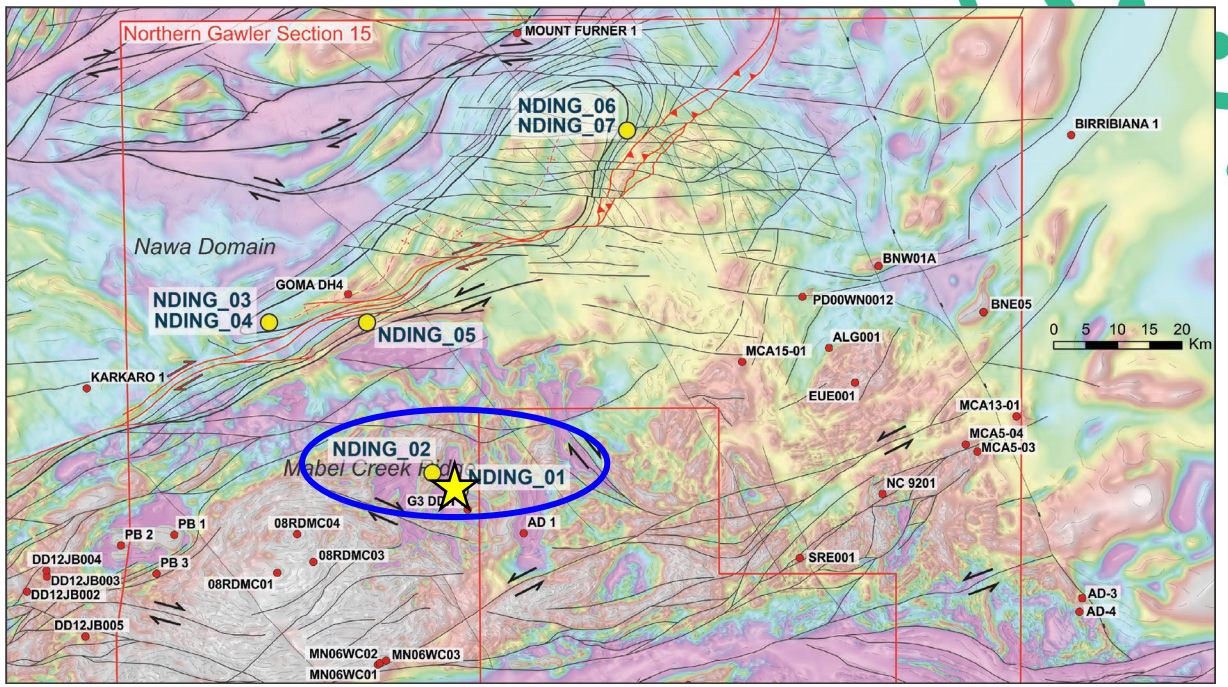
- Placing Nawa Domain in context of Gawler Craton on NAC
- Metamorphic history, including exhumation history (high and low temperature, timing recent and ancient)
  - e.g. characterising Coorabie Event (1470–1450 Ma; shear zone formation and reactivation)
- Thermochronology for younger events (<1500 Ma)
  - E.g. drivers for magmatism, metamorphism, mineralisation
- Isotopic composition
  - E.g. basement and Arckaringa Basin
- Develop mineral potential of the area
  - E.g. Cu-Au (IOCG, ISC), REE, BHT base metals
- Refine Arckaringa Basin and geological characterisation
- Biostratigraphy and depositional environments
- Provenance of glacial erratics – interface sampling

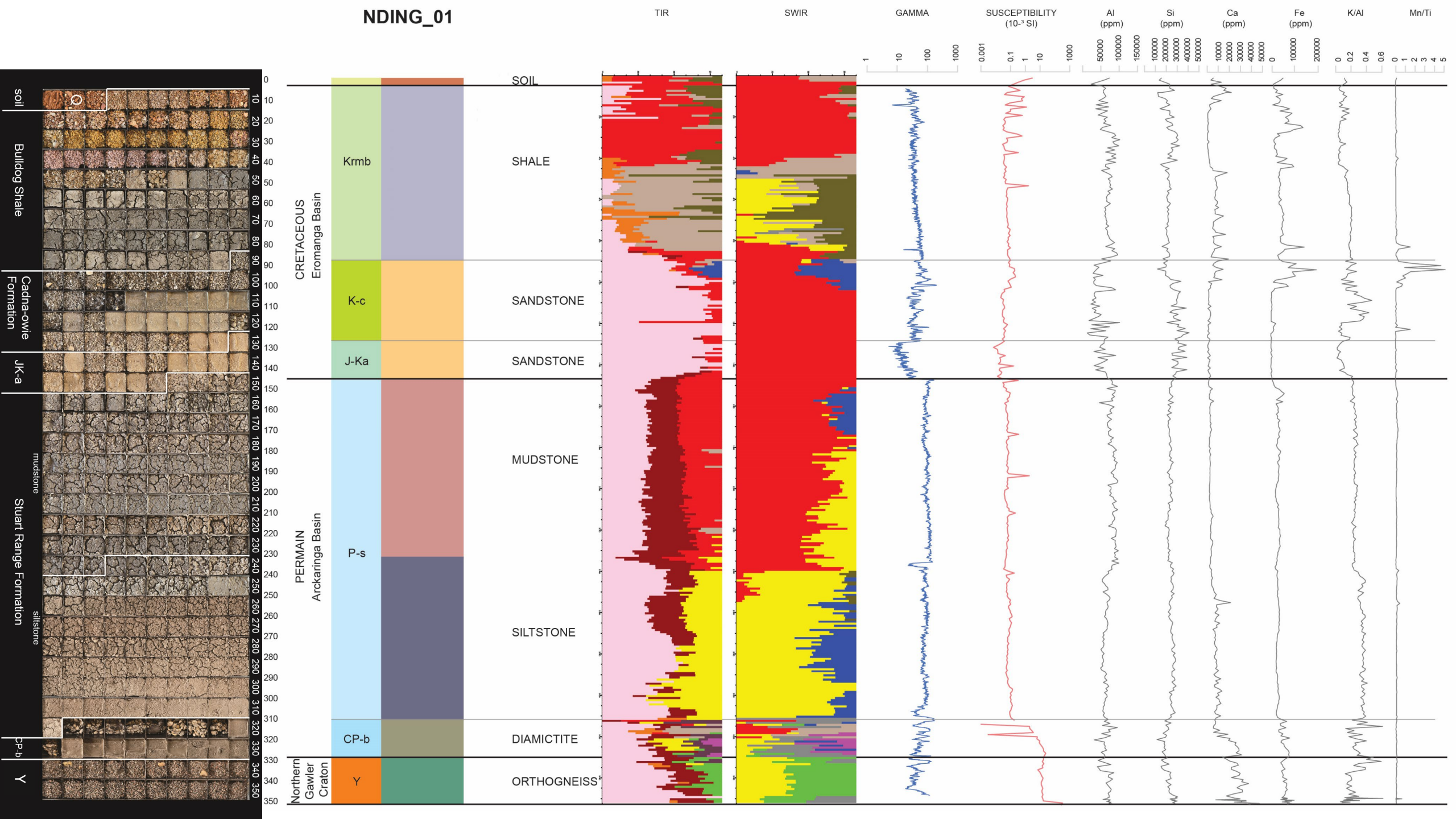
MABEL CREEK RIDGE

NDING_01 and NDING_02 drilled to investigate inversely magnetised and strongly magnetised basement rocks, respectively.

NDING_01:
Basement intersection 330 m; EOH: 352.95 m
Amph-Bi-Plag-Qtz-K-feld-Mag orthogneiss (OTGN)
Magmatic crystallisation age: 1720.2 ± 5.3 Ma



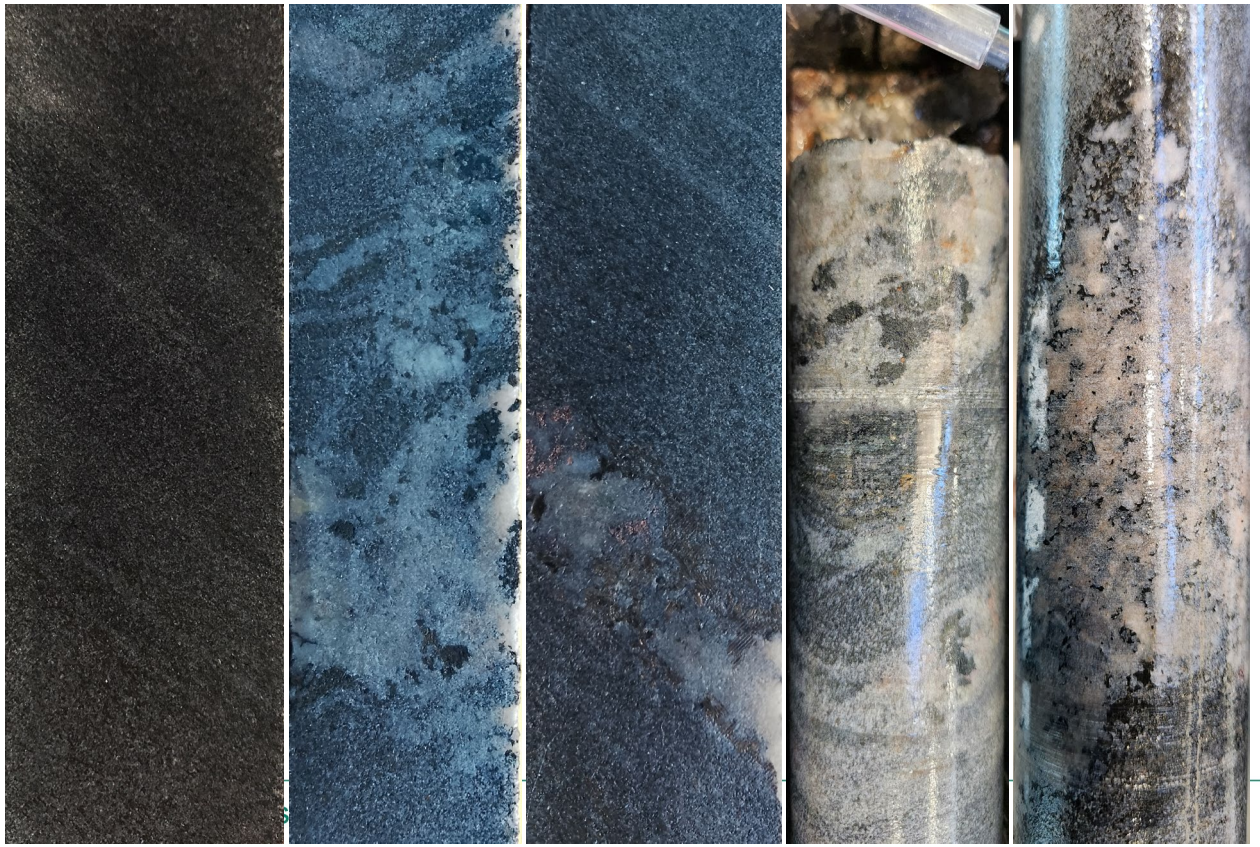


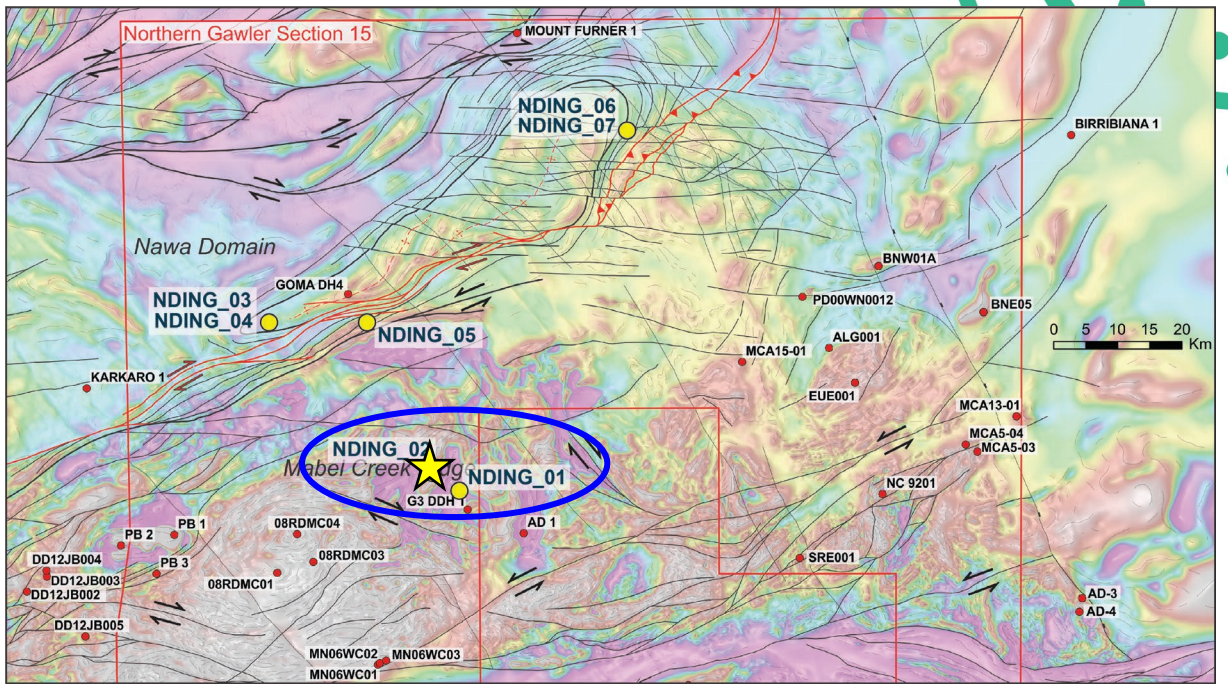

NDING_01
TIR
SWIR
GAMMA
SUSCEPTIBILITY (10-3 SI)
Al (ppm)
Si (ppm)
Ca (ppm)
Fe (ppm)
K/Al
Mn/Ti
soil
Bulldog Shale
Cadna-owie Formation
JK-a
Stuart Range Formation
mudstone
siltstone
CP-b
Y
CRETACEOUS
Eromanga Basin
PERMAIN
Arckaringa Basin
Northern Gawler Craton
Krmb
K-c
J-Ka
P-s
CP-b
Y
SOIL
SHALE
SANDSTONE
SANDSTONE
MUDSTONE
SILTSTONE
DIAMICTITE
ORTHOGNEISS

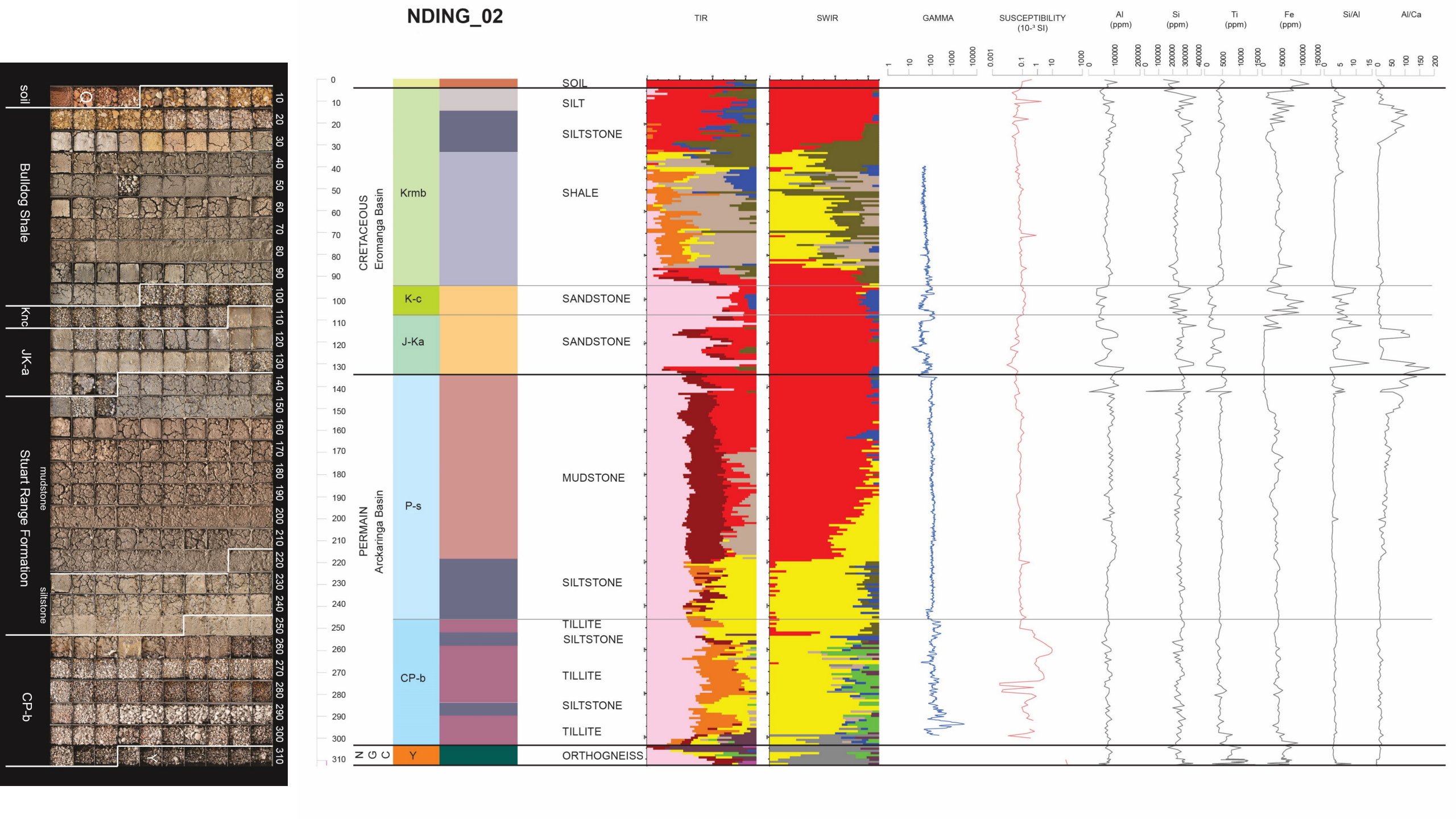
MABEL CREEK RIDGE

NDING_01 and NDING_02 drilled to investigate inversely magnetised and strongly magnetised basement rocks, respectively.

NDING_02:
Basement intersection 303 m; EOH: 313.10 m
Migmatitic Mag-bearing Plag-Qtz-Amph-Bi OTGN
Magmatic crystallisation age: 1723.6 ± 4.2 Ma





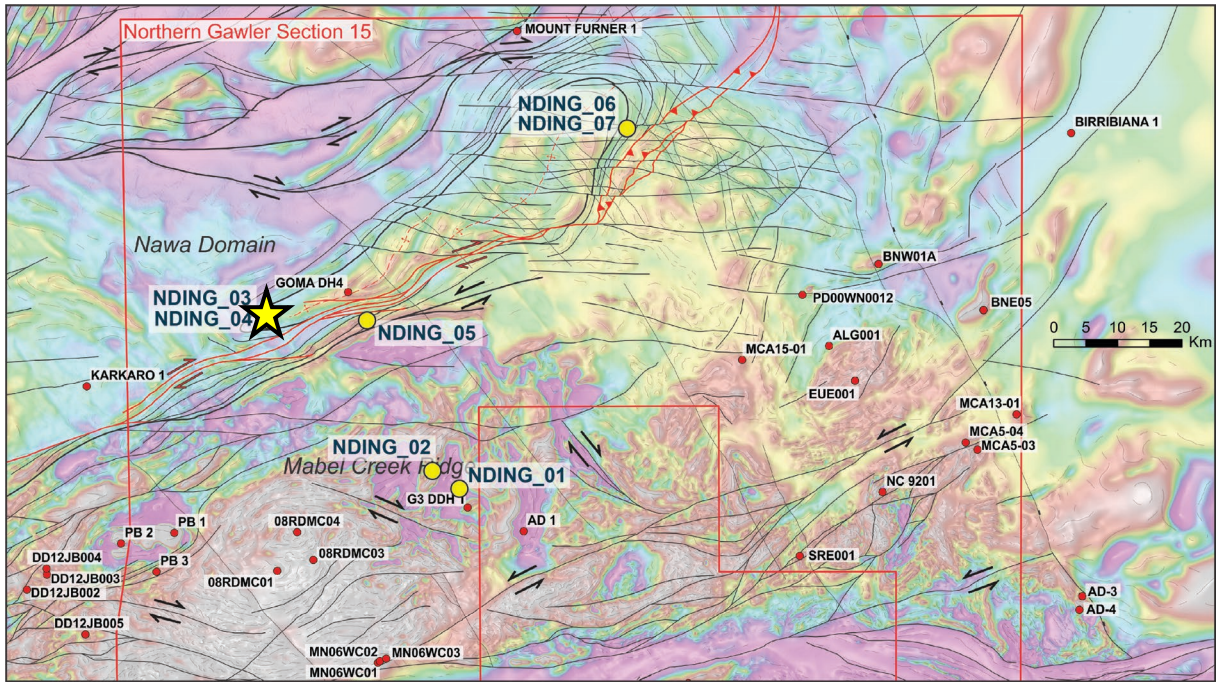

NDING_02
TIR
SWIR
GAMMA
SUSCEPTIBILITY (10-3 SI)
Al (ppm)
Si (ppm)
Ti (ppm)
Fe (ppm)
Si/Al
Al/Ca
soil
Bulldog Shale
Knc
JK-a
Stuart Range Formation
mudstone
siltstone
CP-b
CRETACEOUS
Eromanga Basin
PERMAIN
Arckaringa Basin
Krmb
K-c
J-Ka
P-s
CP-b
Y
SOIL
SILT
SILTSTONE
SHALE
SANDSTONE
SANDSTONE
MUDSTONE
SILTSTONE
TILLITE
SILTSTONE
TILLITE
SILTSTONE
TILLITE
ORTHOGNEISS

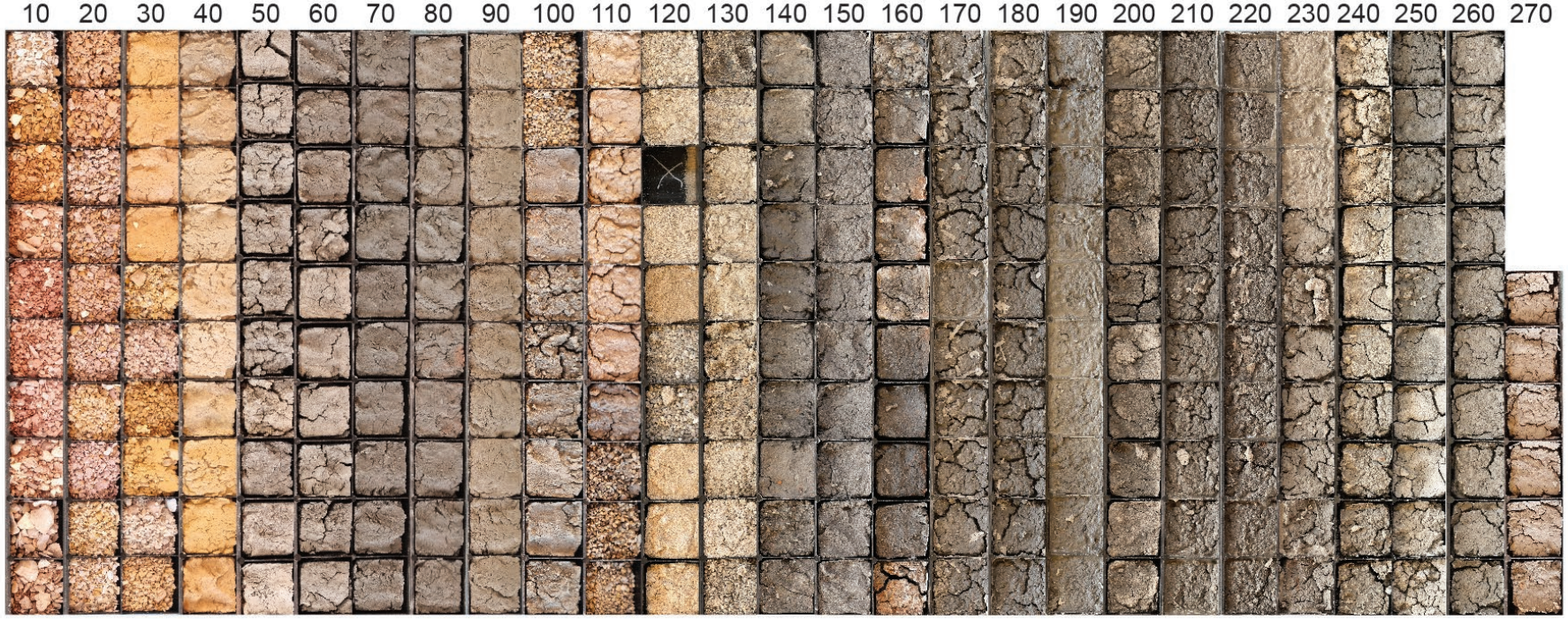
NAWA DOMAIN (SOUTHWEST)

NDING_03 drilled to help constrain extent of Archean basement and timing of deformation and metamorphism (e.g. 1570 Ma and/or 1520 Ma)

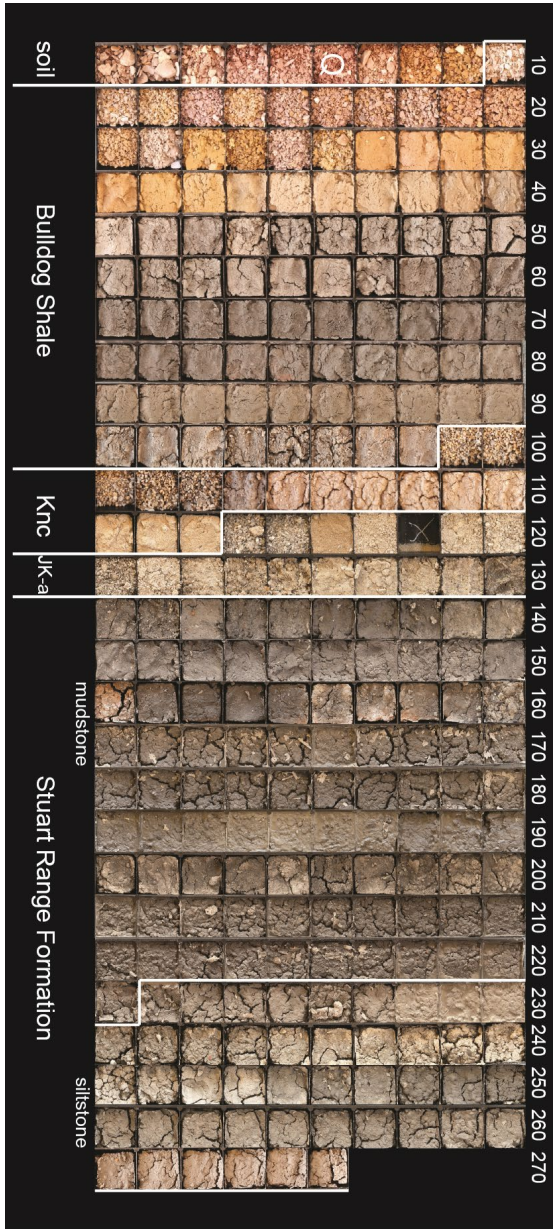
NDING_03:
Basement intersection xx; EOH: 266 m

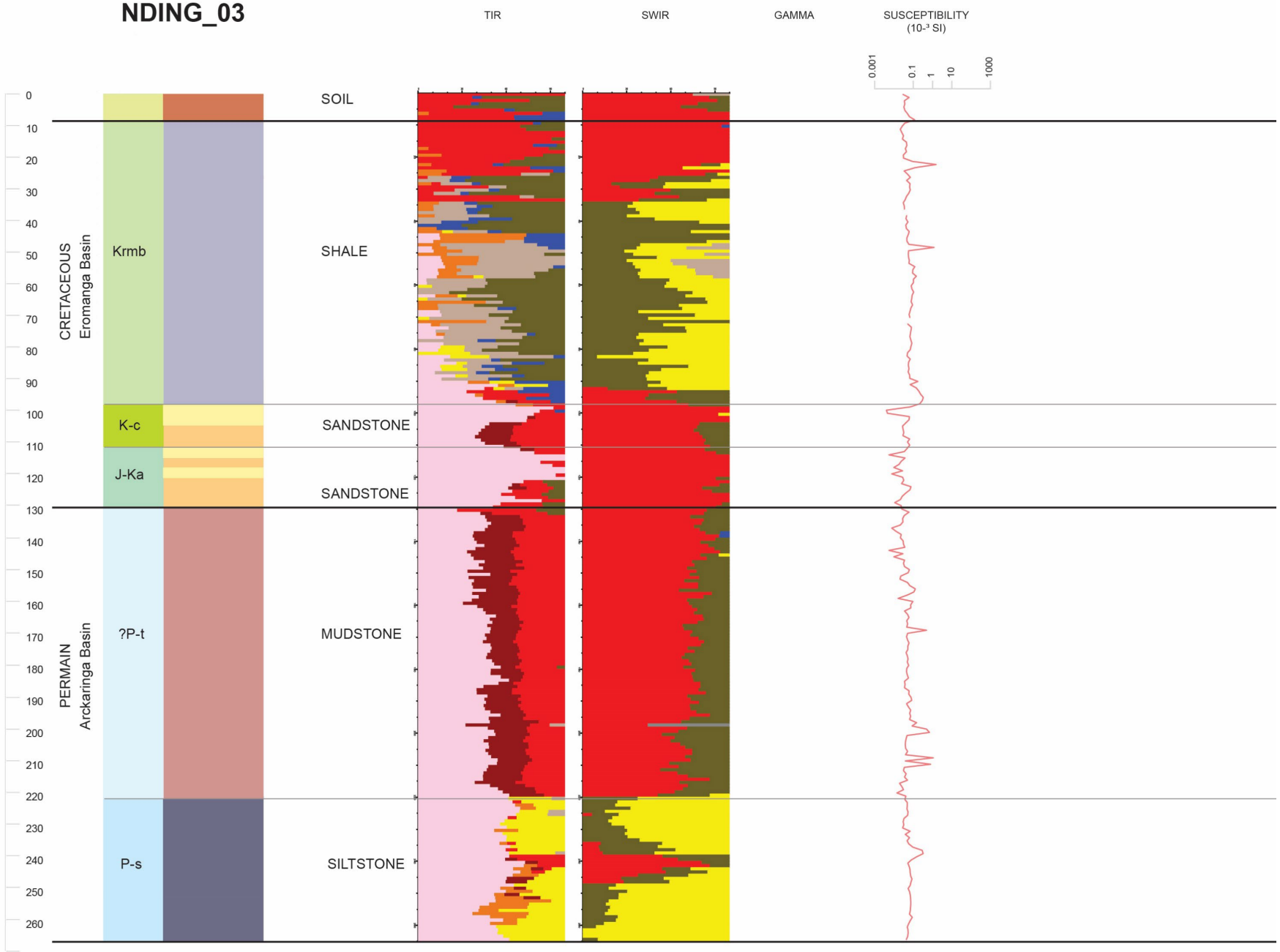
HOLE ABANDONED AT 266 m





NDING_03

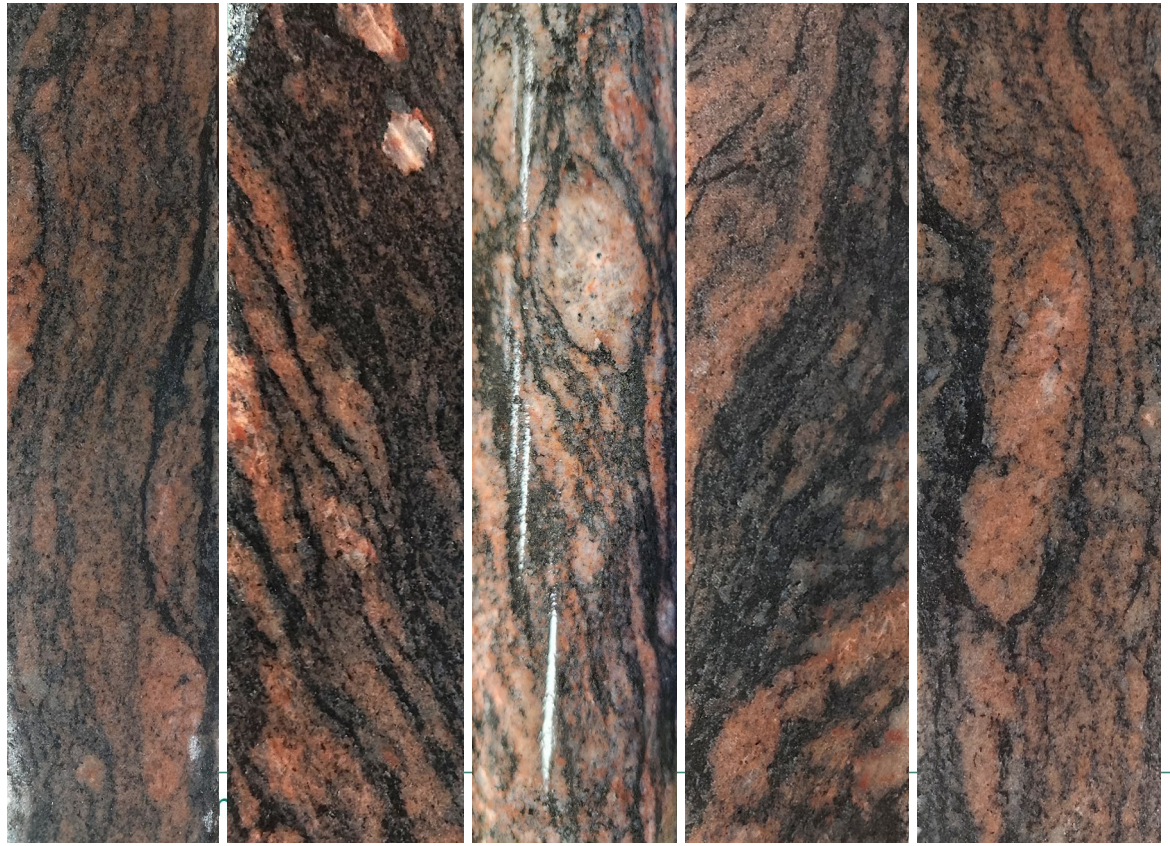

soil
Bulldog Shale
Knc
JK-a
mudstone
Stuart Range Formation
siltstone
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270

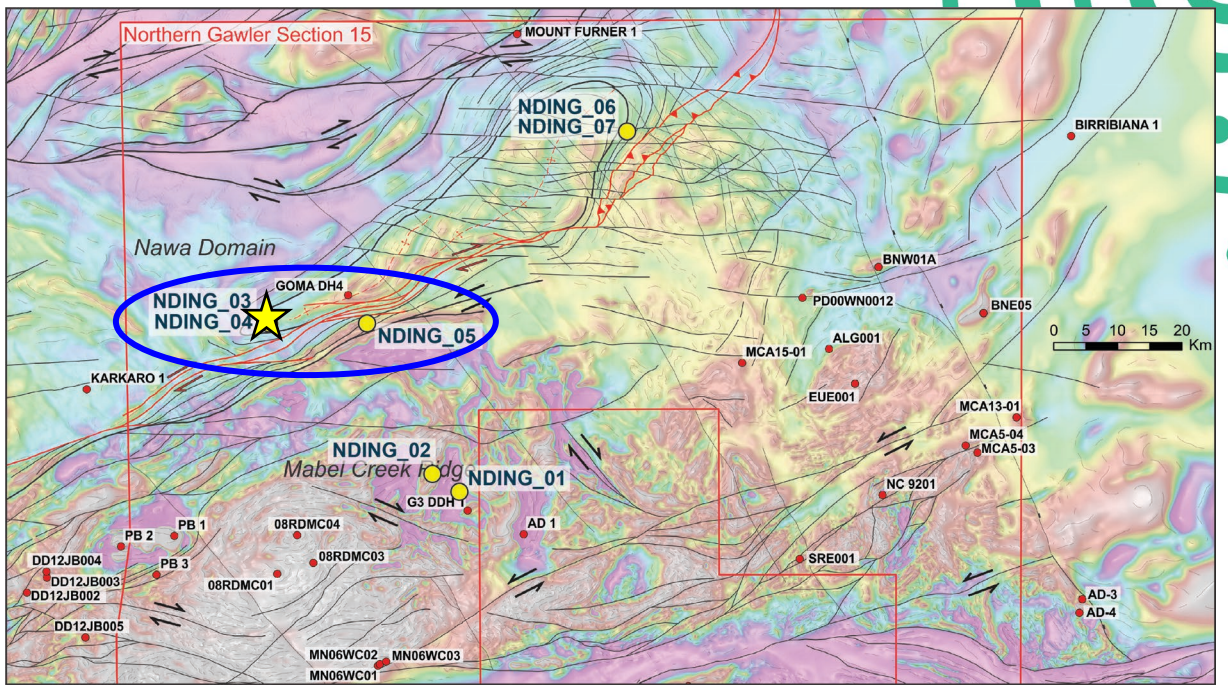

TIR
SWIR
GAMMA
SUSCEPTIBILITY
(10-3 SI)
0.001
0.1
1
10
1000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
CRETACEOUS
Eromanga Basin
PERMAIN
Arckaringa Basin
Krmb
K-c
J-Ka
?P-t
P-s
SOIL
SHALE
SANDSTONE
SANDSTONE
MUDSTONE
SILTSTONE

NAWA DOMAIN (SOUTHWEST)

NDING_04 and NDING_05 drilled to help constrain extent of Archean basement and timing of deformation and metamorphism (e.g. 1570 Ma and/or 1520 Ma)

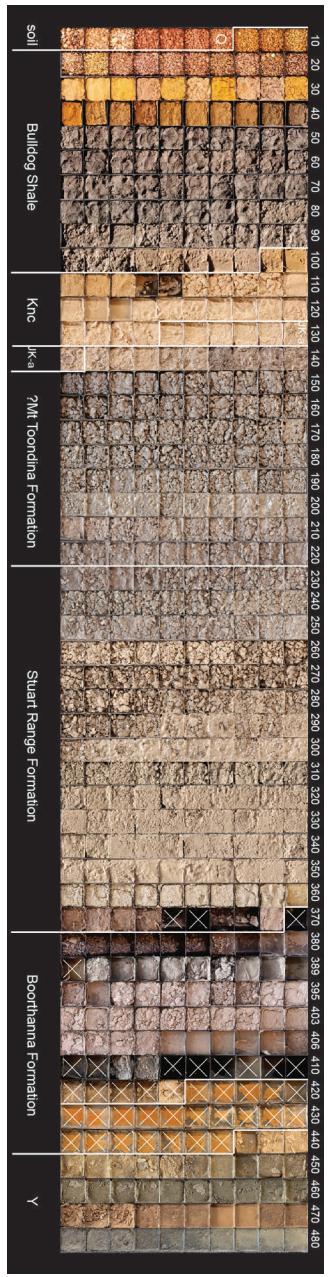
NDING_04:
Basement intersection 437 m; EOH: 482.95 m
Bi-K-feld-Plag-Qtz-Mag OTGN
Magmatic crystallisation age: 1730.8 ± 5.5 Ma

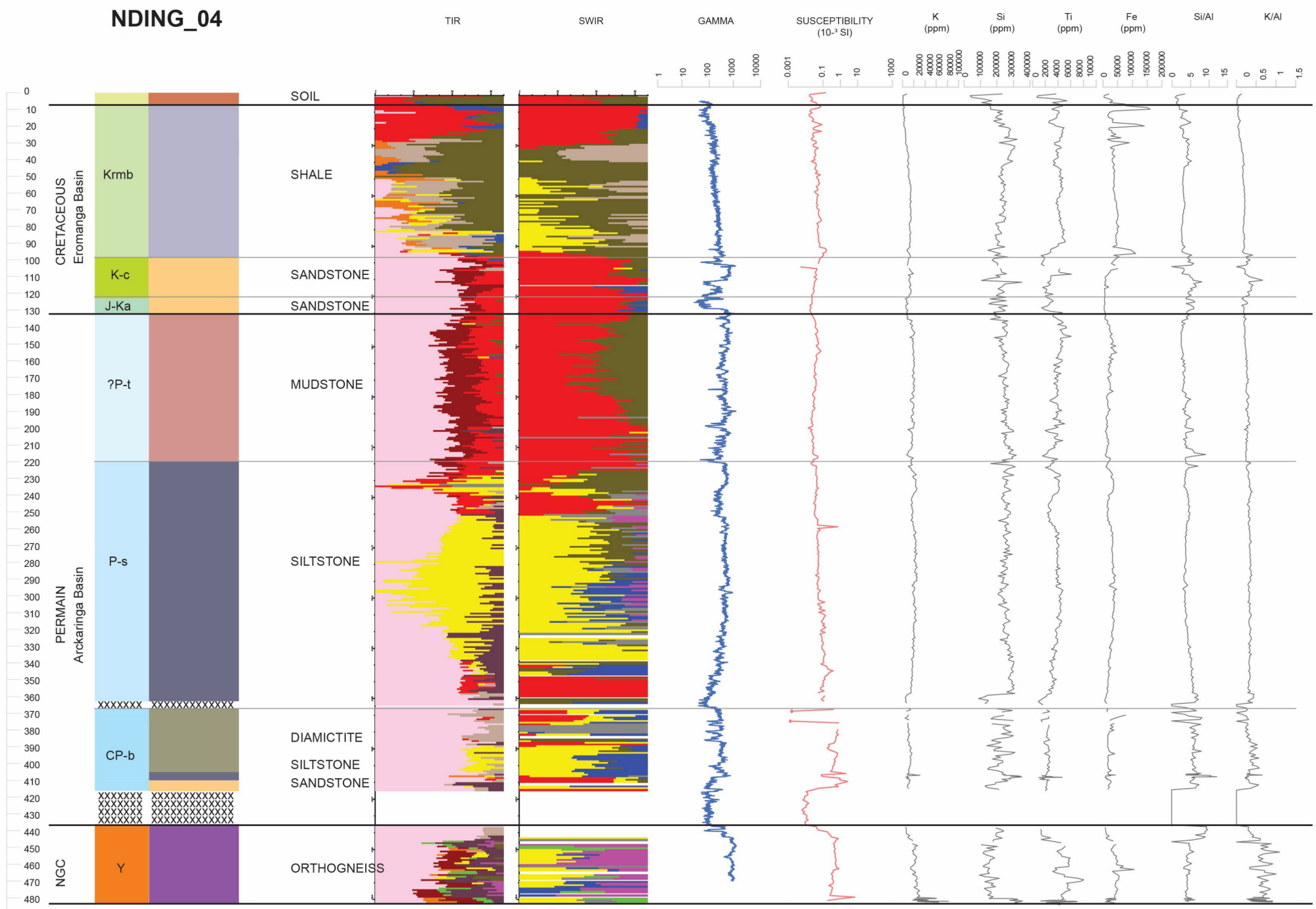




Permian diamictite core, Arckaringa Basin at 406-409 m with basement clasts

NDING_04


soil
Buldog Shale
Knc
JK-a
?Mt Toondina Formation
Stuart Range Formation
Boorthanna Formation
Y

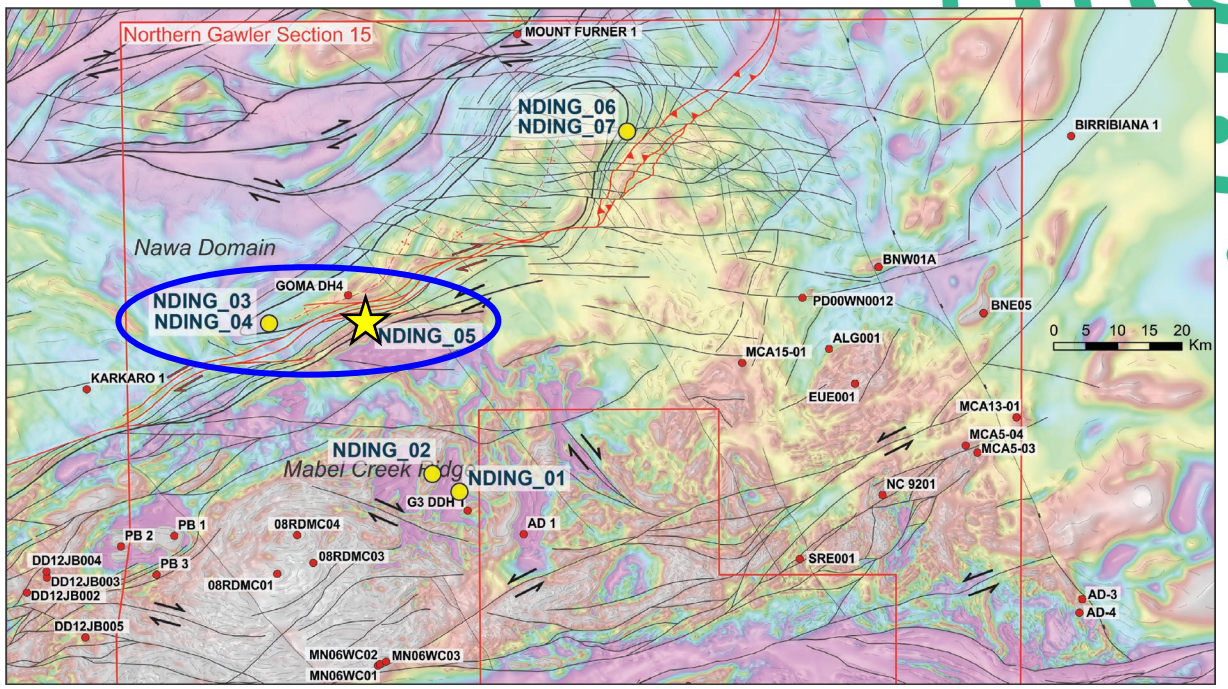

TIR
SWIR
GAMMA
SUSCEPTIBILITY (10-3 SI)
K (ppm)
Si (ppm)
Ti (ppm)
Fe (ppm)
Si/Al
K/Al
CRETACEOUS
Eromanga Basin
Krmb
K-c
J-Ka
PERMAIN
Arckaringa Basin
?P-t
P-s
CP-b
NGC
Y
SOIL
SHALE
SANDSTONE
SANDSTONE
MUDSTONE
SILTSTONE
DIAMICTITE
SILTSTONE
SANDSTONE
ORTHOGNEISS

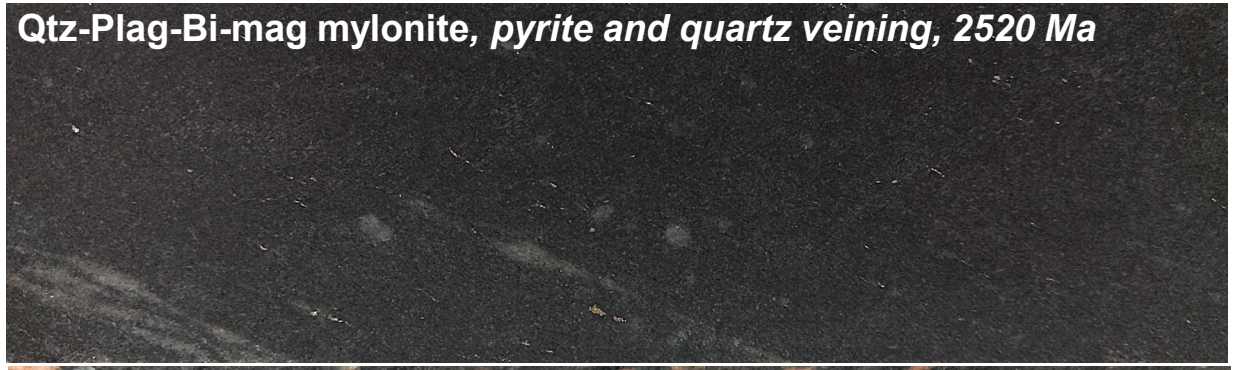
NAWA DOMAIN (SOUTHWEST)

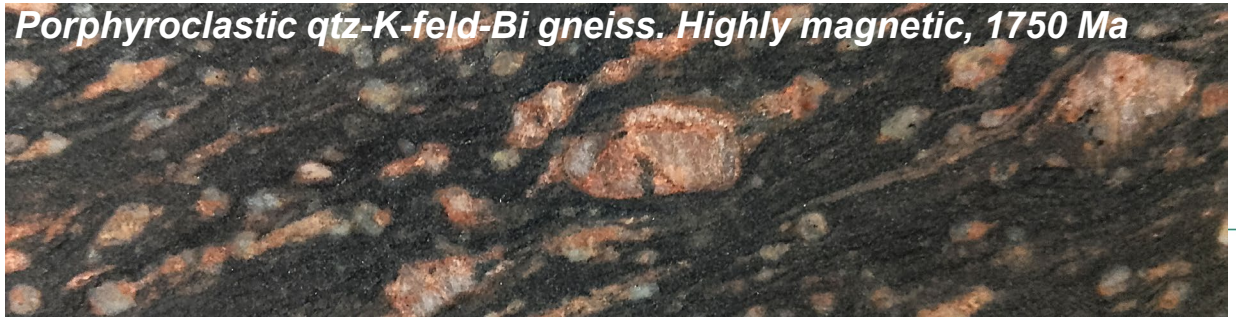
NDING_04 and NDING_05 drilled to help constrain extent of Archean basement and timing of deformation and metamorphism (e.g. 1570 Ma and/or 1520 Ma)

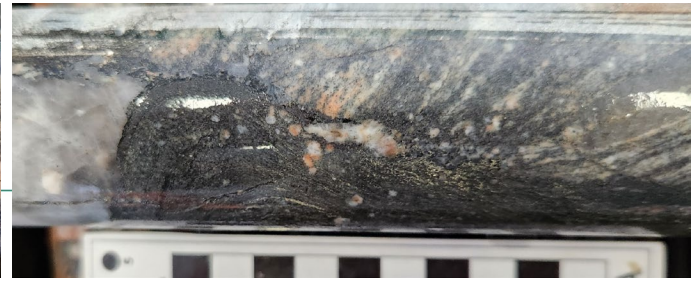
NDING_05:
Basement intersection 378 m; EOH: 402.05 m
Qtz-Plag-Bi-mag mylonite
Maximum depositional age: ca. 2520 Ma

Qtz-K-feld-Bi-Mag porphyroclastic gneiss.
Magmatic crystallisation age: 1751.4 ± 3.6 Ma

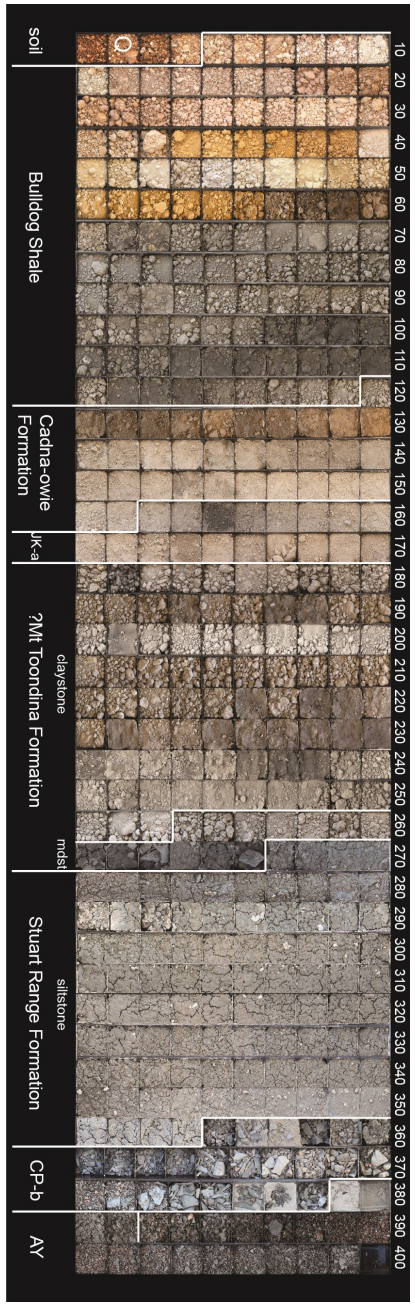


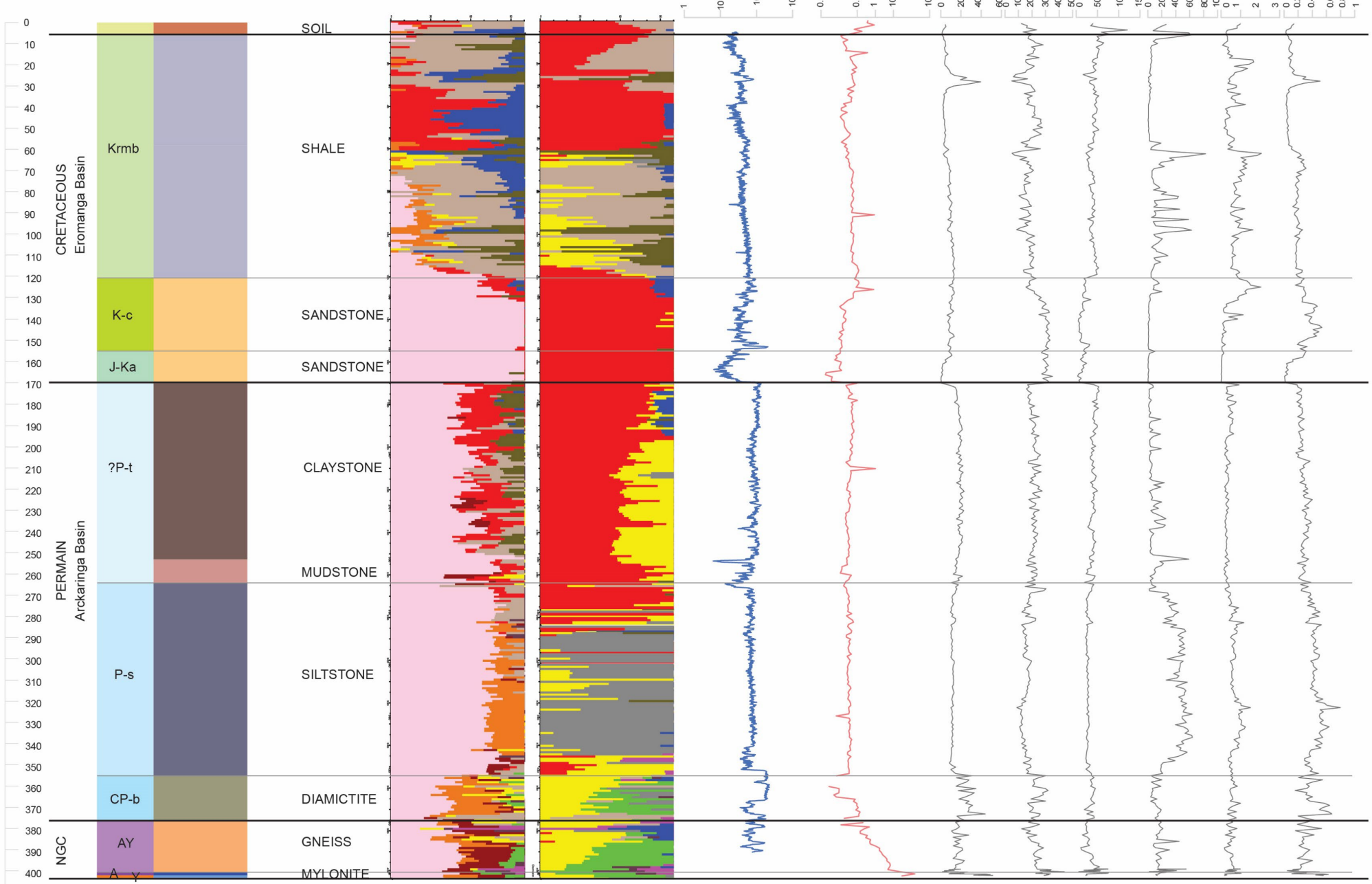






NDING_05

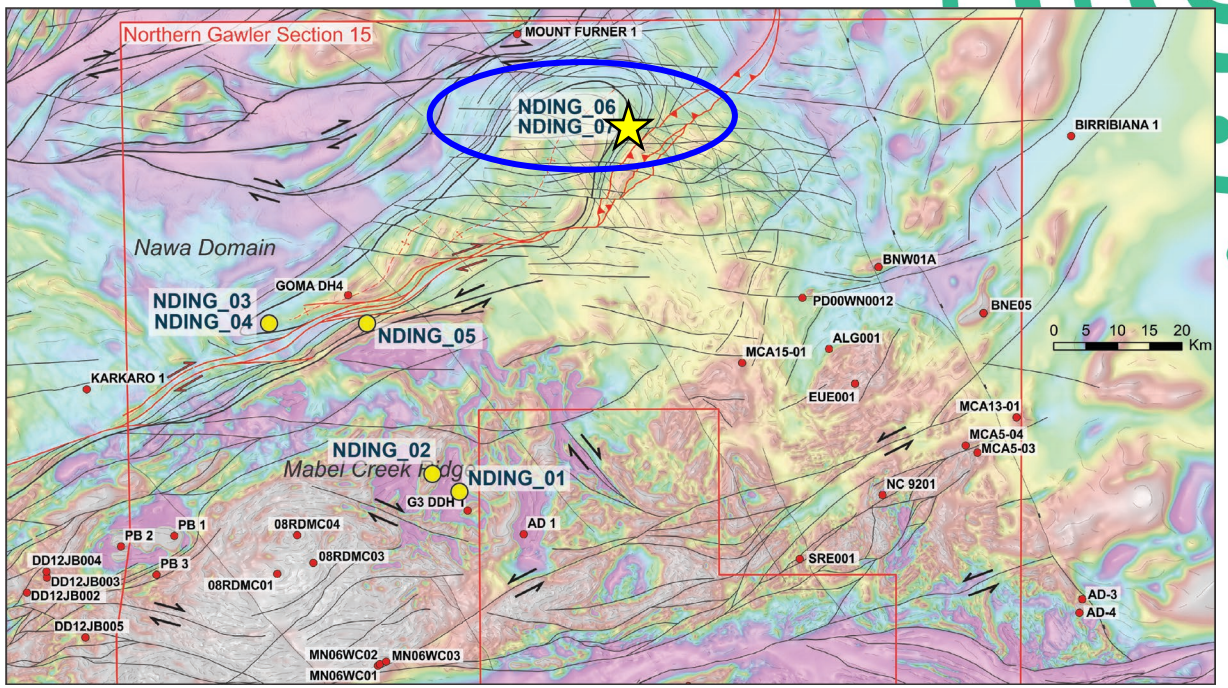

soil
Bulldog Shale
Cadna-owie Formation
JK-a
?Mt Toondina Formation
claystone
mdst
Stuart Range Formation
siltstone
CP-b
AY


TIR
SWIR
GAMMA
SUSCEPTIBILITY (10-3 SI)
K (ppm)
Si (ppm)
Ti (ppm)
Ca (ppm)
Fe/Al
K/Al
CRETACEOUS
Eromanga Basin
PERMAIN
Arckaringa Basin
NGC
Krmb
K-c
J-Ka
?P-t
P-s
CP-b
AY
SOIL
SHALE
SANDSTONE
SANDSTONE
CLAYSTONE
MUDSTONE
SILTSTONE
DIAMICTITE
GNEISS
MYLONITE

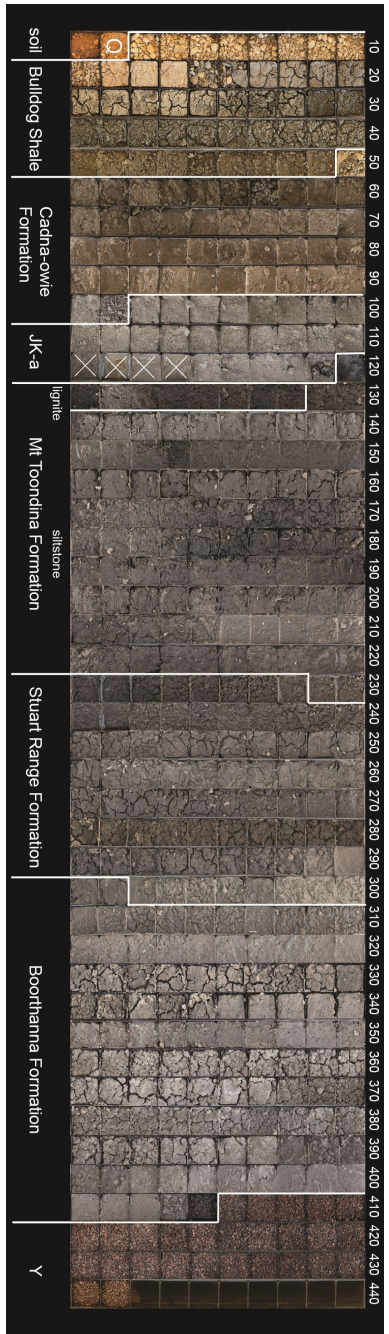
NAWA DOMAIN (NORTHEAST)

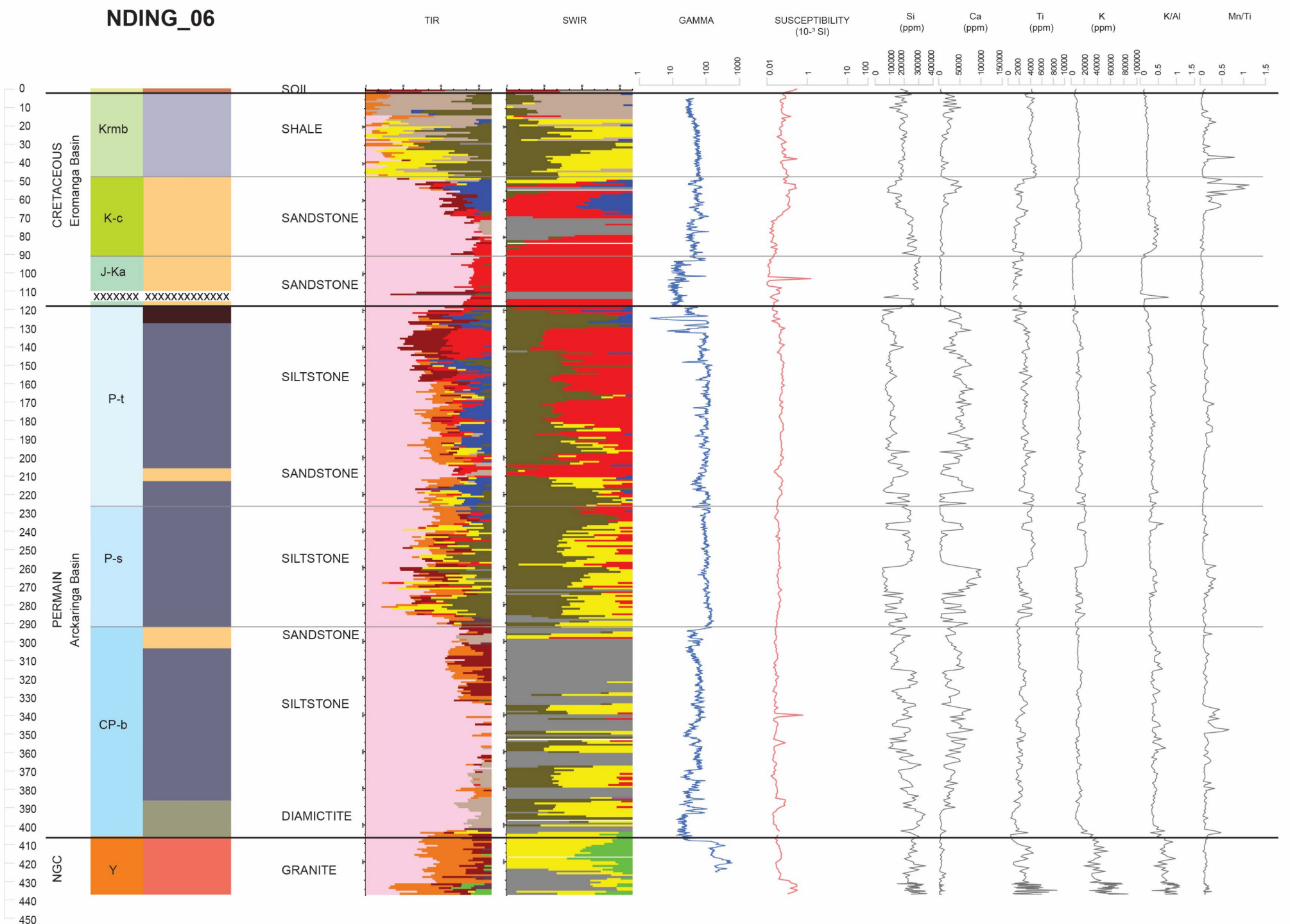
NDING_06 drilled to investigate linear magnetic feature between two ovoid regions (granites?)

NDING_06:
Basement intersection 405 m, EOH: 438.4 m
Migmatitic Bi-K-feld-Qtz gneiss, with pervasive secondary chlorite, hematite, and sulphides
Magmatic crystallisation age: 1730.1 ± 4.4 Ma



NDING_06


soil
Bulldog Shale
Cadna-owie Formation
JK-a
lignite
Mt Toondina Formation
siltstone
Stuart Range Formation
Boorthanna Formation
Y

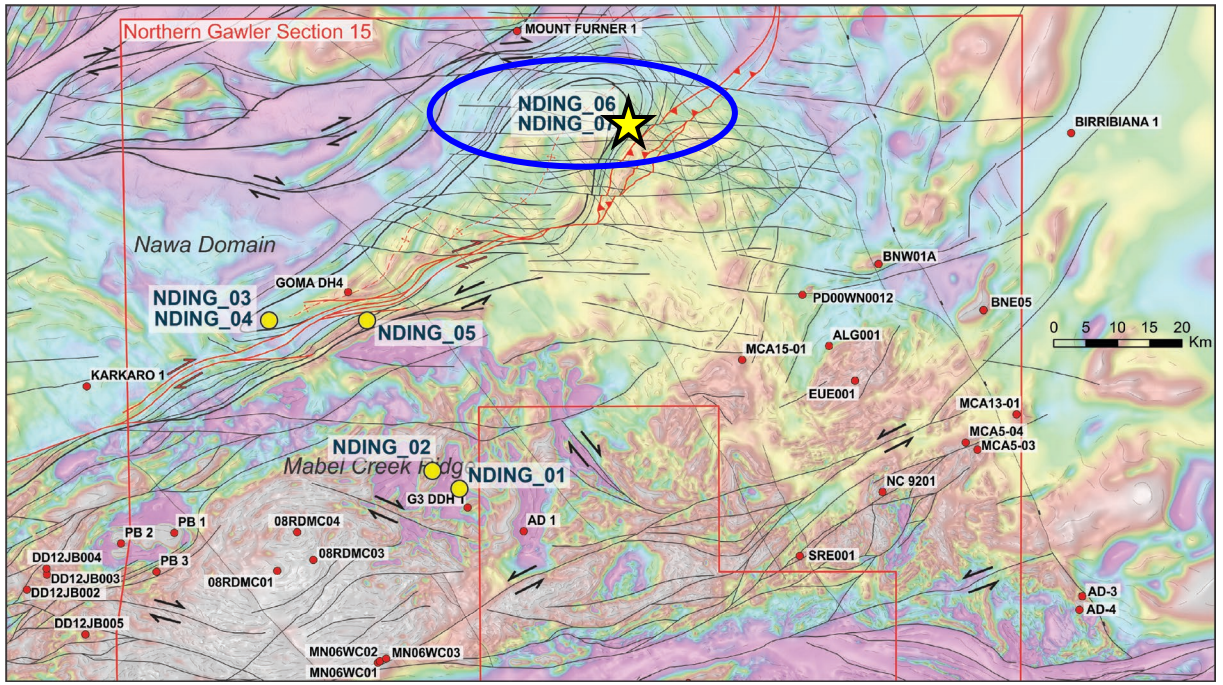

TIR
SWIR
GAMMA
SUSCEPTIBILITY (10-3 SI)
Si (ppm)
Ca (ppm)
Ti (ppm)
K (ppm)
K/Al
Mn/Ti
CRETACEOUS
Eromanga Basin
Krmb
K-c
J-Ka
PERMAIN
Arckaringa Basin
P-t
P-s
CP-b
NGC
Y
SOIL
SHALE
SANDSTONE
SANDSTONE
SILTSTONE
SANDSTONE
SILTSTONE
SANDSTONE
SILTSTONE
DIAMICTITE
GRANITE

NAWA DOMAIN (NORTHEAST)

NDING_07:
Same pad as NDING_06
DEMONSTRATION HOLE

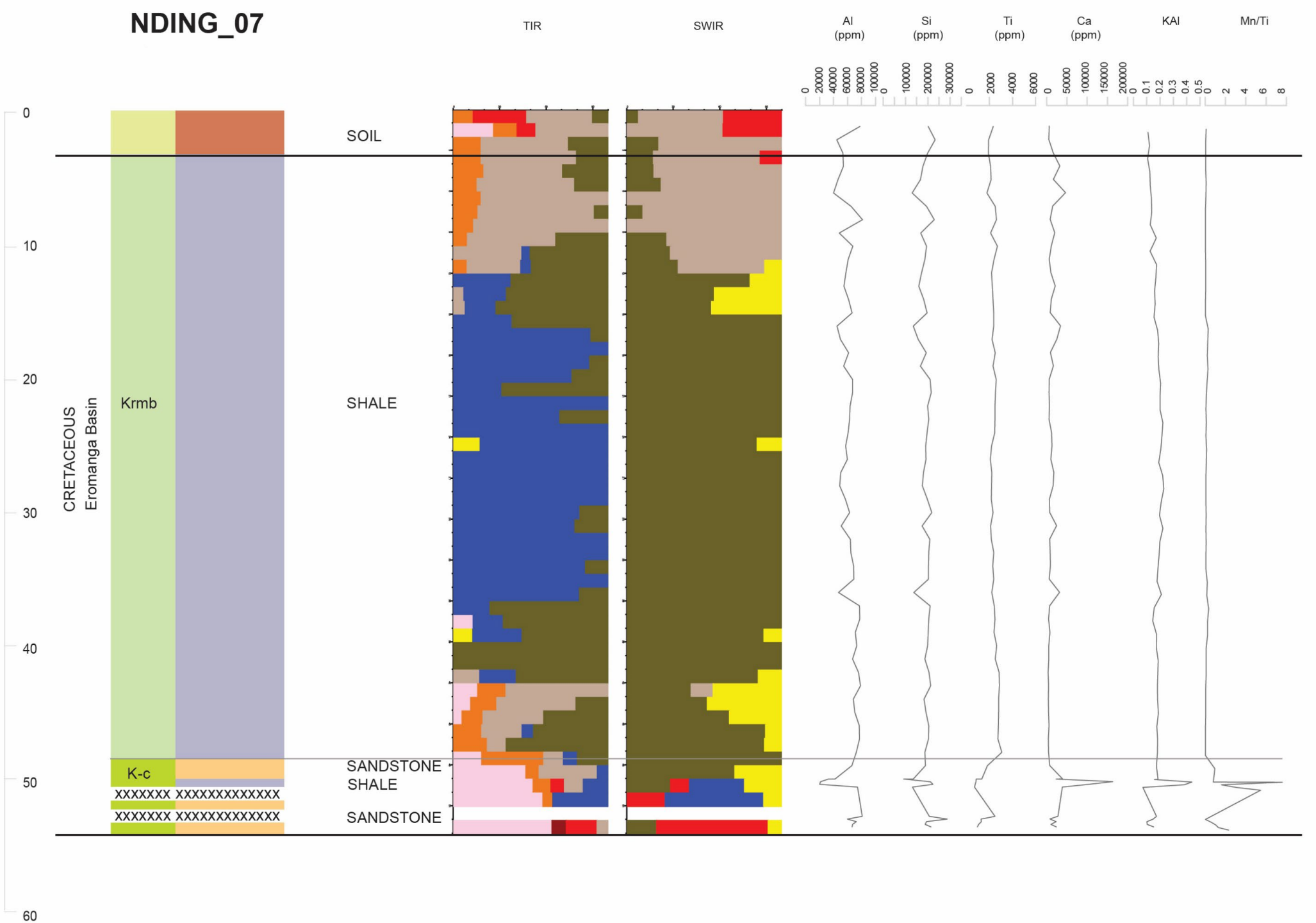
Drilled to 50 m, with two cored sections at bottom of hole in Eromanga Basin sedimentary rocks: upward fining graded bedding sandstone interbedded with shale, bioturbation.

EOH 53.70 m.



NDING_07


10
20
30
40
50
Knc
Q
soil
Bulldog Shale


TIR
SWIR
Al (ppm)
Si (ppm)
Ti (ppm)
Ca (ppm)
KAl
Mn/Ti
0
20000
40000
60000
80000
100000
100000
200000
300000
2000
4000
6000
50000
100000
150000
200000
0.1
0.2
0.3
0.4
0.5
2
4
6
8
0
10
20
30
40
50
60
CRETACEOUS
Eromanga Basin
Krmb
K-c
SOIL
SHALE
SANDSTONE
SHALE
SANDSTONE

Northern Gawler NDI Core Layout

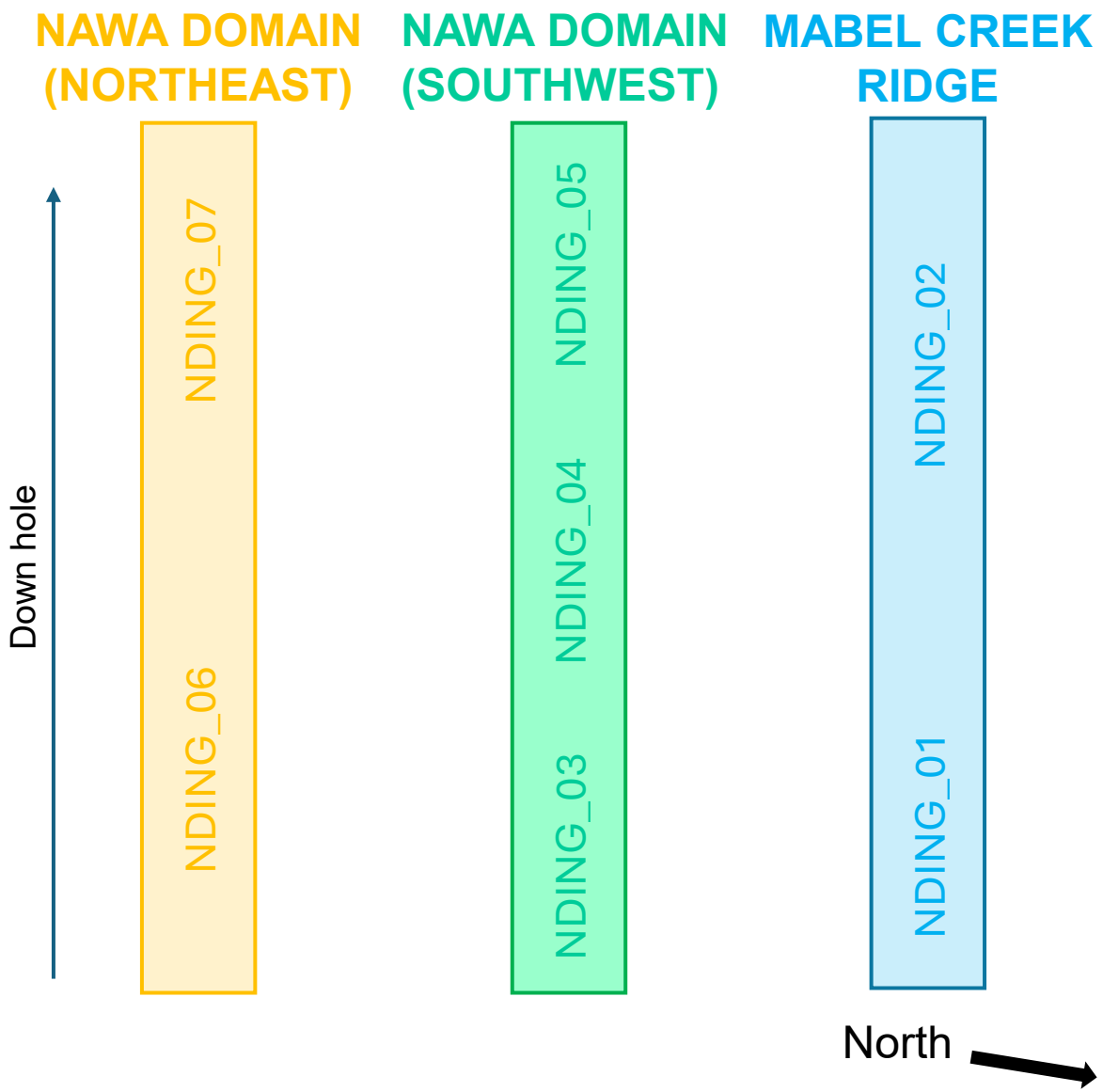
7 drillholes, divided by region: Mabel Creek Ridge, SW Nawa Domain, NE Nawa Domain

Available at each table:

- Geological, hydrostratigraphy and lithology summaries for Eromanga Basin and Arckaringa Basin
- Total Magnetic Intensity map with drillhole locations
- Structural interpretation (compiled by Jack)
- Solid geology interpretation (compiled by Jack)

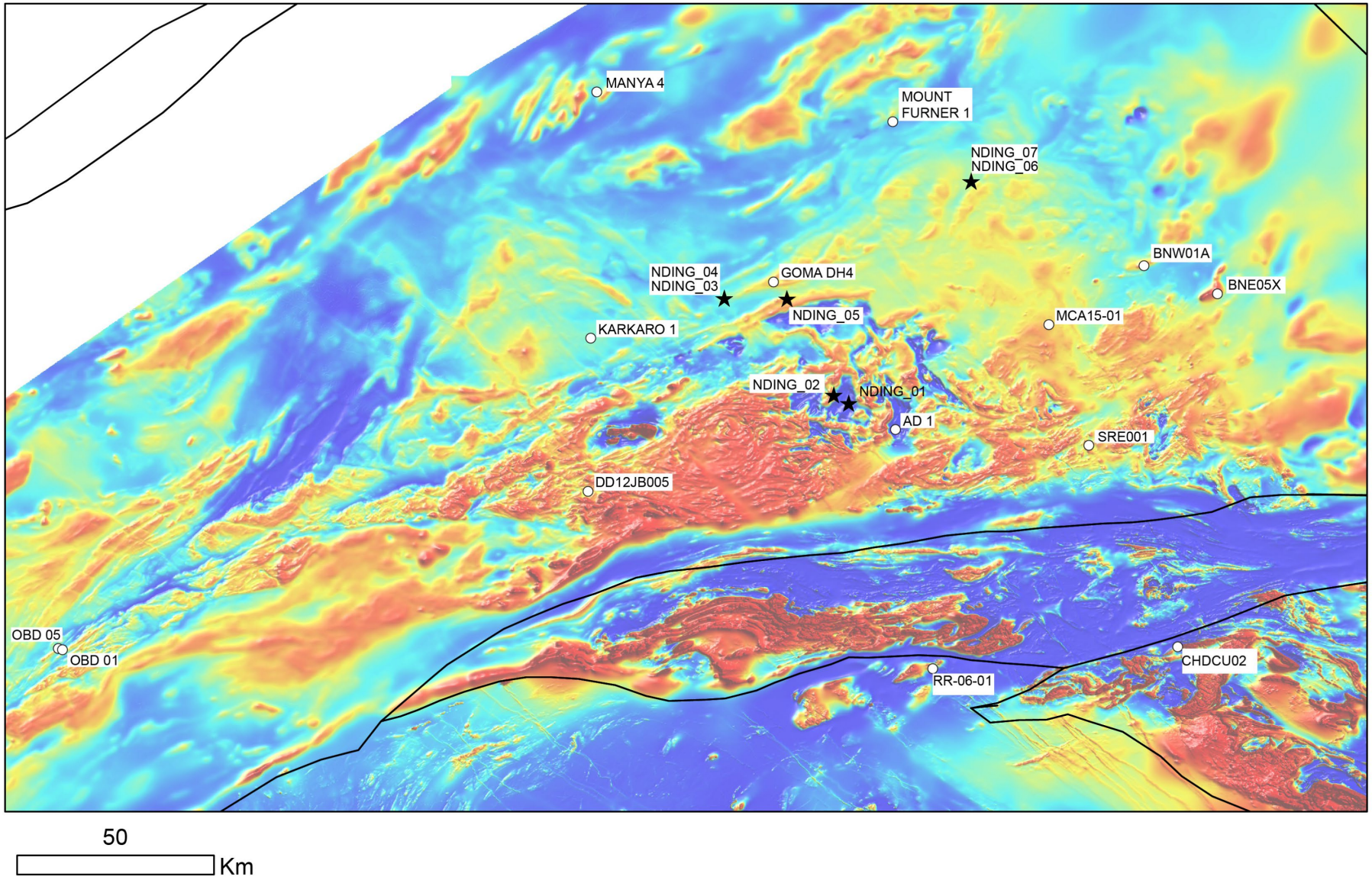
Each drillhole:

- Lithology and stratigraphy log (graphic and tabulated)
- Gamma and mag sus logs
- HyLogger 3 spectra
- Downhole pXRF data
- Data Mosaic

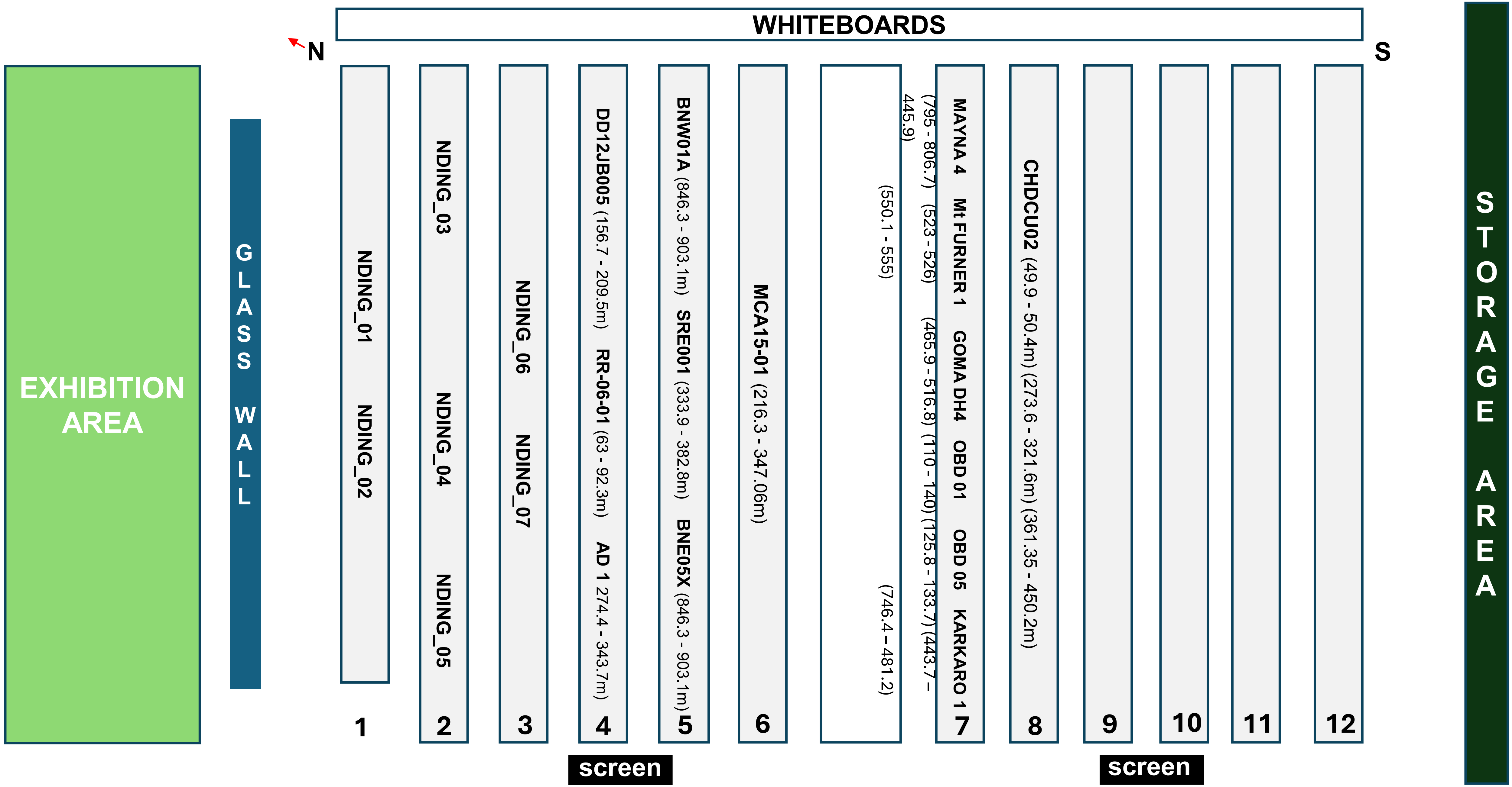


Core Layout – regional drillholes

- Includes 14 legacy drillholes GSSA has collected geochronological and geochemical data for
- Representative basement lithologies across the region
- Grouped by geographic region and/or basement geology type
- Inform Discovery Mapping
- Provide context for domain boundaries, terrane correlations and mineral potential

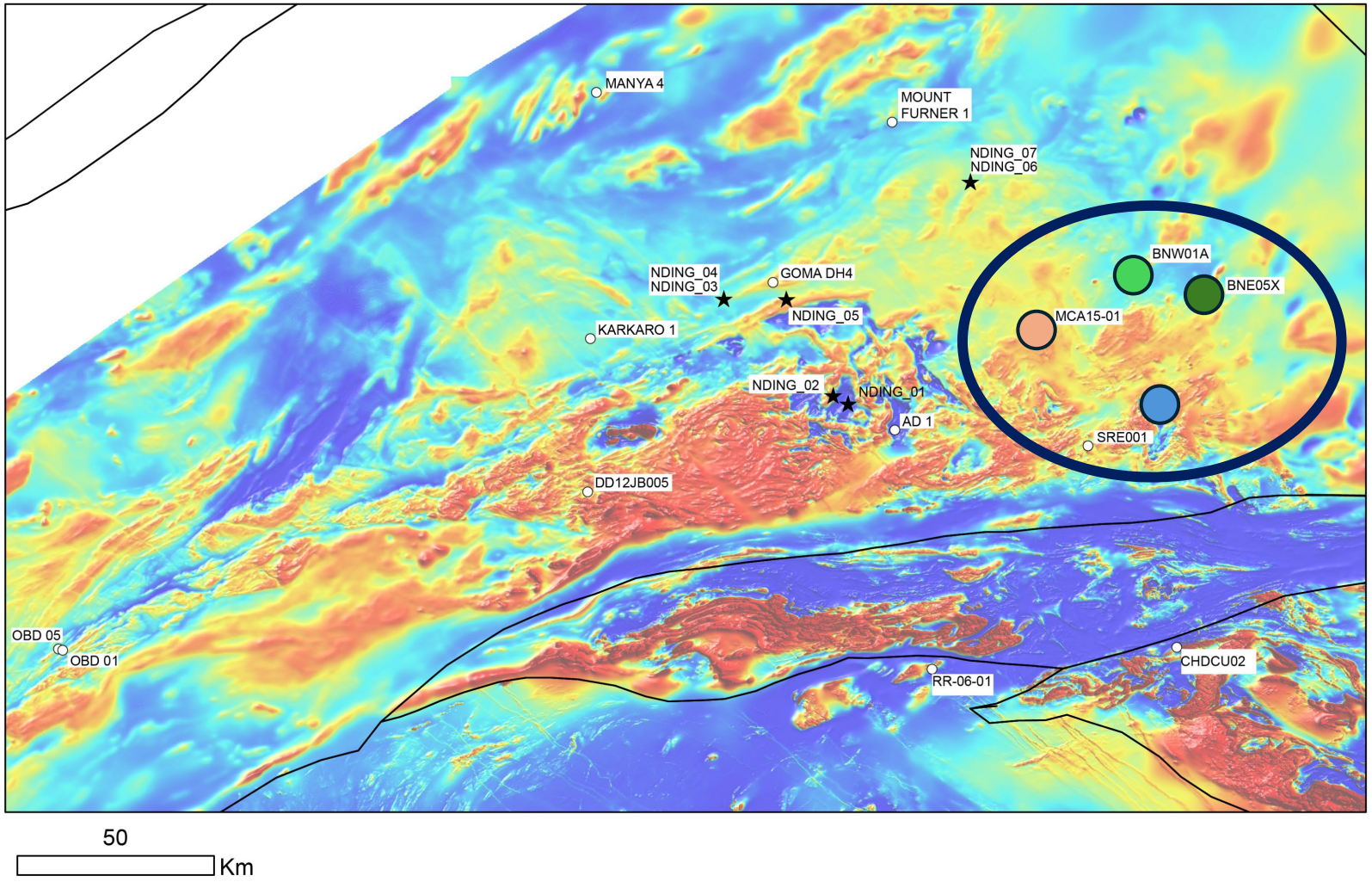


CORE LAYOUT


WHITEBOARDS
N
S
EXHIBITION AREA
GLASS WALL
NDING_01
NDING_02
NDING_03
NDING_04
NDING_05
NDING_06
NDING_07
DD12JB005 (156.7 - 209.5m)
RR-06-01 (63 - 92.3m)
AD 1 274.4 - 343.7m)
BNW01A (846.3 - 903.1m)
SRE001 (333.9 - 382.8m)
BNE05X (846.3 - 903.1m)
MCA15-01 (216.3 - 347.06m)
(550.1 - 555)
(746.4 – 481.2)
MAYNA 4 (795 - 806.7)
Mt FURNER 1 (523 - 526)
GOMA DH4 (465.9 - 516.8)
OBD 01 (110 - 140)
OBD 05 (125.8 - 133.7)
KARKARO 1 (443.7 – 445.9)
CHDCU02 (49.9 - 50.4m) (273.6 - 321.6m) (361.35 - 450.2m)
1
2
3
4
5
6
7
8
9
10
11
12
screen
screen
STORAGE AREA

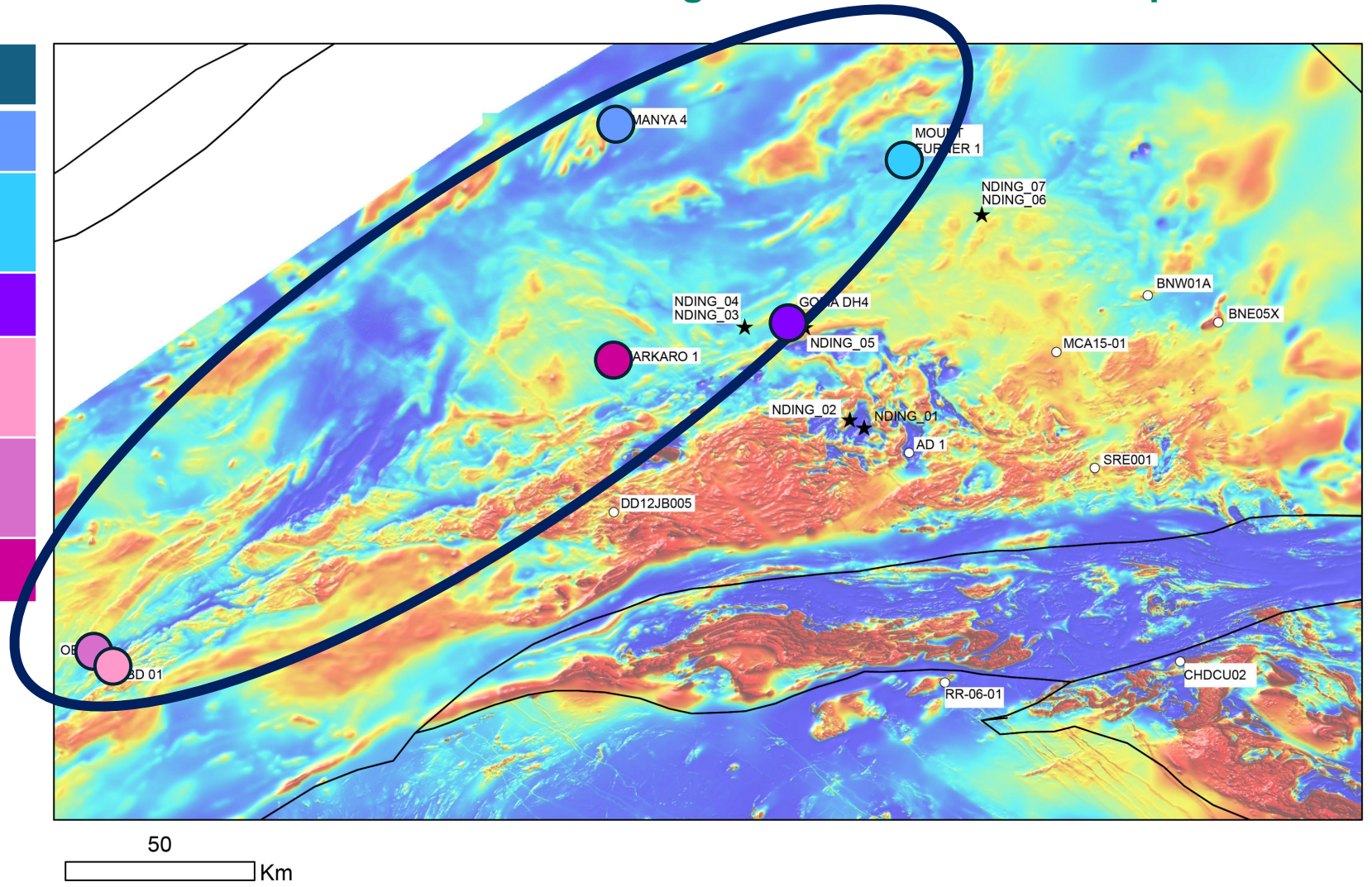
Core Layout – regional drillholes – MCR- P&D - >1750 Ma basement

Drillhole	Example geology
BNW01A	1780 Ma magmatism
BNE05X	1860 Ma deposition 1440 Ma metamorphism?
SRE001	1780 Ma deposition 1460 Ma metamorphism
MCA15-01	>2470 Ma basement: 2470 Ma metamorphism 1800 Ma metamorphism Ca. 1500 Ma pegmatite



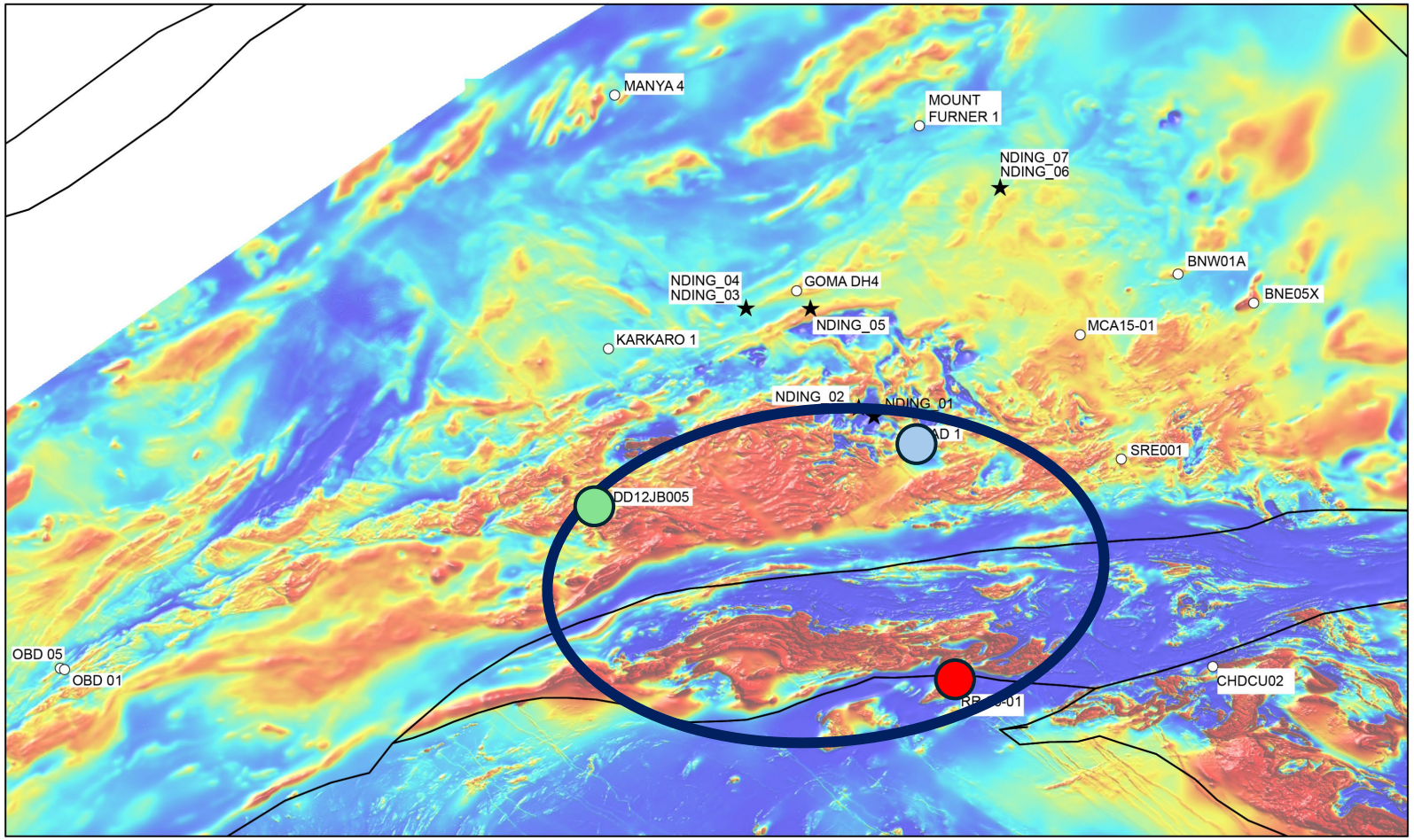
Core Layout – regional drillholes – Nawa Domain – 1770-1750 Ma magmatism and 1740 Ma deposition

Drillhole	Example geology
MANYA 4	1740 Ma deposition
MOUNT FURNER 1	1740 Ma deposition
GOMA DH4	2530 Ma deposition
OBD01	1770–1750 Ma magmatism
OBD05	1770–1750 Ma magmatism
KARKARO 1	1450 Ma magmatism



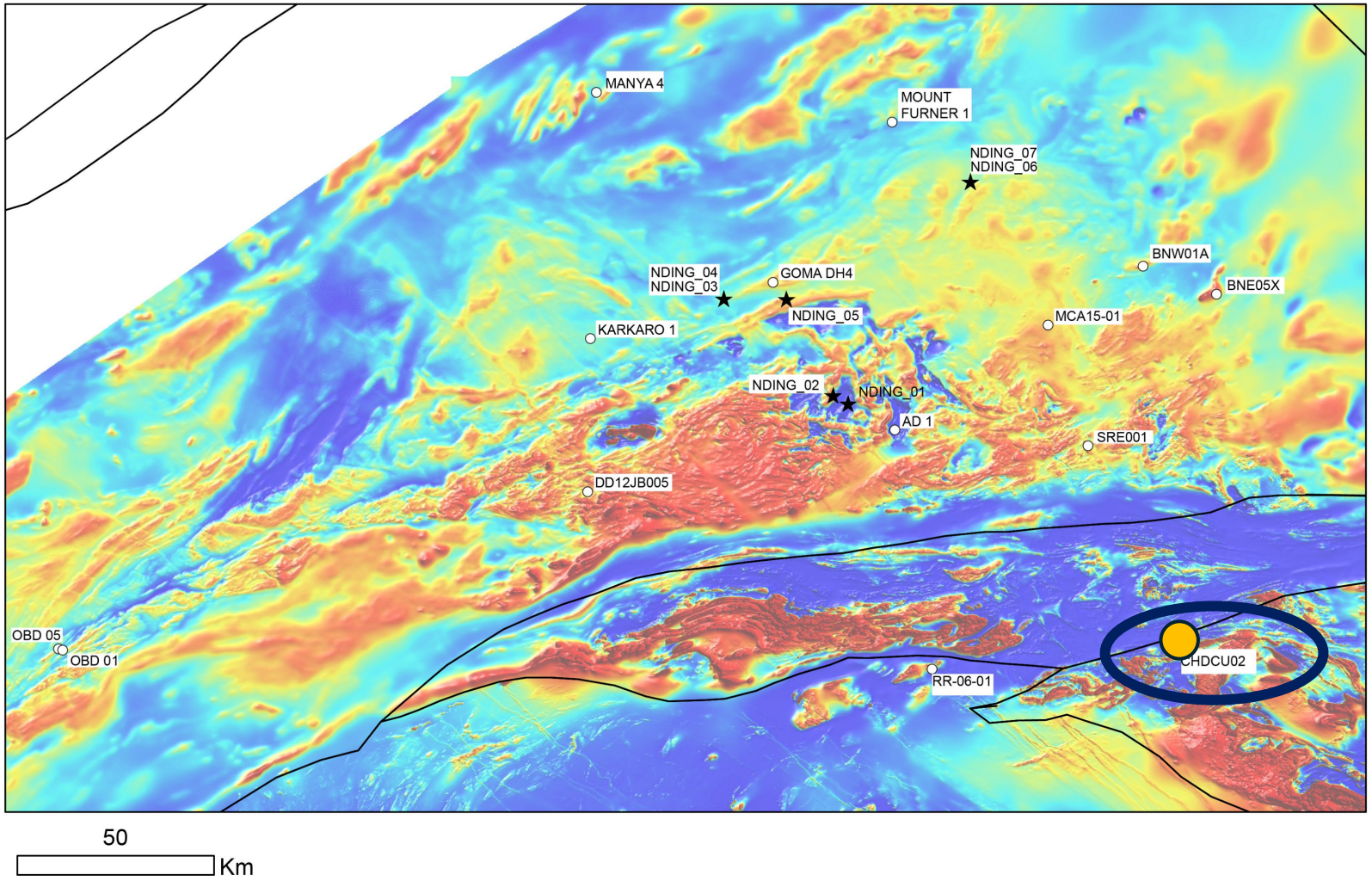
Core Layout – regional drillholes – MCR – CPR/CD 1730-1590 Ma magmatism

Drillhole	Example geology
AD 1	1740 Ma deposition 1580–1570 Ma metamorphism Ca. 1500 Ma metamorphism Ca. 1710 Ma felsic intrusive magmatism 1460–1480 Ma metamorphism
DD12JB005	Ca. 1730 Ma mafic and felsic intrusive magmatism 1590–1580 Ma metamorphism
RR-06-01	1590 Ma mafic magmatism



Core Layout – regional drillholes – Cairn Hill – Cu-Au mineralisation

Drillhole	Example geology
CHDCU02	
45.9–50.4 m	variably foliated granite
273.6–321.6 m	quartz-feldspar-biotite-magnetite gneiss with magnetite-rich zones including chalcopyrite
361.9–450.2 m	quartz-feldspar-biotite-magnetite gneiss with magnetite-rich zones including chalcopyrite



Core Layout – regional drillholes – Cairn Hill

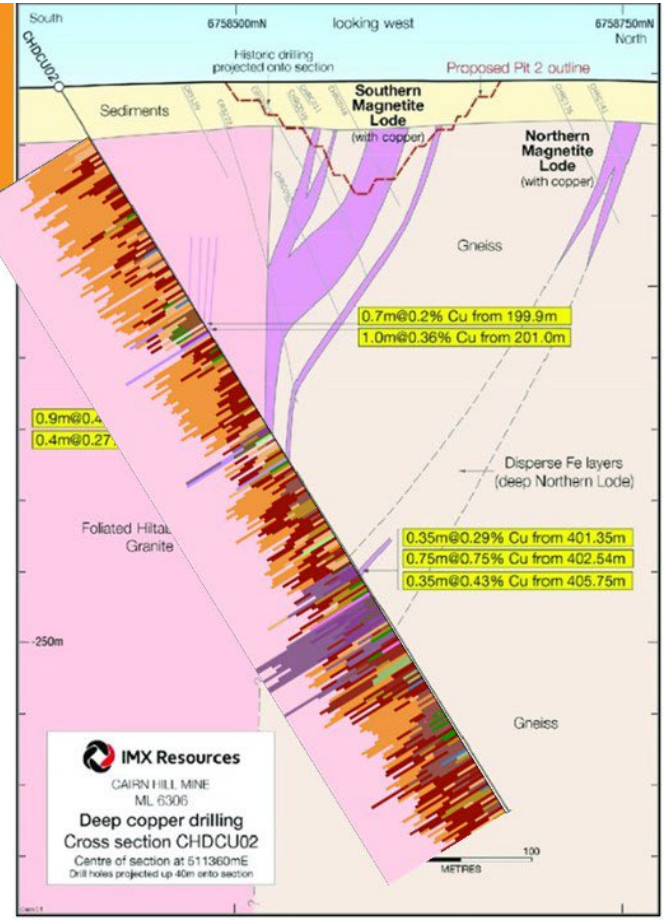
Drillhole	Example geology
CHDCU02	
45.9–50.4 m	variably foliated granite
273.6–321.6 m	quartz-feldspar-biotite-magnetite gneiss with magnetite-rich zones including chalcopyrite
361.9–450.2 m	quartz-feldspar-biotite-magnetite gneiss with magnetite-rich zones including chalcopyrite

285.3–286.20 m – 0.36% Cu
402.55–403.3 m – 0.749% Cu
405.75–406.1 m – 0.426% Cu

286.1–288.4 m – ~60% Fe

Cairn Hill
HT Ca-Fe ± Mg (skarn) + HT K-Fe

J.Clark honours thesis - 2014
1. Na-Ca (albite + scapolite + diopside ± actinolite/titanite)
2. K-Fe (localised zones of magnetite-biotite ±pyrite-pyrrhotite-chalcopyrite)



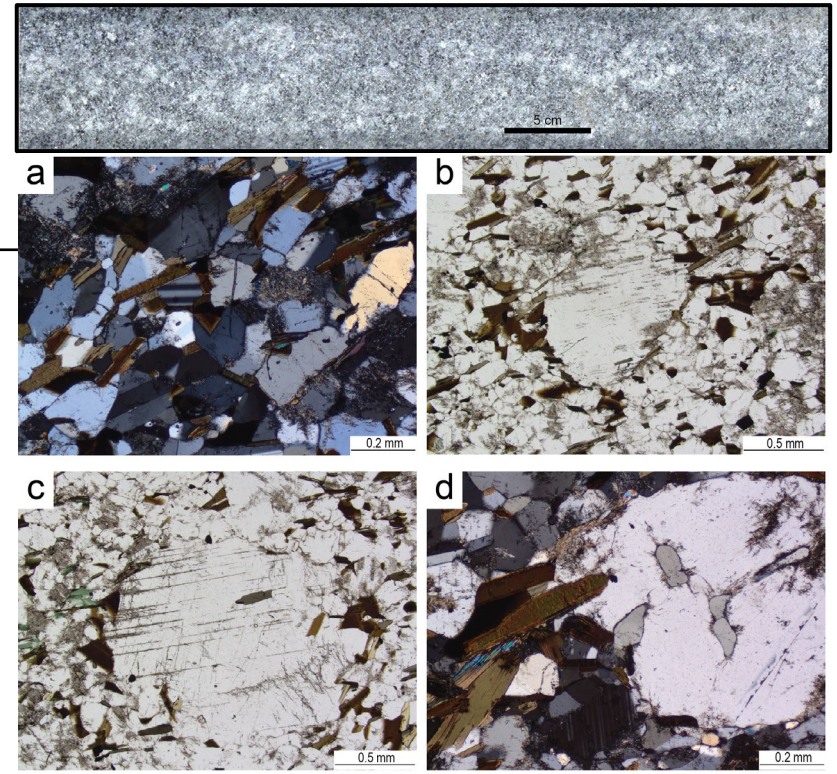
BNW01A

East of Mabel Creek Ridge, southern Nawa Domain
Drillhole number: 237136
Location: 135.0398541, -28.4318113
Interval: 526.8-594.6 m

Quartz-plagioclase-biotite-hornblende felsic gneiss and biotite-bearing felsic augen gneiss. Together with biotite granodiorite.

541.67-542.62 m
R4467805
Plagioclase-quartz-biotite felsic gneiss, magnetite-bearing, minor sulphide

Geochronology Method	Age (Ma)	Type
Zircon SHRIMP U-Pb	1778.0 ± 5.0	Magmatic

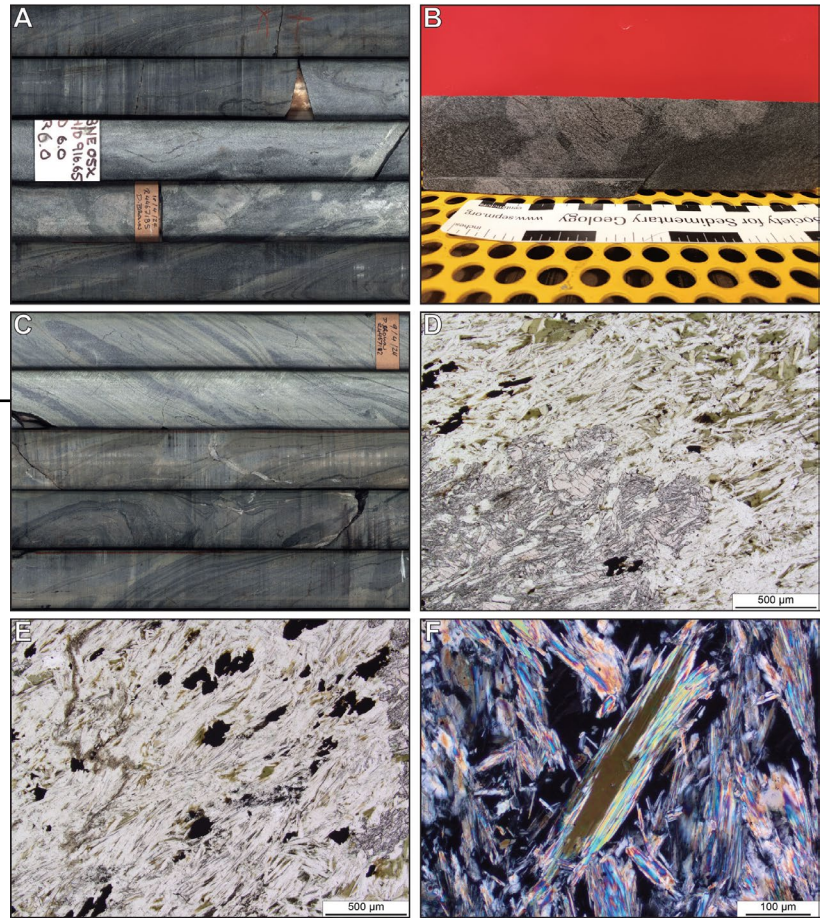


Age reference
Unpublished, in prep (GSSA)

BNE05X

East of Mabel Creek Ridge, southern Nawa Domain
Drillhole number: 279813
Location: 135.207328, -28.4965163
Interval: 846.33-903.10 m

Sulphide-bearing metapsammite and calc-silicate gneiss with thin magnetite and graphite laminae throughout. Massive graphitic unit from 1040.1-1080.3 m.



916.10-918.30 m
R4550708
Garnet-amphibole-magnetite metasedimentary schist, minor chalcopyrite

Geochronology Method	Age (Ma)	Type
Zircon LA-ICP-MS U-Pb	1862.3 ± 3.6	Maximum depositional
Apatite LA-ICP-MS U-Pb	1436.0 ± 58.0	Isotopic re-equilibration

Age reference
Brown D, Percival J, Wise T and Abdullah R, 2025. Geochronology on the buried northern Gawler Craton. Part 1: Multi-mineral laser-ablation U–Pb–Lu–Hf dating, Report Book 2025/00006. Department for Energy and Mining, South Australia, Adelaide.

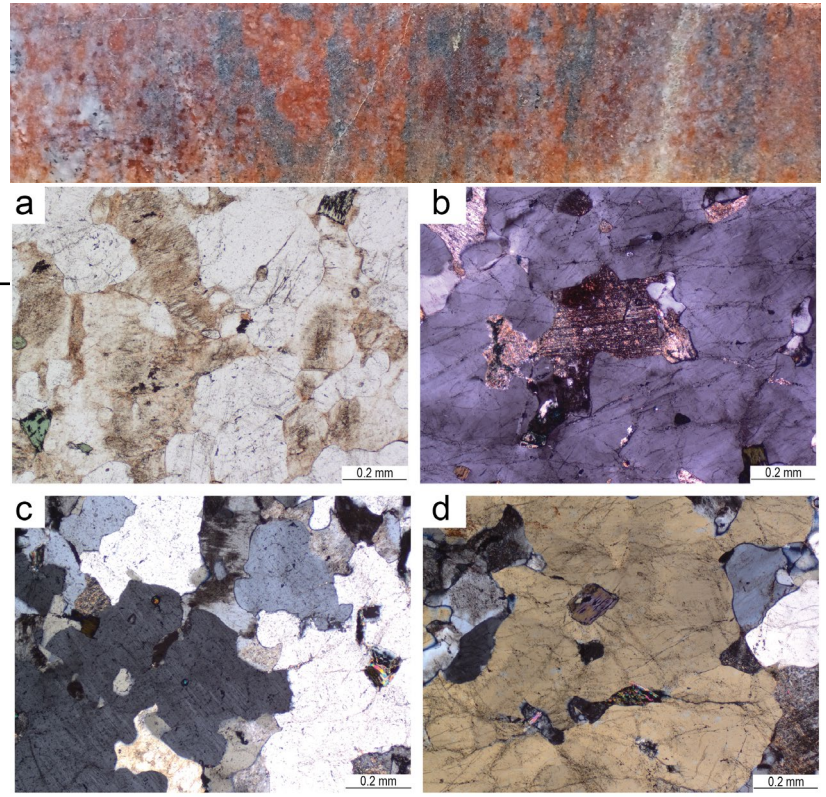
SRE001

East of Mabel Creek Ridge, southern Nawa Domain
Drillhole number: 279097
Location: 134.9138651, -28.8430263
Interval: 333.90-382.80 m

Fabric destructive sericite-chlorite-carbonate hematite alteration of quartz-K-feldspar-plagioclase felsic gneiss. Chalcopyrite present.

355.85-356.67 m
R4467802
Metasedimentary quartzofeldspathic gneiss

Geochronology Method	Age (Ma)	Type
Zircon SHRIMP U-Pb	1779.0 ± 13.0	Maximum depositional
	1457.0 ± 20.0	Metamorphic
Apatite LA-ICP-MS/MS Lu-Hf	1454.0 ± 31.0	Metamorphic



Age reference
Unpublished, in prep (GSSA)

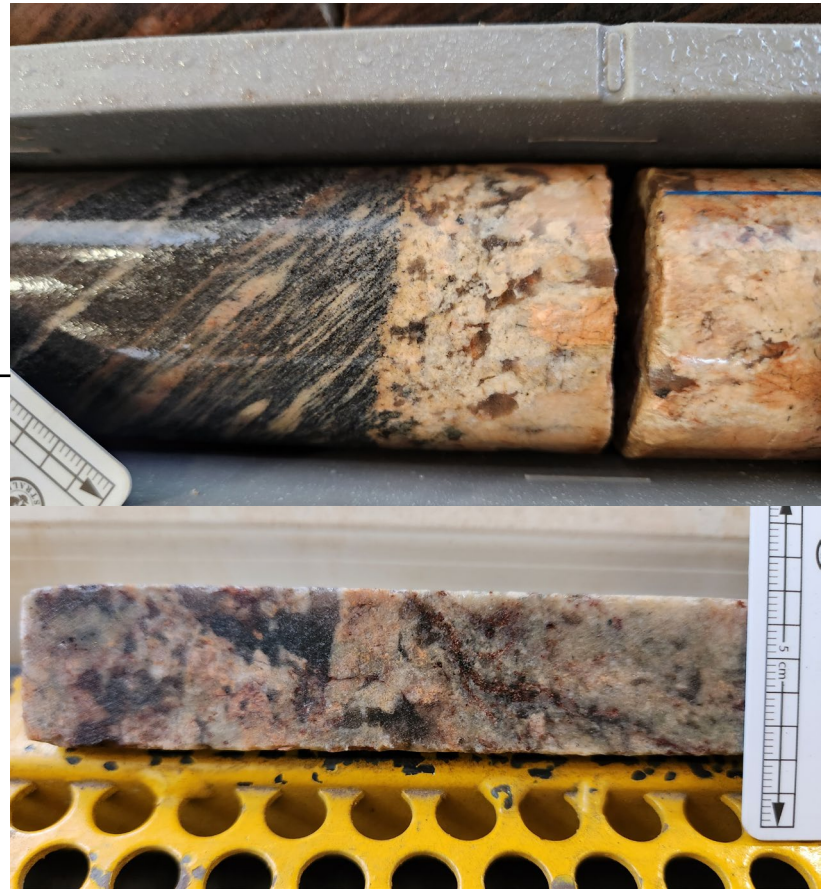
MCA15-01

East of Mabel Creek Ridge, southern Nawa Domain
Drillhole number: 365865
Location: 134.8221001, -28.5667391
Interval: 225.15-347.06 m

Deformed granitic and garnet-bearing metasedimentary gneiss, cut by fine-grained mafic and felsic intrusions. Magnetite present. Garnet-bearing pegmatite cross cuts the gneisses.

230.10-230.80 m
R4593902
Garnet-bearing pegmatite

Geochronology Method	Age (Ma)	Type
Garnet LA-ICP-MS/MS Lu-Hf	1494.8 ± 7.2	Magmatic



Age reference
Unpublished, in prep (GSSA)

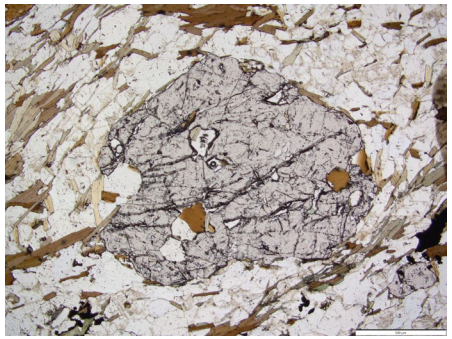
MCA15-01 (cont.)

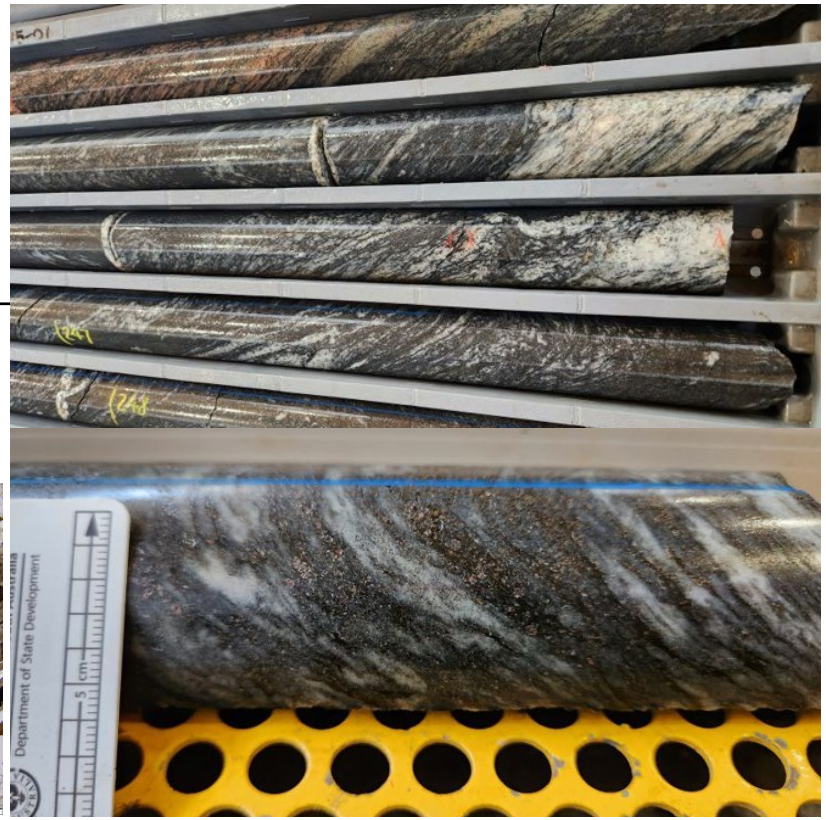
East of Mabel Creek Ridge, southern Nawa Domain
Drillhole number: 365865
Location: 134.8221001, -28.5667391
Interval: 225.15-347.06 m

Deformed granitic and garnet-bearing metasedimentary gneiss, cut by fine-grained mafic and felsic intrusions. Magnetite present. Garnet-bearing pegmatite cross cuts the gneisses.

230.10-230.80 m
R4593904
Garnet-plag-quartz-biotite-ilmenite-sulphide metasedimentary gneiss

Geochronology Method	Age (Ma)	Type
Garnet LA-ICP-MS/MS Lu-Hf	2467.4 ± 19.4	Metamorphic
	1796.5 ± 50.0	Metamorphic





Age reference
Unpublished, in prep (GSSA)

MANYA 4

North of Mabel Creek Ridge, Nawa Domain
Drillhole number: 3583
Location: 133.7891072, -28.0349313
Interval: 795.0-806.1 m

Quartz-feldspar-biotite-garnet gneiss.

801.90-802.10 m
R650703
Quartz-feldspar-biotite-garnet (metasedimentary) gneiss

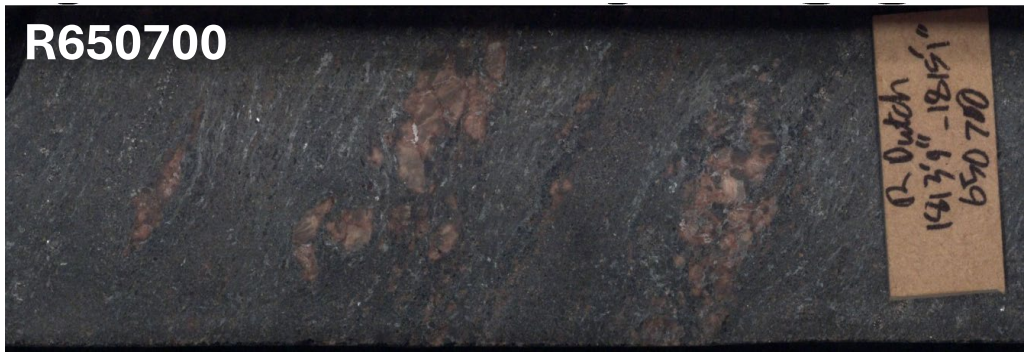
Geochronology Method	Age (Ma)	Type
Monazite LA-ICP-MS U-Pb	1719.0 ± 7.9	Metamorphic

Age reference
Payne J, Hand M, Barovich K, Wade B. 2008. Temporal constraints on the timing of high-grade metamorphism in the northern Gawler Craton: implications for assembly of the Australian Proterozoic. Australian Journal of Earth Sciences. 2008; 55 623-640.

MOUNT FURNER 1

North-east of Mabel Creek Ridge, Nawa Domain
Drillhole number: 5145
Location: 134.4653931, -28.1025323
Interval: 550.1-555.04 m

Felsic gneiss. Quartz–plagioclase–biotite–garnet gneiss



552.0-553.24 m
R650698/650700
Quartz-feldspar-biotite-garnet (metasedimentary) gneiss

Geochronology Method	Age (Ma)	Type
Zircon LA-ICP-MS U-Pb	~1740	Maximum depositional
Monazite LA-ICP-MS U-Pb	1728.0 ± 10.0	Metamorphic

Age reference
Payne J, Hand M, Barovich K, Wade B. 2008. Temporal constraints on the timing of high-grade metamorphism in the northern Gawler Craton: implications for assembly of the Australian Proterozoic. Australian Journal of Earth Sciences. 2008; 55 623-640.

Payne, J., Barovich, K. and Hand, M. 2006. Provenance of metasedimentary rocks in the northern Gawler Craton, Australia: Implications for Palaeoproterozoic reconstructions. Precambrian Research. 148, 275-291.

GOMA DH4

North of Mabel Creek Ridge, Nawa Domain
Drillhole number: 252739
Location: 134.1938732, -28.4687393
Interval: 465.9-516.9 m

Folded and layered felsic gneiss. Medium-grained quartz-K-feldspar layers and darker biotite-quartz-plagioclase layers becoming more quartz-K-feldspar dominant down hole. Granititc, pegmatitic, and quartz monzonite lithologies present. Pyrite occurrences.

510.4-510.6 m
R1707908
Foliated quartz-feldspar-biotite-hornblende ortho(?)gneiss

Geochronology Method	Age (Ma)	Type
Zircon SHRIMP U-Pb	2526.0 ± 7.0	Magmatic
	1521.0 ± 9.0	Metamorphic

Age reference
Jagodzinski E, Reid AJ. 2010. New zircon and monazite geochronology using SHRIMP and LA-ICPMS, from recent GOMA drilling, on samples from the northern Gawler Craton. In GOMA (Gawler Craton-Officer Basin-Musgrave Province-Amadeus Basin) seismic and MT workshop

Reid, A. J., Jagodzinski, E. A., Armit, R. J., Dutch, R. A., Kirkland, C. L., Betts, P. G., & Schaefer, B. F. (2014). U-Pb and Hf isotopic evidence for Neoarchean and Paleoproterozoic basement in the buried northern Gawler Craton, South Australia. Precambrian Research, 250, 127–142. https://doi.org/10.1016/j.precamres.2014.05.019

OBD1

South-west Nawa Domain
Drillhole number: 1582
Location: 132.5681733, -29.3105053
Interval: 110.01-139.99 m

Orthogneiss. plagioclase–garnet–orthopyroxene–quartz–hornblende–biotite–magnetite gneiss

139.20.0-139.80 m
R1643452
plg–gt–opx–qtz–hbd–bi–mag orthogneiss

Geochronology Method	Age (Ma)	Type
Zircon LA-ICP-MS U-Pb	1752.0 ± 9.0	Magmatic
	1715 ± 17.0	Metamorphic

Age reference
Howard, K. E., Hand, M., Barovich, K. M., Payne, J. L., Cutts, K. A., & Belousova, E. A. (2011). U–Pb zircon, zircon Hf and whole-rock Sm–Nd isotopic constraints on the evolution of Paleoproterozoic rocks in the northern Gawler Craton. Australian Journal of Earth Sciences, 58(6), 615–638. https://doi.org/10.1080/08120099.2011.594905

OBD5

South-west Nawa Domain
Drillhole number: 1583
Location: 132.5588203, -29.3073573
Interval:125.81-133.69 m

Orthogneiss. quartz–plagioclase–k-feldspar–chlorite–garnet–biotite gneiss.

132.1-132.5 m
R1643444
qtz–plg–ksp–chl–gt–bi orthogneiss

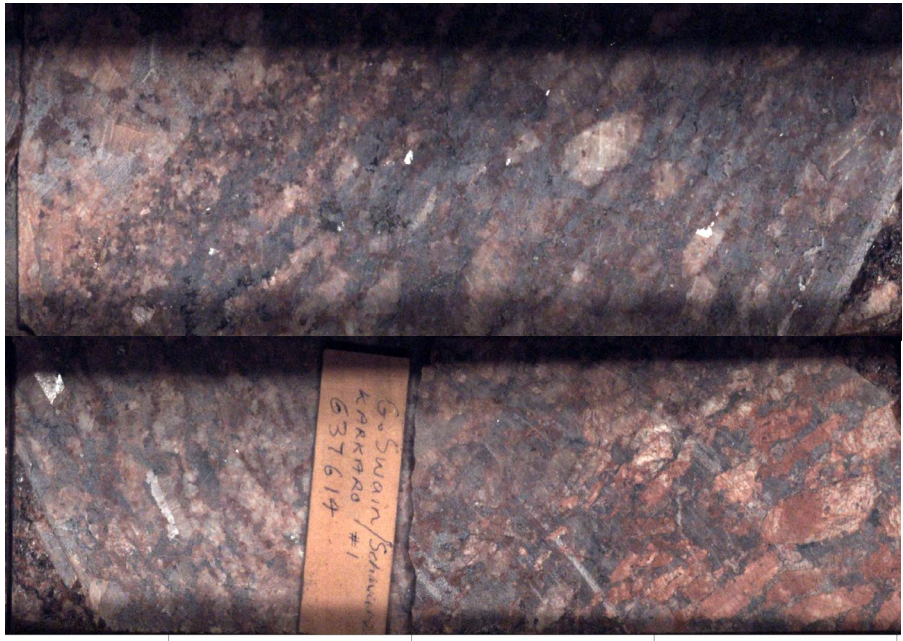
Geochronology Method	Age (Ma)	Type
Zircon LA-ICP-MS U-Pb	1764 ± 14.0	Magmatic
	1722.0 ± 11.0	Metamorphic

Age reference
Howard, K. E., Hand, M., Barovich, K. M., Payne, J. L., Cutts, K. A., & Belousova, E. A. (2011). U–Pb zircon, zircon Hf and whole-rock Sm–Nd isotopic constraints on the evolution of Paleoproterozoic rocks in the northern Gawler Craton. Australian Journal of Earth Sciences, 58(6), 615–638. https://doi.org/10.1080/08120099.2011.594905

KARKARO 1

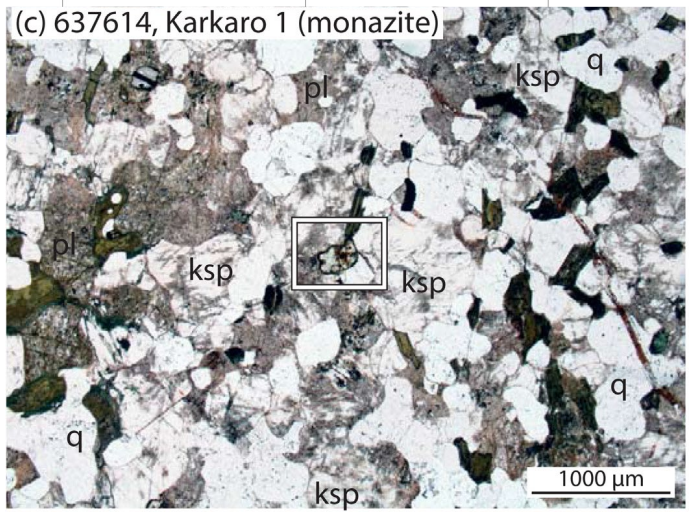
North of Mabel Creek Ridge, Nawa Domain
Drillhole number: 3552
Location: 133.7755032, -28.5979893
Interval: 472.44-481.28 m

Fine-grained granite. K-feldspar phenocrysts, plagioclase, quartz and minor biotite.



477.39-477.57 m
R637614
Fine-grained, unfoliated granite

Geochronology Method	Age (Ma)	Type
Monazite LA-ICP-MS	1442 ± 9.0	Magmatic



Age reference
Morrissey, L. J., Barovich, K. M., Hand, M., Howard, K. E., & Payne, J. L. (2019). Magmatism and metamorphism at ca. 1.45 Ga in the northern Gawler Craton: The Australian record of rifting within Nuna (Columbia). Geoscience Frontiers, 10(1), 175–194. https://doi.org/10.1016/j.gsf.2018.07.006

KARKARO 1

North of Mabel Creek Ridge, Nawa Domain
Drillhole number: 3552
Location: 133.7755032, -28.5979893
Interval: 472.44-481.28 m

Coarse-grained, unfoliated granite. K-feldspar phenocrysts, plagioclase, quartz and minor biotite.

479.45-480.67 m
R637615
Coarse-grained, unfoliated granite

Geochronology Method	Age (Ma)	Type
Monazite LA-ICP-MS	1462 ± 8.0	Magmatic

Age reference
Morrissey, L. J., Barovich, K. M., Hand, M., Howard, K. E., & Payne, J. L. (2019). Magmatism and metamorphism at ca. 1.45 Ga in the northern Gawler Craton: The Australian record of rifting within Nuna (Columbia). Geoscience Frontiers, 10(1), 175–194. https://doi.org/10.1016/j.gsf.2018.07.006

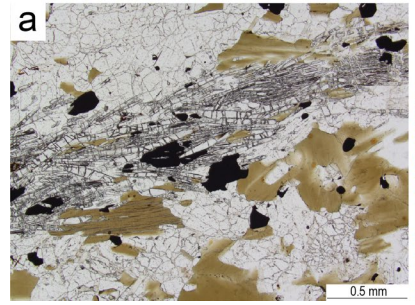
AD 1

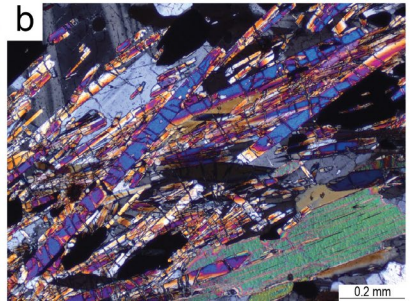
Eastern Mabel Creek Ridge
Drillhole number: 202016
Location: 134.4721051, -28.8071173
Interval: 274.4-343.7 m

Migmatitic sillimanite-cordierite-hematite-bearing metasedimentary gneiss. Less abundant pegmatitic and granitic lithologies.

323.00-324.90 m
R4467186
Sillimanite-hematite-bearing migmatitic metasedimentary gneiss

Geochronology Method	Age (Ma)	Type
Zircon SHRIMP U-Pb	1744.0 ± 11.0	Maximum depositional
	1573.0 ± 5.0	Metamorphic
Monazite LA-ICP-MS U-Pb	1583.3 ± 5.3	Metamorphic
	c. 1500	Metamorphic



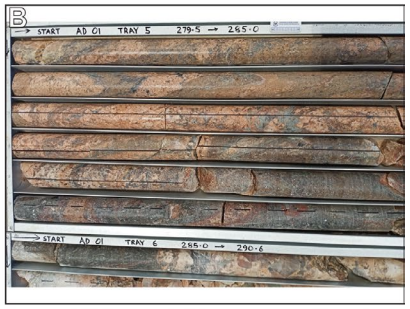


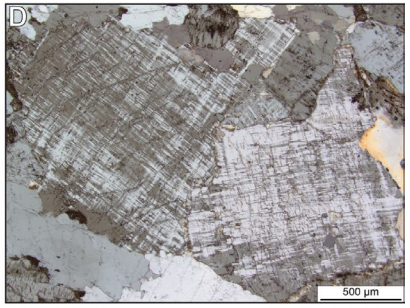
Age reference
Unpublished, in prep (GSSA)

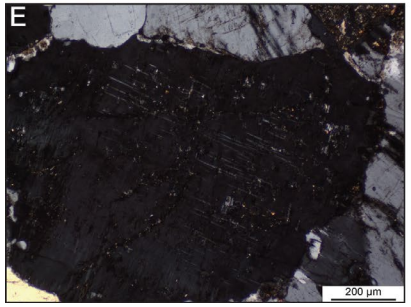
AD 1 (cont.)

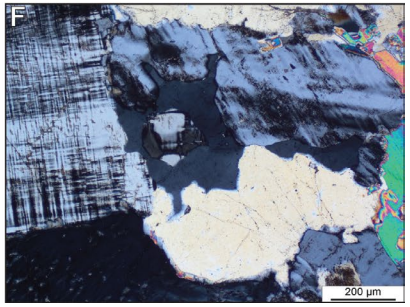
Eastern Mabel Creek Ridge
Drillhole number: 202016
Location: 134.4721051, -28.8071173
Interval: 274.4-343.7 m

Migmatitic sillimanite-cordierite-hematite-bearing metasedimentary gneiss. Less abundant pegmatitic and granitic lithologies.









323.00-324.90 m
R4467806
Pegmatite

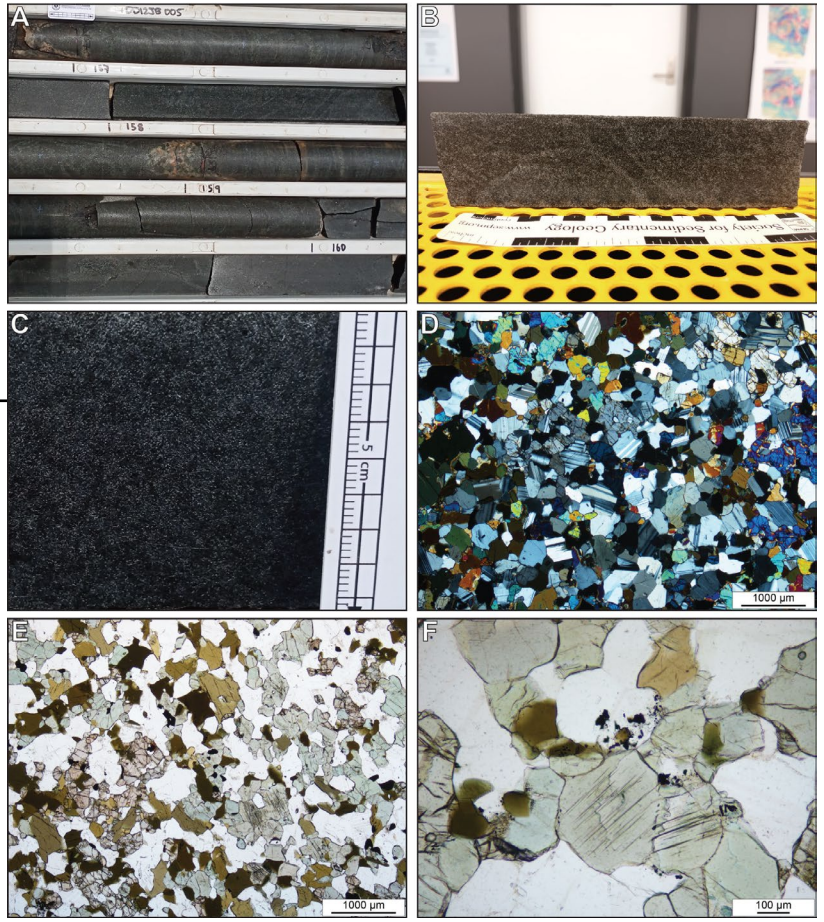
Geochronology Method	Age (Ma)	Type
Monazite LA-ICP-MS U-Pb	1714.4 ± 8.8	Magmatic
	1479.3 ± 6.3	Metamorphic
Rutile LA-ICP-MS U-Pb	1472.5 ± 3.6	Metamorphic
Apatite LA-ICP-MS U-Pb	1439.0 ± 27.0	Isotopic re-equilibration
Apatite LA-ICP-MS/MS Lu-Hf	1476.0 ± 38.3	Metamorphic

Age reference
Brown D, Percival J, Wise T and Abdullah R, 2025. Geochronology on the buried northern Gawler Craton. Part 1: Multi-mineral laser-ablation U–Pb–Lu–Hf dating, Report Book 2025/00006. Department for Energy and Mining, South Australia, Adelaide.

DD12JB005

Jindivic Bore, western Mabel Creek Ridge
Drillhole number: 275455
Location: 133.7686872, -28.9475473
Interval: 156.7-209.5 m

Pyroxene-amphibole-plagioclase mafic granulite. Mafics comprise magnetite-chalcopyrite. Minor felsic gneiss.

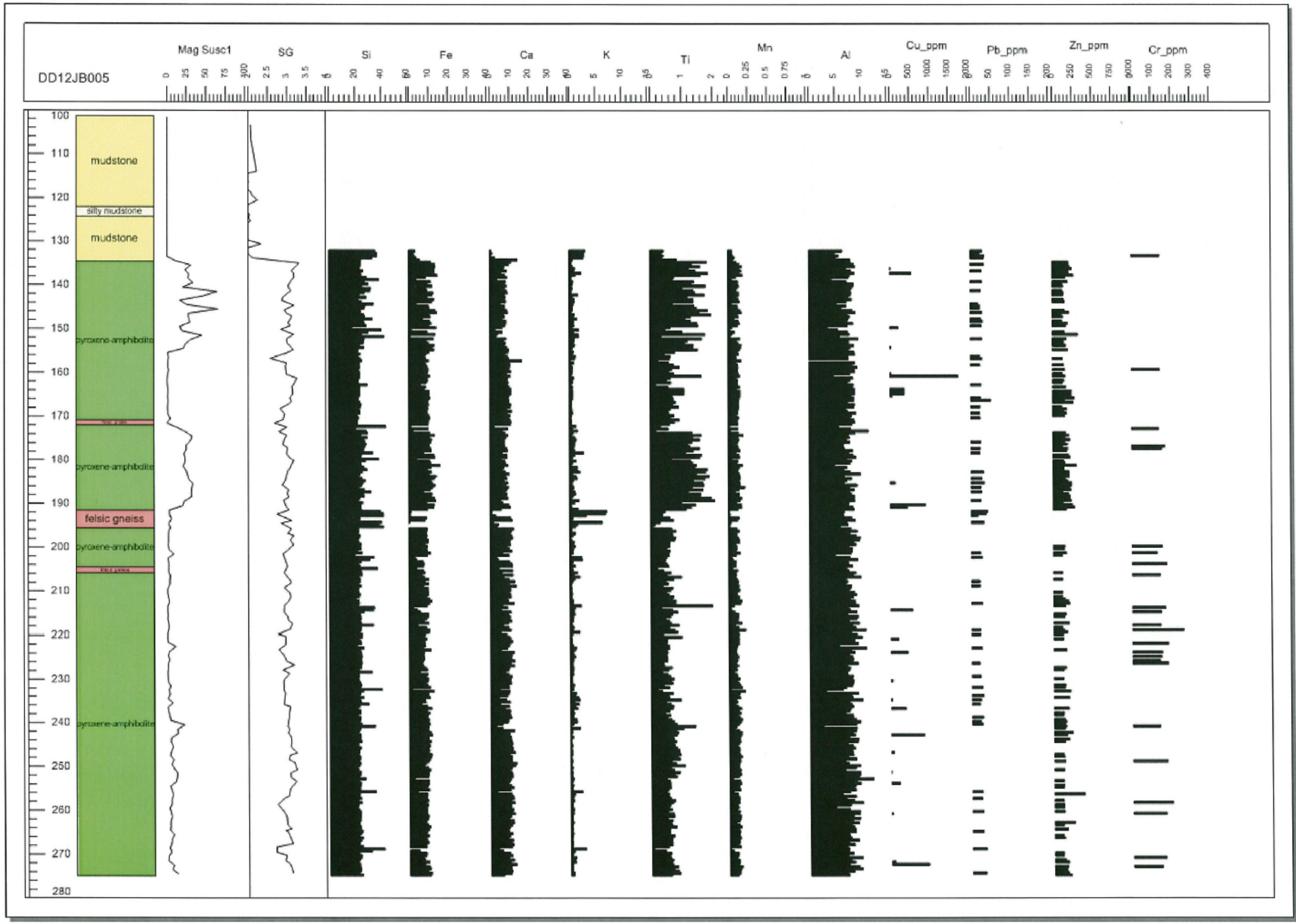


156.92-158.60 m
R4467175
Magnetite-bearing two-pyroxene mafic granofels

Geochronology Method	Age (Ma)	Type
Zircon LA-ICP-MS U-Pb	1728.1 ± 3.8	Magmatic
	1590.0 ± 11.0	Metamorphic
Apatite LA-ICP-MS U-Pb	1486.0 ± 14.0	Isotopic re-equilibration
Apatite LA-ICP-MS/MS Lu-Hf	1567.0 ± 41.7	Metamorphic

Age reference
Brown D, Percival J, Wise T and Abdullah R, 2025. Geochronology on the buried northern Gawler Craton. Part 1: Multi-mineral laser-ablation U–Pb–Lu–Hf dating, Report Book 2025/00006. Department for Energy and Mining, South Australia, Adelaide.

DD12JB005 (cont.)



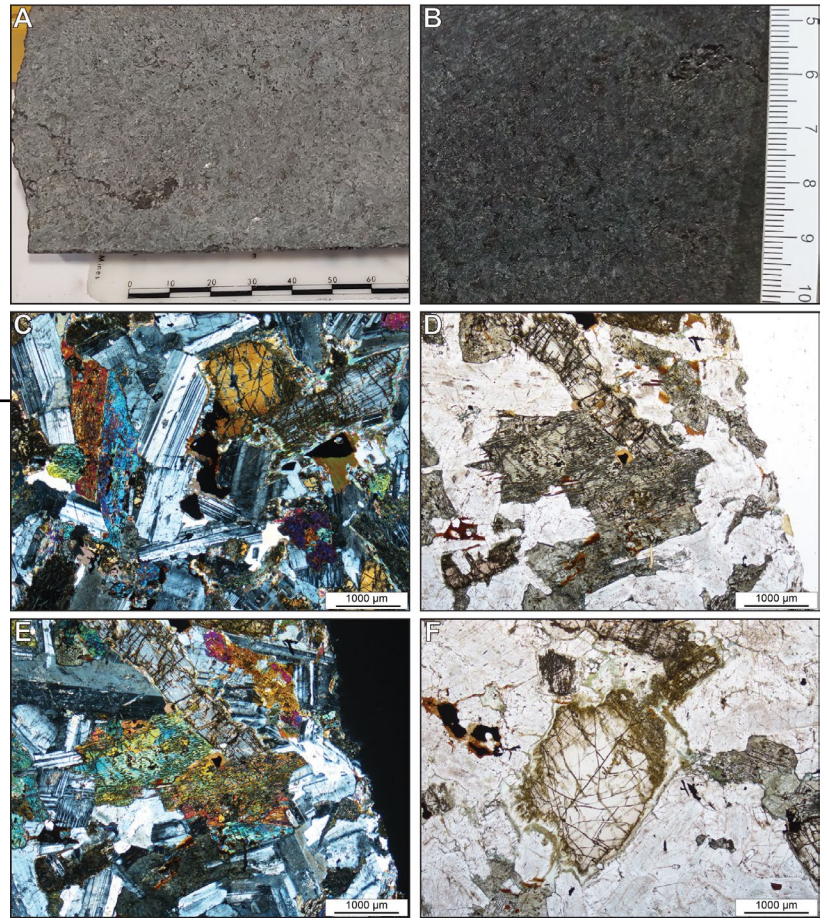
RR-06-01

Robins Rise, southern Coober Pedy Ridge
Drillhole number: 231342
Location: 134.5569451, -29.3532973
Interval: 63.0-92.3 m

Medium to coarse-grained two-pyroxene metagabbro. Amphibole-magnetite-pyrrhotite-bearing.

64.55-66.02 m
R4467035
Magnetite-bearing two-pyroxene metagabbro

Geochronology Method	Age (Ma)	Type
Zircon LA-ICP-MS U-Pb	1587.4 ± 2.4	Magmatic
Apatite LA-ICP-MS U-Pb	1519.0 ± 17.0	Isotopic re-equilibration
Apatite LA-ICP-MS/MS Lu-Hf	1557.0 ± 37.7	Magmatic



Age reference
Brown D, Percival J, Wise T and Abdullah R, 2025. Geochronology on the buried northern Gawler Craton. Part 1: Multi-mineral laser-ablation U–Pb–Lu–Hf dating, Report Book 2025/00006. Department for Energy and Mining, South Australia, Adelaide.

CHDCU02

Mount Woods Inlier

Drillhole number: 274447

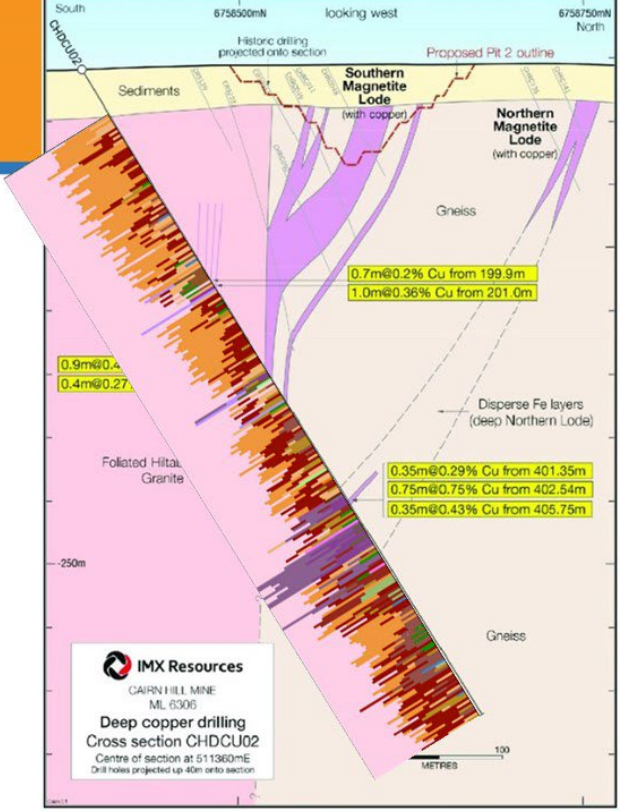
Location: 135.117691, -29.3034663

Interval: 45.9-50.4 m
273.6-321.6 m
361.9-450.2 m

Example of Cu-(Au) mineralisation.

Cairn Hill

HT Ca-Fe ± Mg (skarn) + HT K-Fe



J.Clark honours thesis - 2014

1. Na-Ca (albite + scapolite + diopside ± actinolite/titanite)
2. K-Fe (localised zones of magnetite-biotite ±pyrite-pyrrhotite-chalcopyrite)

Geochronology Method	Age	Type
Zircon SHRIMP U-Pb	1572 ± 6.0	Magmatic
Zircon SHRIMP U-Pb	1514 ± 8.0	Magmatic
Apatite LA-ICP-MS Lu-Hf	c. 1490	Mineralisation
Monazite LA-ICP-MS U-Pb	c. 1460	Mineralisation

285.3-286.20 m – 0.36% Cu
402.55-403.3 m – 0.749% Cu
405.75-406.1 m – 0.426% Cu

286.1-288.4 m – ~60% Fe

Drillhole CHDCU02 (600.8 m) was drilled to test the depth extent of mineralisation at Cairn Hill and extends beneath the southern portion of the orebody. Drillhole CHDCU02 intersects several magnetite-rich ore zones developed within foliated granite and orthogneiss. Geochronology by Jagodzinski and Reid (2017) of the quartz-feldspar-biotite gneiss at 381.15-382.13 m (zircon-SHRIMP) reveal the host rock is 1572 ±6 Ma (Hiltaba Suite). Jagodzinski and Reid (2017) also dated apatite from a magnetite-apatite-amphibole skarn (283.35–283.55 m), elsewhere associated with minor chalcopyrite, recording a U-Pb age of 1466±5 Ma. $^{40}Ar/^{39}Ar$ data from hornblende gave an age of 1492 ± 6 Ma. They interpreted this as a cooling age, based on a 1514 ± 8 Ma (zircon-SHRIMP) age from a granitic dyke from the Cairn Hill pit that truncates the main foliation in the host rock and the magnetite-rich ore zone. In contrast, Yu et al (2024) based on subsequent U-Pb ages from monazite and Lu-Hf ages from apatite, interpreted c1490 Ma and c.1460 Ma as ages of two distinct mineralisation events.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Contacts

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SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

NDING Drilling Insights

Liliana Stoian | 9/12/2025

A Palynological Journey Through the Eromanga and Arckaringa Basins

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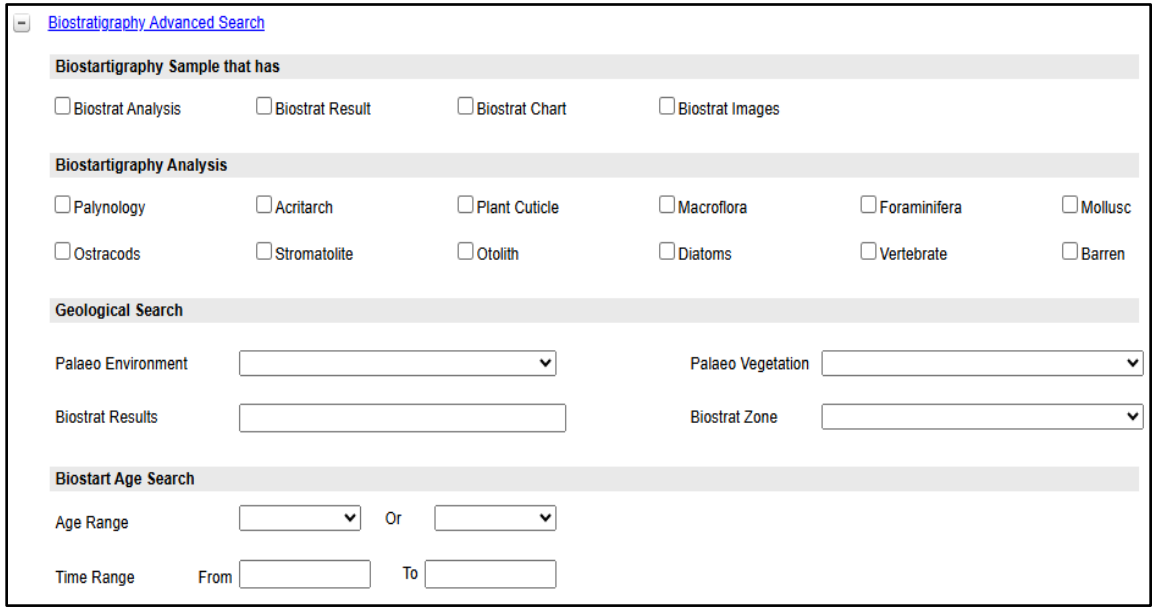
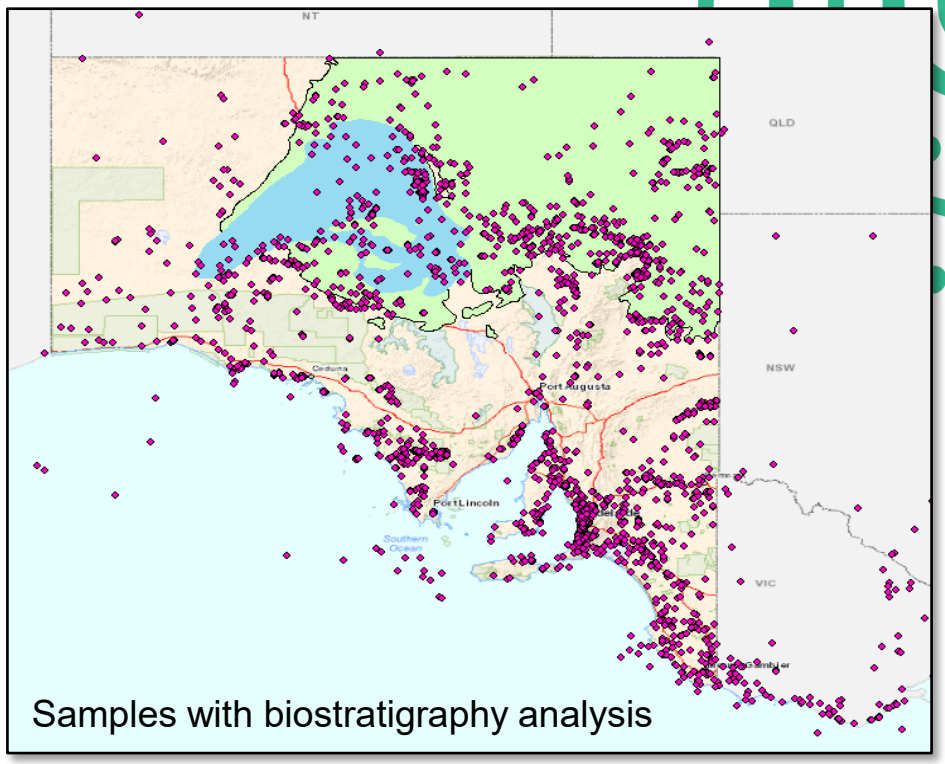
Department for Energy and Mining

Biostratigraphy Database on SARIG

- 19,490 rock samples with biostratigraphy analysis
- 11,267 rock samples with palynology analysis
- 4,120 sites are validated and have Biostrat information (including samples processed for palynology, molluscs, foraminifera, ostracodes, plant cuticles, acritarchs, stromatolites, conodonts)
- Physical samples collection including palynological slides, foraminifera slides, stromatolites, molluscs, ostracods, macroflora is stored at the Core Library



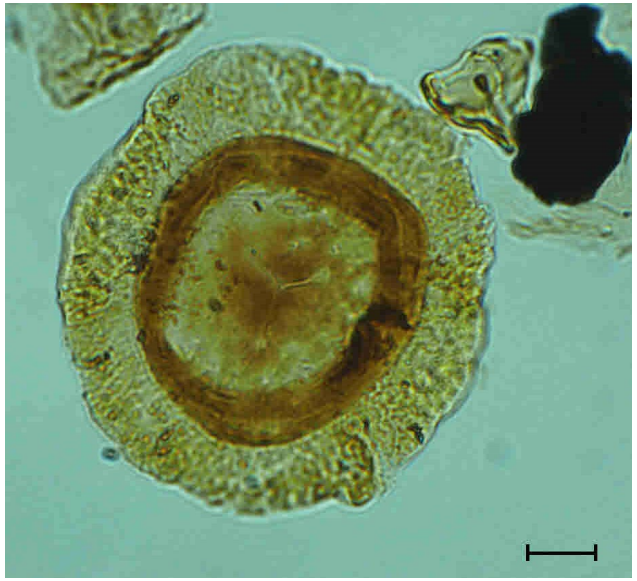


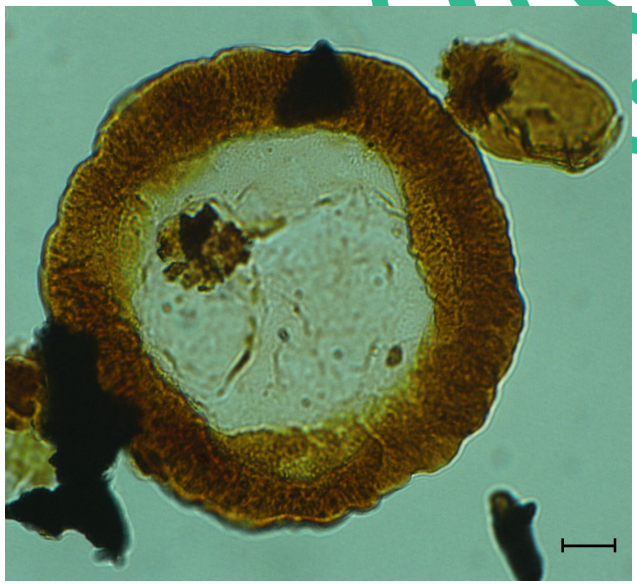
Samples with biostratigraphy analysis

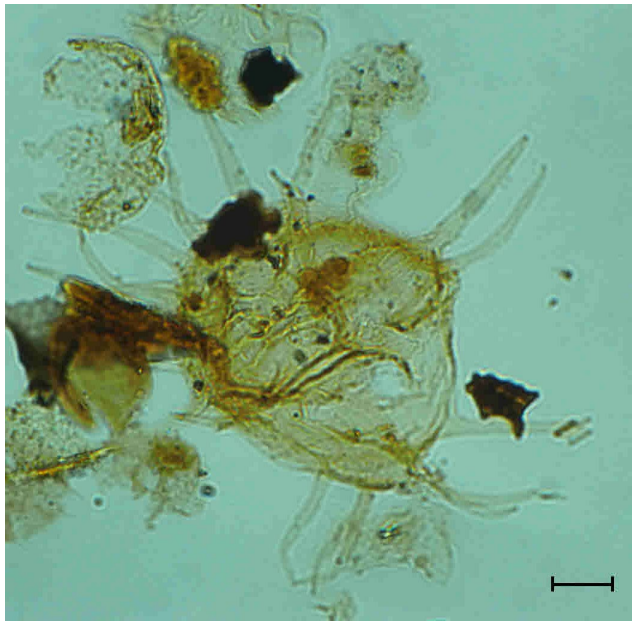

Physical samples collection at the Core Library

Why Palynology

- Palynology is the study of fossil pollen, spores, and organic-walled microfossils (acritarchs, algal cysts, dinoflagellates, fungal remains)
- It is one of the most powerful tools for dating sedimentary successions – traditionally used in petroleum industry
- Palynomorphs are preserved in shales, sandstone, mudstone, clay, siltstone, metamorphic rocks which are not oxidised and rich in organic matter
- Palynomorphs provide strong time markers/zones
- Distinct assemblages allow age separation of formations and stratigraphic units
- Reconstruction of depositional environments: marine, freshwater, brackish, deltaic, lacustrine
- Provide information of the past climates, vegetation reconstruction



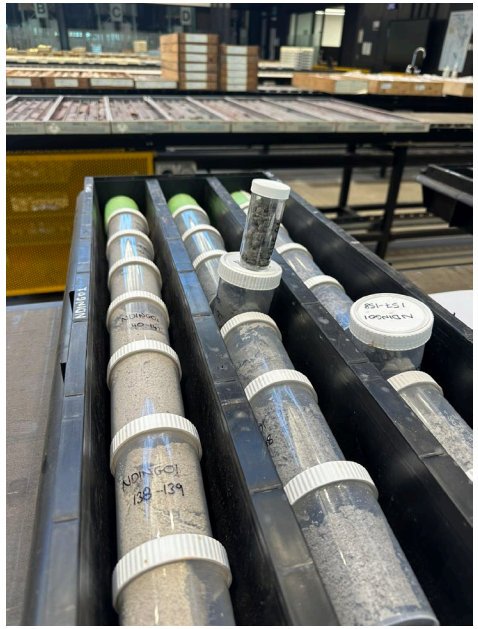


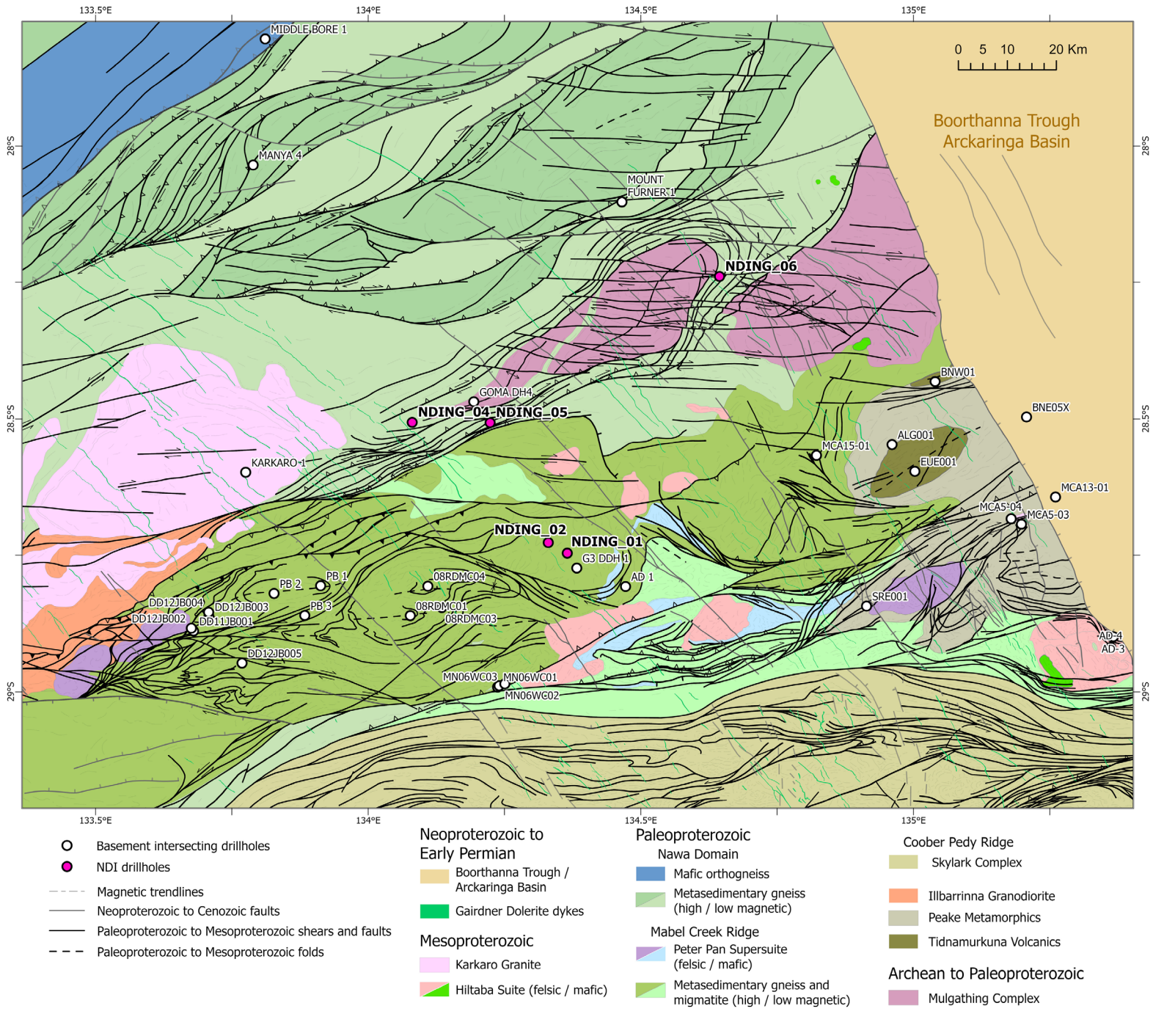


Scale bar 10µm

Sampling

- Twenty-eight samples from selected drillholes have been collected for palynological analysis and dating: NDING_01, NDING_04, NDING_05 and NDING_06
- Sample size: 20–50 grams
- Sample processing and preparation was done by Morgan&Palaeo Laboratory, WA





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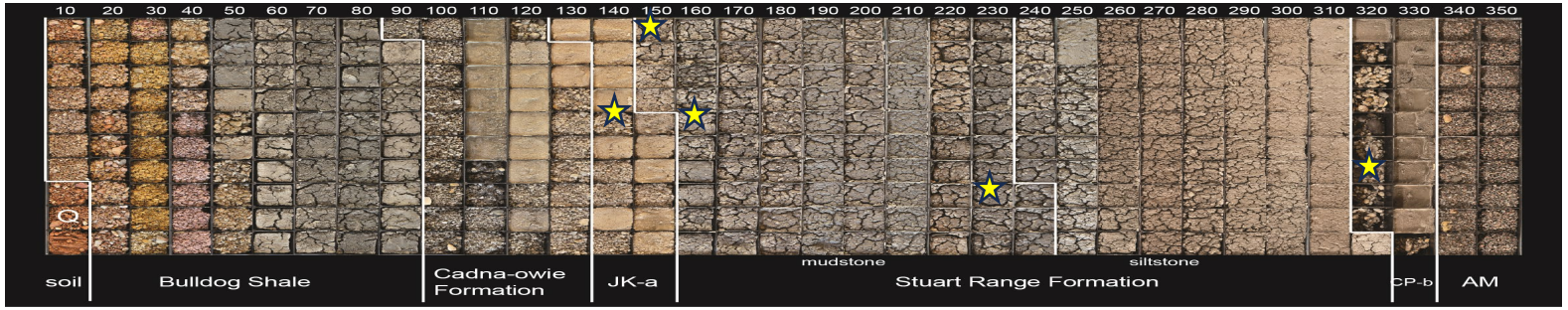

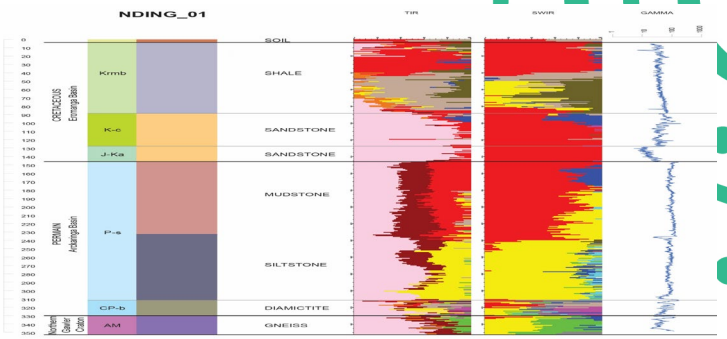

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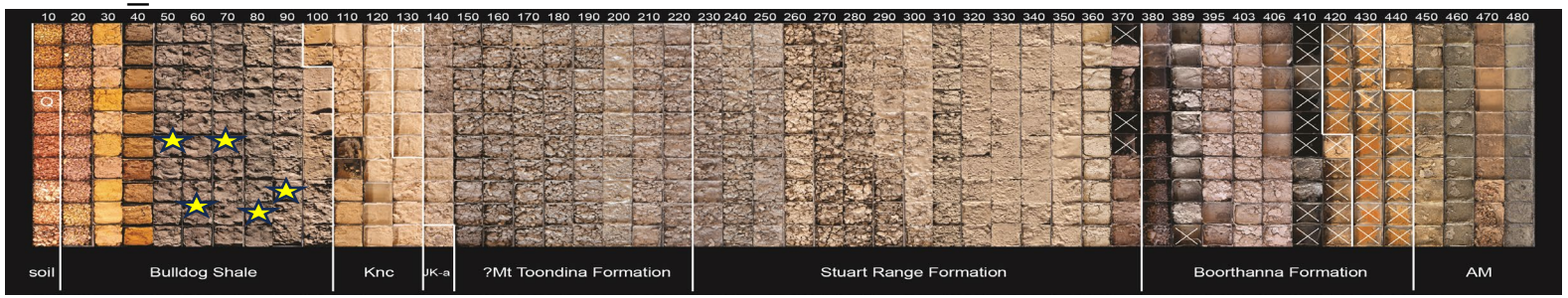

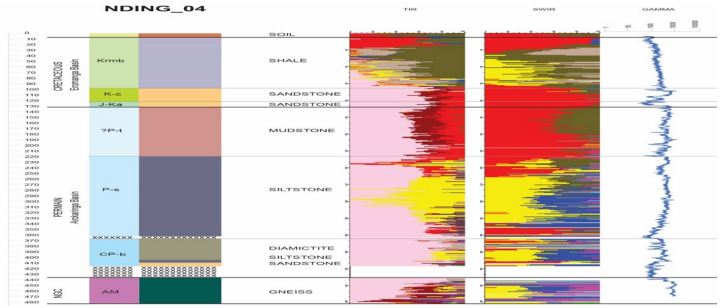

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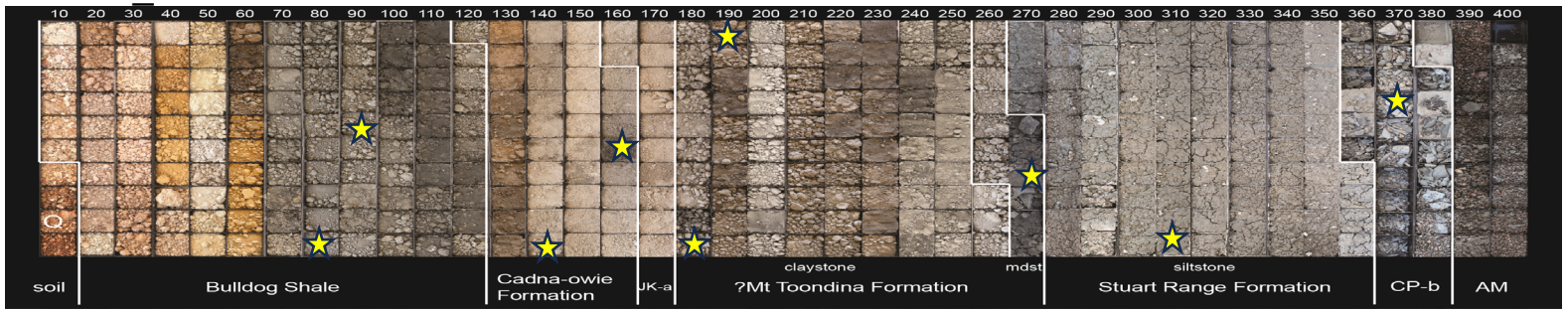
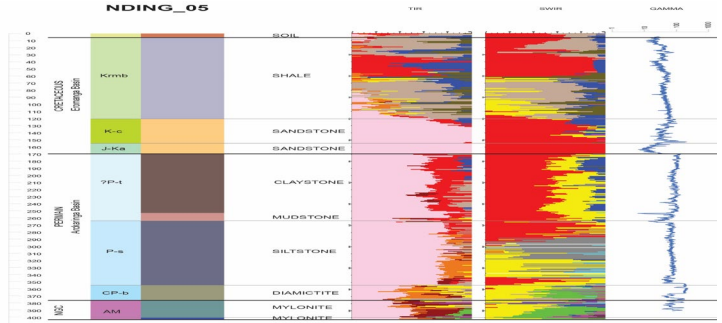
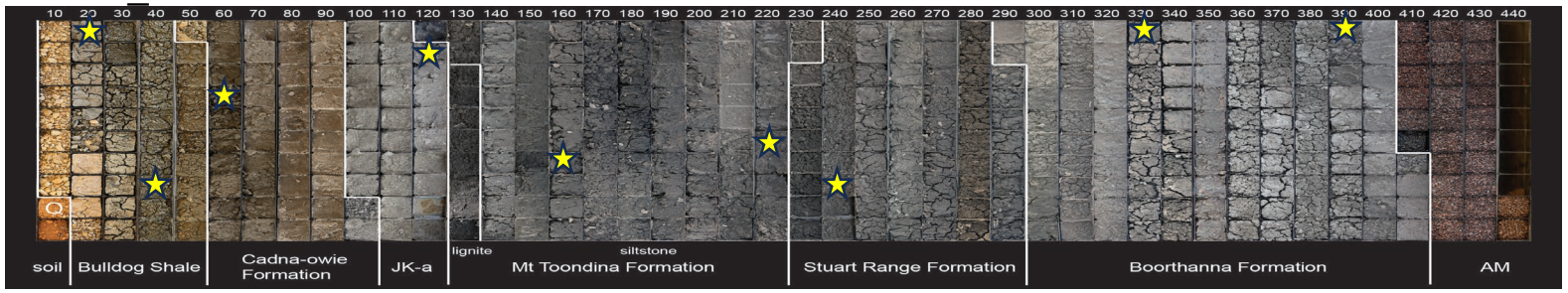
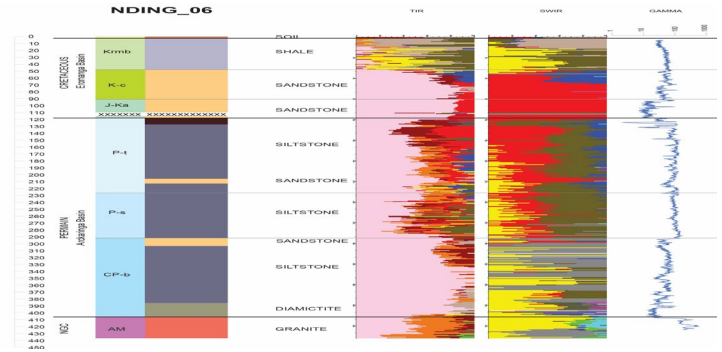




NDING_06





Light Microscope Examination

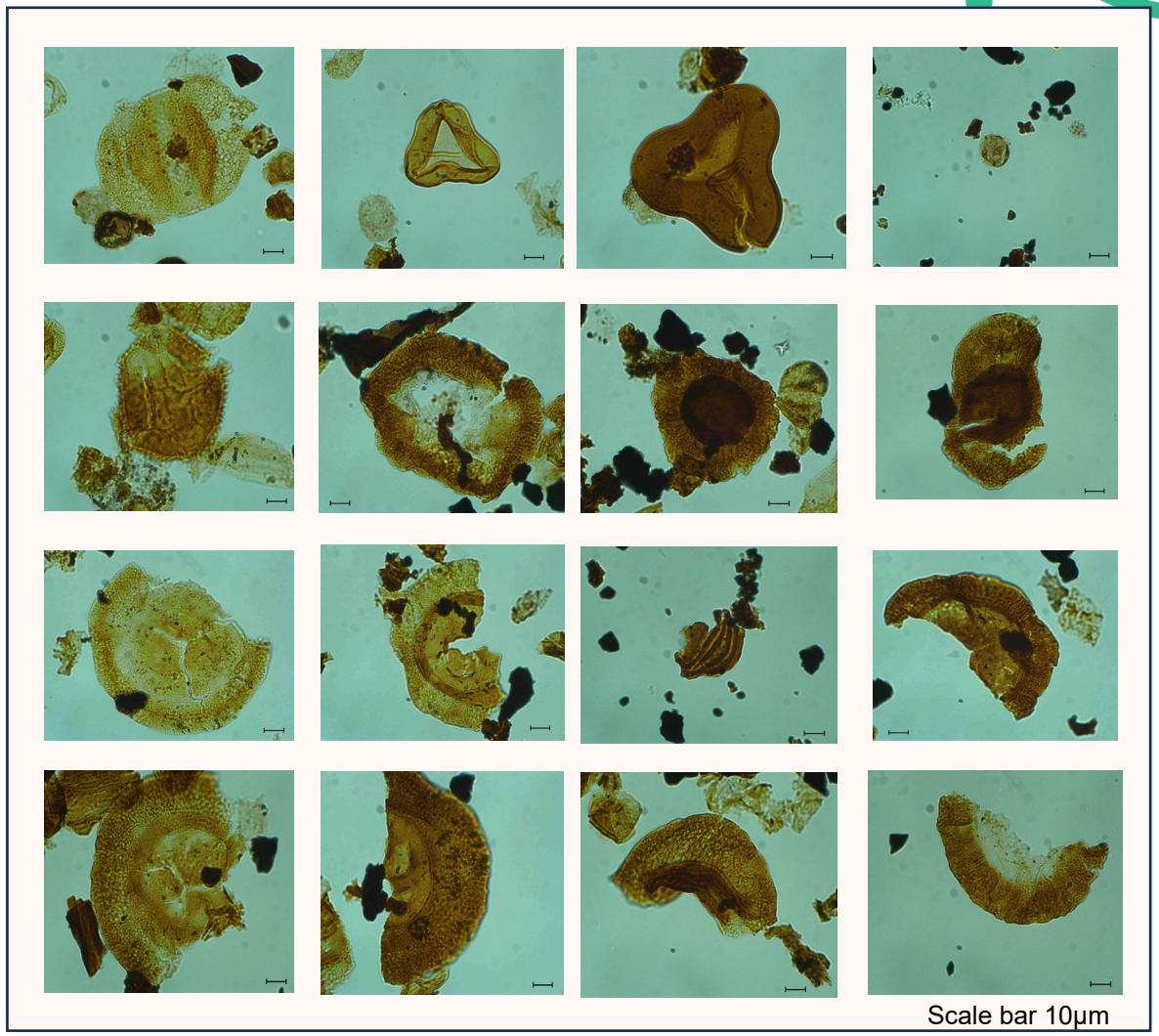
Counts between 300-700 palynomorphs per sample

Presence of both intact and fragmented pollen reflects:

- Variations in oxidation – early diagenesis
- Frosting, compression, burial effects
- Sedimentary rate fluctuations (low vs high energy events)

Causes of pollen fragmentation observed in both Permian and Early Cretaceous samples:

- Fluvial transport
- Chemical degradation: oxidation, acidic soils
- Diagenesis: deep burial in sedimentary basins and higher compaction pressures – causing crushing or deforming of pollen grains
- Laboratory preparation: samples are treated with concentrated acids (HCl and HF) to eliminate all mineral matter which can cause cracks in fragile pollen grains (e.g. perfect middle split)



Examples of palynomorphs with different degrees of preservation

Palynofacies

Amorphous Organic Matter (AOM) is the common type:

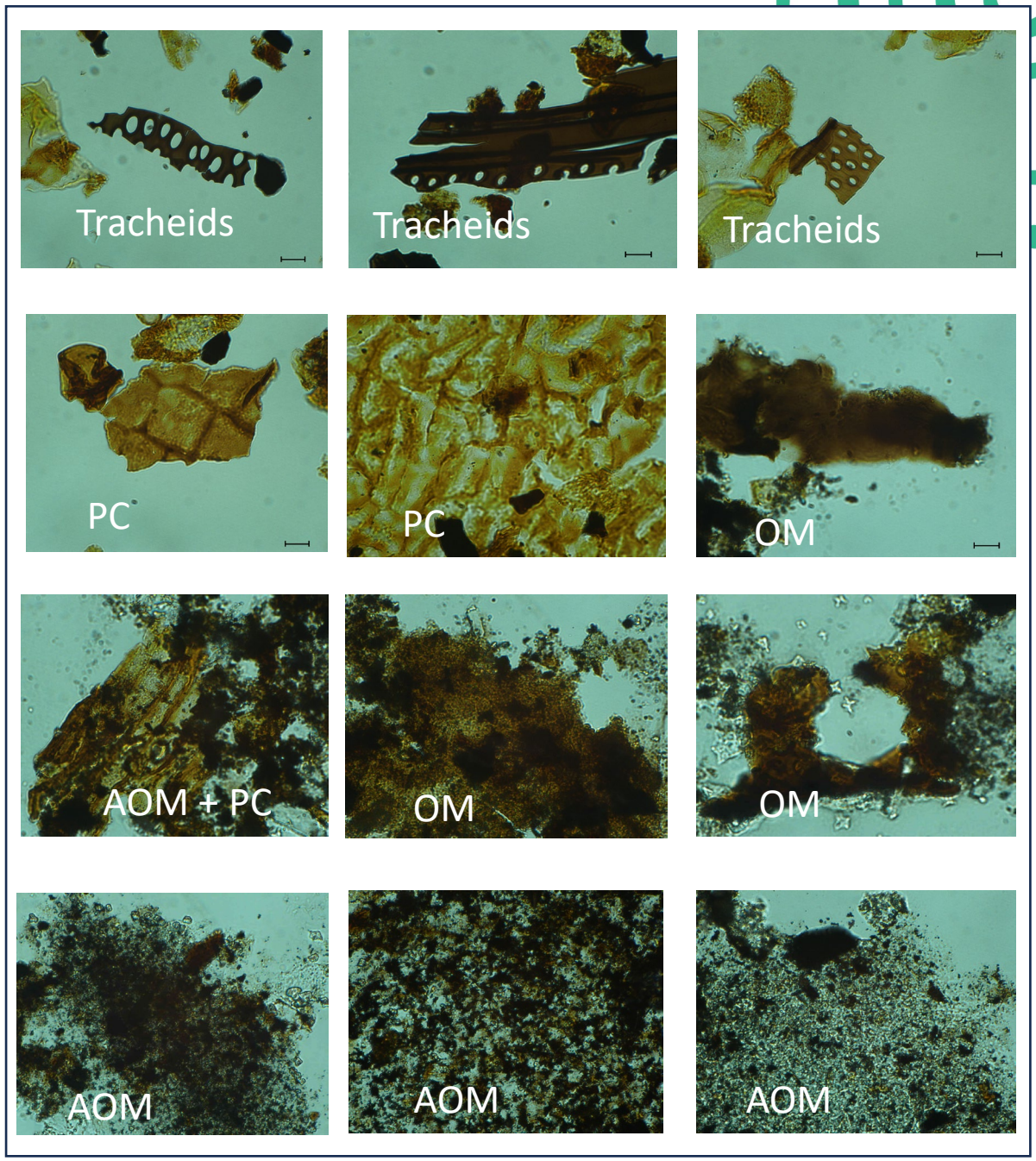
- Appears as dark masses under the microscope
- Structureless, gel like organic debris
- Showing higher degree of oxidation
- Associated with terrestrial input and coal-related organic matter

Wood tissue (tracheids) and plant cuticles fragments from leaves or stems are common in non-marine environments:

- Thick and dark in Permian from conifers and Glossopteris floras
- Fine, lighter in colour in Early Cretaceous from angiosperm leaves

Palynofacies analysis:

- Permian sediments indicate terrestrial source and oxidation
- Early Cretaceous sediments indicate anoxic environment and marginal marine settings



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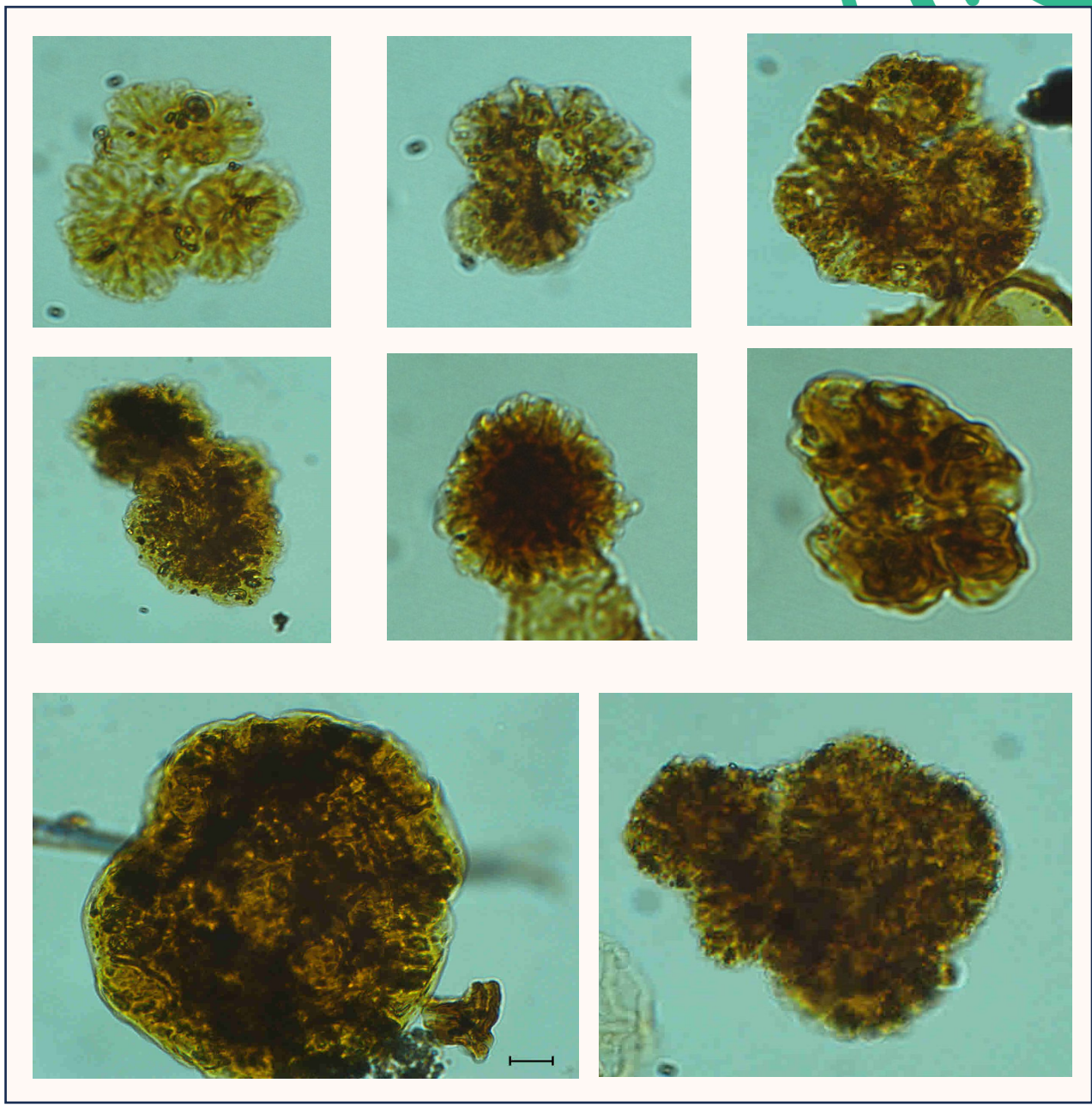
Botryococcus brownii

- *Botryococcus brownii* lives in a variety of aquatic habitats: swamps, bog, freshwater lakes, brackish environment
- Predominance of *B. brownii* indicates shallow water, oligotrophic conditions (e.g. lacking nutrients), slow sedimentation rate
- It is dominant in regressive phases when marine waters retreats causing decreased salinity and the development of freshwater lakes, wetlands, lacustrine environments
- It is a stratigraphic marker for identifying and mapping regressive surfaces, identifying low-stand lacustrine phases
- Under suitable physical and chemical conditions (sunlight, calm and clear waters, warm climate and availability of high nutrients) *B. brownii* form blooms – cells produce oil droplets enabling colonies to float on the water surface
- Relevance for petroleum – during burial and maturation *B. brownii* produces hydrocarbon oils, contributes to local increase in hydrogen index in type I kerogen (oil-prone organic matter type formed in lacustrine environments)



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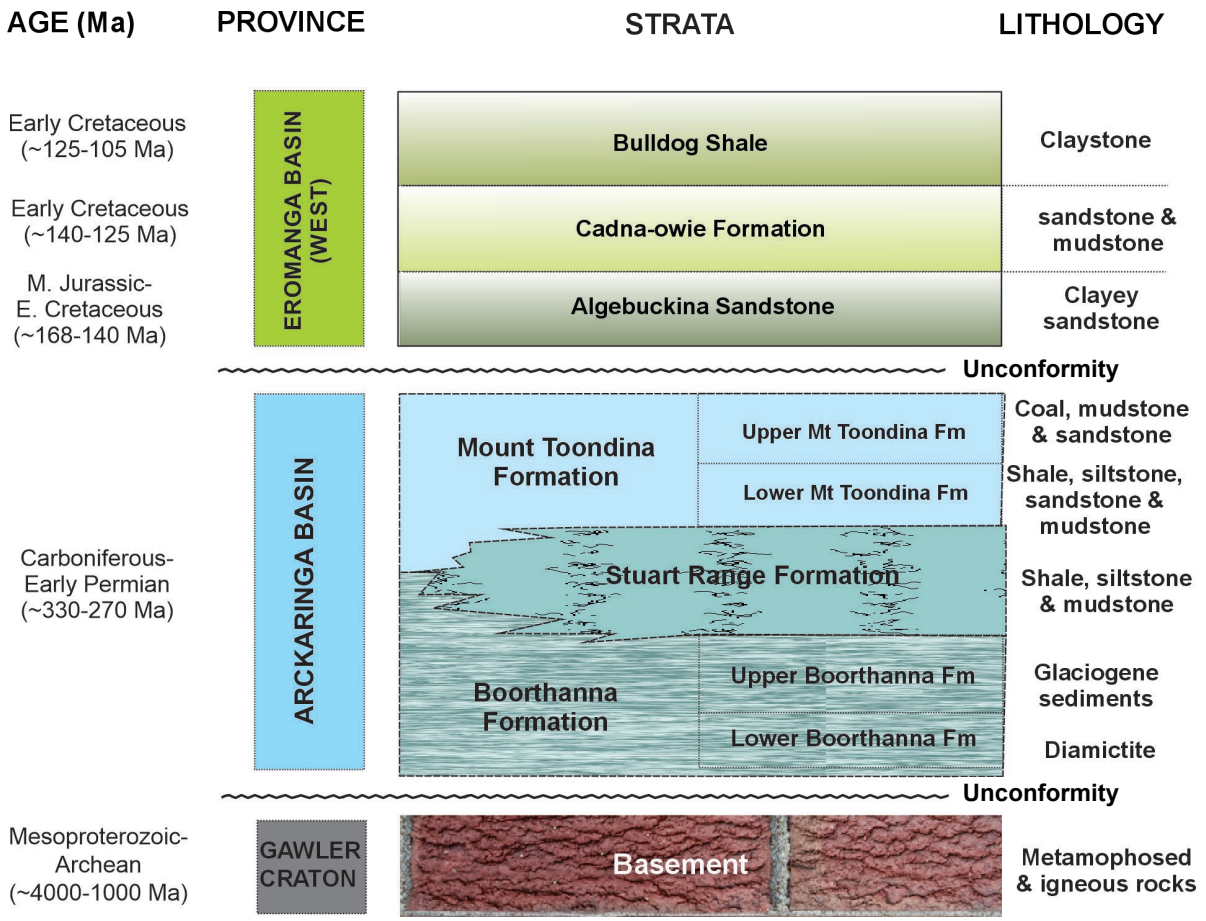
Northern Gawler Craton Basins

- Two cover basin sequences are observed in the Northern Gawler Craton:
- Carboniferous to Early Permian Arckaringa Basin
- Early Cretaceous Eromanga Basin

- Both have unconformable contacts with their underlying units
- Represent different depositional environments



Strata relationships for Eromanga and Arckaringa basins, modified from Baohong Hou

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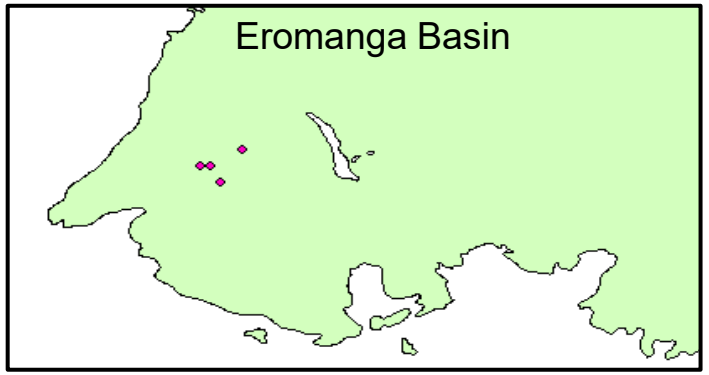
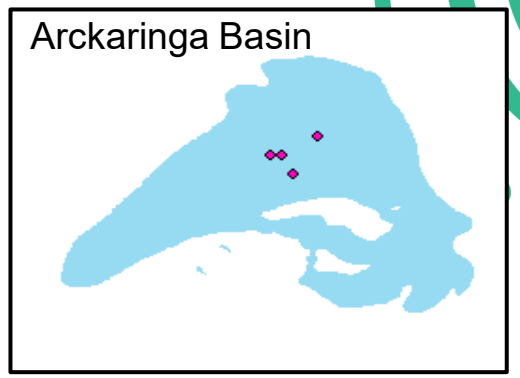
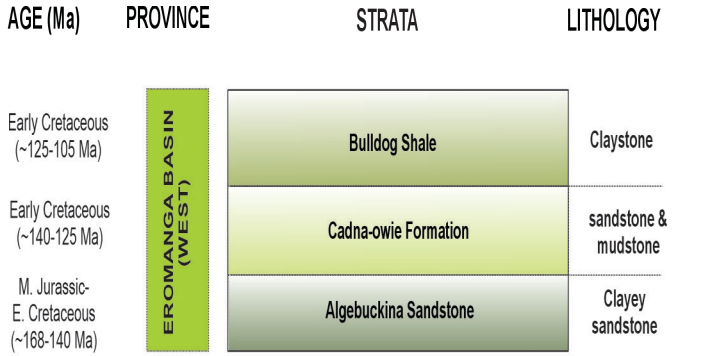
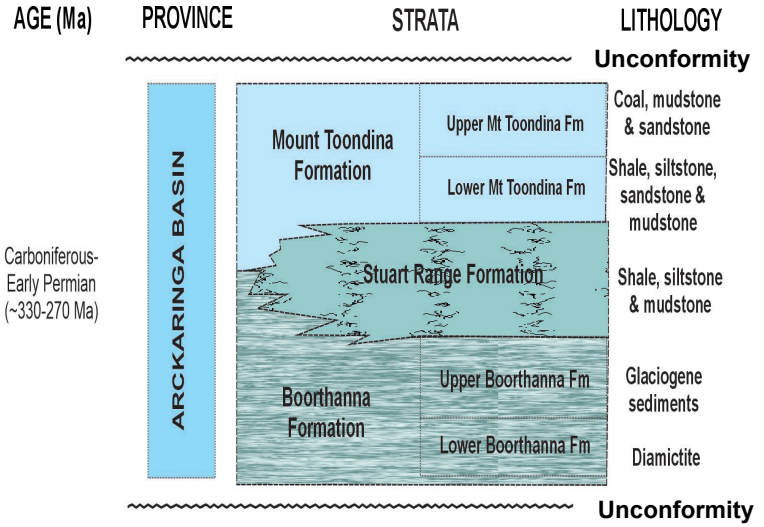
Results

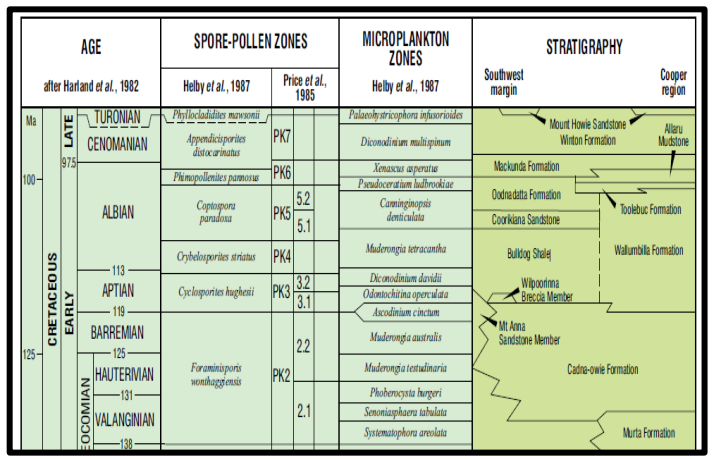
- Determine the age of sediments of intersected stratigraphic units in selected drillholes – key taxa for Spore - Pollen and Microplankton Zones in both basins
- Characterise palynofacies and preservation and organic matter type
- Interpret depositional environments
- Preservation and reworking of palynomorphs including possible reactivation of faults and shear zone during Early Cretaceous
- Provide stratigraphic correlations across NDING drillholes and with regional datasets – refining geological framework and potential for groundwater, gas and oil source rocks

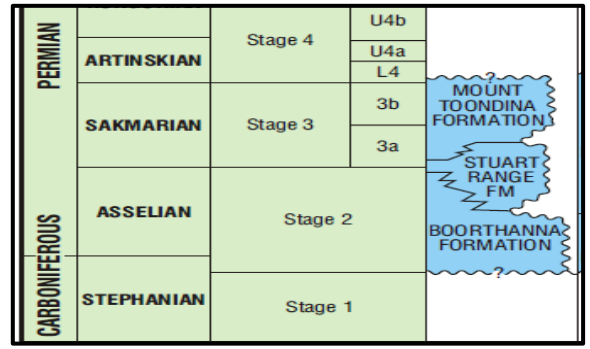










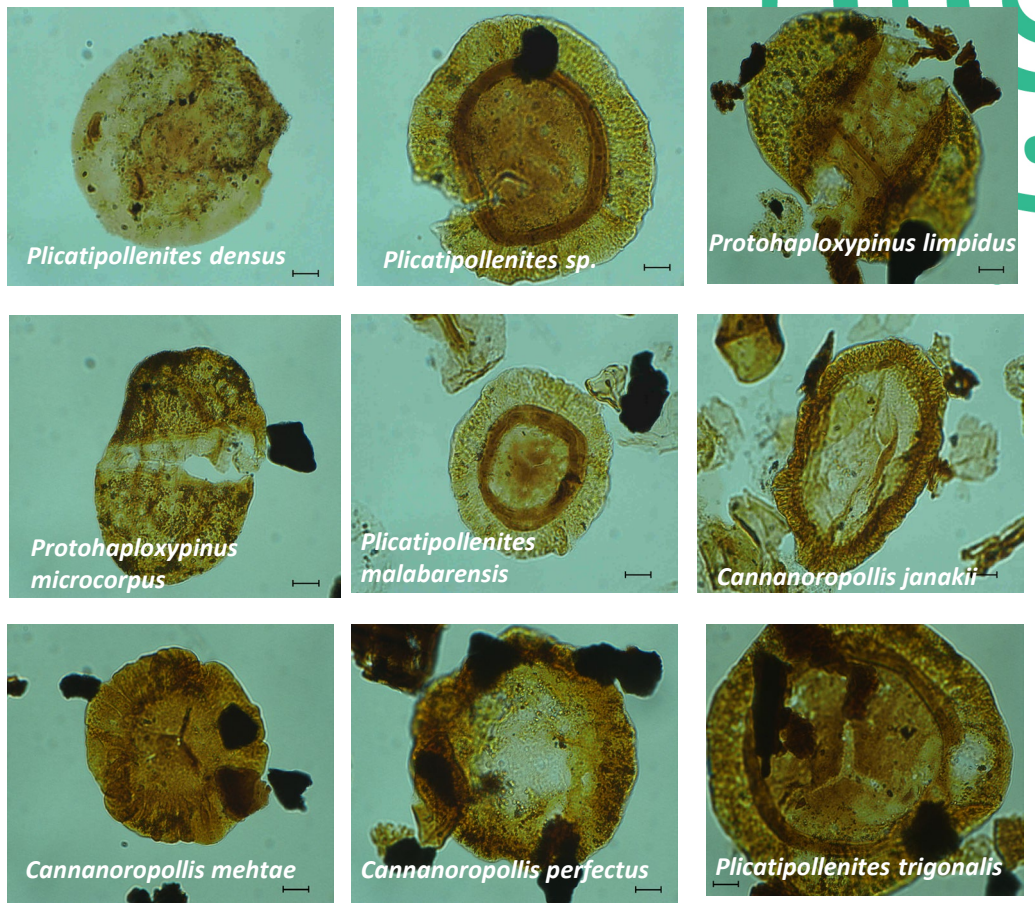


Spore-Pollen and Microplankton Zones for Eromanga and Arckaringa Basins, modified from Bulletin 54 and Baohong Hou

Boorthanna Formation

Palynology results drillholes NDING_01, NDING_05, NDING_06:

- Rich palynological assemblages with monosaccate gymnosperm pollen, spores, plant cuticles and amorphous organic matter, low frequency of freshwater algae *Botryococcus brownii*
- Age: Early Permian (Asselian to Sakmarian) correlated with the *Protohaploxypinus limpidus –Vittatina fasciolata* Palynozones.
- Key taxa: *Cannanoropollis perfectus, C. janakii, C. mehtae, Plicatipollenites trigonalis, P. densus, Protohaploxypinus limpidus, P. microcorpus.*
- Depositional environment: interpreted as a transition from ice-proximal (fragmented pollen grains) to glaciolacustrine (intact pollen grains)
- Organic facies based on palynomorphs colouration indicates low to moderate maturity (shallow burial) and terrestrial type 3 kerogen



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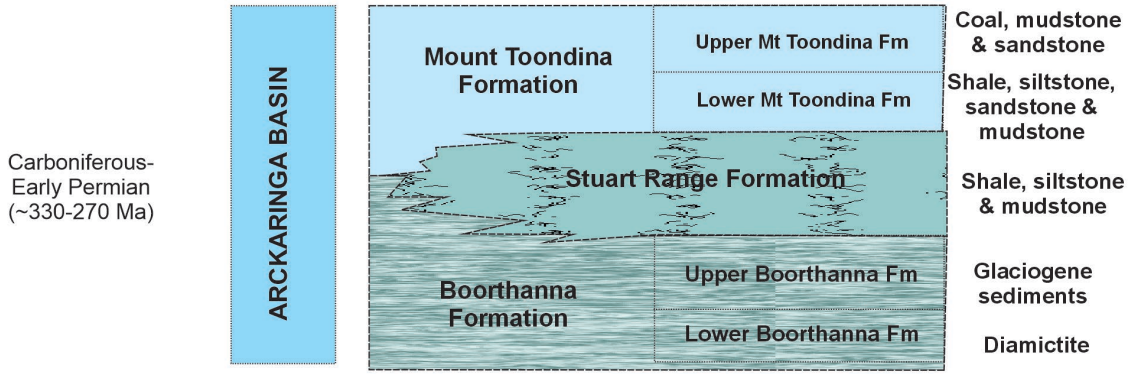
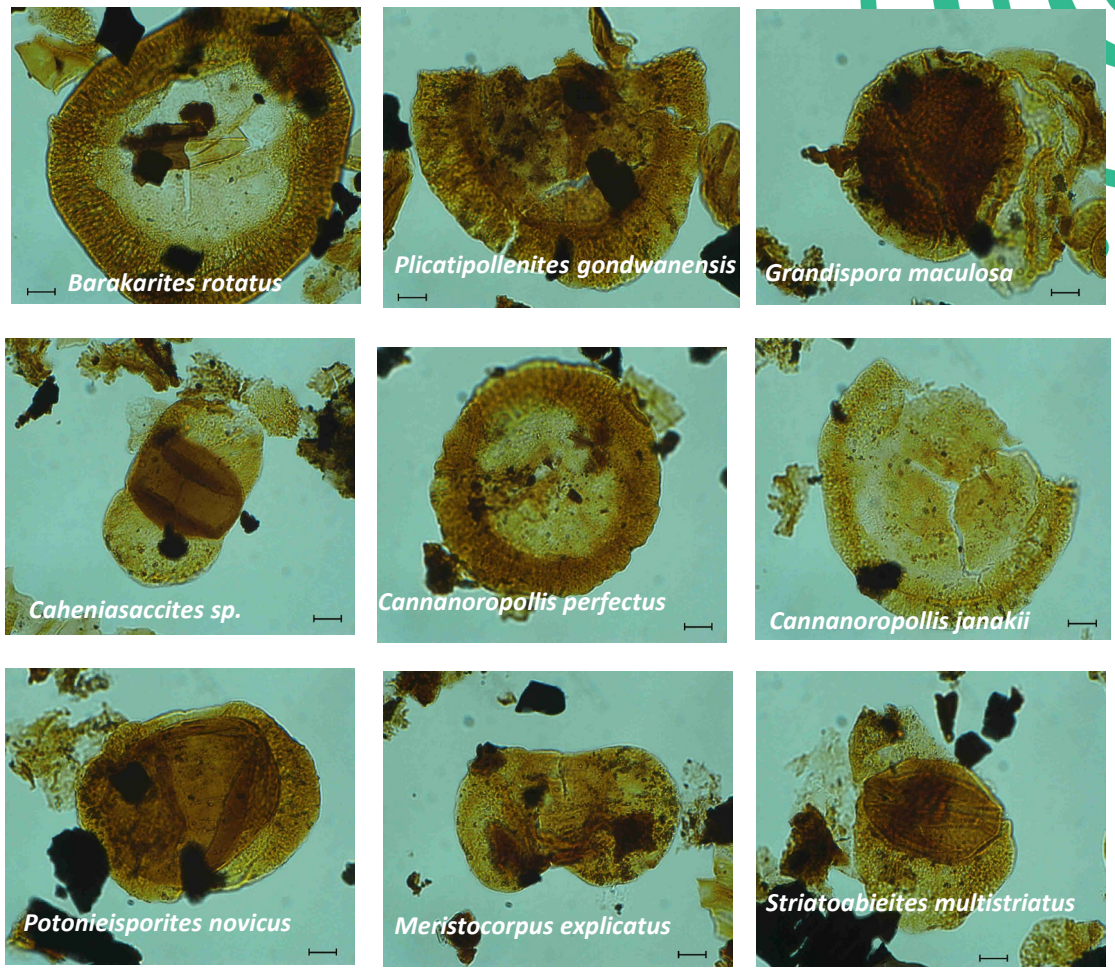
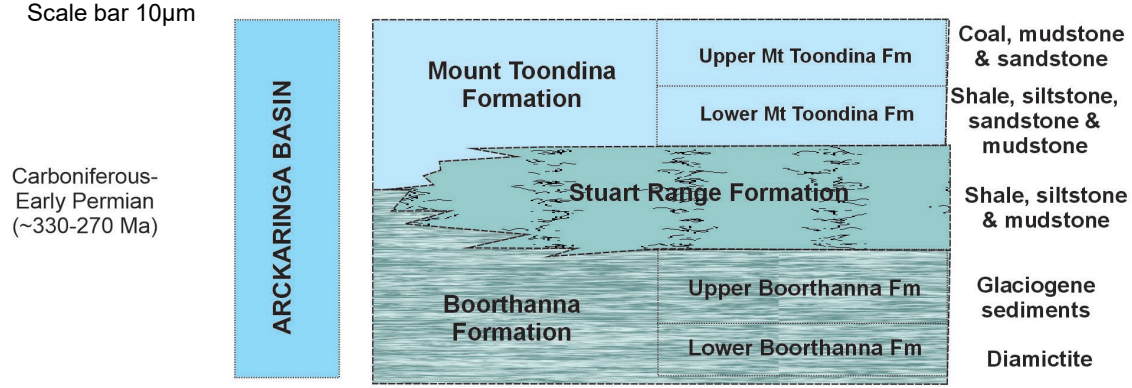


Stuart Range Formation

Palynology results drillholes NDING_01, NDING_05, NDING_06:

- Rich palynological assemblages with Glossopteris floras, gymnosperm pollen, freshwater algae *B. brownii* and rare brackish acritarchs.
- Age: Early Permian (Early Sakmarian) correlated with the PP1 to PP2 Palynozones.
- Key taxa: *Cannanoropollis perfectus, C. janakii, Plicatipollenites gondwanensis, Potonieisporites novicus, Grandispora maculosa.*
- Depositional environment: transition from glaciofluvial to glaciolacustrine, and peat forming floodplain as glaciers retreated– evidence from plant cuticles rich slides, abundance of spores, pollen preservation (both intact and fragmented pollen due to oxidation or reworking and variable transport).





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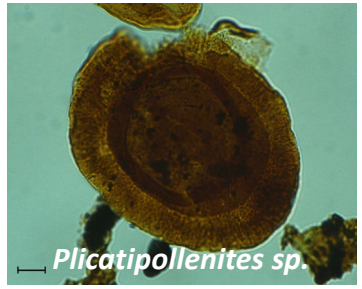
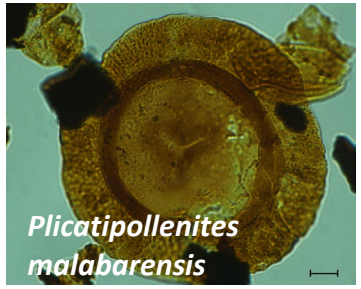
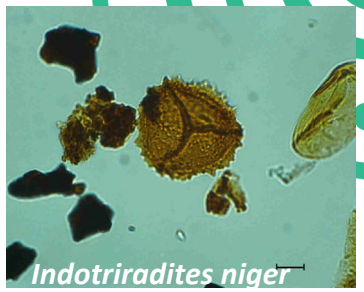
Mount Toondina Formation

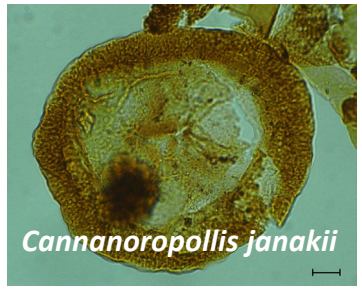
Palynology results drillholes NDING_01, NDING_05, NDING_06:

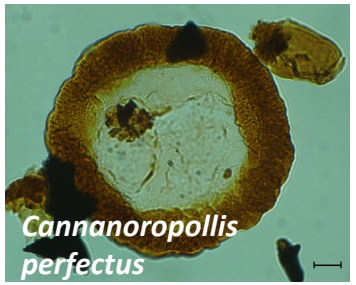
- Rich palynological assemblages with Glossopteris floras and gymnosperm pollen, phytoclasts and amorphous organic matter
- Age: Early Permian (Late Sakmarian) correlated with the PP2 Palynozones.
- Key taxa: *Cannanoropollis perfectus, C. janakii, C. mehtae, Plicatipollenites malabarensis, Protohaploxypinus limpidus, P. amplus.*
- Depositional environment: interpreted as a transition from glaciolacustrine to lacustrine-floodplain– evidence from monosaccate and bisaccate pollen grains, organic matter, terrestrial kerogen
- Organic facies based on palynomorphs colouration indicates low to moderate maturity (shallow burial)

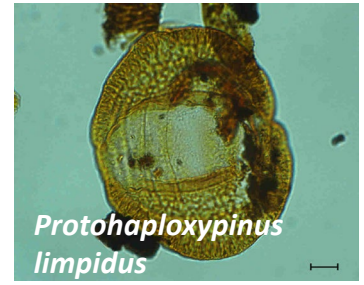


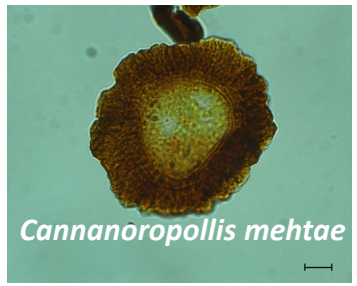


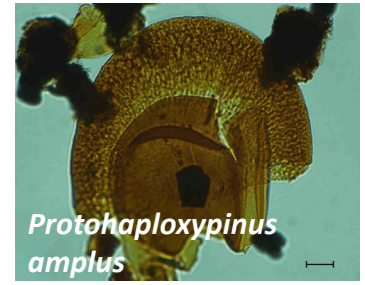












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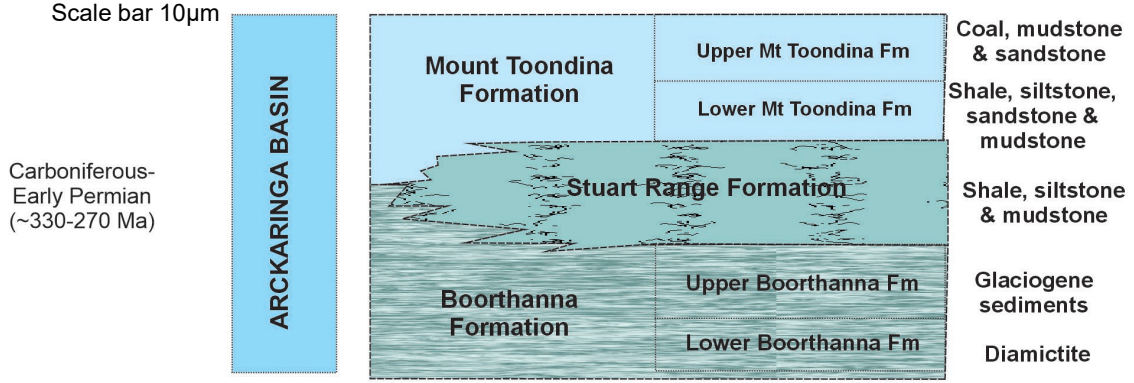

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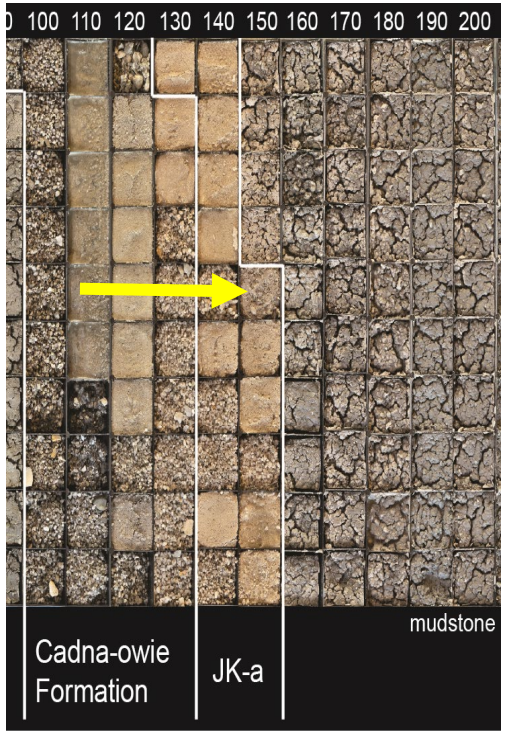
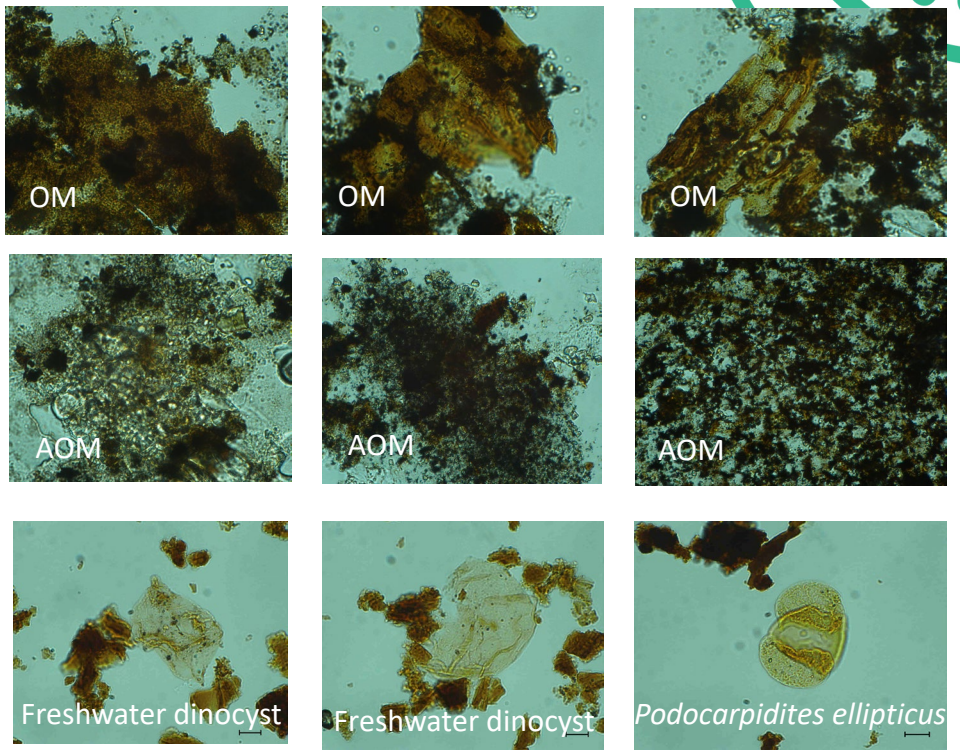
Algebuckina Sandstone

Palynology results drillholes NDING_01 and NDING_05:

- NDING_01 at 145–146m: only AOM, organic matter and plant cuticles suggesting erosional contact with underlying Permian of Mount Toondina palynofacies
- NDING_05 154–155m: rare pollen grains, abundant plant cuticles and occurrence of freshwater dinoflagellate cysts
- Age: Early Cretaceous - very low yield from sandy lithology
- Absence of palynomorphs: not preserved in coarse sandy units associated with high energy fluvial depositional environment





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Early Cretaceous (~125-105 Ma)

Early Cretaceous (~140-125 Ma)

M. Jurassic-E. Cretaceous (~168-140 Ma)

EROMANGA BASIN (WEST)

Bulldog Shale	Claystone
Cadna-owie Formation	sandstone & mudstone
Algebuckina Sandstone	Clayey sandstone

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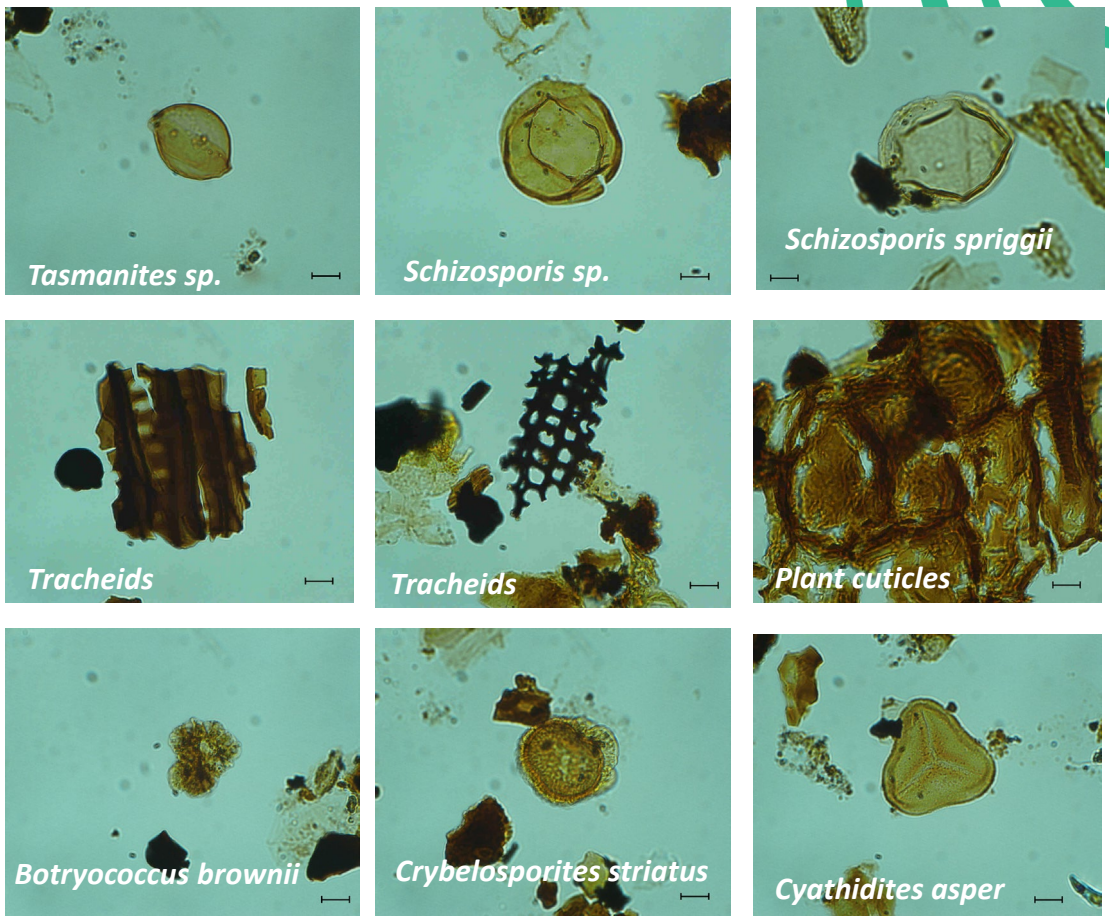
Cadna-owie Formation

Palynology results drillholes NDING_05 and NDING_06:

- Dominance of freshwater algae *Botryococcus brownii, Tasmanites sp.* and *Schizosporis spriggii,* terrestrial pollen and spores, plant cuticles and tracheids
- Age: Late Aptian-Early Albian correlated with the *Crybelosporites striatus* Spore-Pollen Zone
- Key taxa: *Crybelosporites striatus, Biretisporites spectabilis, Leptolepidites verrucatus, Cyathidites asper*
- Depositional environment: upper part of the Cadna-owie Formation deposited in the freshwater fluvio-lacustrine environment



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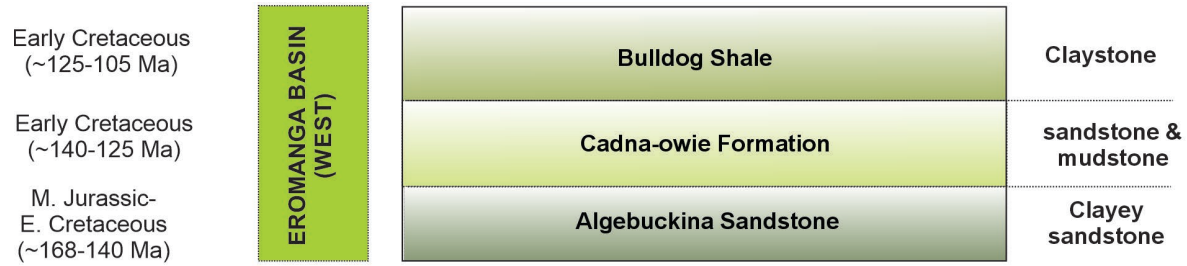

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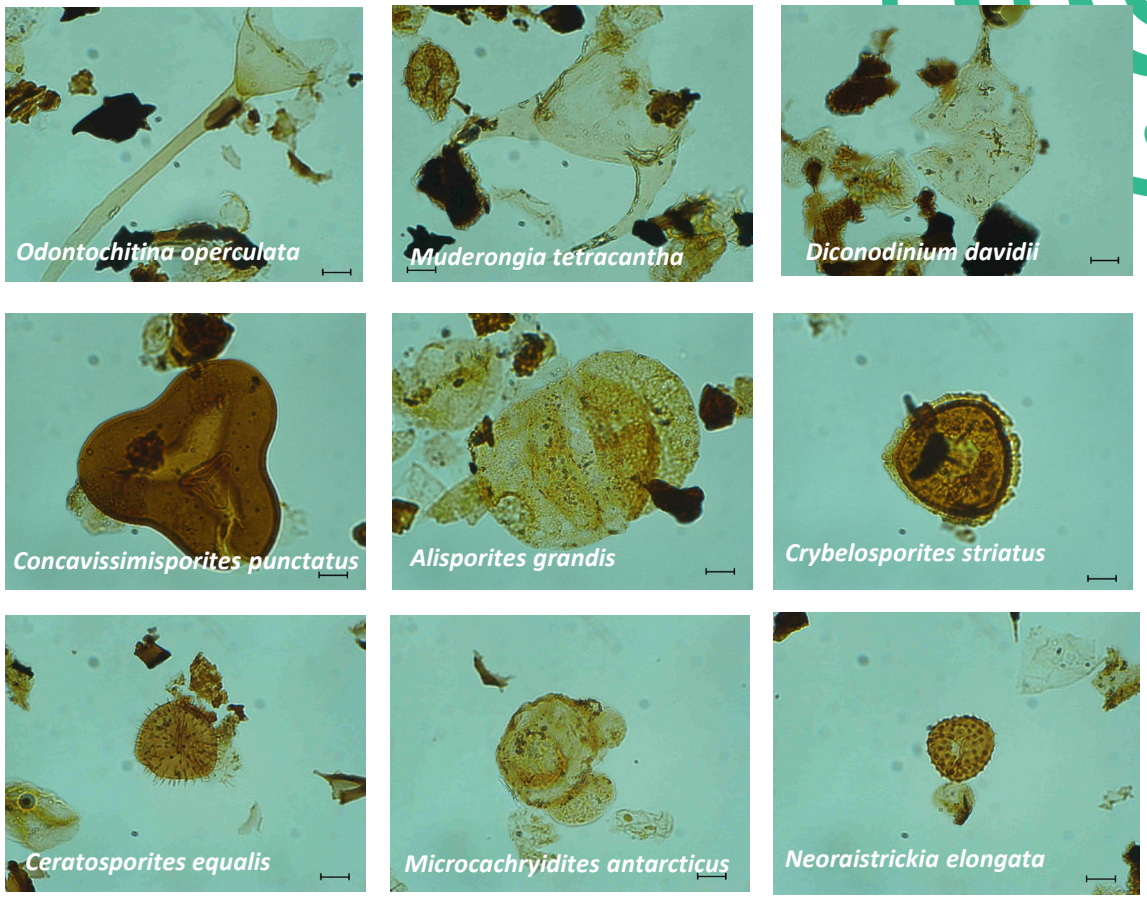
Bulldog Shale

Palynology results drillholes NDING_04, NDING_05, NDING_06:

- Rich and diverse palynomorphs including fern spores, conifer and gymnosperm pollen, marine dinoflagellate cysts, freshwater algae, acritarchs
- Age: Aptian-Early Albian correlated with the *Odontochitina operculata* and *Diconodinium davidii* Dinoflagellate Zone and *Crybelosporites striatus* Pollen-Spore Zone
- Key taxa: *Odontochitina operculata, Muderongia tetracantha, M. australis, Diconodinium davidii, Crybelosporites striatus.*
- Depositional environment: interpreted as shallow marine, conditions changing from fully marine (transgressions) to periodic brackish episodes caused by fluvial and freshwater input.



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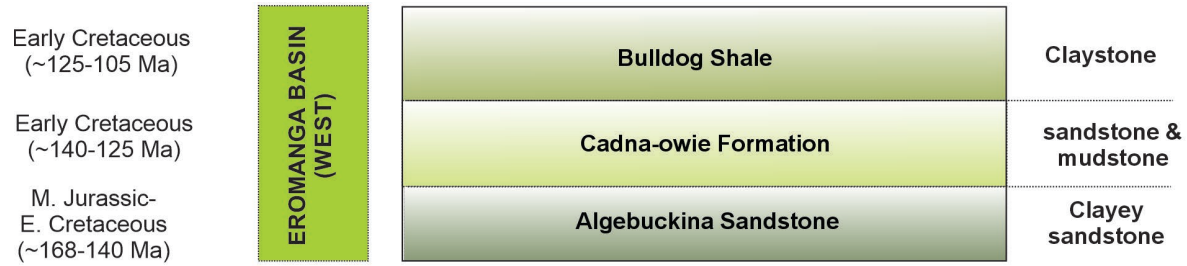

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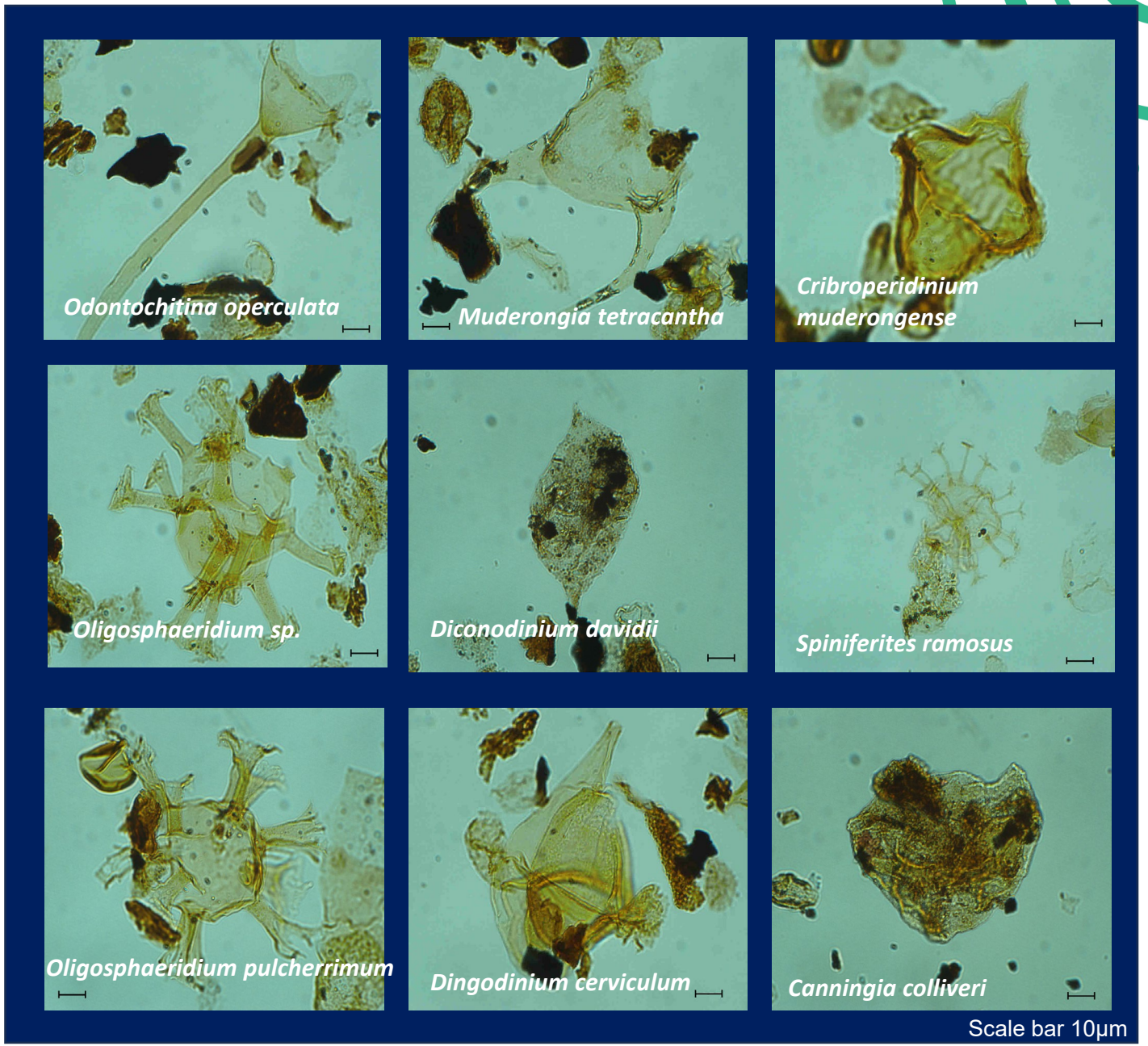
Early Cretaceous Marine Dinocysts

- *Diconodinium davidii, Muderongia tetracantha, M. australis, Dingodinium cerviculum, Odontochitina operculata* are typically associated with inner–middle neritic settings (shallow marine environment), and low to normal salinity conditions
- *Spiniferites ramosus* – a cosmopolitan species common in open marine to neritic waters; suggests normal marine salinity
- *Oligosphaeridium* spp. are marine, often linked to inner to middle shelf, sometimes associated with nutrient-rich waters
- *Canningia colliveri* –indicates shallow marine to marginal-marine

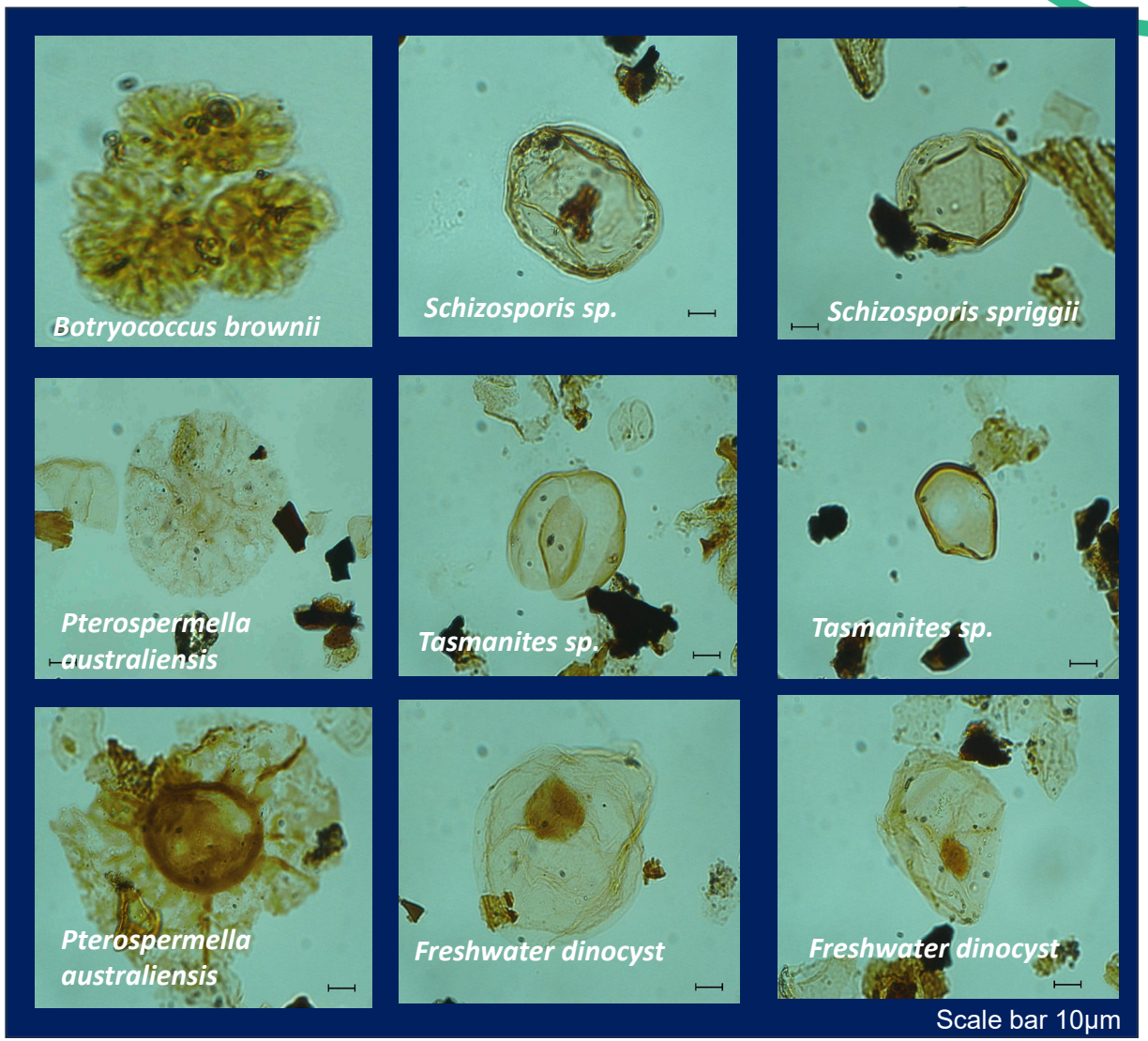


Freshwater - Brackish Taxa Eromanga Basin

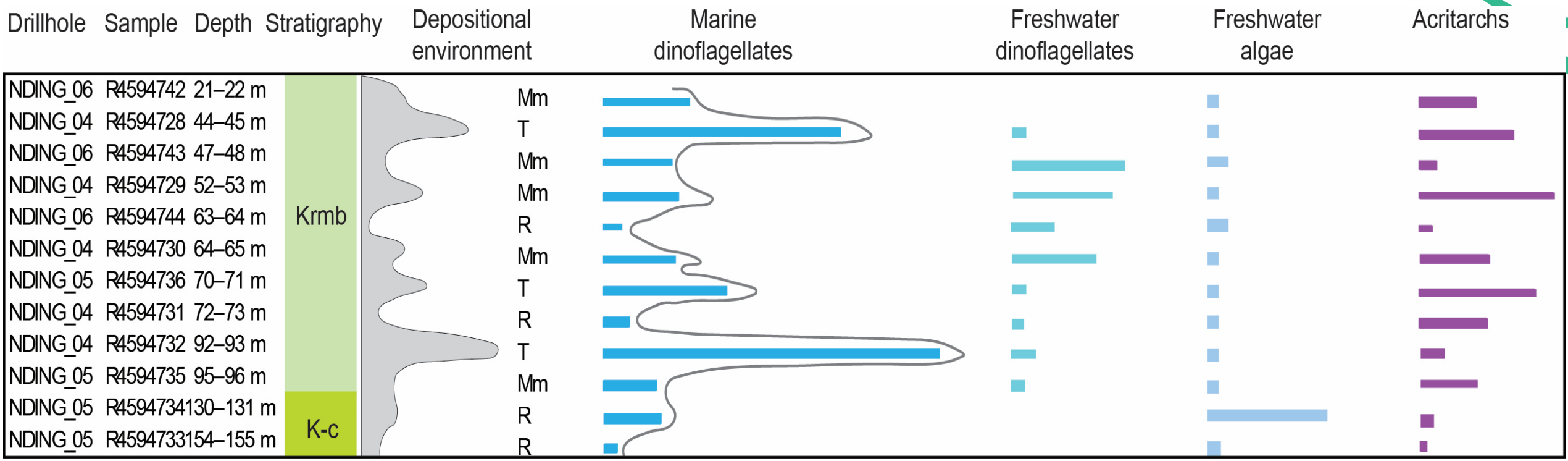
- Freshwater algae *Botryococcus brownii* – indicator of fluvial, marshland or freshwater ponds; associated with low salinity
- Freshwater algae *Schizosporis sprigii* is a strong indicator of river mouth and delta front conditions
- *Pterospermella australiensis* is a low salinity to brackish acritarch, usually found in the samples with freshwater algae. A strong indicator of inner shelf, lagoonal or estuarine environments.

Freshwater taxa are used for detailed stratigraphic interpretation of:

- Shoreline mapping (mix of freshwater and marine)
- Lowstand phase – indicating more fluvial input
- Regressive phase – when seawater retreats and deltas prograde into marine settings



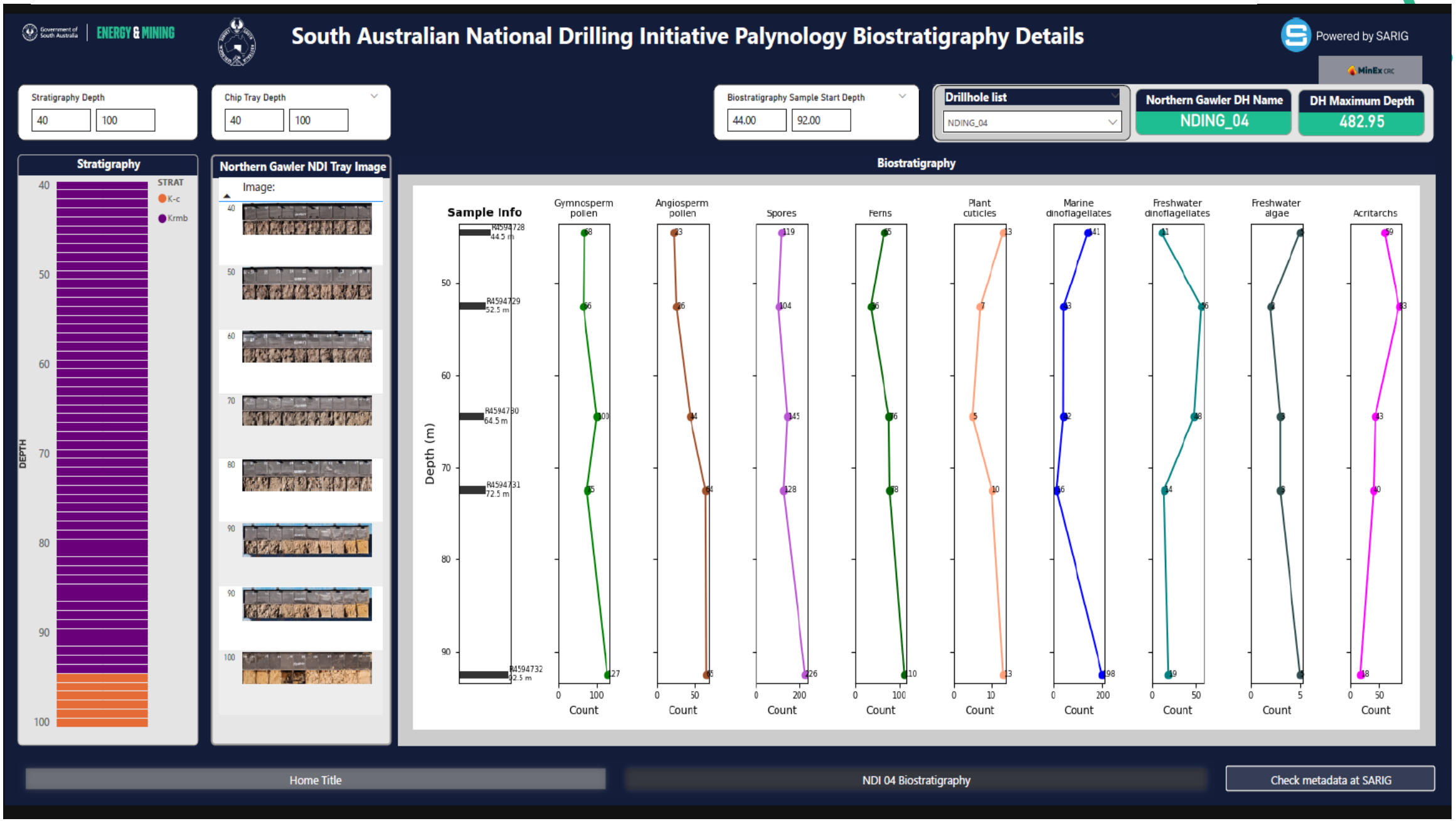
Depositional Environment Eromanga Basin



Mm: marginal marine; T: Transgression; R: Regression

- Palynological evidence for four marine transgressions events in the Bulldog Shale:
- Basal Early Aptian sharp increase in marine dinocysts and reduction of freshwater taxa
- Two Middle Aptian moderate marine transgressions, shallow water, acritarchs and freshwater input
- Late Aptian-Early Albian in the upper part of Bulldog Shale – second major flooding event

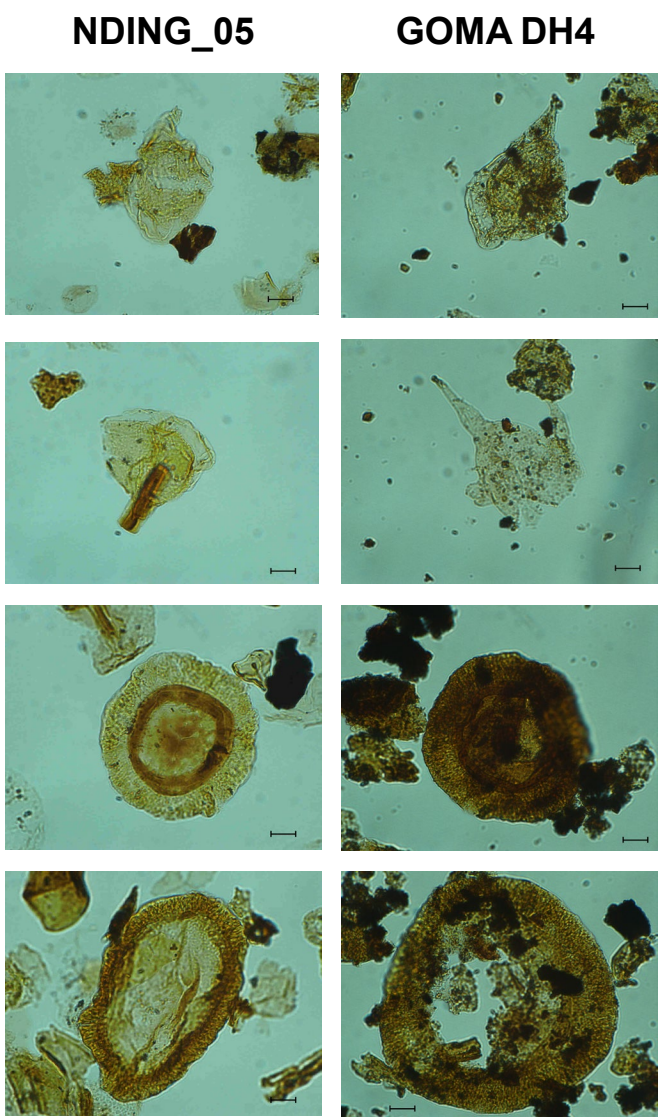
Dashboard Style Biostratigraphy Charts

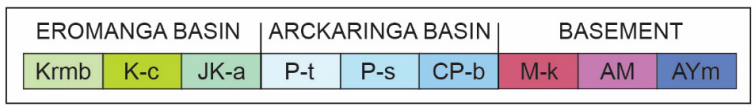


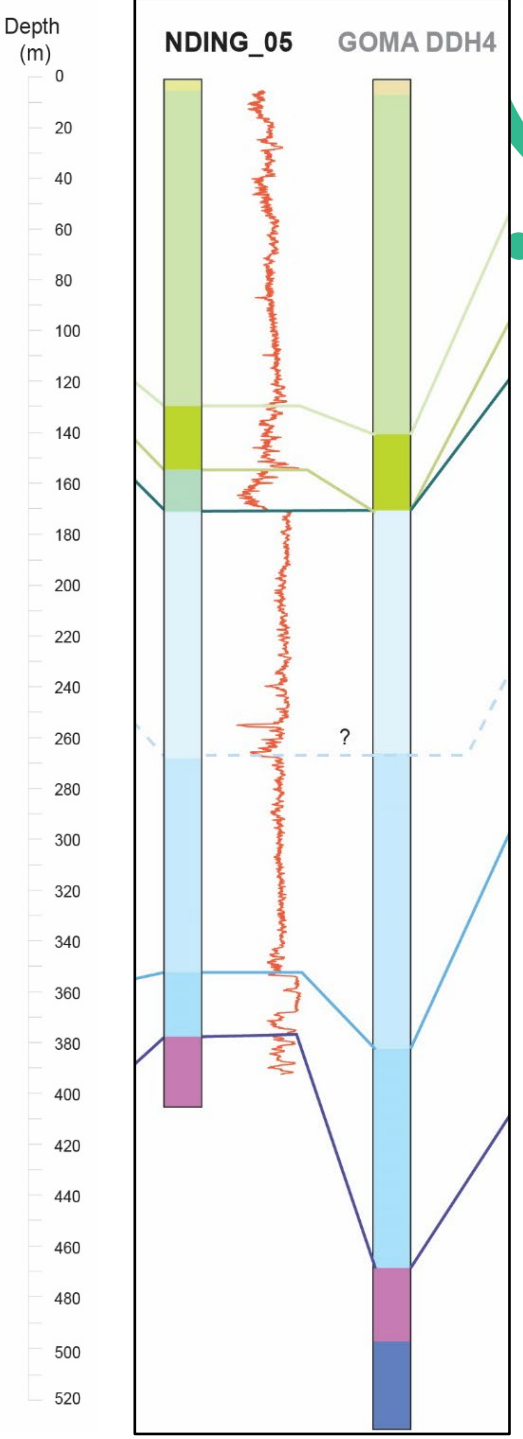
Mesozoic Faults Reactivation

Evidence for supporting tectonic reactivation during Aptian-Albian and introduction of Early Cretaceous palynomorphs into Permian sediments:

- Proximity to a mapped shear zone
- Spatial consistency between multiple drillholes (364–366m in both NDING_05 and GOMA DH4)
- Presence of Aptian-Albian marine dinocysts, well preserved, alongside typical Permian taxa
- Groundwater transport of palynomorphs. Near shear zone groundwater circulates vertically, some fractures remain open and palynomorphs from above Early Cretaceous sediments are transported into underlying Permian rocks.
- Evidence in other basins (Cooper and Otway Basins) reactivation of some faults allows Cenozoic microfossils to appear in Triassic and Cretaceous sediments.







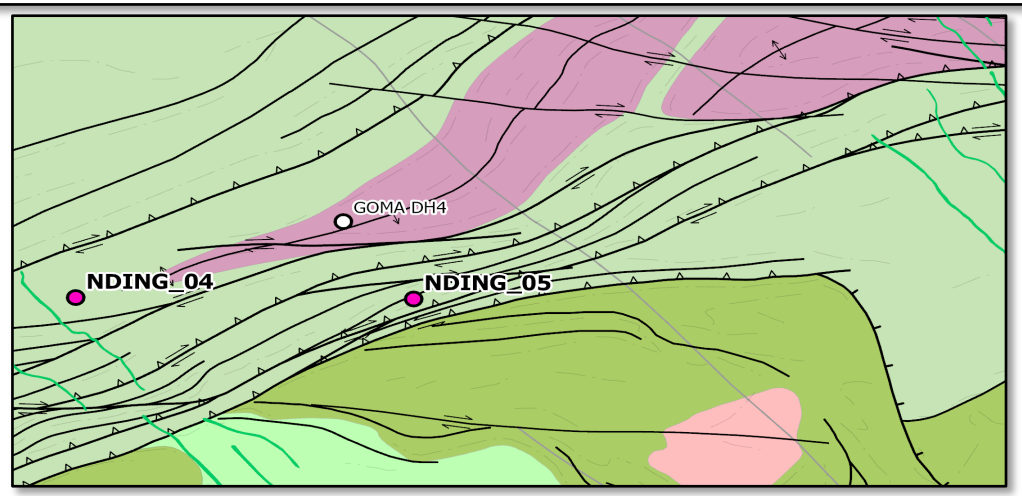
Summary

Palynological analysis and dating is providing age control for:

- Permian formations (Boorthanna, Stuart Range and Mount Toondina in the Arckaringa Basin) assigned to Asselian-Sakmarian and correlated with the SA3 and PP1-PP2 Palynozones
- Early Cretaceous formations (Cadna-owie and Bulldog Shale in the Eromanga Basin) assigned to Aptian to Early Albian and correlated with *Odontochitina operculata-Diconodinium davidii* Dinoflagellate Zones and *Crybelosporites striatus* Pollen-Spore Zones

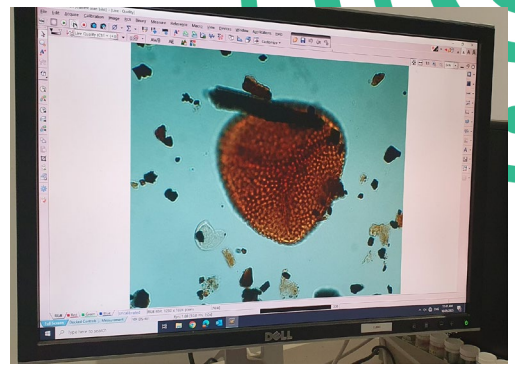
Interpretation of the depositional environment:

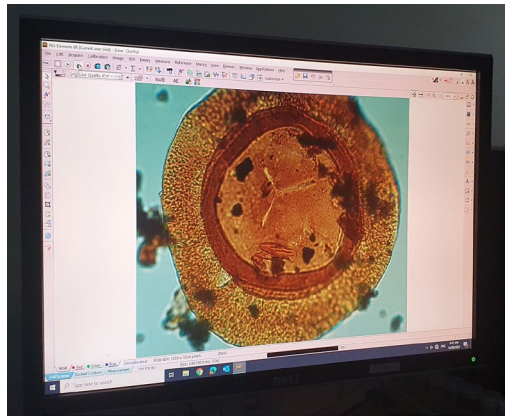
- Glacial to post glacial and lacustrine in Permian
- Fluvio-lacustrine to marginal marine and marine in Early Cretaceous (four marine transgressions in Bulldog Shale)
- Evidence for fault and shear zone reactivation in Mesozoic – downward and lateral transport of Early Cretaceous marine dinoflagellates into Permian units

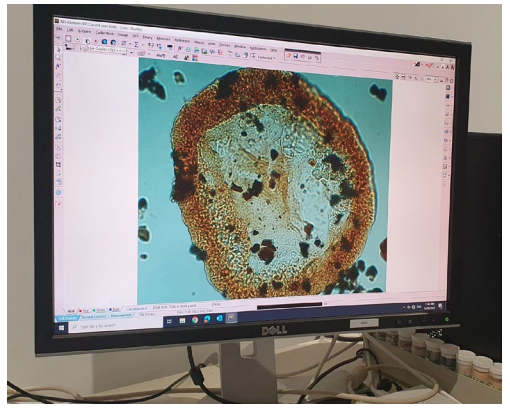


Acknowledgements

- MinEx CRC for full funding of the drilling project and this study
- Claire Wade and Anna Petts for supporting this study
- Jack Percival for producing geological maps
- Alex Zou for writing phython scripts to display biostratigraphy charts on dashboard
- Baohong Hou for producing strata relationships for Arckaringa and Eromanga Basins
- David Groom, Dale Groom, Mark Varga for the help with core inspection and sampling







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Exploring HyLogger data from the Northern Gawler NDI

Dr Alicia Caruso | 9 December 2025

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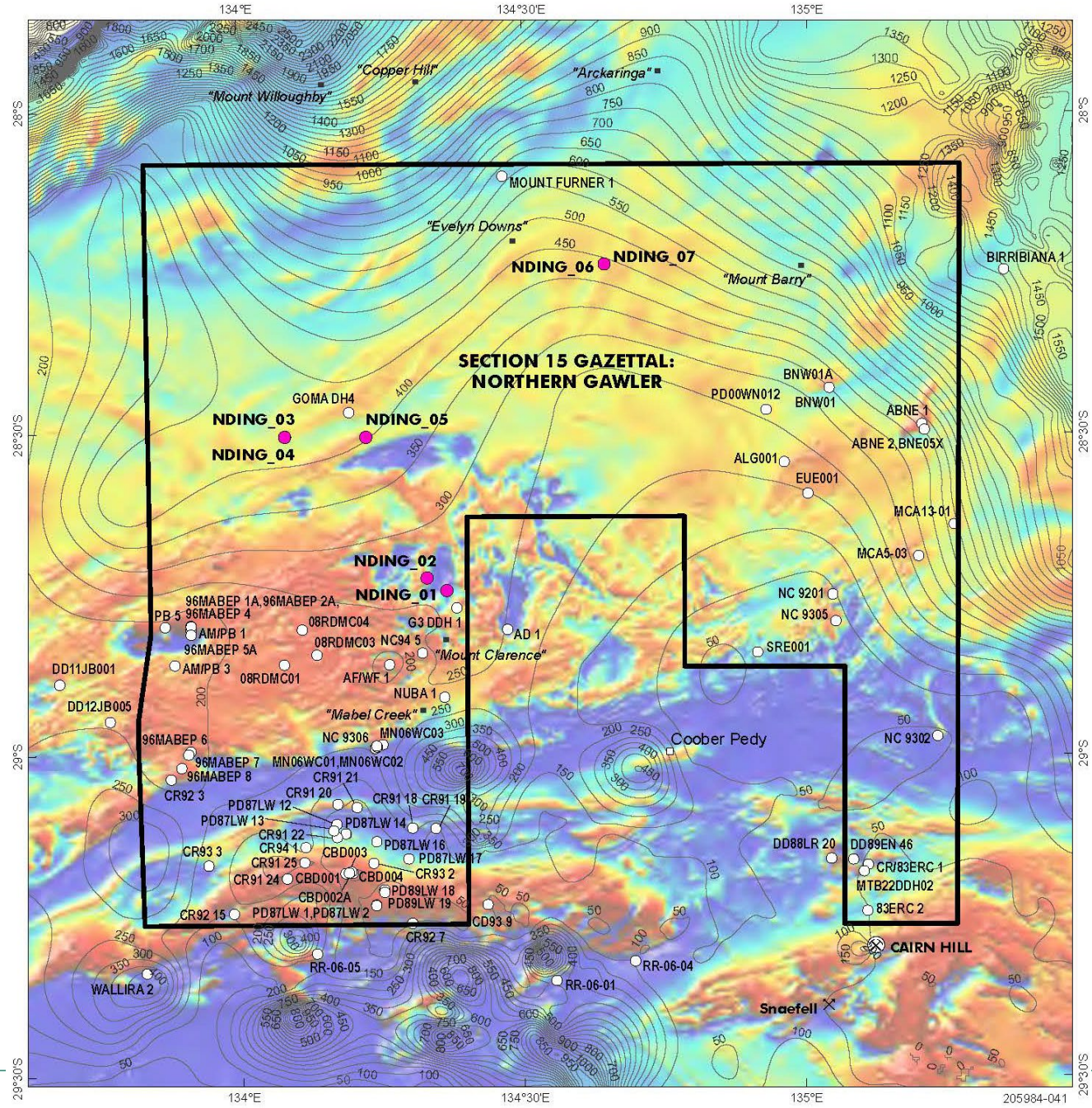
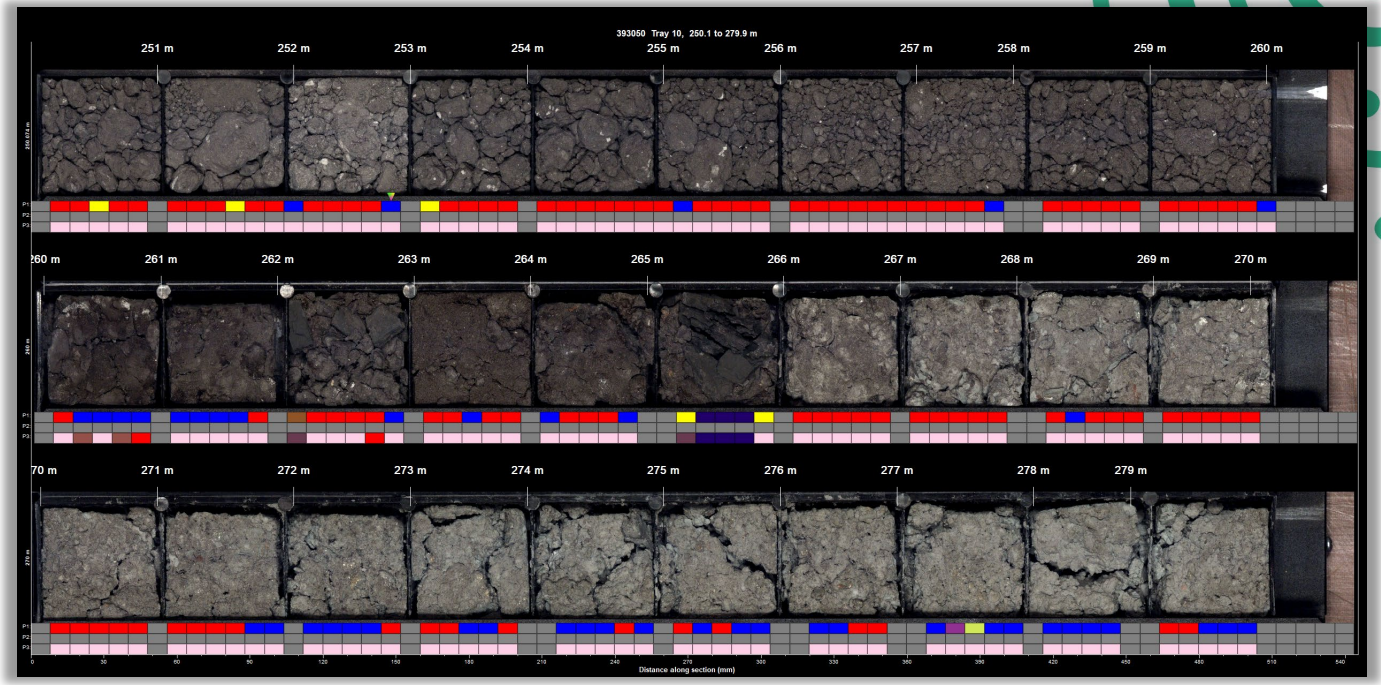
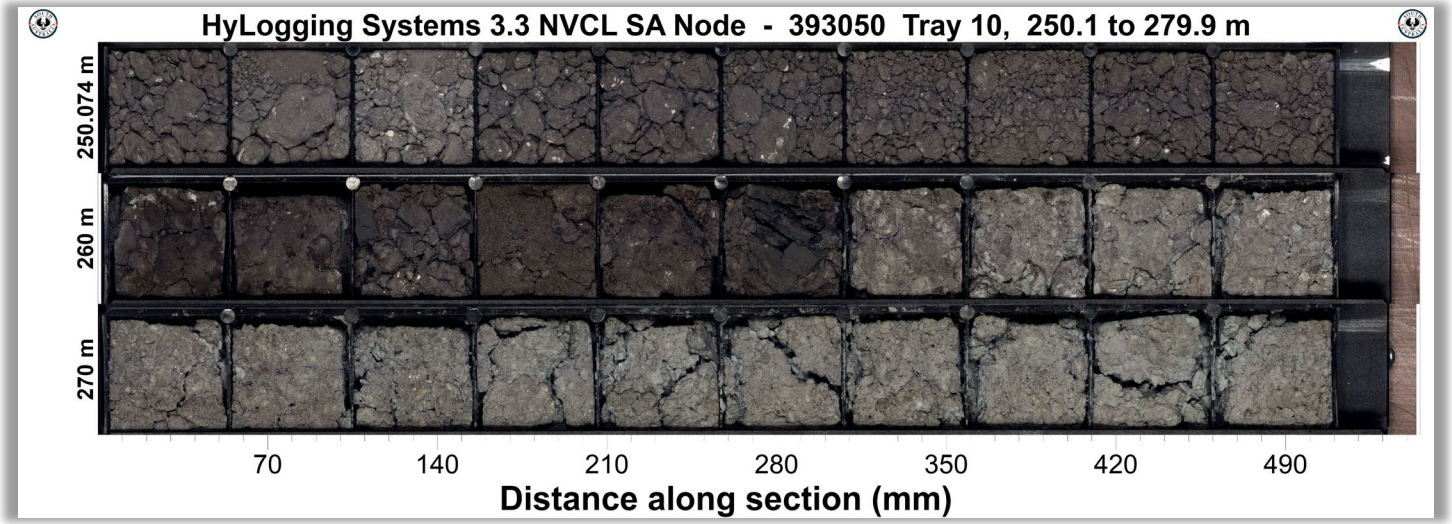
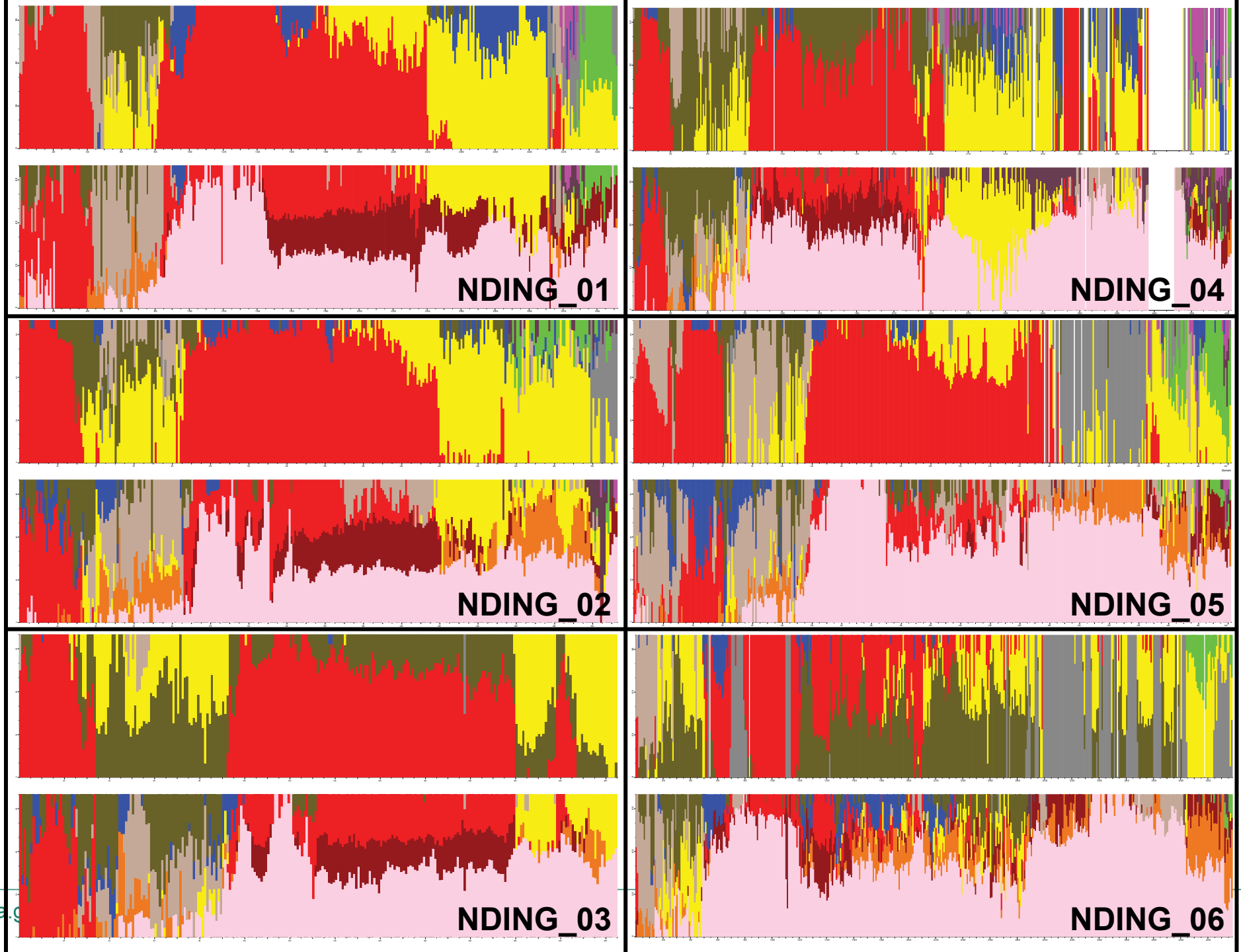

134°E
134°30'E
135°E
28°S
28°30'S
29°S
29°30'S
SECTION 15 GAZETTAL:
NORTHERN GAWLER
NDING_01
NDING_02
NDING_03
NDING_04
NDING_05
NDING_06
NDING_07
MOUNT FURNER 1
"Evelyn Downs"
"Mount Barry"
"Arckaringa"
"Copper Hill"
"Mount Willoughby"
BIRRIBIANA 1
GOMA DH4
BNW01A
PD00WN012
BNW01
ABNE 1
ABNE 2,BNE05X
ALG001
EUE001
MCA13-01
MCA5-03
NC 9201
NC 9305
SRE001
NC 9302
AD 1
G3 DDH 1
"Mount Clarence"
NC94 5
08RDMC04
08RDMC03
08RDMC01
AM/PB 1
AM/PB 3
96MABEP 1A,96MABEP 2A,
96MABEP 4
96MABEP 5A
PB 5
AF/WF 1
NUBA 1
"Mabel Creek"
DD11JB001
DD12JB005
96MABEP 6
96MABEP 7
96MABEP 8
NC 9306
MN06WC03
MN06WC01,MN06WC02
CR91 21
CR91 20
CR91 18
CR91 19
CR92 3
PD87LW 12
PD87LW 13
PD87LW 14
CR91 22
CR94 1
CR91 25
CR91 24
CR93 3
CBD003
CBD001
CBD004
PD87LW 16
PD87LW 17
CR93 2
CBD002A
PD89LW 18
PD89LW 19
CR92 15
PD87LW 1,PD87LW 2
CD93 9
CR92 7
Coober Pedy
DD88LR 20
DD89EN 46
CR/83ERC 1
MTB22DDH02
83ERC 2
CAIRN HILL
RR-06-04
RR-06-01
RR-06-05
WALLIRA 2
Snaefell
205984-041

Data Overview

- Single row scan of each chip tray, merged with core tray data
- Masking and depth adjustments
- ‘Domain edited’ mineralogy
- Addition of updated stratigraphy, lithology logs and pXRF to TSG files
- Scalars available within datasets to explore data further



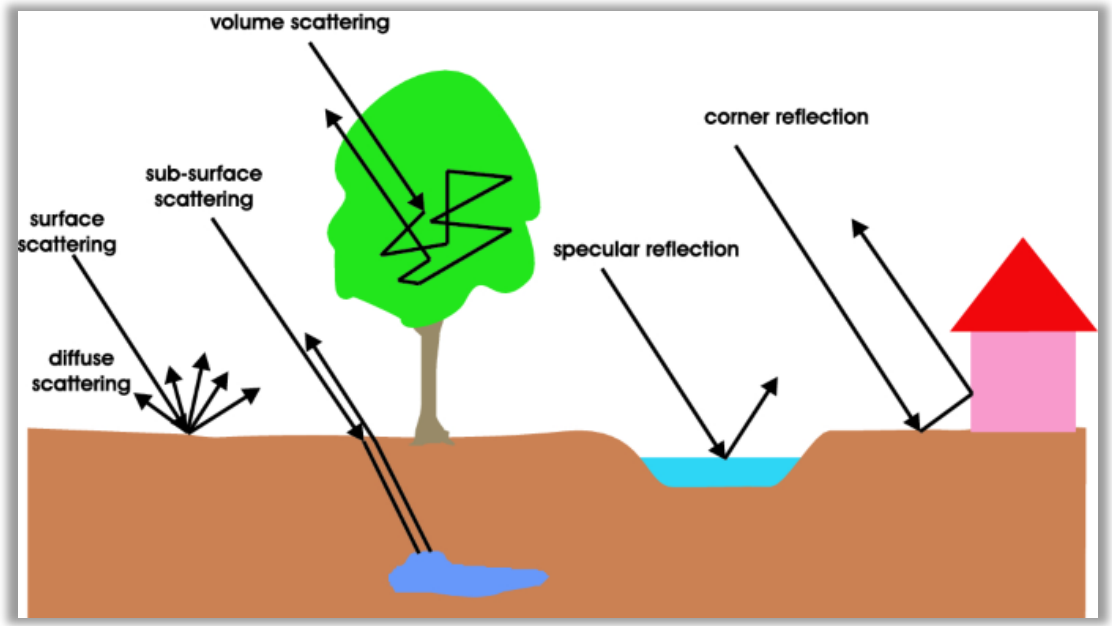




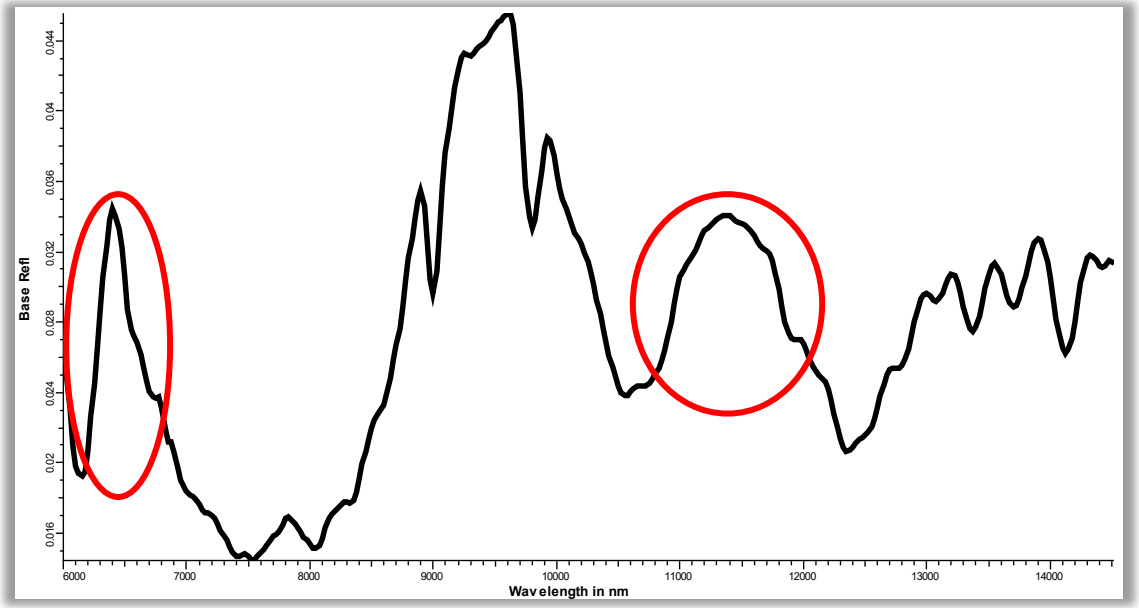
AMPHIBOLE
CARBONATE
CHLORITE
DARK-MICA
INVALID
KAOLIN
K-FELDSPAR
PLAGIOCLASE
SILICA
SMECTITE
SULPHATE
WHITE-MICA

TIR Volume Scattering

- Due to clinging fines
  - Common problem in chips
- Identification of large ‘bump’ at ~11,400 nm, and sharp 6,390 nm (pseudo-carbonate TIR feature)
  - Unmixing algorithms want to identify carbonate
- Does not mean all carbonates are false
- Mappable feature across drill holes



Awange & Kiema (2018)



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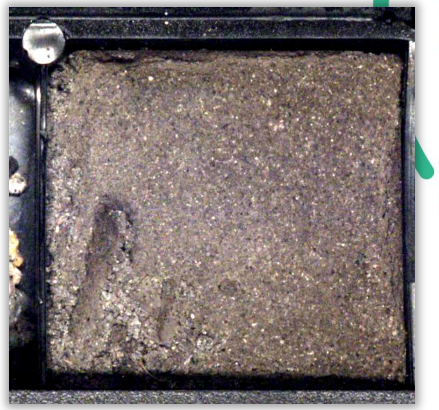
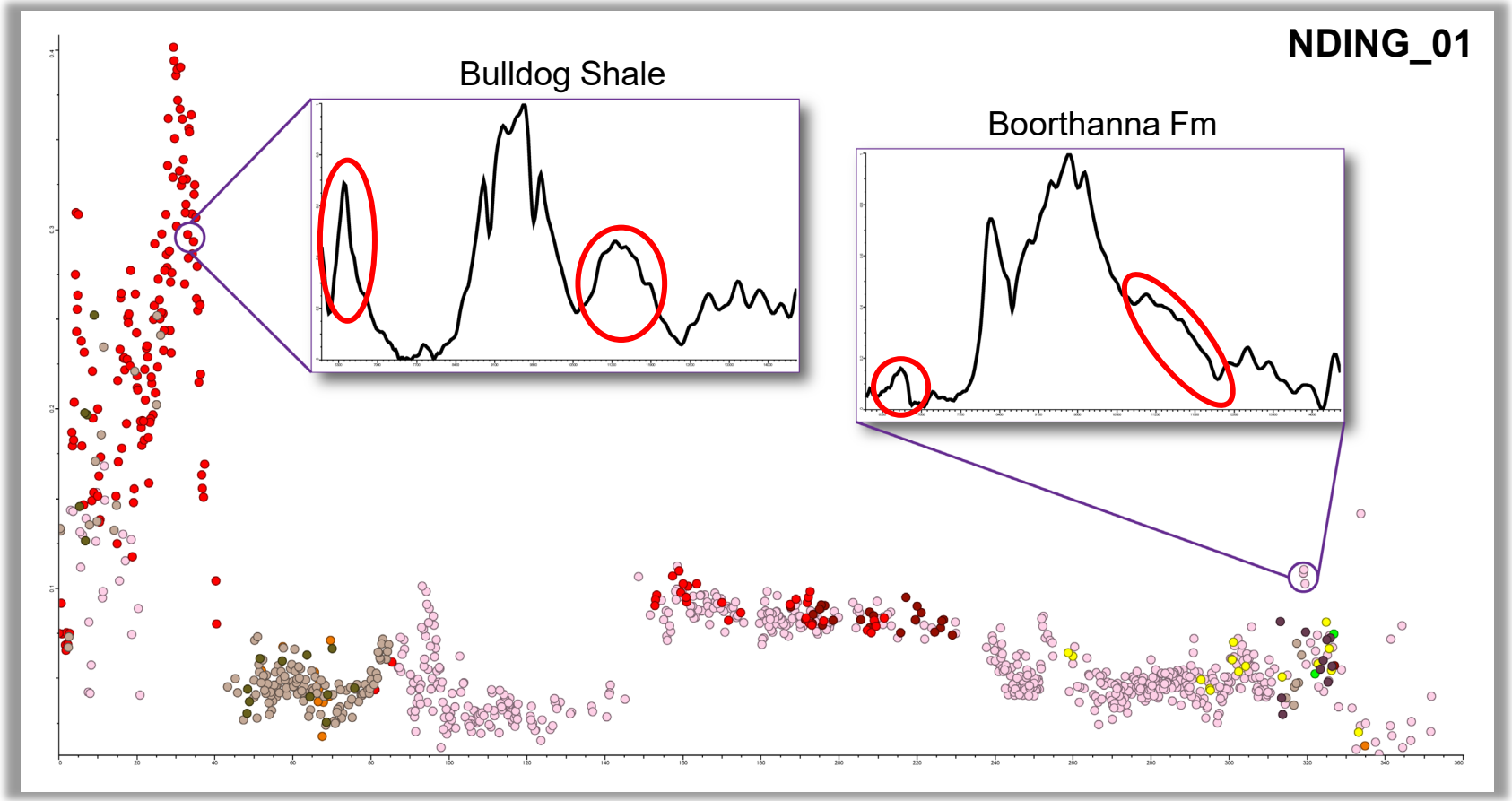
TIR Volume Scattering

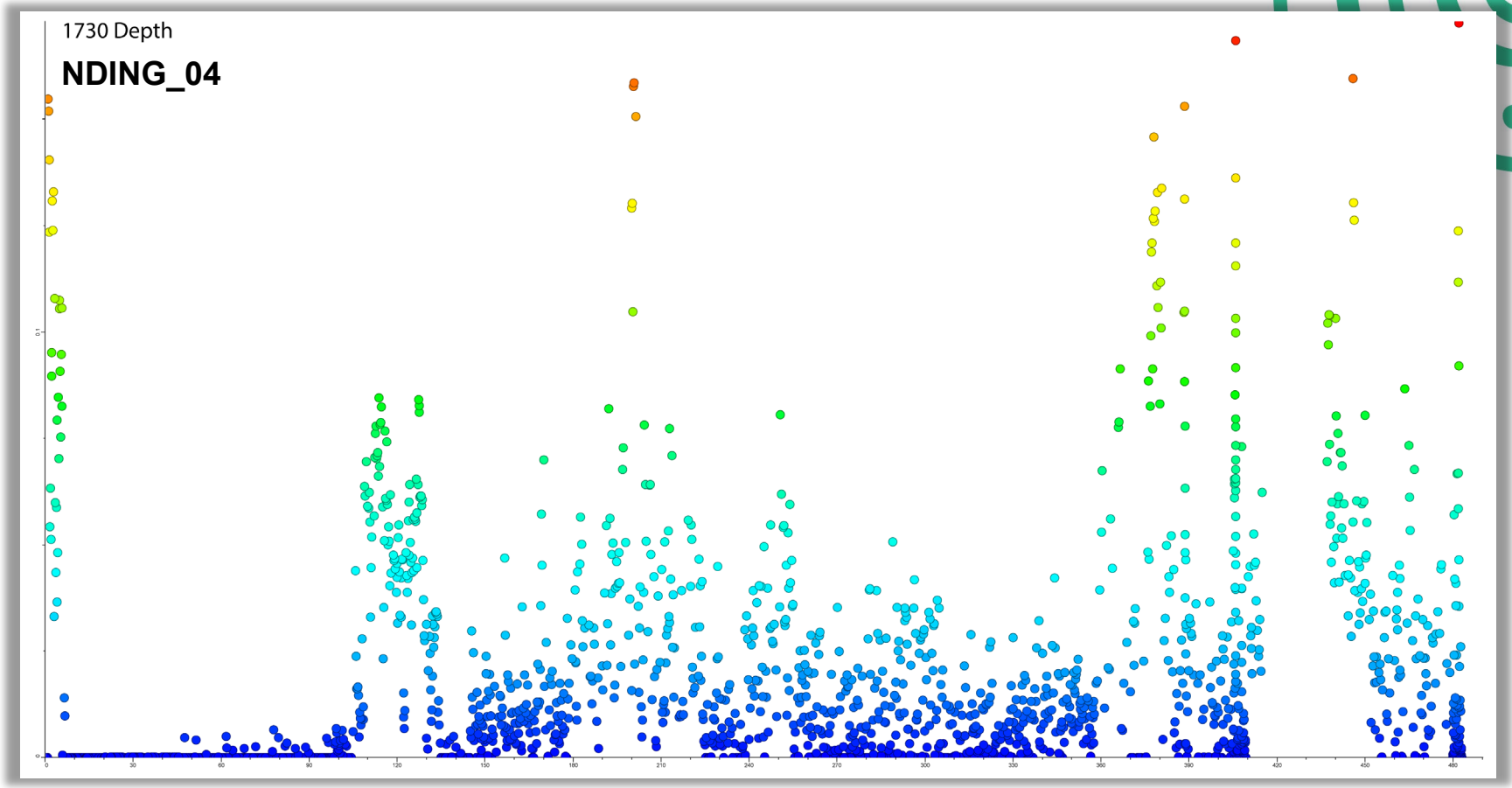


- Greatest impact of volume scattering within Bulldog Shale
- Can impact both coarse- and fine-grained materials
- Some caution should be applied to mineral identification
- Recommended to examine data at ‘Group’ level



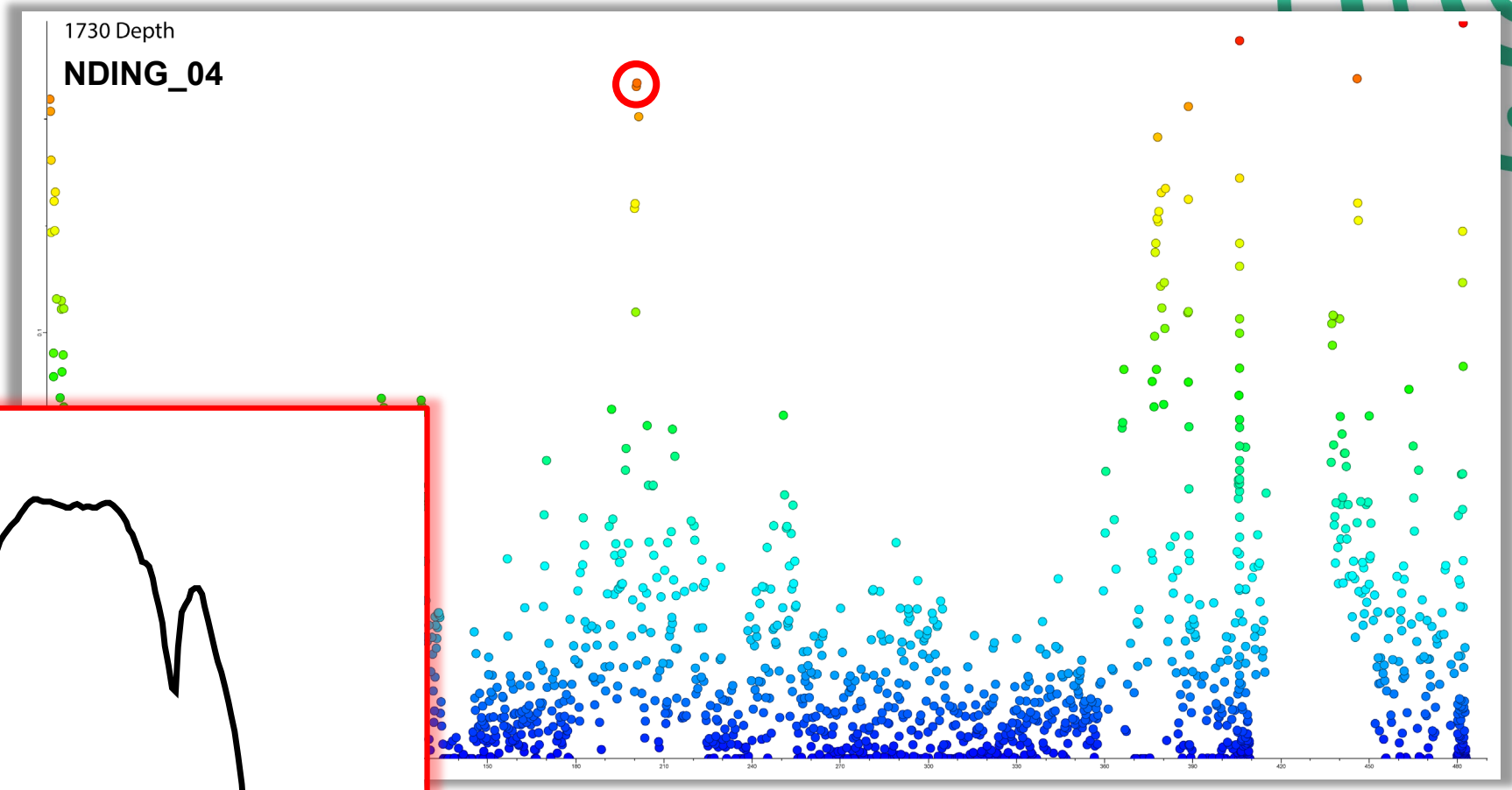
Drilling fluid influence

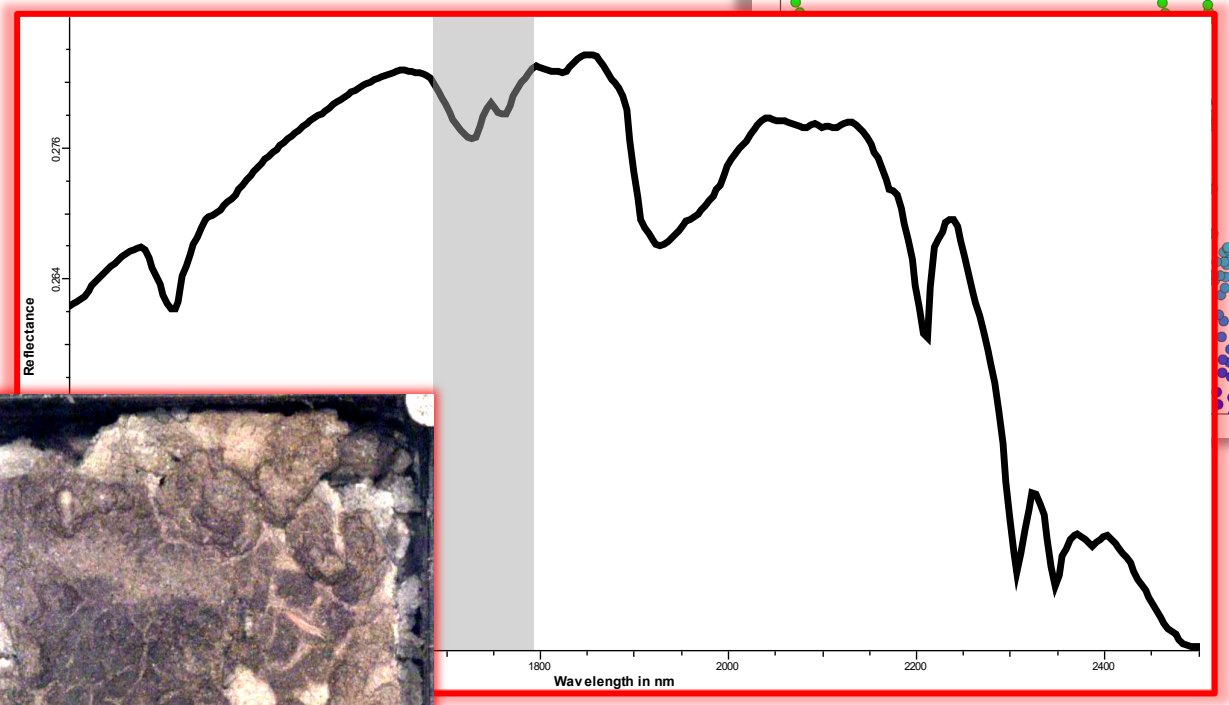
- 1730 nm feature in SWIR



Drilling fluid influence

- 1730 nm feature in SWIR

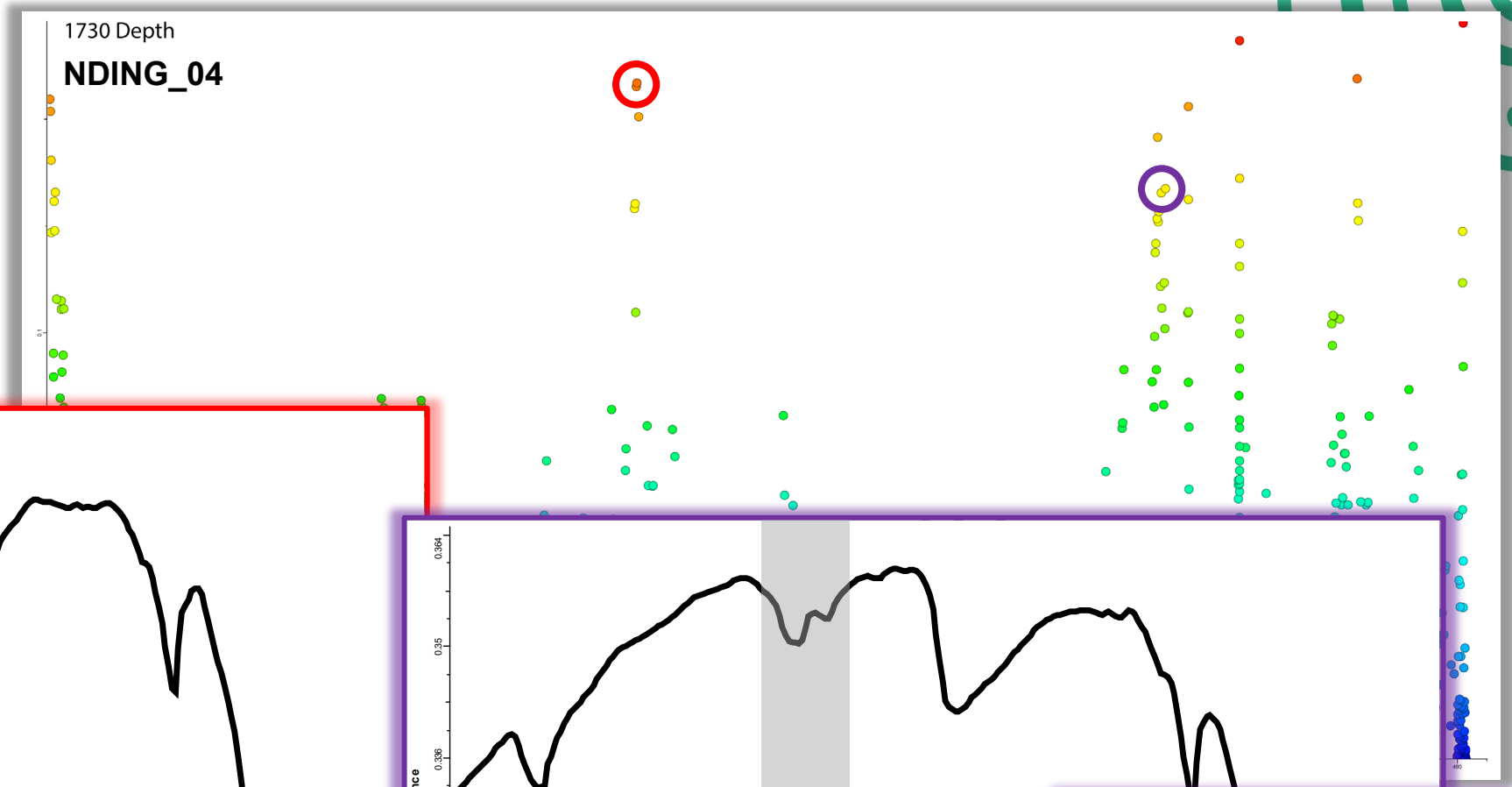


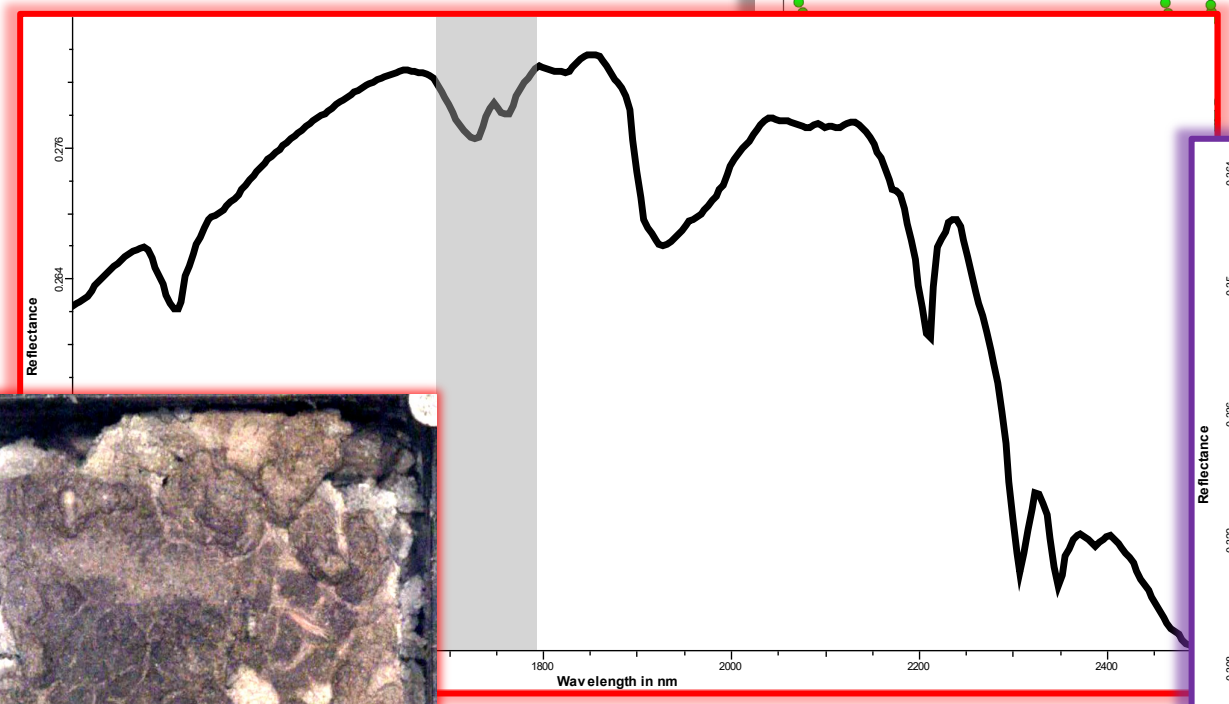


Mt Toondina Fm

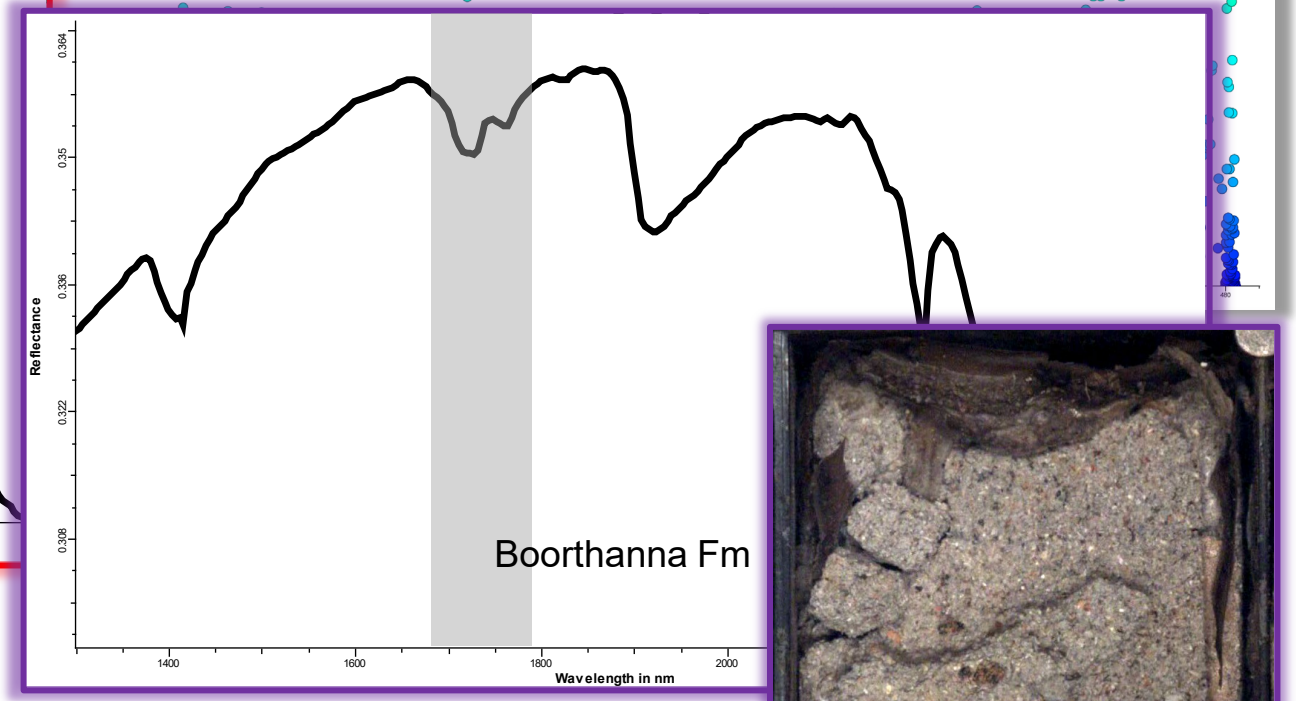
Drilling fluid influence

- 1730 nm feature in SWIR





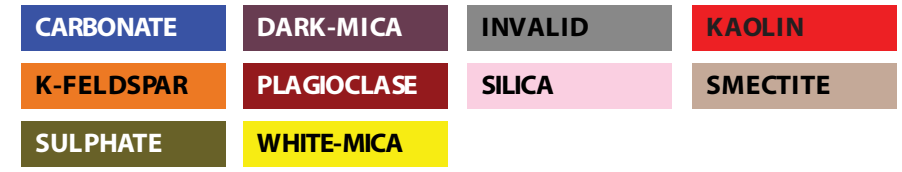
Mt Toondina Fm

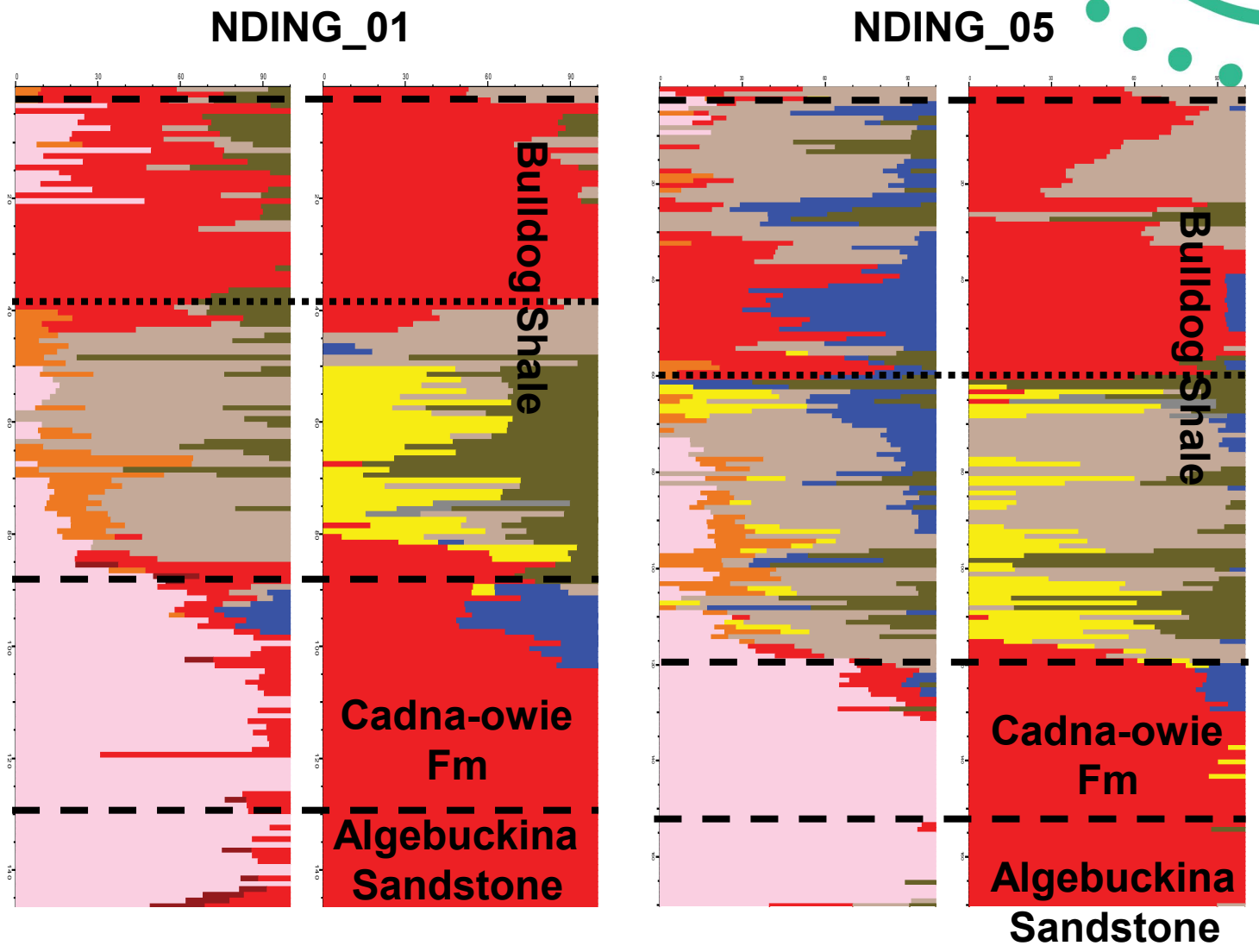


Boorthanna Fm

Mineralogical Overview: Stratigraphy

- Eromanga Basin sediments
  - Bulldog Shale
    - SWIR: kaolin ± smectite ± sulphate (upper), smectite, white mica, sulphate (lower)
    - TIR: kaolin ± quartz (upper), smectite, sulphate, k-feldspar (lower)
  - Cadna-owie Fm
    - SWIR: kaolin, carbonate(?)
    - TIR: quartz, minor kaolin, minor carbonate(?)
  - Algebuckina Sandstone
    - SWIR: kaolin
    - TIR: quartz, minor kaolin, minor plagioclase

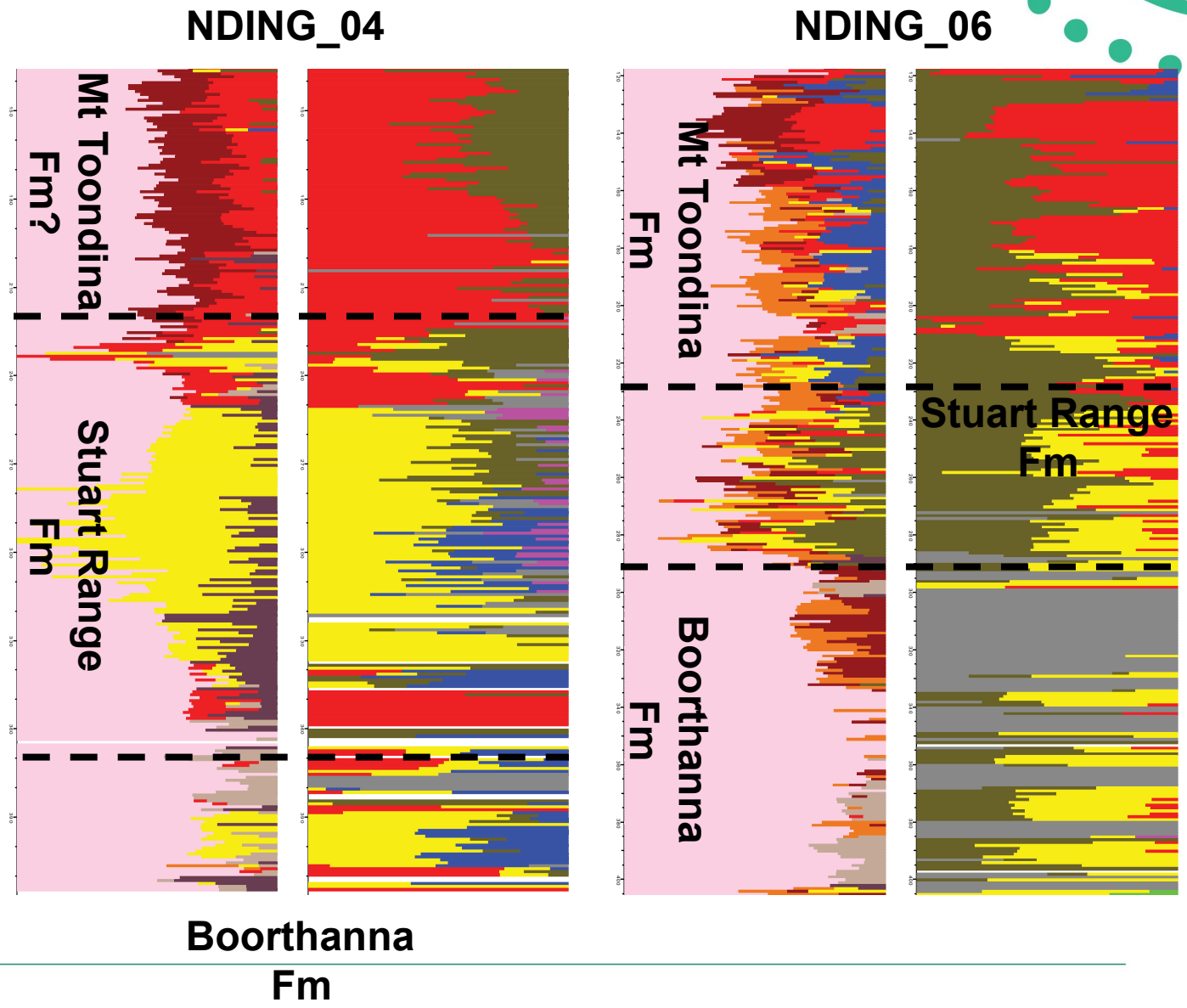




Mineralogical Overview: Stratigraphy

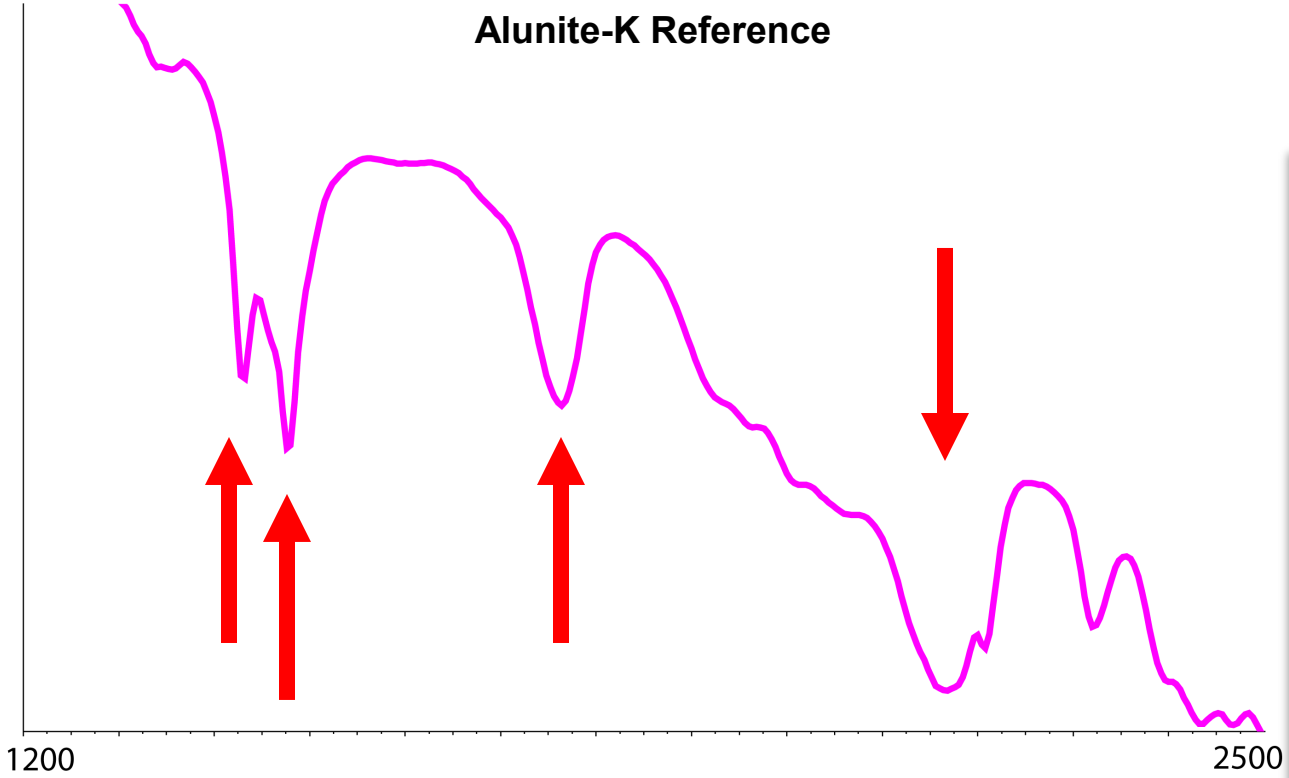
- Arckaringa Basin sediments
  - Mt Toondina Fm
    - SWIR: kaolin, sulphate, white mica
    - TIR: quartz, plagioclase, kaolin, k-feldspar, carbonate(?), white mica
  - Stuart Range Fm
    - SWIR: white mica, sulphate, kaolin, carbonate(?), aspectral
    - TIR: quartz, kaolin, k-feldspar, white mica, dark mica
  - Boorthanna Fm
    - SWIR: white mica, carbonate, sulphate
    - TIR: quartz, smectite, white mica, dark mica minor plagioclase, k-feldspar

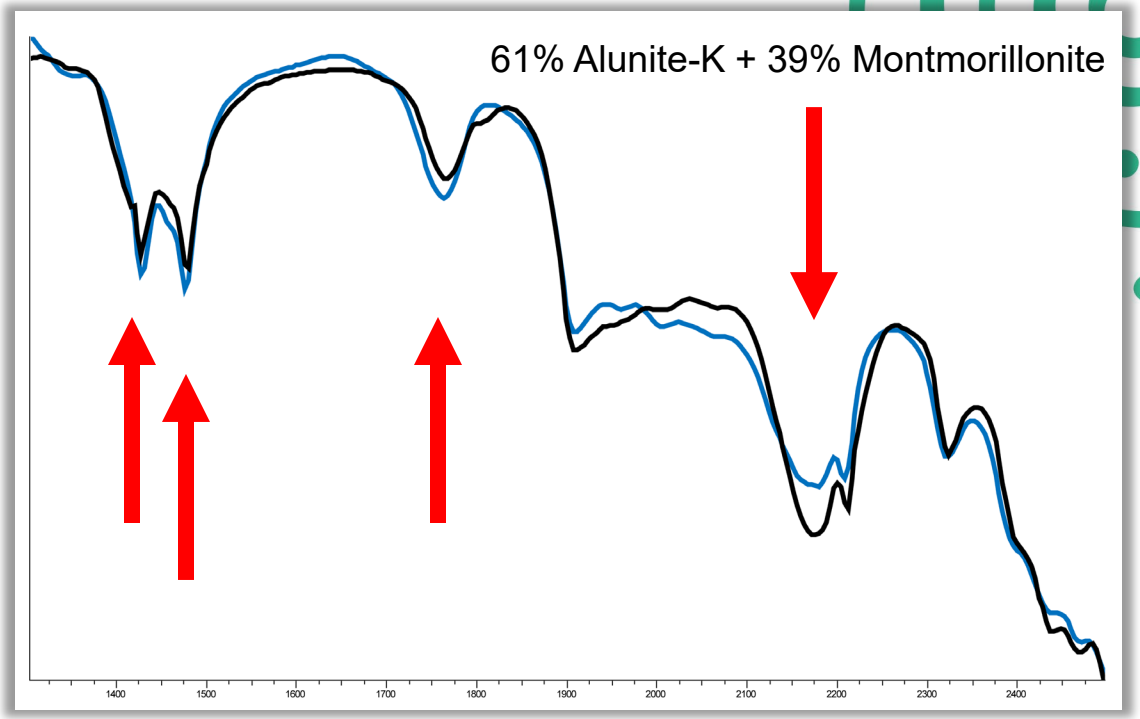
CARBONATE	DARK-MICA	INVALID	KAOLIN
K-FELDSPAR	PLAGIOCLASE	SILICA	SMECTITE
SULPHATE	WHITE-MICA		

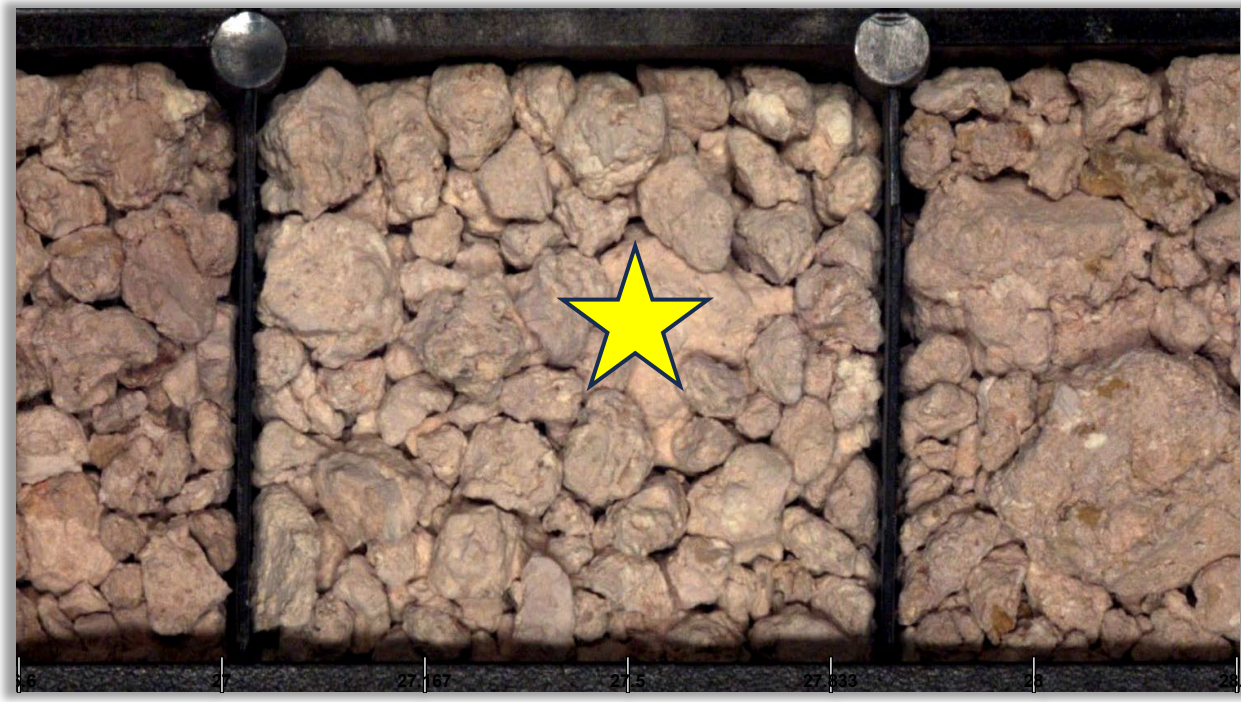


Presence of alunite

- NDING_05 contains an alunite horizon within Bulldog Shale
- Also identified minor alunite in NDING_01, NDING_02

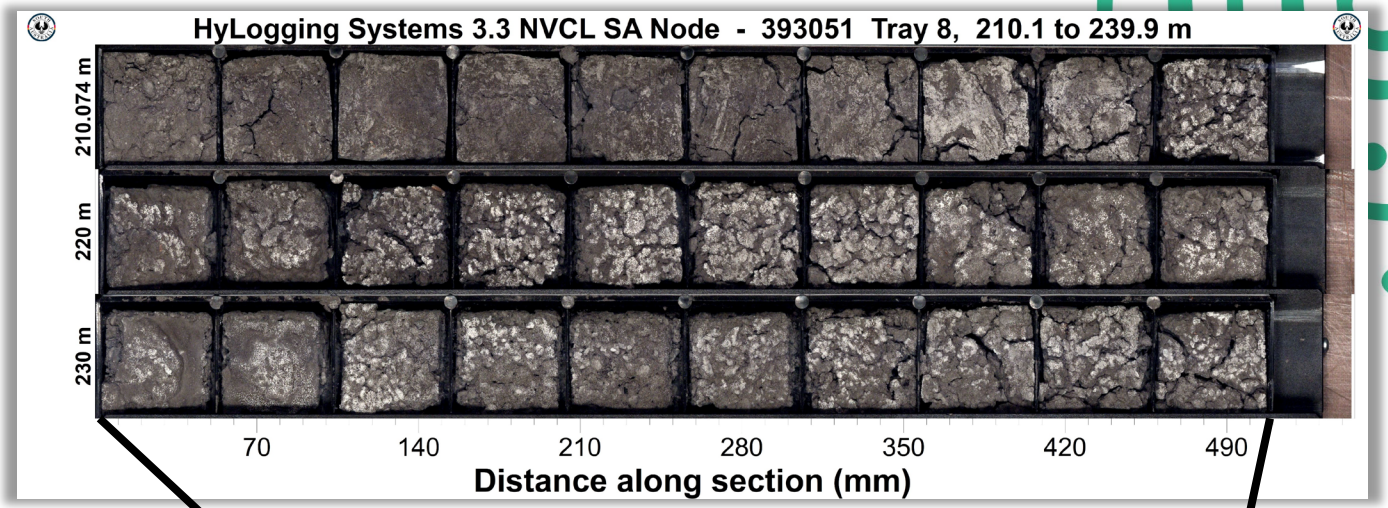


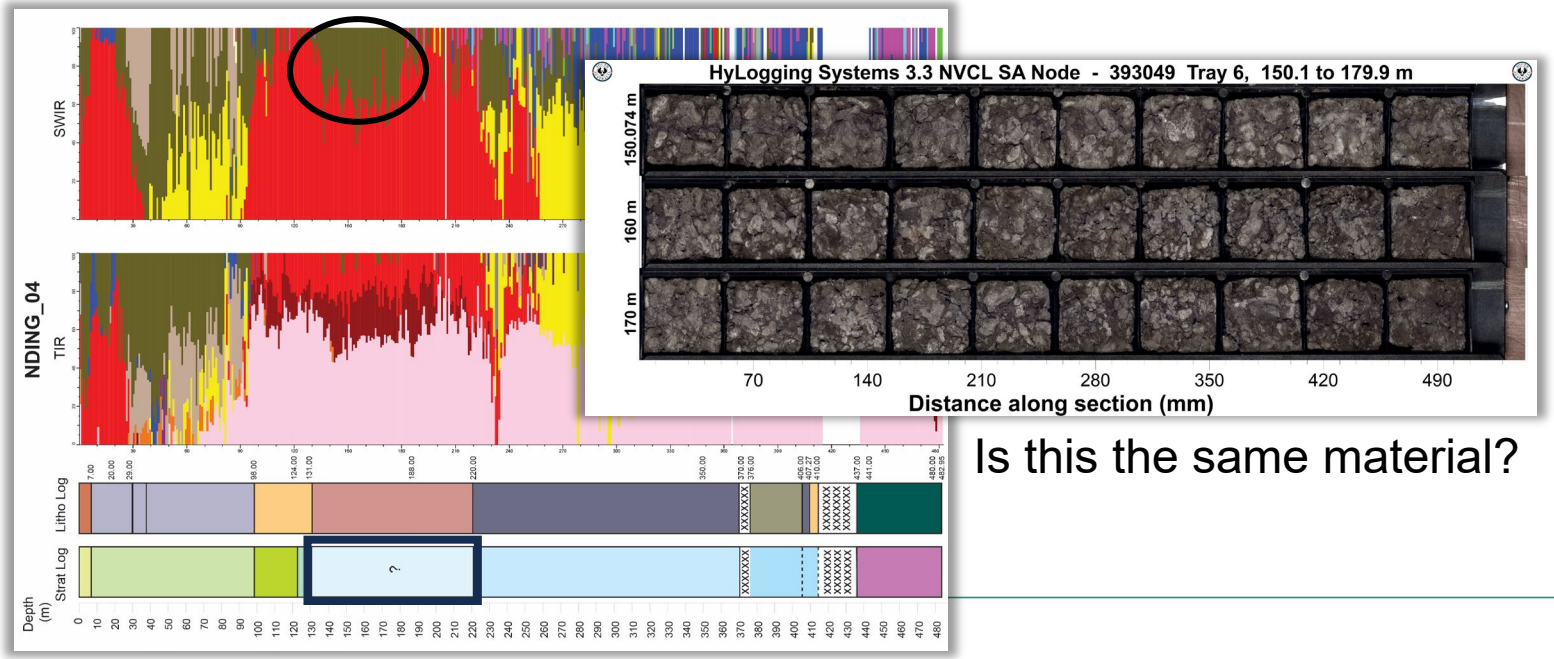




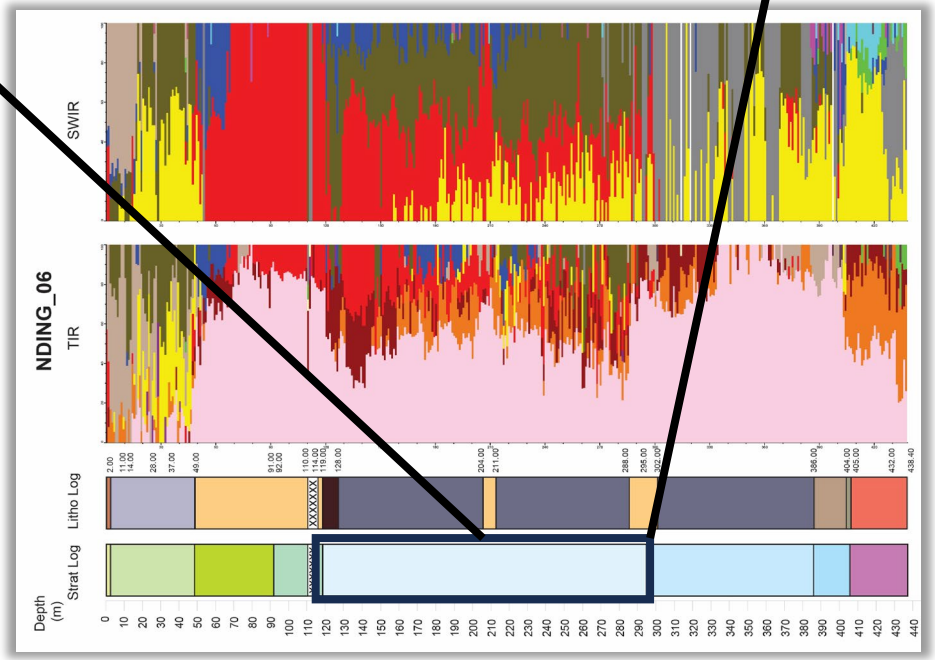
Mt Toondina?

- Mt Toondina identified in more holes than initially logged
- Logged in numerous legacy holes across Nawa Domain
- Is sulphate presence indicative?

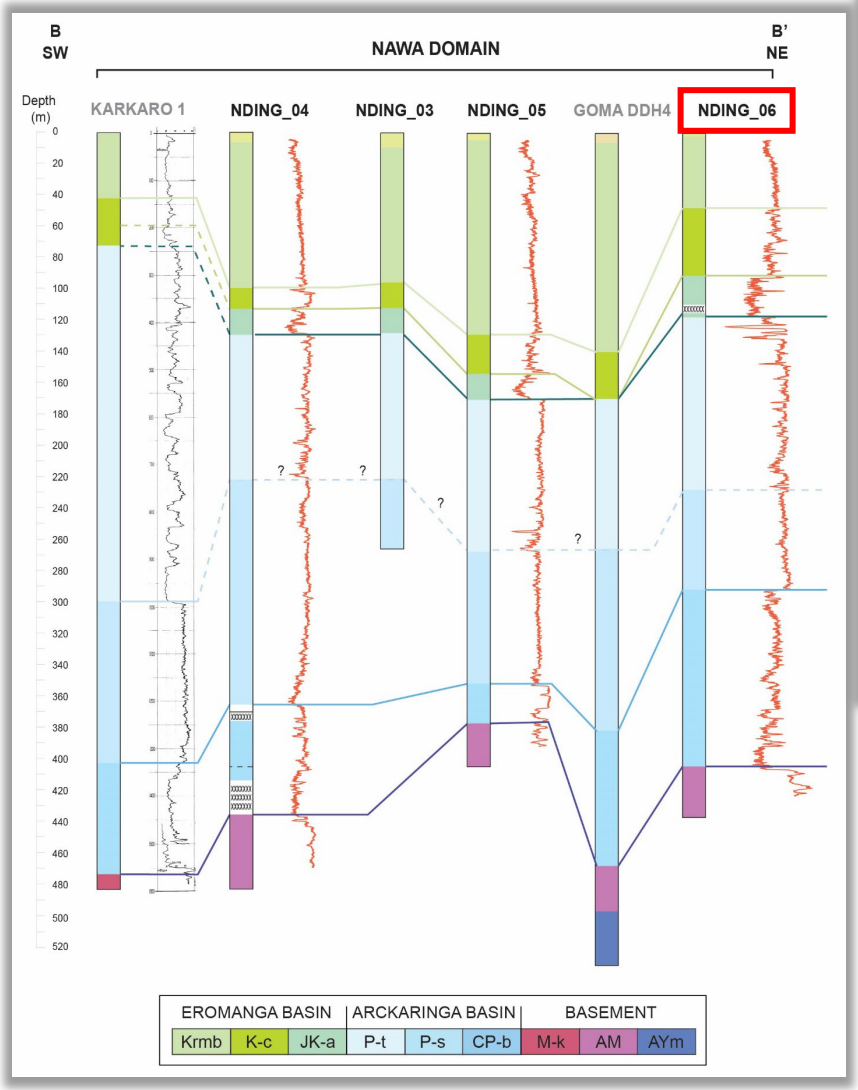


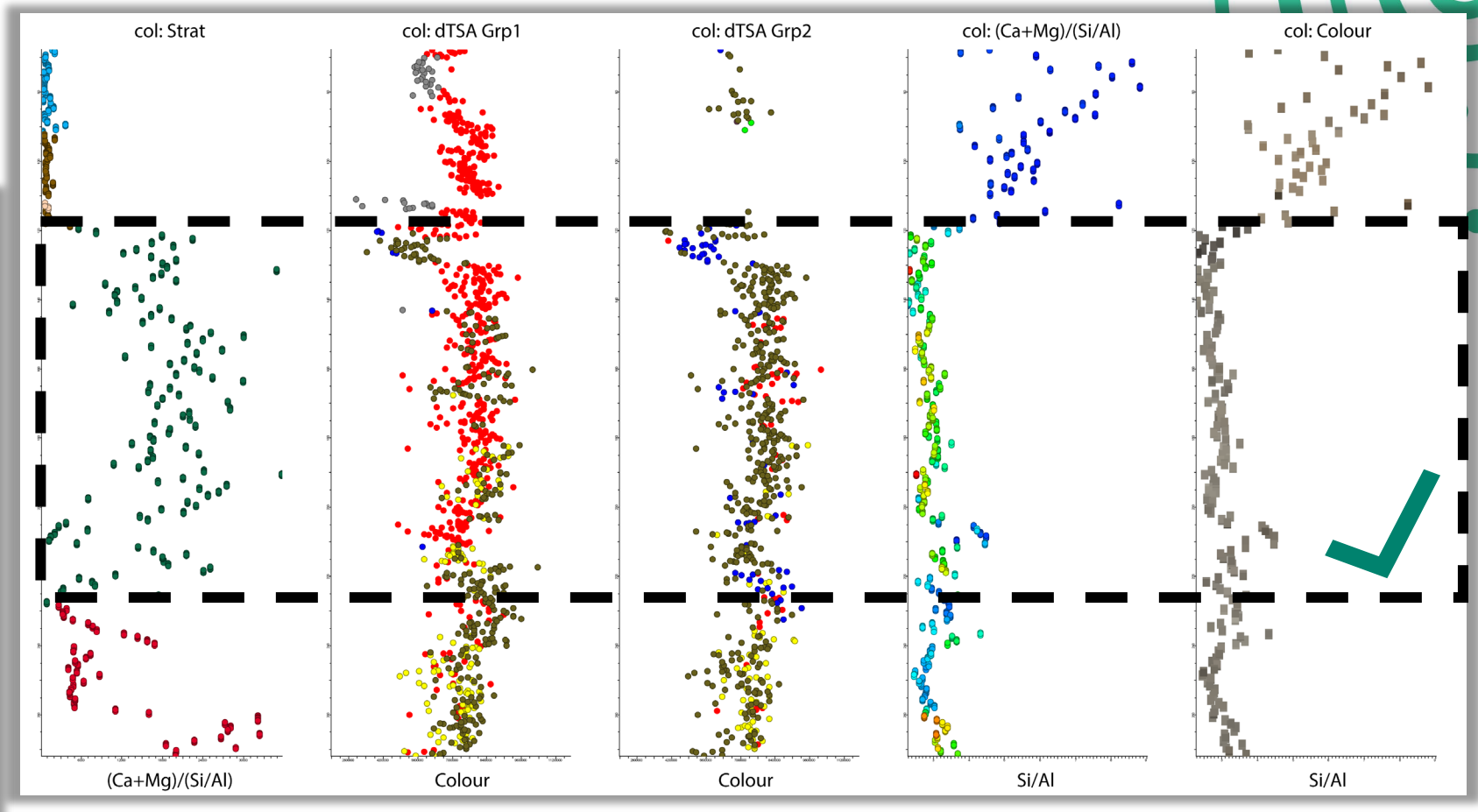


Is this the same material?

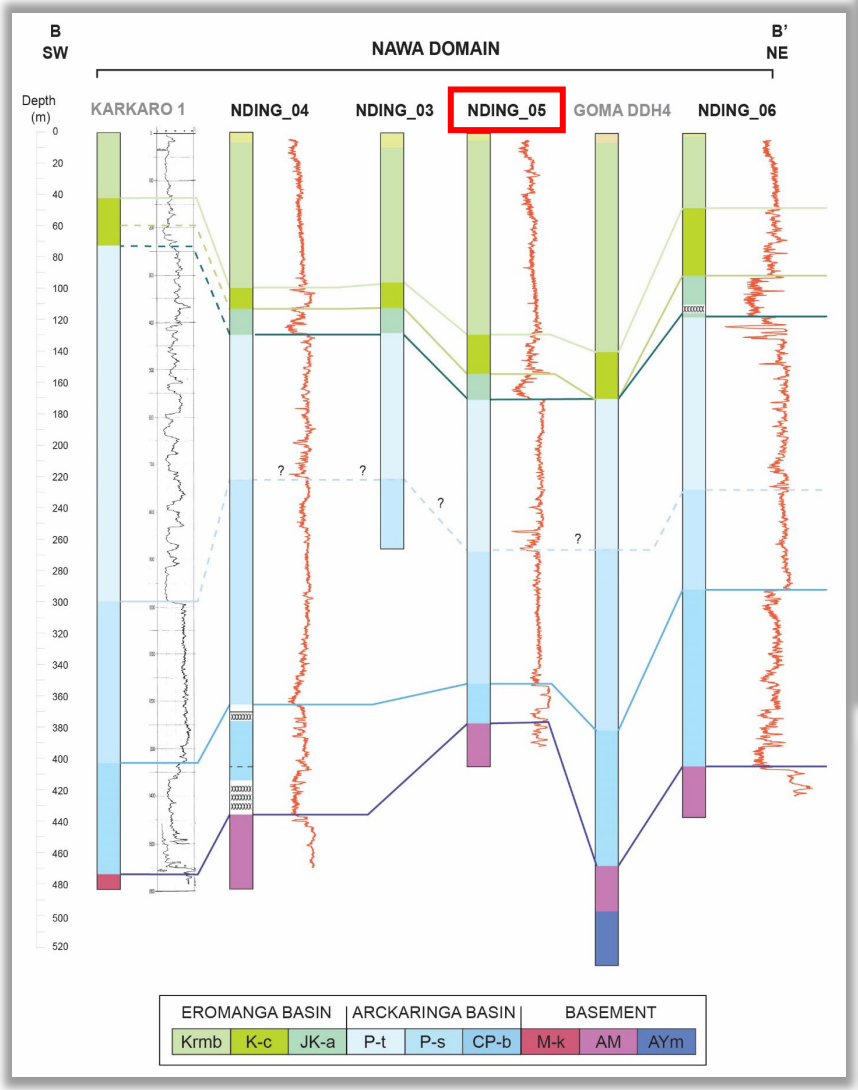


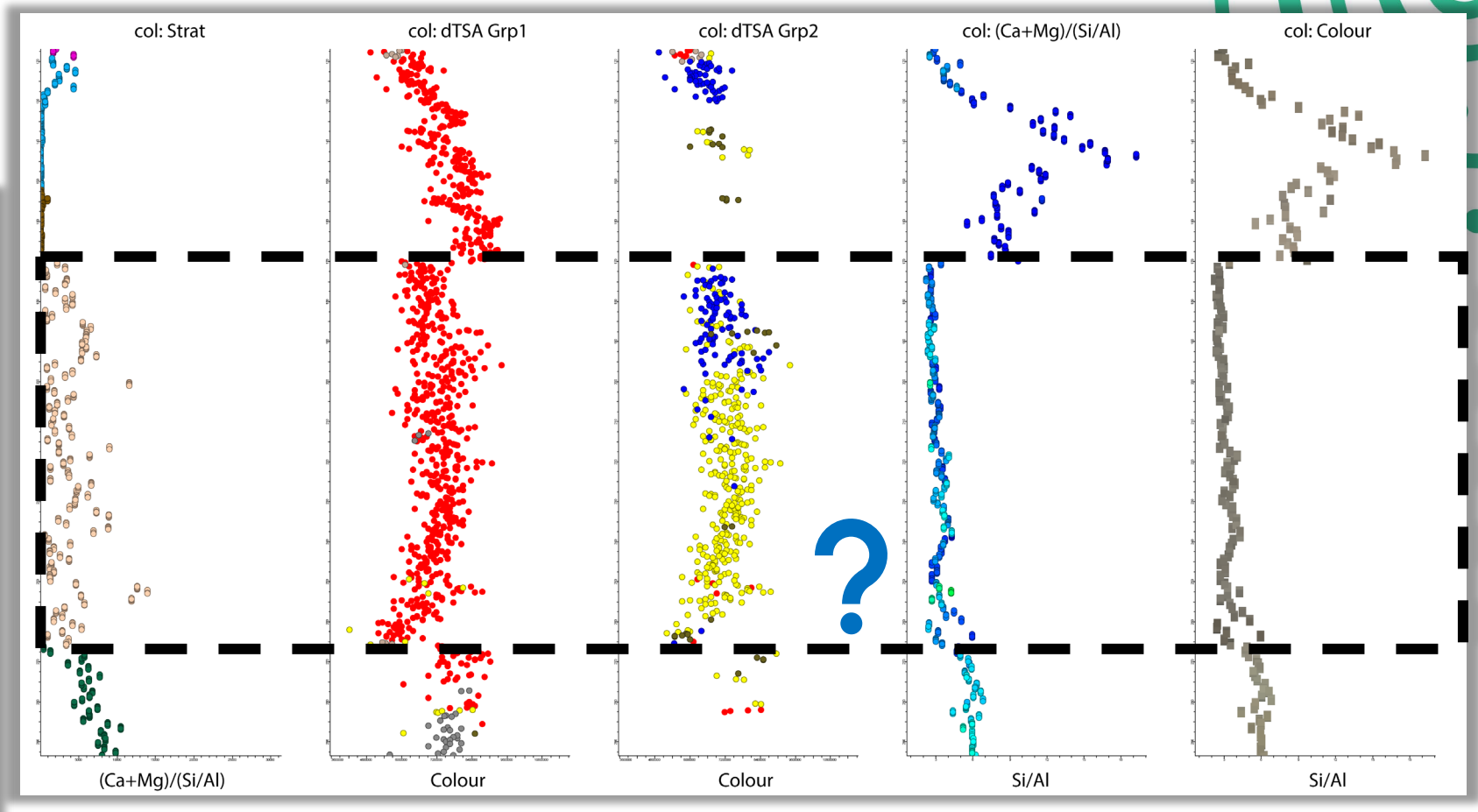
Mt Toondina


B
SW
NAWA DOMAIN
B'
NE
Depth (m)
KARKARO 1
NDING_04
NDING_03
NDING_05
GOMA DDH4
NDING_06
EROMANGA BASIN
ARCKARINGA BASIN
BASEMENT
Krmb
K-c
JK-a
P-t
P-s
CP-b
M-k
AM
AYm

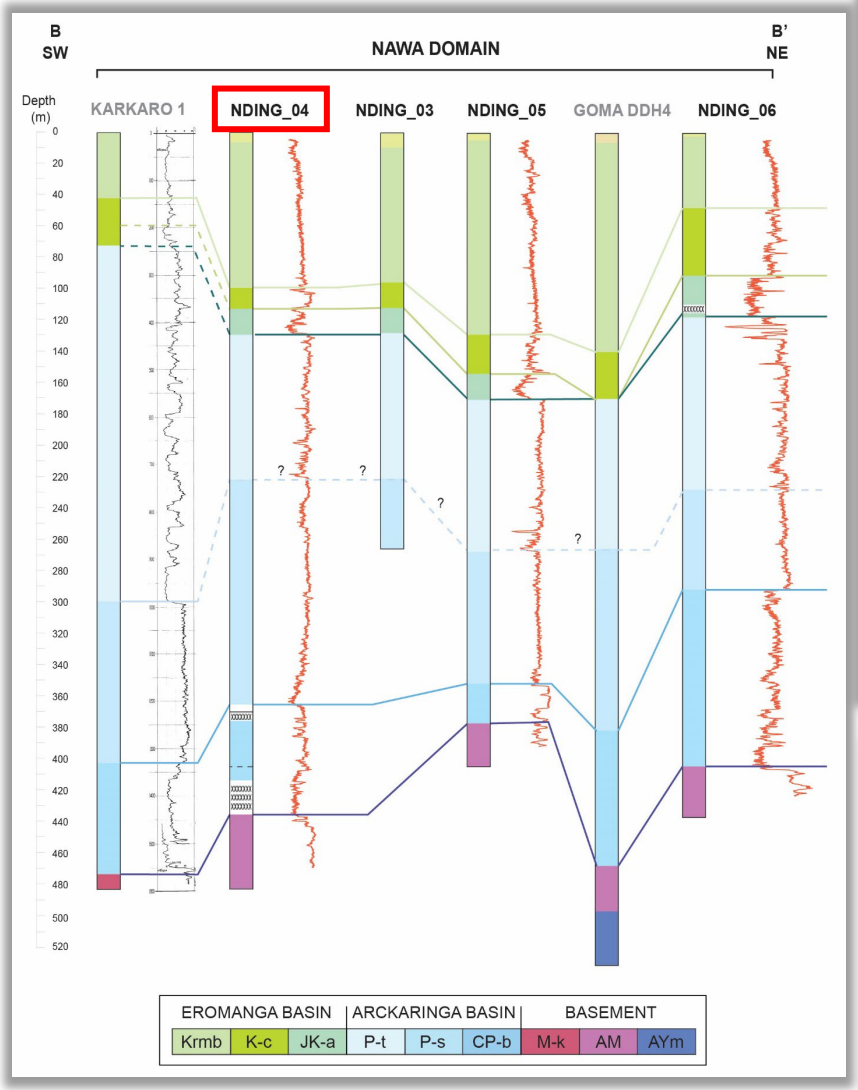

col: Strat
col: dTSA Grp1
col: dTSA Grp2
col: (Ca+Mg)/(Si/Al)
col: Colour
(Ca+Mg)/(Si/Al)
Colour
Colour
Si/Al
Si/Al

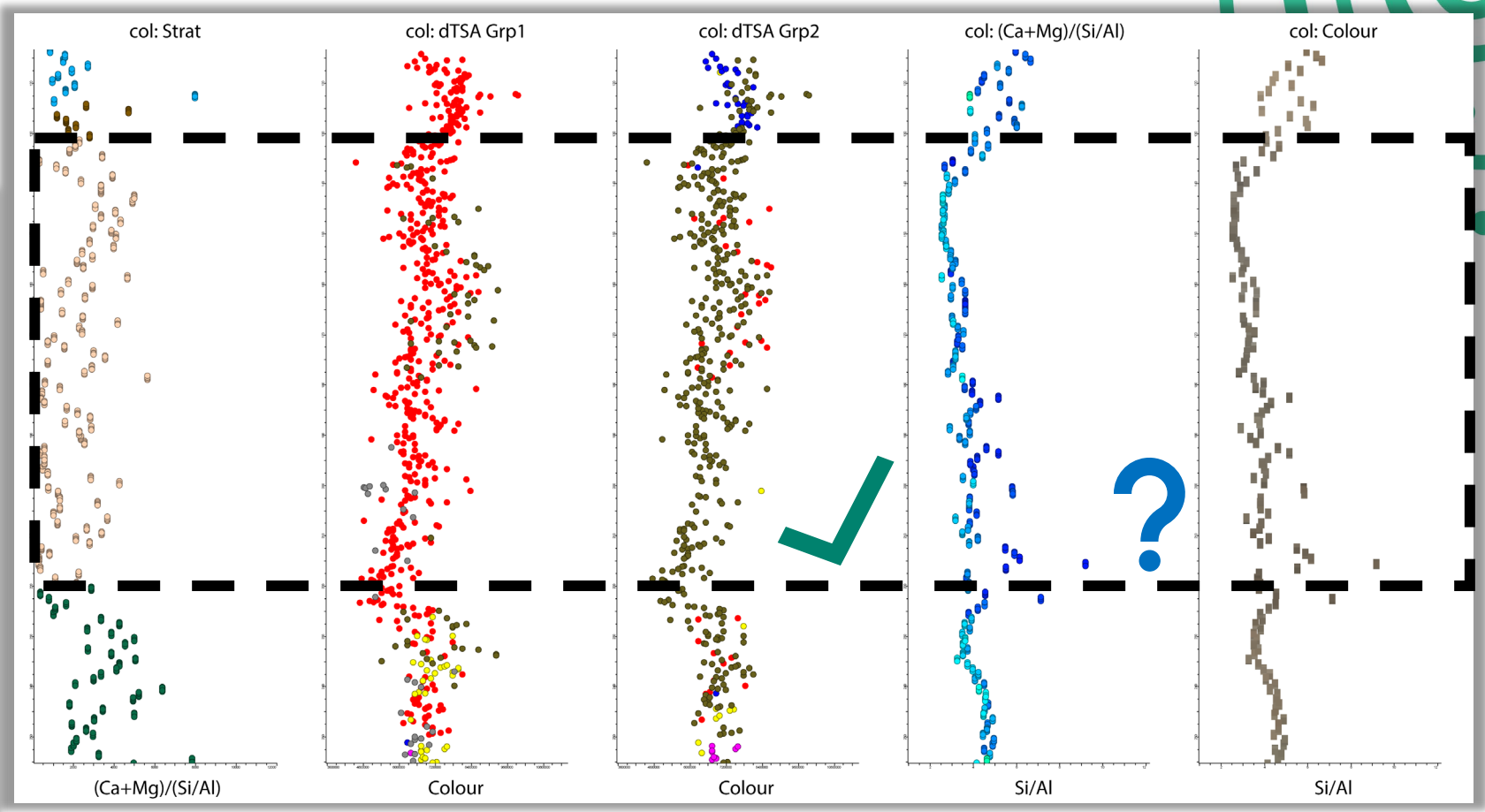
Mt Toondina


B
SW
NAWA DOMAIN
B'
NE
Depth (m)
KARKARO 1
NDING_04
NDING_03
NDING_05
GOMA DDH4
NDING_06
EROMANGA BASIN
ARCKARINGA BASIN
BASEMENT
Krmb
K-c
JK-a
P-t
P-s
CP-b
M-k
AM
AYm


col: Strat
col: dTSA Grp1
col: dTSA Grp2
col: (Ca+Mg)/(Si/Al)
col: Colour
(Ca+Mg)/(Si/Al)
Colour
Colour
Si/Al
Si/Al

Mt Toondina

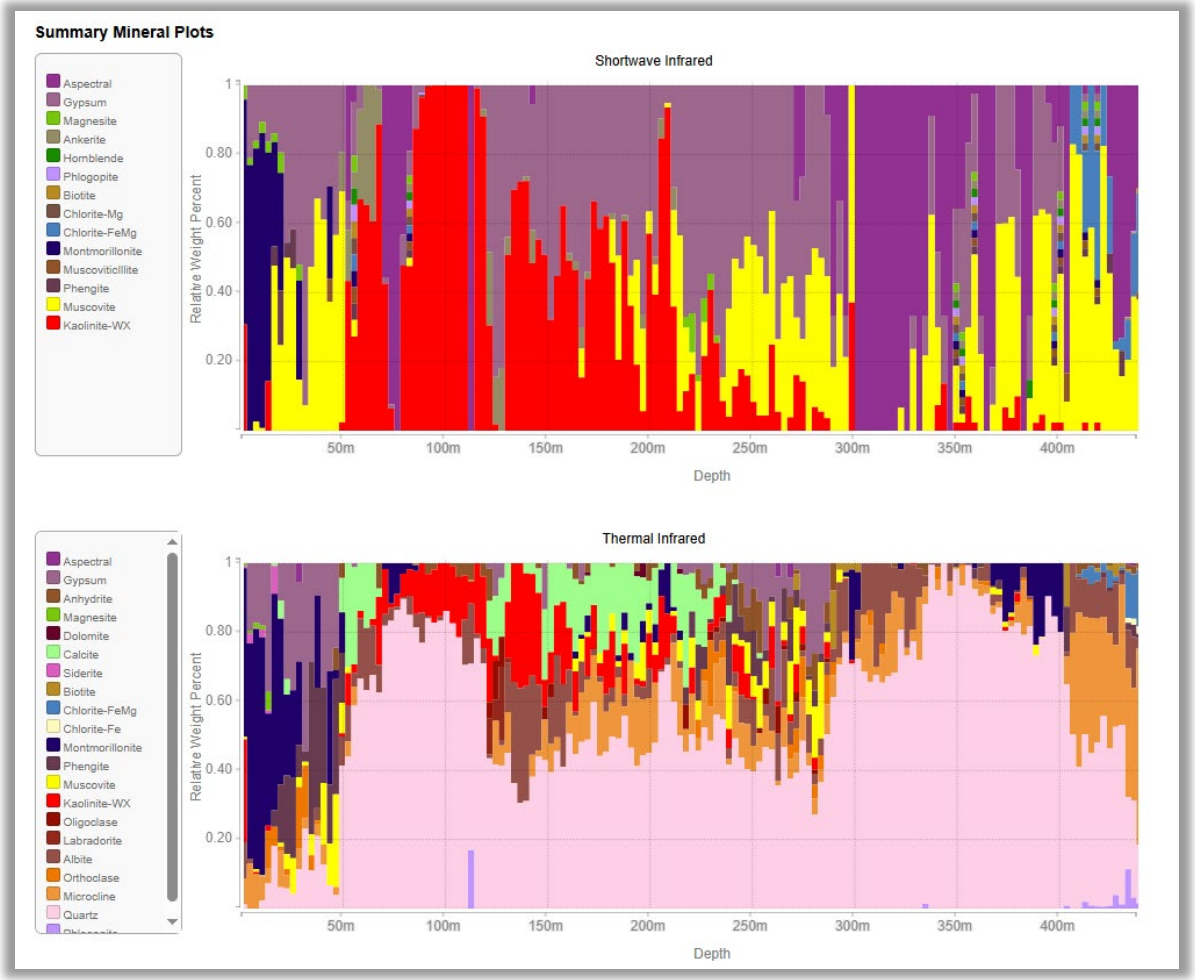

B
SW
NAWA DOMAIN
B'
NE
Depth (m)
KARKARO 1
NDING_04
NDING_03
NDING_05
GOMA DDH4
NDING_06
EROMANGA BASIN
ARCKARINGA BASIN
BASEMENT
Krmb
K-c
JK-a
P-t
P-s
CP-b
M-k
AM
AYm


col: Strat
col: dTSA Grp1
col: dTSA Grp2
col: (Ca+Mg)/(Si/Al)
col: Colour
(Ca+Mg)/(Si/Al)
Colour
Colour
Si/Al
Si/Al

Data Access

- HyLogger-3 data available on SARIG now!
  - TSG files with auxiliary data
  - Tray images
  - Scalar plots for interactive viewing

Scan here!



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Geochronology of the buried Northern Gawler Craton

with highlights from recent NDI drilling

Geochronologists: Liz Jagodzinski, Dillon Brown

Discovery mapping team: Jack Percival, Rashed Abdullah, Mark Pawley, Frank Rarity

NDI drilling team: Claire Wade, Anna Petts

Regional synthesis: Tom Wise

09/12/2025

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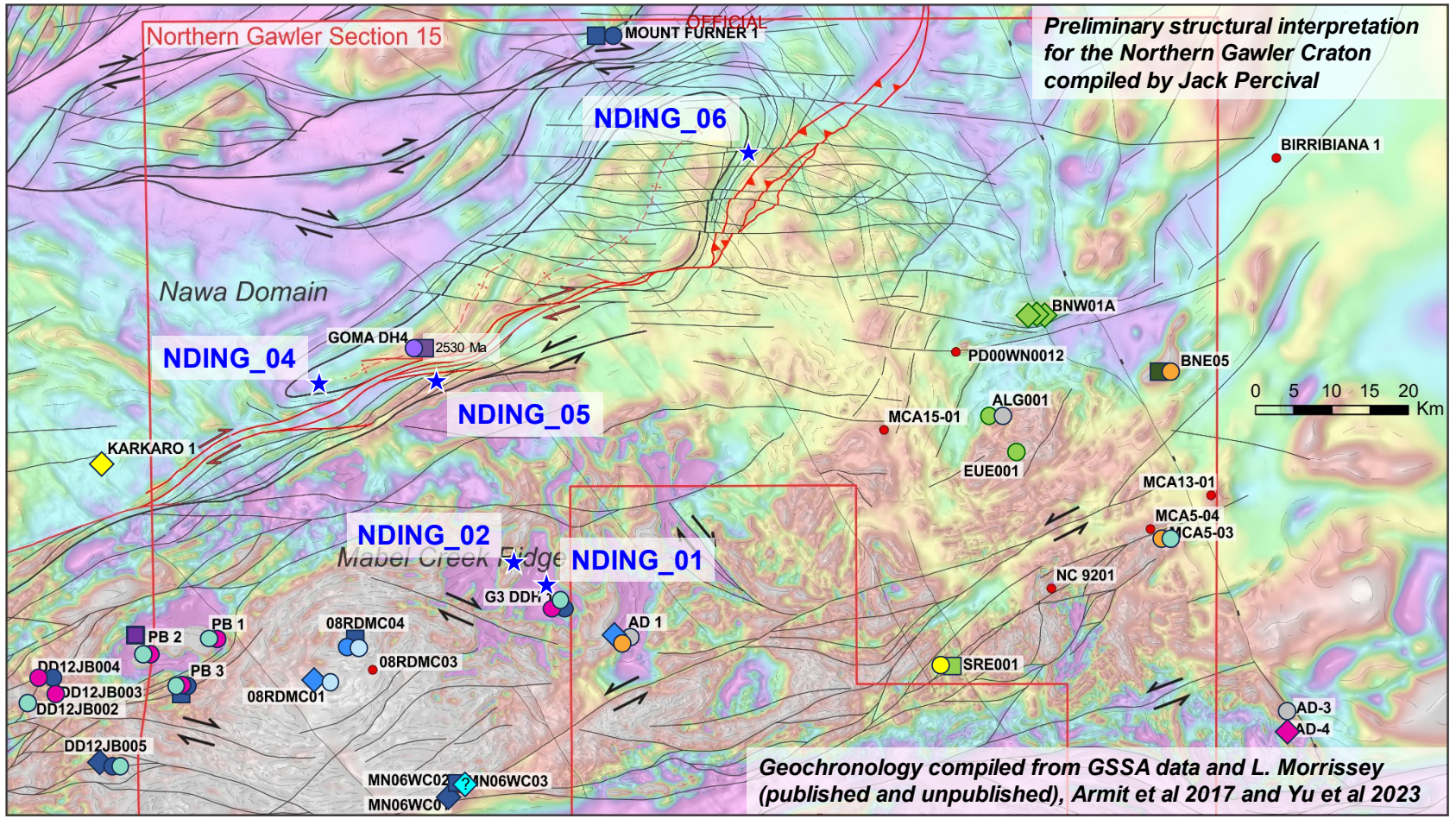
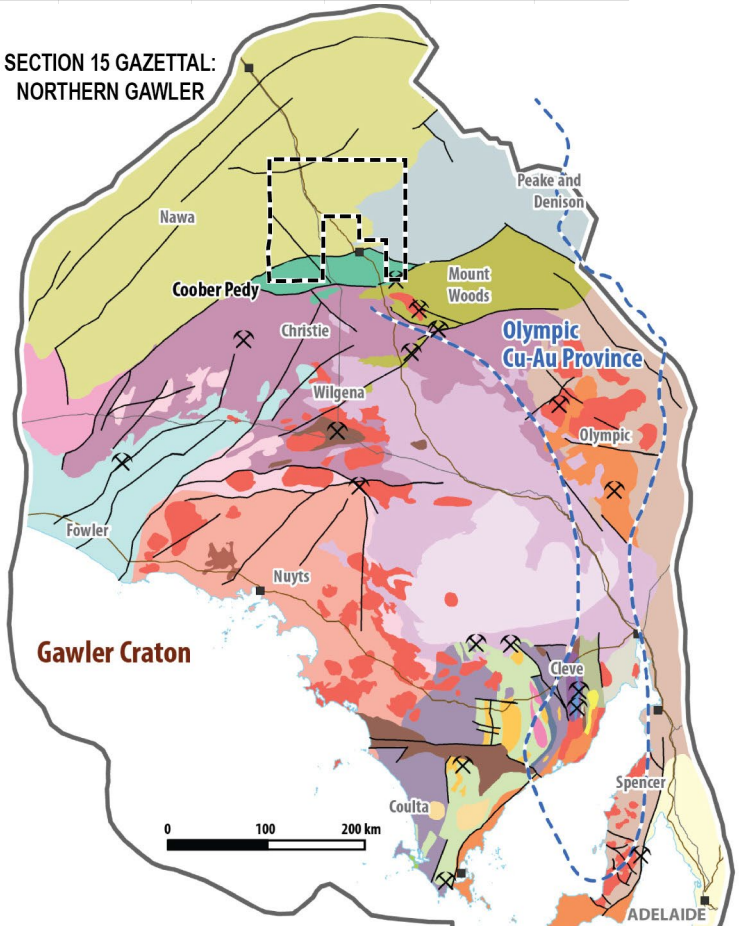
MinEx CRC

NDI DRILLING PROGRAM



Sedimentation	Magmatism	Metamorphism
	1450 Ma	1450 Ma
		1470 Ma
		1490 Ma
		1520 Ma
		1560 Ma
	1590 Ma	1590 Ma
		1630 Ma
	1700 Ma	1700 Ma
1730 Ma	1730 Ma	1730 Ma
1780 Ma	1780 Ma	1780 Ma
1860 Ma		
	2530 Ma ?	2530 Ma
2550 Ma		



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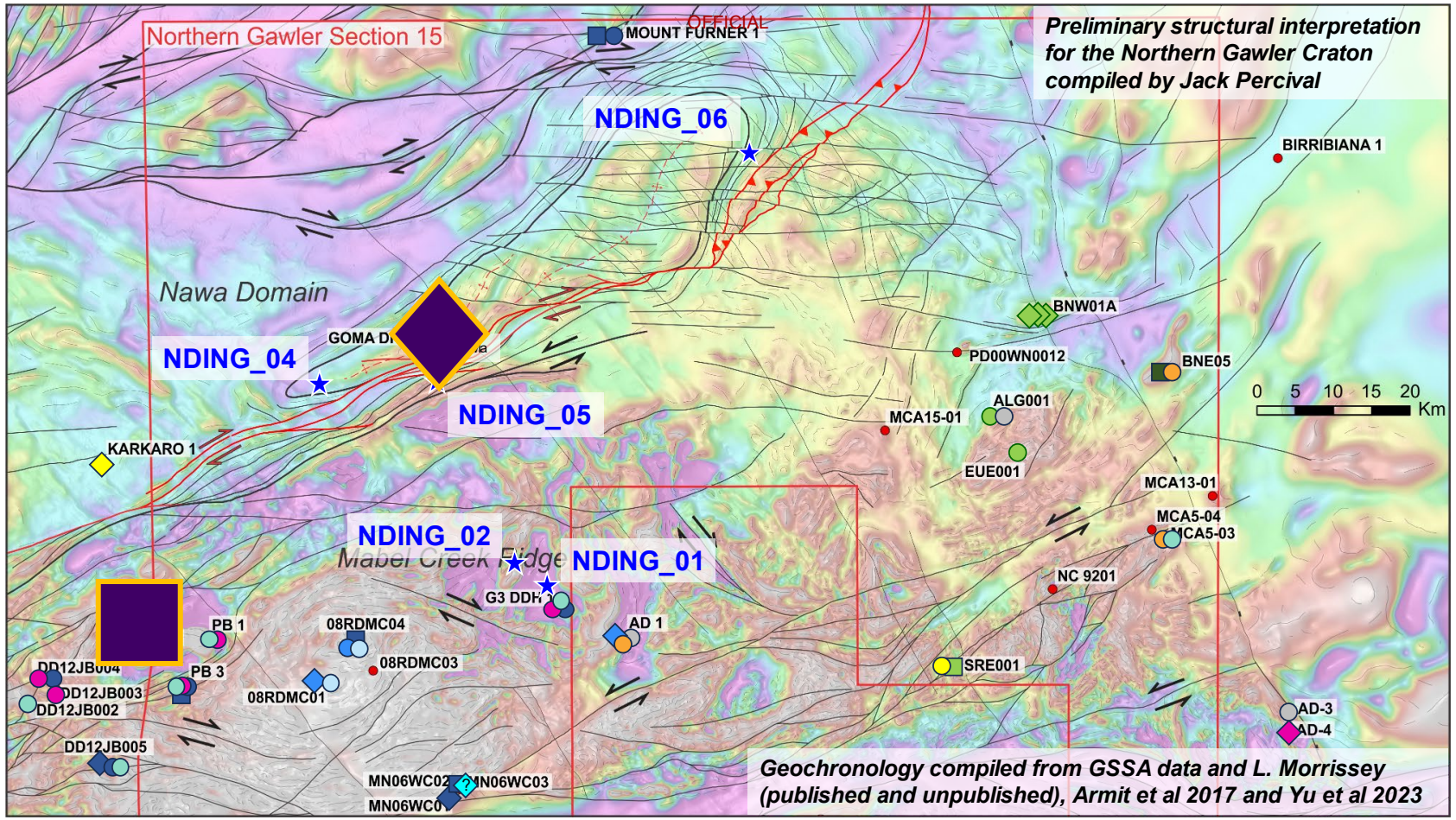
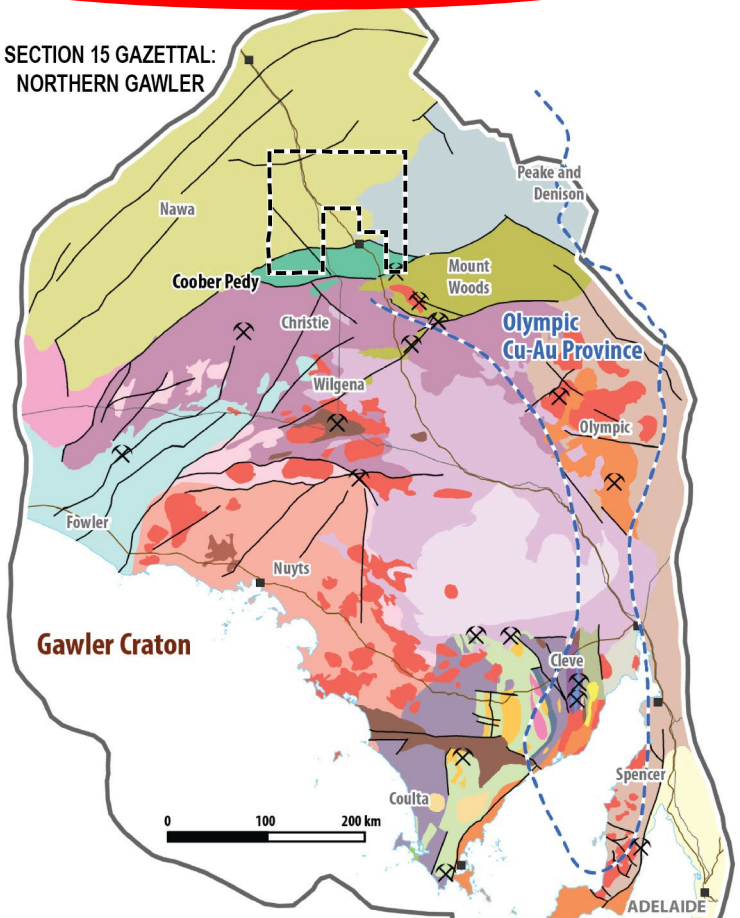
NDI DRILLING PROGRAM ARCHAEAN



Sedimentation	Magmatism	Metamorphism
	1450 Ma	1450 Ma
		1470 Ma
		1490 Ma
		1520 Ma
		1560 Ma
	1590 Ma	1590 Ma
		1630 Ma
	1700 Ma	1700 Ma
1730 Ma	1730 Ma	1730 Ma
1780 Ma	1780 Ma	1780 Ma
1860 Ma		
	2530 Ma ?	2530 Ma
2550 Ma		



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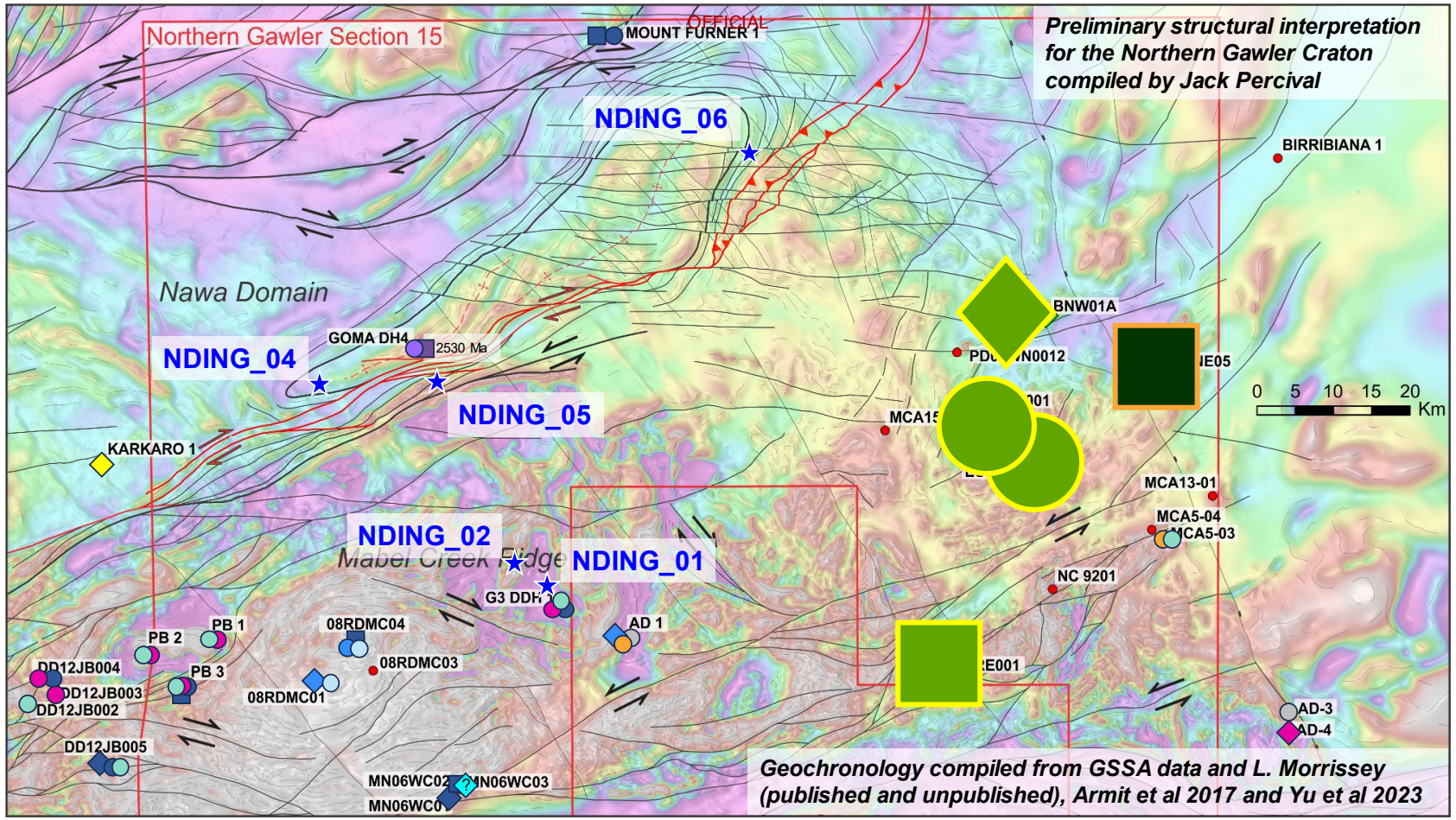
NDI DRILLING PROGRAM PRE-KIMBAN



Sedimentation	Magmatism	Metamorphism
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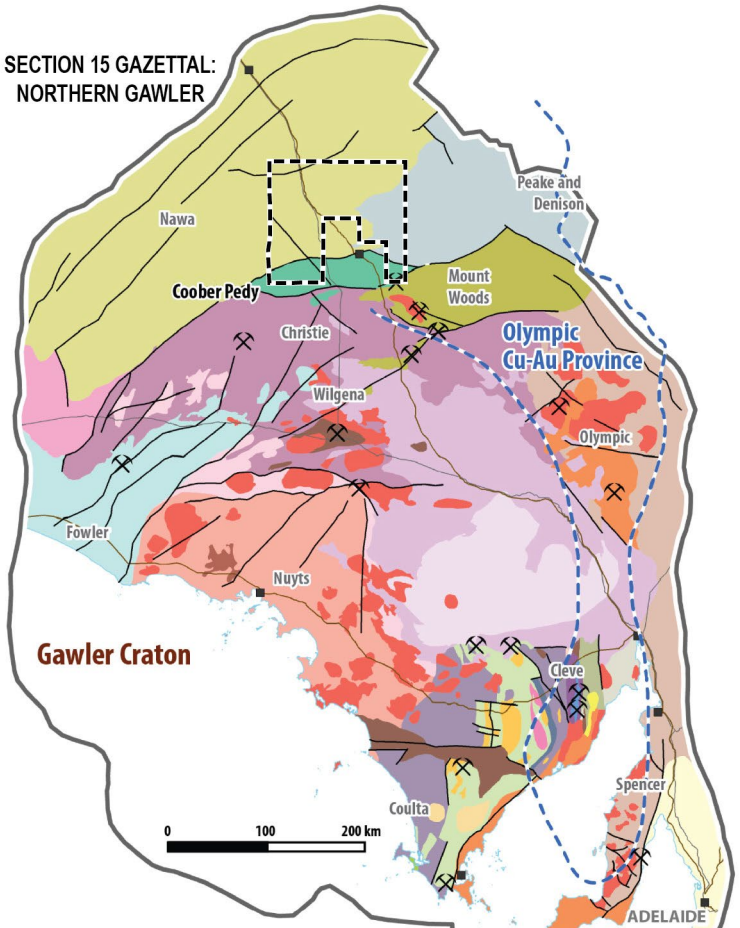
		1470 Ma
		1490 Ma
		1520 Ma
		1560 Ma
	1590 Ma	1590 Ma
		1630 Ma
	1700 Ma	1700 Ma
1780 Ma	1780 Ma	1780 Ma
2550 Ma	2530 Ma ?	2530 Ma



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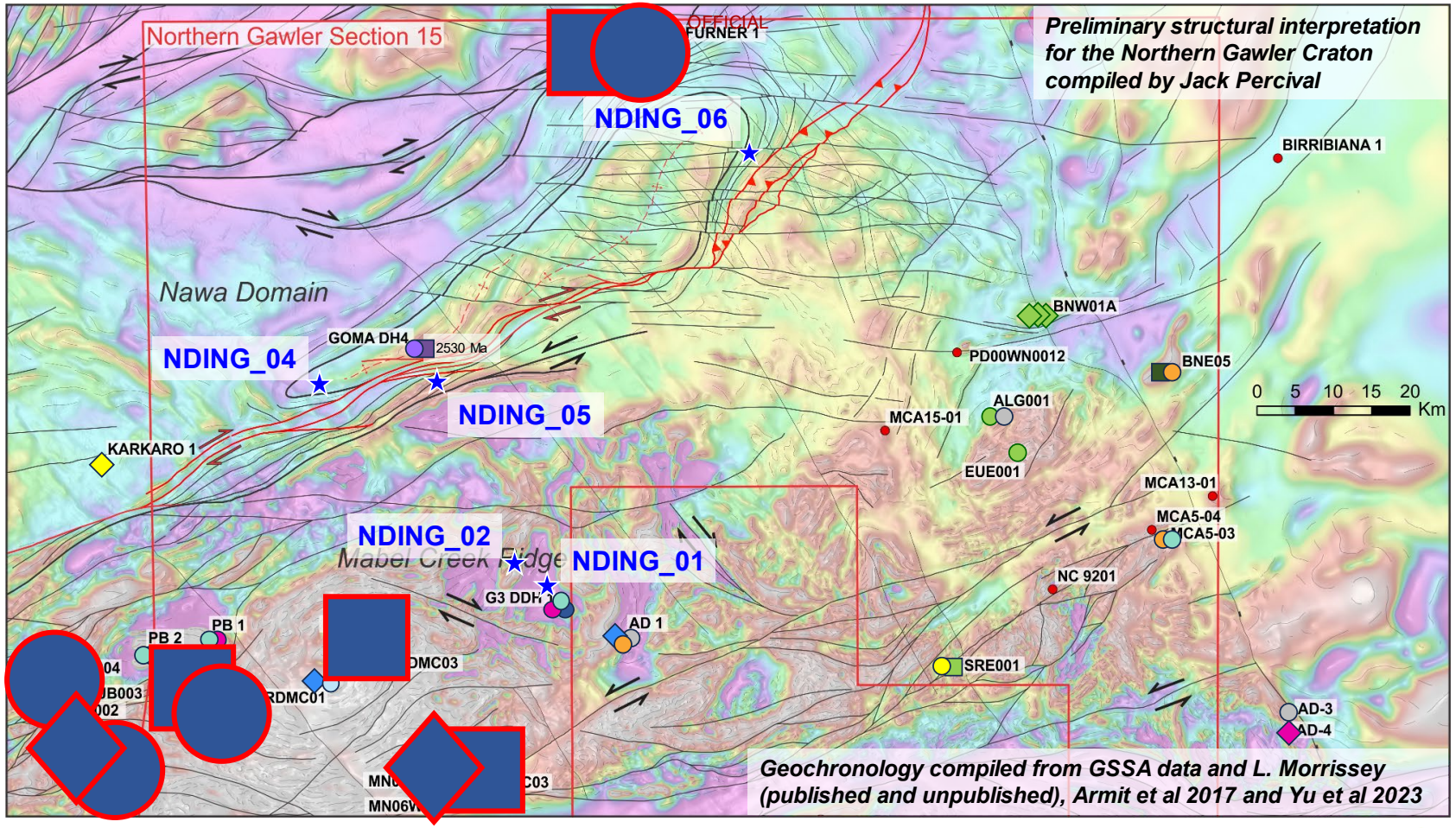
EARLY KIMBAN



Sedimentation	Magmatism	Metamorphism
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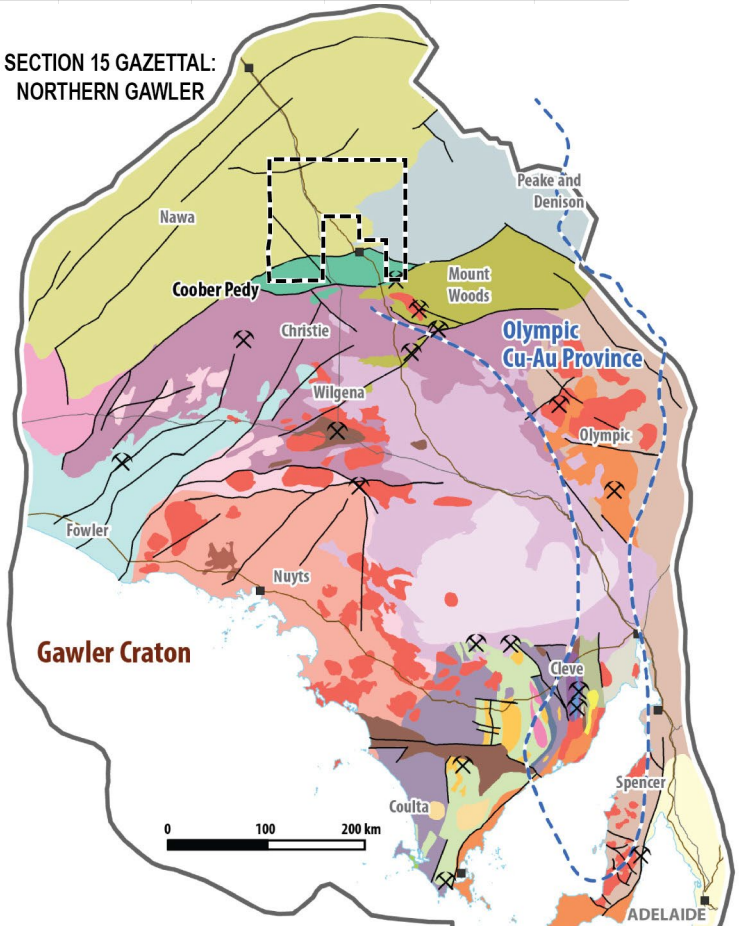
		1470 Ma
		1490 Ma
		1520 Ma
		1560 Ma
	1590 Ma	1590 Ma
		1630 Ma
	1700 Ma	1700 Ma
1730 Ma	1730 Ma	1730 Ma
1780 Ma	1780 Ma	1780 Ma
1860 Ma		
2550 Ma	2530 Ma ?	2530 Ma



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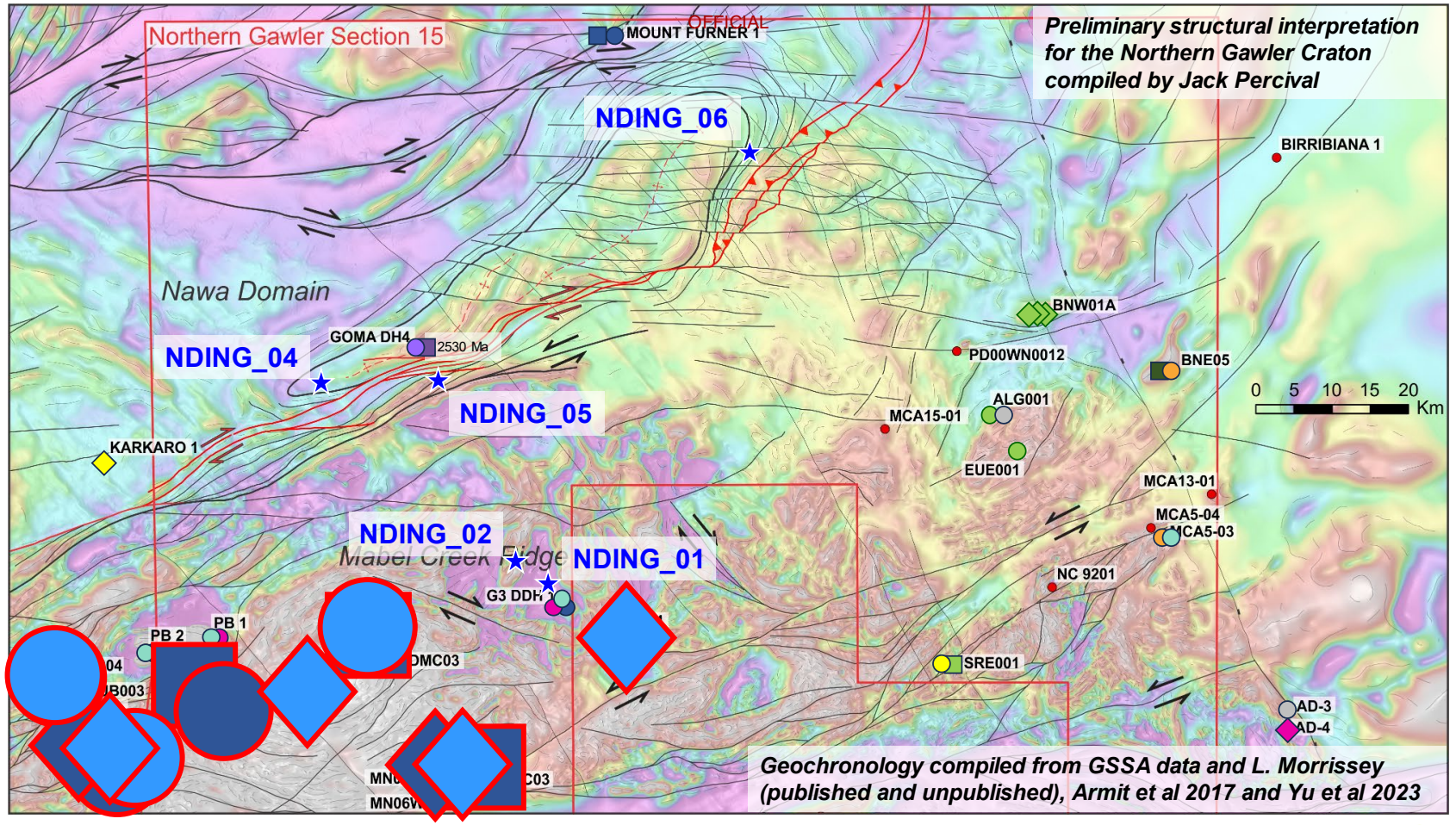
LATE KIMBAN



Sedimentation	Magmatism	Metamorphism
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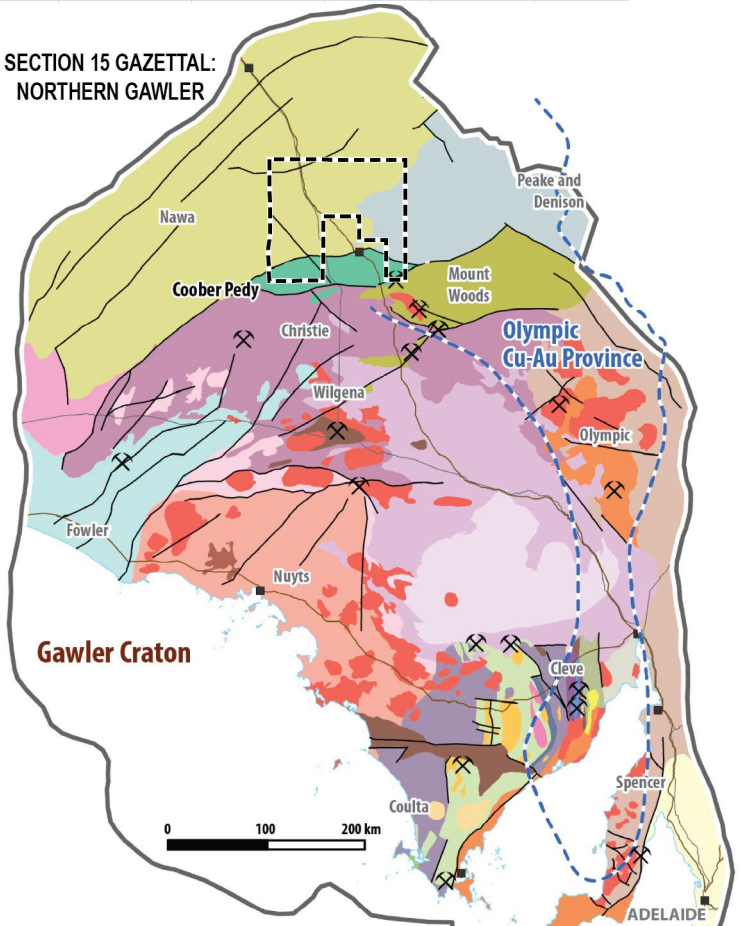
		1470 Ma
		1490 Ma
		1520 Ma
		1560 Ma
	1590 Ma	1590 Ma
		1630 Ma
	1700 Ma	1700 Ma
1730 Ma	1730 Ma	1730 Ma
1780 Ma	1780 Ma	1780 Ma
1860 Ma		
2550 Ma	2530 Ma ?	2530 Ma



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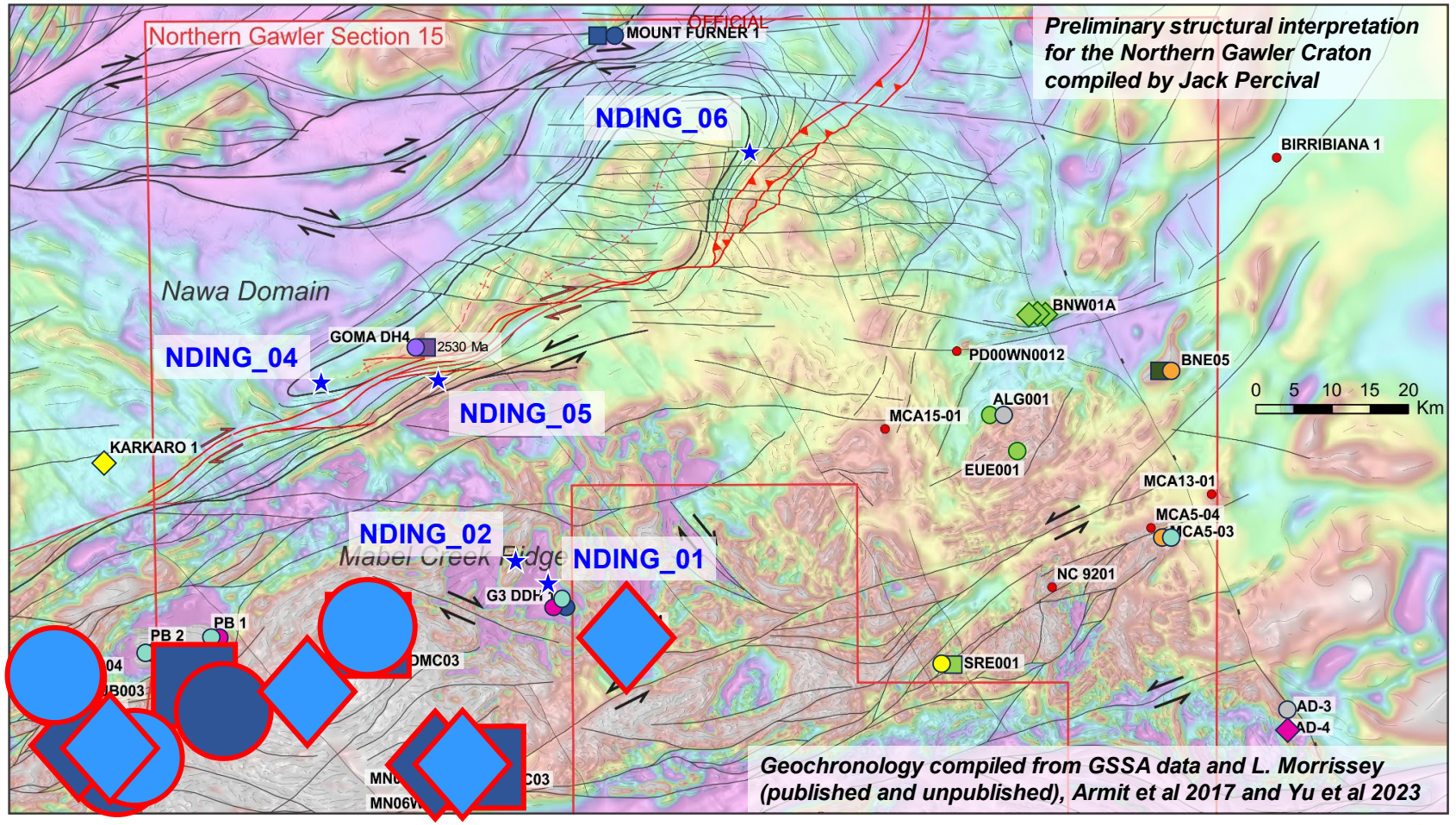
LATE KIMBAN



Sedimentation	Magmatism	Metamorphism
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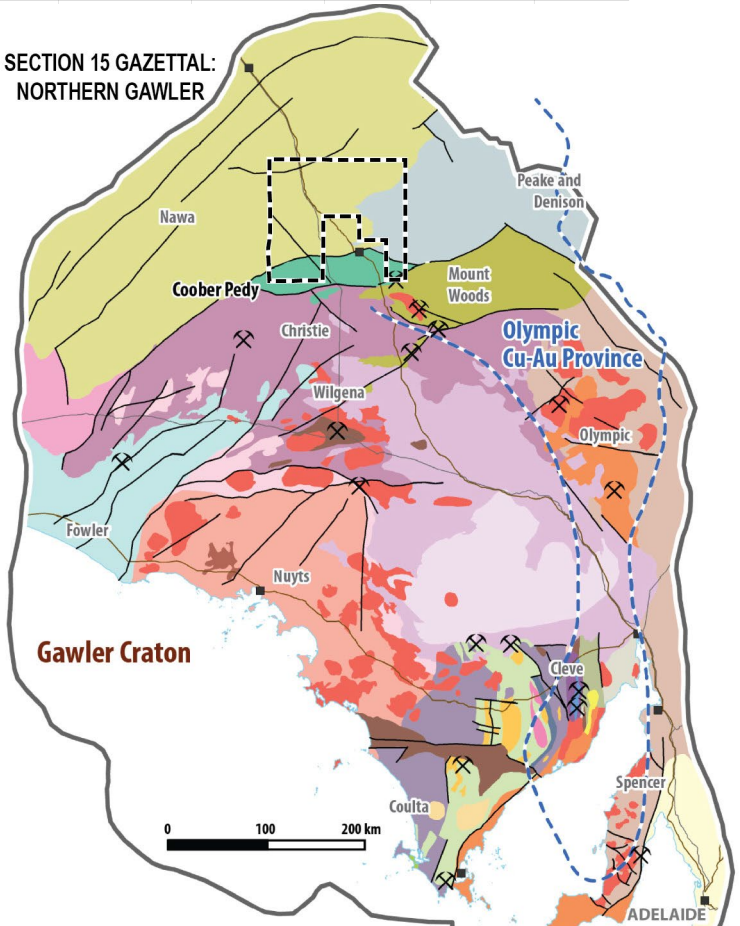
		1470 Ma
		1490 Ma
		1520 Ma
		1560 Ma
	1590 Ma	1590 Ma
		1630 Ma
	1700 Ma	1700 Ma
1730 Ma	1730 Ma	1730 Ma
1780 Ma	1780 Ma	1780 Ma
1860 Ma		
2550 Ma	2530 Ma ?	2530 Ma



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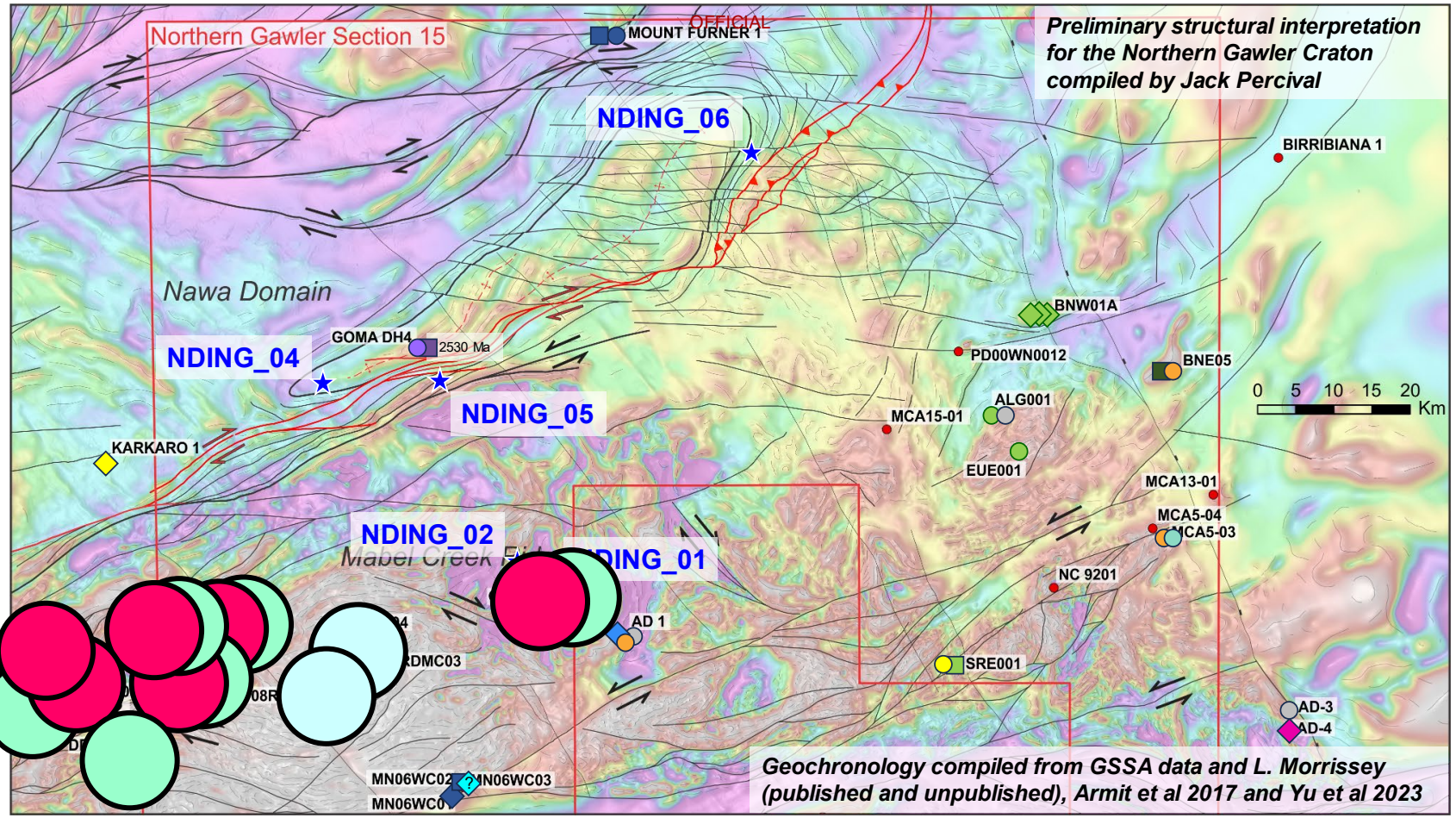
HILTABA/KARARAN



Sedimentation	Magmatism	Metamorphism
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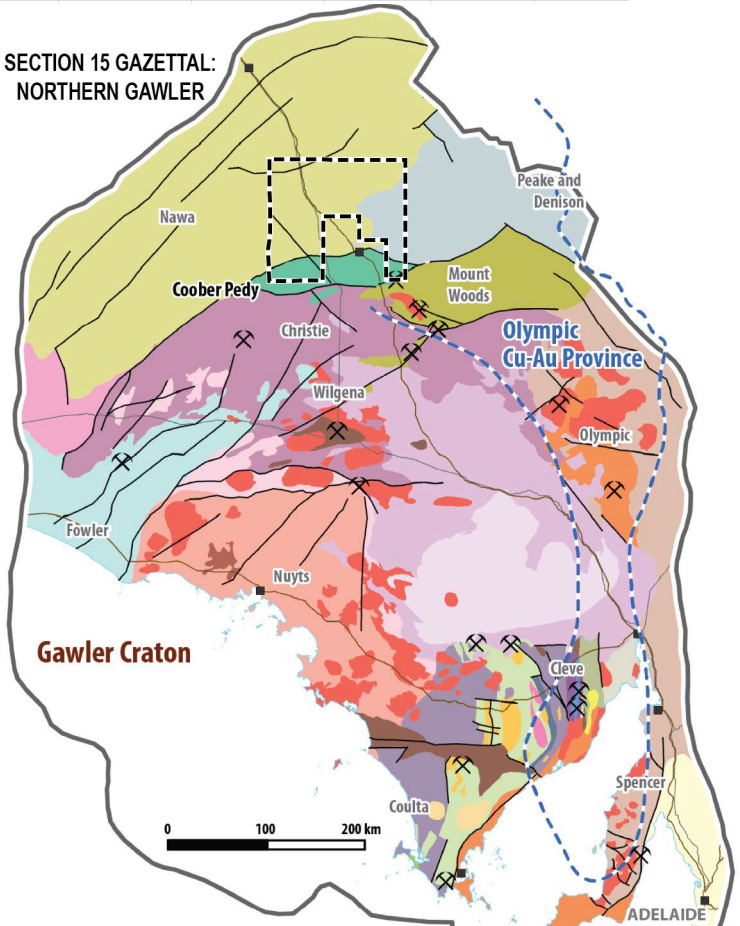
		1470 Ma
		1490 Ma
		1520 Ma
		1560 Ma
	1590 Ma	1590 Ma
		1630 Ma
	1700 Ma	1700 Ma
1730 Ma	1730 Ma	1730 Ma
1780 Ma	1780 Ma	1780 Ma
1860 Ma		
2550 Ma	2530 Ma ?	2530 Ma



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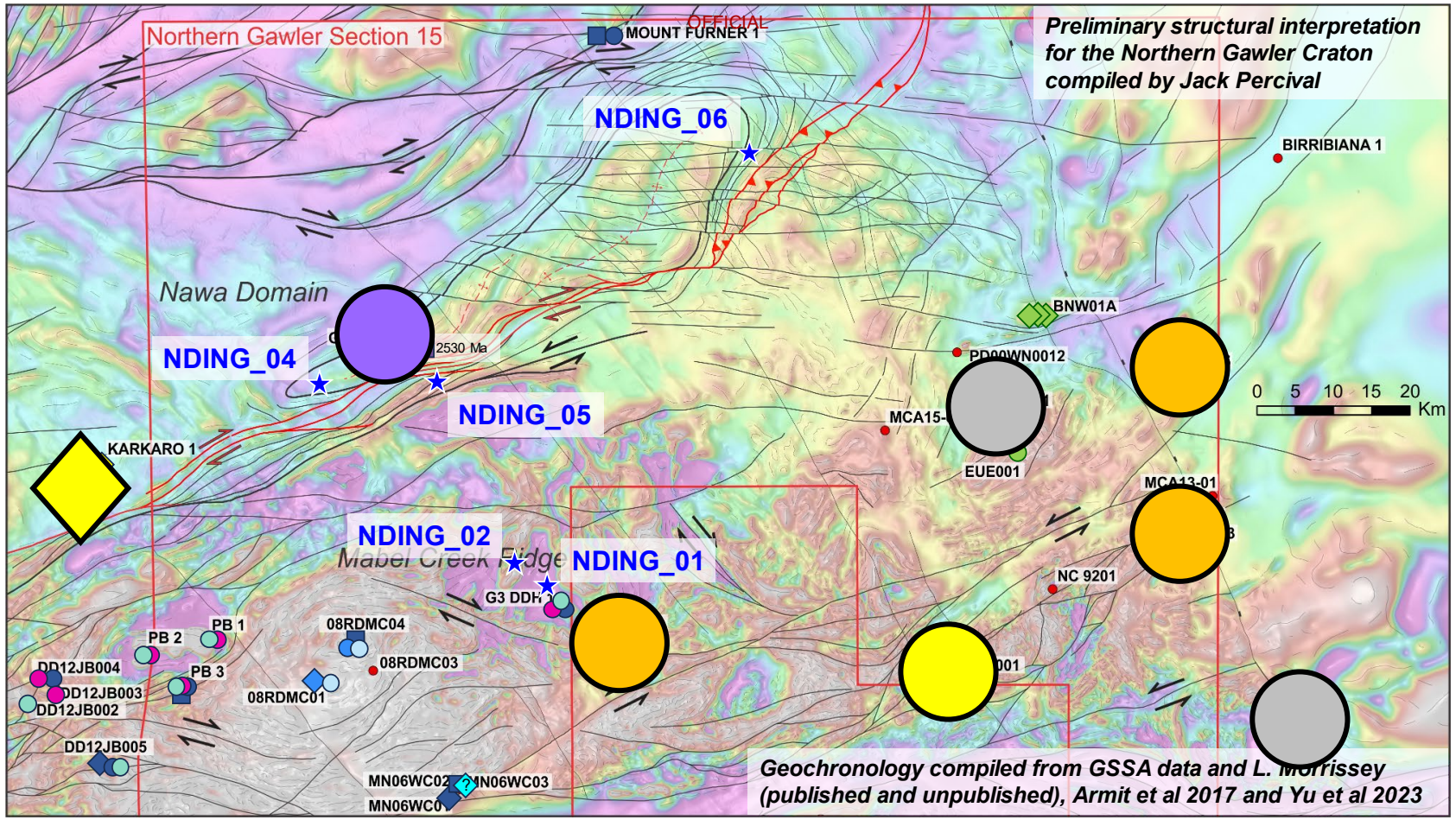
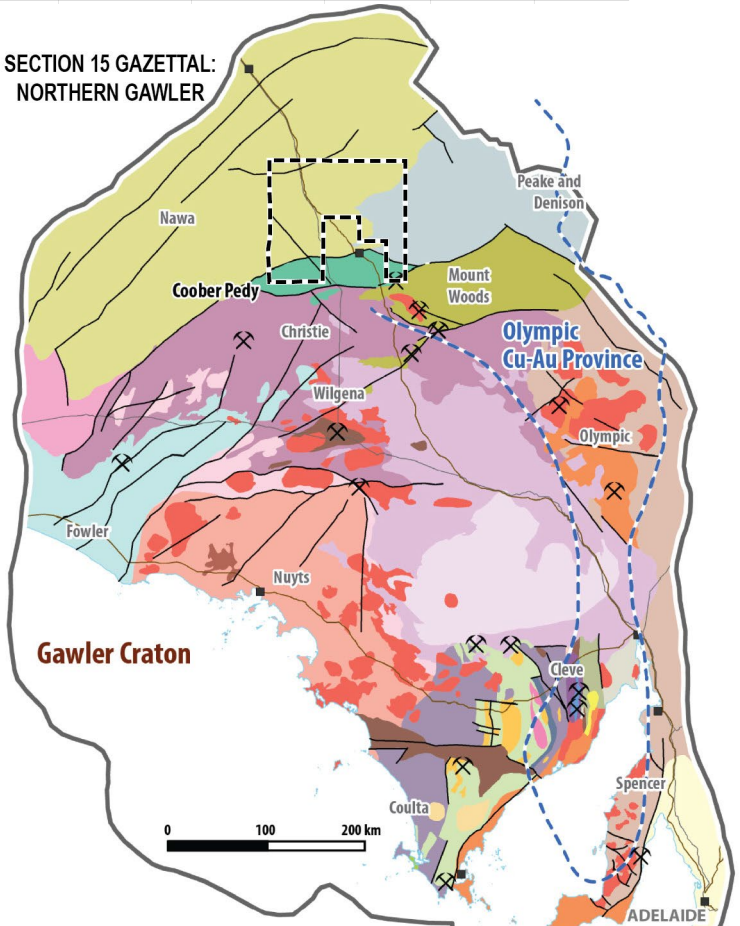
POST_HILTABA/KARARAN



Sedimentation	Magmatism	Metamorphism
	1450 Ma	1450 Ma
		1470 Ma
		1490 Ma
		1520 Ma
1520 – 1450 Ma		1560 Ma
	1590 Ma	1590 Ma
		1630 Ma
	1700 Ma	1700 Ma
1730 Ma	1730 Ma	1730 Ma
1780 Ma	1780 Ma	1780 Ma
1860 Ma		
2550 Ma	2530 Ma ?	2530 Ma



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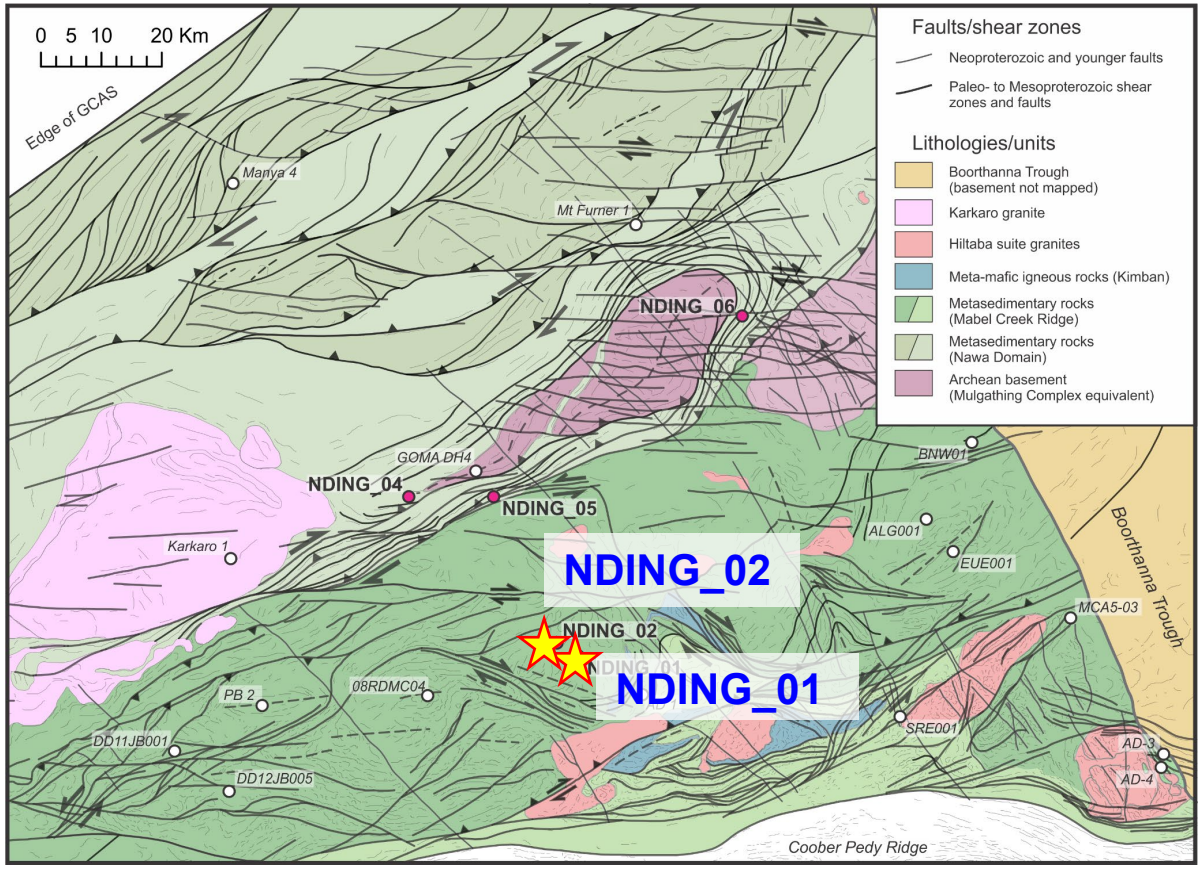
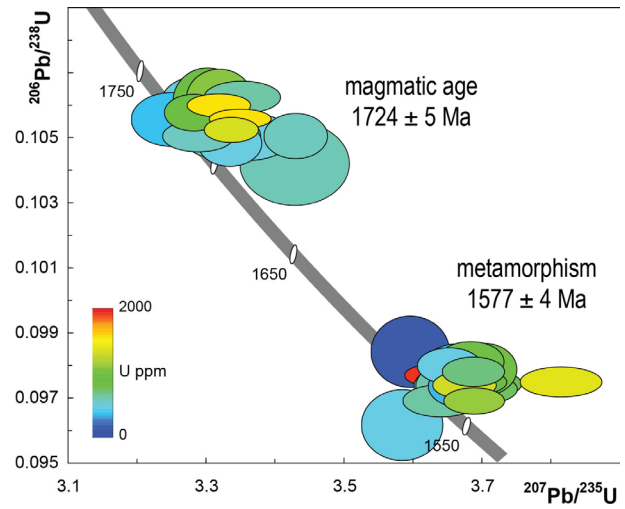
NDI DRILLING PROGRAM

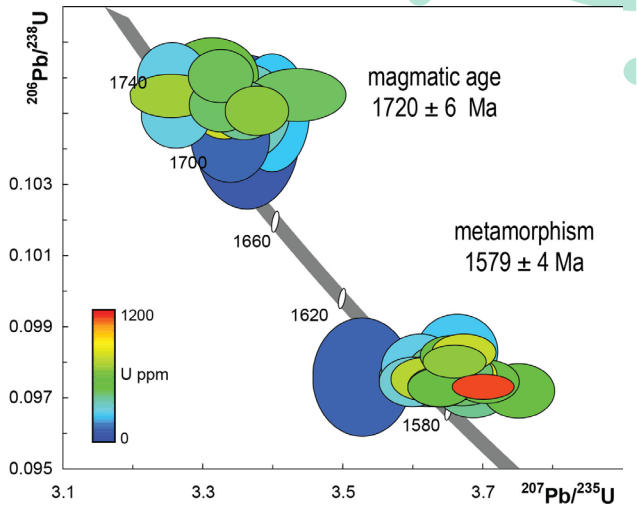


MABEL CREEK RIDGE

NDING_02



NDING_01

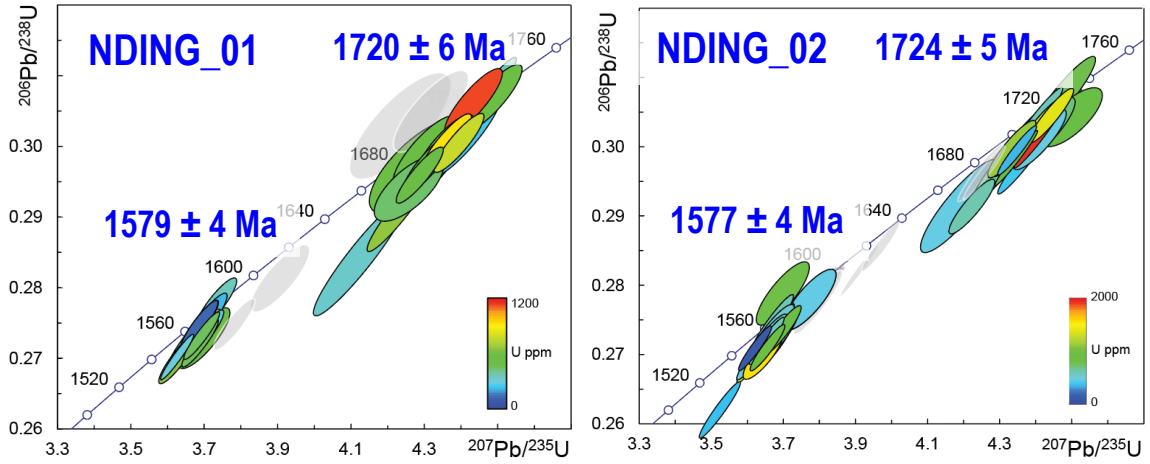


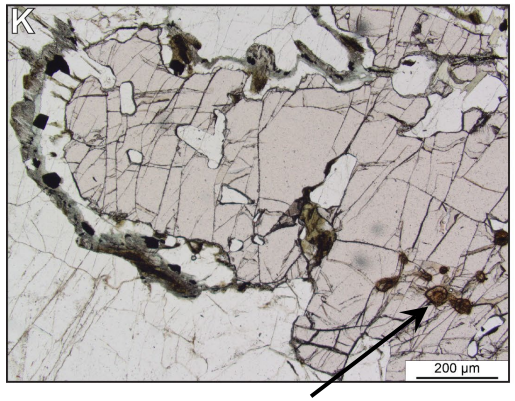
Sample 4575452 (NDING_02)

Monazite UPb geochronology (in thin section)

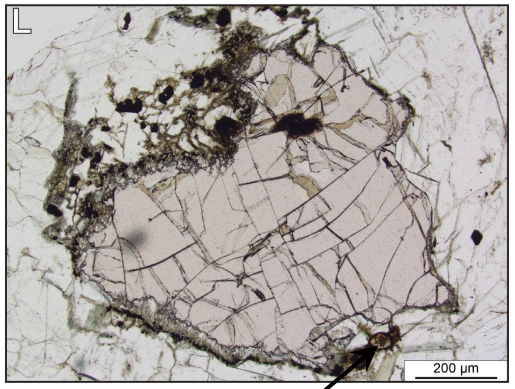
MABEL CREEK RIDGE

Zircon



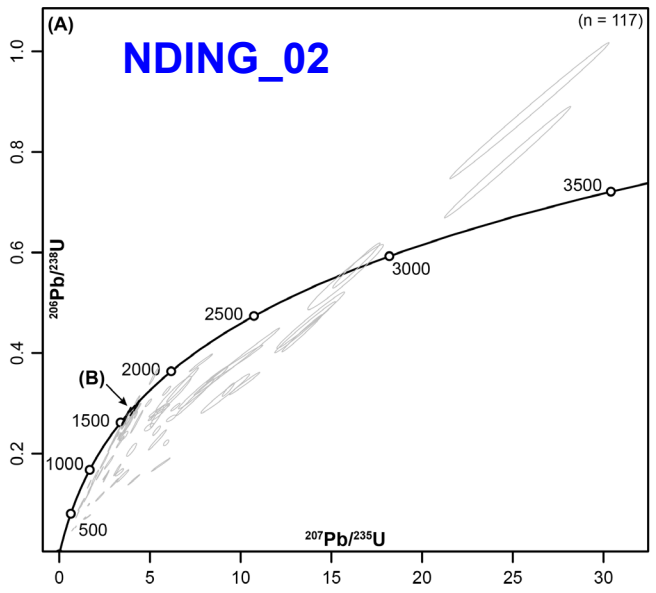


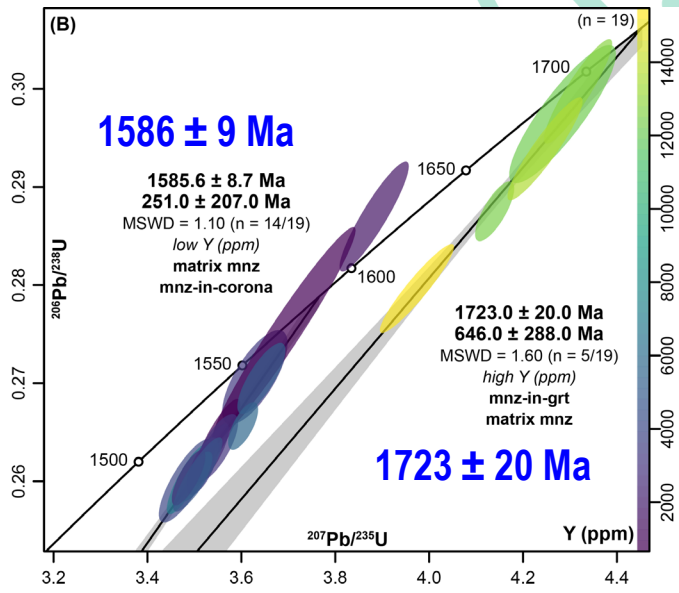
Mnz-in-grt
Kimban

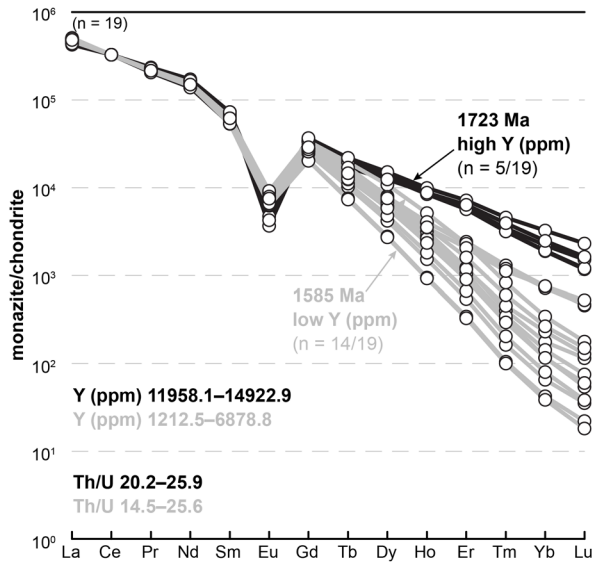


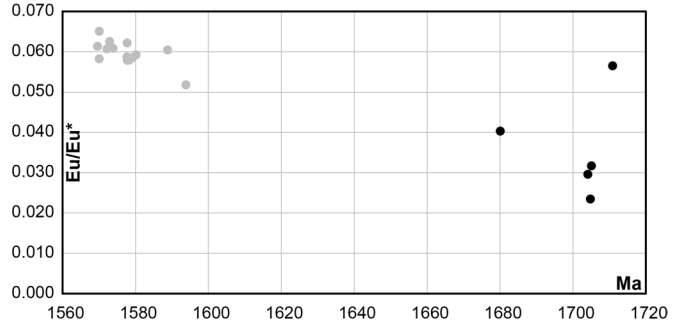
Mnz-in-pl corona
Kararan

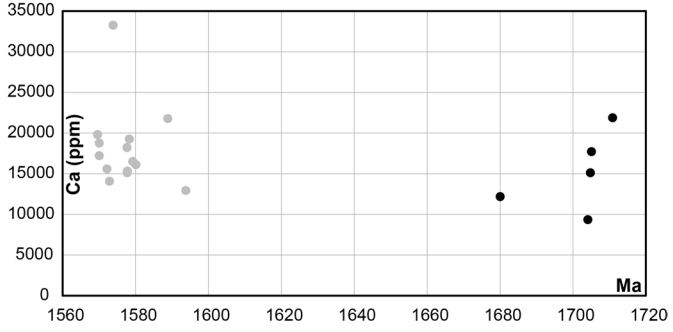
Monazite





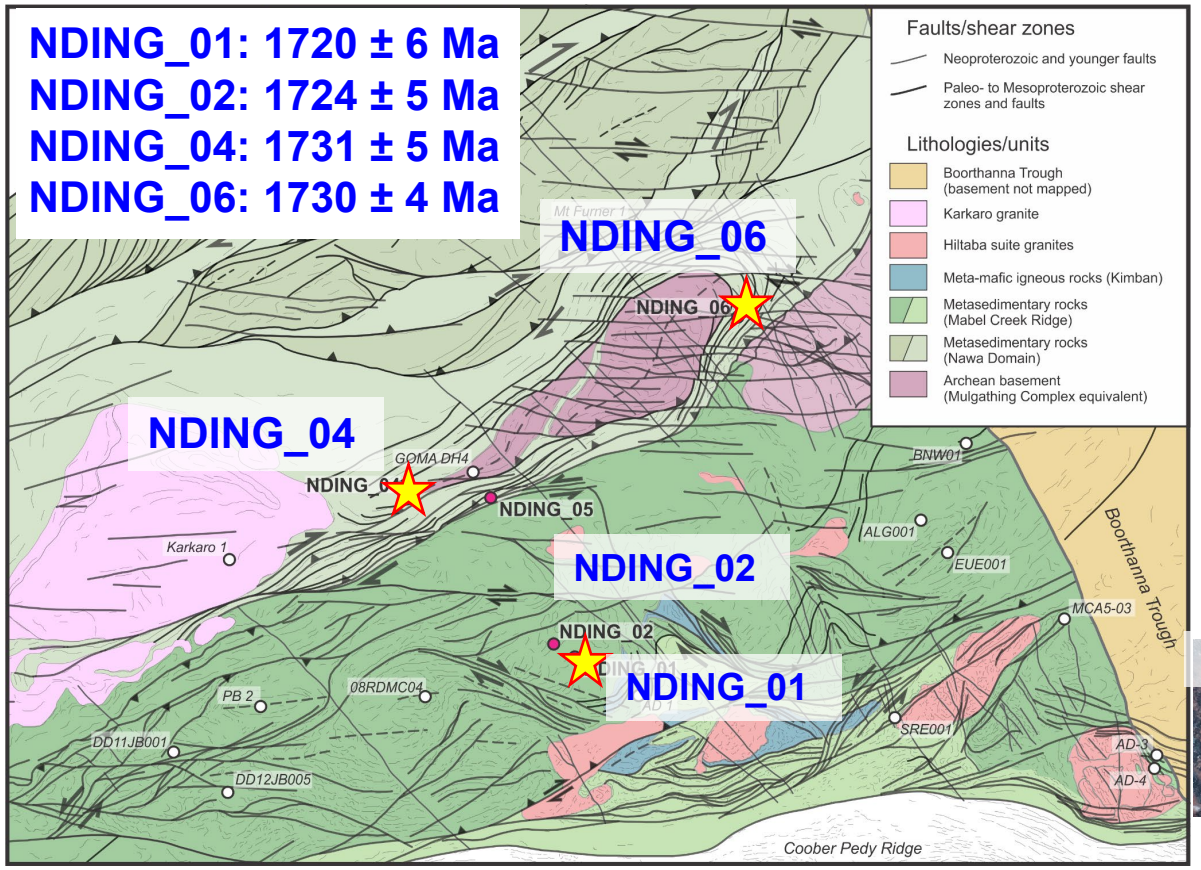




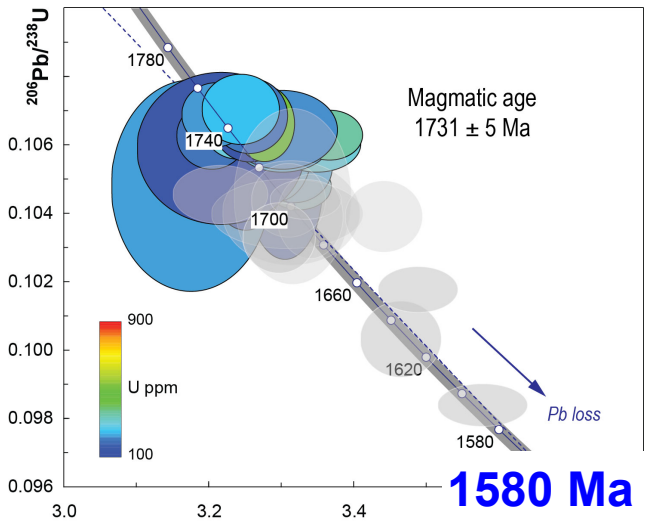


NDI DRILLING PROGRAM

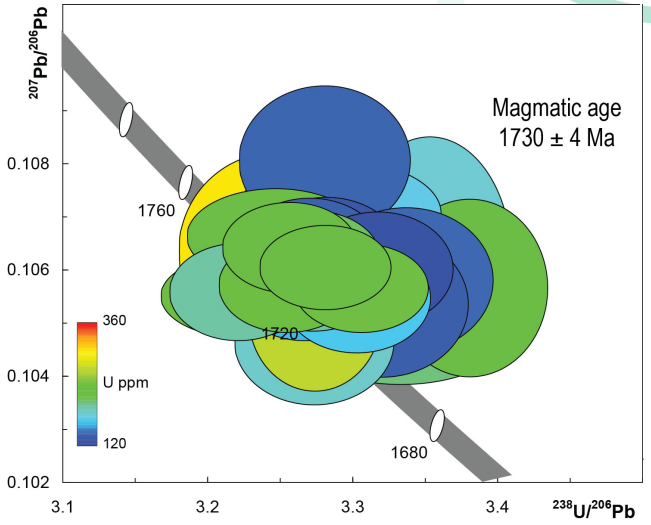
NAWA DOMAIN

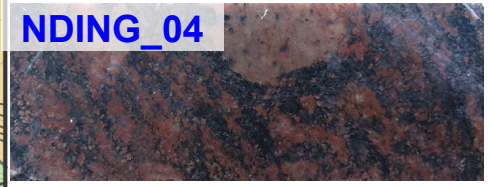


NDING_04



NDING_06

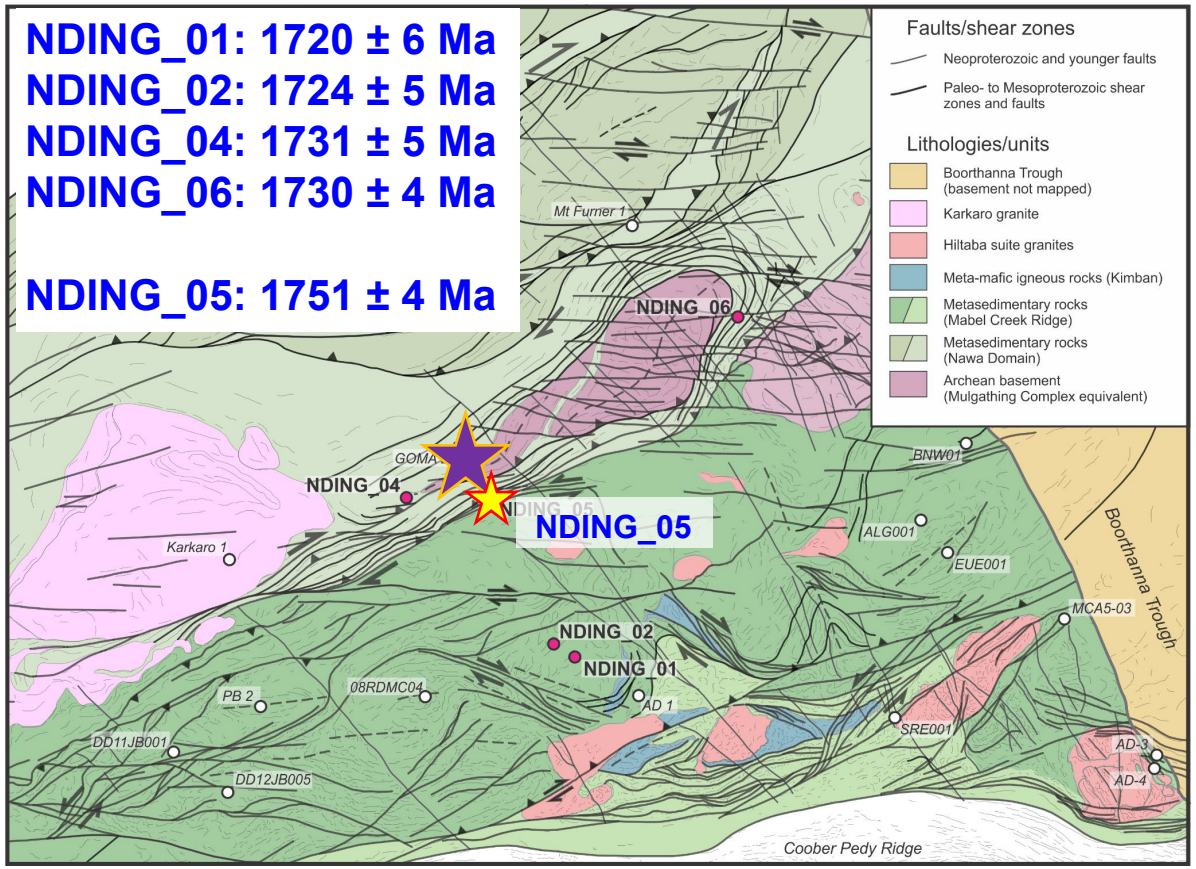




NDI DRILLING PROGRAM

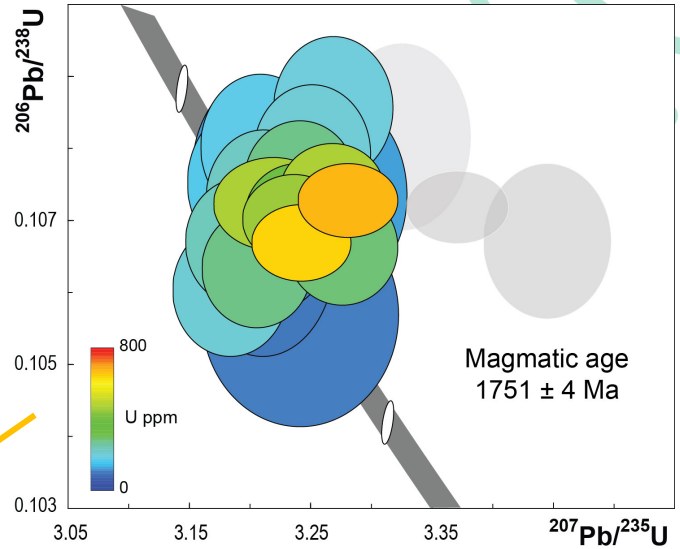
NDING_01: 1720 ± 6 Ma
NDING_02: 1724 ± 5 Ma
NDING_04: 1731 ± 5 Ma
NDING_06: 1730 ± 4 Ma

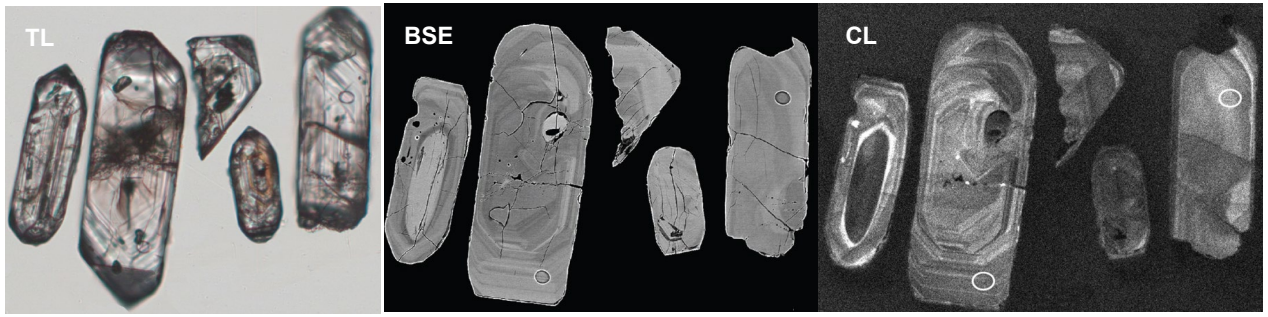
NDING_05: 1751 ± 4 Ma



NAWA DOMAIN

NDING_05

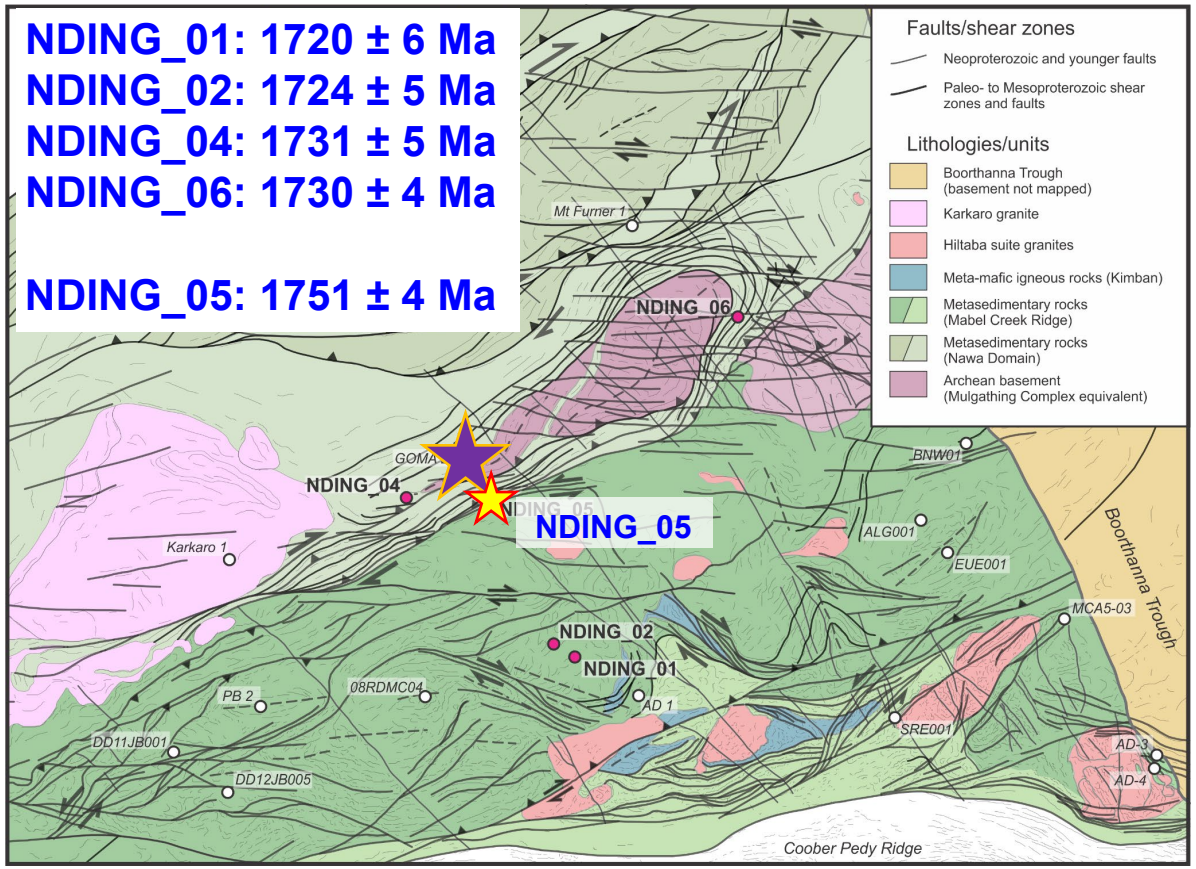




NDI DRILLING PROGRAM

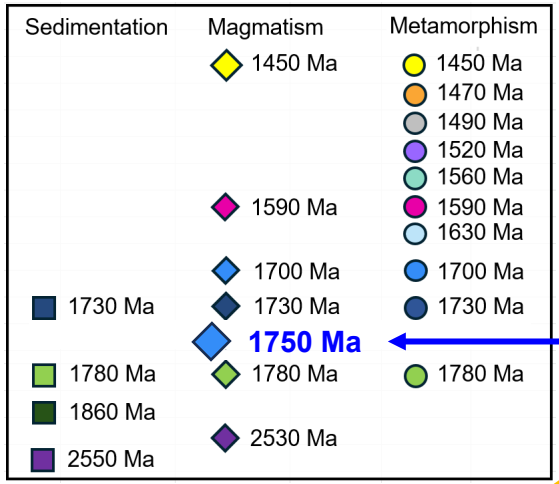
NDING_01: 1720 ± 6 Ma
NDING_02: 1724 ± 5 Ma
NDING_04: 1731 ± 5 Ma
NDING_06: 1730 ± 4 Ma

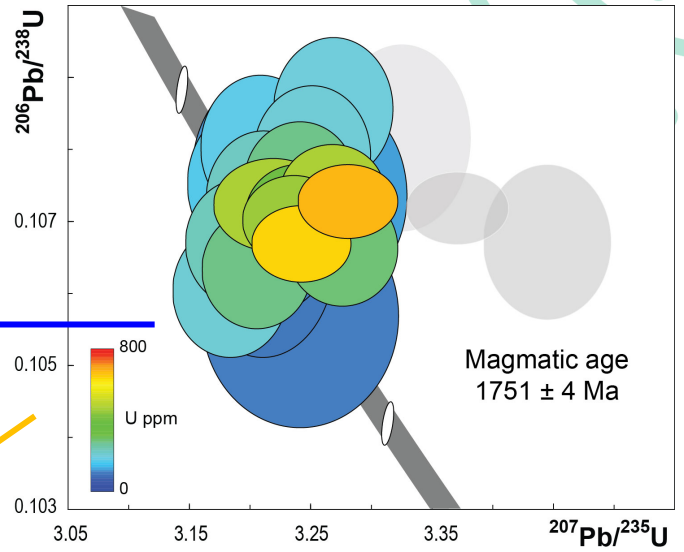
NDING_05: 1751 ± 4 Ma

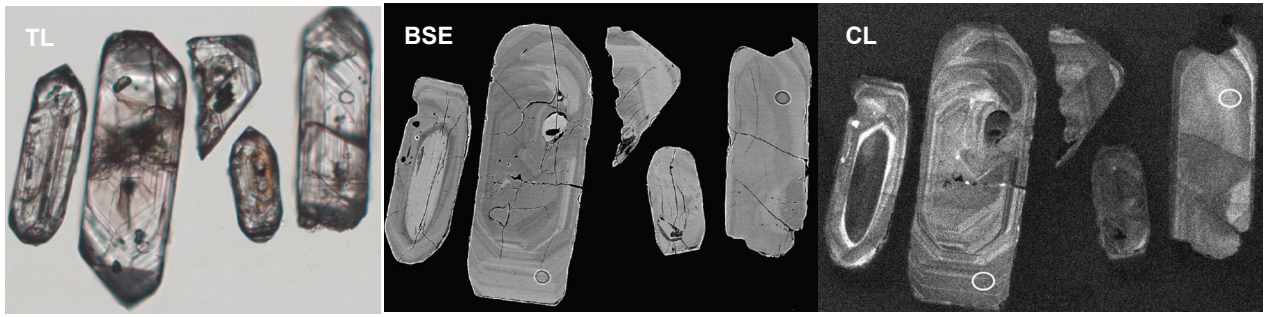


NAWA DOMAIN

NDING_05





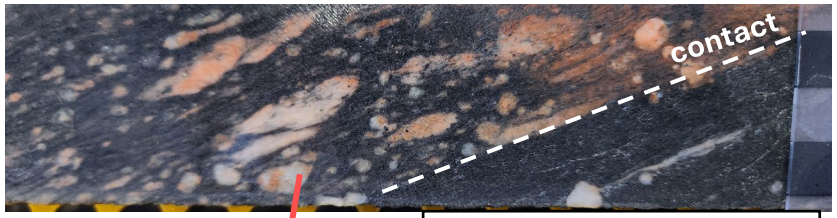


Sample 4575457 (NDING_05)

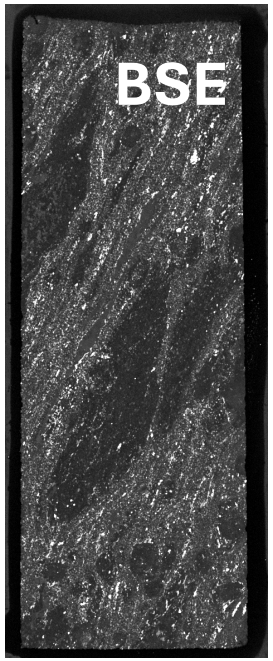
Strongly foliated felsic gneiss comprising medium- to coarse-grained feldspar porphyroblasts which sit within a strongly foliated fine-grained matrix of quartz, plagioclase, K-feldspar, and biotite

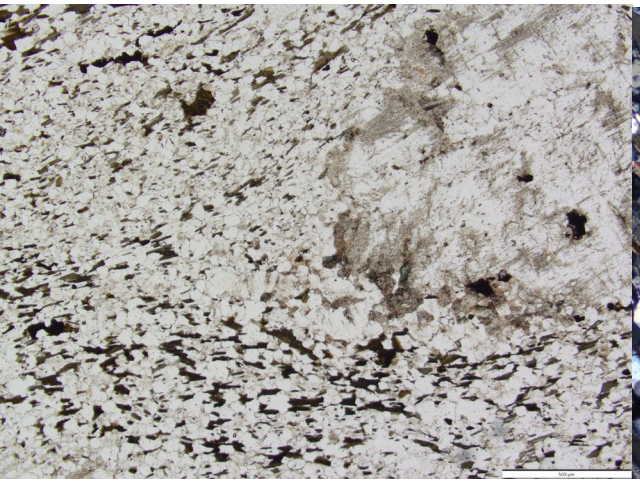
Monazite UPb geochronology (in thin section)

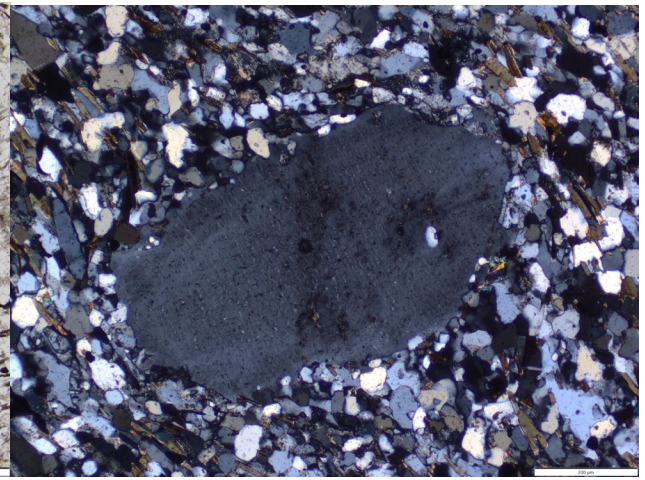
Foliated felsic gneiss (4575457)

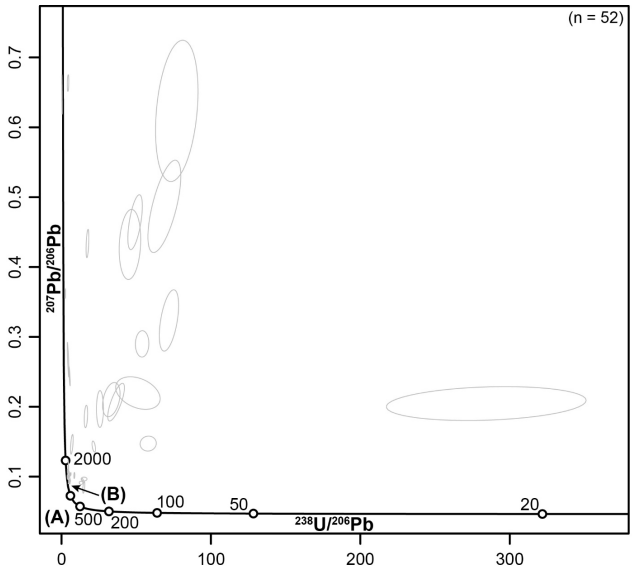


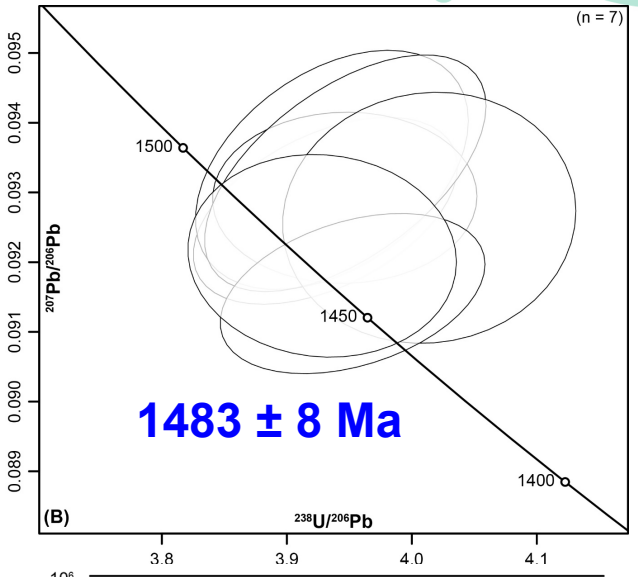
Ultra-mylonite (4575454)

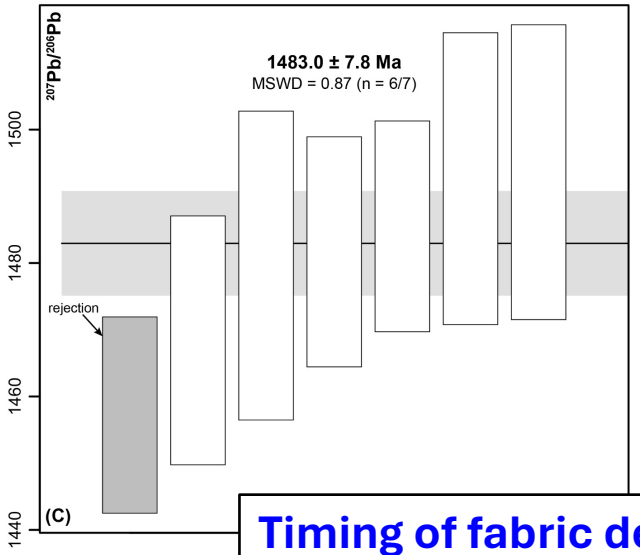


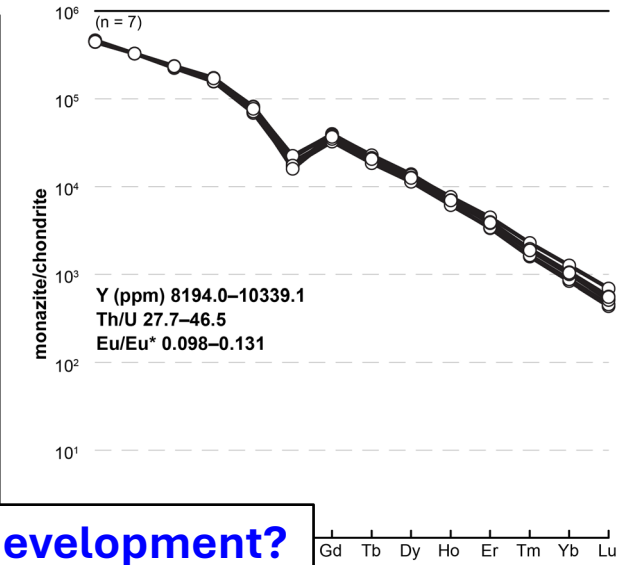






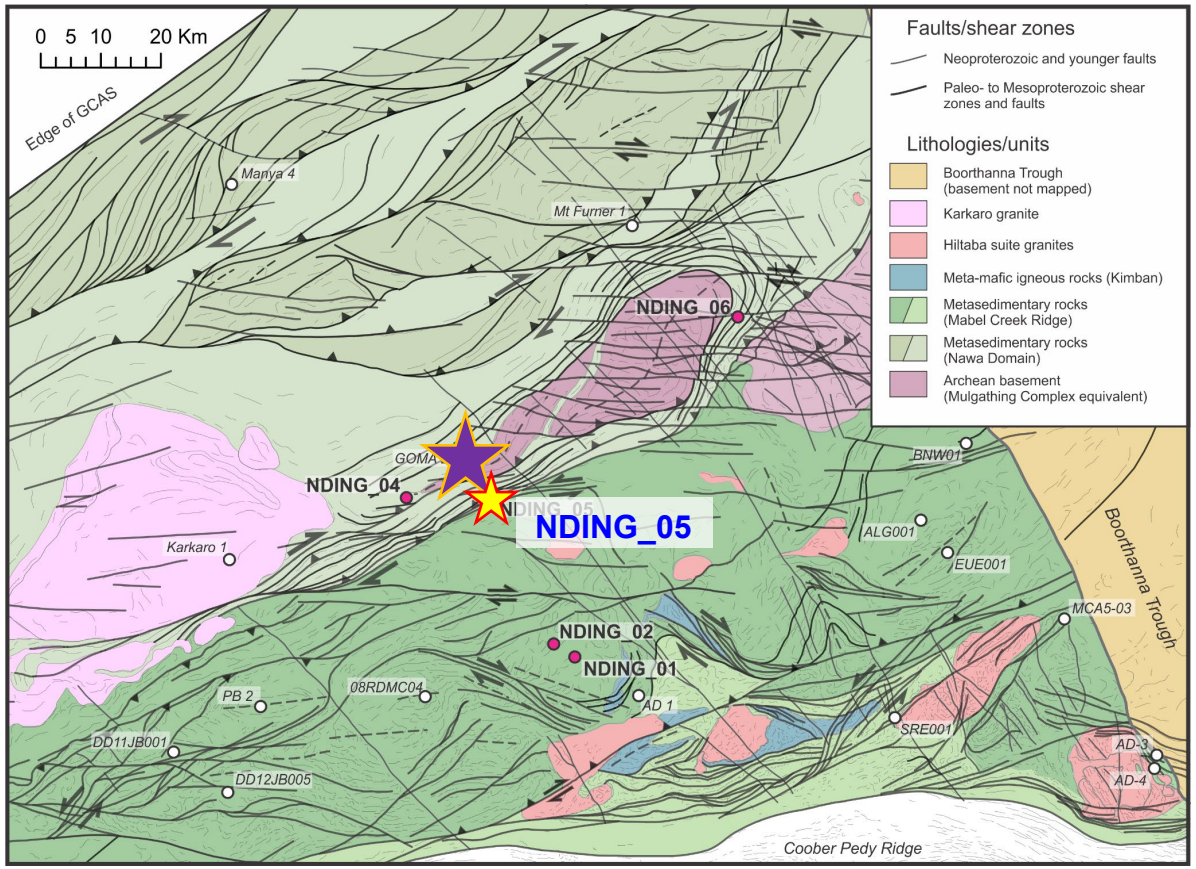






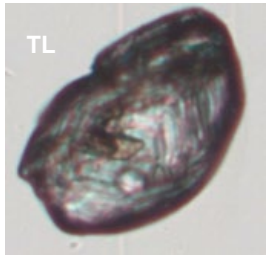
Timing of fabric development?

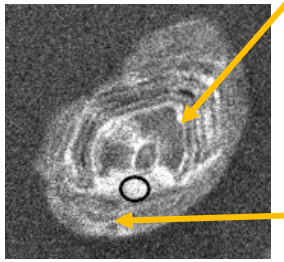
NDI DRILLING PROGRAM

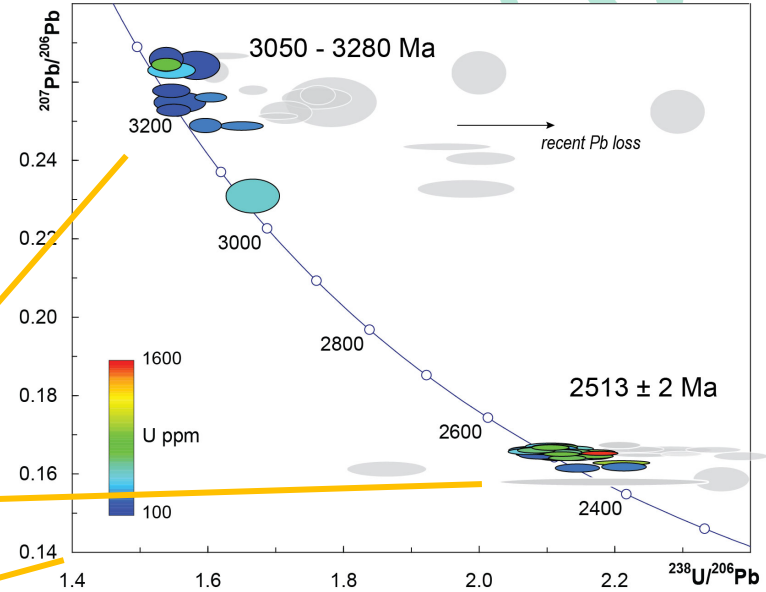


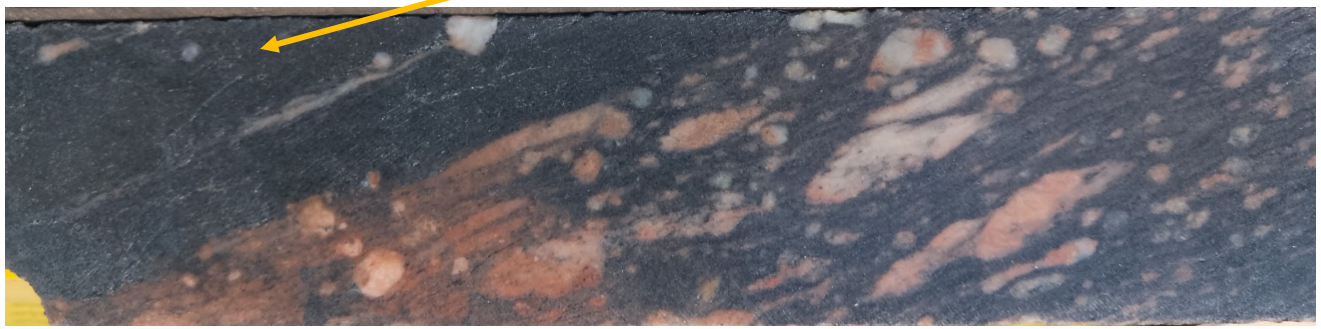
NAWA DOMAIN

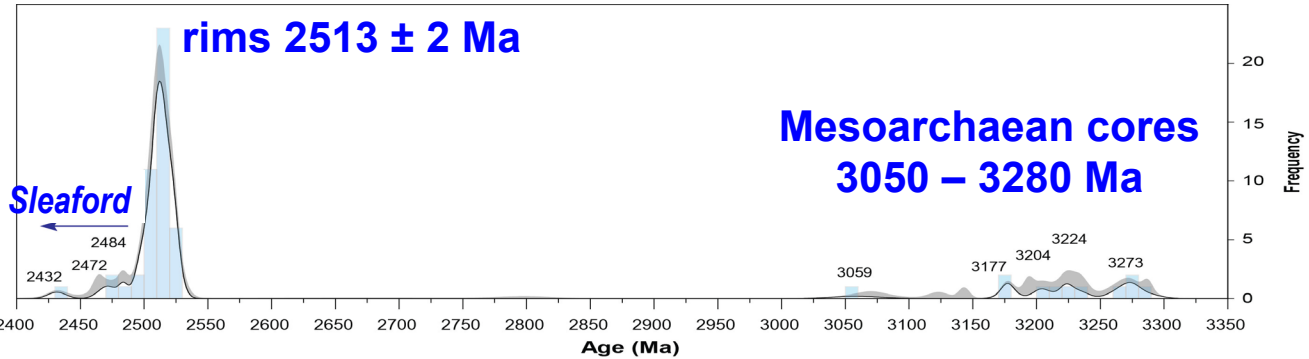
NDING_05











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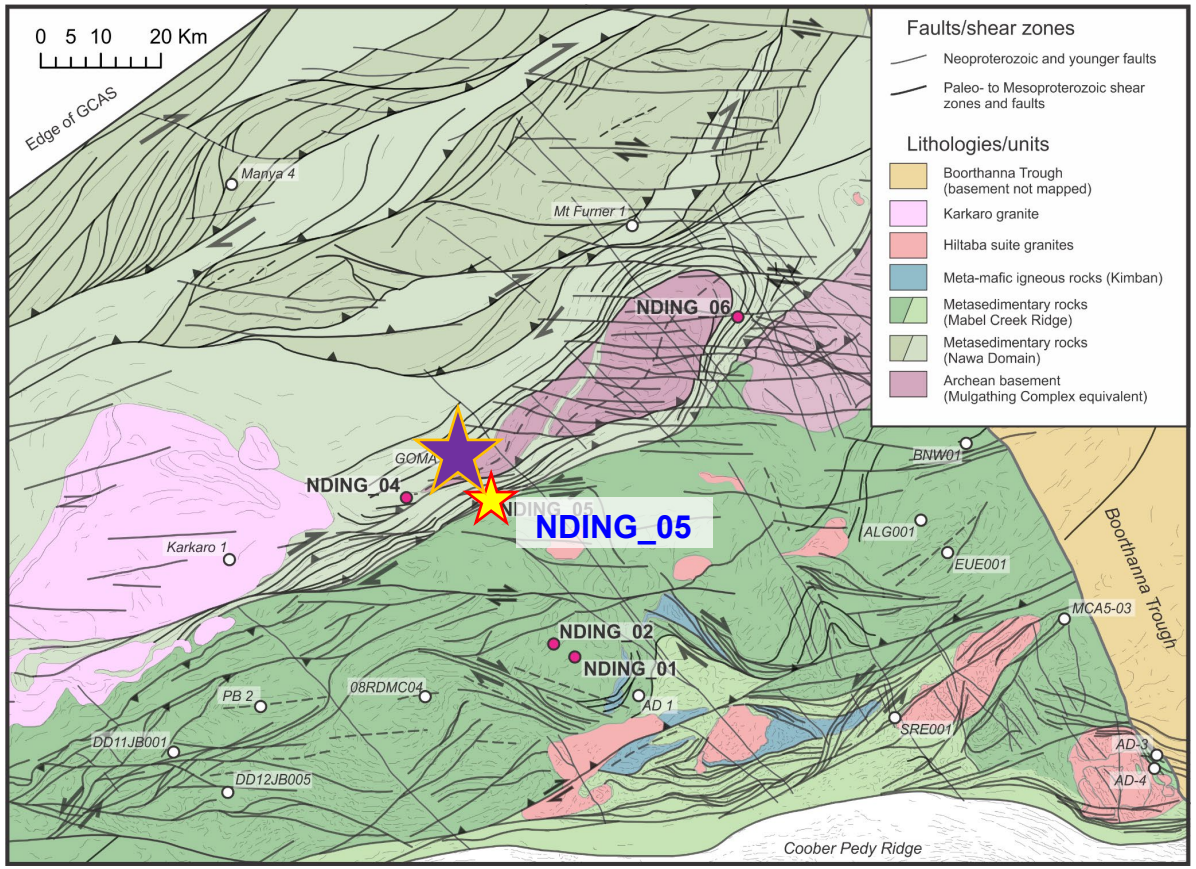
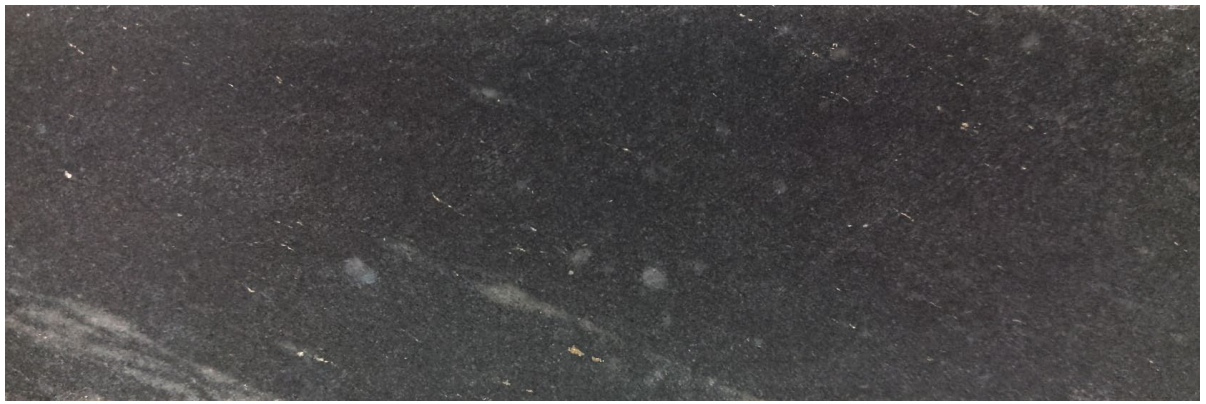
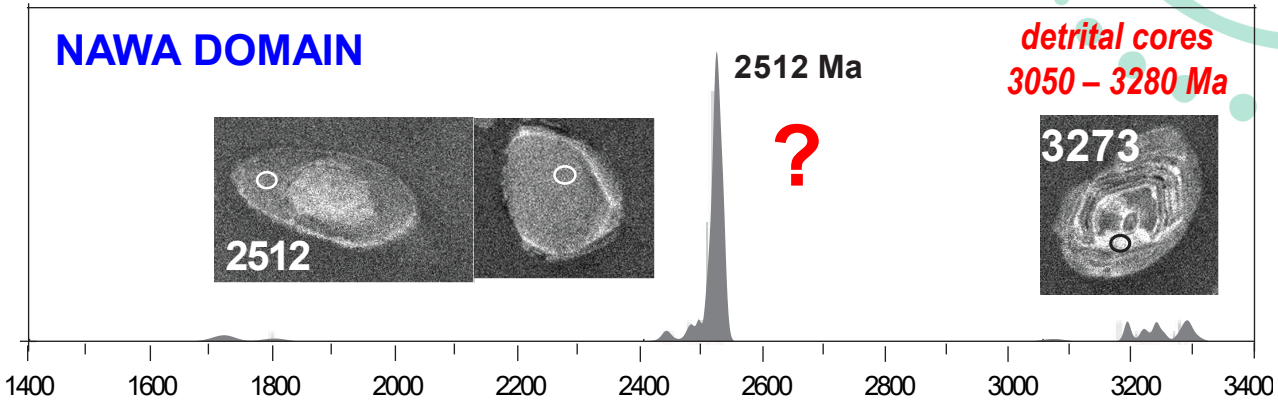




NAWA DOMAIN

NDING_05



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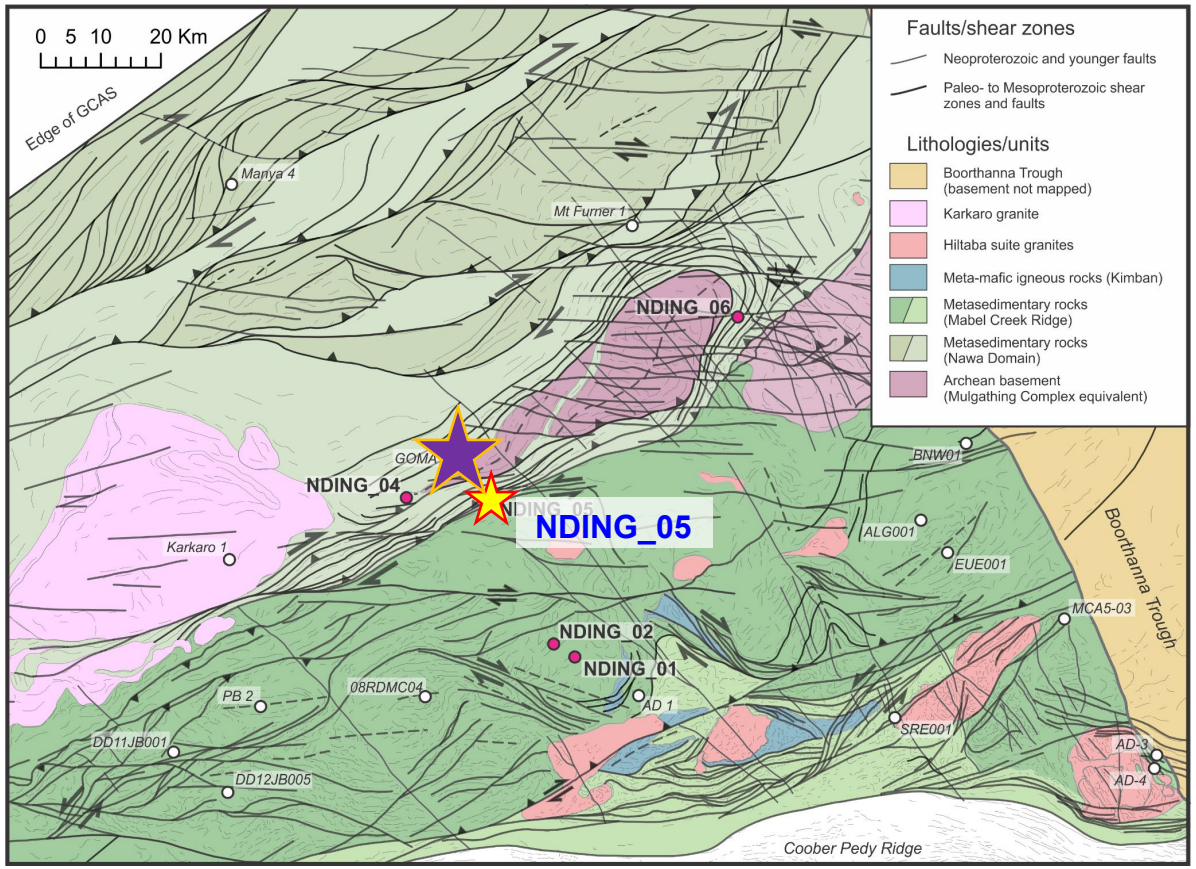

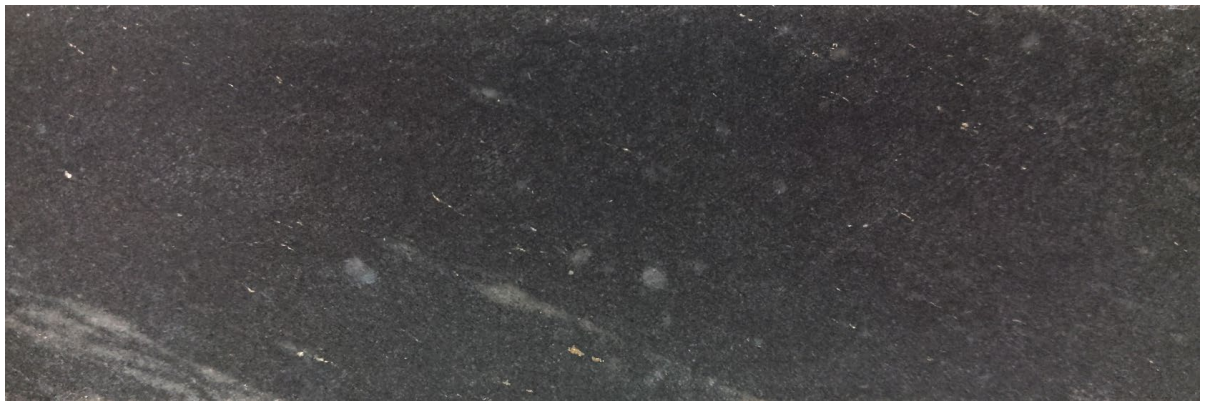

NAWA DOMAIN

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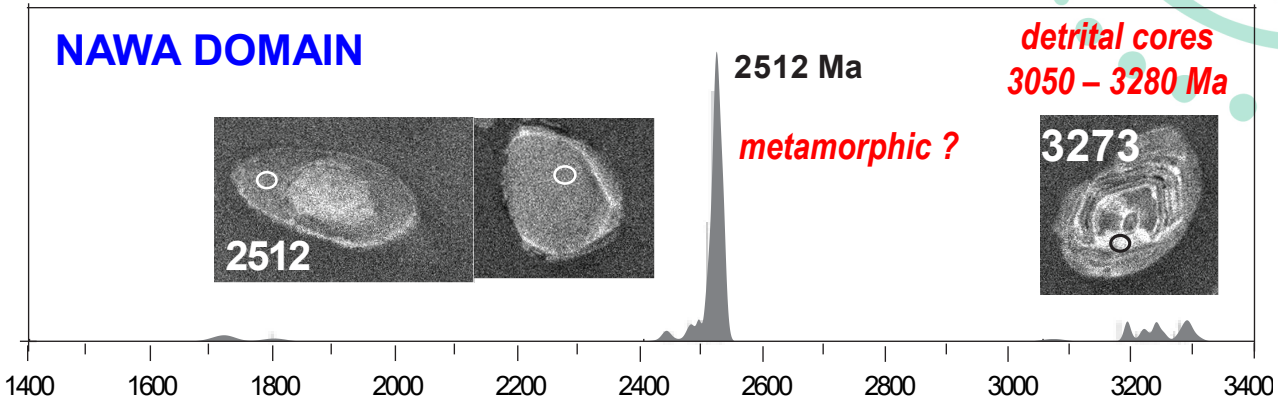
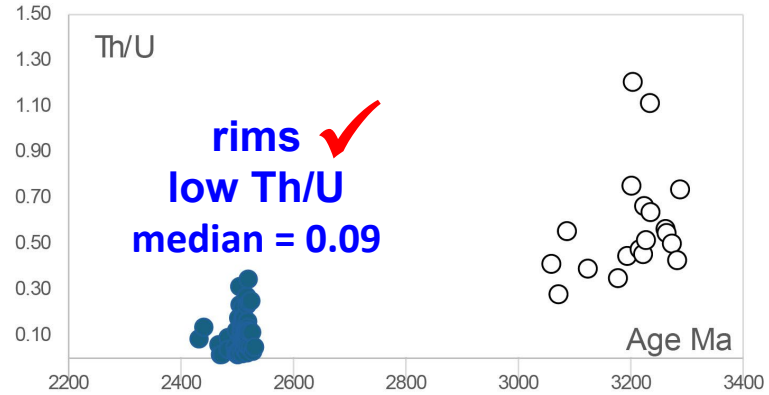
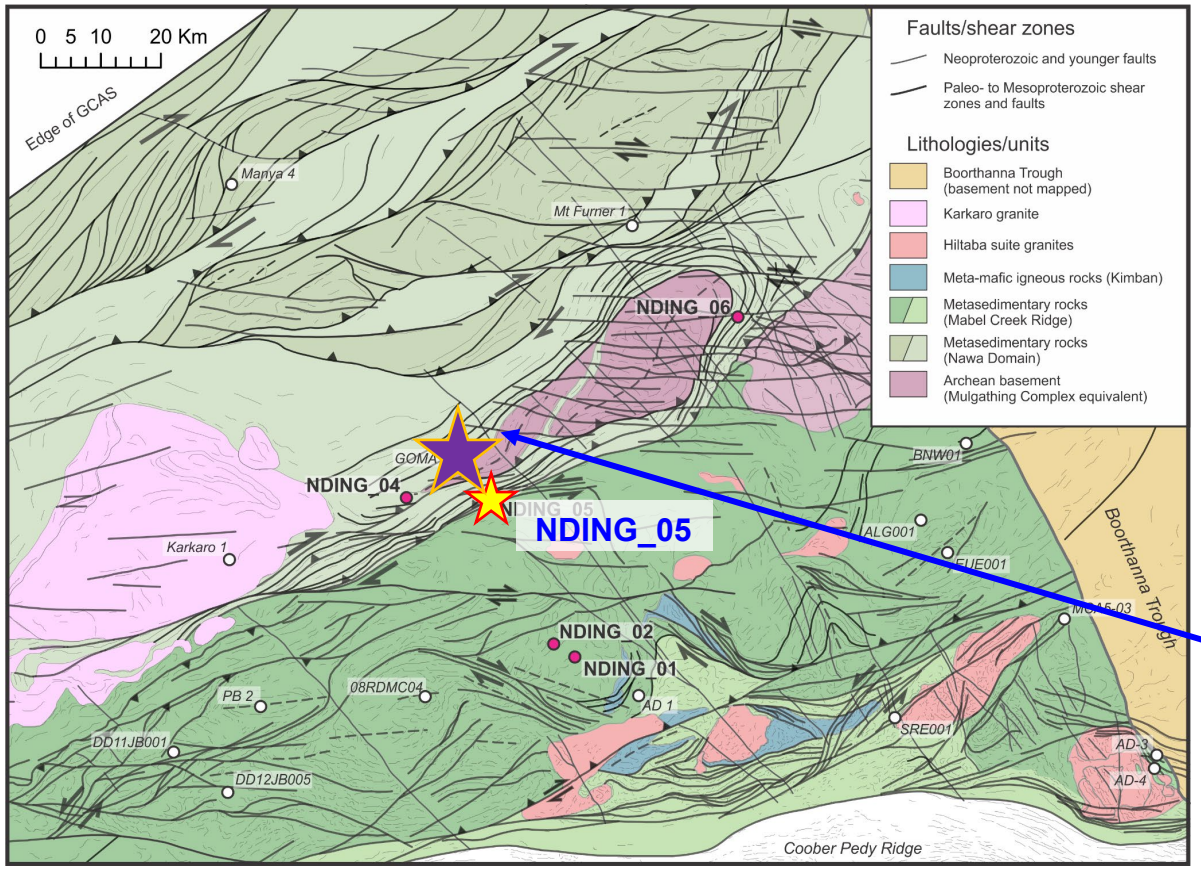


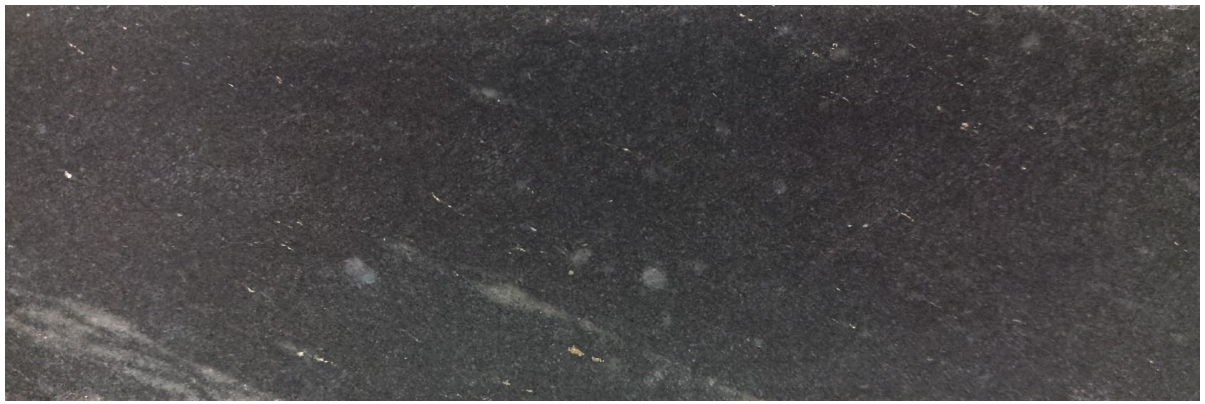
dk CL ✓
homogenous



rims ✓
low Th/U
median = 0.09

NDI DRILLING PROGRAM





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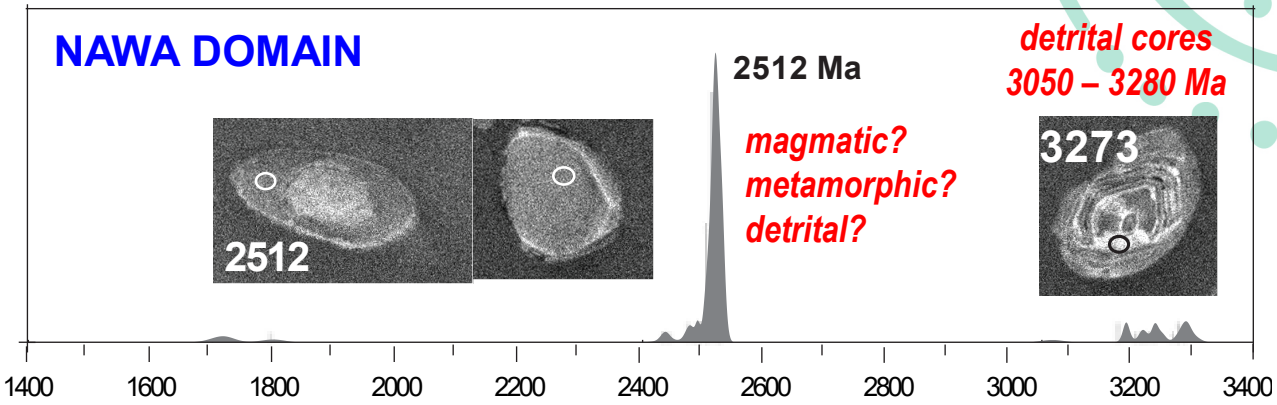
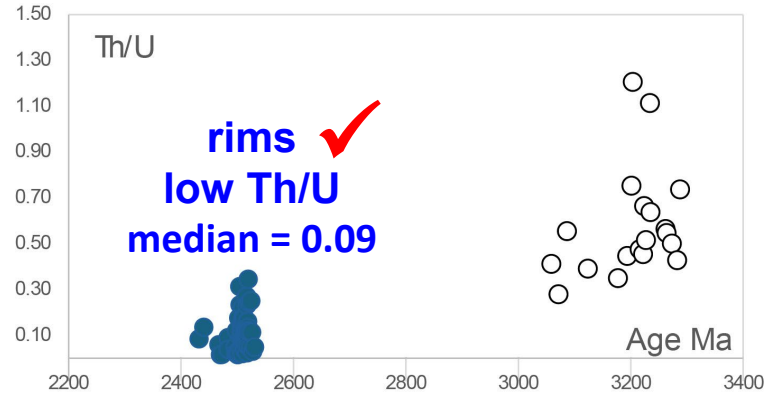


dk CL ✓
homogenous

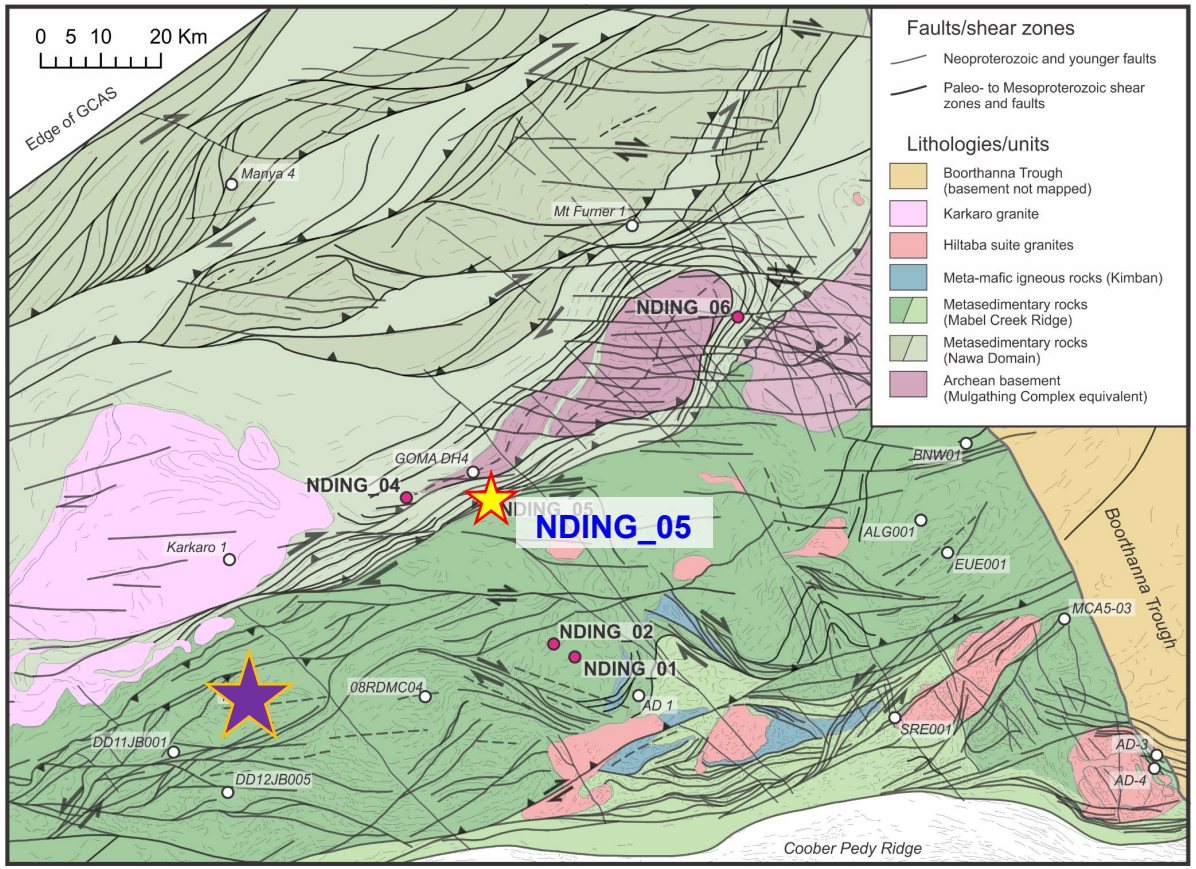
GOMA 4? X
rims = 2526 Ma

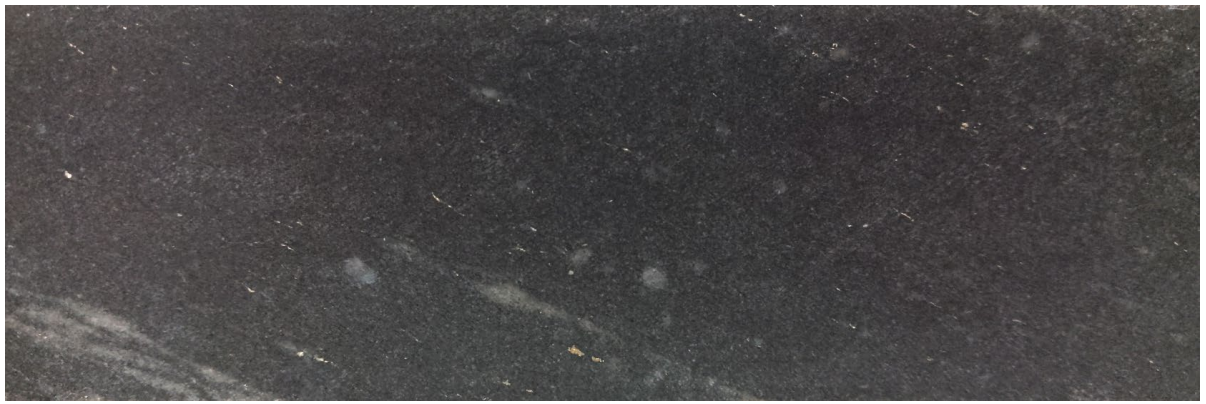


rims ✓
low Th/U
median = 0.09

Sleaford Orogeny X
c. 2470 – 2410 Ma

NDI DRILLING PROGRAM





NAWA DOMAIN

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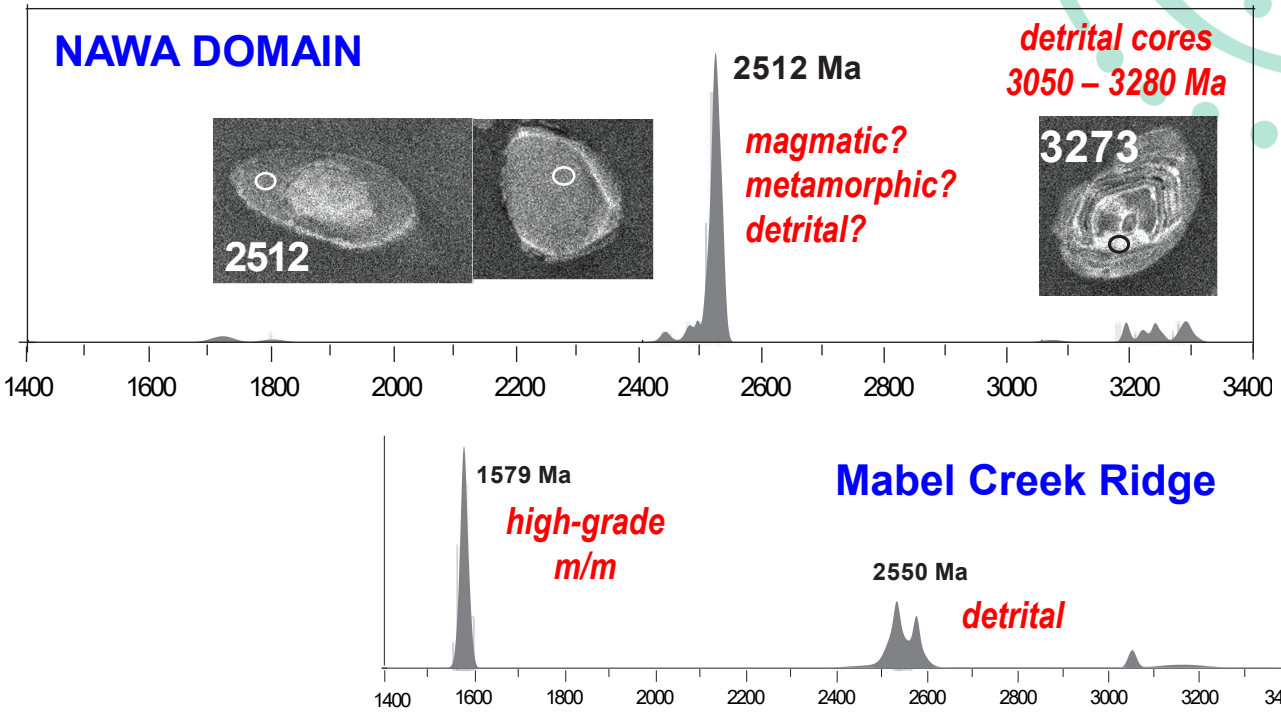

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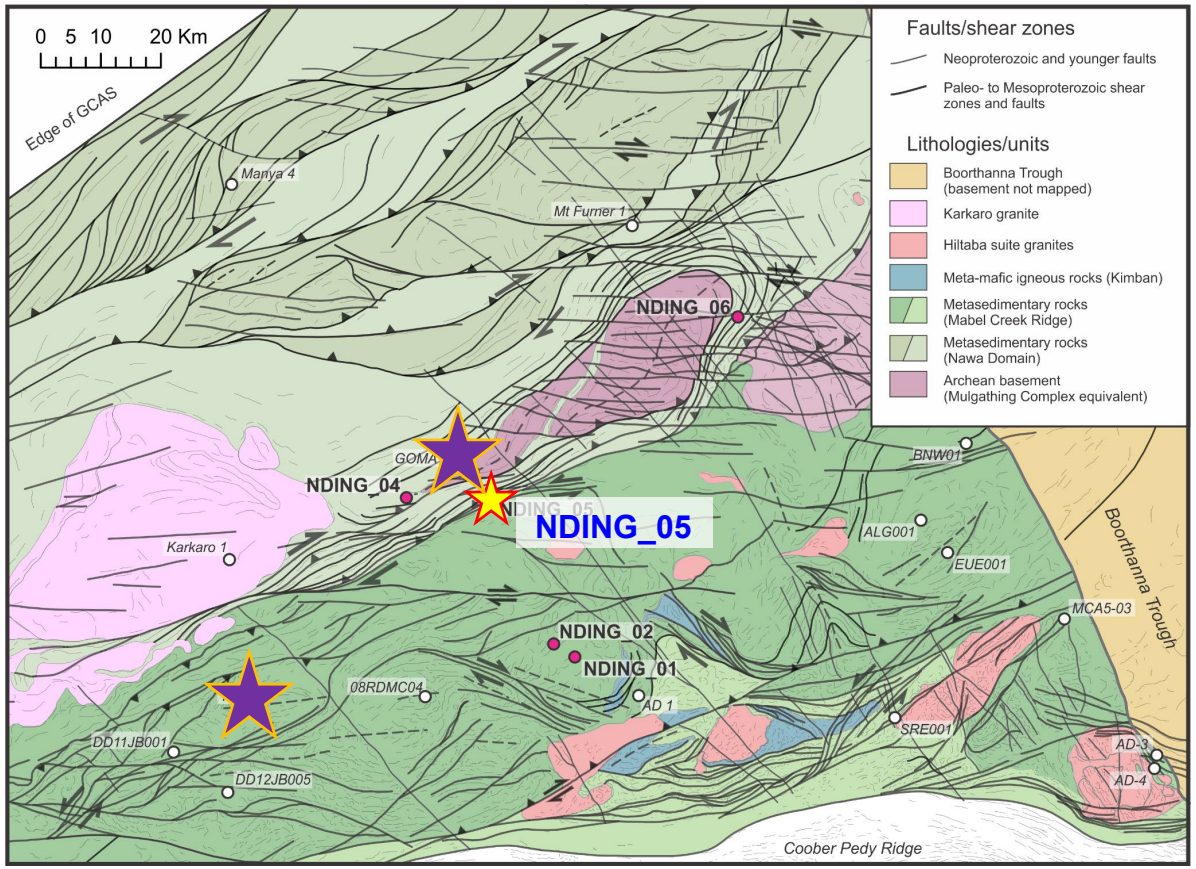

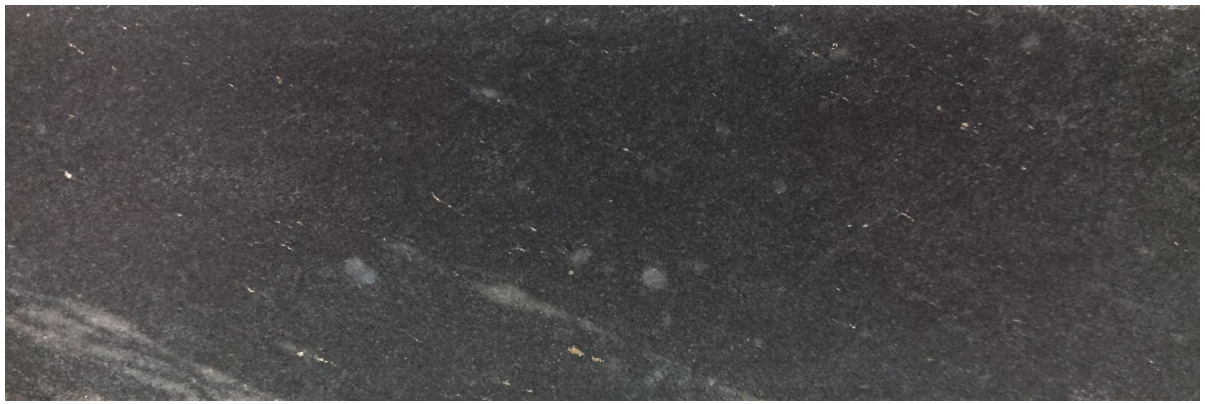

NAWA DOMAIN

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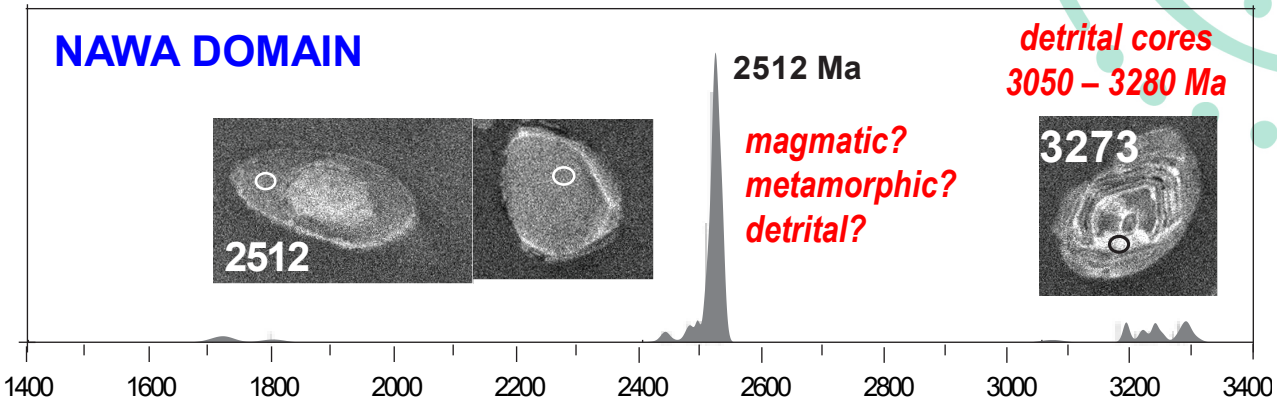

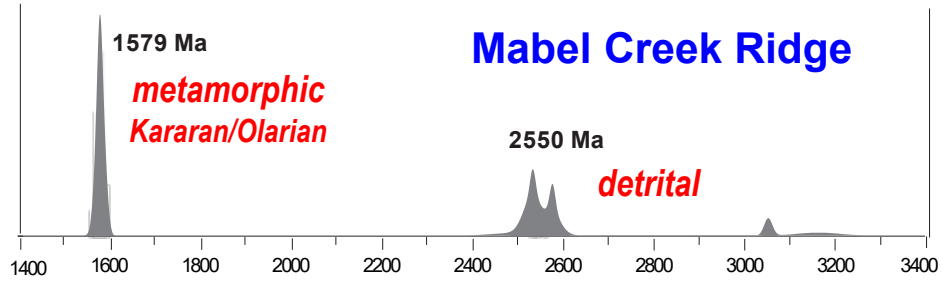

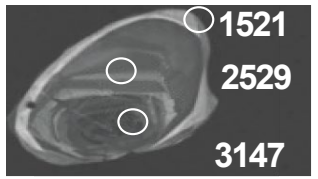

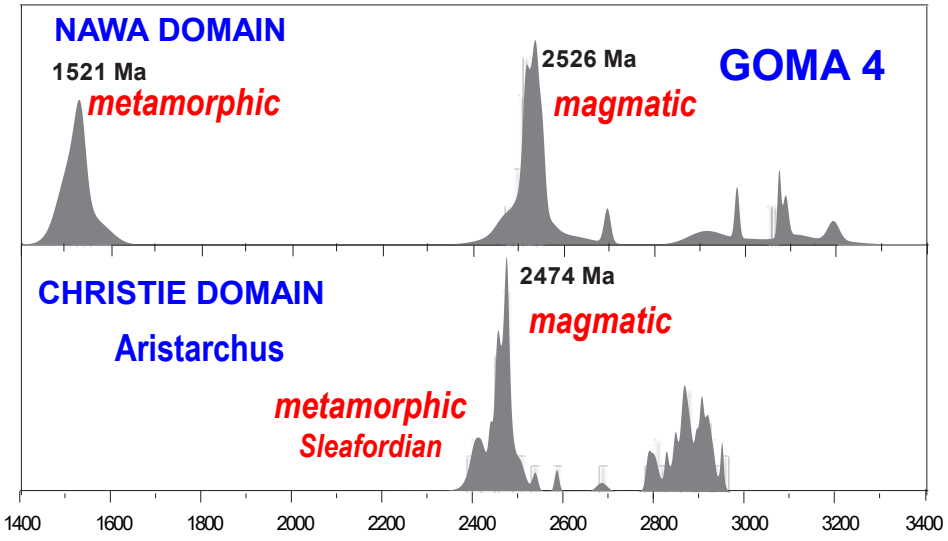

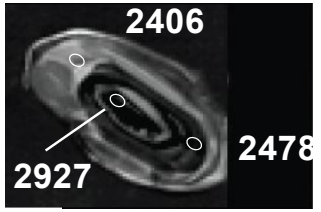

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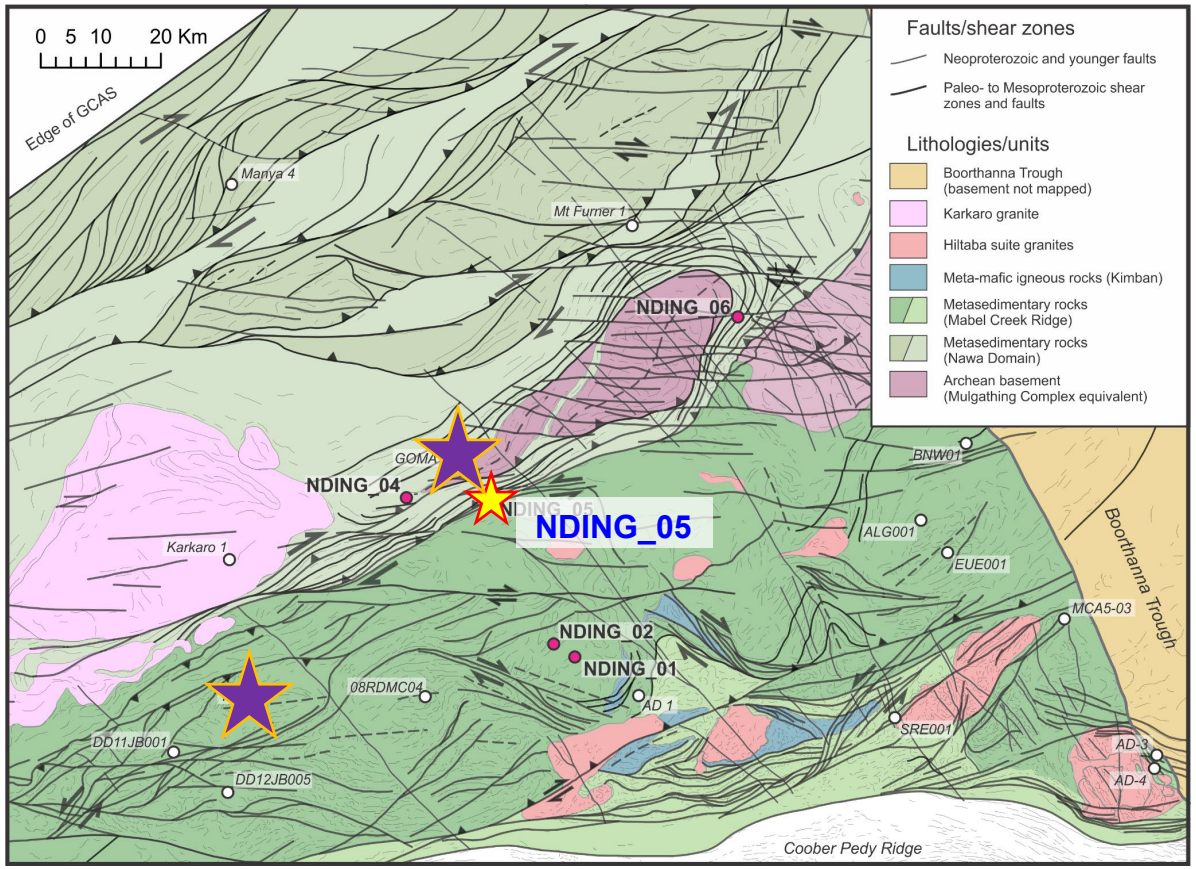
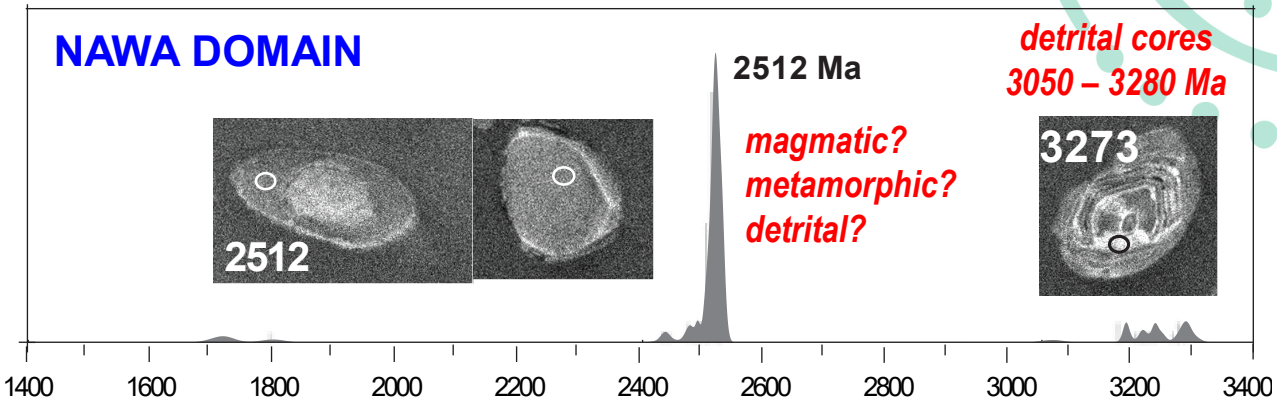
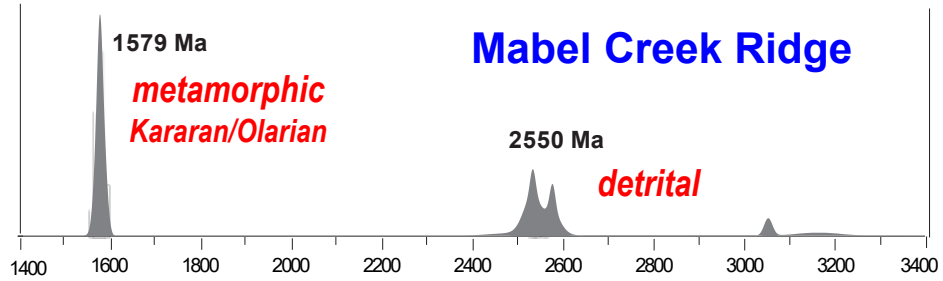


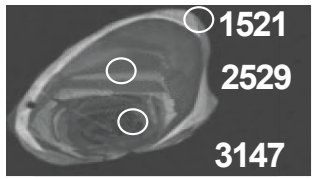
1. detritus deposited in the Paleoproterozoic and derived from the Christie Domain
2. Archaean basement underlying the southern Nawa Domain extended from the Mulgathing Complex to the south.

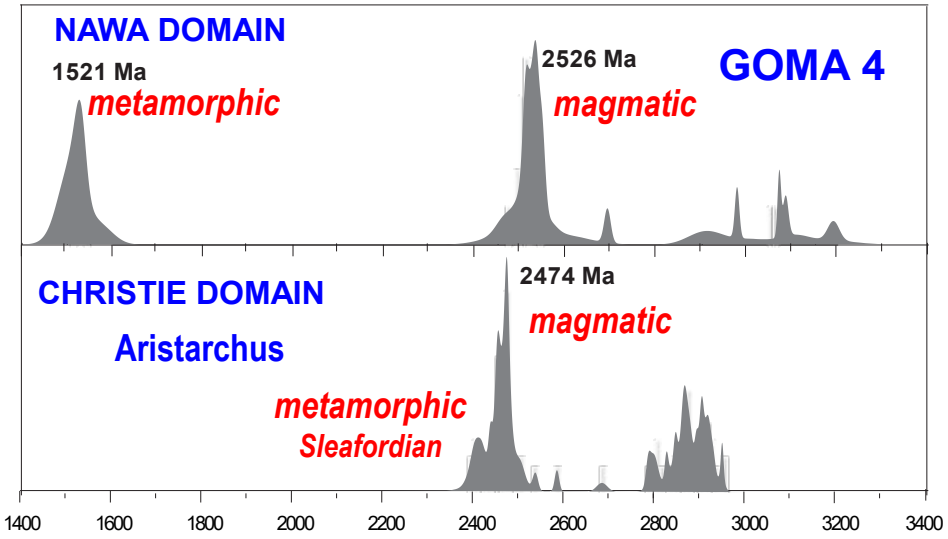
NAWA DOMAIN

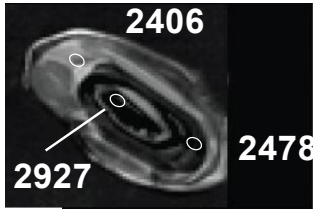
NDING_05











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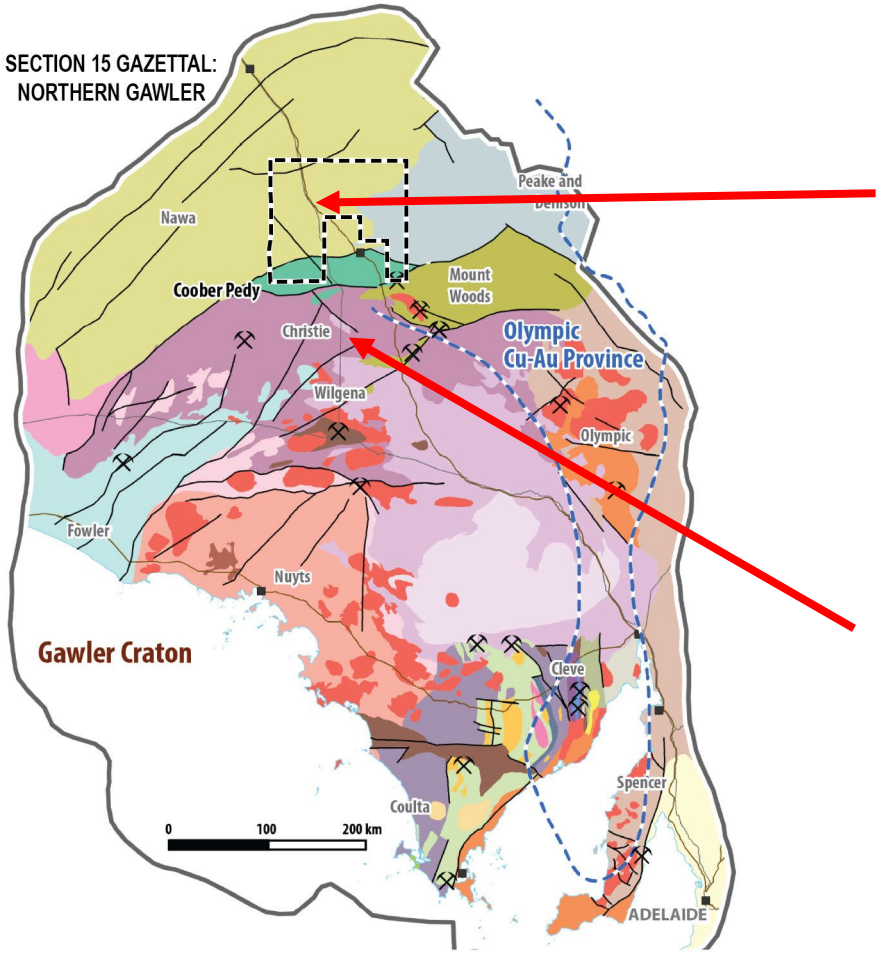
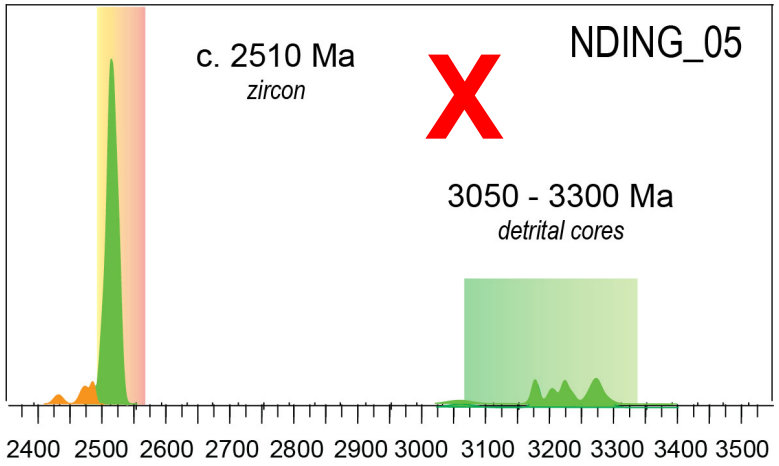
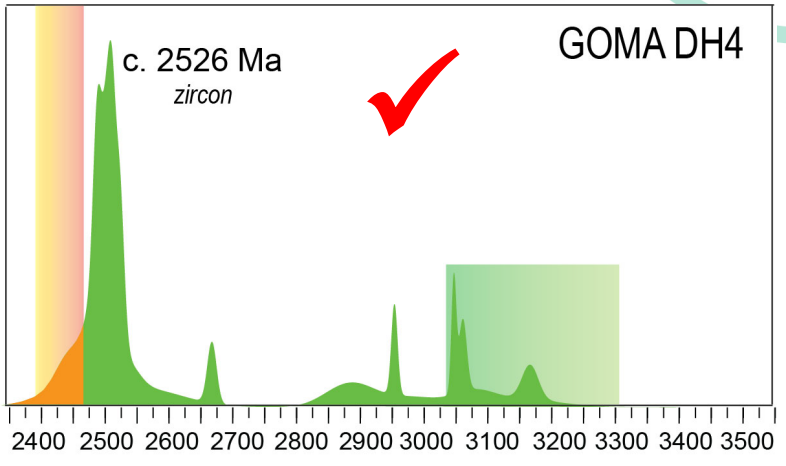
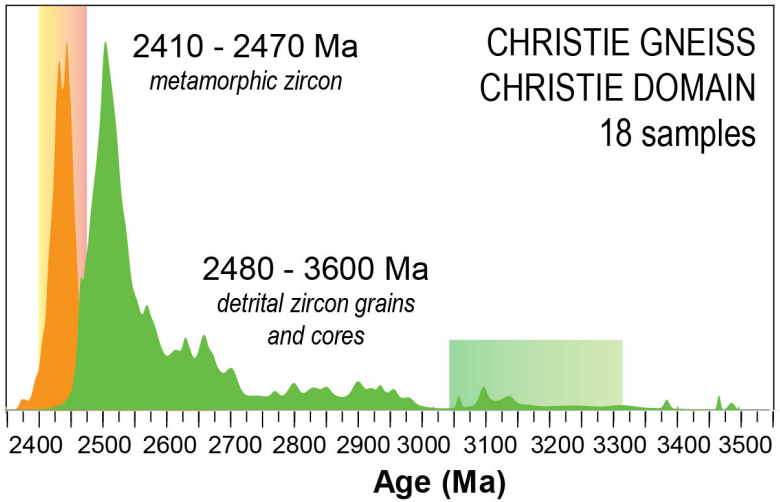
NAWA DOMAIN

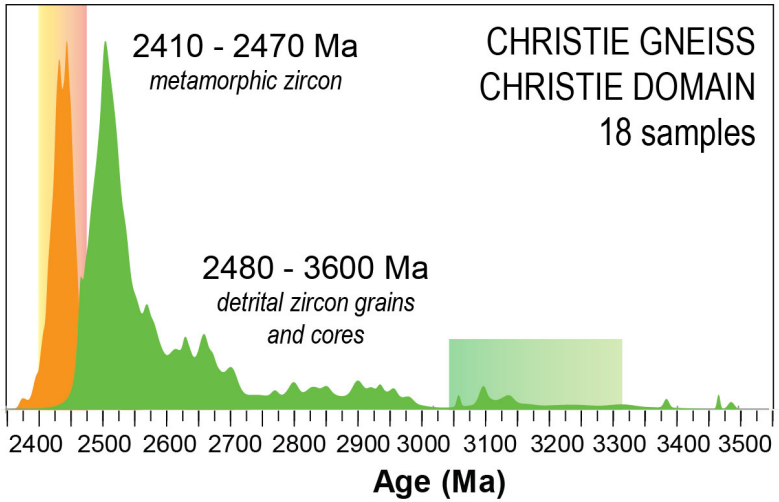
NDING_05









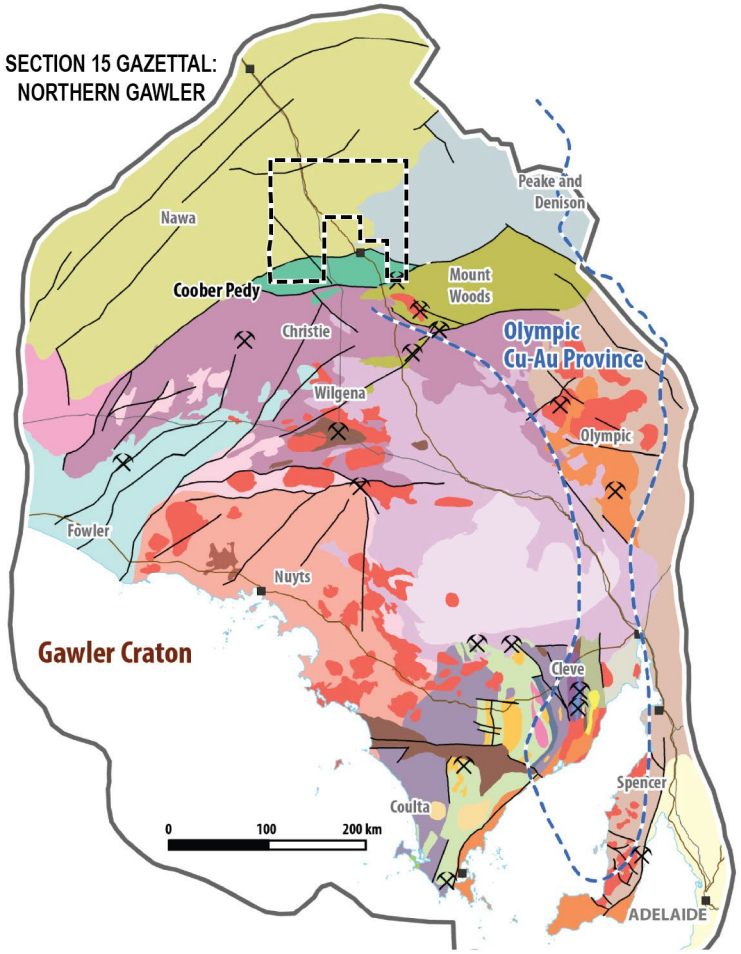


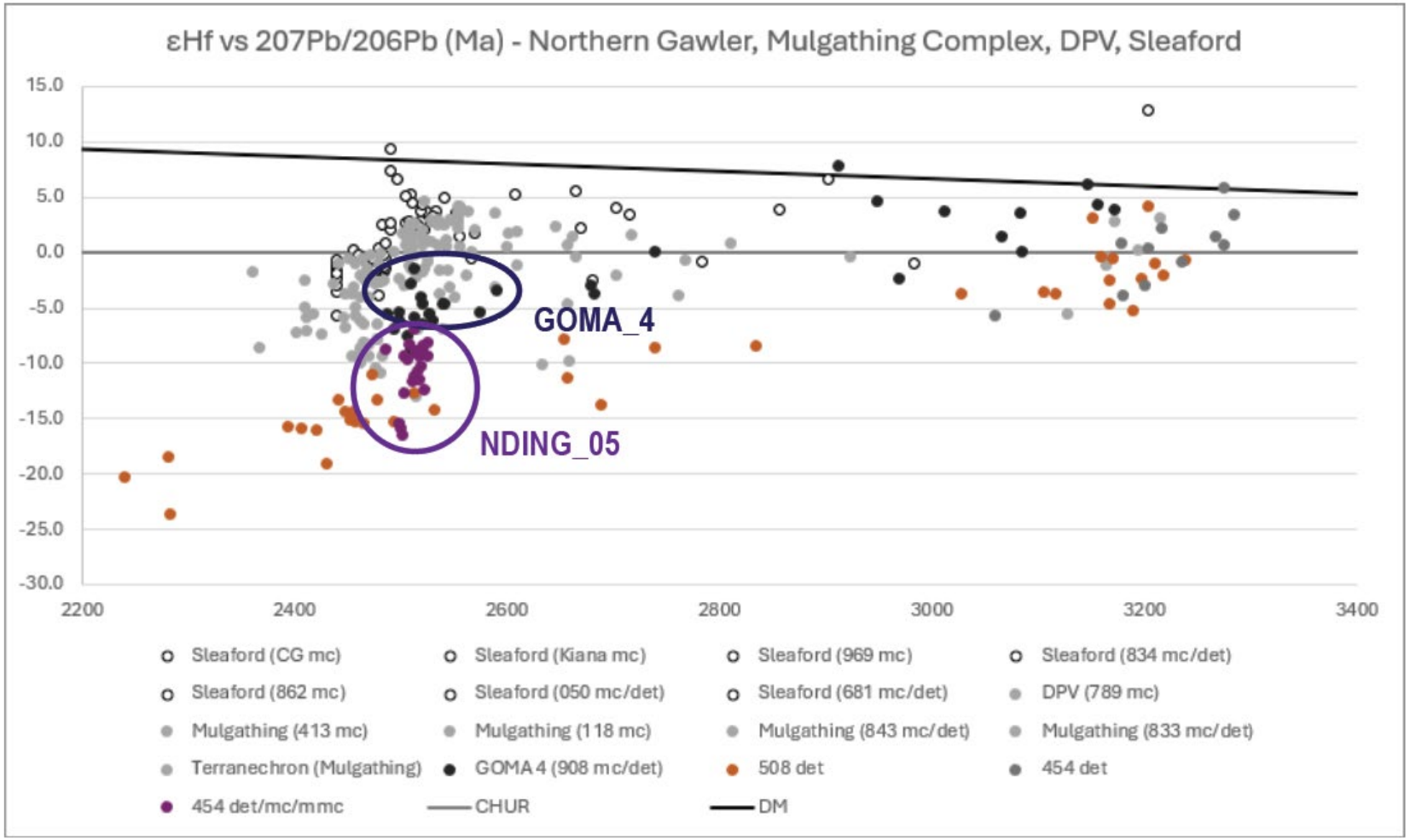
1. detritus deposited in the Paleoproterozoic and derived from the Christie Domain
2. Archaean basement underlying the southern Nawa Domain extended from the Mulgathing Complex to the south.

NDI DRILLING PROGRAM

NAWA DOMAIN

NDING_05





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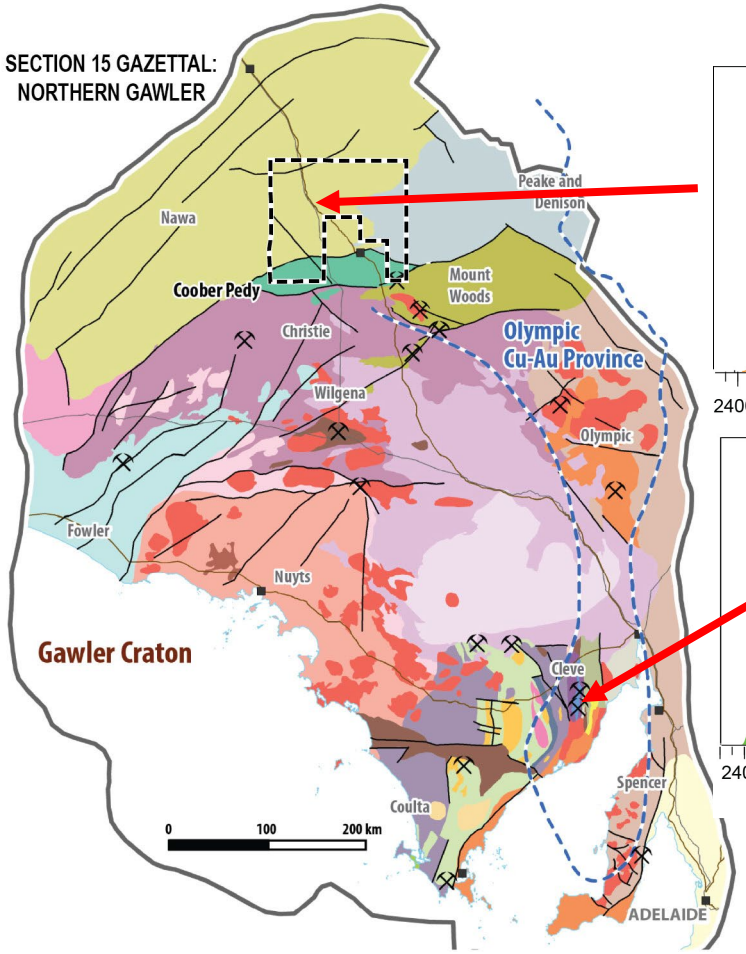
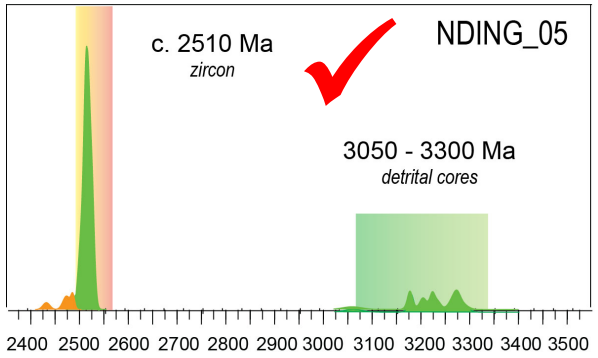
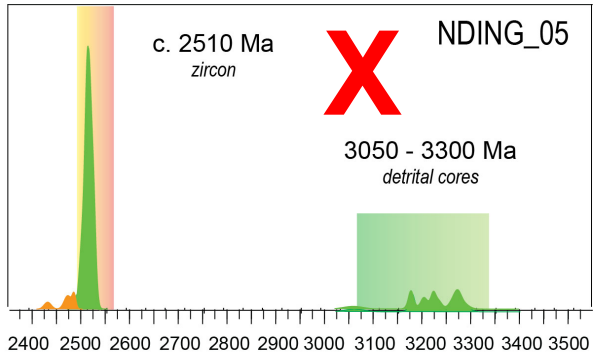
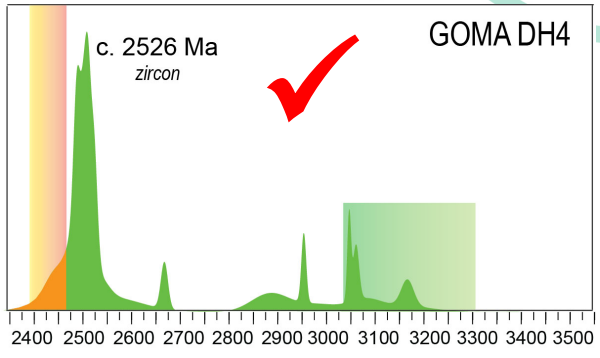
NAWA DOMAIN

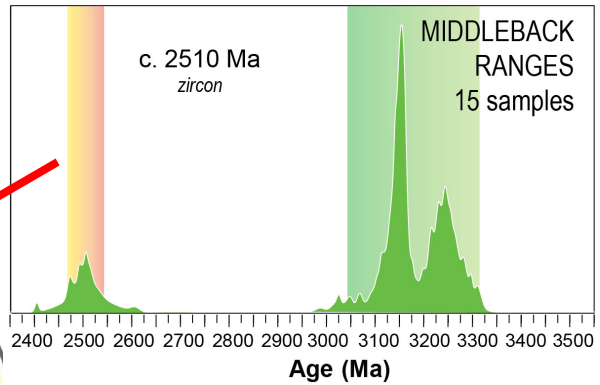
NDING_05

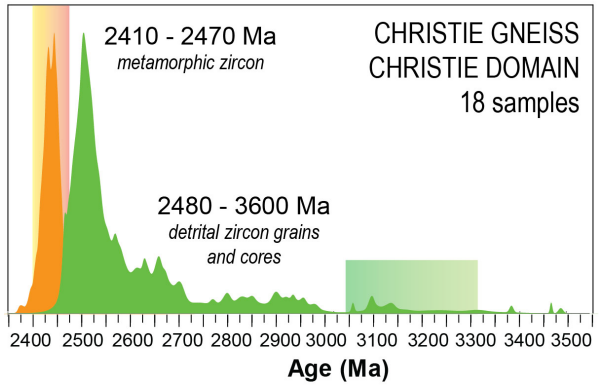


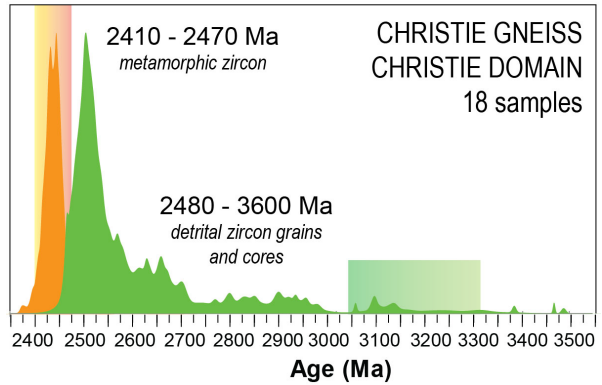












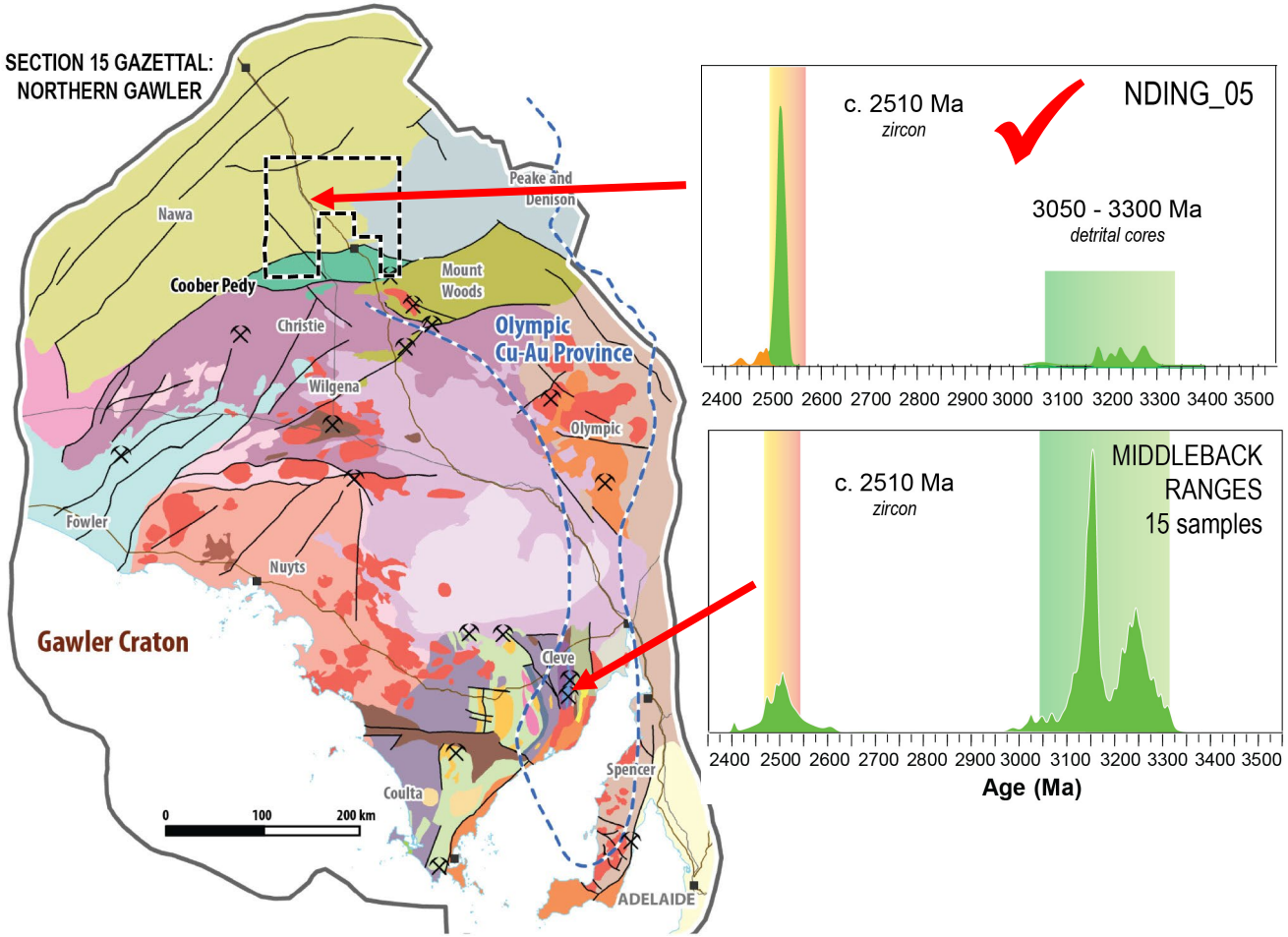
1. detritus deposited in the Paleoproterozoic and derived from the Christie Domain
2. Archaean basement underlying the southern Nawa Domain extended from the Mulgathing Complex to the south.

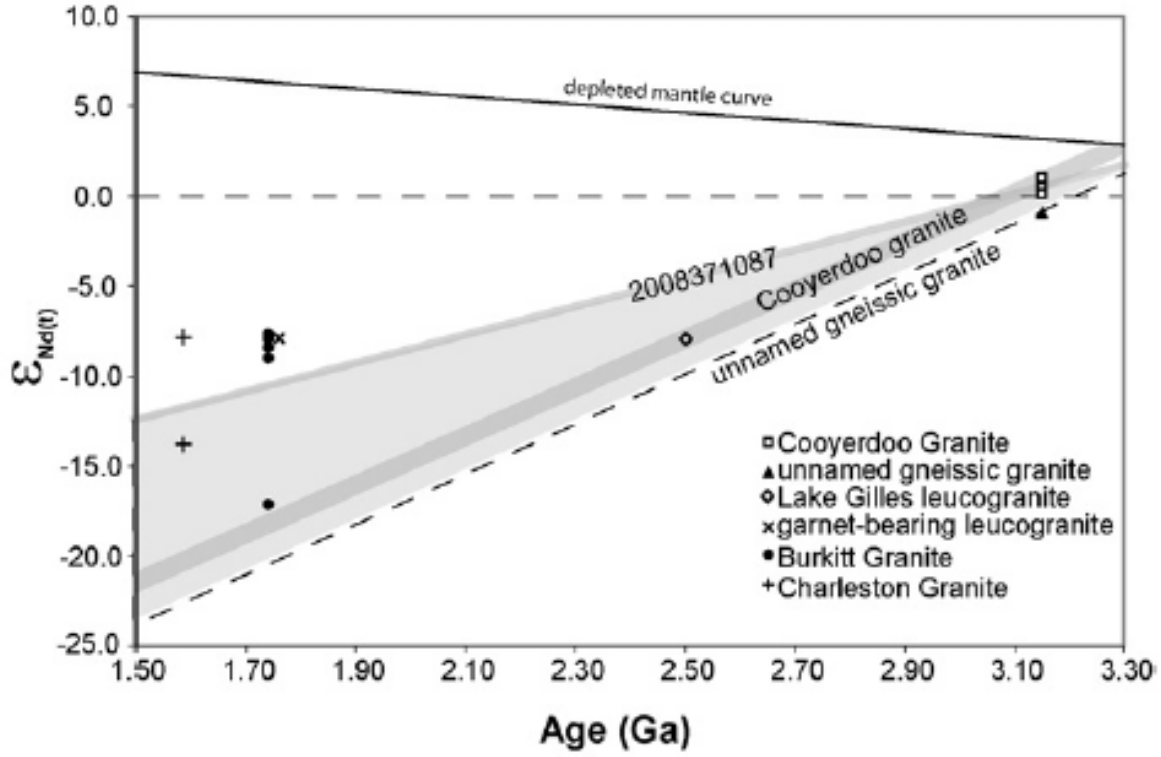
3. Link to the Mesoarchaean basement in the Southern Gawler Craton

NDI DRILLING PROGRAM

NAWA DOMAIN

NDING_05





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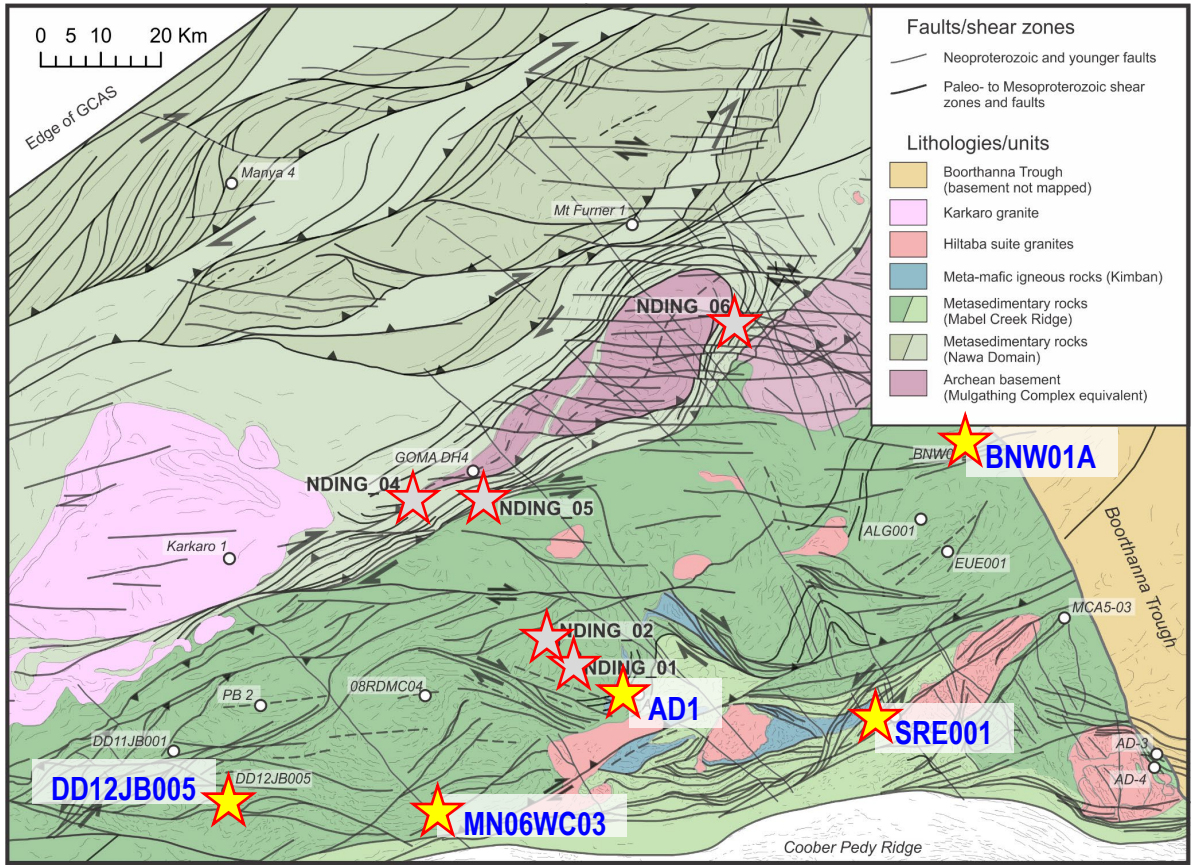
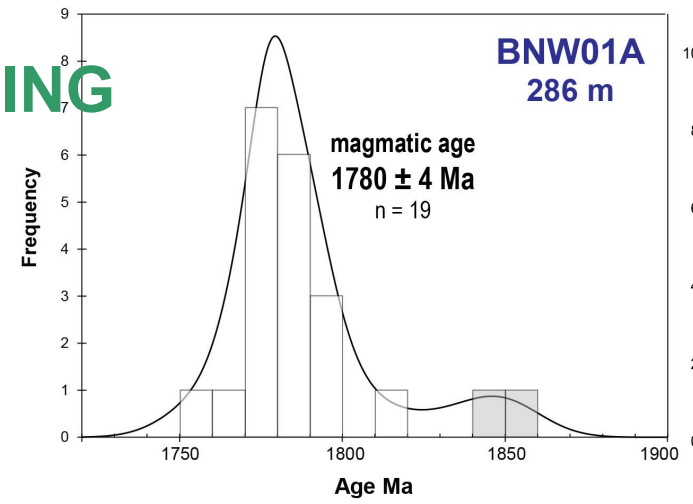
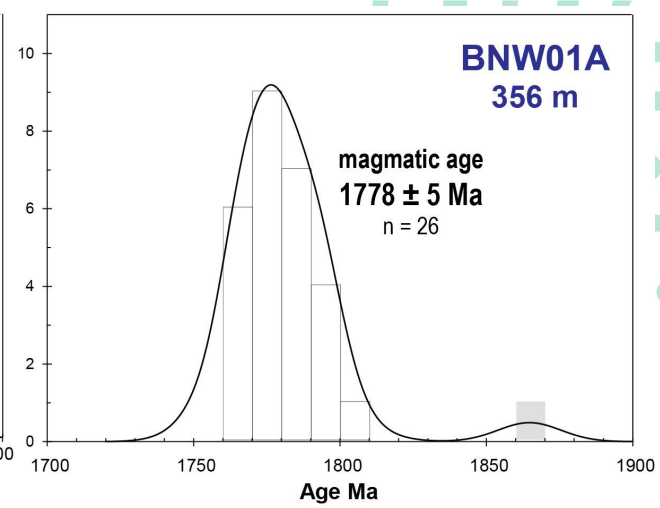
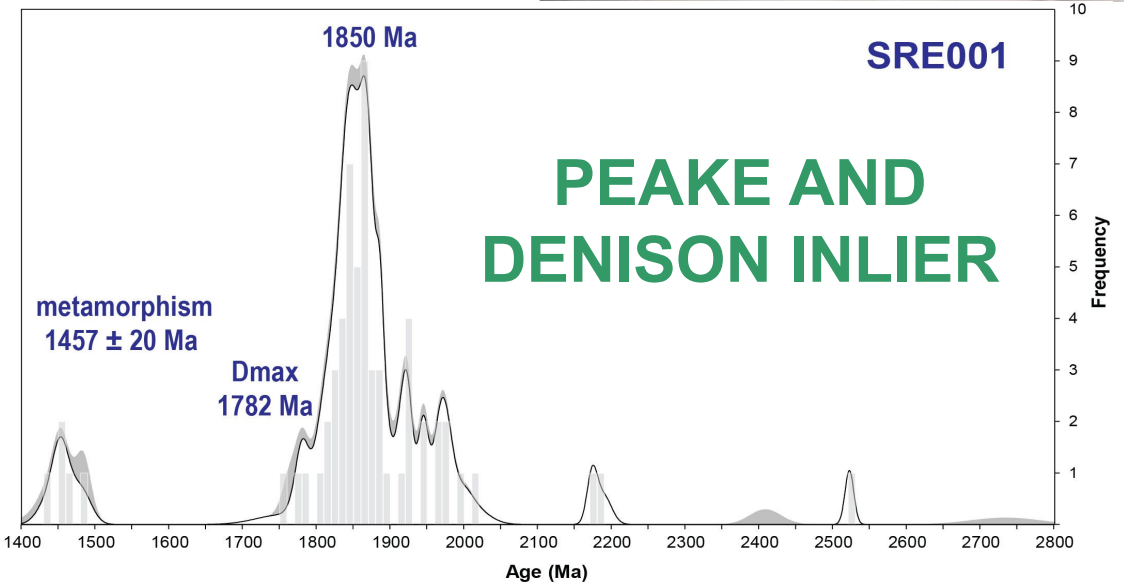
SOUTH AUSTRALIA DISCOVERY MAPPING









in prep. Jagodzinski EA, Brown D and Percival J. 2025. *Geochronology on the buried northern Gawler craton. Part 3: SHRIMP U-Pb dating of high-grade gneisses of the Peake and Denison and Nawa Domains.* Report Book 2025/00011. Department for Energy and Mining, South Australia, Adelaide.

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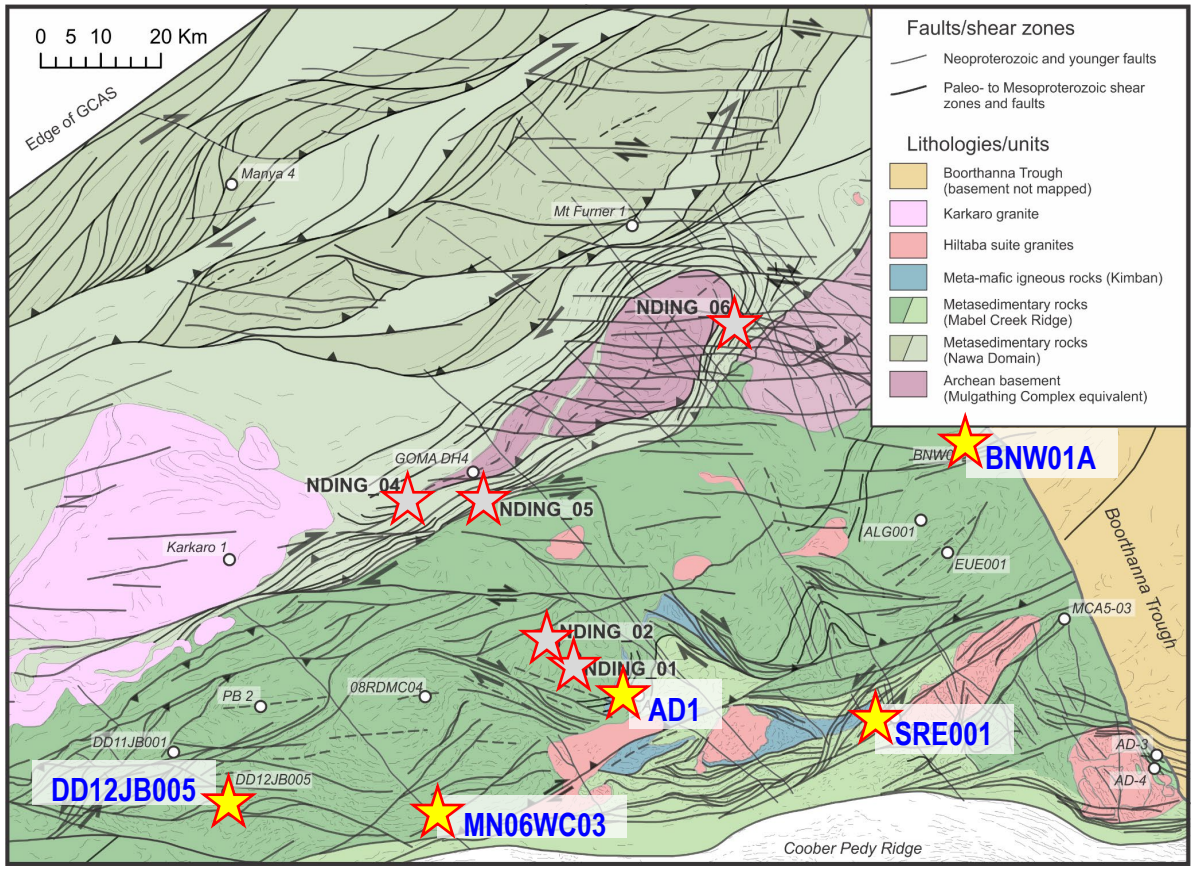

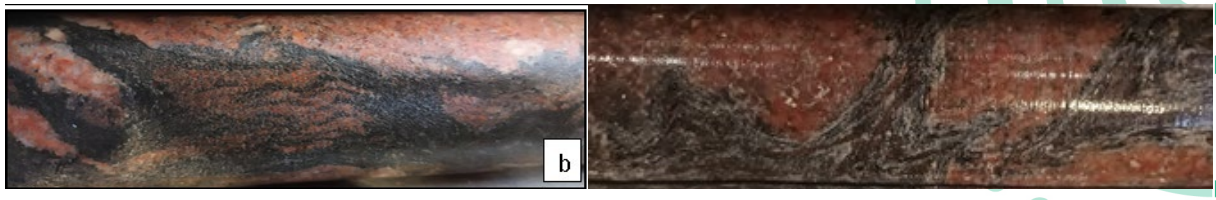

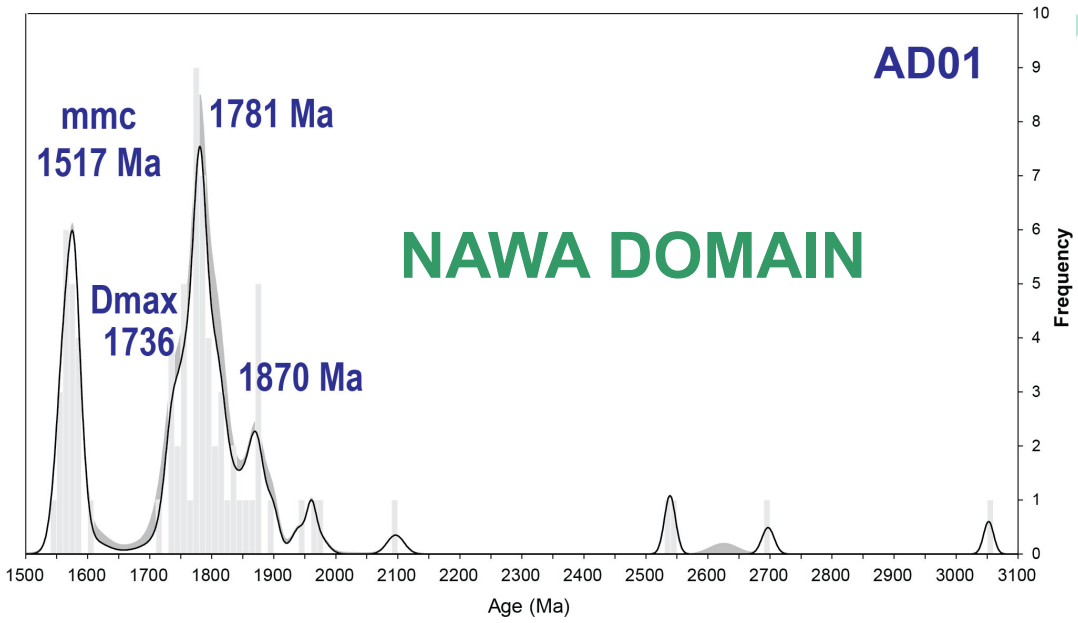

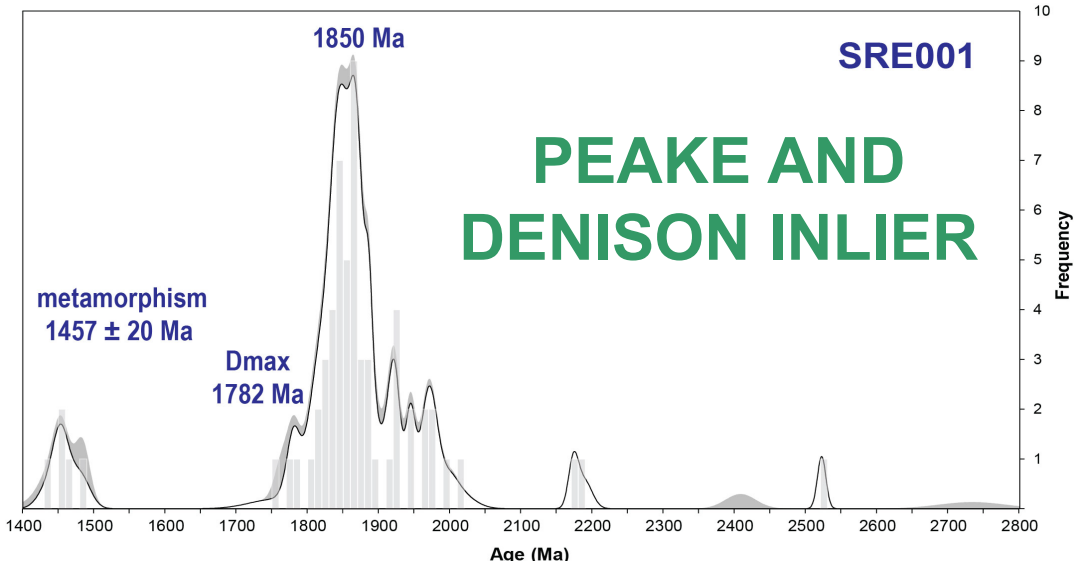

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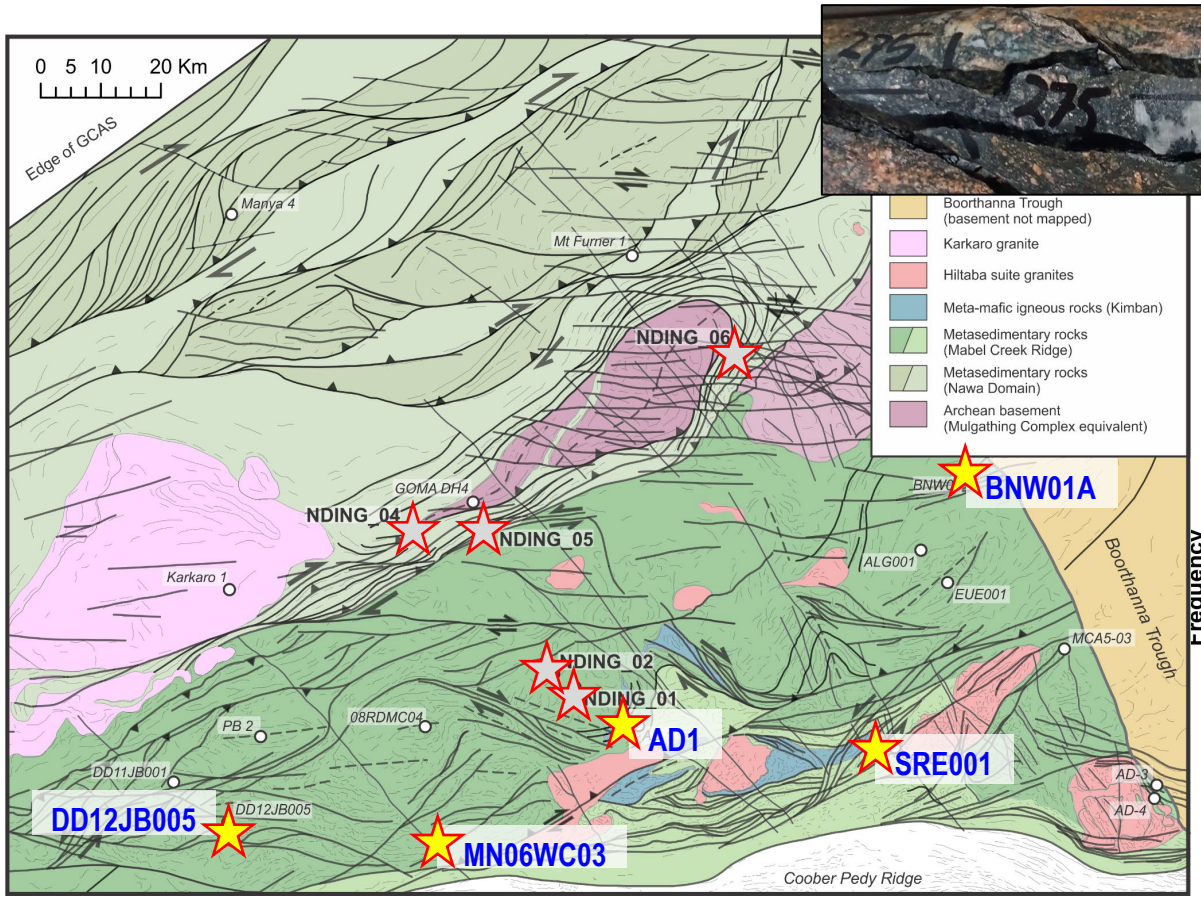
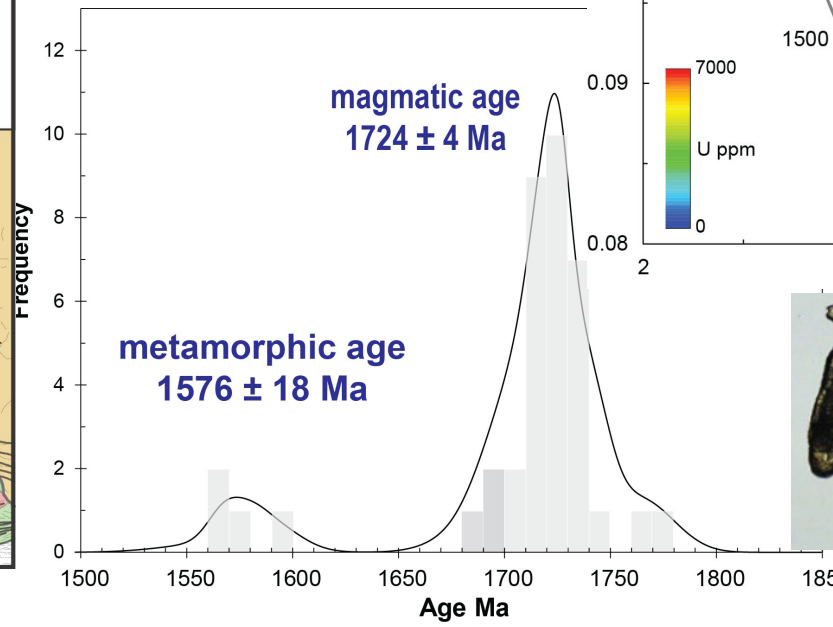
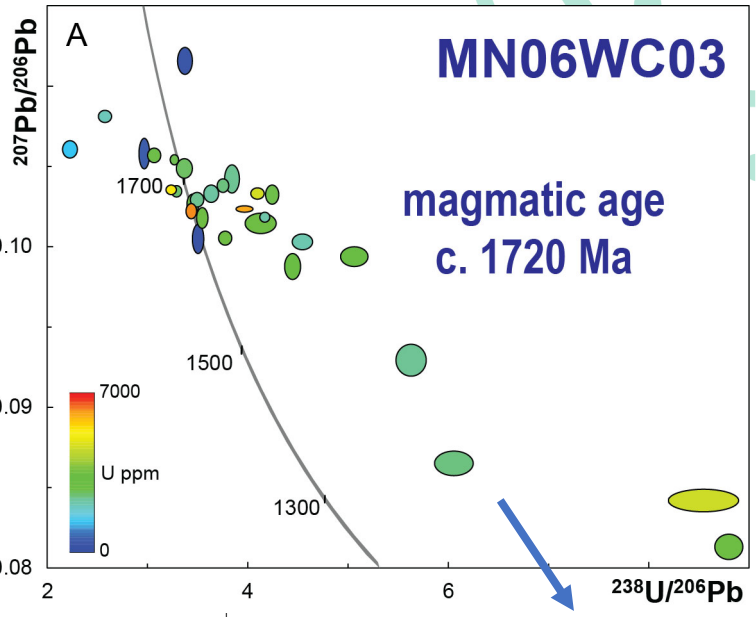
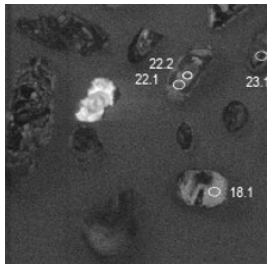
SOUTH AUSTRALIA DISCOVERY MAPPING

MABEL CREEK RIDGE









in prep. Jagodzinski EA, Brown D and Percival J. 2025. *Geochronology on the buried northern Gawler craton. Part 3: SHRIMP U-Pb dating of high-grade gneisses of the Peake and Denison and Nawa Domains.* Report Book 2025/00011. Department for Energy and Mining, South Australia, Adelaide.

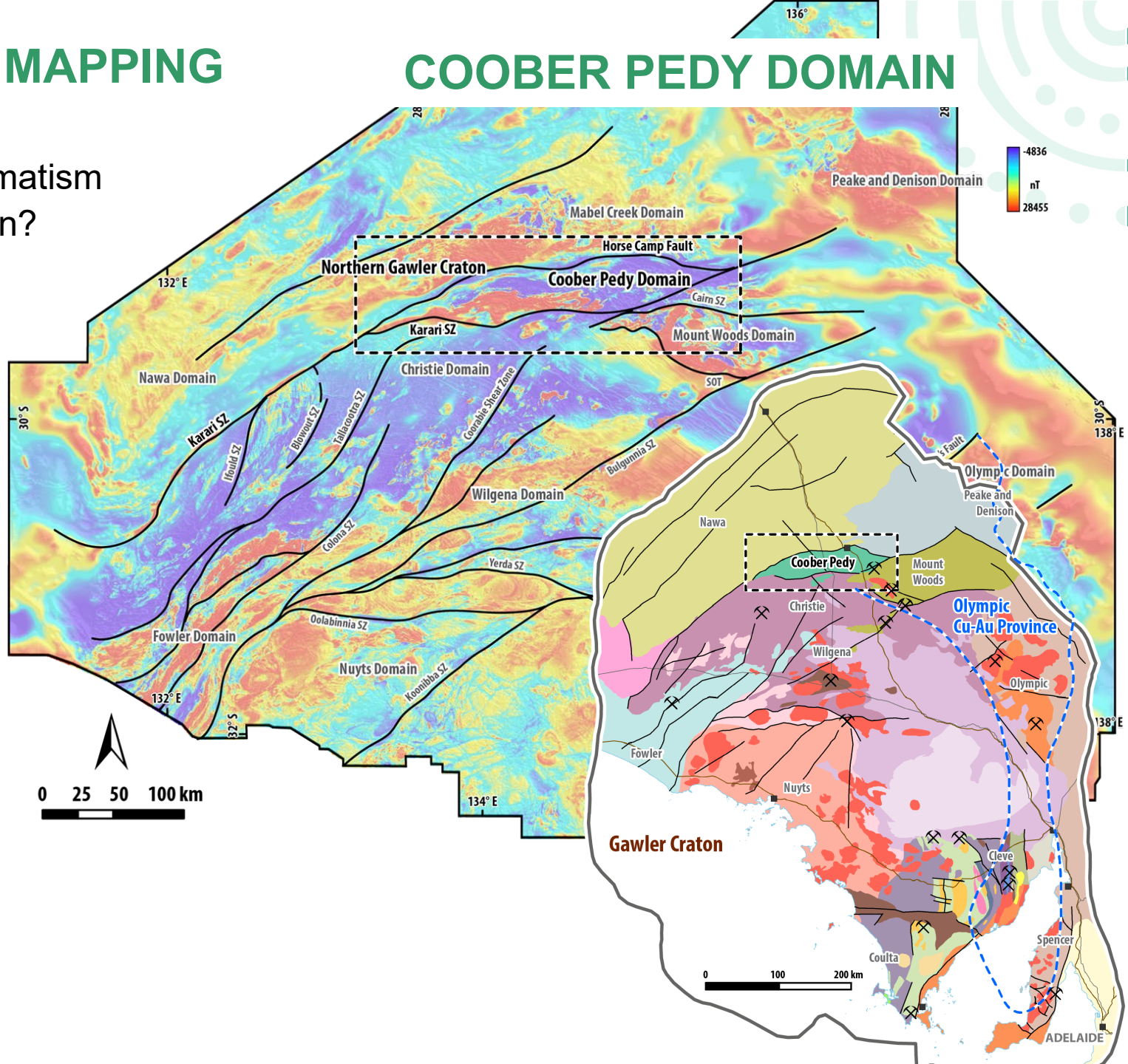
SOUTH AUSTRALIA DISCOVERY MAPPING

COOBER PEDY DOMAIN

Q 1: What is the timing of sedimentation, magmatism and metamorphism in the Coober Pedy Domain?

Q 2: What are the kinematics and 3D geometry of the major structures or shear zones in the Coober Pedy Domain?

Q 3: How did these structures or shear zones evolve in time and space?



Jagodzinski EA, Brown D, Abdullah R. 2025. *Geochronology on the buried northern Gawler craton. Part 2: SHRIMP U-Pb dating of high-grade gneisses of the Coober Pedy Ridge and Mt Woods Inlier.* Report Book 2025/00010. Department for Energy and Mining, South Australia, Adelaide. in prep.

SOUTH AUSTRALIA

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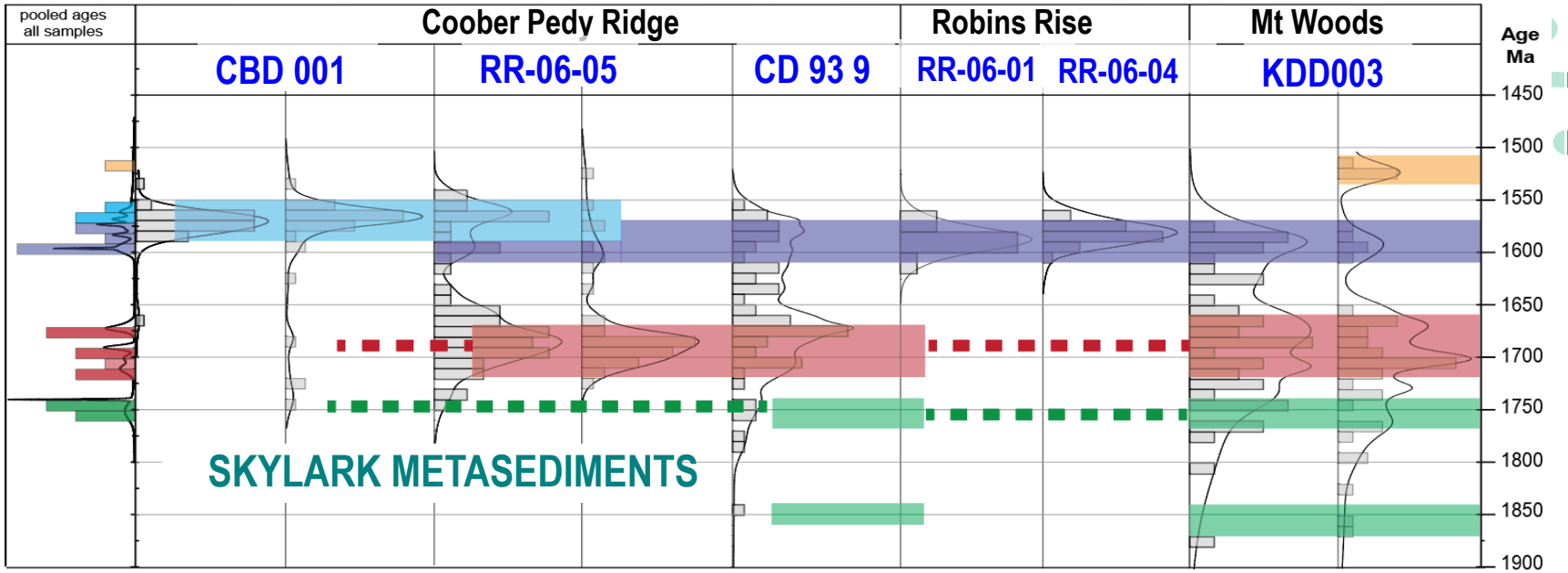
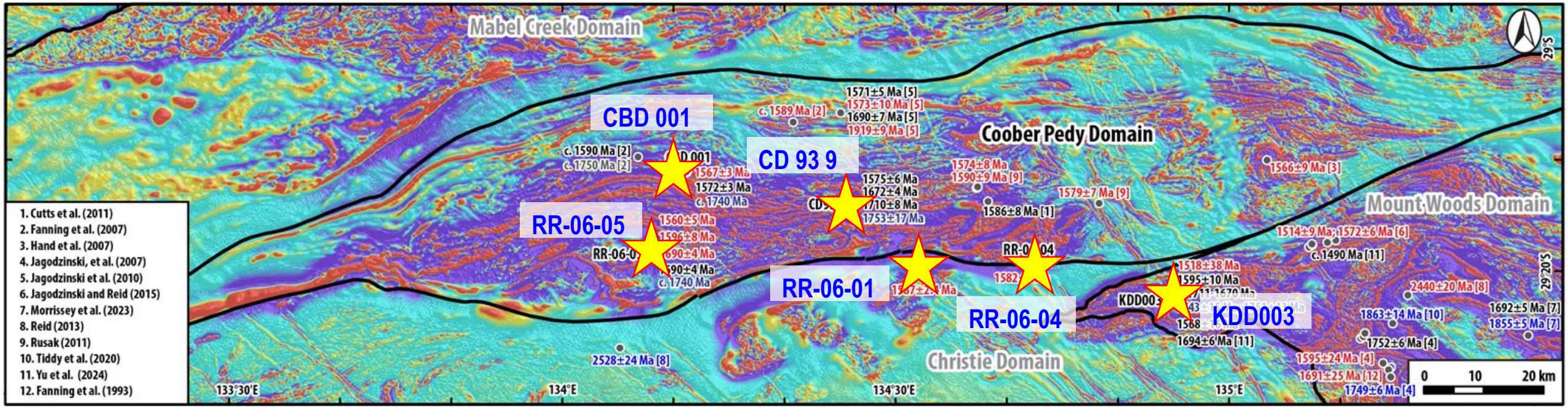
SOUTH AUSTRALIA DISCOVERY MAPPING

COOBER PEDY DOMAIN

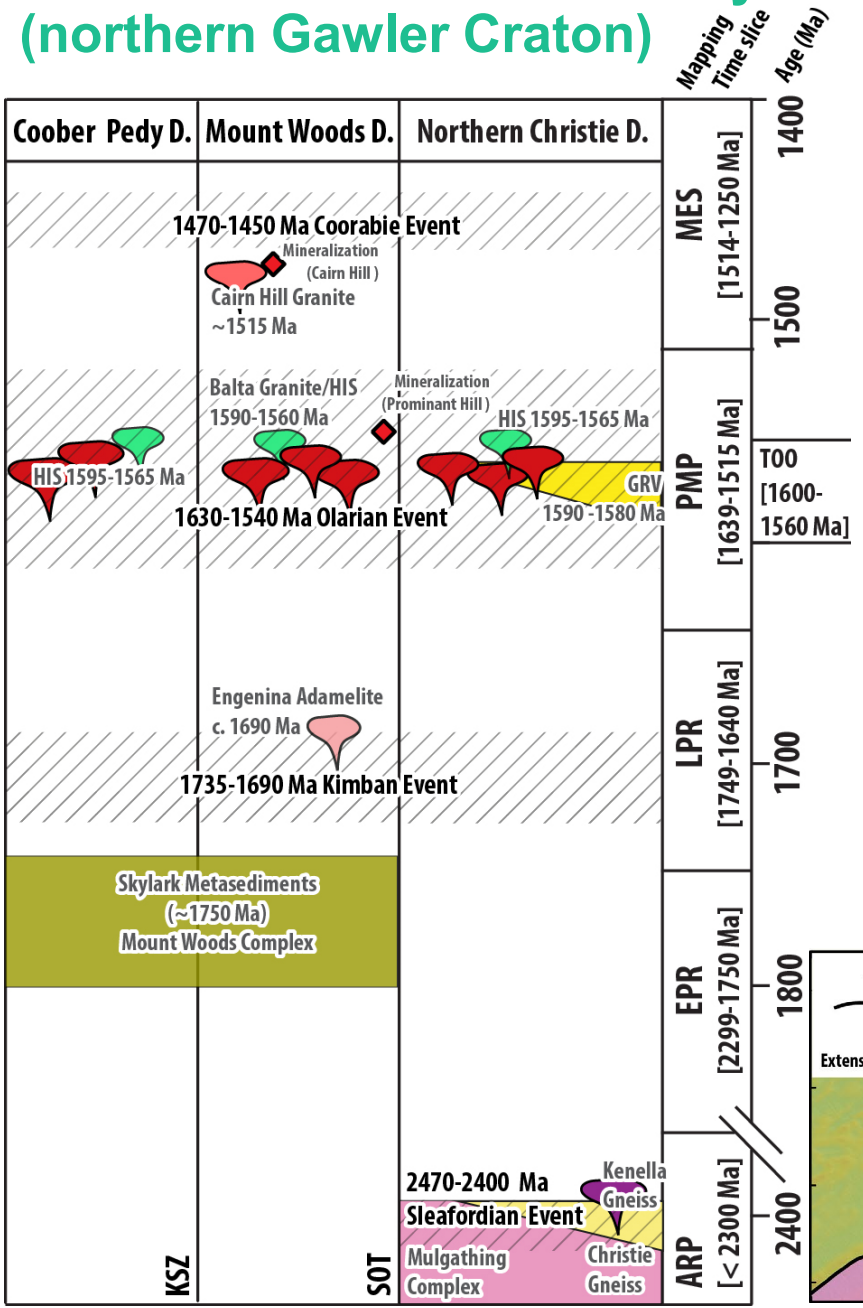
Geochronology overview

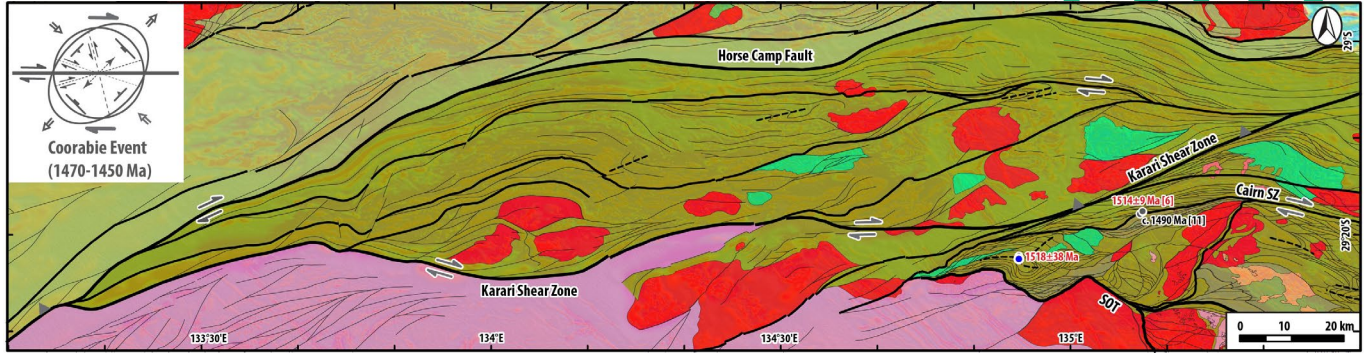
- c. 1520 Ma — Post-Olarian
- c. 1550 – 1595 Ma — Olarian/Kararan event
- c. 1565 – 1585 Ma — Hiltaba-aged magmatism
- c. 1670 – 1720 Ma — Kimban event
- c. 1740 – 1770 Ma — Pre-Kimban protolith

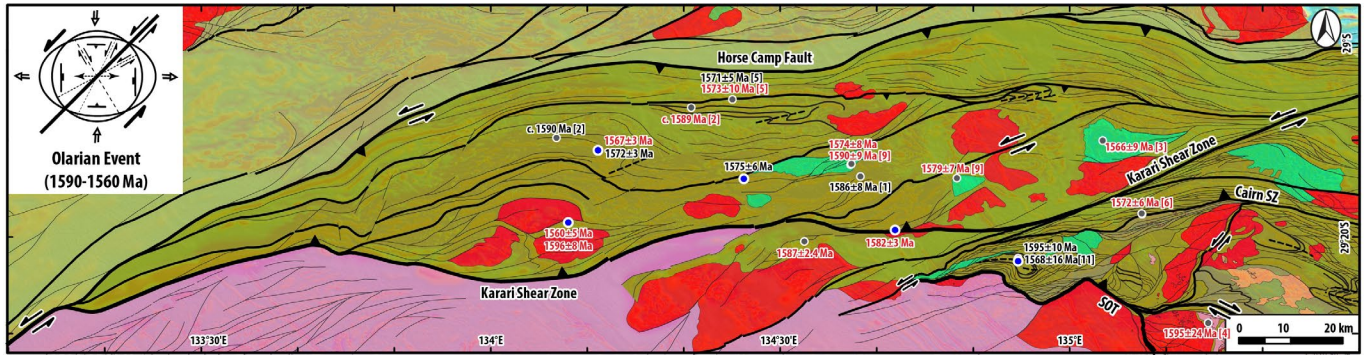


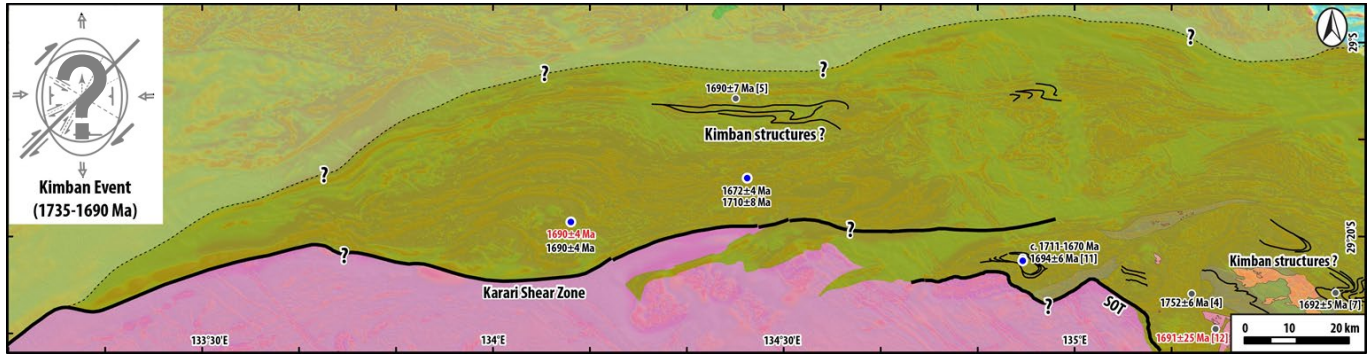


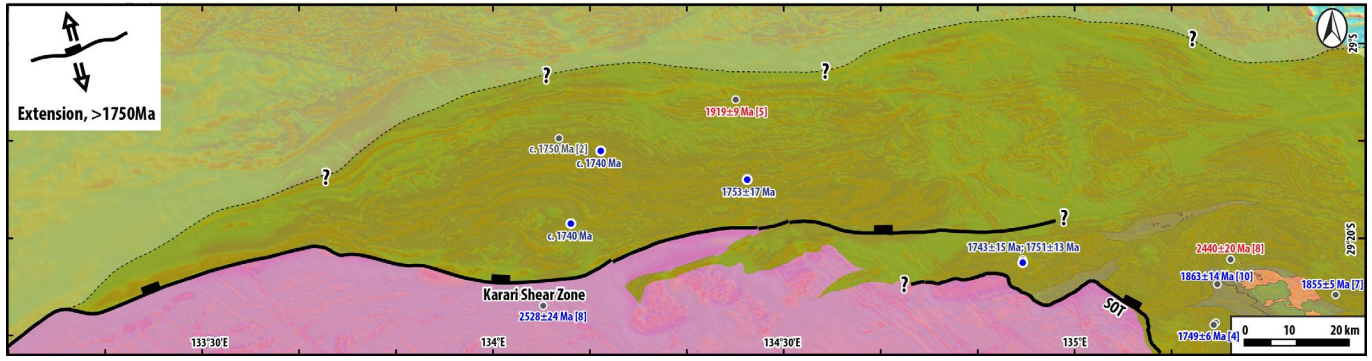
Paleo- to Mesoproterozoic Tectonic evolution of the Coober Pedy Domain (northern Gawler Craton)

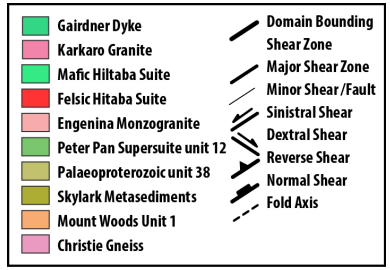




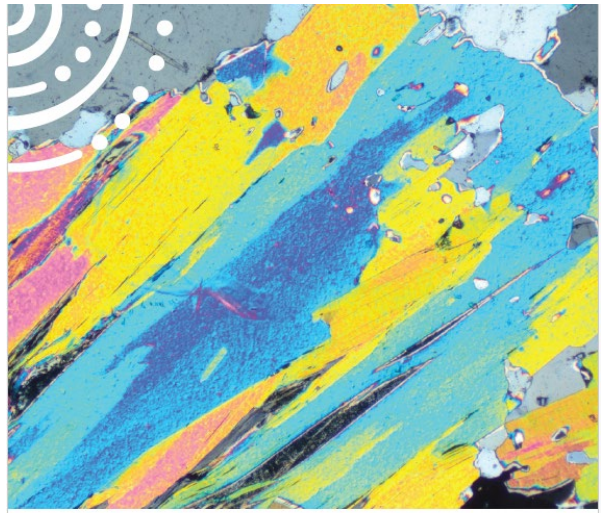








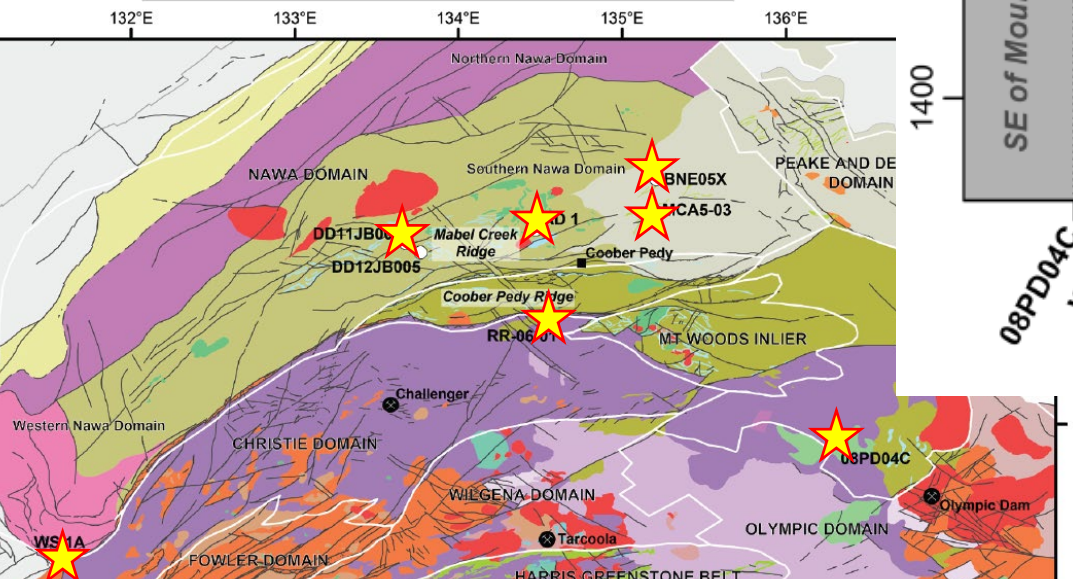
SOUTH AUSTRALIA DISCOVERY MAPPING

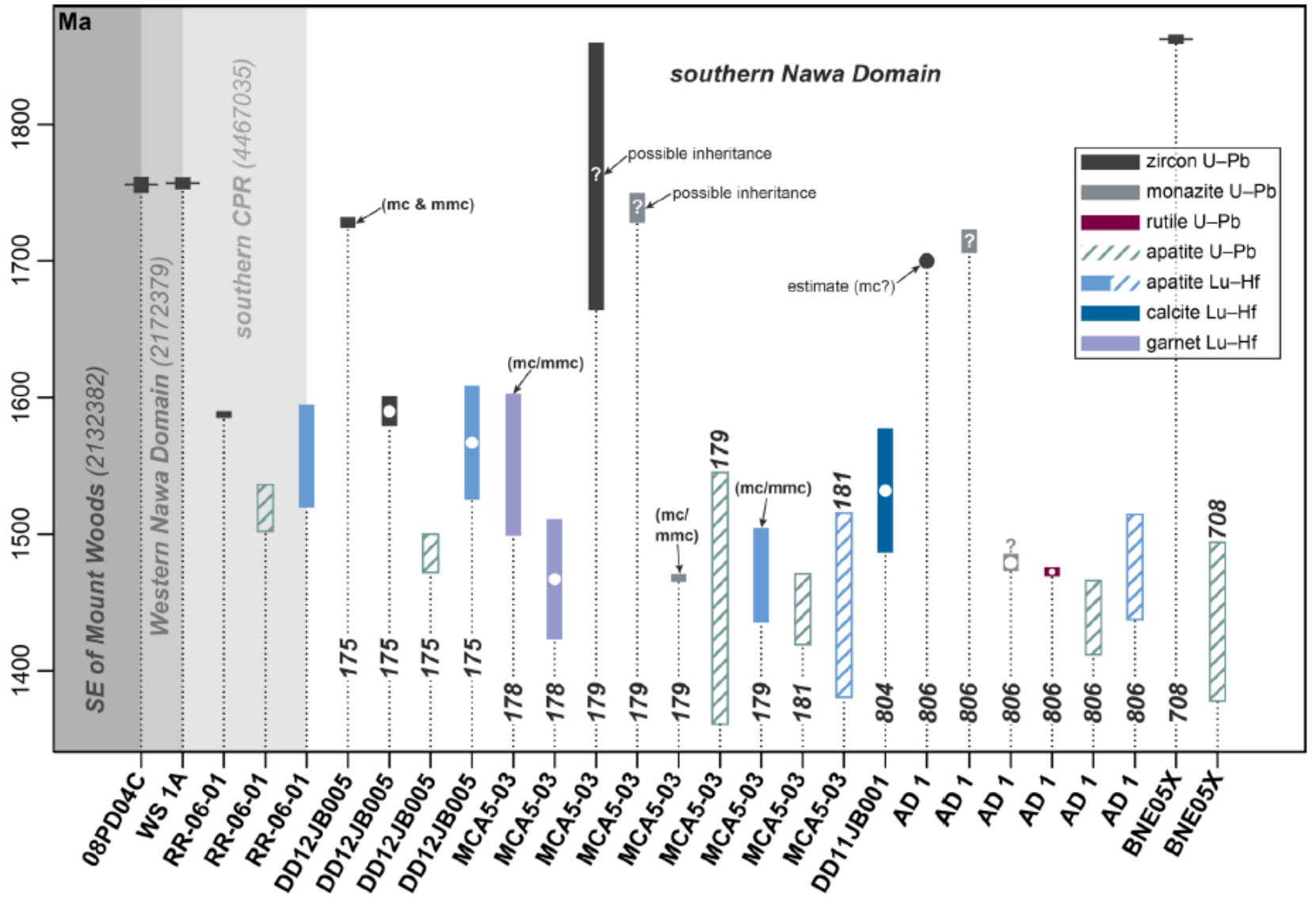


Geochronology on the buried northern Gawler Craton
Part 1: Multi-mineral laser-ablation U–Pb–Lu–Hf dating

Dillon Brown, Jack Percival, Tom Wise and Rashed Abdullah

Government of South Australia
Department for Energy and Mining





GEOCHRONOLOGY PUBLICATIONS

1. Wade C, Brown D, Jagodzinski EA, Percival J, Caruso A, Petts A and Stoian L. in prep. Connections in the North: Results from the Northern Gawler National Drilling Initiative. Report Book 2026/00001. Department for Energy and Mining, South Australia, Adelaide.
2. Brown D, Percival J, Wise T and Abdullah R, 2025. *Geochronology on the buried northern Gawler Craton. Part 1: Multi-mineral laser-ablation U–Pb–Lu–Hf dating.* Report Book 2025/00006. Department for Energy and Mining, South Australia, Adelaide.
3. Jagodzinski EA, Brown D, Abdullah R. in prep. *Geochronology on the buried northern Gawler craton. Part 2: SHRIMP U-Pb dating of high-grade gneisses of the Coober Pedy Ridge and Mt Woods Inlier.* Report Book 2025/00010. Department for Energy and Mining, South Australia, Adelaide.
4. Jagodzinski EA, Brown D and Percival J. in prep. *Geochronology on the buried northern Gawler Craton. Part 3: SHRIMP U-Pb dating of high-grade gneisses of the Peake and Denison and Nawa Domains.* Report Book 2025/00011. Department for Energy and Mining, South Australia, Adelaide.

to be continued...

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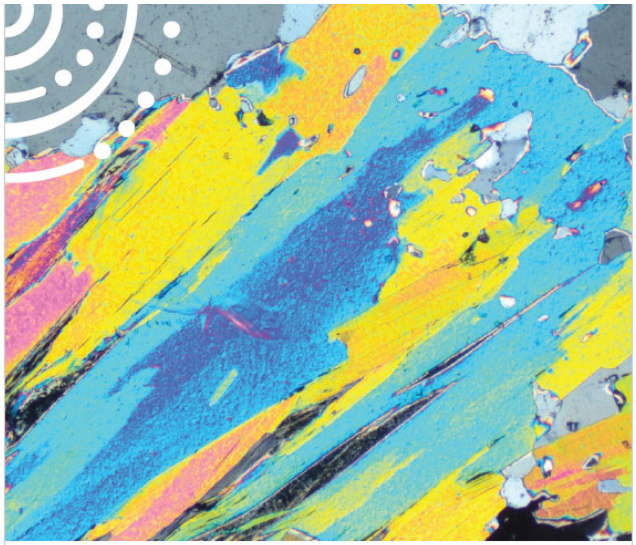

Geochronology on the buried northern Gawler Craton
Part 1: Multi-mineral laser-ablation U–Pb–Lu–Hf dating

Dillon Brown, Jack Percival, Tom Wise and Rashed Abdullah

Government of South Australia
Department for Energy and Mining

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Remote Mapping of the Nawa Domain

Insights from the Northern Gawler NDI and South Australia Discovery Mapping projects

Jack Percival | December 2025

Dillon Brown, Liz Jagodzinski, Claire Wade, Mark Pawley, Frank Rarity, Rashed Abdullah

Geological Survey of South Australia; MinEx CRC

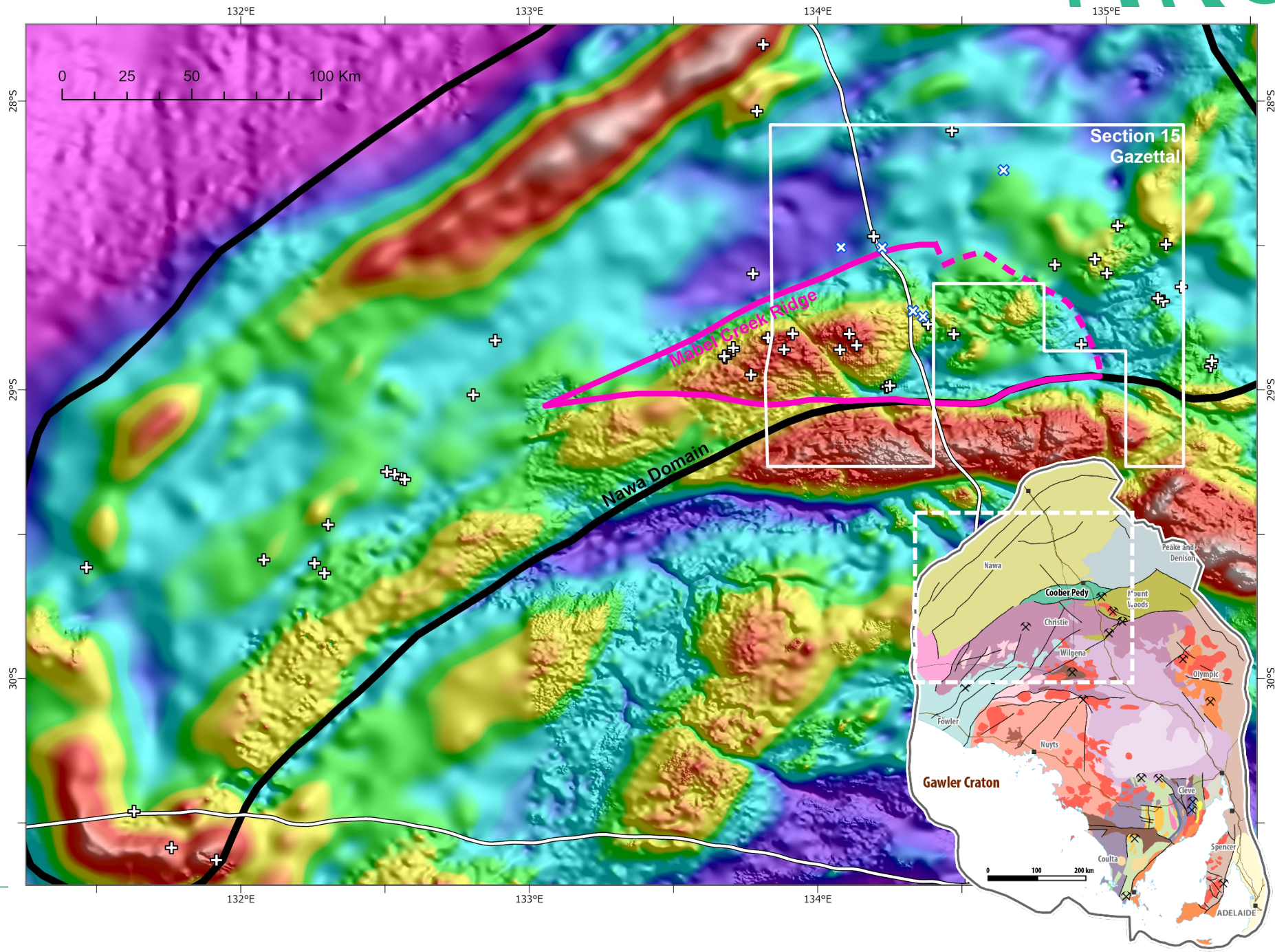
SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

MinEx CRC

Nawa Domain

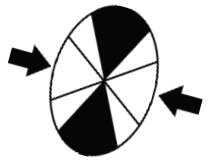
- Entirely covered by Neoproterozoic to Cenozoic sedimentary rocks
- Interpretation and mapping using remote geophysics
- *Aeromagnetics*
- *Gravity*
- *Seismics*



Background – Tectonic events

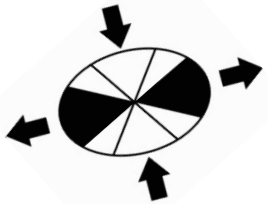
Paleoproterozoic

- **Kimban Orogeny** (ca. 1730–1690 Ma)
  - Dextral transpression*
  - W–E to NW–SE directed shortening

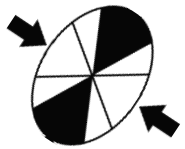


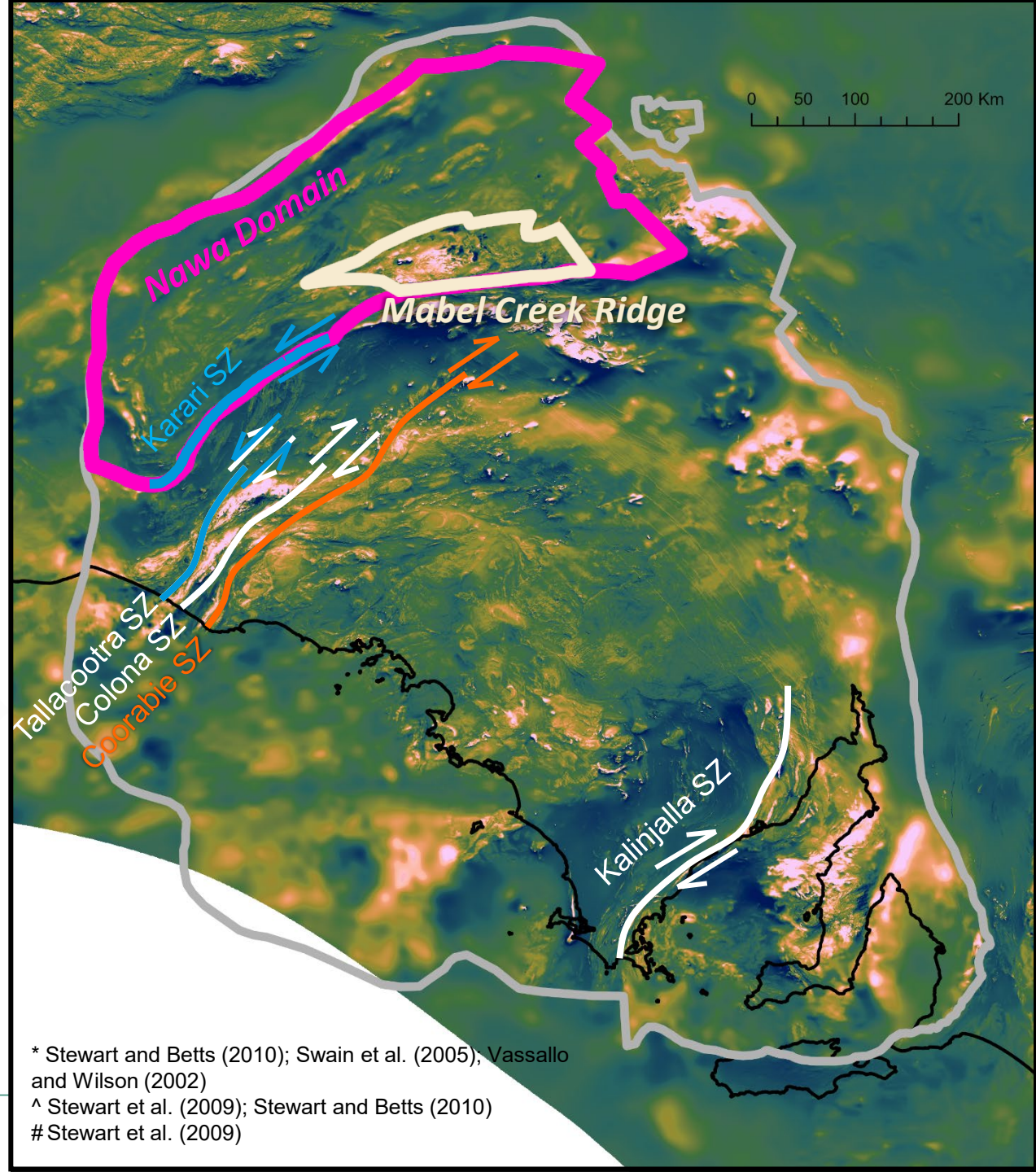
Mesoproterozoic

- **Olarian Orogeny** (ca. 1620–1550 Ma)
  - Sinistral strike slip^
  - N–S to NE–SW directed shortening?
  - NE – SW directed extension?



- **Coorabie Event** (ca. 1520–1450 Ma)
  - Dextral transpression#
  - NW–SE directed shortening

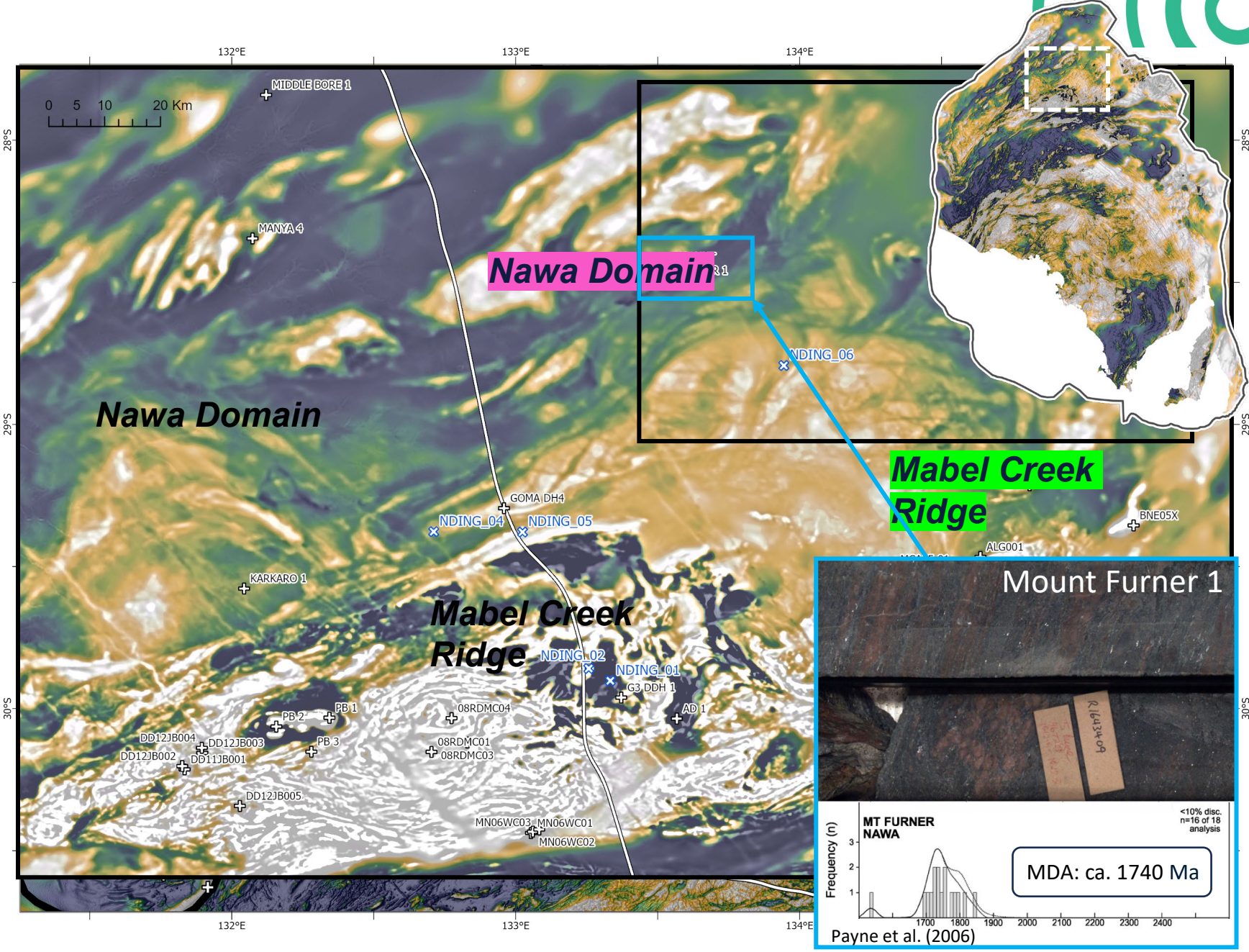




* Stewart and Betts (2010); Swain et al. (2005); Vassallo and Wilson (2002)
^ Stewart et al. (2009); Stewart and Betts (2010)
# Stewart et al. (2009)

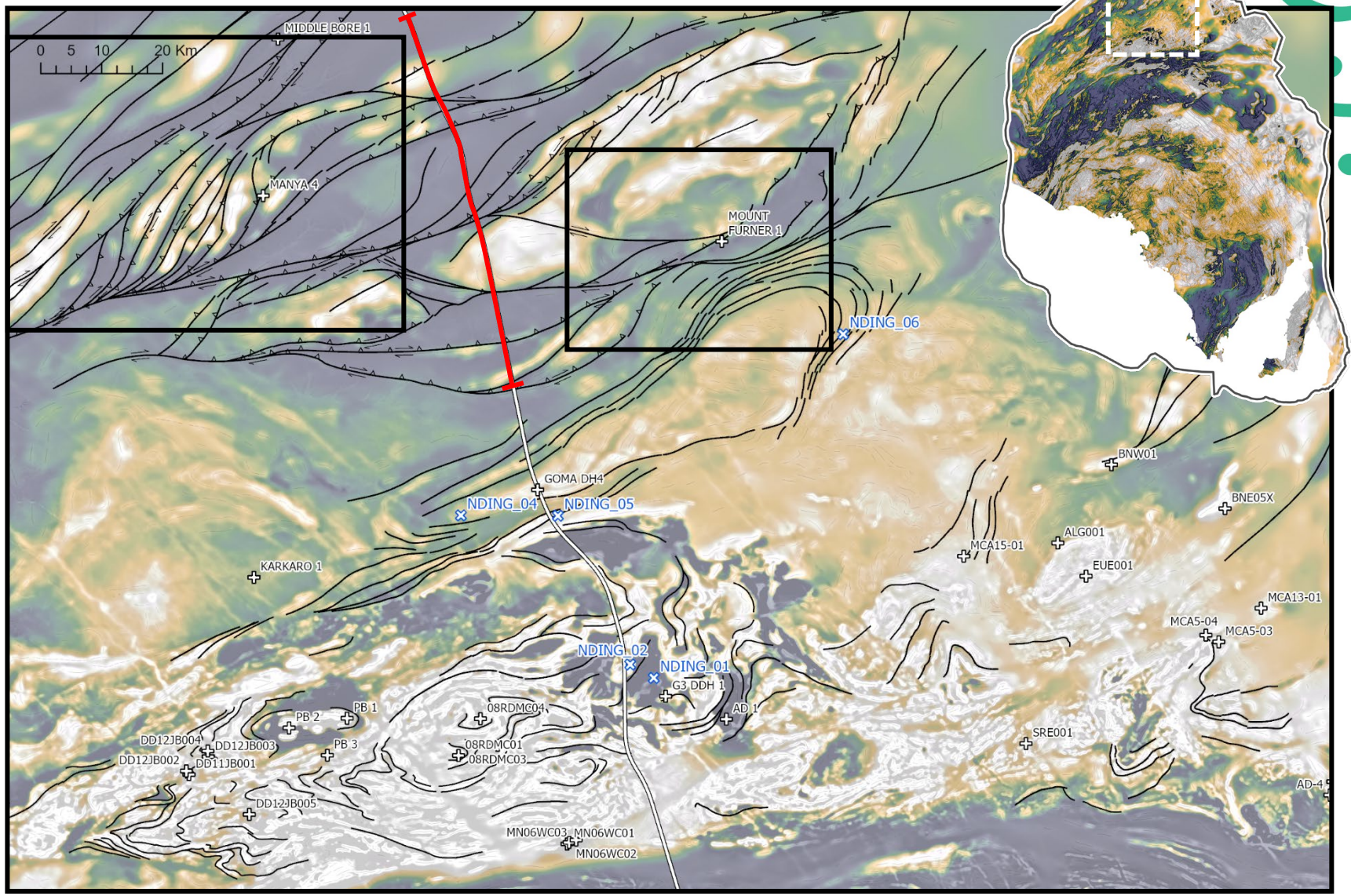
Northern Nawa Domain

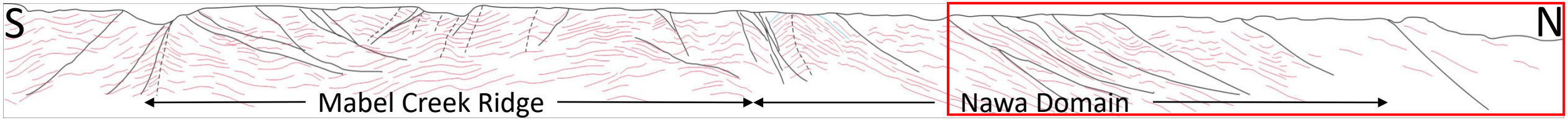
- Northern Nawa Domain
- Five drillholes intersect basement in the northern Nawa Domain
- Minor (?) mafic and felsic orthogneisses
- Metasedimentary gneisses
  - Max. Dep. Age ca. 1740 Ma



Northern Nawa Domain

- ENE-trending structures
- Northward dipping structures
- Anastomosing, connected demagnetised shear zones





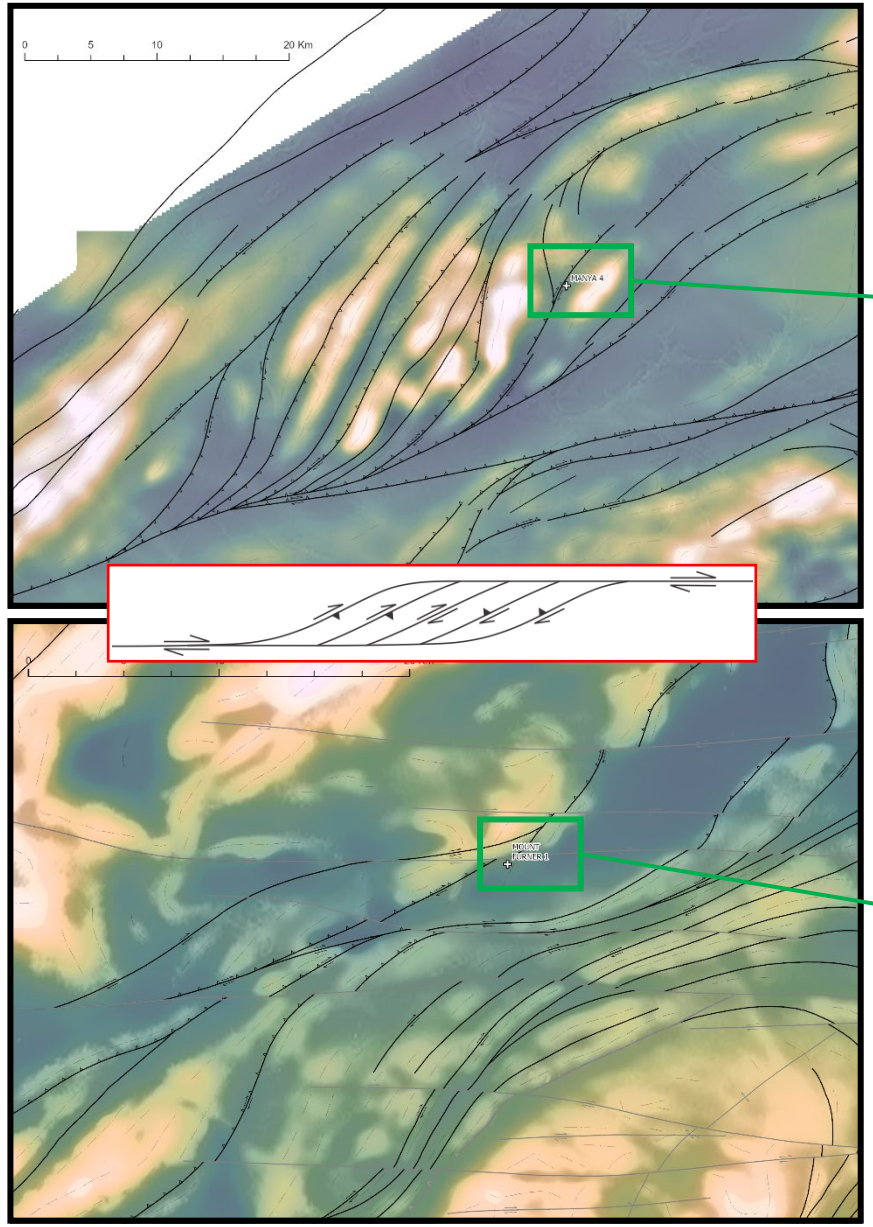
Northern Nawa Domain

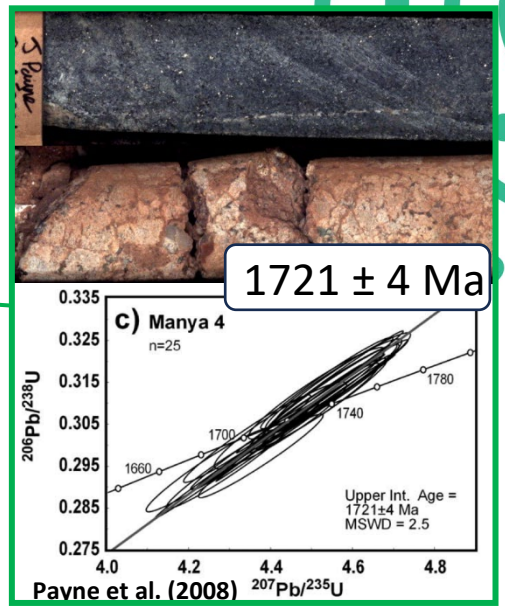
- Dextral strike-slip duplex structures and σ-shaped domains
- Northward dipping structures

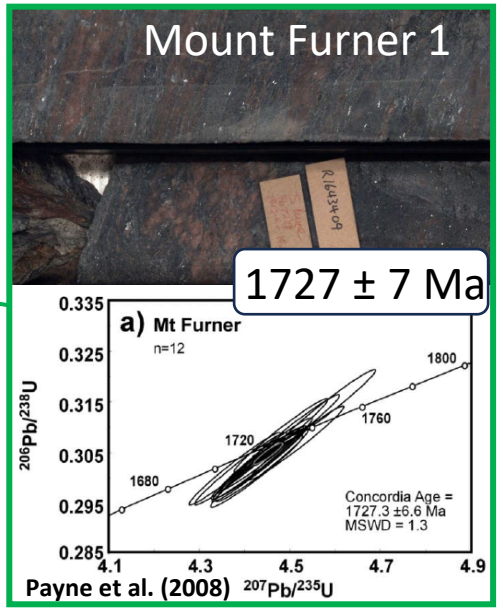
Metamorphism and deformation:

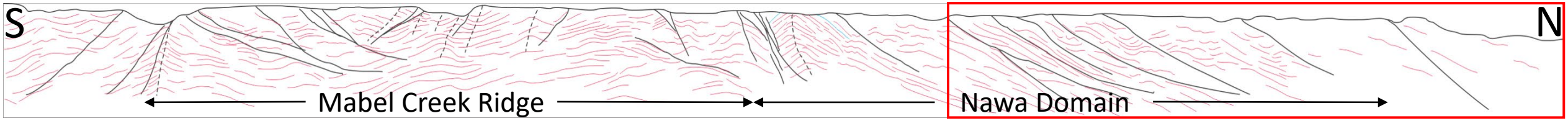
ca. 1725 Ma

Early Kimban Orogeny



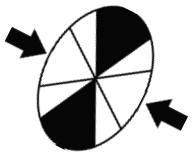




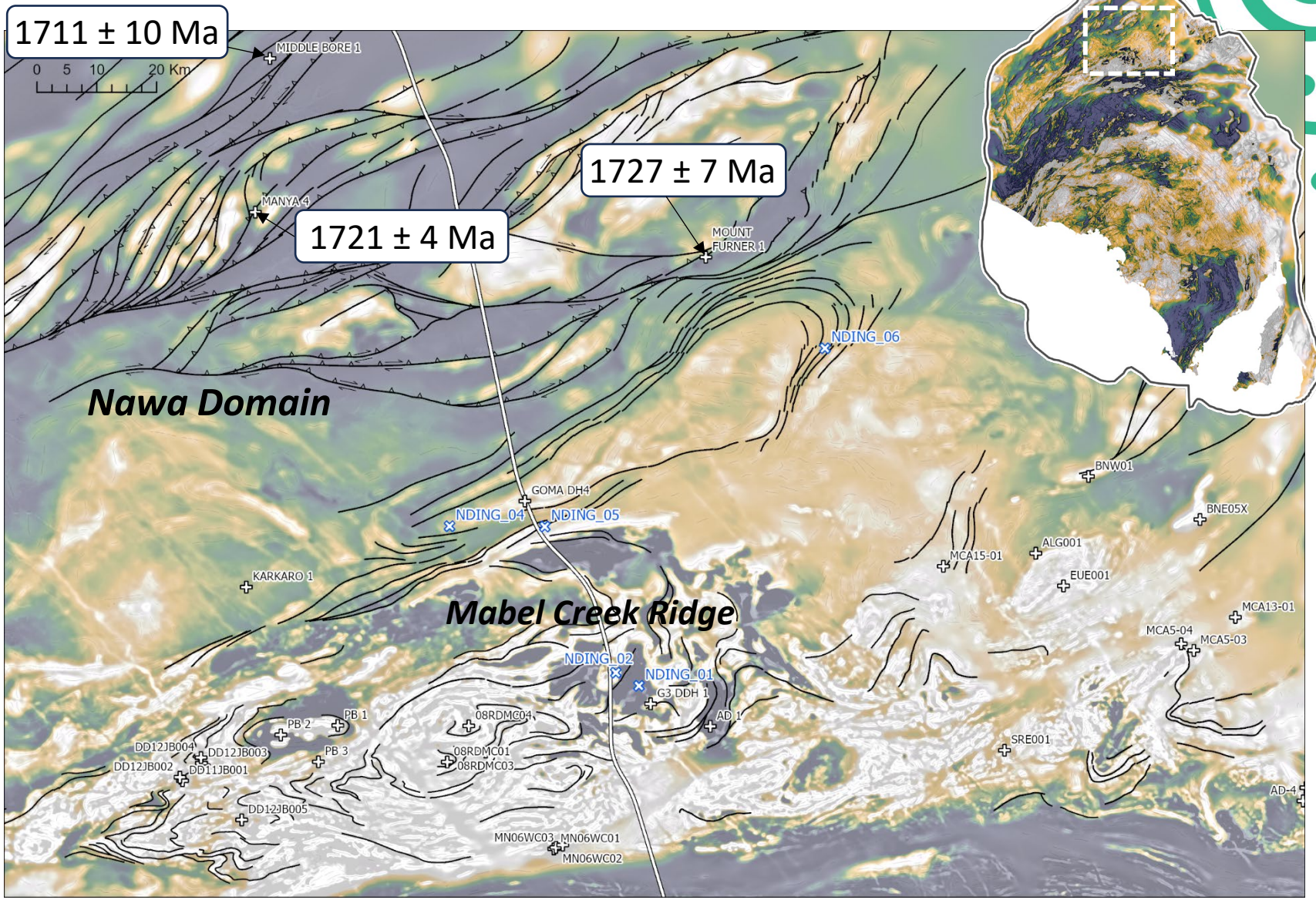


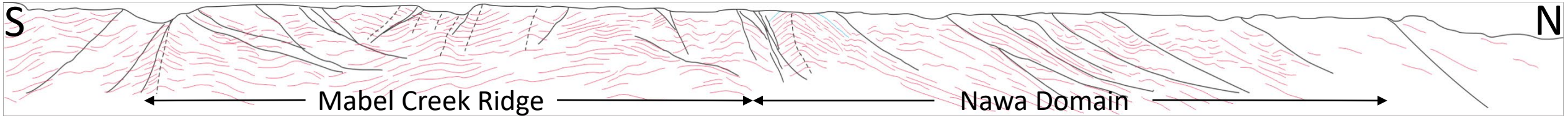
Northern Nawa Domain

- Dextral transpression
- Top to ESE
- **WNW – ESE directed shortening* during Kimban Orogeny from ca. 1725 Ma**



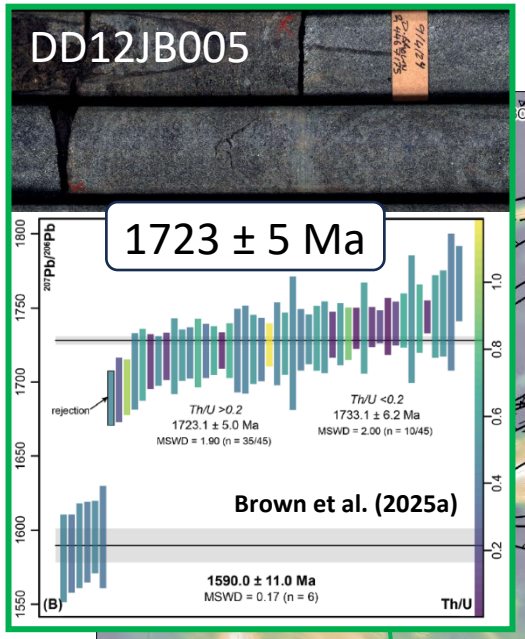
*See: Baines et al. (2011); Payne et al. (2008)

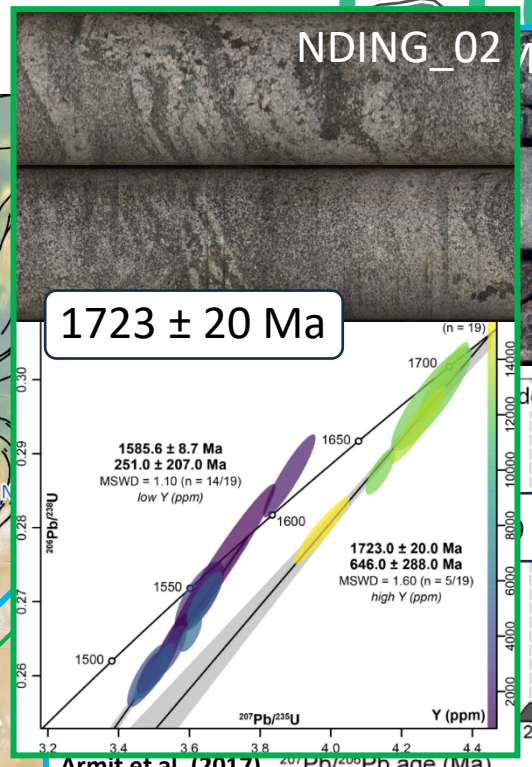


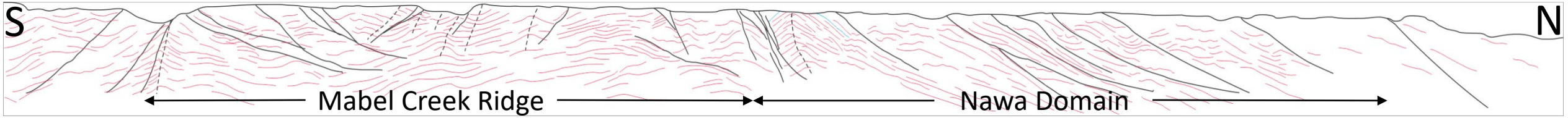


Mabel Creek Ridge

- Mabel Creek Ridge
- A dozen or so drillholes intersecting basement
- Minor mafic and felsic orthogneisses
- Iron-rich metasedimentary gneisses
  - Max. Dep. Age ca. 1744 Ma
- Kimban metamorphism and magmatism

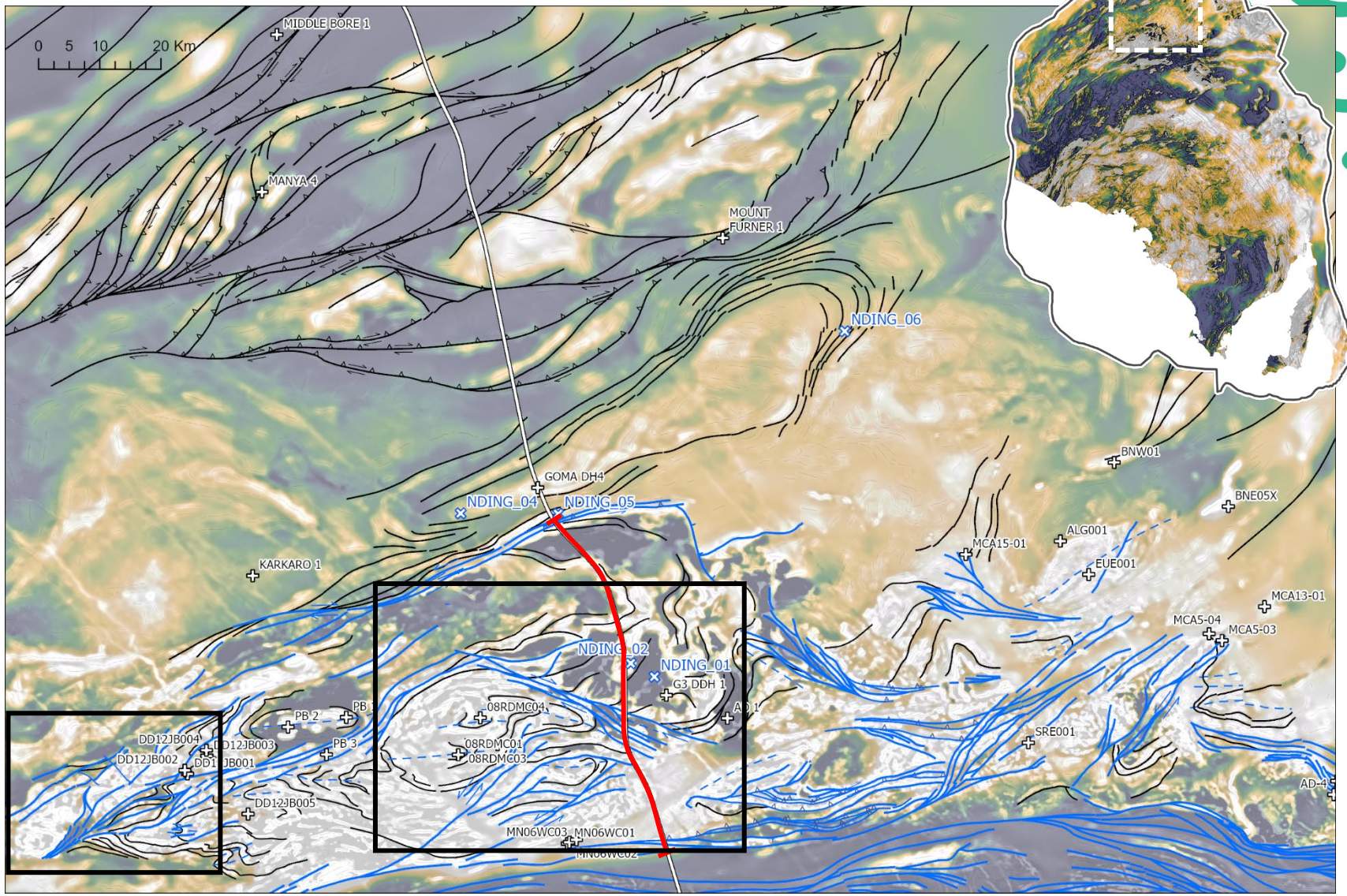


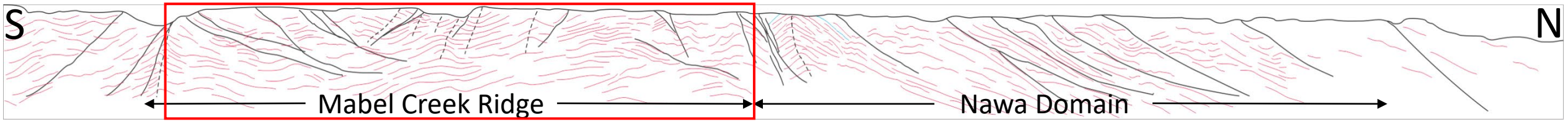




Mabel Creek Ridge

- Complexly deformed
- SE *and* SW trending shear structures
- E – W trending folds evident in magnetics and seismics





Mabel Creek Ridge

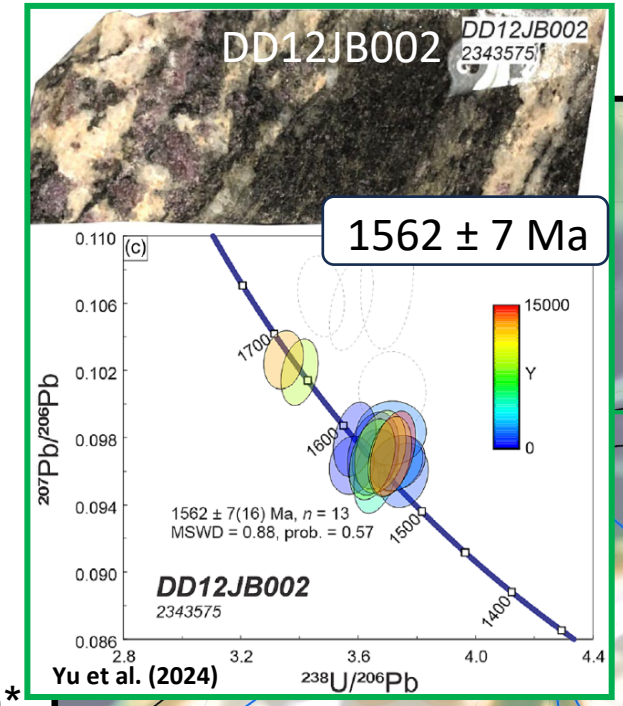
- Multiple generations of sinistral shearing
- Shear zones overprinting folds
- Granulite facies metamorphism*

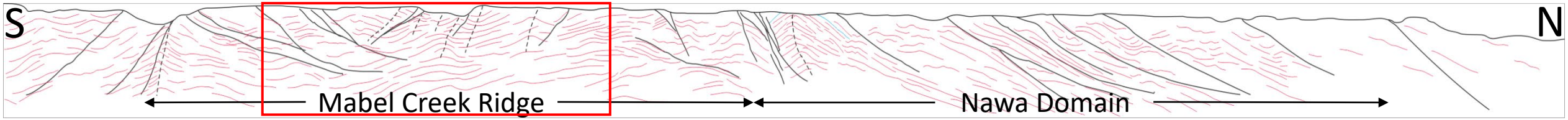
Metamorphism and deformation:

ca. 1600 – 1560 Ma

Olarian Orogeny

*See: Cutts et al. (2011); Yu et al. (2024)





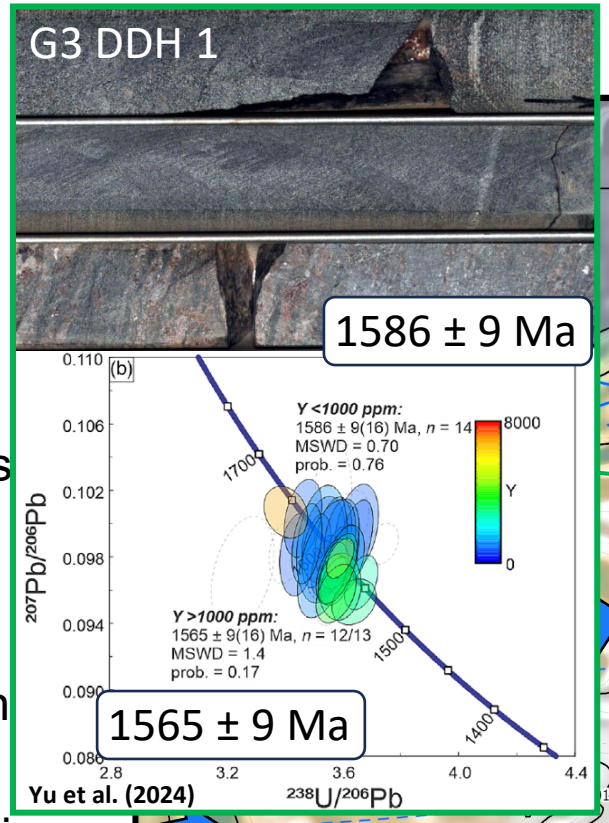
Mabel Creek Ridge

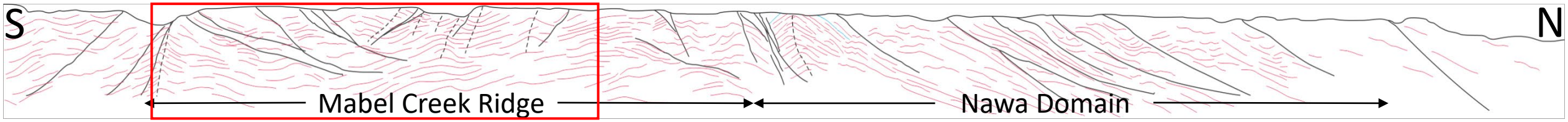
- Multiple generations of sinis and dextral shearing
- E – W trending folds
- Granulite facies metamorph

Metamorphism and deformation:

ca. 1600 – 1560 Ma

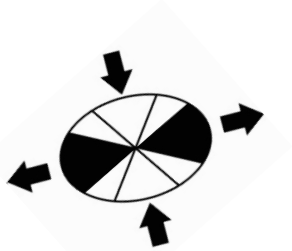
Olarian Orogeny

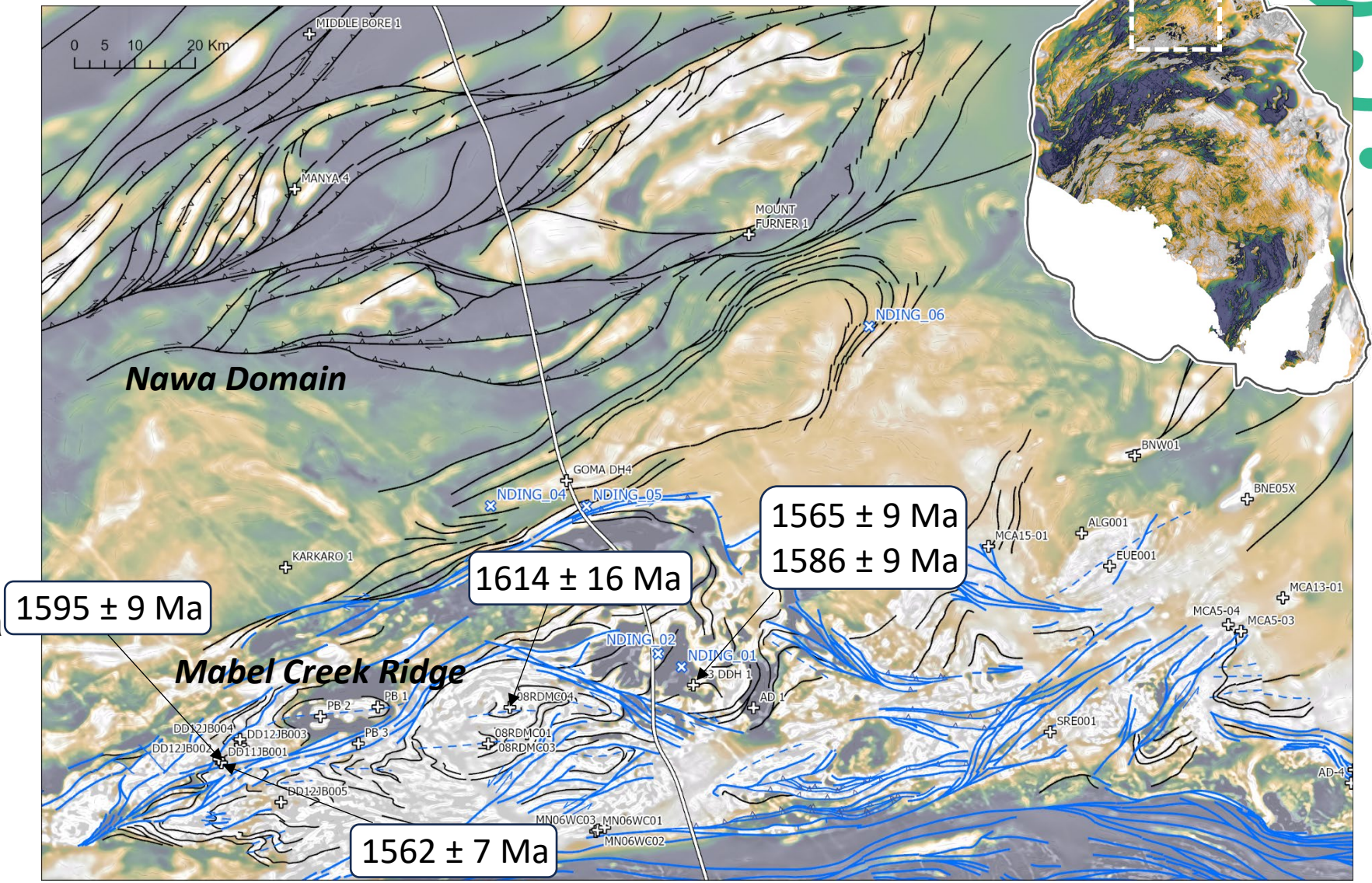


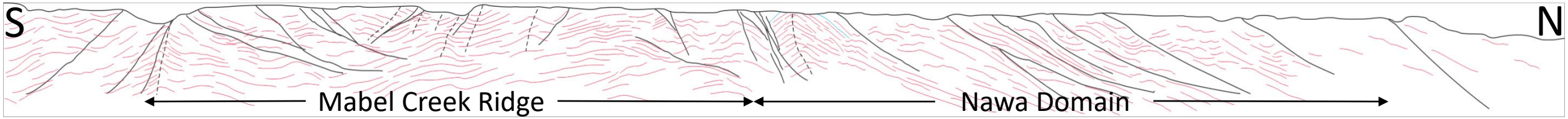


Mabel Creek Ridge

- ENE trending sinistral shearing *and* ESE trending dextral shearing
- E–W trending folding
- **N–S directed shortening during Olarian Orogeny between ca. 1600 – 1560 Ma**

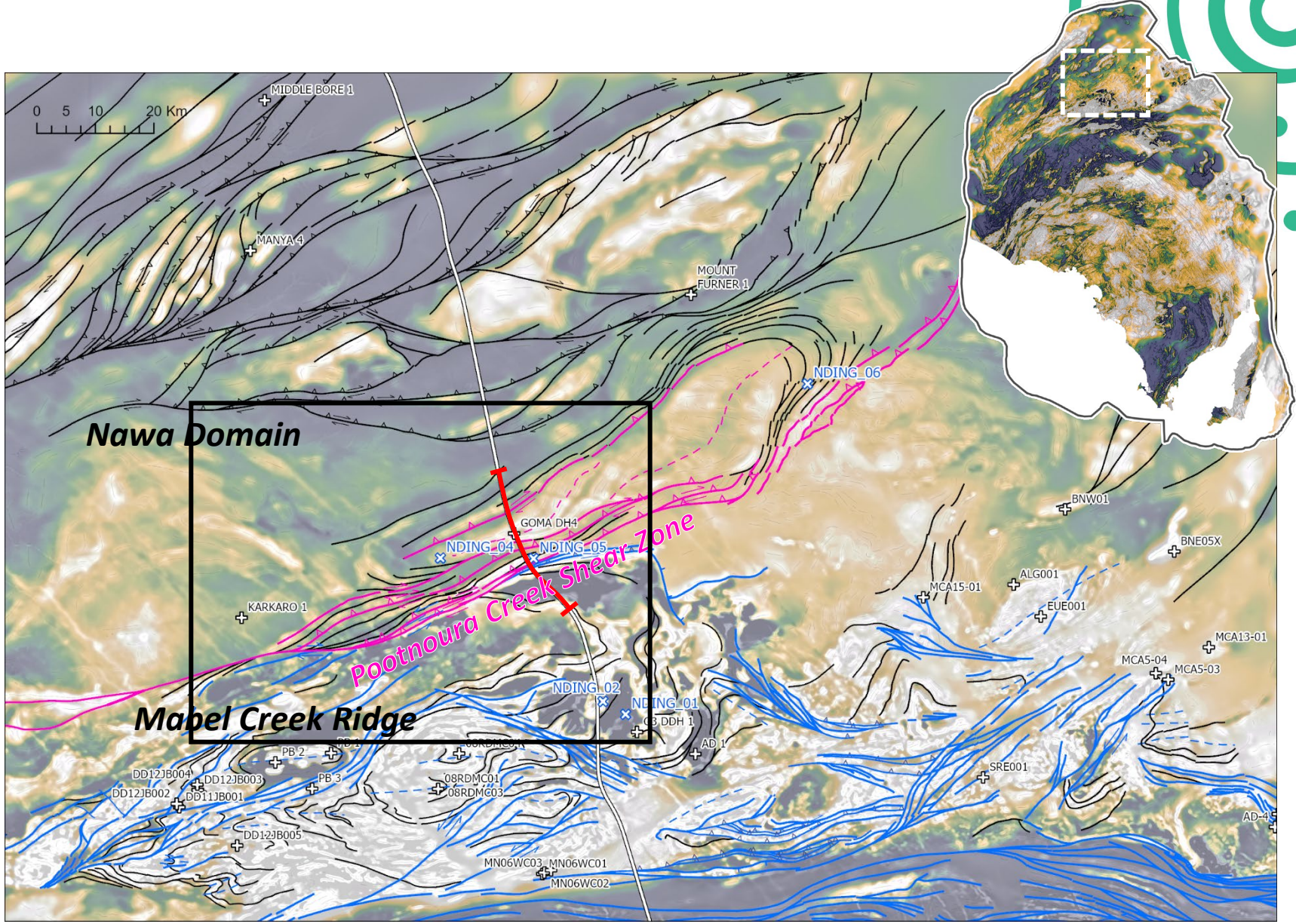


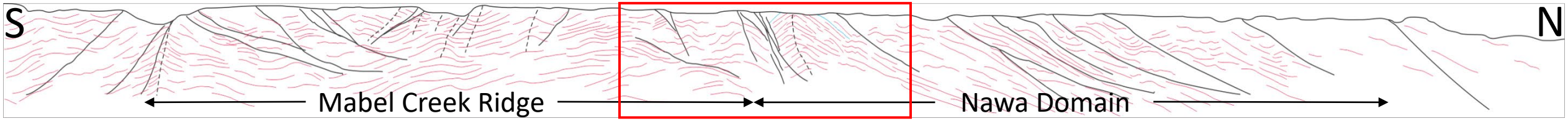




Pootnoura Creek Shear Zone

- Domain bounding shear zone between Mabel Creek Ridge and northern Nawa Domain
- Folding of Nawa Domain basement rocks against shear zone





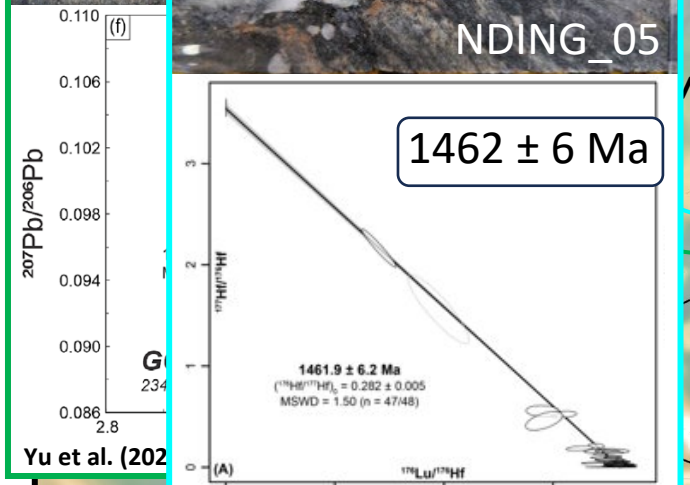
Pootnoura Creek Shear Zone

- Multiple generations of reactivated faults and shears
- Apparent dextral deflection of Nawa Domain fabric, and dextral shear bands within shear zone
- Apparent sinistral deflection of magnetic fabric in MCR

Metamorphism and deformation:

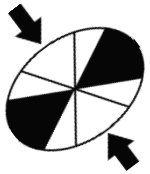
ca. 1520 – 1460 Ma

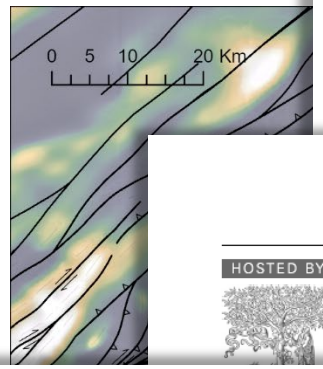
Coorabie Event (?)

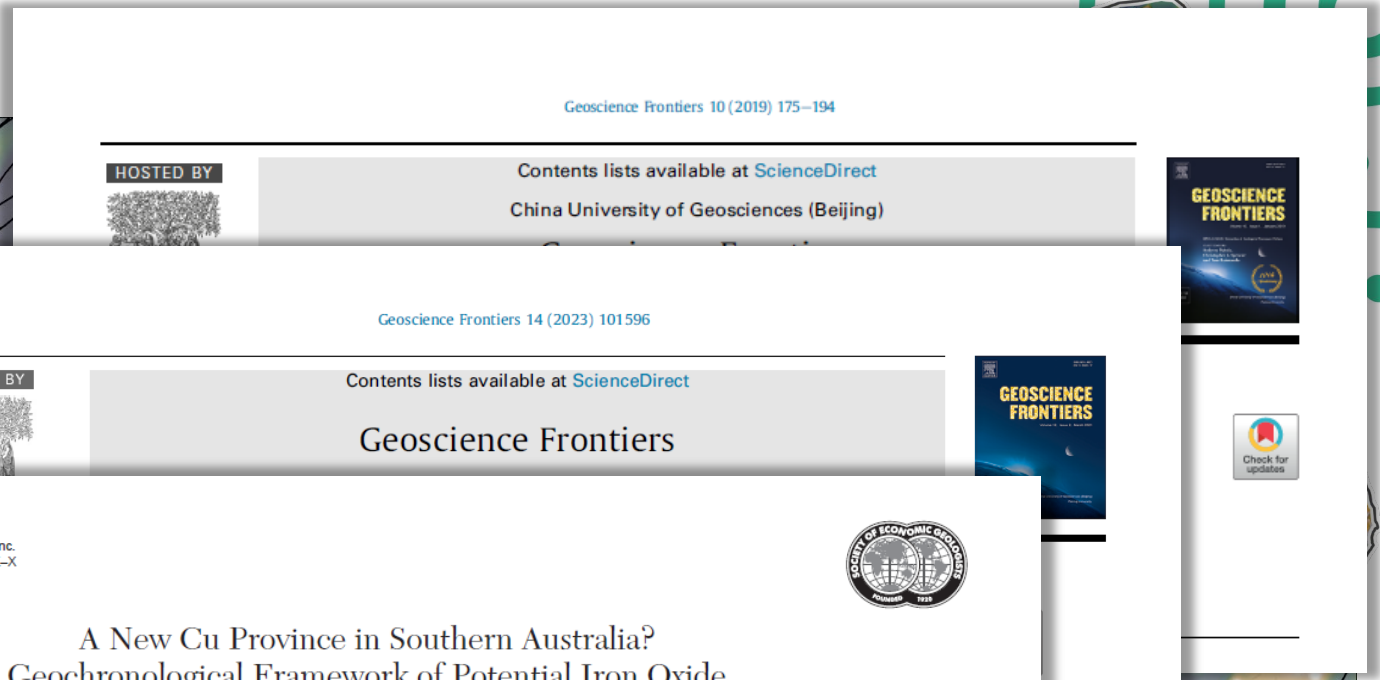


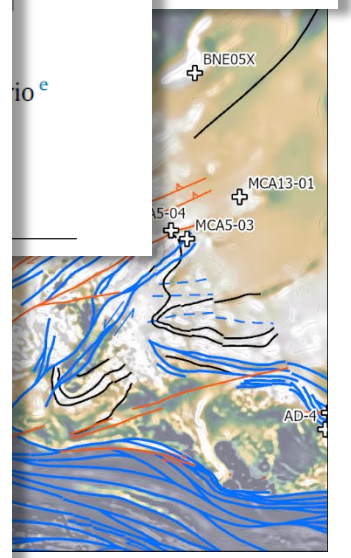
Coorabie Event

- Extensive E–W-trending dextral faults
- ENE-trending dextral reverse faults
- Post-metamorphic cooling from ca. 1460 Ma*
- Granite emplacement ca. 1450 Ma^
- **NW–SE directed shortening (?) during the Coorabie Event between ca. 1520 – 1450 Ma**





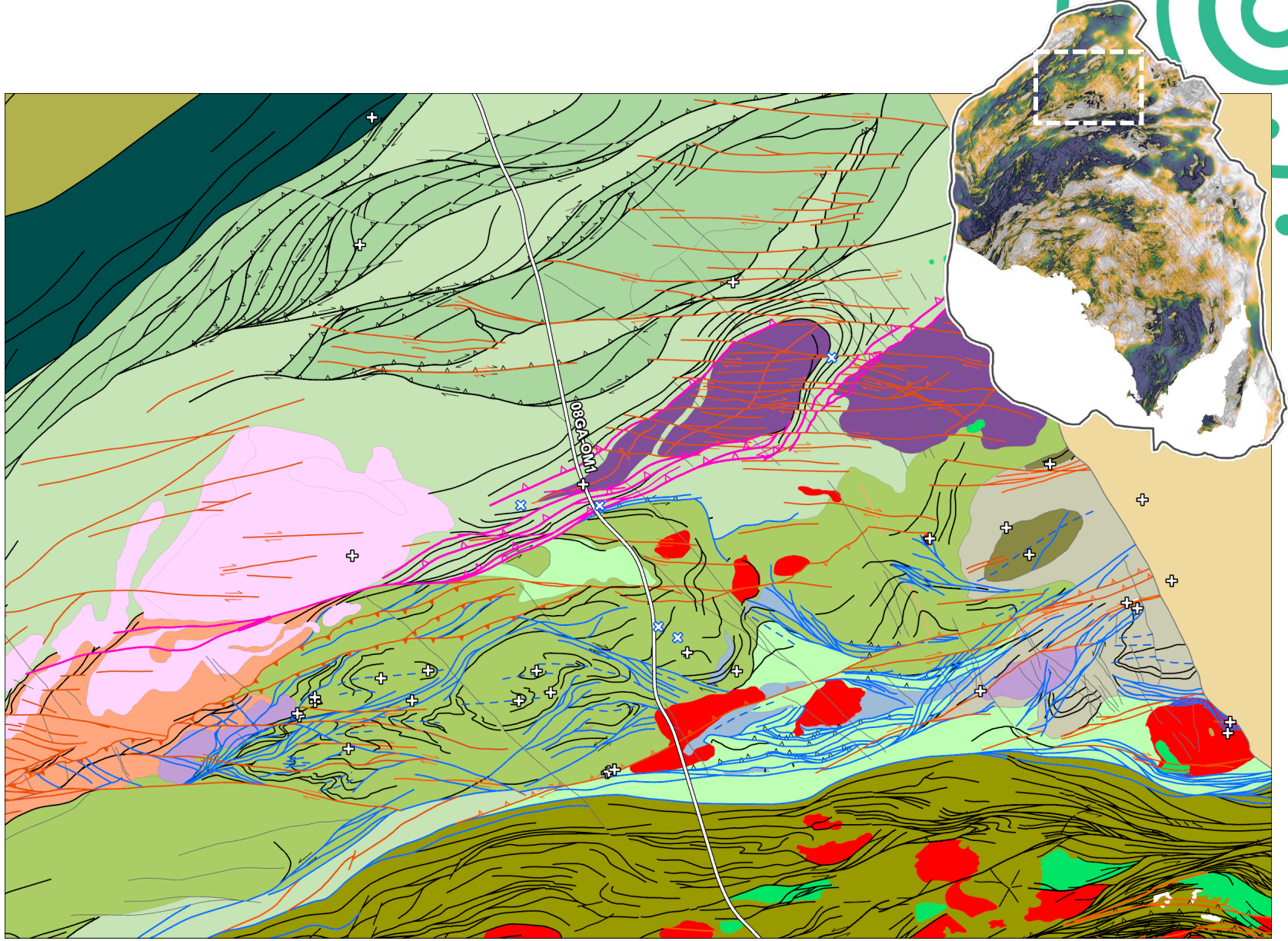




* Reid and Forster (2021); ^ Morrissey et al. (2019)

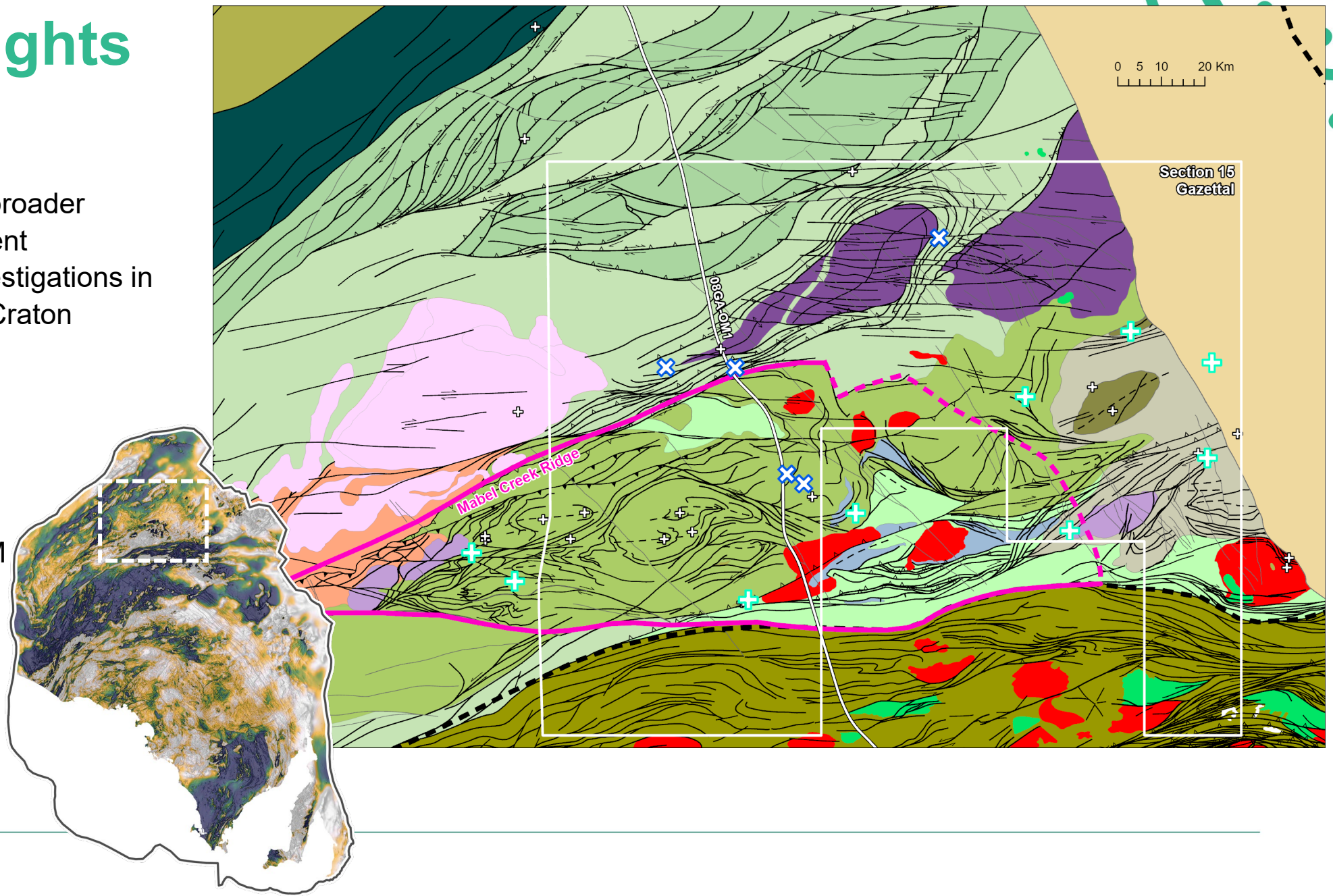
Structural Interpretation

- Northern Nawa Domain and Mabel Creek Ridge affected by dextral transpression during the **Kimban Orogeny**
- Only the Mabel Creek Ridge affected by N–S shortening (?) during the **Olarian Orogeny**
- **Pootnoura Creek Shear Zone** reactivated during the Coorabie Event as a dextral transpressional shear zone
- Entire northern Gawler Craton affected by late **Coorabie Event** dextral faulting



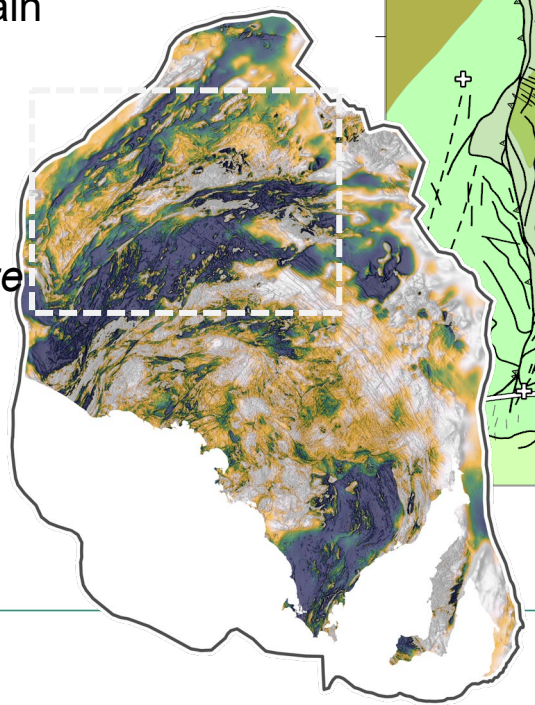
Further Insights

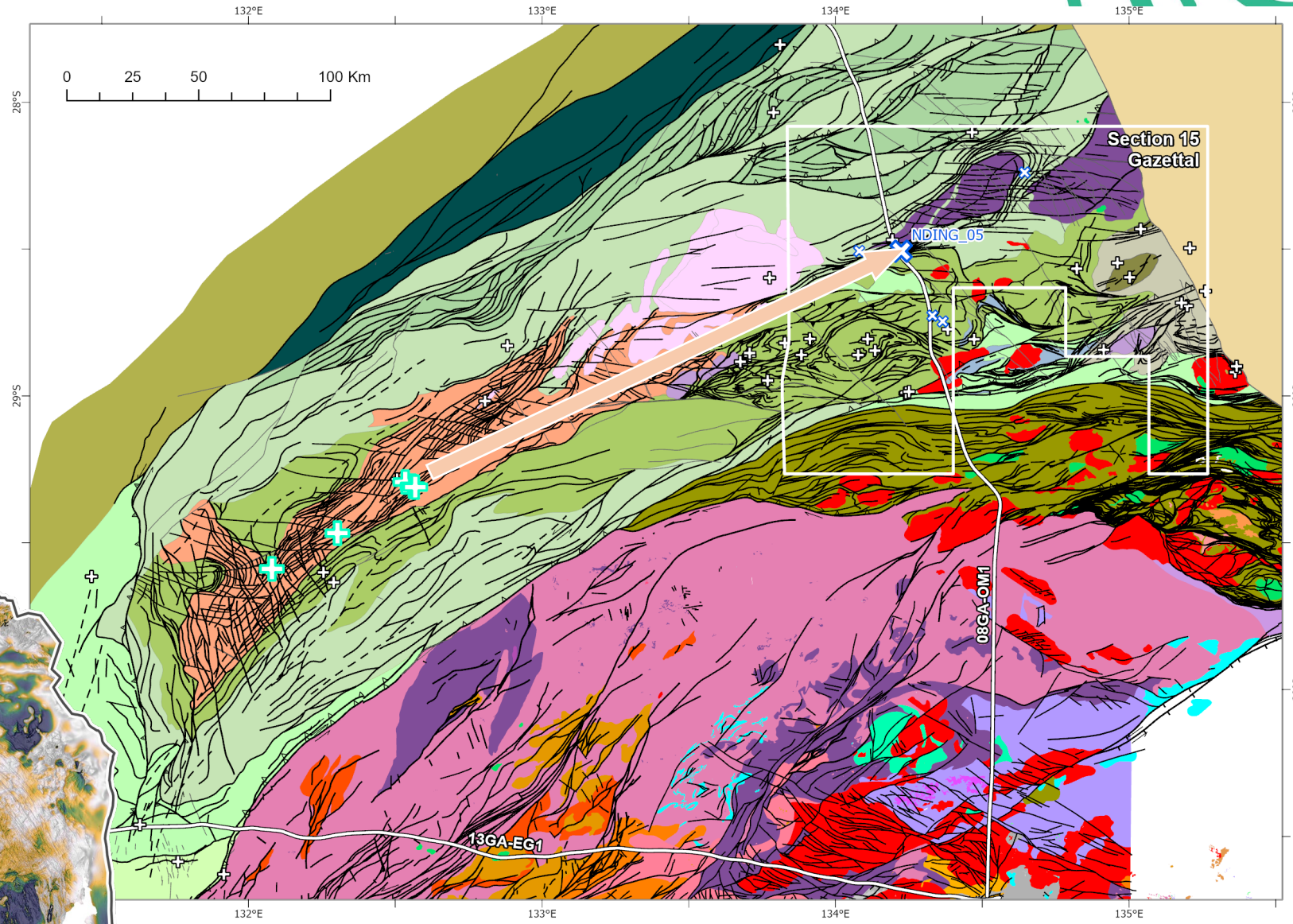
- Further insights and broader implications from recent geochronological investigations in the northern Gawler Craton
- Nine legacy drillholes and 5 NDI drillholes were sampled to investigate lithologies and test hypotheses based on initial SADM interpretations



Illbarrinna Granodiorite

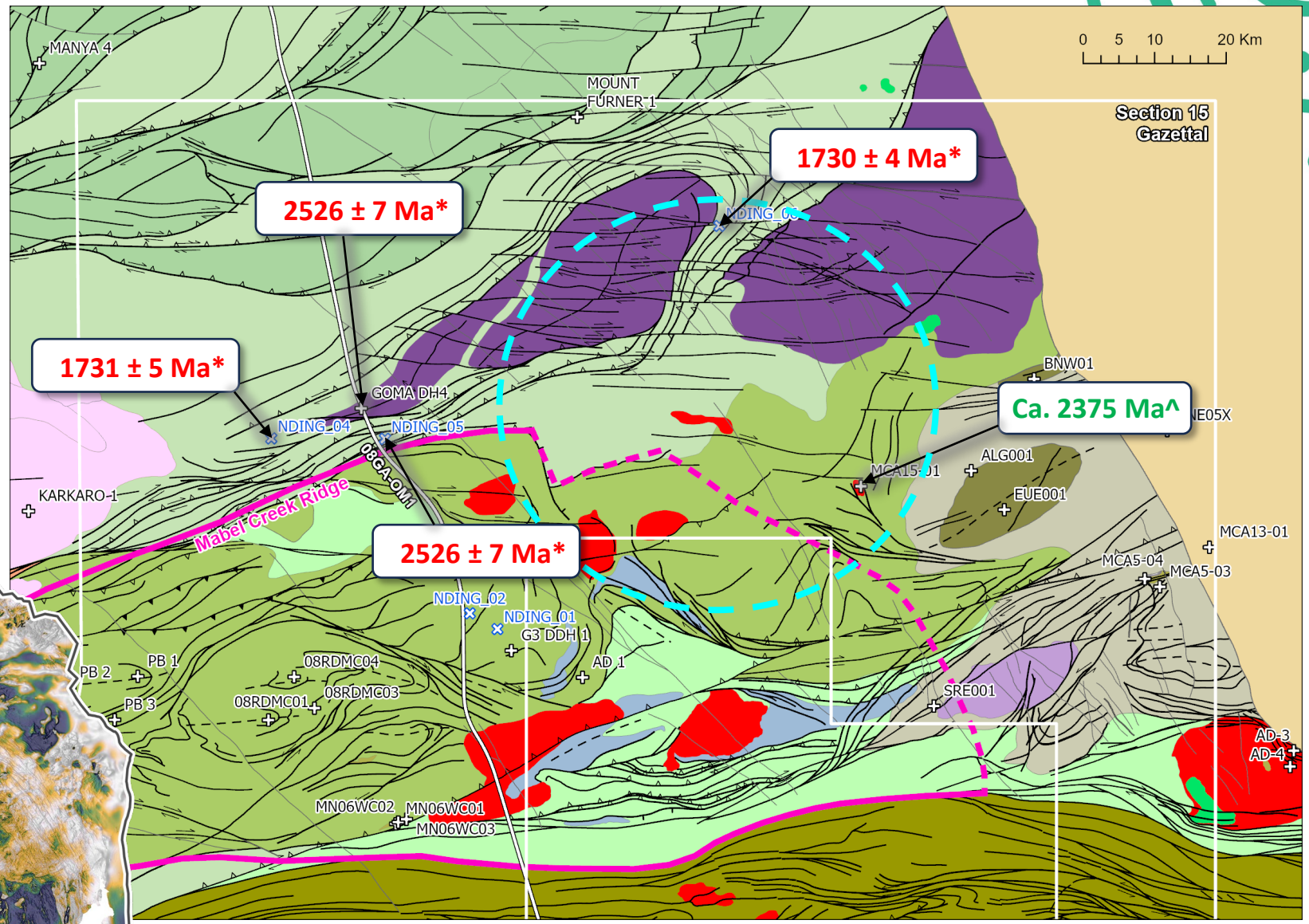
- NDING_05 intersects ca. 1750 Ma granodioritic orthogneiss
- Temporally correlates with ca. 1770 – 1750 Ma intermediate orthogneisses
- Basement to metasedimentary rocks in central Nawa Domain
- Shares geochemical similarities
- *Extends footprint of Illbarrinna Granodiorite basement complex further to the north-east*





Archean Basement

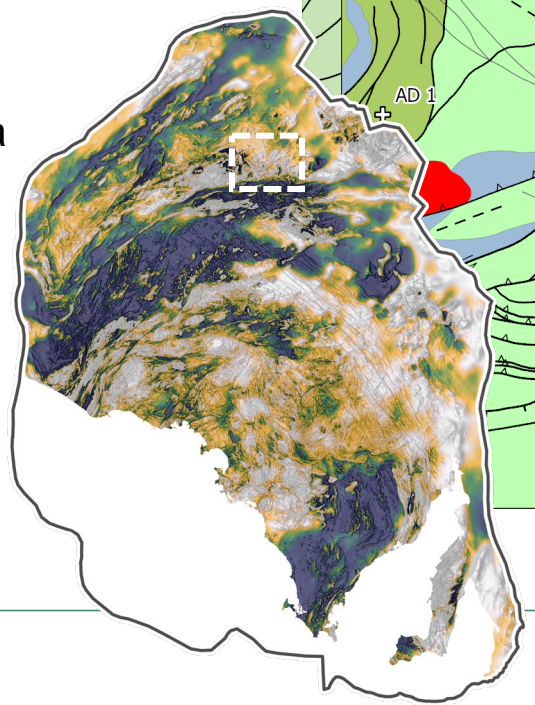
- The extent of Archean basement rocks is poorly constrained – dating from drillhole GOMA DH4 and extrapolations from aeromagnetics
- New data indicates Archean metasedimentary rocks between MCR and P&D
- Requires re-interpretation of basement geology

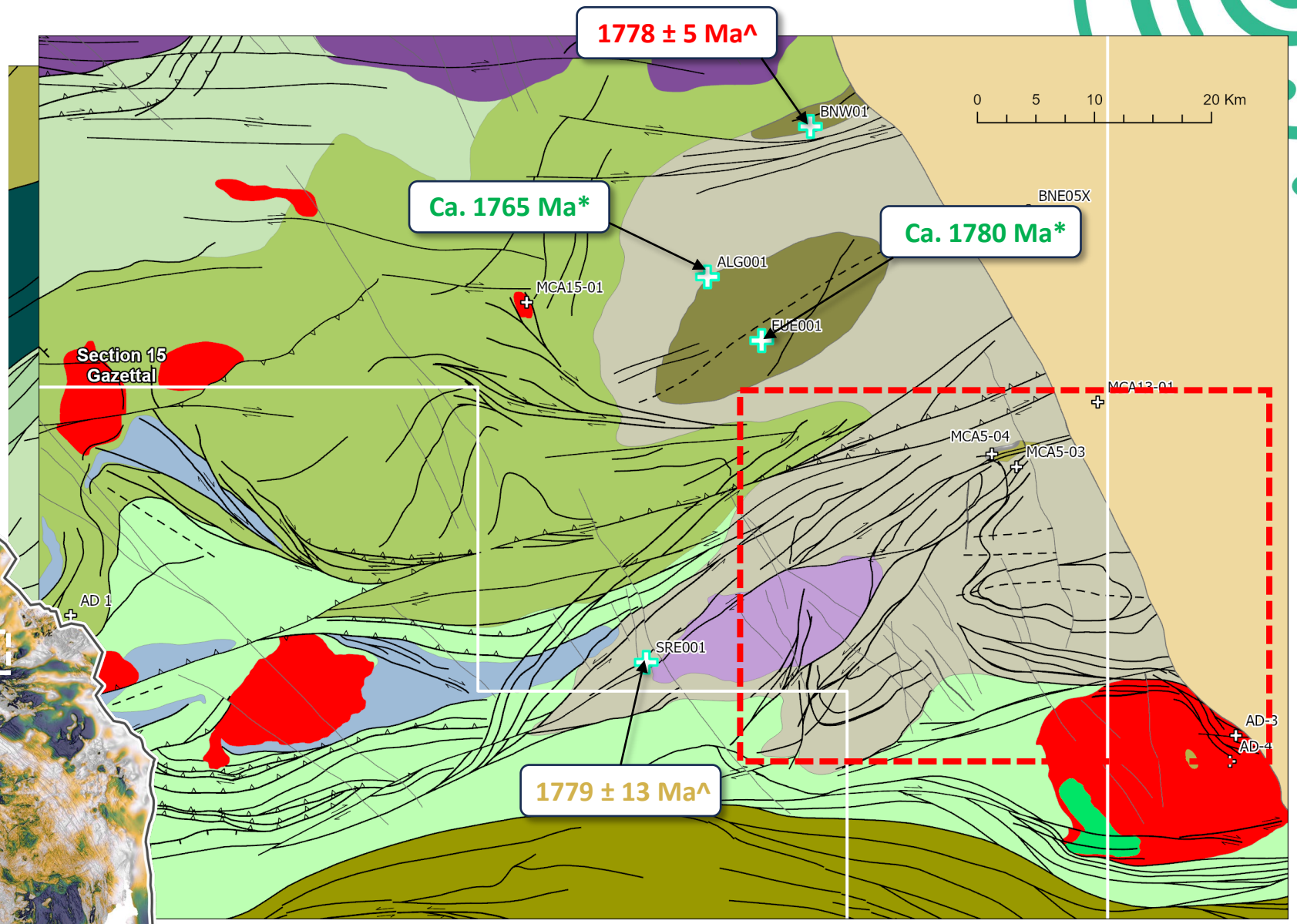


- * Reid et al., 2014
- ^ Brown, pers. comm.

Peake and Denison Domain

- Peake metamorphics (ca. 1780 metasedimentary and metavolcanic rocks) have been interpreted to extend into the eastern Nawa Domain
- New **metamorphic**, **magmatic**, and **sedimentary** geochronological data support this interpretation:
  - **SRE001**
  - **BNW01A**
  - **ALG001**
  - **EUE001**

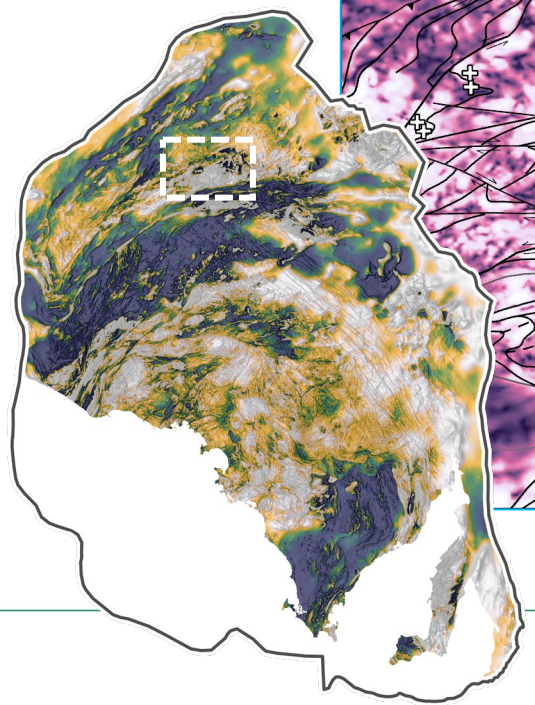


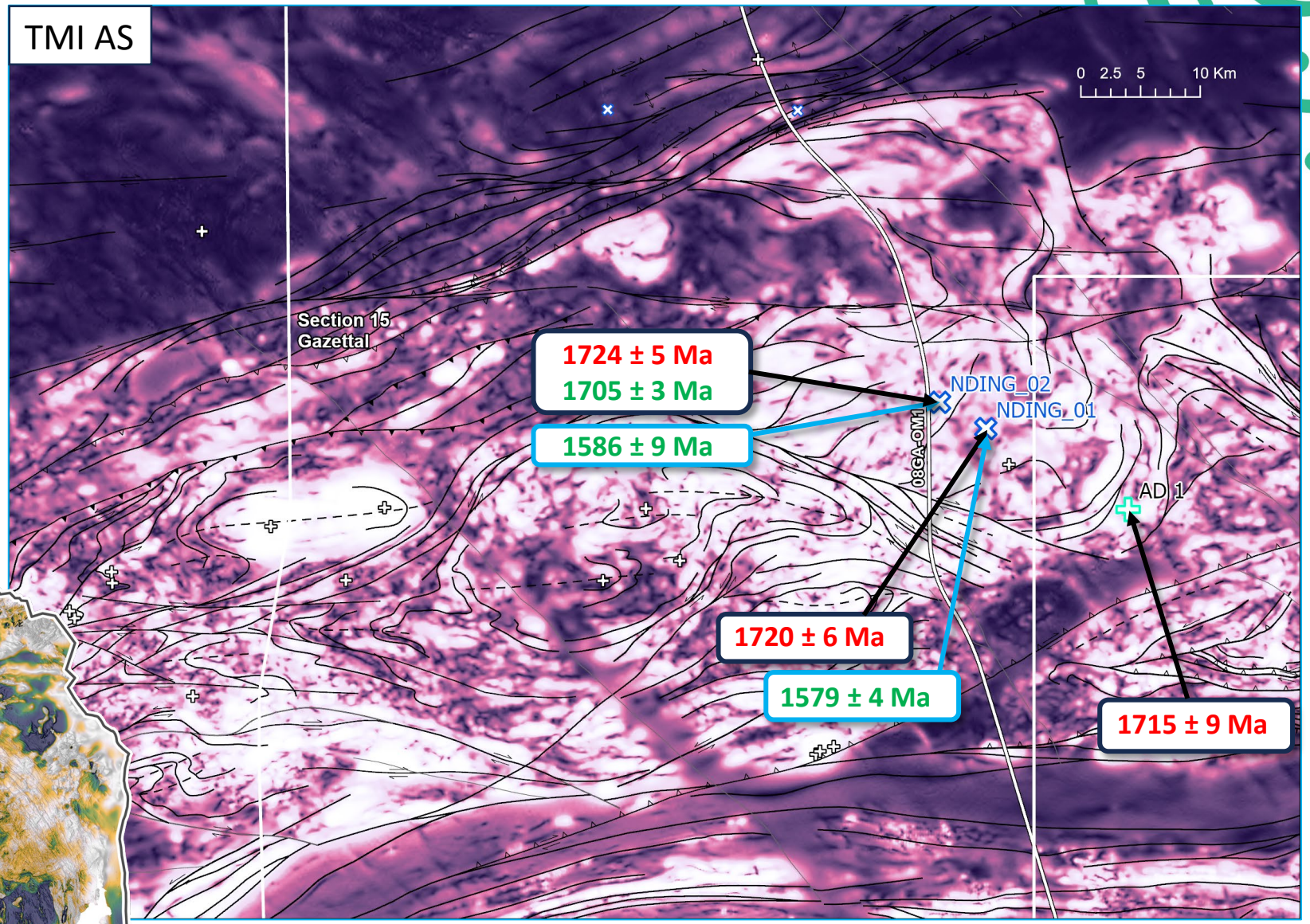


- * Morrissey, pers. comm.
- ^ Jagodzinski, in prep.

Mabel Creek Ridge

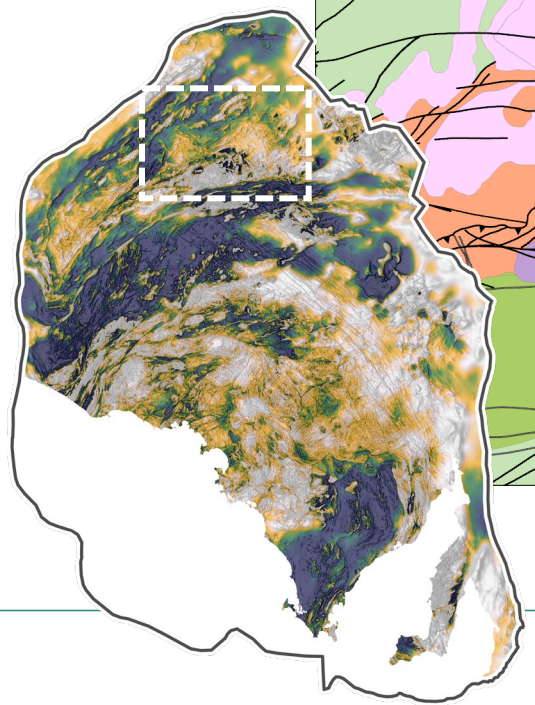
- Extensive Olarian-aged granulite-facies metamorphism and deformation in the western half of the MCR
- New data confirms the same **Kimban** and **Olarian metamorphic** and **magmatic** histories in the eastern MCR
  - **NDING_01**
  - **NDING_02**
  - **AD 1**

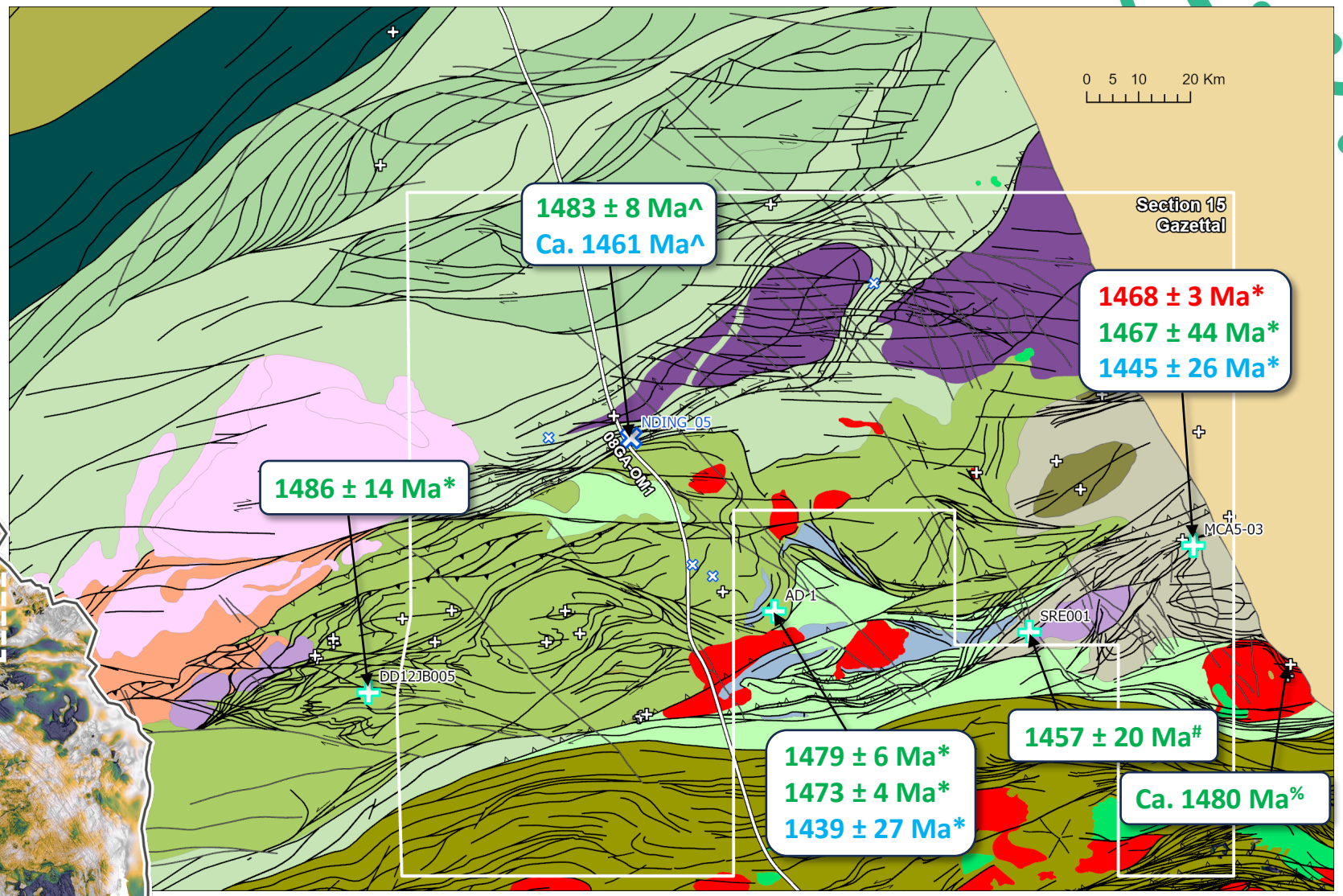




Coorabie Event

- More evidence for widespread **deformation/metamorphism**, **magmatism**, and **(hydro)thermal activity** during the Coorabie Event between ca. 1480 – 1450 Ma
  - **NDING_05**
  - **DD12JB005**
  - **MCA5-03**
  - **SRE001**
  - **AD 1**

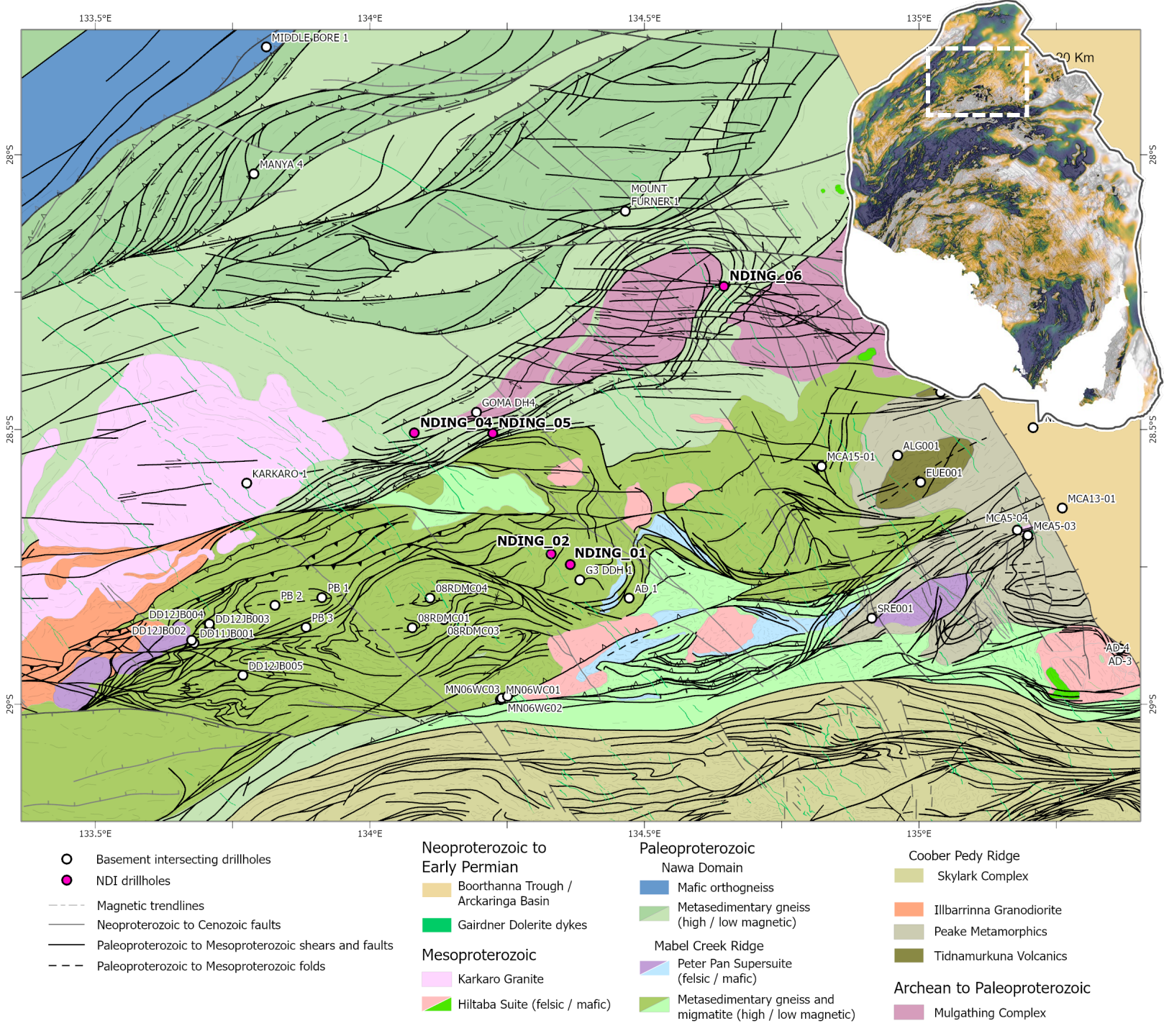




- * Brown et al., 2025
- ^ Brown, pers. comm.
- # Jagodzinski et al., in prep.
- % Morrissey et al., pers. comm.

Summary

- Revised interpretation of the northern Gawler Craton solid geology
- Structural framework correlates structures with specific tectonic events across the Gawler Craton
- SA Geology allows for ongoing updates and refinements of maps and models



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Connections to the North

Evolution of the buried Northern Gawler Craton Basement

The stories from magmatic rocks

Claire Wade | 9/12/2025

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MinEx CRC

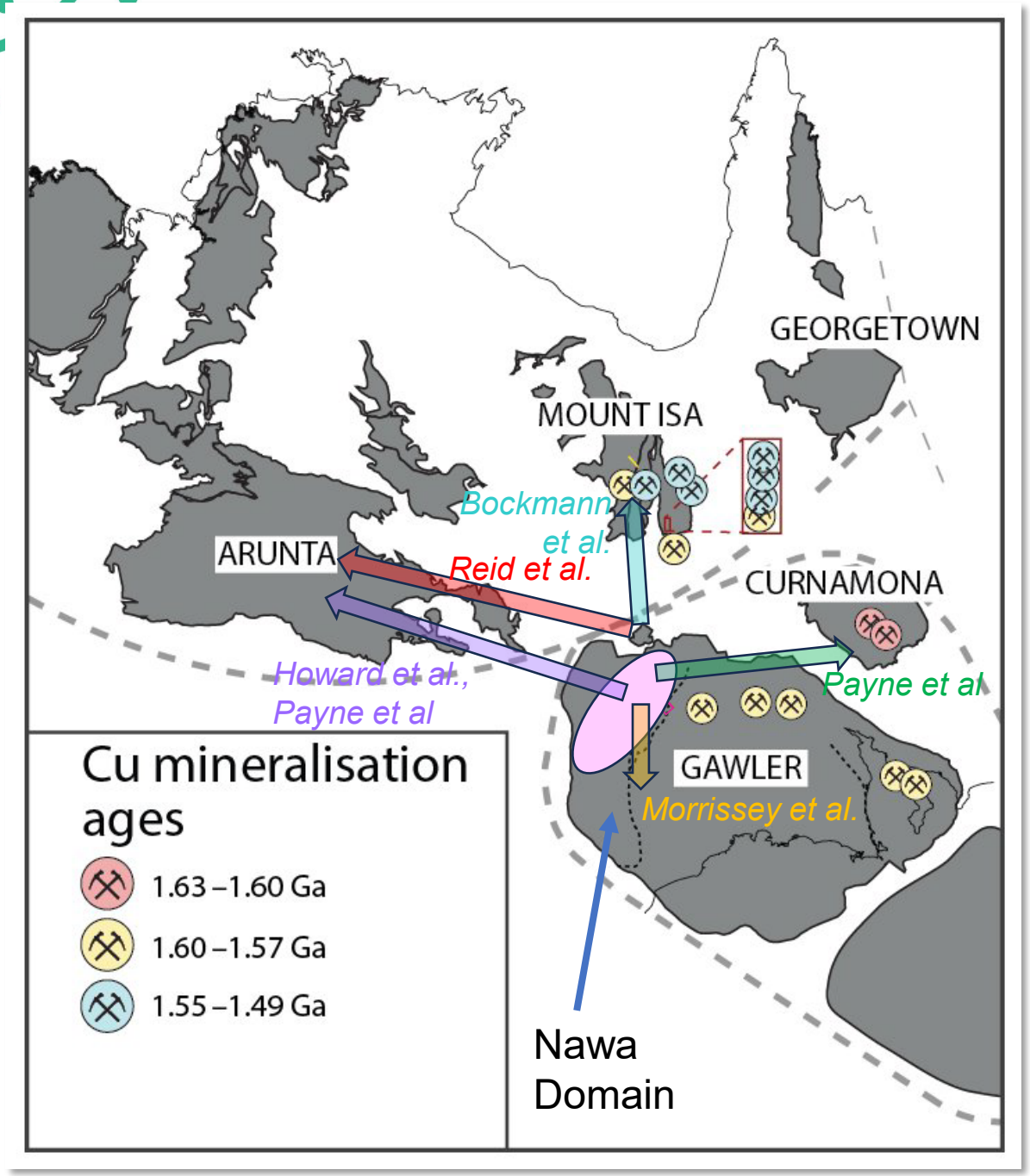
Northern Gawler Craton

The Northern Gawler Craton encompasses a crucial zone that can contextualise and strengthen links with the North Australian Craton

Explore terrane correlations

- ***How do the bits of the northern Gawler Craton fit together?***
- ***Correlation with north Australia (Aileron/Arunta, Mt Isa) and other parts of South Australia (Peake and Denison, Gawler Craton, Curnamona Province)***
- ***What are the main rock types, protolith, metamorphic and magmatic ages?***

Use magmatic rocks to refine tectonic setting and source regions – implications for overall Proterozoic Australia evolution



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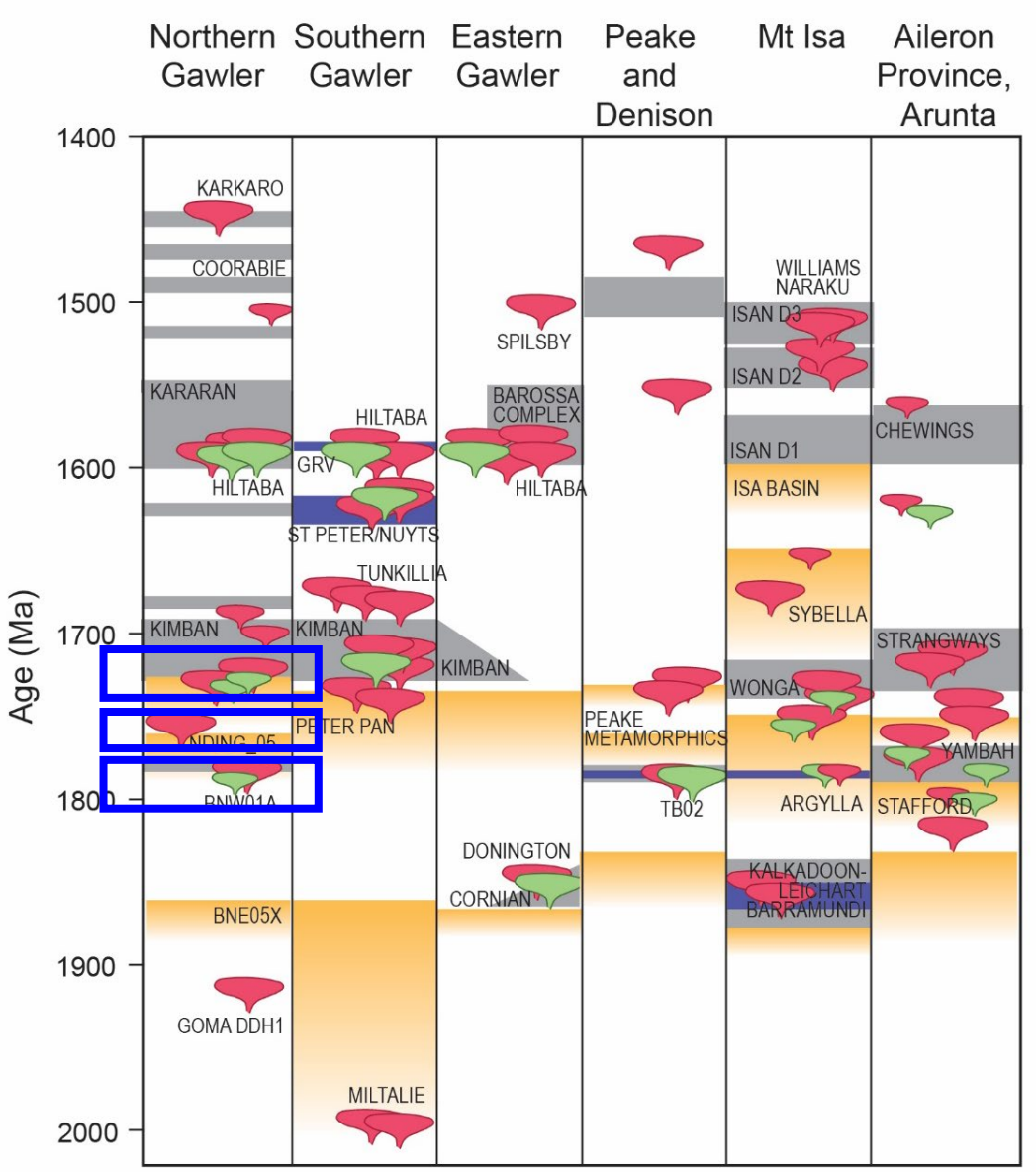
Northern Gawler Craton magmatism

Three periods of magmatism identified in Northern Gawler Craton

- 1790–1780 Ma
- 1770–1750 Ma
- 1730–1720 Ma

Fit into broader time period of 1860 to 1670 Ma Proterozoic Australia



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Models for 1860–1670 Ma Proterozoic Australia

1860–1670 Ma was a busy time in Proterozoic Australia

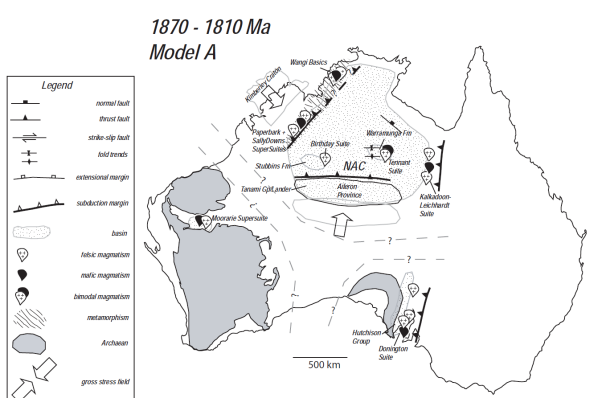
Large basin systems developed in the NAC and SAC, punctuated by magmatism and deformation

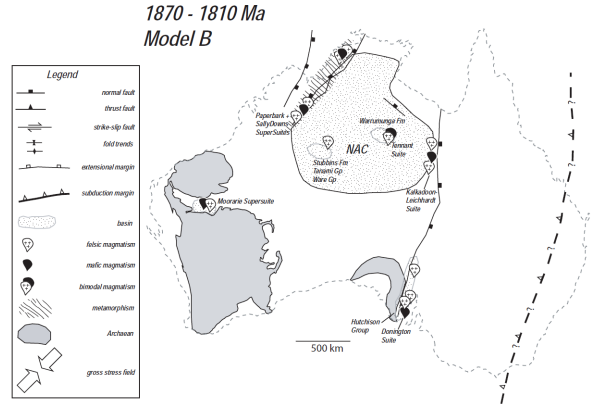
Models include:

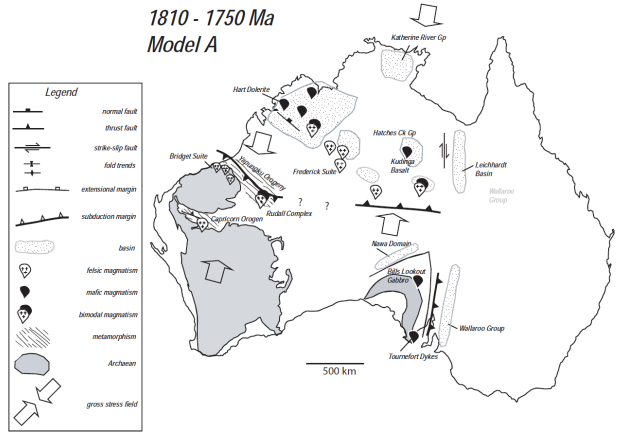
Subduction/accretion-dominated (Model A)

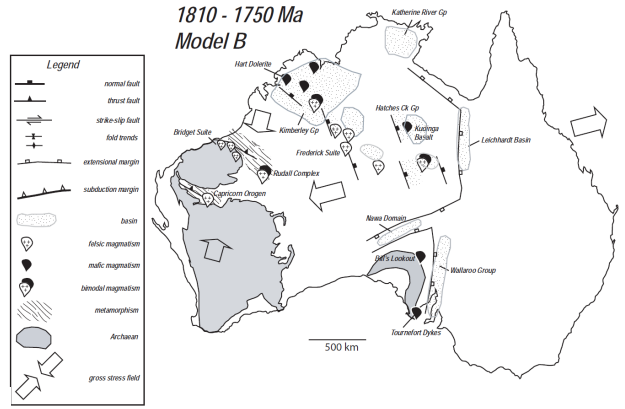
Extension-dominated (Model B)

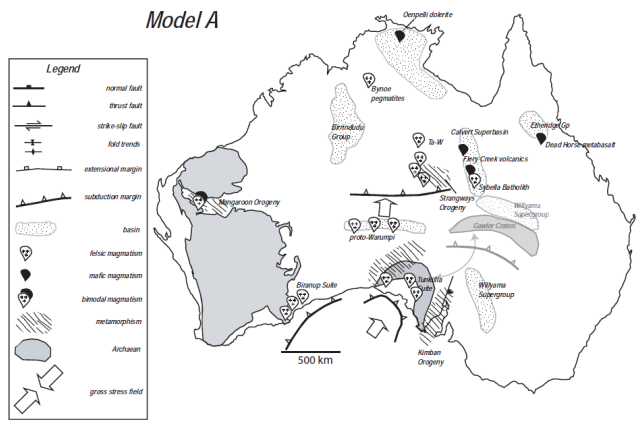
Nawa Domain/Northern Gawler plays a role in understanding that development

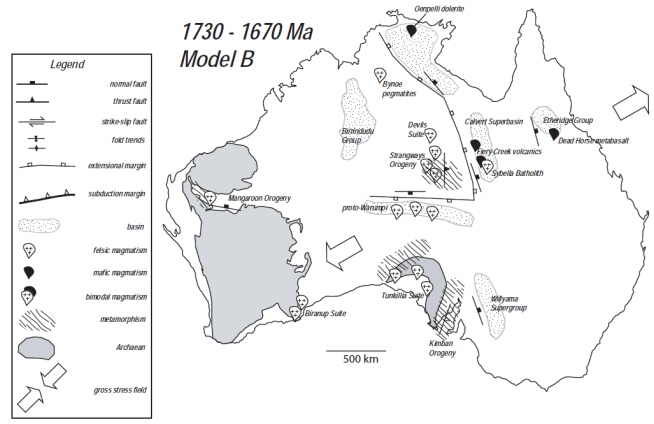












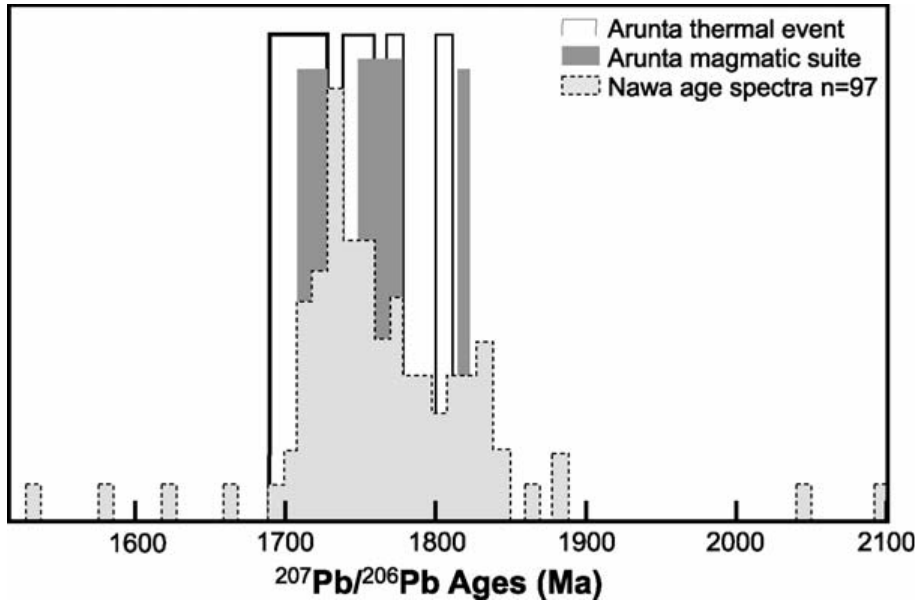
Fraser et al., 2007 Record 2007/016 https://www.ga.gov.au/bigobj/GA10959.pdf

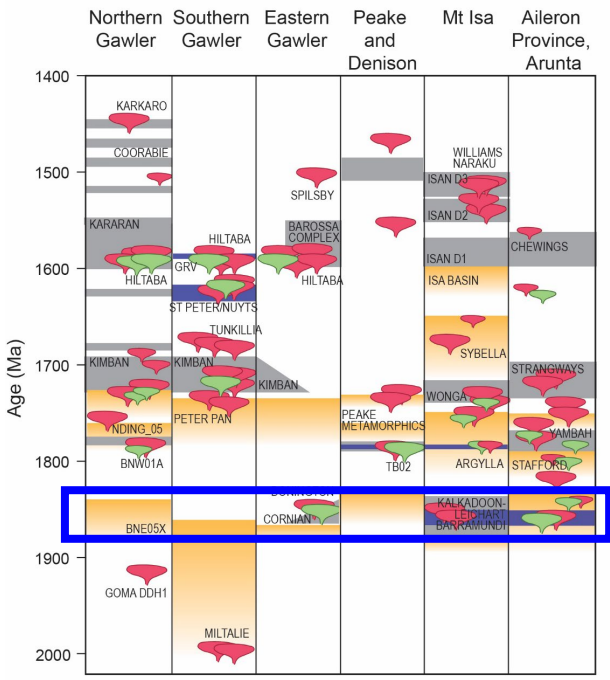
1860–1780 Ma

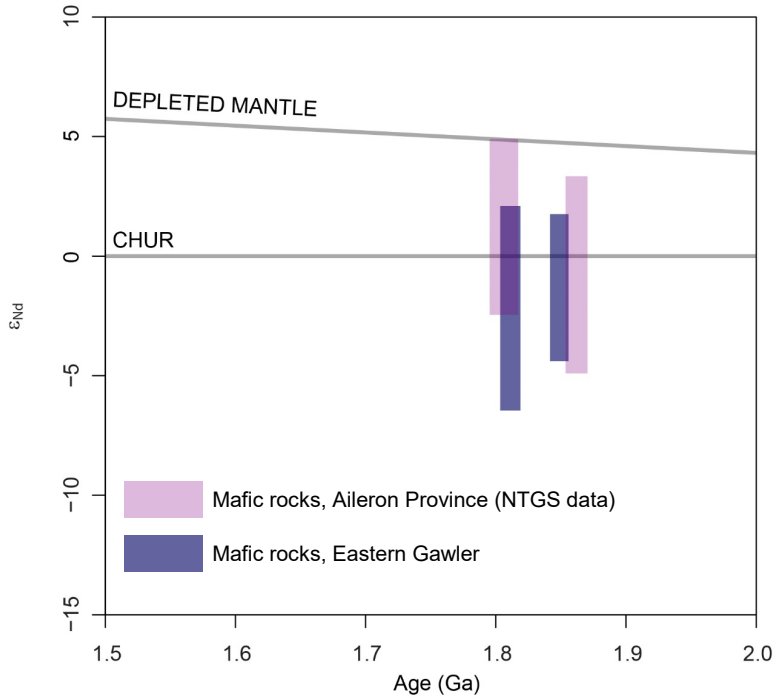
Basin development from 1860 Ma accompanied by volcanism and intrusive magmatism in Eastern Gawler Craton, Mt Isa and Aileron Province

Ca. 1860 Ma to 1800 Ma intrusive mafic magmatism occurs as sills and dykes attributed to back-arc rifting (extensional setting)

Deposition in Nawa Domain from ca. 1860 Ma (e.g. BNE0X5) suggests basin development may be related to basins in North Australian Craton







Top: Combined detrital zircon age spectra of the Nawa Domain metasedimentary rocks with magmatic and thermal events of the Arunta region (Payne et al., 2006 https://doi.org/10.1016/j.precamres.2006.05.002)

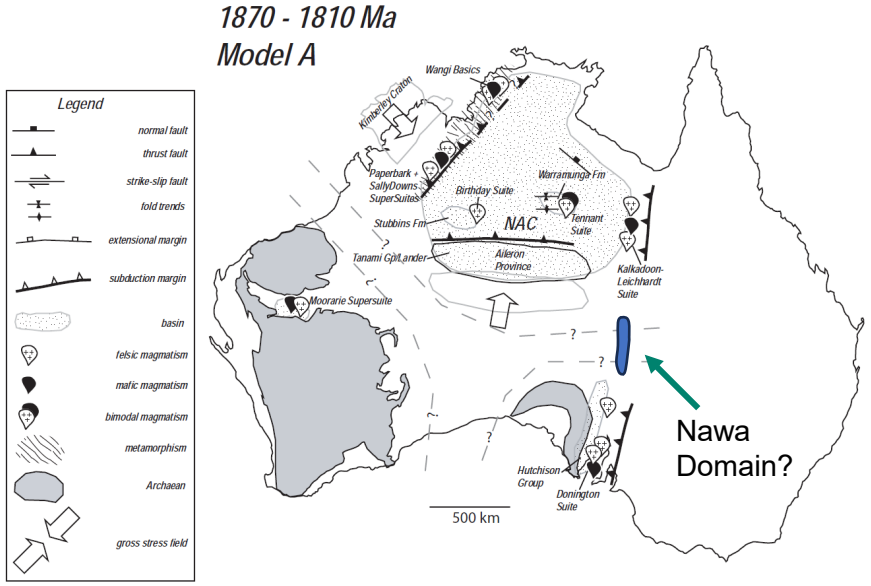
Botton: ε_{Nd} isotope evolution diagram for >1800 Ma mafic rocks from Eastern Gawler Craton and Aileron Province

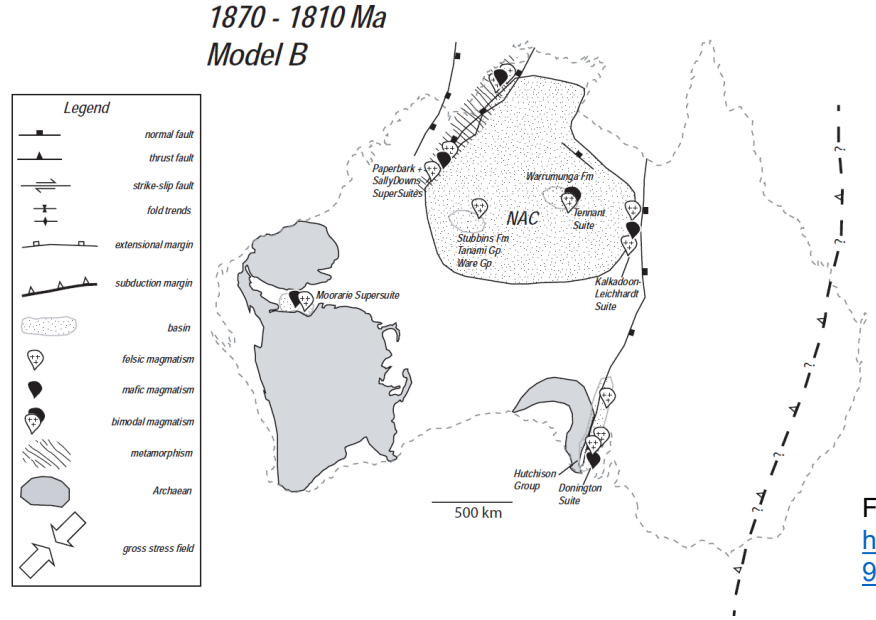
1860–1780 Ma

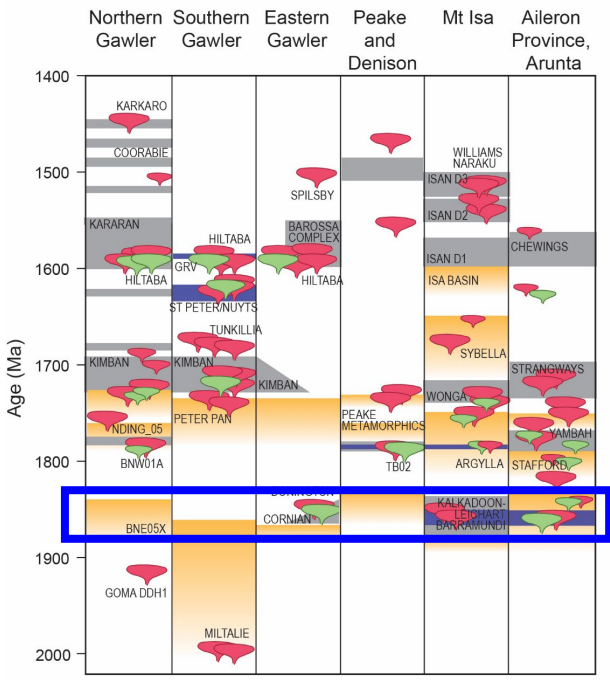
Basin development from 1860 Ma accompanied by volcanism and intrusive magmatism in Eastern Gawler Craton, Mt Isa and Aileron Province

Deposition focussed on eastern margin as either subduction (A) or extensional margin (B)

Does the Nawa Domain fit along this margin?







Fraser et al., 2007 Record 2007/016
https://www.ga.gov.au/bigobj/GA10959.pdf

1860–1780 Ma

Bimodal magmatism occurred ca.1790–1780 Ma in Northern Gawler, Peake and Denison, Mt Isa and Aileron Province

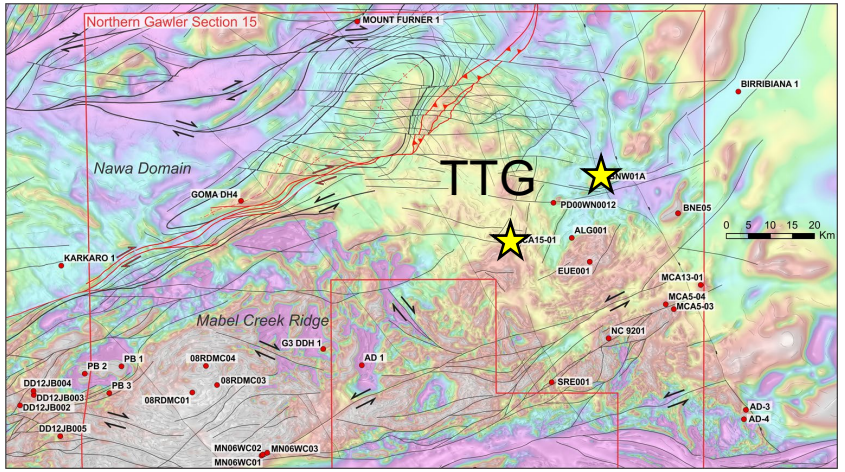
In Northern Gawler, granodiorite and diorite in BNW1A yield magmatic crystallisation ages of ca. 1780 Ma

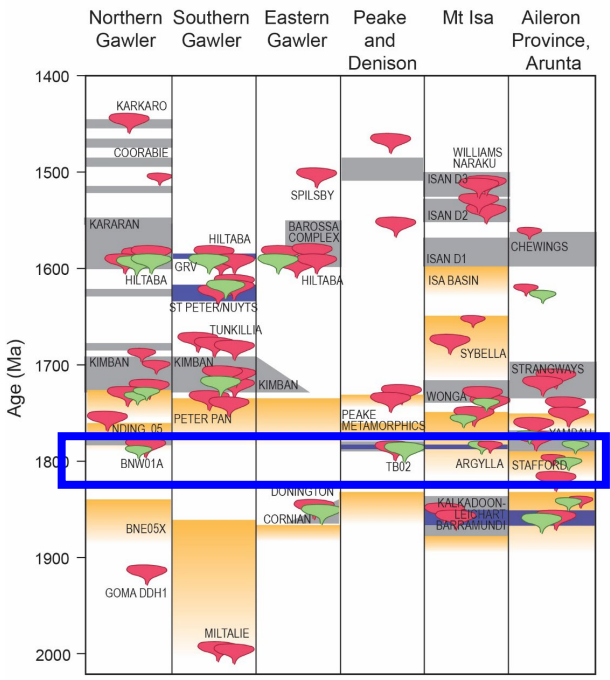
Steep REE may be attributed to TTG-like source region

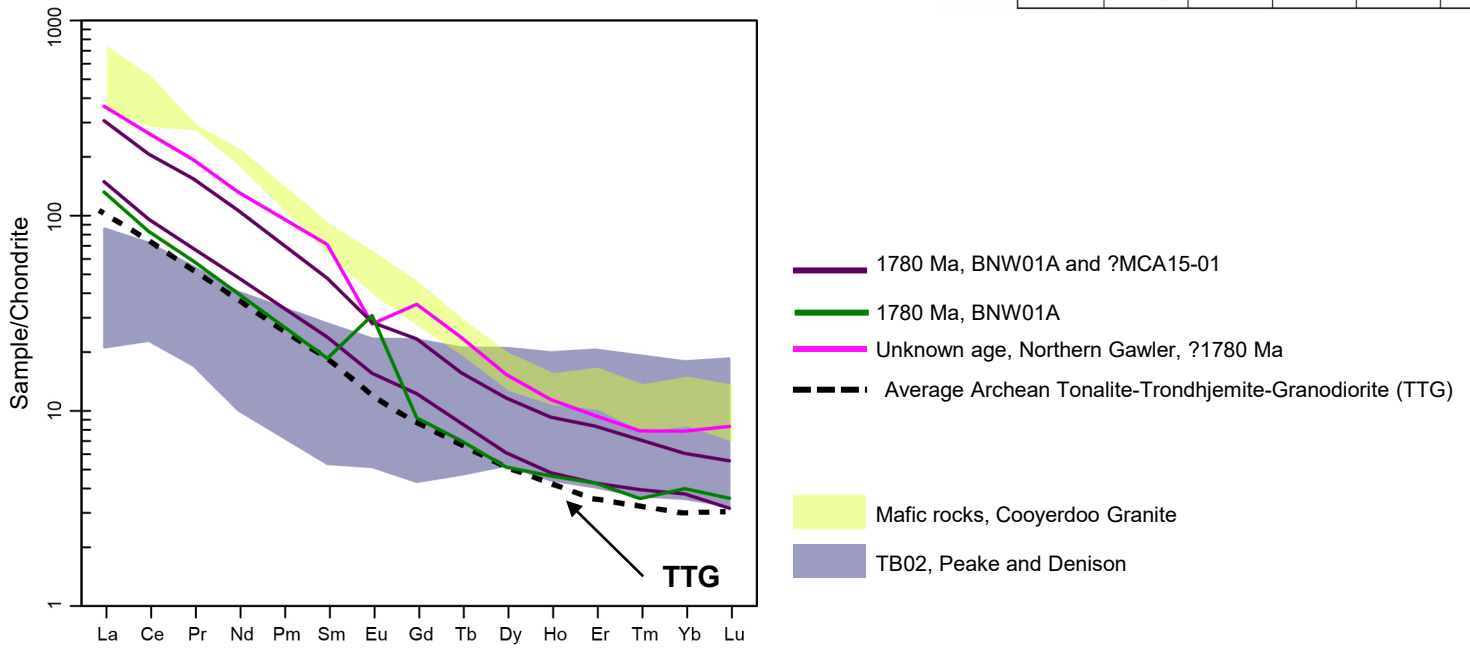
High Th/Nb – subduction modified/ metasomatised lithospheric mantle

Two samples with similar compositions identified in drillhole MCA15-01 – possible correlation

Temporal with mafic magmatism in TB02 in Peake and Denison Domain (Reid et al., 2017)





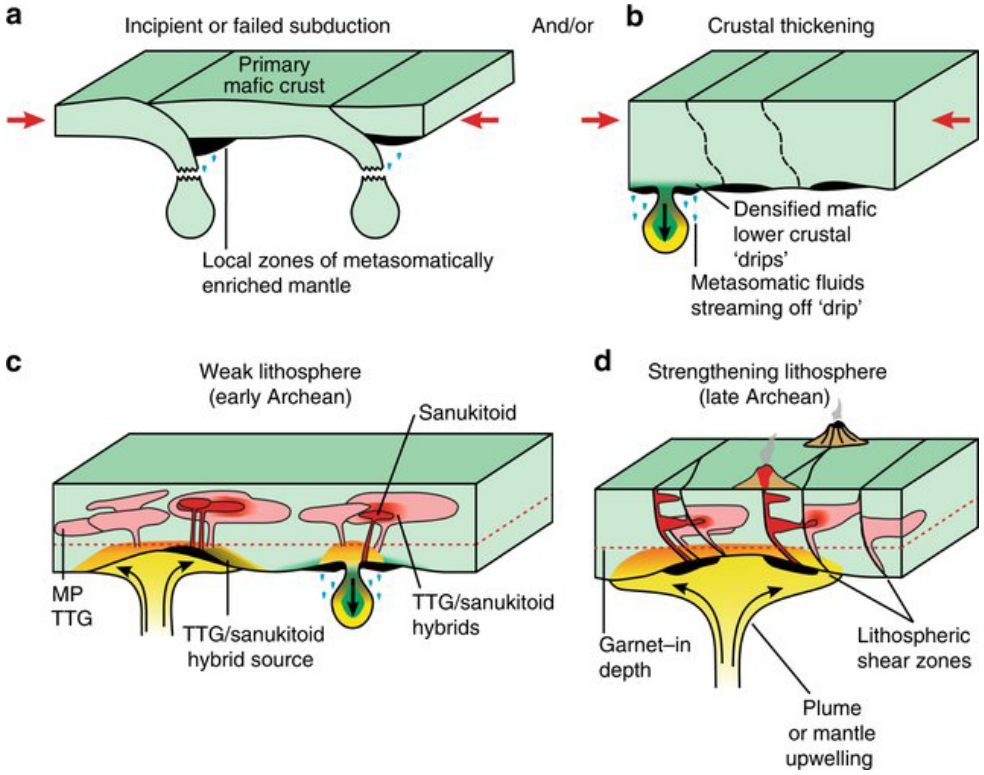


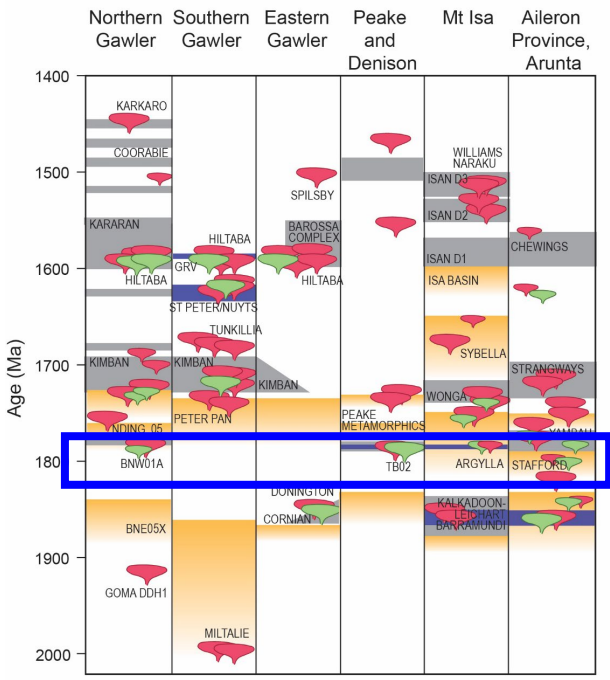
1860–1780 Ma

Bimodal magmatism at 1790–1780 Ma in Northern Gawler may represent TTG-like rocks

e.g. TB02 high Mg component, BNW1A and MCA-15-01 TTG component

Convergent margin setting or previously metasomatised lithospheric mantle source?



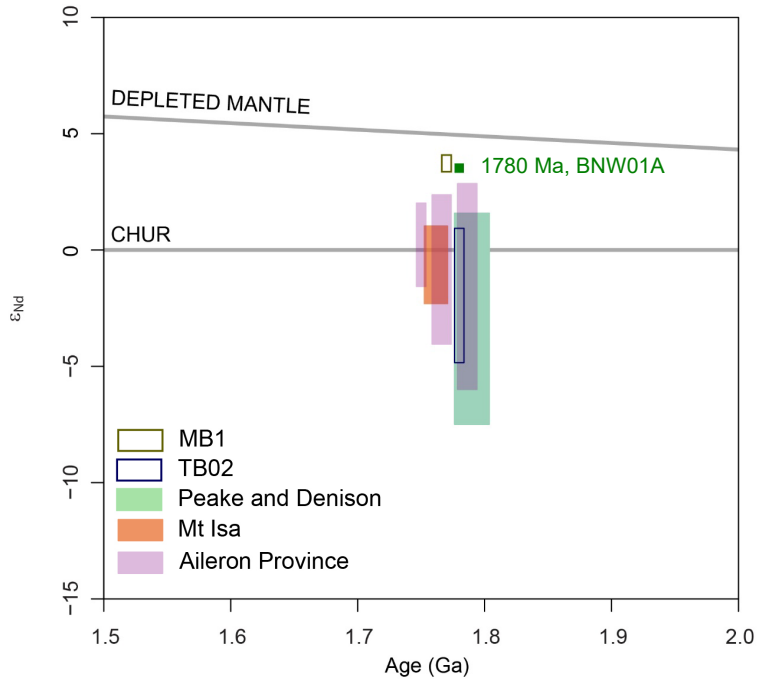


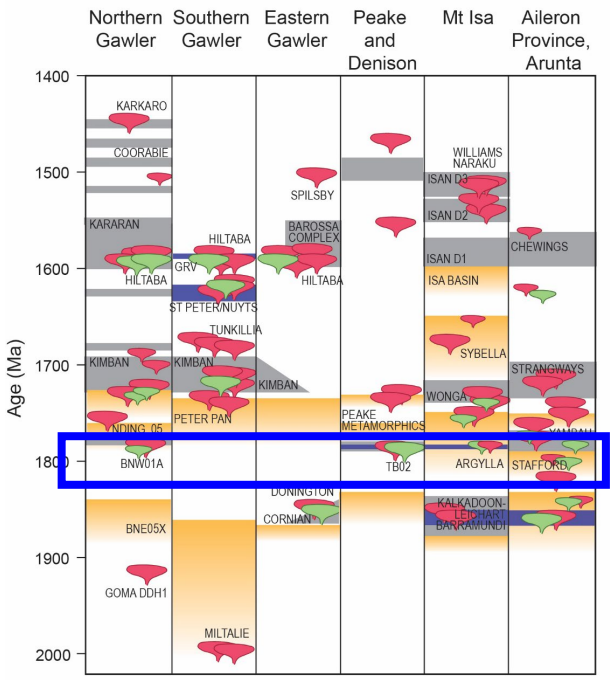
Schematic model showing the geological environment of TTG and sanukitoid (high Mg granitoid) formation as a possible setting for 1780 Ma magmatism in Northern Gawler Craton (e.g. TB02 high Mg rocks and BNW1A and MCA15-1 TTG. Smithies et al., 2019
https://doi.org/10.1038/s41467-019-13547-x

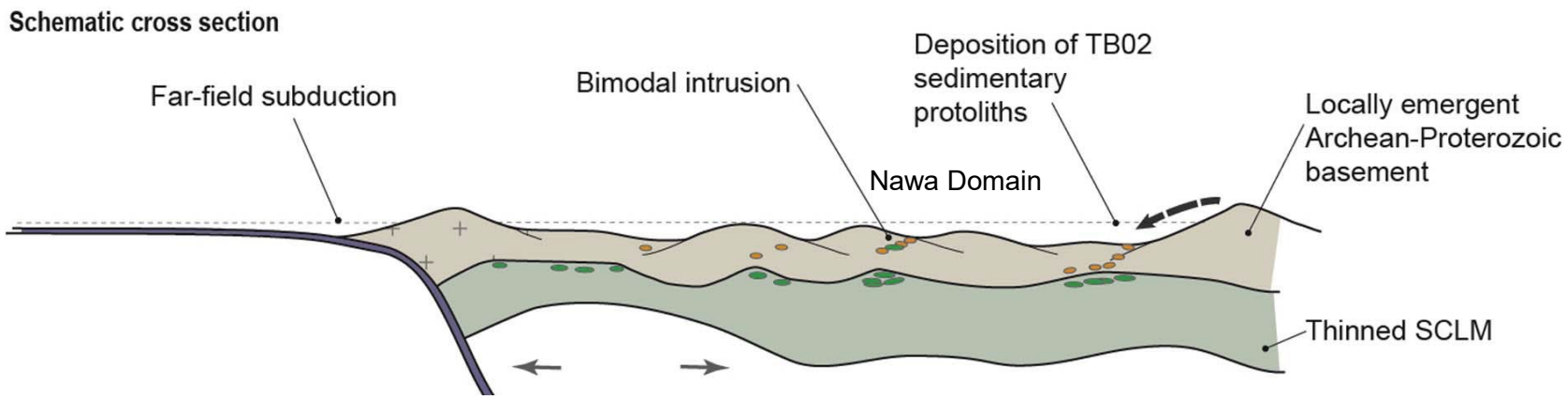
1860–1780 Ma

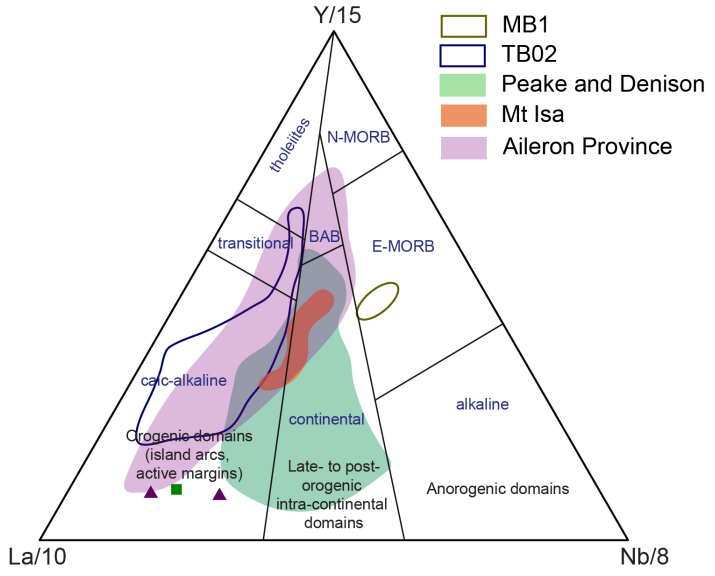
More broadly, mafic magmatism suggests heterogenous mantle sources – enriched and juvenile – occurred throughout the 1800–1780 Ma time period in the North Australia Craton

Back-arc to active margin settings









Schematic tectonic reconstruction of a hypothesised far-field back arc setting for deposition of protoliths to the metasedimentary gneisses of drill hole TB02. This model for the northeastern Gawler Craton at c. 1840–1780 Ma is similar to that envisaged for the Aileron Province during the Yambah Event by Howlett et al. (2015).

1770–1750 Ma

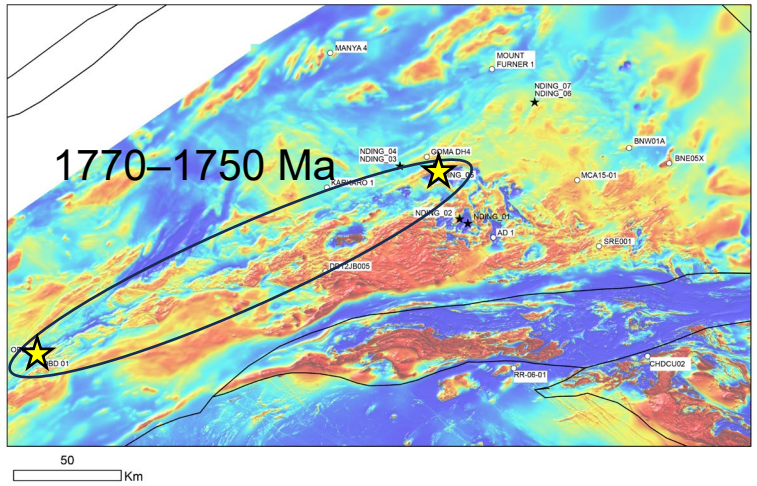
Howard et al. (2015) recognised 1770–1750 Ma magmatism in SW Nawa Domain

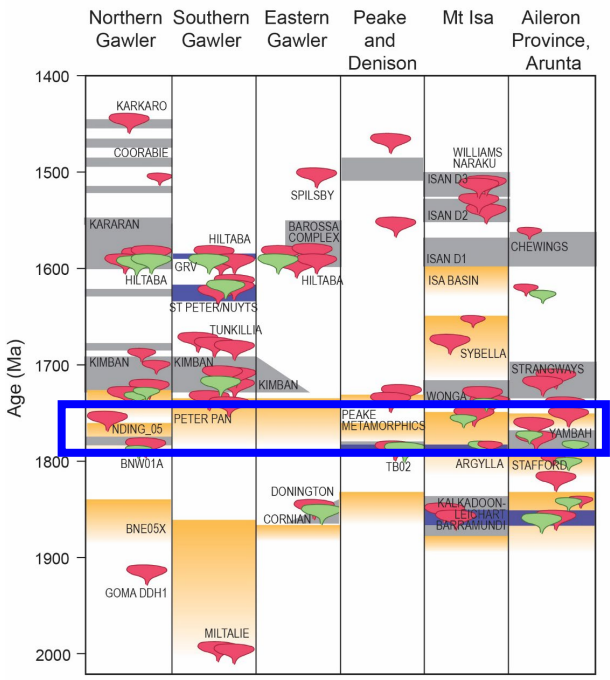
NDING_05 yielded magmatic crystallisation age of 1750 Ma

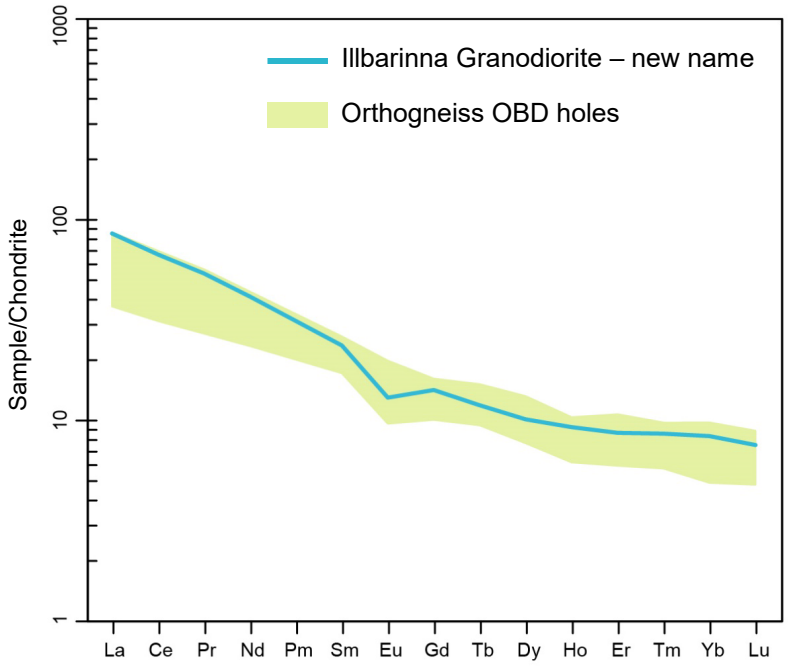
Shows geochemical and isotopic affinity to 1770–1750 Ma orthogneiss from OBD holes, now recognised as Illbarinna Granodiorite

Could represent a ribbon of crust that exists on the southern margin of the Nawa Domain

Strengthens links with NAC?





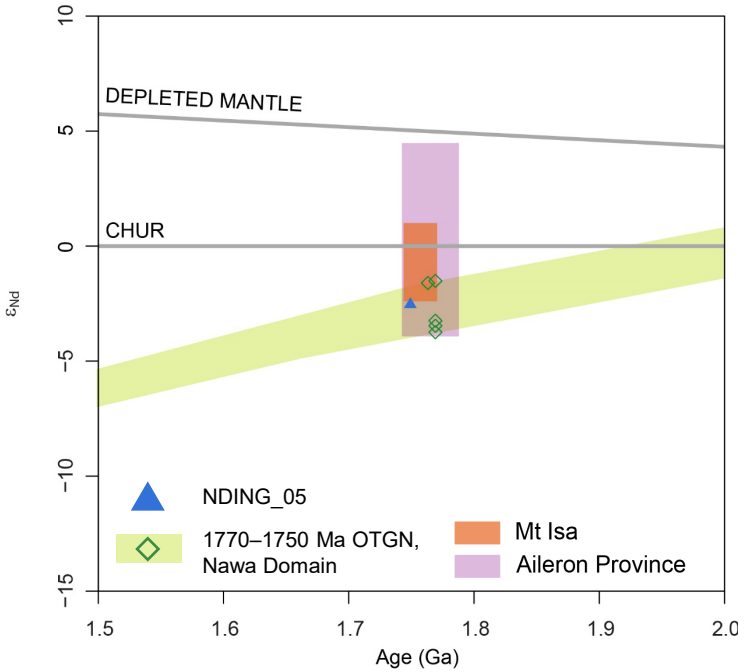


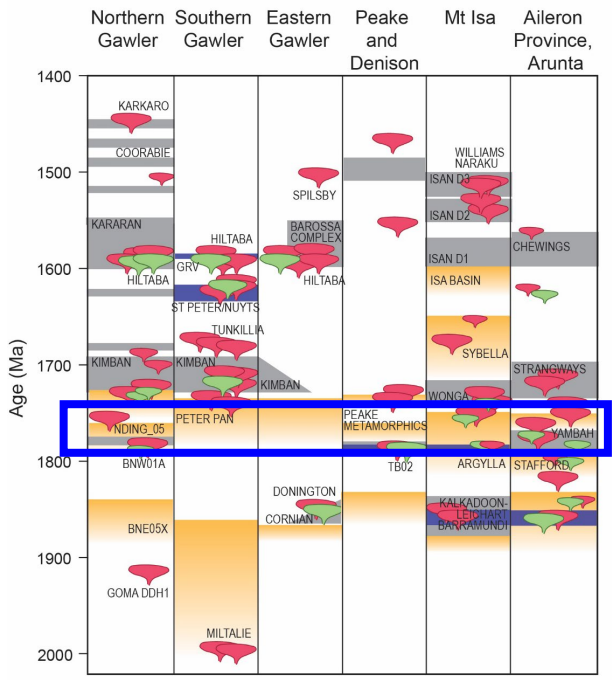
1770–1750 Ma

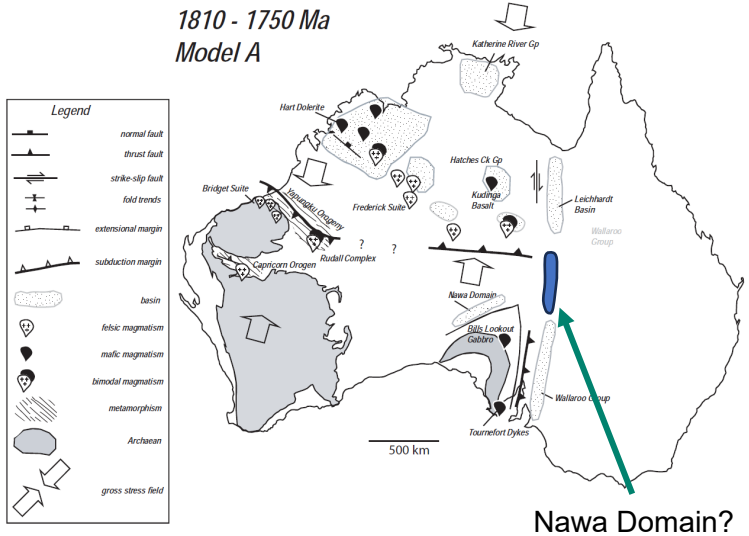
Howard et al. 2015 attributed 1770–1750 Ma magmatism in SW Nawa Domain to Aileron Province and Yambah Event.

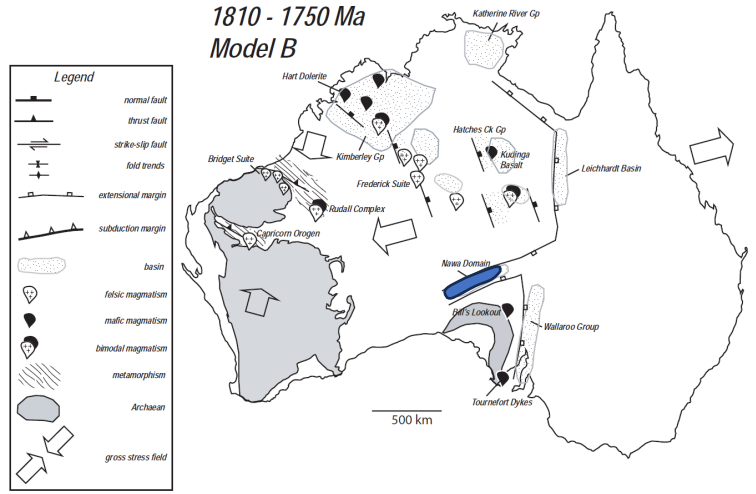
Aileron Province and Mt Isa eastern succession have juvenile and evolved crustal sources

Back-arc setting linked to prolonged north-directed subduction







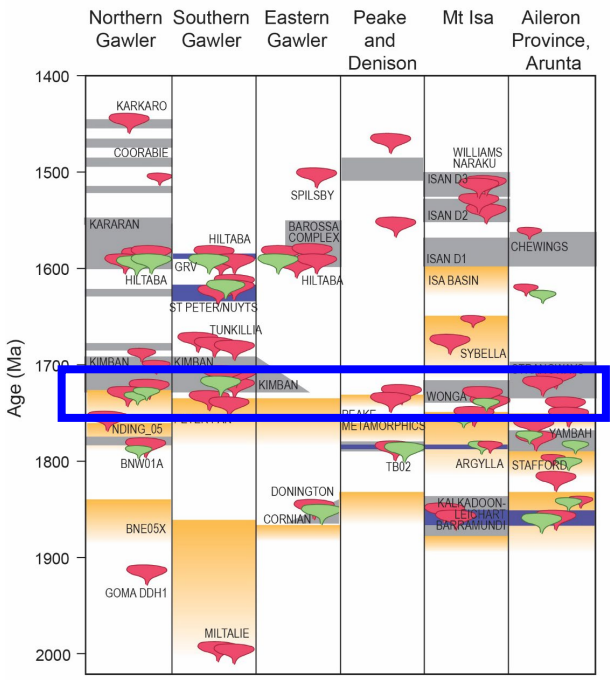


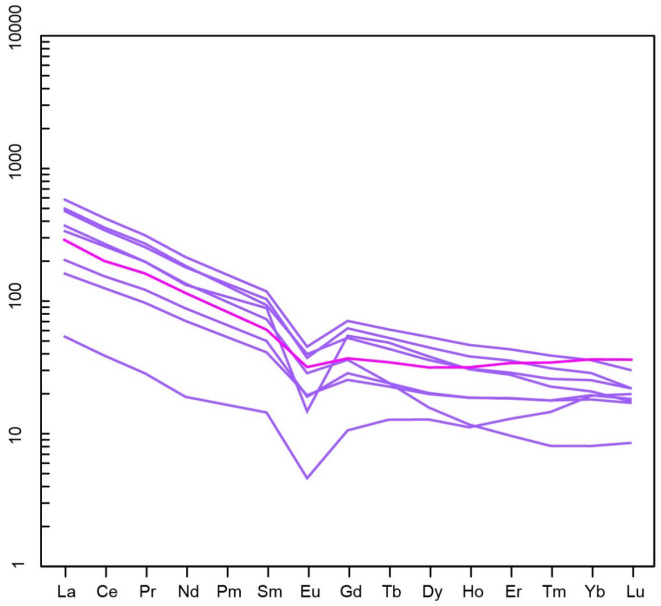
1740–1720 Ma

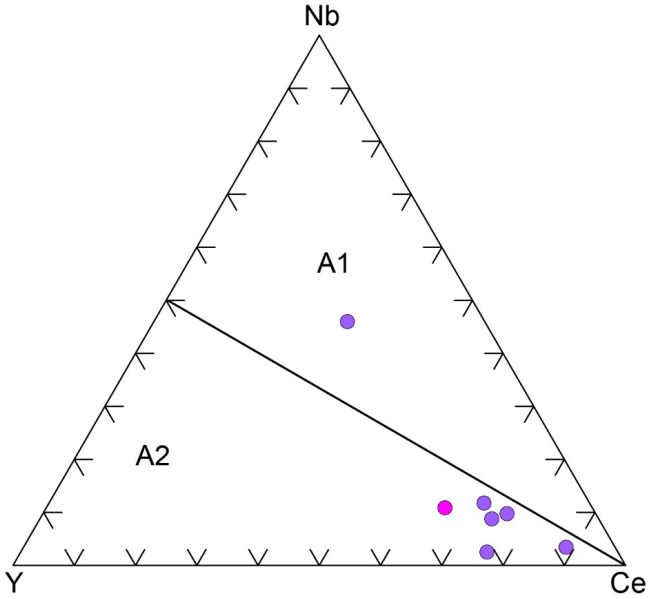
NDI drillholes and legacy holes in Northern Gawler Craton have revealed bimodal magmatism ca. 1740–1720 Ma

Metasedimentary rocks in Nawa Domain deposited between 1740–1720 Ma (Payne et al., 2006) indicating syn-depositional magmatism

Felsic rocks derived from a crustal source, possibly island arc or previously subduction modified lithosphere







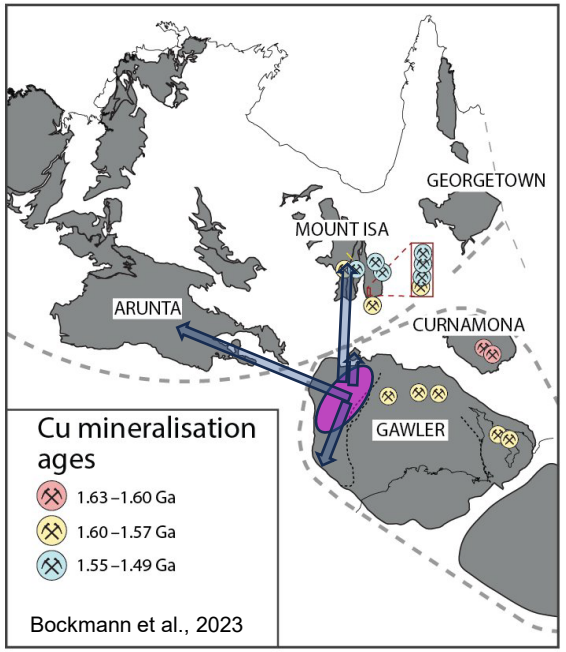
A1: OIB source (intraplate and continental rift)
A2: crustal source (island arc or subduction-modified lithosphere, continental margin)

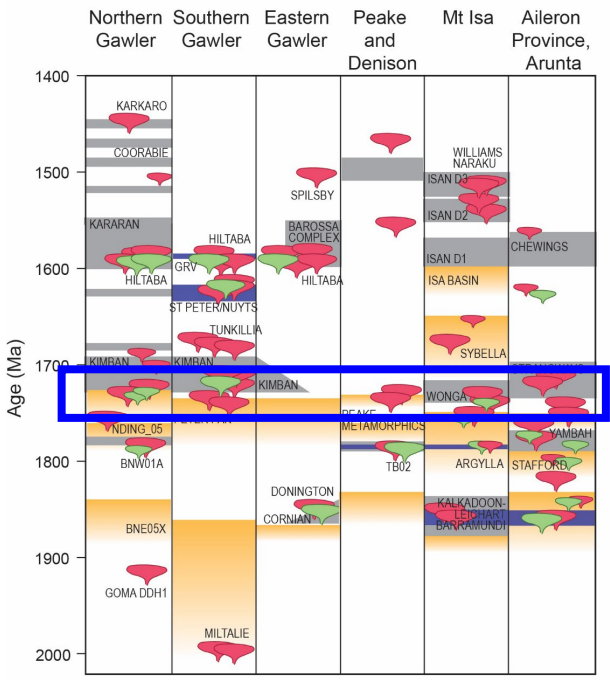
1740–1720 Ma felsic rocks

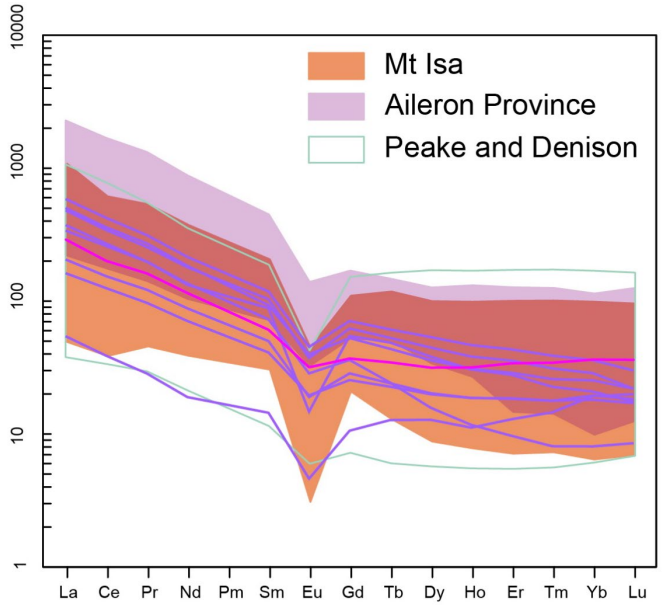
1740–1720 Ma

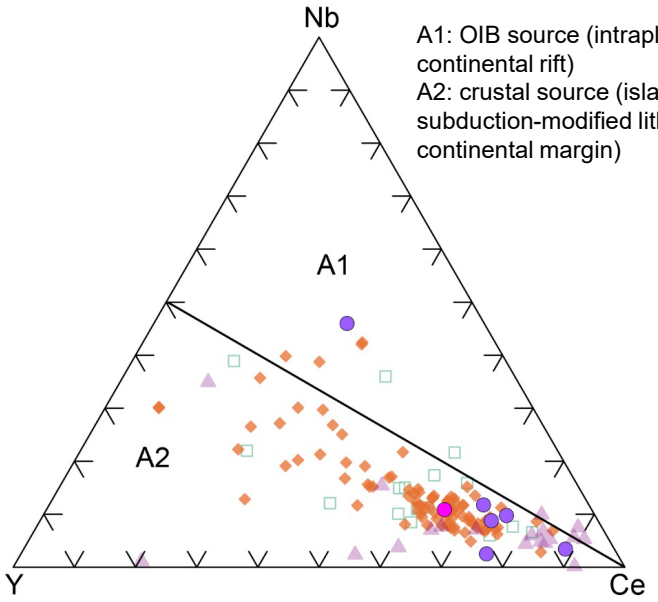
1740–1720 Ma felsic rocks in Northern Gawler Craton show geochemical and isotopic affinity to Aileron Province and Mt Isa (Wonga-Burstall igneous units) suggesting similar crustal sources (possibly island arc or previously subduction modified lithosphere)

Wonga Batholith, Mt Isa (1750–1735 Ma), attributed to an extensional event.

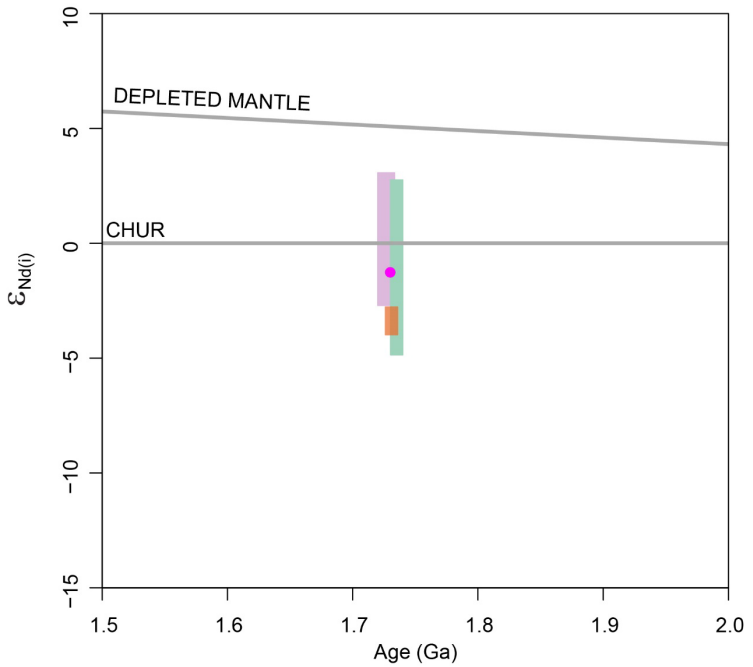








A1: OIB source (intraplate and continental rift)
A2: crustal source (island arc or subduction-modified lithosphere, continental margin)



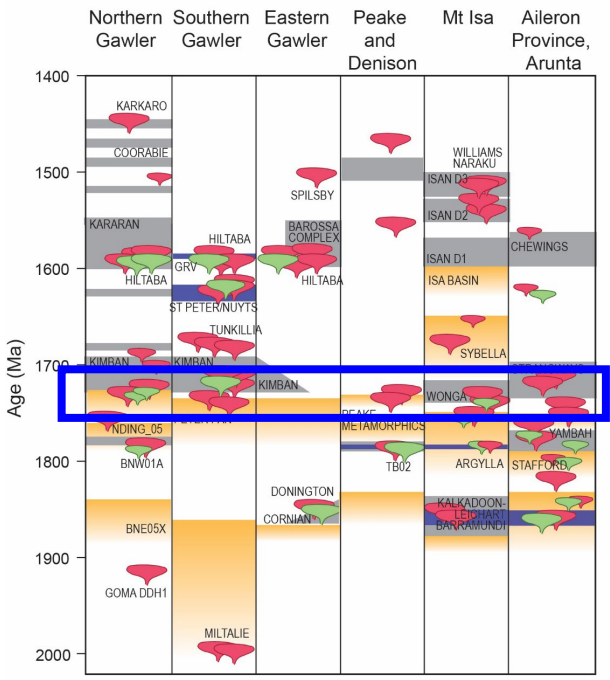
1740–1720 Ma

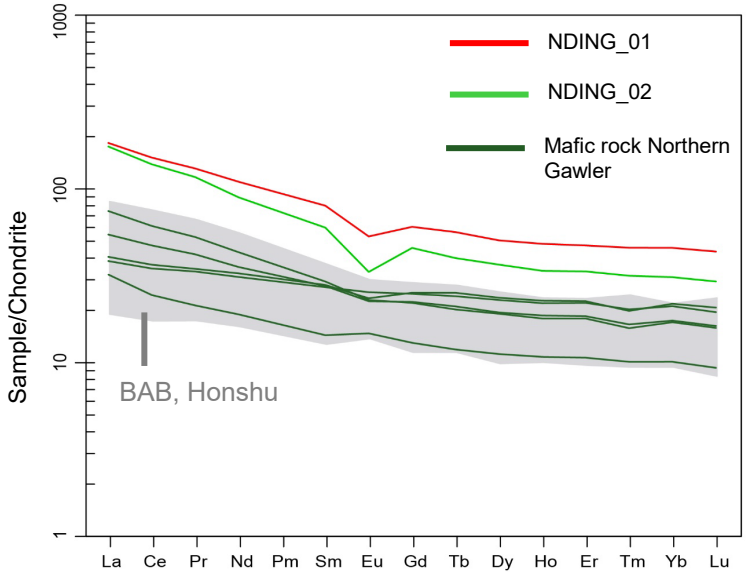
Mafic intrusive rocks occur in multiple drillholes in Northern Gawler Craton and may represent dykes or sills – syn-depositional

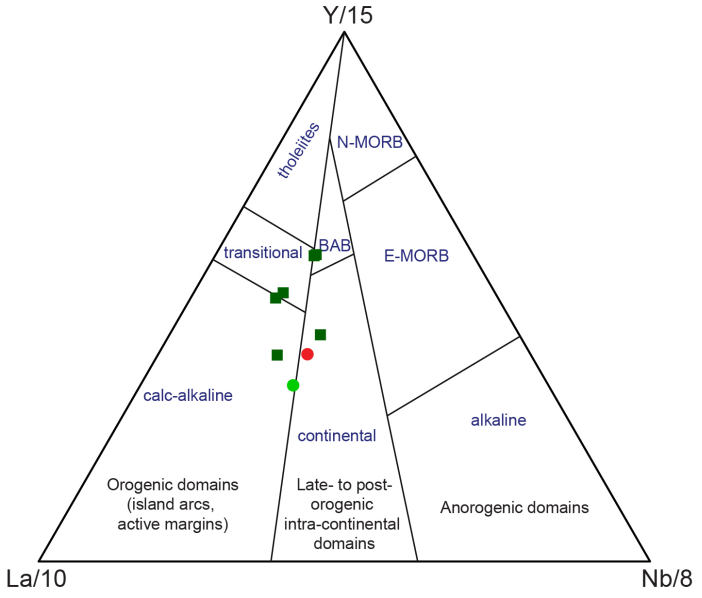
NDI samples display more enriched REE relative to regional samples; however, have similar isotopic compositions

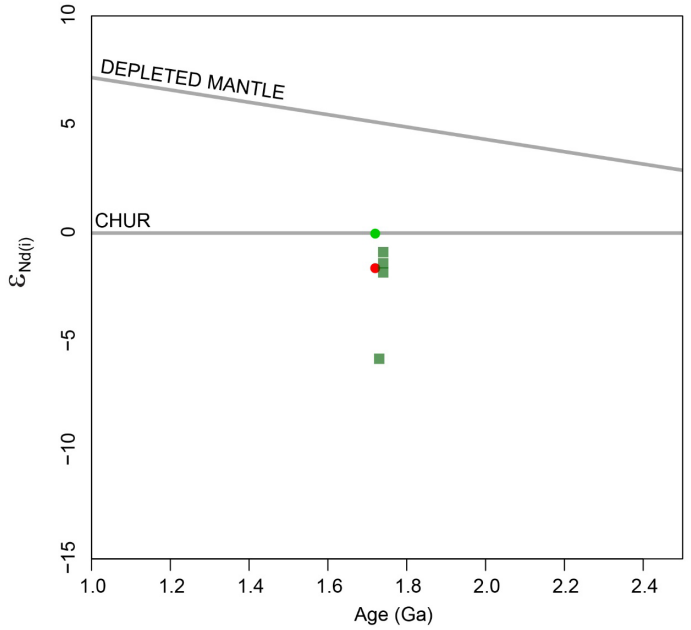
Suggest (heterogeneous) enriched juvenile mantle source

Possible rift basin – back-arc basin







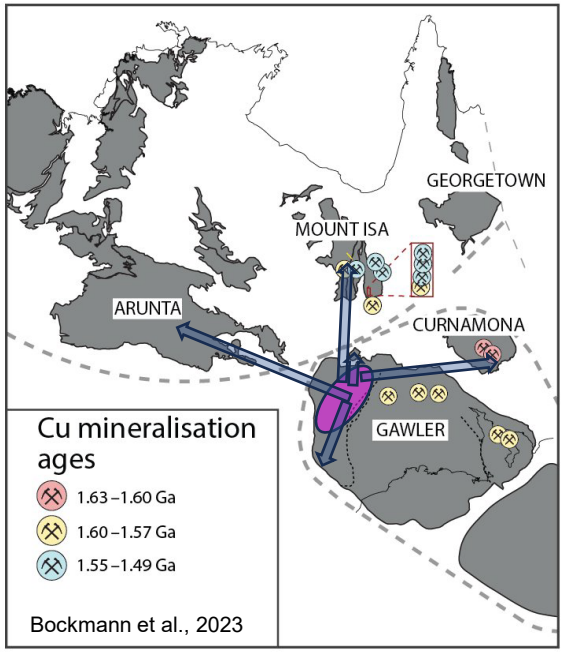


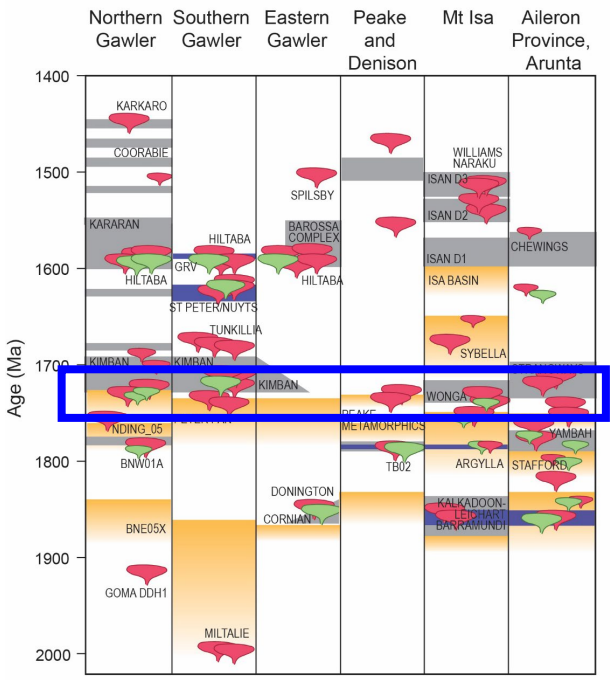
1740–1720 Ma

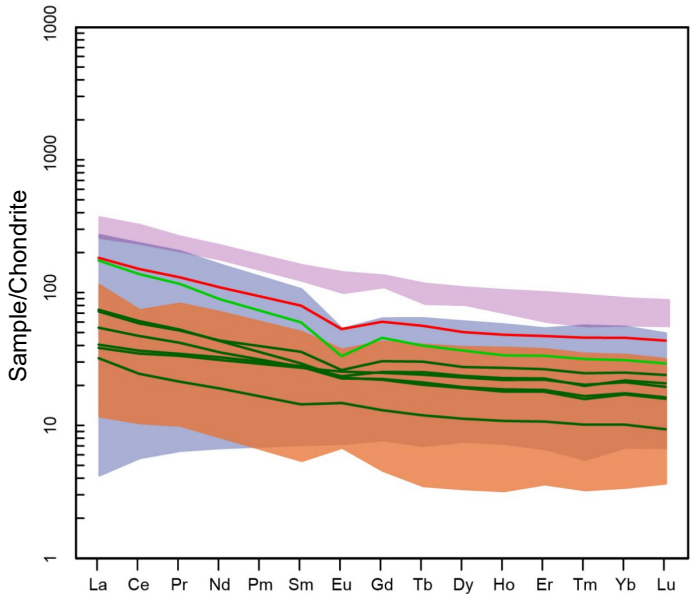
Share geochemical and isotopic affinity to temporal mafic rocks in Willyama Supergroup, Mt Isa and Aileron Province

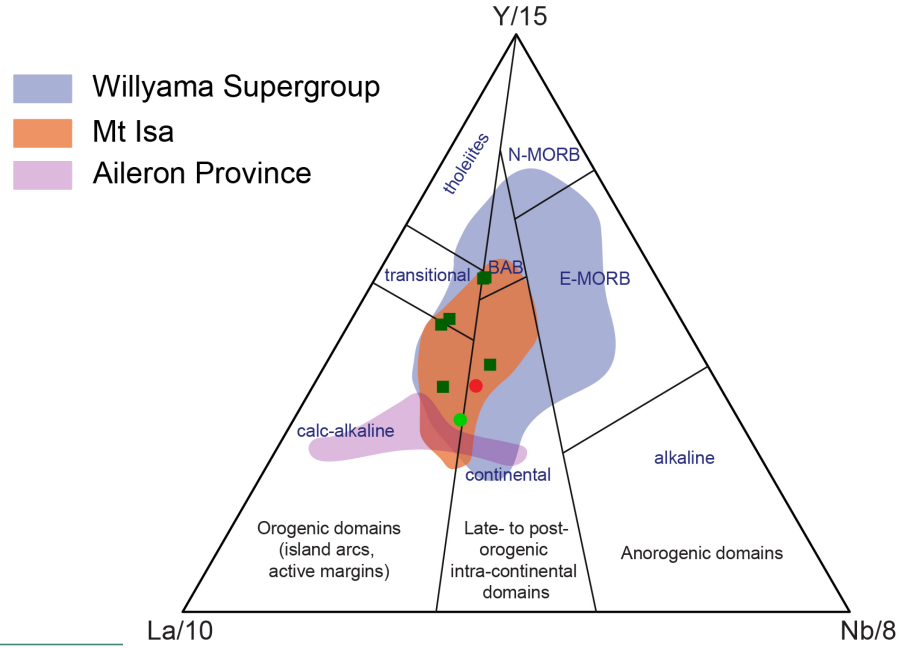
Wonga Batholith (1750–1735 Ma) extensional event

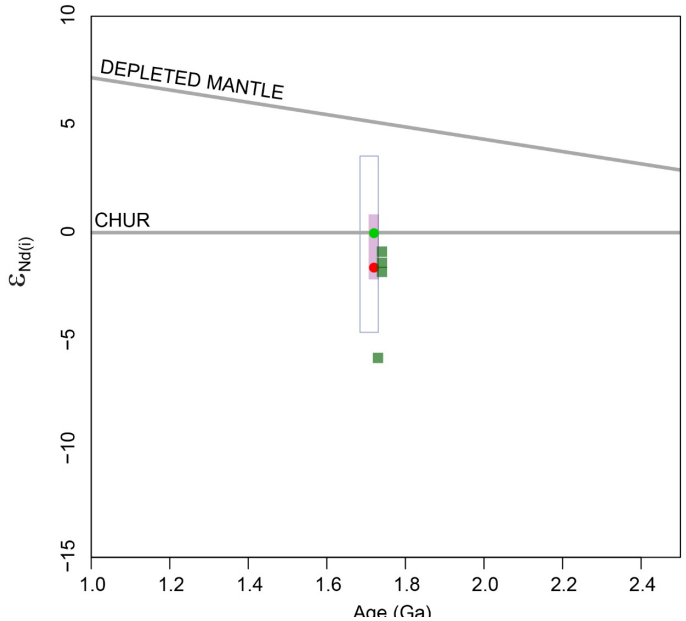
Willyama Supergroup (1720–1680 Ma) – back-arc basin











1740–1720 Ma mafic rocks

1740–1720 Ma

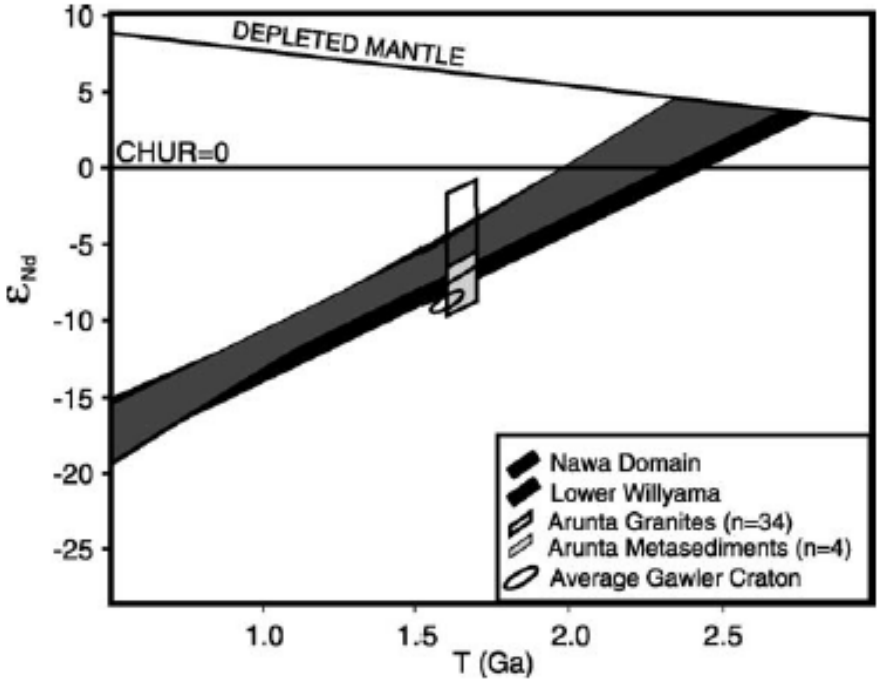
Provenance correlations drawn between the Nawa Domain metasedimentary rocks, lower part of the Willyama Supergroup and Mount Isa region suggest contiguity of these crustal terranes during the late Palaeoproterozoic

Share similar sequence of events to Willyama Supergroup and Mount Isa:

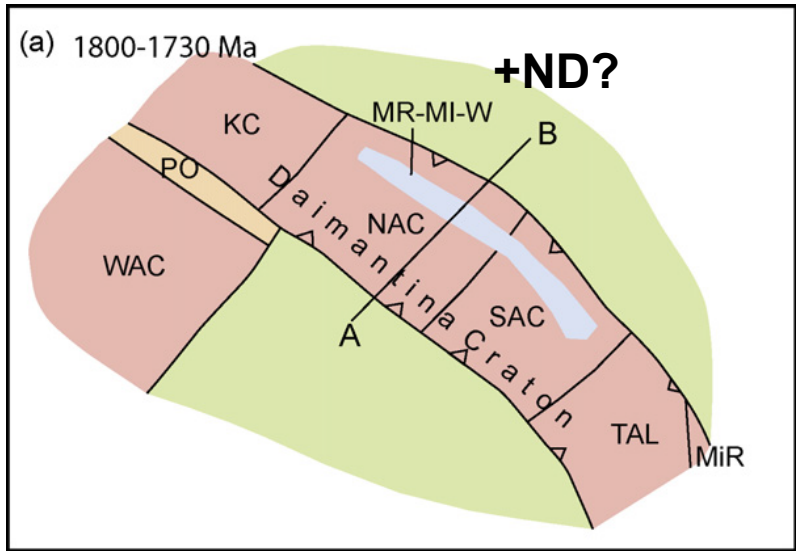
- Extensional basins later intruded by bimodal magmatism
- Following intrusion, the rocks experienced significant deformation (ductile deformation and mylonitisation)

Form part of the larger orogenic cycle in NAC during the Palaeoproterozoic

Suggest the setting was largely a back-arc



ε_{Nd} evolution diagram for metasedimentary rocks from Nawa Domain, Willyama Supergroup and Arunta region (Payne et al., 2006 https://doi.org/10.1016/j.precamres.2006.05.002)



Schematic plan view of Palaeoproroterozoic Australia, highlighting long-lived subduction zones along its NE and SW margins resulting in a largely back-arc environment. MR-MI-W: McArthur River-Mount Isa-Willyama, ND: Nawa Domain; Cawood and Korsch 2008: https://doi.org/10.1016/j.precamres.2008.08.006

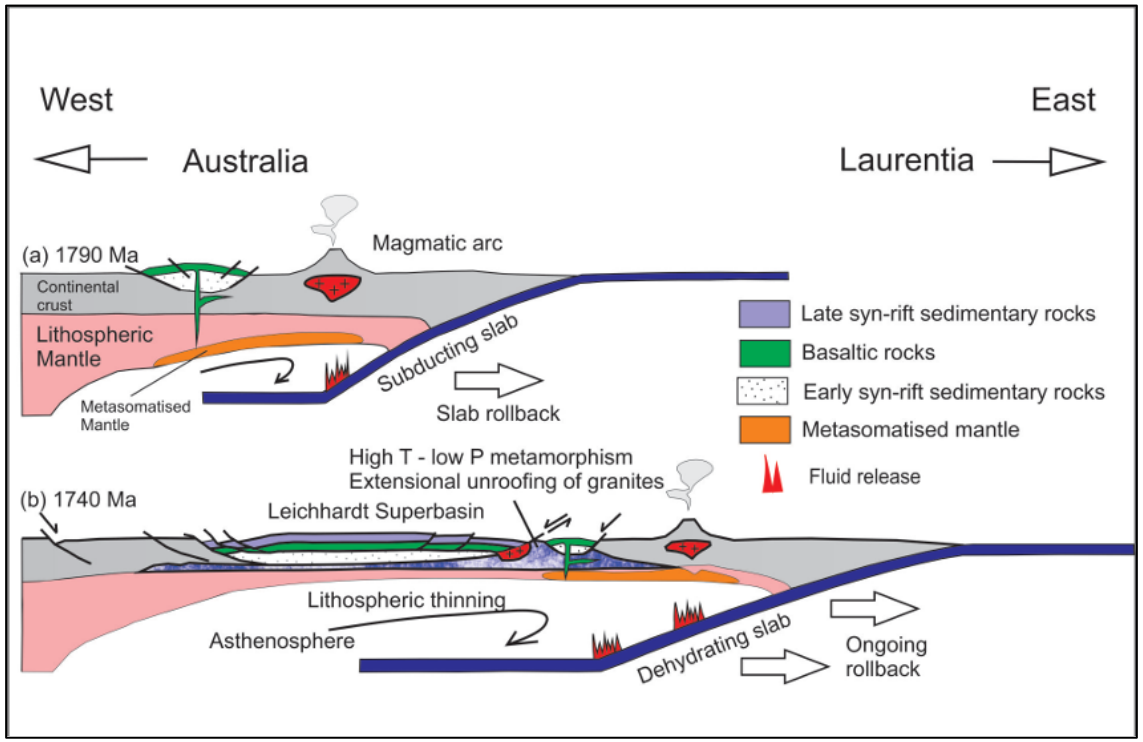
A few concluding remarks

Tectonic models for Palaeoproterozoic Australia include both subduction and extensional models

Evidence for aspects from both of these models are observed in the magmatic rocks (e.g. metasomatised lithospheric mantle suggests supports previous subduction and juvenile crustal and mantle sources support extension)

Magmatic rocks in these terranes point toward a largely back-arc basin setting during the late Palaeoproterozoic

Links with Northern Gawler Craton and Aileron Province and Mt Isa are observed from 1860–1740 Ma



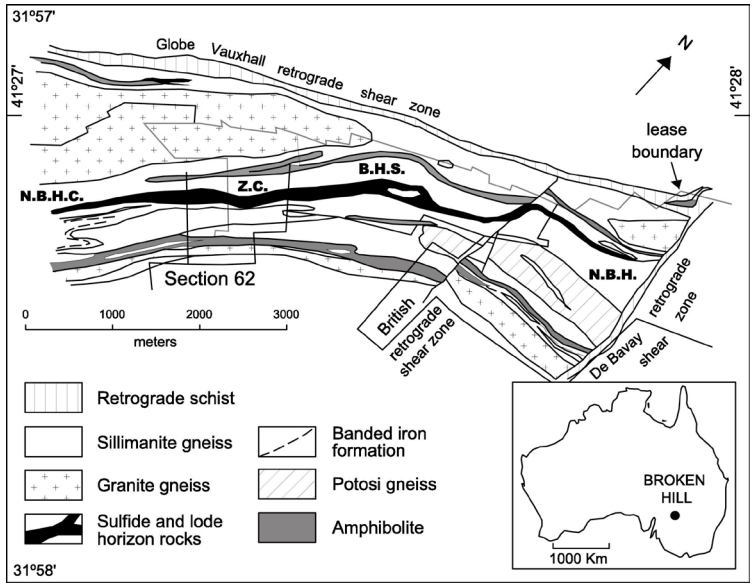
Basin evolution in northern Australia from 1800-1740 Ma. (a) Onset of extensional faulting and rift-related magmatism at 1790 Ma in a back-arc extensional setting. Subduction commenced ≥ 1840 Ma following separation of Laurentia from Australia; (b) Subduction rollback and lithospheric thinning are well advanced by the end of 1740 Ma; flat-slab subduction leads to reduced amounts of basaltic magmatism but rifting continues accompanied by extensional unroofing of earlier formed 1780 Ma granites and mid-crustal rocks. Higher heat flow promotes crustal thinning, doming and low pressure-high temperature metamorphism (Gibson et al., 2018 http://www.largeigneousprovinces.org/18aug)

A few concluding remarks

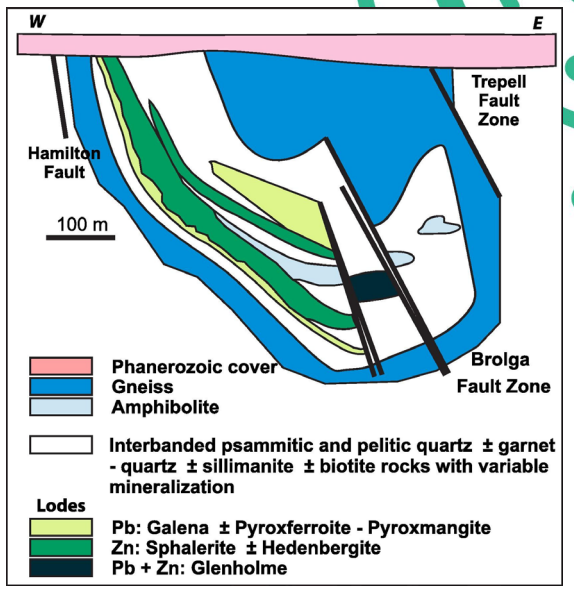
From 1740–1720 Ma correlations with Mt Isa and Willyama Supergroup are emerging

Implications for mineral potential (e.g. BHT or SEDEX base metal systems):

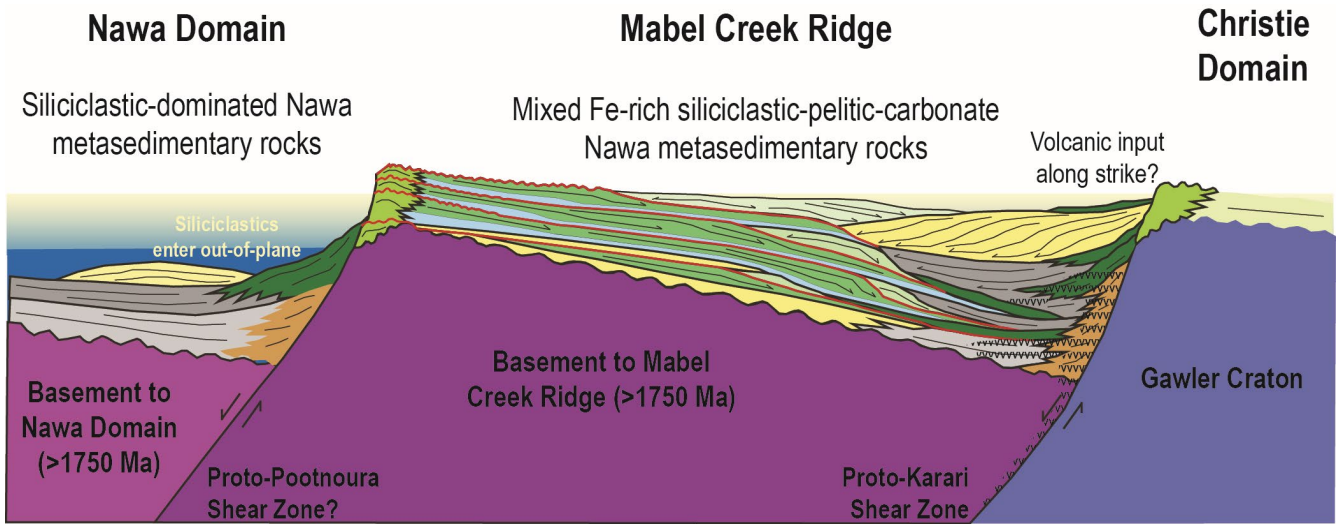
- Evidence for Palaeoproterozoic (rift) basin development and deformation with a long and high-gradient thermal history
- Bimodal magmatism, clastic metasedimentary rocks



Geological map of the Broken Hill Deposit, Spry and Teale (2021) https://doi.org/10.1016/j.oregeorev.2020.103935



Generalized cross section of the Southern zone (4700 mN) of the Cannington deposit showing the disposition of the lodes, Spry and Teale (2021) https://doi.org/10.1016/j.oregeorev.2020.103935



Cartoon cross section of the Nawa Domain and Mabel Creek Ridge ca. 1750–1740 Ma showing the potential basin and structural architecture of the Northern Gawler Craton, modified from Dorobek (2008): https://doi.org/10.2110/pec.08.89.0057

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SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Regional Implications and mineral prospectivity

Northern Gawler NDI

Tom Wise & NDI team | 09/12/2025

(some slides from Claire, Jack, Mitch & Baohong)

energymining.sa.gov.au

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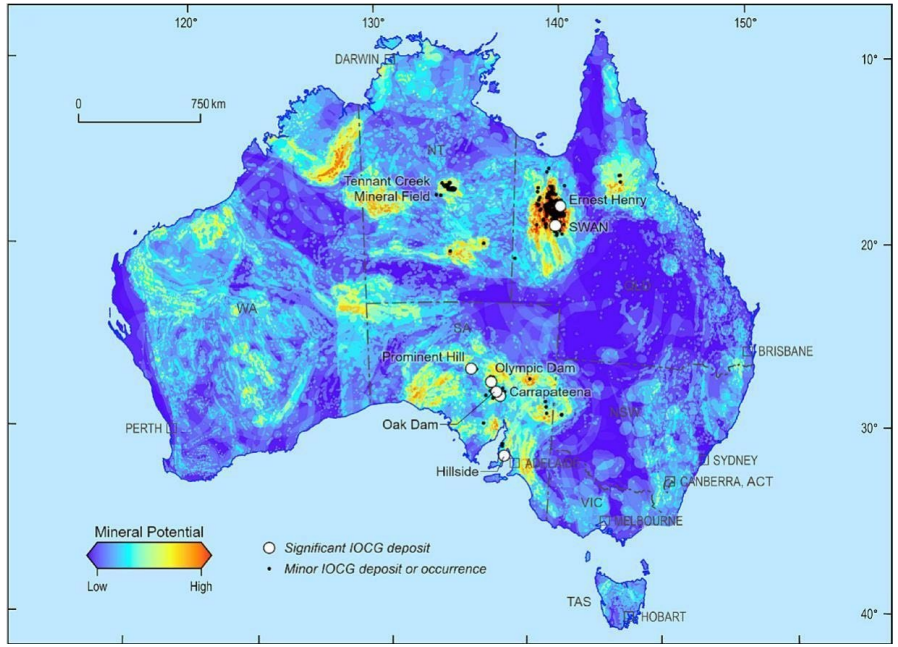
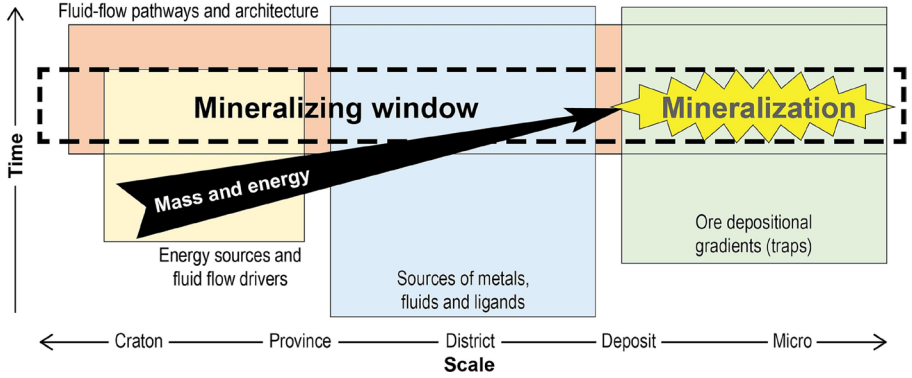
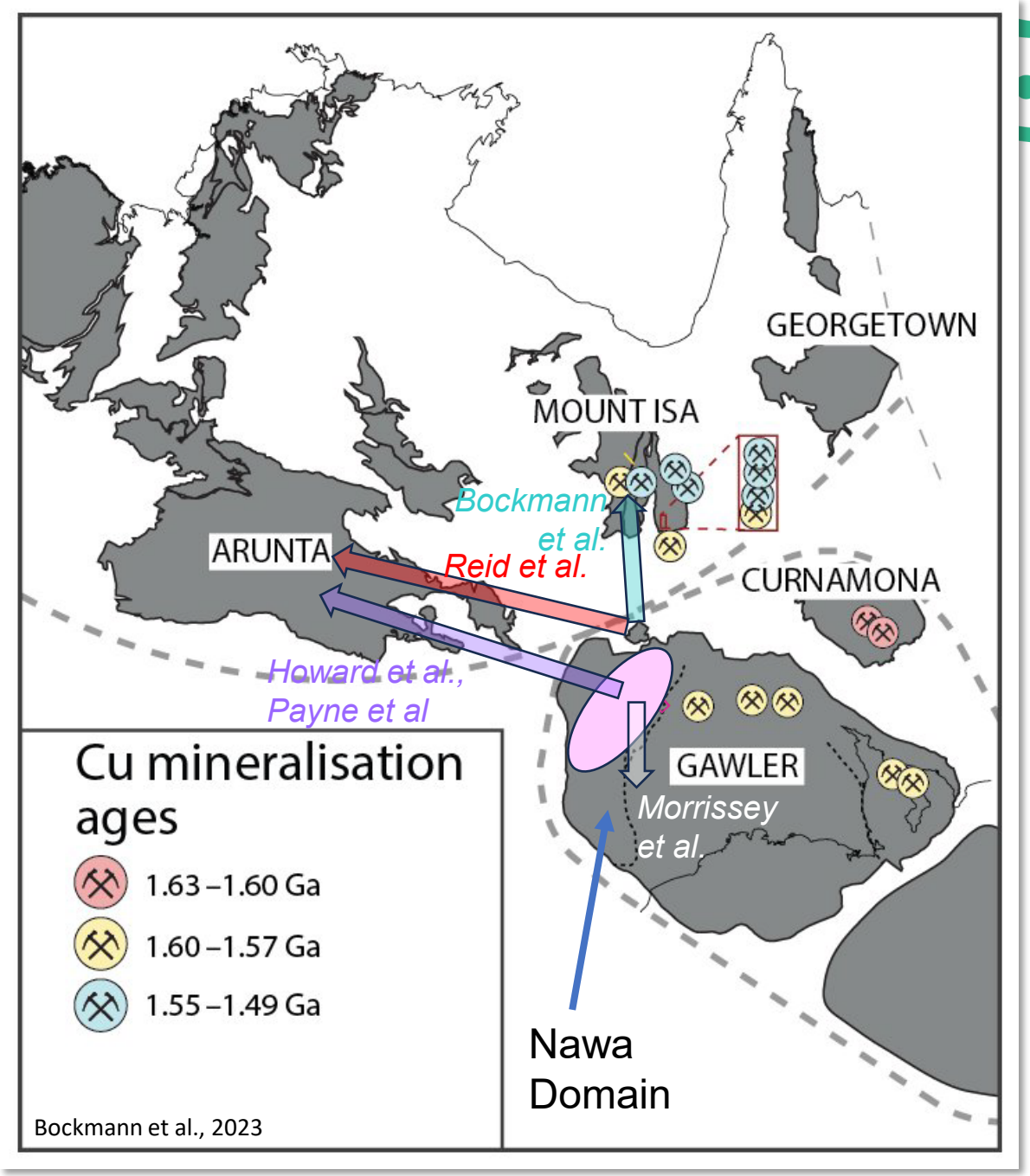
Mapping what, where and when.



Cloutier et al., 2025

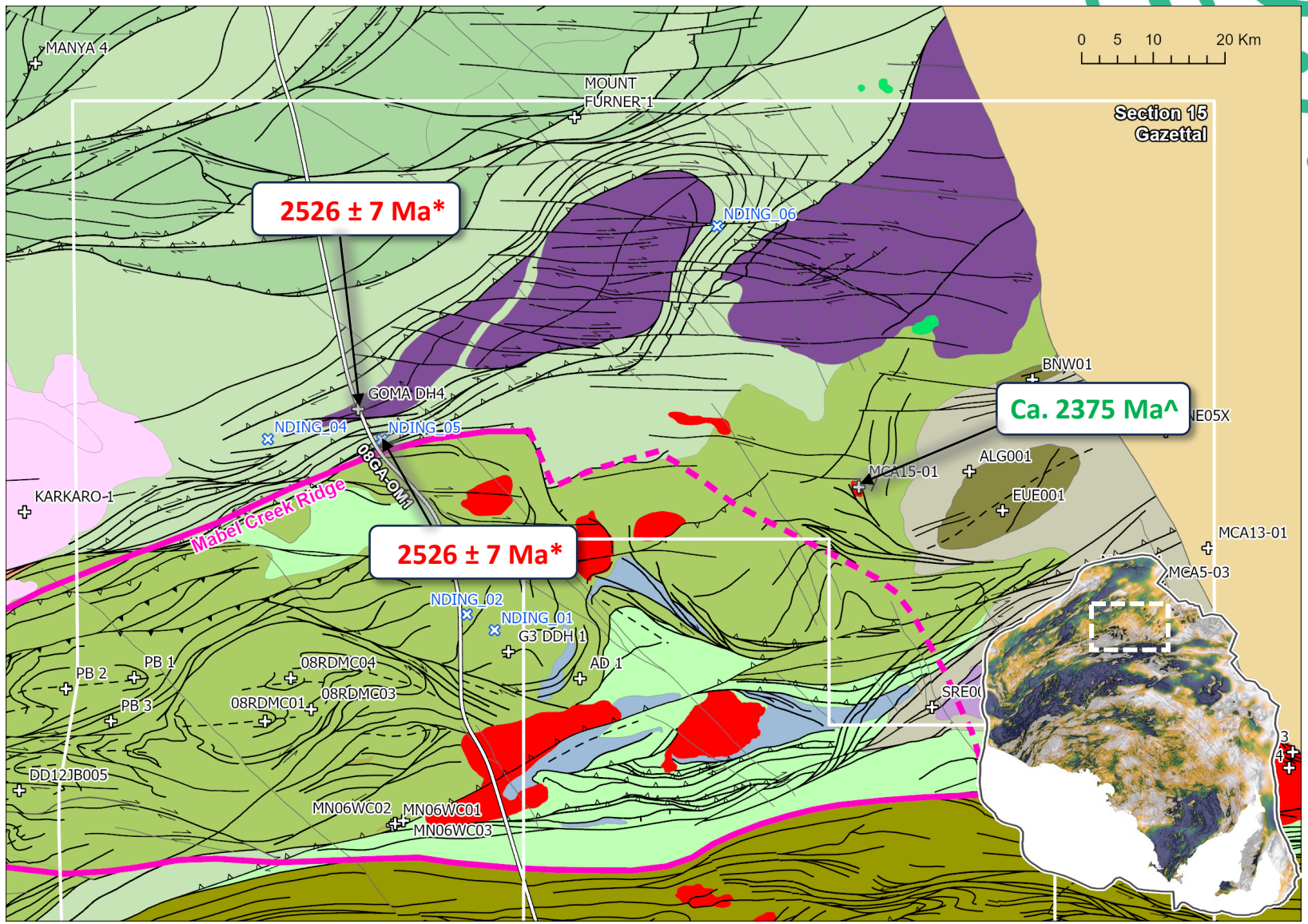




Bockmann et al., 2023

Archean Basement

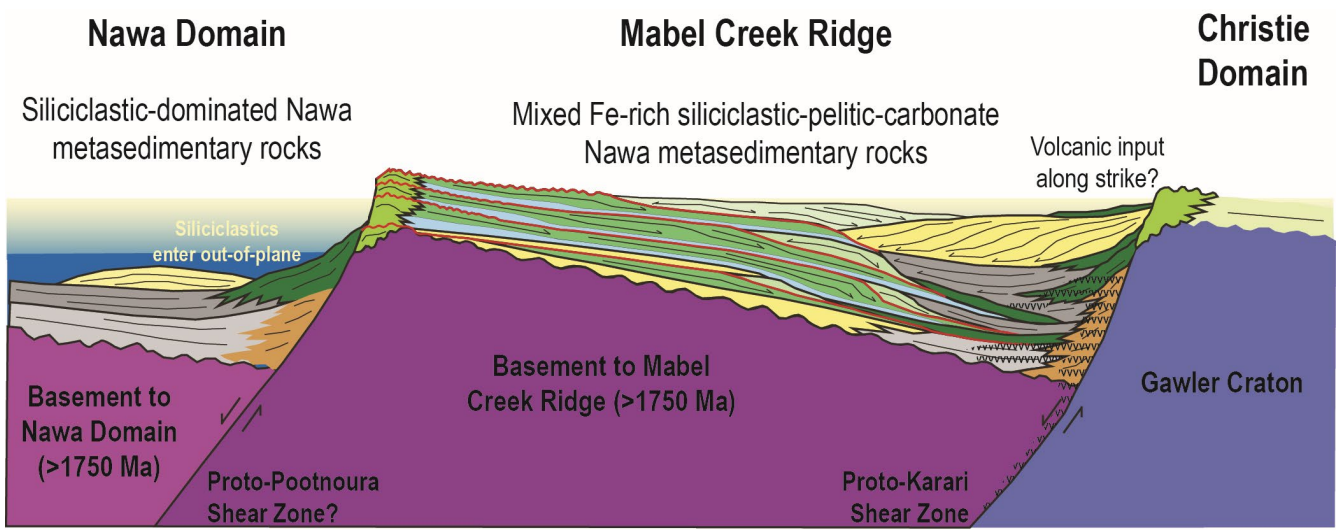
- The extent of Archean basement rocks is poorly constrained – dating from drillhole GOMA DH4 and extrapolations from aeromagnetics
- New data indicates Archean metasedimentary rocks between MCR and P&D
- Requires re-interpretation of basement geology
- Overlain by c. 1780 Ma Peake and Denison Domain, c. 1750-1740 Ma Nawa metasedimentary rocks



- * Reid et al., 2014
- ^ Brown, pers. comm.

Palaeoproterozoic syn-epigenetic mineralisation?

Potential for Broken Hill Type (BHT) systems in Nawa metasedimentary rocks. Coober Pedy/Mabel Creek ridges considered most prospective.



Cartoon cross section of the Nawa Domain and Mabel Creek Ridge ca. 1750–1740 Ma showing the potential basin and structural architecture of the Northern Gawler Craton, modified from Dorobek (2008): https://doi.org/10.2110/pec.08.89.0057

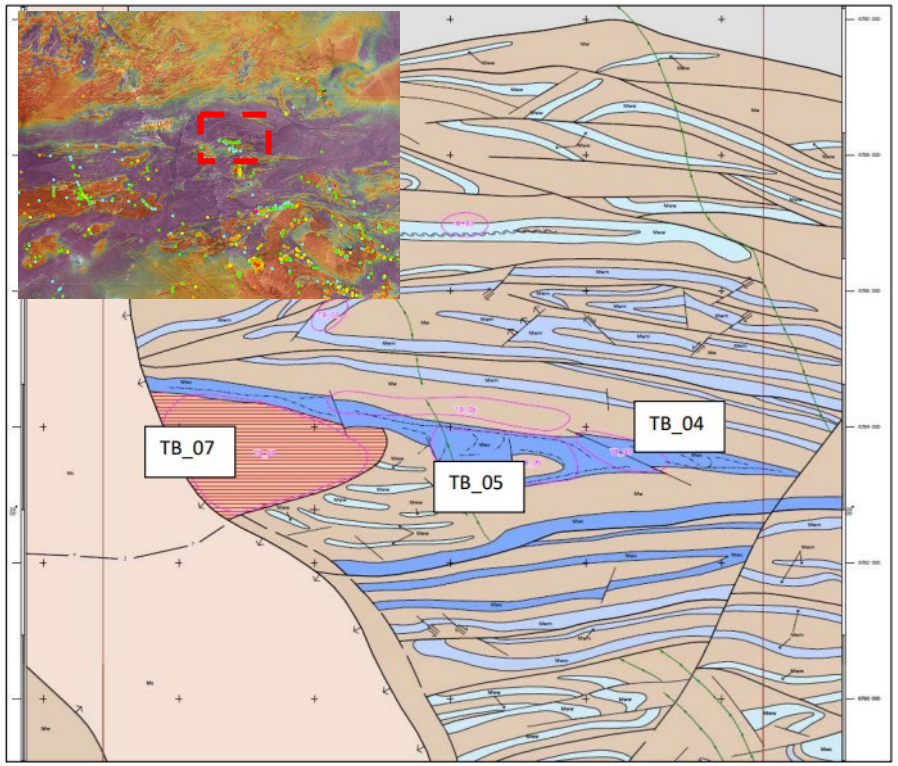


Fig 11: Dingo Prospect showing location of targets TB_04, TB_05 and TB_07

4.2 Dingo Copper Prospect (BHP anomaly #7)

The Dingo Prospect lies about 10 km north of the Mount Brady Prospect and 25 km ESE of Coober Pedy. The prospect lies on a linear, moderately strong magnetic anomaly possibly associated with the Horse Camp Fault – interpreted to be a south-dipping antithetic splay that defines the northern margin of the Coober Pedy Domain.

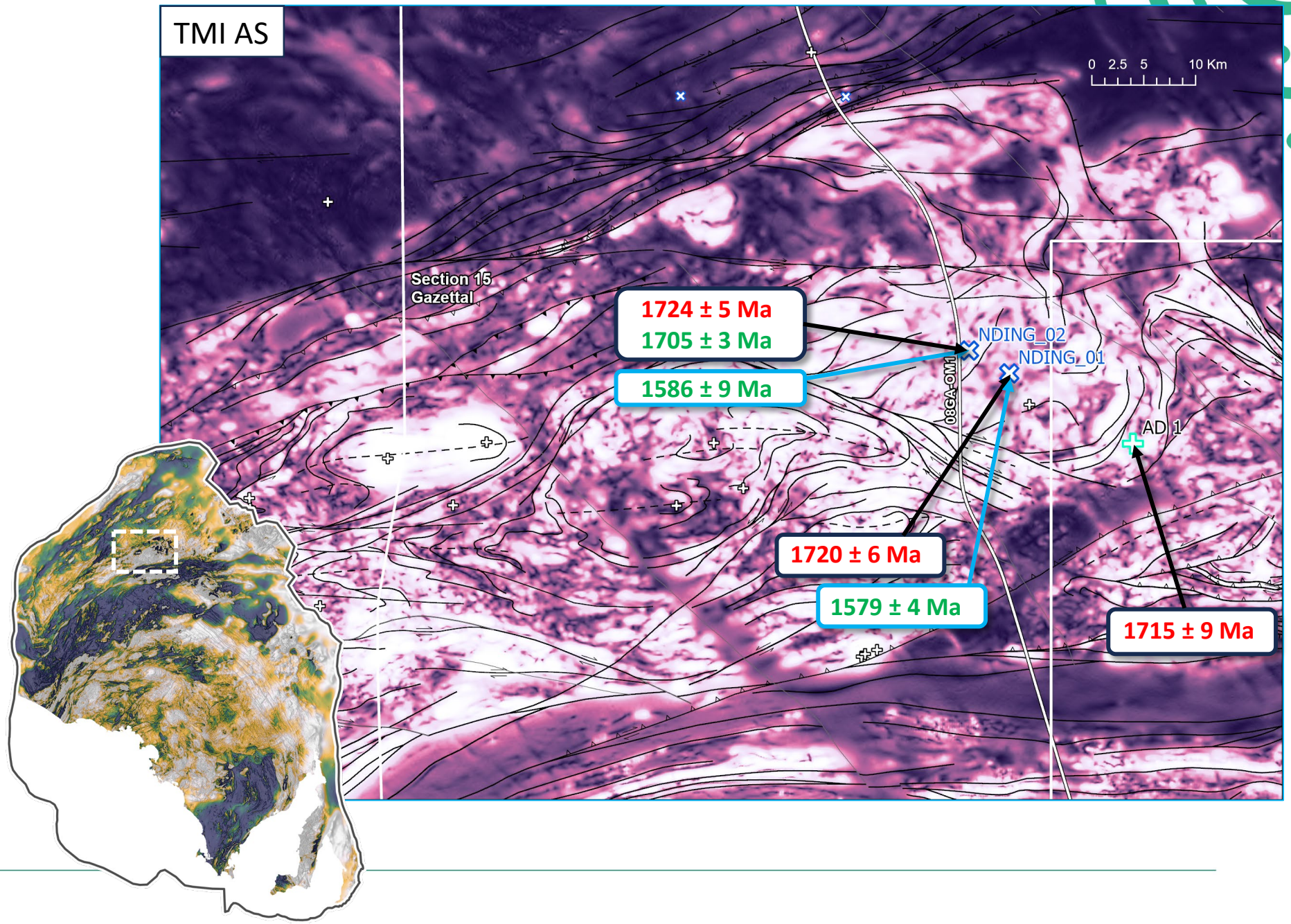
BHP explored the prospect from 1991-1993, having classified the prospect as 'Economically Interesting'. Work included ground mag and gravity surveys, a 61-hole aircore program designed to penetrate the 60-70 deep overburden and to sample weathered bedrock, and a limited RC and diamond drilling program (Fig 10).

The drilling showed that gravity high coincided with a basement high, but that the mag feature was due to 'magnetite-garnet-quartzite'.

SEM probing of garnets detected Mn-rich almandine, and probing of a spinel detected a composition intermediate between Fe-rich hercynite and Zn-rich gahnite. The presence of almandine and zincian hercynite was considered significant, and suggested the possibility of Broken Hill style mineralisation.

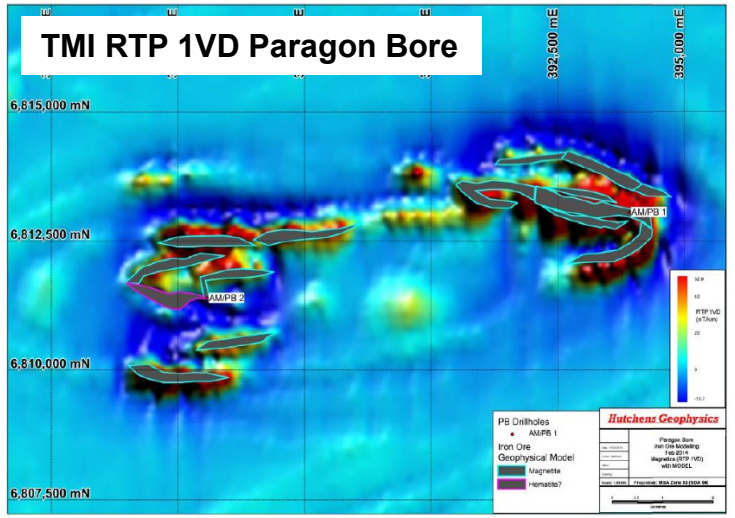
Mabel Creek Ridge

- Extensive Olarian-aged granulite-facies metamorphism and deformation in the western half of the MCR
- Opportunities to upgrade mineralisation e.g. BH?
- Hiltaba Suite magmatism is present. Deeper parts of IOCG systems preserved?



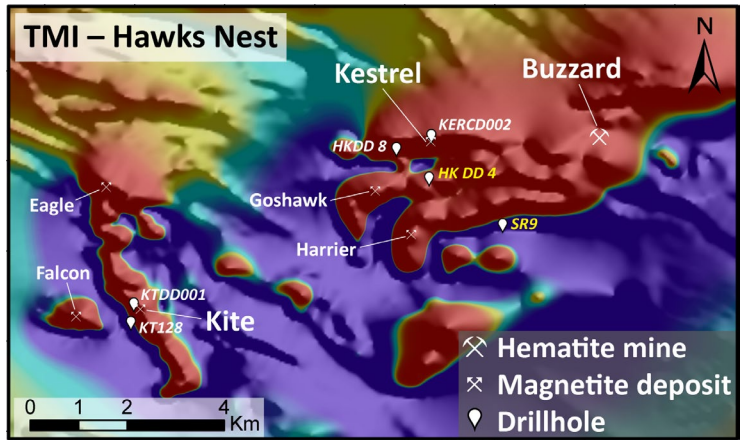
Hawks Nest -?- Paragon Bore

Hawks Nest is a group of hematite and magnetite deposits with magnetite BIF head grades around **35% Fe** and zones of **~60% Fe** (Kite deposit)

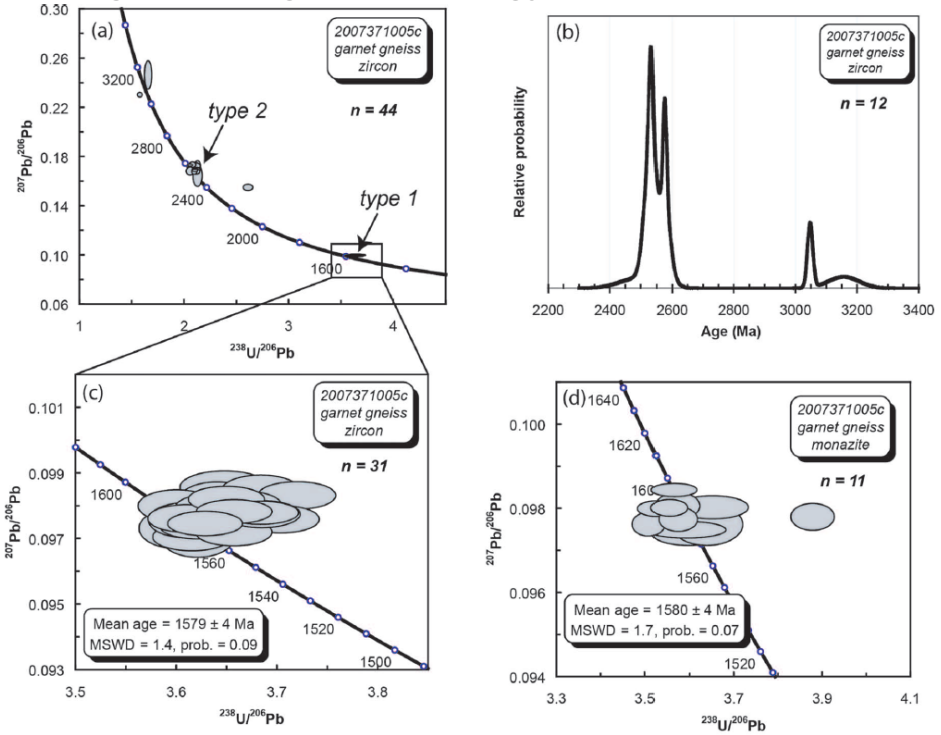


ENV13076

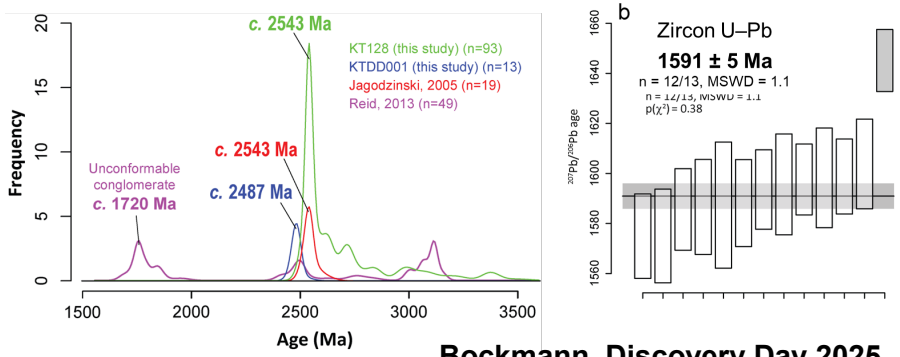
- 3.2 – 2.5 Ga zircon in Fe-rich metasedimentary package (latest Archean?).
- Overlain by 1740-1720 Ma sediments.
- Upgraded (?) during 1590-1580 Ma metamorphism



Paragon Bore geochronology (Fraser et al., 2012)

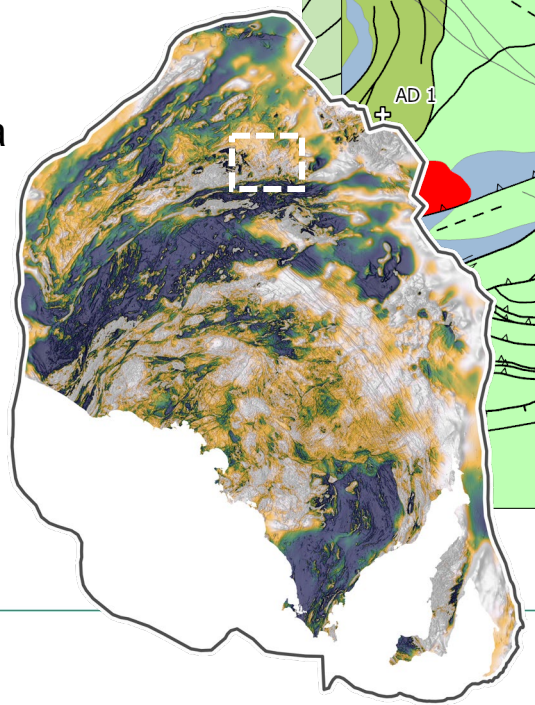


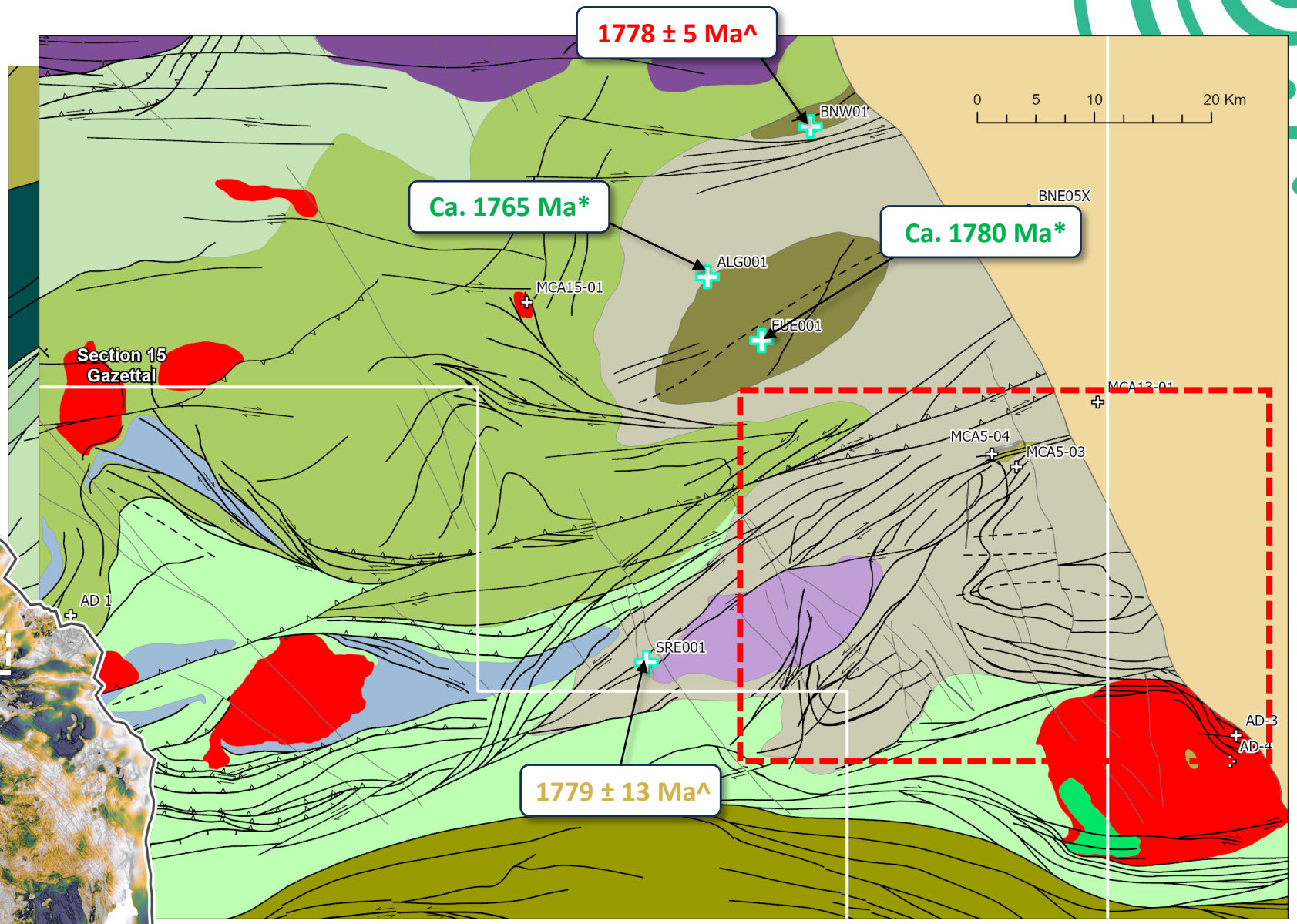
All zircons from metasediments at Hawks Nest



Peake and Denison Domain

- Peake metamorphics (ca. 1780 metasedimentary and metavolcanic rocks) have been interpreted to extend into the eastern Nawa Domain
- New **metamorphic**, **magmatic**, and **sedimentary** geochronological data support this interpretation:
  - **SRE001**
  - **BNW01A**
  - **ALG001**
  - **EUE001**

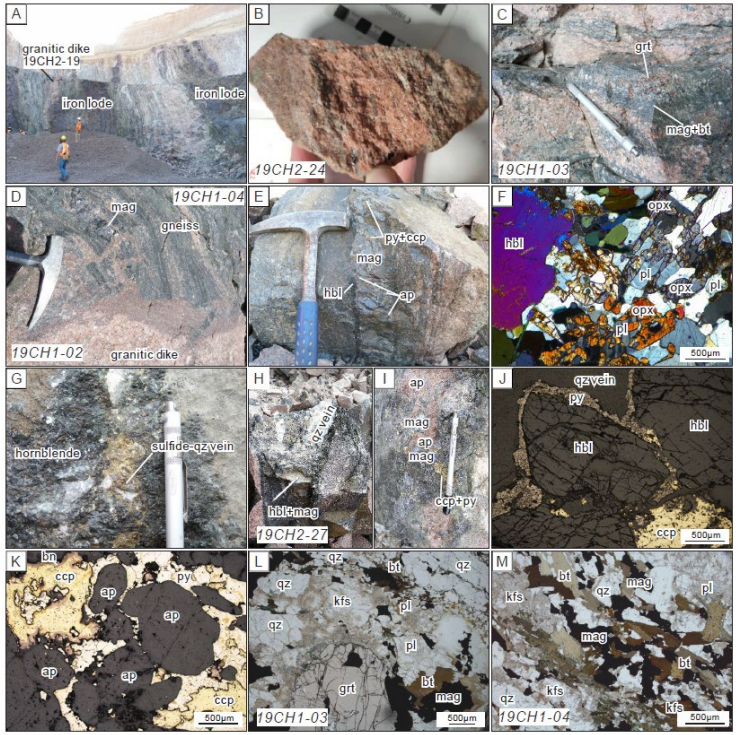




- * Morrissey, pers. comm.
- ^ Jagodzinski, in prep.

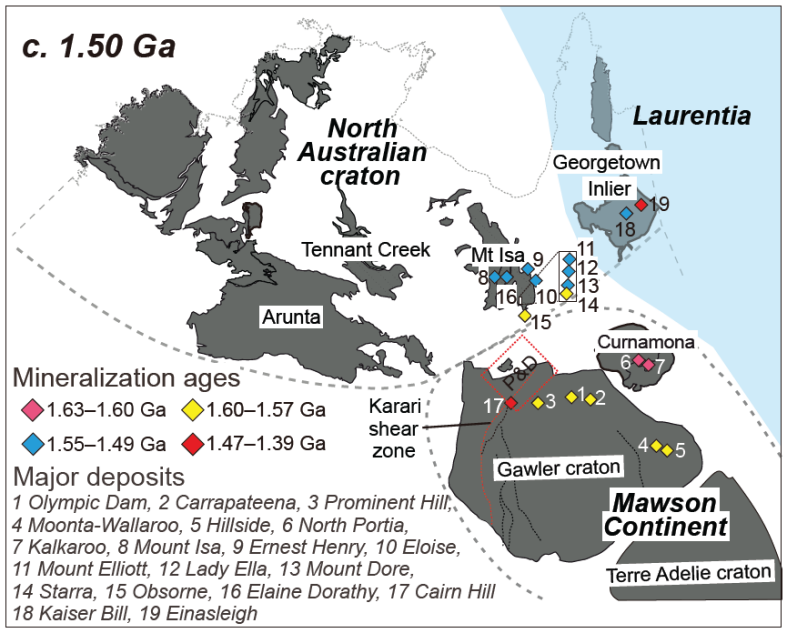
A building copper story…

- Copper mineralisation across the northern Gawler is different, younger, and an emerging opportunity

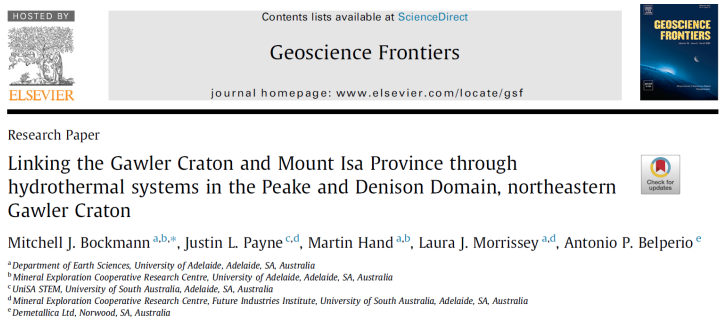


Yu et al., 2023

Post 1490 Ma Cu mineralisation at Cairn Hill



Yu et al., 2025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Contents lists available at ScienceDirect
Geoscience Frontiers
journal homepage: www.elsevier.com/locate/gsf

Research Paper

Linking the Gawler Craton and Mount Isa Province through hydrothermal systems in the Peake and Denison Domain, northeastern Gawler Craton

Mitchell J. Bockmann [a,b,*], Justin L. Payne [c,d], Martin Hand [a,b], Laura J. Morrissey [a,d], Antonio P. Belperio [e]

[a] Department of Earth Sciences, University of Adelaide, Adelaide, SA, Australia
[b] Mineral Exploration Cooperative Research Centre, University of Adelaide, Adelaide, SA, Australia
[c] UniSA STEM, University of South Australia, Adelaide, SA, Australia
[d] Mineral Exploration Cooperative Research Centre, Future Industries Institute, University of South Australia, Adelaide, SA, Australia
[e] Demetallica Ltd, Norwood, SA, Australia

1530-1465 Ma Cu mineralisation & hydrothermal systems in the Peake and Denison Domain

Yu et al., 2025

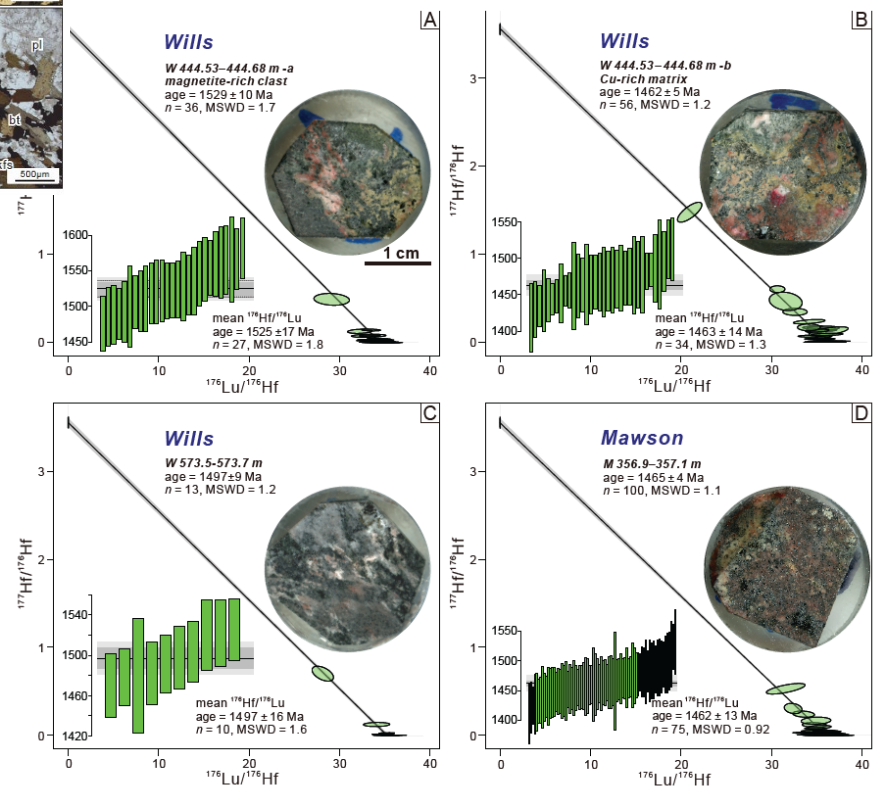
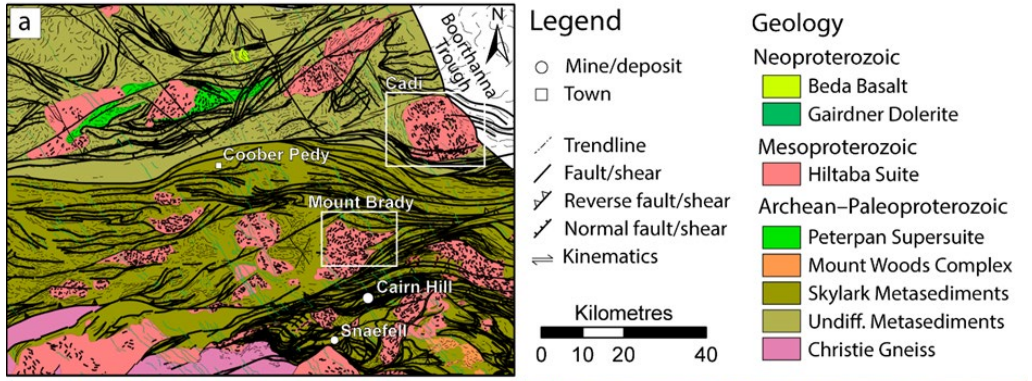
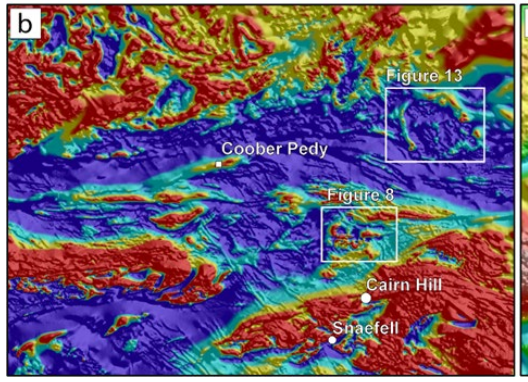
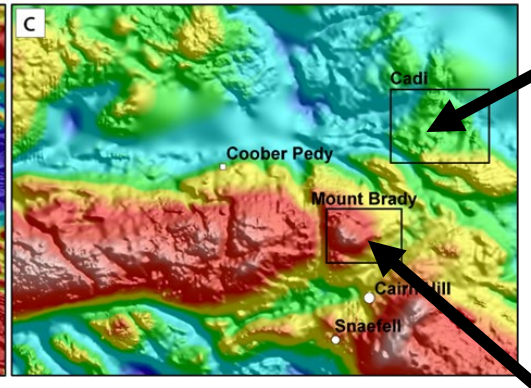


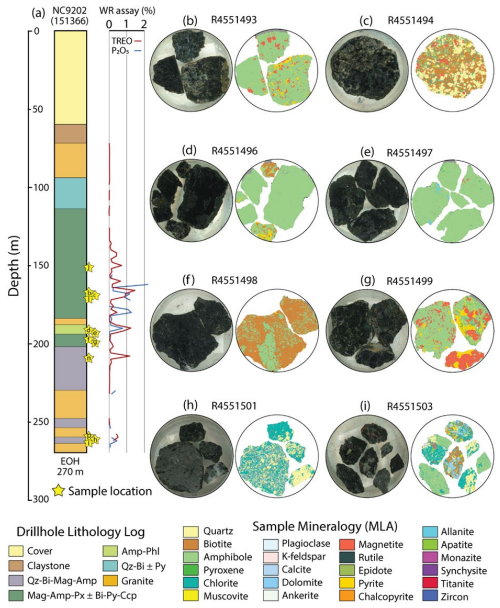
Fig. 11. Apatite Lu-Hf inverse isochron ages and weighted mean $^{176}Hf/^{176}Lu$ ages for samples (A) magnetite-rich clast in W 444.53–444.68 m, (B) Cu-rich matrix in W 444.53–444.68 m, (C) W 573.5–573.7 m, and (D) M 356.9–357.1 m. MSWD = mean square of weighted deviates.

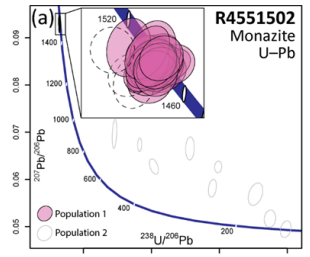
Regional metasomatic/ hydrothermal systems

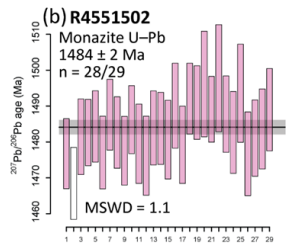


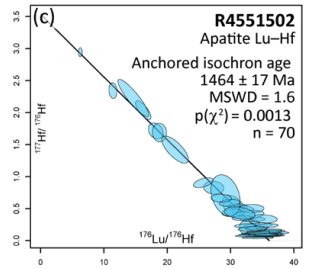






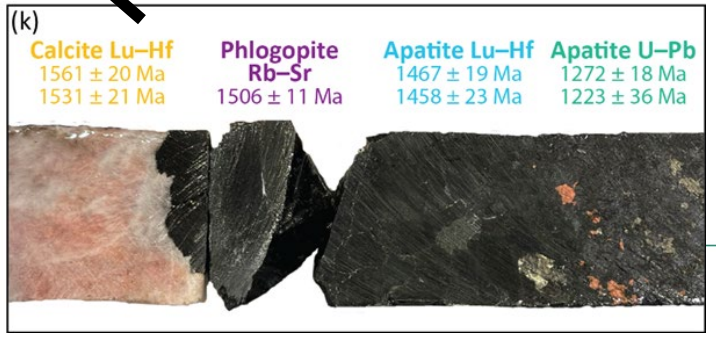


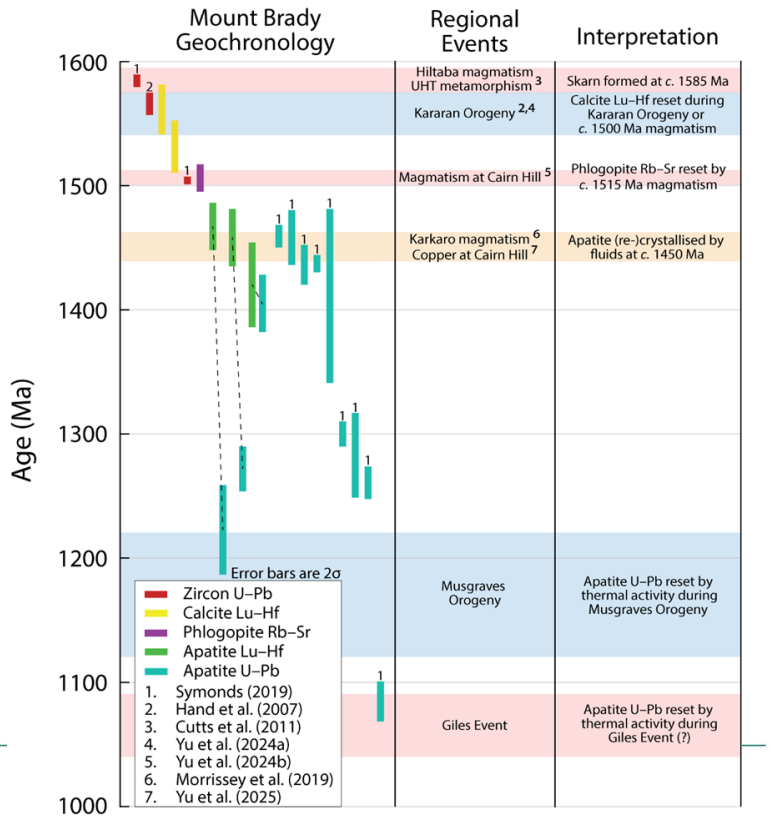




Cadi

Mount Brady

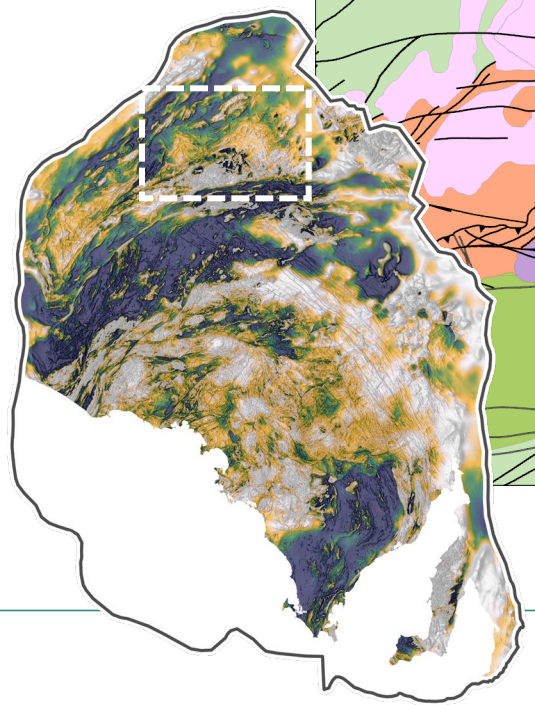


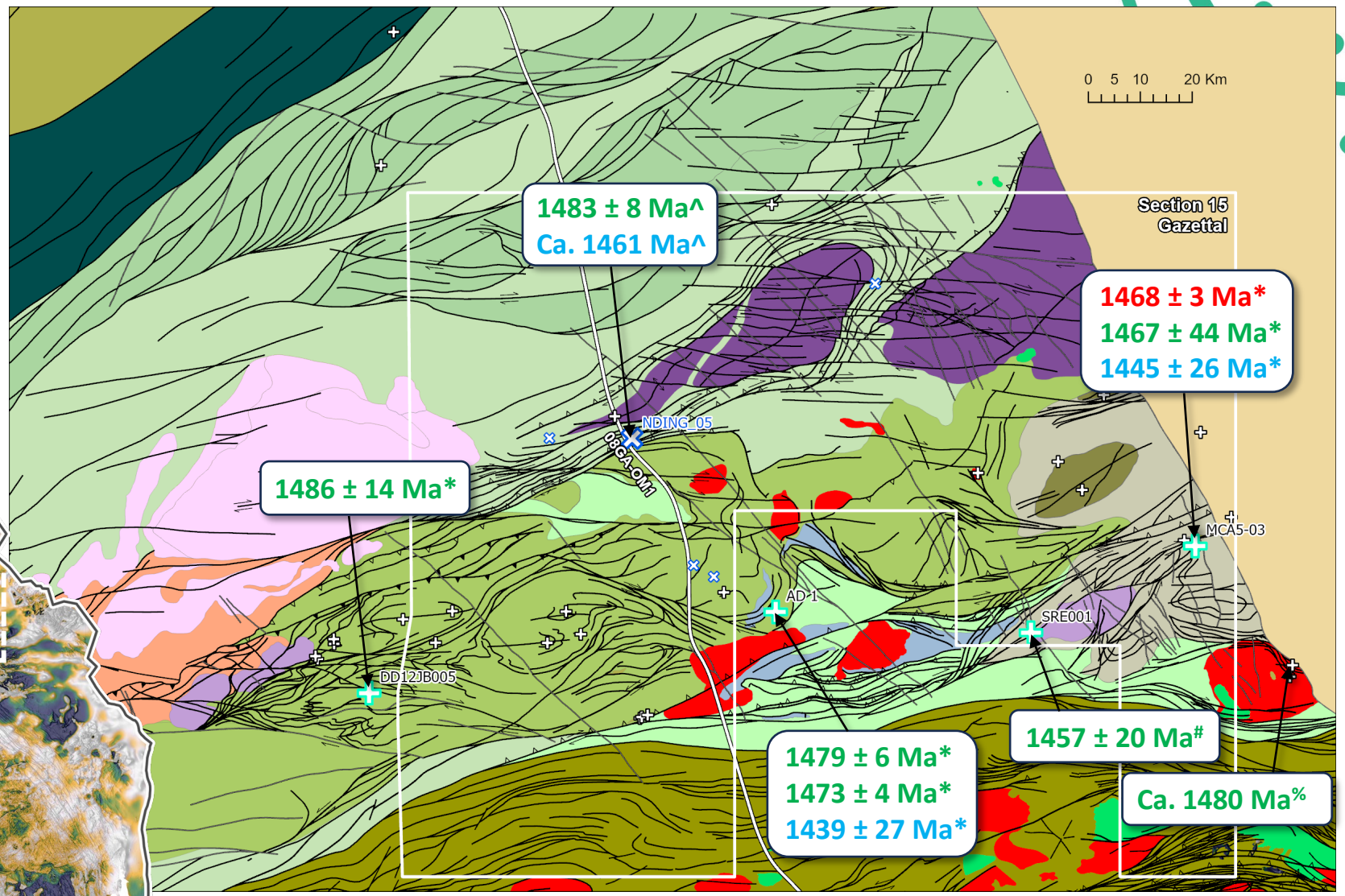


In press, Bockmann et al., report book.

Coorabie Event

- More evidence for widespread **deformation/metamorphism**, **magmatism**, and **(hydro)thermal activity** during the Coorabie Event between ca. 1480 – 1450 Ma
  - **NDING_05**
  - **DD12JB005**
  - **MCA5-03**
  - **SRE001**
  - **AD 1**





- * Brown et al., 2025
- ^ Brown, pers. comm.
- # Jagodzinski et al., in prep.
- % Morrissey et al., pers. comm.

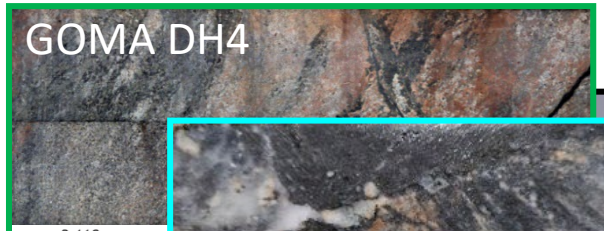
Pootnoura Creek Shear Zone

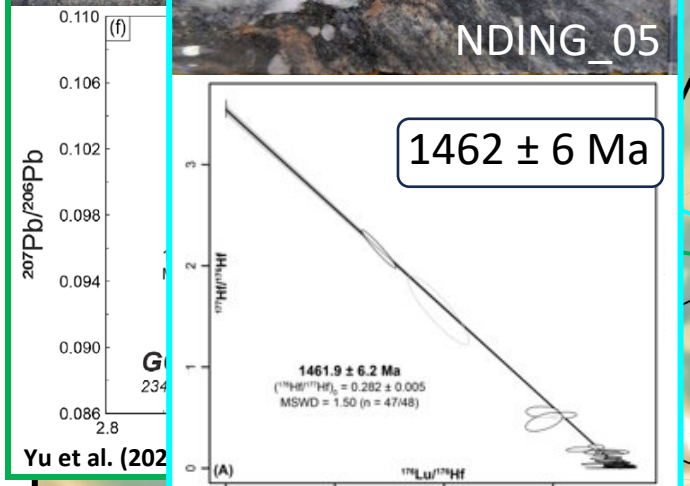
- Multiple generations of reactivated faults and shears
- Apparent dextral deflection of Nawa Domain fabric, and dextral shear bands within shear zone
- Apparent sinistral deflection of magnetic fabric in MCR

Metamorphism and deformation:

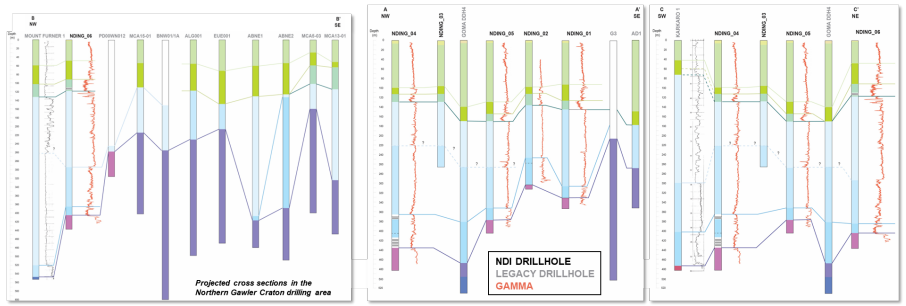
ca. 1520 – 1460 Ma

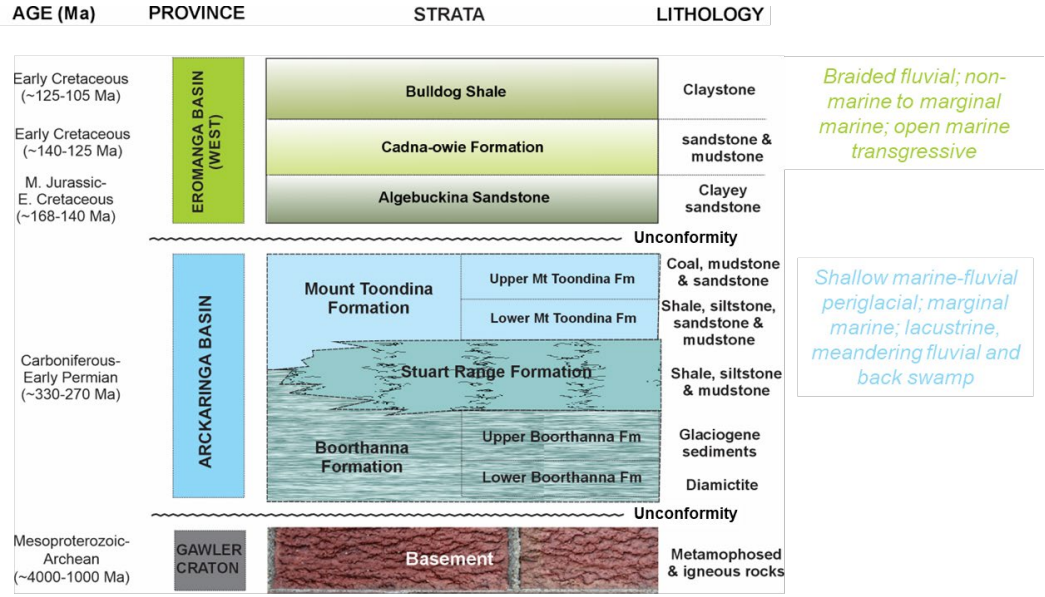
Coorabie Event (?)





Uranium, HMS, REE in cover sediments?





Strata relationships for Eromanga and Arckaringa basins, modified from Baohong Hou

HEAVY MINERAL SANDS TARGETS IDENTIFIED AT THE PEAKE PROJECT

Highlights

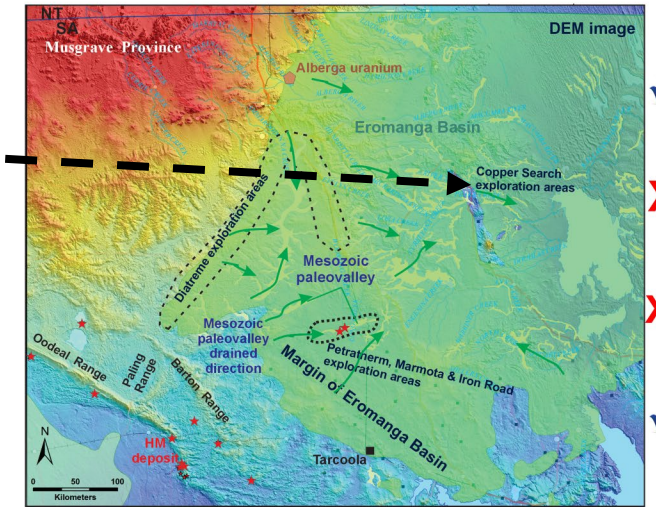
- **Promising HMS assemblage** of **high-value zircon** and **titanium minerals – rutile, ilmenite and leucoxene** identified in recent external review of the Peake Project, South Australia
- **The Eromanga Basin is known to host significant HMS discoveries, including recent finds by Petratherm (ASX: PTR) and Marmota (ASX: MEU), underscoring the region's strong HMS potential**
- **Assay[1] highlights of pan-concentrated grab samples include:**
  - **35% zircon, 20% Ilmenite, 20% leucoxene, 5% Rutile (CUSHM002)**
  - **25% zircon, 50% Ilmenite, 10% leucoxene, 5% Rutile (CUSHM001)**
  - **25% zircon, 55% Ilmenite, 5% leucoxene, 5% Rutile (CUSHM003)**
  - All with low amounts of "trash" minerals

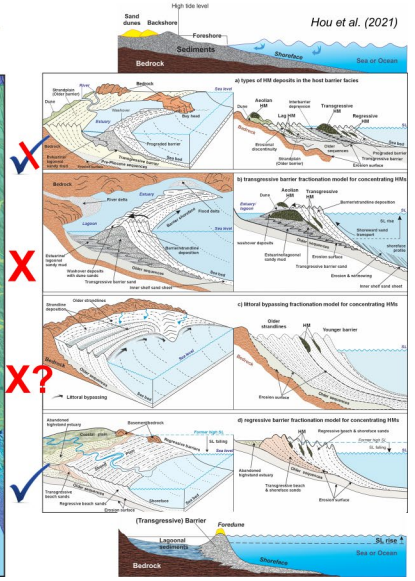
Terrain features suggest potential trap sites for heavy minerals along the outcropping Peake and Denison Ranges

- **The Peake Project area has an extensive thickness of HMS target horizons, host to heavy mineral sand deposits elsewhere**
- A second tenement area (in application) reveals promising magnetic signatures that may indicate ilmenite-rich strand lines—an exploration model proven in regions like the Murray Basin
- Appointment of minerals sands expert Ian Warland as Principal Consultant
- **Ian and his team discovered the world-class Jacinth - East Eucla HMS Deposits[2]** (depleted) **of 301Mt @ ~5.1% HM in South Australia and saw the project through to production for Iluka Resources (ASX: ILU)**
- **Titanium** is listed as a critical mineral by the U.S. and EU for its key role in aerospace, defence, and medical sectors—vital for security, supply chains, and tech independence

Altitude Minerals, July 1 ASX *Page 1*

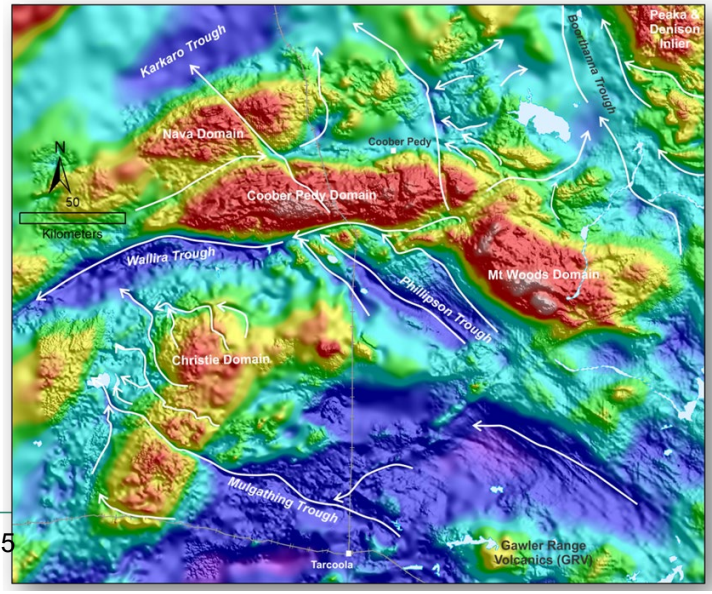
Mesozoic HMS-Uranium-groundwater





Paleozoic paleovalleys transport direction in Arckaringa Basin

Alley et al. (in press)



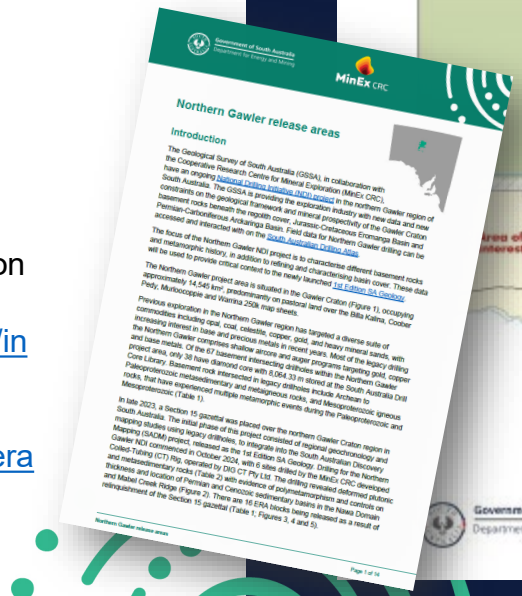
Baohong Hou, Discovery Day 2025

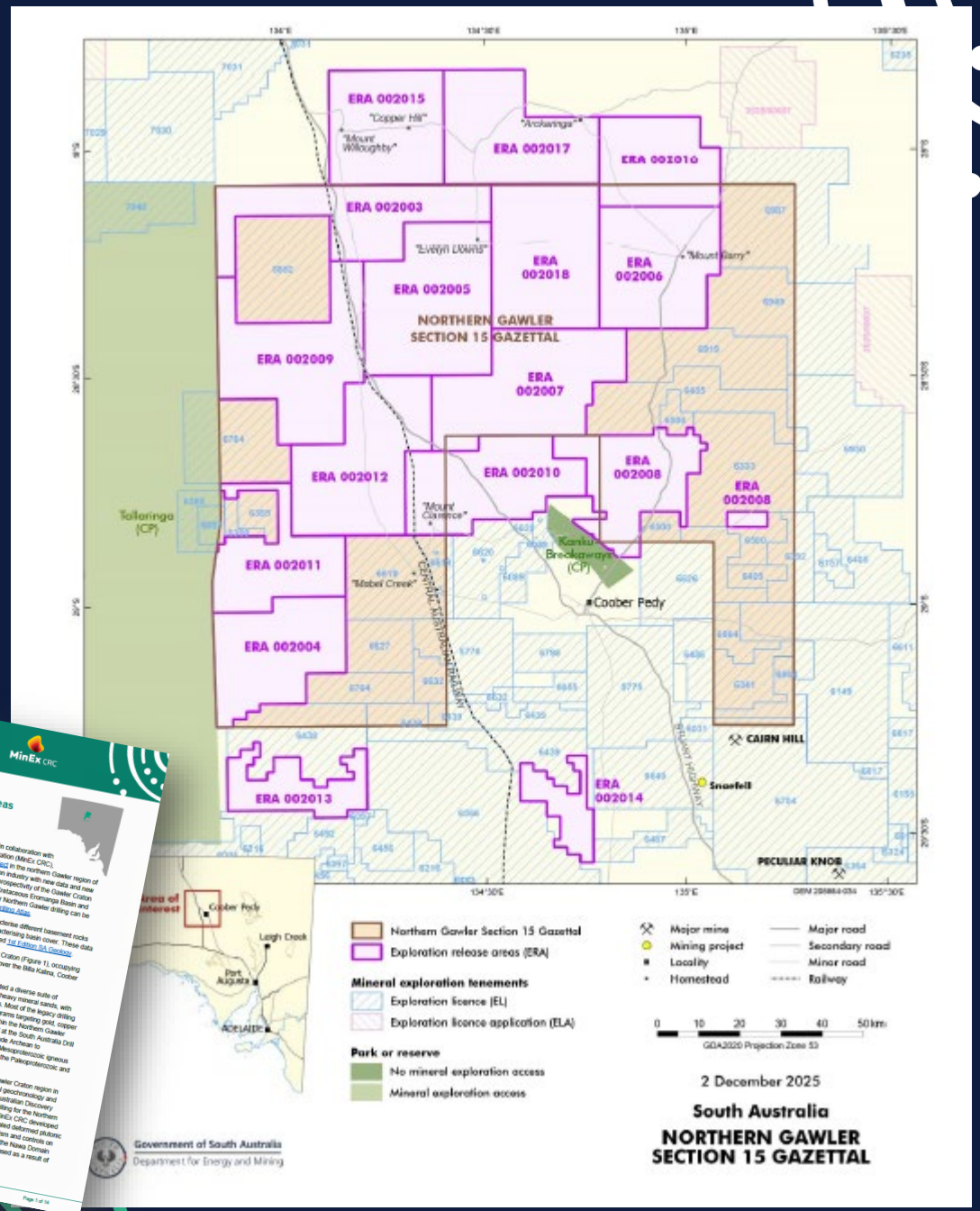
Exploration Release Areas

Sixteen exploration release areas (ERAs) across the northern Gawler Craton are now available for viewing, with competitive application **opening 9 February 2026** and **closing 27 February 2026**.

These blocks are offering new opportunities for mineral exploration in South Australia, informed by fresh geological insights from the National Drilling Initiative and supported by data available through SARIG(external site) and the 1st Edition South Australian Geology(external site), and the National Drilling Atlas.

Fact sheet & ERA process information here: https://www.energymining.sa.gov.au/industry/minerals-and-mining/exploration/public-notices/exploration_release_areas_eras





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Department for Energy and Mining

Contacts

Tom Wise, Manager – Regional Geoscience

Geological Survey of South Australia

Department for Energy and Mining

11 Waymouth Street,
Adelaide, South Australia 5000
GPO Box 320
Adelaide, South Australia 5001
E: Tom.Wise@sa.gov.au

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MinEx CRC

Mining Exploration and Regulation System (MERS) Update – Exploration Release Areas

Northern Gawler NDI workshop

9 Dec 2025, SA Drill Core Library

Bronwen Lee, Minerals Regulation

energymining.sa.gov.au

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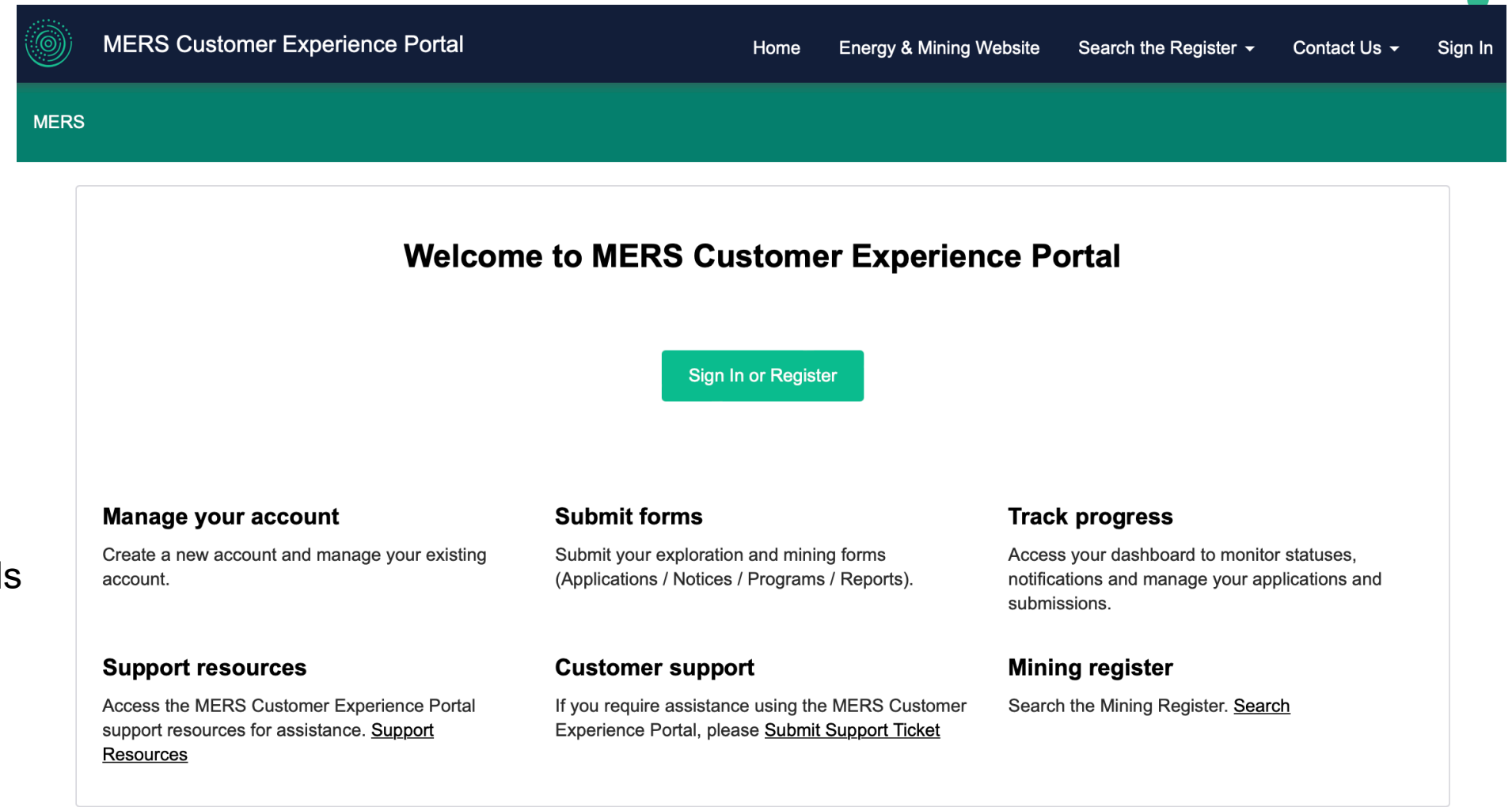
Mining Exploration and Regulation System (MERS)

- All new applications are made through MERS Portal
- Must be a registered user with an account
- Complete the registration process here: MERS (mers.powerappsportals.com)



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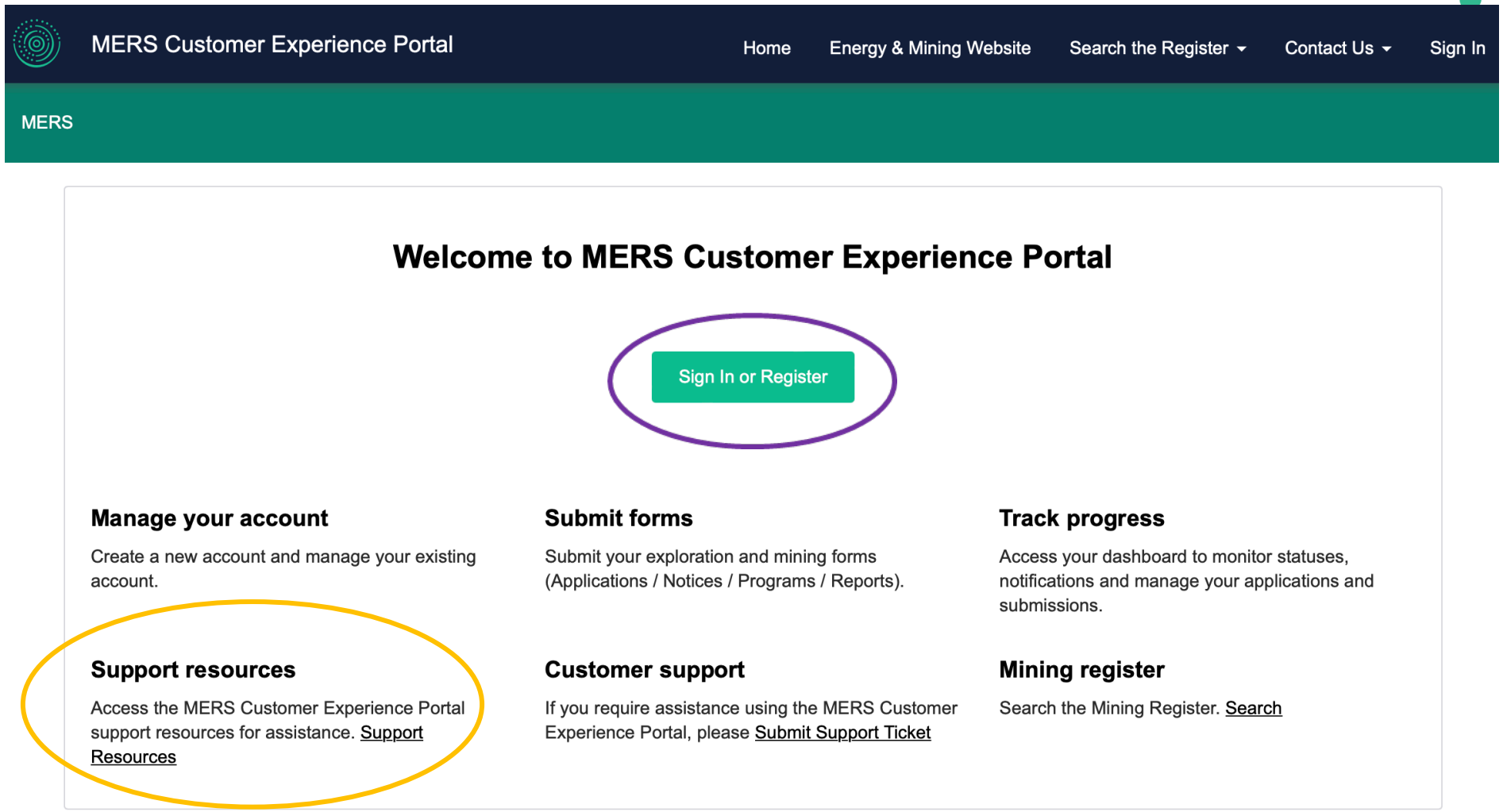
Mining Exploration and Regulation System (MERS)

- Click on

  Sign in or Register

- There are support resources available



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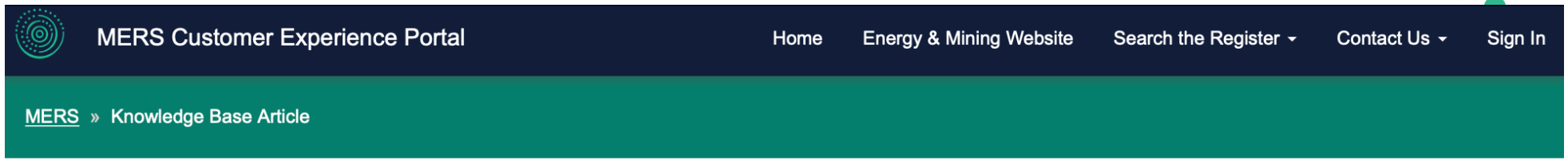
Mining Exploration and Regulation System (MERS)

Support line:

Ph. **08 8429 4450**



MERS Portal Support

We are excited to introduce the **MERS Customer Experience Portal**, the Department for Energy and Mining's (DEM) digital platform.

The MERS Portal is a customer-facing interface that provides a modern, consolidated digital platform, designed to make it easier for you to interact with DEM.

Looking for answers? Check out our **Frequently Asked Questions**.

Do you require urgent assistance? Please call our MERS Support line **08 8429 4450**. If you have a non-urgent issue or a suggestion, please feel free to submit a support ticket — we're here to help!

Portal Overview

- If this is your first time accessing the MERS Portal, please watch the Portal Overview (9:14 minutes)

Creating an Account

- How to create a new MERS Portal Account
- How to set up and manage Multi-Factor Authentication
- How to reset your password
- View the latest MERS Terms of Use.

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How to apply for a Northern Gawler ERA

STEP 1:

Visit Energy & Mining (DEM) website Exploration release area (ERA) page

https://www.energymining.sa.gov.au/industry/minerals-and-mining/exploration/public-notices/exploration_release_areas_eras

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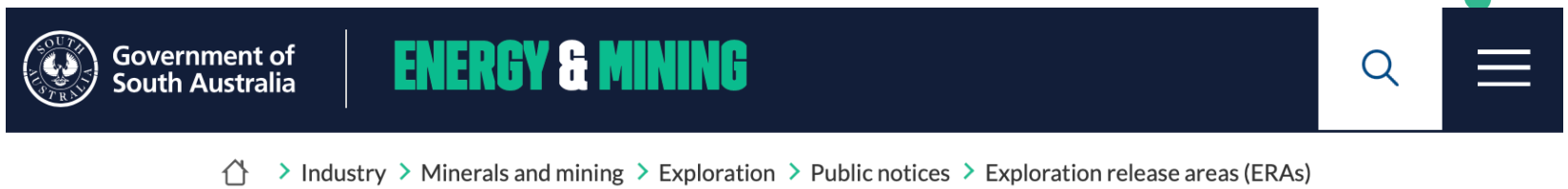
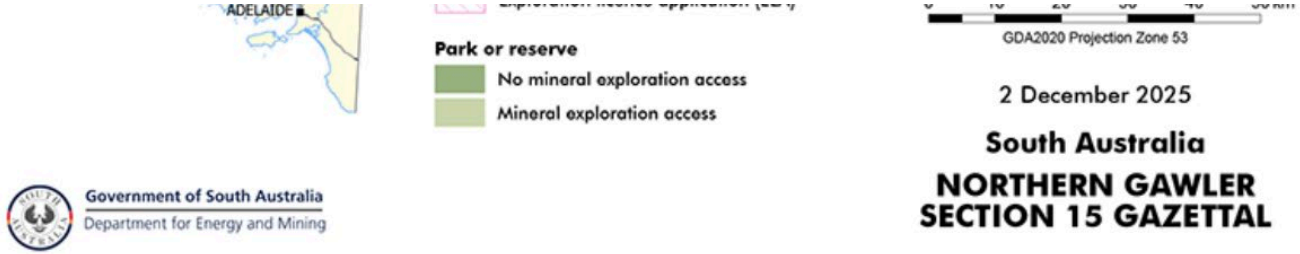


How to apply for a Northern Gawler ERA

STEP 2:

Click the link to the Exploration release areas (ERAs) list

This will take you to the ERA's listing in the MERS portal.



- Explore the data
- Northern Gawler factsheet

ERA list and submitting applications

A list of all ERAs including an 'Apply' button next to those that are open for application can be found on the MERS portal:

- Exploration release areas (ERAs)

Application fees

An ERA application must be accompanied by the statutory EL application fee.

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How to apply for a Northern Gawler ERA

MERS Customer Experience Portal | Home | Energy & Mining Website | Search the Register | Contact Us | Sign In

MERS » ERA

Exploration Release Area Application

Published exploration release area (ERA) applications

Show 10 entries

Search:

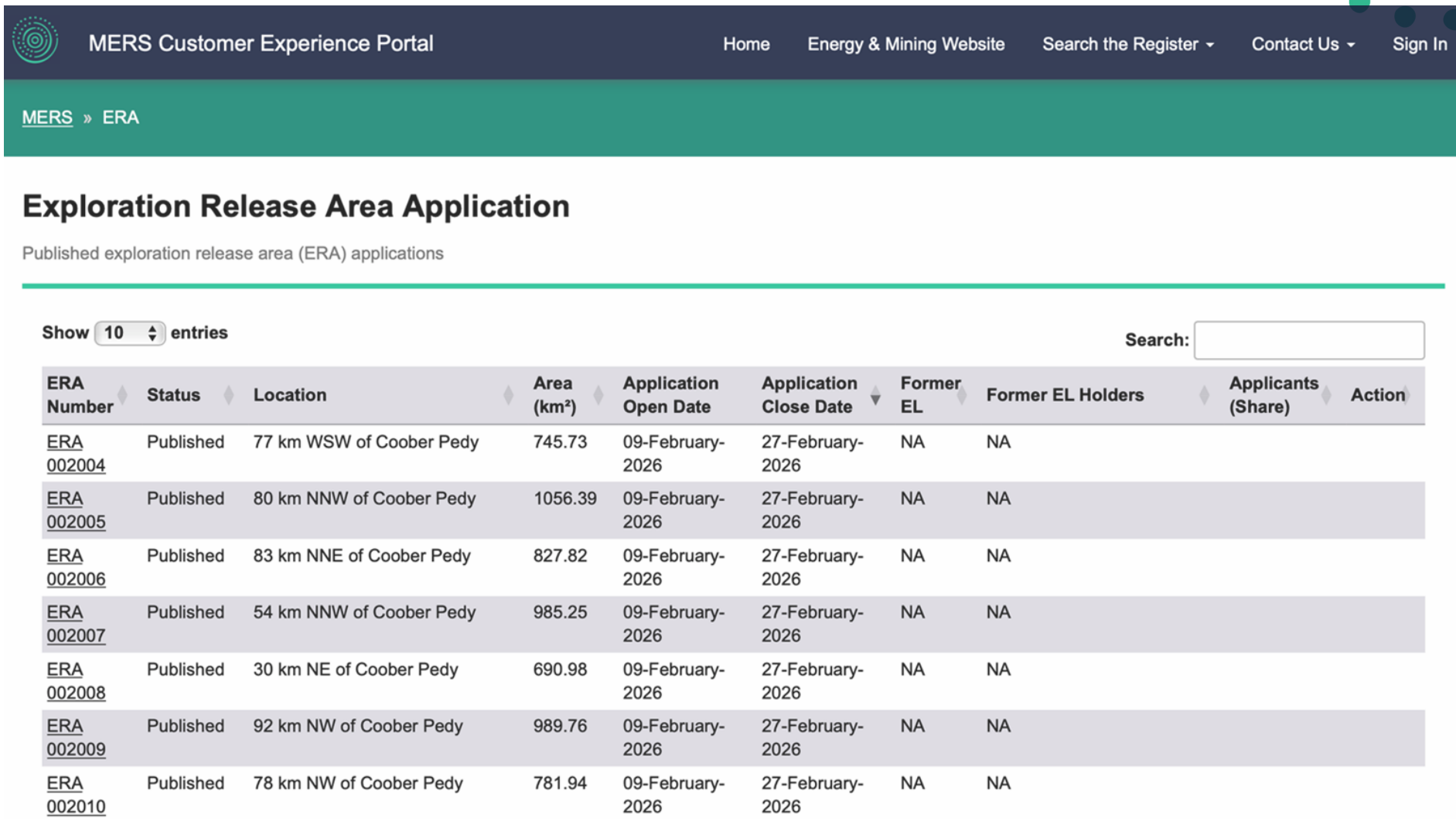
ERA Number	Status	Location	Area (km²)	Application Open Date	Application Close Date	Former EL	Former EL Holders	Applicants (Share)	Action
ERA 002004	Published	77 km WSW of Coober Pedy	745.73	09-February-2026	27-February-2026	NA	NA		
ERA 002005	Published	80 km NNW of Coober Pedy	1056.39	09-February-2026	27-February-2026	NA	NA		
ERA 002006	Published	83 km NNE of Coober Pedy	827.82	09-February-2026	27-February-2026	NA	NA		
ERA 002007	Published	54 km NNW of Coober Pedy	985.25	09-February-2026	27-February-2026	NA	NA		
ERA 002008	Published	30 km NE of Coober Pedy	690.98	09-February-2026	27-February-2026	NA	NA		
ERA 002009	Published	92 km NW of Coober Pedy	989.76	09-February-2026	27-February-2026	NA	NA		
ERA 002010	Published	78 km NW of Coober Pedy	781.94	09-February-2026	27-February-2026	NA	NA		

How to apply for a Northern Gawler ERA

STEP 3:

Find the ERA you wish to apply for on the list.

- List can be sorted by each heading using the up and down arrows
- The ERA number (format [ERA 00xxxx]) can be typed into ‘Search’ box; e.g. search ‘2018’ or ‘ERA 002018’



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Department for Energy and Mining

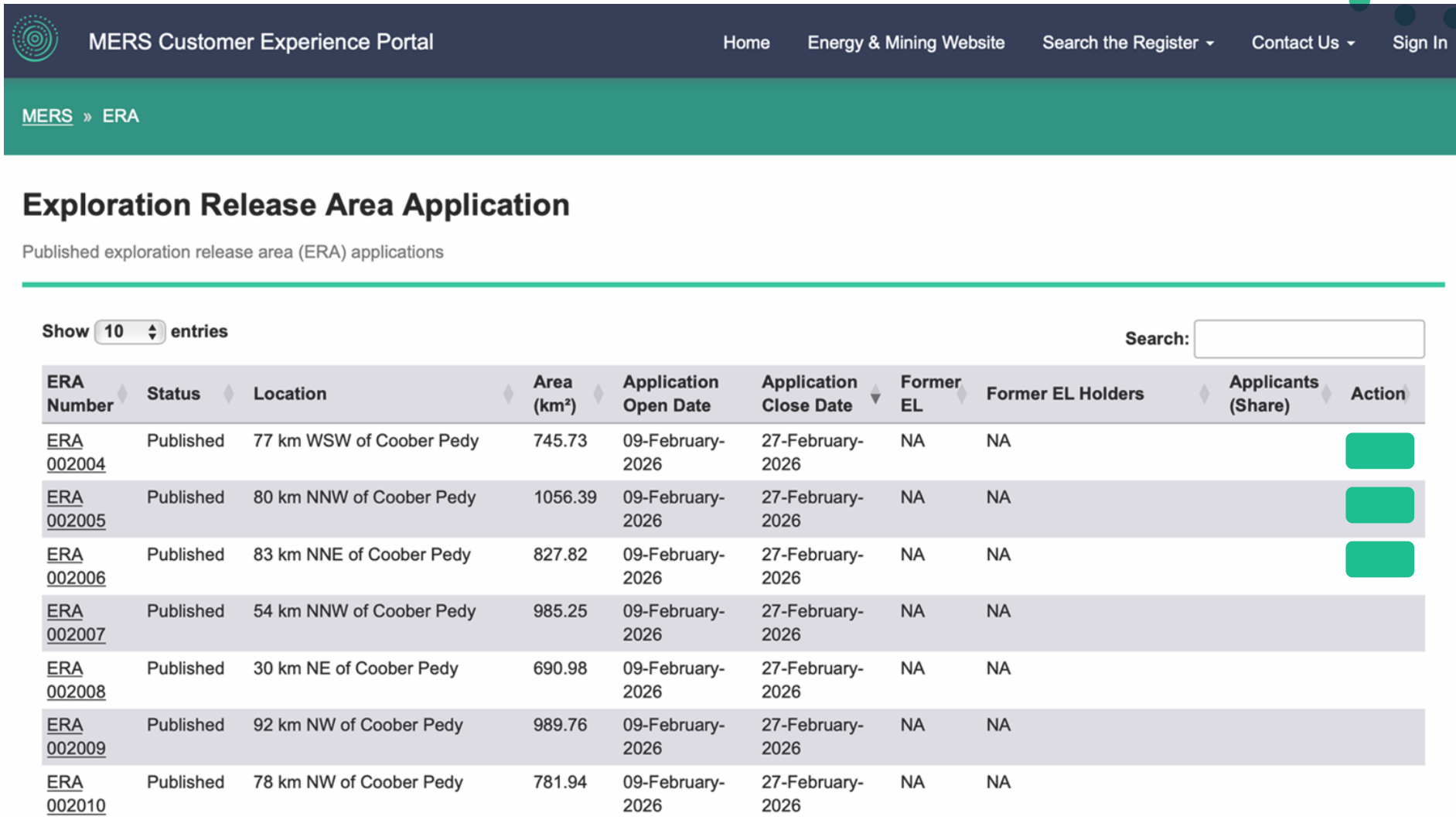
How to apply for a Northern Gawler ERA

STEP 4:

APPLY

Between **9 Feb – 27 Feb 2026** a green ‘APPLY’ button will appear in the ‘Action’ column

Click on ‘APPLY’ to open the MERS application form for the chosen ERA.



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How to apply for a Northern Gawler ERA

STEP 5:

Complete and submit the MERS Exploration release area application form

- Recommend reading through section on ERAs in DEM Guideline MG33 – Mineral exploration licences before completing application.
- Payment of fee at time of submission (online)
- After submission an acknowledgement will be sent to the nominated email address and, MERS Dashboard Notifications.

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Government of South Australia
Department for Energy and Mining

How to apply for a Northern Gawler ERA

STEP 6:

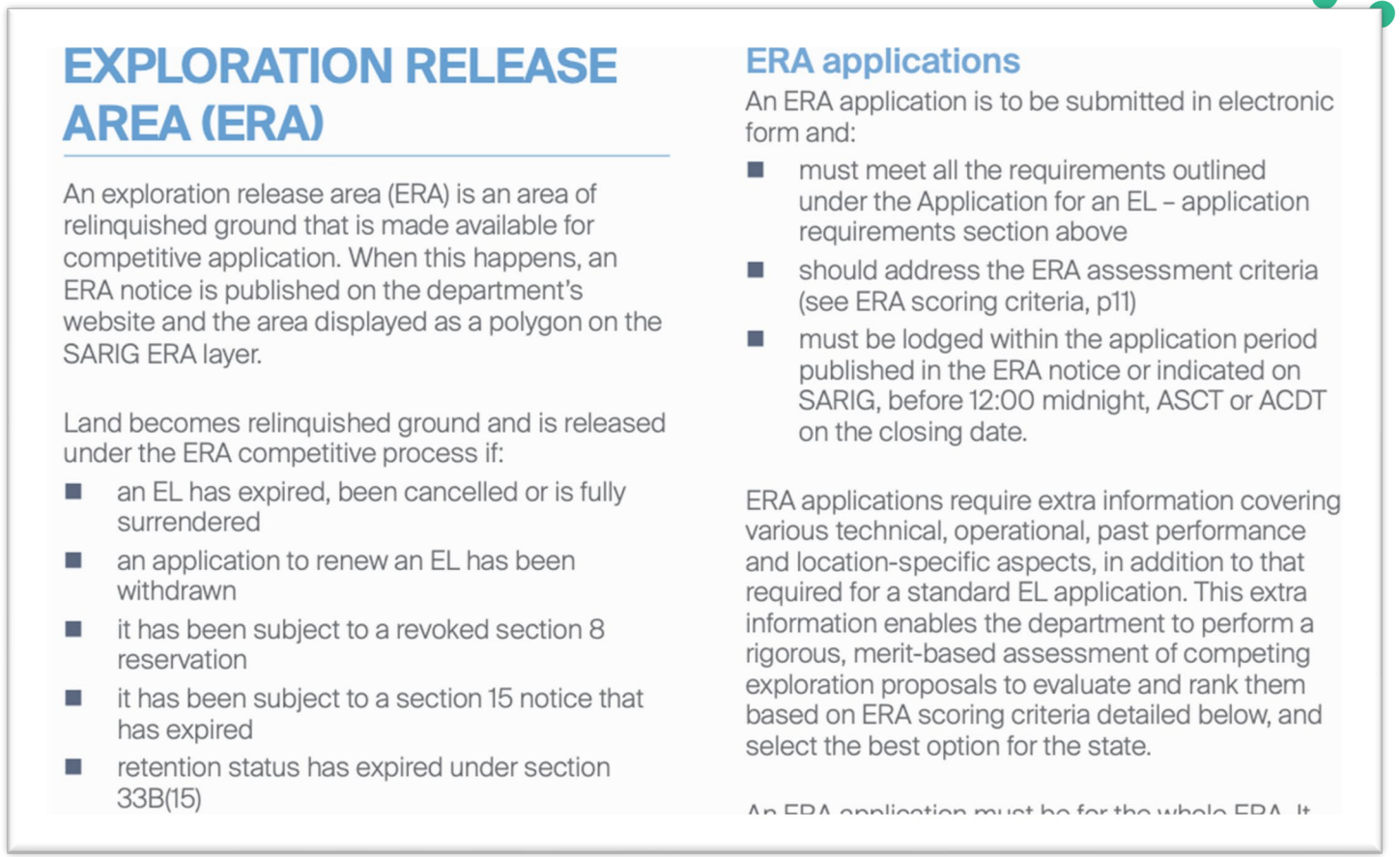
DEM Assessment

Applications will be assessed in accordance with the published ERA criteria and procedures outlined on pages 10-13 of DEM Guideline MG33 – Mineral exploration licences .

STEP 7:

Notification

Applicants will be notified of the outcome



EXPLORATION RELEASE AREA (ERA)

An exploration release area (ERA) is an area of relinquished ground that is made available for competitive application. When this happens, an ERA notice is published on the department's website and the area displayed as a polygon on the SARIG ERA layer.

Land becomes relinquished ground and is released under the ERA competitive process if:

- an EL has expired, been cancelled or is fully surrendered
- an application to renew an EL has been withdrawn
- it has been subject to a revoked section 8 reservation
- it has been subject to a section 15 notice that has expired
- retention status has expired under section 33B(15)

ERA applications

An ERA application is to be submitted in electronic form and:

- must meet all the requirements outlined under the Application for an EL – application requirements section above
- should address the ERA assessment criteria (see ERA scoring criteria, p11)
- must be lodged within the application period published in the ERA notice or indicated on SARIG, before 12:00 midnight, ASCT or ACDT on the closing date.

ERA applications require extra information covering various technical, operational, past performance and location-specific aspects, in addition to that required for a standard EL application. This extra information enables the department to perform a rigorous, merit-based assessment of competing exploration proposals to evaluate and rank them based on ERA scoring criteria detailed below, and select the best option for the state.

An ERA application must be for the whole ERA. It

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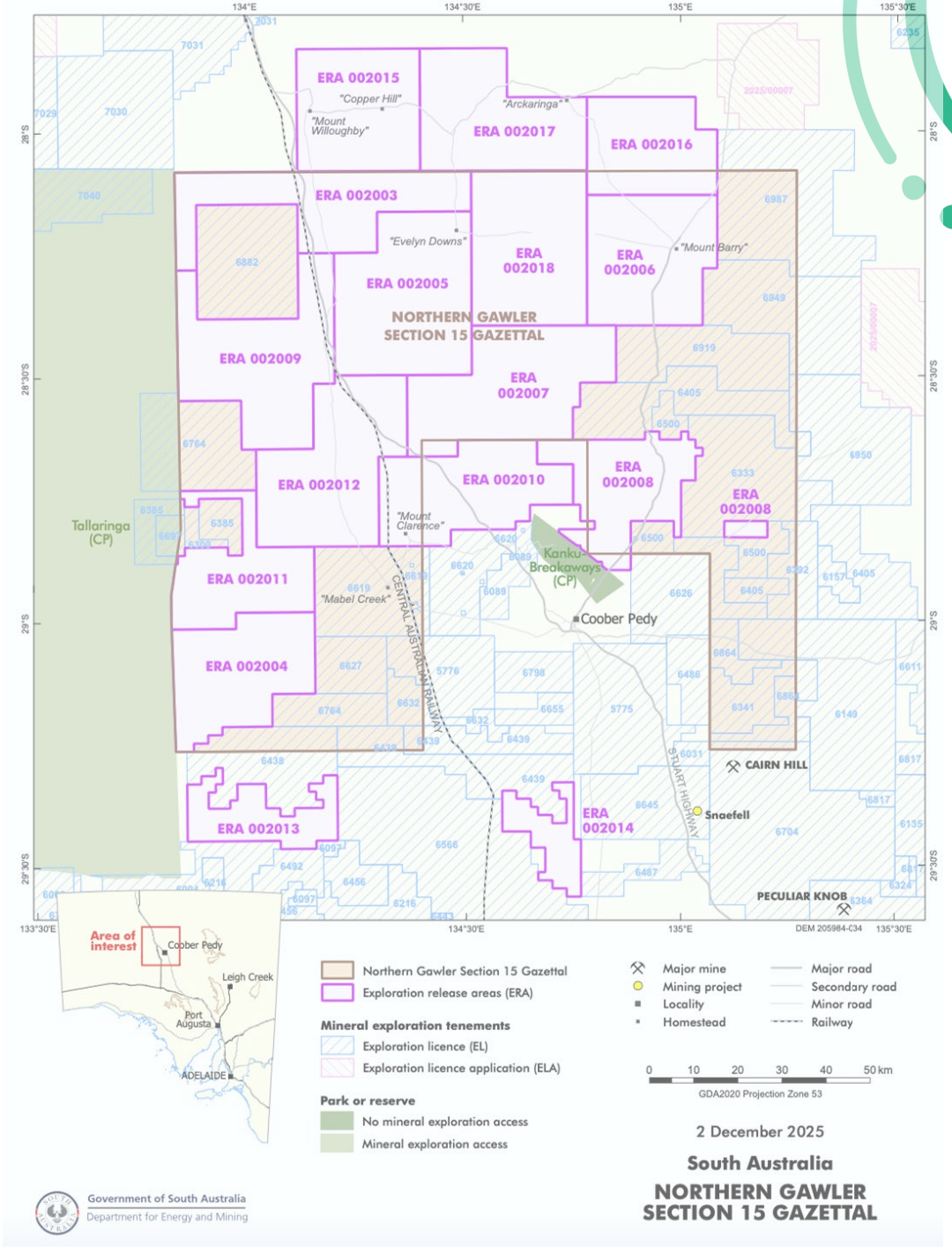
Questions? Get in touch! DEM.Minerals@sa.gov.au

Summary

- Competitive application process:

  9 Feb – 27 Feb 2026

- To apply must have MERS portal account
- Complete online form with payment of application fee
- Assessment based on ERA criteria (see MG33)
- Notification of outcome (Q2 2026)



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