

# 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.,



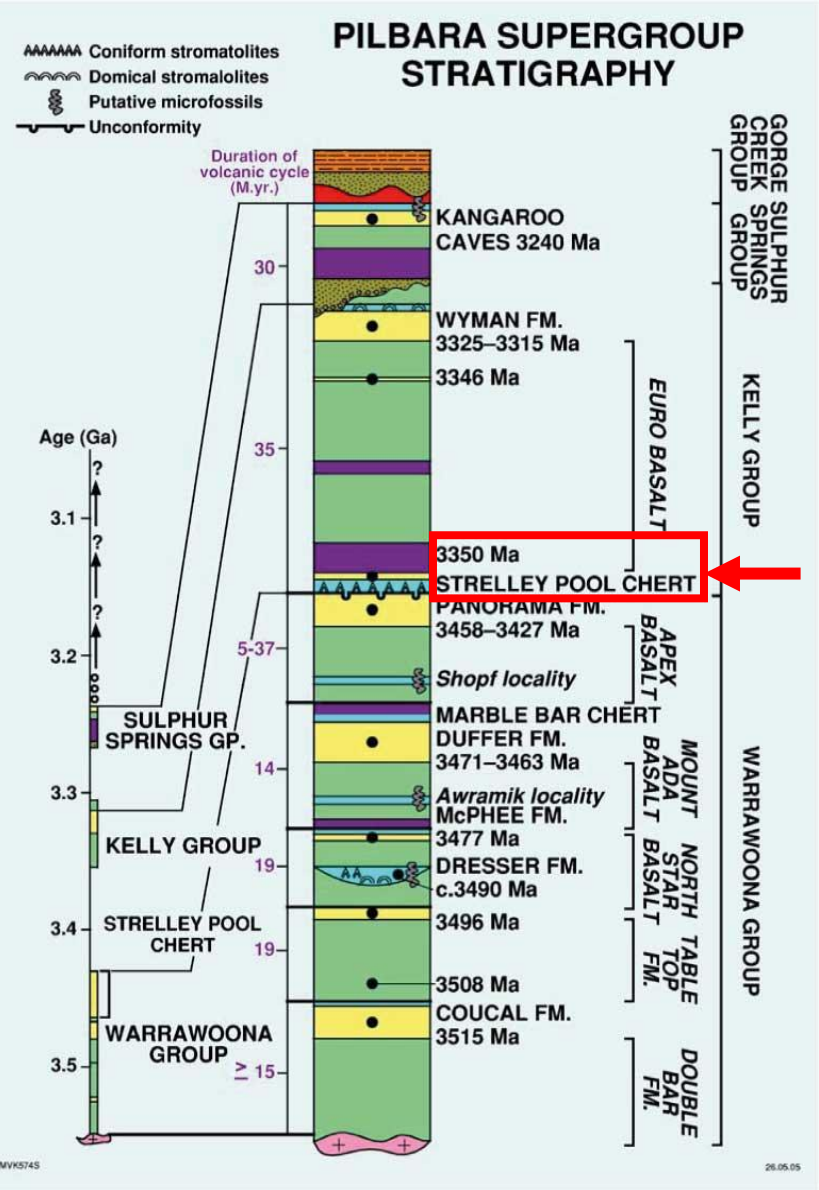
LIÈGE université  
Early Life



Université  
de Lille



# Strelley Pool Chert – Farrel Quartzite

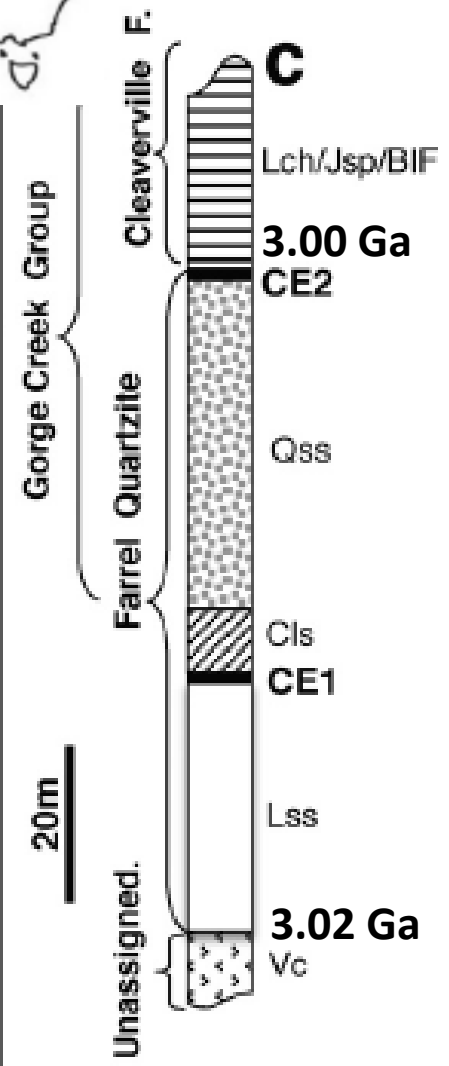


Siliceous deposits - Chert w/ carbonaceous matter

~3.4 Ga

Banded black & white chert

~3.0 Ga



Van Kranendonk, 2006

@Coutant

Sugitani et al., 2009a

# To be fossil or not fossil ?

# 3.46 Ga Apex Chert (Western Australia)

Organic filaments

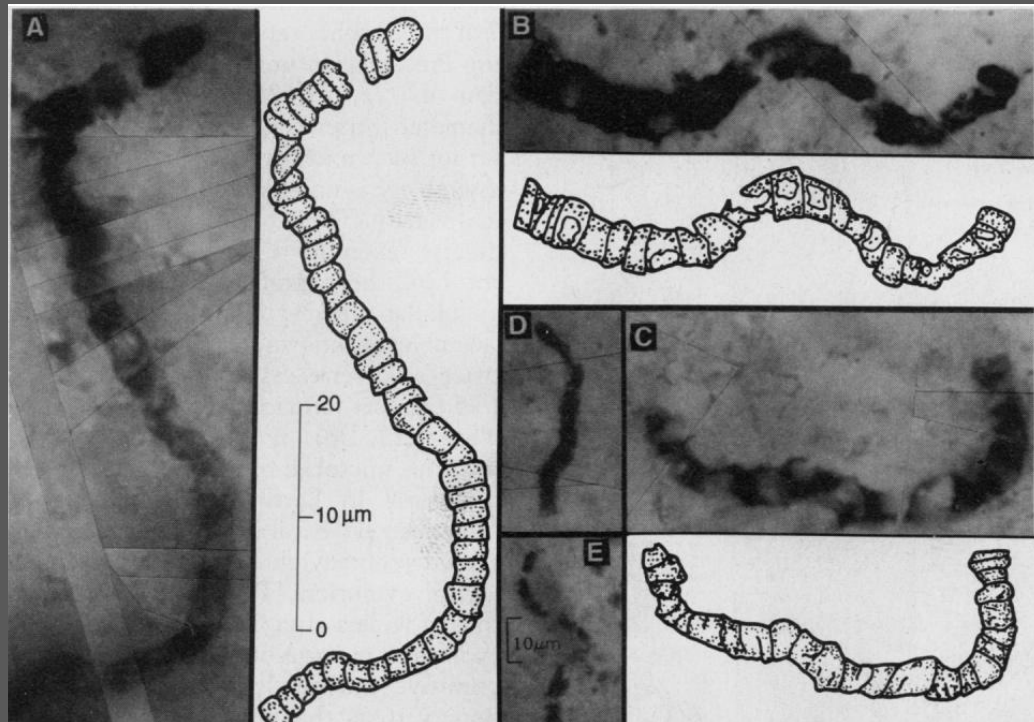
Hydrothermal veins

Segmentations

Organic diffusion

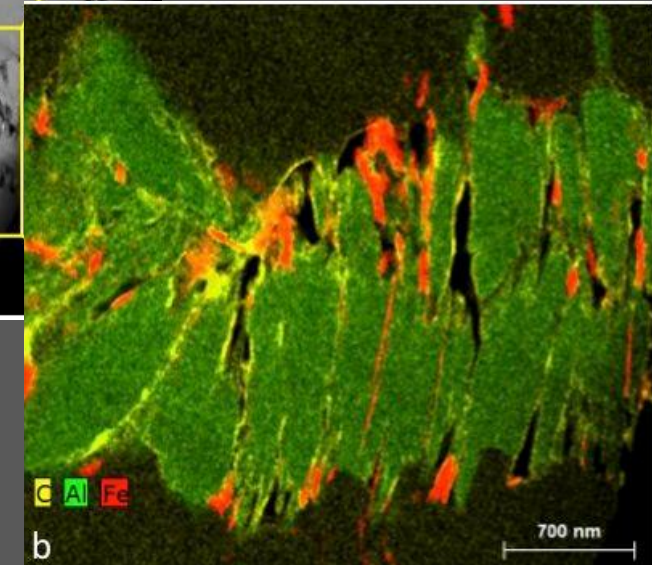
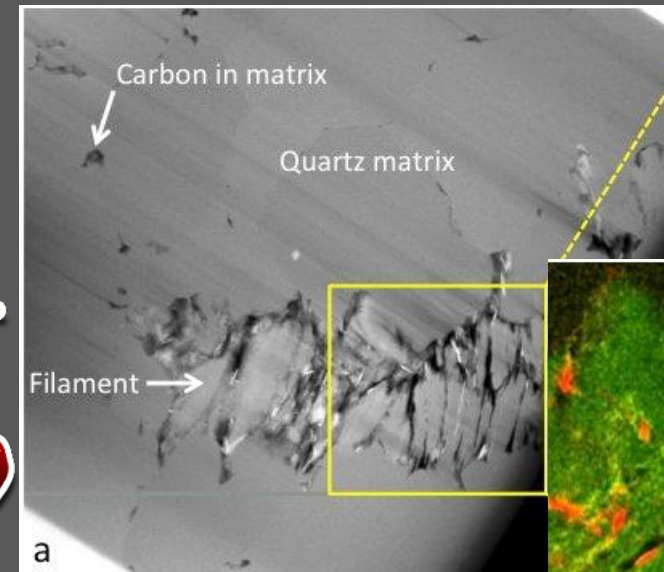
Cell lumina

Vermiculite



Schopf & Packer, 1987  
Schopf, 1993

VS



Brasier et al., 2015  
Wacey et al., 2016

# To be fossil or not fossil ?

# 3.46 Ga Apex Chert (Western Australia)

Organic filaments

Hydrothermal veins

Segmentations

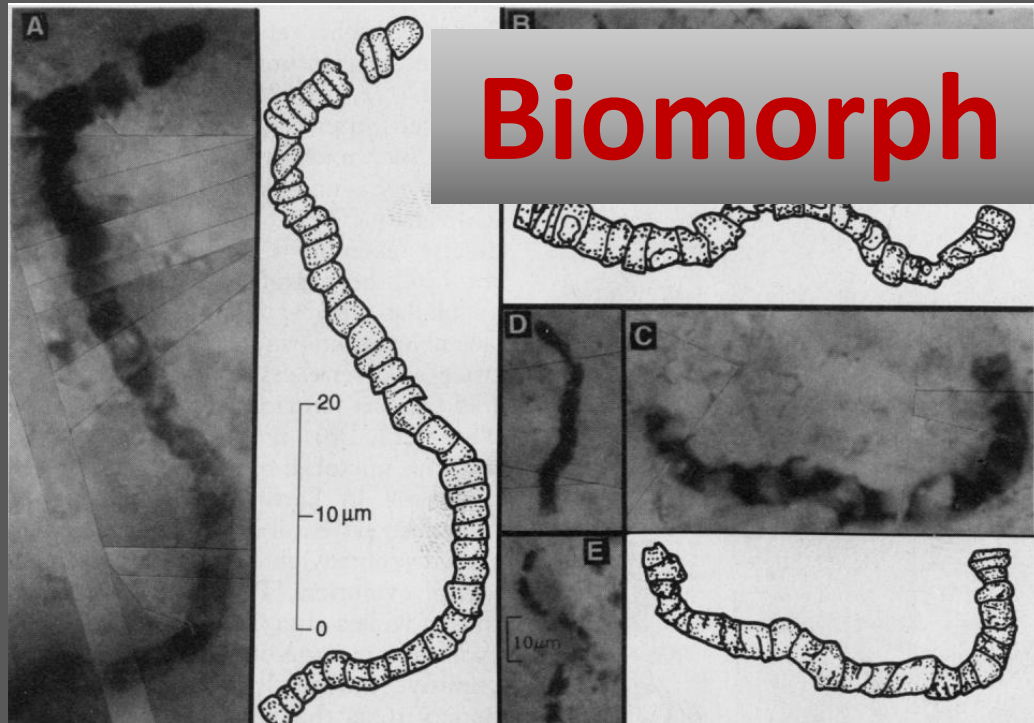
Organic diffusion

Cell lumina

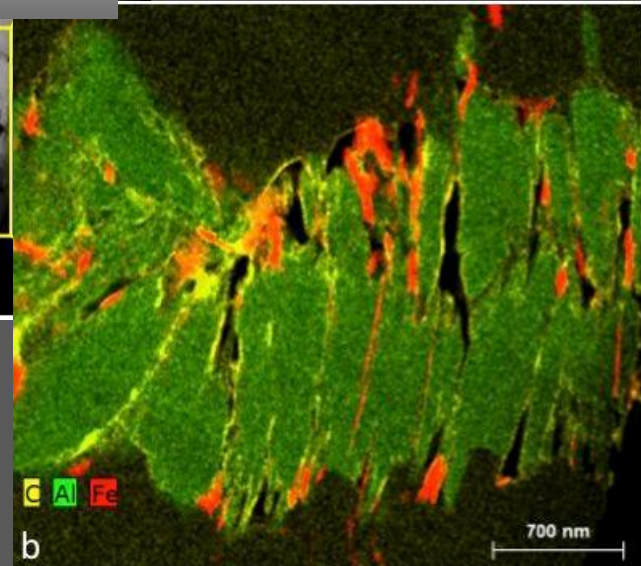
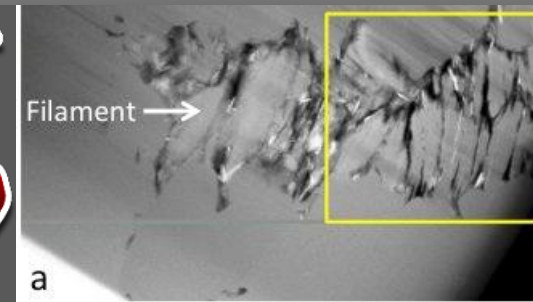
Vermiculite



**Biomorph = looks like  $\mu$ fossil**



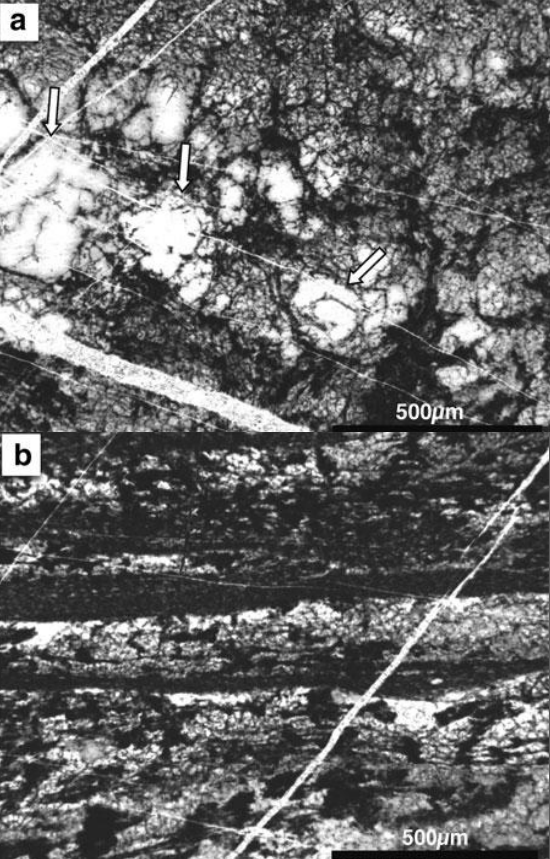
**VS**

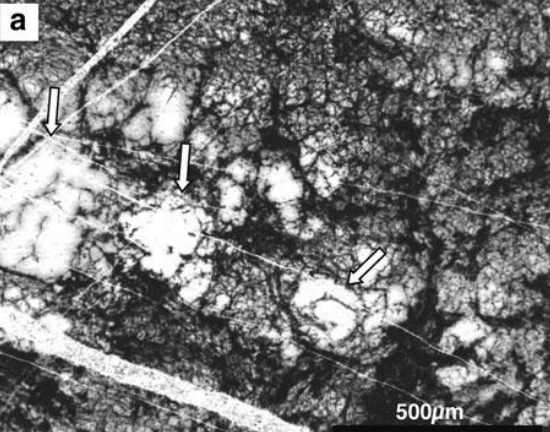


Schopf & Packer, 1987  
Schopf, 1993

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

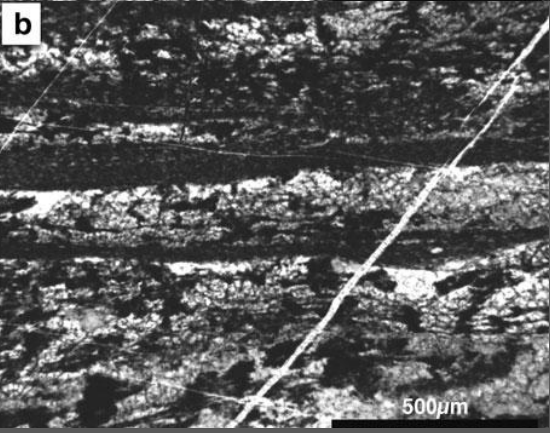
# Filaments





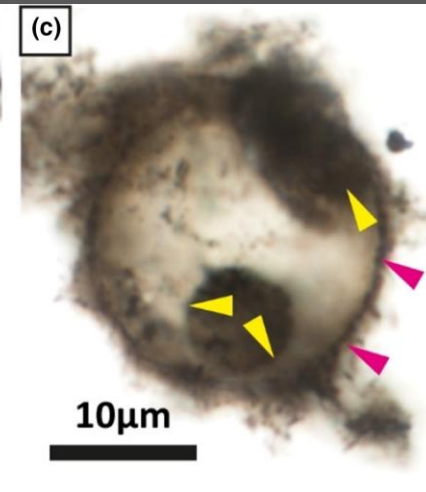
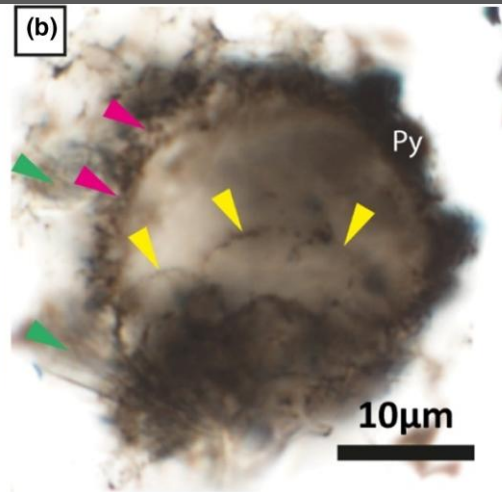
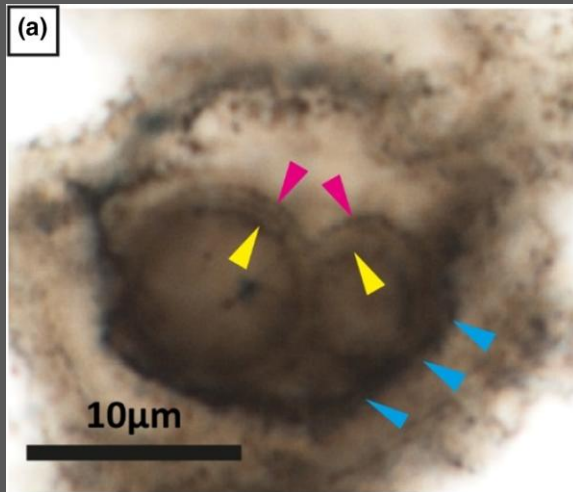
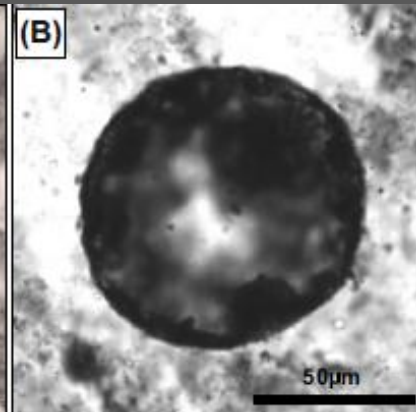
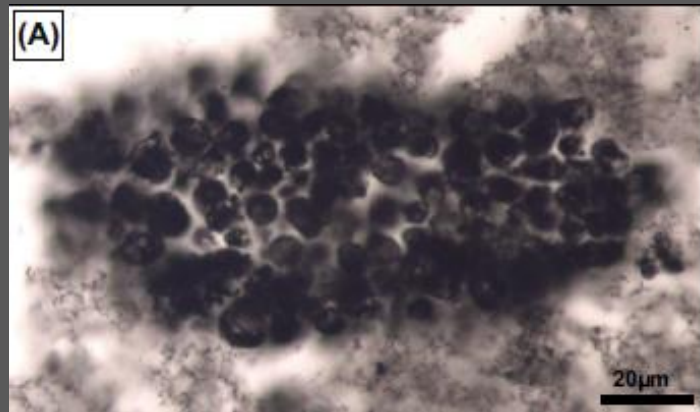
Sugitani *et al.*, 2010

# Filaments

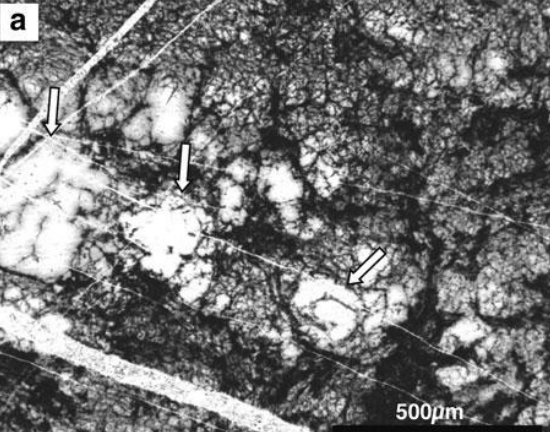


# Spheres

Sugitani *et al.*, 2015b

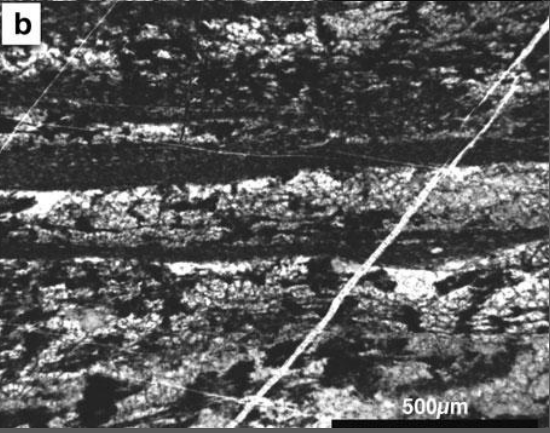


Coutant *et al.*, 2022



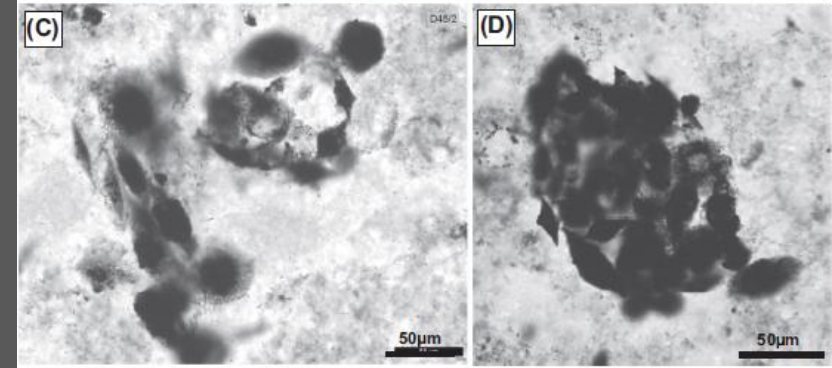
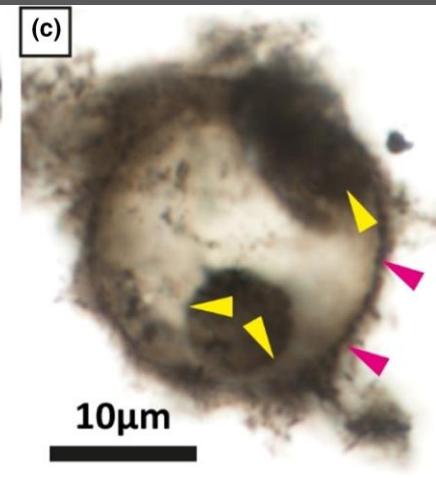
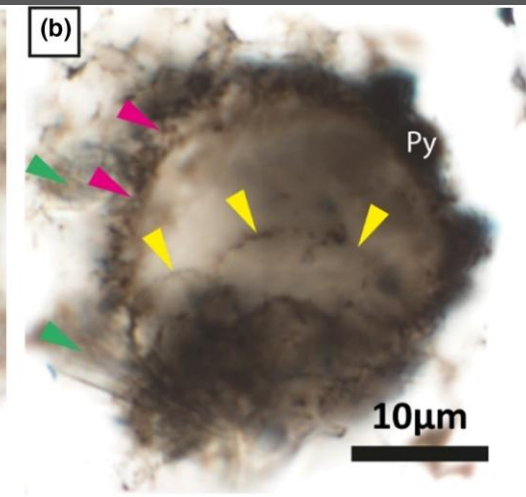
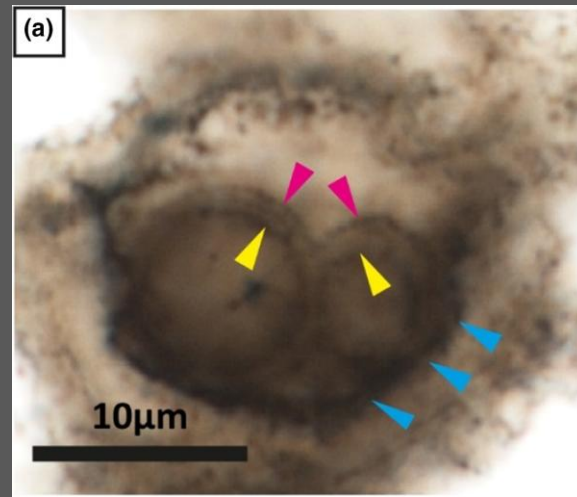
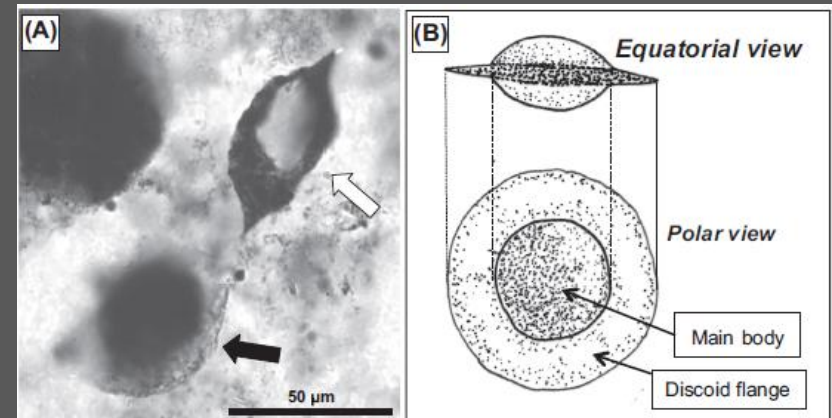
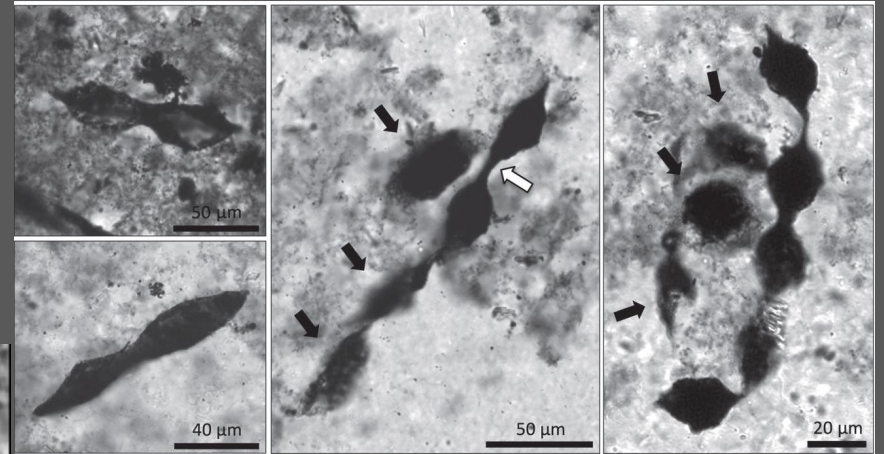
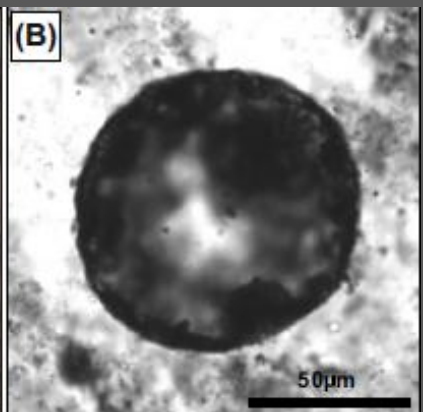
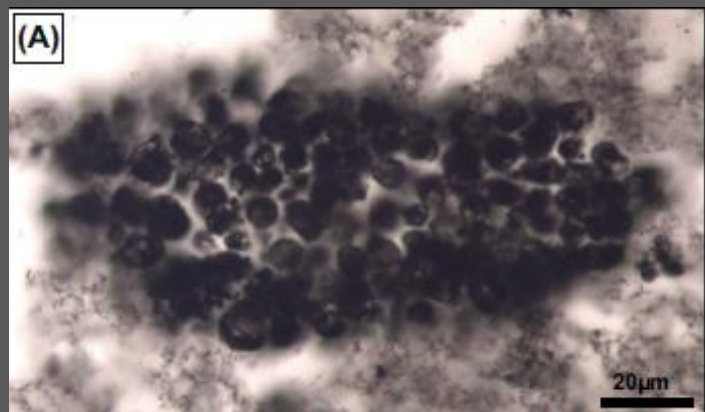
Sugitani *et al.*, 2010

# Filaments



# Spheres

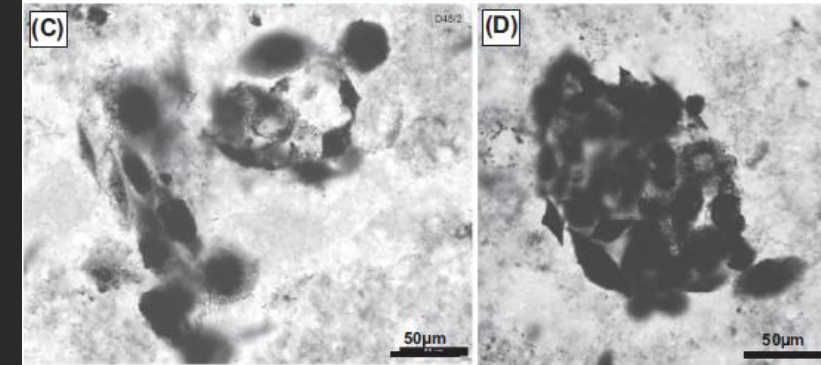
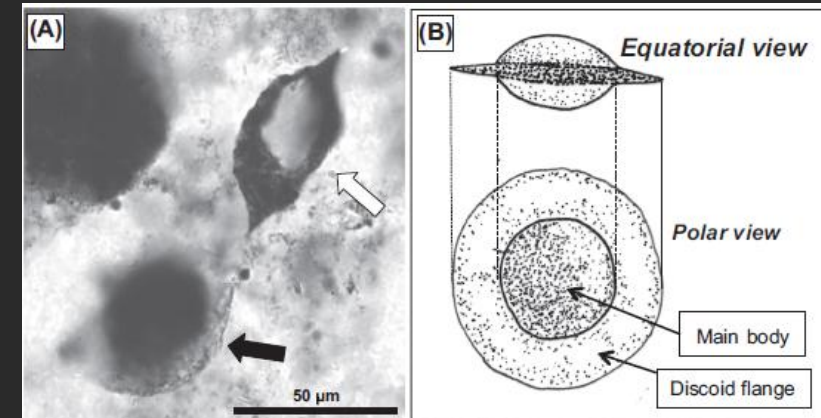
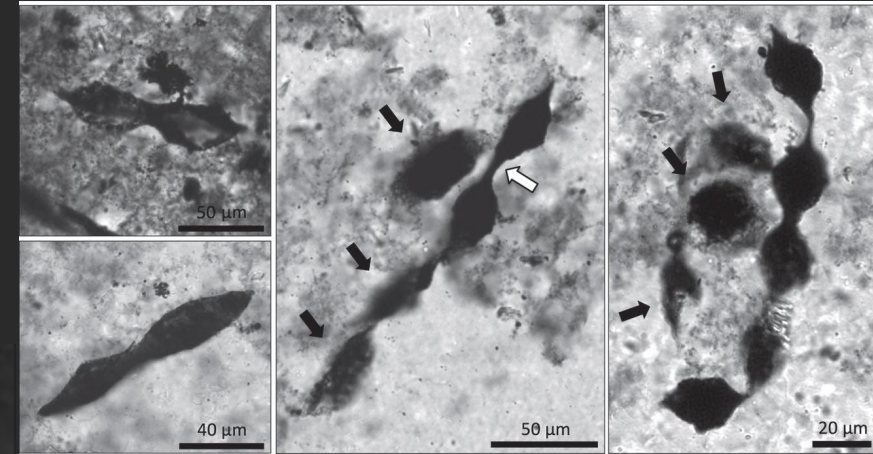
Sugitani *et al.*, 2015b



Coutant *et al.*, 2022

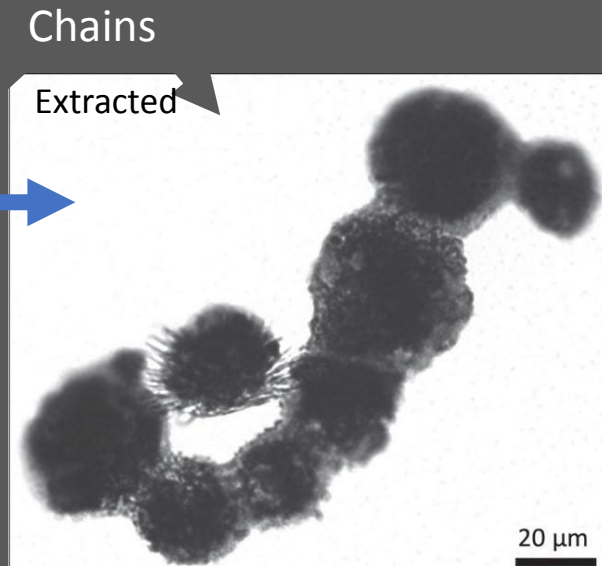
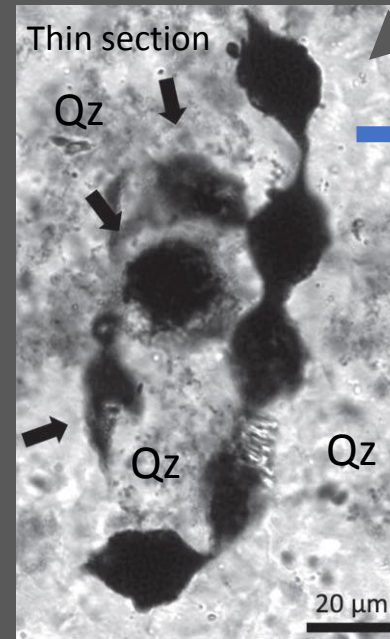
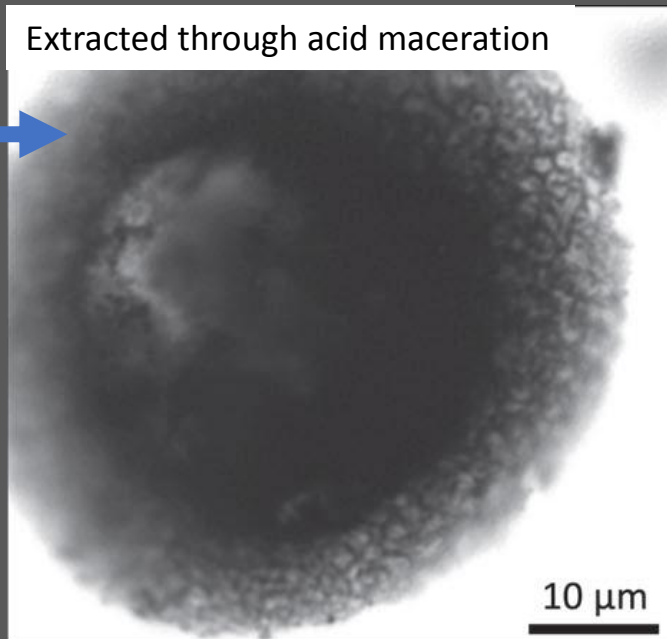
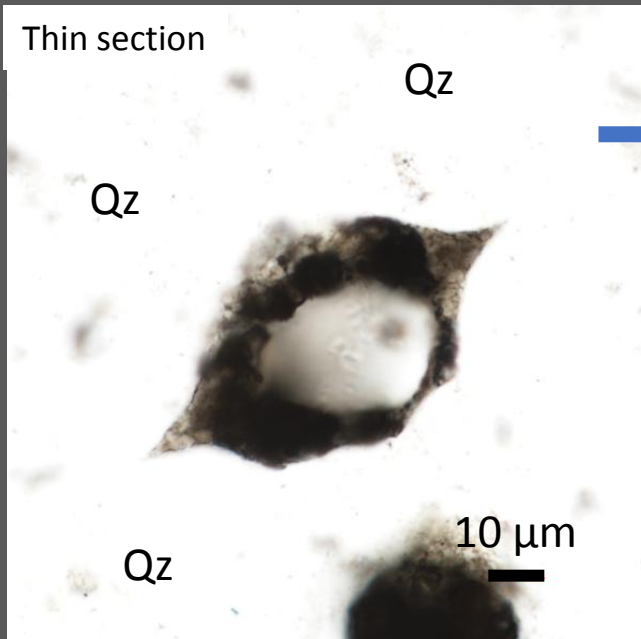
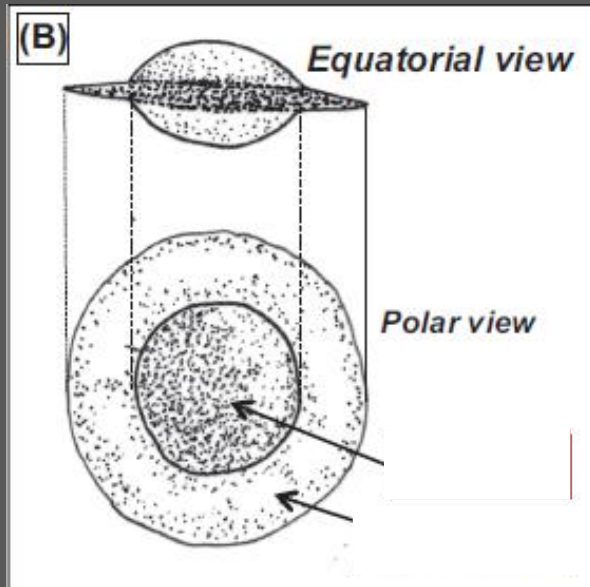
# Lenticular

- Specific to Archean rocks
- Distinctive structure
- Multiple shapes
- Abundant (over 100 sp. /sections)





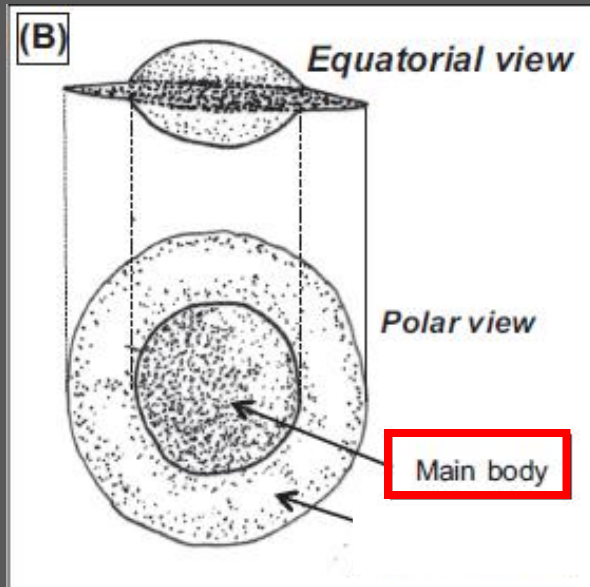
- $<100\ \mu\text{m}$  length -  $<50\ \mu\text{m}$  width
- Ovoid shape made of CM



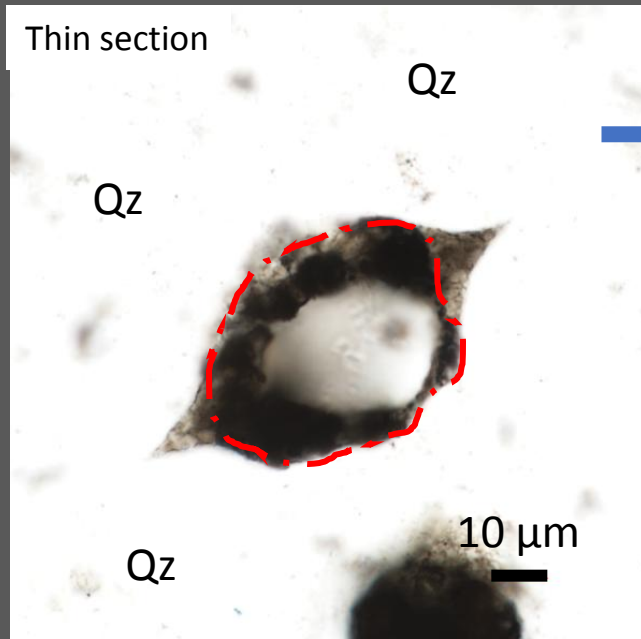
Coutant *et al.*, in prep.

Sugitani *et al.*, 2015a

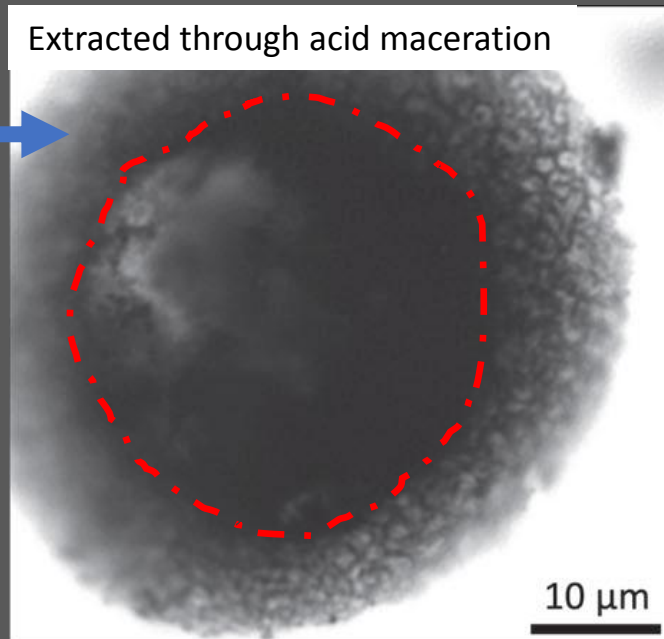
Sugitani *et al.*, 2015a



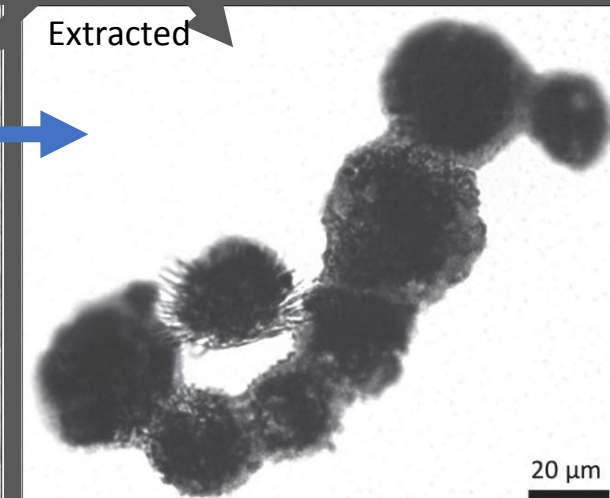
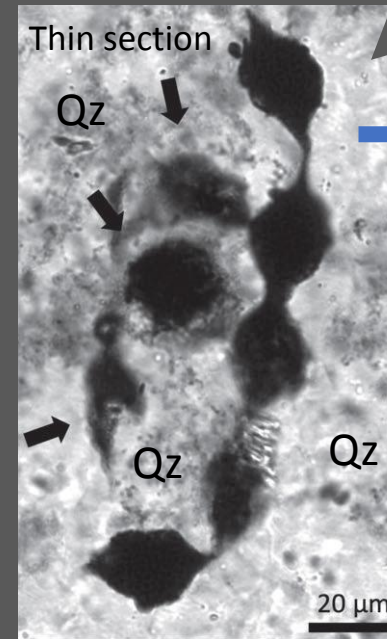
- $<100\ \mu\text{m}$  length -  $<50\ \mu\text{m}$  width
- Ovoid shape made of CM
- Main body **C-boundaries** – (partly) filled C-granules and/or silica



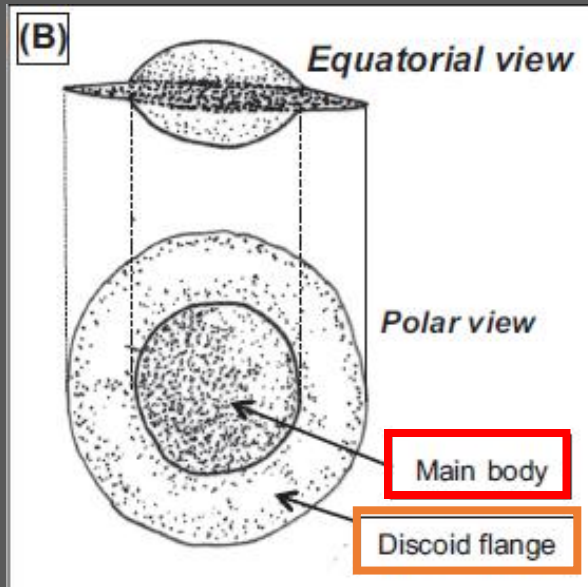
Coutant *et al.*, in prep.



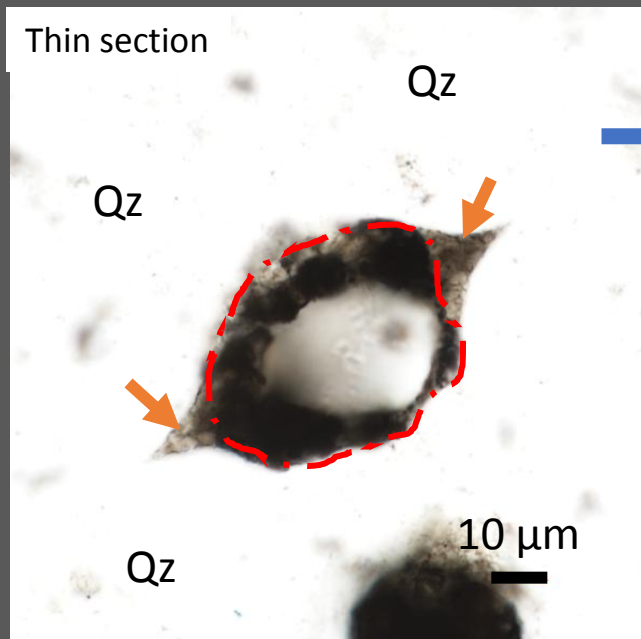
Sugitani *et al.*, 2015a



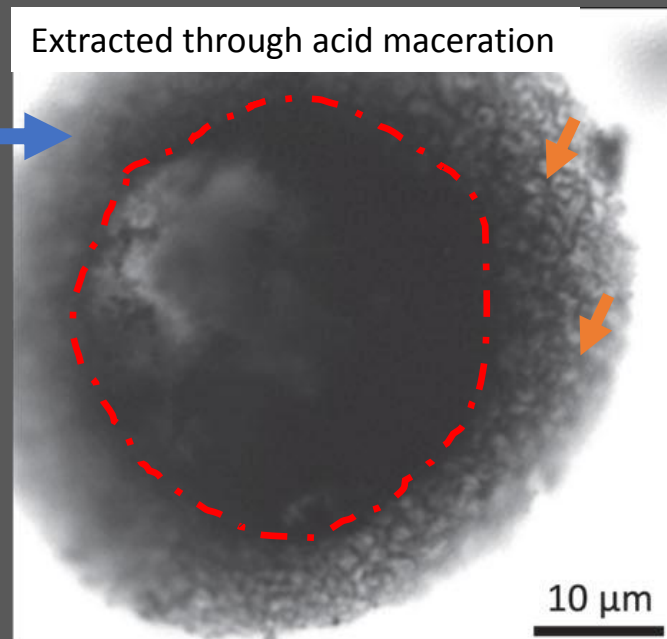
Sugitani *et al.*, 2015a



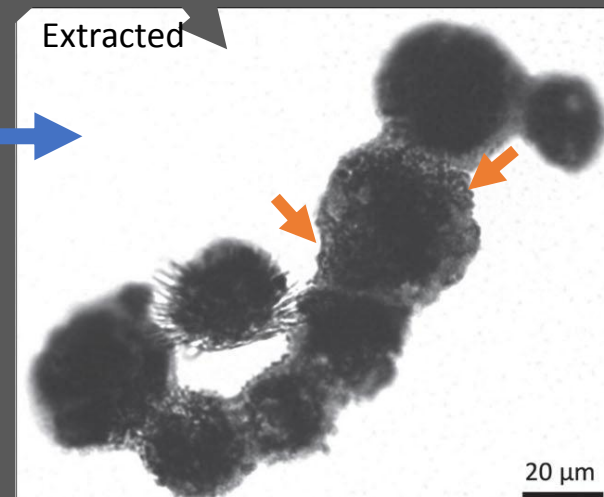
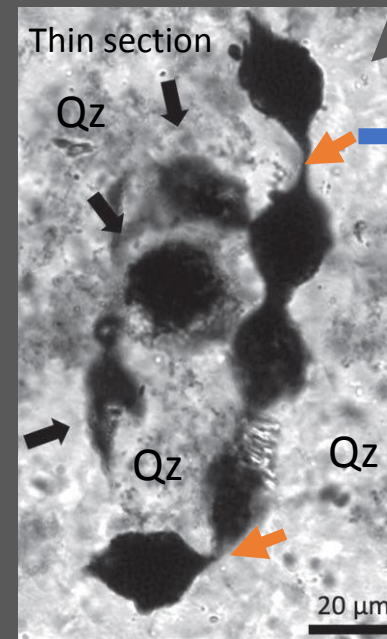
- <math><100\ \mu\text{m}</math> length - <math><50\ \mu\text{m}</math> width
- Ovoid shape made of CM
- Main body **C-boundaries** – (partly) filled C-granules and/or silica
- ‘**Flange**’ reticulated network of CM



Coutant *et al.*, in prep.



Sugitani *et al.*, 2015a



Sugitani *et al.*, 2015a

# Advanced petrography on texture and ultrastructures

Received: 20 October 2021 | Revised: 4 May 2022 | Accepted: 20 May 2022  
DOI: 10.1111/gbi.12506

ORIGINAL ARTICLE

gebiology WILEY

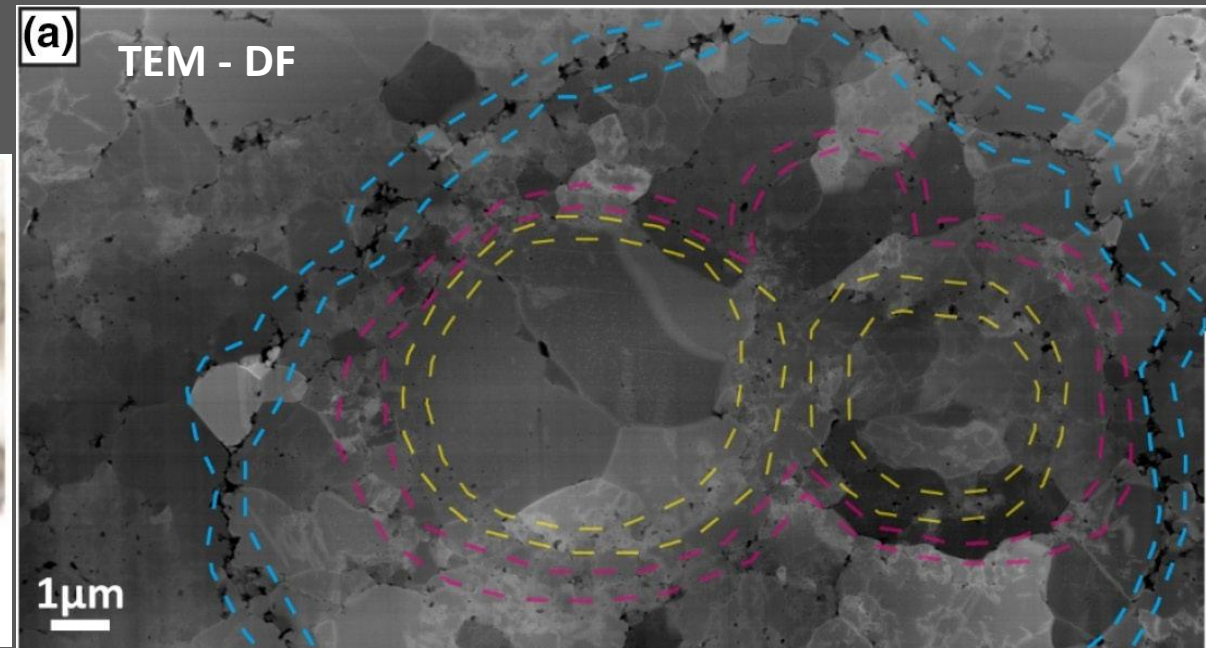
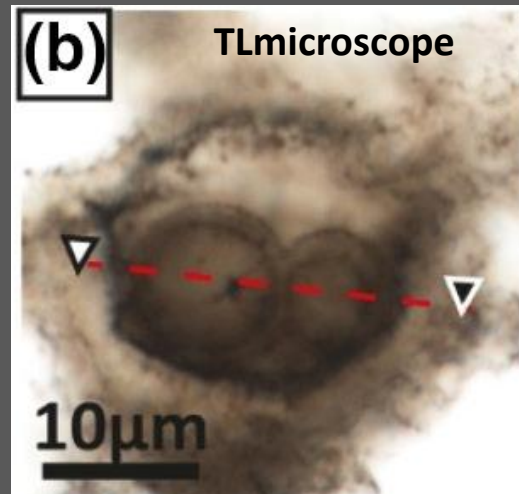
## Distinguishing cellular from abiotic spheroidal microstructures in the ca. 3.4 Ga Strelley Pool Formation

Maxime Coutant<sup>1,2</sup> | Kevin Lepot<sup>1,3</sup> | Alexandre Fadel<sup>4</sup> | Ahmed Addad<sup>4</sup> |  
Elodie Richard<sup>5</sup> | David Troadec<sup>6</sup> | Sandra Ventalon<sup>1</sup> | Kenichiro Sugitani<sup>7</sup> |  
Emmanuelle J. Javaux<sup>2</sup>

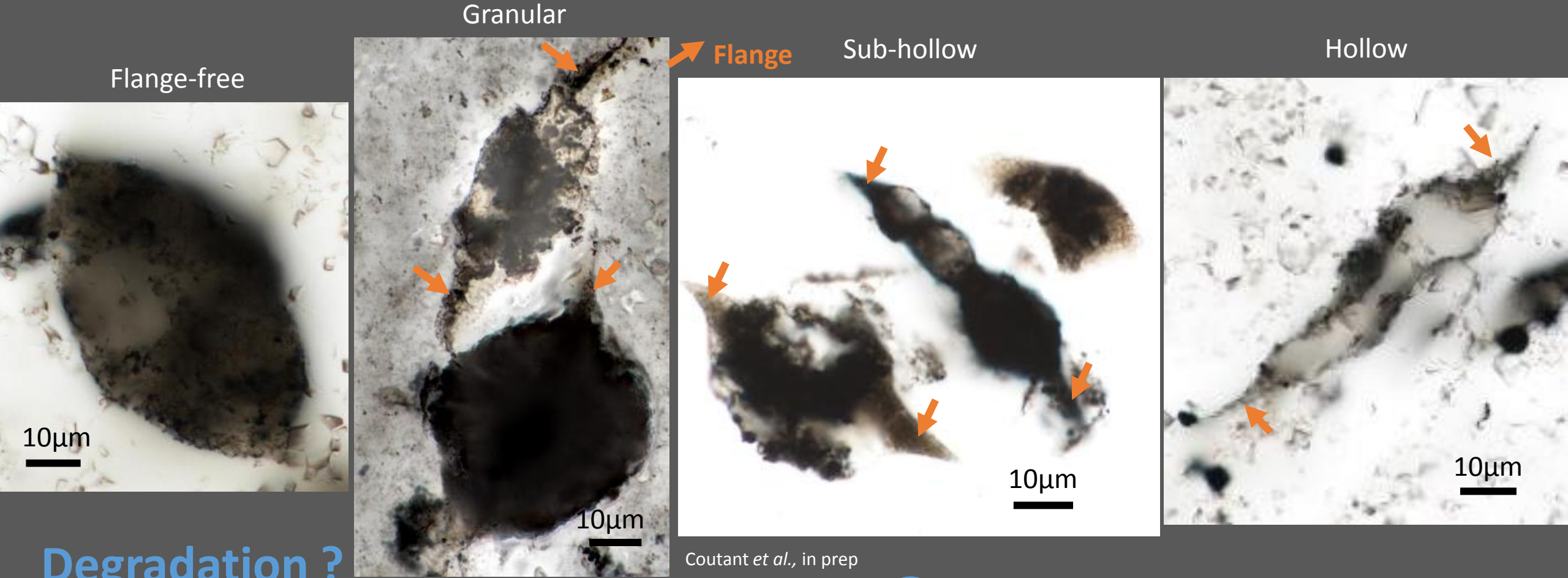
Coutant *et al.*, 2022

- ◇ 5 different types
- ◇ 2 likely abiotic morphogenesis
- ◇ 3 dubiofossils (2 types are unique)

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



# General morphologies - Shapes gradation ?



Degradation ?  
Silicification ?  
Biogenicity ?



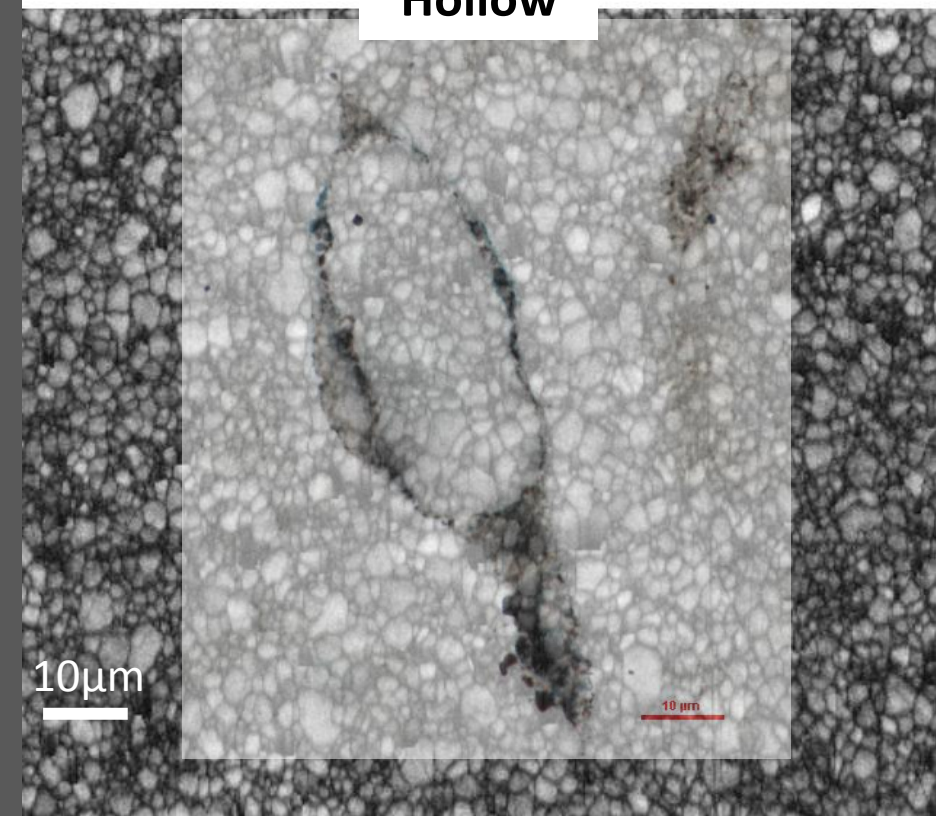
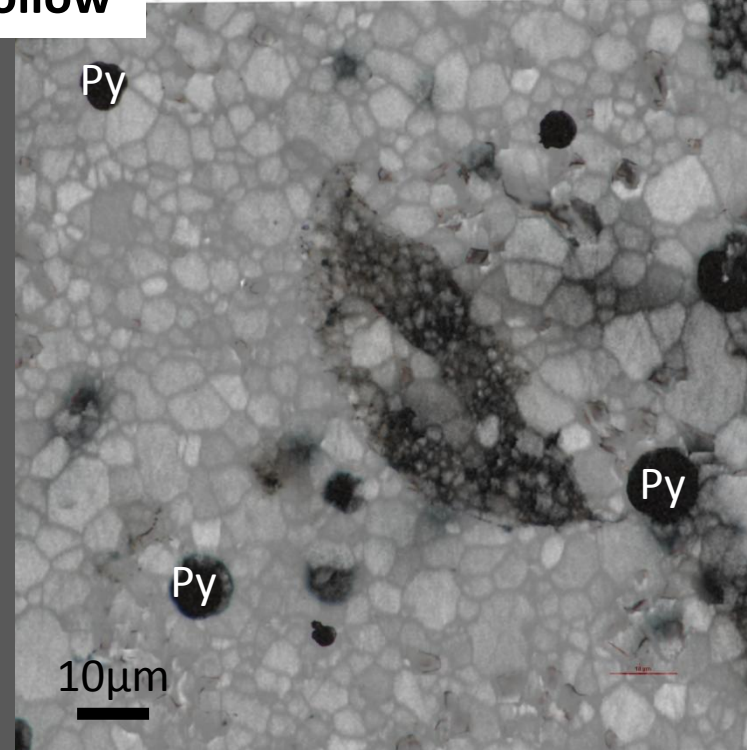
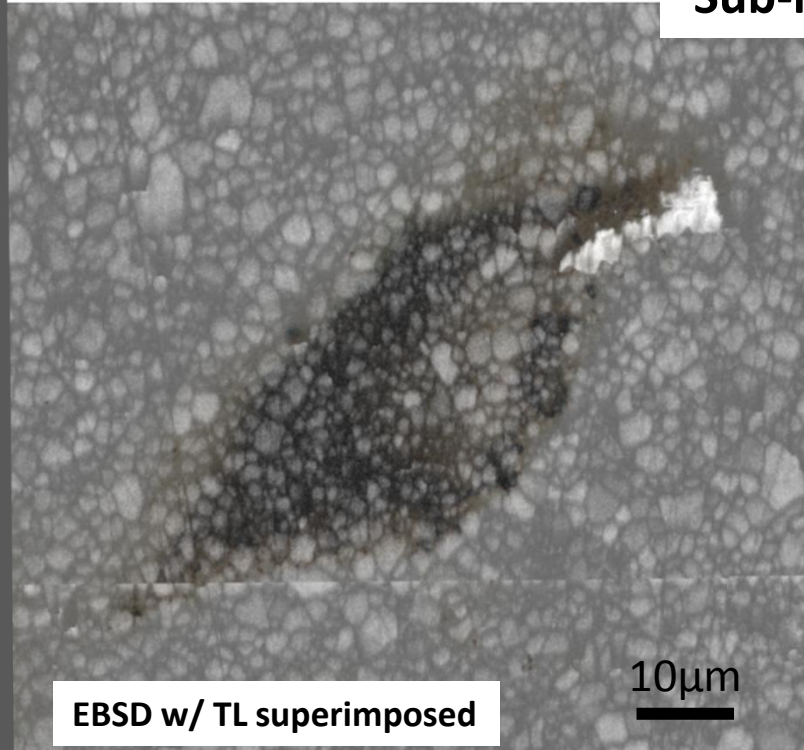
# μPetrography – Quartz-CM relationship

Band Contrast 14

Sub-hollow

Band Contrast 6

Hollow



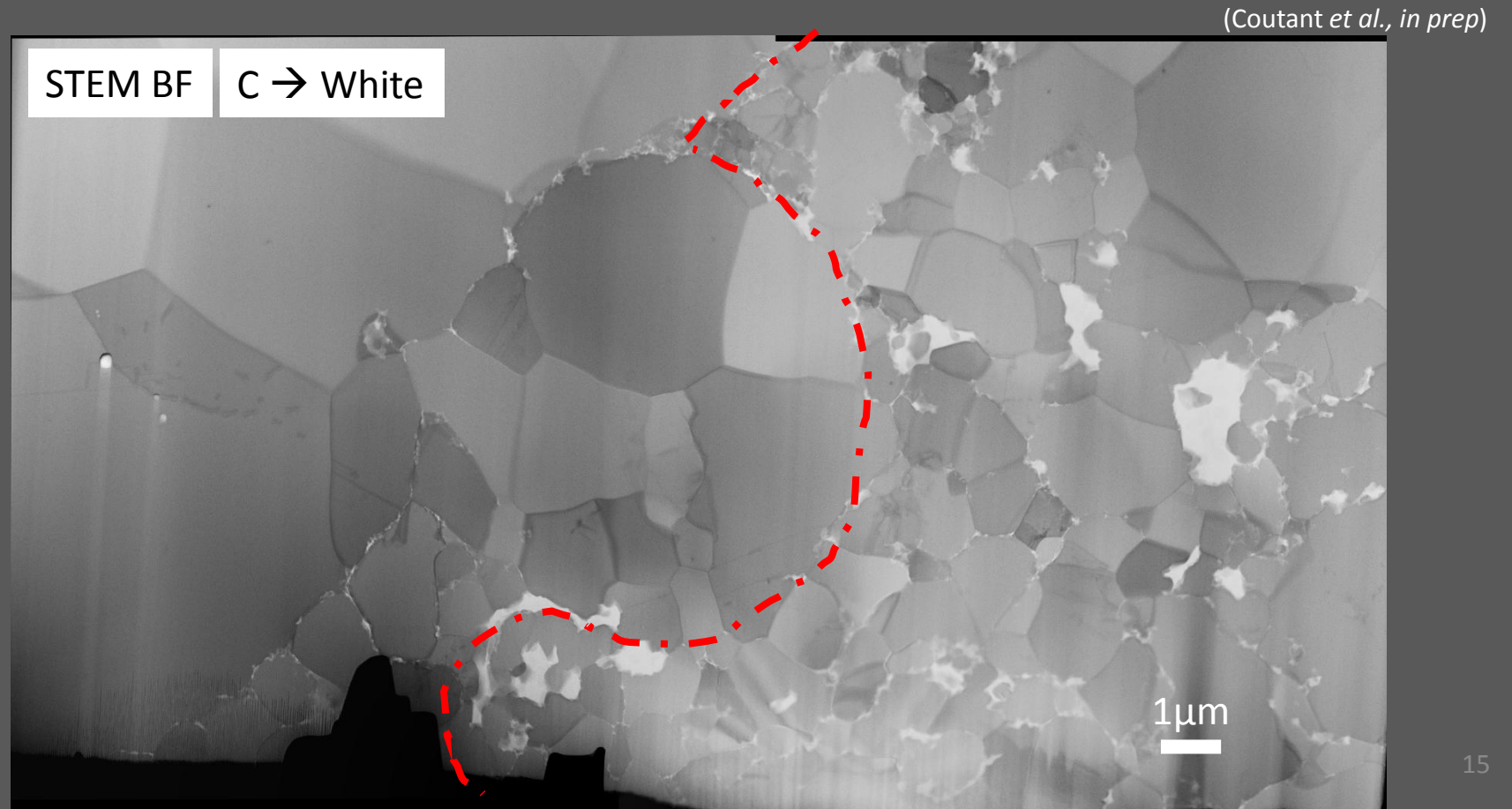
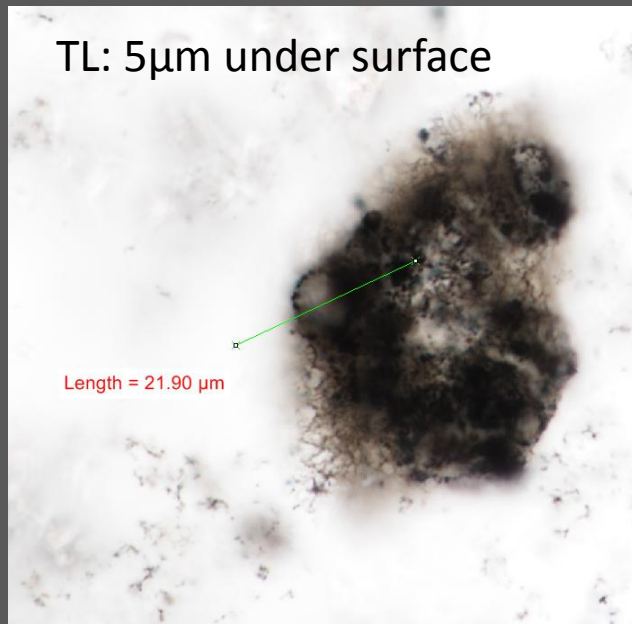
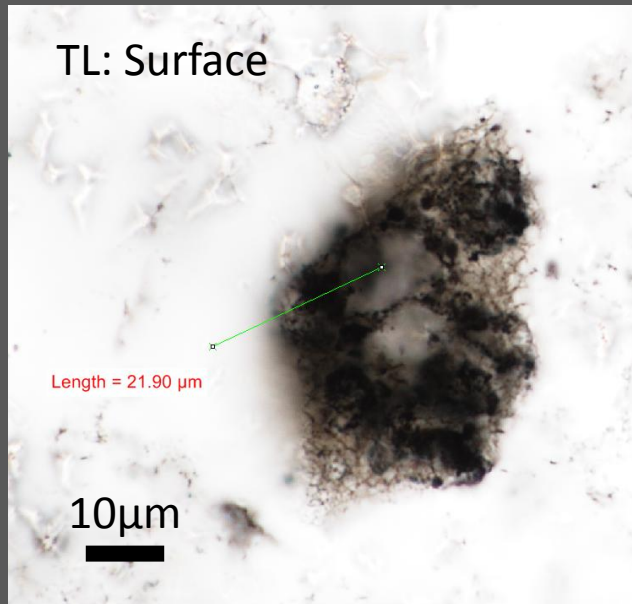
- Often large crystals in **vesicles** (Sugitani *et al.*, 2015a)
- Small **crystals** when associated to **CM**
- CM at Qz boundaries (no cross-cutting → abiogenic)

# Ultrastructure – nanoPetrography

Coutant *et al.*, in prep

## Granular/Sub hollow

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

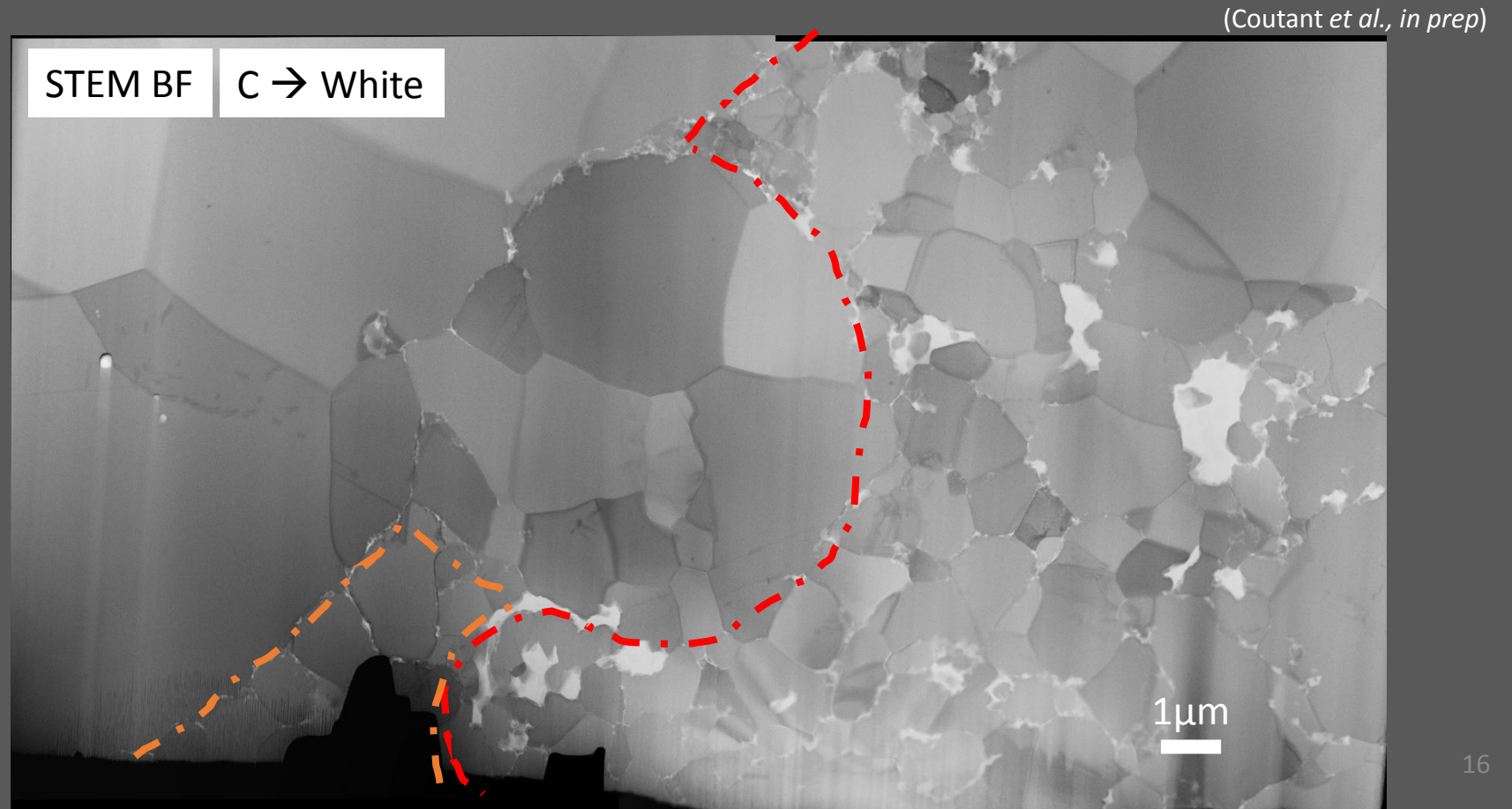
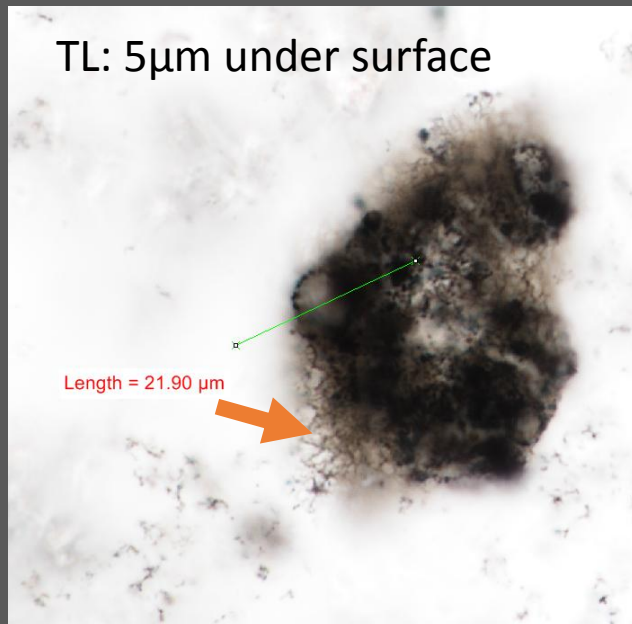
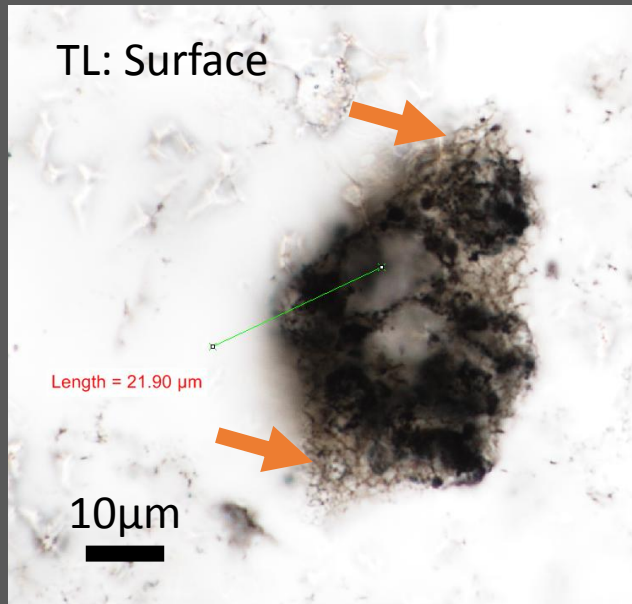


# Ultrastructure – nanoPetrography

Coutant *et al.*, in prep

## Granular/Sub hollow

- C-granules → **Main body** – no walled structures
- **Reticulated CM** → **Flange**





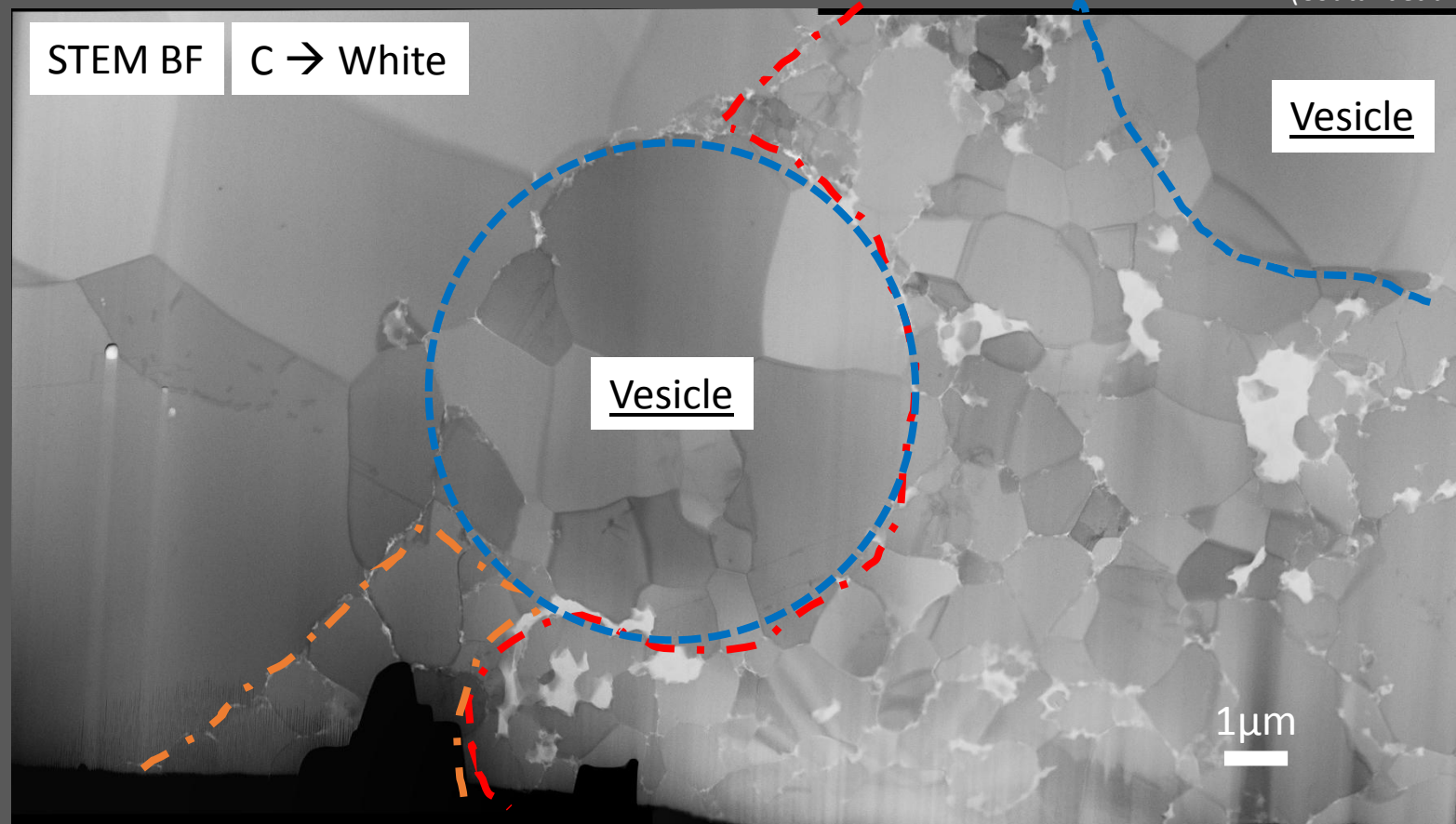
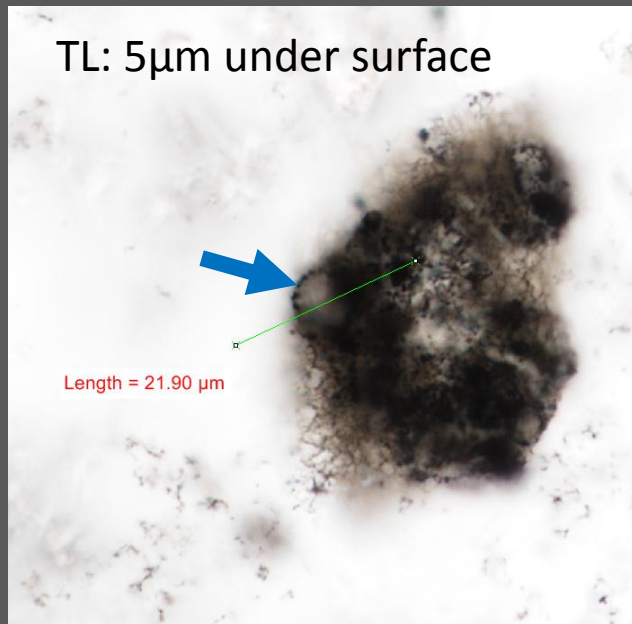
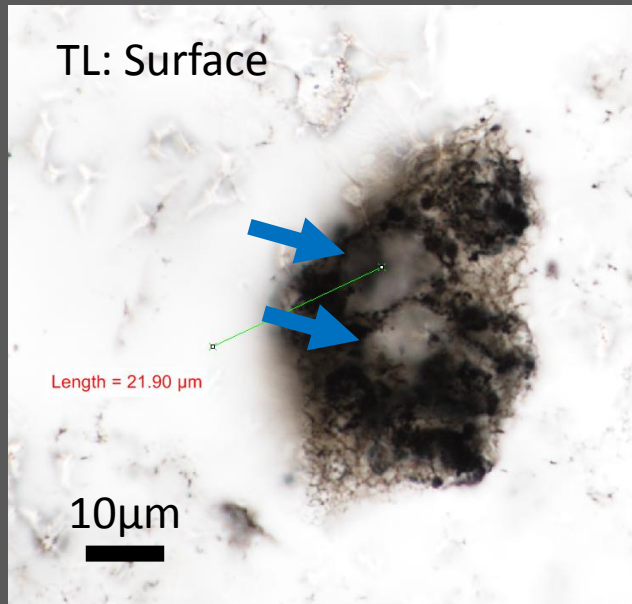
# Ultrastructure – nanoPetrography

Coutant *et al.*, in prep

## Granular/Sub hollow

- C-granules → **Main body** – no walled structures
- **Reticulated CM** → **Flange**
- No cross-cutting structures ≠ abiotic spheres

(Coutant *et al.*, in prep)



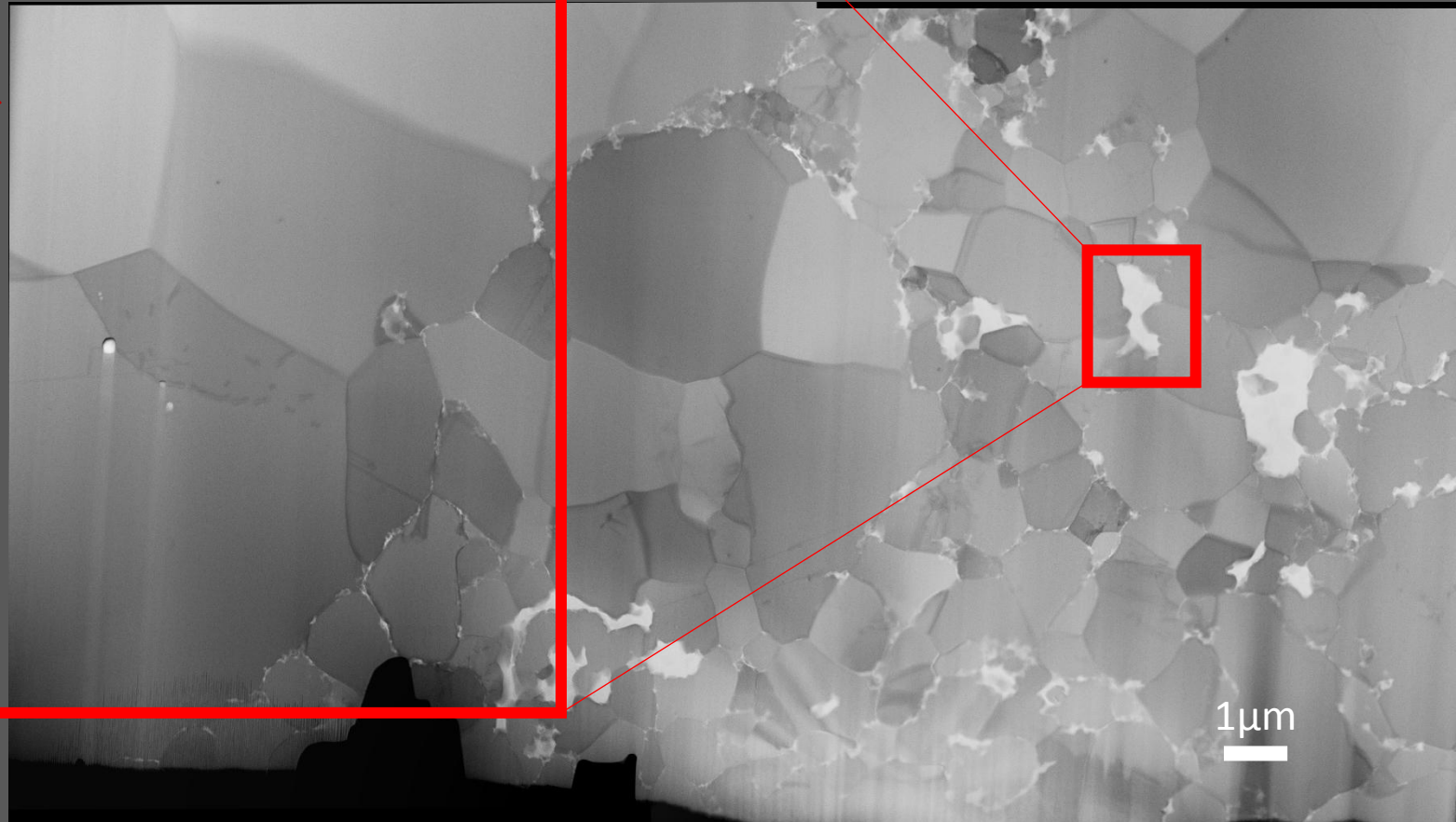
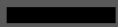
# Ultrastructure – nanoPetrography

## Granular/Sub hollow

High contrasted DF



200nm



- Nanopores inside C granules
- Pyrobitumen ?

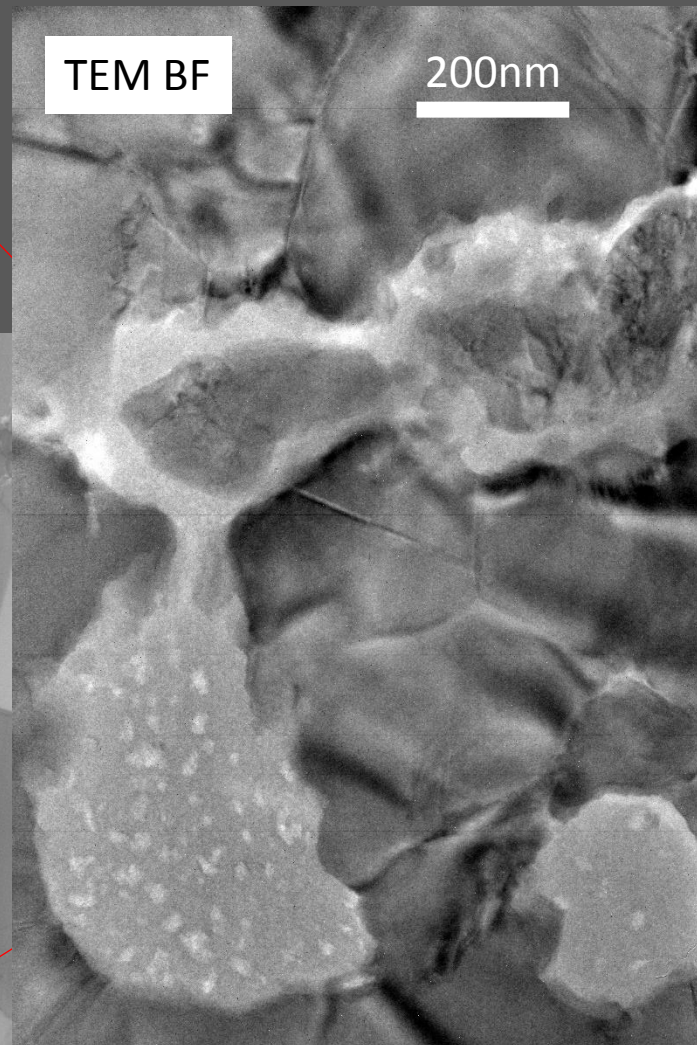
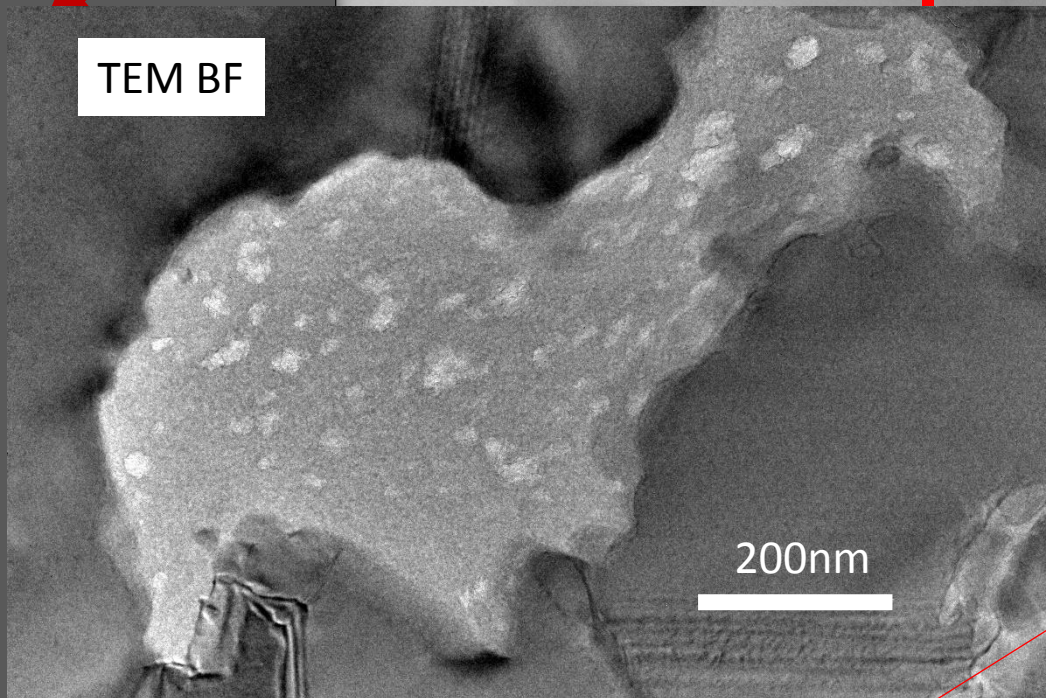
1 $\mu$ m



# Ultrastructure – nanoPetrography

## Granular/Sub hollow

High contrasted DF



anules

- 
- 

200nm

1 $\mu$ m

# Ultrastructures – nanoPetrography

# 1,9 Ga Gunflint Formation (Canada)

Rasmussen *et al.*, 2021

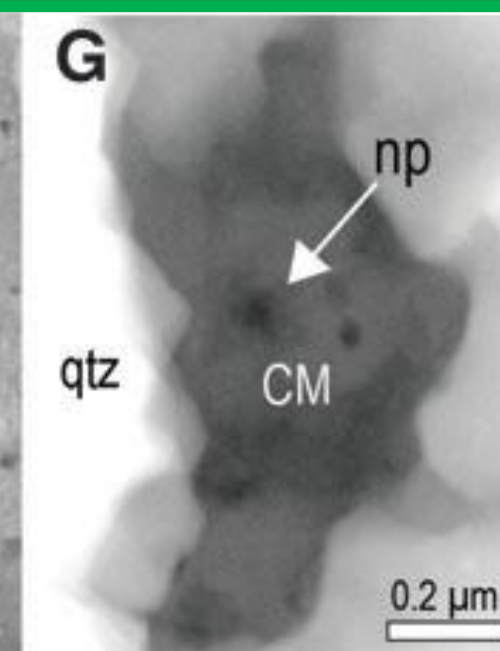
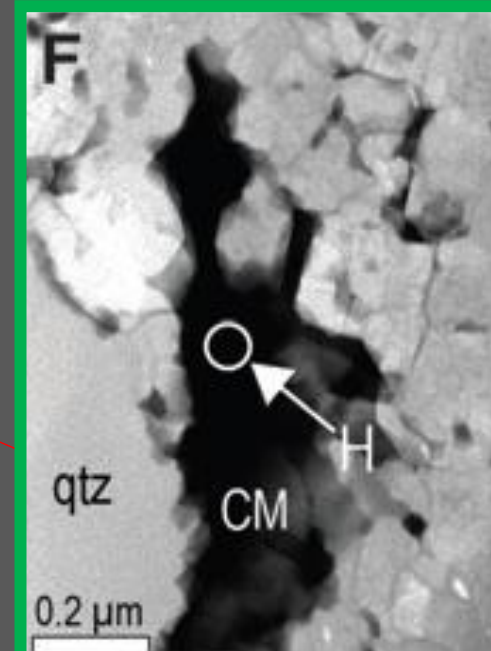
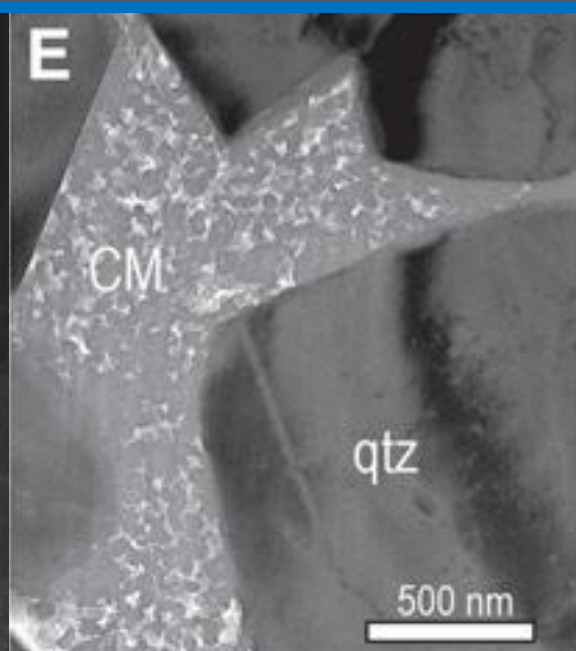
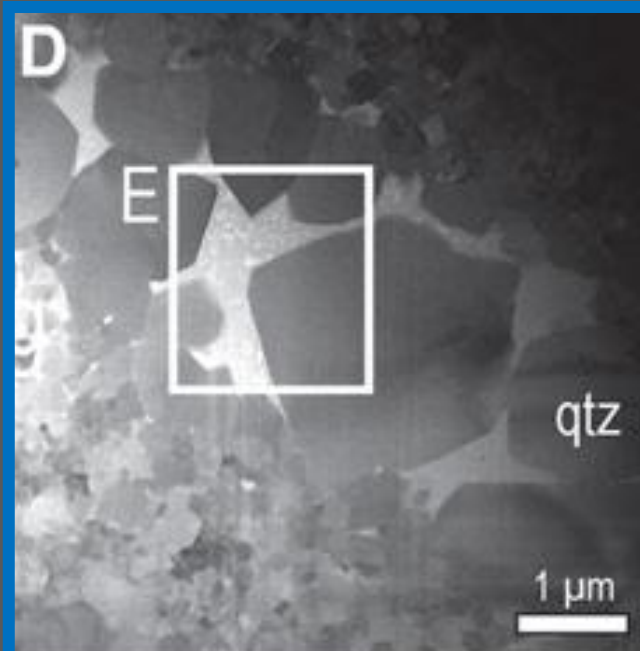
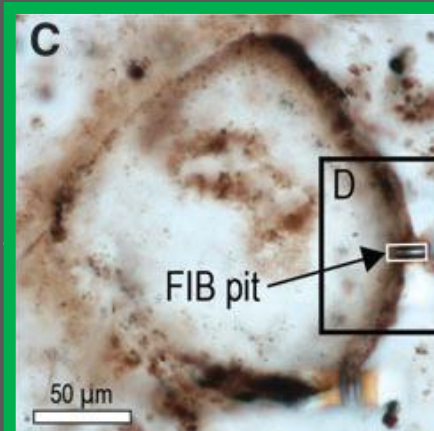
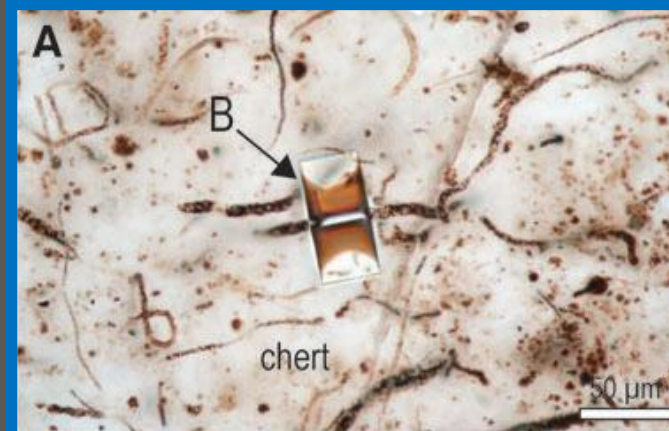
Microfossil

Quartz Grain

Nanophases in CM and Qz

Infiltration of exogenous soluble CM (pyrobitumen)

Nano-inclusion → Multiple generation of CM

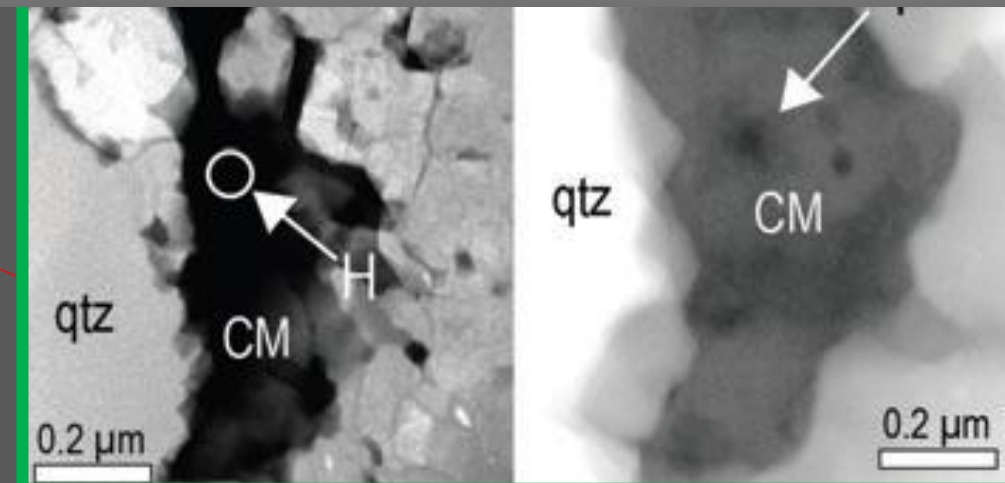
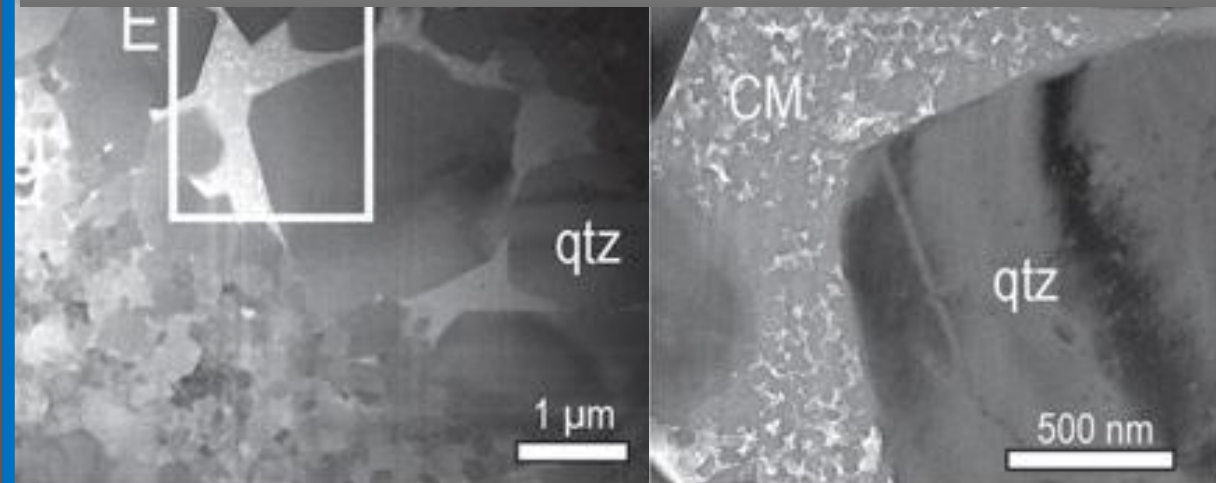




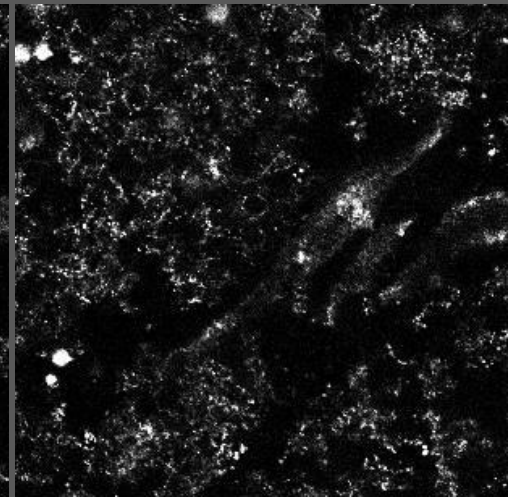
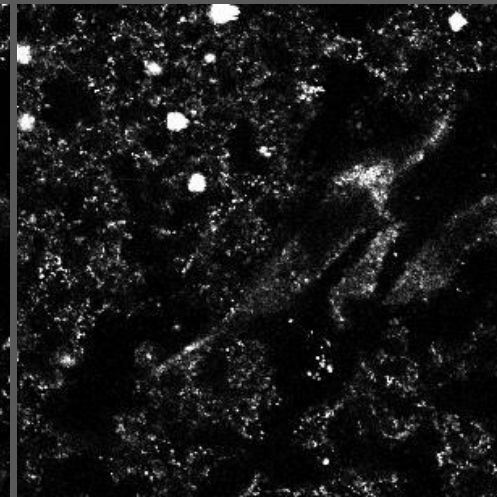
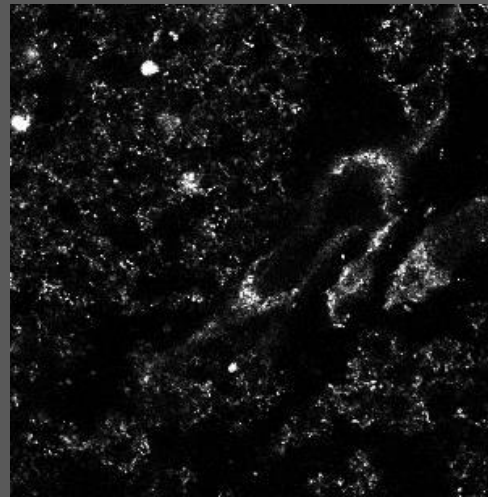
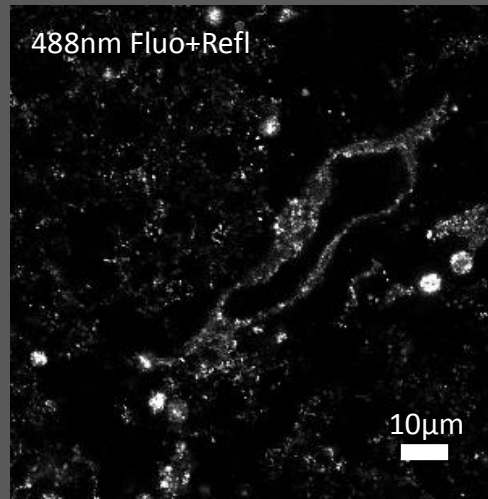
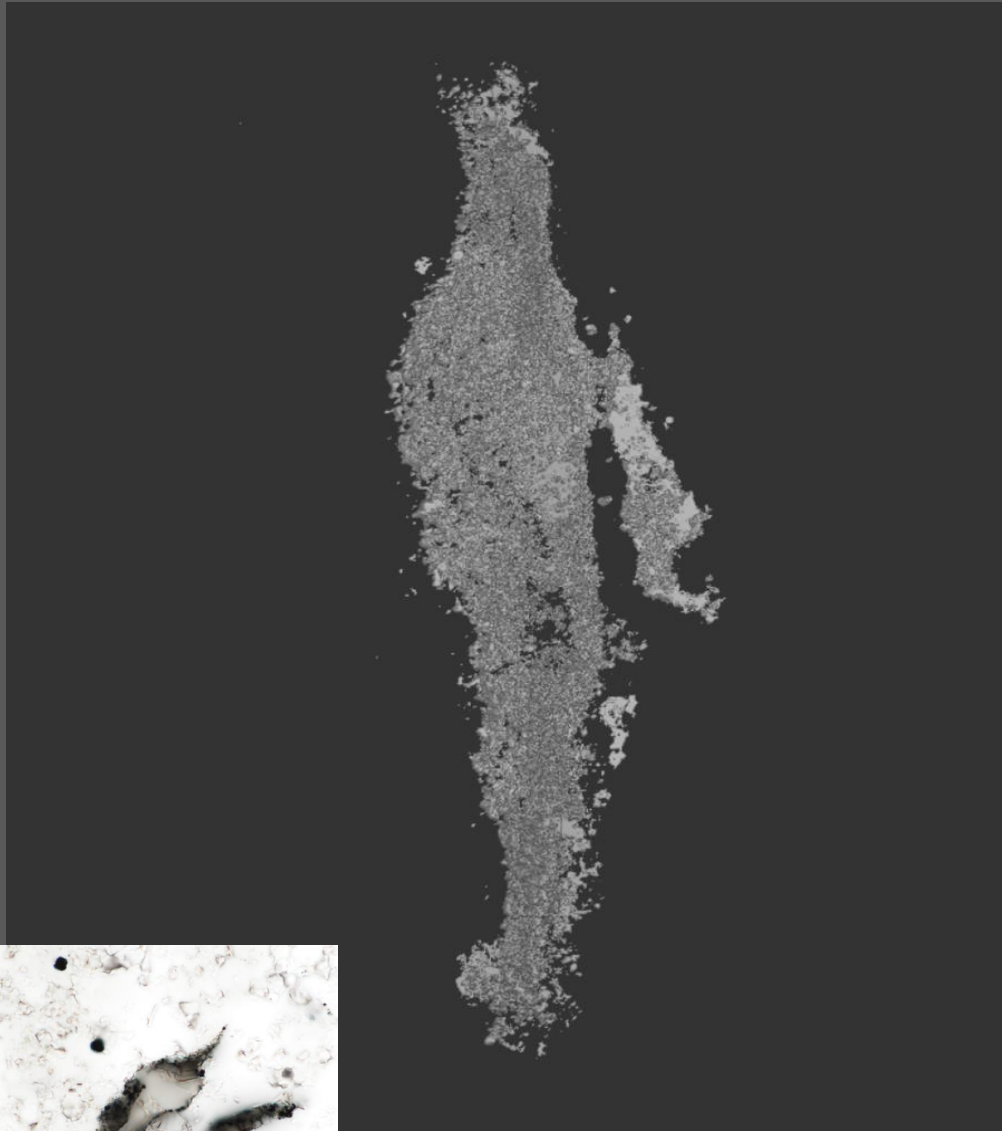
Nanophases in CM and Qz

Infiltration of exogenous soluble CM (pyrobitumen)

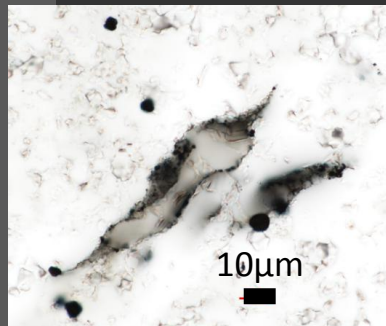
**Pyrobitumen may infills  $\mu$ fossils as well as biomorphs**



# μPetrography – 3D CLSM

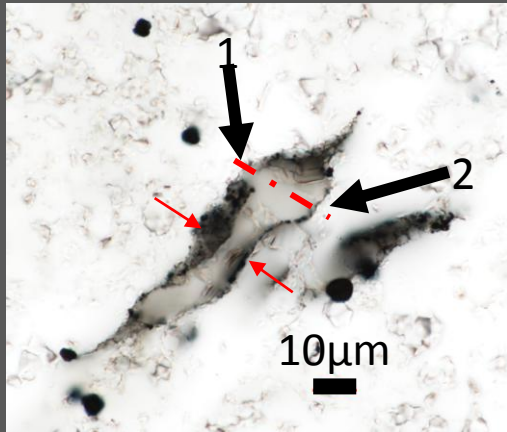


- Continuous wall
- Folding of the wall – taphonomy ? = Biogenic ?

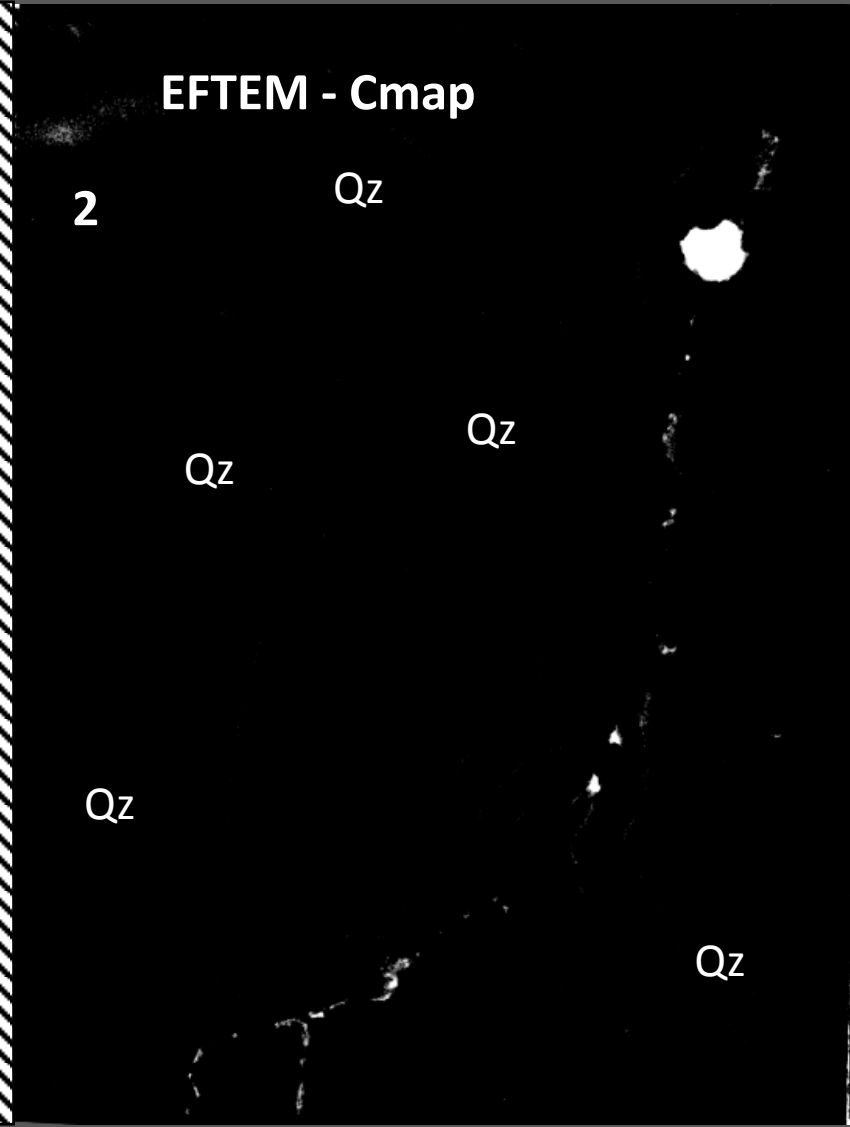
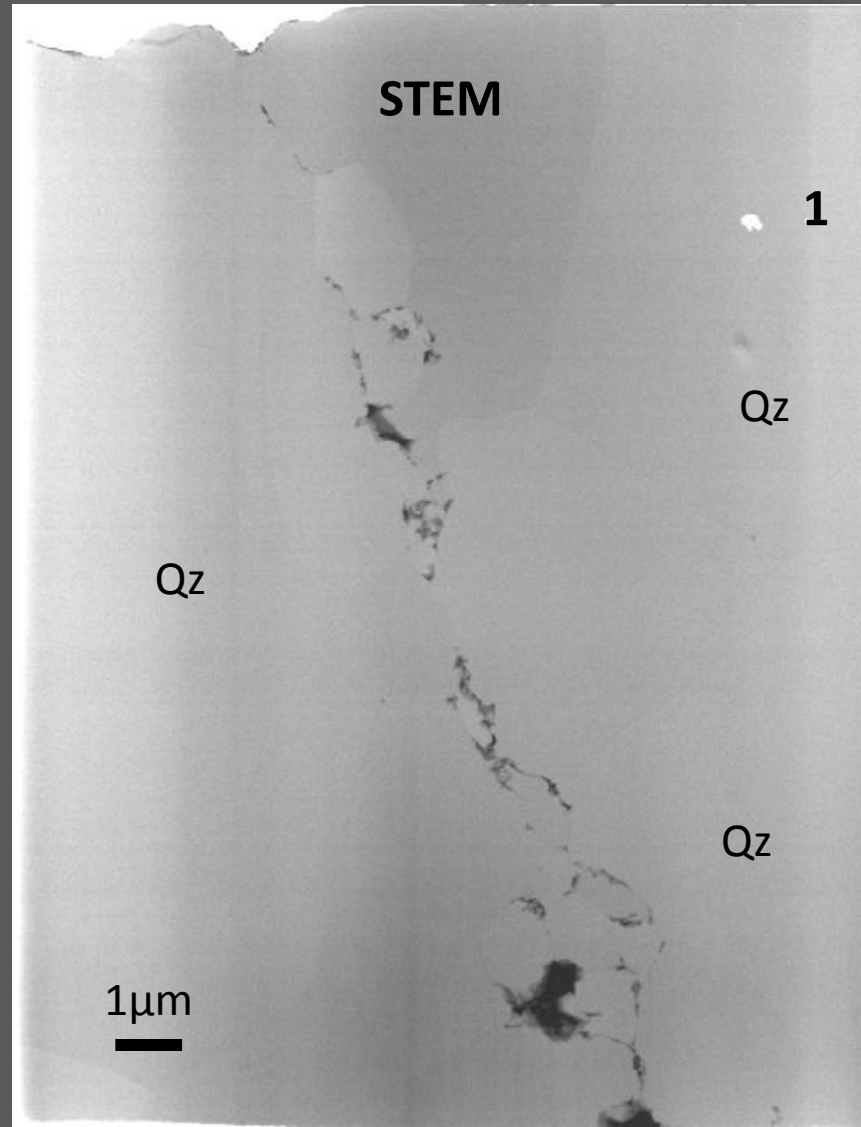


# Ultrastructures – nanoPetrography

Hollow



Coutant *et al.*, in prep

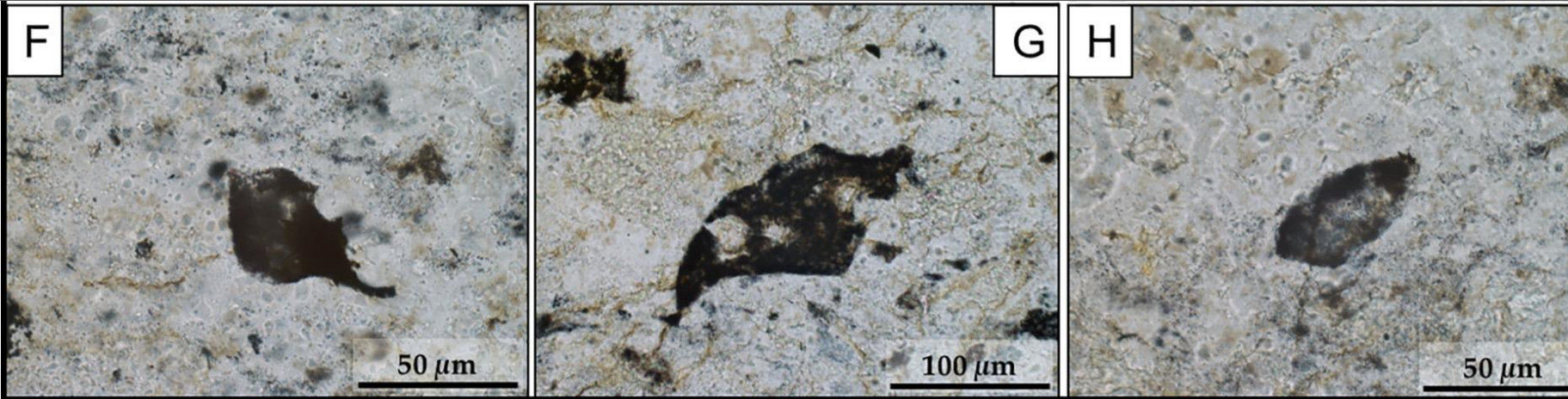


Walls (sub)continuous  
CM @ Qz boundaries **only**  
Folding  
No cross-cutting structure

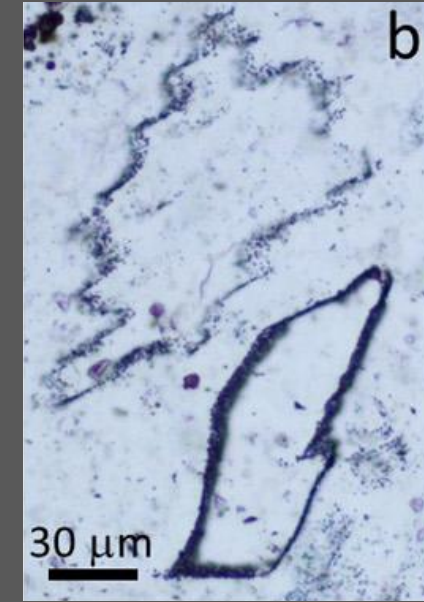
Likely biogenic ?

# Hollowness = biogenic ?

Hickman-Lewis *et al.*, 2018

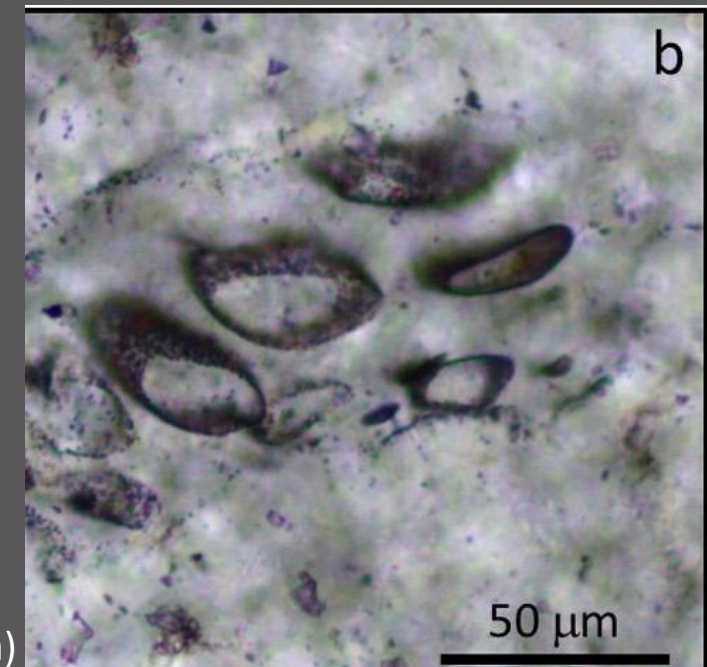


Volcaniclastic siltstone 3.47 Ga Middle Marker (South Africa)



Wacey *et al.*, 2018b

Volcanic structure (pumice-tephra) covered by CM that could **mimick** our  $\mu$ structures



Volcaniclastic sandstone 3.4 Ga Strelley Pool Formation (Western Australia)



# Take-home messages

- Gradient ?

Degradation →  $\mu$ fossil?

Impregnation (pyro) →  $\mu$ fossil & biomorphs?

- Granular texture appears **abiotic**, Hollow may exist in **biomorphs**
- In situ mass spectrometry is the next step, new features → Stay tuned !
- Find out the most efficient criteria to define genuine biogenicity

# Thank you for your attention

Acknowledgements :

Supervisors



E.J. Javaux



K. Lepot



Université  
de Lille

PMEL



Other collaborators

A. Fadel – A. Addad – E. Richard – C. Spriet – T. Bance – S. Ventalon