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Resource potential of the Carrara Sub-basin from the deep stratigraphic well NDI Carrara 1

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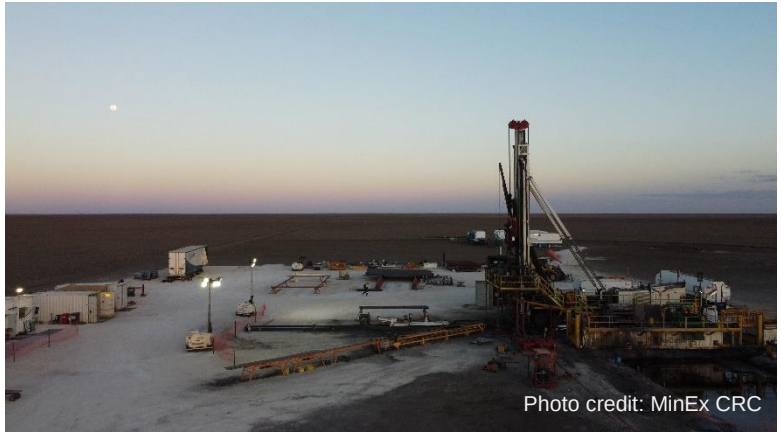
Photo credit: MinEx CRC

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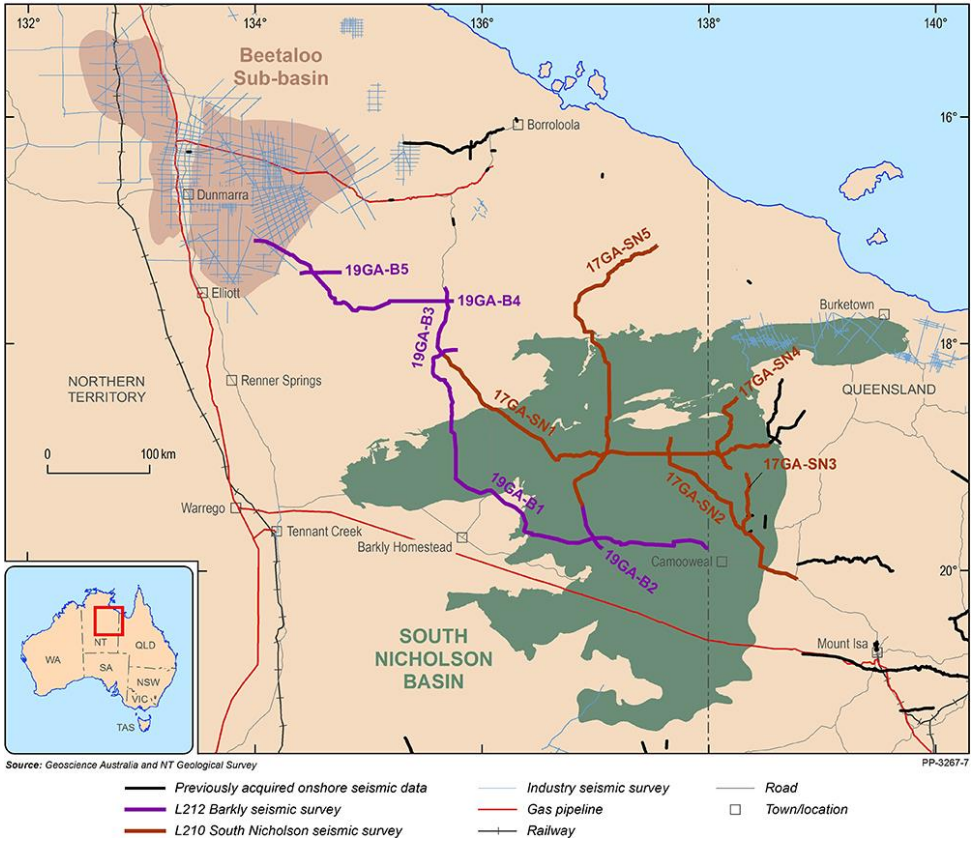
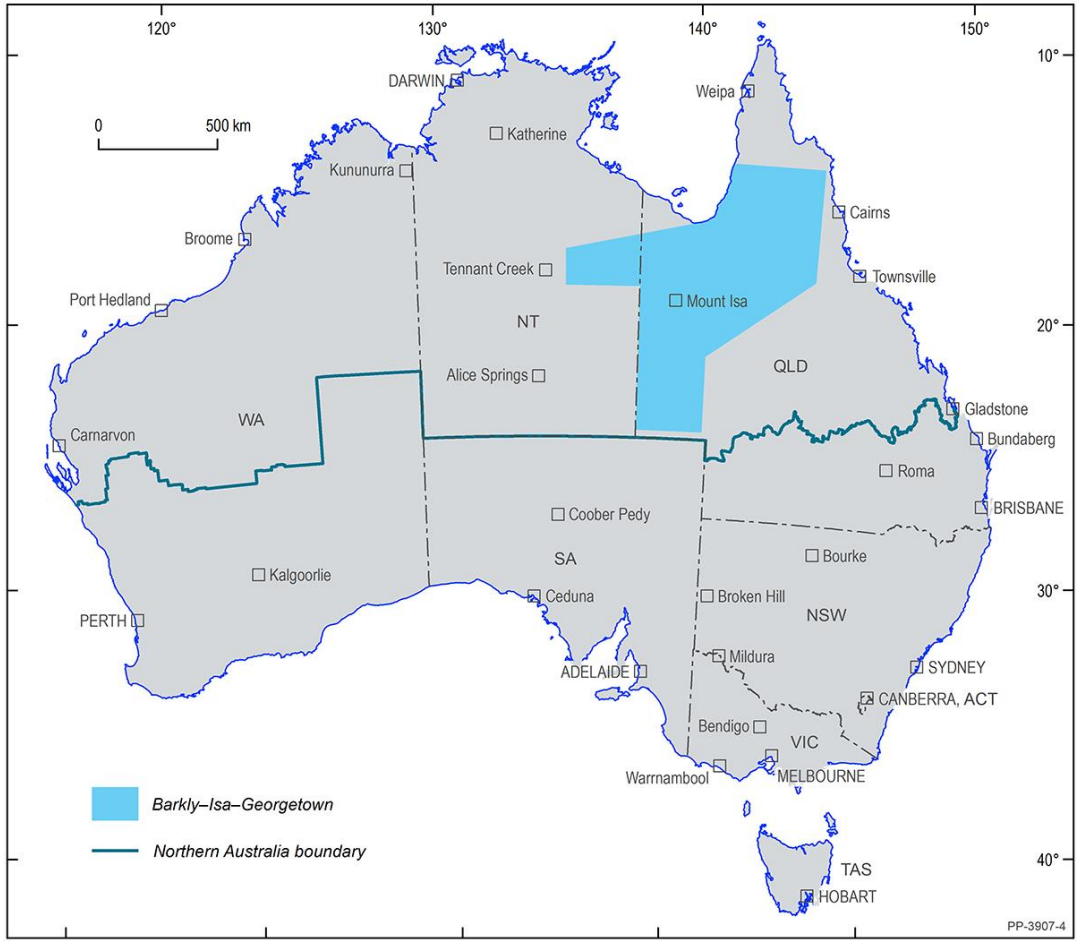
EFTF: 2016-2020

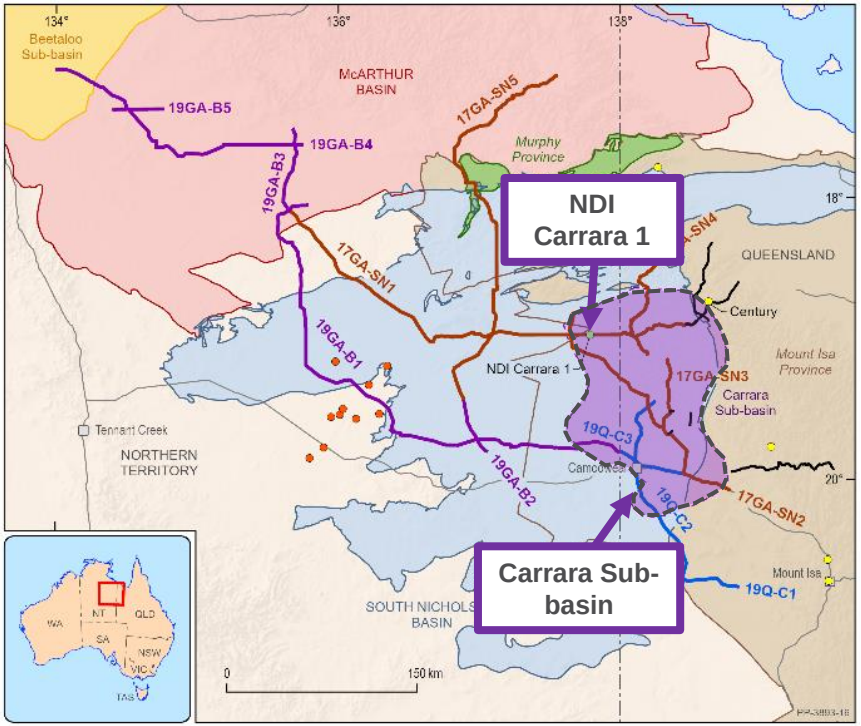


- A comprehensive data acquisition program was conducted under EFTF across the South Nicholson Basin region, NW QLD and NT.
- 2017: Acquired L210 deep crustal seismic survey.
- 2019: Acquired L212 deep crustal seismic survey.
- 2020: Drilled NDI Carrara 1.
- Extensive analysis of legacy and field samples.

EFTF: 2020-2024

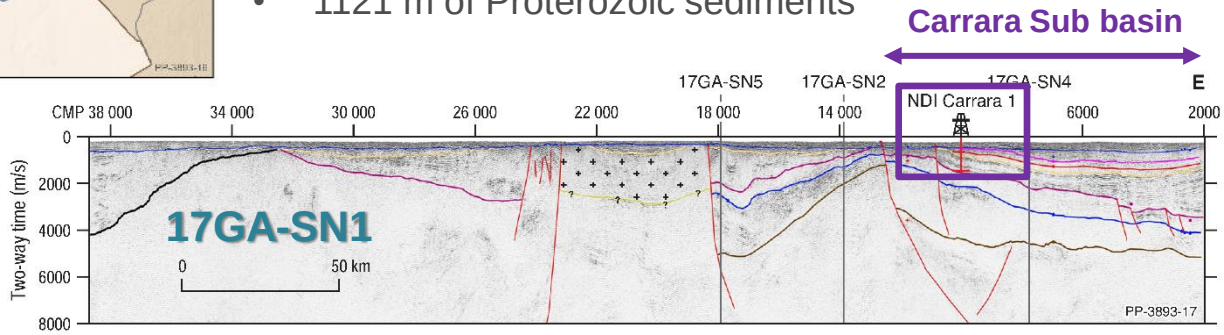
- “South Nicholson National Drilling Initiative”
- Part of the Barkly-Isa-Georgetown Project.
- Builds on work completed in the first four years of EFTF.
- Undertaking analysis of South Nicholson region samples .
- In collaboration with the MinEx CRC and NTGS.



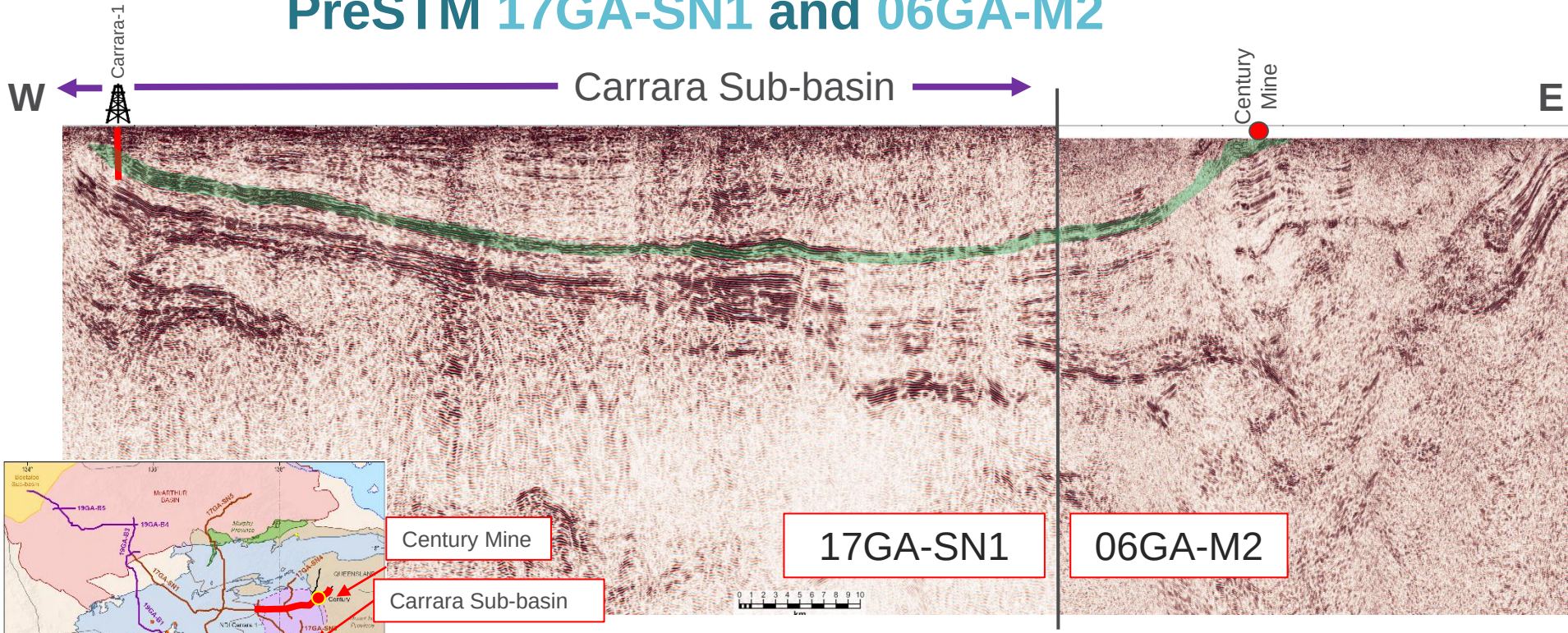


The Carrara Sub-basin and NDI Carrara 1

- Carrara Sub-basin discovered during EFTF 1 South Nicholson Seismic Survey in 2017
- NDI Carrara 1 located on western flank of Carrara Sub-basin
- Drilling of NDI Carrara 1 completed in Dec 2020
- EOH 1751 m
- 630 m of Cambrian Georgina Basin
- 1121 m of Proterozoic sediments



PreSTM 17GA-SN1 and 06GA-M2



- 17GA-SN1 links with legacy line 06GA-M2
- Important for geological control, well-studied outcrop
- Extrapolation into the concealed Carrara Sub-basin

See also:
Frogtech SEEBASE 2017
Gibson et al., 2017, 2016
Carr et al., 2019

NDI Carrara 1 drill hole

Macrofossils study (Laurie, 2022)
Middle Cambrian

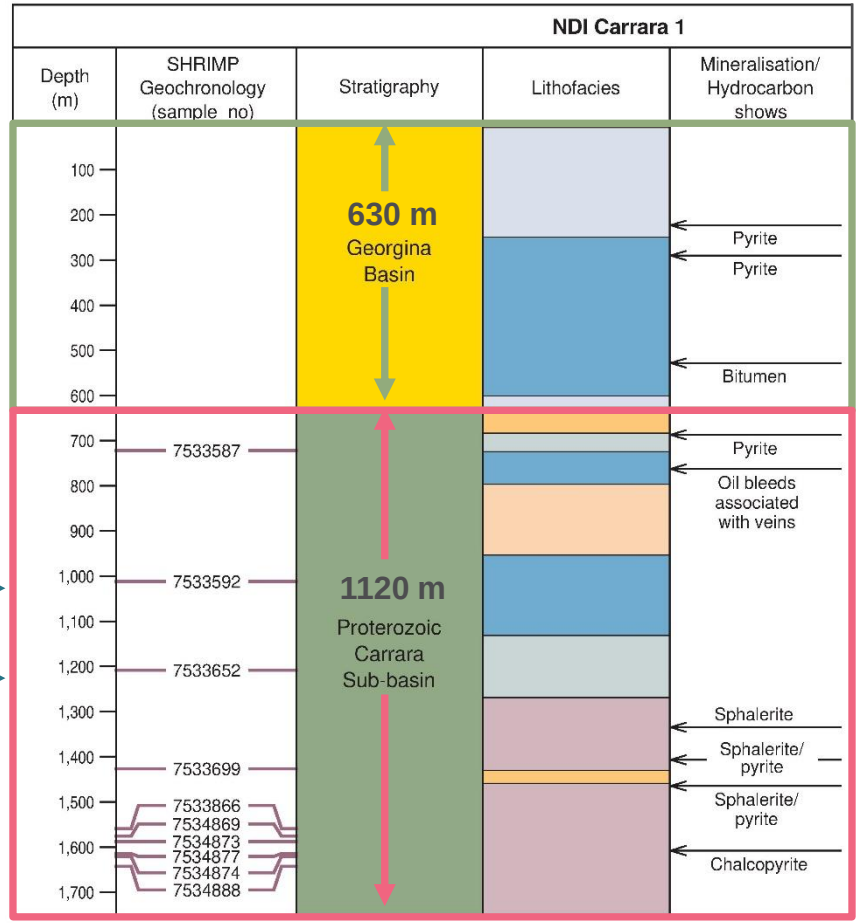
basal unconformity
@ 630 m

Equivalent to the Paleo- to Mesoproterozoic middle to upper Lawn Hill Fm.

~ 1588 Ma @1012 m

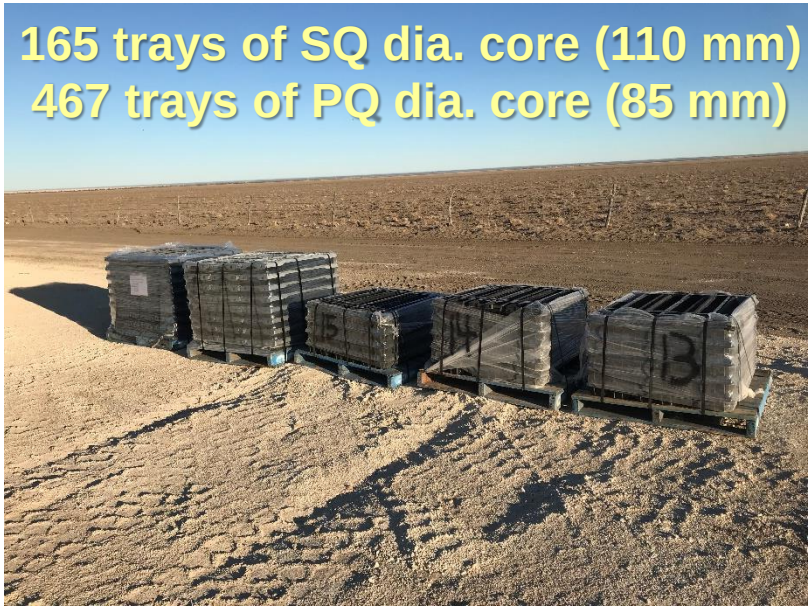
~ 1601 Ma @1204 m

1611 Ma
@1580–1650 m



Sampling program

Continuous coring from 284 m to TD (1750.85 m)



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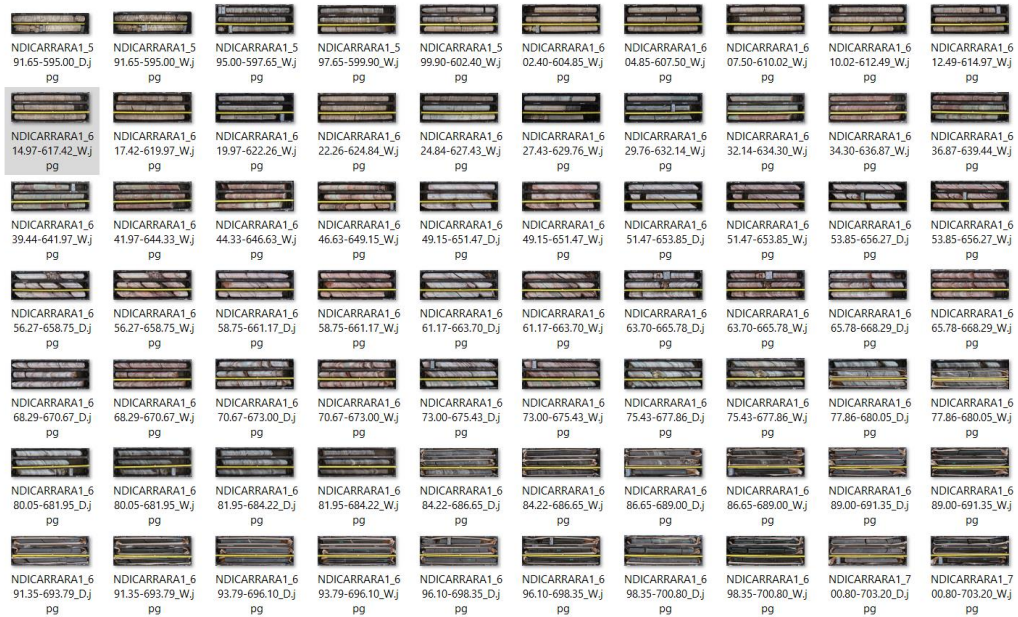
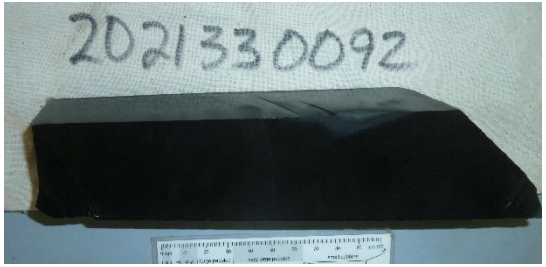


Borehole Completion Report: https://portal.ga.gov.au/bhcr/minerals/648482

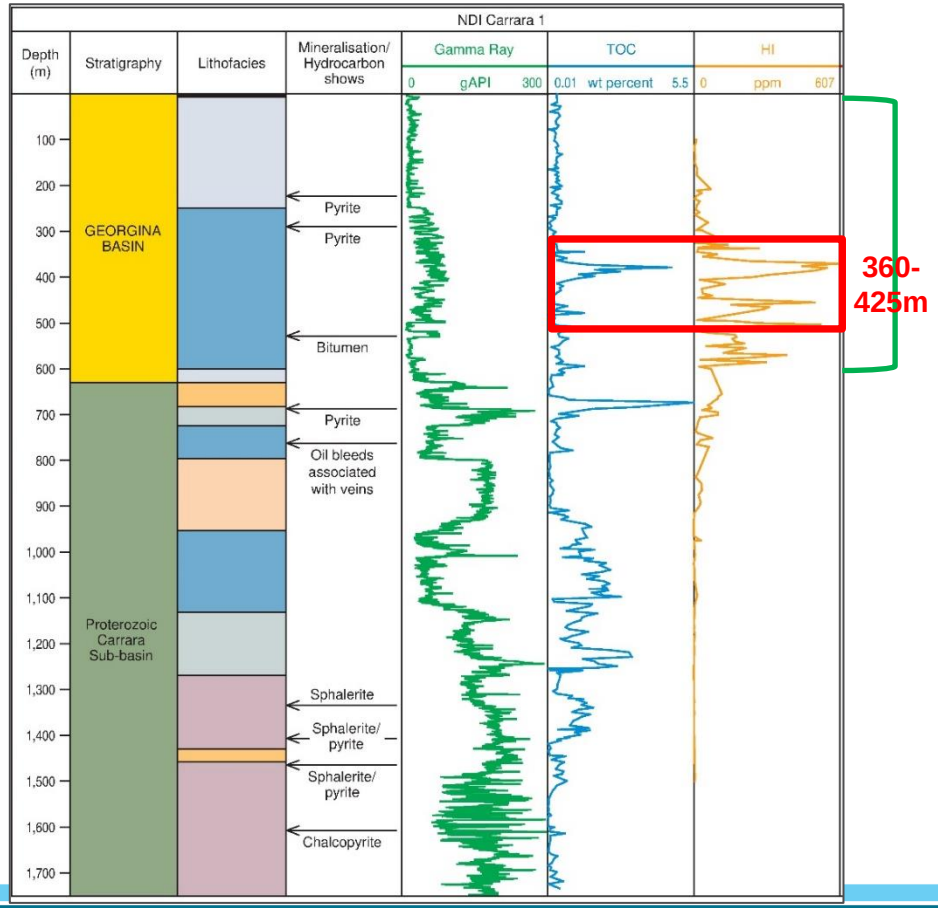
One sample every 4m on average for ‘routine’ analyses: ~500 samples

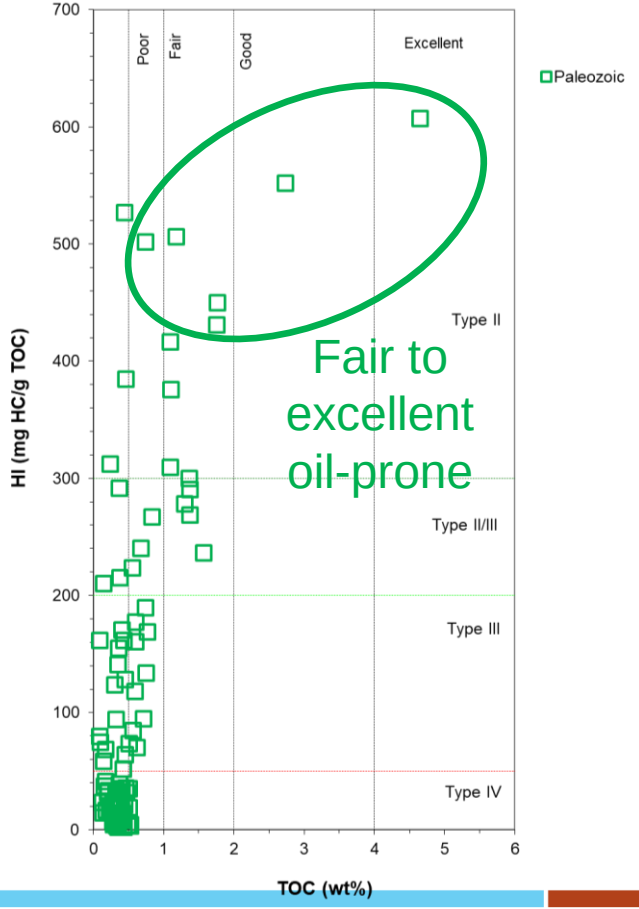
Analyses

- Organic geochemistry: TOC, Rock-Eval, biomarkers
- Organic petrology
- Inorganic geochemistry: qXRD, elemental analyses
- Geochronology
- Fluid inclusion stratigraphy
- Isotopic analyses
- Petrology
- Petrophysics
- Geomechanics
- Sequence stratigraphy

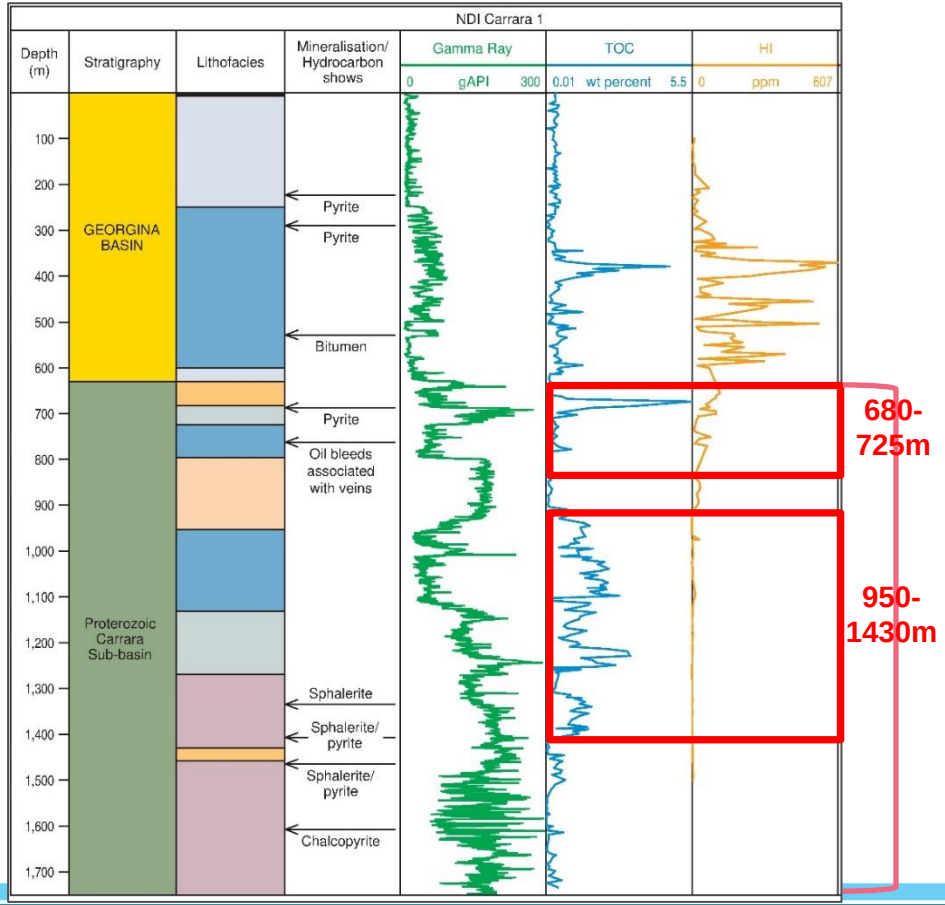


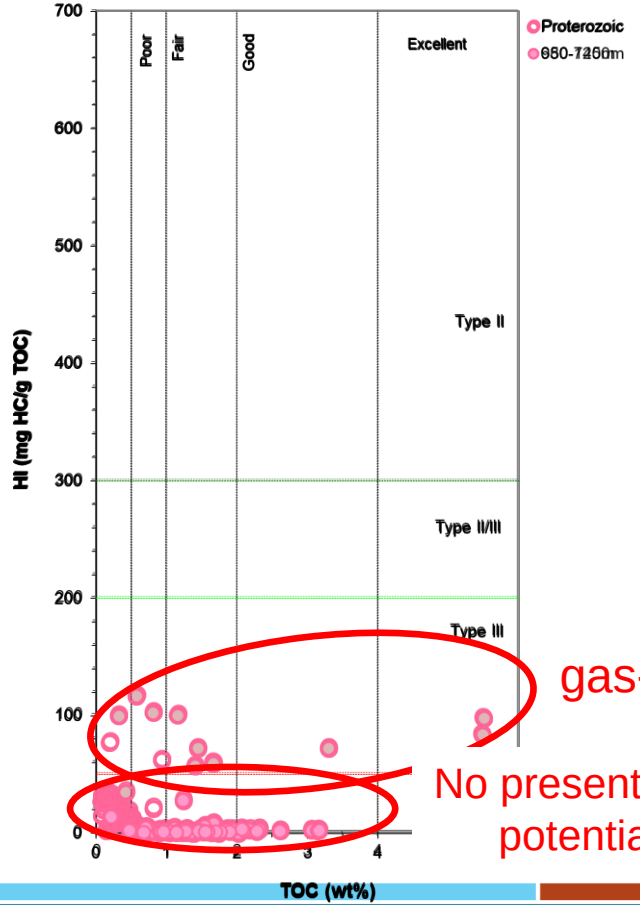
Source rock potential: Georgina Basin rocks



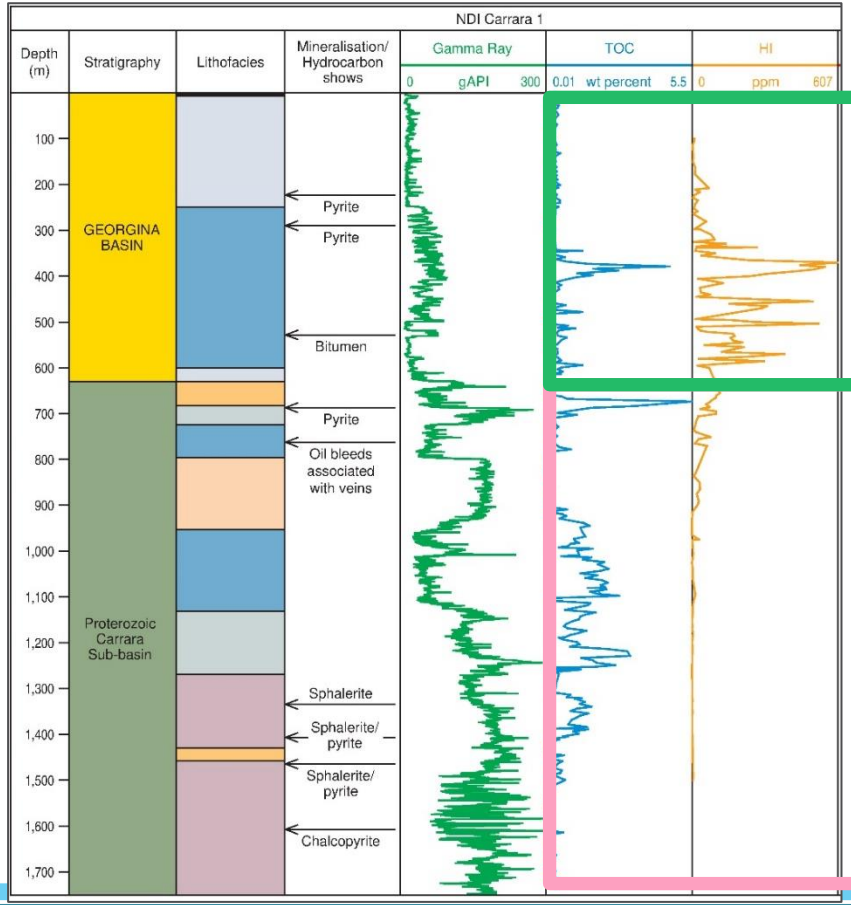


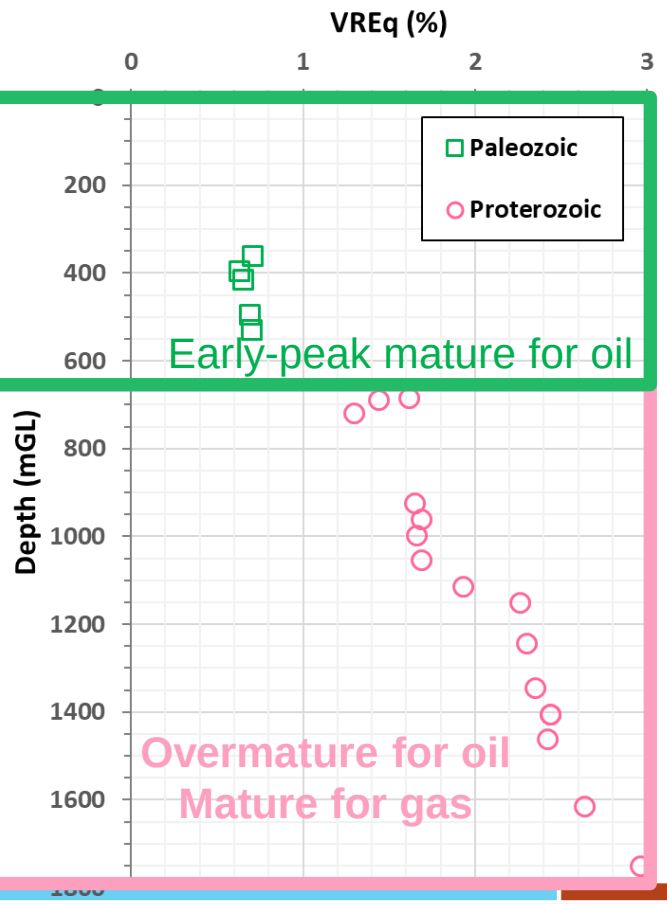
Organic Geochemistry: Source rock potential





Organic Geochemistry: Thermal maturity





Hydrocarbon shows

@528 m

@763 m

@765 m

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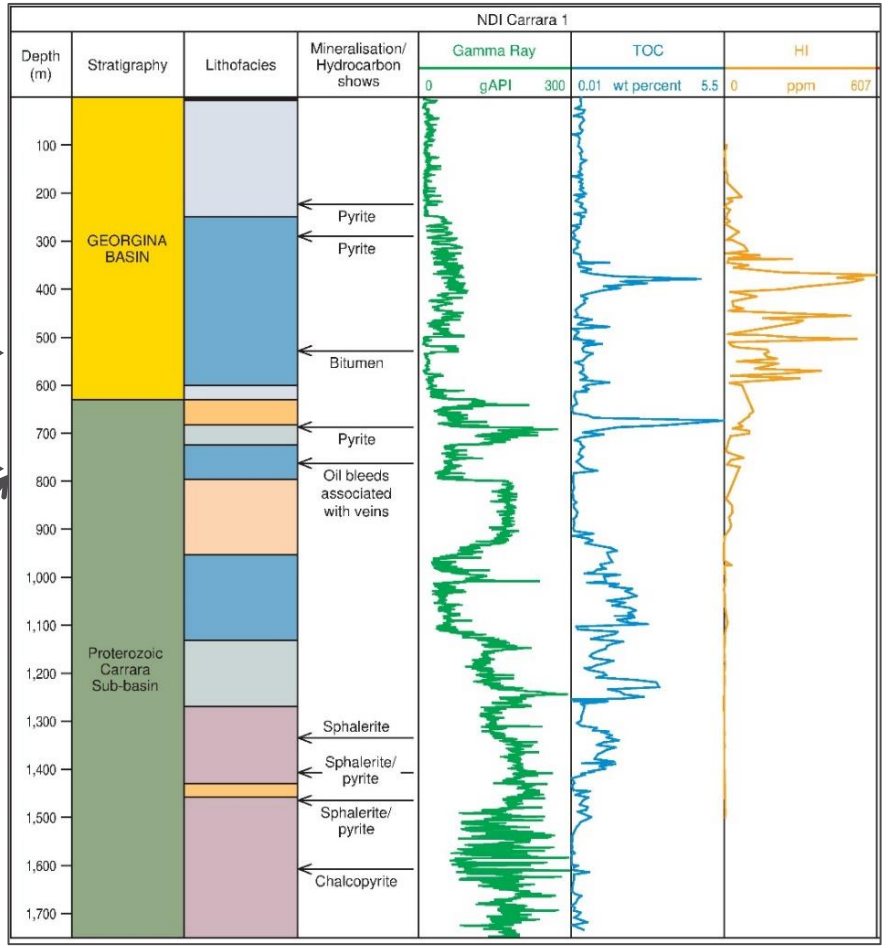
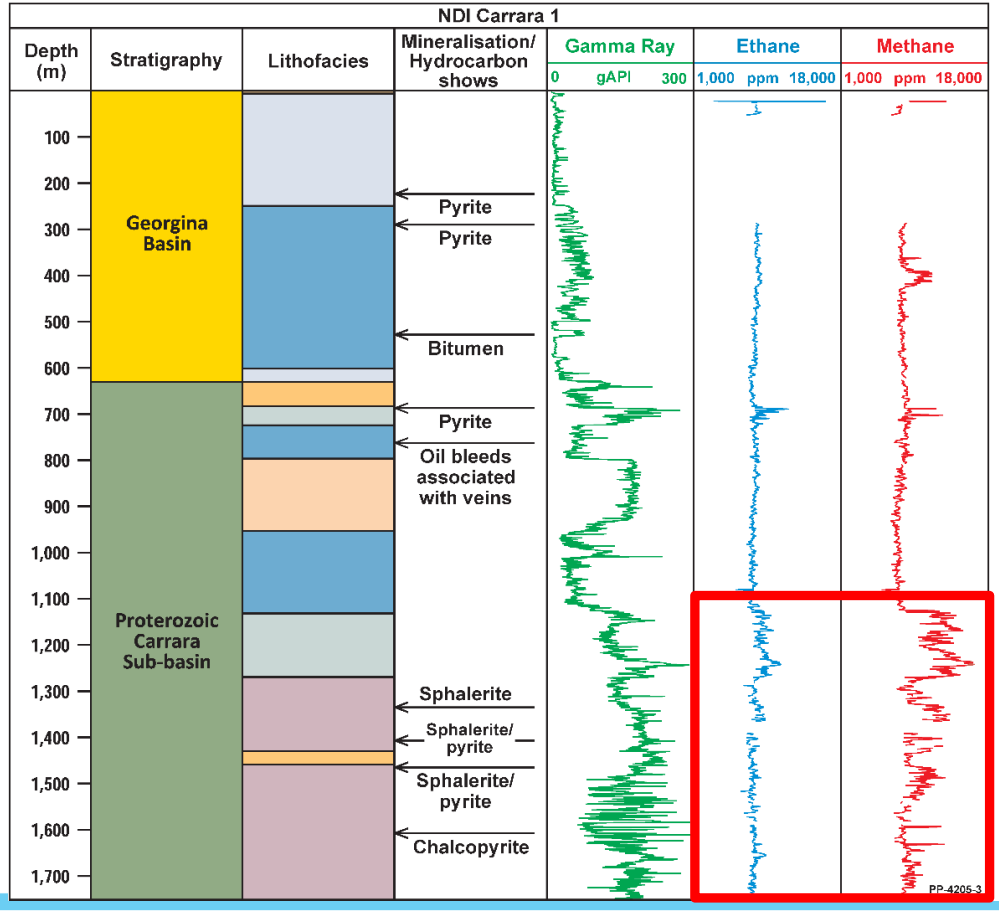
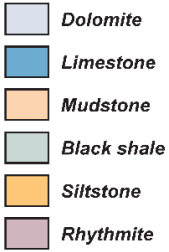
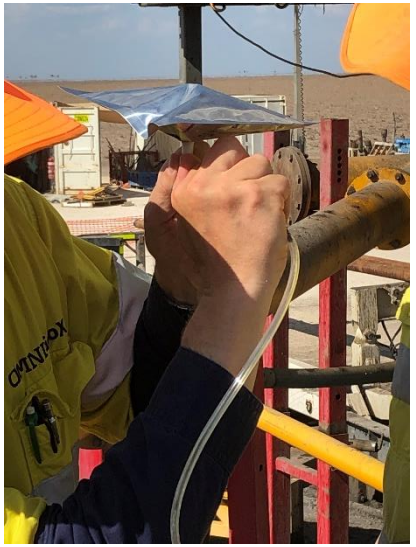


Hydrocarbon shows





Gas sample



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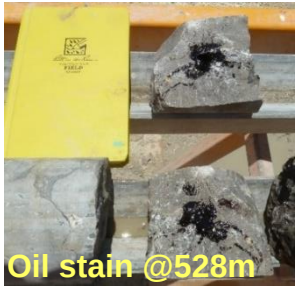
Gas sourced from local, thermally mature organic-rich rocks

Boreham et al 2022. Exploring for the Future - NDI Carrara 1 gas geochemistry. GA Record.

Hydrocarbon shows: Petroleum systems summary

Era/period	Petroleum (Super)system
Cambrian	Larapintine 1
Neoproterozoic	Centralian
Mesoproterozoic	Beetaloo/Urapungan
Paleo- to Mesoproterozoic	Lawn
Paleoproterozoic	McArthur
Paleoproterozoic	Redbank

Bradshaw et al 1994; Jarrett et al 2021



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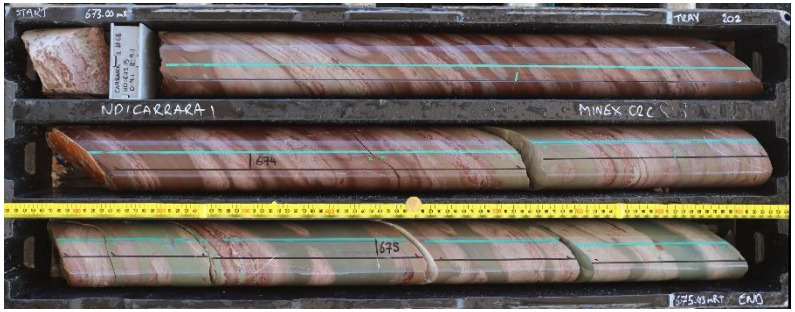
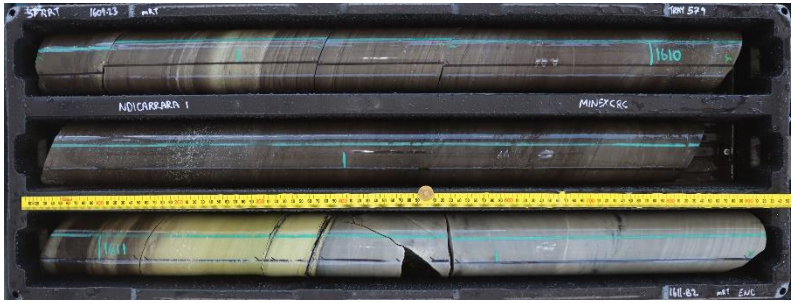
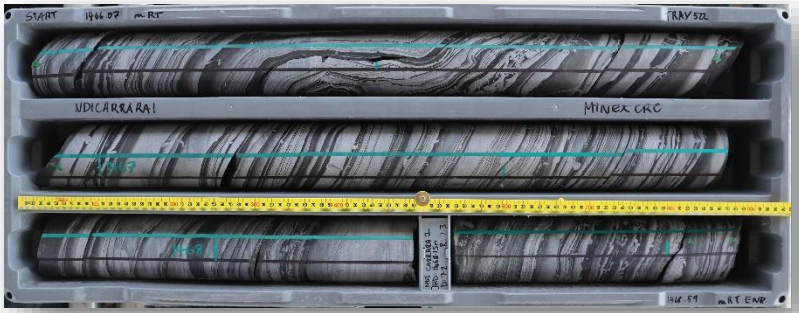
Rock mineralogy

- XRD analyses were undertaken on the routine samples.
- 420 samples analysed via Quantitative XRD (qXRD).
- Provided bulk mineralogy of samples:
  - Identification of 18 mineral groups.
  - One extra group for unknown minerals.
- XRD can be used to calculate rock strength proxies, i.e. Brittleness Index







Rock mineralogy: Brittleness Index

Egilabria 2 DW1 flare. Photo credit, Armour Energy

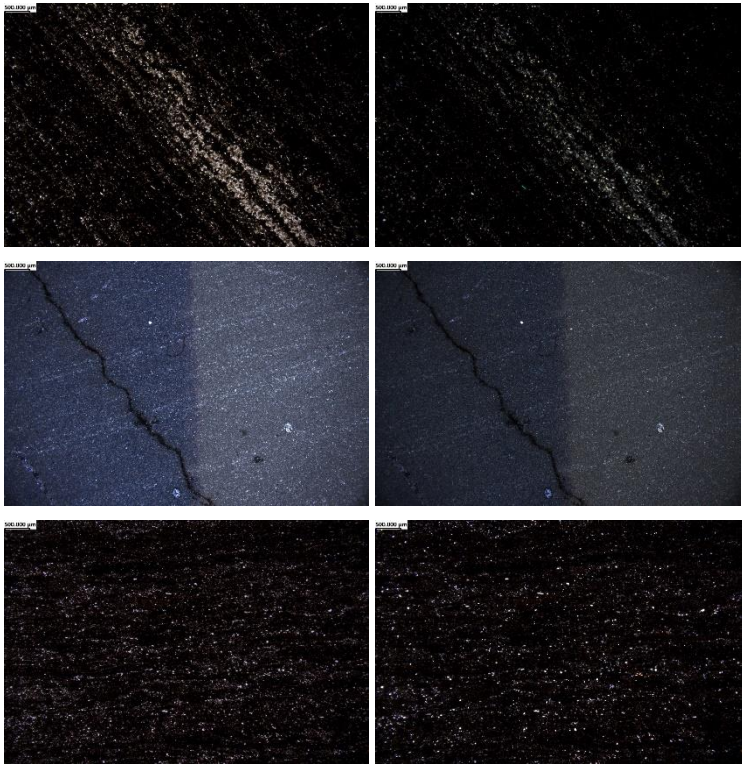
Why bother calculating BI?

- Shale reservoirs can generate and trap vast quantities of hydrocarbons.
- Extremely limited permeability = very limited gas flow… unless the reservoir can be stimulated to generate connected permeability.
- Shale reservoirs mechanical properties (e.g. strength, plasticity, brittleness and elasticity) are often a function of mineralogy.
- A proxy for rock strength, the Brittleness Index (BI) can be calculated from XRD mineralogy.

Rock mineralogy: Brittleness Index

Why bother calculating BI?

- BI *can* provide an insight into stimulation effectiveness.
- However, not always a successful indicator for rock strength.
- An understanding of depositional and diagenetic processes is essential to fully comprehending the relationship between mineralogy and brittleness.
- **In basins with limited data availability BI is a useful and cost effective tool for identifying zones of interest over a large area**



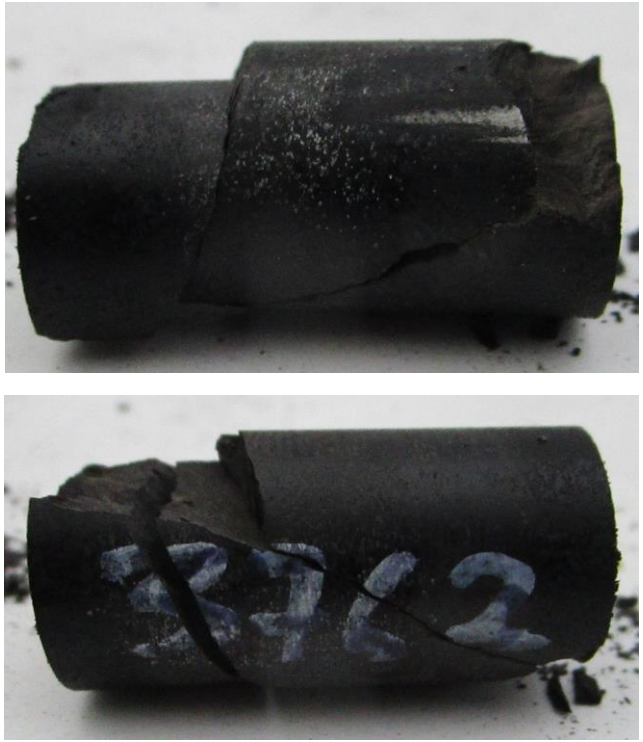
Thin section photomicrographs of high TOC (>2%) shales within NDI Carrara 1 (695 m, 1114 m, and 1245 m (Madden et al., 2022)

Rock mineralogy: Brittleness Index

- Numerous methods for calculating BI exist.
- The most commonly used is the Jarvie *et al.* (2007):

$$BI = \frac{\text{Quartz}}{\text{Quartz} + \text{Carbonate} + \text{Clay}}$$

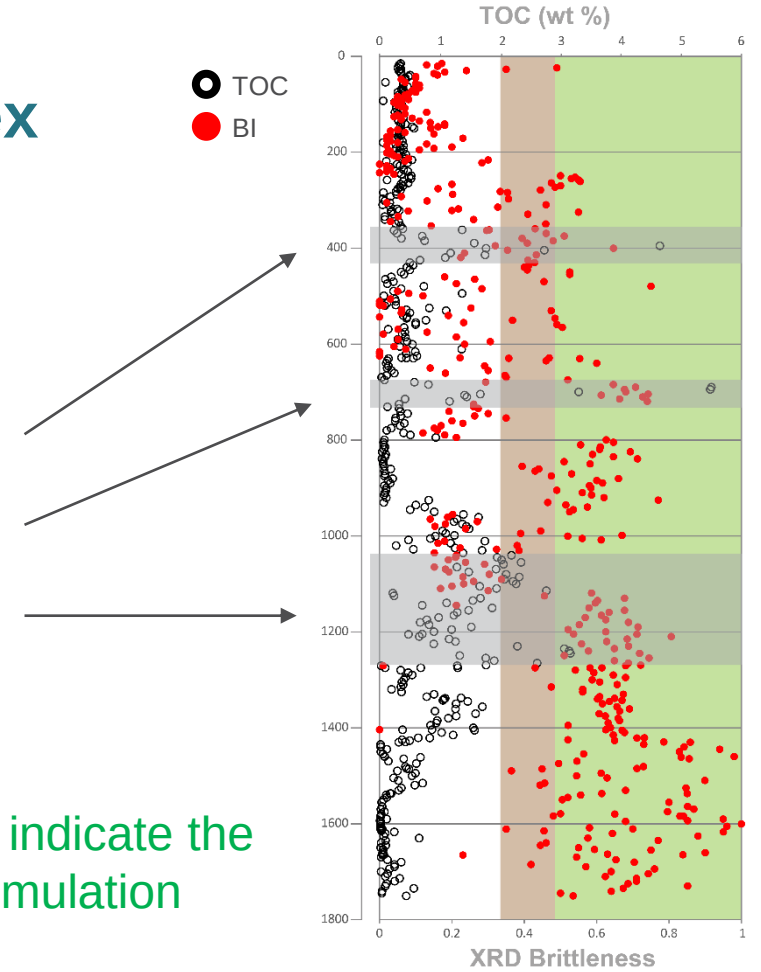
- Ductile: < 0.16,
  Less ductile = 0.16 - 0.32,
  Less brittle = 0.32 - 0.48
  Brittle: > 0.48



Geomechanics plug from NDI Carrara 1

Rock mineralogy: Brittleness Index

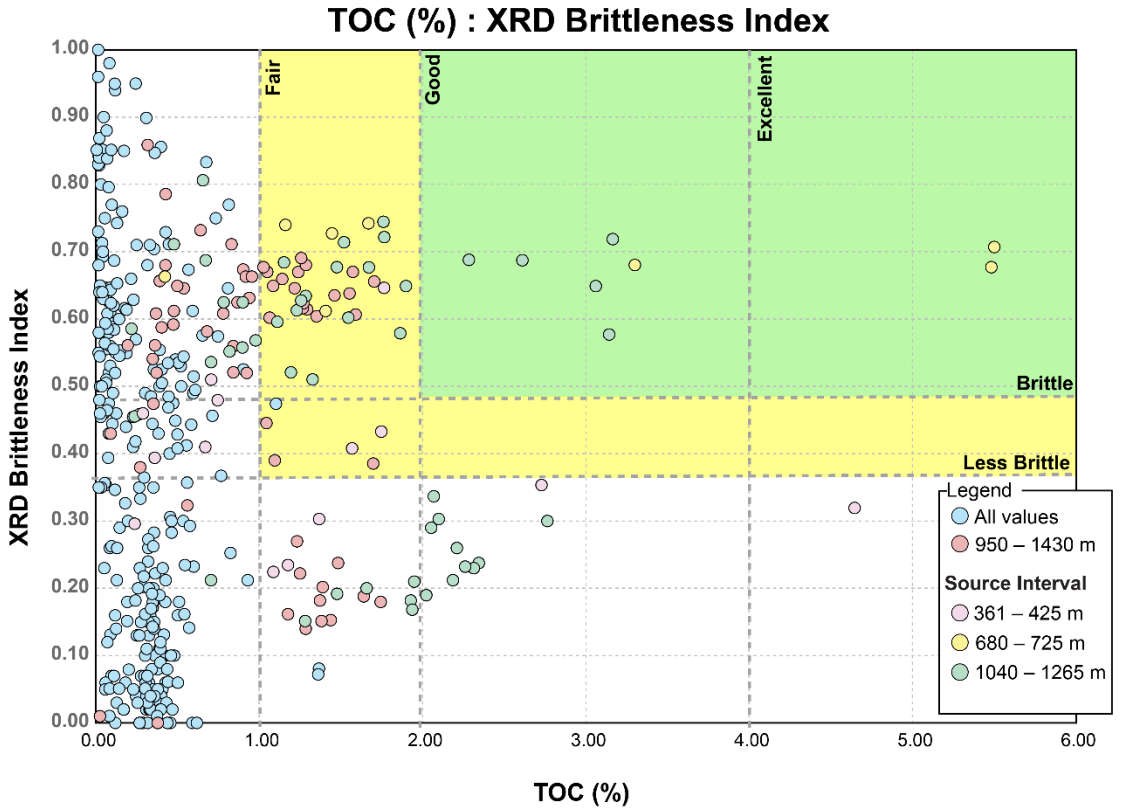
Source Interval (m)	*Mean BI*	*BI range*	*BI standard deviation*	*Brittleness*
361 – 425	0.39	0.22 – 0.65	0.11	Less Brittle
680 - 725	0.65	0.26 – 0.74	0.13	Brittle
1040 - 1265	0.48	0.15 – 0.81	0.20	Brittle



Carrara Sub-basin organic-rich shales have BI that indicate the presence of brittle rocks, likely favourable for stimulation

Carrara Sub-basin: A shale play?

- Crossplot of TOC and BI.
- Highlights area of high TOC, brittle rocks.
- These are in the previously identified source intervals.

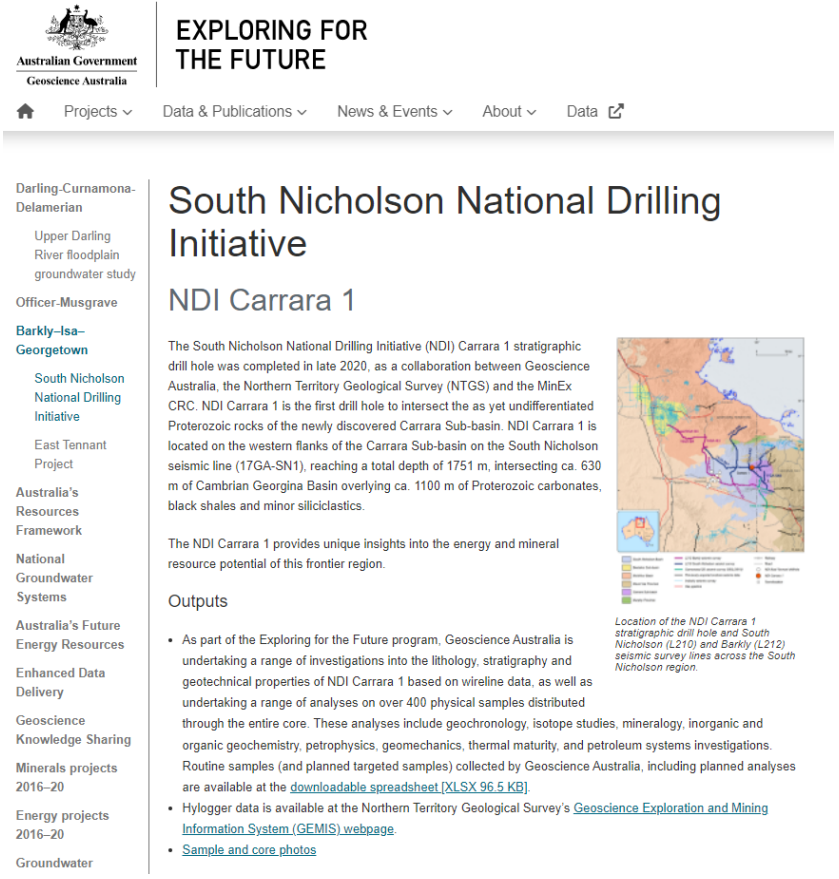


Still to come:

- Triaxial and UCS tests to confirm rock elastic and strength properties.
- Detailed petrophysical data (poroperm, MICP, adsorption/desorption etc).

These data can help us further constrain the prospectivity of the Carrara Sub-basin black shales.

http://www.ga.gov.au/eftf/projects/barkly-isa-georgetown/south-nicholson-national-drilling-initiative



Summary

- NDI Carrara 1 is the first intersection of the Carrara Sub-basin.
- Distinct links with the known Proterozoic shale plays of the northern Lawn Hill Platform.
- Organic geochemistry highlights the presence of two organic-rich intervals within the Proterozoic section and one within the overlying Cambrian interval.
- Brittleness indices demonstrate that these two shale intervals are likely to be brittle and, hence, hydraulic stimulation is likely to enhance permeability.
- These data imply that these black shales may form potential shale gas plays within the Carrara Sub-basin.
- **A continuation of the Proterozoic shale play fairway across the Northern Territory and northwest Queensland?**

Credit MinEx CRC

Thank you – Questions?

Please keep in mind that the Commonwealth Government is currently in caretaker mode and keep questions ***scientific*** in nature, as no policy related questions can be addressed at this time.

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