

High resolution analysis of carbonaceous texture within lenticular microstructure from Archean chert (SPF-FQ) of the Pilbara Craton (Western Australia)

Coutant Maxime, Lepot, K., Fadel, A., Addad, A., Javaux, E.J.,



LIÈGE université
Early Life



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de Lille



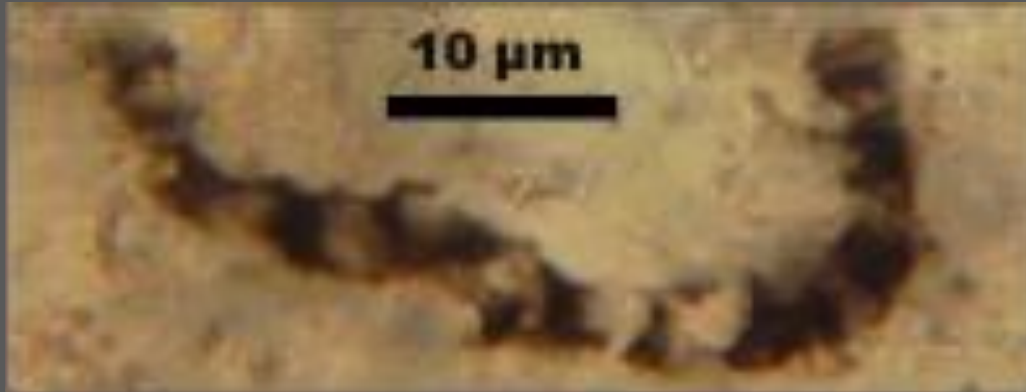
To be fossil or not fossil ?

3.46 Ga Apex Chert (Western Australia)

Stratiform chert

Filamentous microfossil

Cell lumina



Schopf & Packer, 1987

Schopf, 1993, 2006, 2007

Schopf & Kudryavtsev 2012

Schopf *et al.*, 2017

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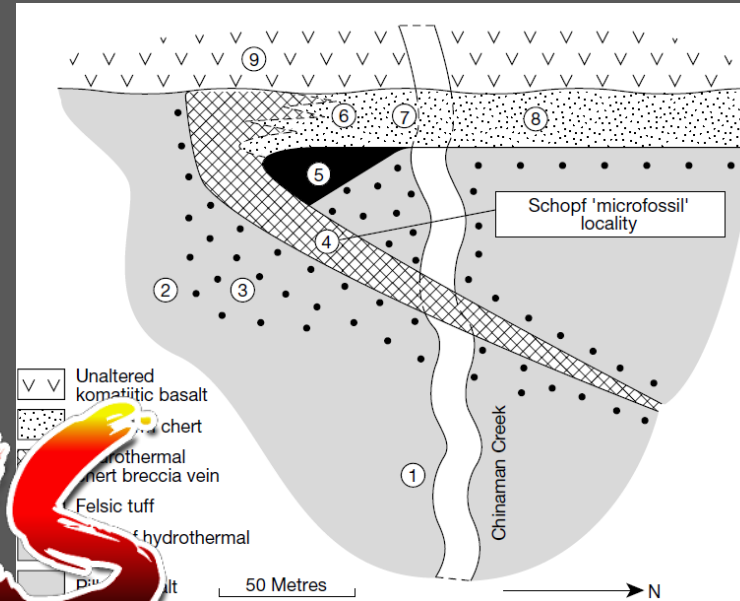
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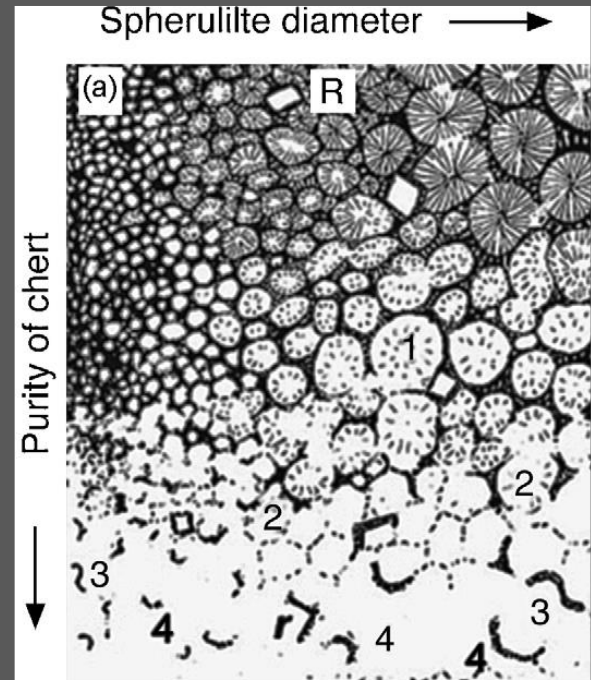
Cell lumina



Not sedimentary but hydrothermal



Organic diffusion through silica crystallization



Schopf & Packer, 1987
Schopf, 1993, 2006, 2007
Schopf & Kudryavtsev 2012
Schopf *et al.*, 2017

Brasier *et al.*, 2005, 2015
Wacey *et al.*, 2016, 2019

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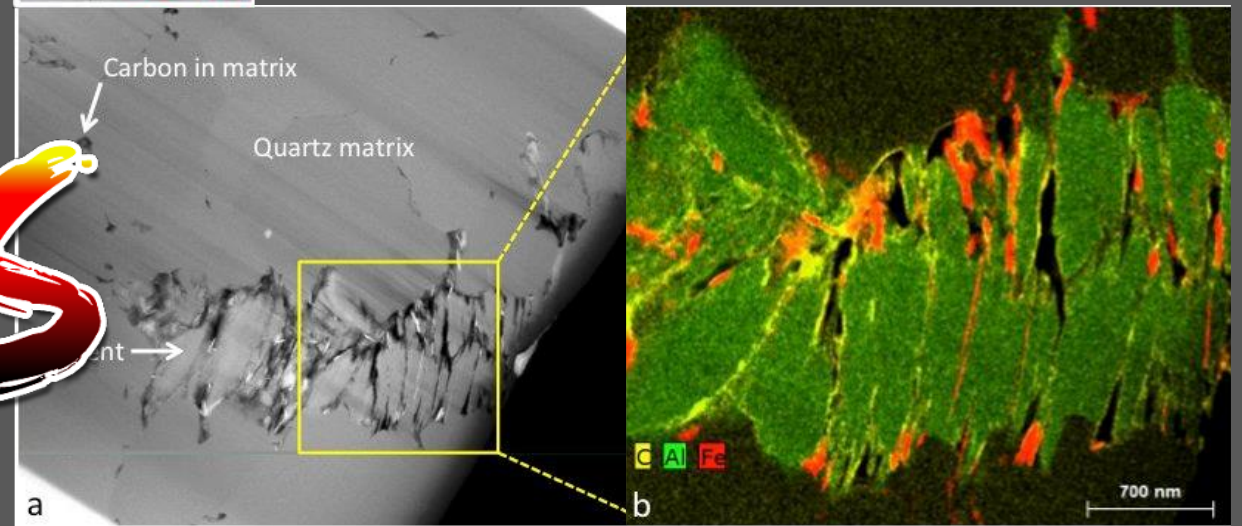
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Clay minerals that form the « cell wall »



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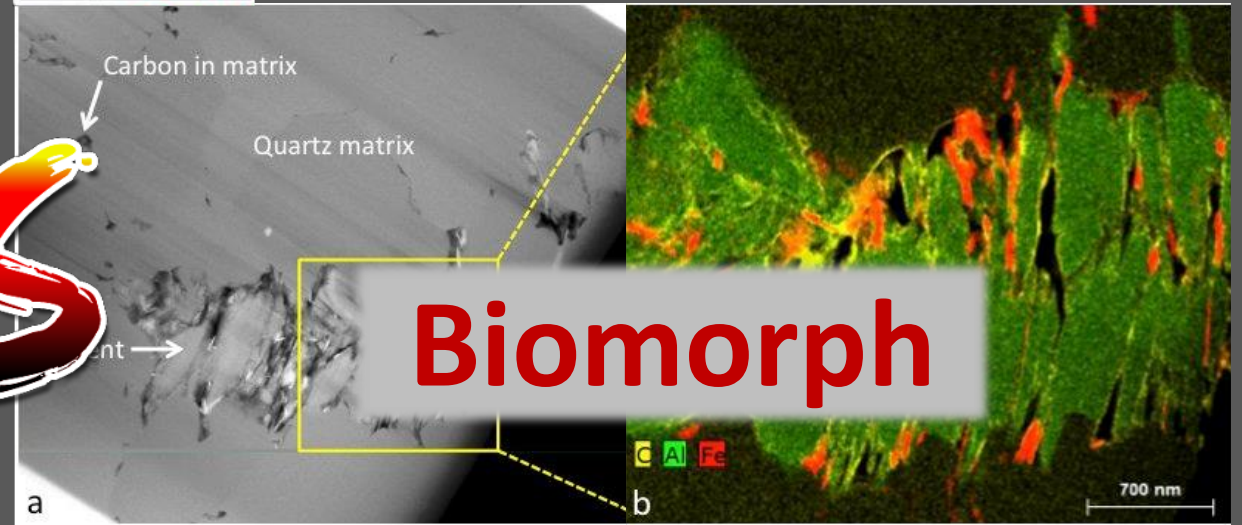
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3.4 Ga Strelley Pool Chert – 3.0 Ga Farrel Quartzite



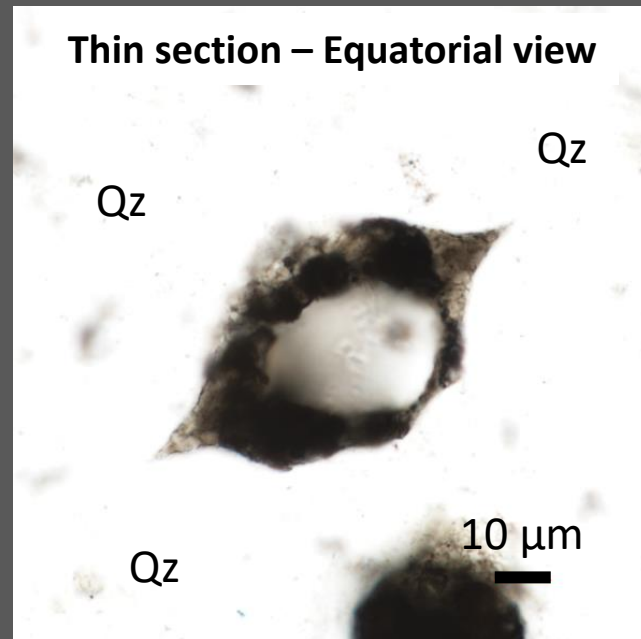
@Coutant



Sandstones – Volcaniclastic – Basalt
Massive black chert (>95% Qz)
Carbonaceous matter, pyrites, oxides, sulfides

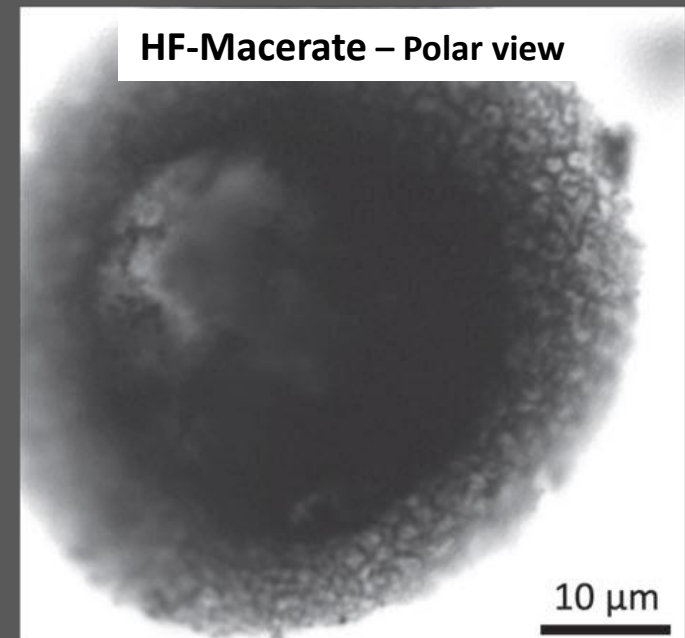
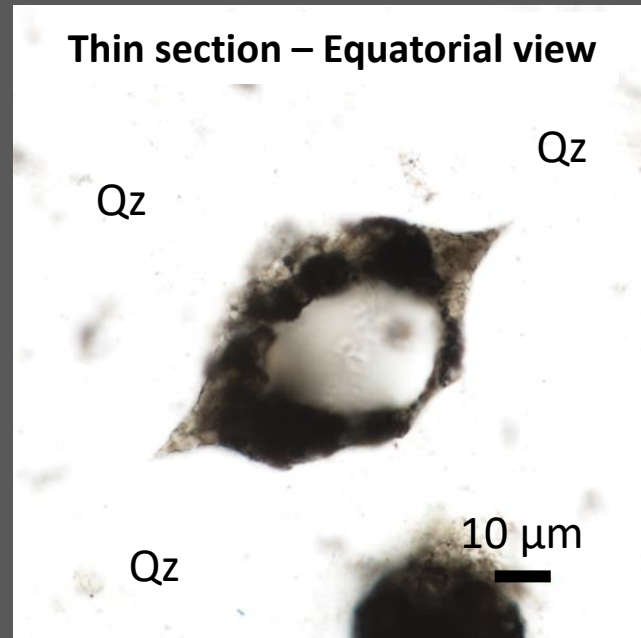
Carbonaceous Lenses of SPF & FQ cherts: morphology

- <100 μm length - <50 μm width – ovoid to circular



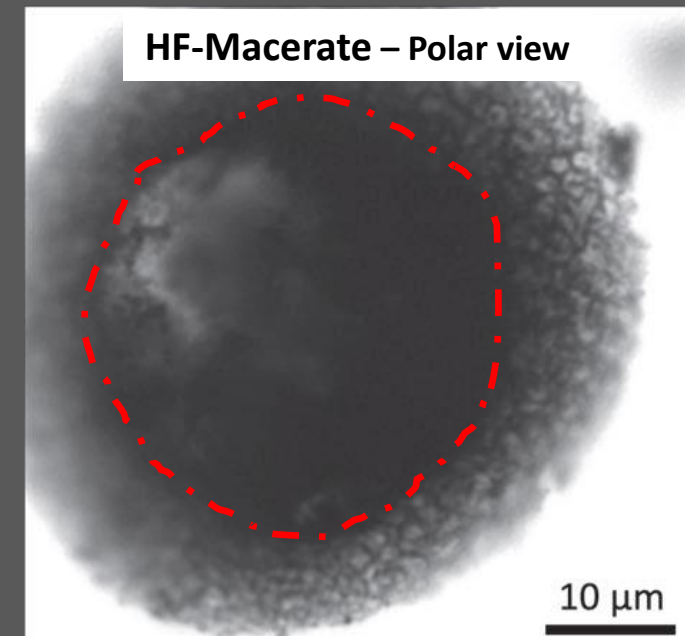
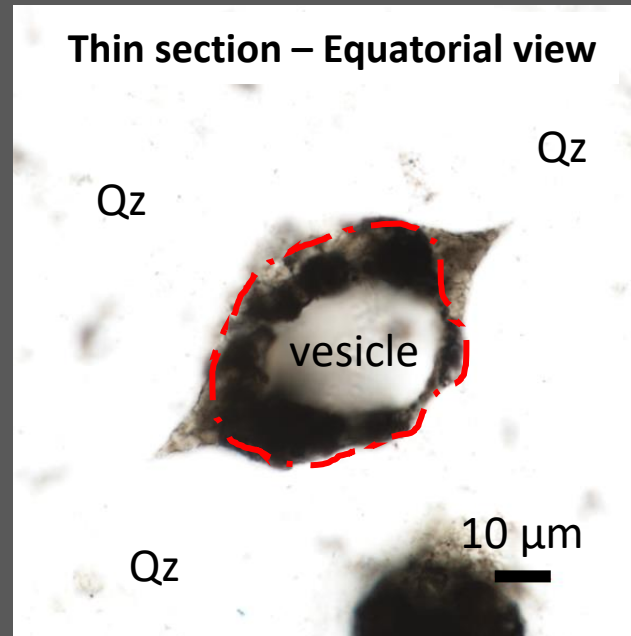
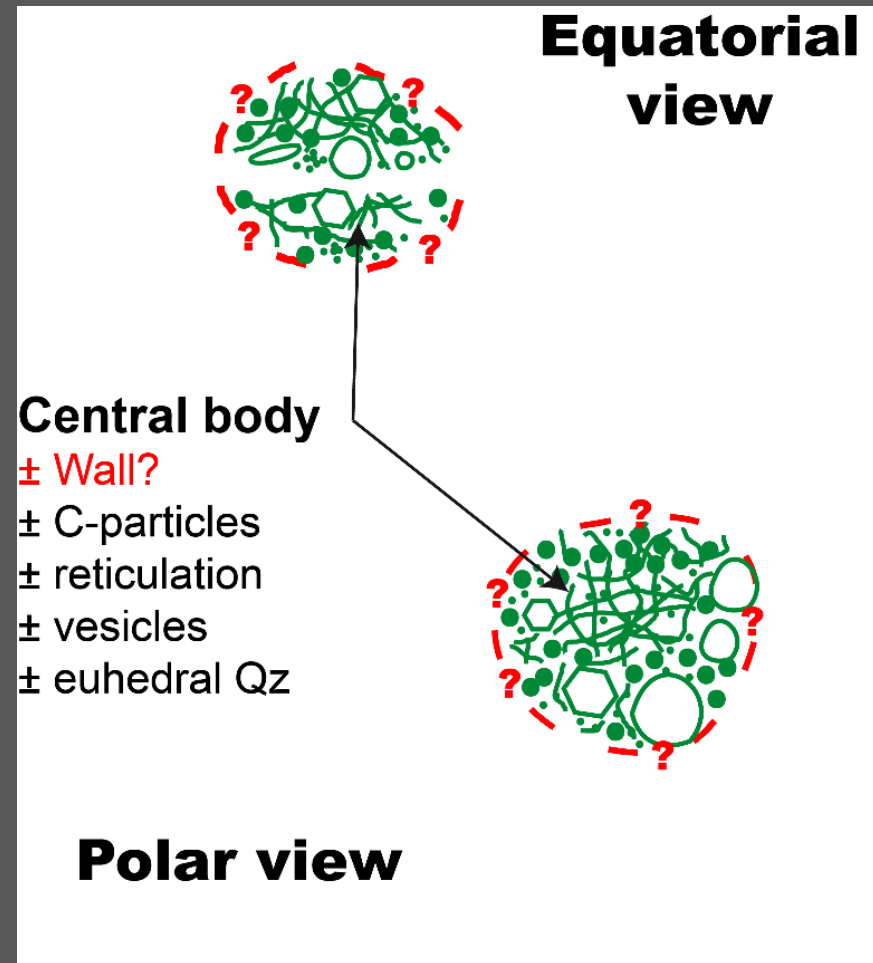
Carbonaceous Lenses of SPF & FQ cherts: morphology

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- Acid-resistant \rightarrow cohesive palynomorph



Carbonaceous Lenses of SPF & FQ cherts: morphology

- <math><100\ \mu\text{m}</math> length - <math><50\ \mu\text{m}</math> width – ovoid to circular
- Acid-resistant \rightarrow cohesive palynomorph
- ‘**Central body**’ CM – (partly) filled C-granules and/or silica



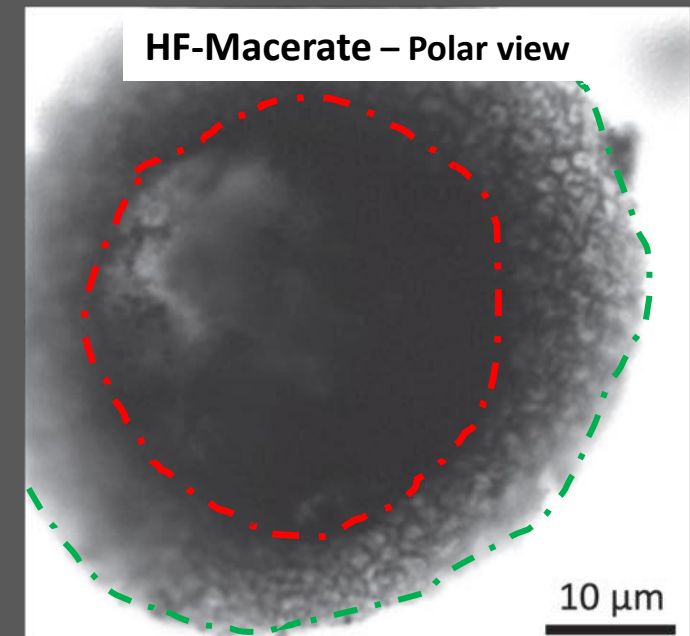
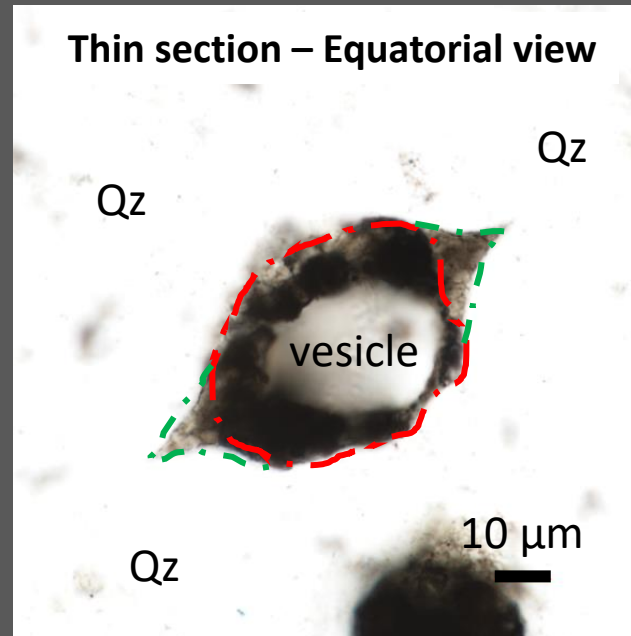
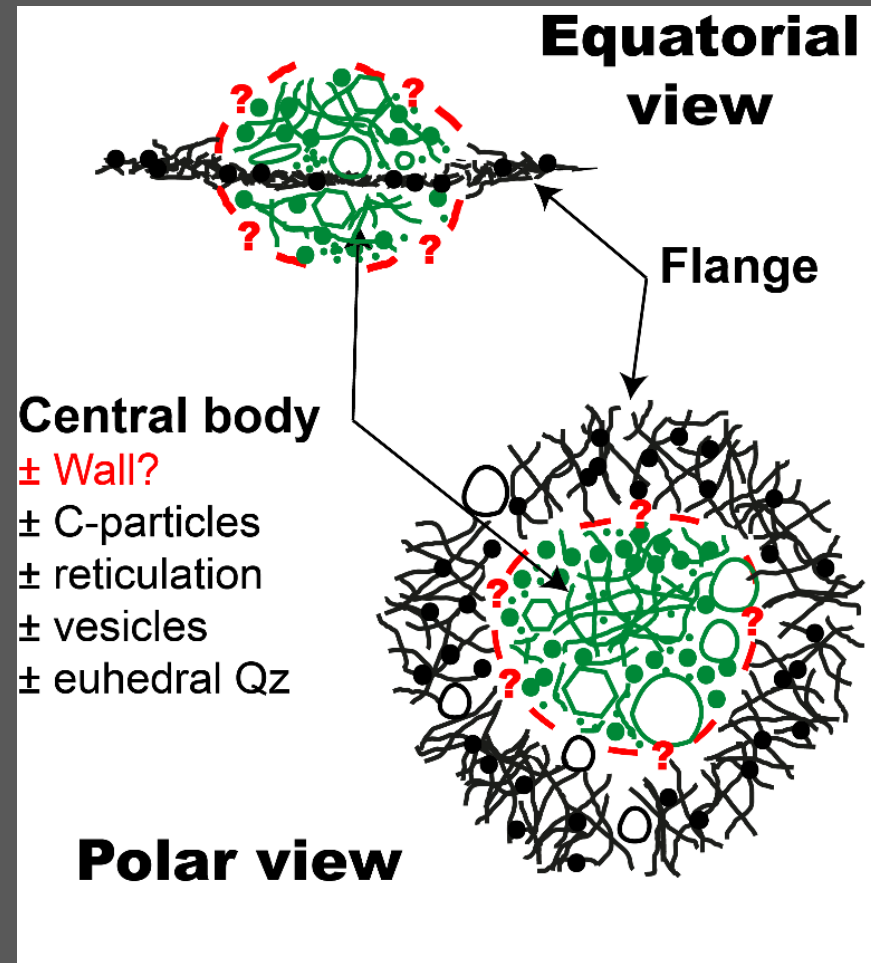
Coutant *et al.*, adapted from Sugitani *et al.*, 2018

Coutant *et al.*, in prep.

Sugitani *et al.*, 2015a

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- Acid-resistant \rightarrow cohesive palynomorph
- ‘**Central body**’ CM – (partly) filled C-granules and/or silica
- ‘**Flange**’ reticulated network of CM

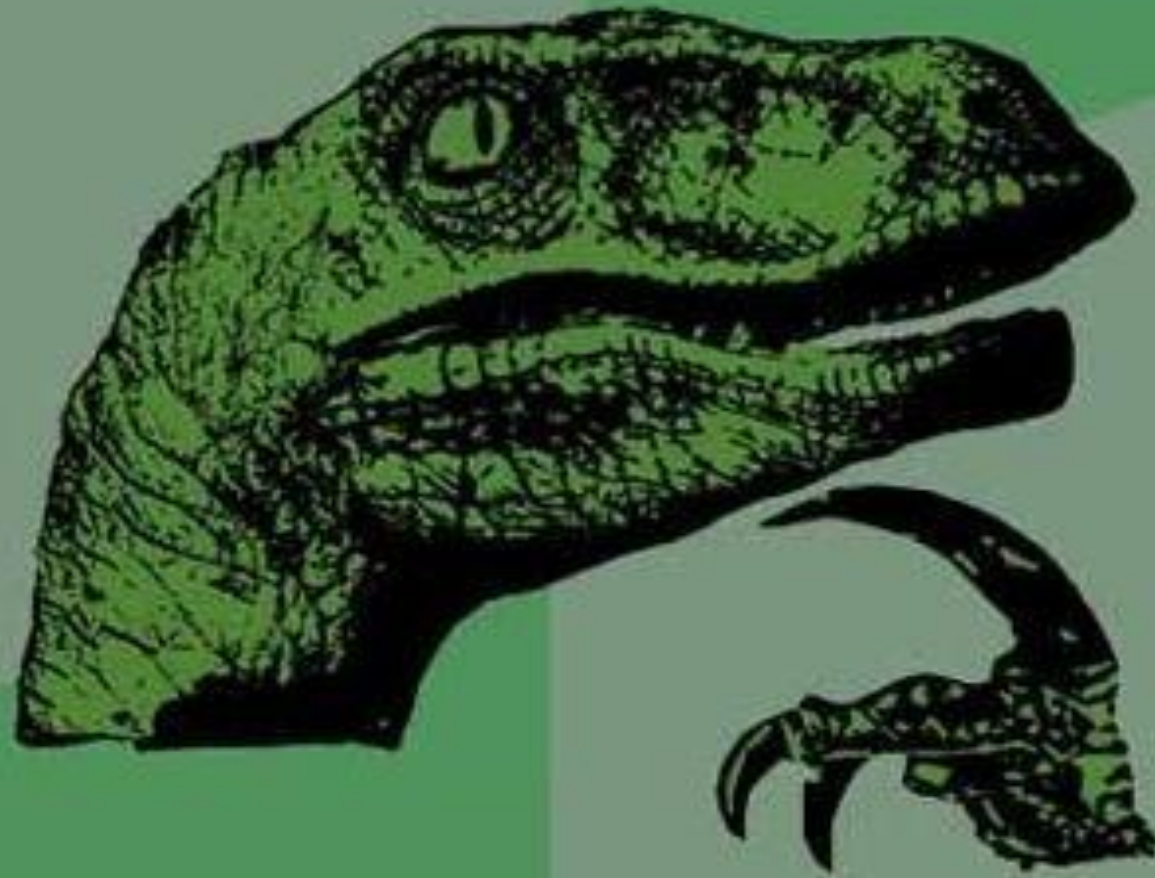


Coutant *et al.*, adapted from Sugitani *et al.*, 2018

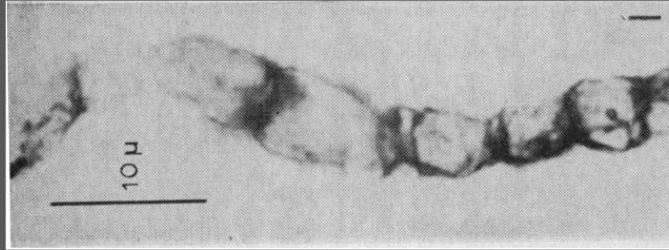
Coutant *et al.*, in prep.

Sugitani *et al.*, 2015a

Why looking at such weird object?

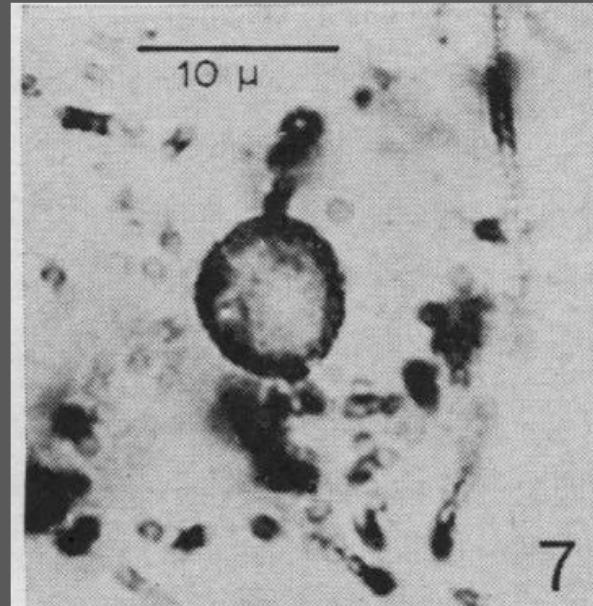


1.9 Ga Gunflint Formation μ fossils



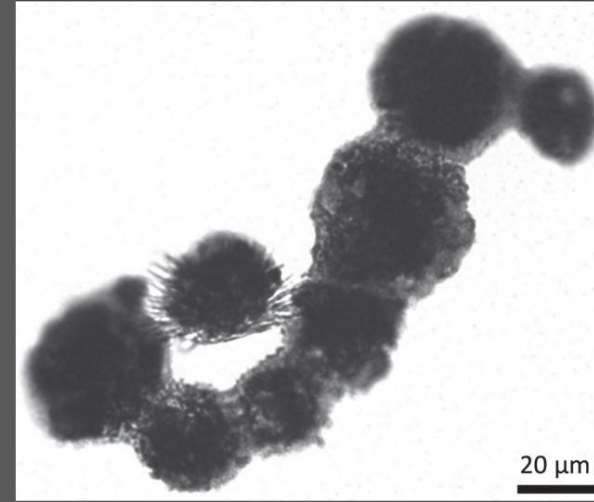
G. grandis

Barghoorn & Tyler, 1965

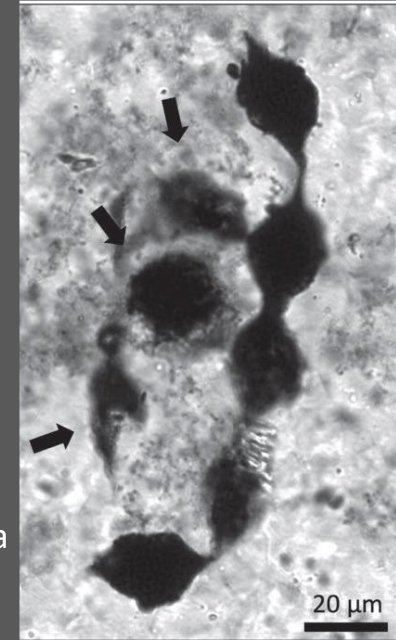


H. macroreticulata

3.4 Ga SPF – Chain of Lenses



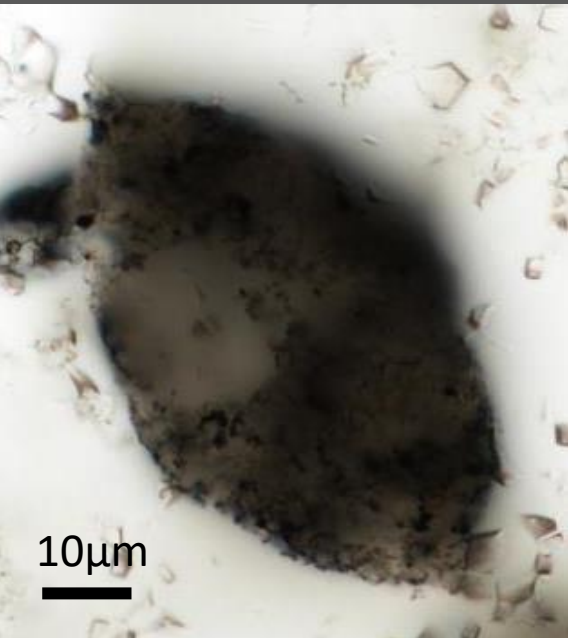
Sugitani *et al.*, 2015a



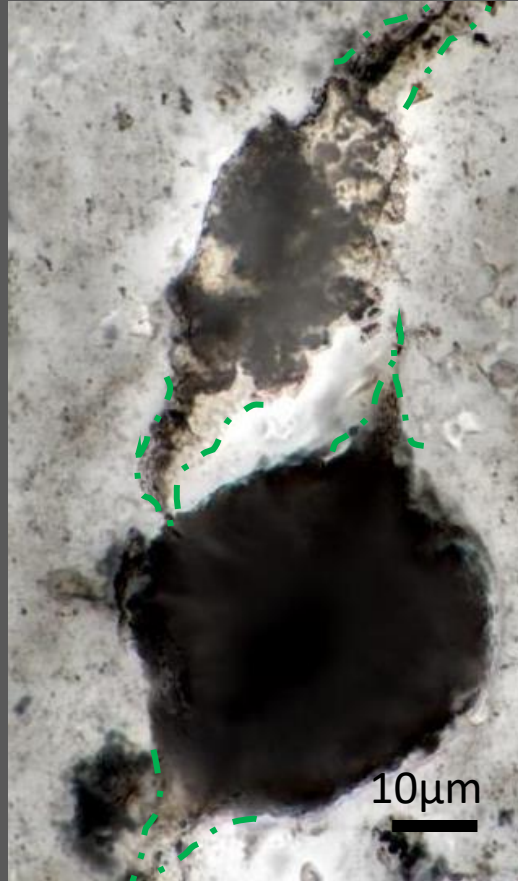
- Specific to **Archean** rocks
- **Multiple** shapes + **chained** specimens
- Best candidates for the **oldest μ fossil**

Different types of Lenses - Shapes gradation?

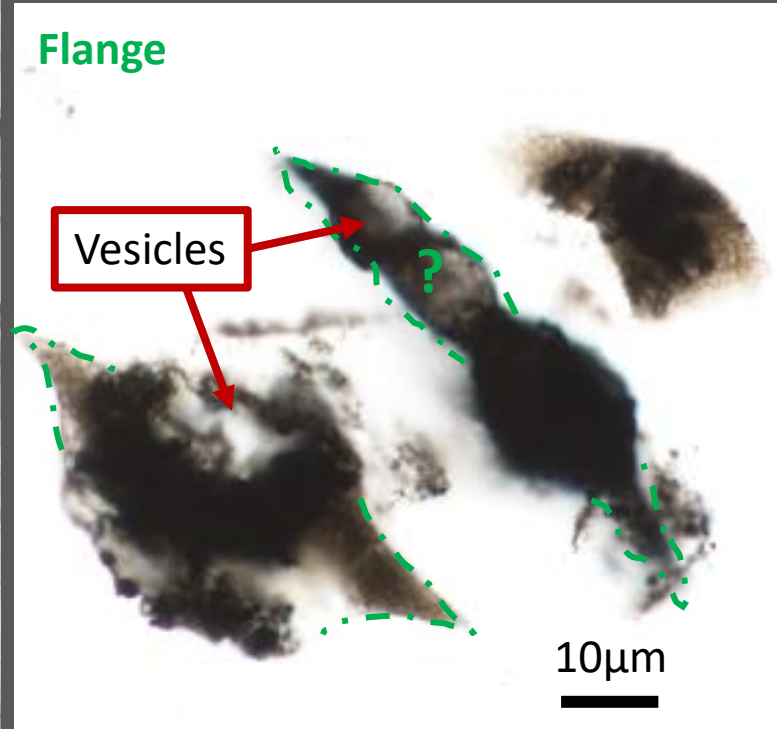
Flange-free



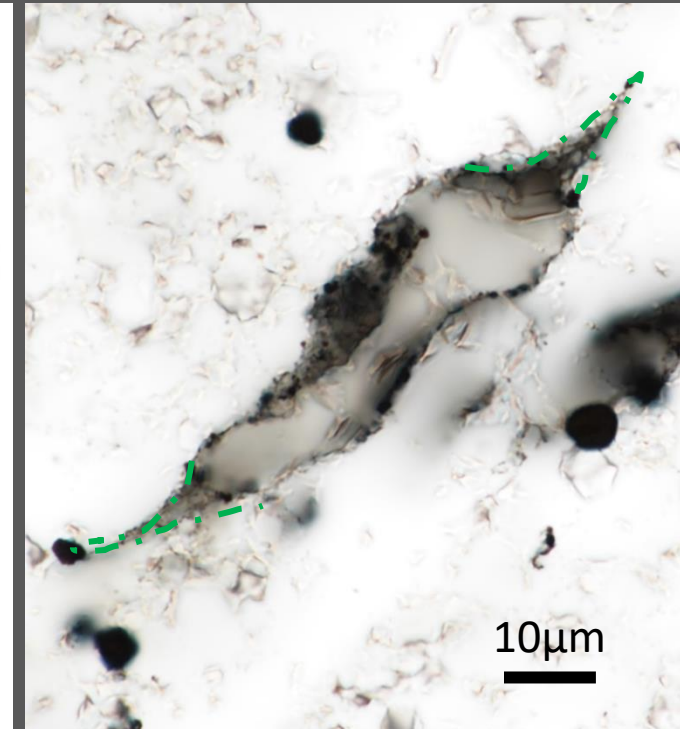
Granular



Sub-hollow



Hollow



Degradation ?
Silicification ?
Biogenicity ?



Coutant *et al.*, in prep

μ to nano Petrography – Qz-CM / Ultrastructure

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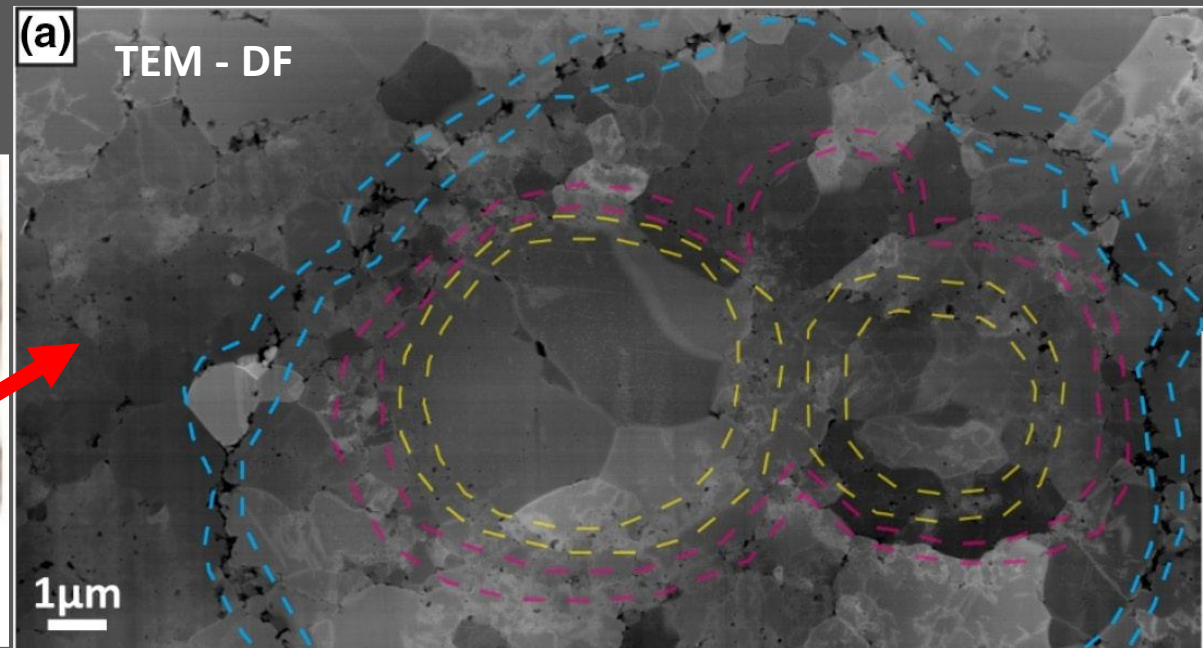
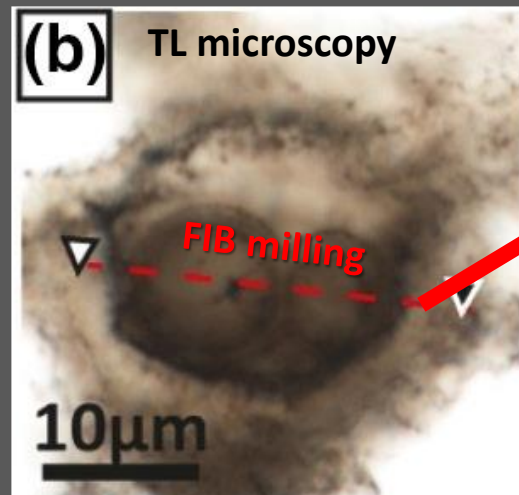
Distinguishing cellular from abiotic spheroidal microstructures in the ca. 3.4 Ga Strelley Pool Formation

Maxime Coutant^{1,2} | Kevin Lepot^{1,3} | Alexandre Fadel⁴ | Ahmed Addad⁴ |
Elodie Richard⁵ | David Troadec⁶ | Sandra Ventalon¹ | Kenichiro Sugitani⁷ |
Emmanuelle J. Javaux²

high-res petrography methods used to distinguish **abiotic spheroids** in the SPF rocks also hosting **lenses**

Blue : between grains + continuous = ? biotic
Pink/Yellow : inside grains + coalescence = ? abiotic

Coutant *et al.*, 2022



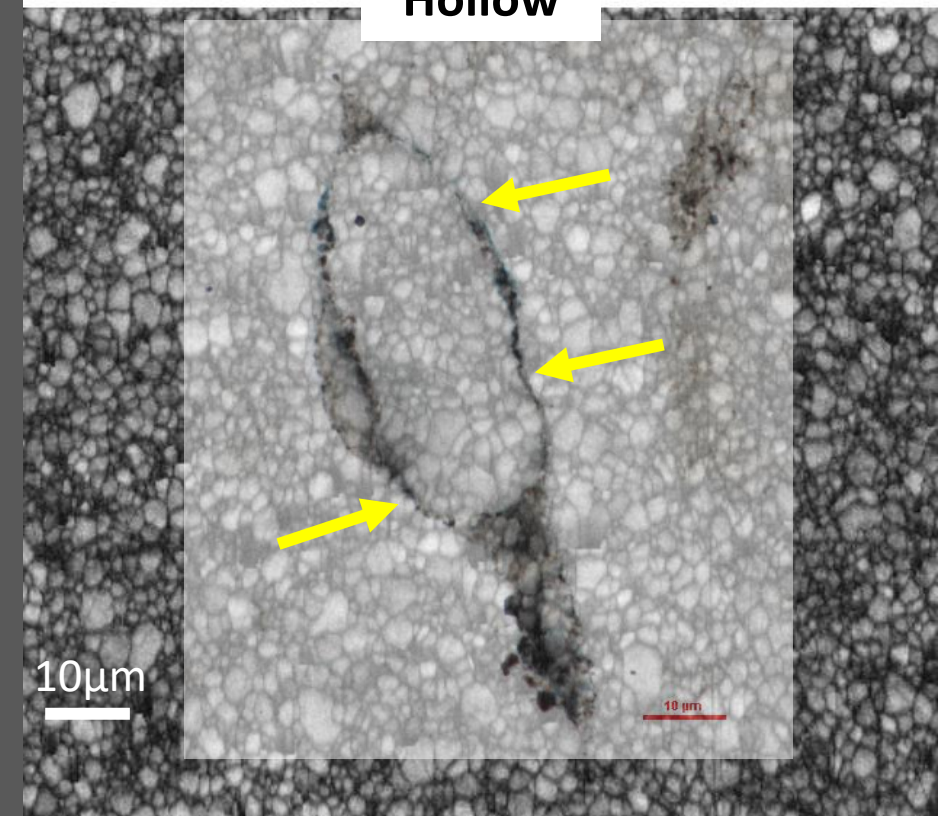
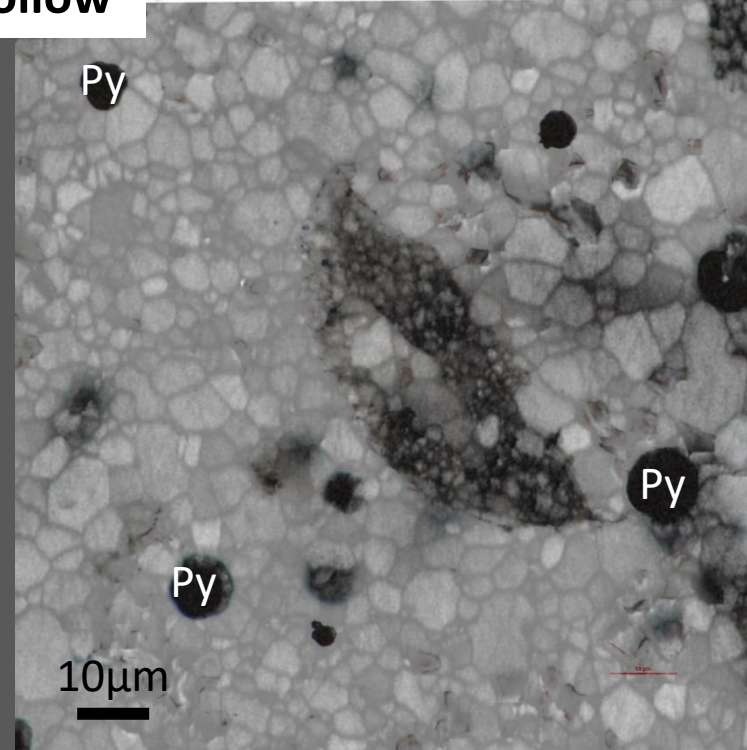
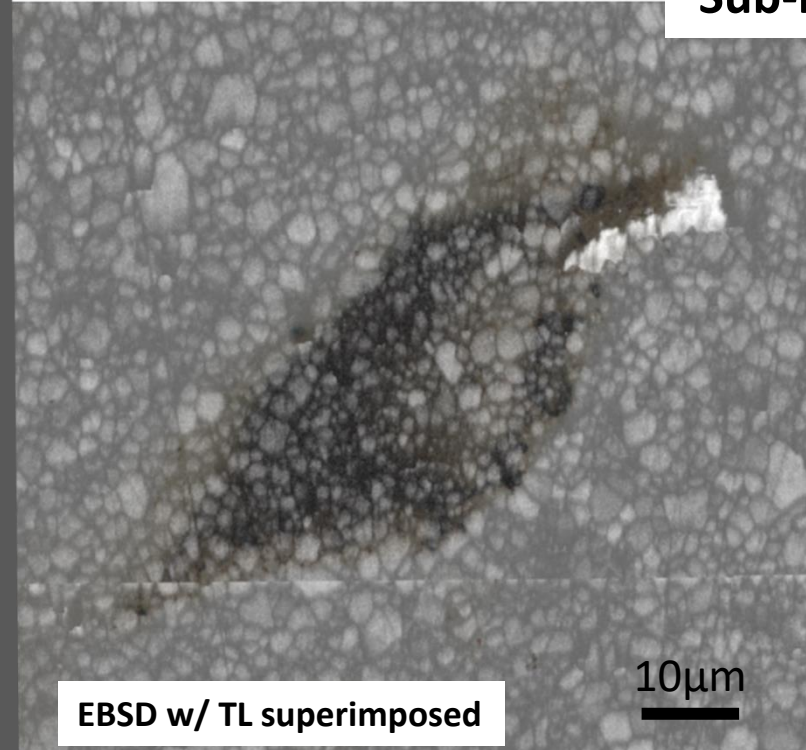
μPetrography – Quartz-CM relationship

Band Contrast 14

Sub-hollow

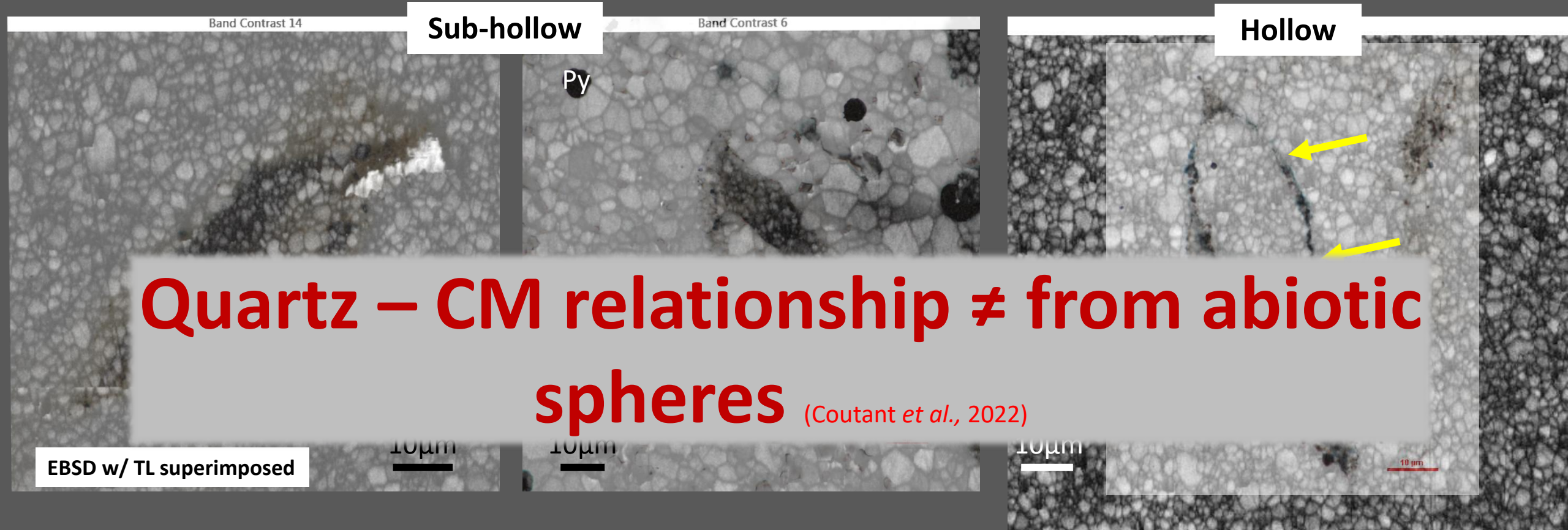
Band Contrast 6

Hollow



- Often larger crystals in **vesicles** (TEM-Sugitani *et al.*, 2015a)
- **CM at Qz boundaries only** = no cross-cutting structure

μPetrography – Quartz-CM relationship



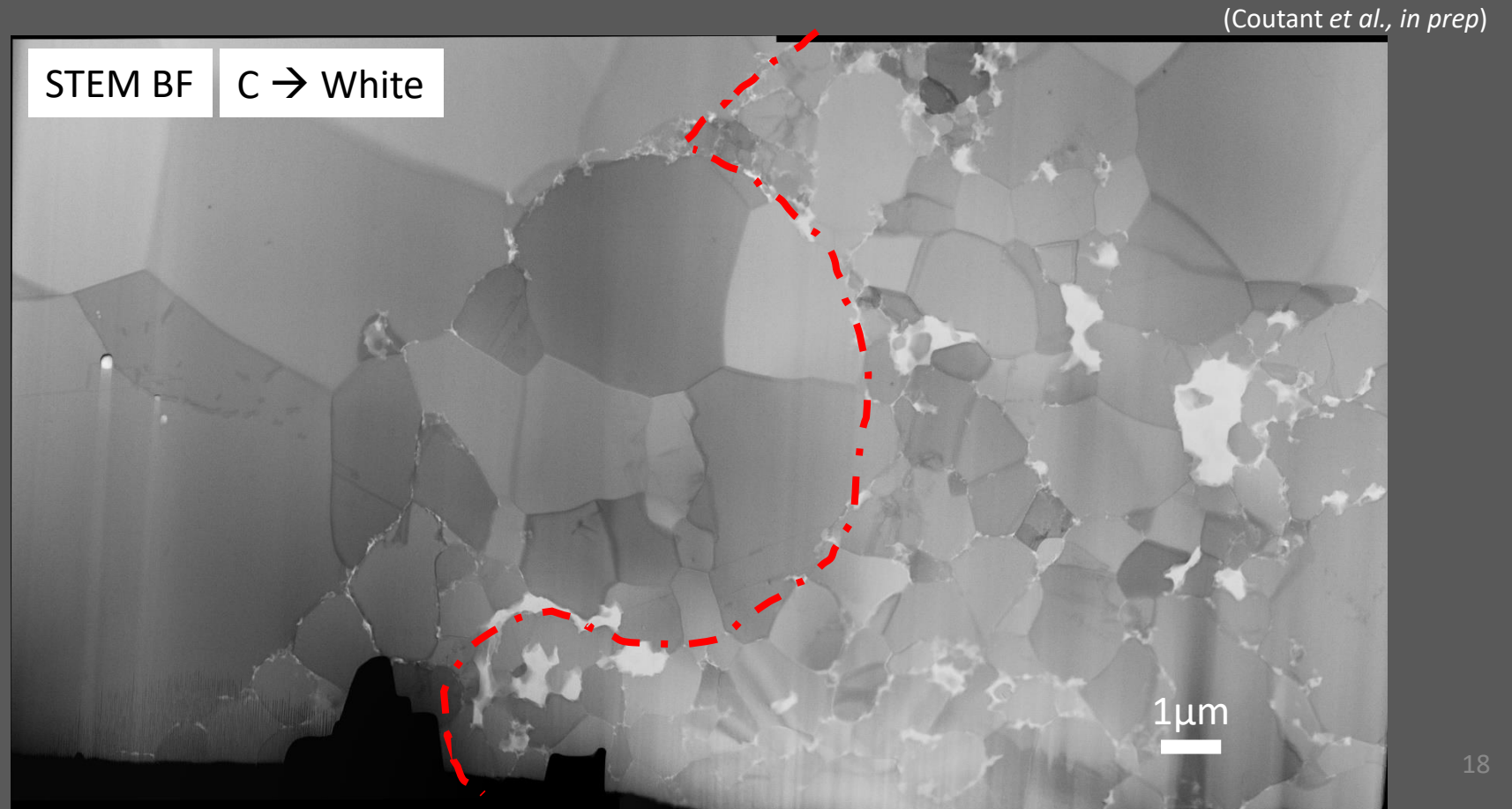
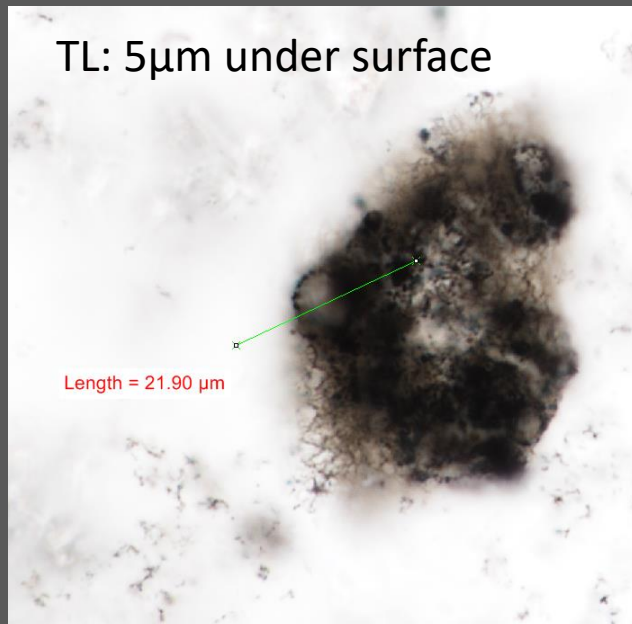
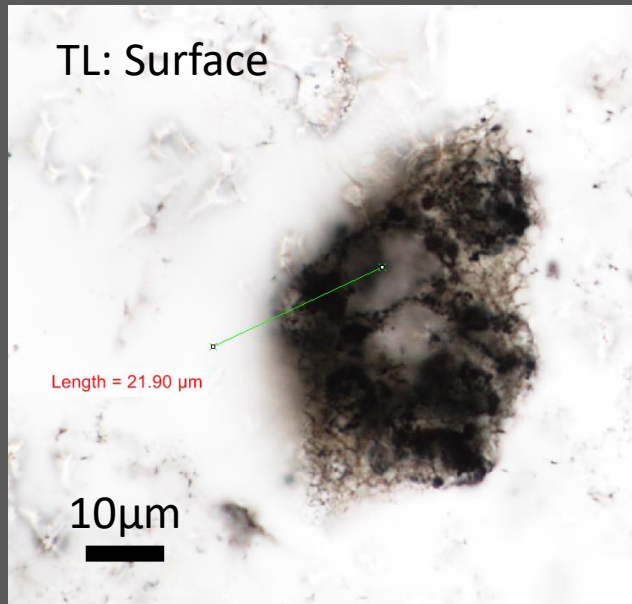
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nanoPetrography – Ultrastructure

Coutant *et al.*, in prep

Granular/Sub hollow

- C-granules → **Central body** – no walled structures



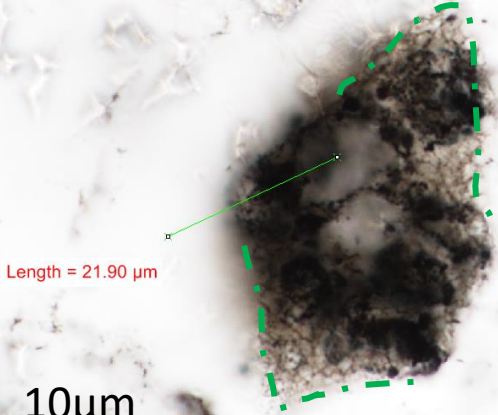
nanoPetrography – Ultrastructure

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- C-granules → **Central body** – no walled structures
- **Outline reticulated CM** → **Flange**

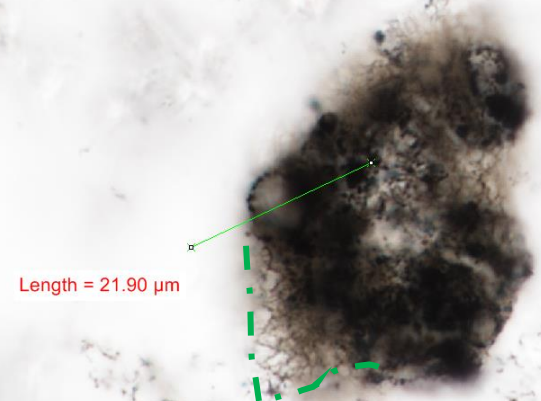
TL: Surface



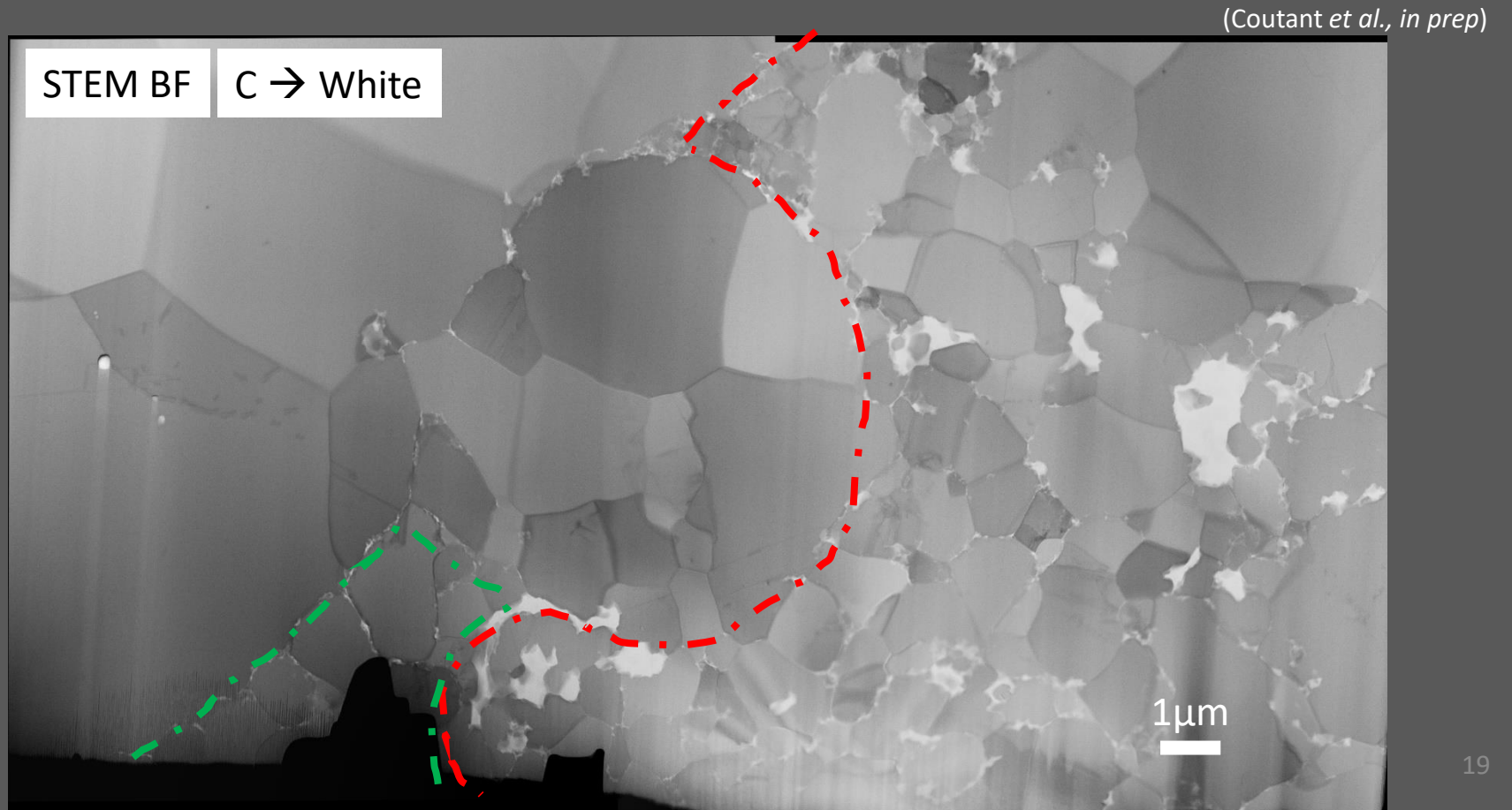
Length = 21.90 μm

10 μm

TL: 5 μm under surface



Length = 21.90 μm



1 μm

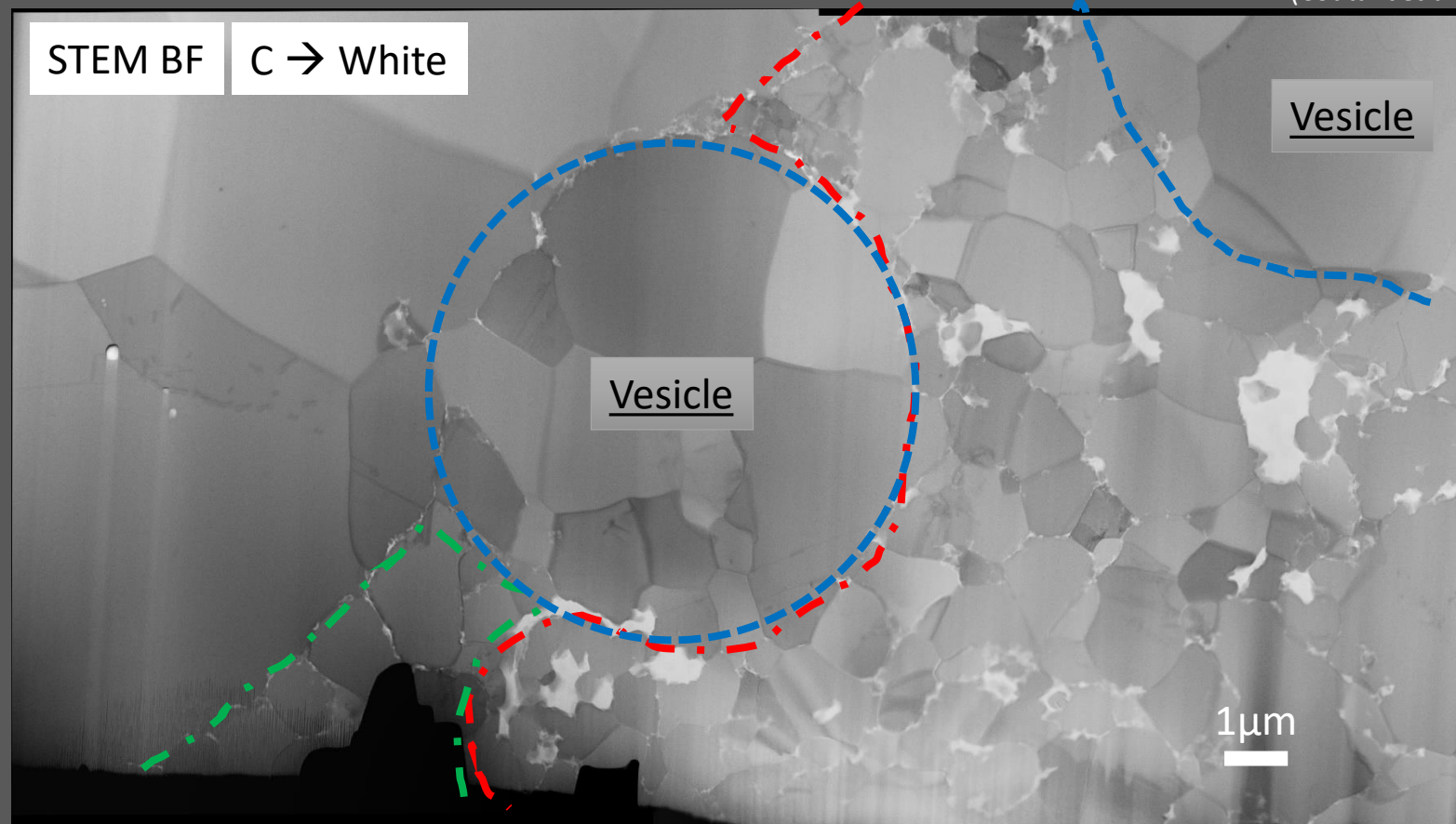
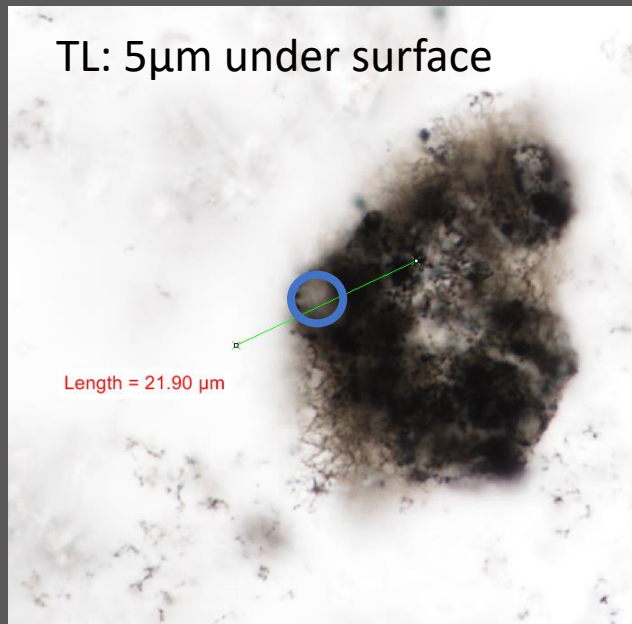
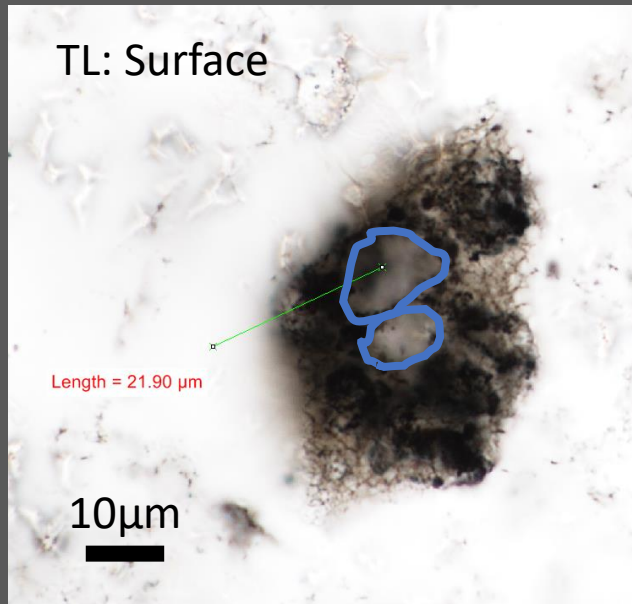
nanoPetrography – Ultrastructure

Coutant *et al.*, in prep

Granular/Sub hollow

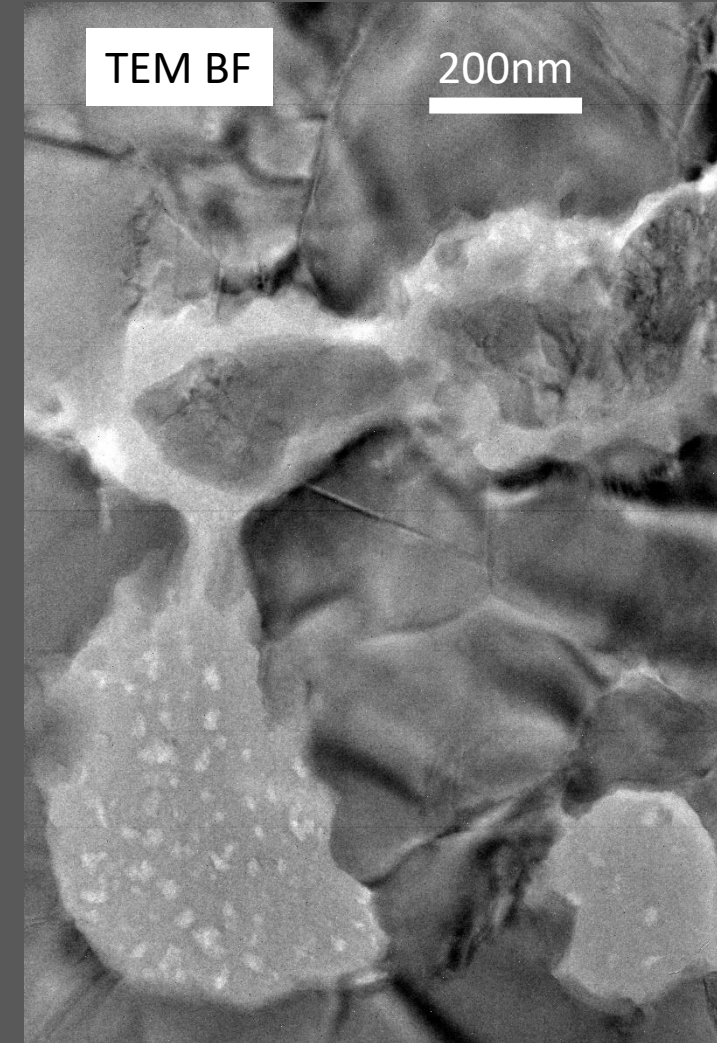
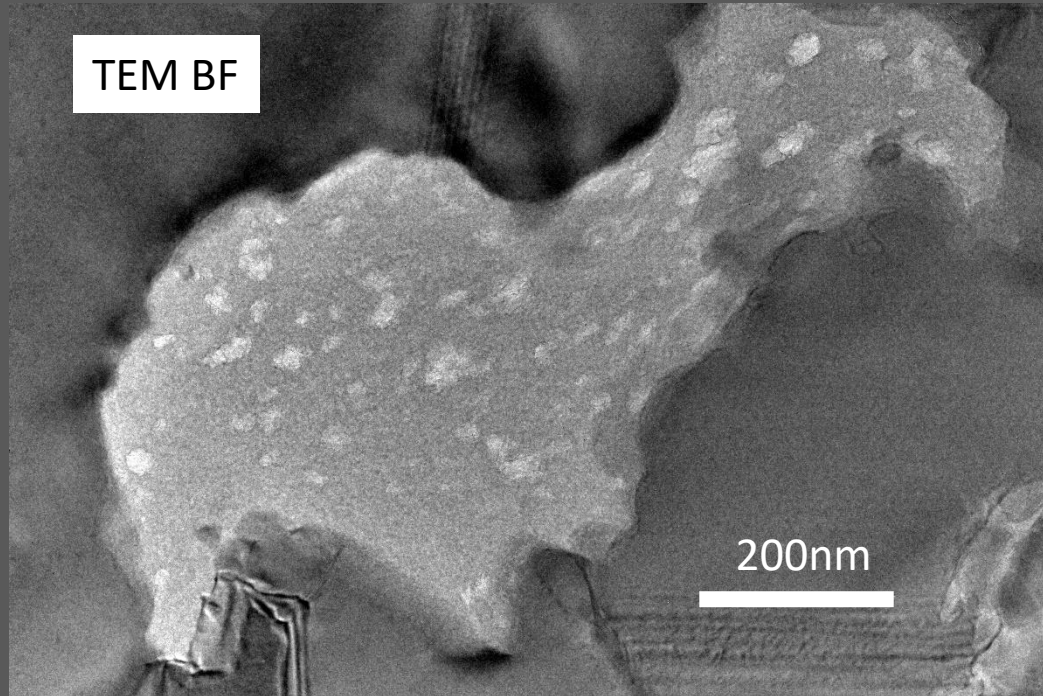
- C-granules → **Central body** – no walled structures
- **Outline reticulated CM** → **Flange**
- No cross-cutting structures ≠ abiotic spheres

(Coutant *et al.*, in prep)



nanoPetrography – Ultrastructure

Granular/Sub hollow



- Nanopores inside C granules
- Pyrobitumen ?

nanoPetrography – Ultrastructure

1,9 Ga Gunflint Formation (Canada)

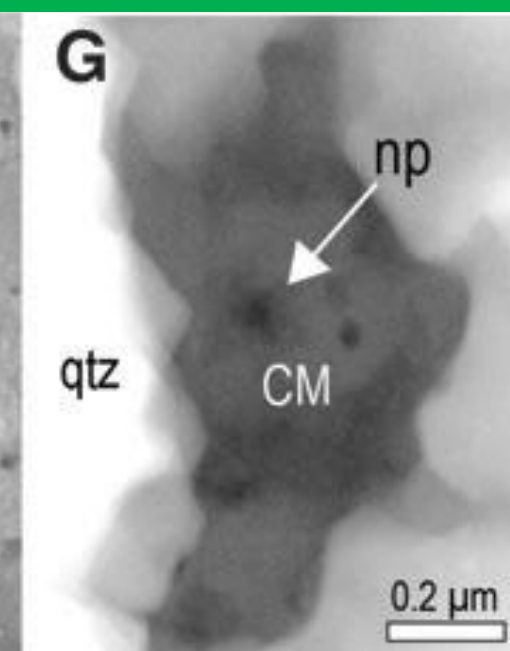
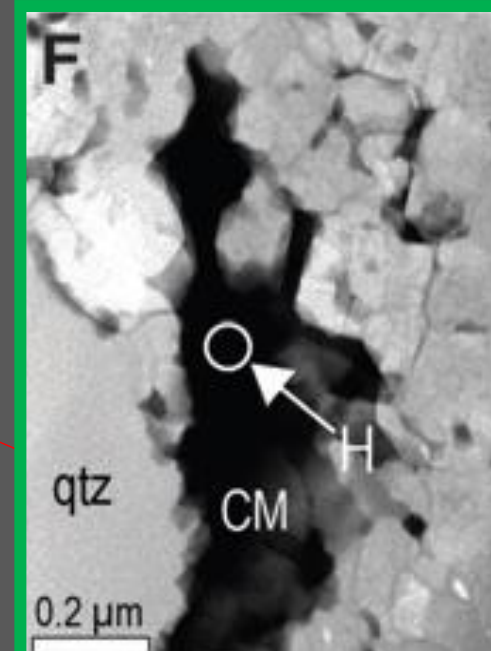
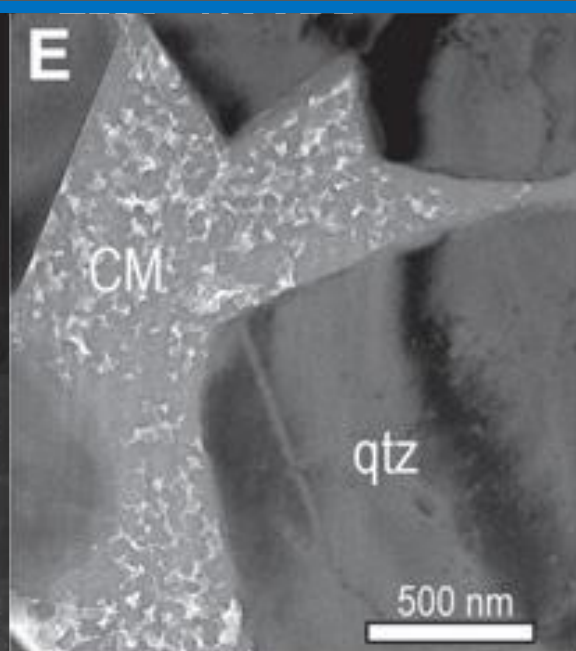
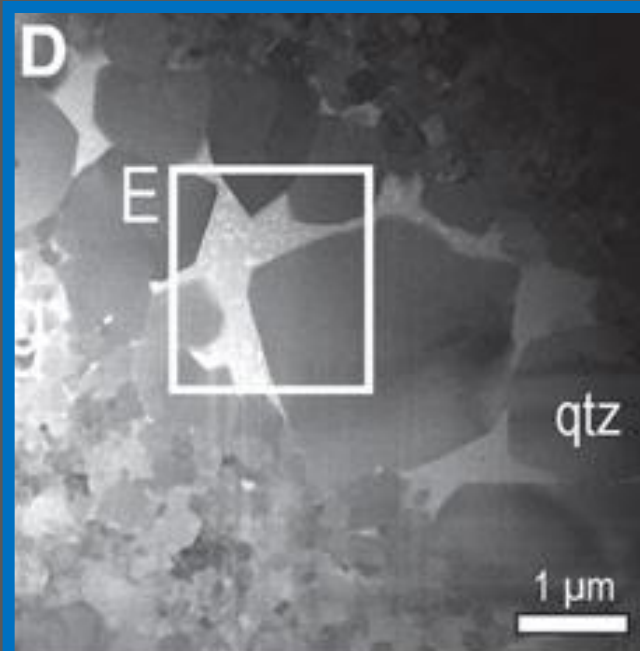
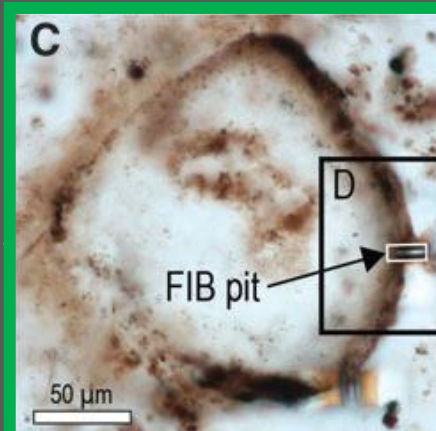
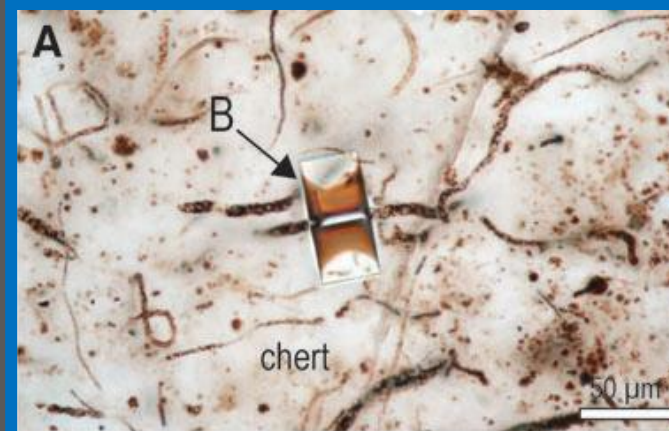
Microfossil

Quartz Grain

Nanopores in CM and Qz grains

Infiltration of exogenous soluble CM (pyrobitumen)

→ Multiple generation of CM

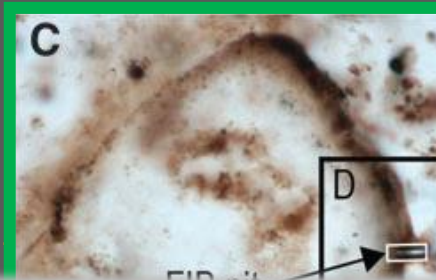


nanoPetrography – Ultrastructure

1,9 Ga Gunflint Formation
(Canada)

Microfossil

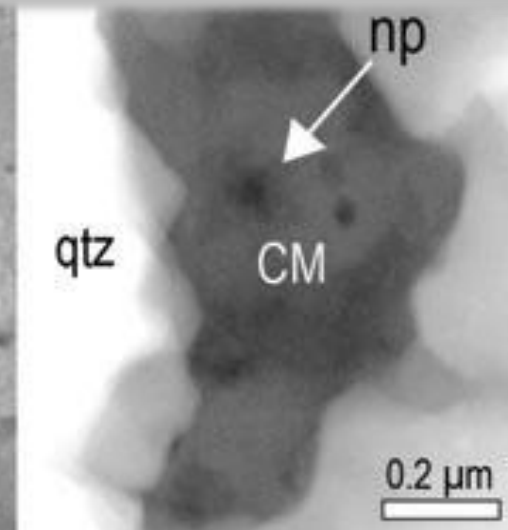
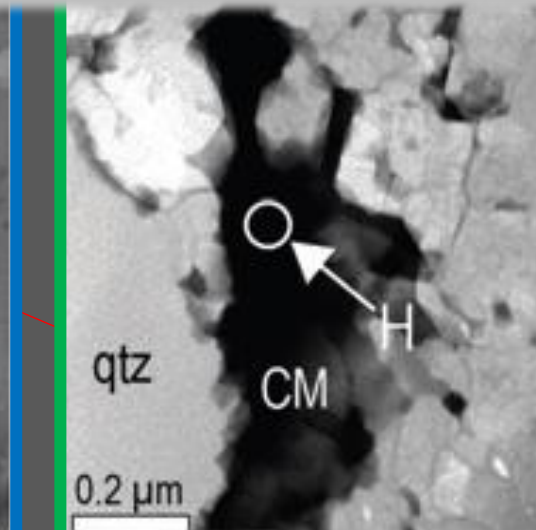
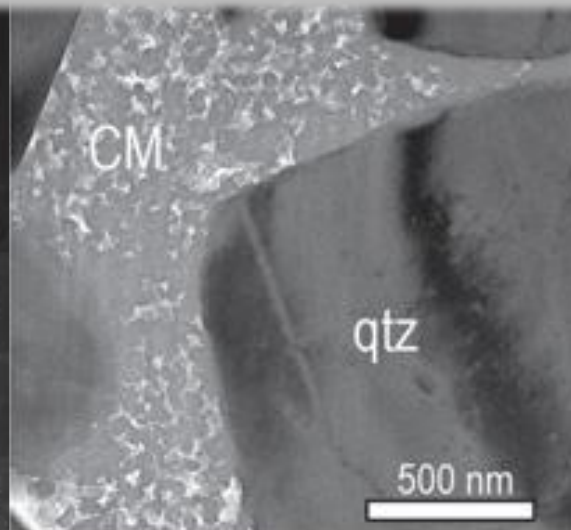
Quartz Grain



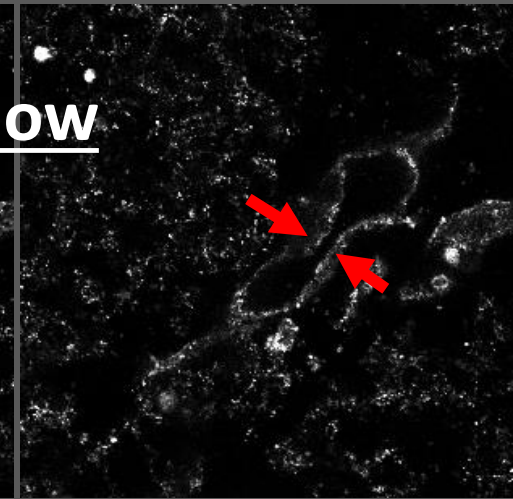
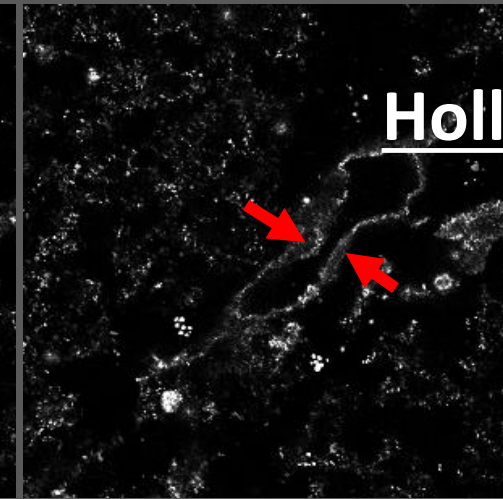
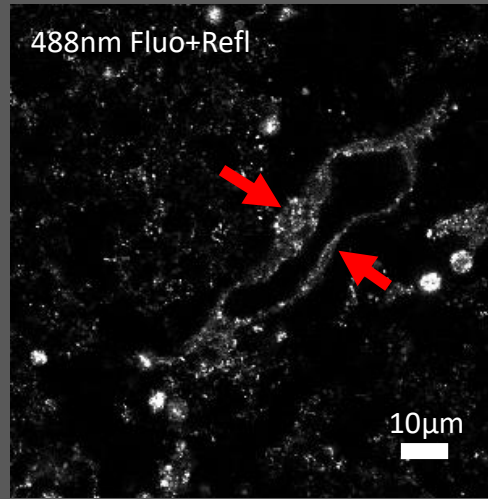
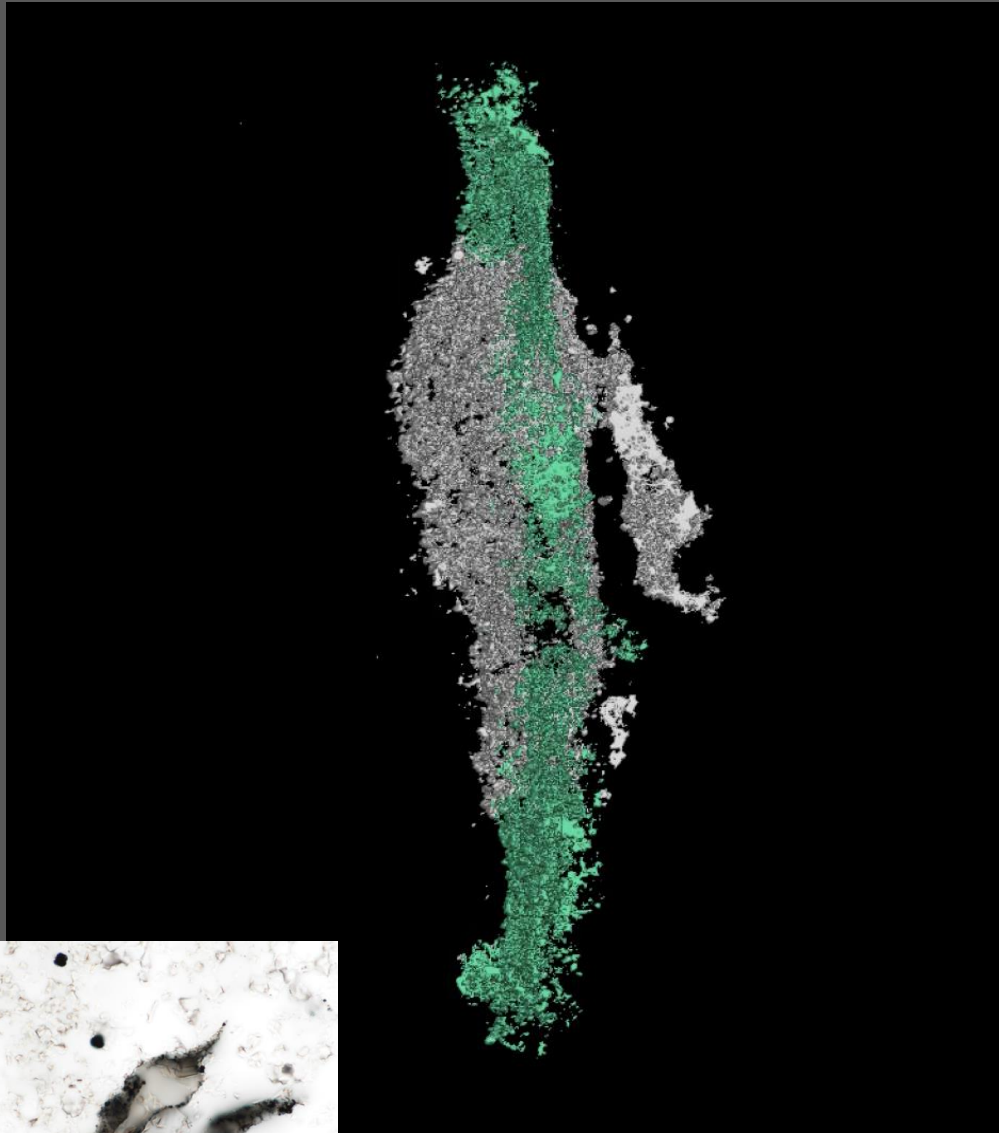
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Infiltration of exogenous soluble CM (pyrobitumen)

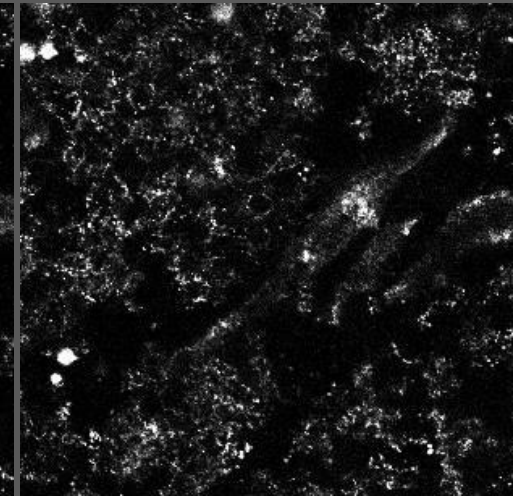
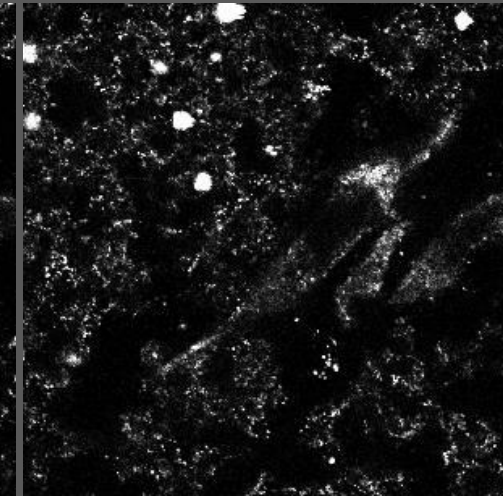
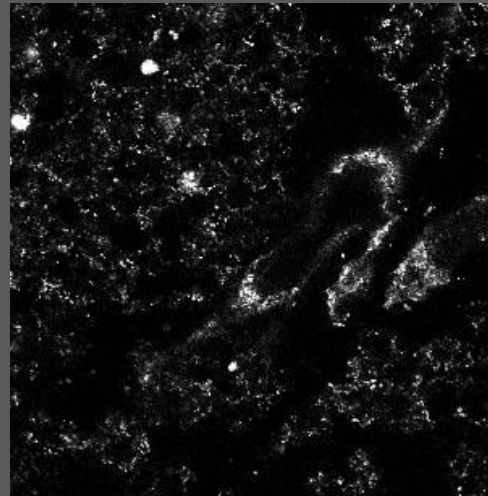
Pyrobitumen may infills μ fossils as well as biomorphs



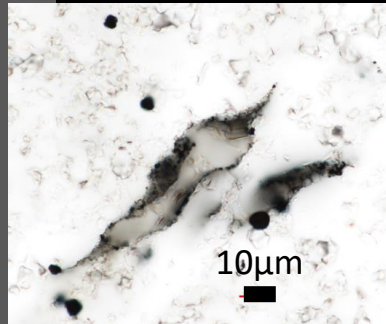
μPetrography – 3D CLSM



Hollow

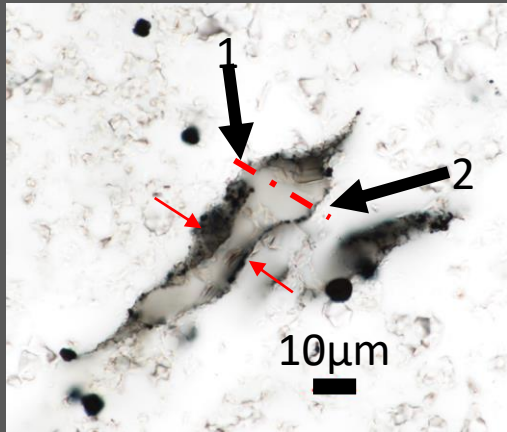


- Likely continuous wall
- **Folding** of the wall – taphonomy ? = Biogenic ?

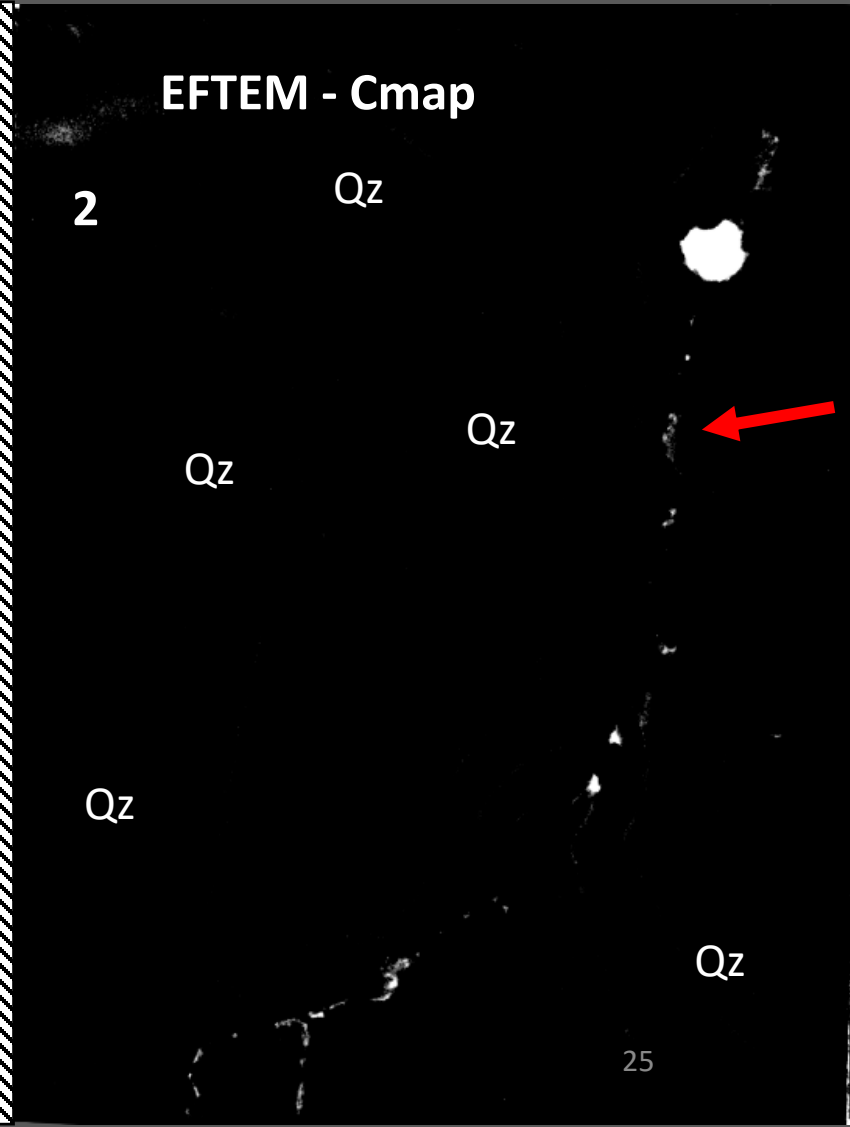
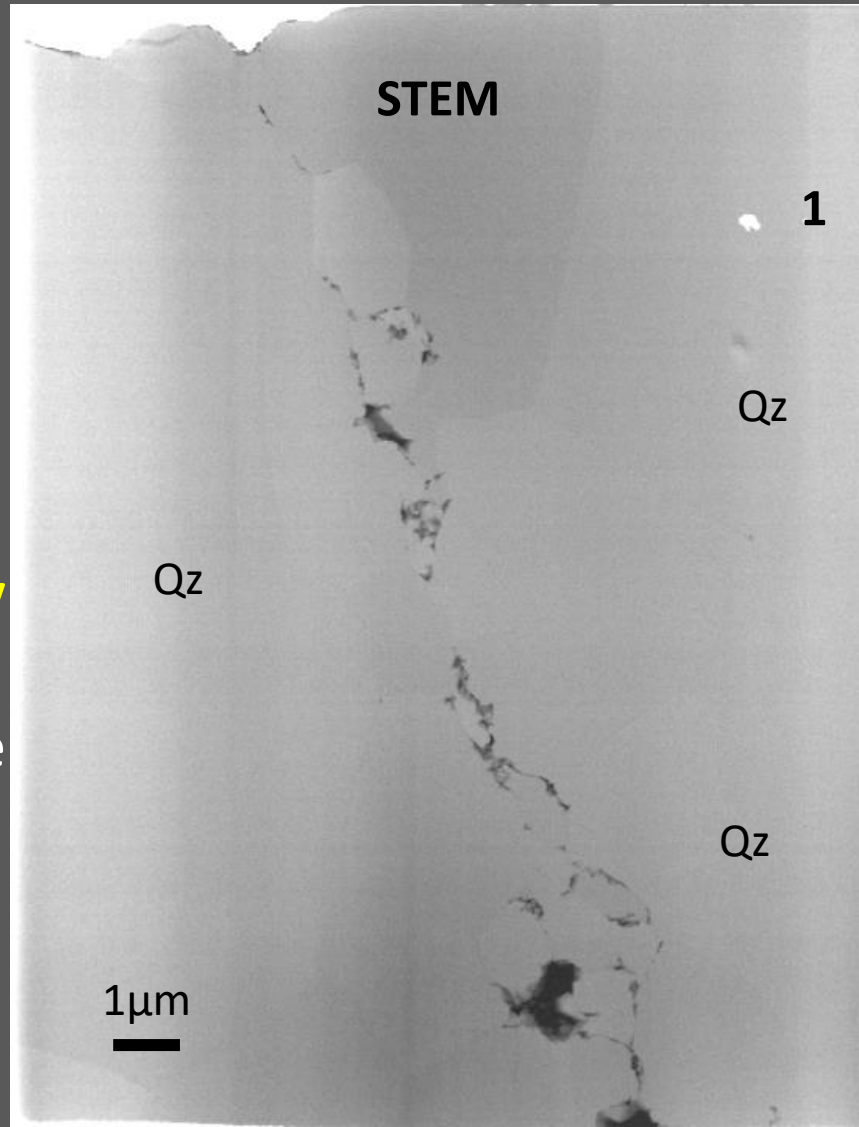


nanoPetrography – Ultrastructure

Hollow



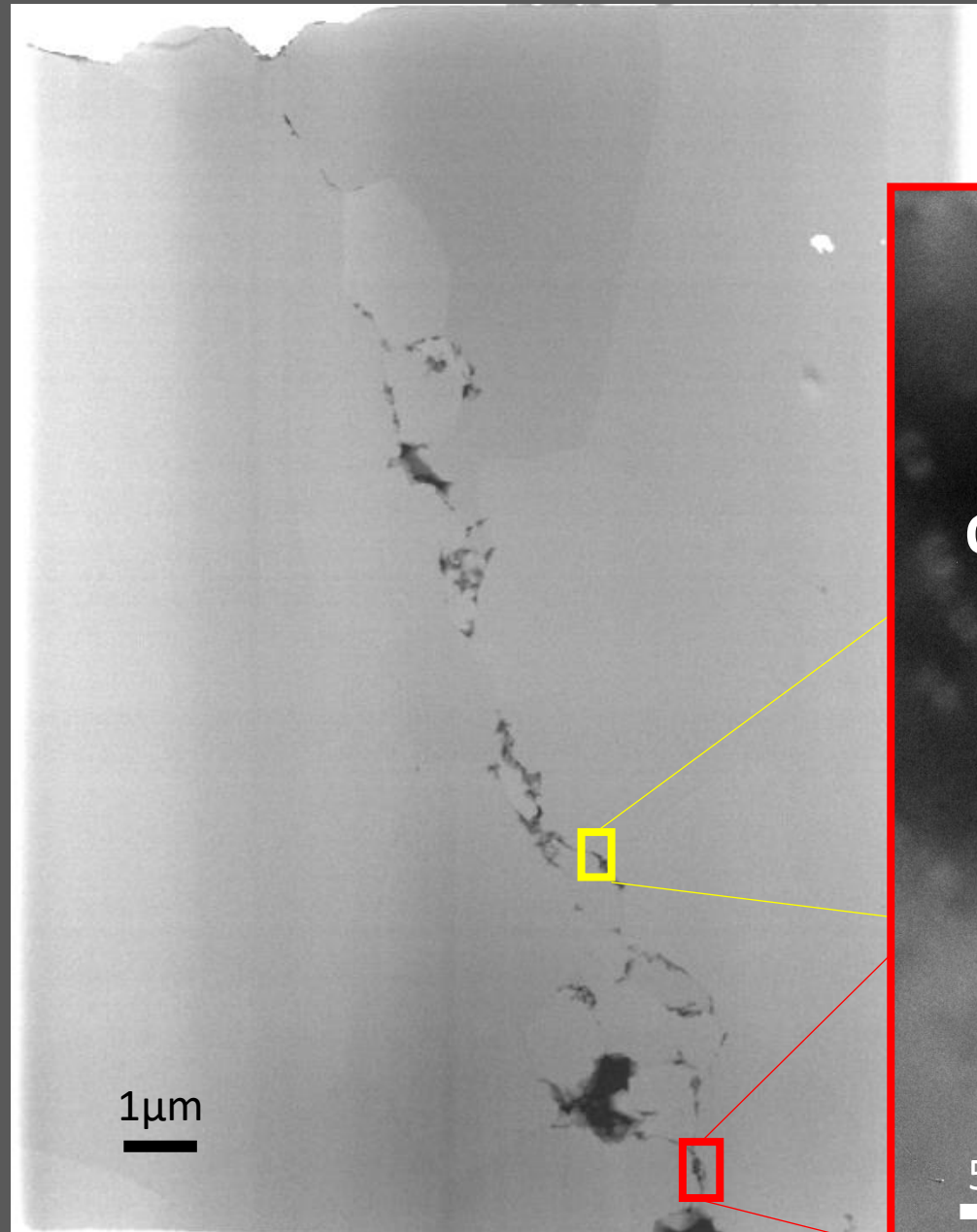
Coutant *et al.*, in prep



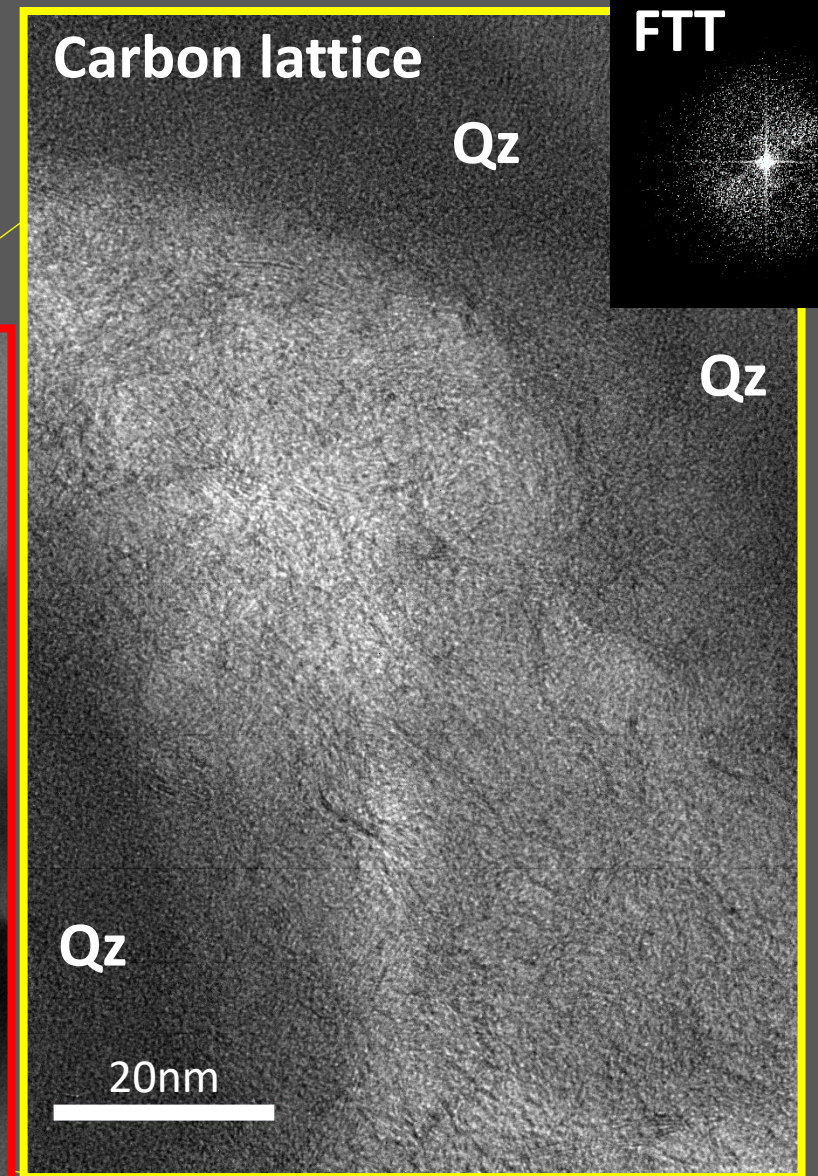
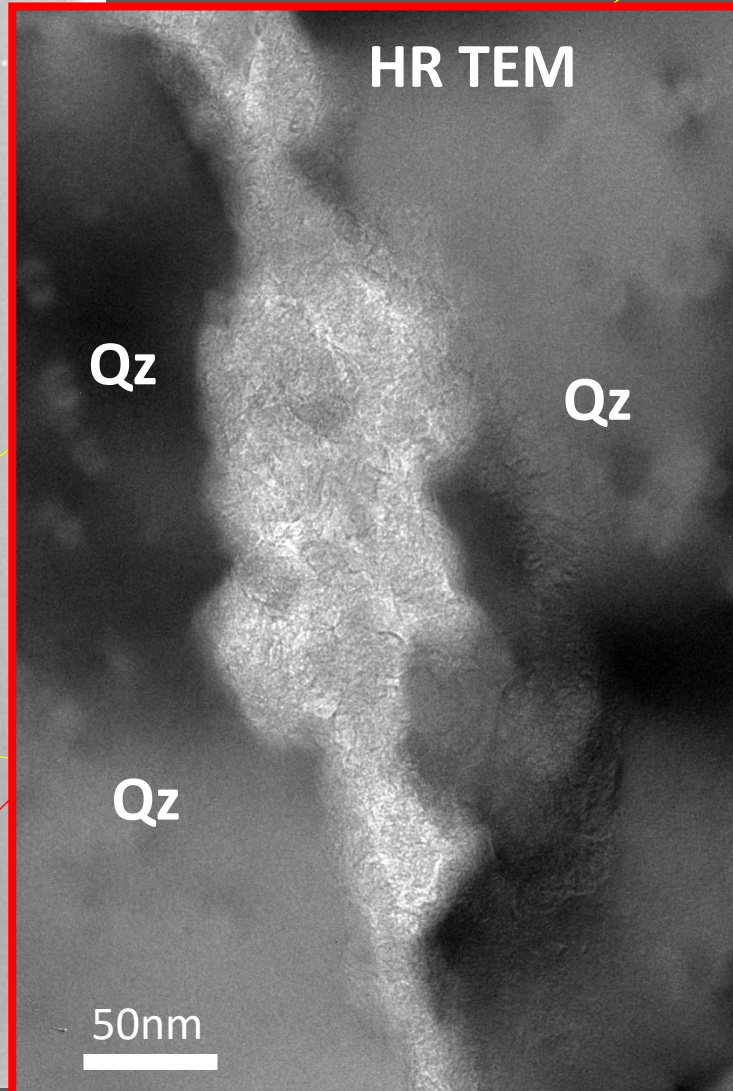
- Walls (sub)continuous
- CM @ Qz boundaries **only**
- **Folding**
- No **cross-cutting** structure

Consistent with μfossils

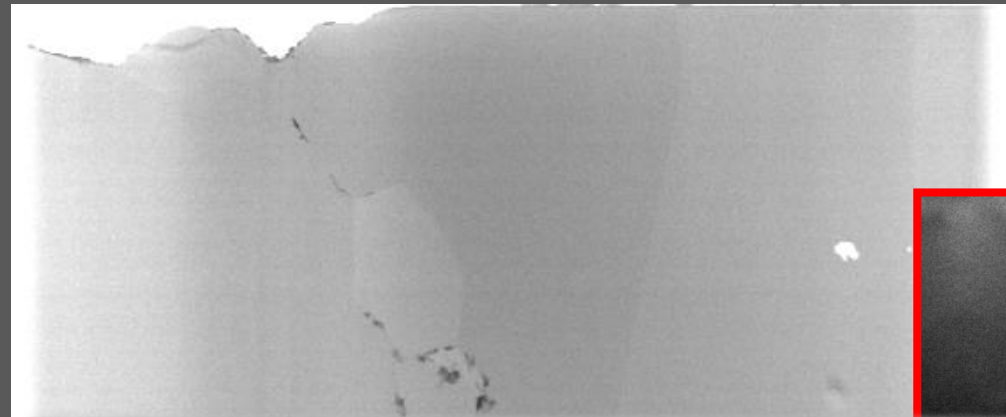
nanoPetrography – Ultrastructure



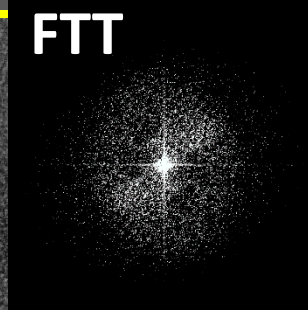
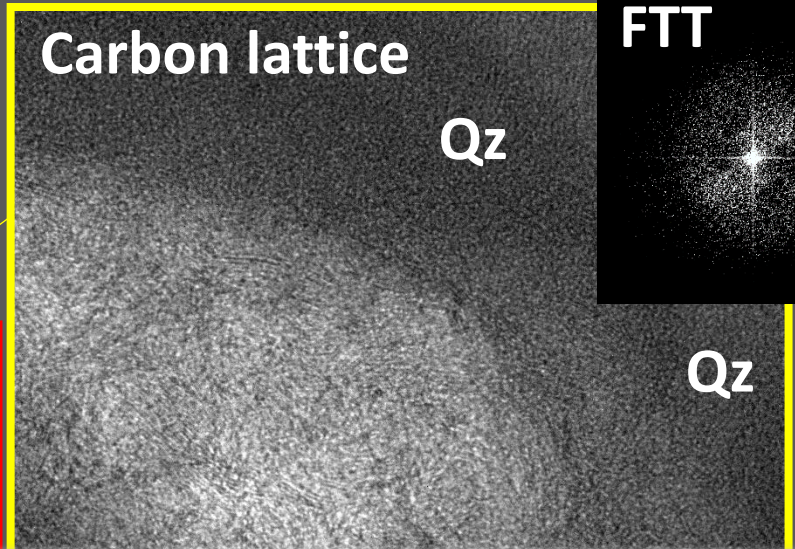
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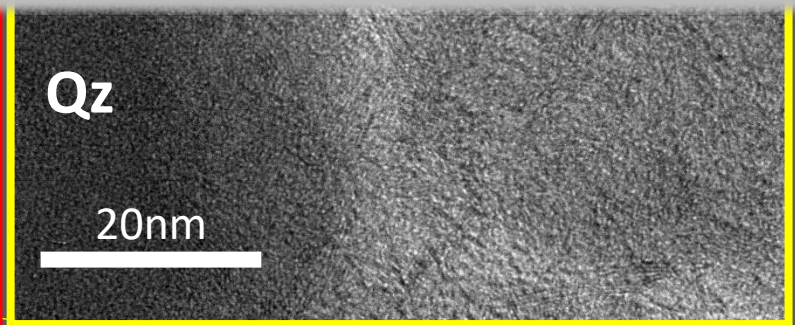
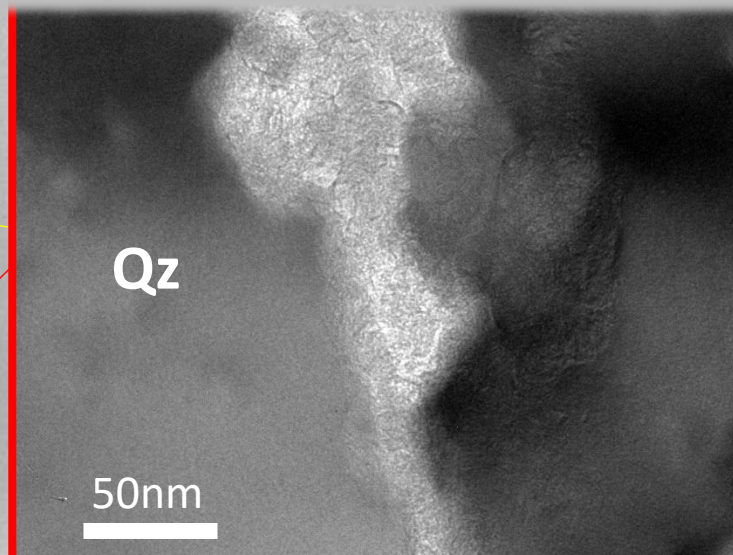
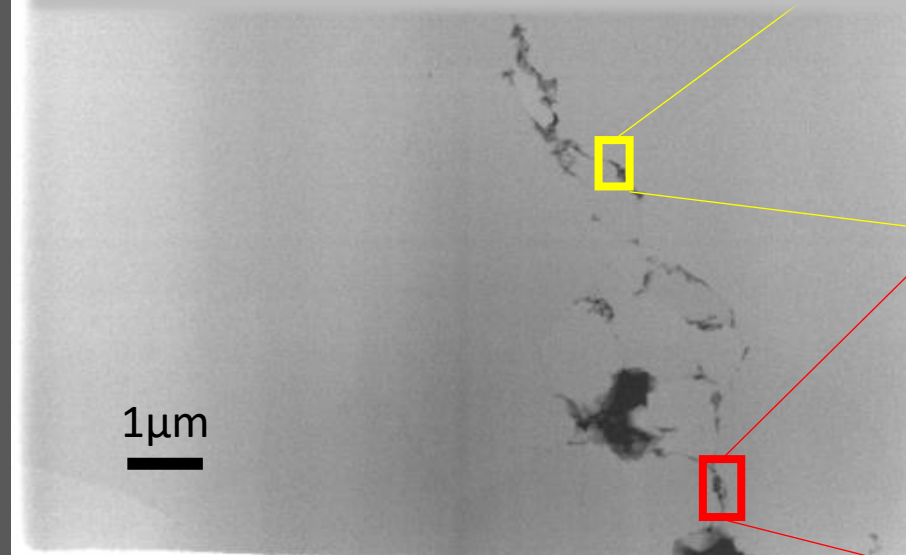
nanoPetrography – Ultrastructure



Coutant *et al.*, in prep



**No porosity in carbon structure
≠ from granular specimens (C-granules)**



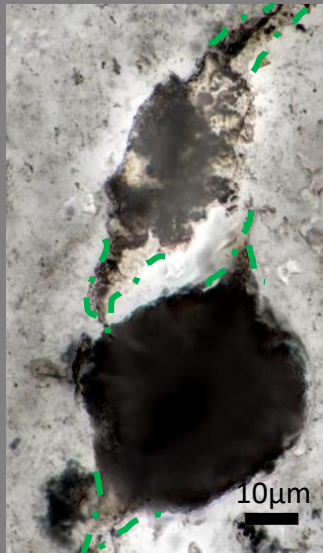
Take-home messages

- Morphological gradient

Granular

- No walled structures
- Nanopores inside granules (*in situ* bitumen or kerogen)
- CM mobilization?

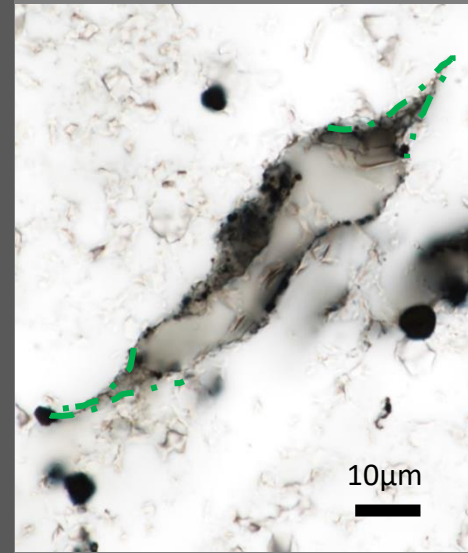
➤ **Abiotic?**



Hollow

- Evidence of walled structures
- Folded wall (taphonomy)
- No porosity (biopolymers)

➤ **Biotic?**



Sub-Hollow vesicles = crystallization from amorphous phase within the CM impregnated microstructures

➤ **Dubious**

What's next?

- Investigation of **additional** specimens required?
- *In situ* mass spectrometry is the next step, new features → Stay tuned !

Thank you for your attention

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Other collaborators

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