Using microbialites to recreate microbial ecosystems of the late Archean

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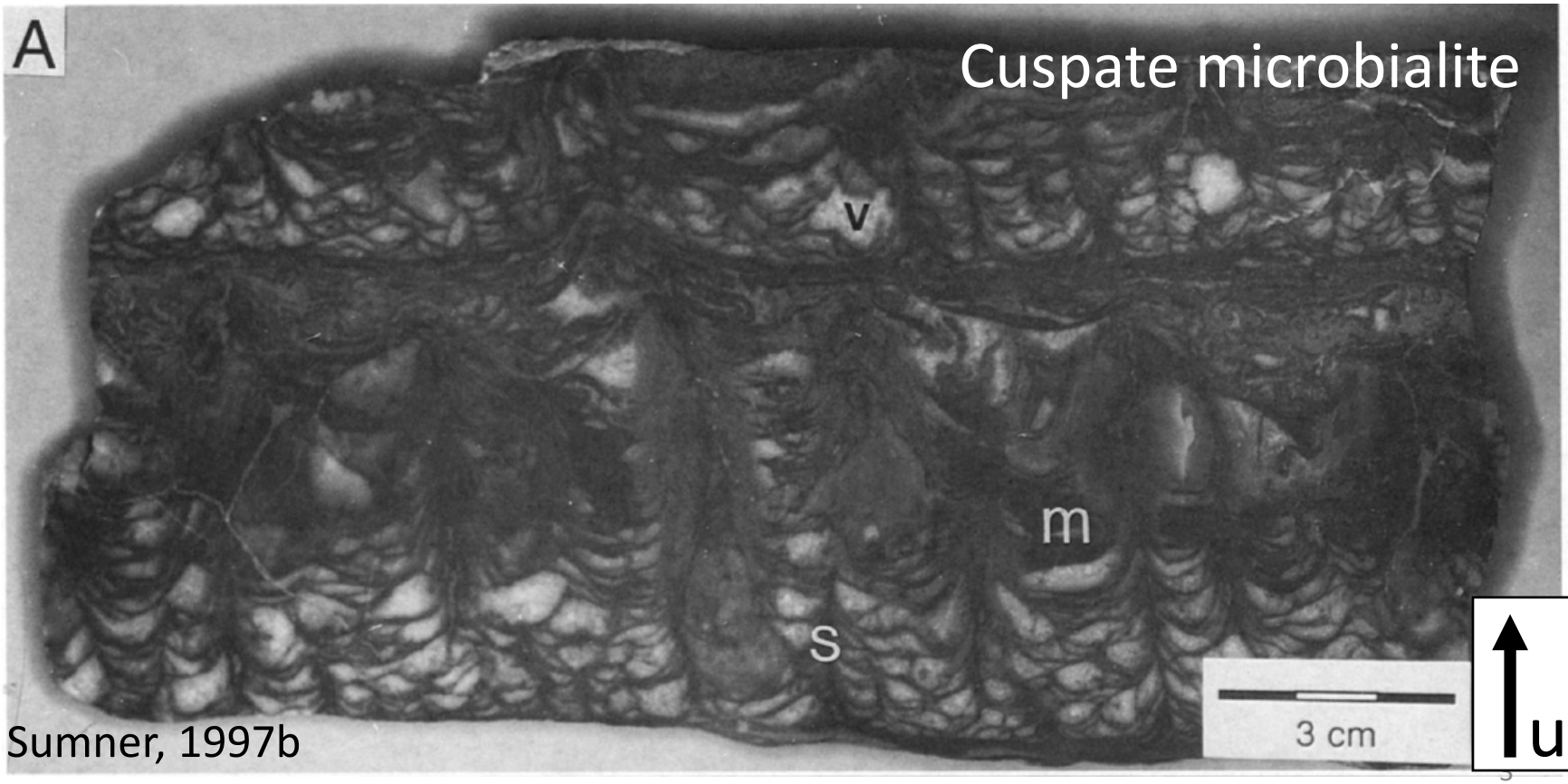
Roadmap

- Introduction- cuspate microbialites and growth models
- Background- interpretation of depositional environment
- Fieldwork results- comparison of cuspate microbialites at two stratigraphic sections
- Interpretation- how Archean cuspate microbialites fit within the proposed growth models
- Conclusions

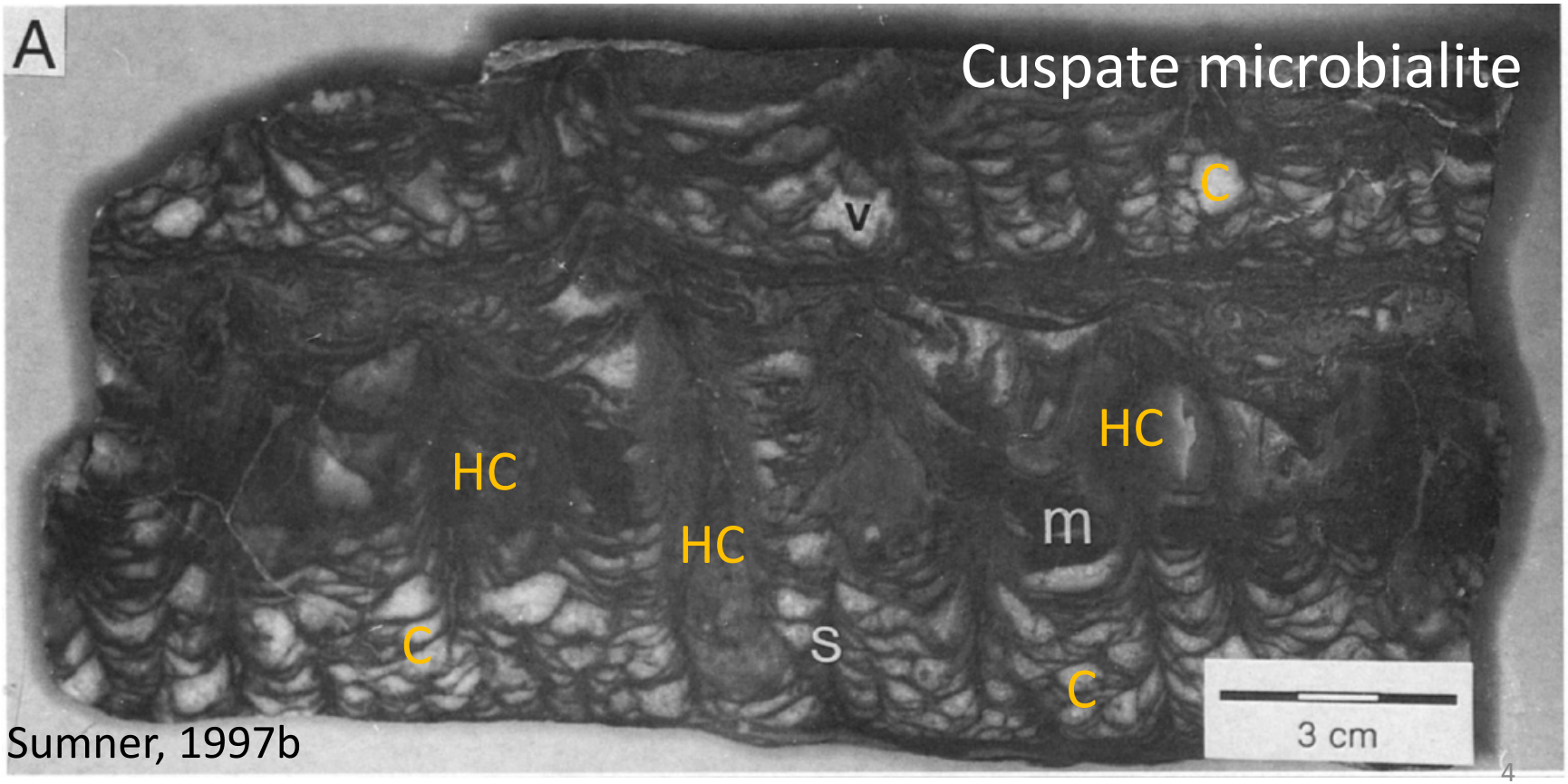
Microbialites are organosedimentary deposits that have accreted as a result of a benthic microbial community trapping and binding detrital sediment and/or forming the locus of mineral precipitation (Burne & Moore, 1987).



Sumner, 1997b

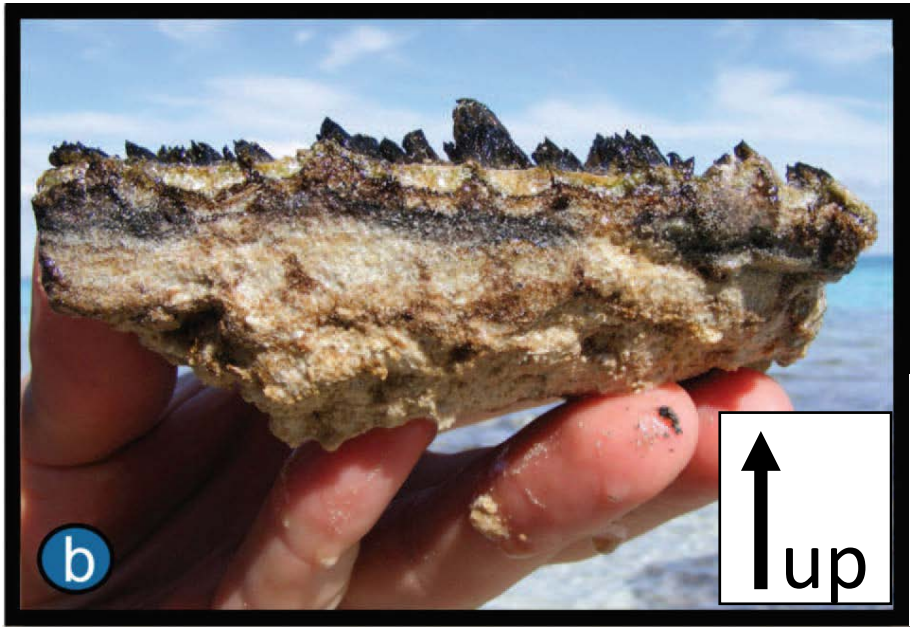
2.521±3 Ga microbialites of the Gamohaan Formation, SA

Cuspate microbialites formed by the interactions of two distinct microbial communities that influenced the precipitation of cements differently (Sumner,1997b)



Cuspate growth models

- The relief in tufted/cuspate microbialites from hot springs formed as phototactic microbial communities migrated towards the light (Walter, 1976)
- Modern cuspate biofilms are always associated with cyanobacteria. They might be used to track the geologic record of cyanobacteria (Flannery et al.,2011)



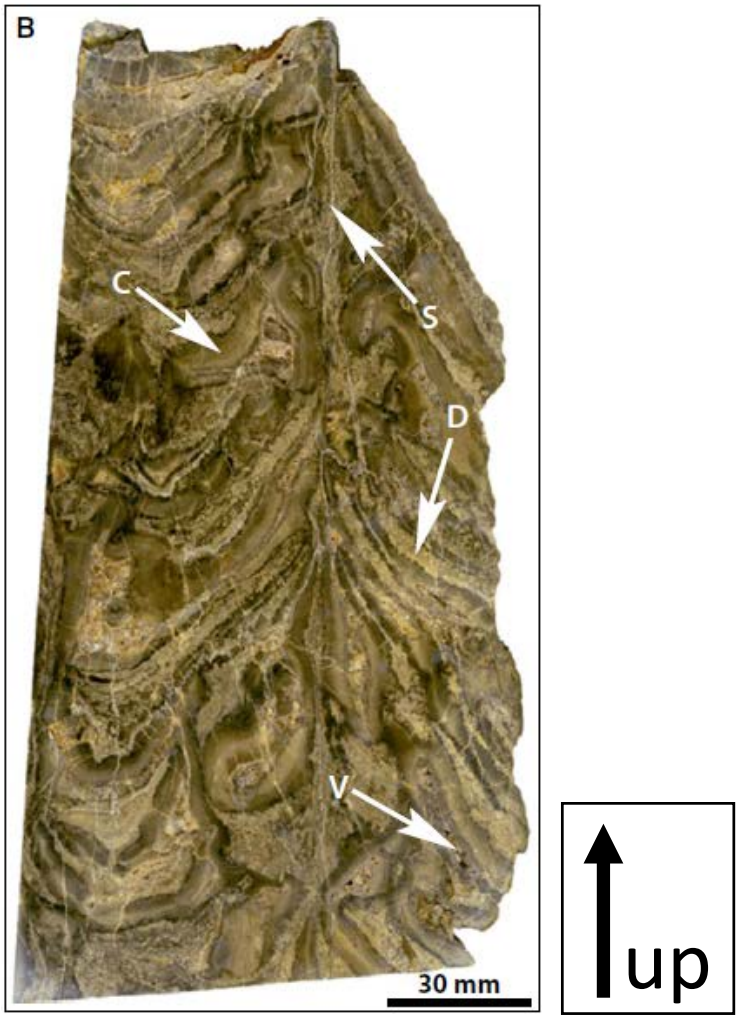
Modern tufted/cuspate microbialites from Shark Bay, Australia

Cuspate growth models continued

Cuspate structure influenced by growth across a chemical boundary

Upward growth of supports by a motile filamentous bacteria like cyanobacteria or sulfur oxidizing bacteria

lateral growth of laminae by anaerobic bacteria under reducing conditions (Bartley et al., 2014)



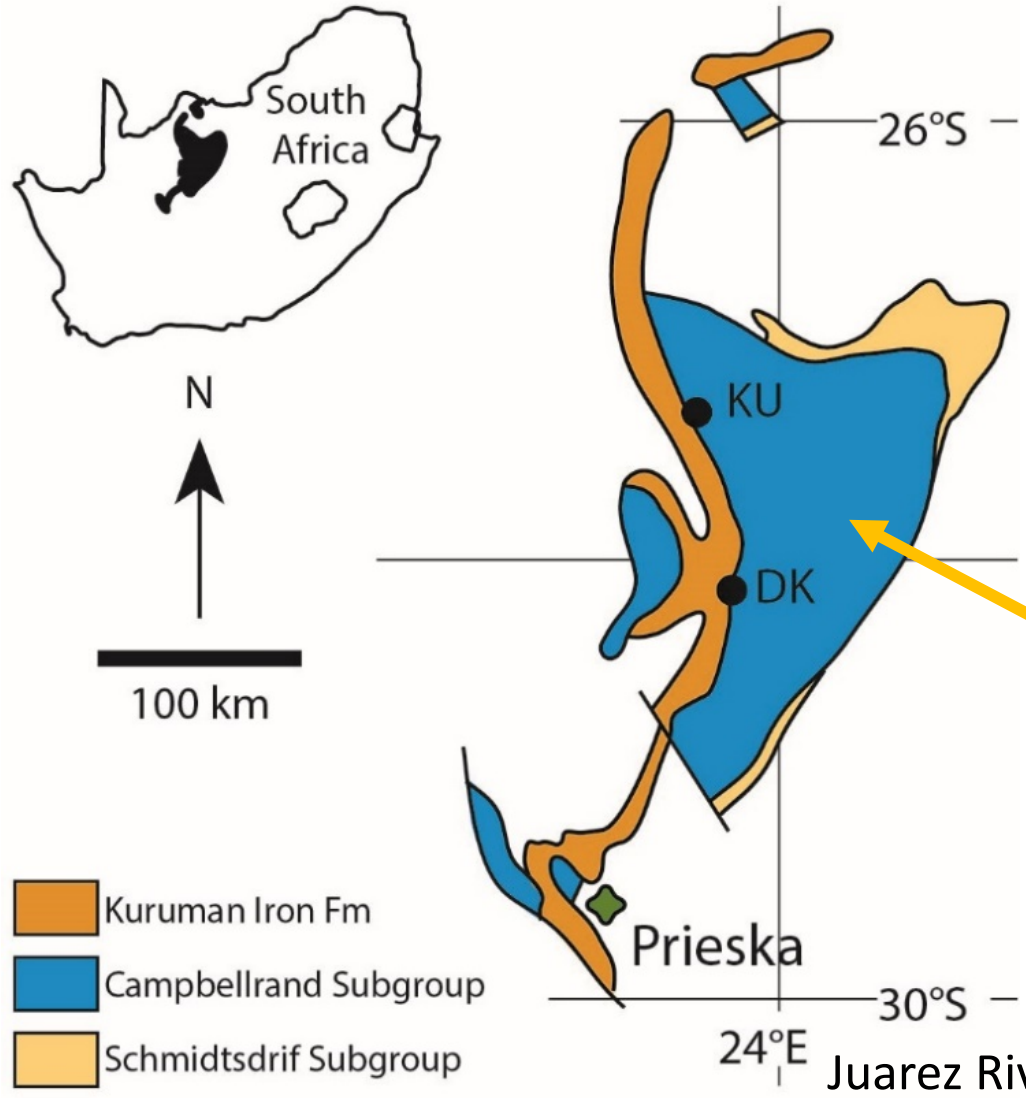
Mesoproterozoic (~1.8 Ga) cuspate microbialite from the Dismal Lakes Group.

Question:
What growth model do Archean cuspate microbialites fall under?

Field-based approach

Tracked morphological changes in microbialites to see if cuspate morphology was conserved with spatial and temporal changes.

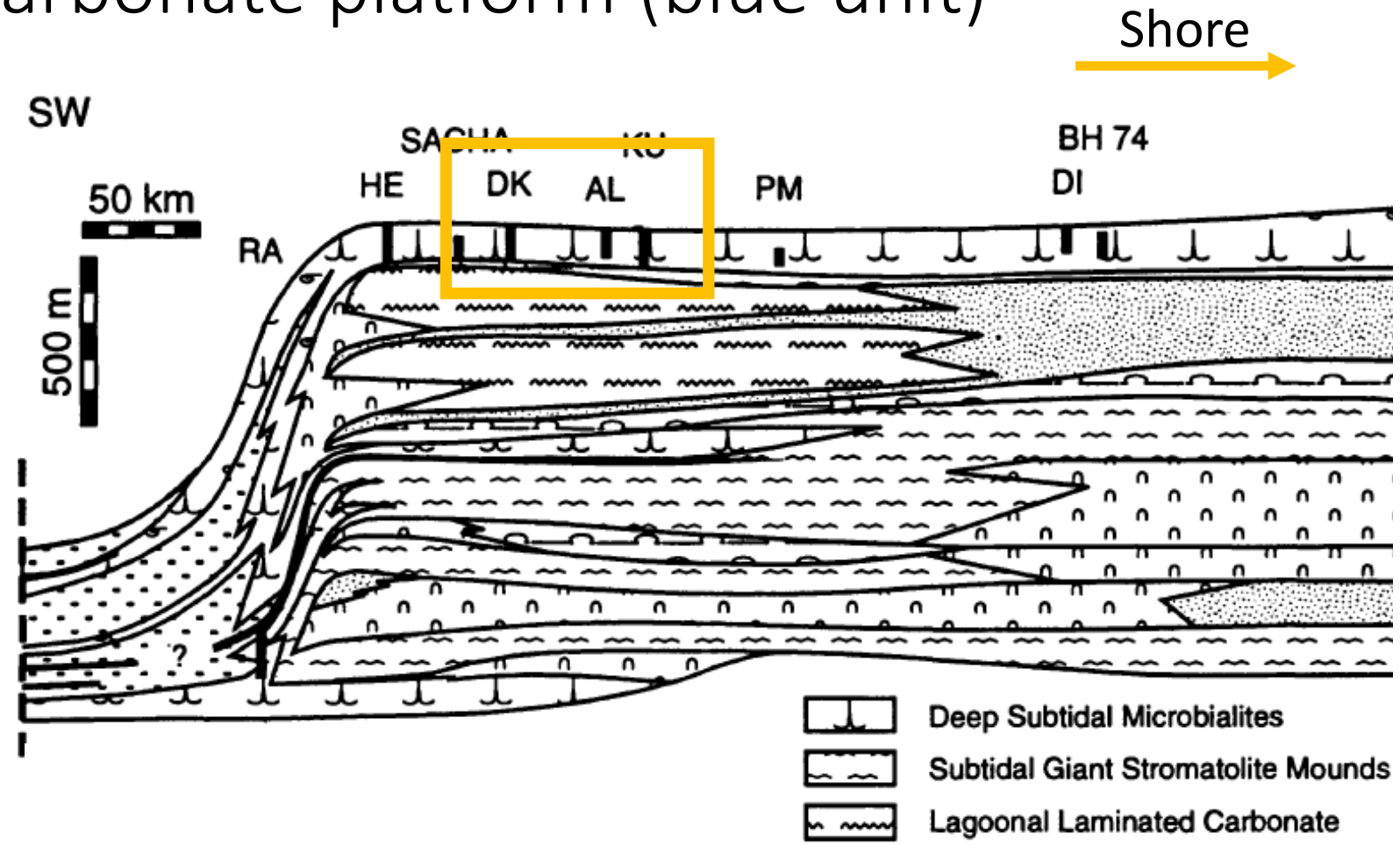
Geologic background



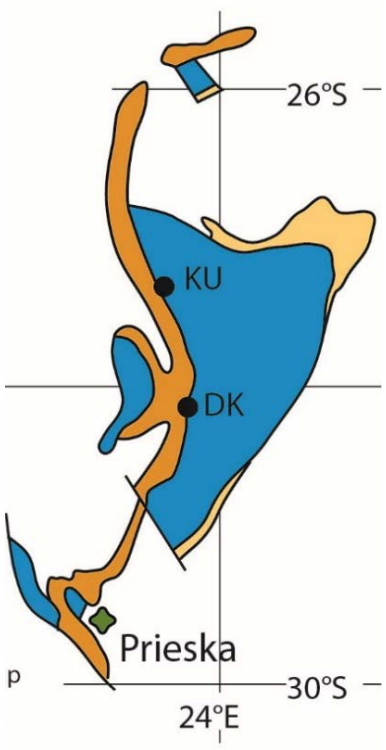
Carbonate platform

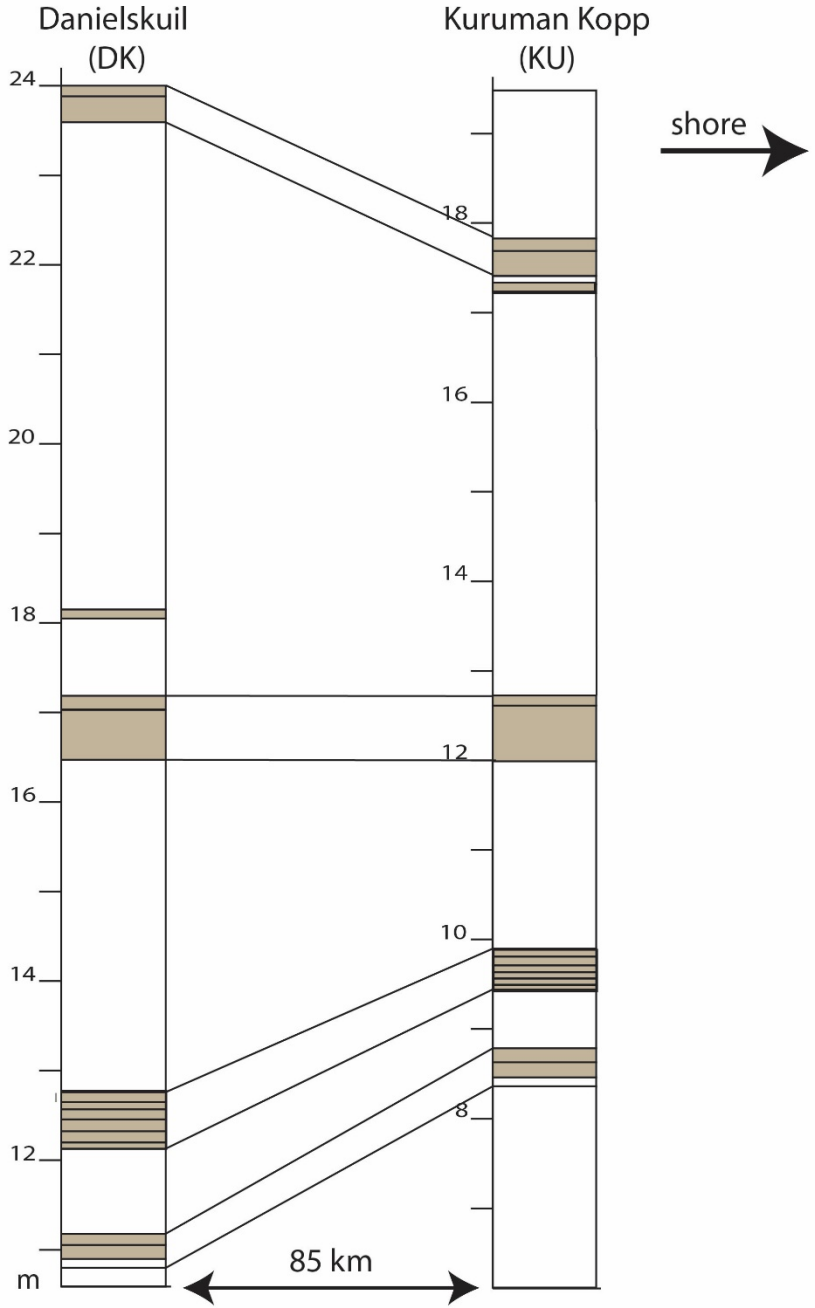
Juarez Rivera & Sumer, 2014

Cross section of the Campbellrand carbonate platform (blue unit)



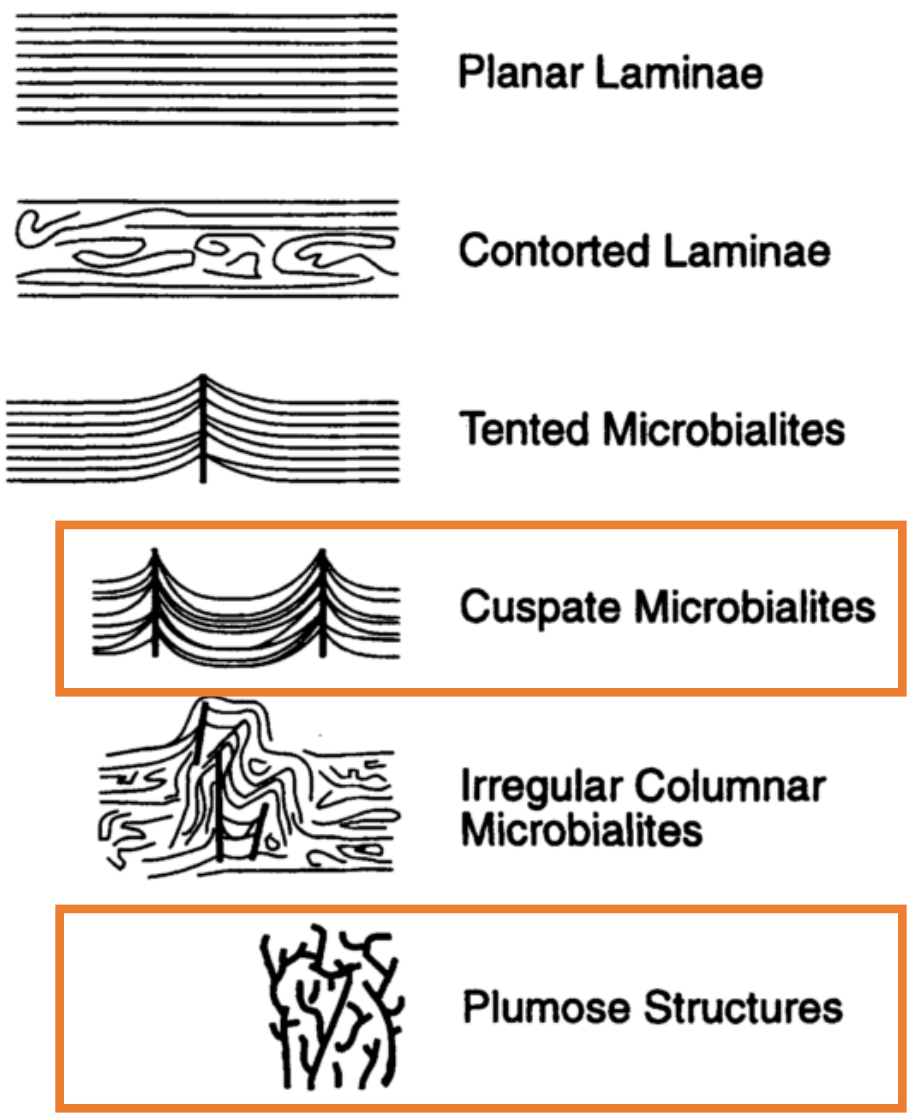
Sumner, 1997b





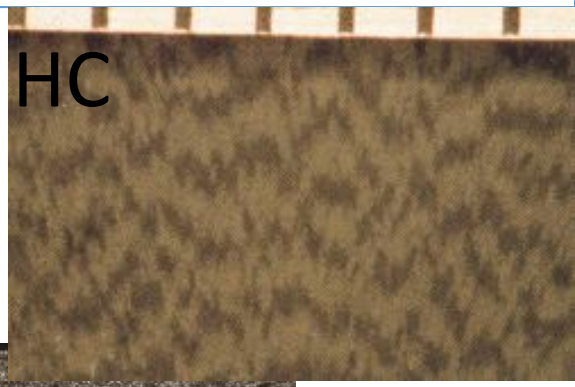
Stratigraphy in the Gamohaan Formation is laterally continuous

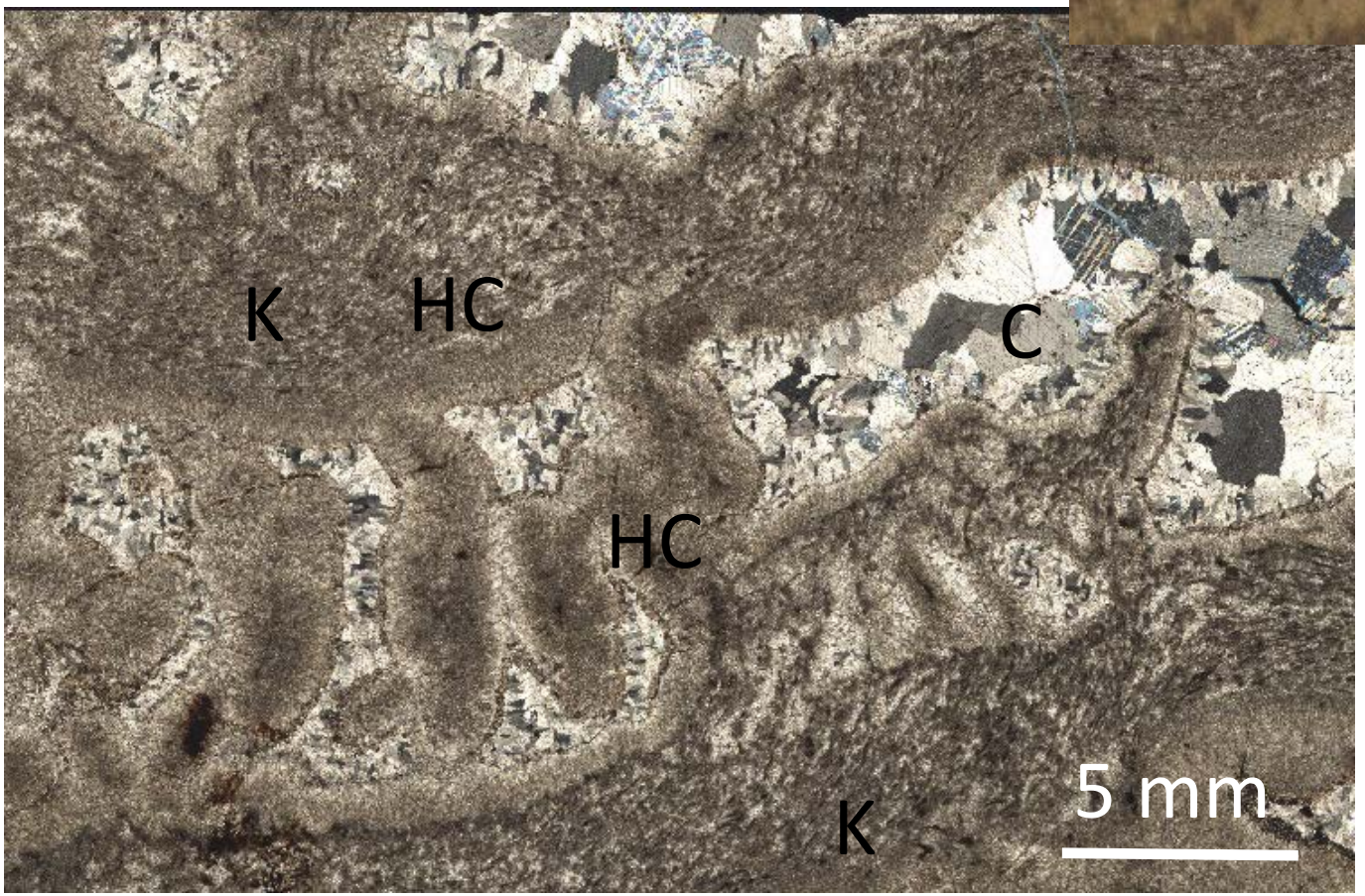
At least six morphologies



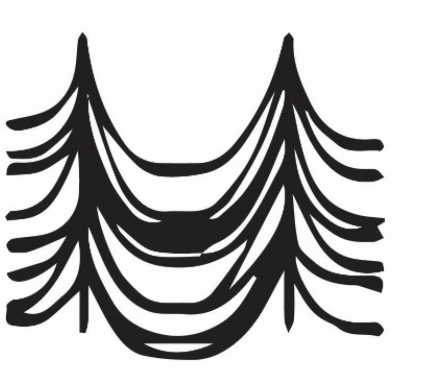
Sumner (1997a)

Kerogen (K) is encased in herringbone calcite (HC), void space is filled by bladed and blocky calcite (C)

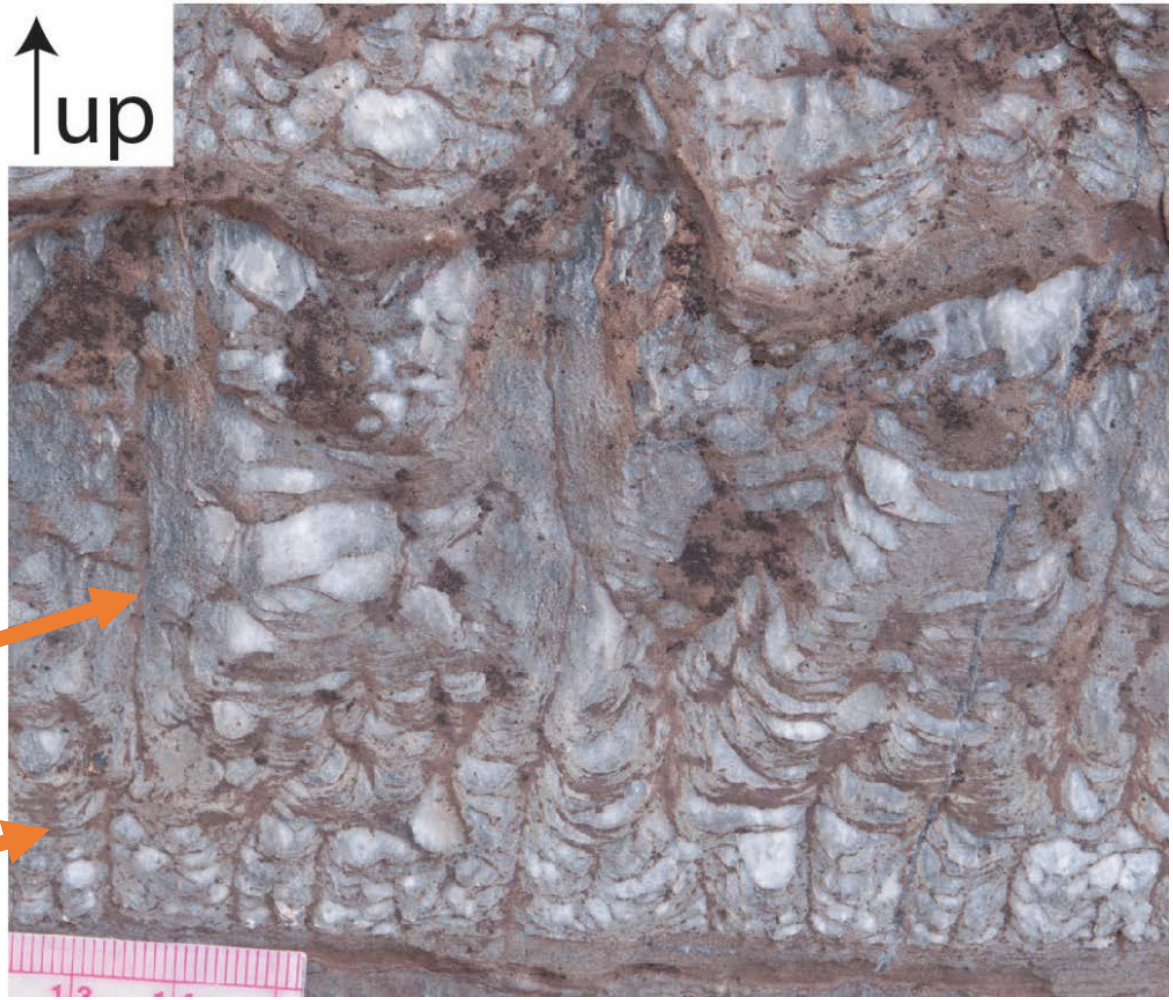




Thin section in cross-polarized light



Cuspate microbialites



Supports are 50-200 µm wide and oriented vertically (Sumner 1997b).

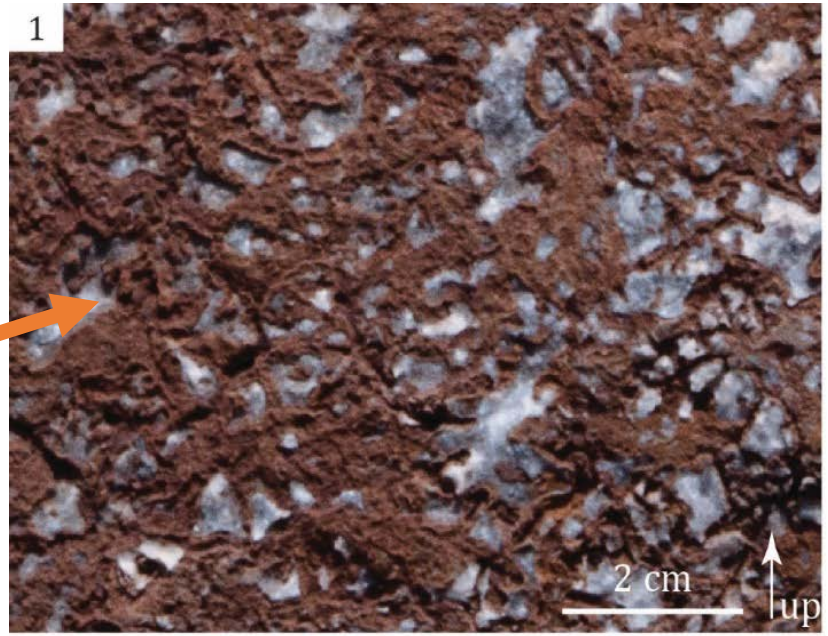
Laminae are 3-20 µm thick. Found as packages in outcrop.

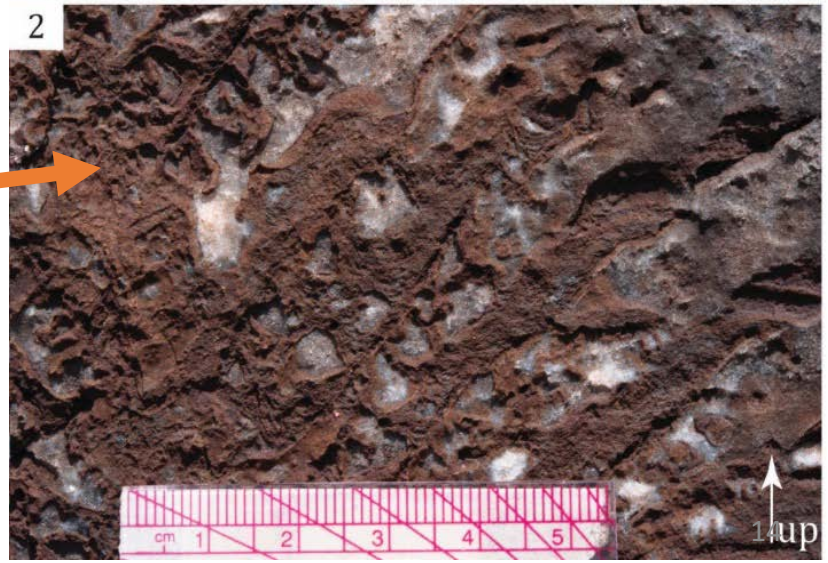
Plumose microbialites

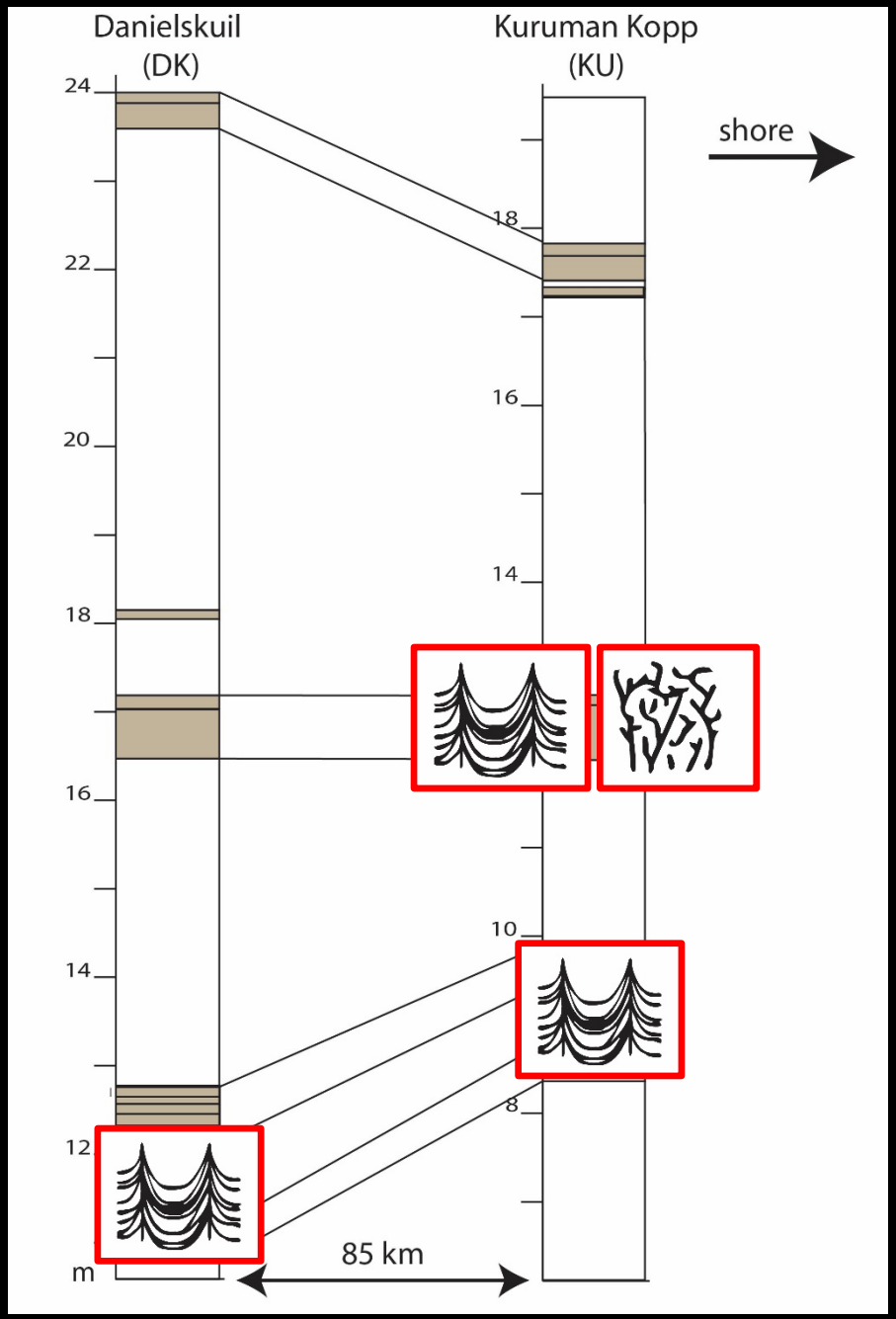
Branching septa

- thin like supports but often branch
- 2 to 30 mm long

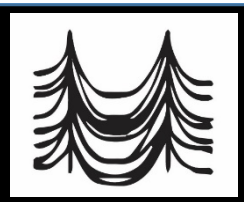
Undulose structures





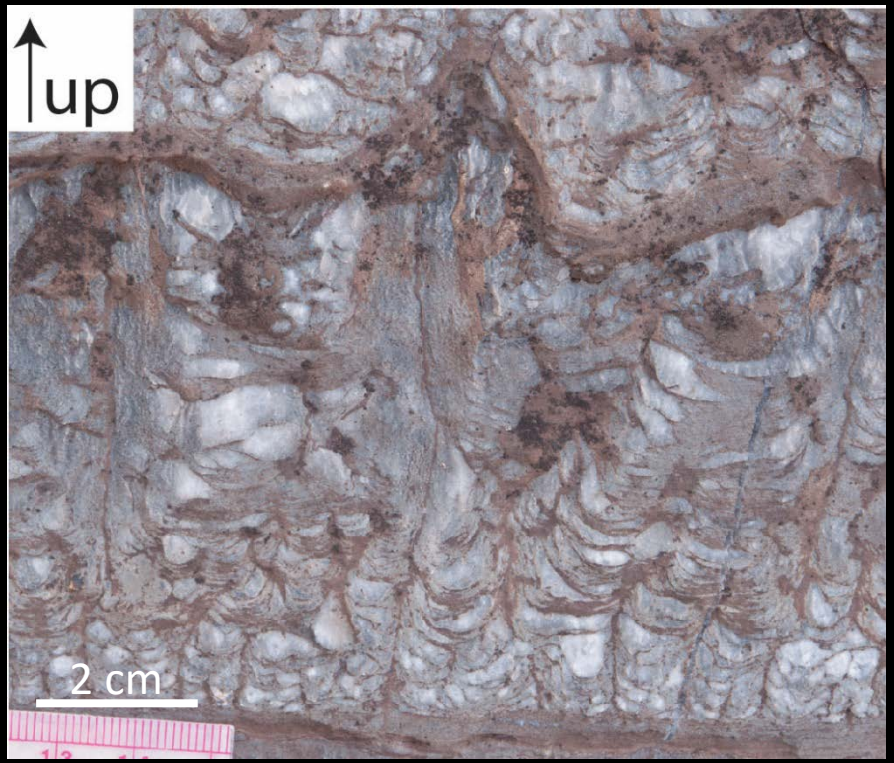

Danielskuil
(DK)
Kuruman Kopp
(KU)
shore
24
22
20
18
16
14
12
m
18
16
14
10
8
85 km

Cuspate at KU (closest to shore)

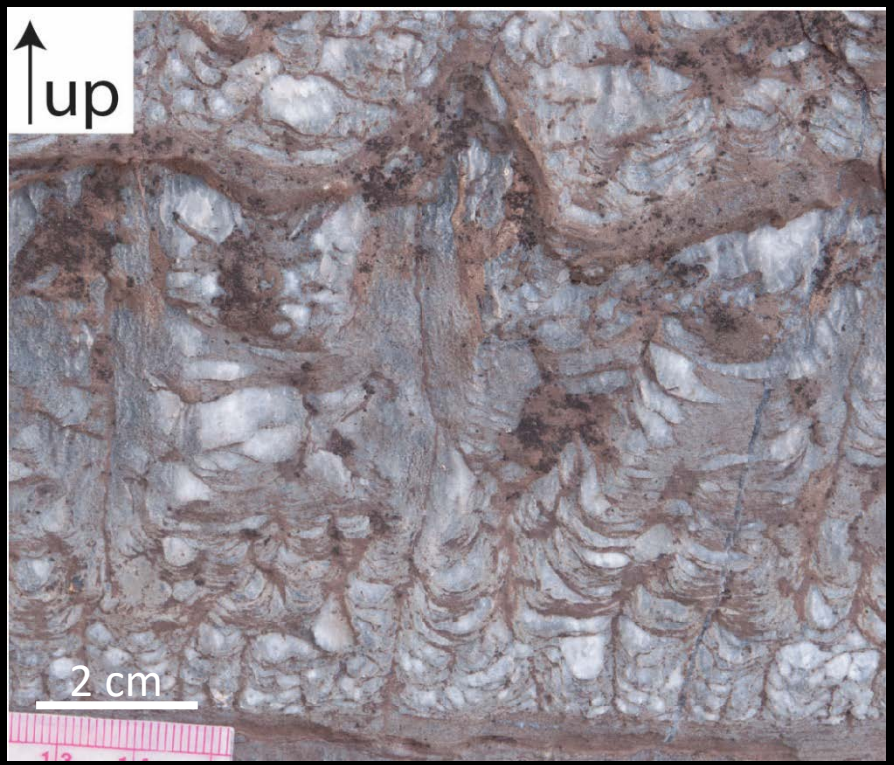


Continuous growth but varied

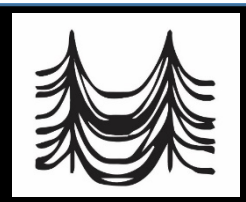
- Support spacing increases from 3 mm to 70 mm
- Laminae group thickness starts <5 mm and increases to 25 mm



- Supports are always vertically
- Laminae always “hanging” from supports and facing up
- Similar to cuspate microbialites in other outcrops and active biofilms

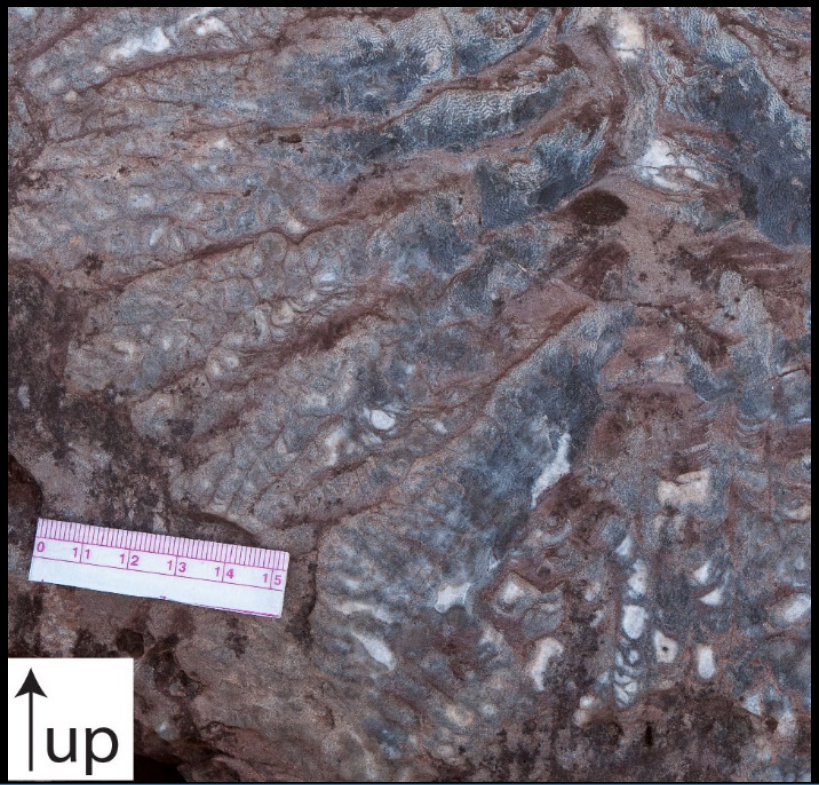


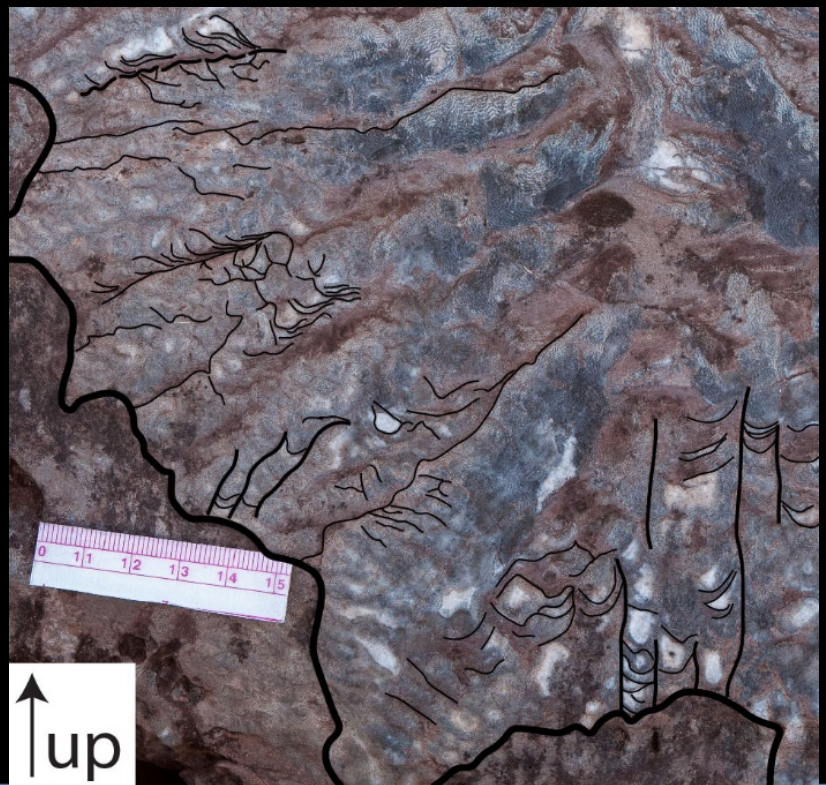
Cuspate at DK (furthest from shore)



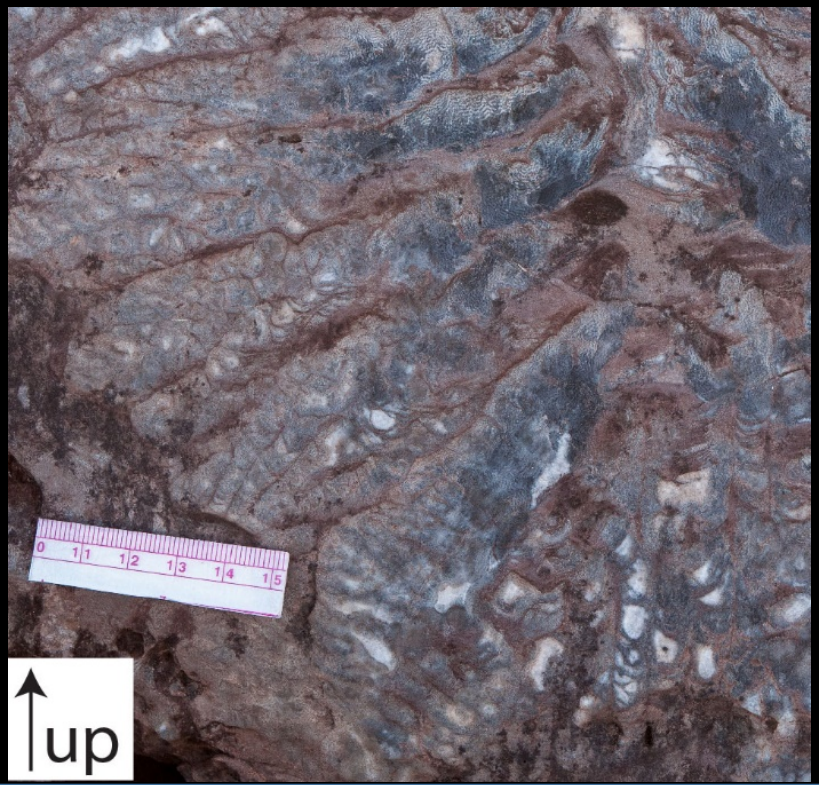
Support and laminae abundance also varies upward

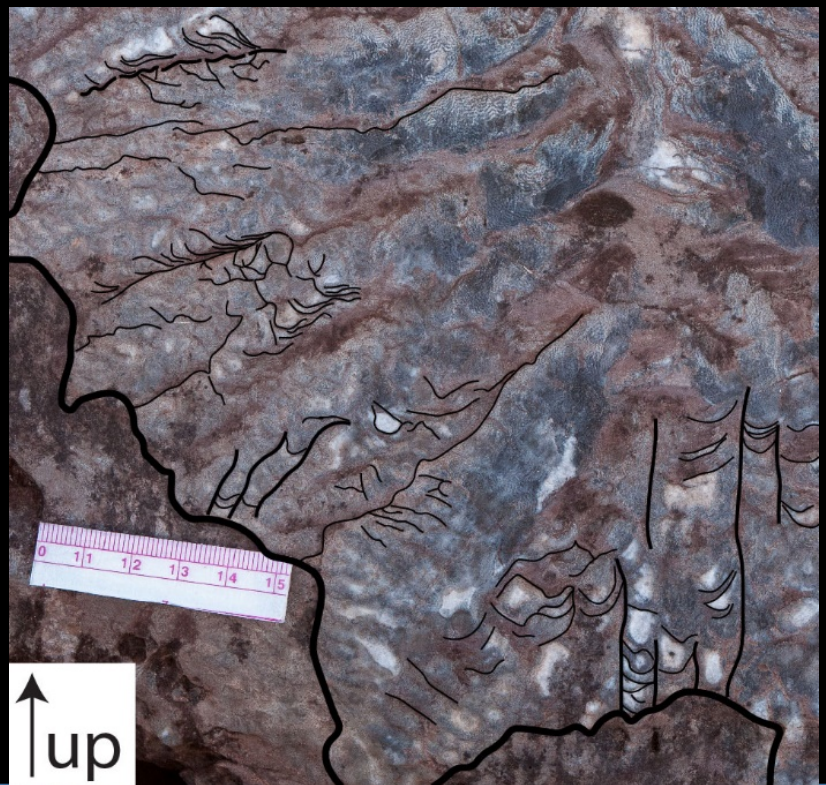
- Support spacing increases from 3 mm to 50 mm
- Lamina groups are <5 mm to 10 mm, not as thick as in KU.



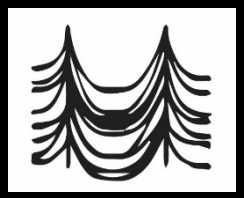


- Supports did not always grow vertically, in places almost horizontally
- Laminae always facing up, not present under inclined supports or under overhangs
- Different than previously described cuspate microbialites

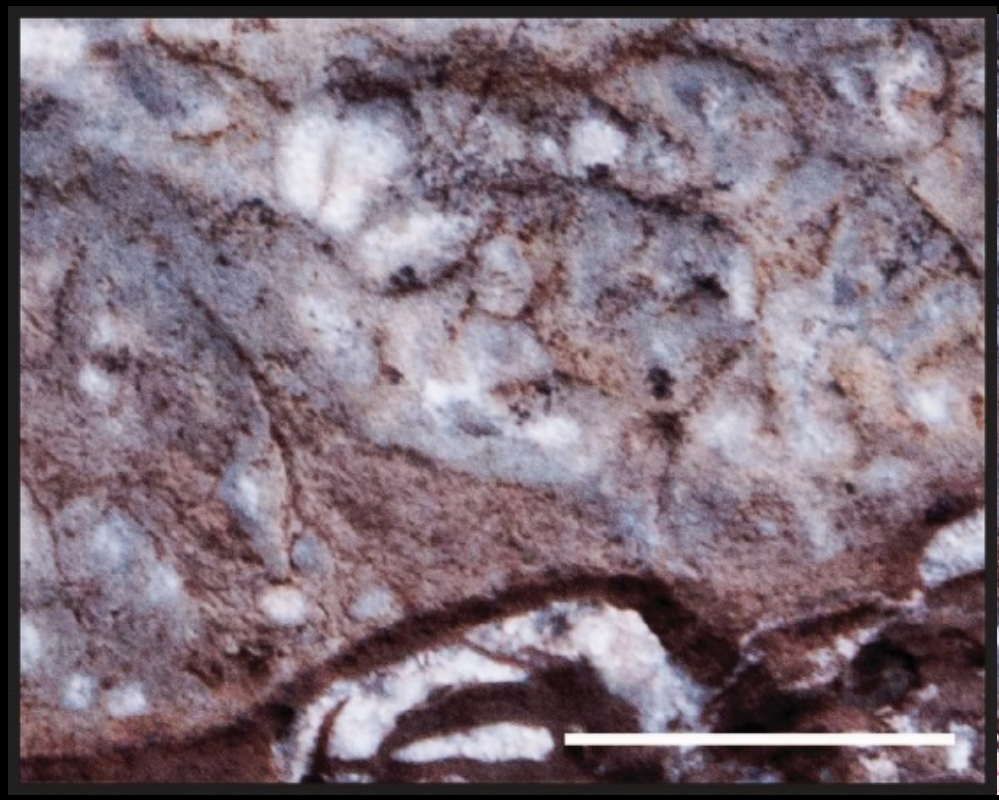


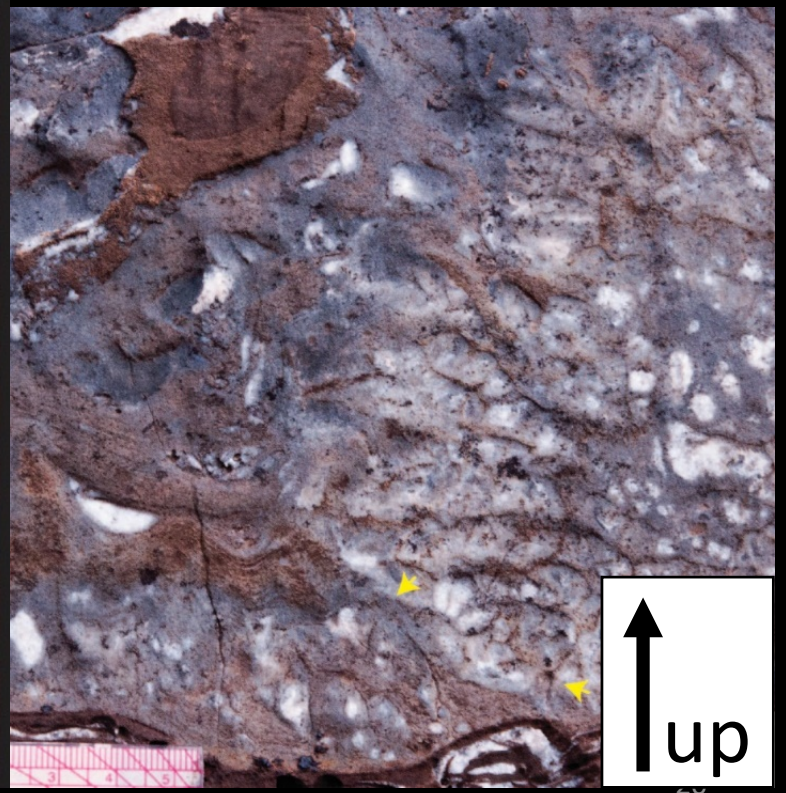


Lateral plumose-cuspate transitions

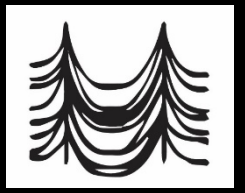


- Cuspate and plumose microbialites grew side by side
- Continuity between supports and branching septa

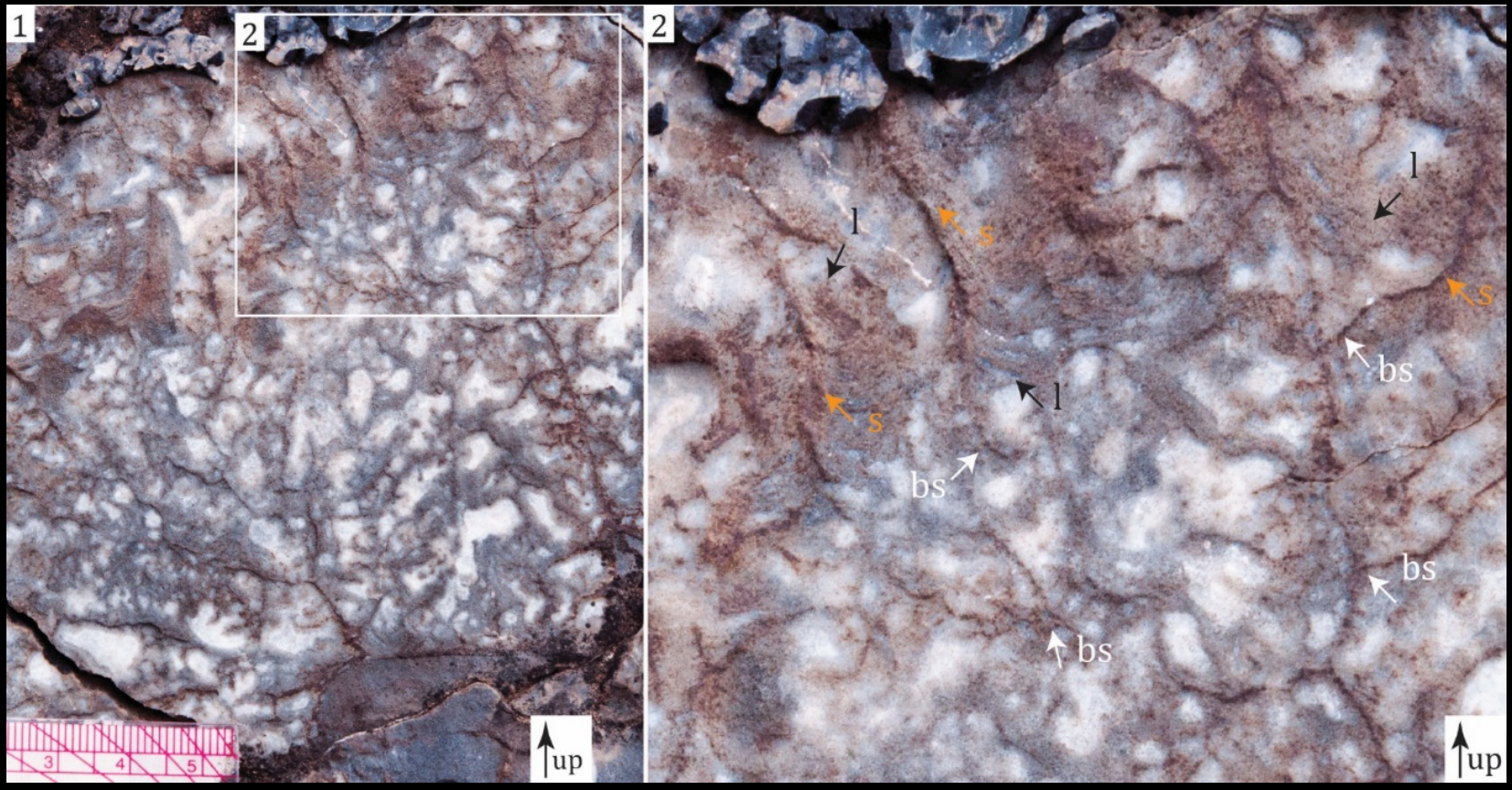




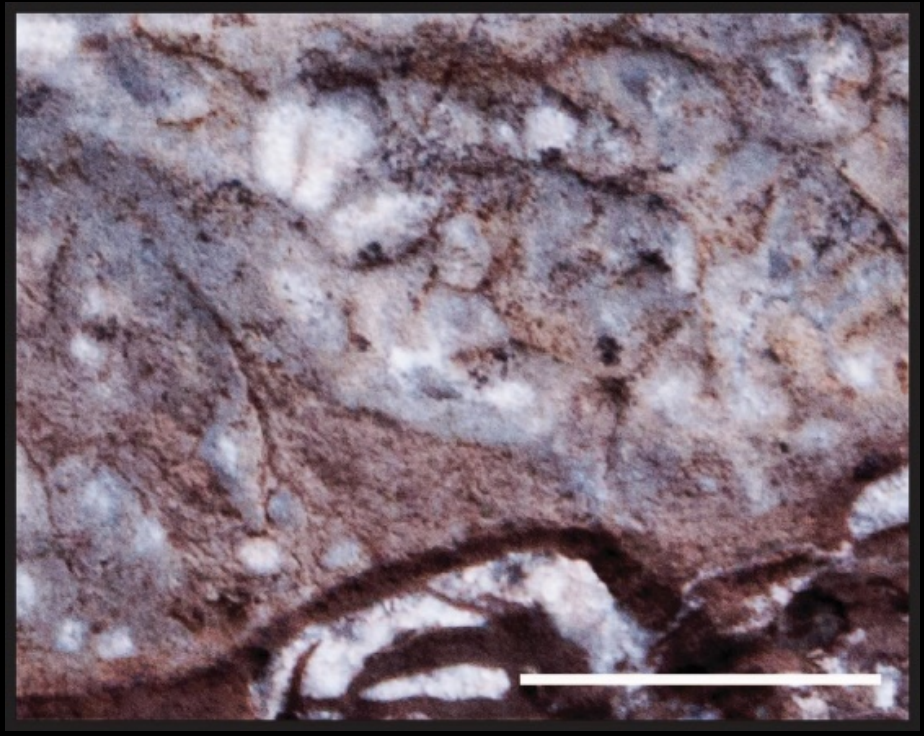
Vertical plumose-cuspate transitions

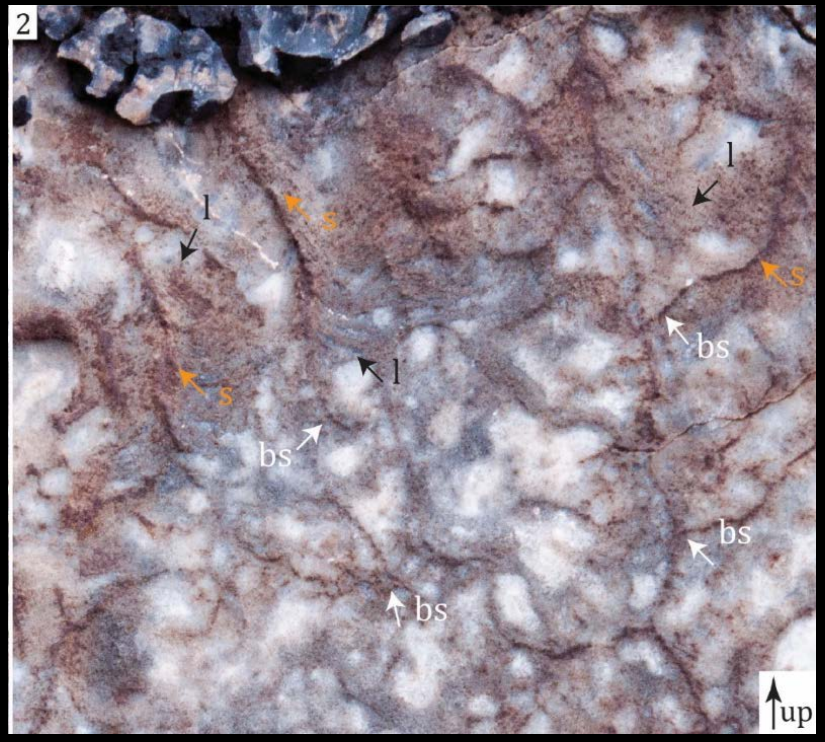


- Some branching septa can be traced into supports that get draped by the laminae.



- **B**ranching septa grew outward, away from surfaces like supports
- Similar growth pattern and continuity between supports and branching septa suggests that they were formed by similar microbial communities



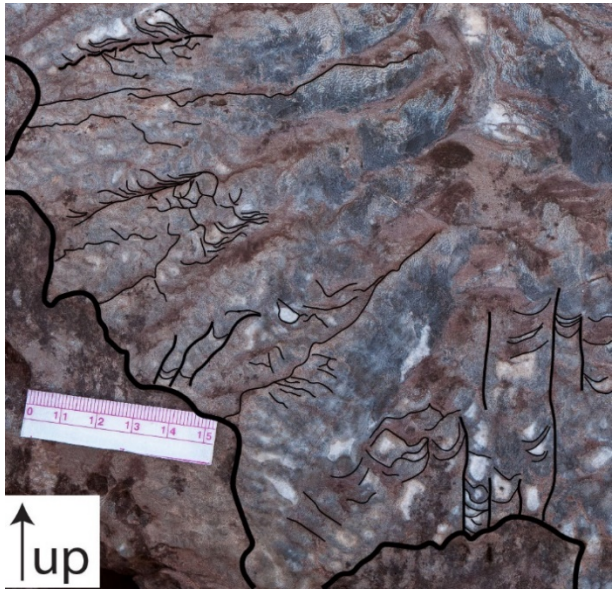


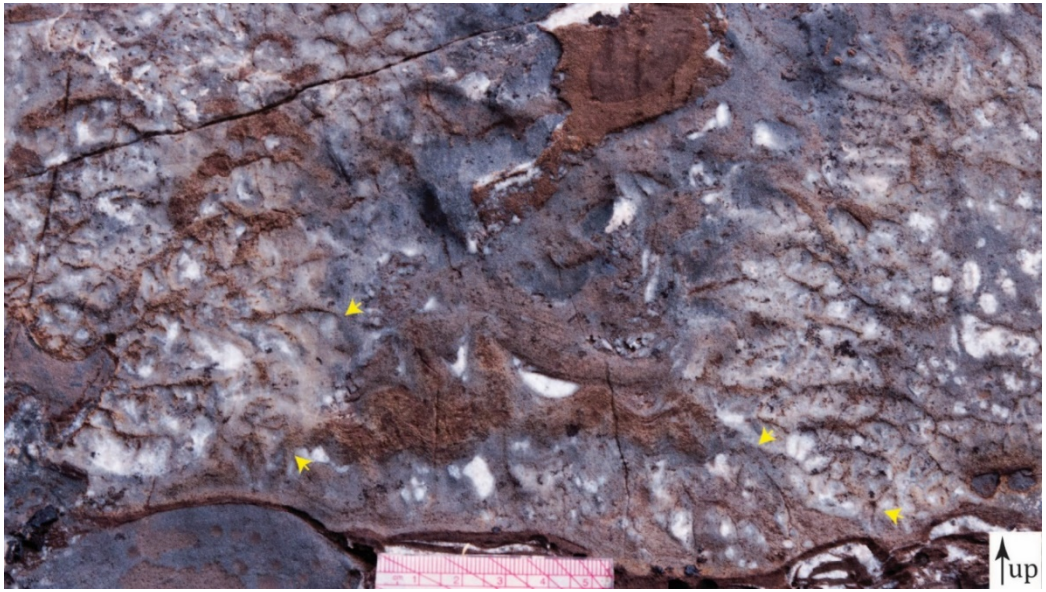
Growth form summary

1) Laminae grew horizontally irrespective of the orientation of the underlying surface
2) Supports and branching septa created structures that grew outward into the water column
3) There was continuity between support and branching septa

Do cuspate microbialites fit within a chemically driven growth model?

Would need to maintain complex chemical gradients to influence the growth of regular cuspate structure and that of inclined supports with laminae on top





Do cuspate microbialites fit with in a phototactic growth model?

- Expected to see a phototactic response but that is not the case furthest from shore.
- Supports grew outward, including down off overhangs.
- Do not know how much light was available

Proposed growth model: Growth of supports and branching septa was strongly influenced by nutrient diffusion limitation

This outward and branching growth style leads to high diffusive exchange with the water column, which could increase delivery of necessary nutrients to the microbial community.

Conclusions

- Cuspate microbialites in the Gamohaan Formation grew prior to oxidation of the Earth's atmosphere.
- Their interpretation as possible photosynthetic mats is important for understanding the early history of cyanobacteria.
- The morphology of cuspate microbialites furthest from shore inconsistent with previous growth models.
- We propose a new cuspate growth model where supports and branching septa growth was driven by nutrient diffusion limitation.

Thank you!

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