Rhodophyta (Red Algae)

Three groups calcify:

most CORALLINALES

some GIGARTINALES
(Peyssonneliaceae)

a few NEMALIALES

marine algae


CORALLINALES
common components in
Cenozoic carbonates

Coralline algae or corallines the most abundant extant group of calcareous algae

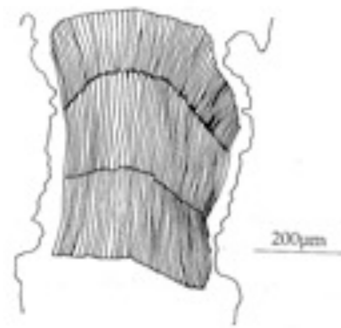
Modern corallines known since the Early Cretaceous – 100 Ma - 3 families

There are 3 types of coralline algae from a preservation-potential (geological application) point of view:

1. Geniculate corallines: calcified segments separated by non-calcified genicula

after death they produce
sand grade particles

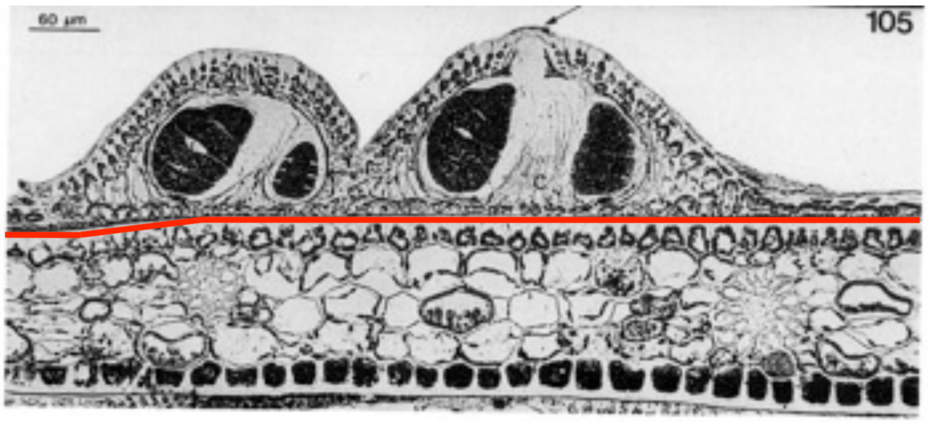
botanical taxonomy based upon non-calcified
characters with low preservation potential



2. Thin non-geniculate

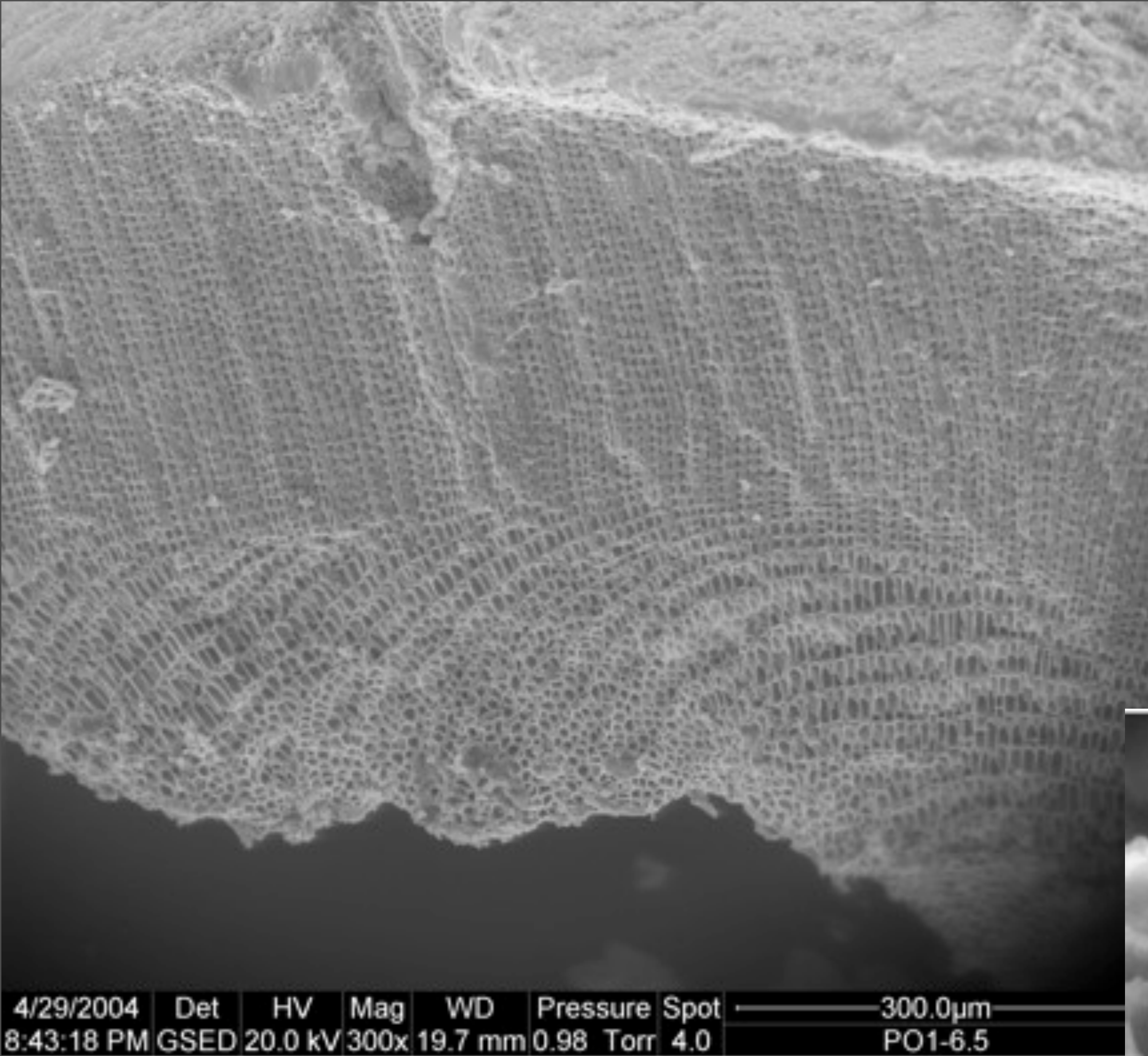
thin crusts: thin thalli,
< 100 microns,
usually two cell thick,
except in conceptacles
(reproductive structures)

low preservation potential,
frequently micritised,
difficult to identify
in fossil assemblages



3. Thick or normal non-geniculate (> 100 microns thick)

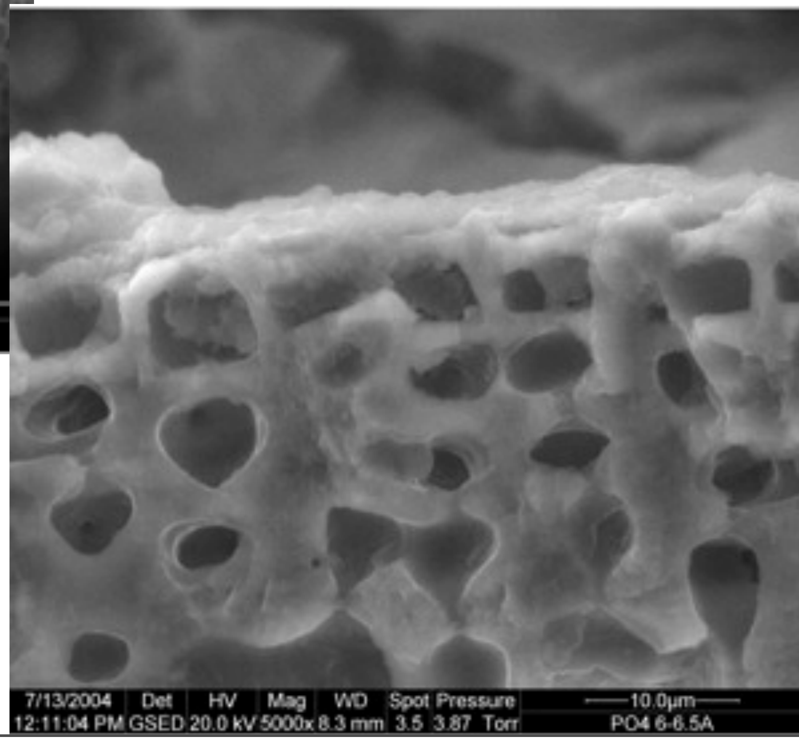
volumetrically important components of present-day reefs and platforms

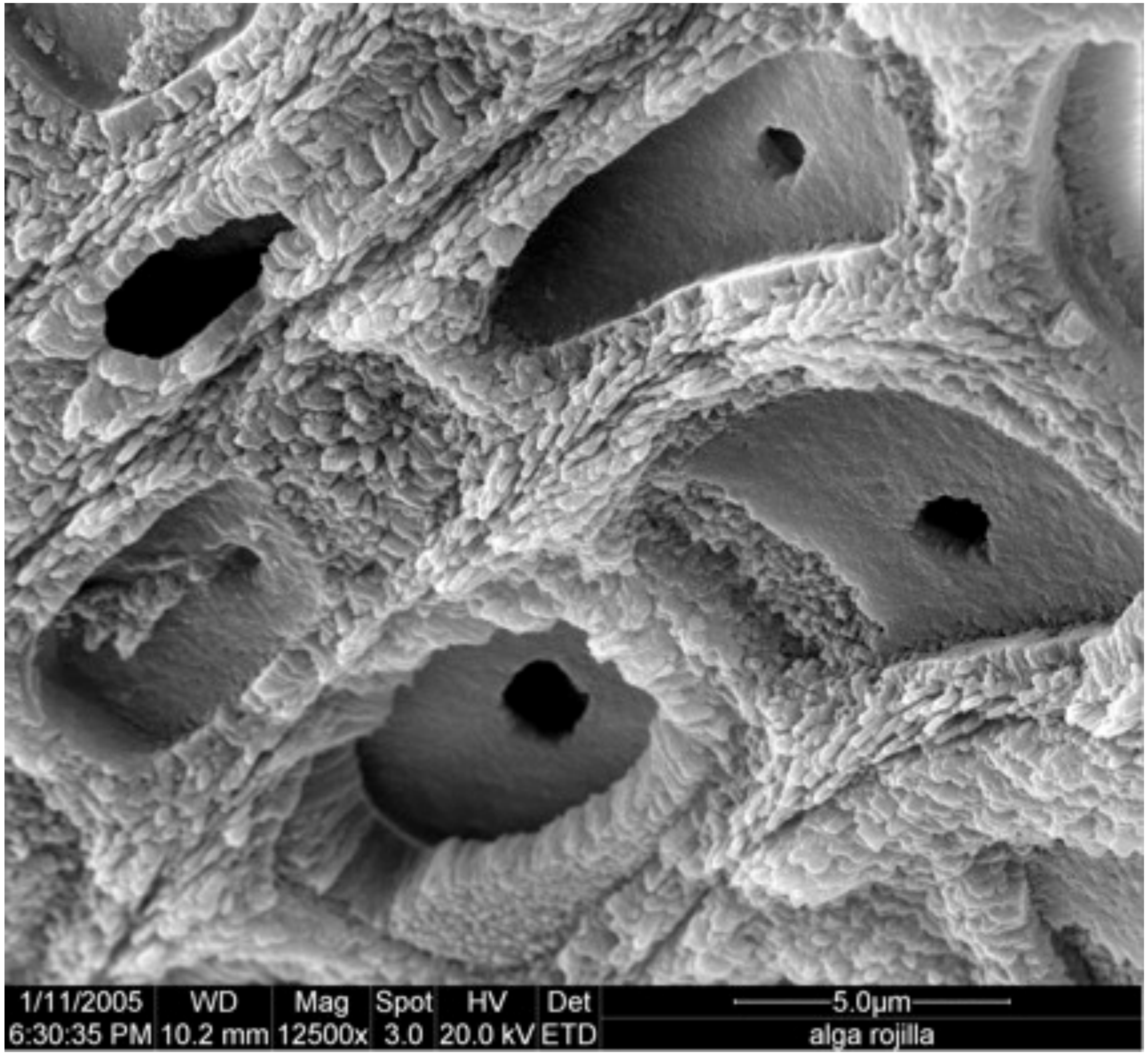


The thallus (body) is a coherent mass of cell filaments

calcified cell walls except in cells at the very surface

High-Mg calcite

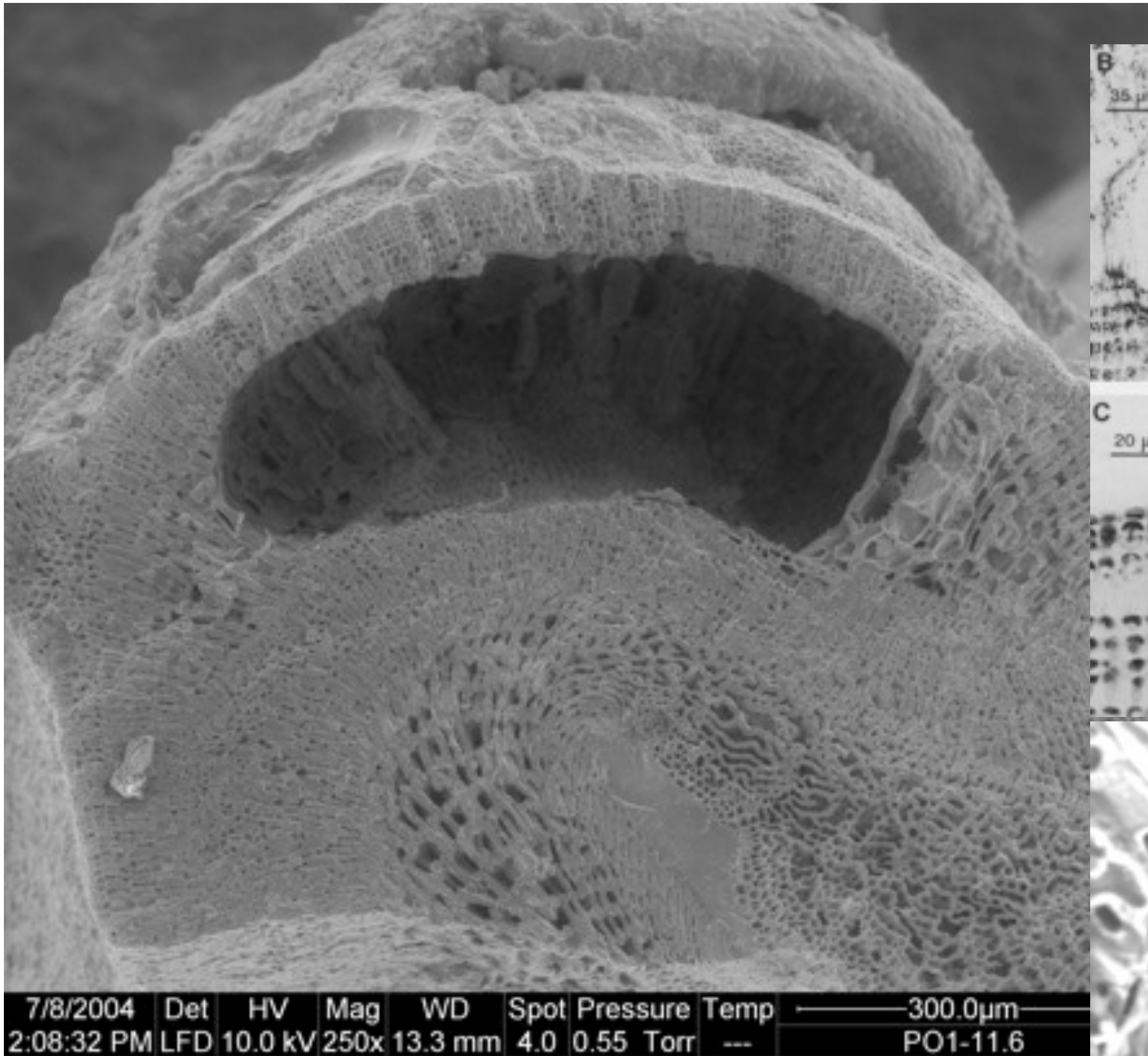


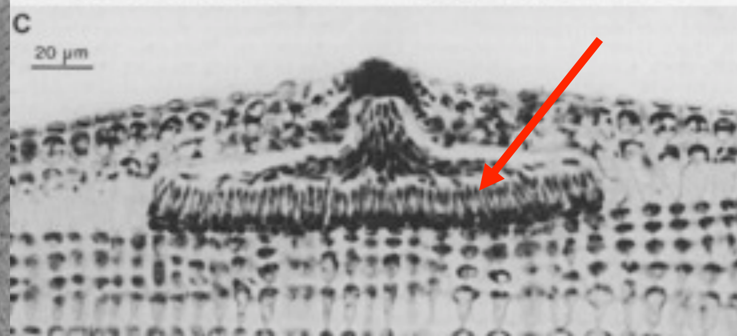


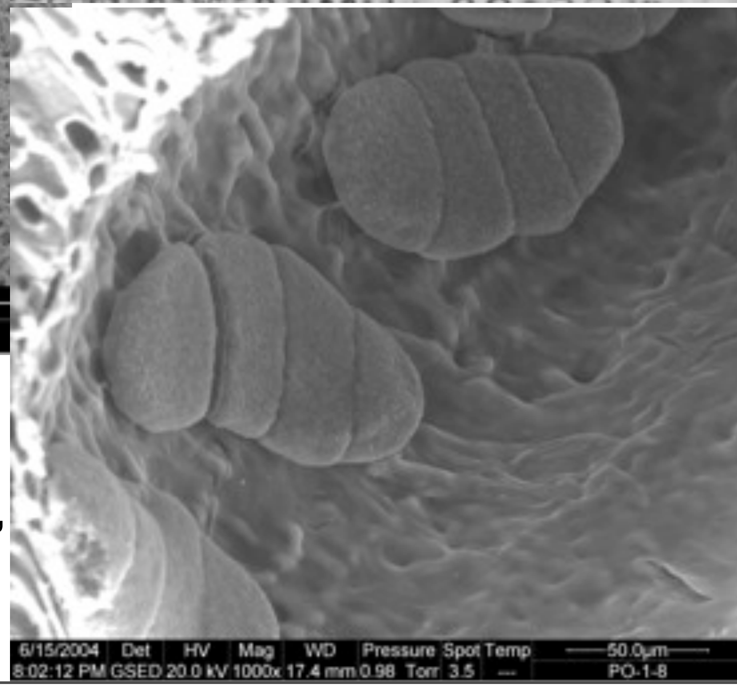
calcification is fully controlled by the plant

independent from calcium carbonate saturation state of sea water

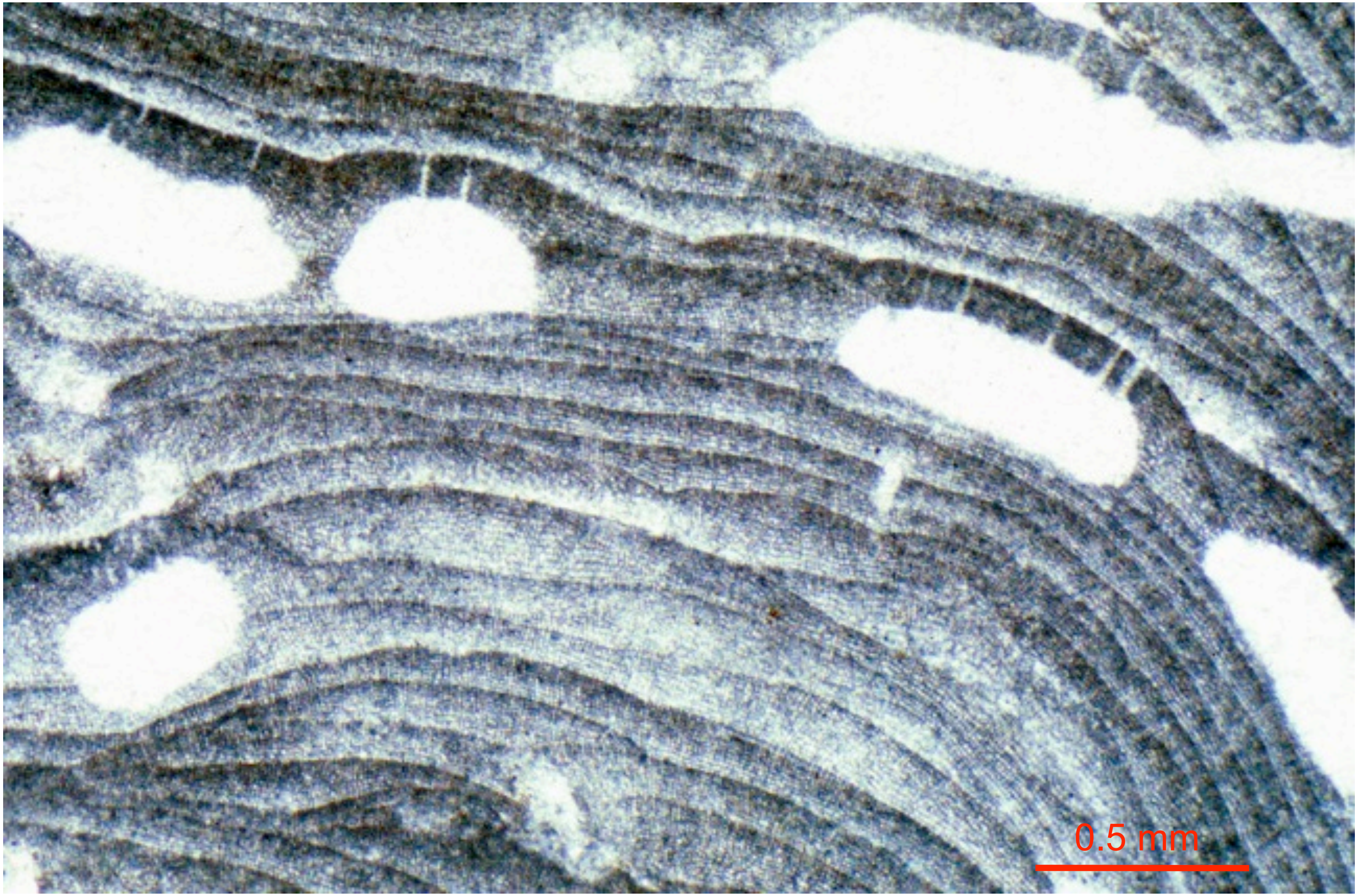
high preservation potential







most diagnostic characters in botanical taxonomy can be preserved in fossil plants; a few taxa, however, are defined by non-calcified reproductive structures


0.5 mm

As a group they are cosmopolitan

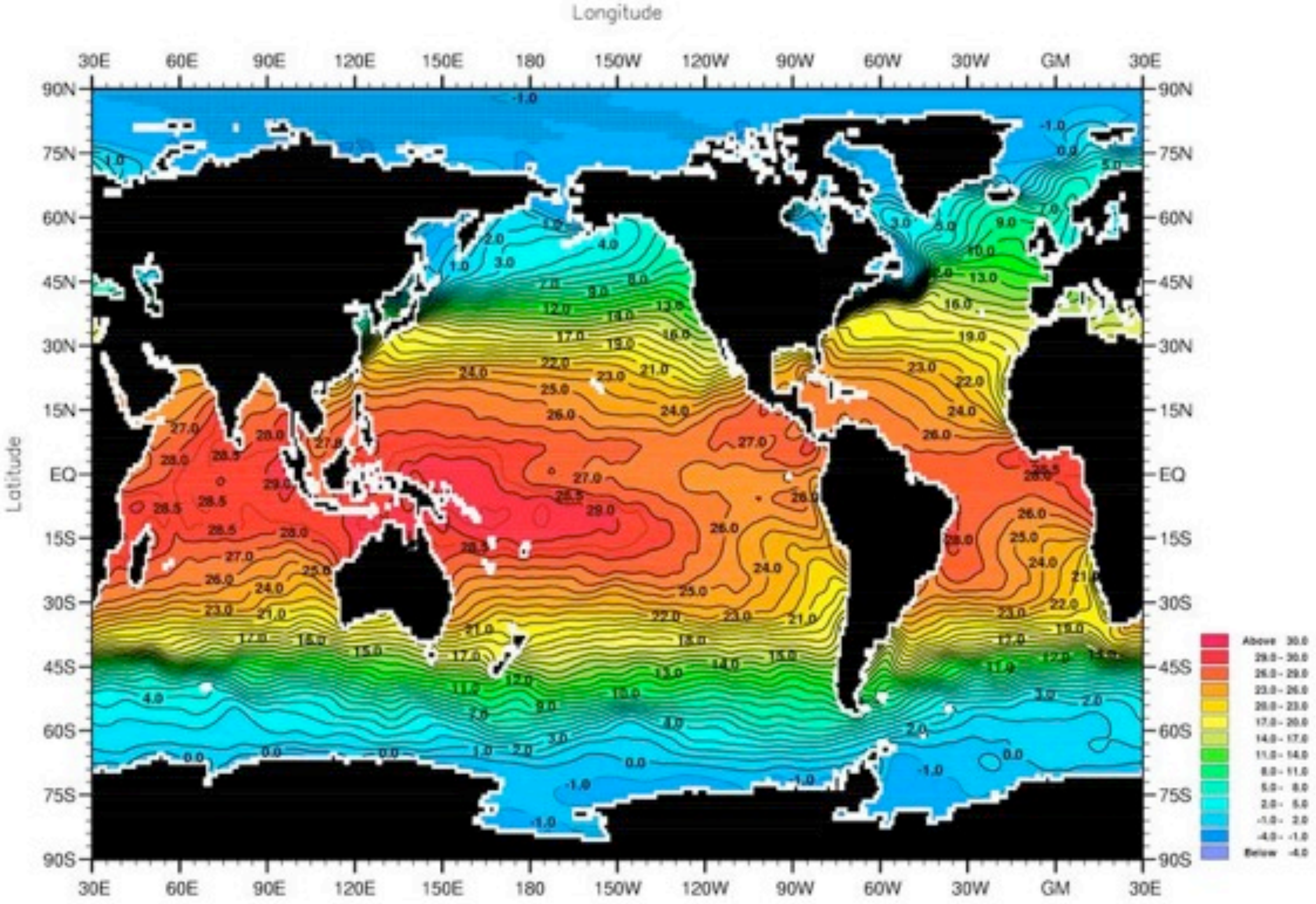


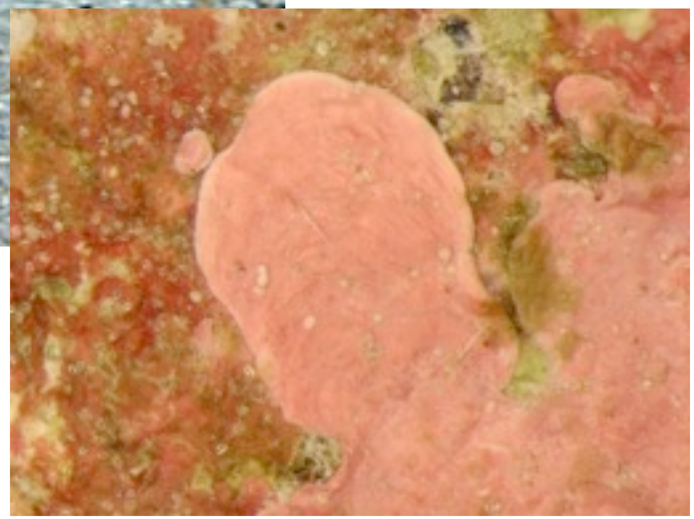
Fig. B2-1. Winter (Jan.-Mar.) mean temperature (°C) at the surface.
Minimum Value= -2.10 Maximum Value= 29.99 Contour Interval: 1.00

from blue to red regions


Applecross, Scotland

In tropical regions

They occur from intertidal-shallow subtidal zones…



…to relatively deep areas

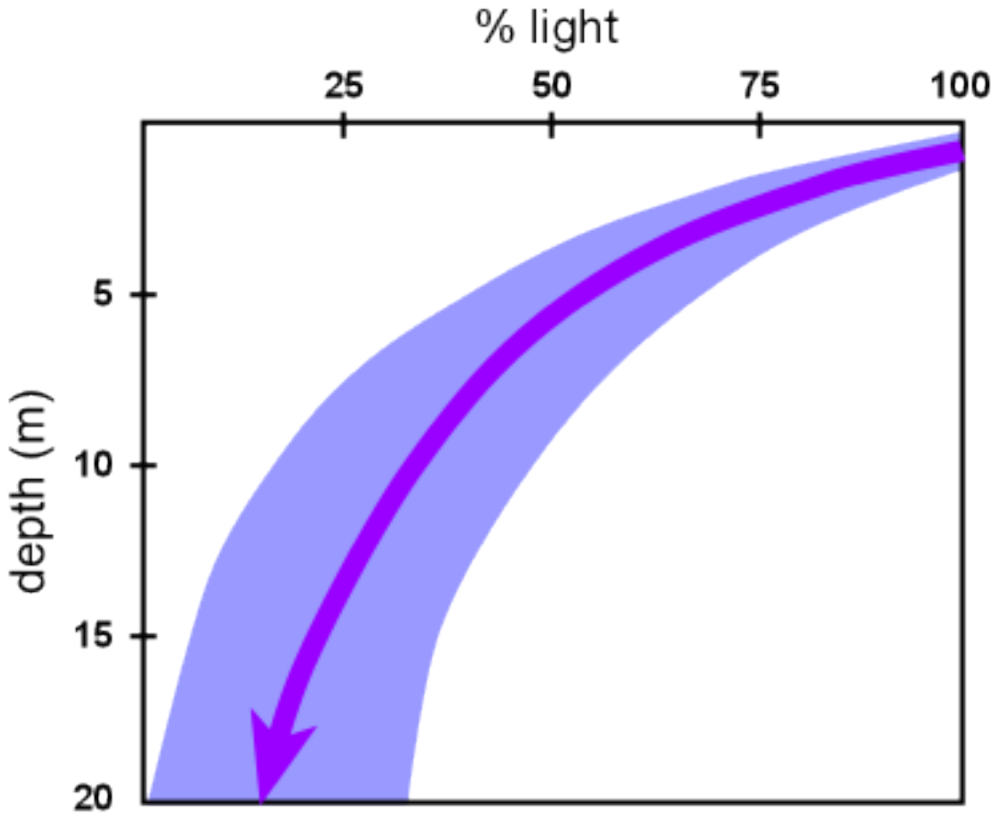
record: 269 m in San Salvador (Bahamas)

individual species and genera

- have relatively restricted dispersal areas
- sensitivity to light conditions, trophic levels, wave energy…

these habitat preferences make fossil corallines useful palaeoenvironmental indicators

Light is the major factor controlling coralline species distribution



light intensity decreases with depth and consequently

coralline species assemblages change with depth

Coralline assemblages are useful palaeodepth indicators

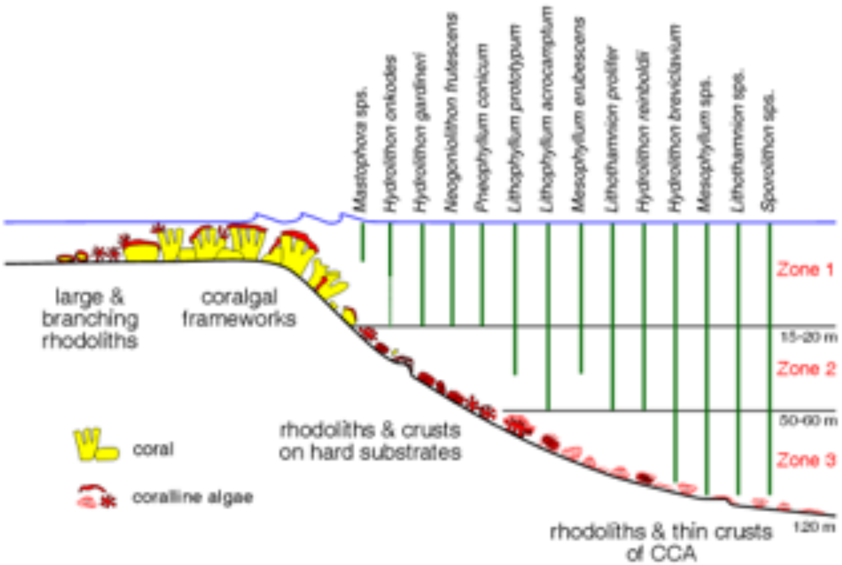
The validity of this “transferred ecology” approach seems to be particularly appropriate in Quaternary deposits

especially in the case of reef frameworks (displacement discarded)
in combination with corals

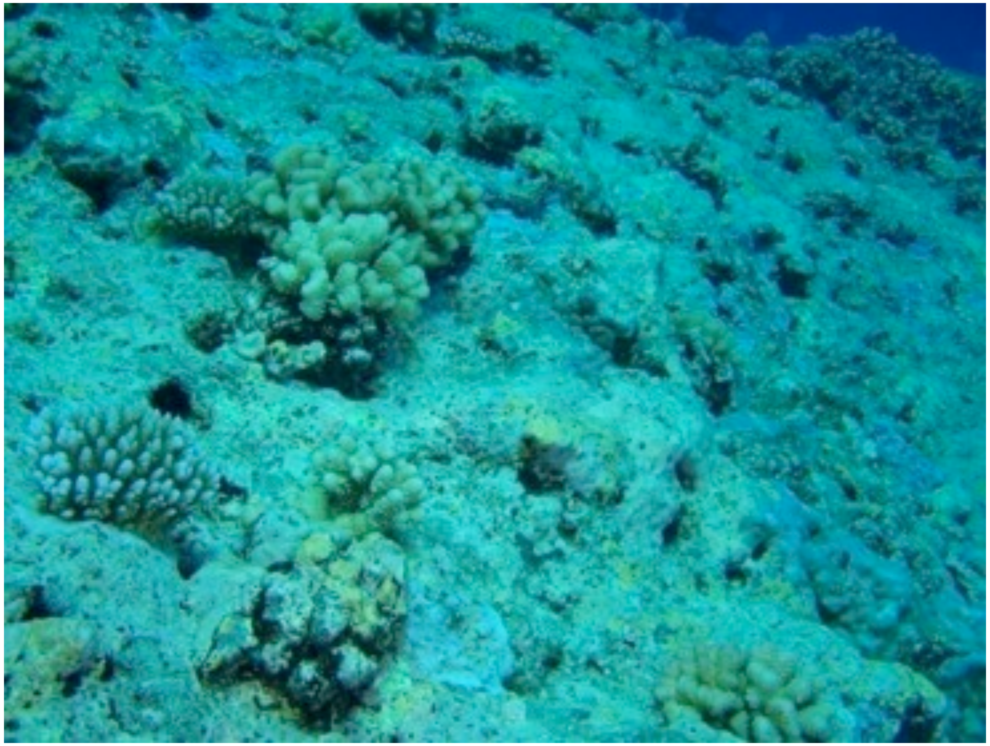
Playa Cambiaso (DR)

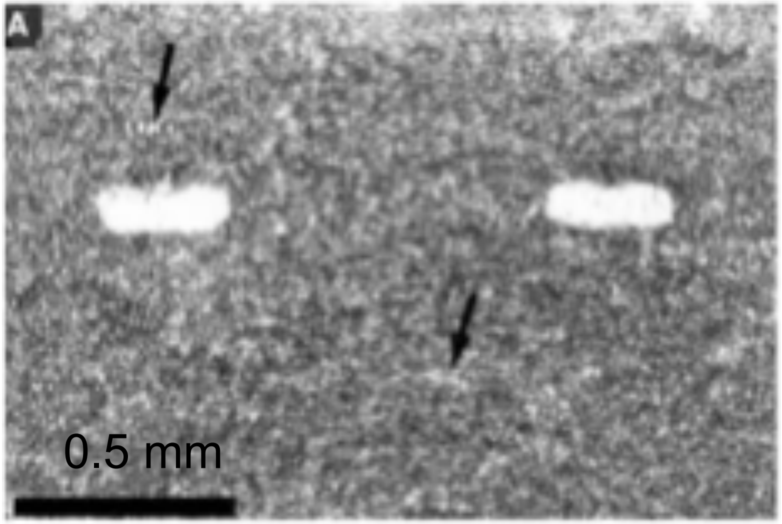
even if some taxa change their environmental requirements with time
for example, Iryu & Matsuda (1996) showed that *Hydrolithon murakoshii* has a more limited depth range in present-day reefs than in Pleistocene ones in the Ryukyu Islands

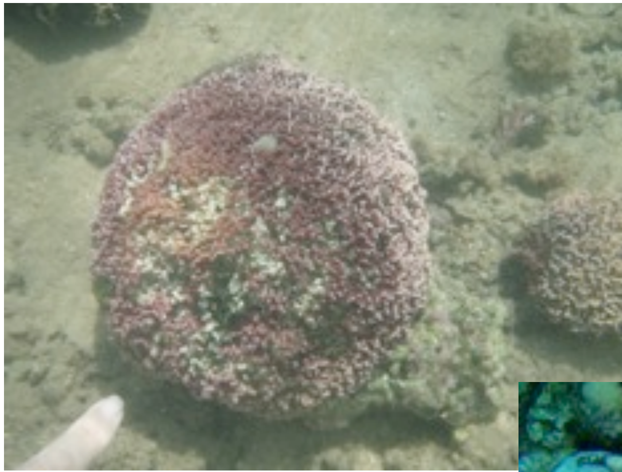
Coralline assemblages show a depth zonation in present-day Indo-Pacific reefs



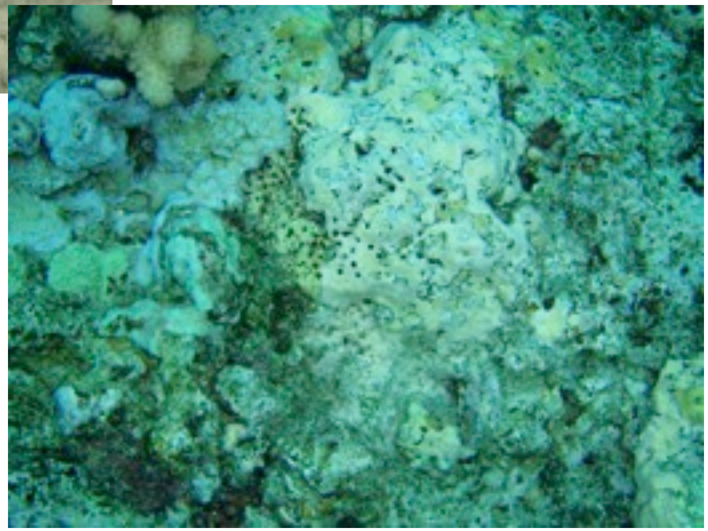
reef crest, Moorea, FP

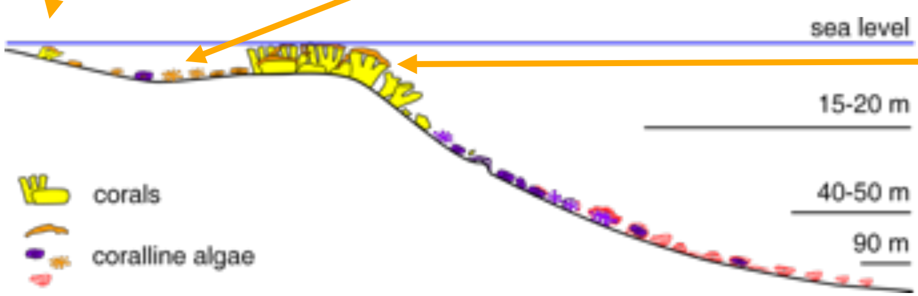






Hydrolithon onkodes
H. gardineri
Lpm. kotschyanum group
Mastophora pacifica

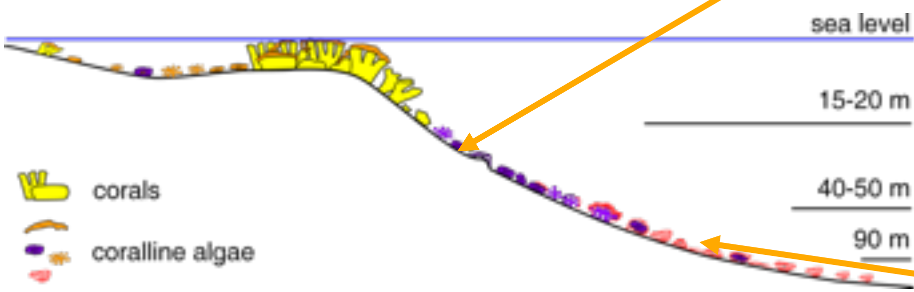




shallow-water assemblages

coralline algae can be integrated in a model of palaeoenvironmental/ palaeobathymetric distribution

Mesophyllum &
Lithothamnion species

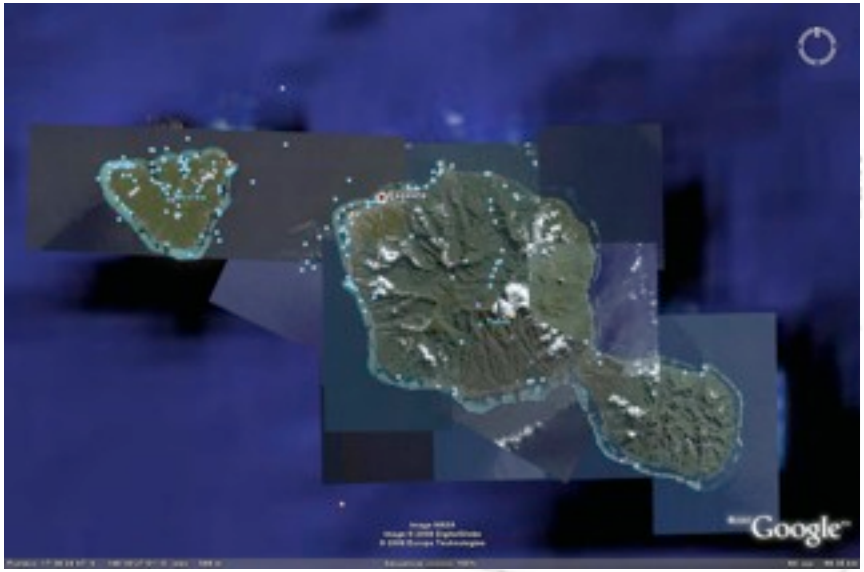


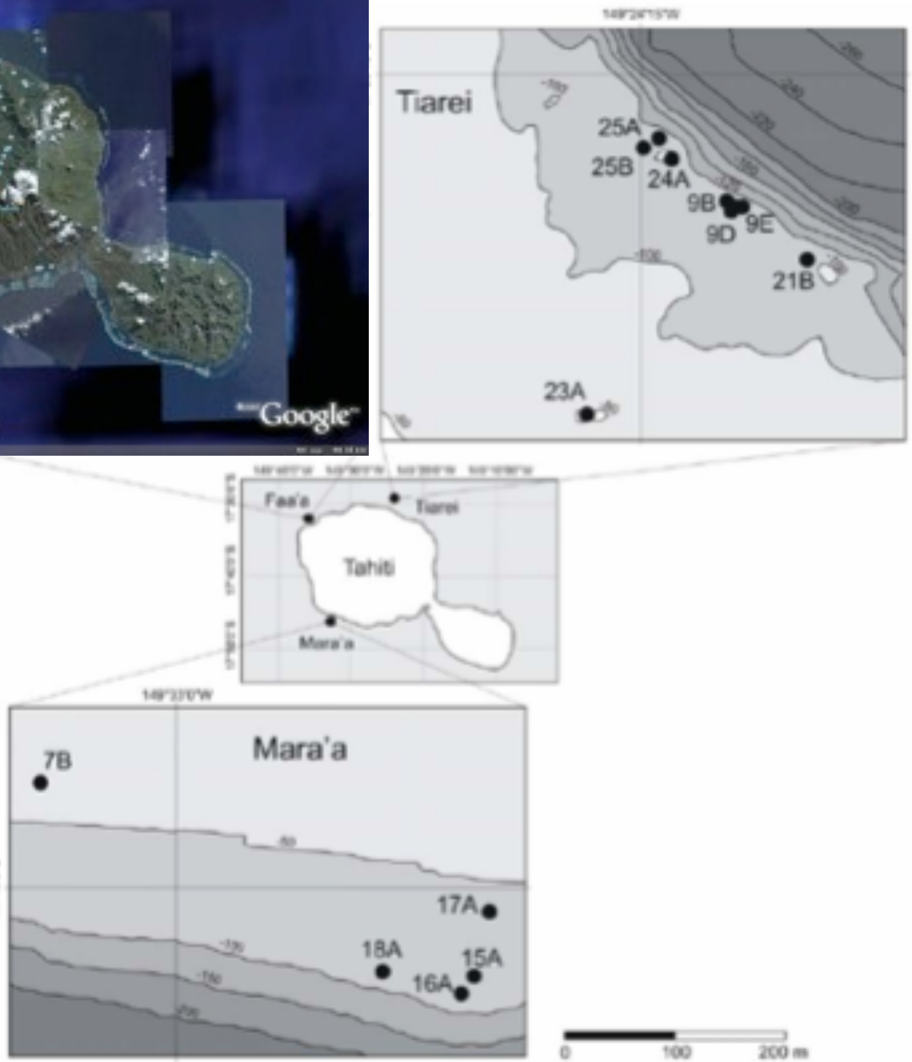
deep-water assemblages

(Webster et al., 2007)

Applying the model to postglacial Tahiti reefs

Exp. 310, IODP

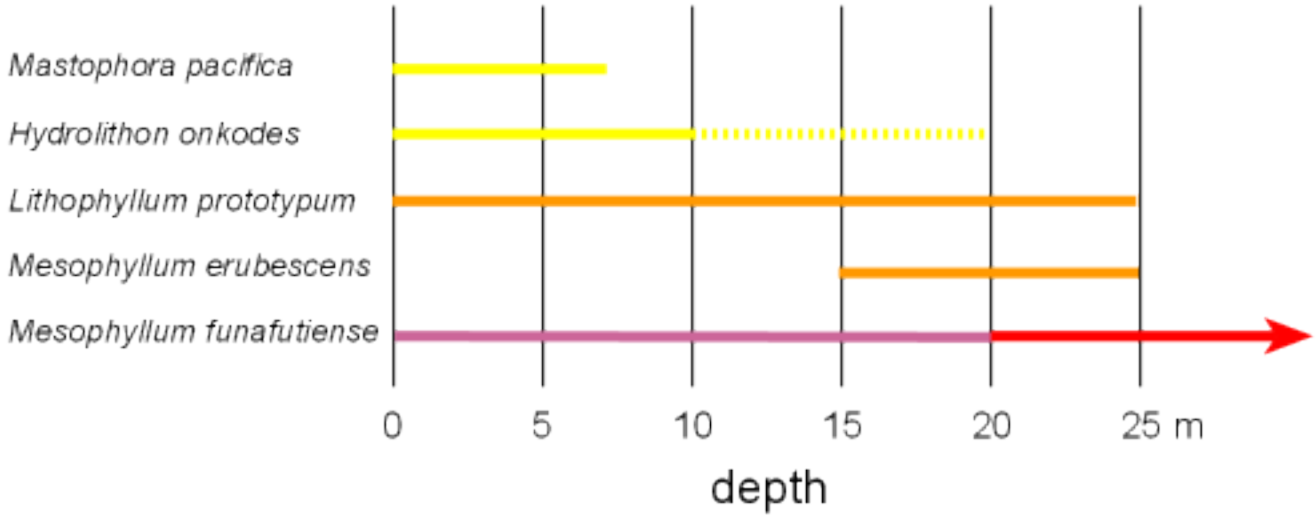




Heindel et al., Figure 2

The 24 corallines species identified in postglacial reef at Tahiti are living today in French Polynesia reefs, according to Payri et al. (2002) and Littler & Littler (2004)

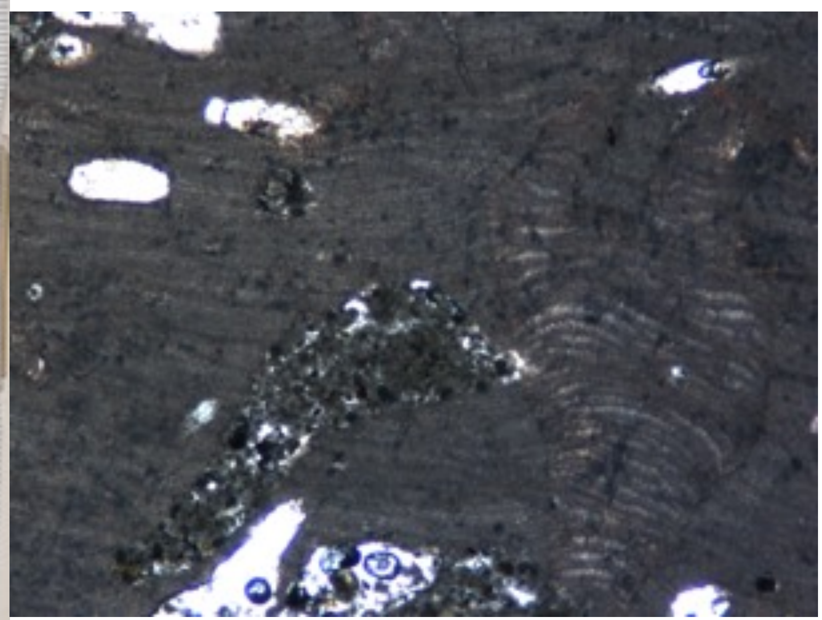
Several species can be used for interpreting paleodepth



shallow-water assemblages, < 10 m

Thick crusts of *Hydrolithon onkodes*

very common occurrence



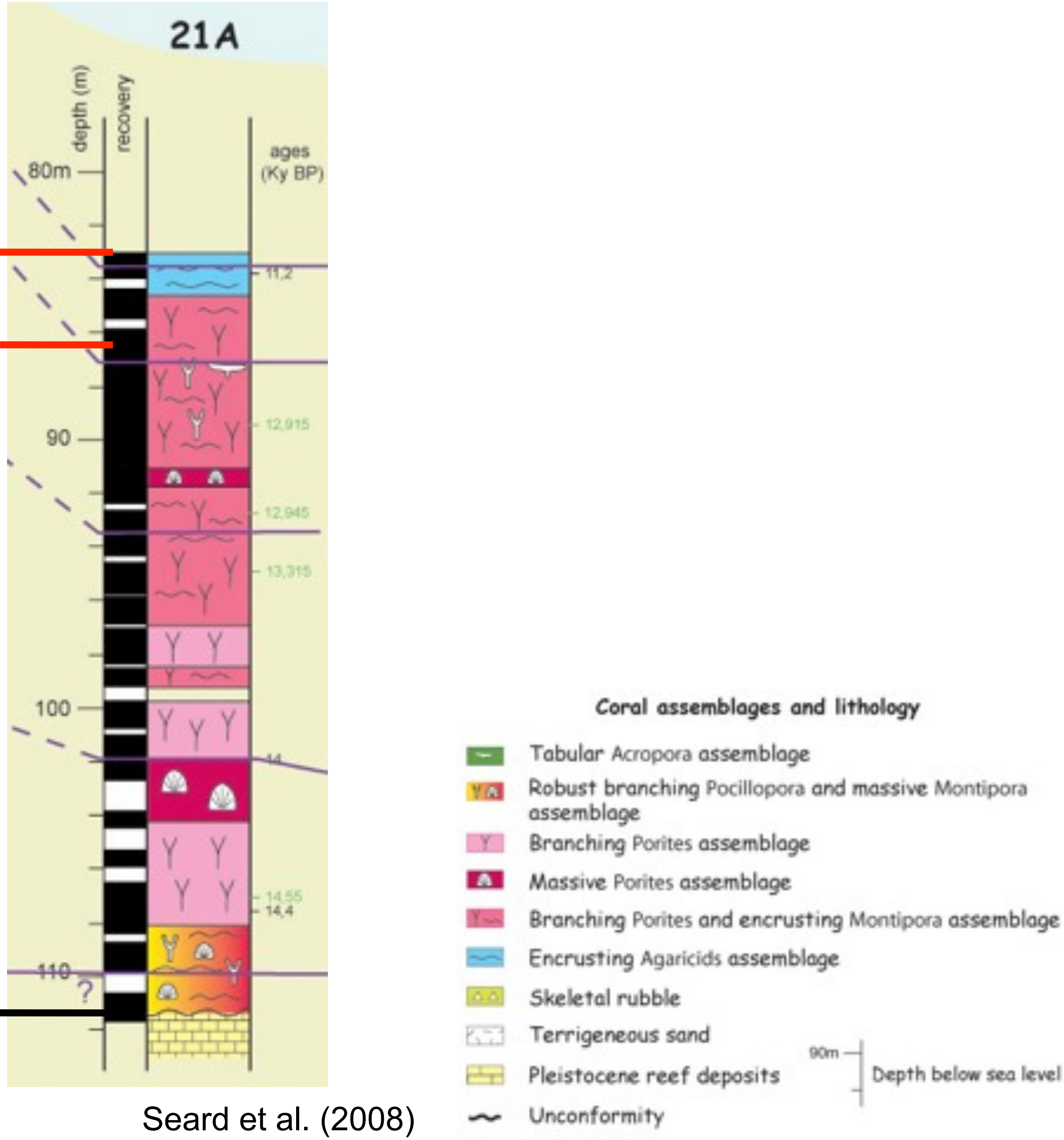
Deeper-water assemblages, > 20 m

Thin frameworks of *Mesophyllum funafutiense* and *Lithoporella*

coralline results

deep drowning

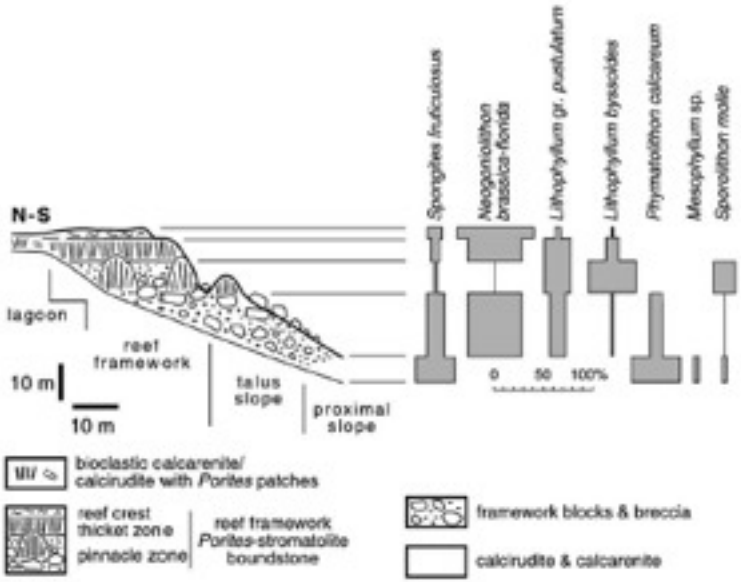
shallow keeping-up

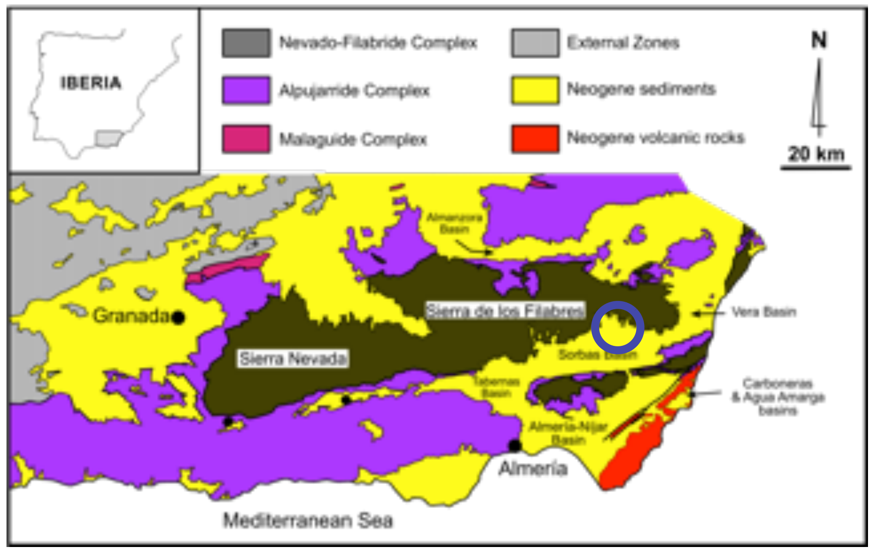


Seard et al. (2008)

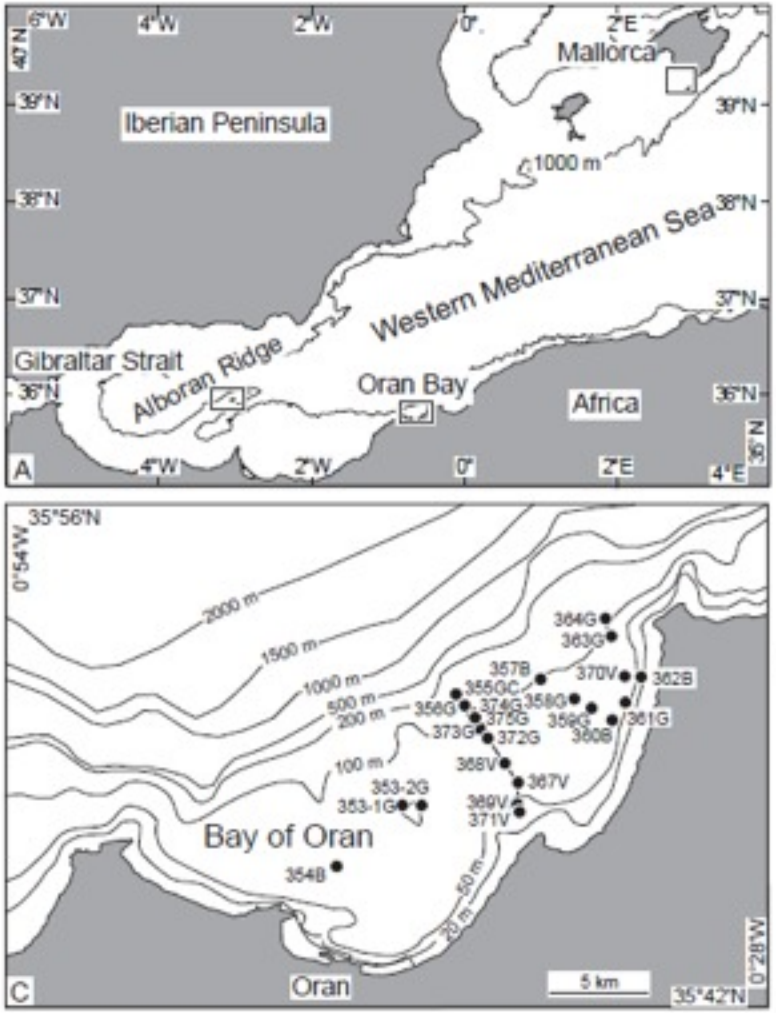
In older reefs, CCA distribution patterns have to be developed

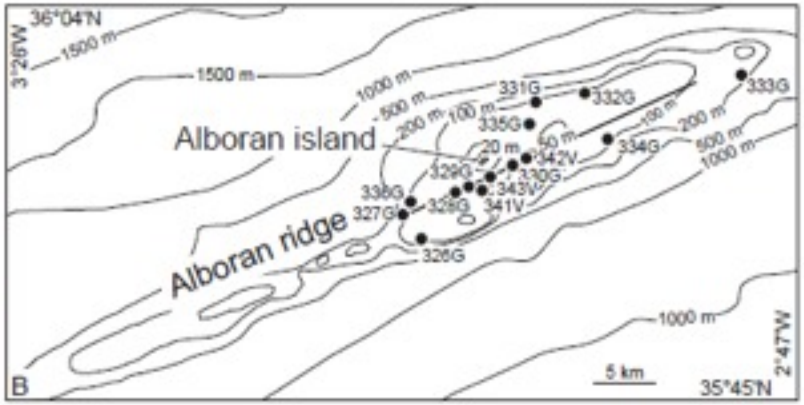
Caritiz reef in the Sorbas Basin





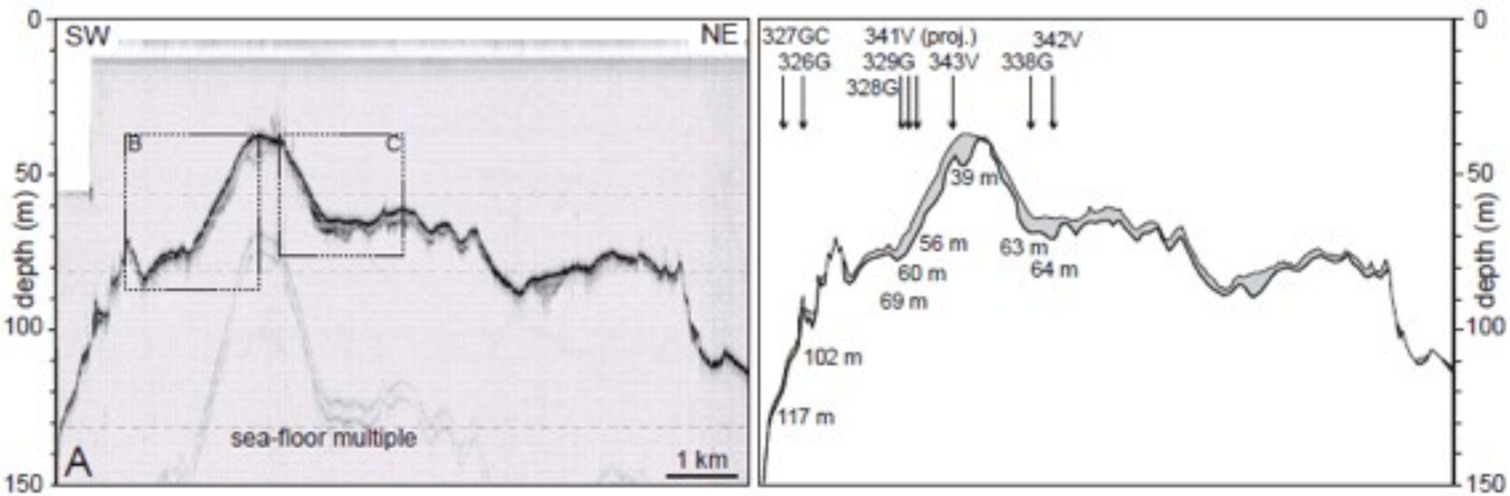
In temperate regions





Betzler et al. (2011)

Isla de Alborán



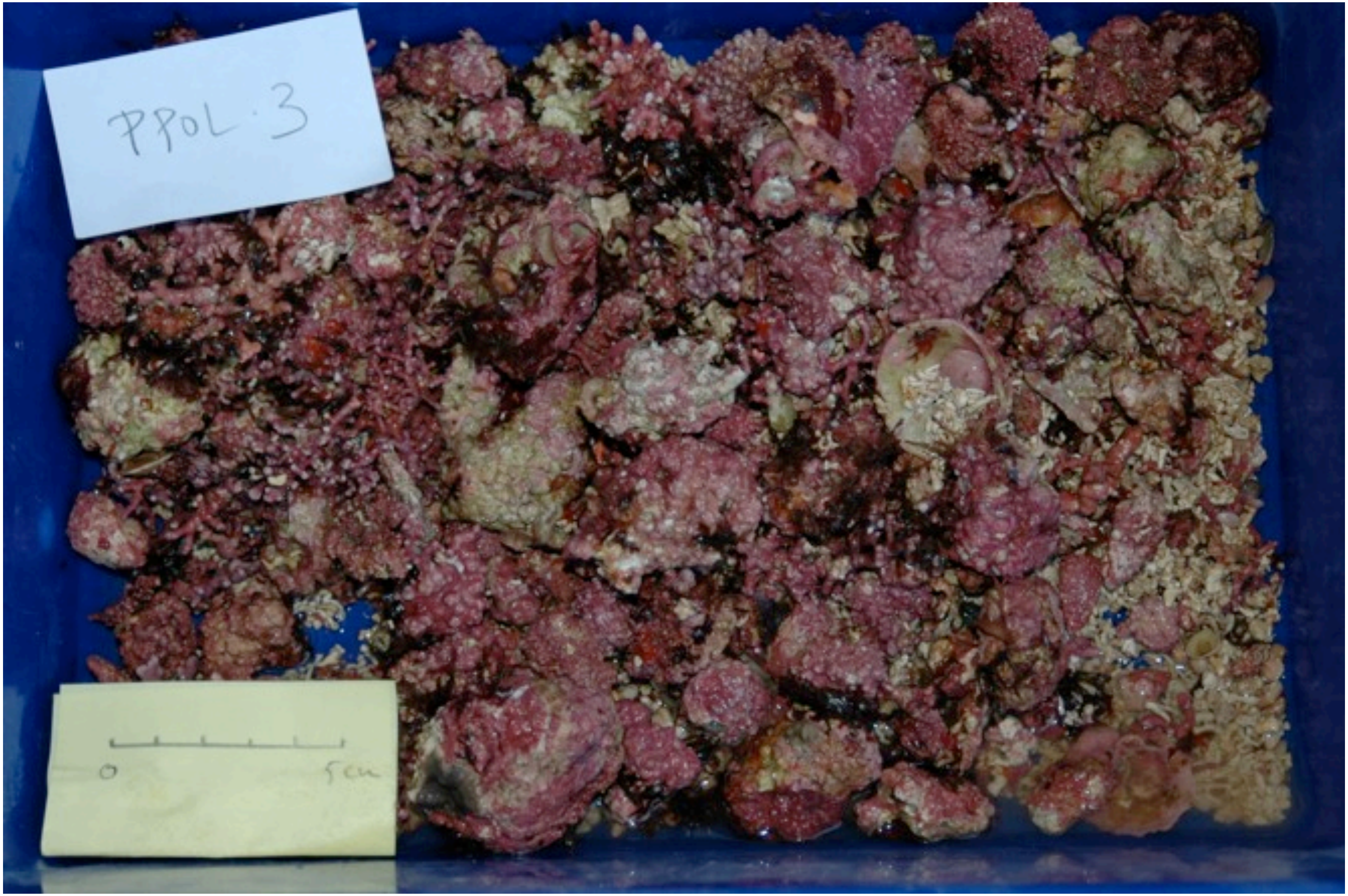
crusts on rocky shores
and submarine cliffs

from shallow subtidal

Intermediate water depths

20 to 40 m

rhodoliths with *Lithophyllum racemus, Neogoniolithon, Mesophyllum, Lithothamnion, Phymatolithon*

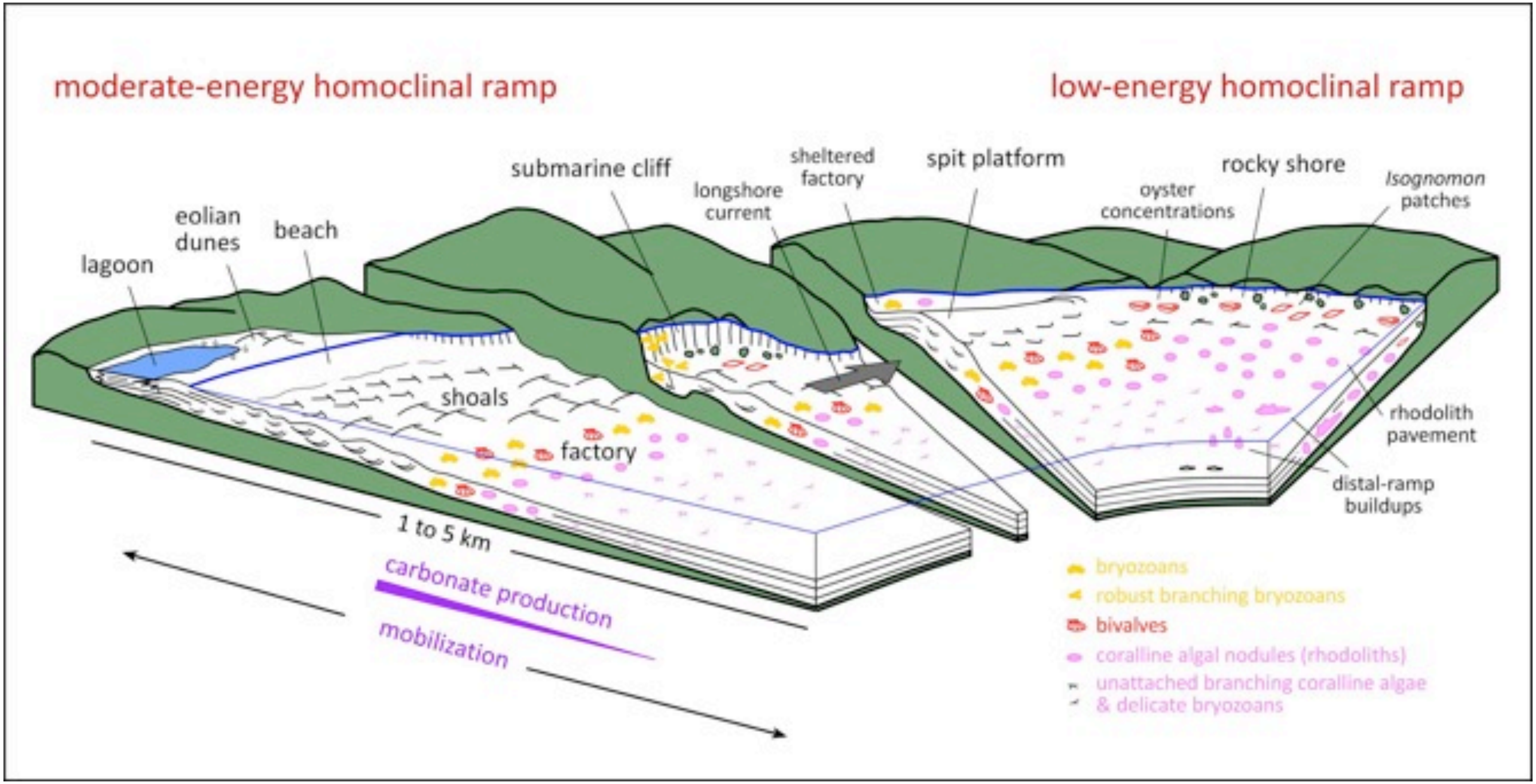


dredged sample from 30 m

dredged sample from 60 m, open branching growths of *Phymatolithon* and *Lithothamnion*

serpulid-algal nodules

Neogene fossil examples



Braga et al. (2006)

crusts on rocky shores, Pliocene, Almería Basin

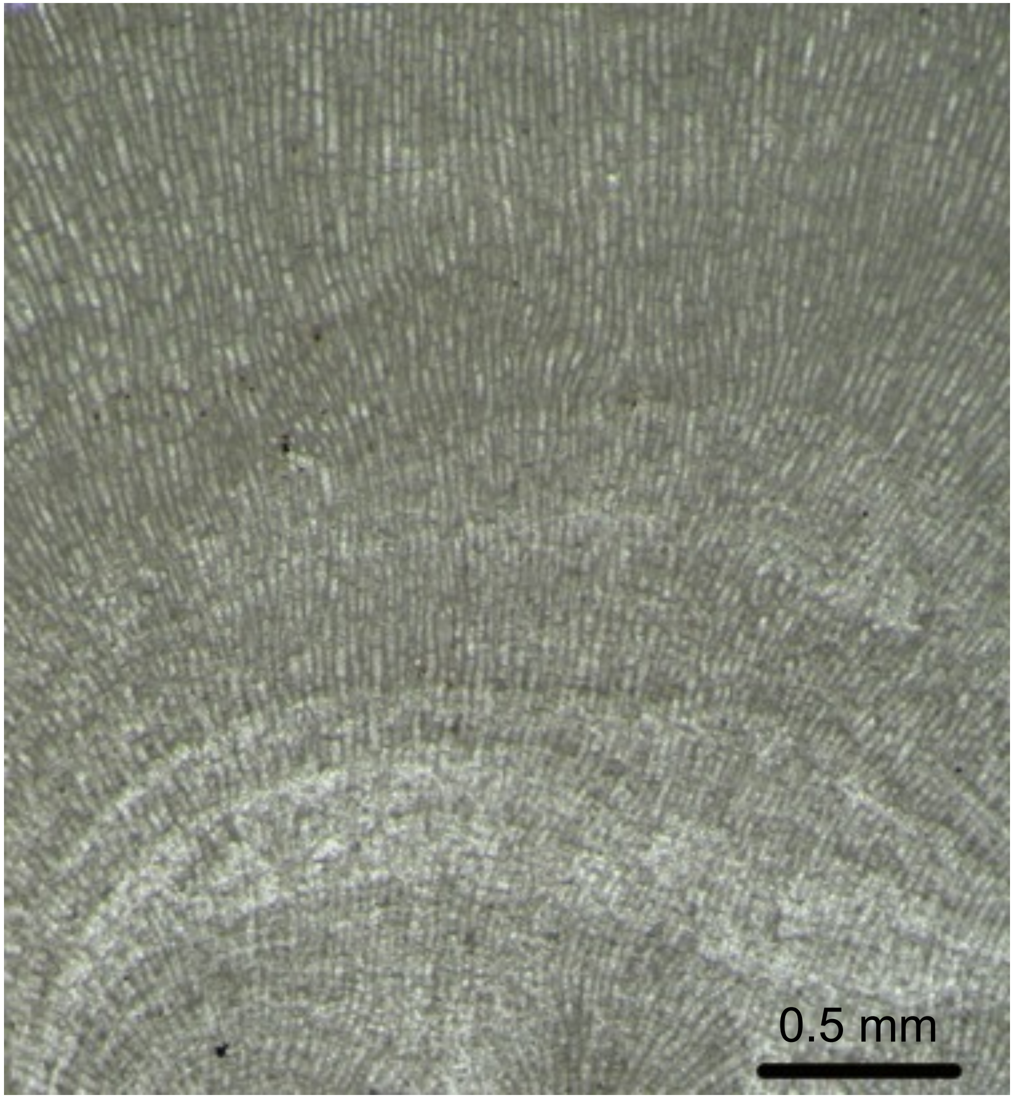
rhodoliths, inner-mid ramp

Pliocene, Almería Basin

open branching growths, outer mid ramp

Pliocene, Almería Basin

More calcareous red algae….



“Solenoporaceans”

Corallinales with unknown reproductive organs

Ordovician-Miocene

Archaeolithophyllum

Palaeozoic red algae

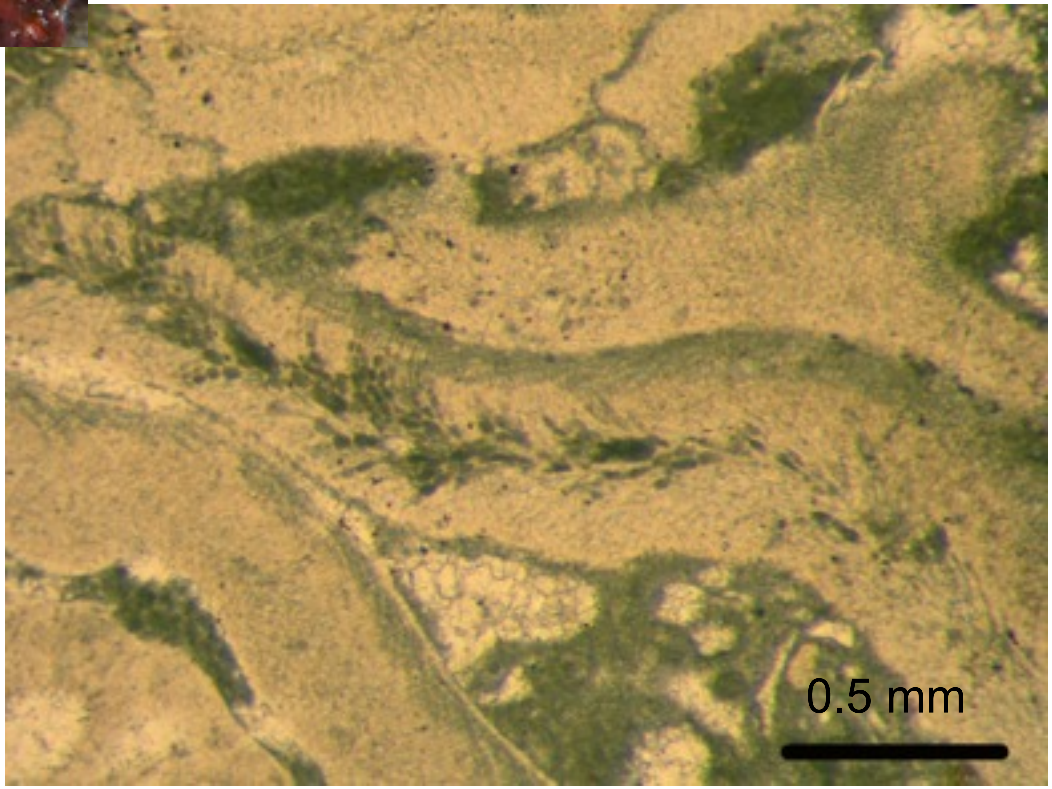
A mixture of taxa of unknown affinity

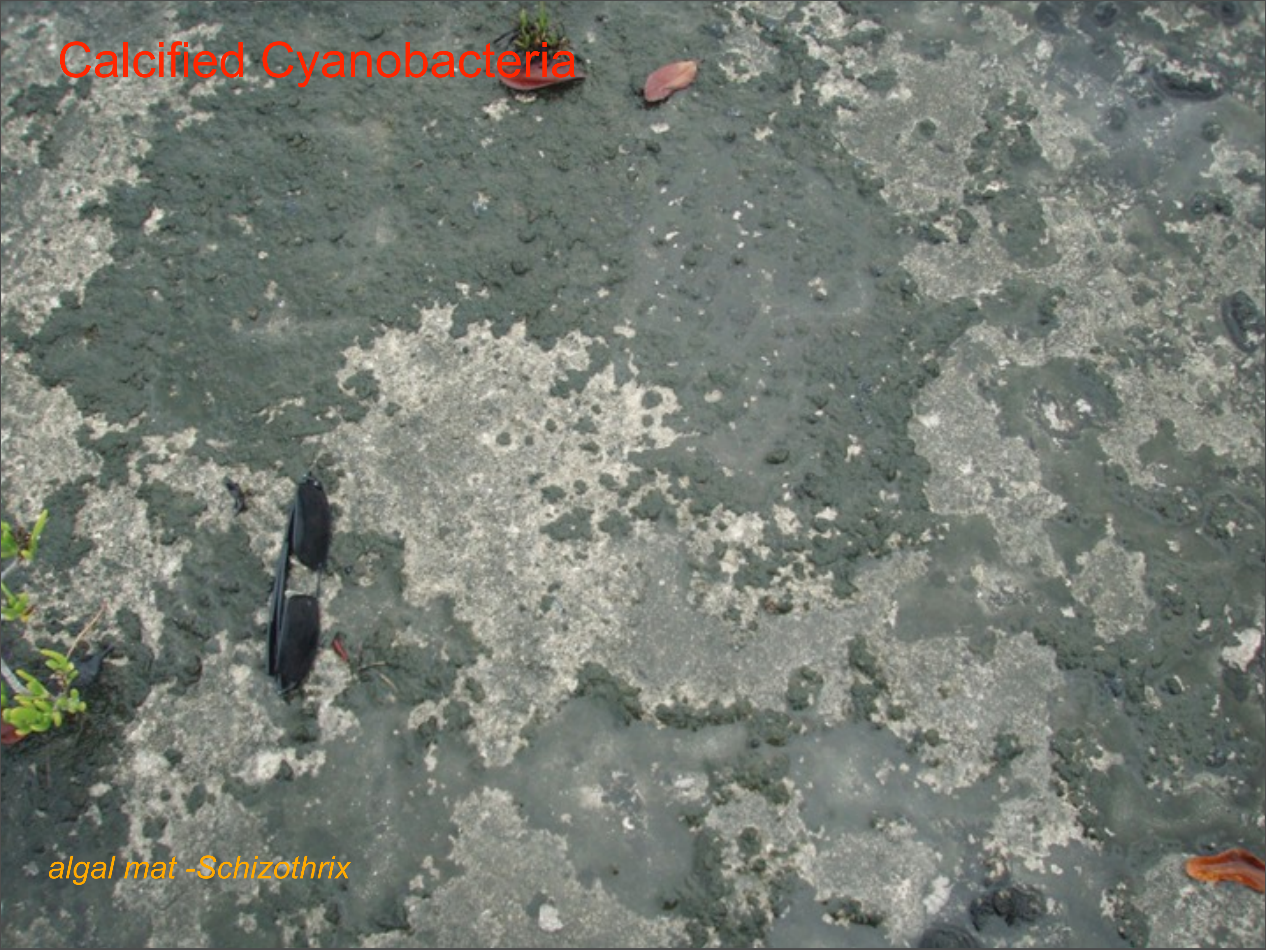
GIGARTINALES (Peyssonneliaceae)

aragonitic skeleton

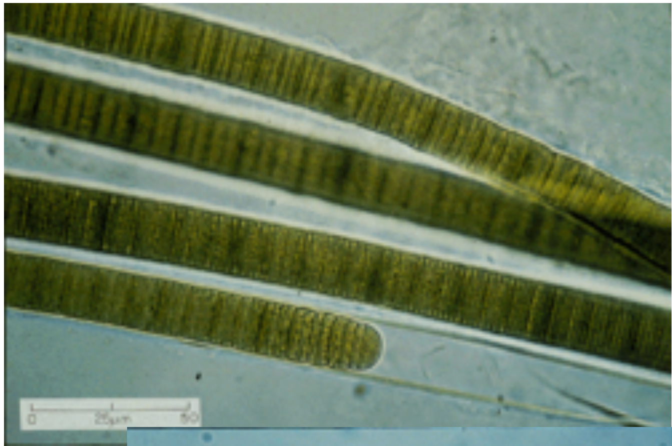
poor preservation but
relatively common components in
shallow-water carbonates

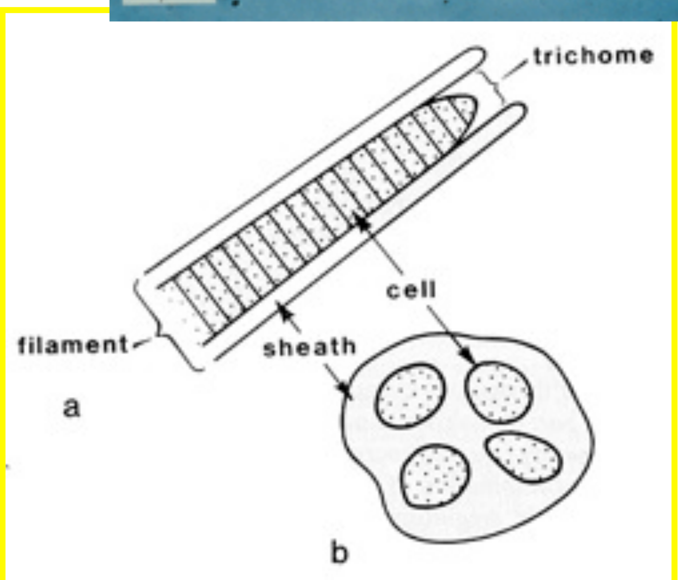
Cretaceous-Recent




Calcified Cyanobacteria
algal mat -Schizothrix

prokaryotes





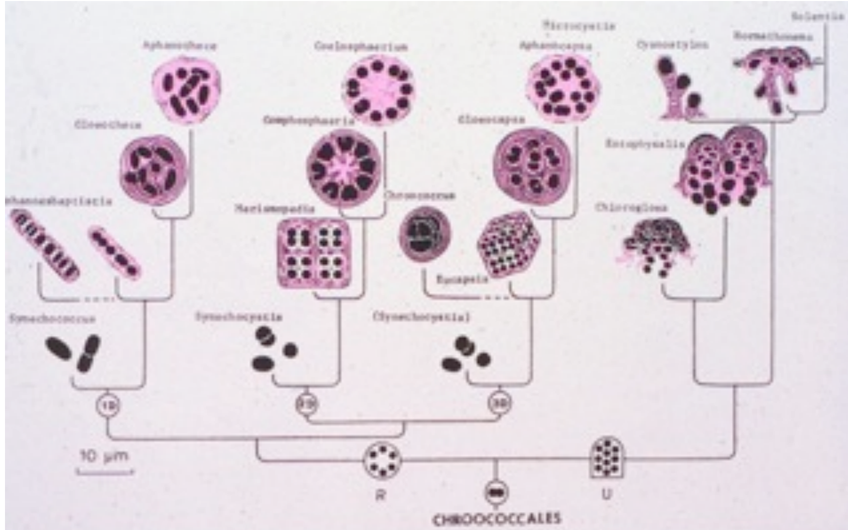


Fig. 1. Morphological affinities of coccoid cyanophytes: Chroococcales. Genera similar with respect to gel production are placed at the same level. The sequence from below upward includes genera with no, sparse, layered and diffluent gelatinous envelopes. 1D, 2D, and 3D = one-, two-, and three-dimensional cell-division patterns; R = radially symmetrical colonies (Chroococcaceae); U = unidirectional colonies with rows of cells (Entophysalidaceae).

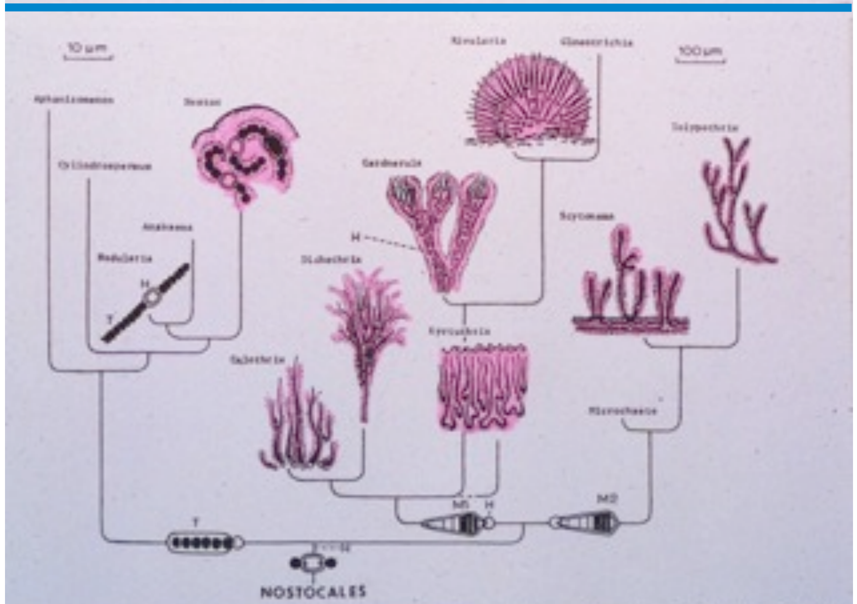
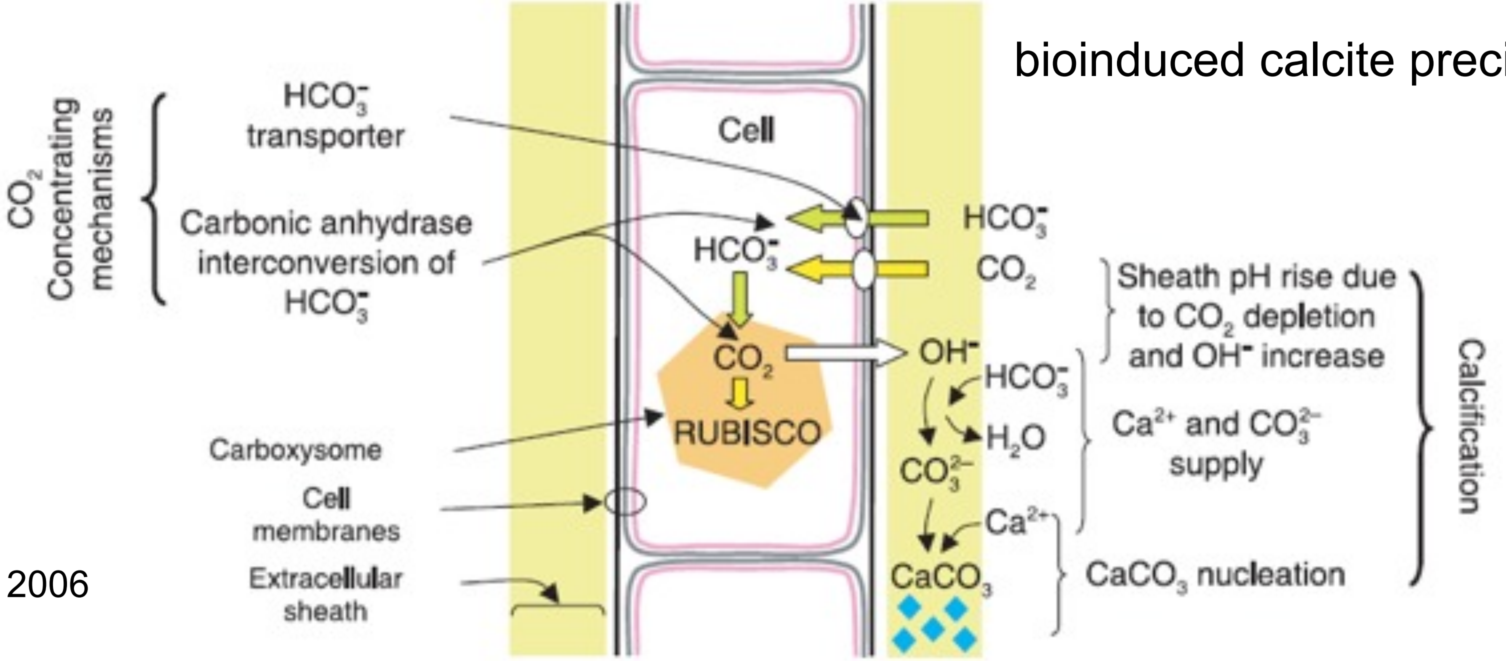
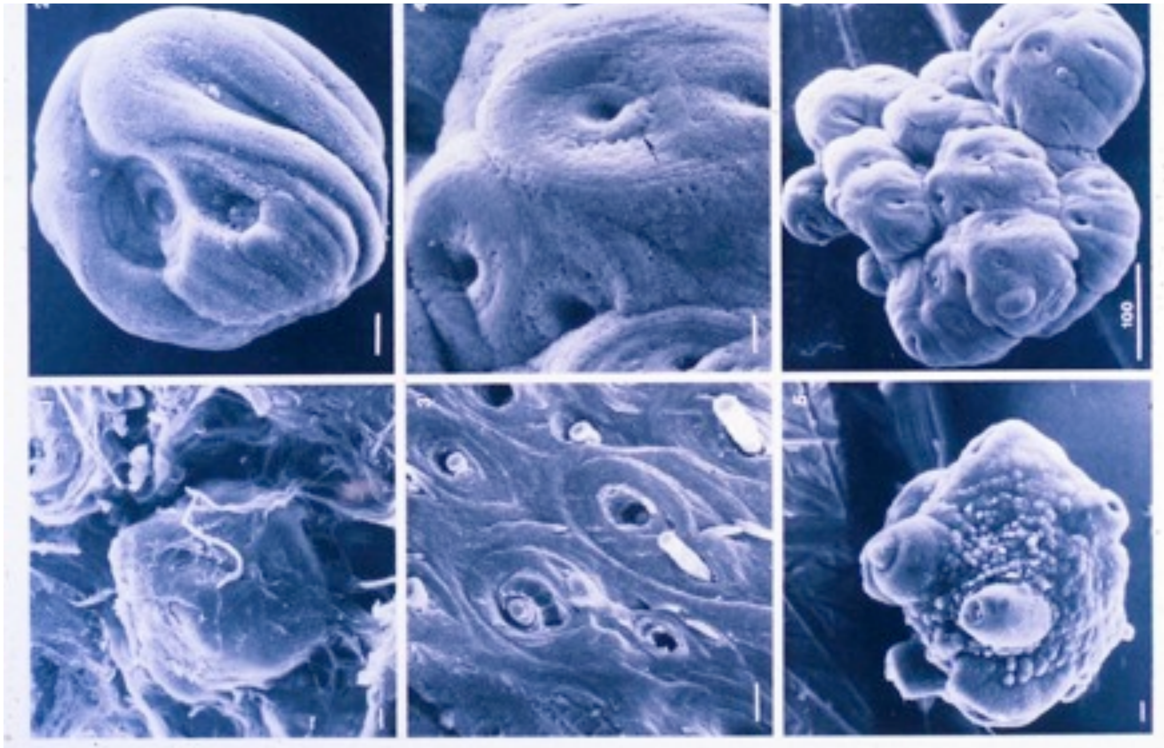


Fig. 4. Morphological affinities of filamentous cyanophytes: Nostocales. H = heterocyst formation; T = trichomes without differentiation in distinct "meristematic" zones (Nostocaceae); M1 = "meristematic" zones basal (or intercalary), trichome ends tapered (Rivulariaceae); M2 = "meristematic" zones subapical (Scytonemataceae).

bioinduced calcite precipitation

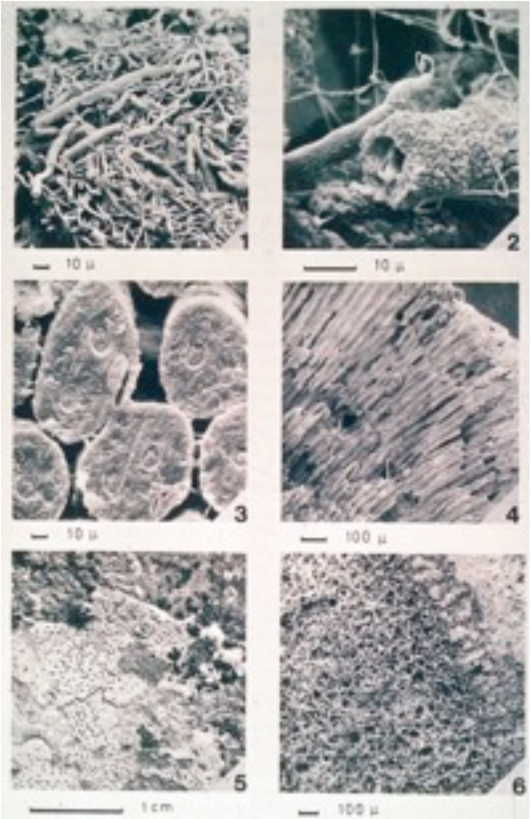


Riding, 2006



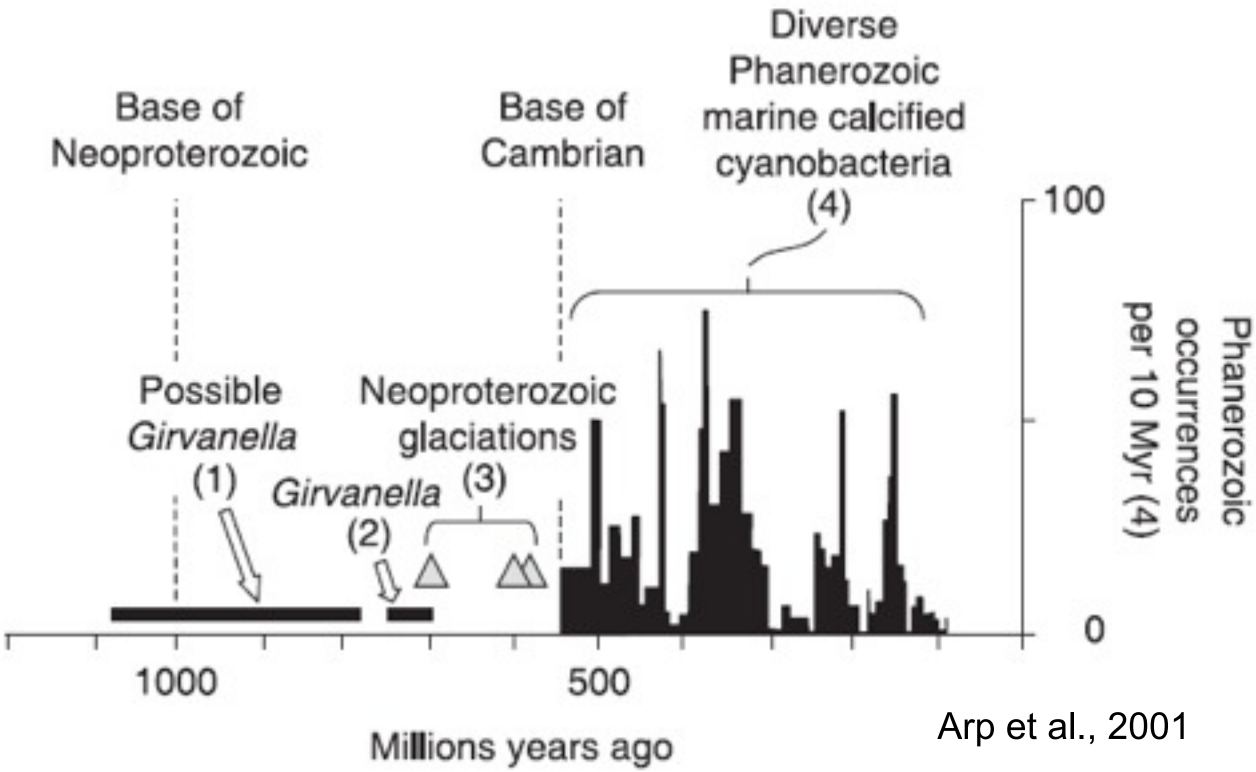
Golubic, 1993

calcification needs a high calcium carbonate saturation

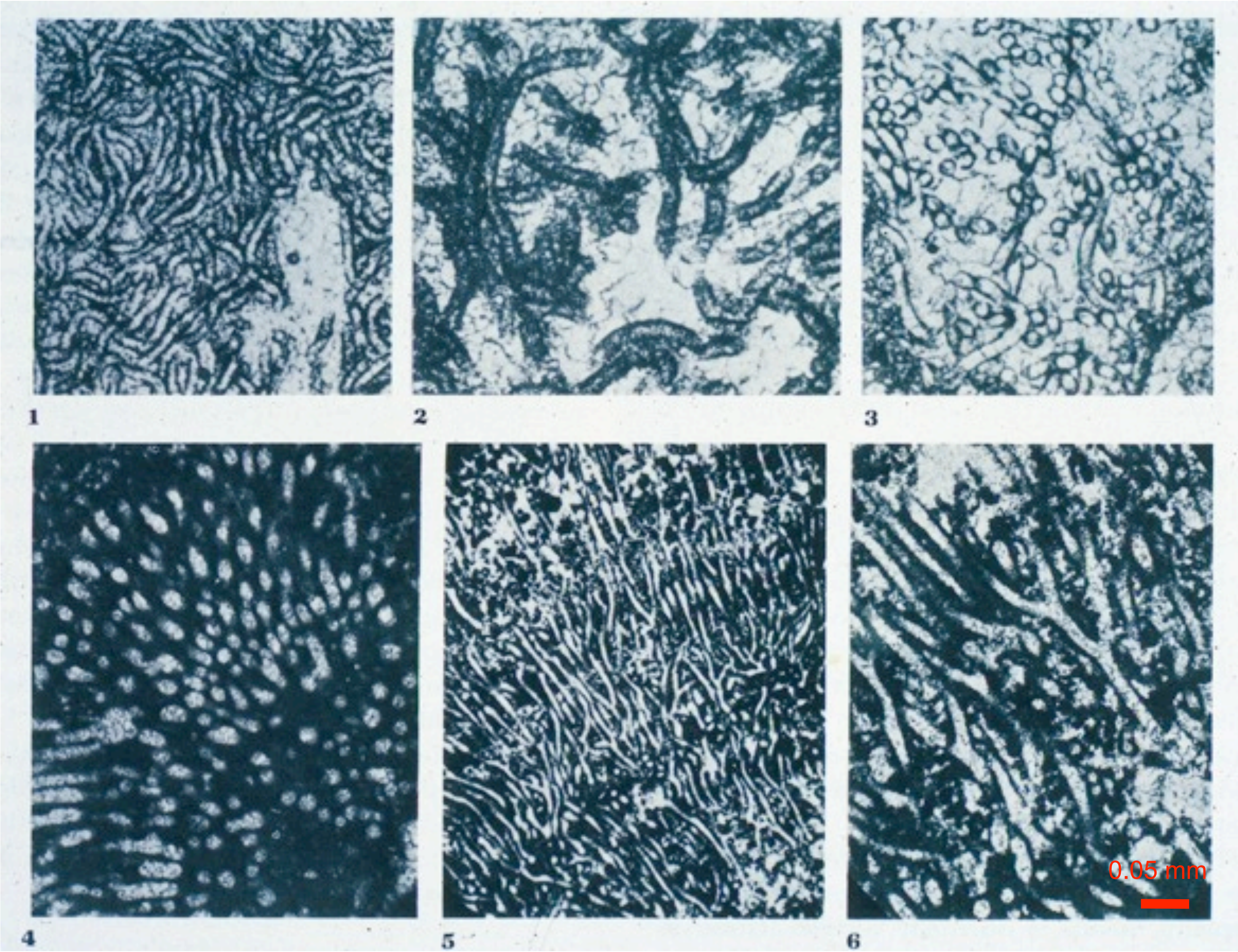


Golubic, 1993

present-day cynobacteria only calcify in fresh water

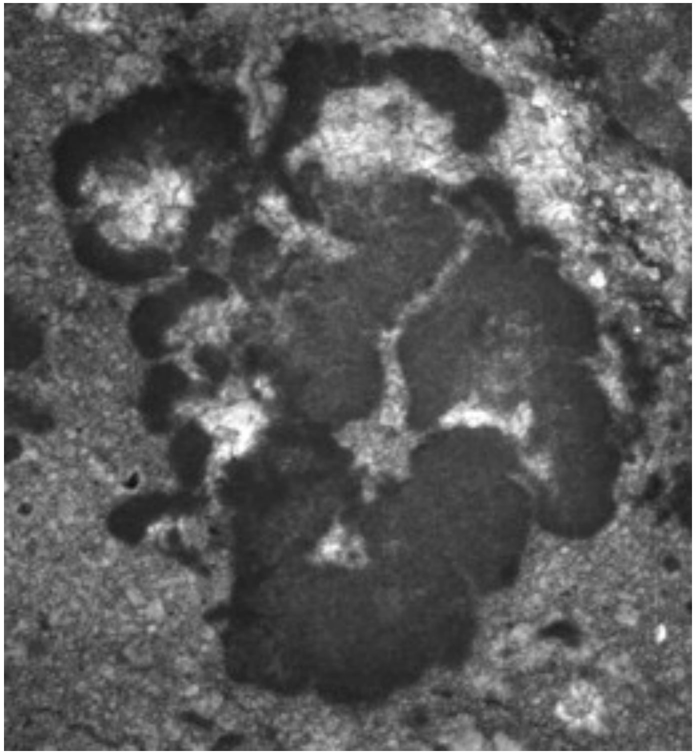


Arp et al., 2001

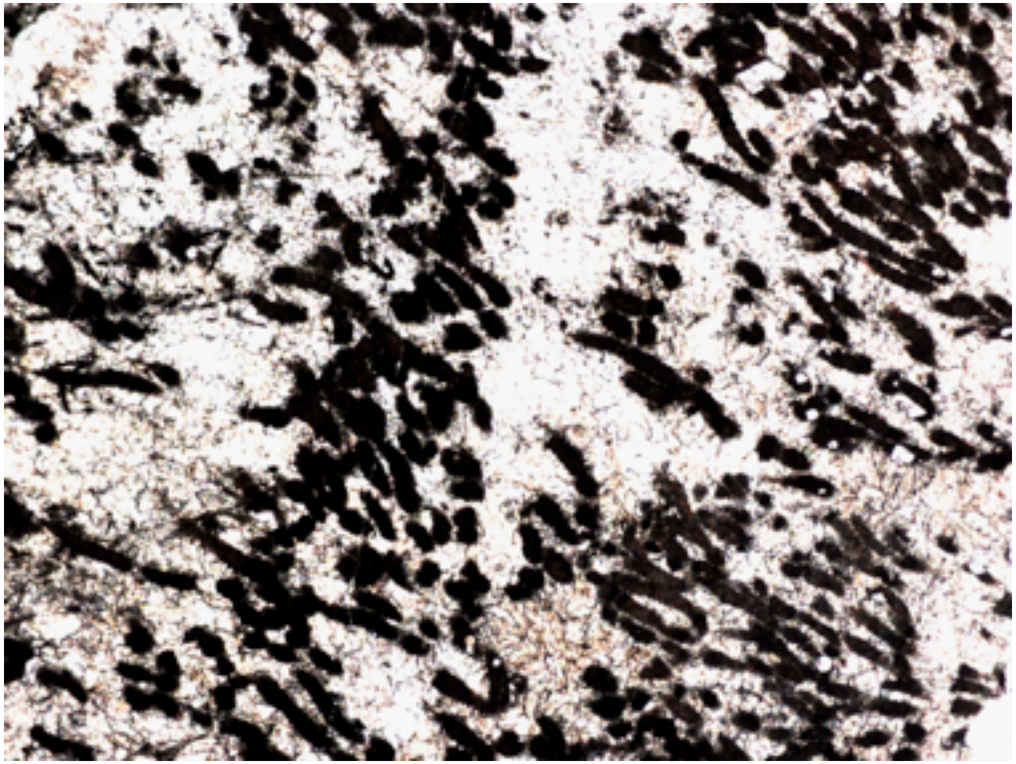


fossil calcified cyonabacteria

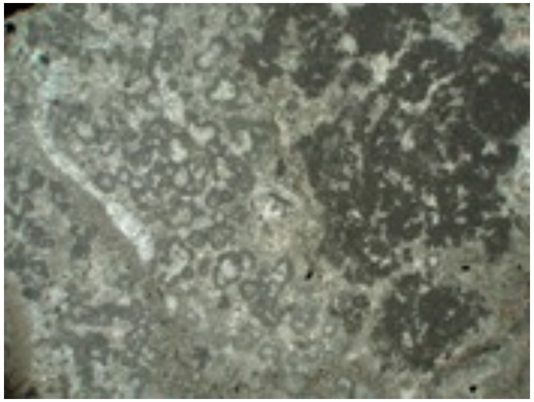
mainly occur in reef related carbonates



Renalcis, Cambrian, Morocco

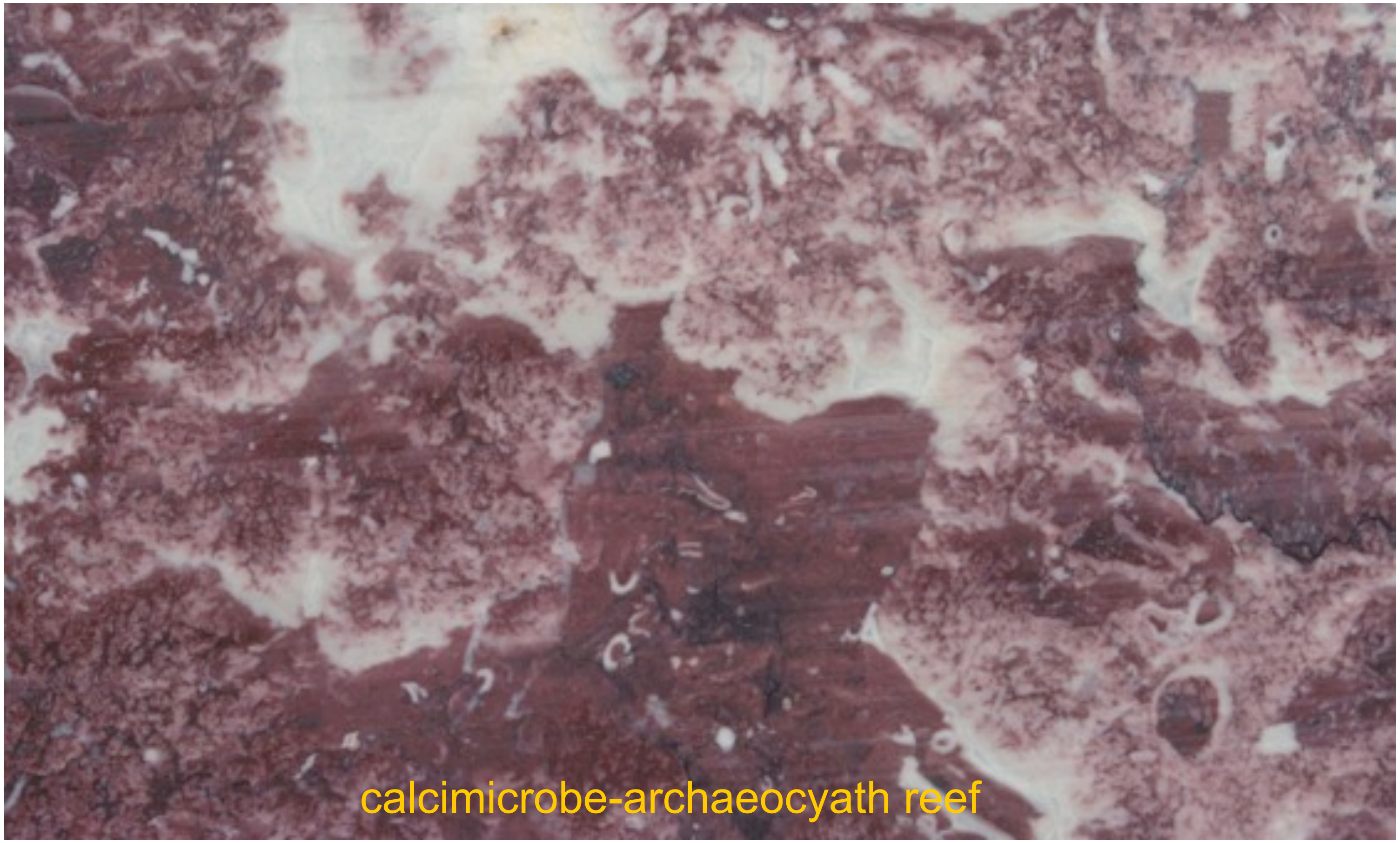


Epiphyton, Cambrian, Siberia

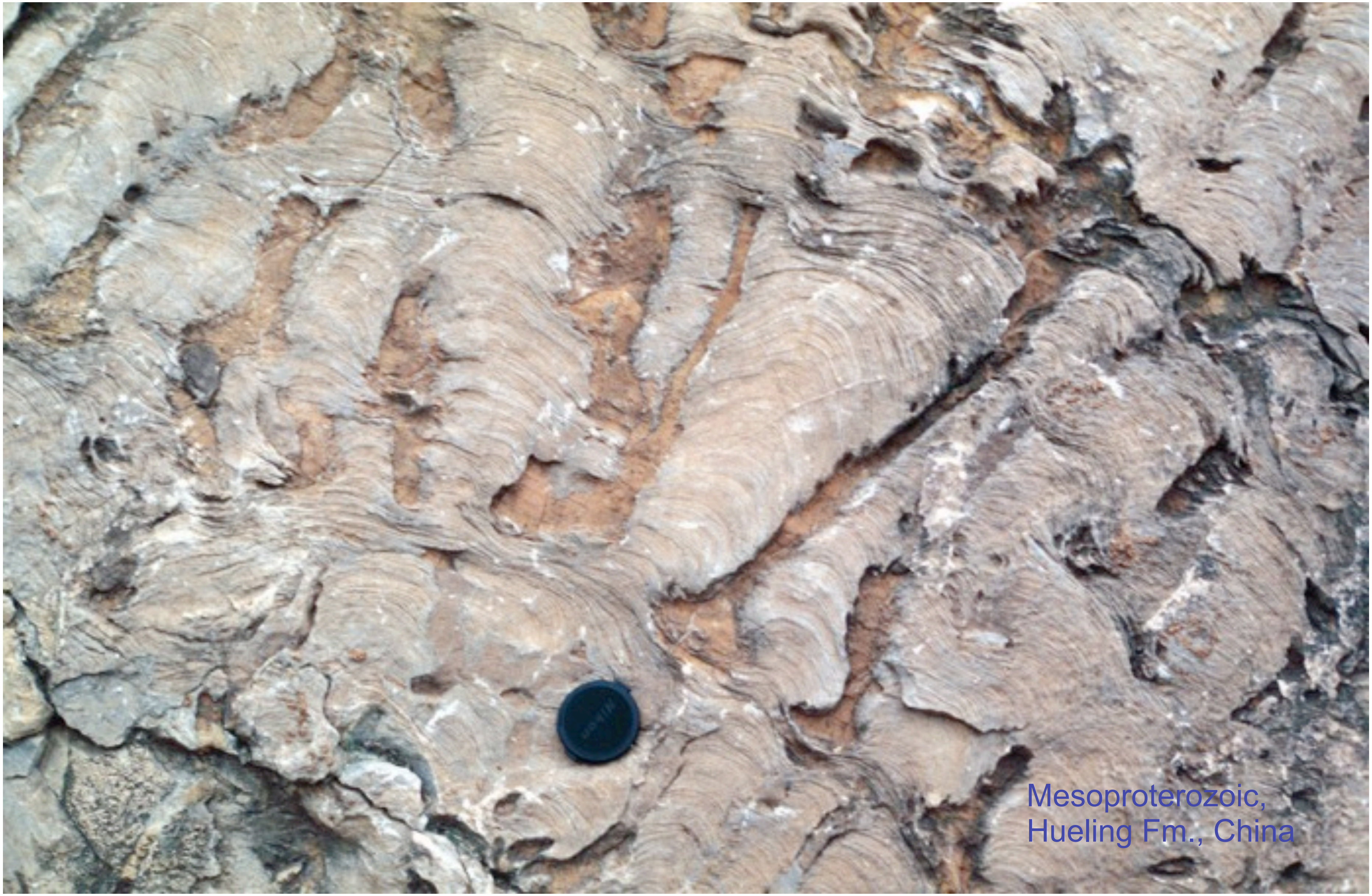


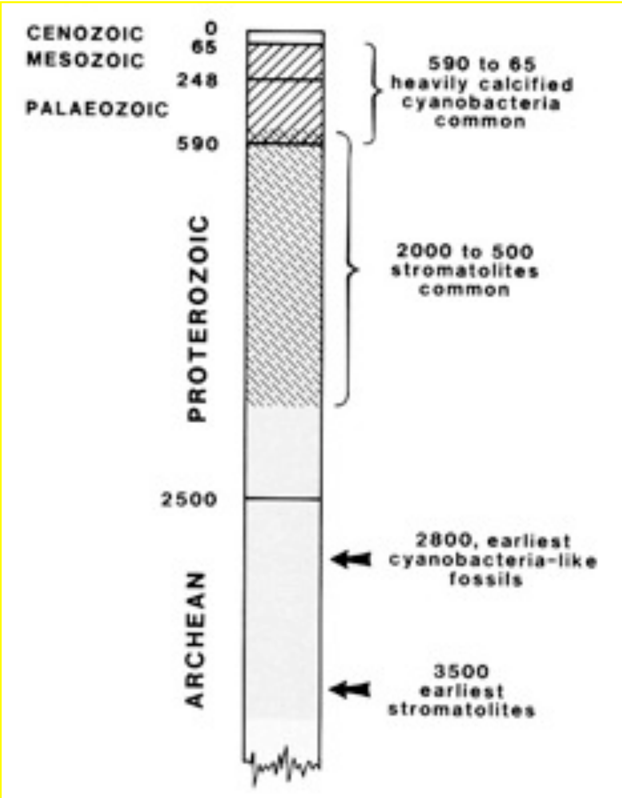
Can be important components in Early Palaeozoic reefs

Epiphyton and *Renalcis*, Early Cambrian, Morocco



So, what about stromatolites?




CENOZOIC
MESOZOIC
PALAEOZOIC
PROTEROZOIC
ARCHEAN
0
65
248
590
2500
590 to 65
heavily calcified
cyanobacteria
common
2000 to 500
stromatolites
common
2800, earliest
cyanobacteria-like
fossils
3500
earliest
stromatolites


Nikon

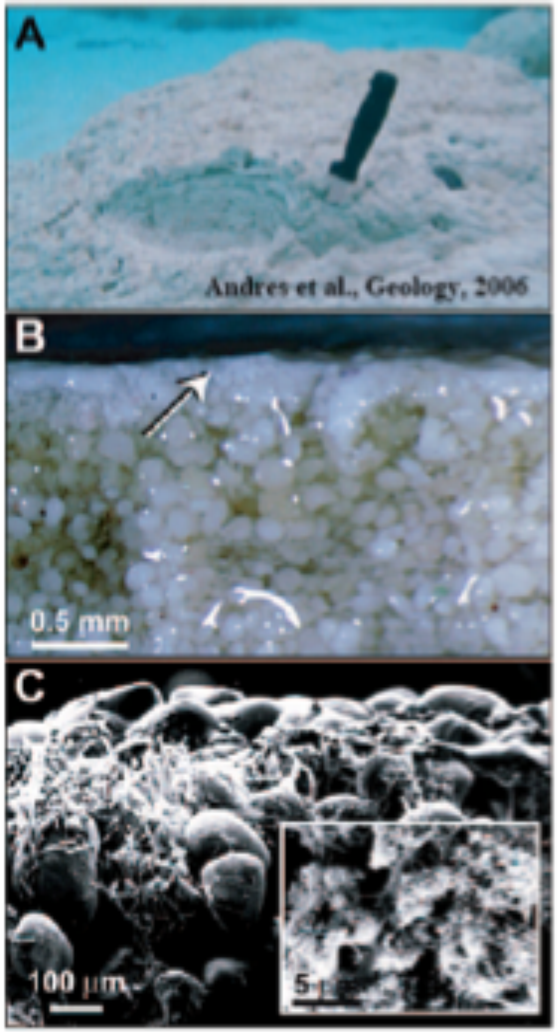
Hammelin Pool, Shark Bay
(Western Australia)

web page Nature Shark Bay

Ooid sand shoals and cays occur in highest-energy areas close to platform margins


Highbourne Cay, Bahamas
(Photo: Miriam Andres)


Highbourne Cay, Bahamas
(Photo: Miriam Andres)

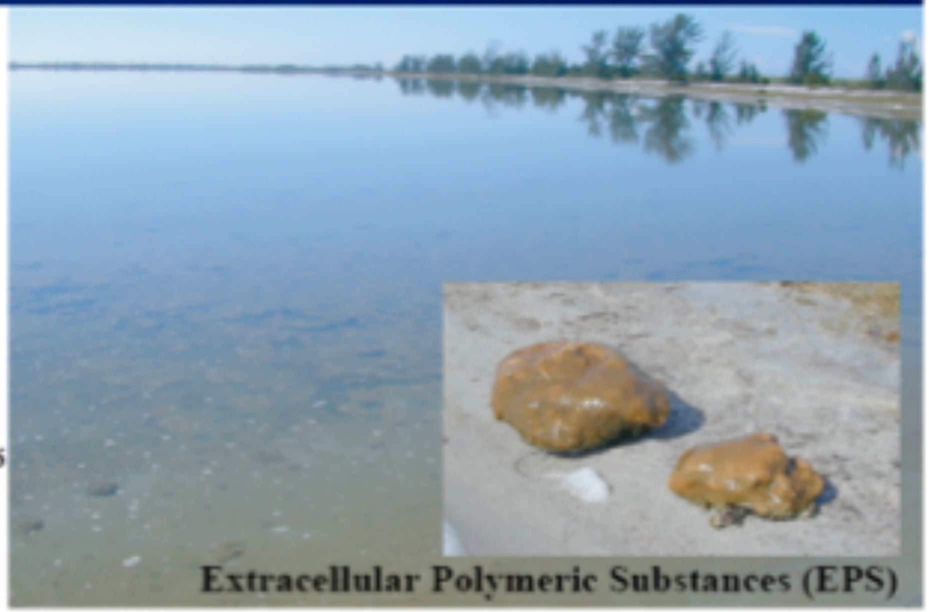

A
Andres et al., Geology, 2006
B
0.5 mm
C
100 µm


2 cm
Trapping & Binding

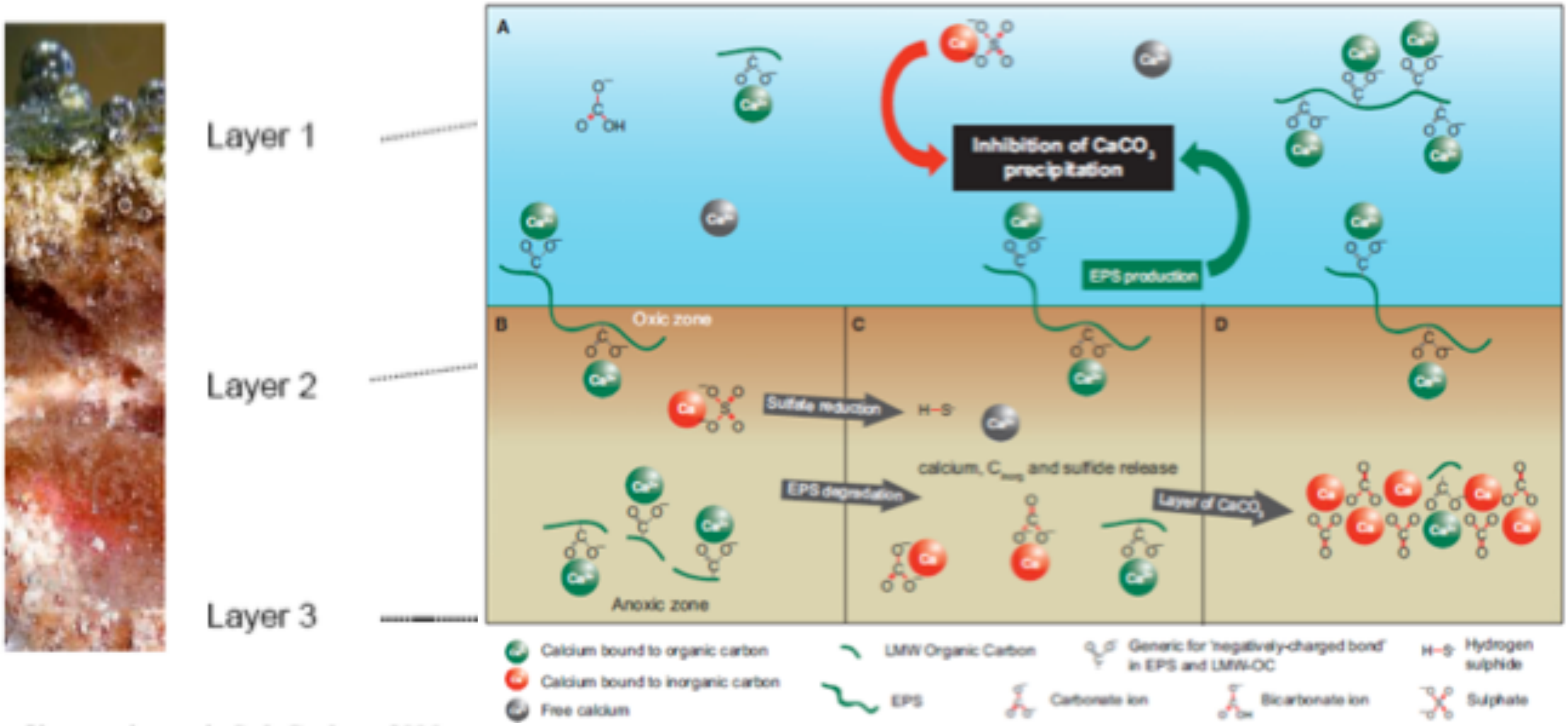
- Hypersaline
- Shallow (<2m) depth
- Anoxic bottom water
- Microbial mats
- Stromatolite growth
- Dolomite formation

Vasconcelos et al., Sed. Geology, 2006

Geomicrobiology Laboratory
ETH Zürich



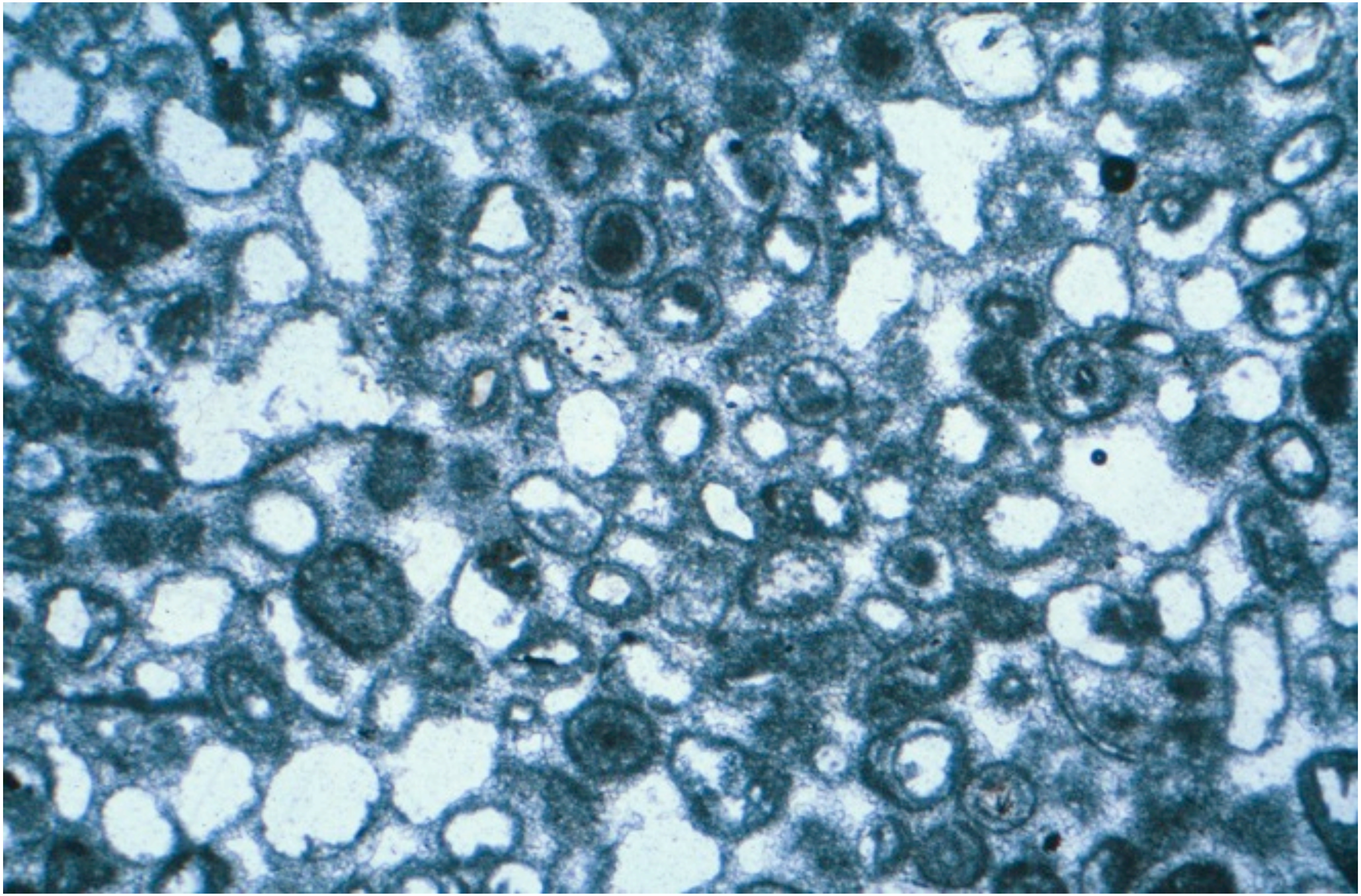
SEM of minerals in a Lagoa Vermelha stromatolite/mat



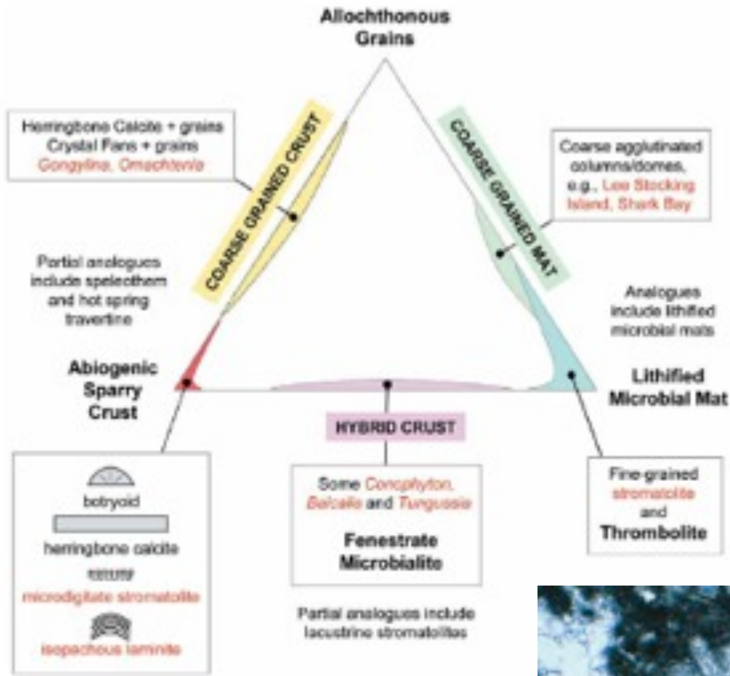
Vasconcelos et al., Sed. Geology, 2006

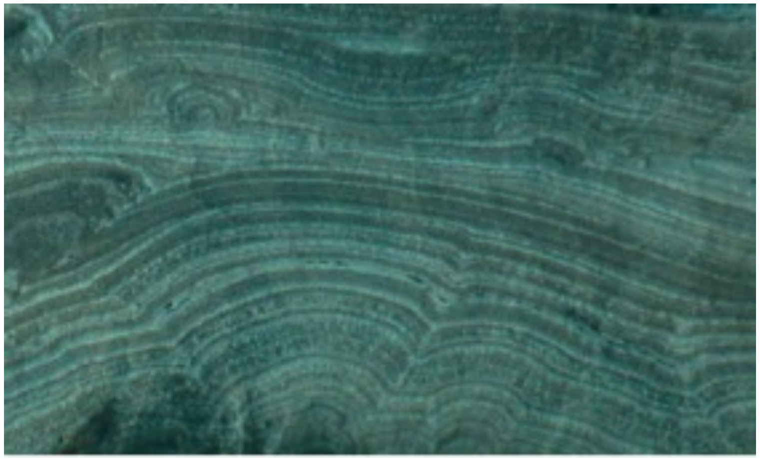
Taken from Glunk et al. (2011)

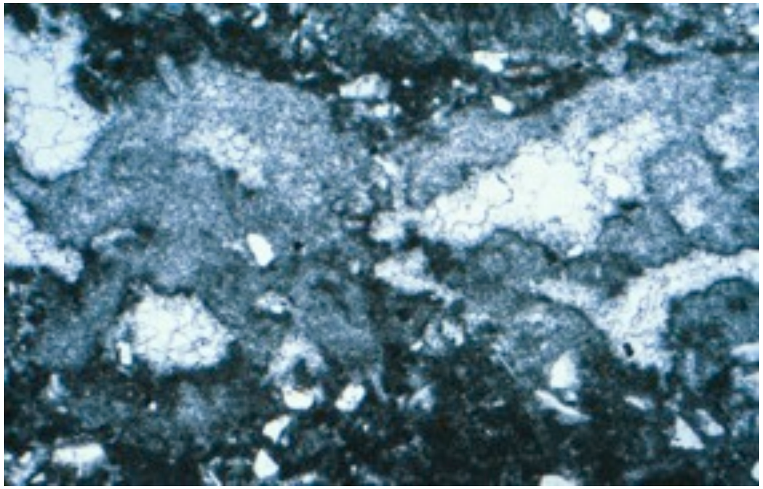
Messinian, Almería Basin



Ancient stromatolites



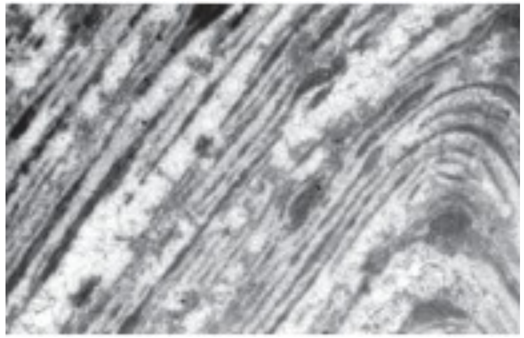




Society Cliffs Formation, Baffin Island, ~1.2 Ga, width of view, ~7cm. Riding (2008)

Base of the Proterozoic, China, North of Beijing

some Archaean and Early Proterozoic stromatolites can be inorganic precipitates



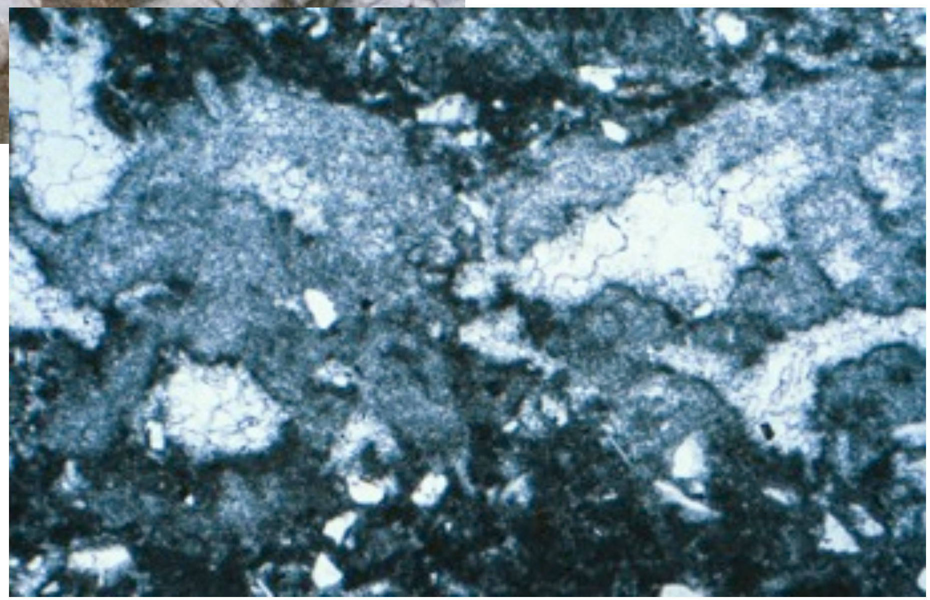
width of view 8 mm

other probably are hybrid combinations of inorganic precipitates and bioinduced calcification

Conophyton

Wumishan Formation,
Mesoproterozoic,
~25 km north of Beijing

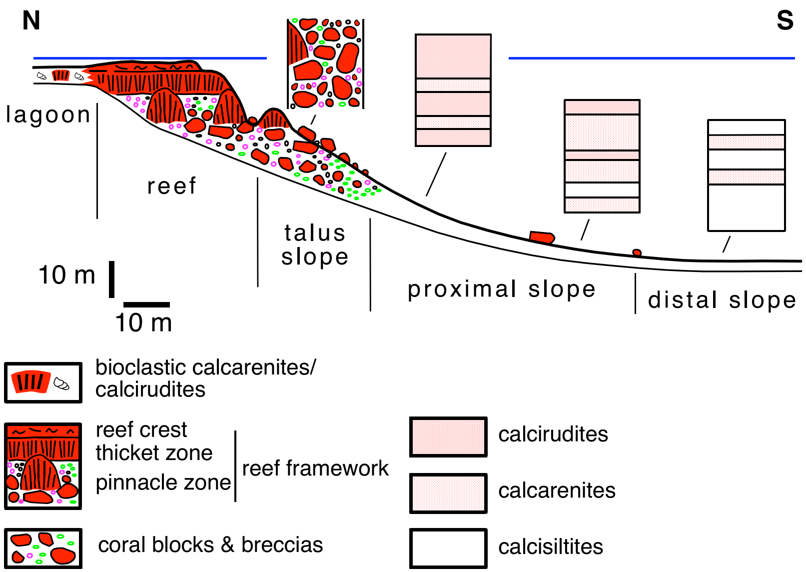
Mesoproterozoic,
Hueling Fm., China

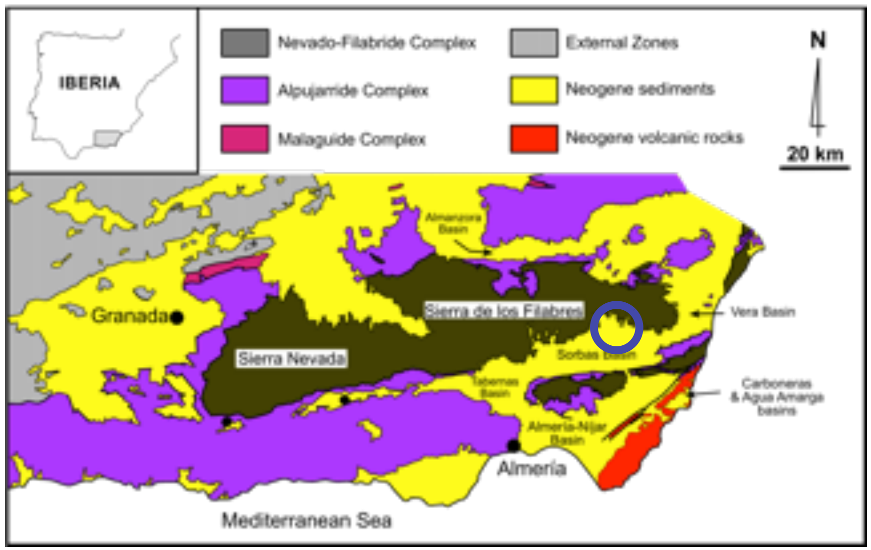


other formed in microbial mats as a result of synsedimentary calcification associated with oxygenic photosynthesis and bacterial sulphate reduction

Microbialites in reefs

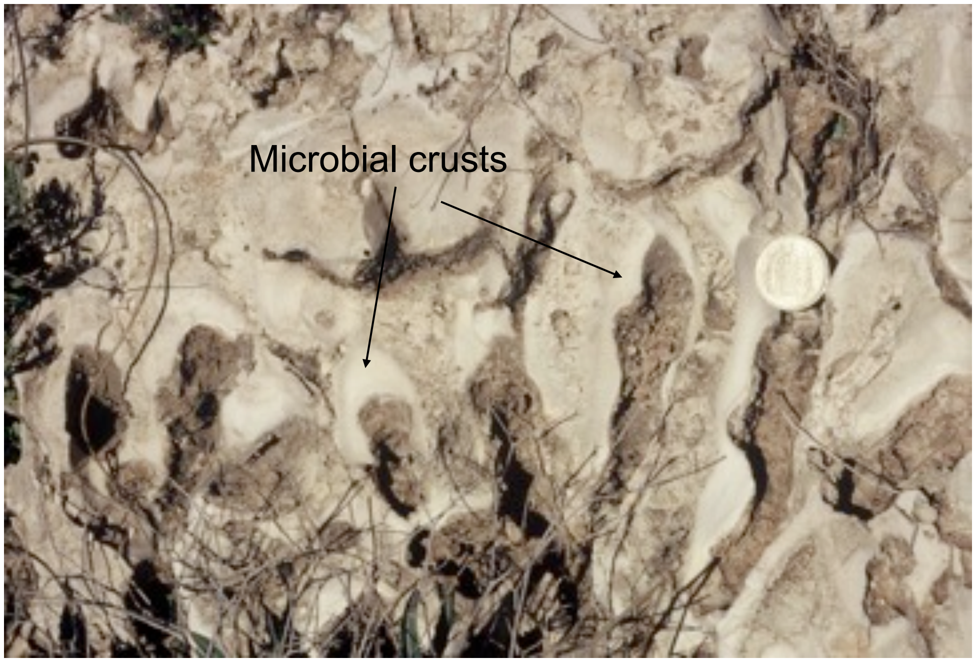
Caritiz reef in the Sorbas Basin

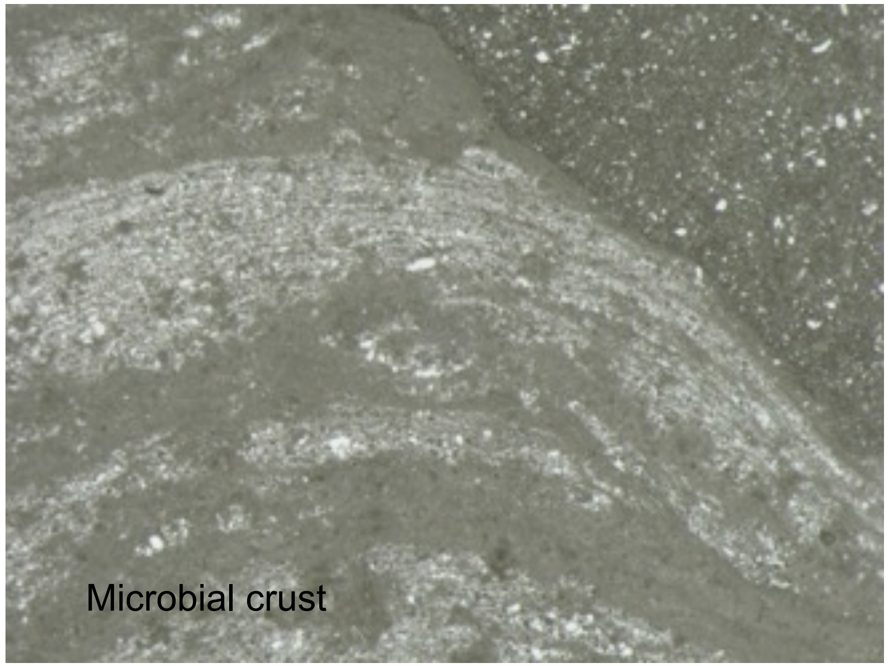


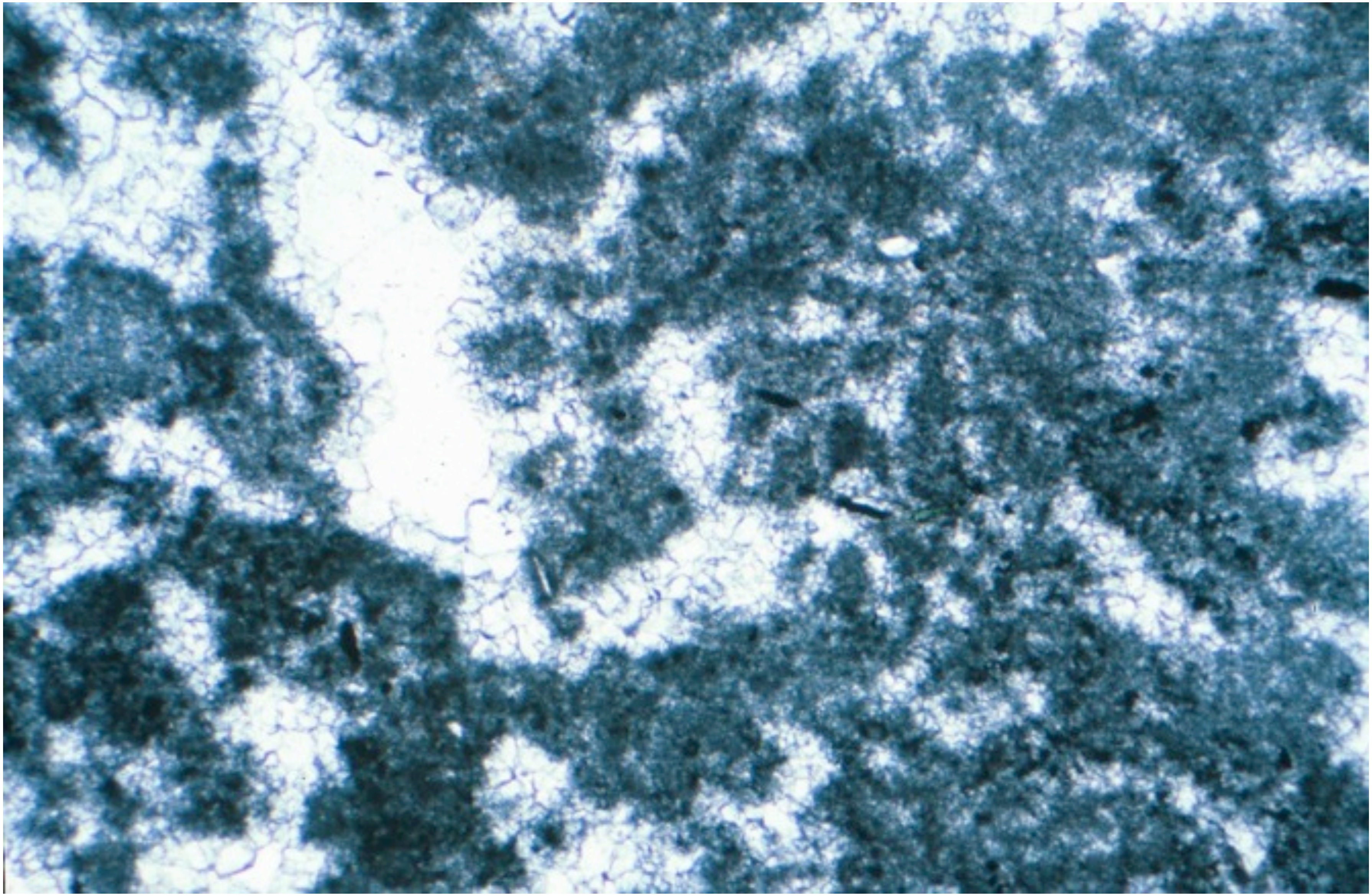


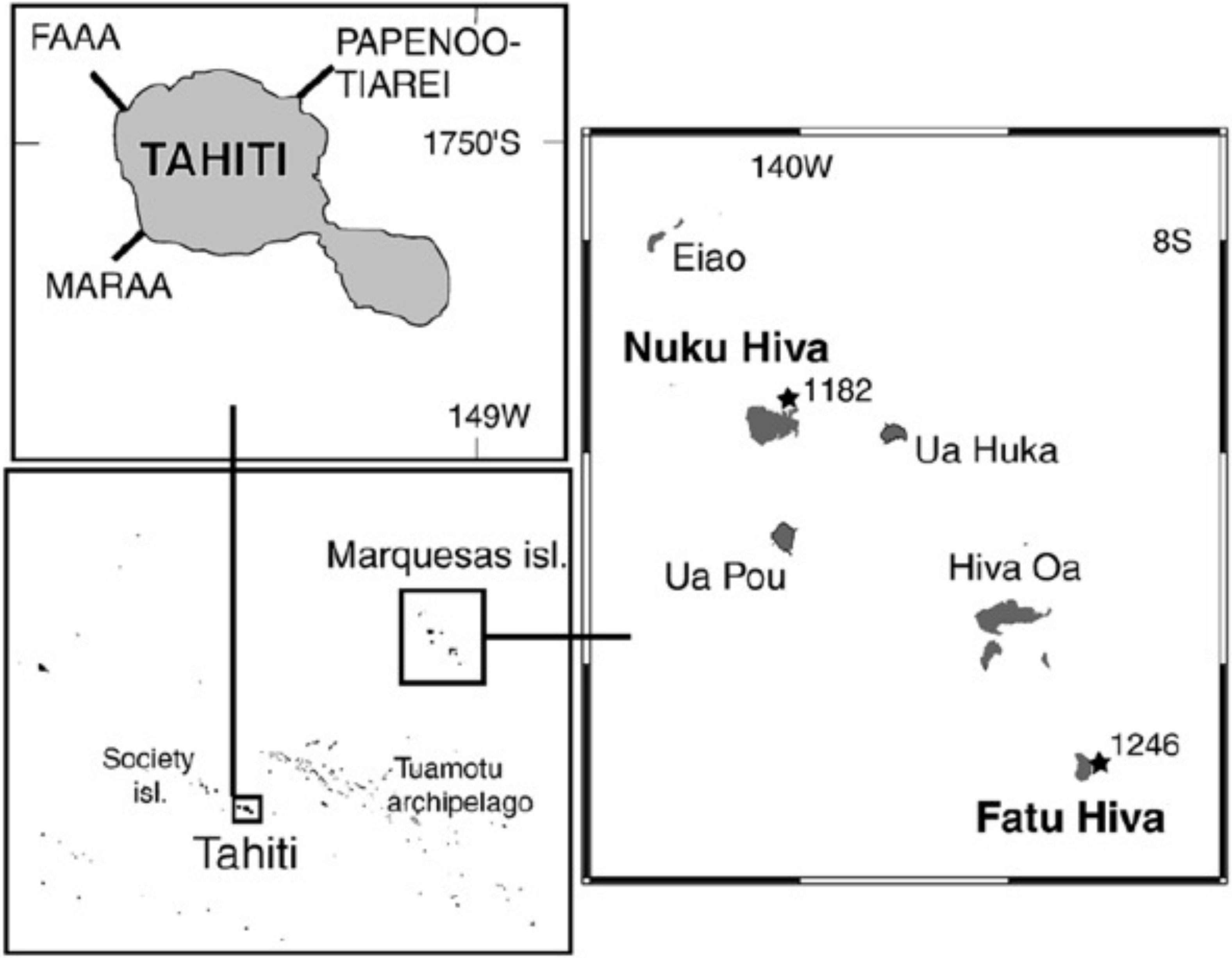

Stick-like *Porites*


Stick-like *Porites*

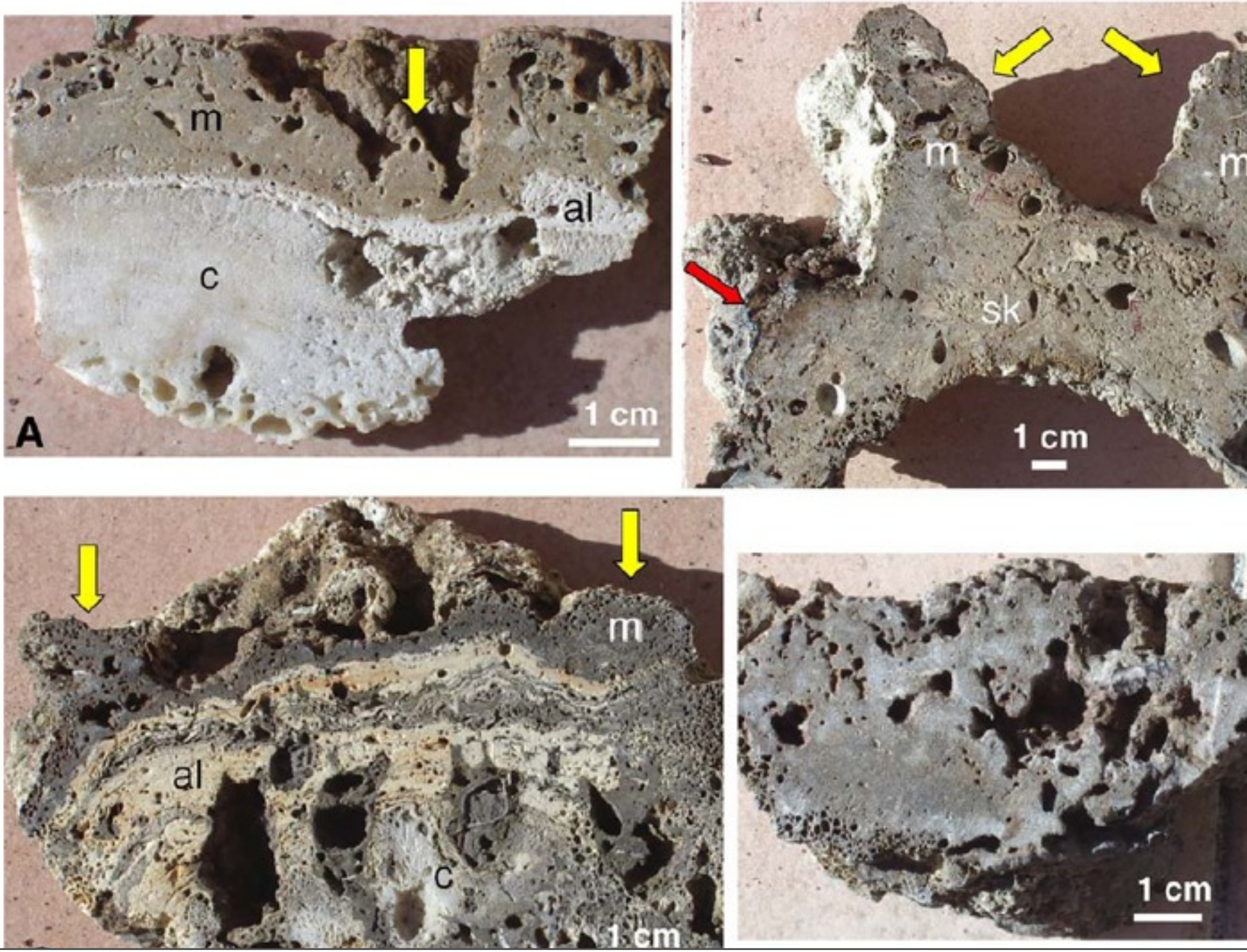

Microbial crusts


Microbial crust





Camoin et al. (2006)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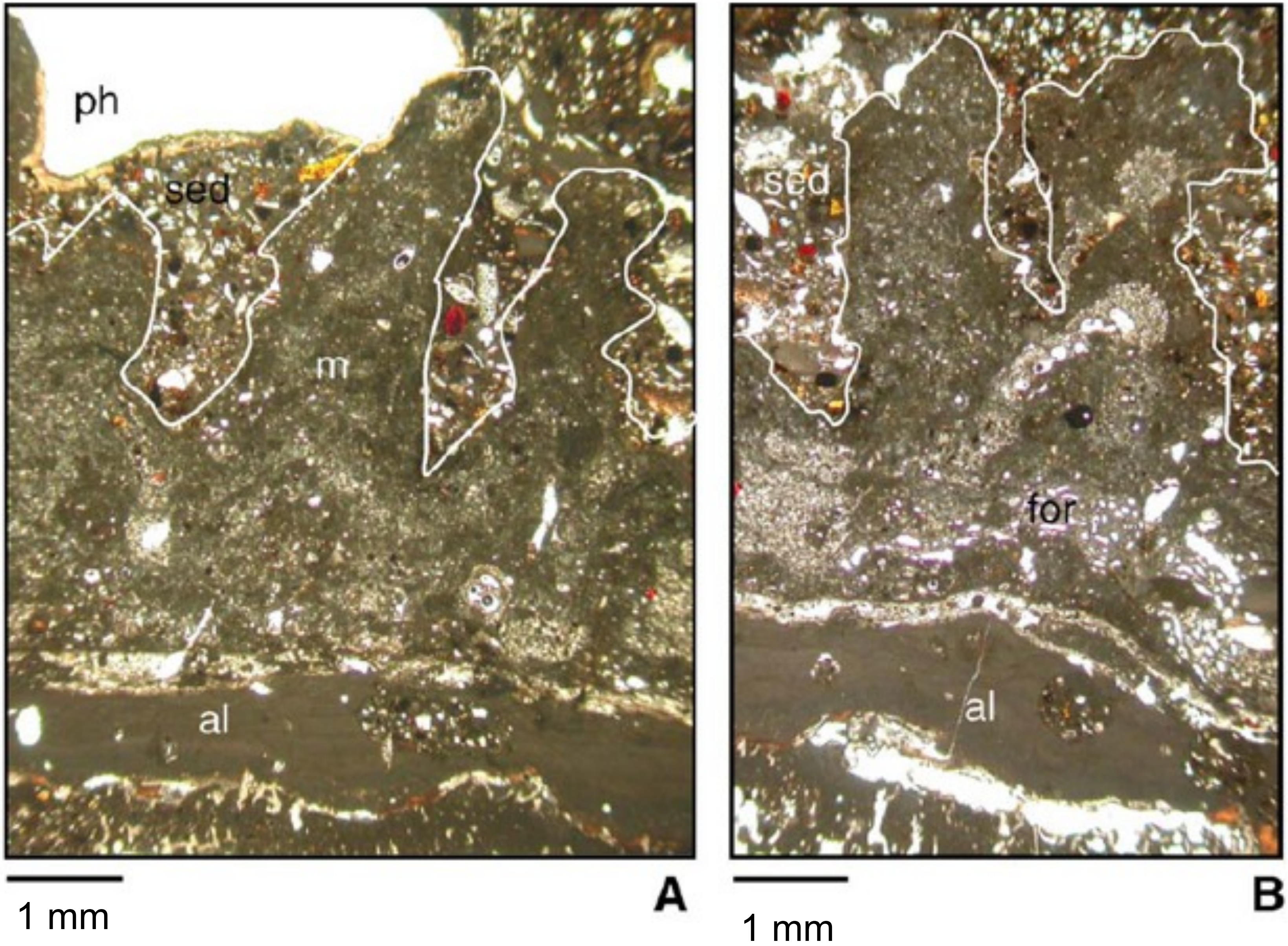
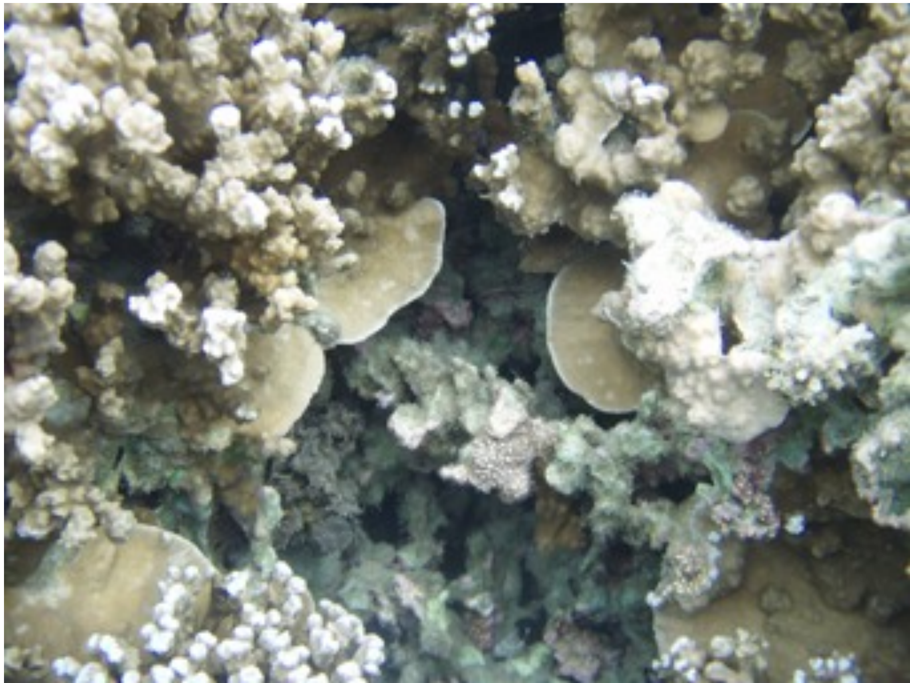
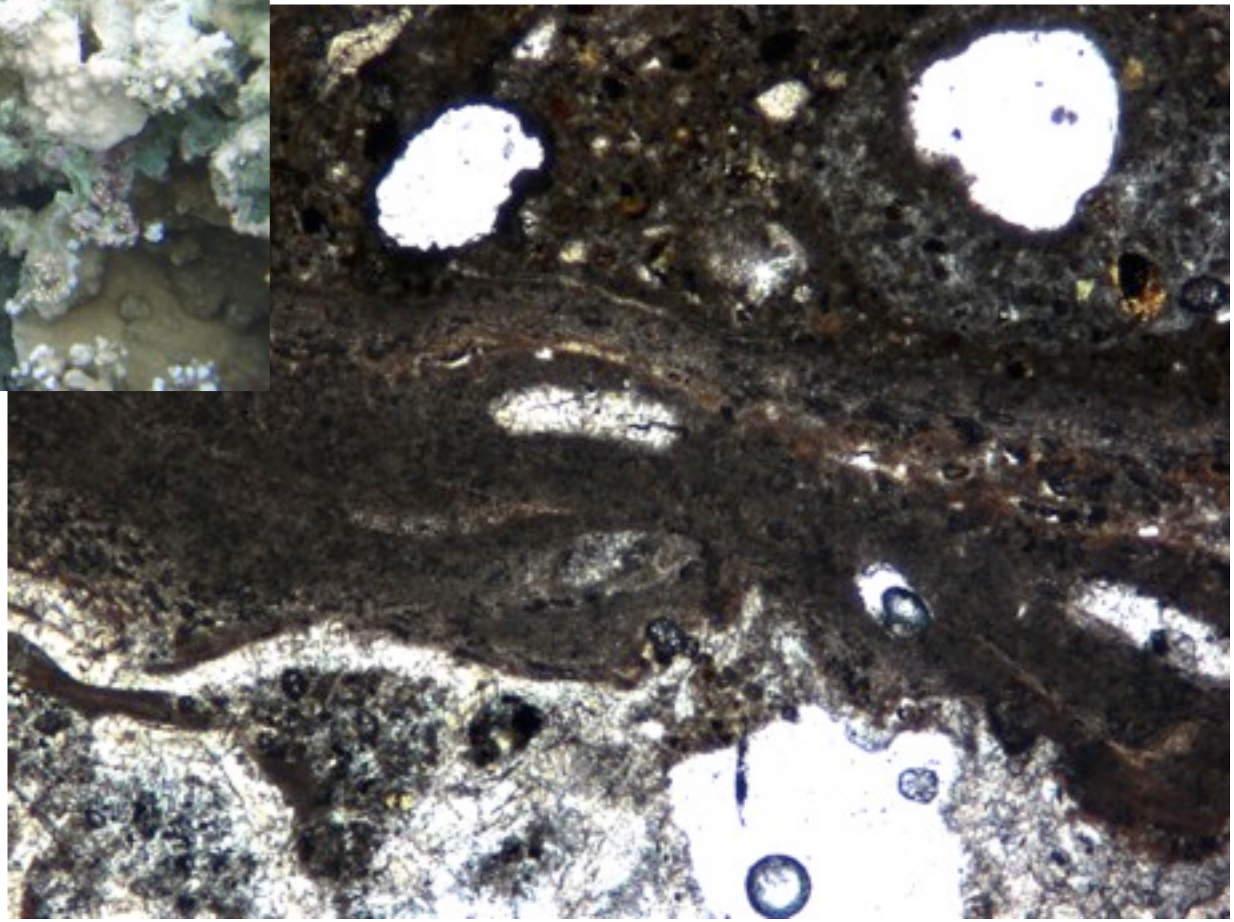


Camoin et al. (2006)

sulphate reducing bacteria

As light is the major controlling factor, crevices, caves and cavities have a “deepening” effect, which has to be discarded





“shade” corallines are “deep-water” assemblages ocurring with shallow-water algae in the same sample/interval, usually inmediately predating microbial crusts