A multidisciplinary evaluation of the Velkerri Formation in the Beetaloo Sub-Basin: Implications for geological history and reservoir quality

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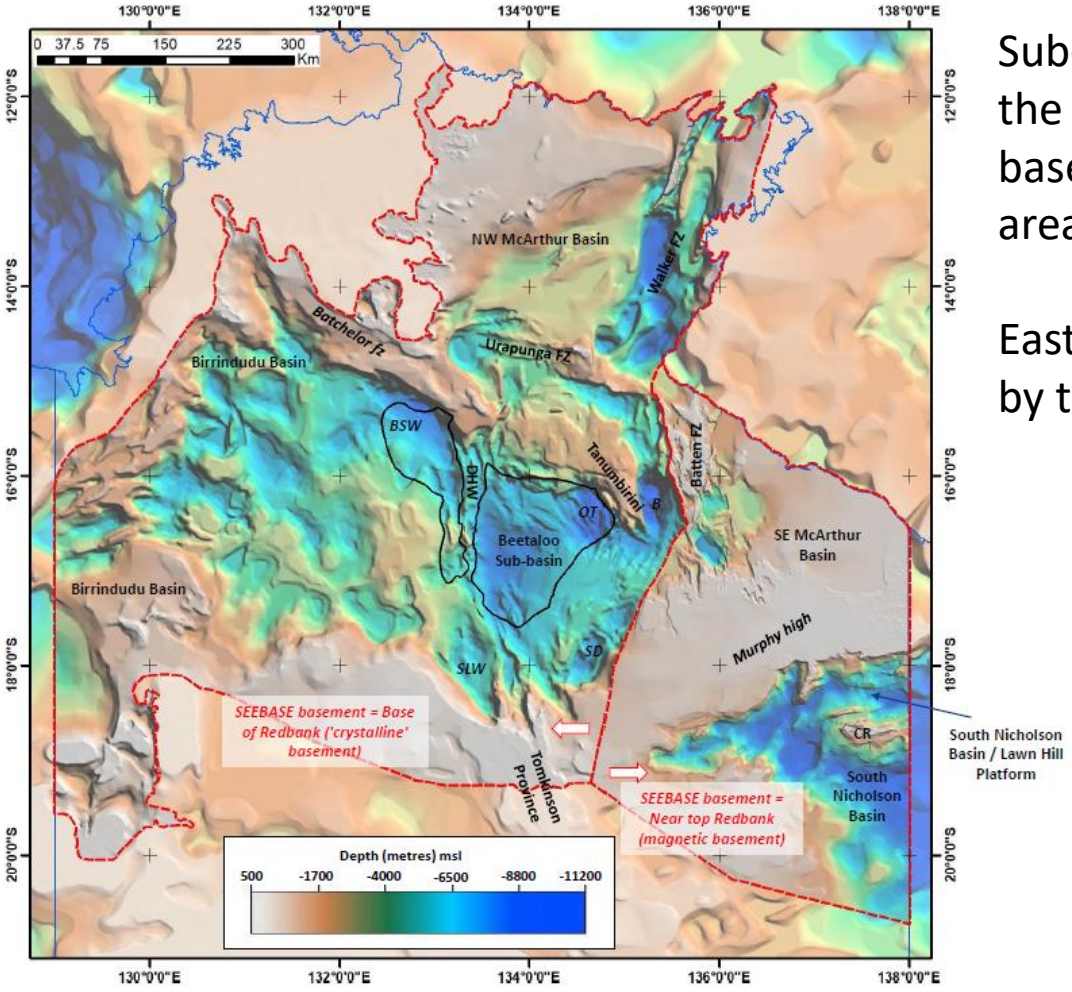
Beetaloo Sub-Basin

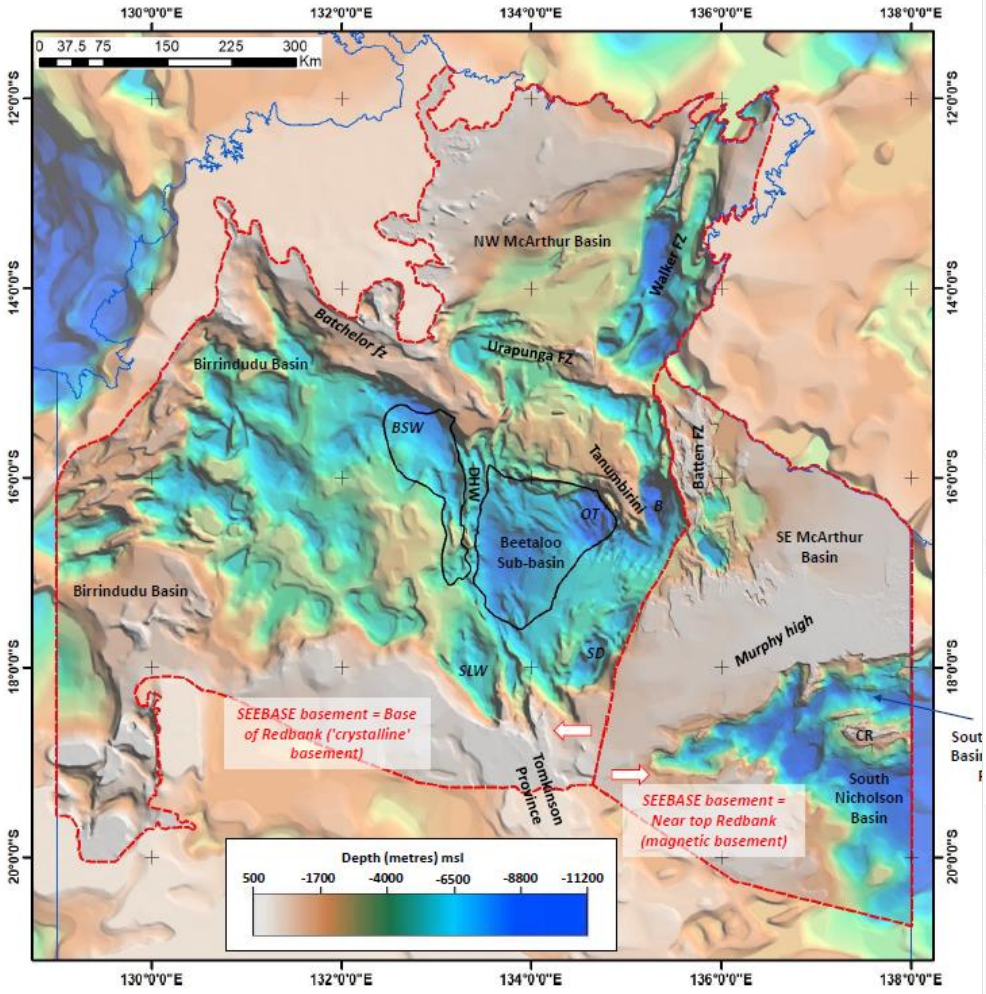


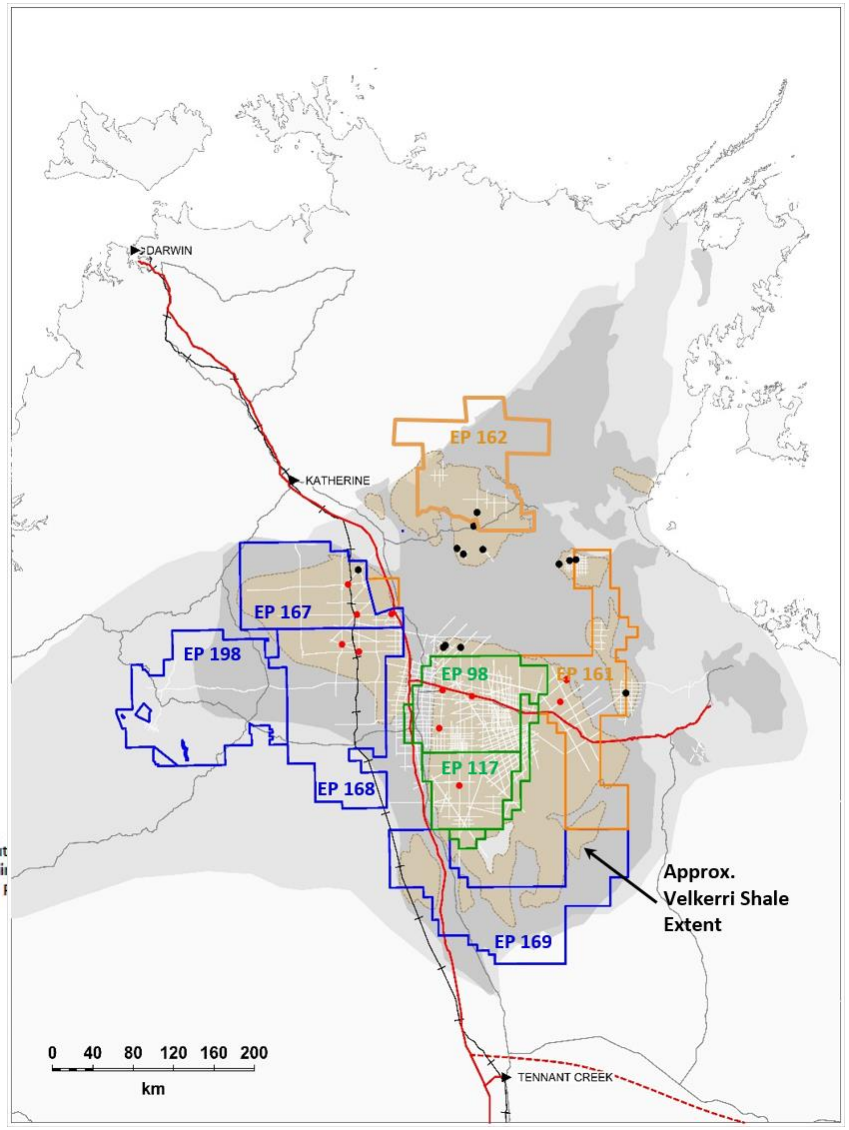
Sub-basin boundaries defined by top of the Kyalla Fm at 400 m below the surface based on seismic data (does not limit the areas of hydrocarbon potential)

Eastern and western domains separated by the Daly Waters Fault Zone

Frogtech Geoscience, 2018. SEEBASE® study and GIS for greater McArthur Basin. NTGS DIP 017

Beetaloo Sub-Basin





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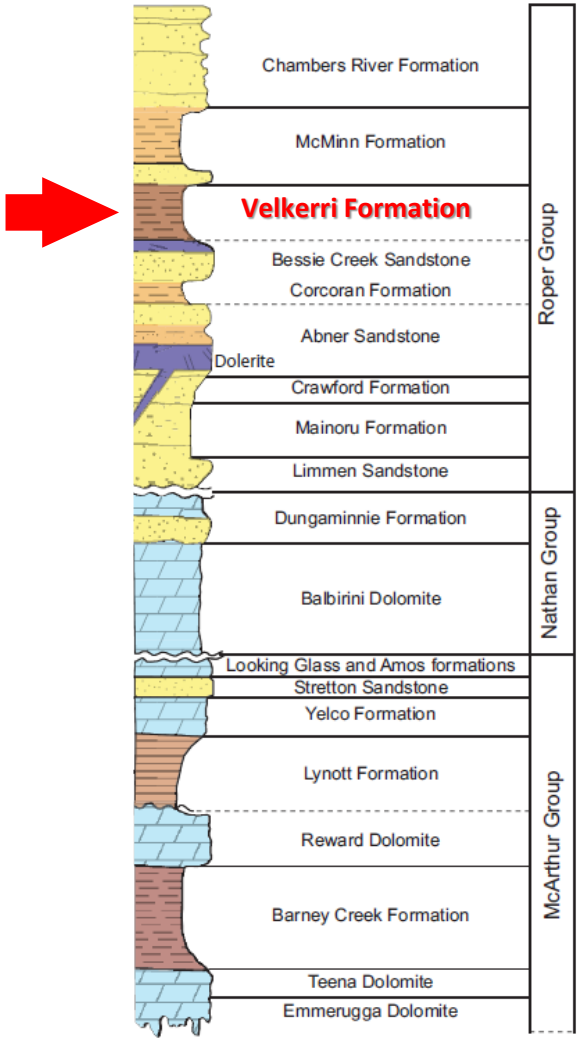
Velkerri Formation



Marine, organic rich siliceous mudstone (ca 1430 Ma old)

Self sourced hydrocarbon reservoir with organic material mostly composed of bacteria and primitive algae

Laterally continuous with ubiquitous gas and oil shows

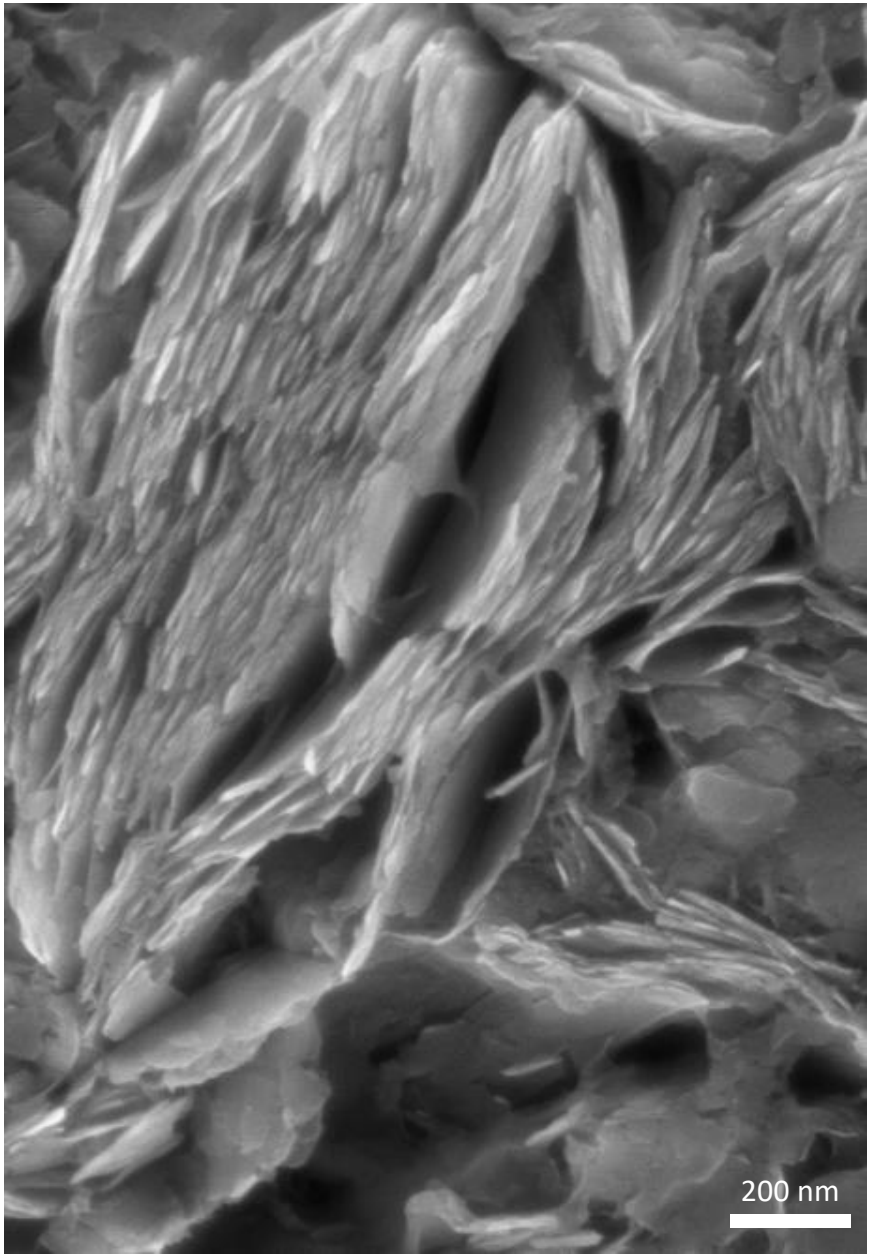
Demonstrated dry gas play via well testing and hydraulic fracturing

Liquid rich play also under exploration but yet to be tested

Dutkiewicz et al 2007

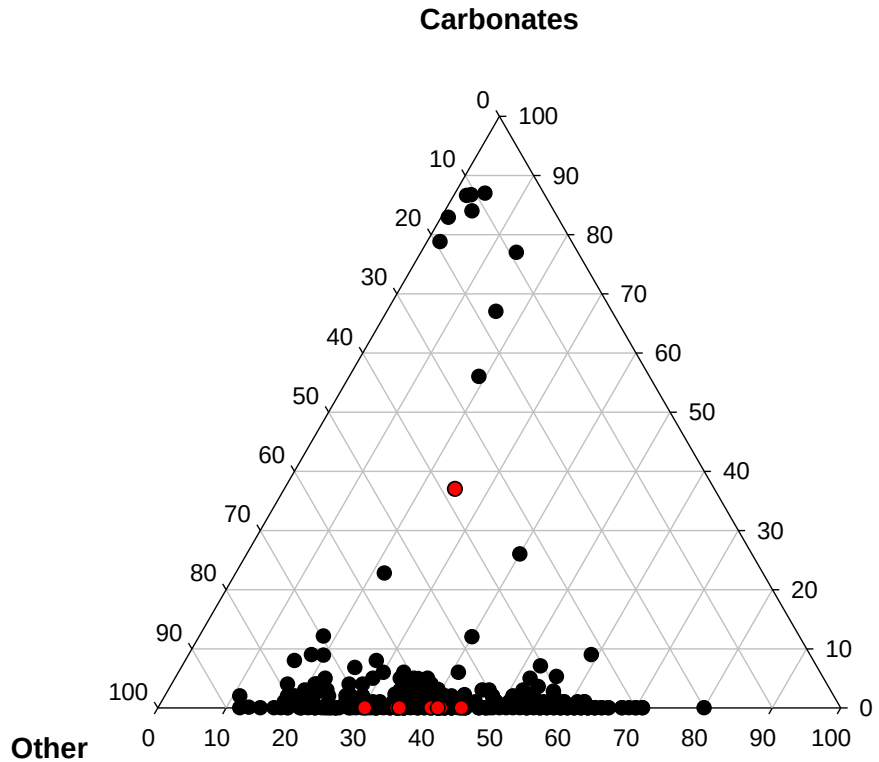
Objectives

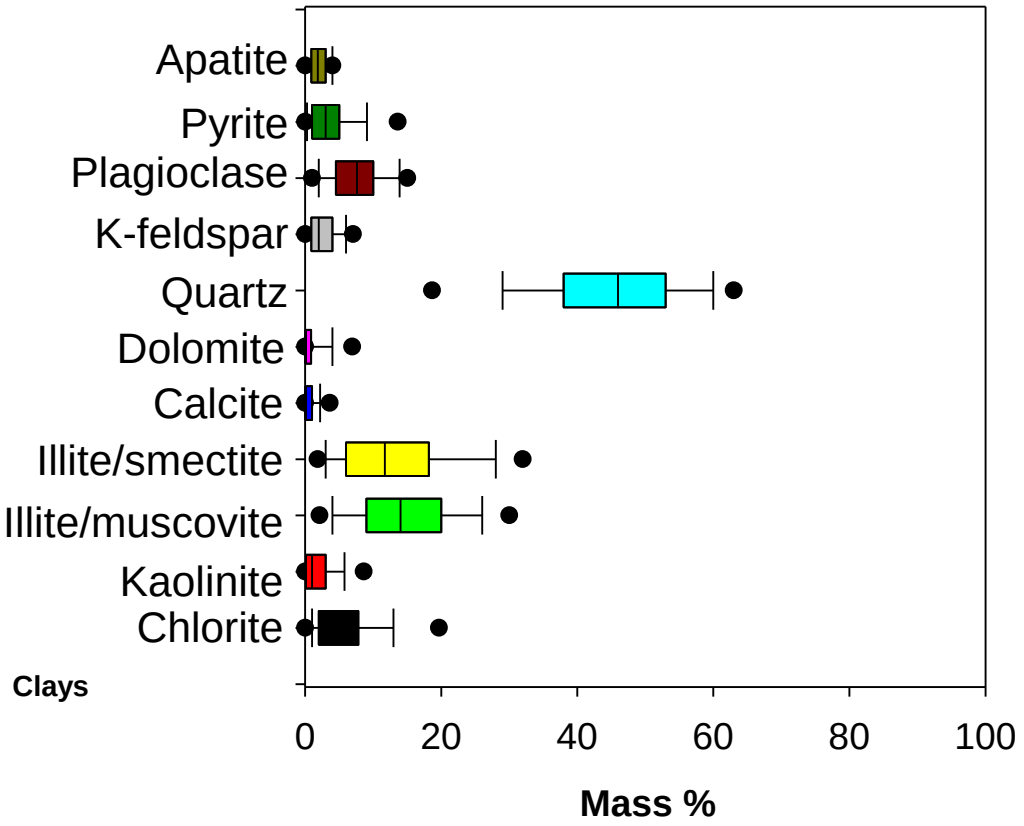
- Expand database on reservoir characteristics of the Velkerri Fm.
- Evaluate alternative thermal maturity indices using Raman spectroscopy
- Assess timing of hydrocarbon generation and migration using geochronology and fluid inclusion analysis



Reservoir characteristics of the Velkerri Fm

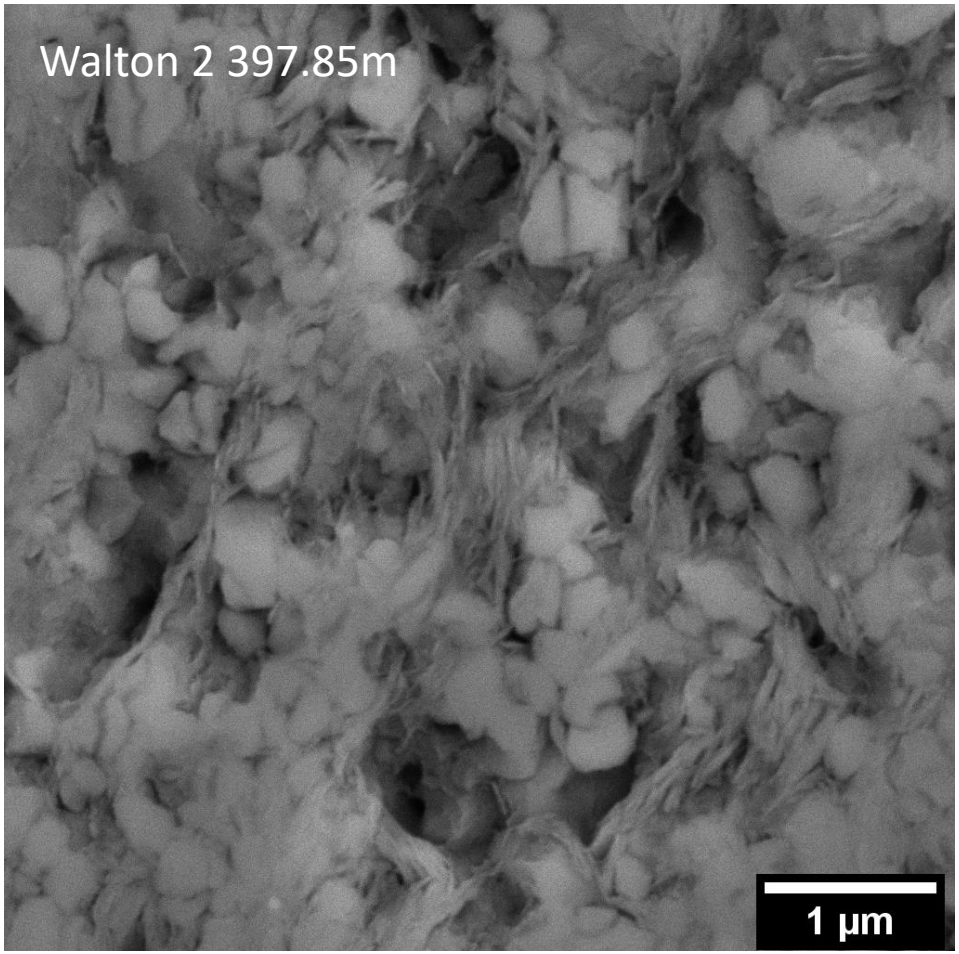
XRD mineralogy

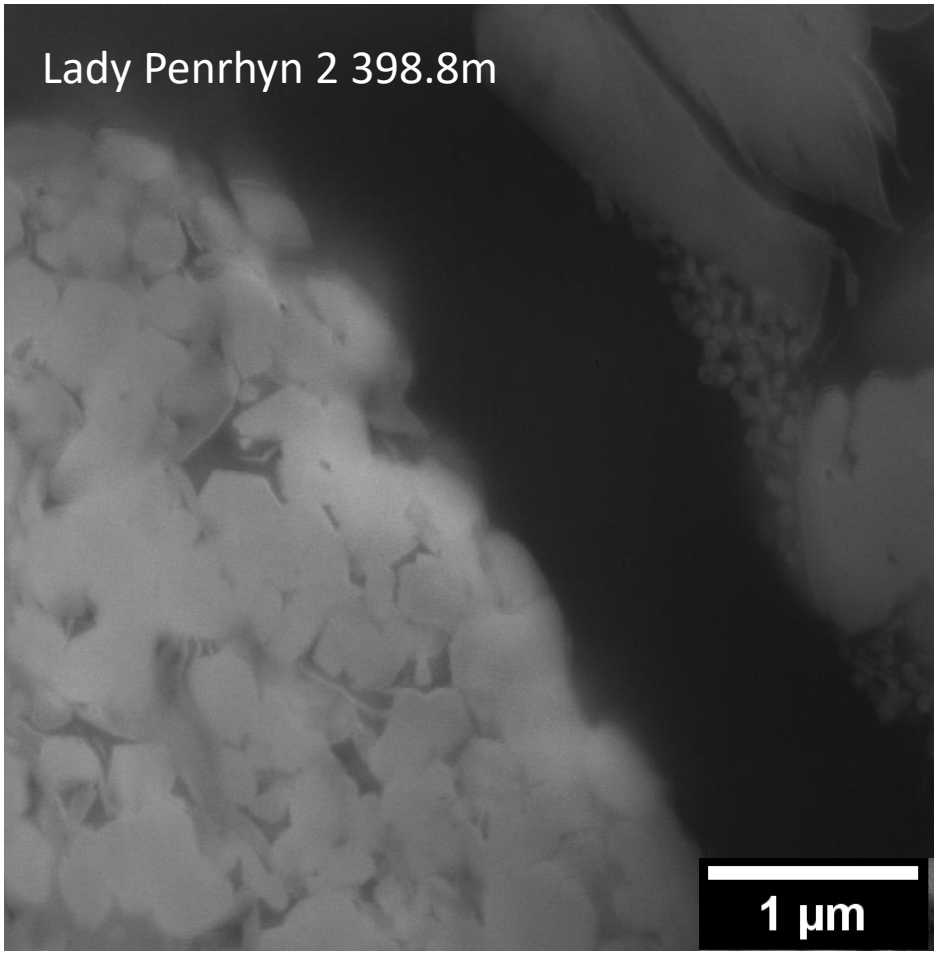




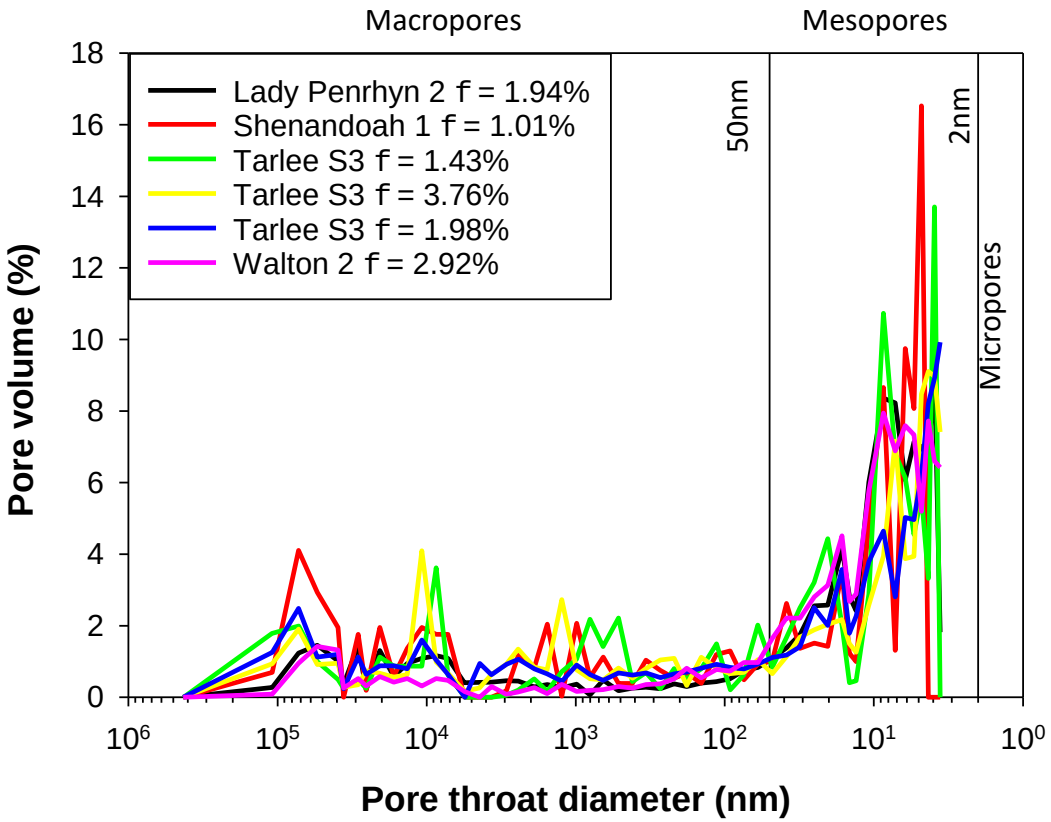
- NTGS DIP014 (n = 178)
- CSIRO (n = 6)

SEM images of microcrystalline quartz



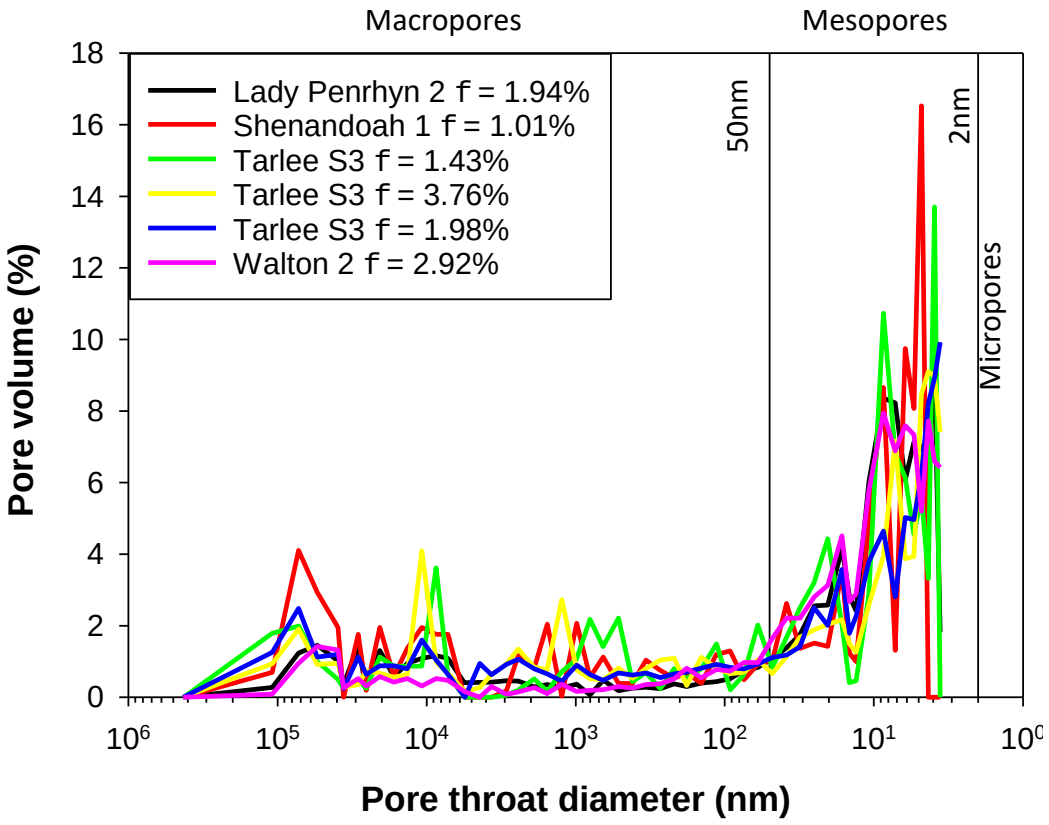


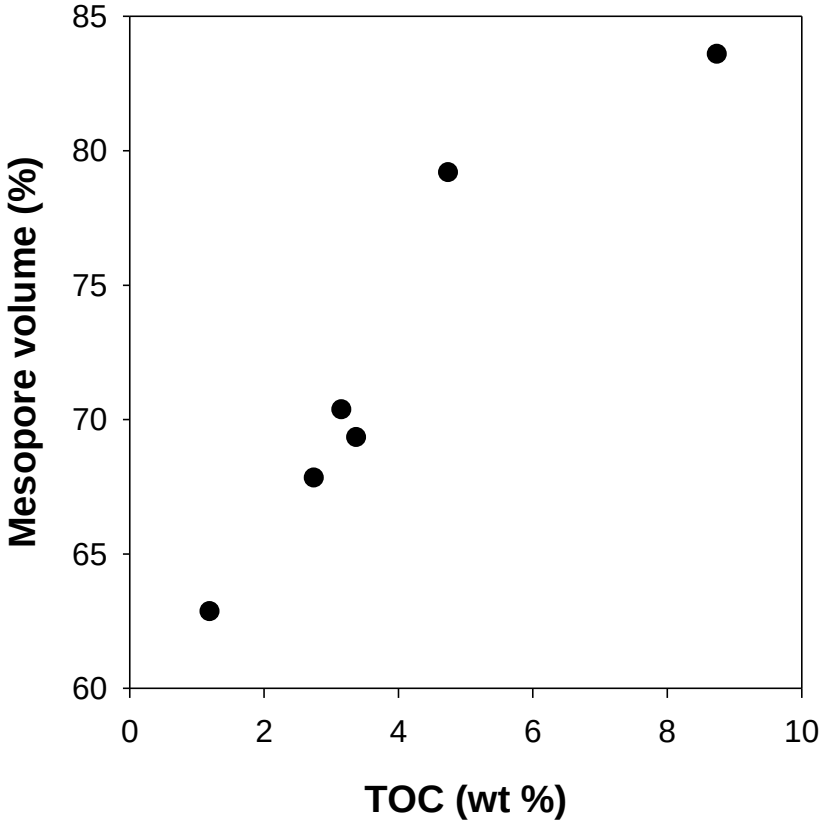
Pore size distribution: Hg porosimetry



Most of the accessible porosity is in the small mesopore range (i.e. < 10 nm)

Pore size distribution: Hg porosimetry

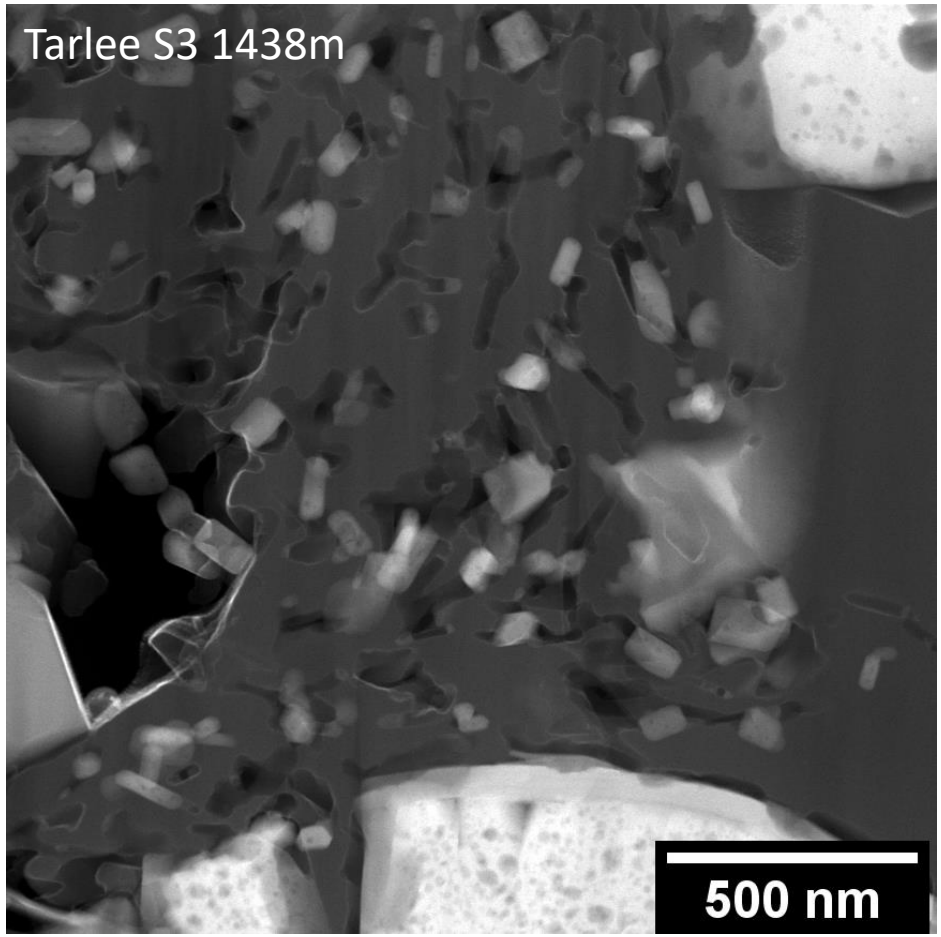


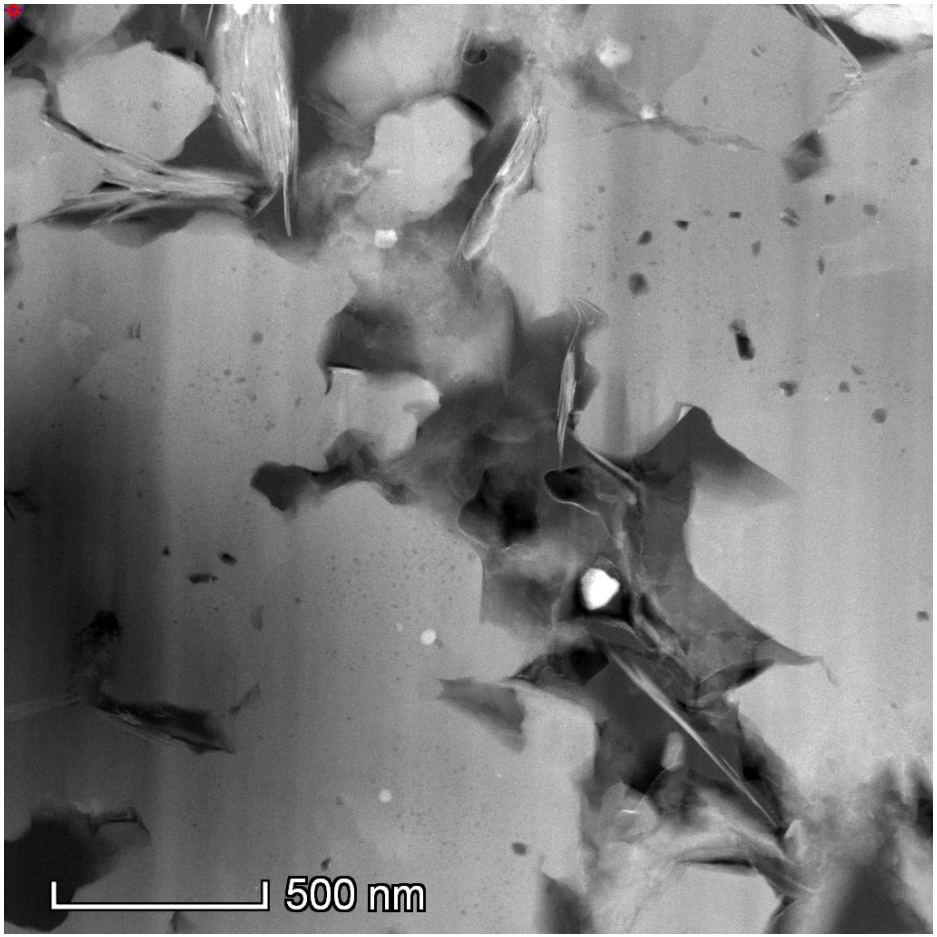


Most of the accessible porosity is in the small mesopore range (i.e. < 10 nm)

Positive correlation between TOC and % of mesopores (50 <d < 10 nm)

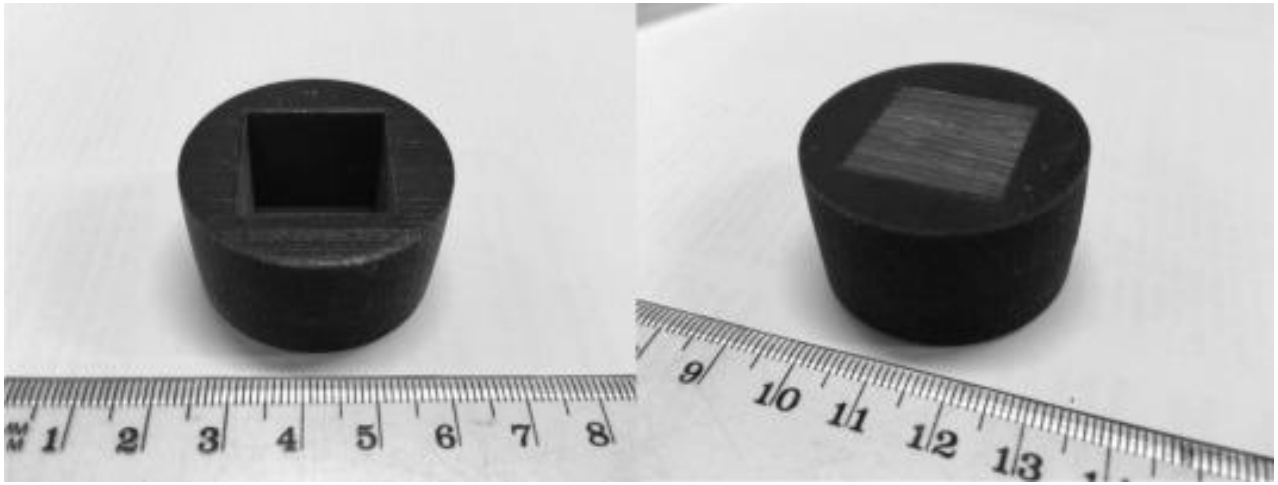
TEM images of organic hosted porosity

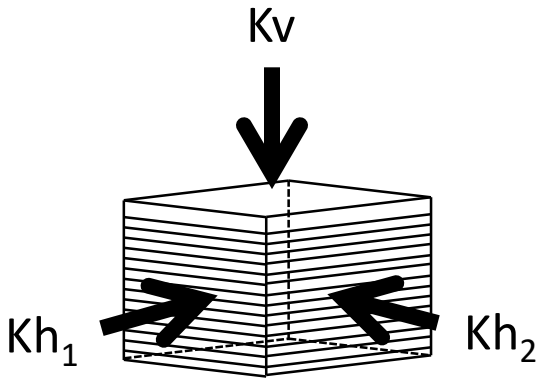




Experimental CH4 permeability

Stress and directional dependency of permeability using cubic samples



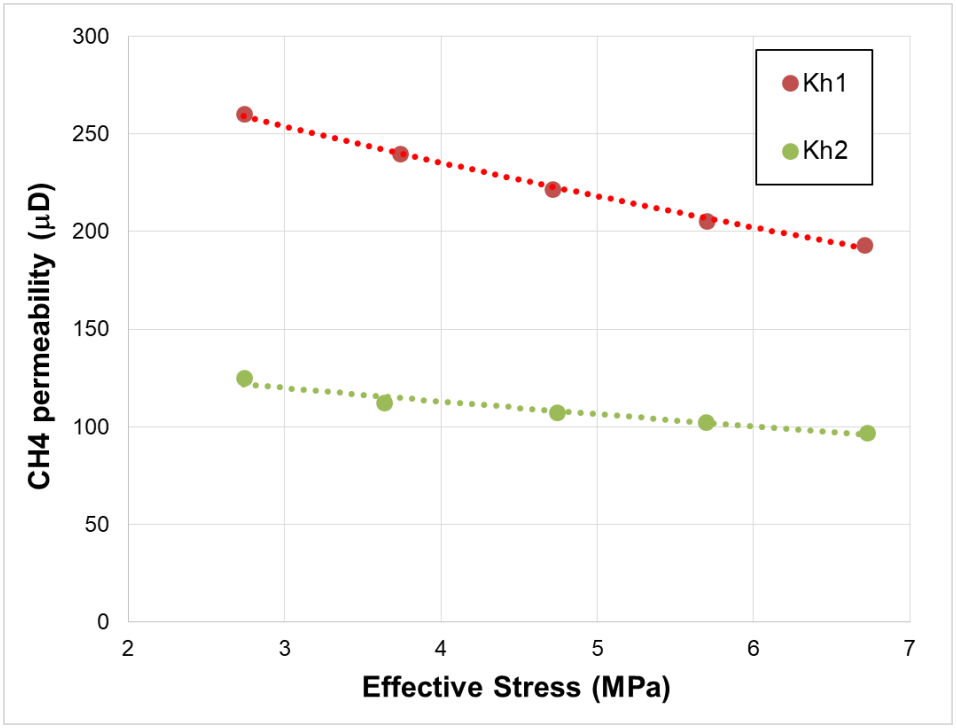


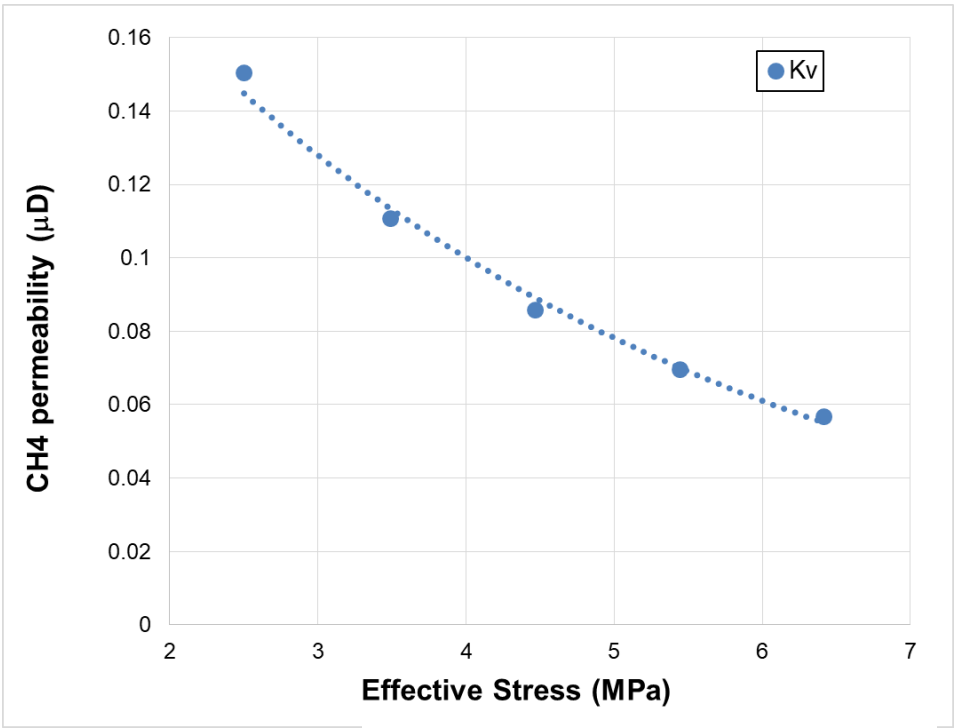
Pan et al 2015

Experimental CH4 permeability

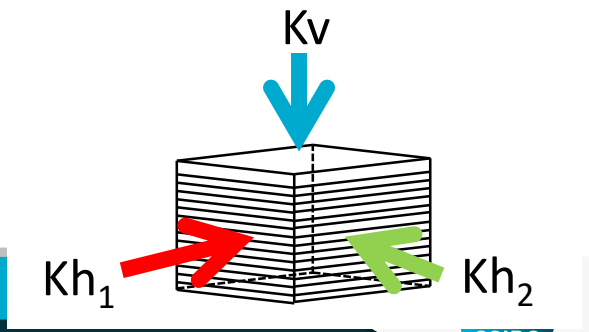
Limited experimental data due to complications with sample preparation

Experimental CH4 permeability Tarlee S3 sample



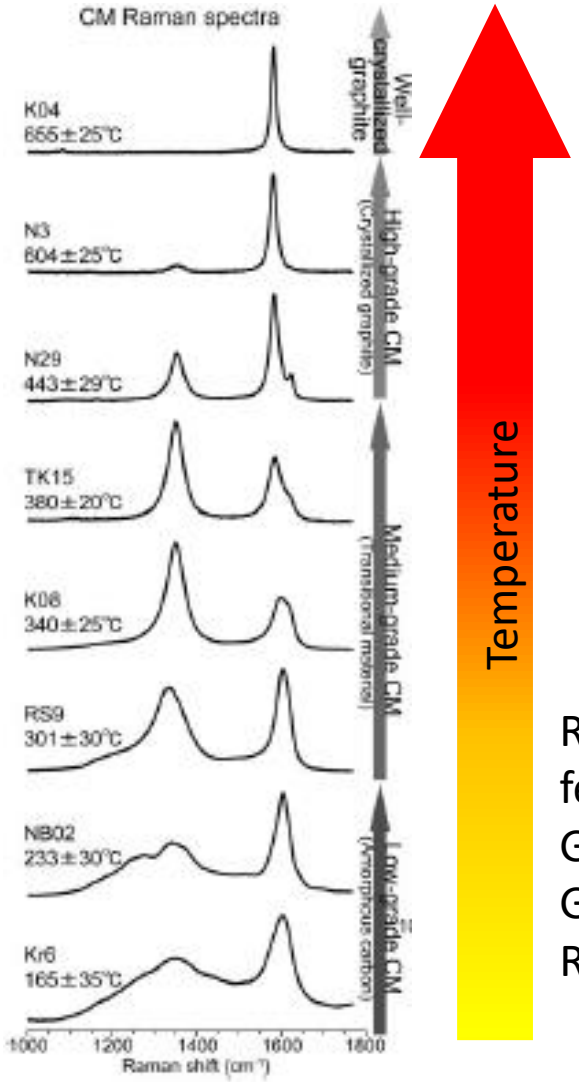


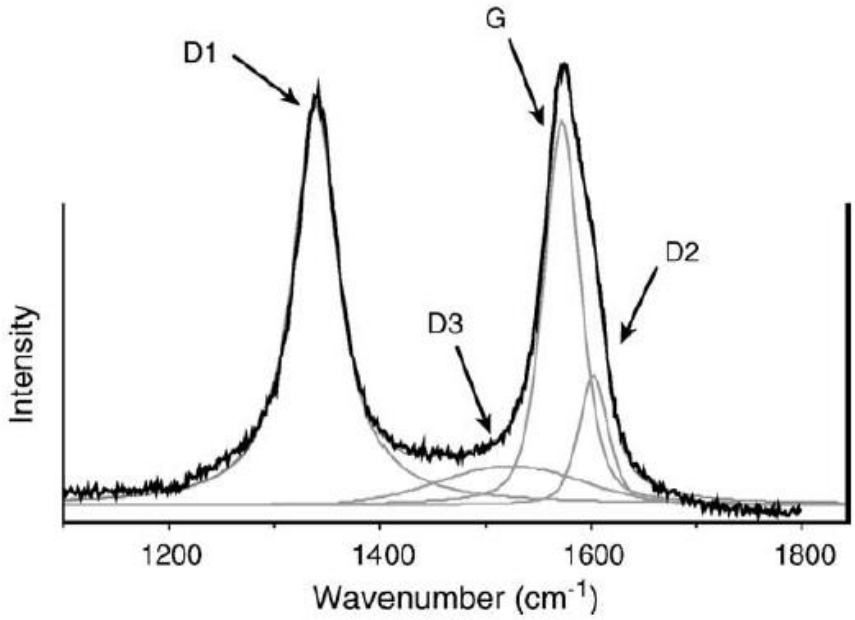
Along bedding permeability is more than 3 orders of magnitude higher than that across bedding



Evaluation of thermal maturity using Raman spectroscopy

Raman spectroscopy: organic matter





Raman spectra of carbonaceous material show two main features:

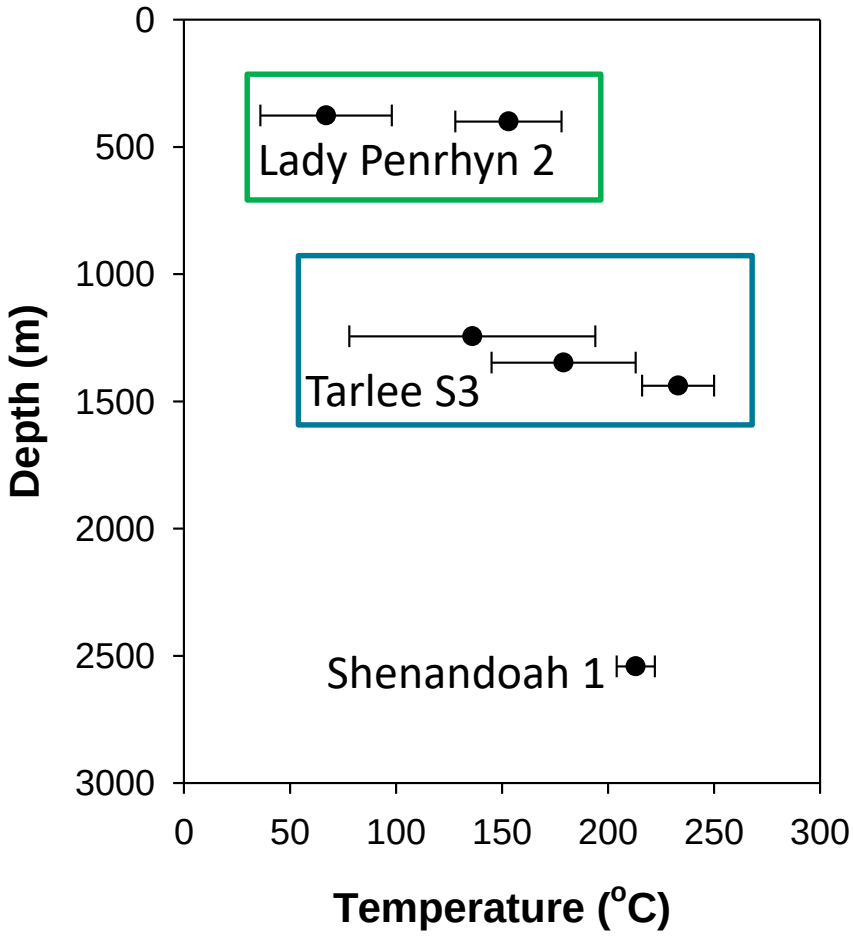
G peak (1580–1600 cm^{-1}) and the D peak (1350 cm^{-1})

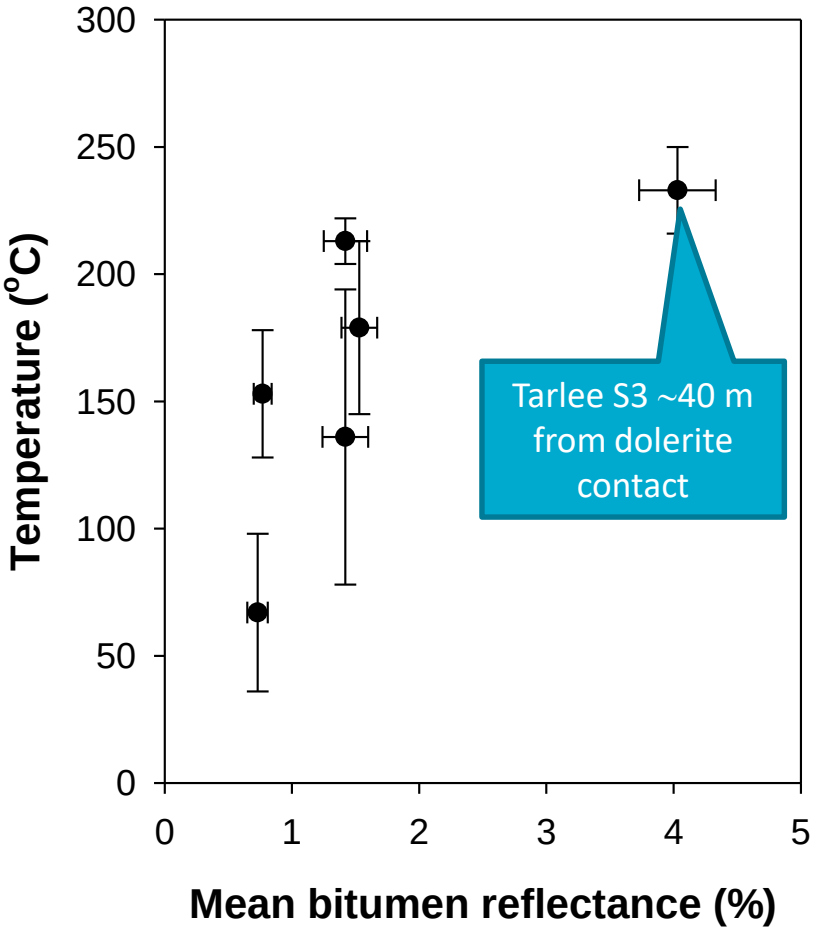
G and D peaks are seen to evolve with increasing temperature

Raman signal of OM can be used as a geothermometer

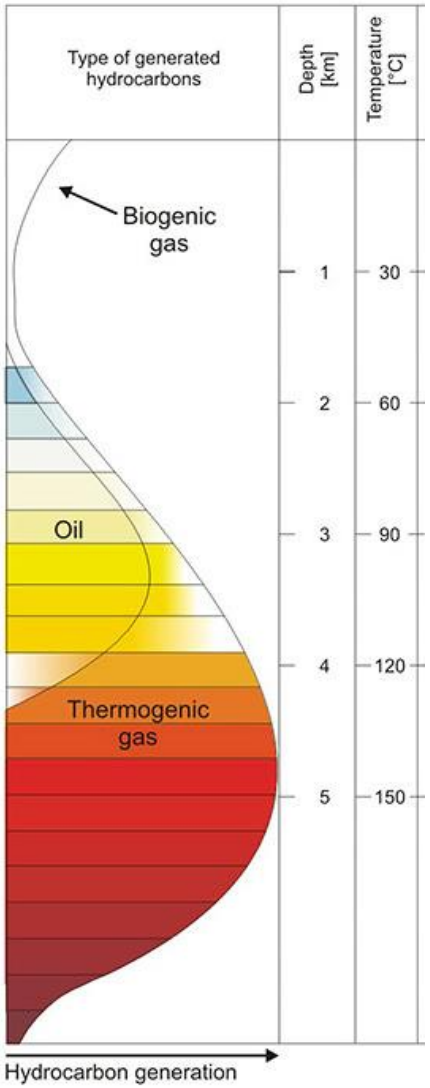
Kouketsu et al 2014

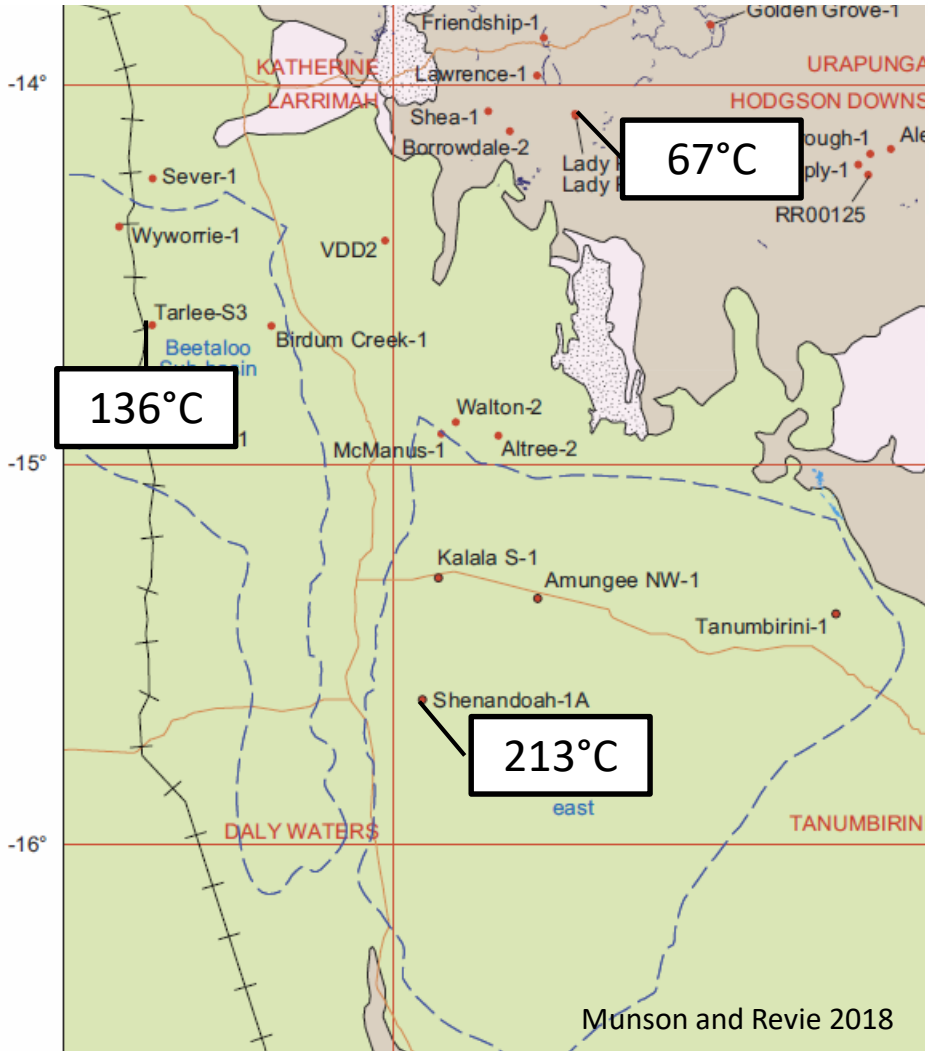
Raman geo-thermometry

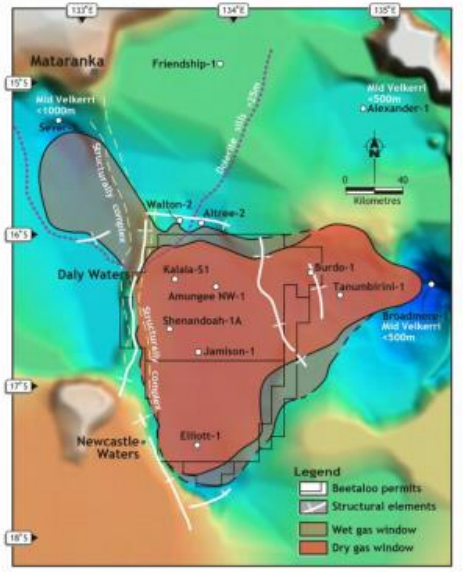




Palaeo-temperature and prospectivity







Dry gas

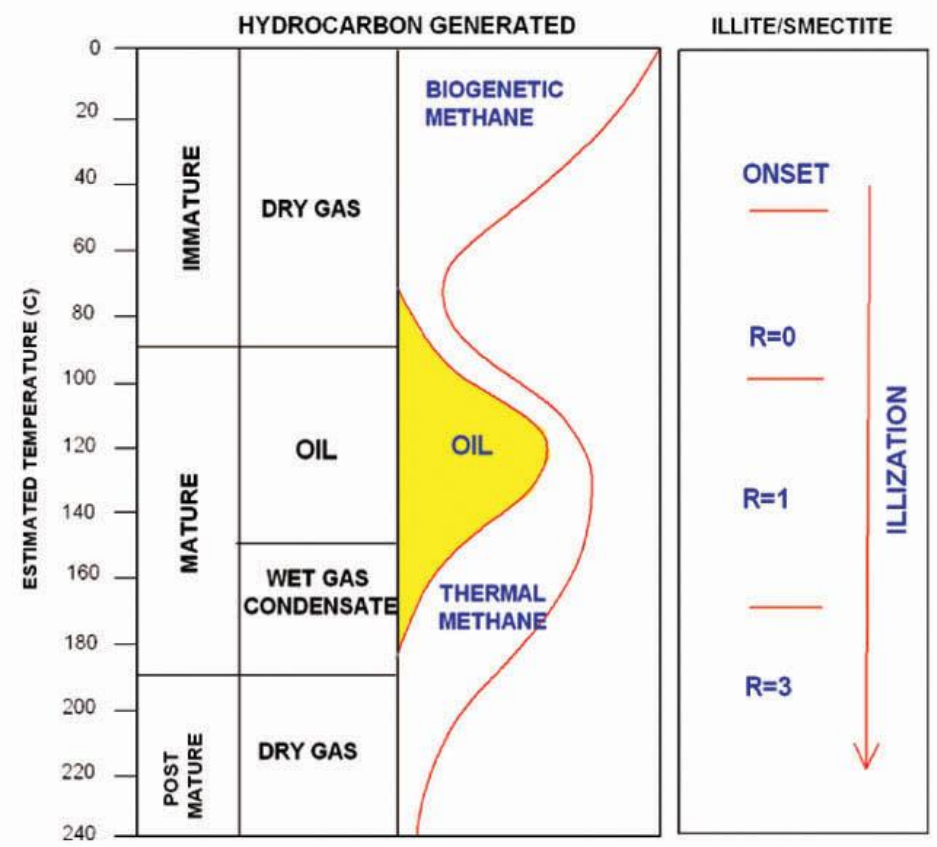
Wet gas

Close et al 2016

Timing of hydrocarbon generation and migration

Geochronology: K-Ar dating

- Illitization of smectite is one of the most common diagenetic processes in siliciclastic rocks
- Illite contains K and is therefore suitable for K-Ar dating
- Illite forms in shales in response to heating in the same temperature range as hydro-carbon formation
- K-Ar dating offers clues about timing of hydrocarbon generation



Geochronology: U-Pb dating

Calcite U-Pb dating: dating fluid flow event responsible for precipitation of calcite in fractures

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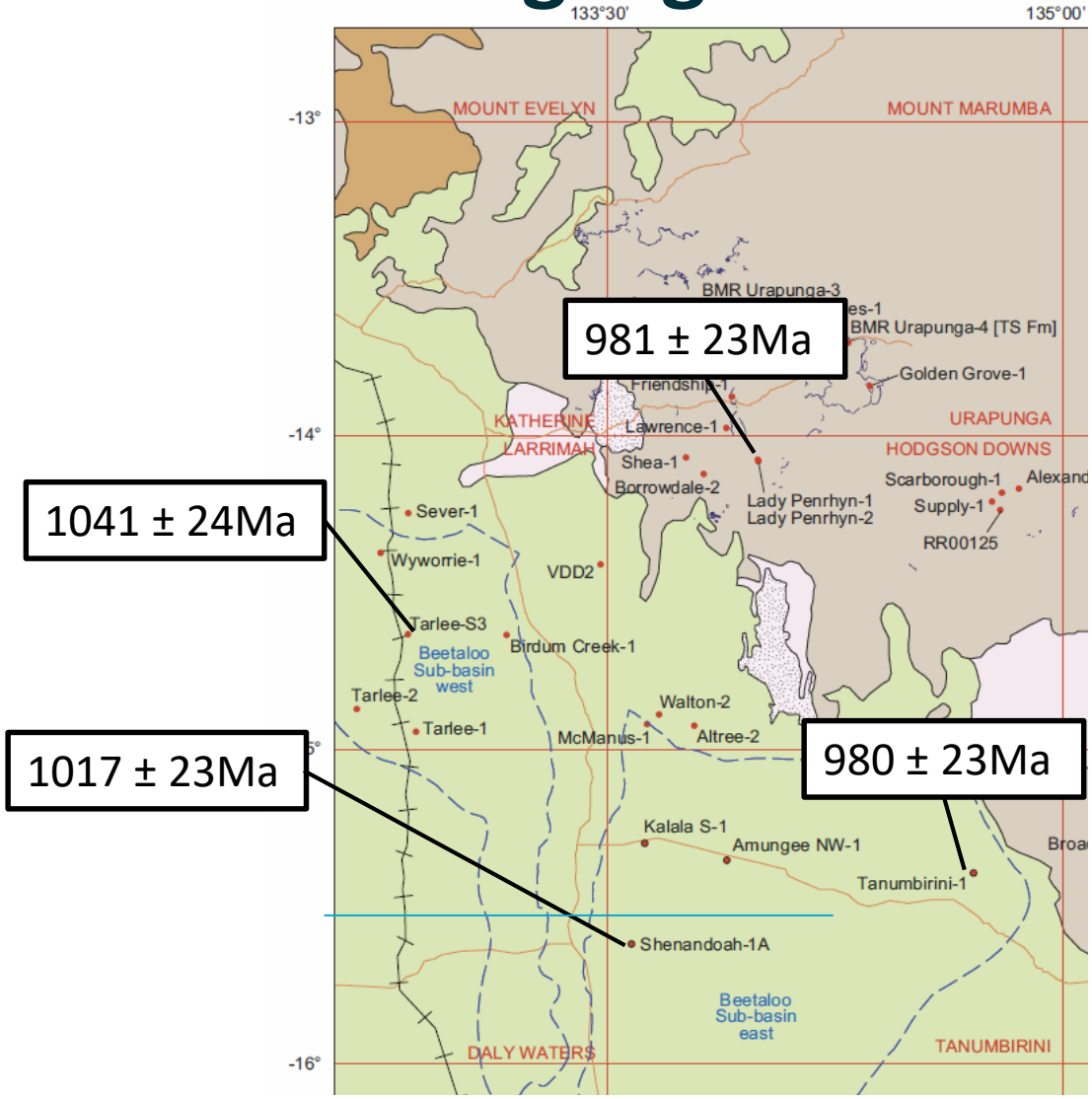
K-Ar illite dating: age of thermal maxima



K-Ar ages are broadly consistent across different holes

Later stages of amalgamation of the Rodinia supercontinent

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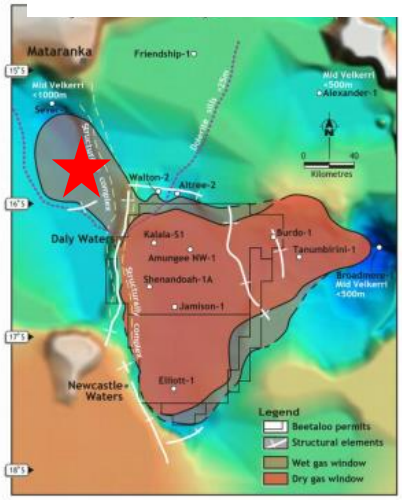
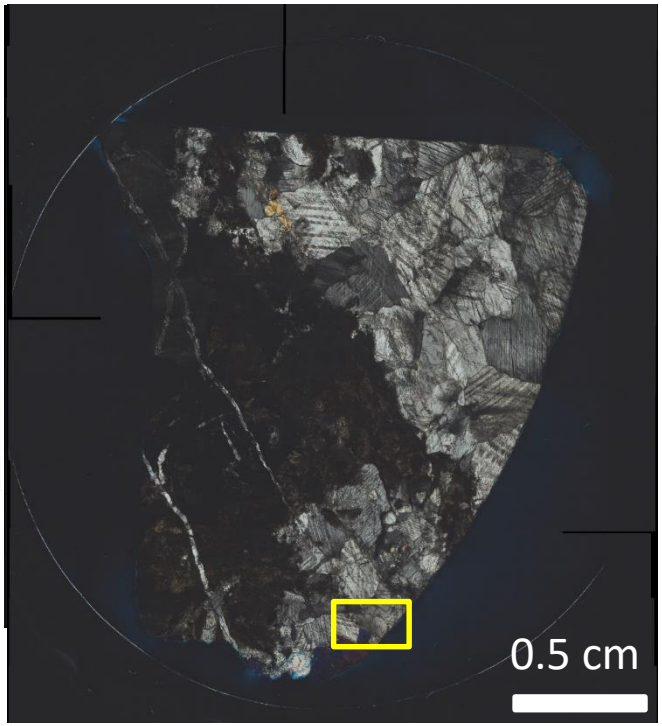
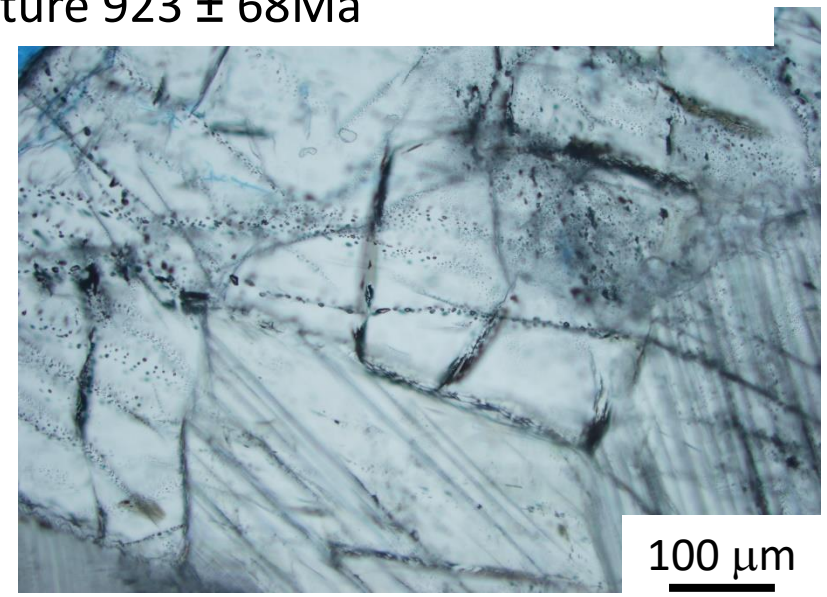
Tarlee S3 (1509.35 m)

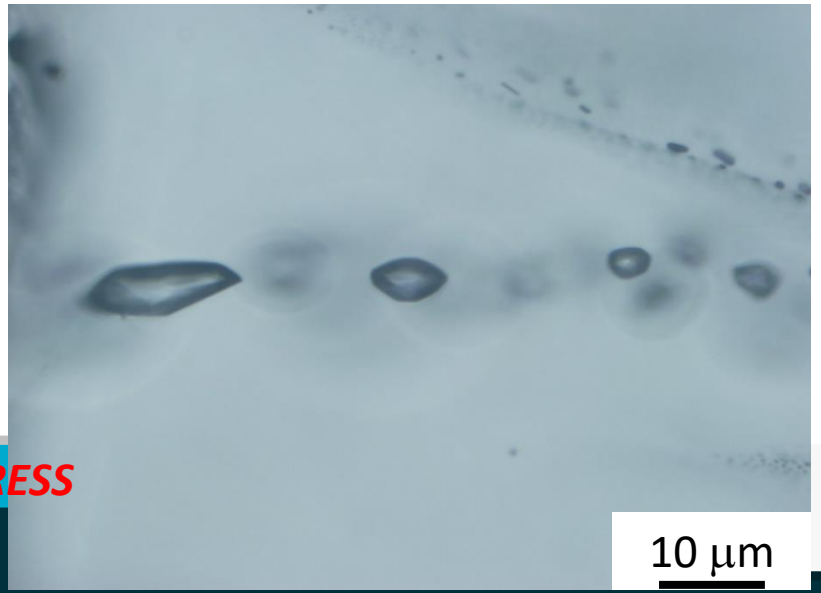
U-Pb age of calcite filling fracture 923 ± 68Ma



Well in gas mature part of the basin







Gas-bearing inclusions trapped in the calcite filling fractures

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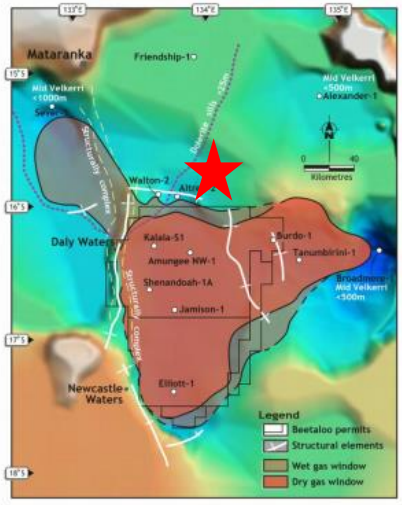
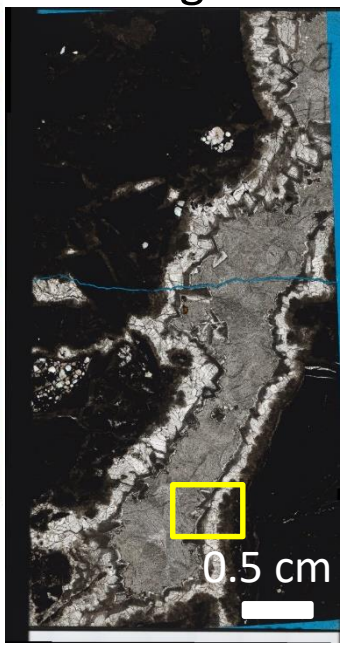
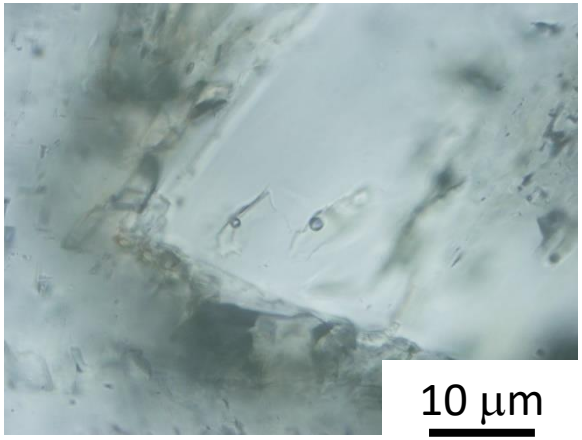
Borrowdale 2 (113.7 m)

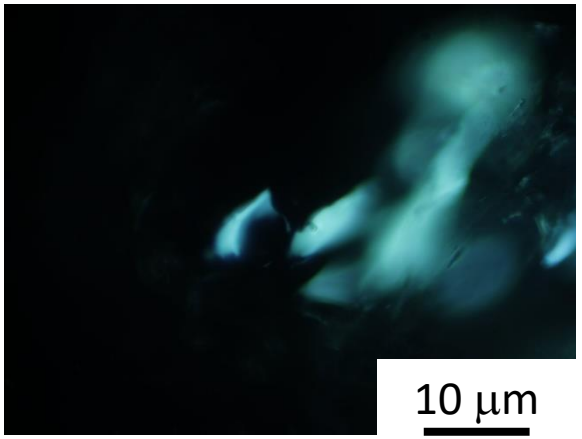
U-Pb age of calcite filling fracture 118 ± 14Ma



Well in oil mature part of the basin

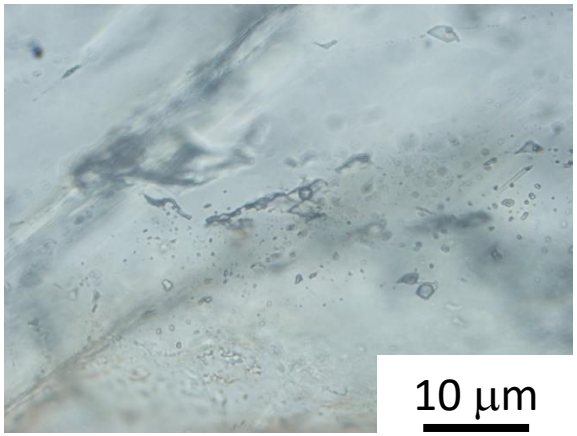


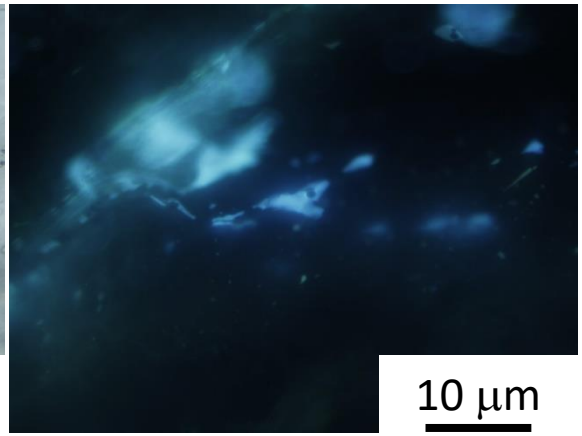




Transmitted light

UV fluorescence





Oil-bearing inclusions trapped in the calcite filling fractures

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Summary

- Pore system in Velkerri Fm. dominated by meso- and micro-pores controlled by abundance of organic matter
- Permeability is highly anisotropic and this should be accounted for in models production scenarios
- Raman geothermometry, K-Ar geochronology and gas in fluid inclusions indicate a temperature maximum at ca. 1040 – 980 Ma possibly coinciding with hydrocarbon generation in the W part of Beetaloo Sub-Basin
- Younger (118 ±14 Ma) fluid flow event assisted brittle fracturing and oil migration in the low maturity part of the Basin

Thank you

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