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Origin of rod and dumbbell shaped phosphate precipitates in Namibian shelf sediments

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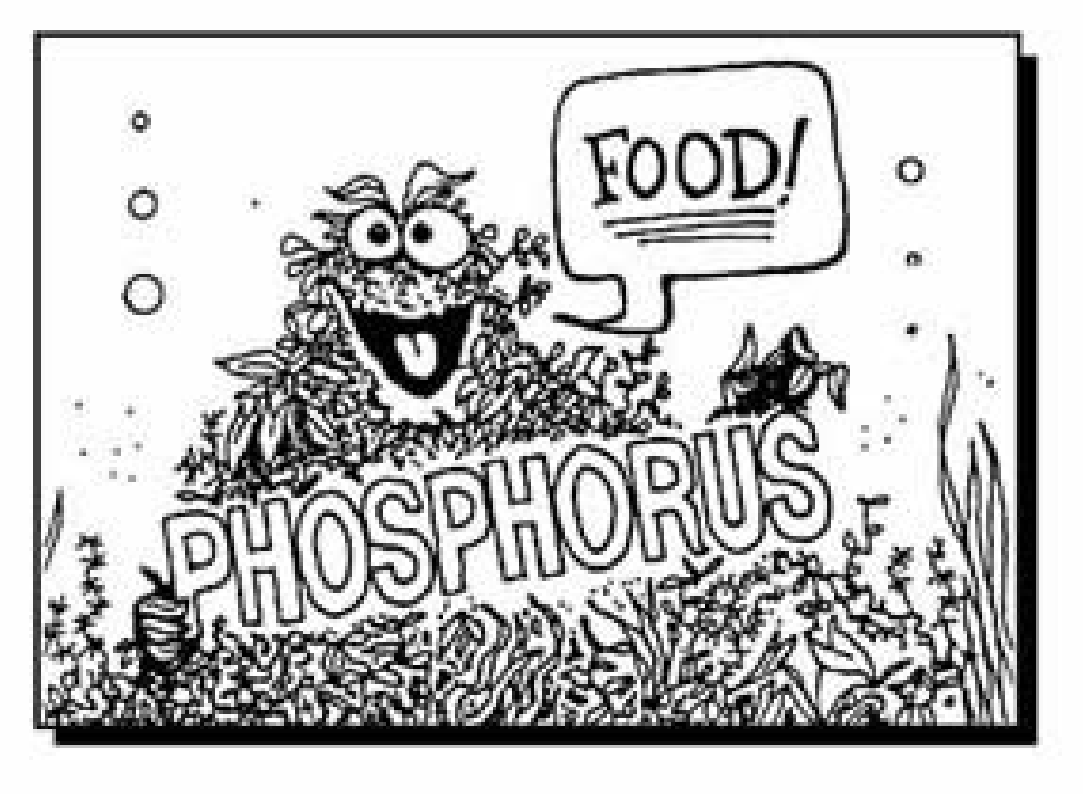
GEOLOGICAL SURVEY OF NORWAY
- NGU -

RGNO
Research Discovery Camp

Introduction

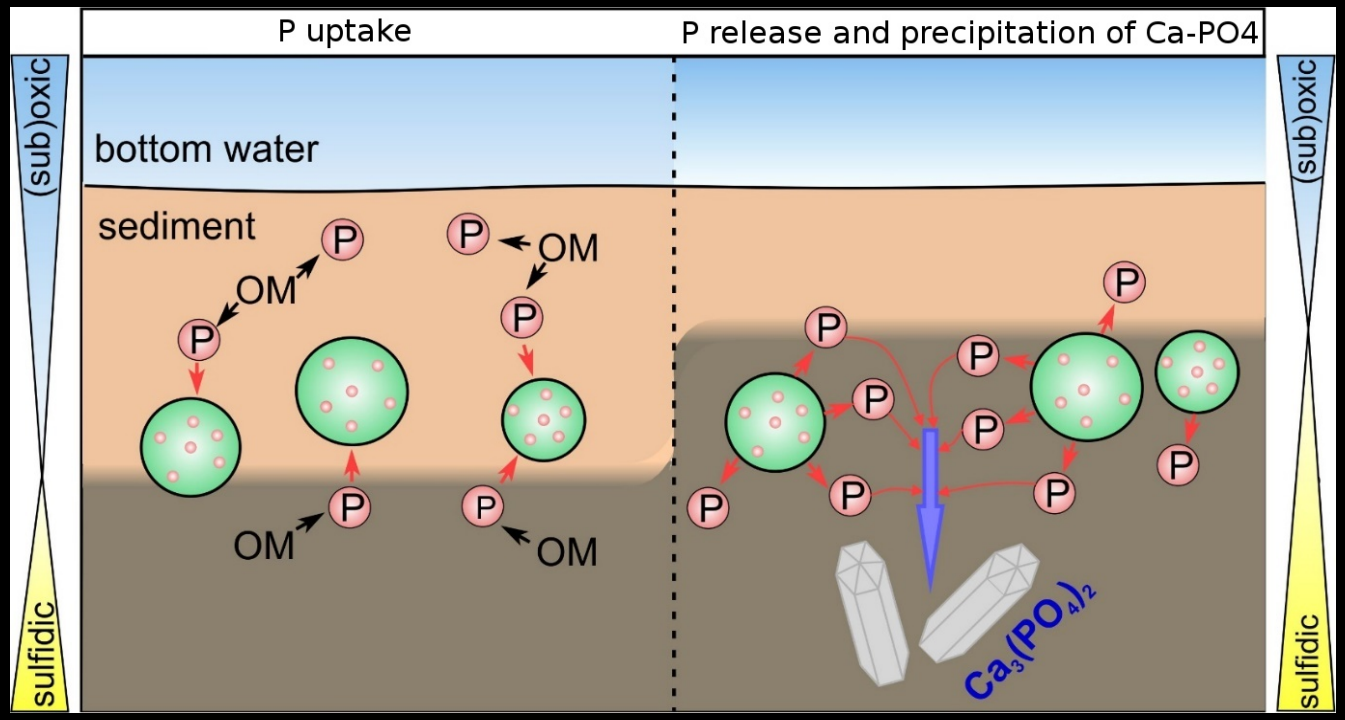
- Phosphorous can be the limiting nutrient in a variety of marine and terrestrial ecosystems.
- As a component of fertilizers, it is important in agriculture.



http://www.lakegeorgeassociation.org/what-we-do/lake-friendly-living/The-Trouble-with-Phosphorus.htm

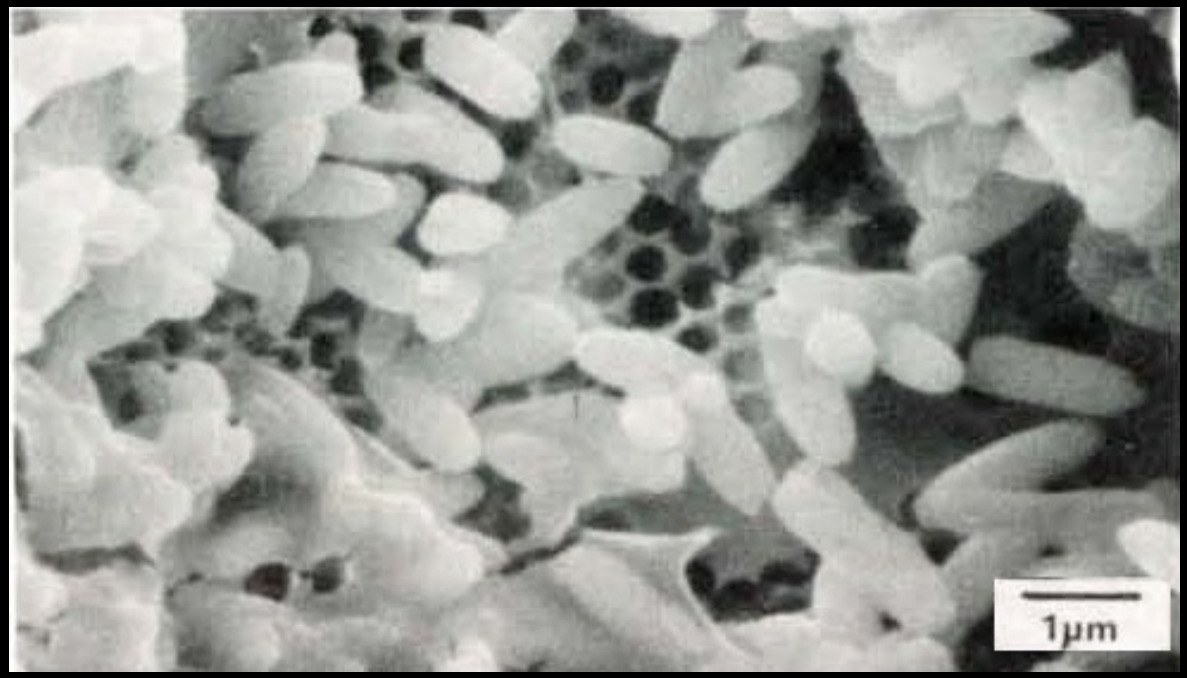
Microbially mediated phosphogenesis

- The origins of phosphorites are still poorly understood.
- One of the proposed formation mechanisms emphasizes the role of polyphosphate-metabolizing bacteria that are capable of storing and releasing phosphate.



Modified, Brock and Schulz-Vogt (2011)

Phosphatization is well-known as a fossilization mechanism



- Apatitic microstructures in ancient and recent phosphorites have been (controversially) interpreted as fossilized microbes (e.g. Lamboy, 1990), therefore providing evidence for the important role of microbial processes on phosphogenesis.

Goals

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- The goals of this study are:
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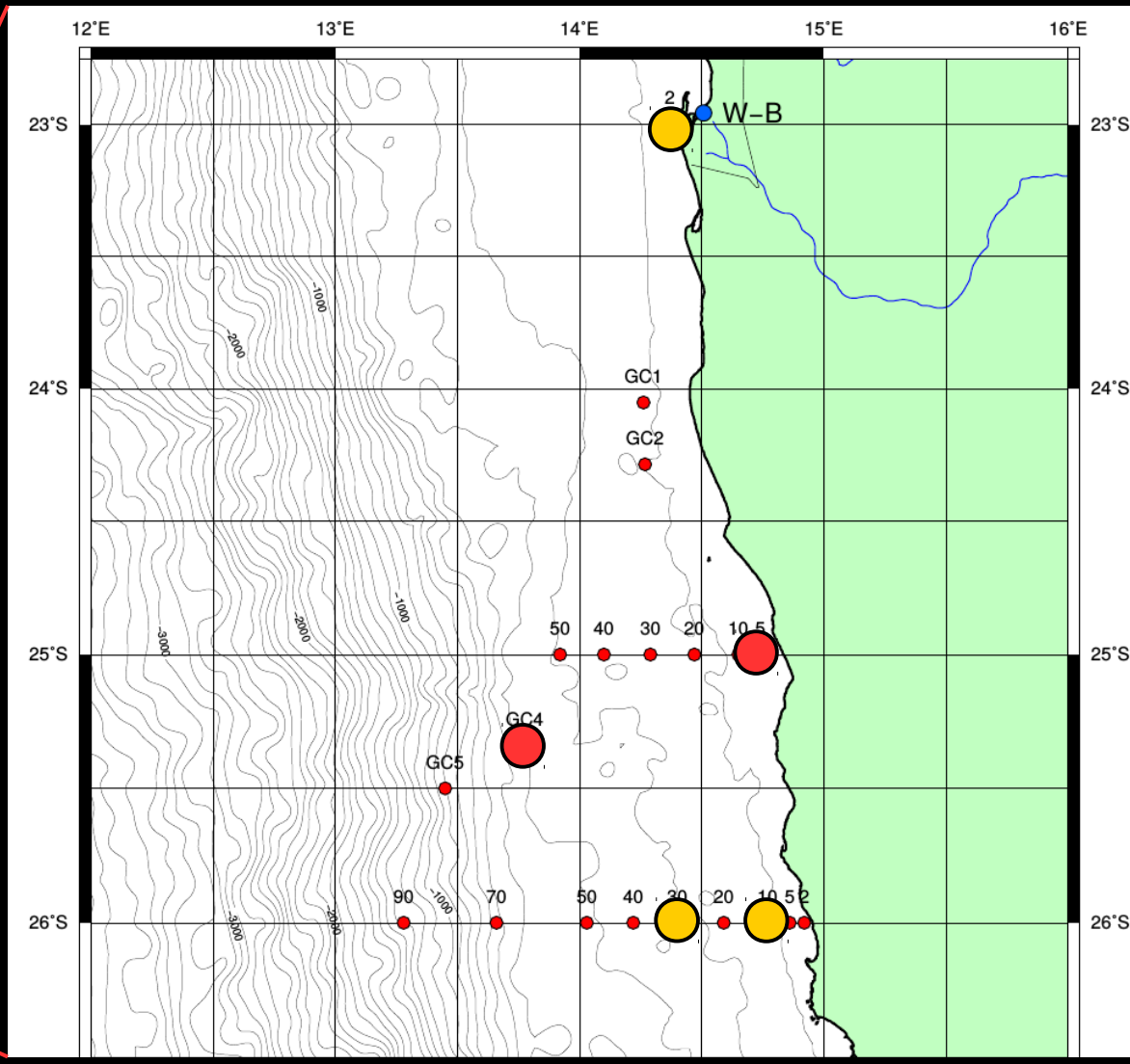
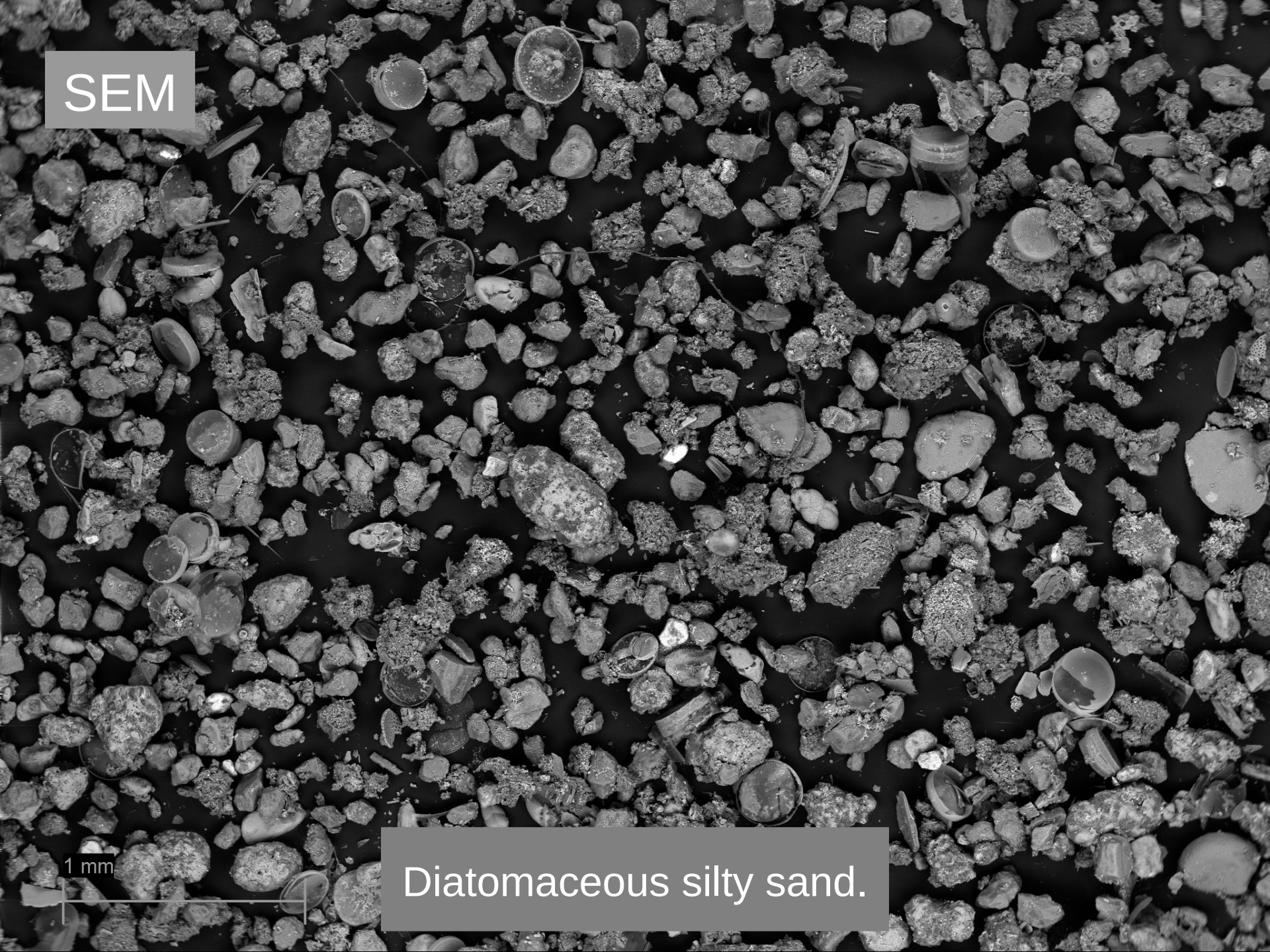
- The goals of this study are:
  - to study microbial structures present and preserved in modern phosphorites;
  - to understand if and how phosphate precipitation is controlled/influenced by microbial/biological structures.
- Recrystallization of ancient phosphorites makes it difficult to recognize primary structures, but comparison with modern phosphorites can help assess controls of past phosphogenesis.

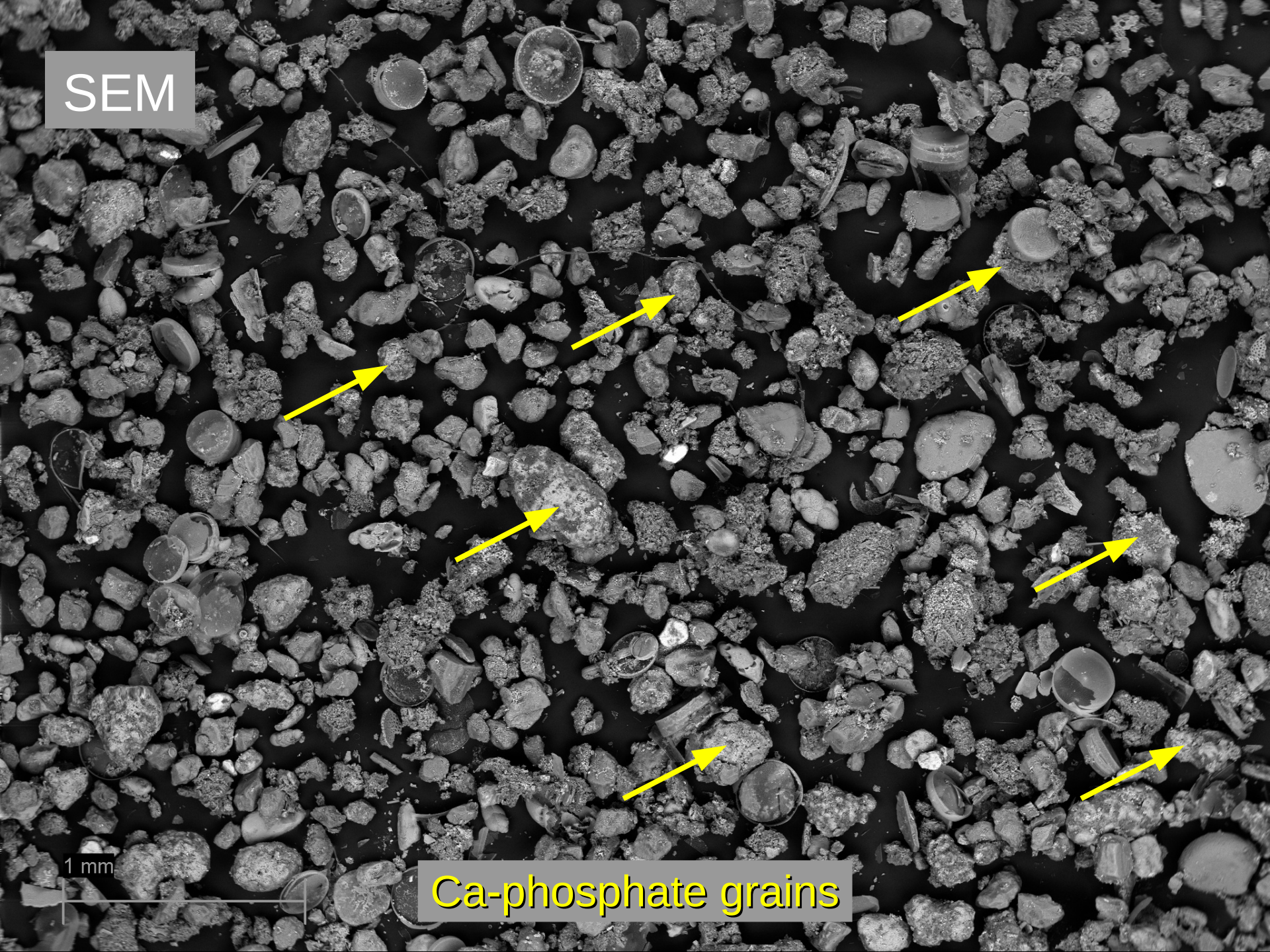
Materials

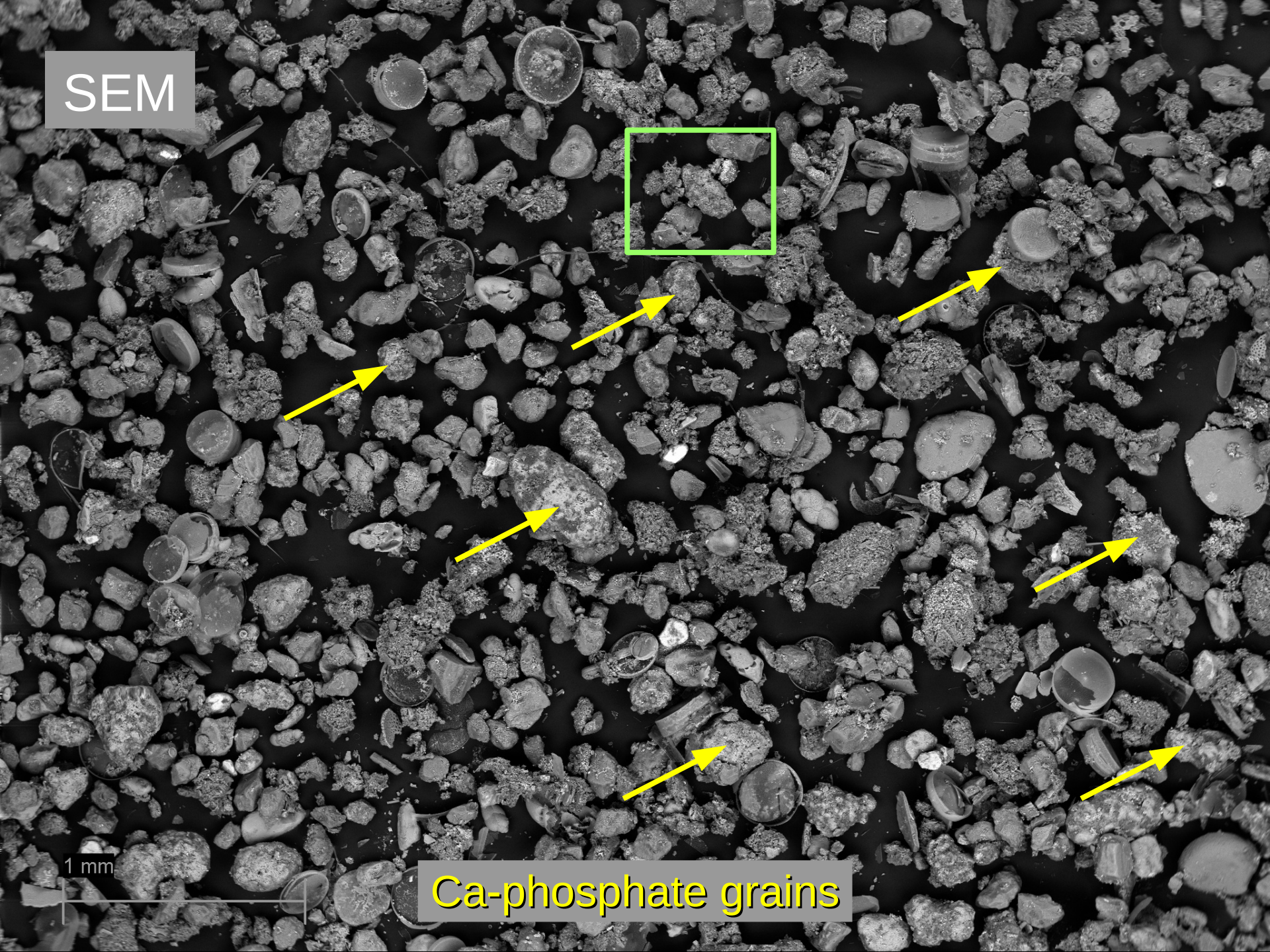


- Samples were collected from the Benguela Upwelling System off of Namibia, a site of modern phosphogenesis.

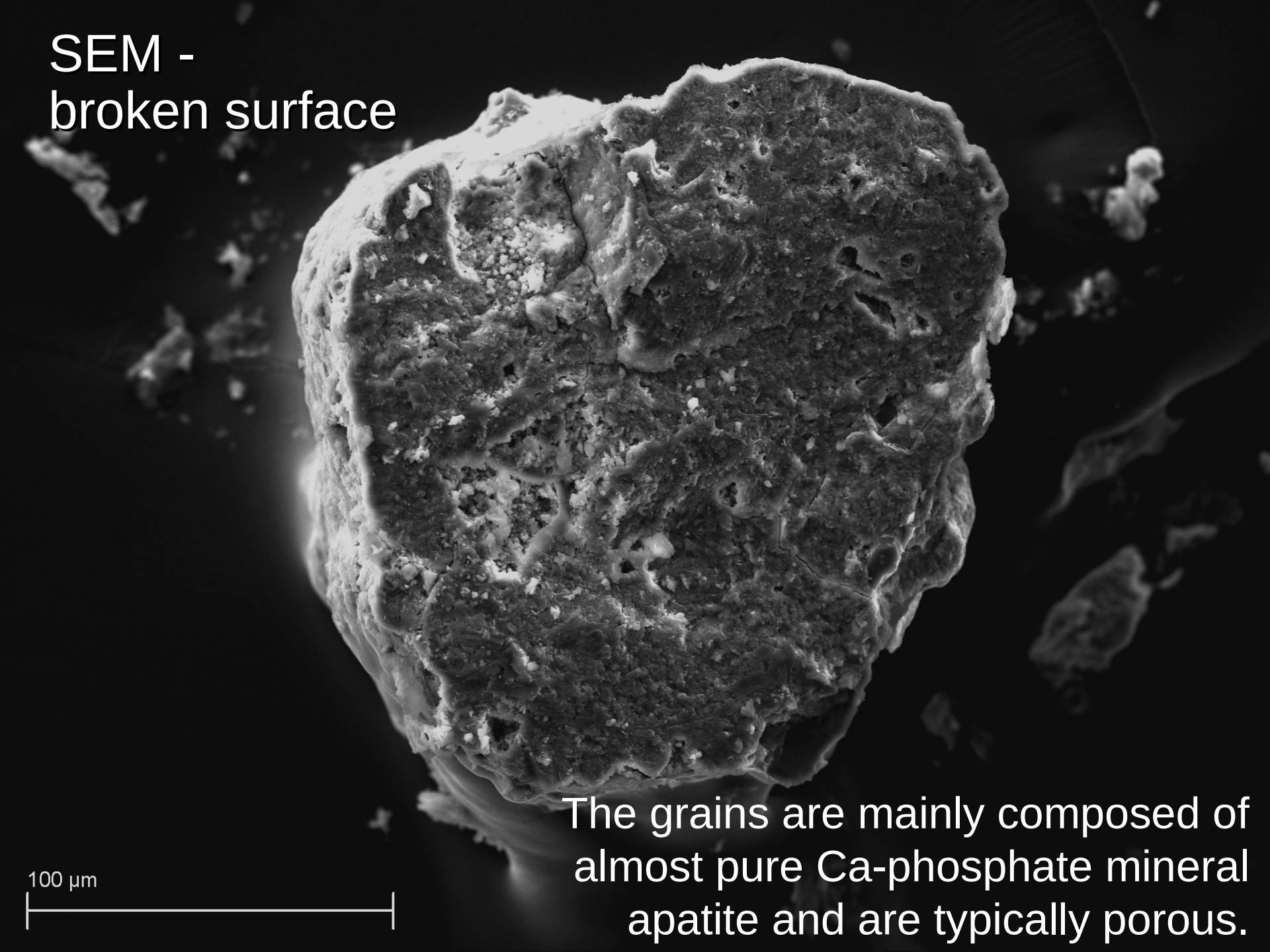


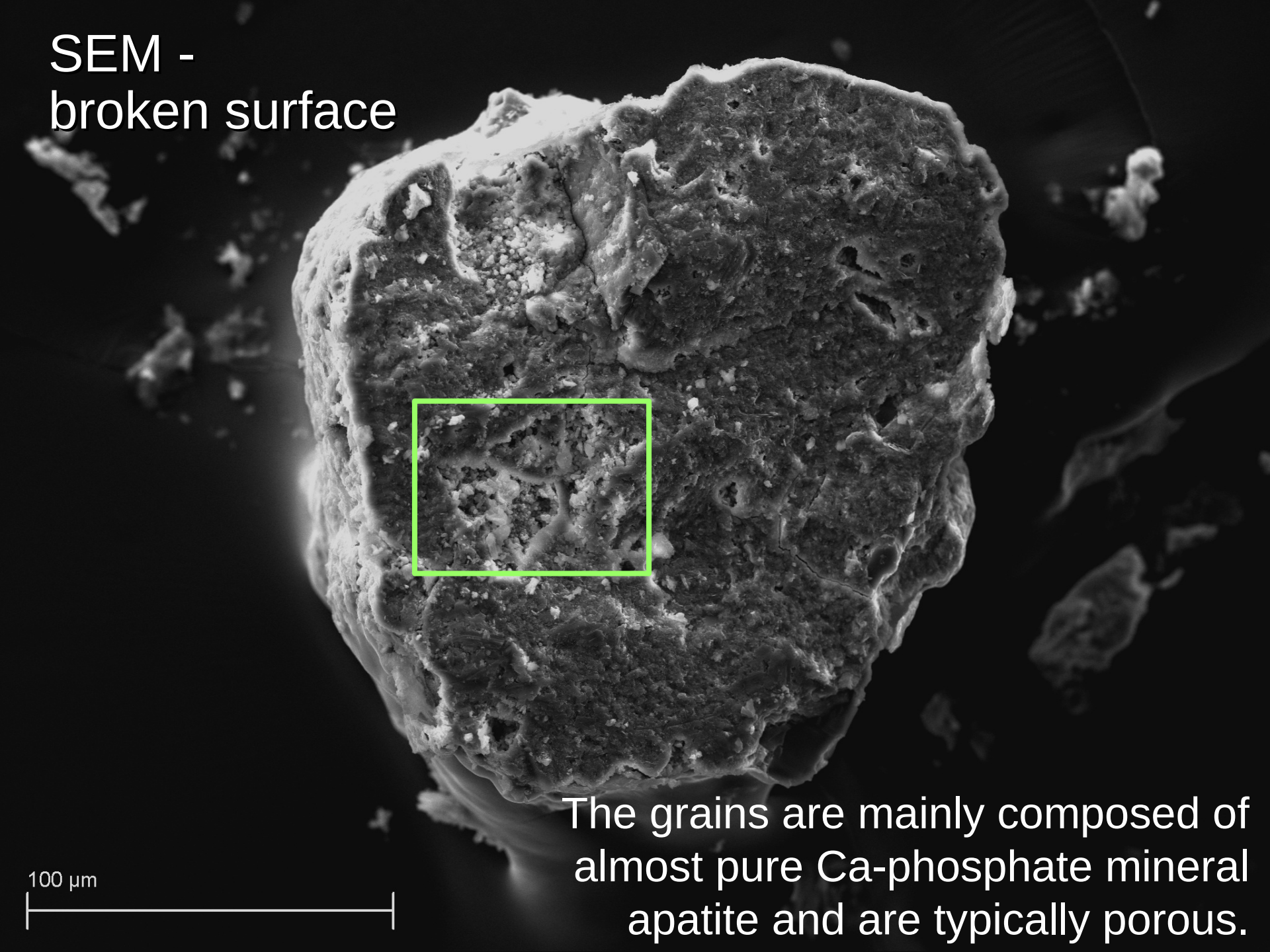
Diatomaceous silty sand.


SEM
1 mm
Ca-phosphate grains


SEM
1 mm
Ca-phosphate grains

The grains are rounded and a few hundred µm in diameter.


SEM -
broken surface
100 µm
The grains are mainly composed of almost pure Ca-phosphate mineral apatite and are typically porous.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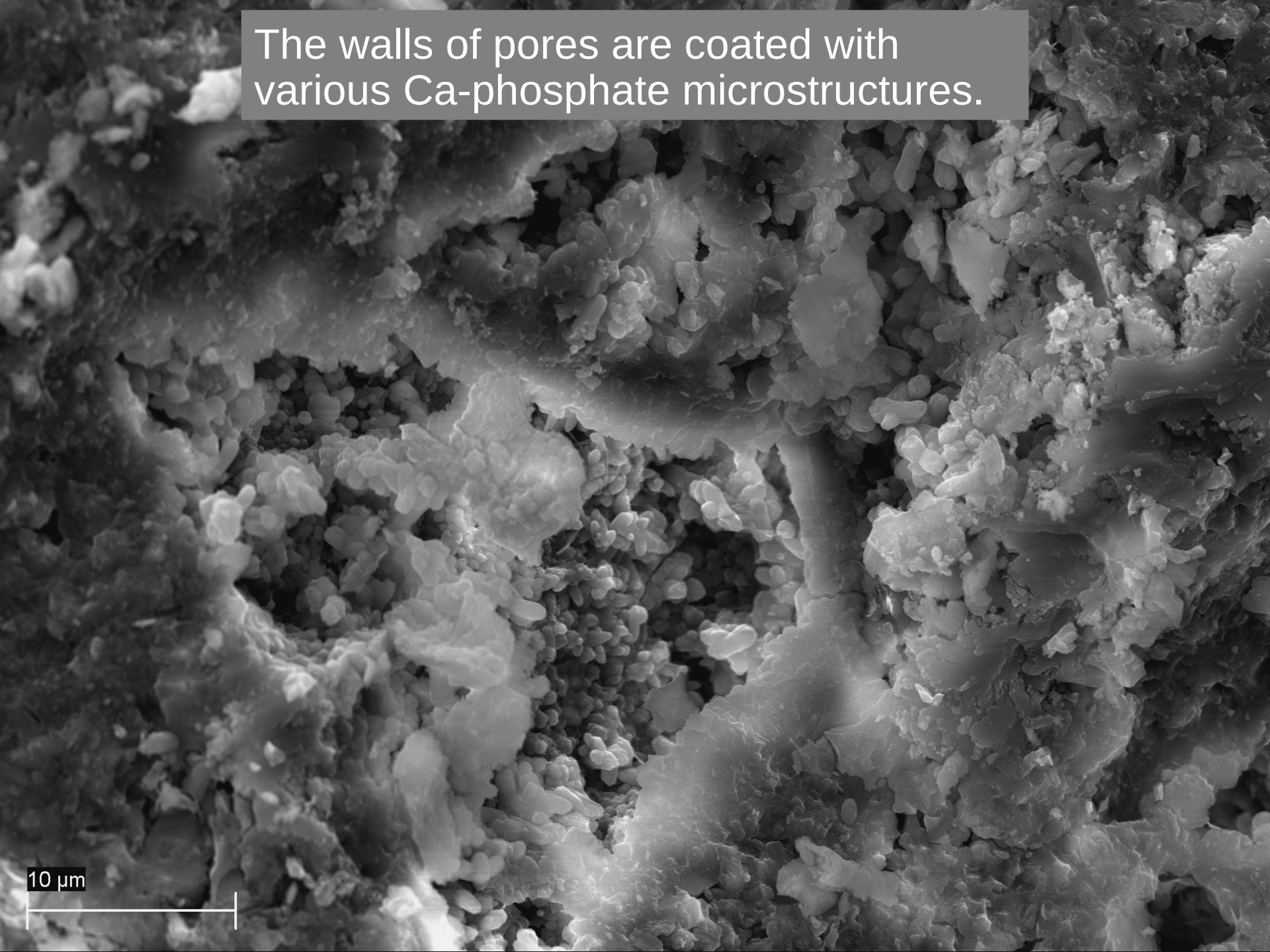
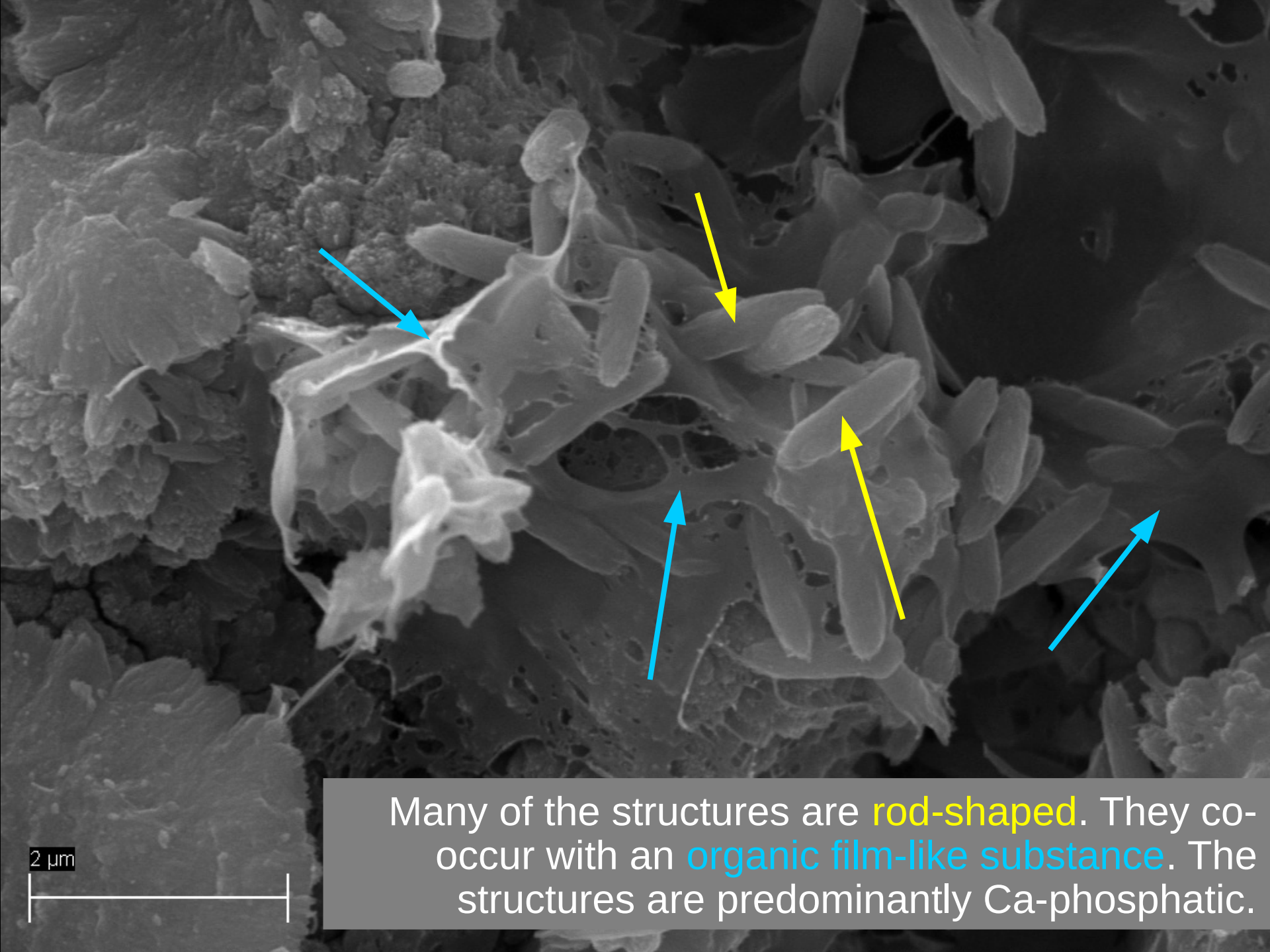
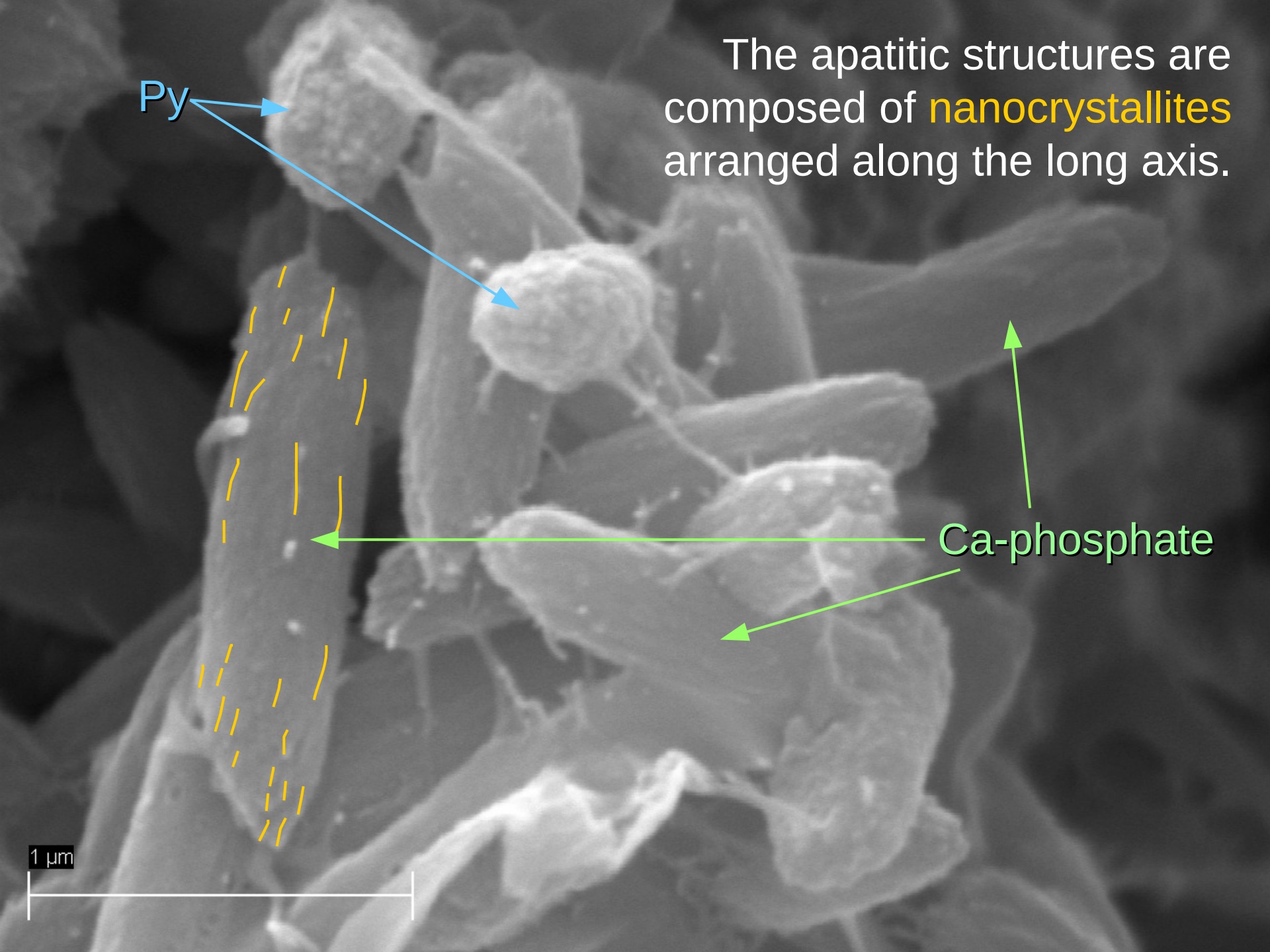
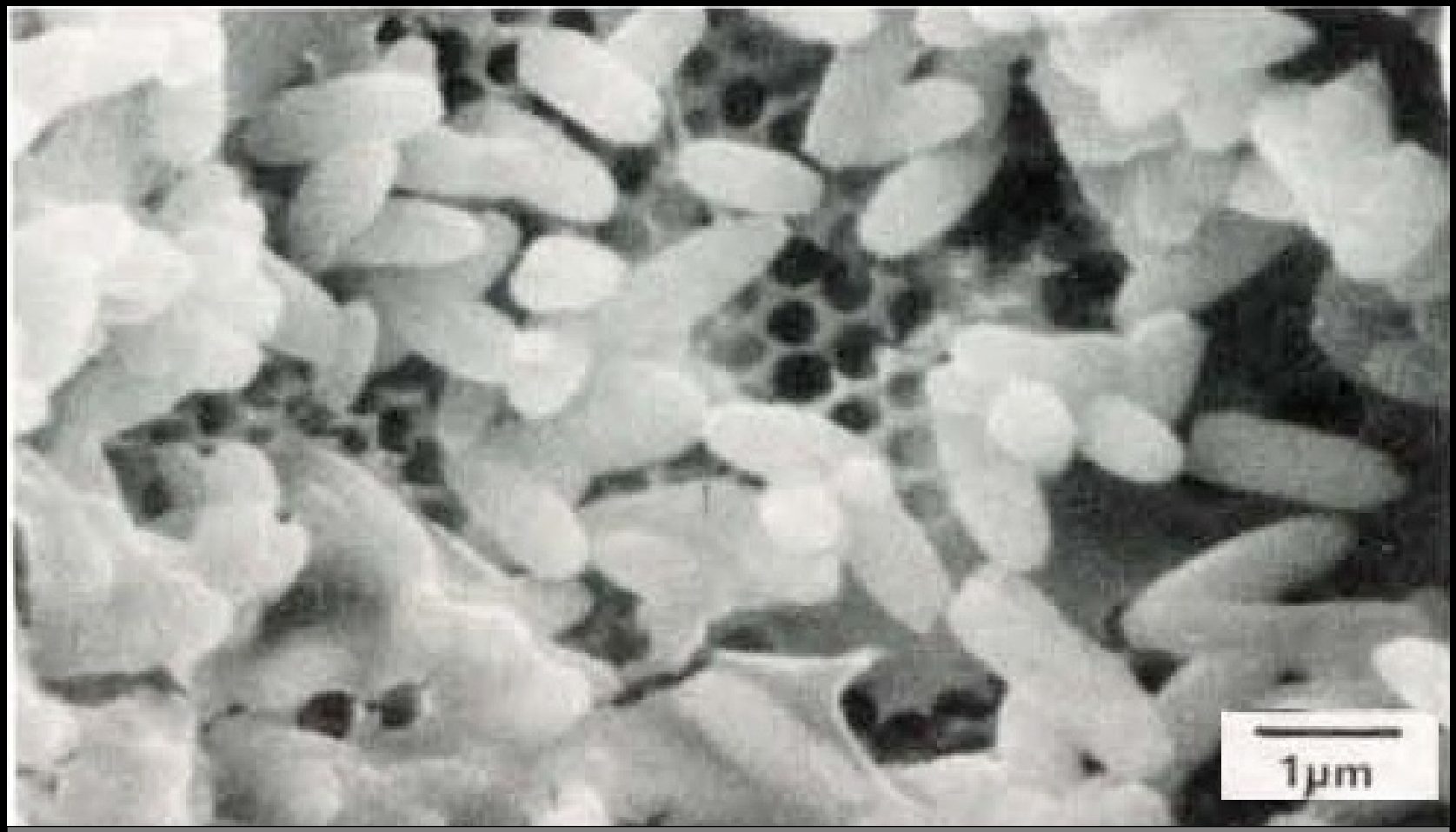

The walls of pores are coated with various Ca-phosphate microstructures.
10 µm



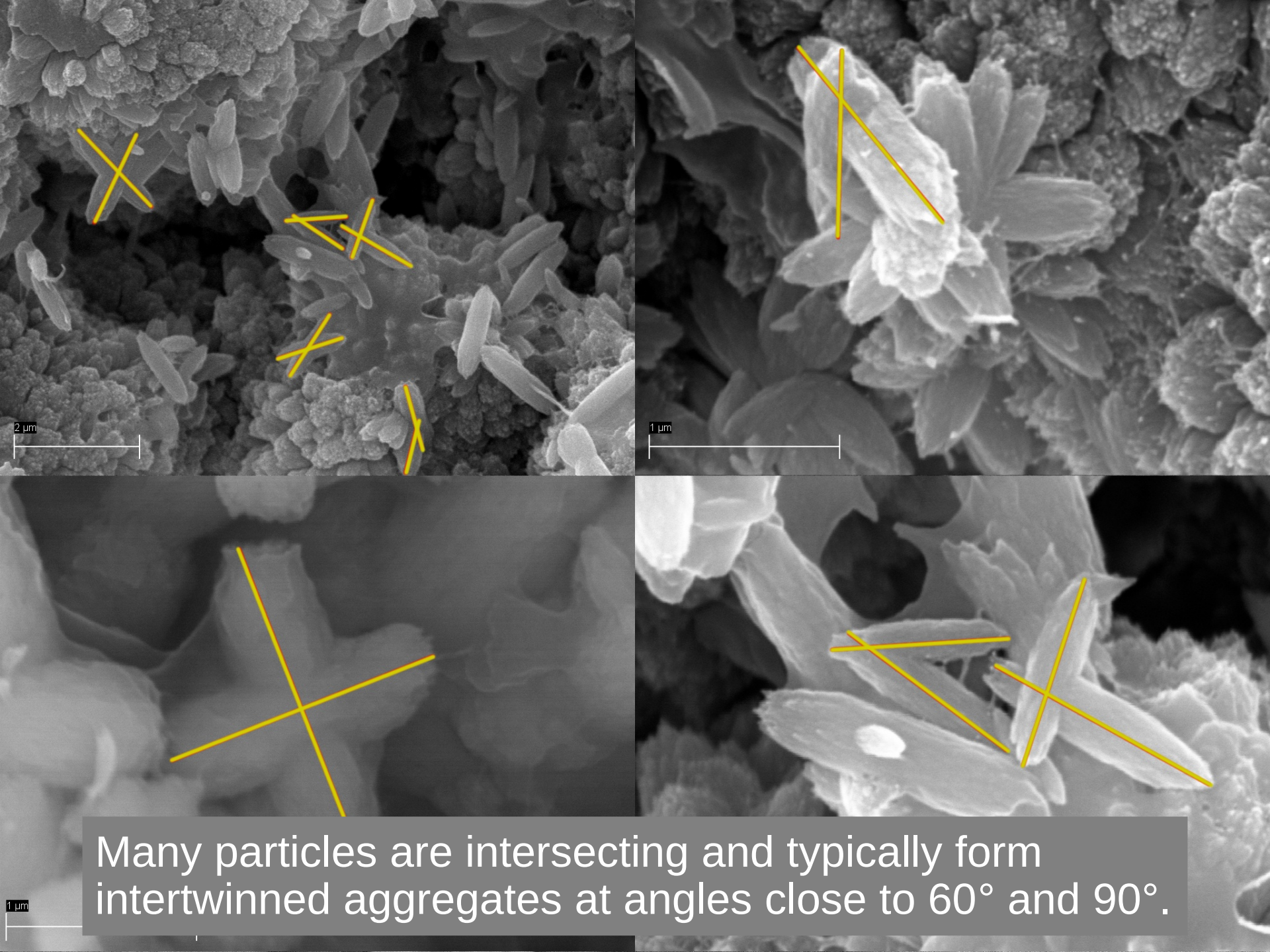
Many of the structures are rod-shaped. They co-occur with an organic film-like substance. The structures are predominantly Ca-phosphatic.


Py
The apatitic structures are composed of nanocrystallites arranged along the long axis.
Ca-phosphate
1 µm

Interpretation: what are these structures?

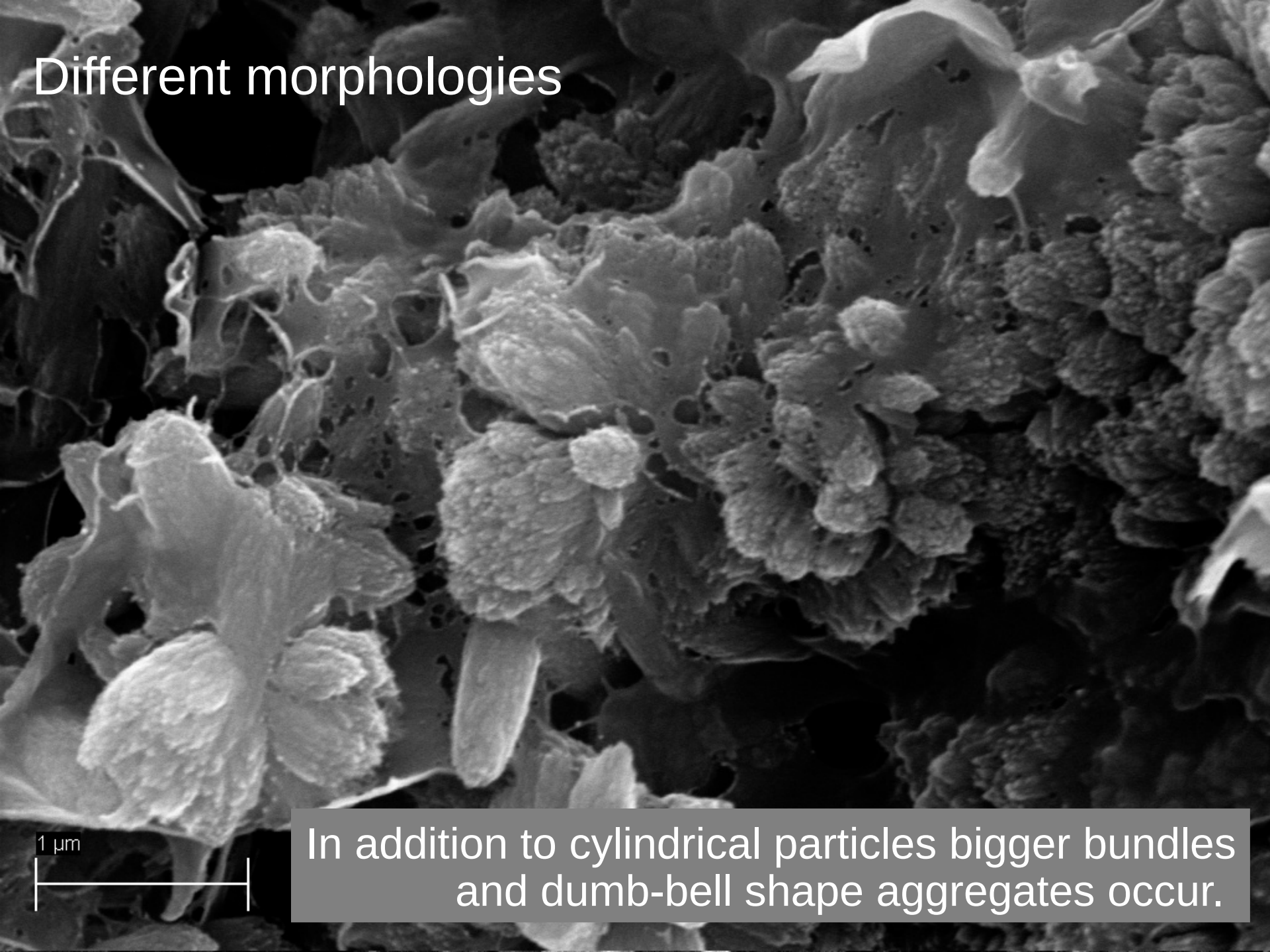


Similar apatite microstructures in phosphorites have been previously interpreted as fossilized microbes (e.g. Lamboy, 1990).

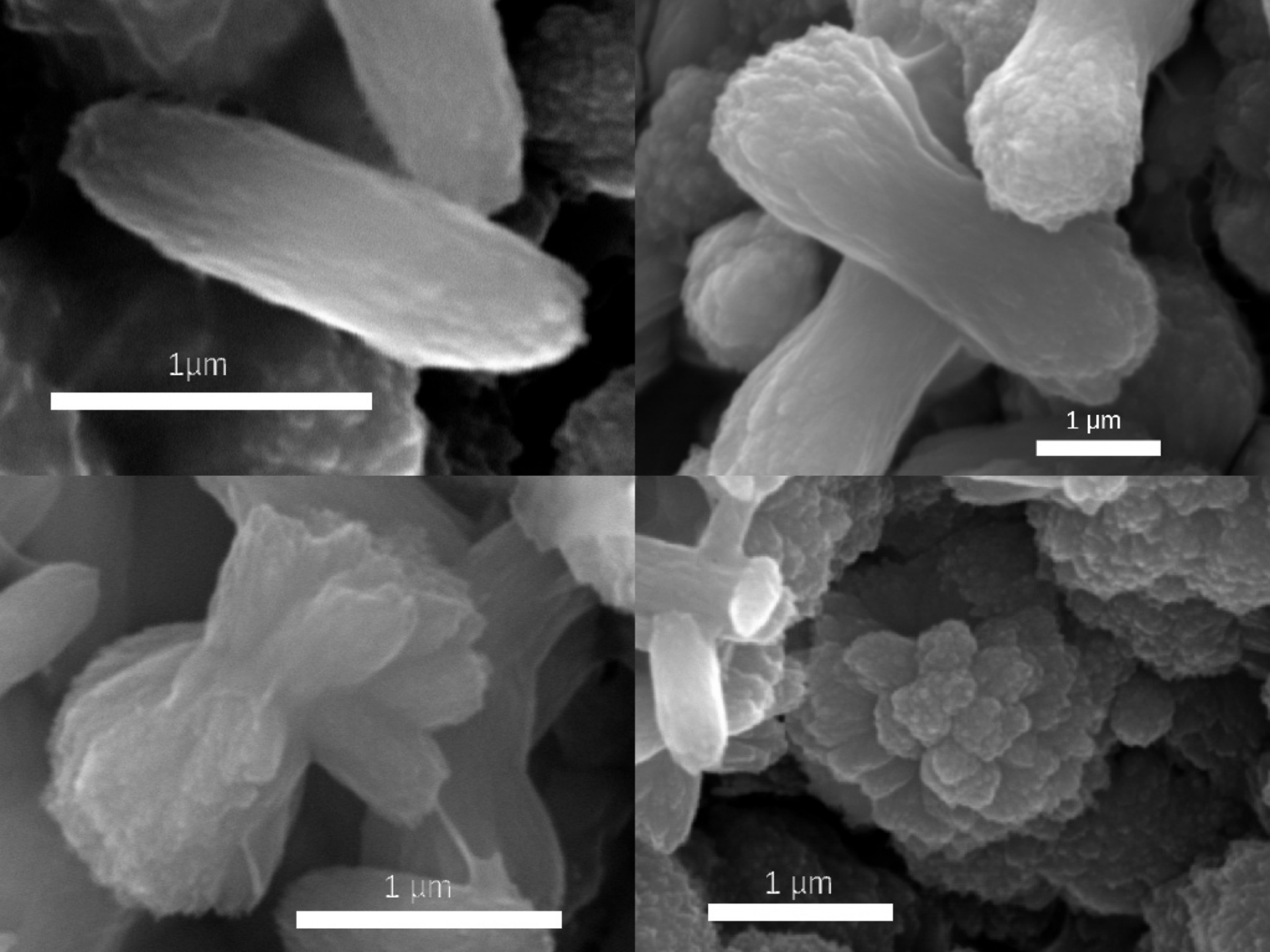


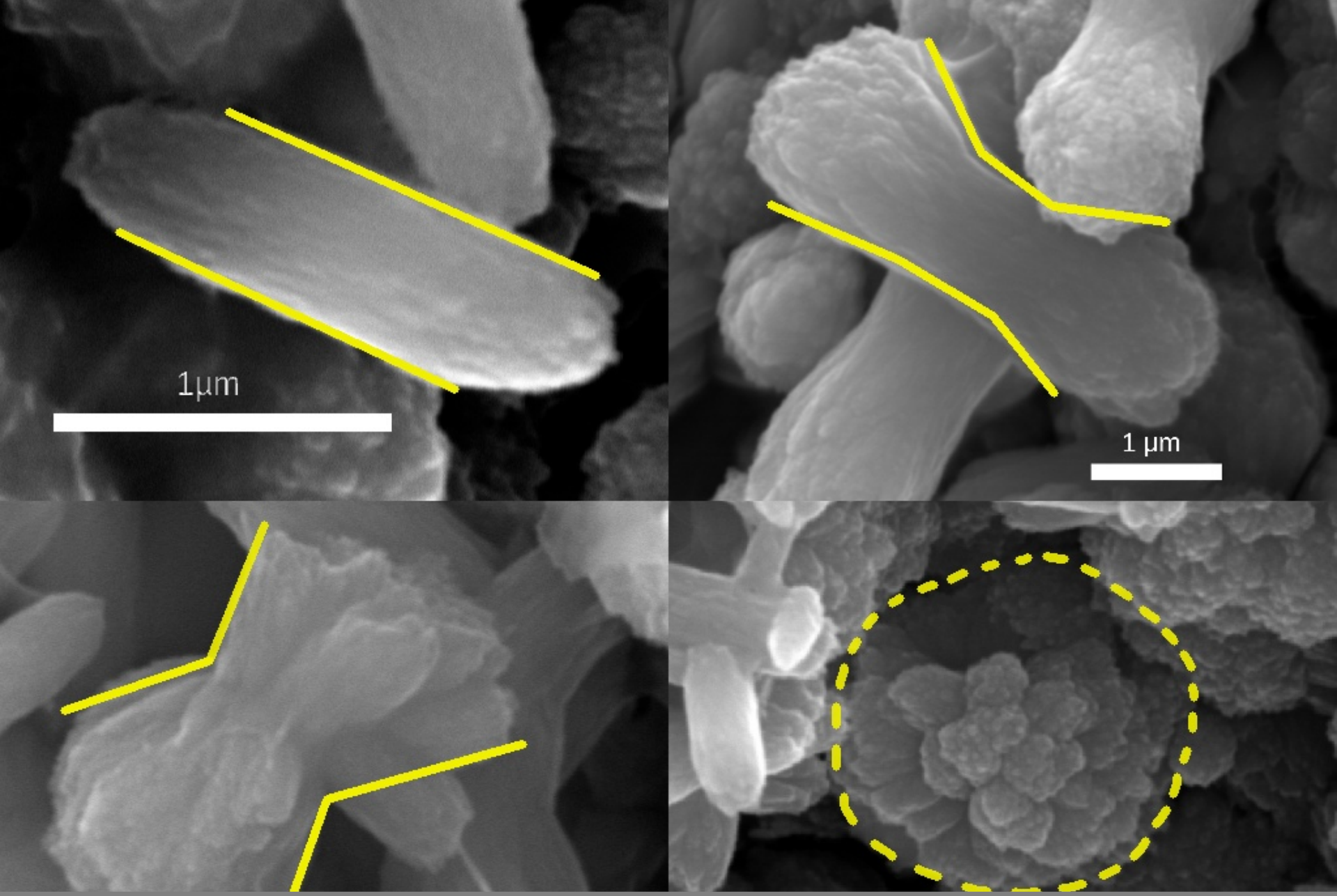
Many particles are intersecting and typically form intertwinned aggregates at angles close to 60° and 90°.

Different morphologies



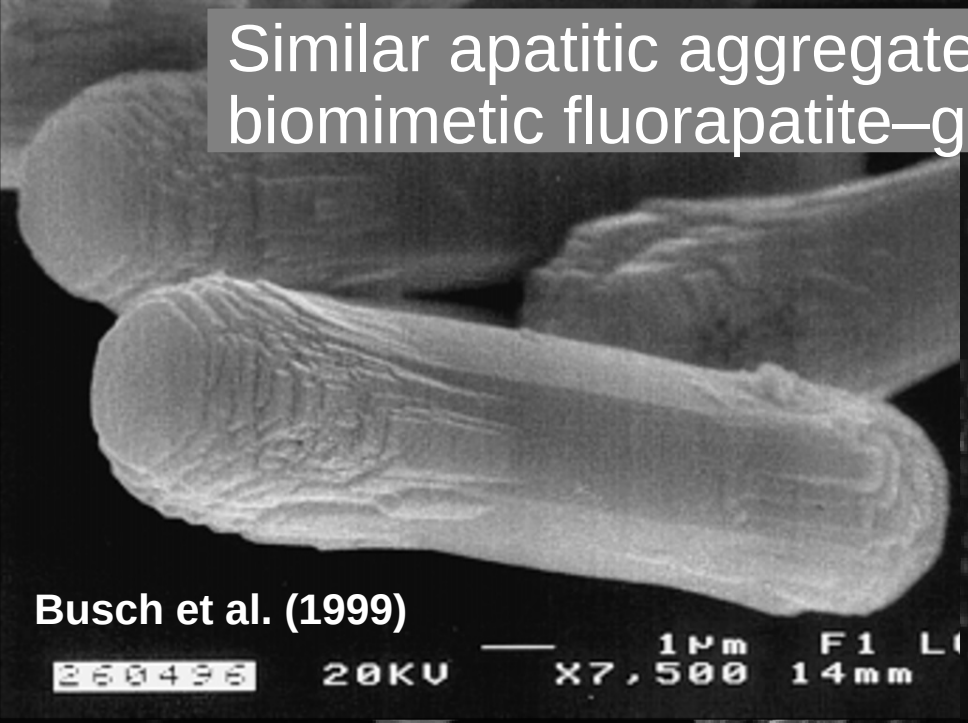
In addition to cylindrical particles bigger bundles and dumb-bell shape aggregates occur.


1µm
1 µm
1 µm
1 µm

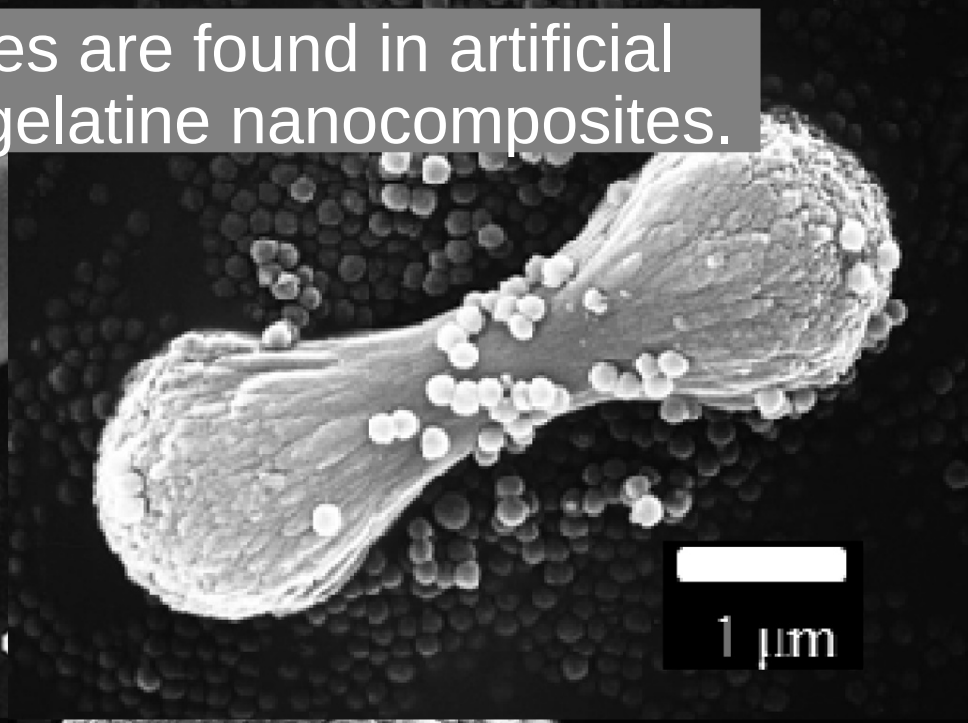


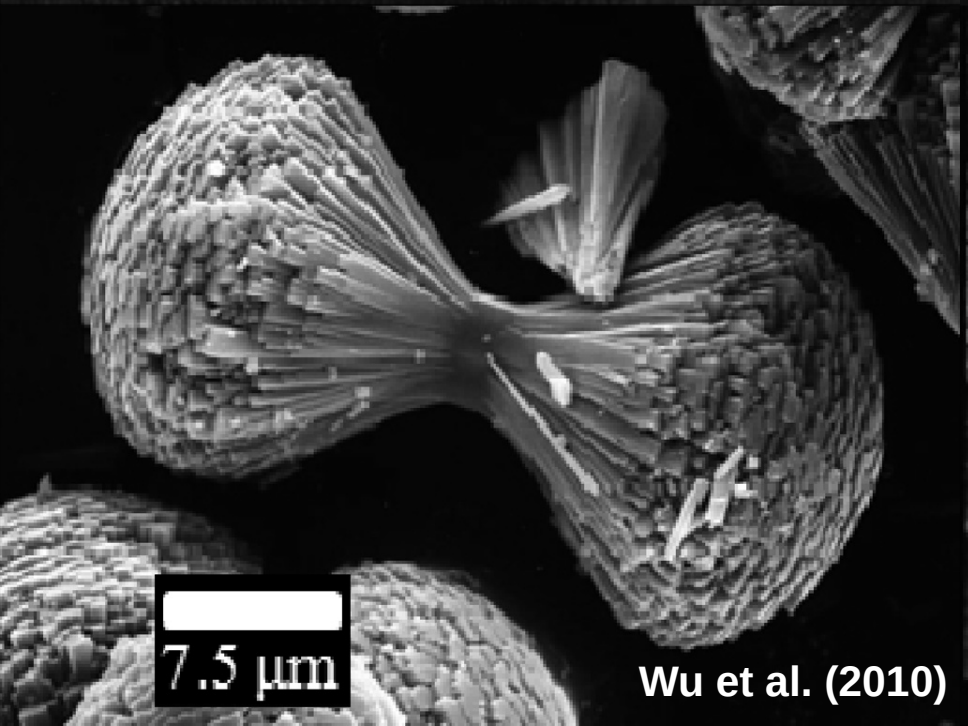
Cylindrical particles show a progression from rods to dumb-bells with widened ends to finally spherical forms.

Similar apatitic aggregates are found in artificial biomimetic fluorapatite–gelatine nanocomposites.

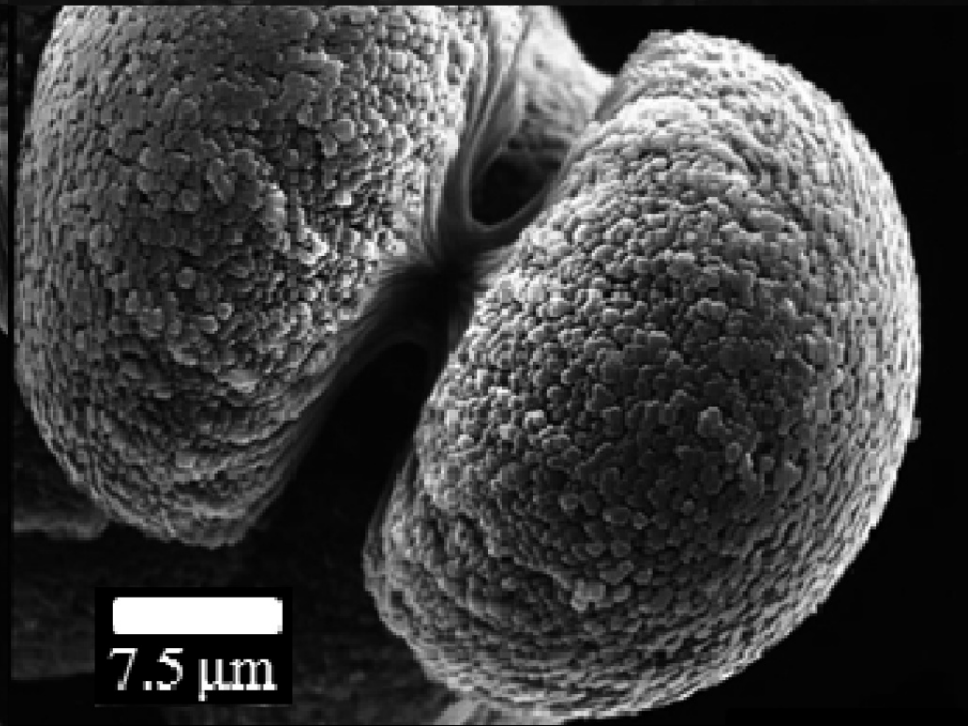


Busch et al. (1999)

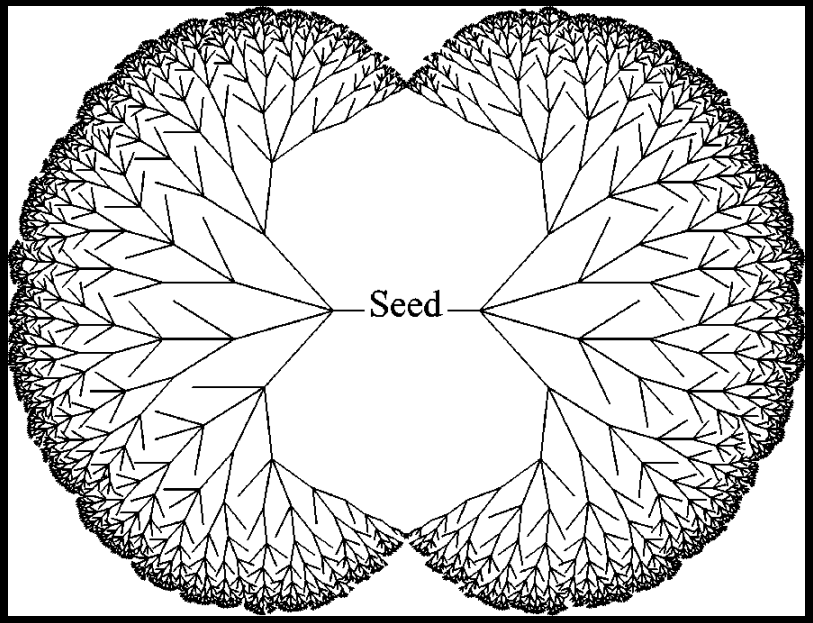




Wu et al. (2010)



Formation mechanism of biomimetic fluorapatite–gelatine nanocomposites



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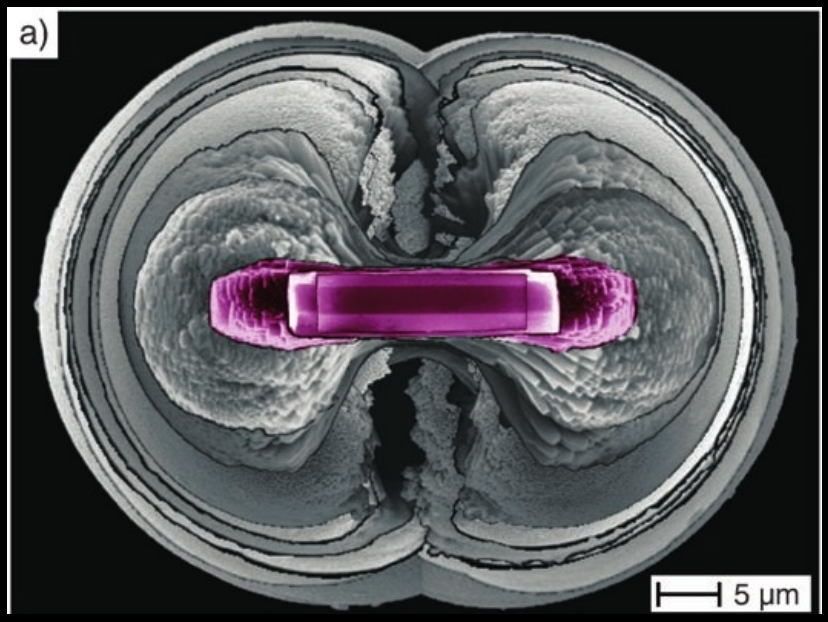
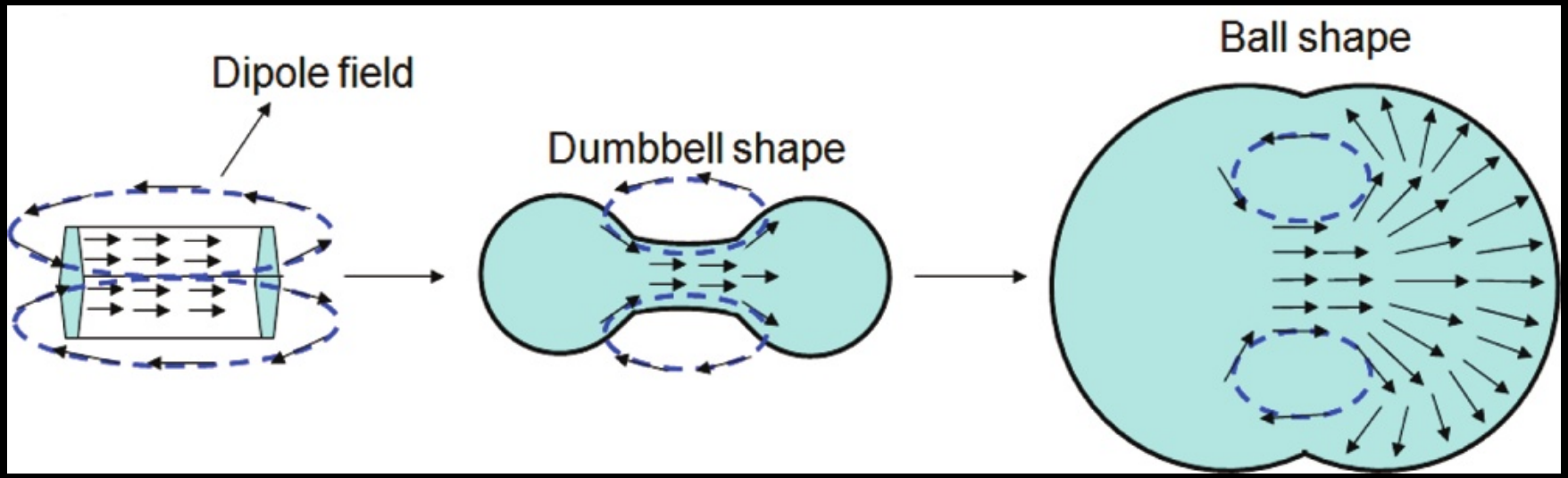


Simon et al. (2006)

- Fractal growth of an initial seed crystal results in formation of a dumbbell-shape and eventually a closed sphere.

Formation mechanism of biomimetic fluorapatite–gelatine nanocomposites: link to biomatrices



Modified, Wu et al. (2010)

- The growth is related to the arrangement and charge of organic molecules in the matrix of the structures.

Conclusions

- The Namibian phosphatic grains contain conspicuous rod-shaped Ca-phosphate particles.

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- These occur in forms from rod-shaped to bulged dumbbell-like particles representing stages of growth of apatite structures similar to biomimetic fluorapatite–gelatine nanocomposites.

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- However, these structures are still formed in presence of biological matrices.
- It is still unclear what triggered Ca-phosphate nucleation. Do the microorganisms serve as nucelation templates? How do the phosphatic grains grow?

Acknowledgements:

- RGNO instructors and students
- RV Mirabilis crew and NatMIRC
- UNAM Sam Nujoma Campus
- Agouron Institute

Conclusions

- The Namibian phosphatic grains contain conspicuous cylindrical Ca-phosphate particles.
- These occur in forms from cylindrical to bulged dumbbell-like particles representing stages of growth of apatite structures similar to biomimetic fluorapatite–gelatine nanocomposites.
- “Bacteriomorphic” apatitic microstructures thus need not be fossils.
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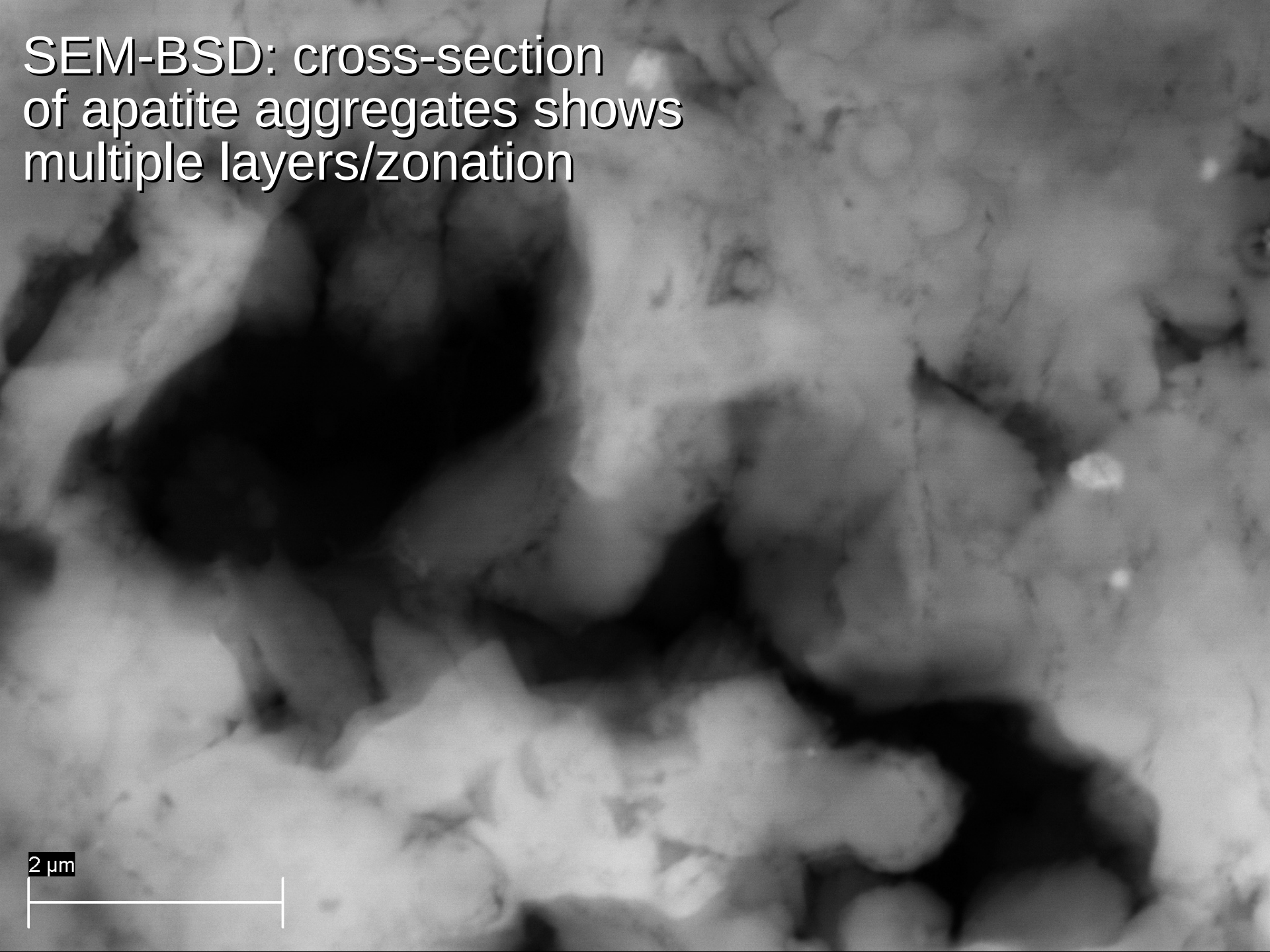
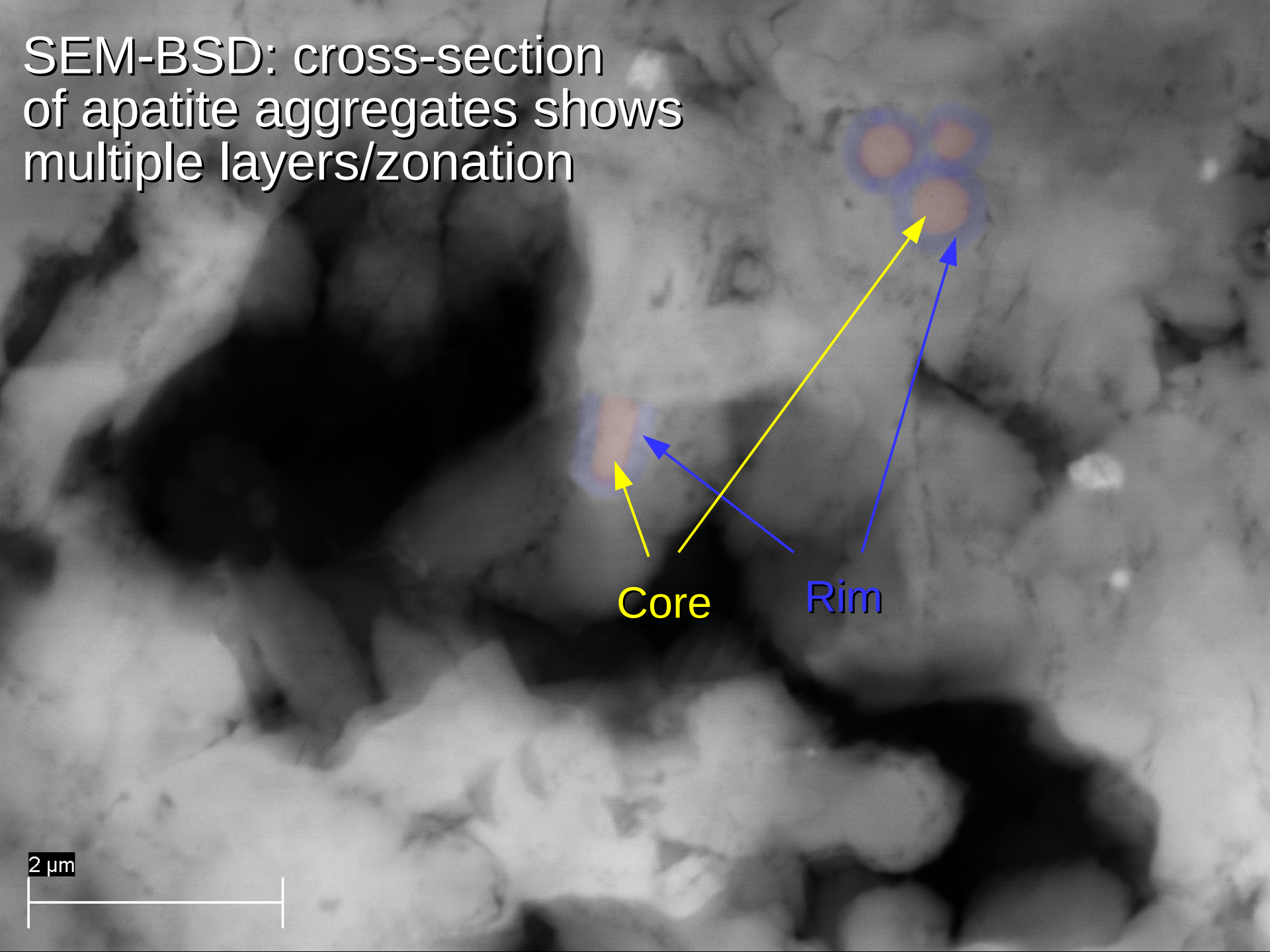

SEM-BSD: cross-section
of apatite aggregates shows
multiple layers/zonation
2 µm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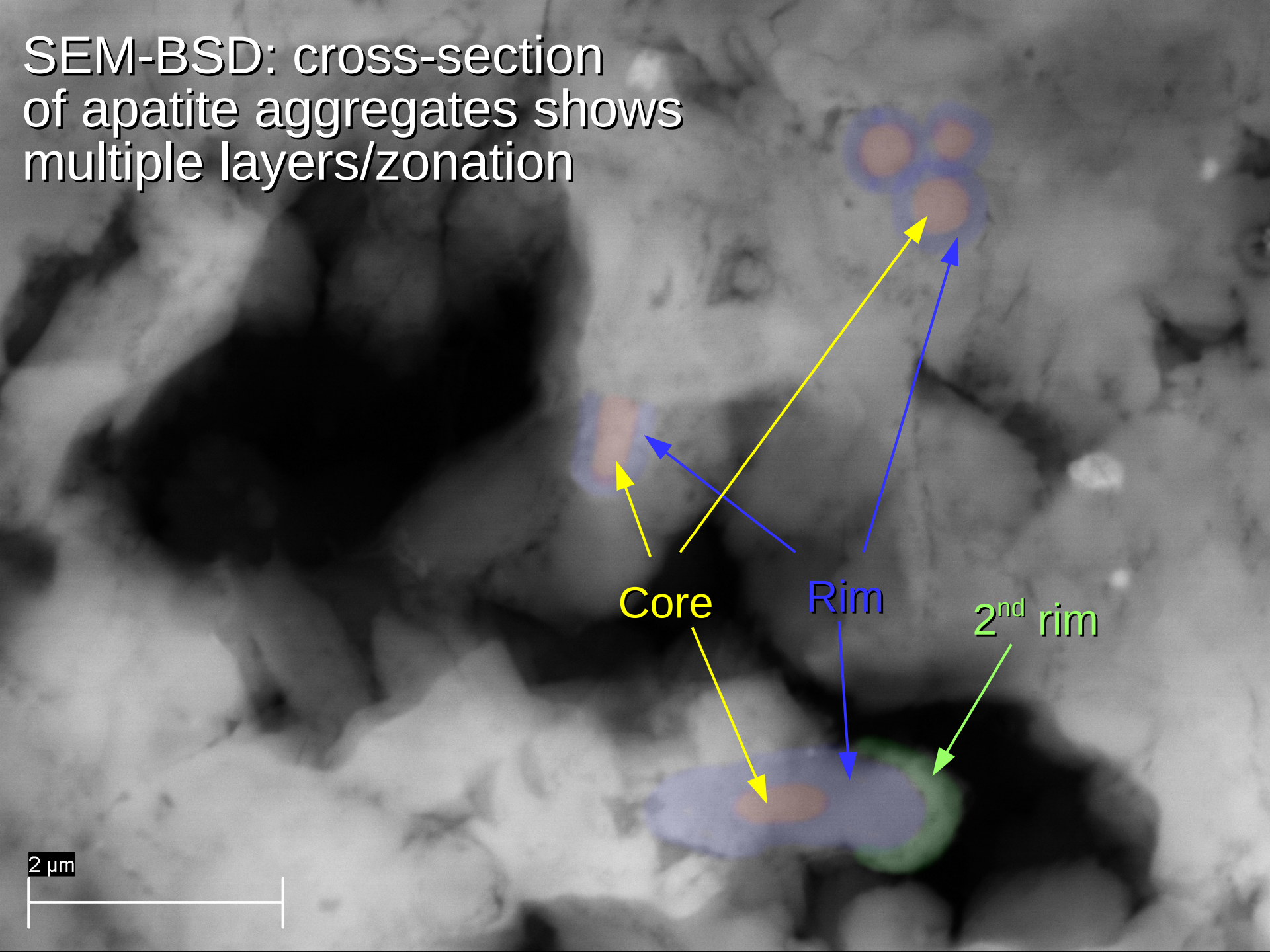
Core
Rim
2 µm


SEM-BSD: cross-section
of apatite aggregates shows
multiple layers/zonation
Core
Rim
2nd rim
2 µm

Rods grow out of the pore walls:
do they form the bulk of the grain?