Petrographic outlook on the silicification mechanism of the petrified wood from Sarawak

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INTRODUCTION

- Petrified wood is a remains of wood after it has been fossilized throughout Geologic Time.
  - Paleontologist – the most valued scientific specimen to relate with their geological history.
  - Public – various perceptions with regards to myths, believes and secrets.

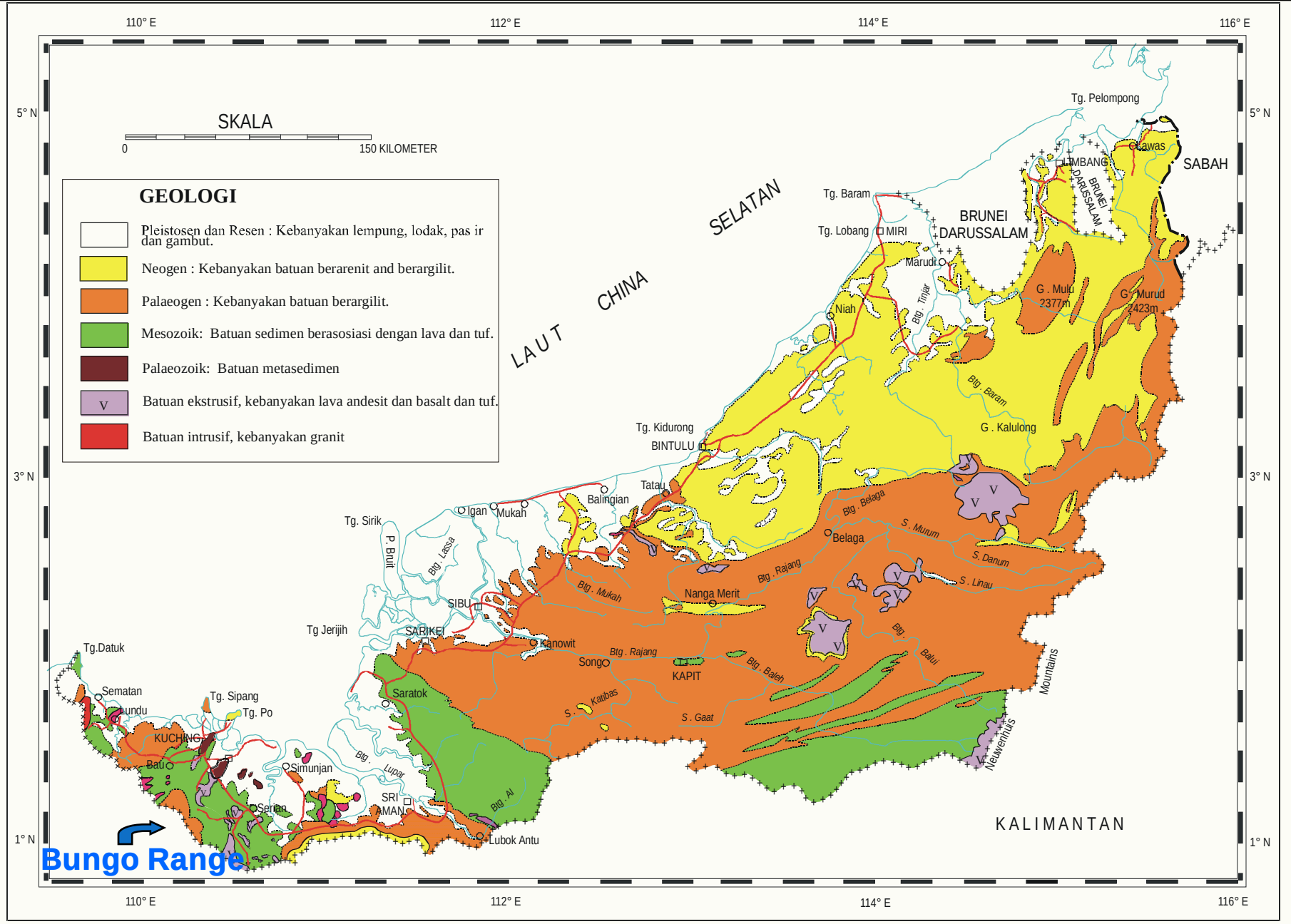
Petrified palm wood (*Oncosperma filamentosa*) showing rod-like structure.

WHERE IS PETRIFIED WOOD FOUND?

- Boulders of various sizes in Sg. Semadang, main tributary of Sg. Sarawak Kiri – located in the Bungo Range ± 40 km SW of Kuching.
- Incorporated within the Miocene Kayan Sandstone not very far from Kg. Sadir, Penrissen, Borneo Highlands.
- A popular collection (intrinsic value) for local people (Bidayuh) for some purposes, but not yet commercialized.

..continued

- Three stages of silicification
  - complete petrification of palm wood (palm, nipah & sago)
  - partly petrified wood and
  - fully petrified wood.
- Besides Sarawak, petrified wood is also found in Java and Kalimantan, Indonesia, where they are related to young volcanic activities.



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Geological Map of Sarawak

GENERAL GEOLOGY

- Comprehensive scientific studies on the formation and distribution of petrified wood in Sarawak are not properly documented yet. However, the occurrence of fossil wood had been reported by Tan (1993) in the Kayan Sandstone (Santubong) and Plateau Sandstone (Teluk Limau, Bako)
- Observations based on macroscopic and microscopic studies to indentify the replaced material.

RELATIONSHIP & CORRELATION

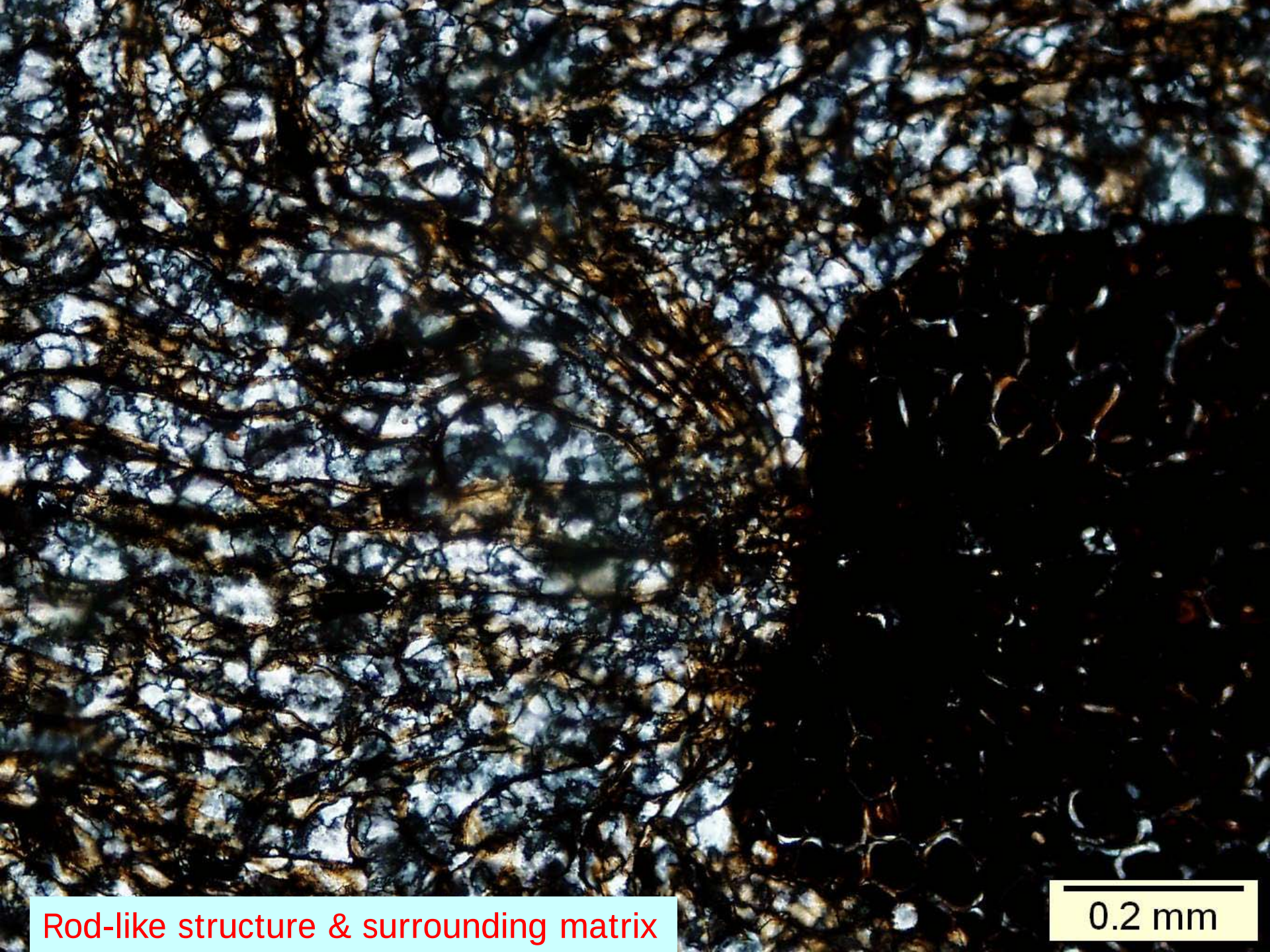
- Petrified woods about 25cm in diameter were observed within the Kayan Sandstone outcrop, cemented together with chalcedony, jasper, quartz and chert pebbles.
- The Kayan Sandstone is a continental deposit (mollasse) in a delta environment during Late Cretaceous to Early Eocene based on pollen (Wilford, 1965; Tan, 1993) – thick sandstone sequence interbedded with thin shale, mudstone and conglomerate.
- Petrified wood seems to be older than the Kayan Sandstone?

TYPES OF PETRIFIED WOOD

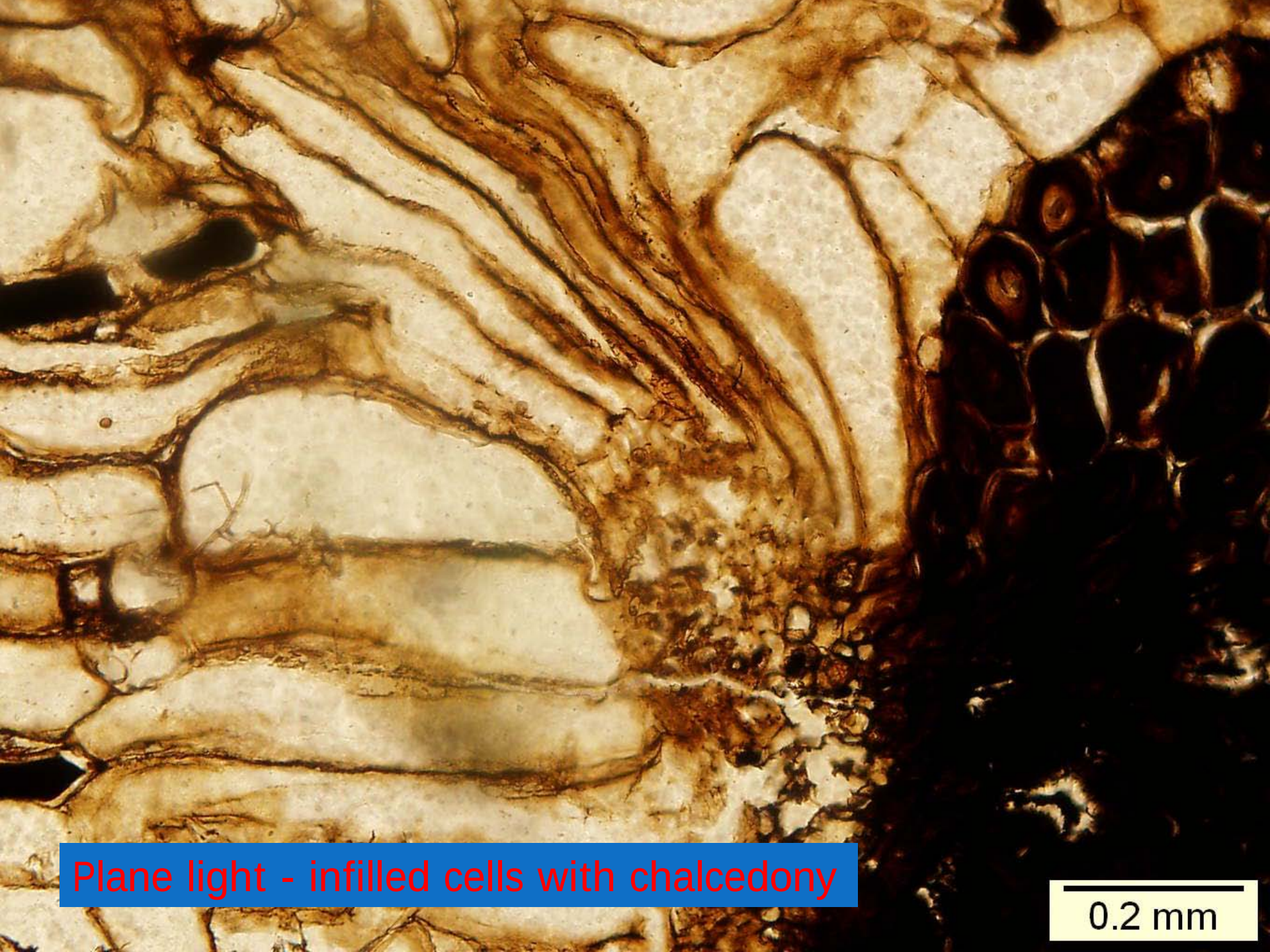
- Petrified palmwood (*Oncosperma filamentosa*) shows rod-like structures floating within the finer silicified groundmass.
  - The rod-like structure, which consists of the bonding of *sclerenchyma* or part of wood tissues, gave rise the vertical strength (Blackwell, 1984).
- Nipah (*Nipah frutican*), sago, other palms and *Rhizophora spp*.(?) are among the petrified wood found from this area.

Petrified Sago (*Nipah frutican*)

Rod-like structure representing the hardest part of palmwood



Rod-like structure & surrounding matrix

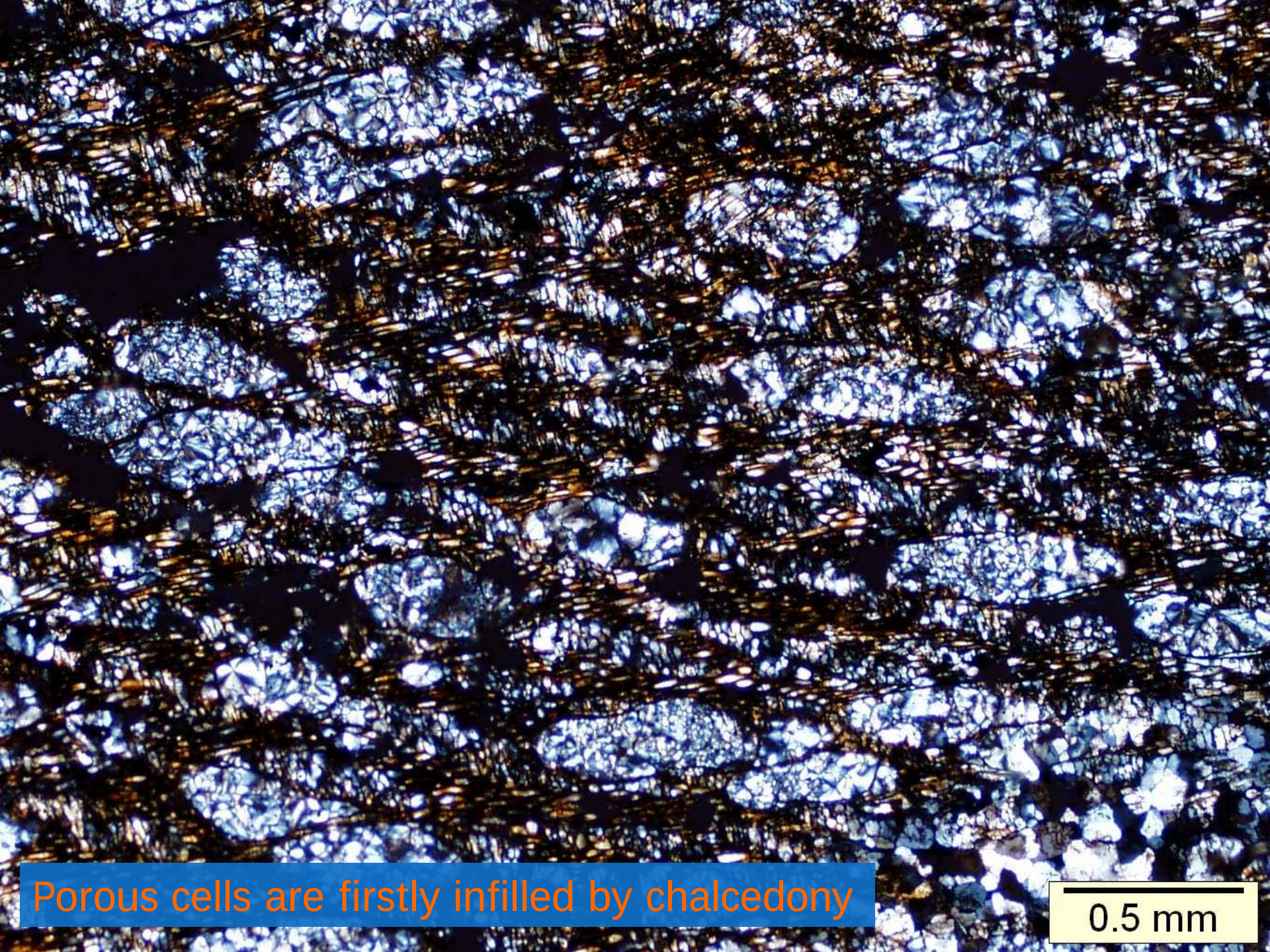

Plane light - infilled cells with chalcedony
0.2 mm

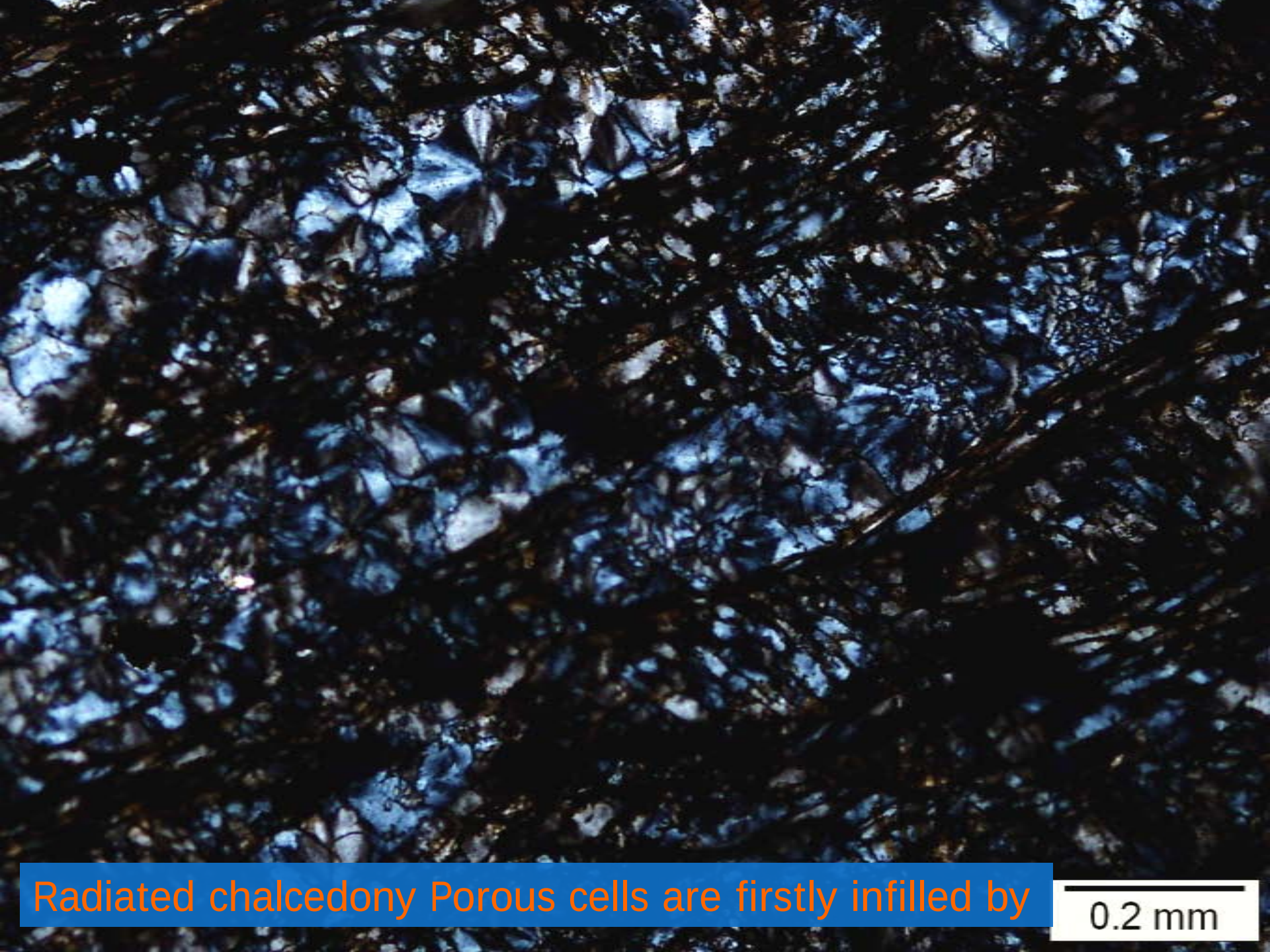
Nature of fossil wood

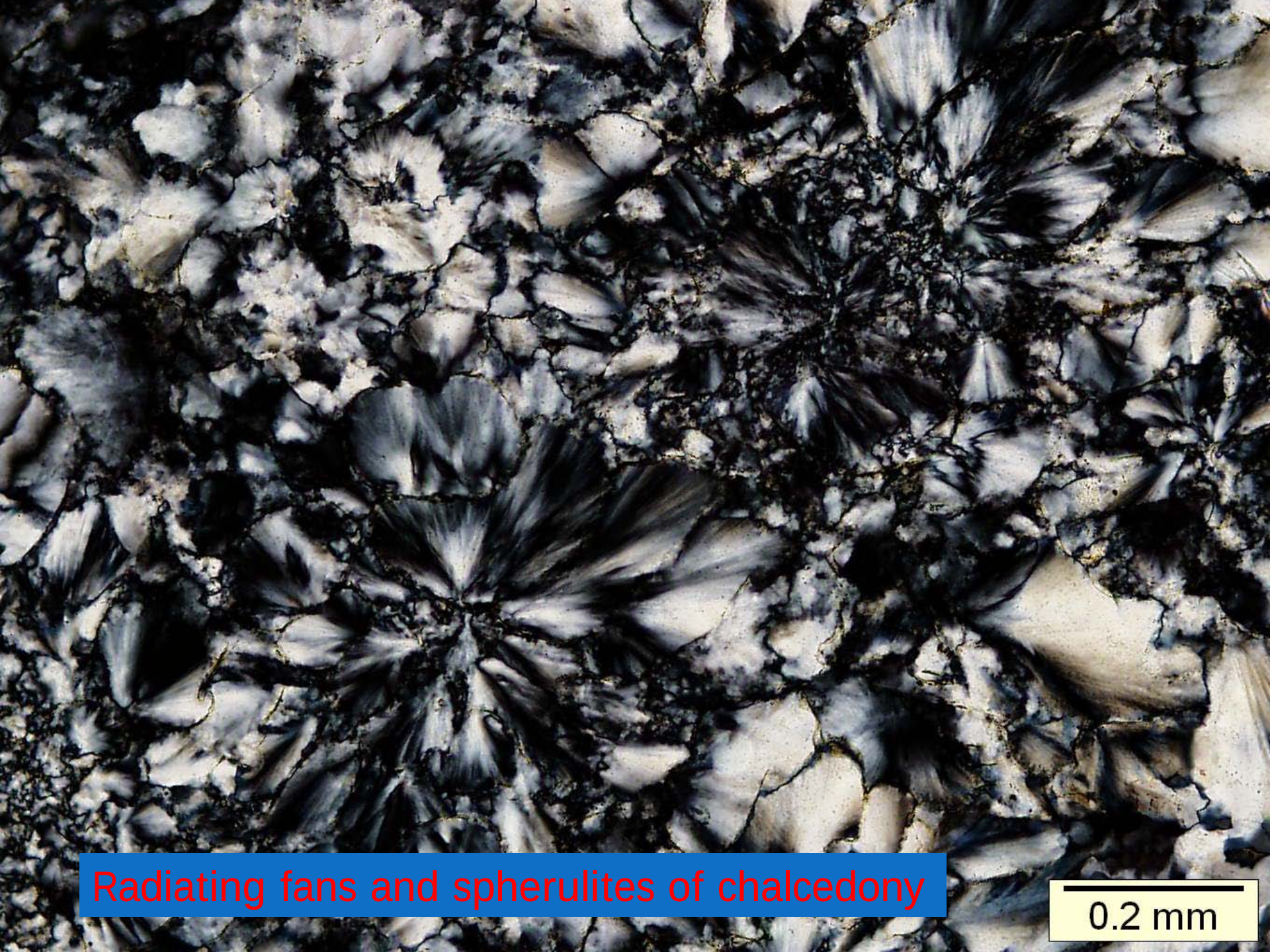
- Fossil wood looks like an ordinary wood and is easy to recognize with the naked eyes.
- Under the microscope, the cell structure seems to be quite similar to the original wood, but their composition is totally different.
- Almost 95% of the substances were replaced by low temperature cryptocrystalline quartz or chalcedony.
- The mineralization or replacement processes occurred either through physical or chemical processes over a long period of time.

Replacement Process

- Are they permineralized or petrified?
- Petrification ≠ permineralization.
  - Permineralization has their original pore space infilled with minerals
  - Petrification has their pore spaces infilled with minerals, the original material of the plant is also replaced with minerals.
- Petrified wood can preserve the original structure of the wood in all its detail, down to the microscopic level. Structures such as tree rings and the various tissues are often observed features.


Porous cells are firstly infilled by chalcedony
0.5 mm


Radiated chalcedony Porous cells are firstly infilled by
0.2 mm

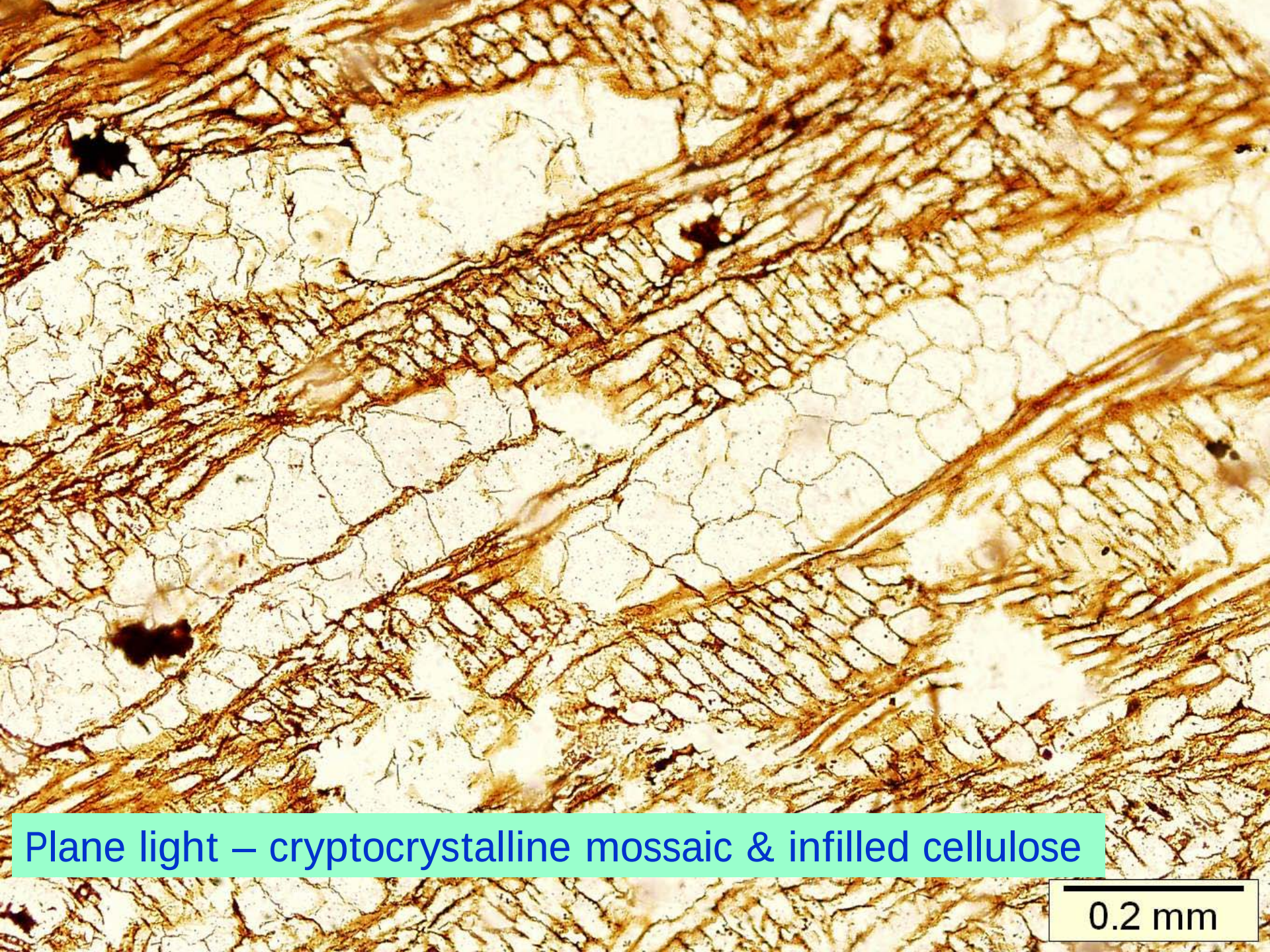

Radiating fans and spherulites of chalcedony
0.2 mm

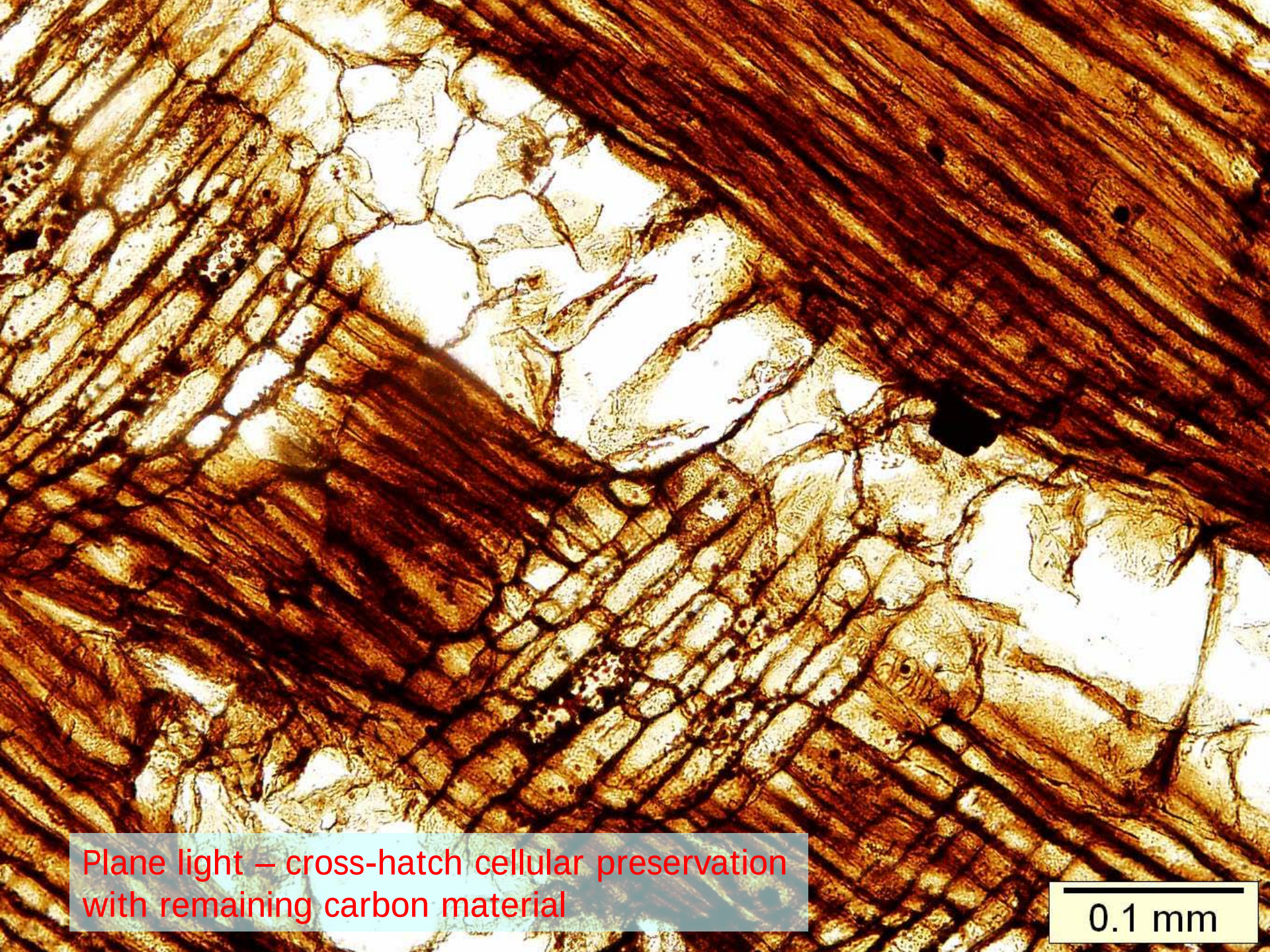
Permineralization

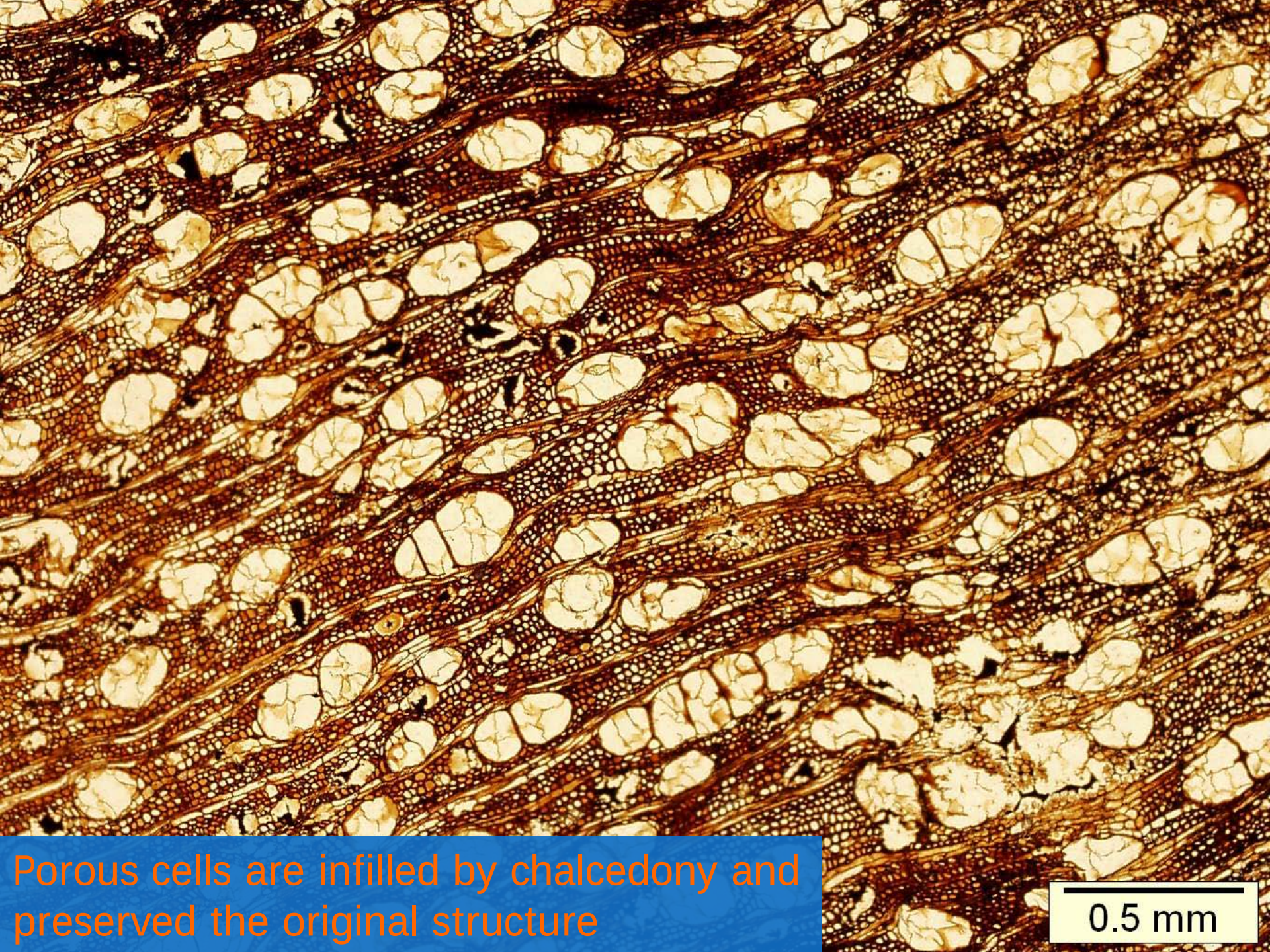
- Permineralization occurs when the plant tissues are infiltrated with mineral-rich fluid.
- Minerals are commonly silica, carbonate, phosphate or pyrite, precipitate in cell lumens and intercellular spaces - preserving internal structures or retain the original cellular structures in 3D - structural preservation.
- Organic material (commonly cell walls) is preserved - detailed information about the internal structure.
- Petrified wood preserves the cellular detail of wood anatomy and the lignin of cell walls that has been "fixed" by a mineral in-filling.

Petrification

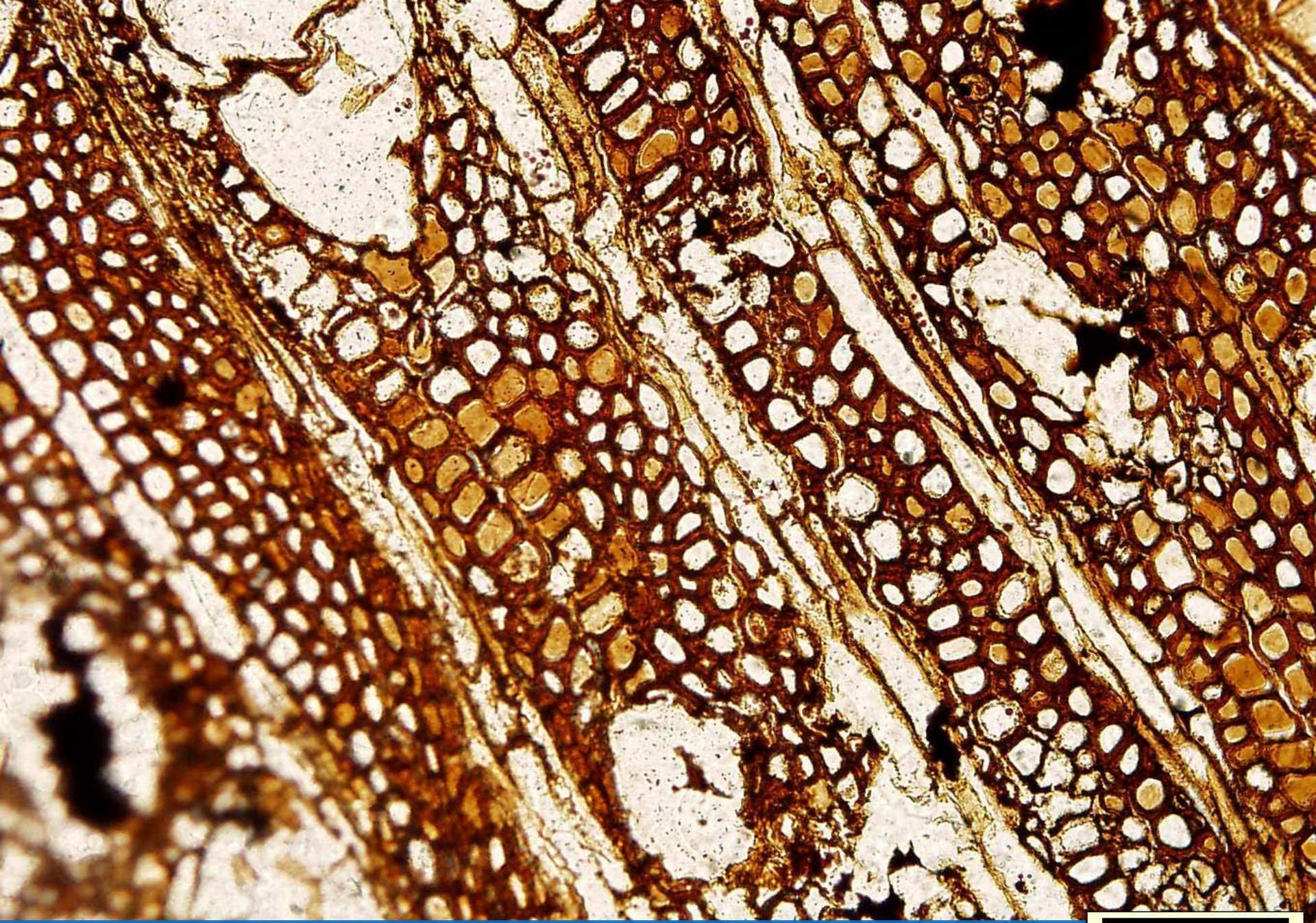
- When mineral matter actually replaces the cell-wall, plus other internal structures, e.g. cellular details are lost with the organic material.
- Silica permineralization or silicification commonly occurs in areas where silica-rich volcano-clastic sediments are undergone weathering.
- Organic matter of the tissue was replaced molecule by molecule with mineral material entering in solution in percolating groundwater.
- Mineral emplacement, where the organic residues are filled with solid substance which infiltrates in solution.


Plane light – cryptocrystalline mossaic & infilled cellulose
0.2 mm


Plane light – cross-hatch cellular preservation
with remaining carbon material
0.1 mm



Porous cells are infilled by chalcedony and preserved the original structure



Pyrite dissemination indicates anaerobic environment

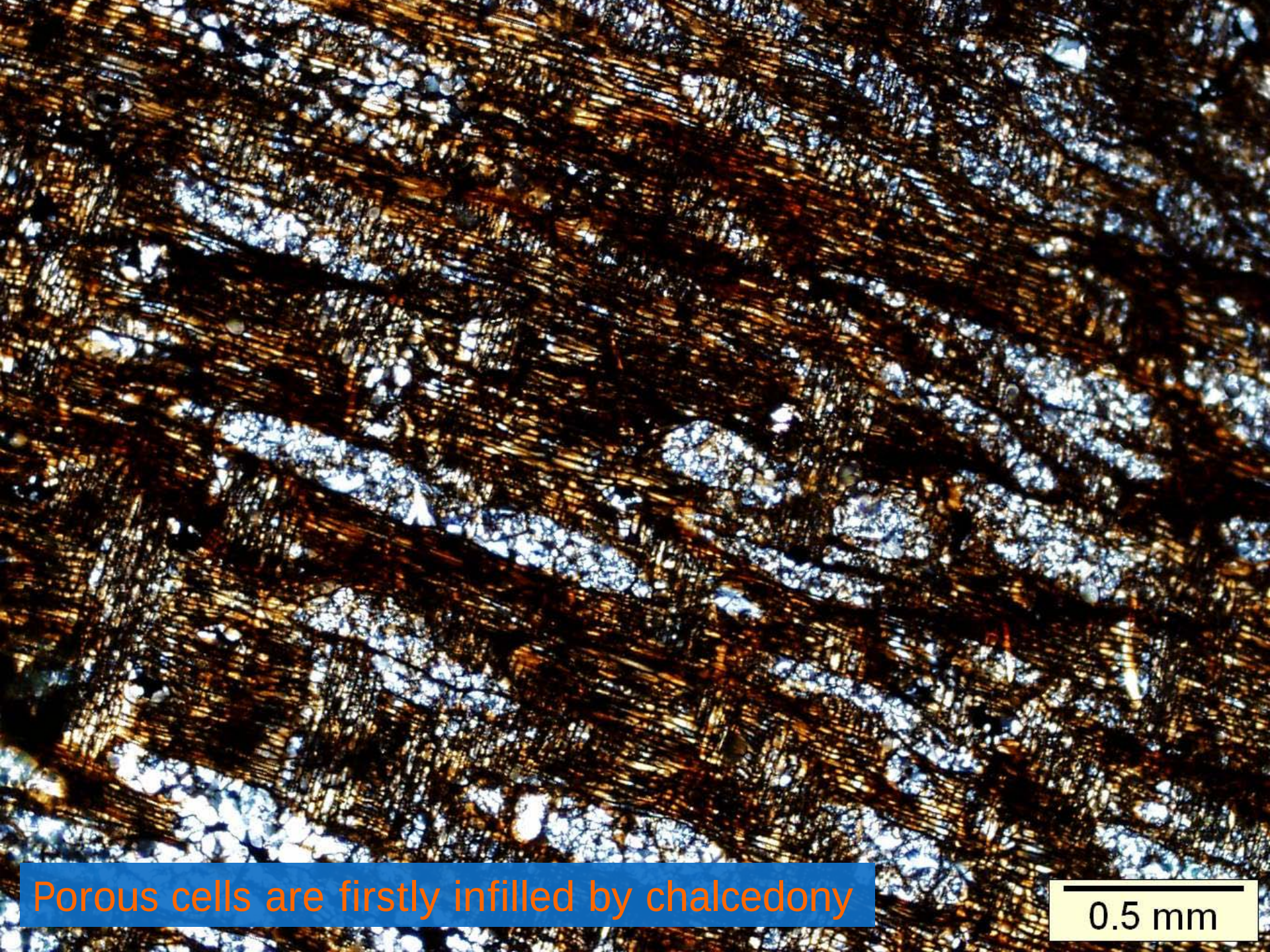
Silicification

- A material formed by the silicification of wood, generally in the form of opal or chalcedony.
- Silicate minerals are commonly released due to the weathering of rocks produced body of still water.
- It becomes a gel and will dehydrate, forming an opaline crystal structure. that is an internal cast of the organism.
- It reveals information about what type of environment.
- Silicification is the most common type of permineralization.

Total dissolved silicon as calculated by PHREEQC using the llnl.dat database [Anonymous]

Temperature (°C)	Quartz Solubility (mg/L)	Chalcedony Solubility (mg/L)
0.01	0.68	1.34
25.0	2.64	4.92
50.0	6.95	12.35
75.0	14.21	24.23
100.0	24.59	40.44

Chalcedony is more soluble than quartz under low-temperature conditions because it is extremely fine-grained (cryptocrystalline) and has a very high surface area to volume ratio


Porous cells are firstly infilled by chalcedony
0.5 mm

Conclusion

- Sarawak fossilized palmwood undergone the permineralization with spectacular preservation of cellular structure.
- Silicification or silica permineralization is a process of replacement by crytallocrystalline silicate minerals, mainly chalcedony.
- Sarawak petrified woods are unique with impressive scientific value and match to world's establishment specimens.

THANK YOU

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