

THE ROLE OF CYANOBACTERIA IN NUCLEATING THE PRECIPITATION OF CALCIUM CARBONATE IN THE EVERGLADES: VATERITE AND ARAGONITE

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Early Work: Calcareous Periphyton

-periphyton give rise to calcitic marl
-different crystals on different species
-water column chemistry is important

CALCAREOUS PERIPHYTON AND WATER CHEMISTRY IN THE EVERGLADES

by

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ABSTRACT

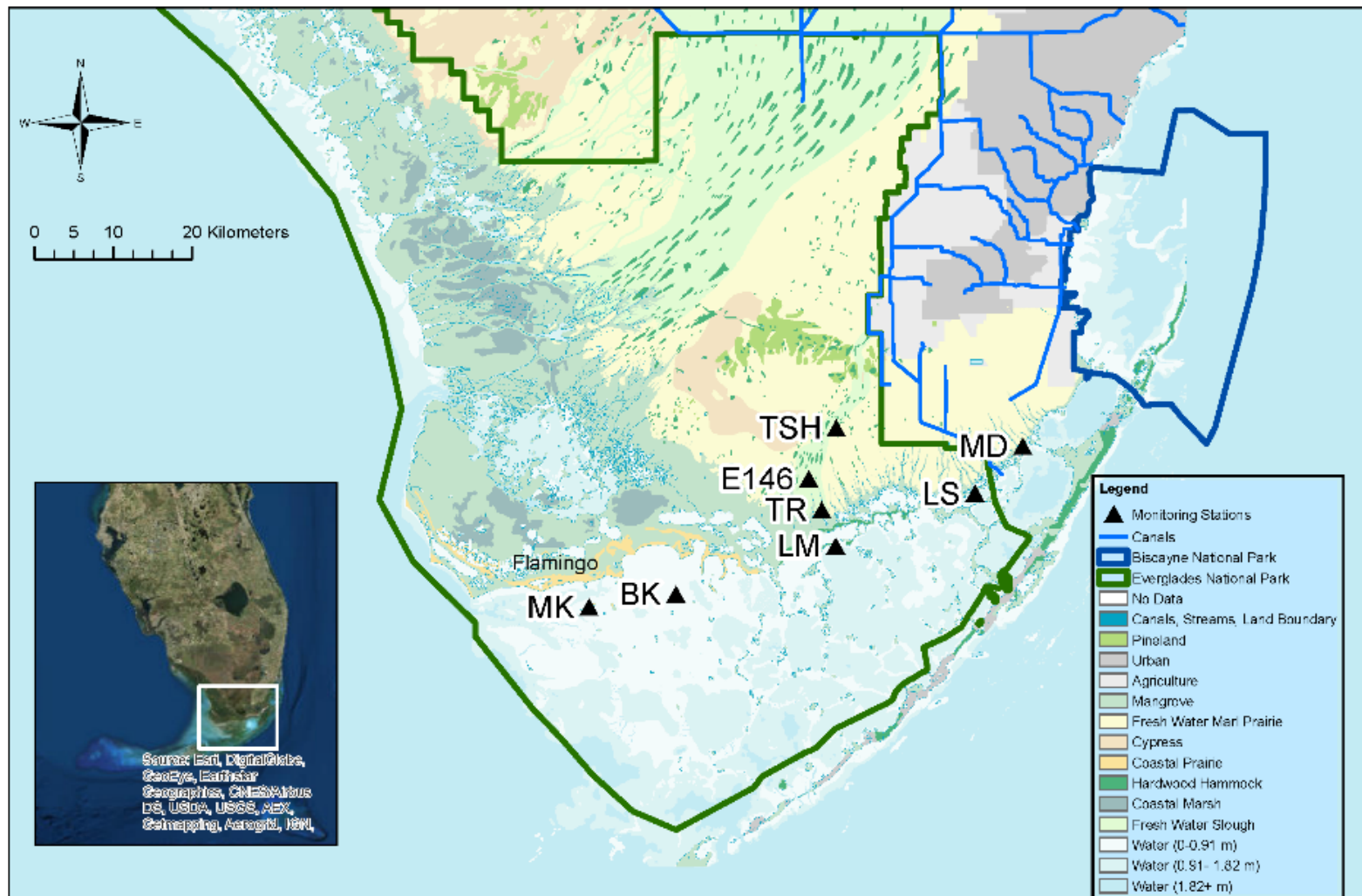
Calcareous blue-green algal periphyton covers large areas of wetlands within South Florida. The periphyton appears to give rise to a fresh water calcitic marl within the lower Everglades as indicated by numerous crystal-algal filament relationships: 1) different crystals on different algal species. 2) exoskeletal crystal formations and evidence of crystal growth on *Saytonema hofmannii*. 3) lithified encrustations and the lack of uniformity of calcification on all algal species. 4) calcium concentration variations in water overlying periphyton. 5) higher basic pHs within the periphyton relative to those in water surrounding the periphyton.

Preliminary research suggests that the calcareous periphyton is responsive to changes in water chemistry. Within Conservation Area 1 the high biomass blue-green algal flora occurs principally in the basic, alkaline water of peripheral areas. The algal flora changes to non-calcareous predominately green algal periphyton of lower biomass within the acid, poorly-buffered water in the interior of Conservation Area 1.

...and Pat's Ph. D thesis

...and Joan Browder, Dave Swift

Calcareous Wet Prairies and Marl Prairies



Park, J.; Stabenau, E.; Redwine, J.; Kotun, K. South Florida's Encroachment of the Sea and Environmental Transformation over the 21st Century. *J. Mar. Sci. Eng.* **2017**, *5*, 31.

Calcareous Wet Prairies and Marl Prairies

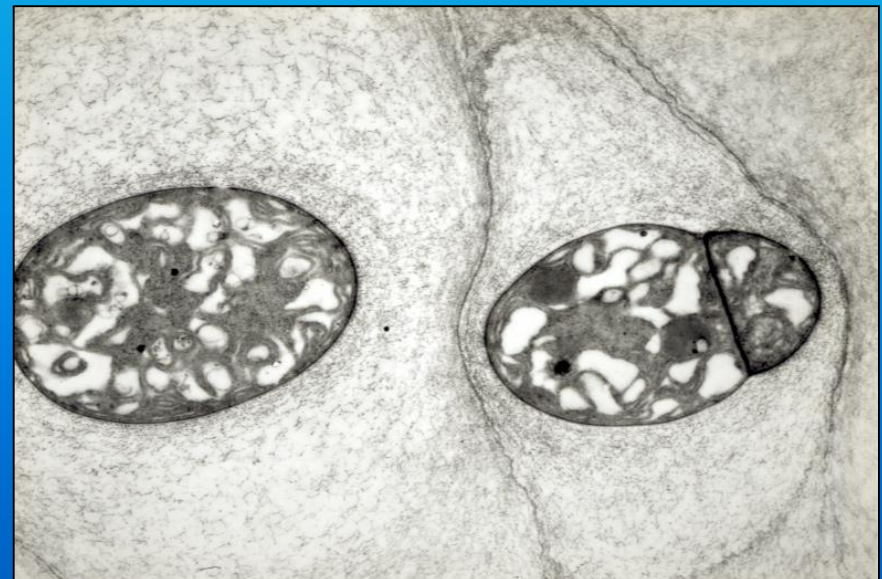
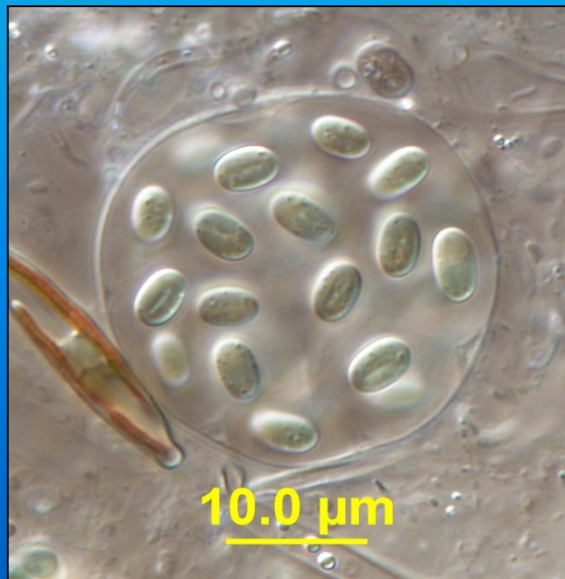
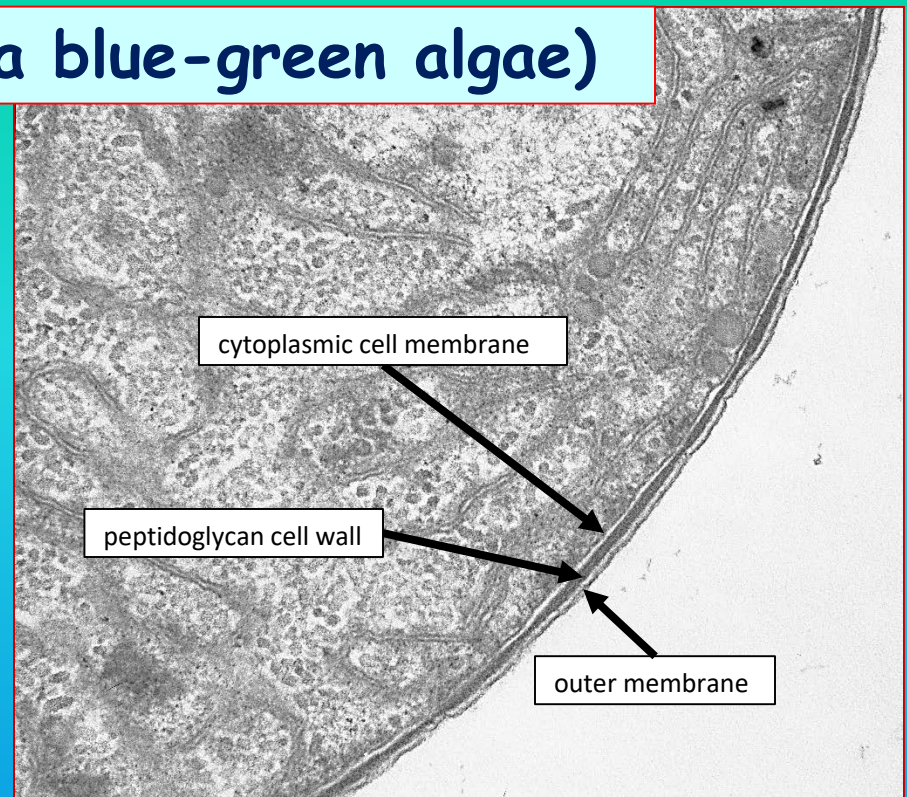


“Marls are fine white calcareous muds formed from calcite precipitated by a mixture of green algae, blue-green algae, and diatoms, known as periphyton. These soils are highly alkaline and impermeable, sealing off the underlying limestone and causing water to pond during the wet season. In the rocky glades region of the southeastern Everglades marl prairies occur on exposed limestone bedrock where limestone pinnacles are exposed through the marl soils forming a micro-karst topography” (USFWS 1999).

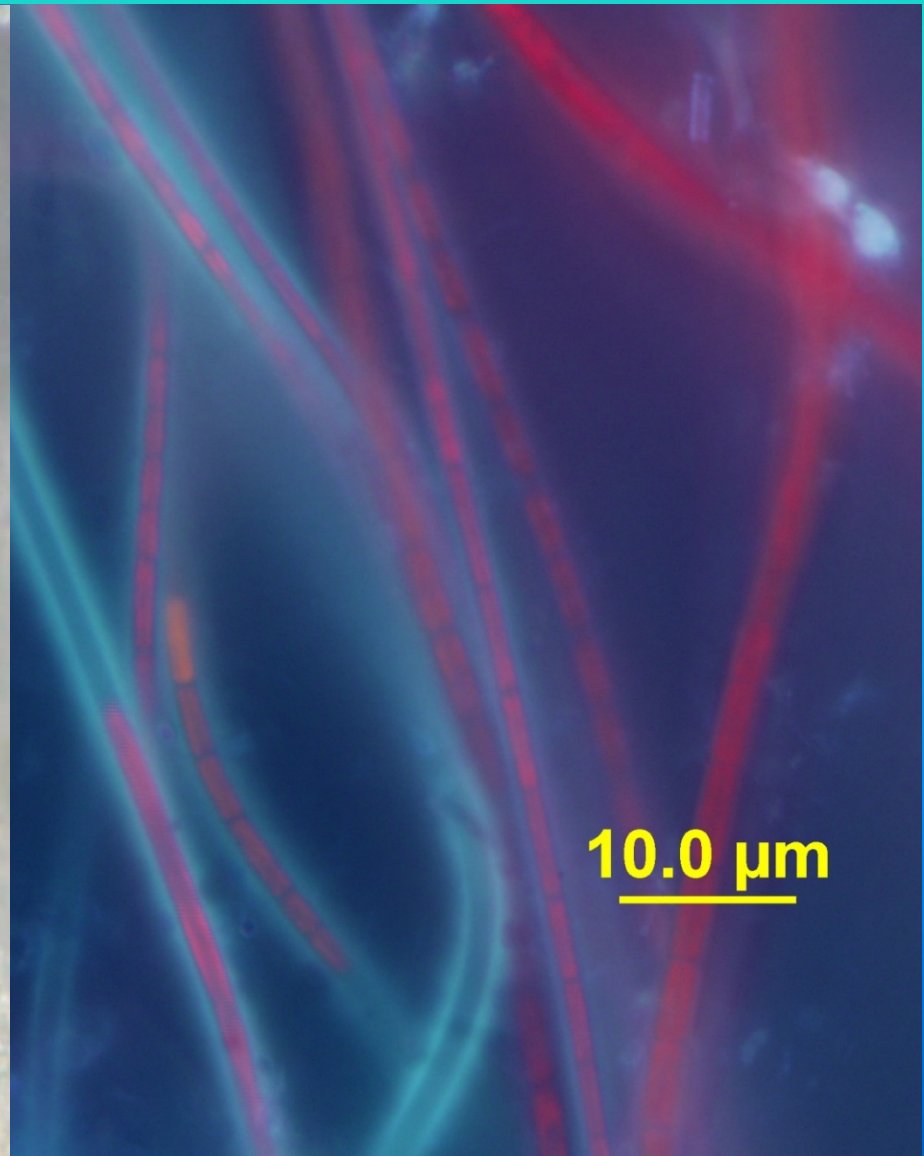
***A finer
point
follows***

Cyanobacteria (aka blue-green algae)

- gram-negative bacteria
- pigments in thylakoids
- exopolymeric substances



Ecological Strategies: desiccation tolerant (exopolymeric substances)



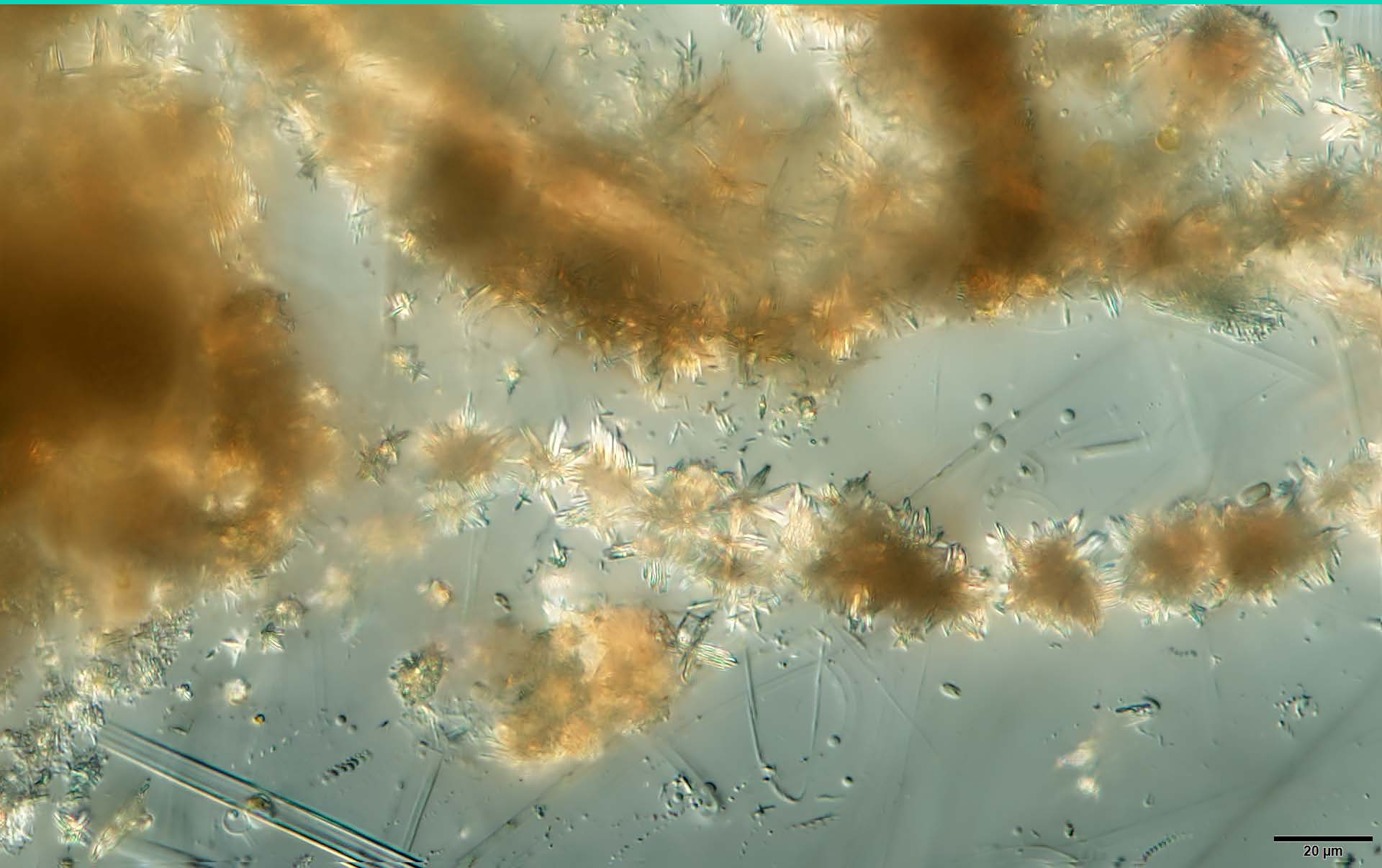
The cyanobacteria milieu promotes calcium carbonate nucleation: *Schizothrix*

Factors:
sheath/bacteria,
available Ca, high
pH,
CO₂-concentrating
mechanism

“a biochemical system that allows the cells to raise the concentration of CO₂ for Rubisco, up to 1000-fold over that in the surrounding medium”

Kamennaya and others,
2012

Calcium carbonate nucleation: *Schizothrix*

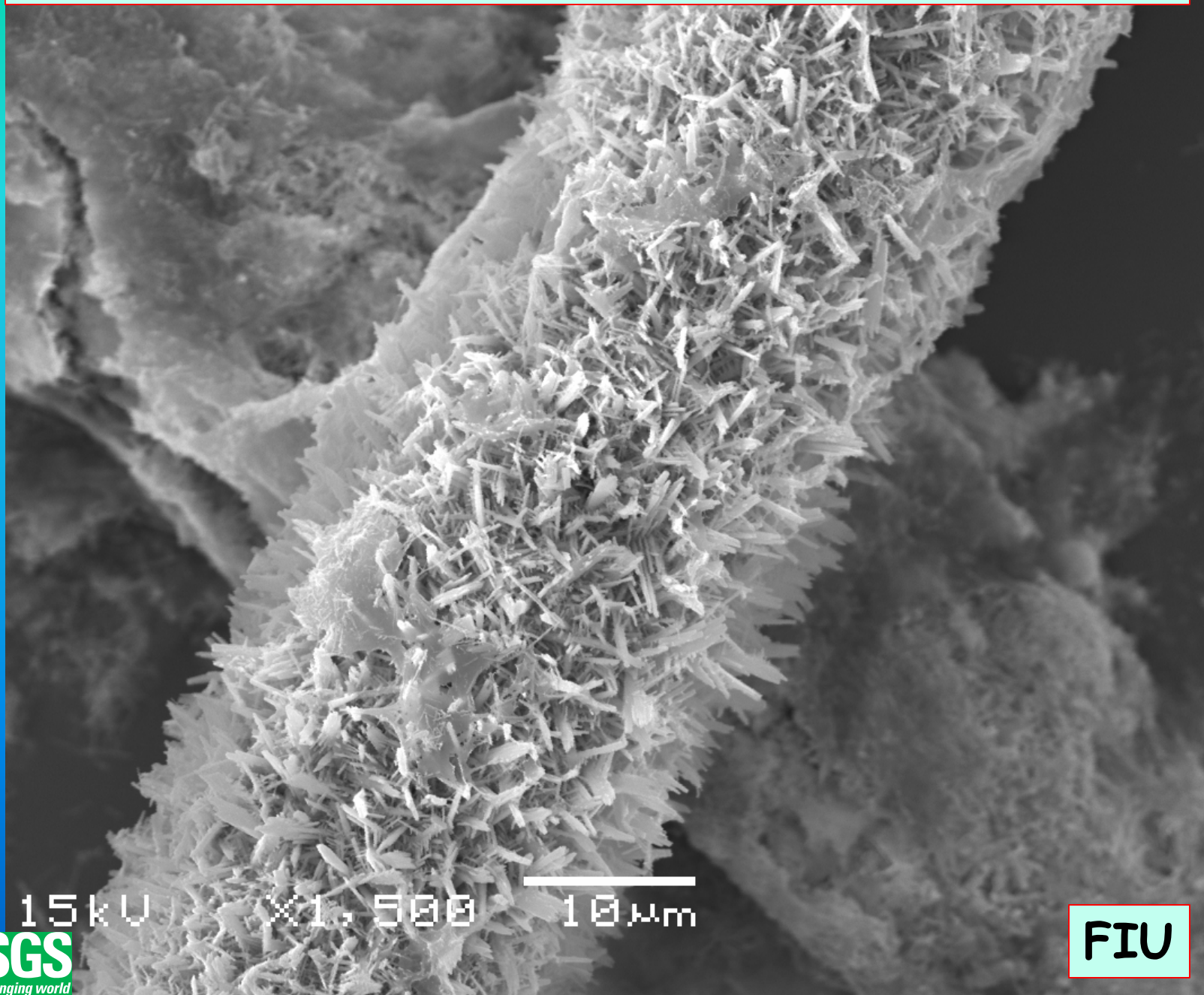


20 μ m

Calcium carbonate nucleation: *Schizothrix* (UV)

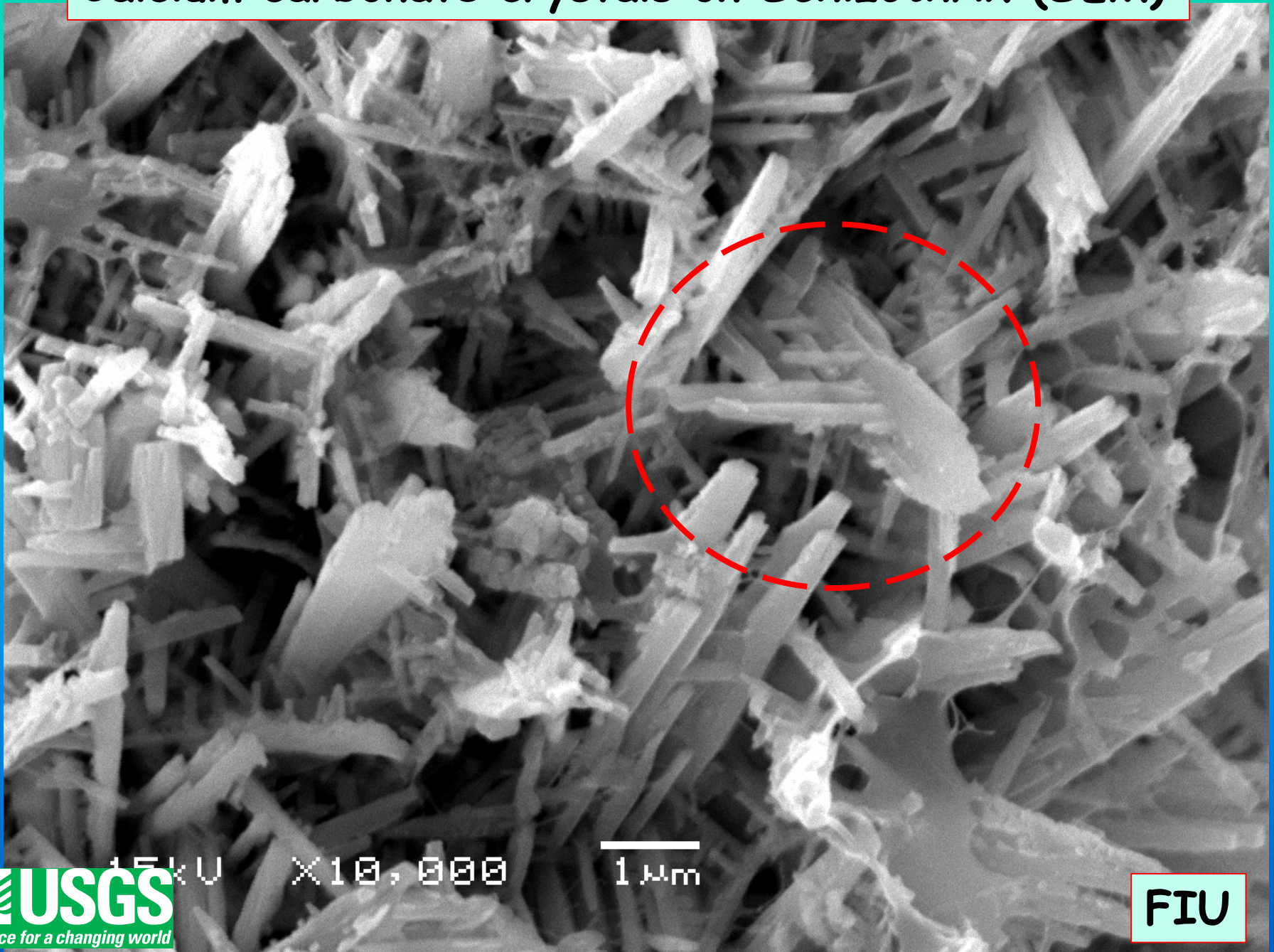


Calcium carbonate crystals on *Schizothrix* (SEM)



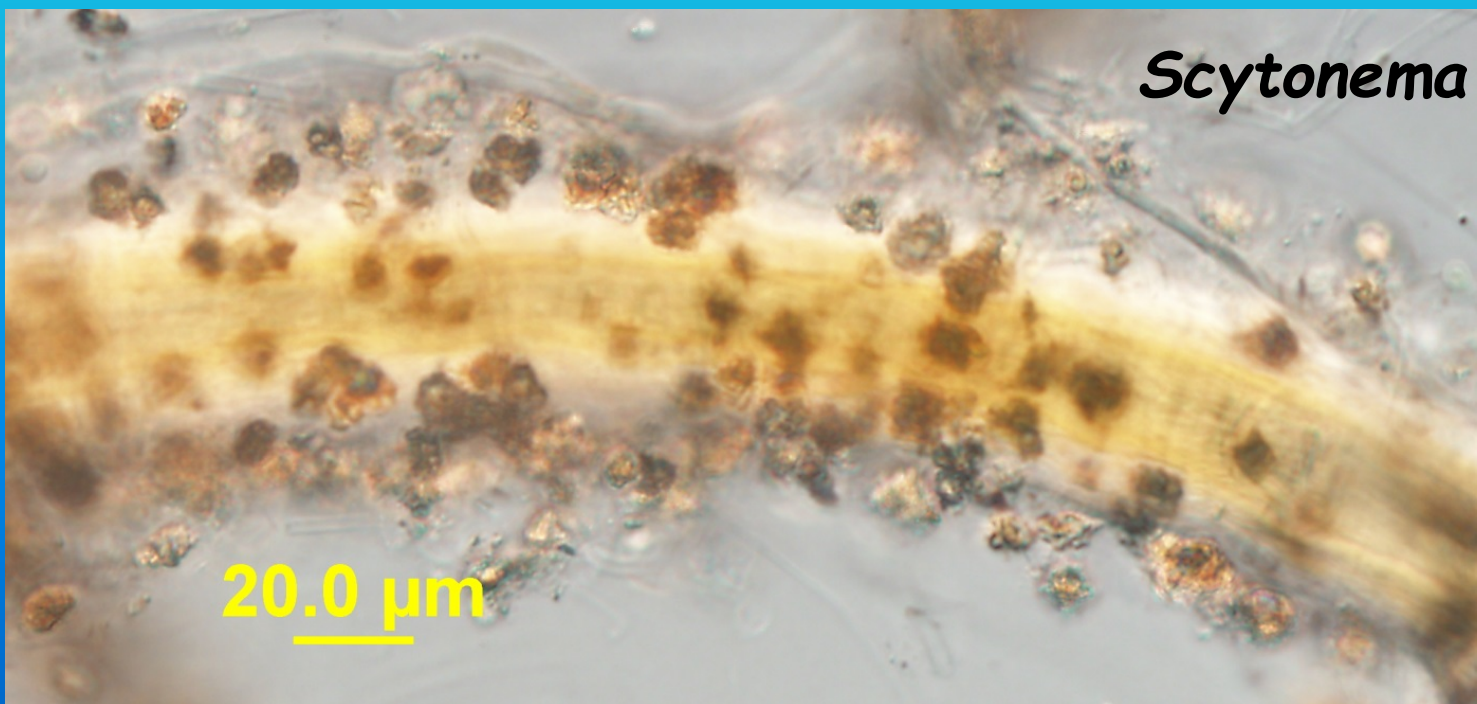
15kV x1,500 10µm

Calcium carbonate crystals on *Schizothrix* (SEM)

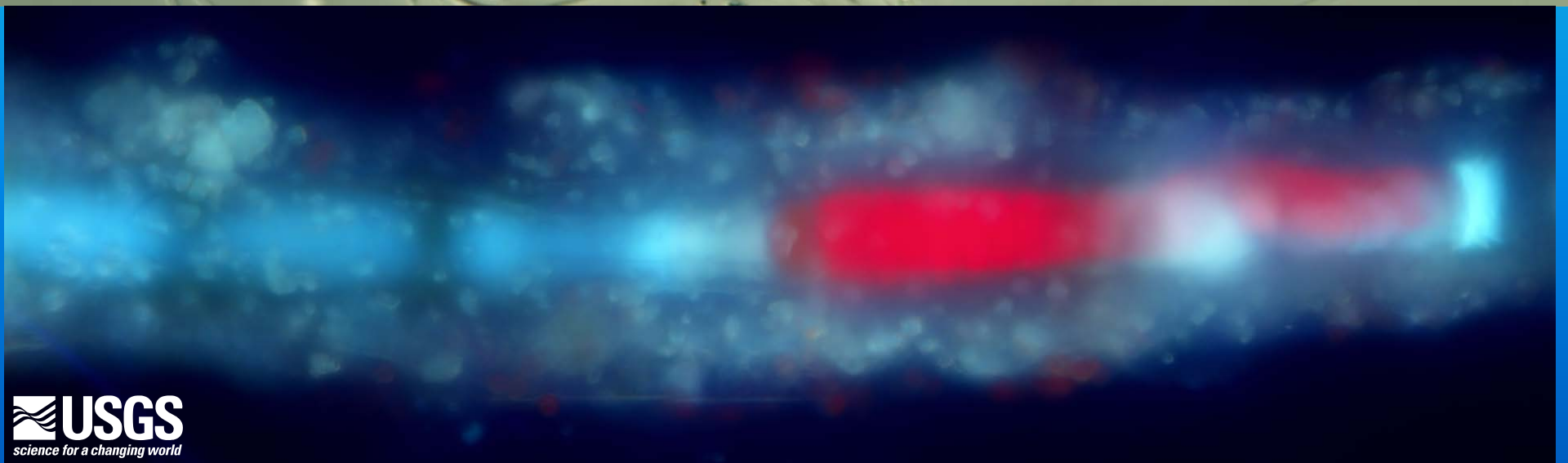


15kV X10,000 1µm

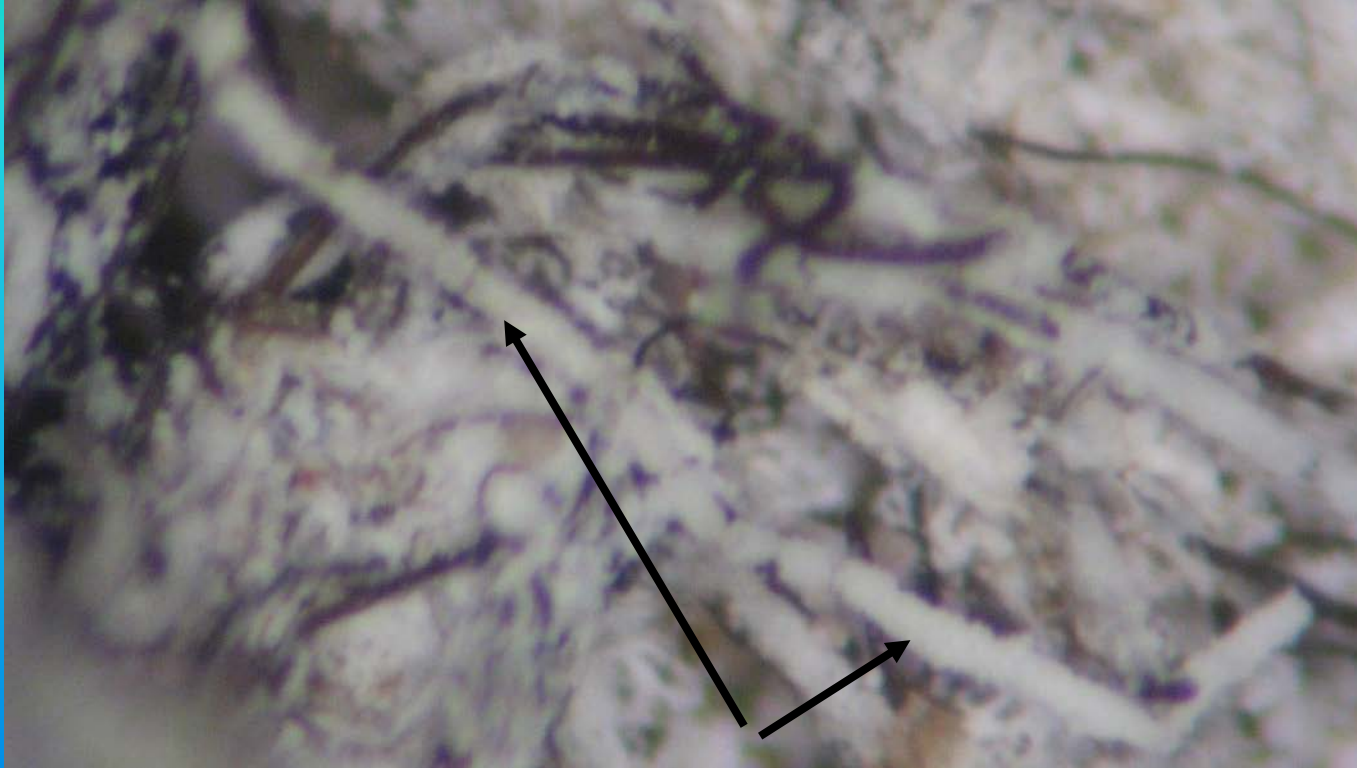
Schizothrix vs. *Scytonema* crystals



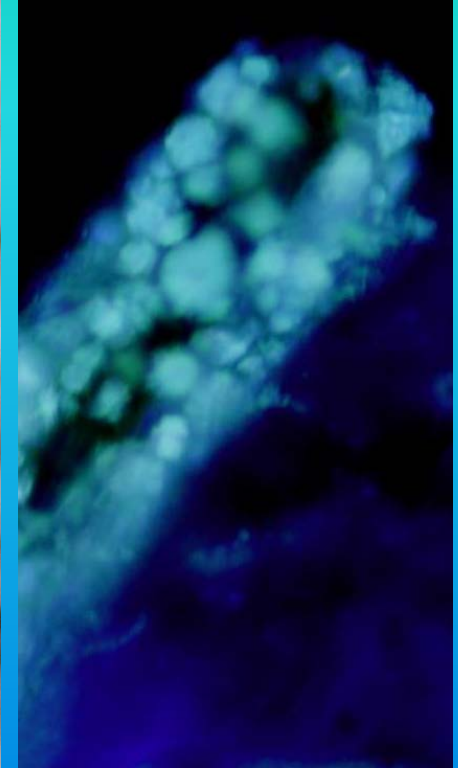
The cyanobacteria milieu promotes calcium carbonate nucleation: *Scytonema*



Scytonema

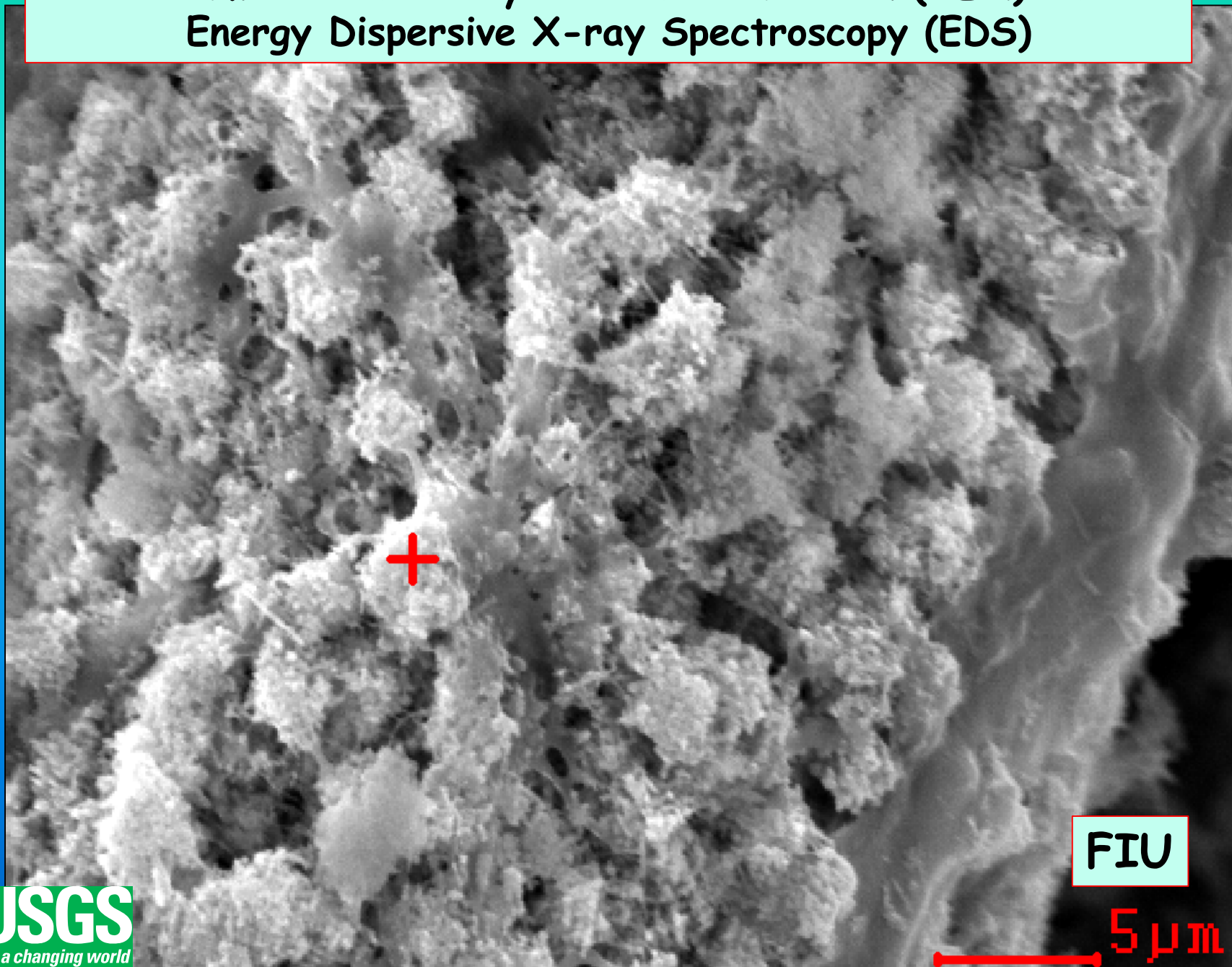


Visible crusts



UV

Calcium carbonate crystals on *Schizothrix* (SEM) and
Energy Dispersive X-ray Spectroscopy (EDS)



FIU

5 μm

Energy Dispersive X-ray Spectroscopy

	<i>Scytonema</i>		<i>Shizothrix</i>	
	Wt%	At%	Wt%	At%
Ca	31.1	14.1	63.5	39.5
C	19.4	29.4	9.12	18.9
O	49.5	56.4	26.1	40.7
	aragonite		vaterite	
	CaC_2O_4	CaC_2O_5		Ca_2CO_2
	CaC_2O_2			

Note, no

phosphorus

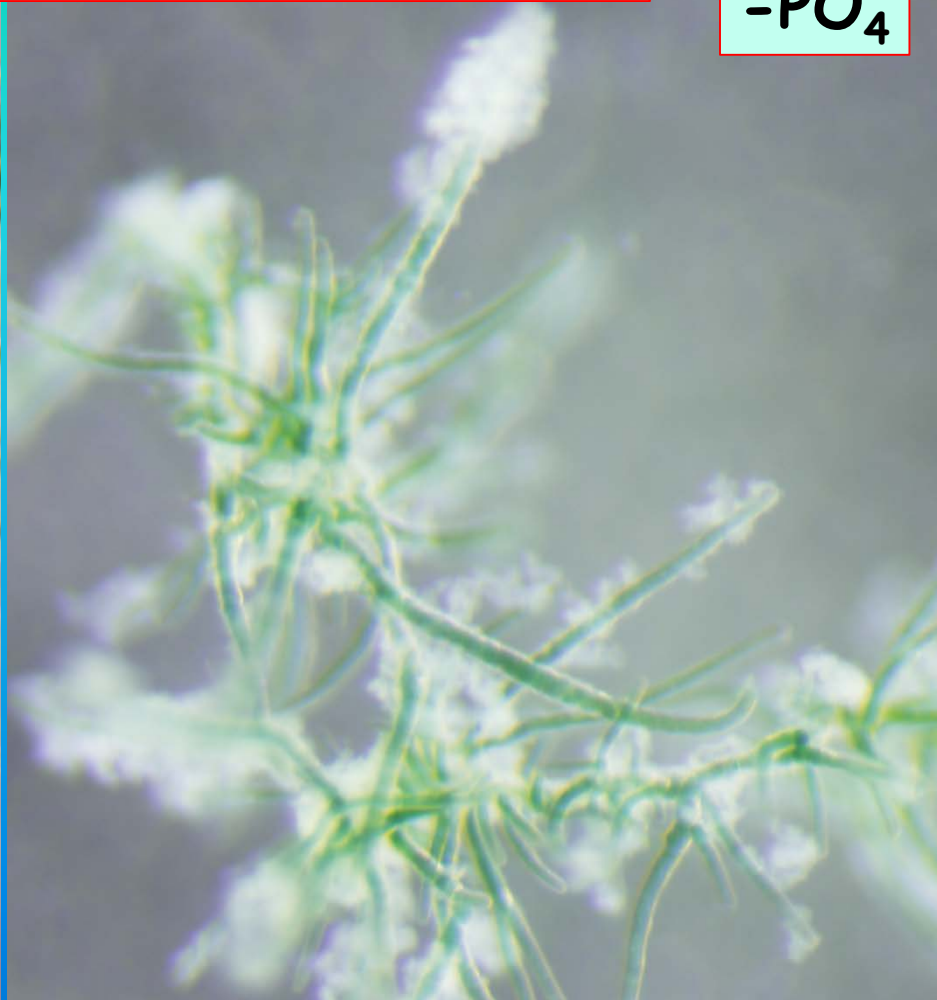
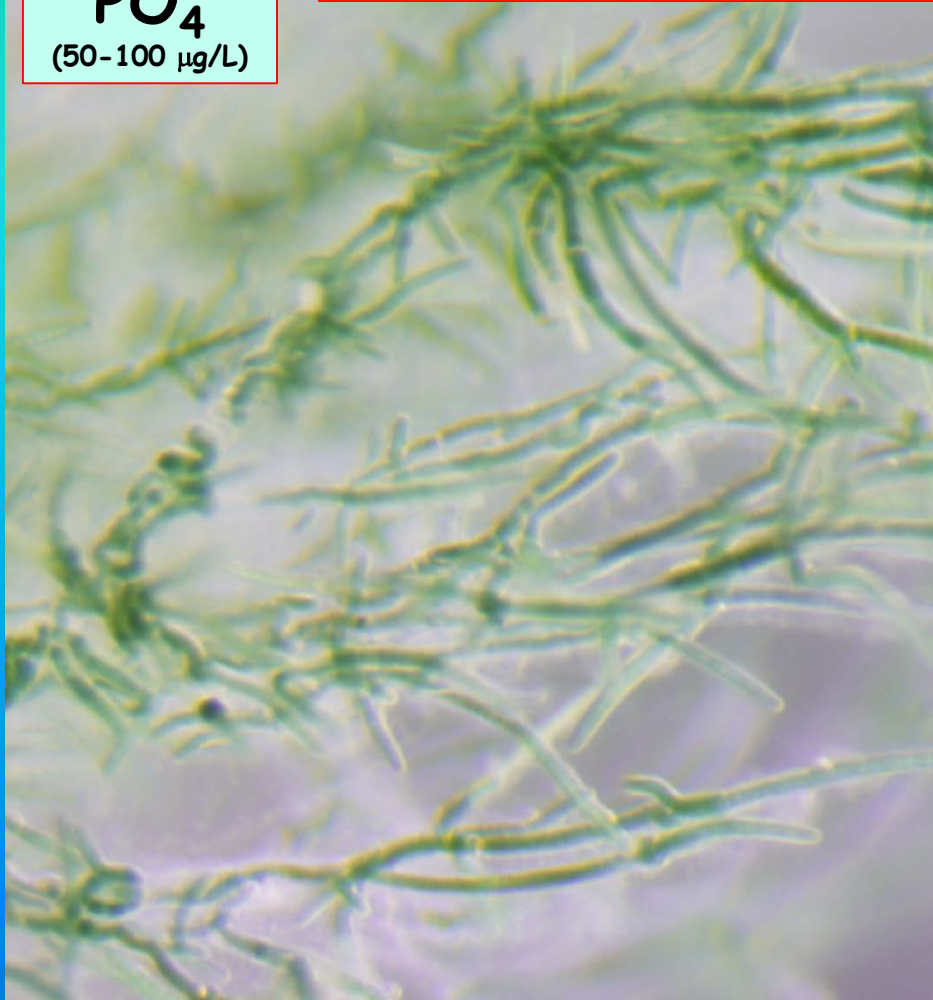
FIU

“chemical microanalysis technique used in conjunction with scanning electron microscopy (SEM)”.

Turning "off" the nucleation in the presence of phosphorus (*Chakia*)

PO_4
(50-100 $\mu\text{g/L}$)

$-\text{PO}_4$



Review

Minerals 2012, 2, 338-364; doi:10.3390/min2040338

Cyanobacteria as Biocatalysts for Carbonate Mineralization

Nina A. Kamennaya, Caroline M. Ajo-Franklin, Trent Northen and Christer Jansson *

Turning "off" the nucleation in the presence of phosphorus (*Chakia*)



Other Cyanobacteria



Thank You!
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