Microbialites from around Lake Turkana: Macro-, Meso-, and Microstructures*

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Abstract

Lake Turkana Rift sediments preserve a variety of macro-, meso-, and microstructures in the Plio-Pleistocene microbialites outcropping near the modern lake margins. Published works, focused on the northern (Nachakui) and central (Koobi Fora) basins have classified Lake Turkana microbialites as stromatolites. However, some of these "stromatolites" actually contain laminae that are thrombolitic, dendritic, and stromatolitic all within the same individual. These mesostructures can then be subdivided by their microstructures into tussocks, clots, fine laminations, and branching fabrics; any of which may or may not contain microbial filaments. Macrostructures of these microbial forms can be described as bioherms, biostroms, and oncolites. Individual oncoids are the most common deposit and nucleate on basaltic pebbles, cobbles, or on shells. In some cases, these oncoids will coalesce up-section forming biostroms and, in a few areas, oncoid sizes will also increase up-section. In the South Basin of Lake Turkana, three discrete, mounded stromatolites were mapped.

Oncoids and larger microbialite mounds show little diagenetic alteration after initial calcite cementation, unlike the other carbonate facies that are abundant along the margin of the South Basin of the lake. Lack of diagenetic alteration and advanced dissolution in these microbial mound samples, which are presently subaerially exposed, suggests oncoid/microbialite lithologies have low initial porosity and permeability. From three porosity and permeability measurements, porosity ranges from 14-39%, with permeability ranging from 0.47-22.8 md. Where alteration has occurred, such as in the case of the precipitation of rhombic dolomite crystals, the cements are in vugs that were synsedimentary and formed as part of the primary 'reefal' or mound system.

Turkana Basin oncoids and stromatolites likely formed where alluvial stream channels provided a cobble substrate for nucleation. Smaller oncoids that nucleated on shell material formed near shore, where shell material was available. The large mounded stromatolite outcrops are interpreted as having formed along spring seeps adjacent to faults and/or fractures. All three mounds are oriented N/NE-S/SW, consistent with the orientation of faults in the area. Modern hydrothermal deposits are found on North and Central Islands, and a fossilized hot spring was described by Renaut et al. (2002) along the western side of lake, supporting this interpretation.

References

Cerling, T.E., 1996, Pore water chemistry of an alkaline lake; Lake Turkana, Kenya, in T.C. Johnson, and E.O. Odada, (eds.), The limnology, climatology and paleoclimatology of the East African lakes: Gordon and Breach Publishers, Australia, p. 225-240.

Renaut, R.W., C.K. Morley, and B. Jones, 2002, Fossil hot-spring travertine in the Turkana Basin, northern Kenya; structure, facies, and genesis, in R.W. Renaut, and G.M. Ashley, (eds.), Sedimentation in continental rifts: Special Publication, Society for Sedimentary Geology, v. 73, p. 123-141.

Microbialites from around Lake Turkana: macro-, meso-, and microstructures

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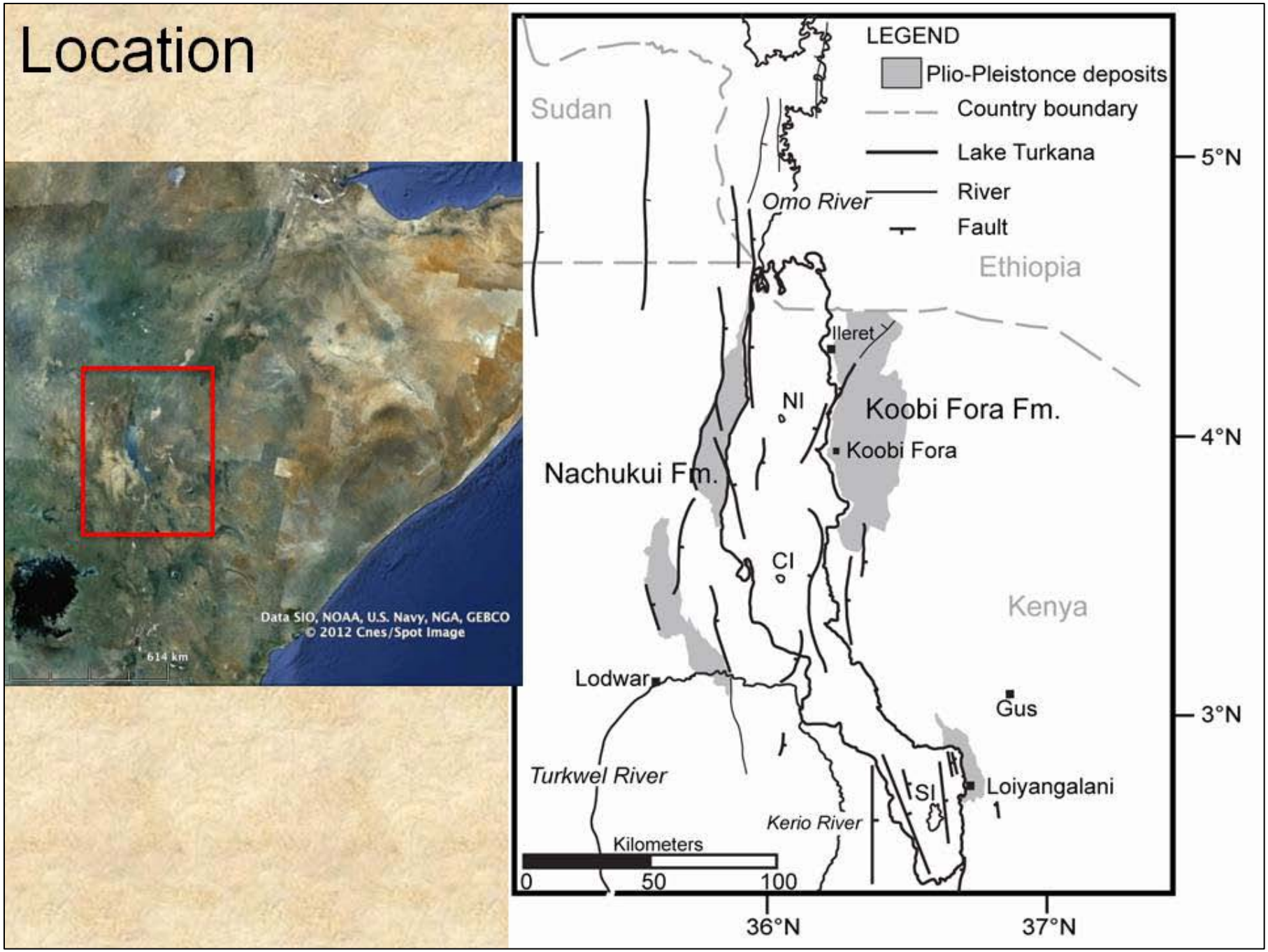


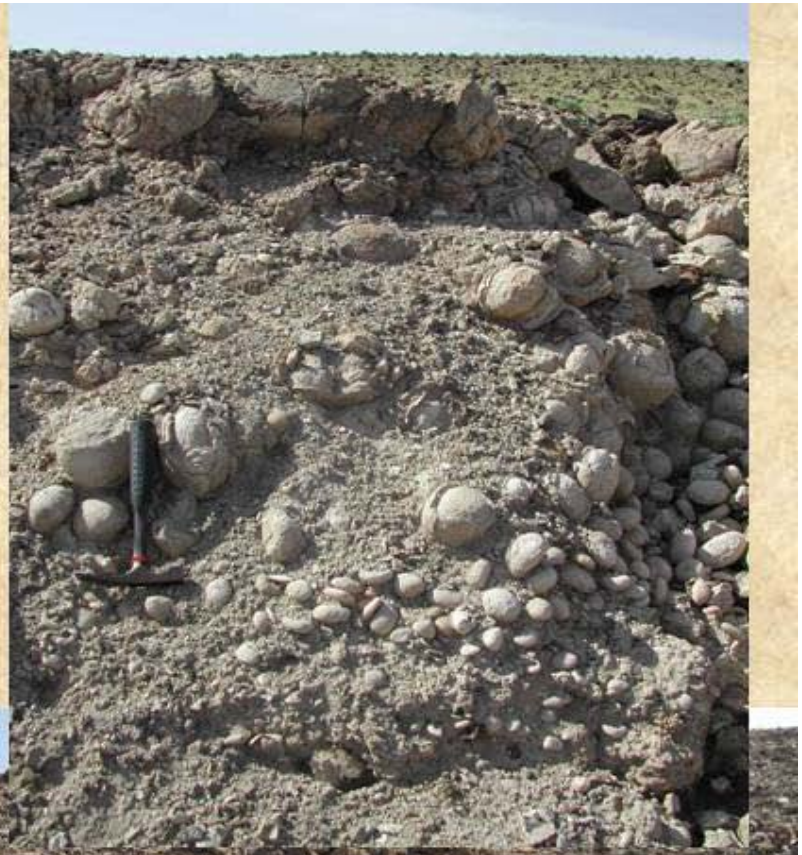
Presenter's Notes: Mixed siliclastic and carbonate system.

Outline

- Observations
  1. Macrostructures
  2. Mesostructures
  3. Microstructures
     - Diagenesis
- Controls on fabrics

Macrostructures

- Oncoids
  - Common and Fundamental form
  - Layers of individuals
  - Increase in size up-section
  - Coalesce up-section
  - Nucleate on cobble, pebbles, gastropod and/or bivalves



Presenter's Notes: Discontinuous beds.

Macrostructures

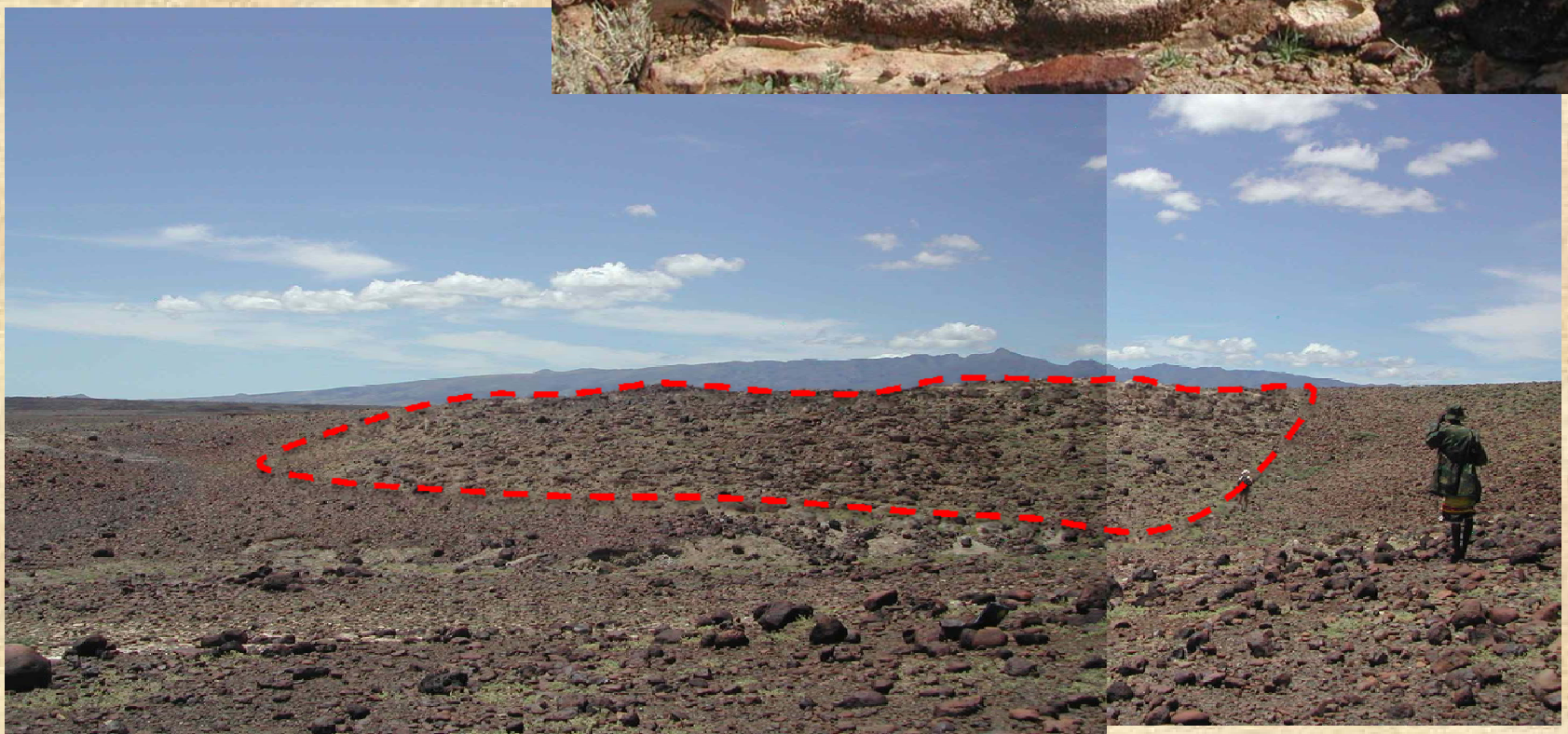
- Biostromes
  - Only local lateral continuity

- Nachakui contains most abundant and stacked
- Nucleate on cobbles or coalesced oncoids

Presenter's Notes: Not very laterally continuous like oncoids.

Macrostructures

- Mounds
  - Only found in the south basin (3 mounds)
  - Up to 7.5m thick
  - Individuals range from 20-30cm thick
  - Trend NNE/SSW



Macrostructures

Presenter’s Notes: Onlapping grainstones.

Mesostructures

- Layering:
  - Stromatolitic = laminar
  - Spongy
  - Thrombolitic = clotted
  - Dendritic = branching/bushy

Stromatolitic layers

- No systematic variation from layer to layer

Mesostructures

- Spongy

Mesostructures

- Dendritic—bushy/branching

Mesostructures

- Thrombolitic

Mesostructures

- Surface textures:
  - Pitted
  - Meandering/brain-like
  - Smooth
  - Petal
  - Cauliflower

Mostly outer surfaces are pitted

Mesostructures

- Surface textures:
  - Meandering/brain-like

Cross-sectional fabric:
Dendritic
Spongy
Thrombolitic
Stromatolitic

Mesostructures

- Surface textures:
  - Smooth
  - Petal

Mesostructures

- Surface textures:
  - Cauliflower

Cross-sectional fabrics:
Thrombolitic
Spongy
Dendritic

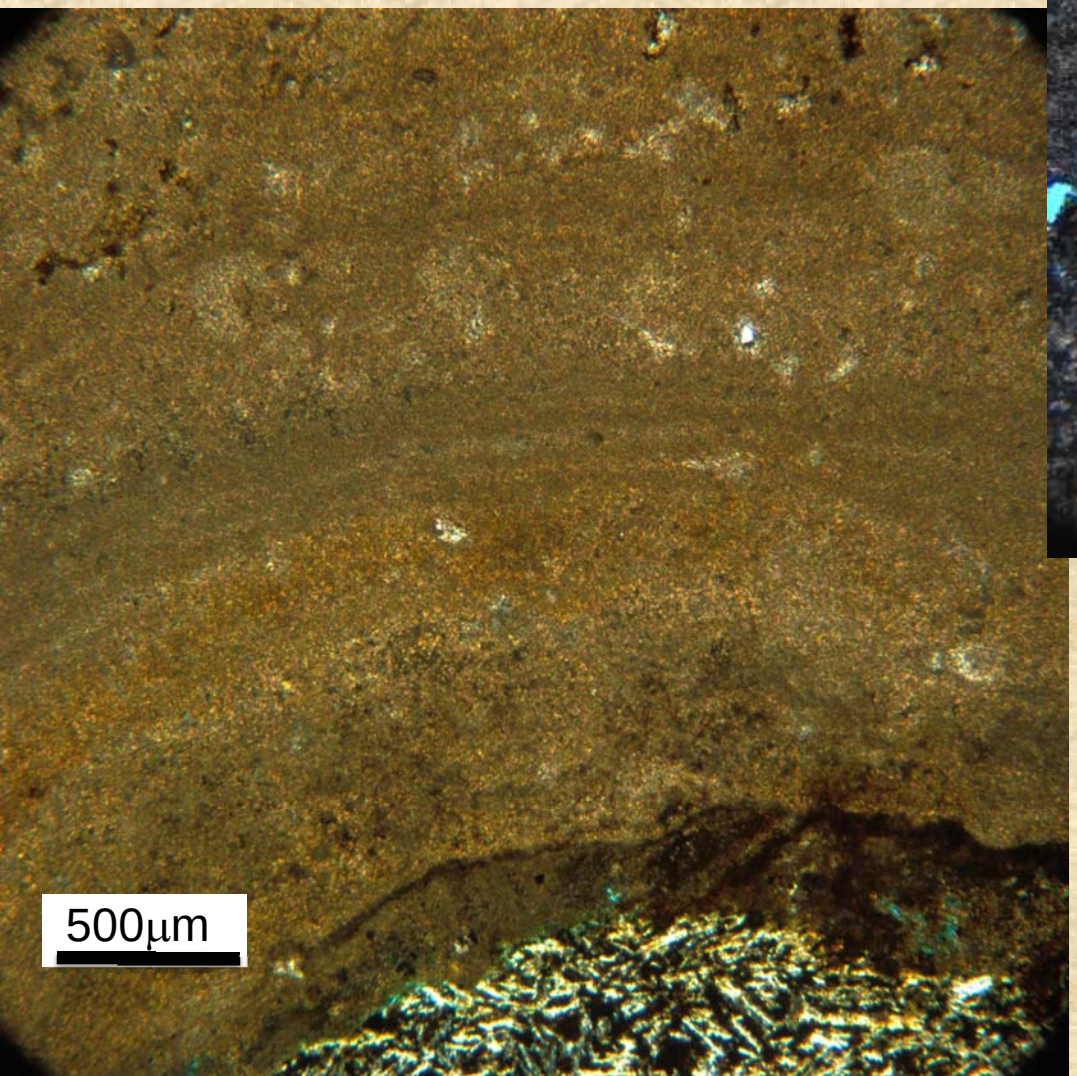
Microstructures

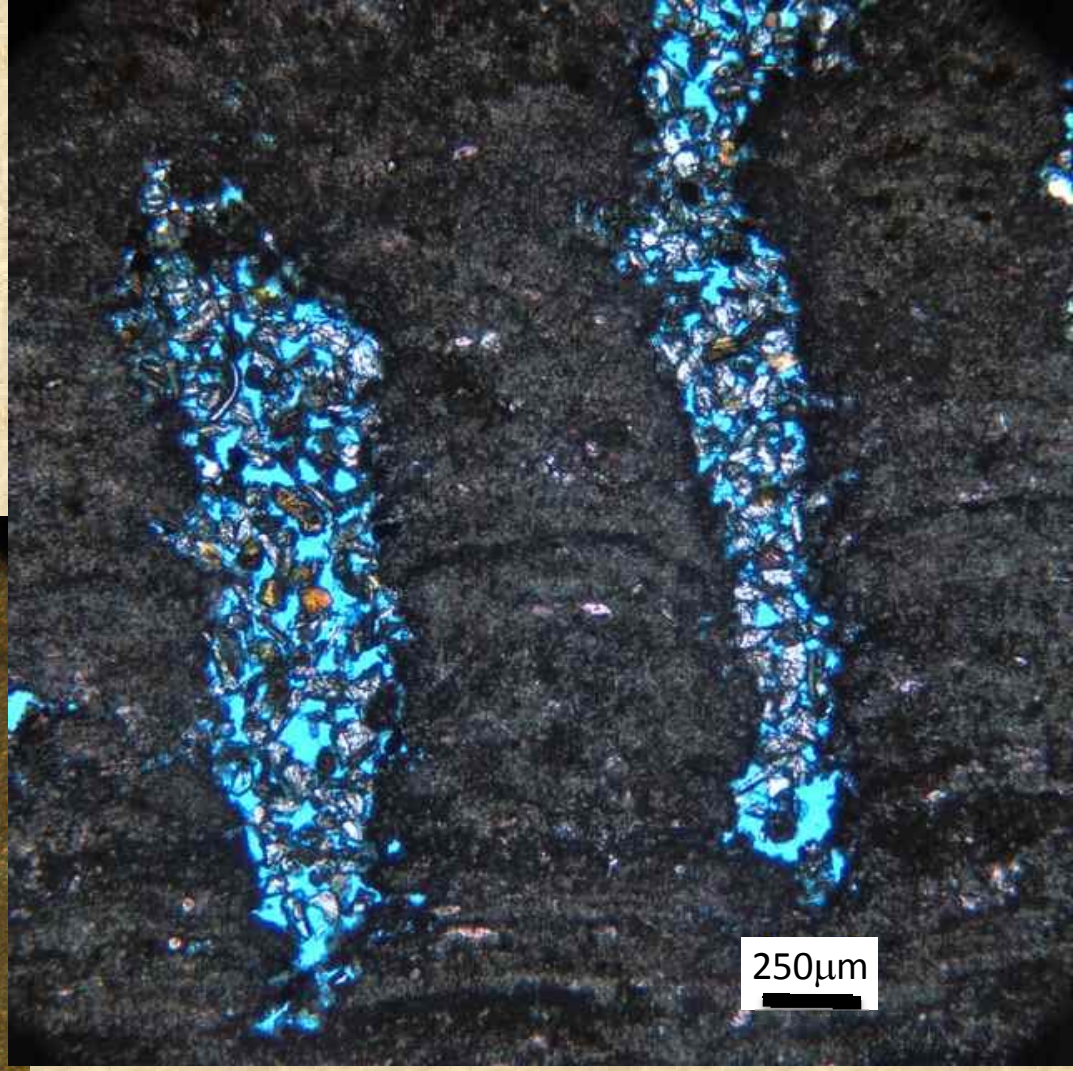
- Synsedimentary Cementation
- Variety of textures
  - Laminated
  - Clotted-Chaotic
  - Tussocky
  - Branching
- Vuggy and moldic porosity
- Range of porosity and permeability

Presenter's Notes: All impregnated with blue epoxy. Some stained with alizerin red.

Microstructures

- Laminated

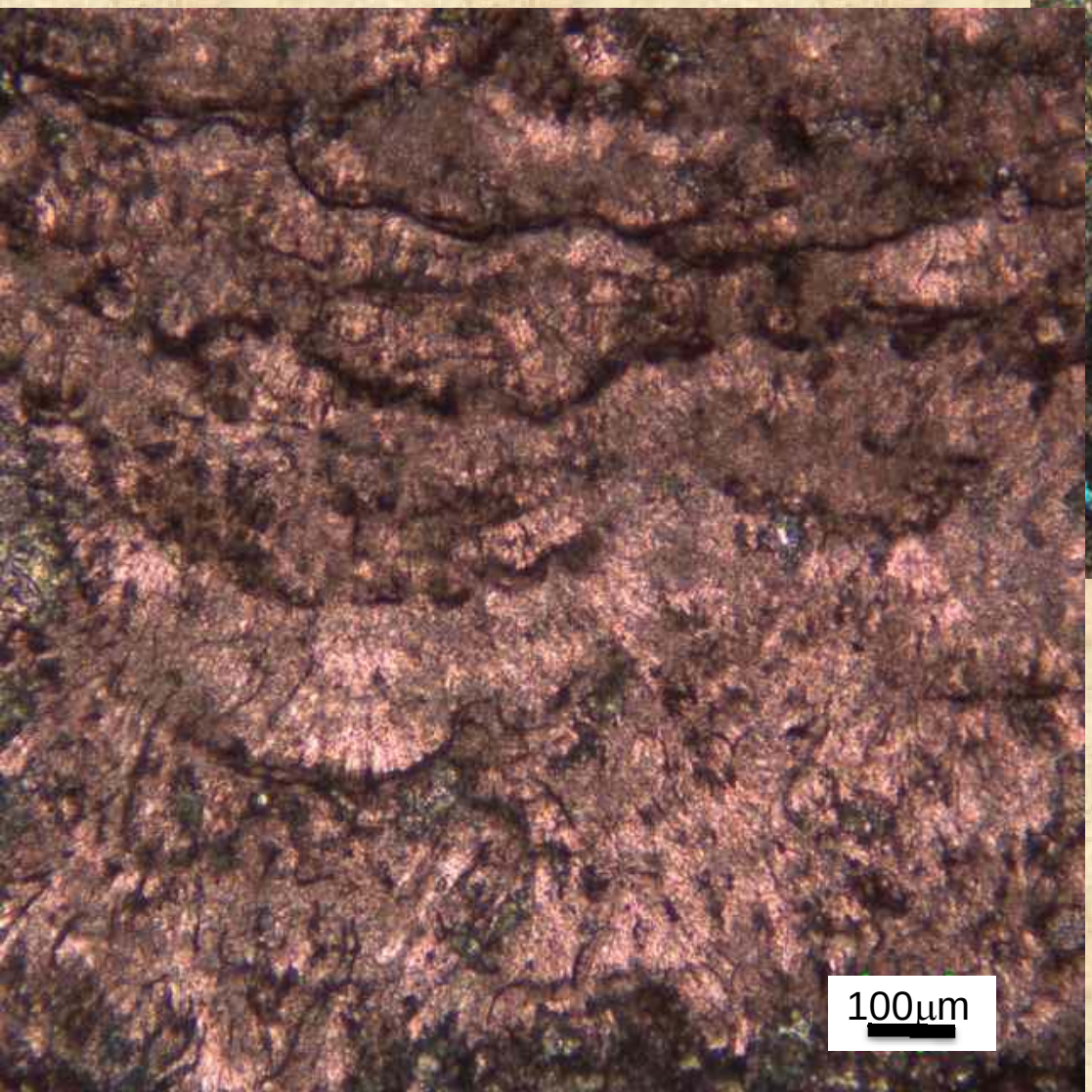


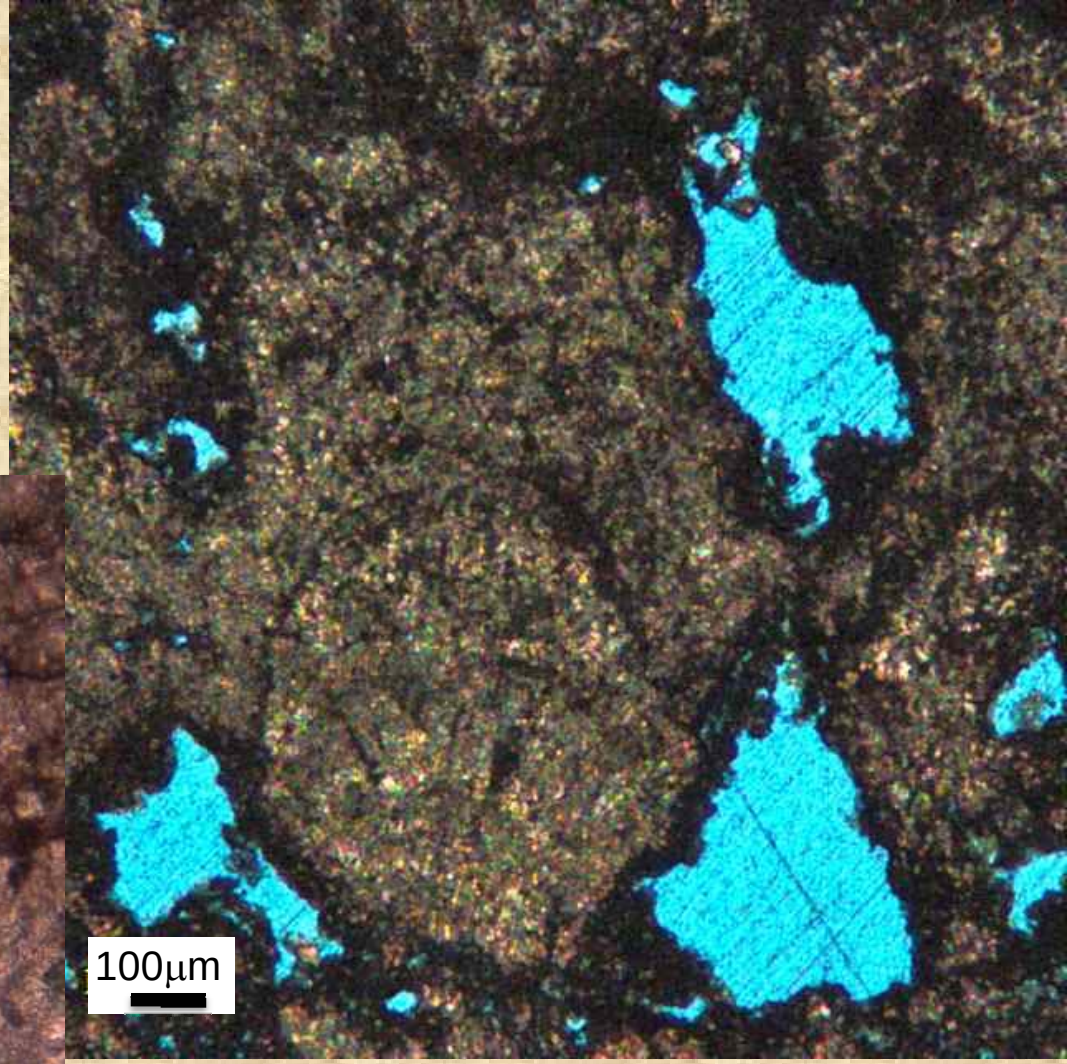


Mesoscale fabric:
Stromatolitic
Dendritic
spongy

Microstructure

- Tussocky

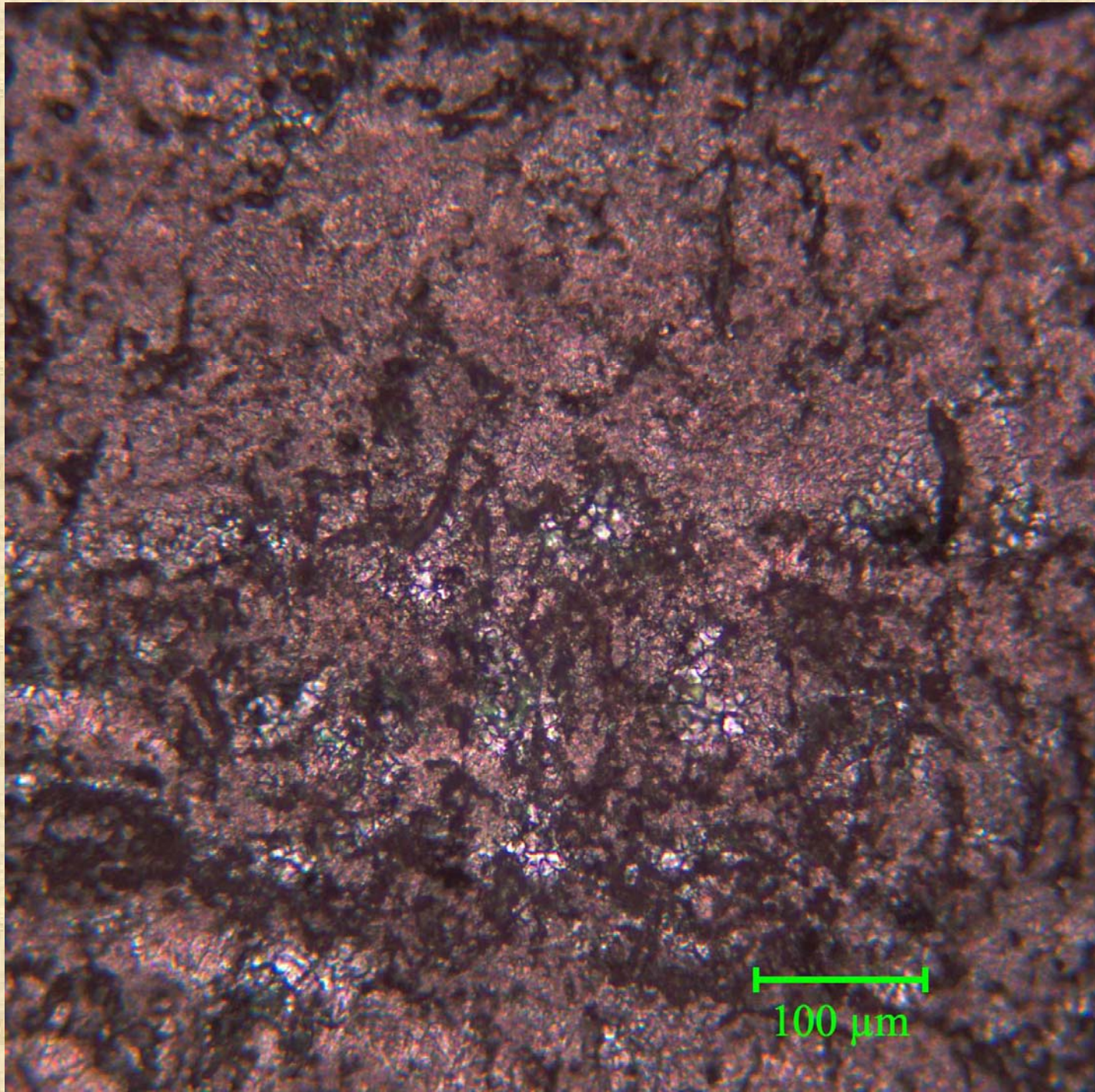


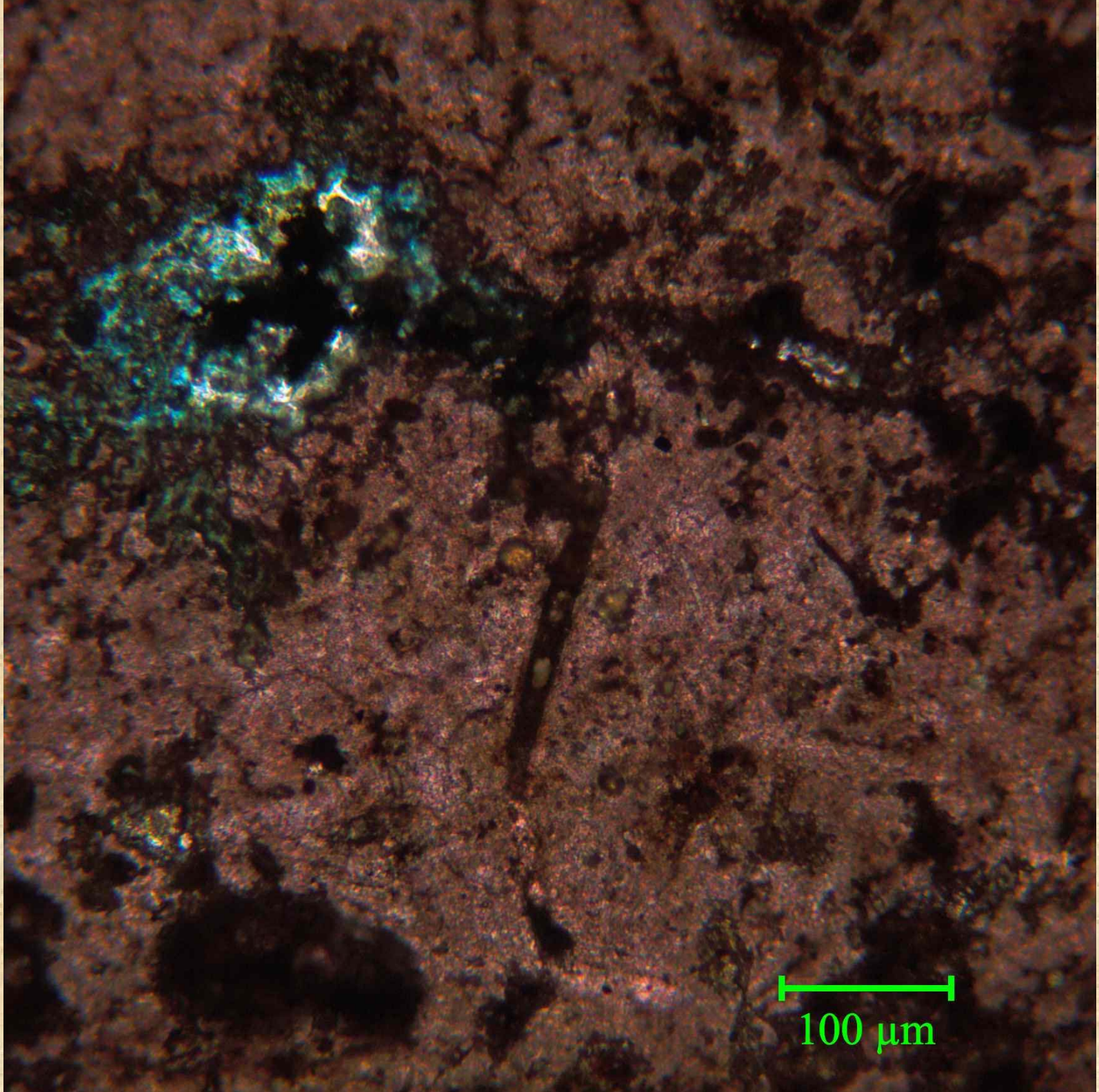


Mesoscale fabric:
Stromatolitic
Dendritic
spongy

Microstructures

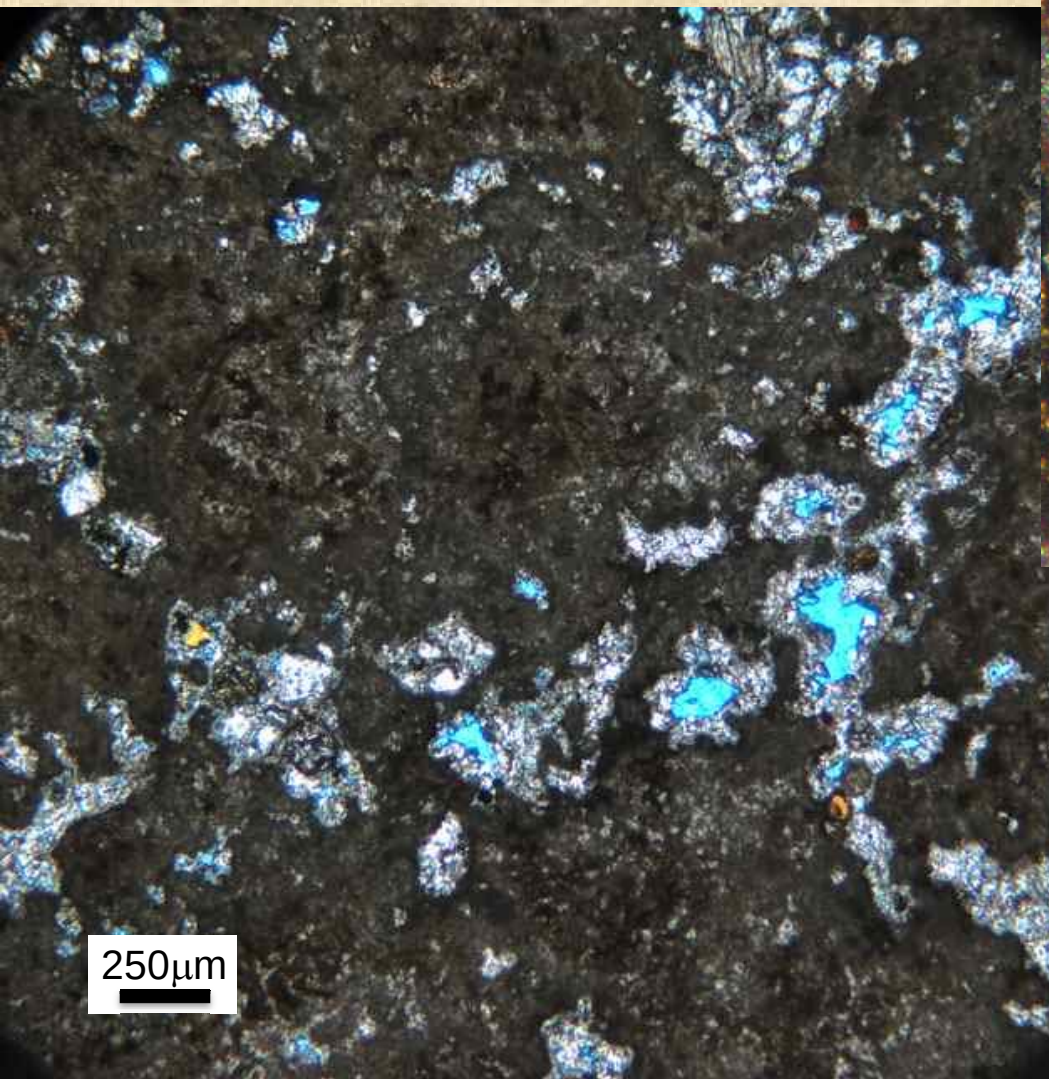
- Preserved filaments

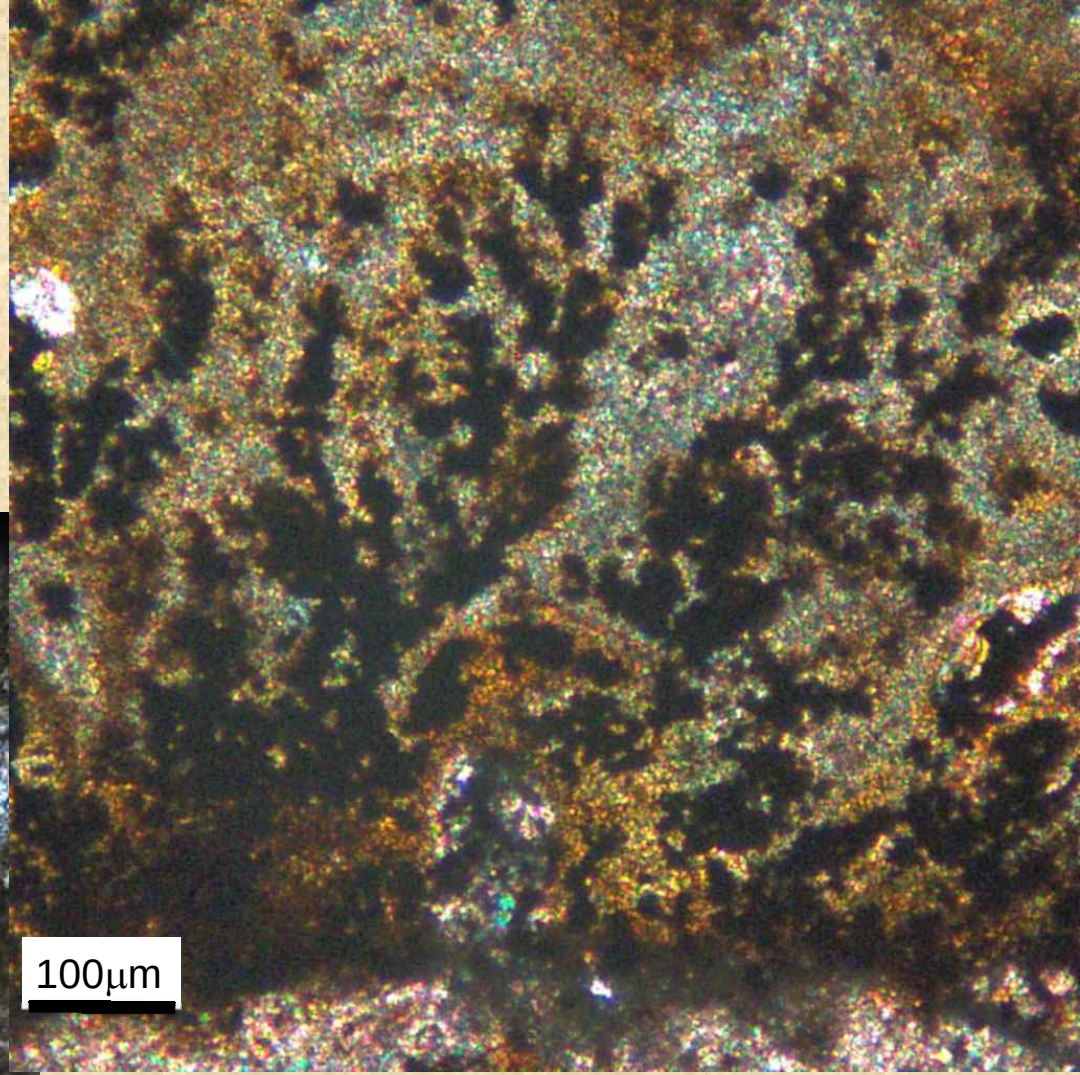



100 µm

Microstructure

- Clotted

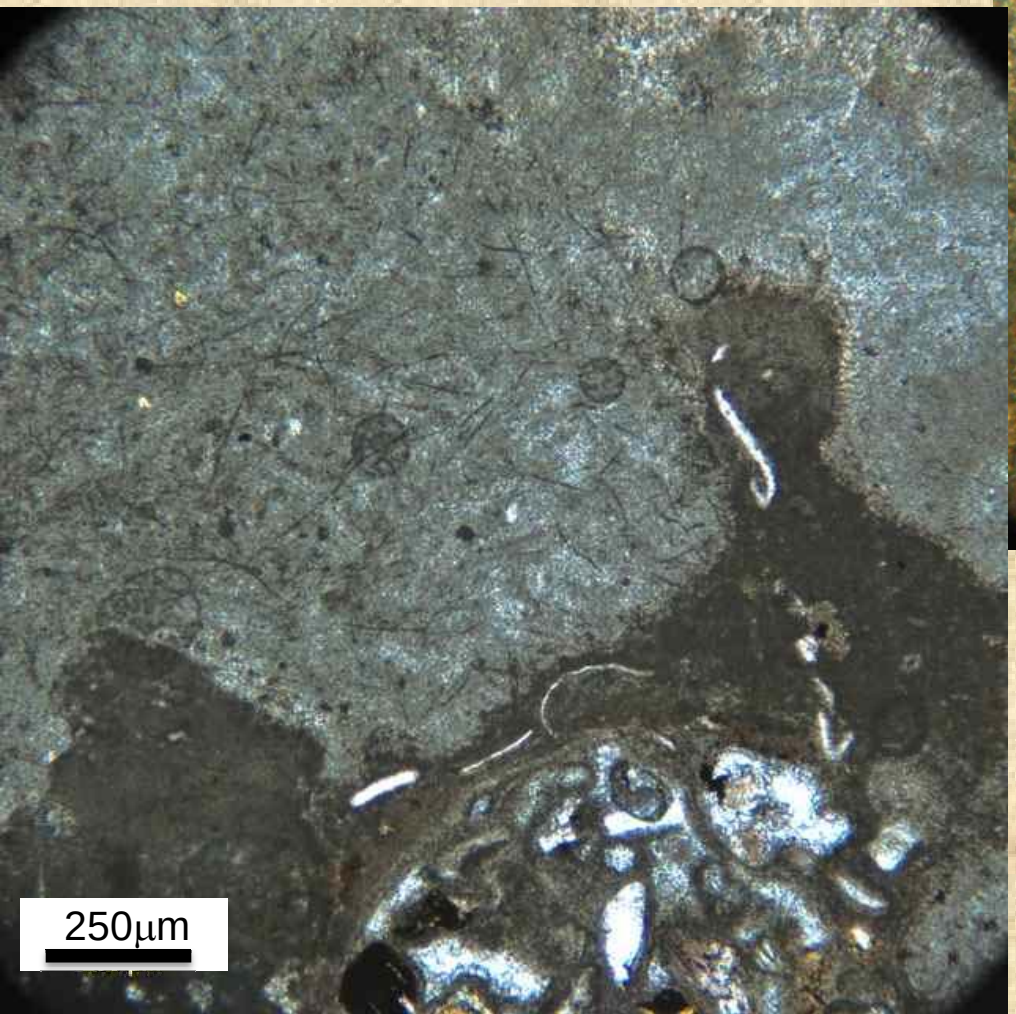


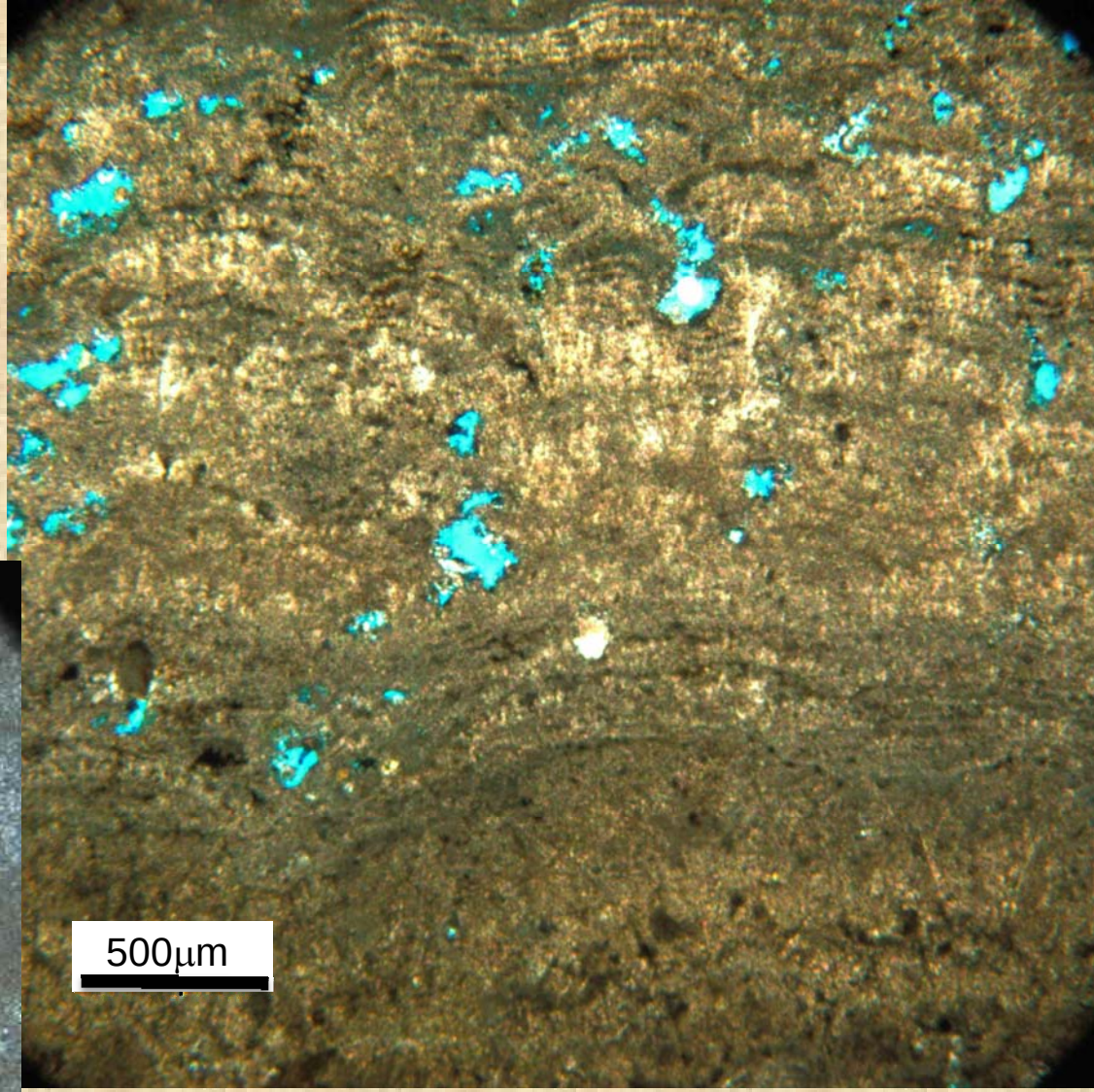


Branching

Mesoscale fabric:
Spongy
Thrombolitic

Microstructures

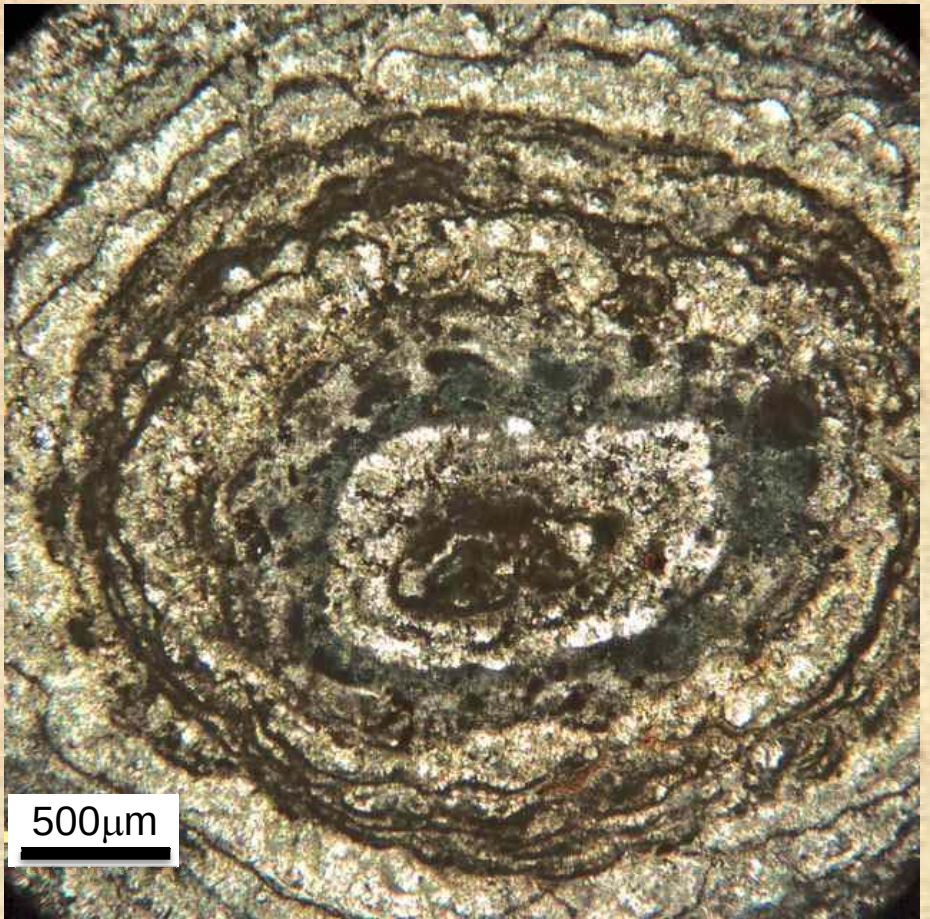


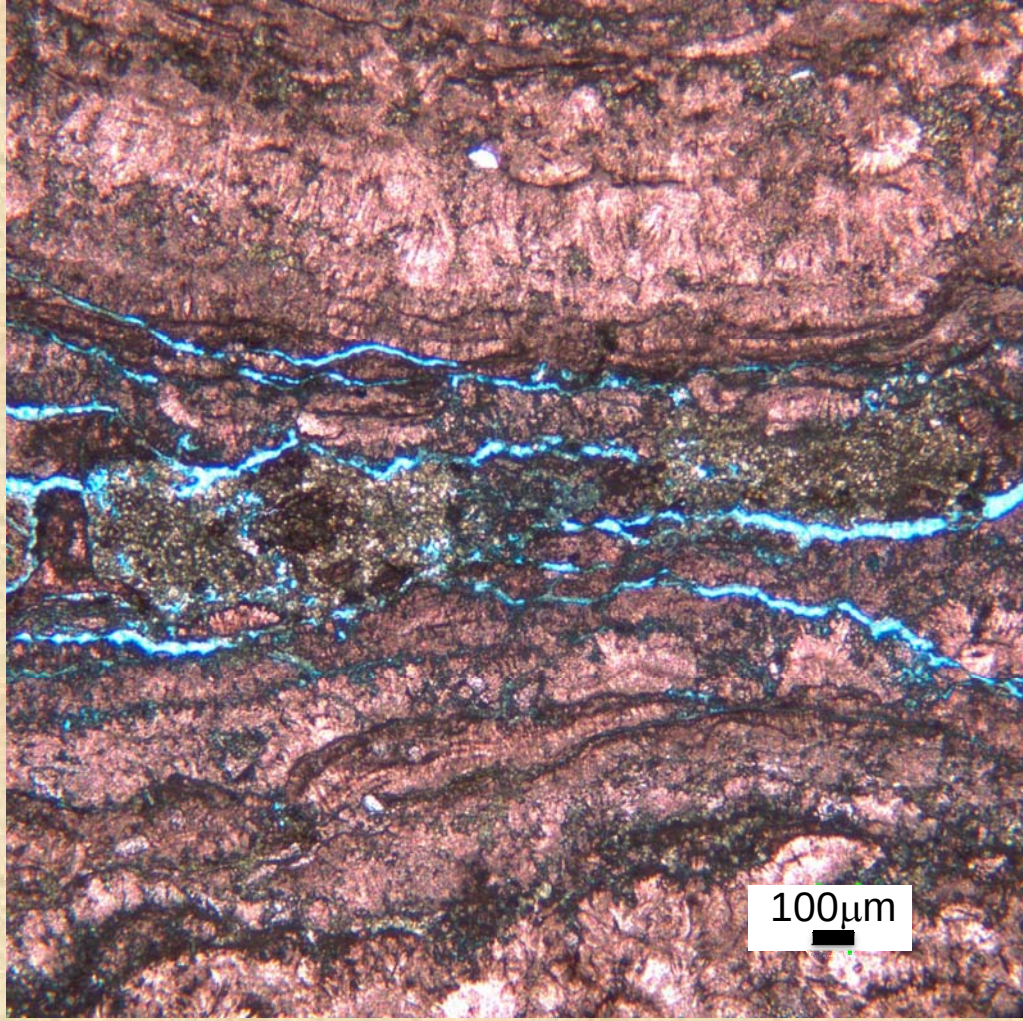


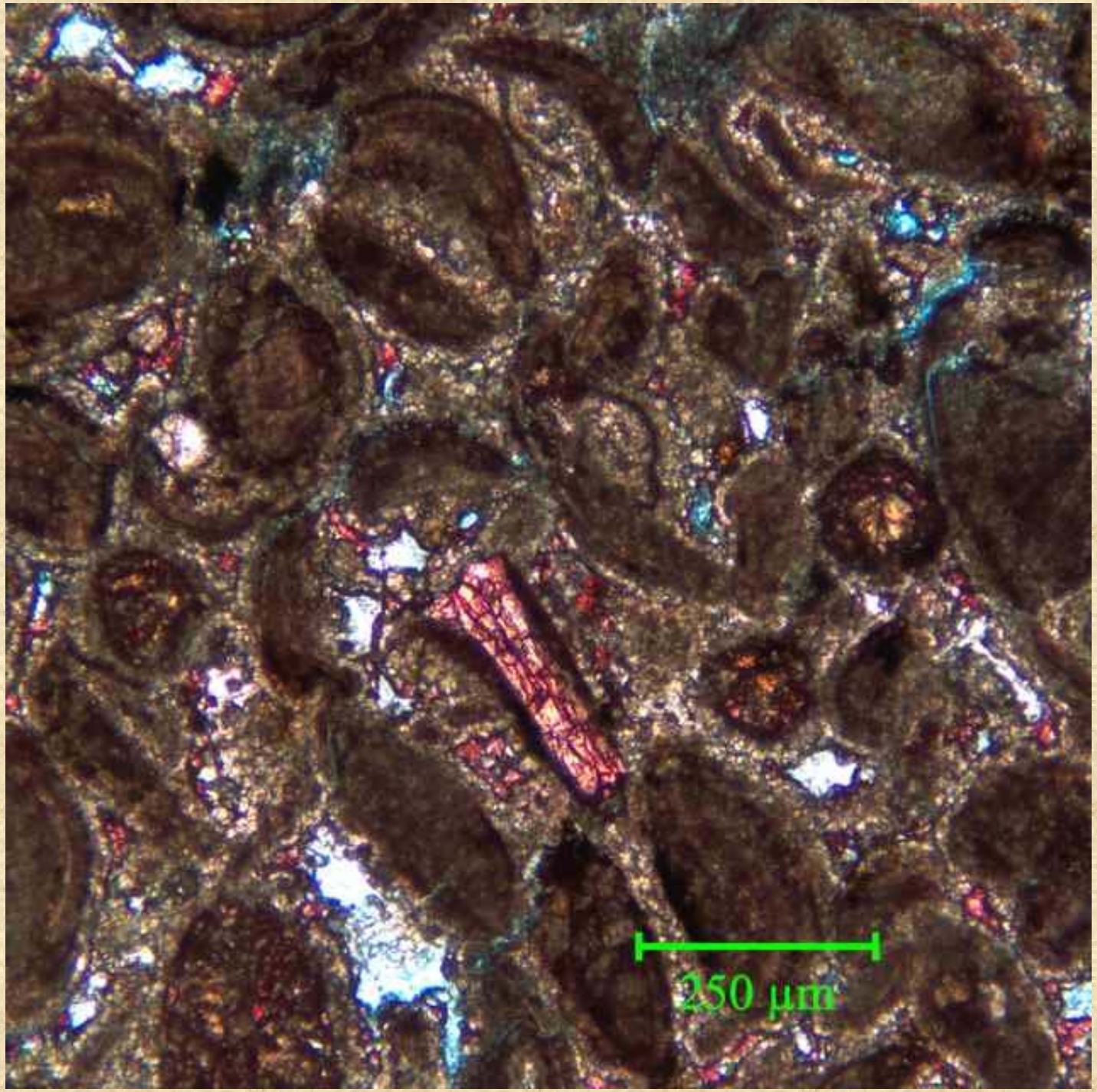
Mixed fabrics

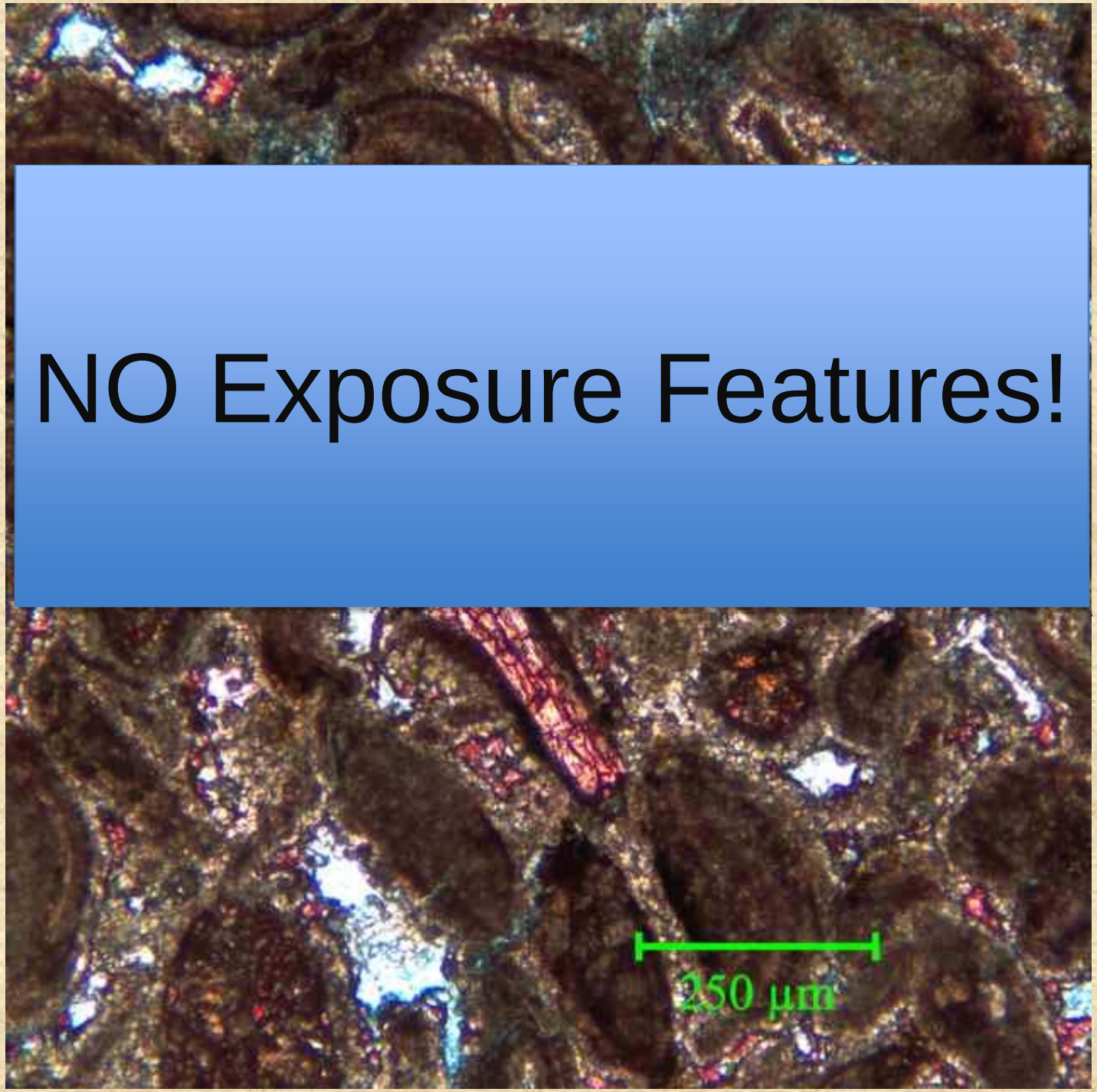
Diagenesis

- Microbialites--Early cementation
- Little initial porosity and permeability



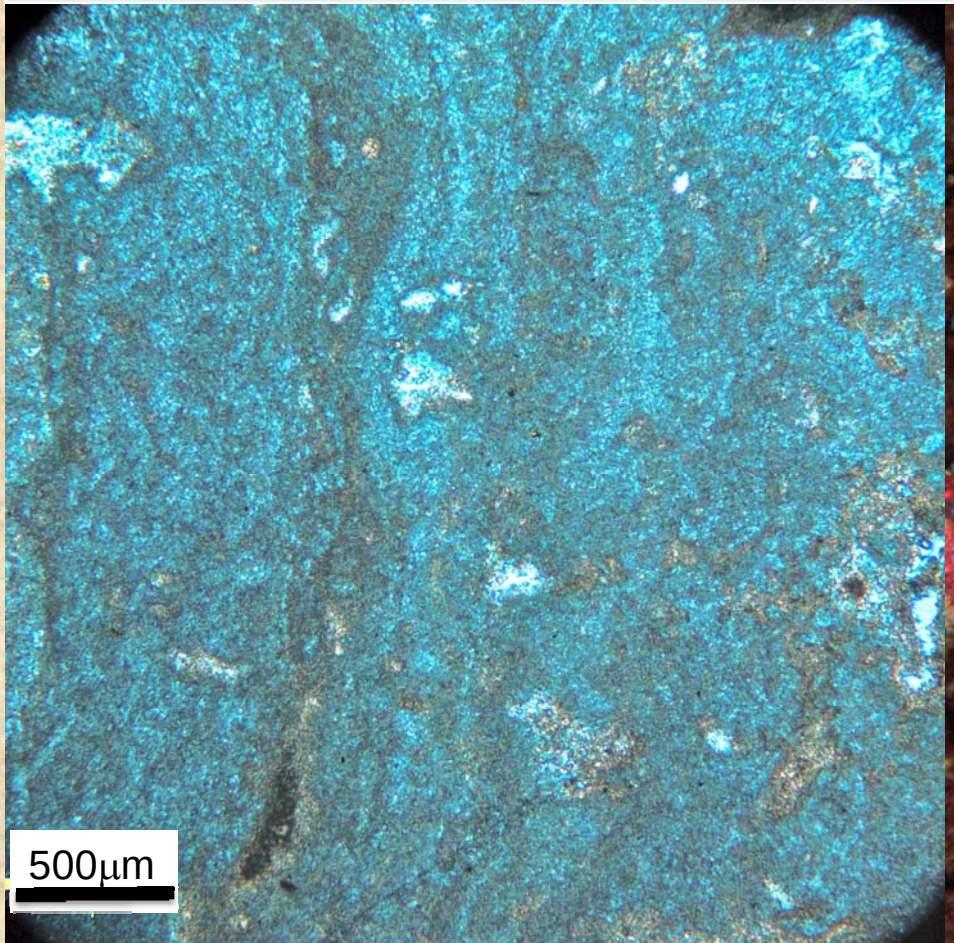


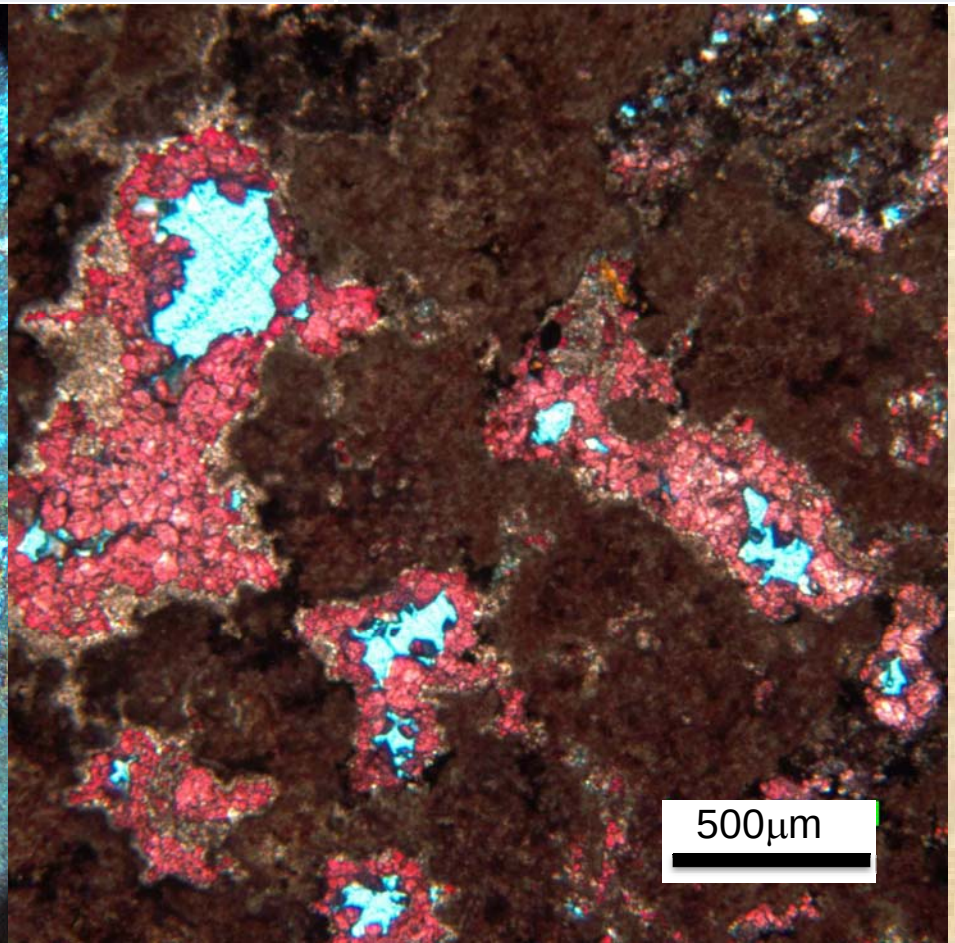

250 µm


NO Exposure Features!
250 µm

Porosity and Permeability

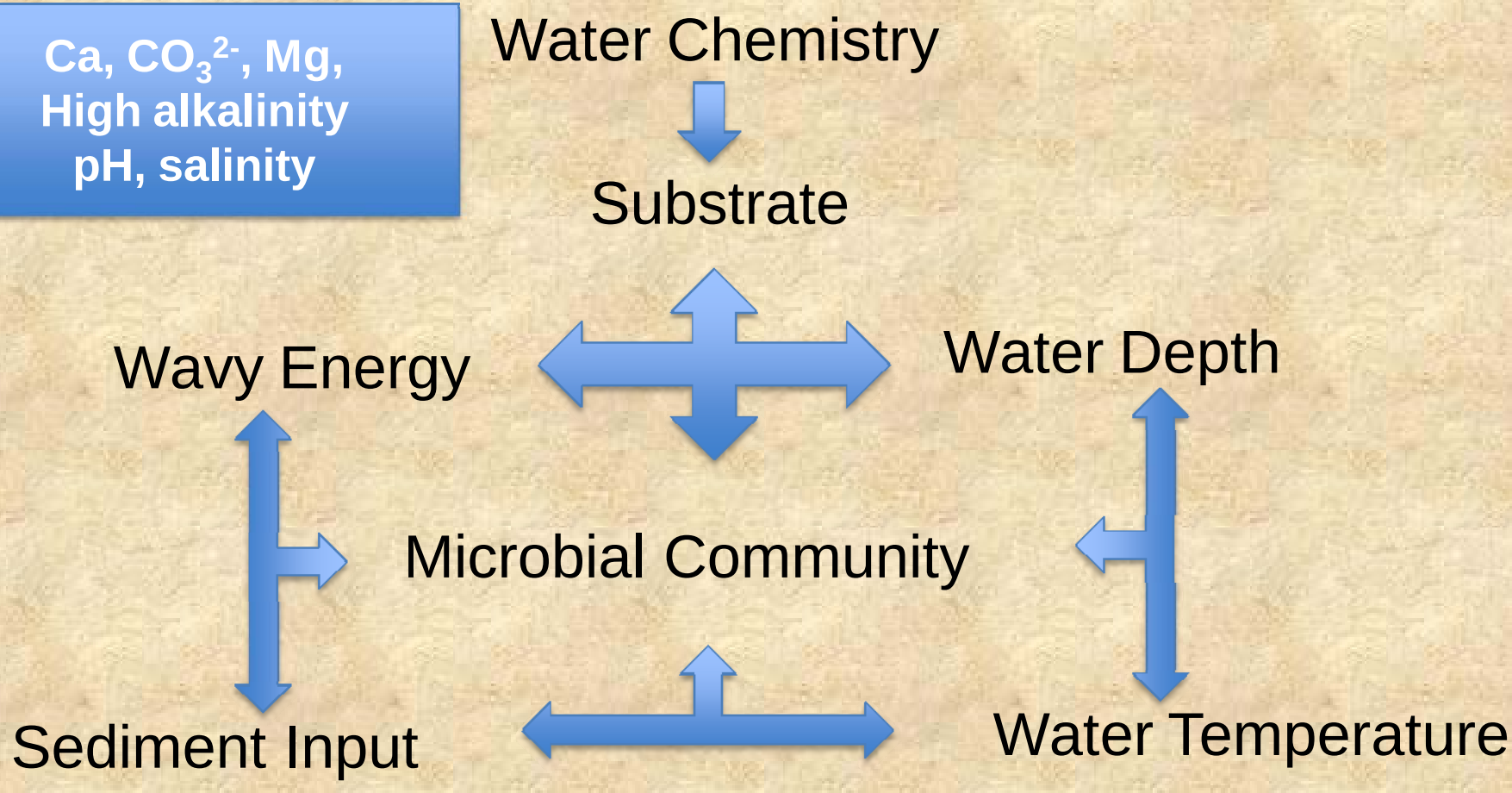
Rock type	Porosity (%)	Permeability (mdarcy)
Oncolite	39.194	22.865
Microbialite	14.837	0.695
Oncolite	16.0	0.47
Tufa (laminar)	12.8	1.91



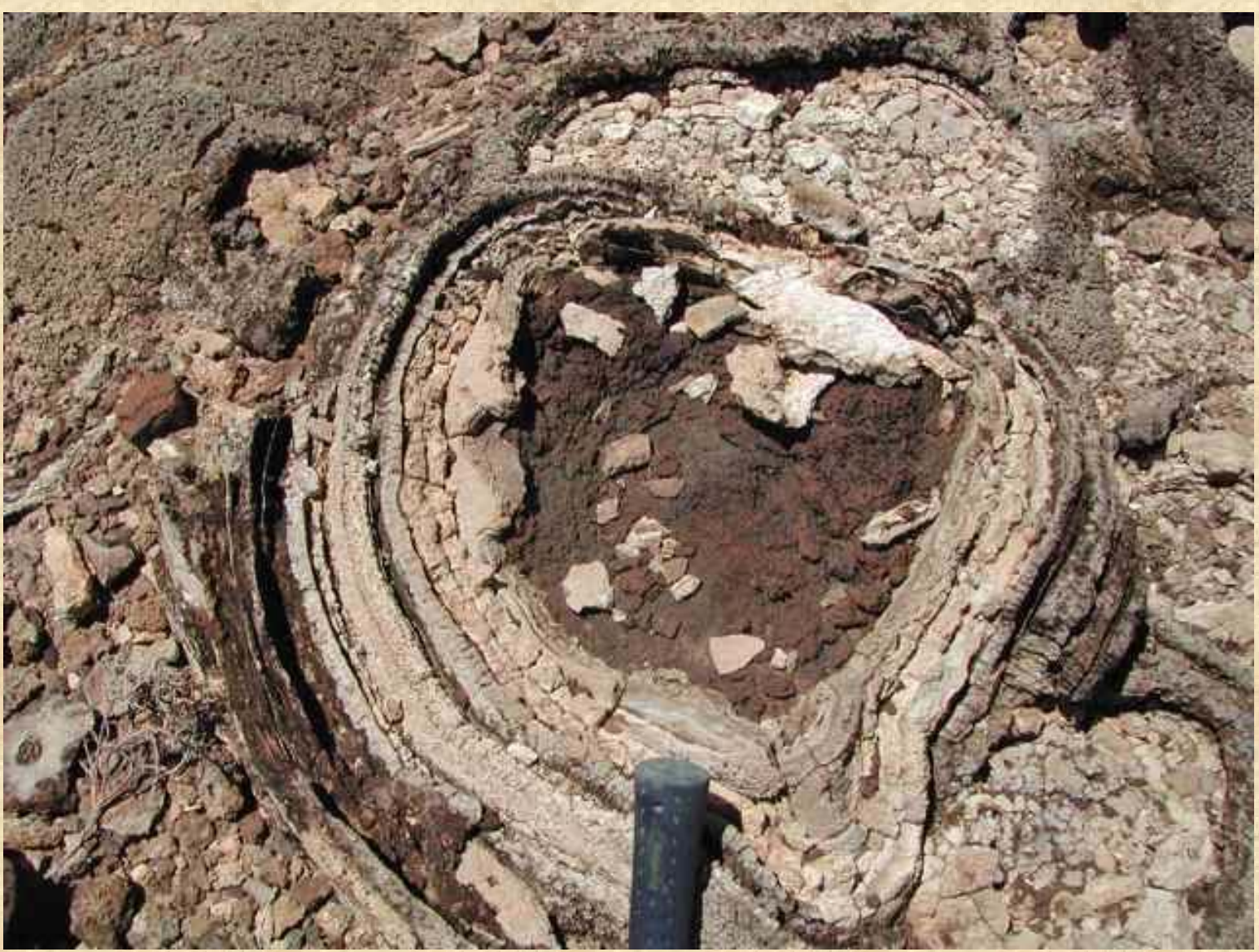


Controls on microbialites

Ca, CO_3^{2-}, Mg,
High alkalinity
pH, salinity

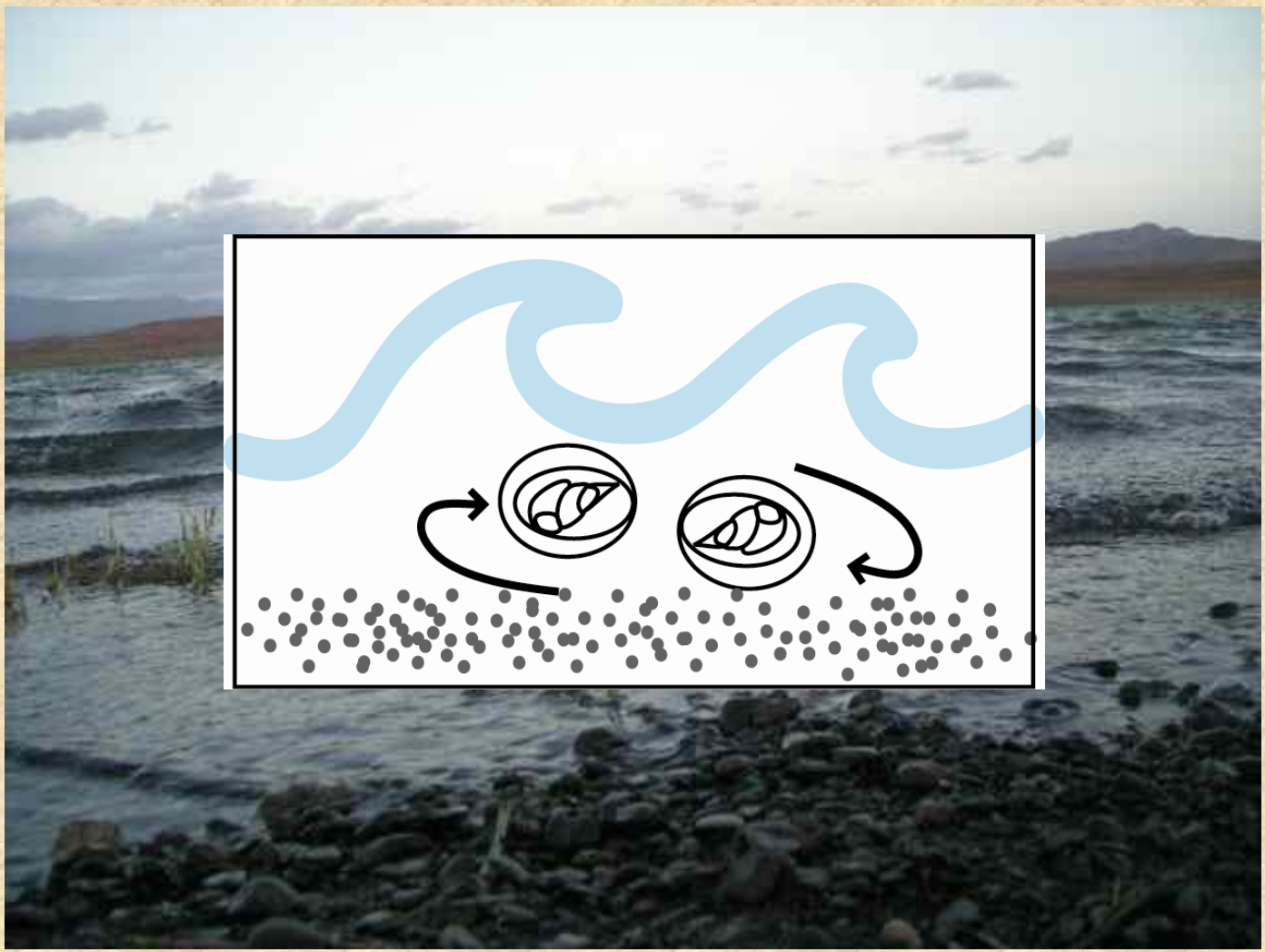


Controls on microbialites

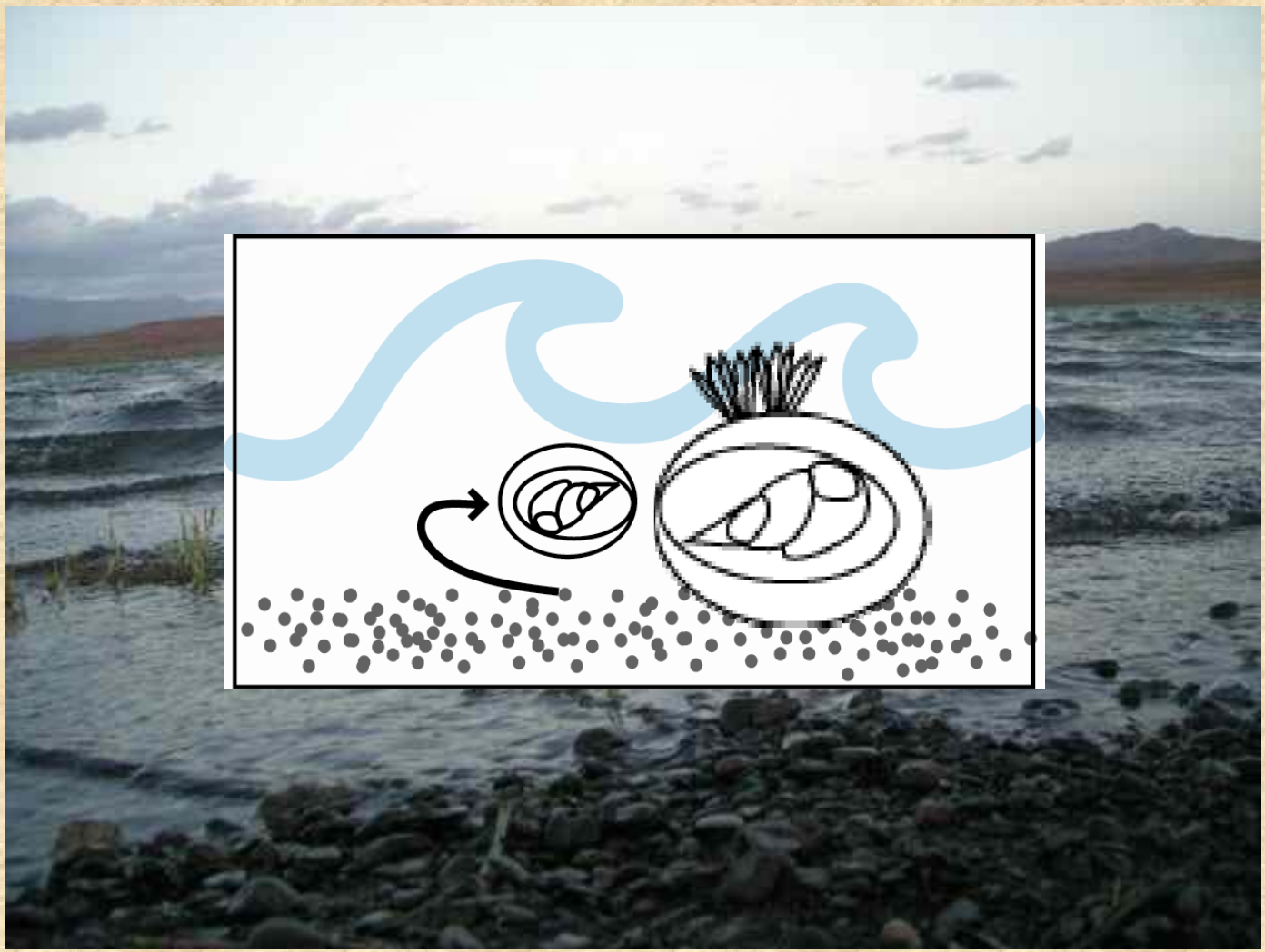


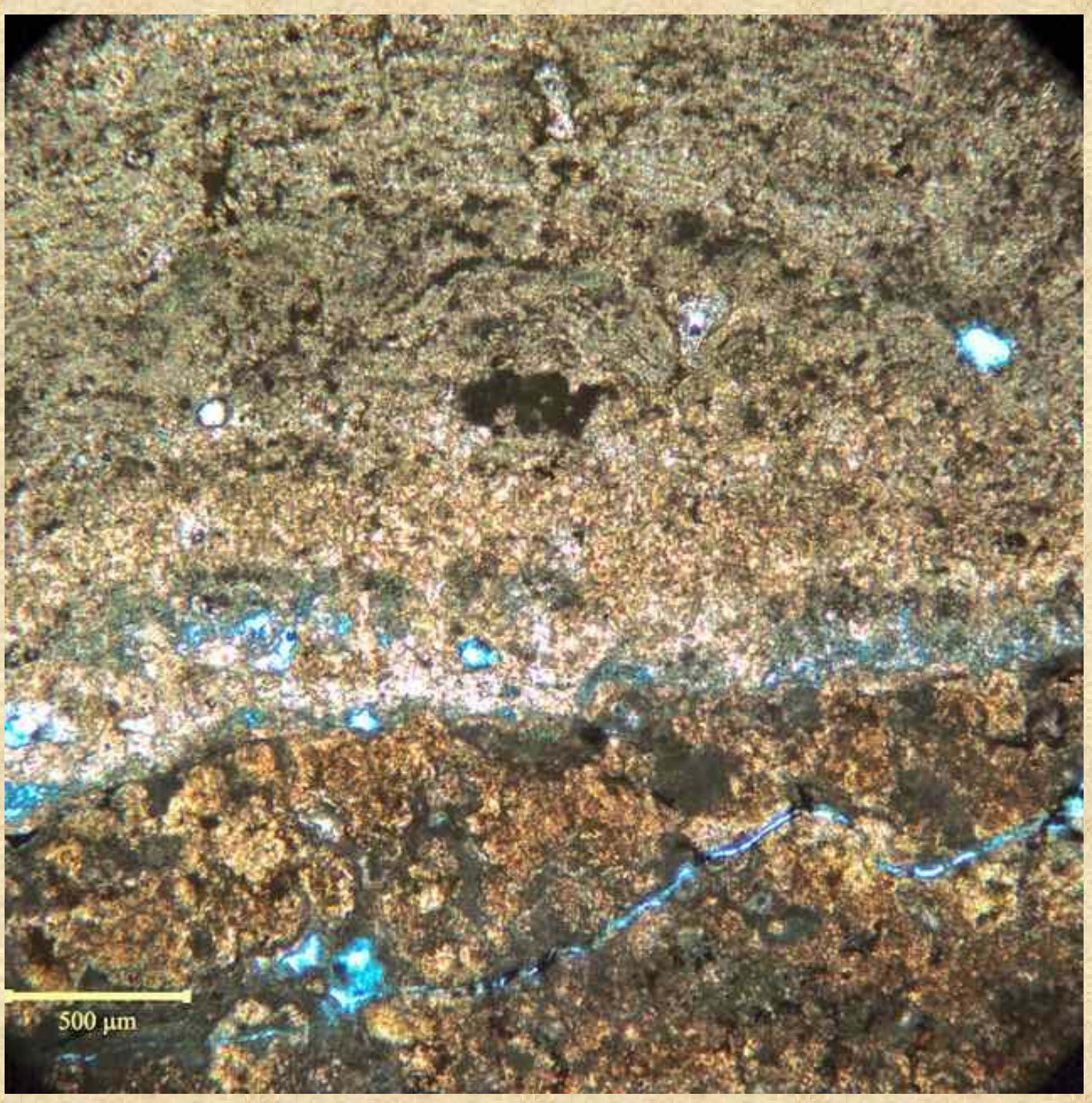
Controls on microbialites

Controls on microbialites

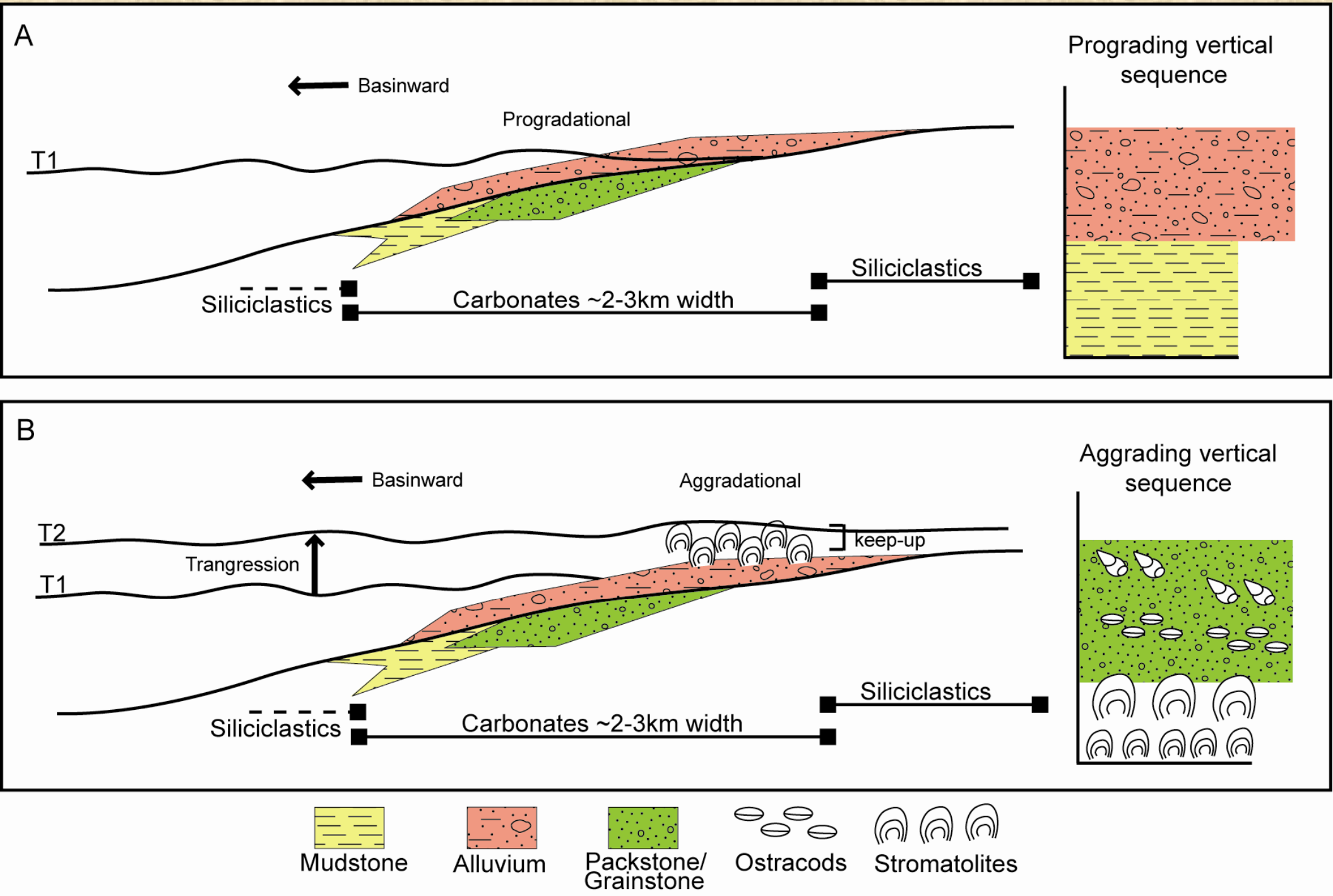


Controls on microbialites

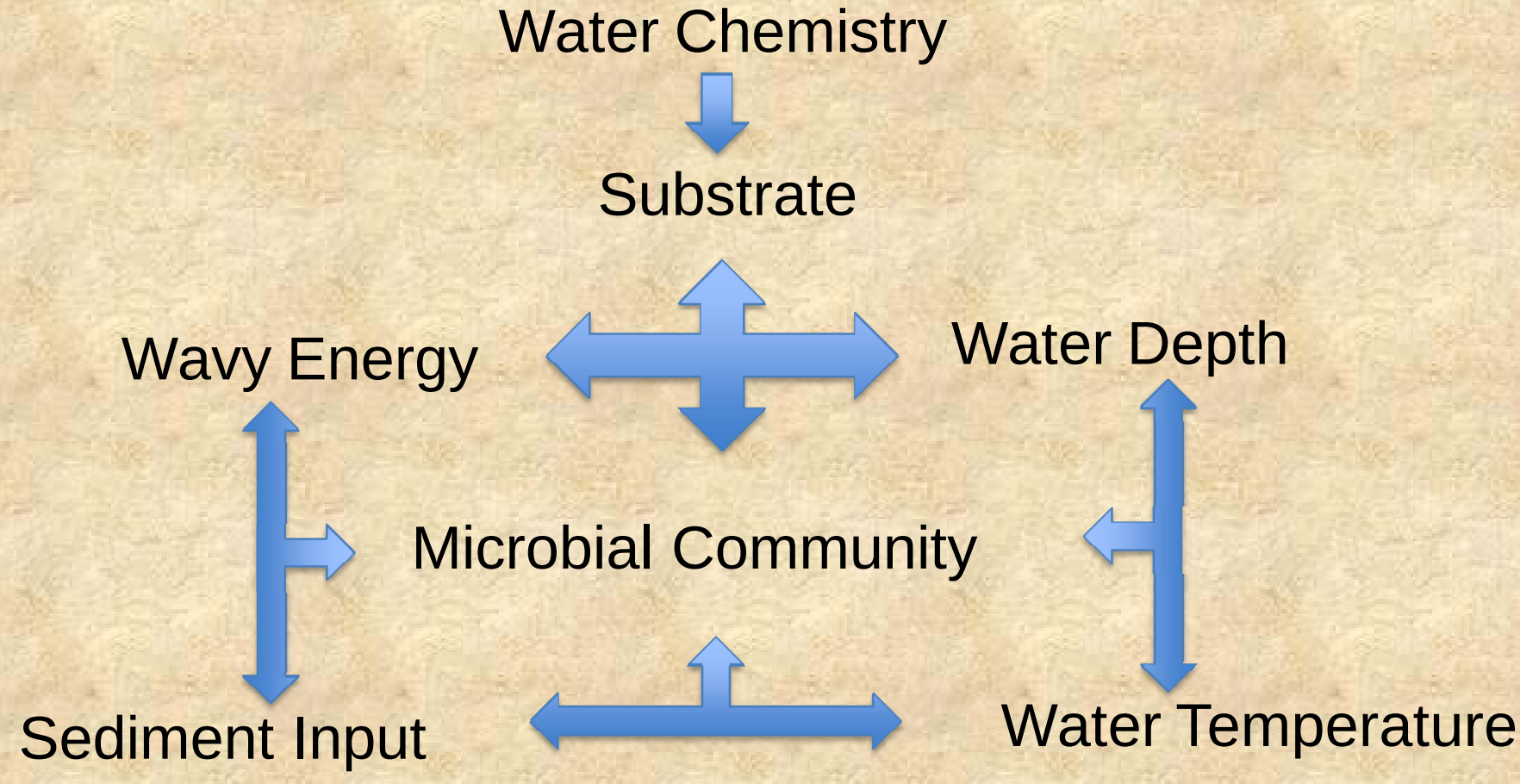



500 µm

Parasequences

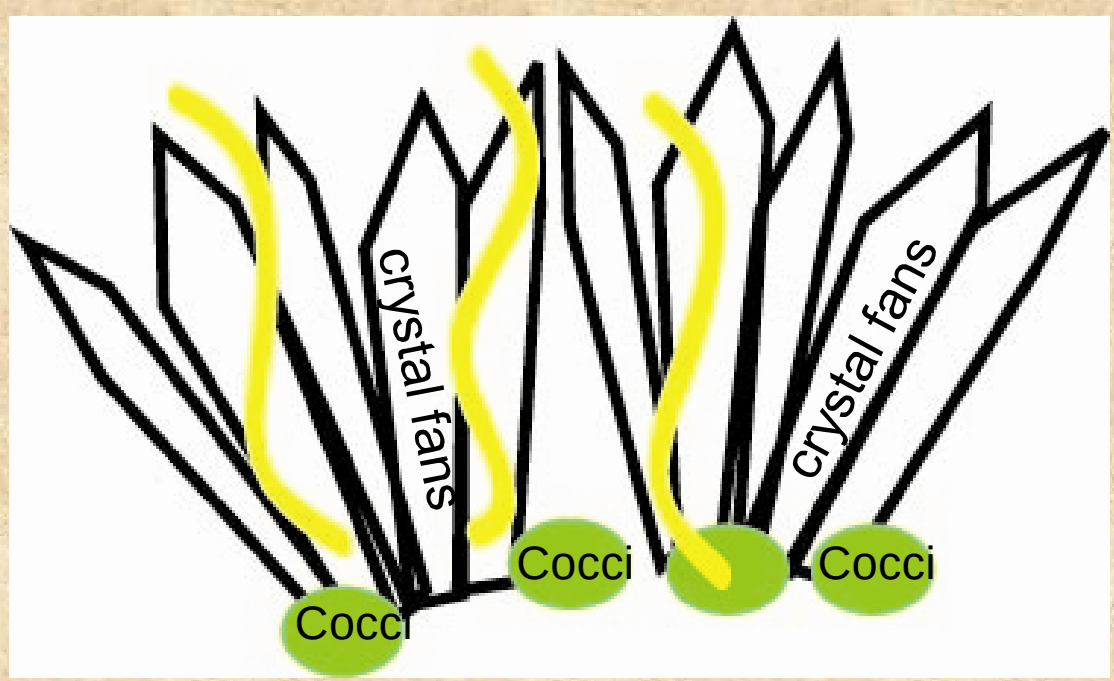


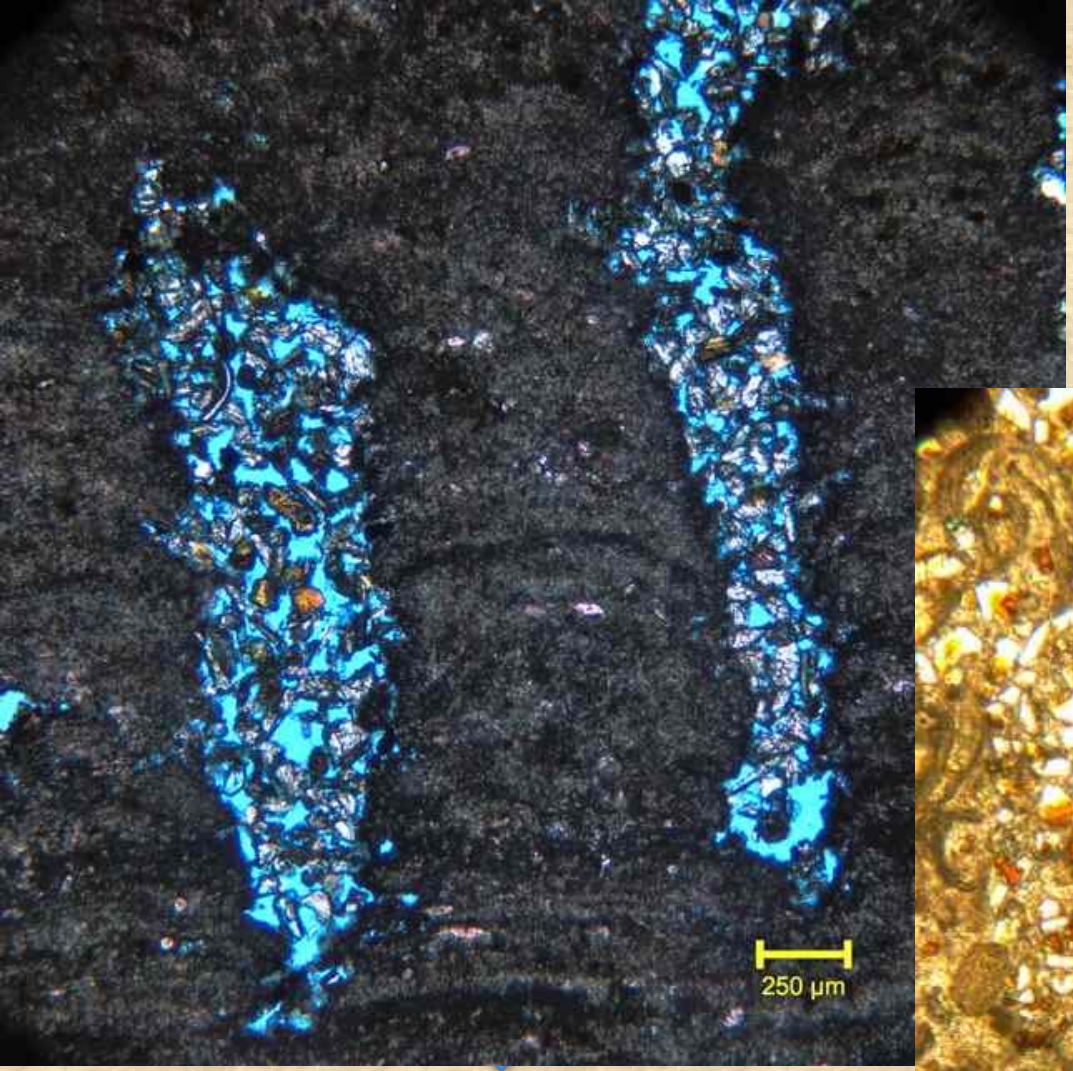
Controls on microbialites

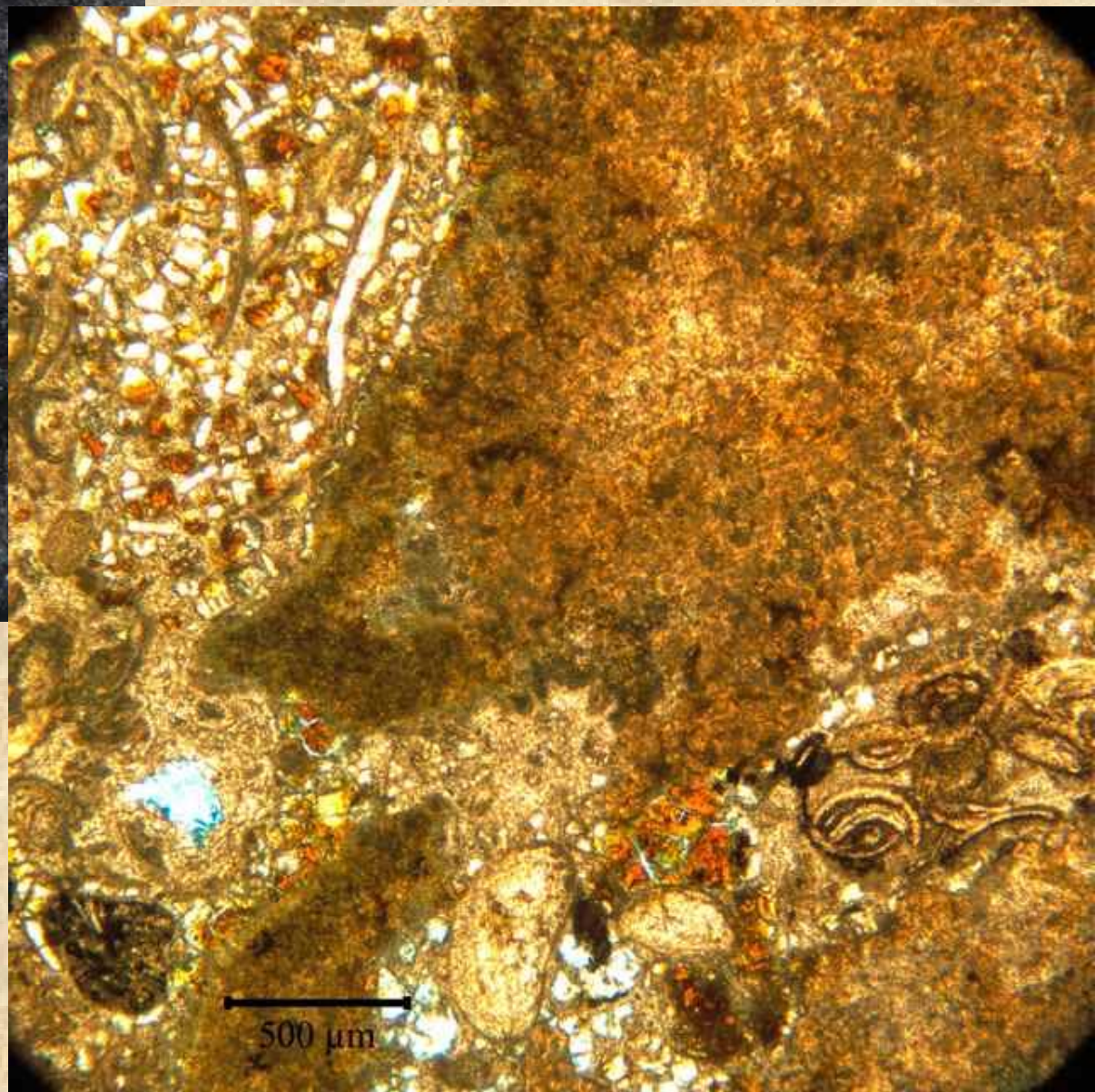


Controls on microbialites

Controls on microbialites




250 µm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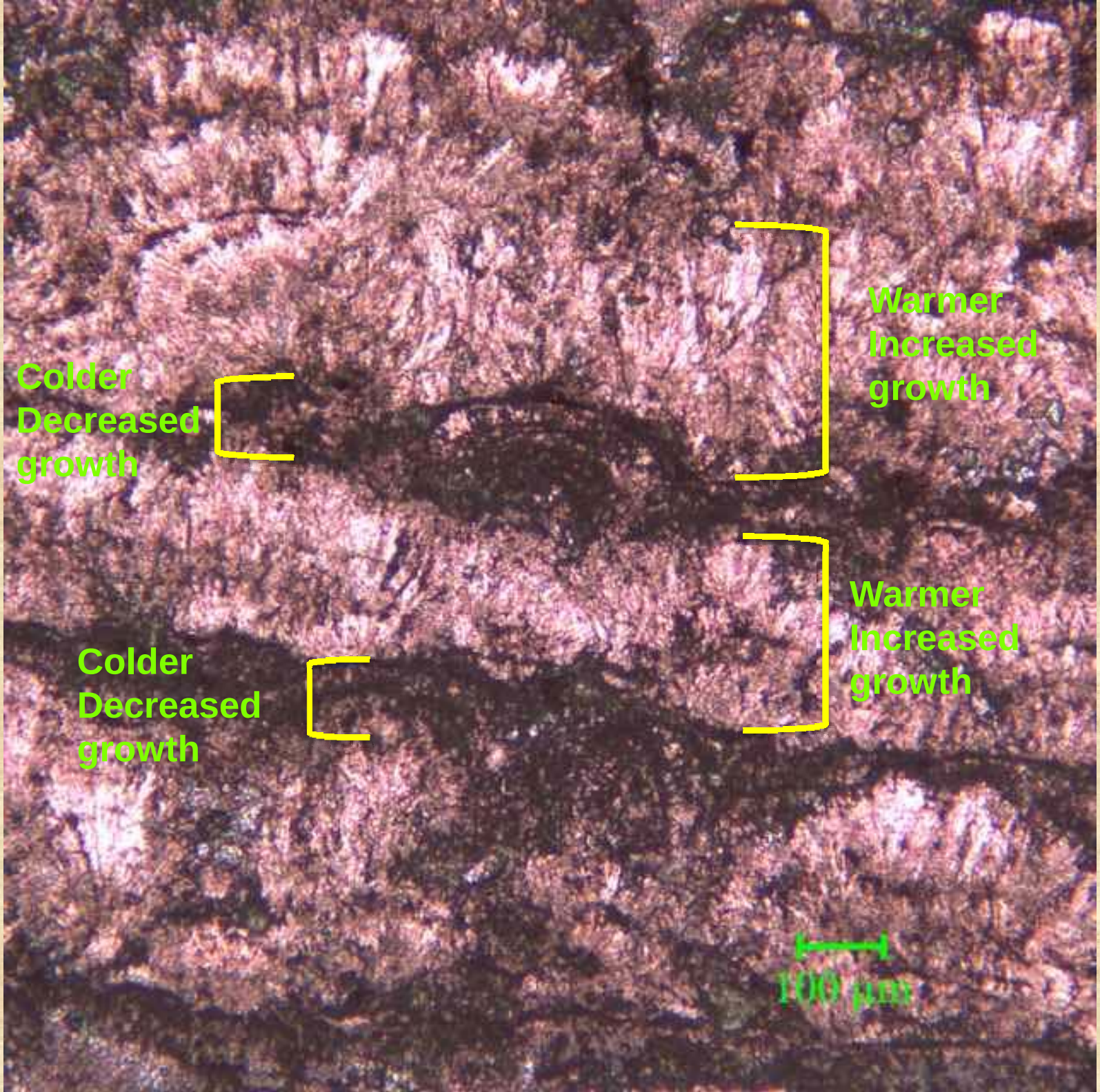
Colder
Decreased
growth
Warmer
Increased
growth
Colder
Decreased
growth
Warmer
Increased
growth
100 µm

Chemistry

Controls

Macroscale

Substrate

Water Depth

Wave Energy

1. Oncoid form
2. Size
3. Connectedness

Mesoscale

Water Depth

Wave Energy

Sediment Input

1. Cortex thickness variations
2. Columnar vs. laminar growth
3. Surface features

Microscale

Water Depth

Wave Energy

Sediment Input

Microbial community

Water Temperature

1. Thrombolitic vs. tussocky growth
2. Microbial community
3. Light and dark banding

Key findings

- Substrate: Prograding and Aggrading parasequences control locations of prominent microbial growth
  - Progradation of coarse material provides nuclei
- A variety of factors can influence meso- and microstructures of microbialites
- Determining the key controls maybe lake dependant
  - But these controls can be determined


Thanks