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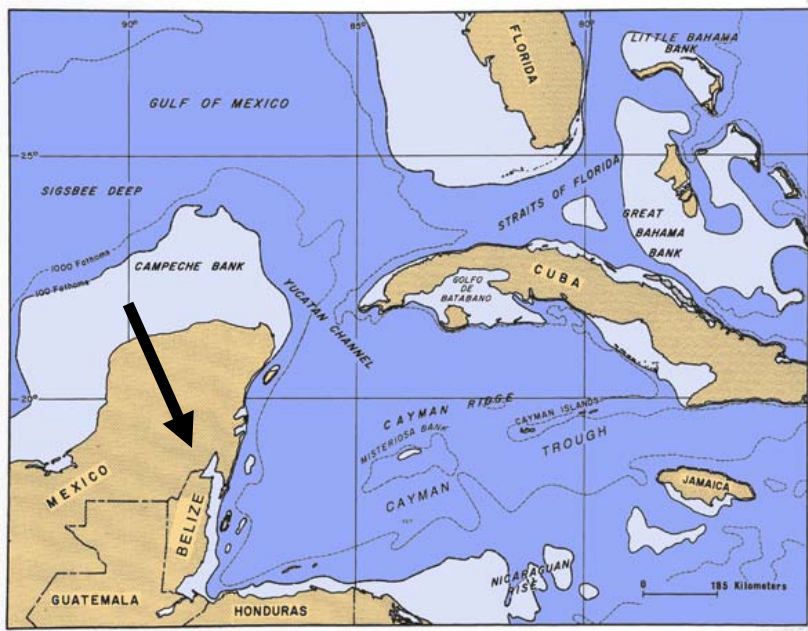
**Giant Holocene
Freshwater Microbialites (Stromatolites)**
Bacalar, Quintana Roo, Mexico
(Holoceno gigante De agua dulce
"estromatolitos")

Take-home Points

- Laguna Bacalar home to rare impressive freshwater microbialite structures (one of largest in world)
- Great geologic value as paleoenvironmental indicators - need study
- Archives of environmental change - useful!
- Intimately tied to water chemistry geology of area
- Great potential in ecotourism (educational topic unique)
- Bacalar microbialites are already in danger from development of area
- Still much to do to fully understand them



Remember Bob Ginsburg's Points!



annual prec.:
1,400 mm

Bacalar lagoon

satellite image

Coccolitos Stromatolites



MEXICO

Chetumal

Chetumal
Bay
(Brackish)

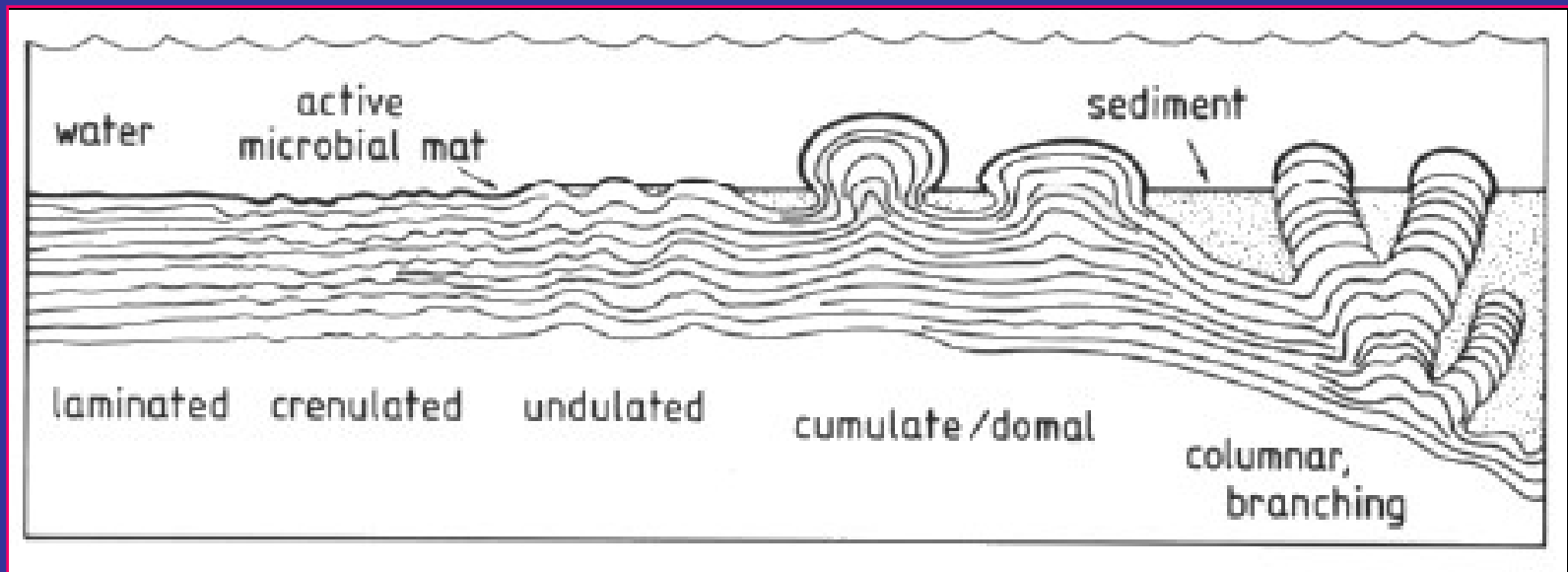
BELIZE

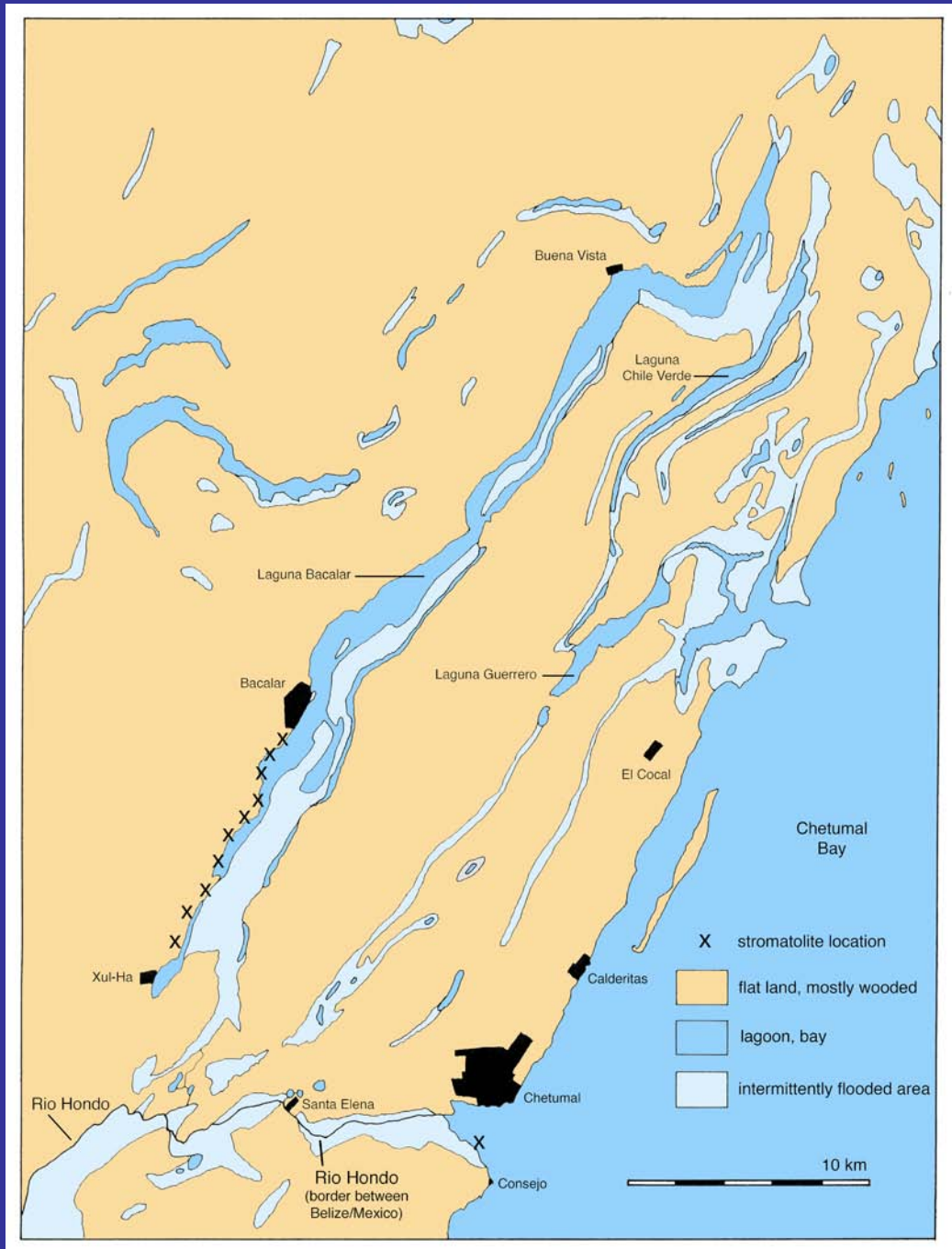
Rio Hondo

(Rasmussen et al.
1993)

Microbialites & Stromatolites

- **Microbialites** - laminated organo-sedimentary structures formed by matting behavior of bacteria & algae
- **Oncoids** - "algal biscuits"
- **Thrombolites** - microbialites w/clotted internal structure
- **Stromatolites** - domal to reef-like microbialite organo-sedimentary structures formed by accretion
 - Usually calcareous in composition when living
 - Most Pre-Phanerozoic stromatolites silicified





- 10 km stretch of microbialites between Bacalar & Xul-Ha
- One of longest freshwater occurrences globally
- Appear to be associated with cenotes (*steep-walled karst cave*) in Neogene limestones
- Fault control?

10 km de microbialites entre Bacalar y Xul-Ha

Uno de los sucesos a nivel mundial de agua dulce más largo

Parecen estar asociados con cenotes (escarpadas paredes karst cueva) en calizas Neógeno

Bacalar lagoon, view to NE

- *max. lagoon depth 15 m*
- *stromatolites in shallow areas*
- *depths cenotes ca. 90 m*

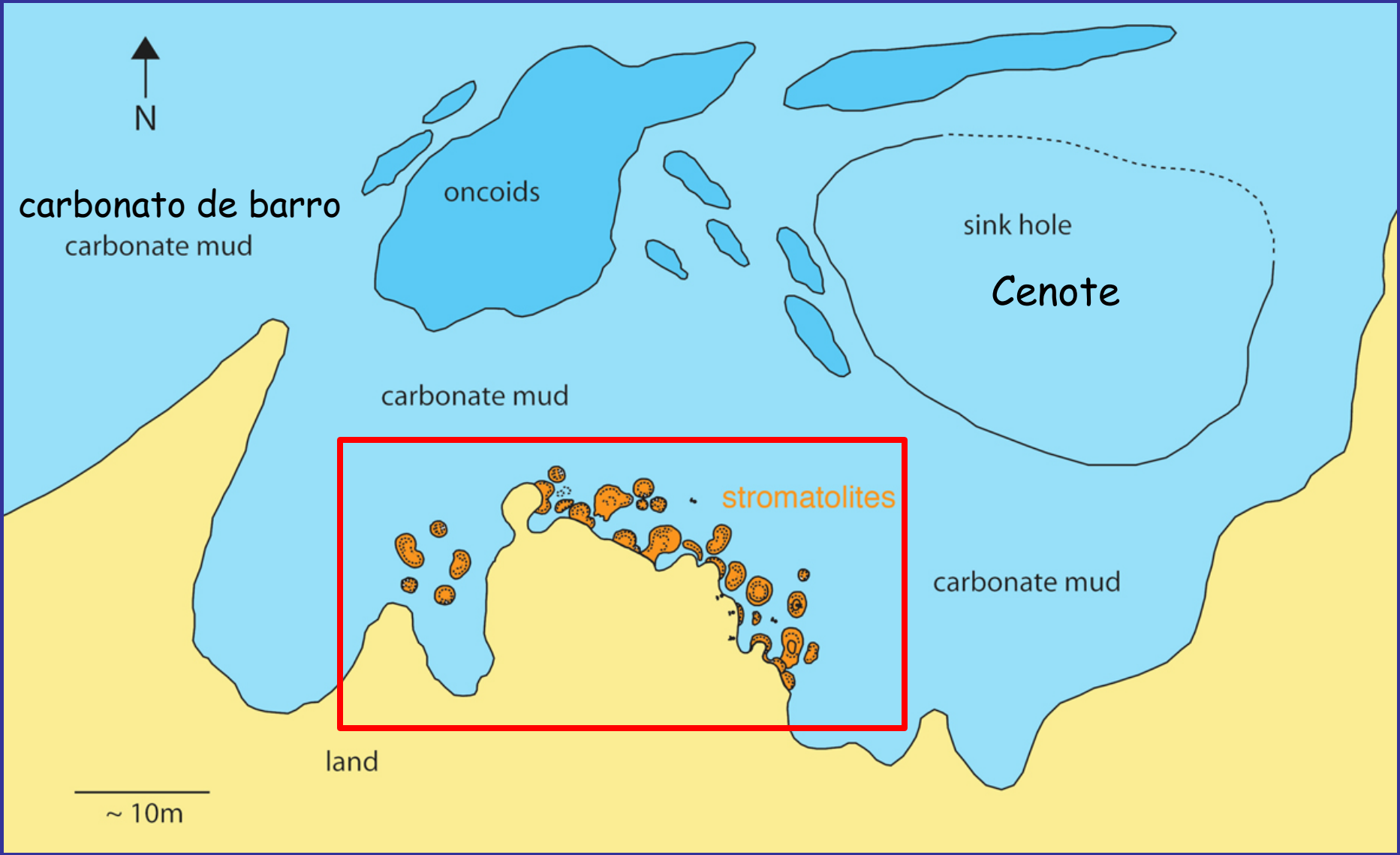
Location 2 (Coccolitos)



Cenote

- *máx. laguna de 15 m de profundidad*
- *estromatolitos en áreas*
- *profundidades cenotes ca. 90 m*

Map of Location 2 (Cocolitos)



Location 2 (Coccolitos)

Size:

- up to 2 m high
- up to 4 m across
- "prograding" or "micro-atoll"
- microbialites

("prograding" o "micro-atolón"
microbialites)



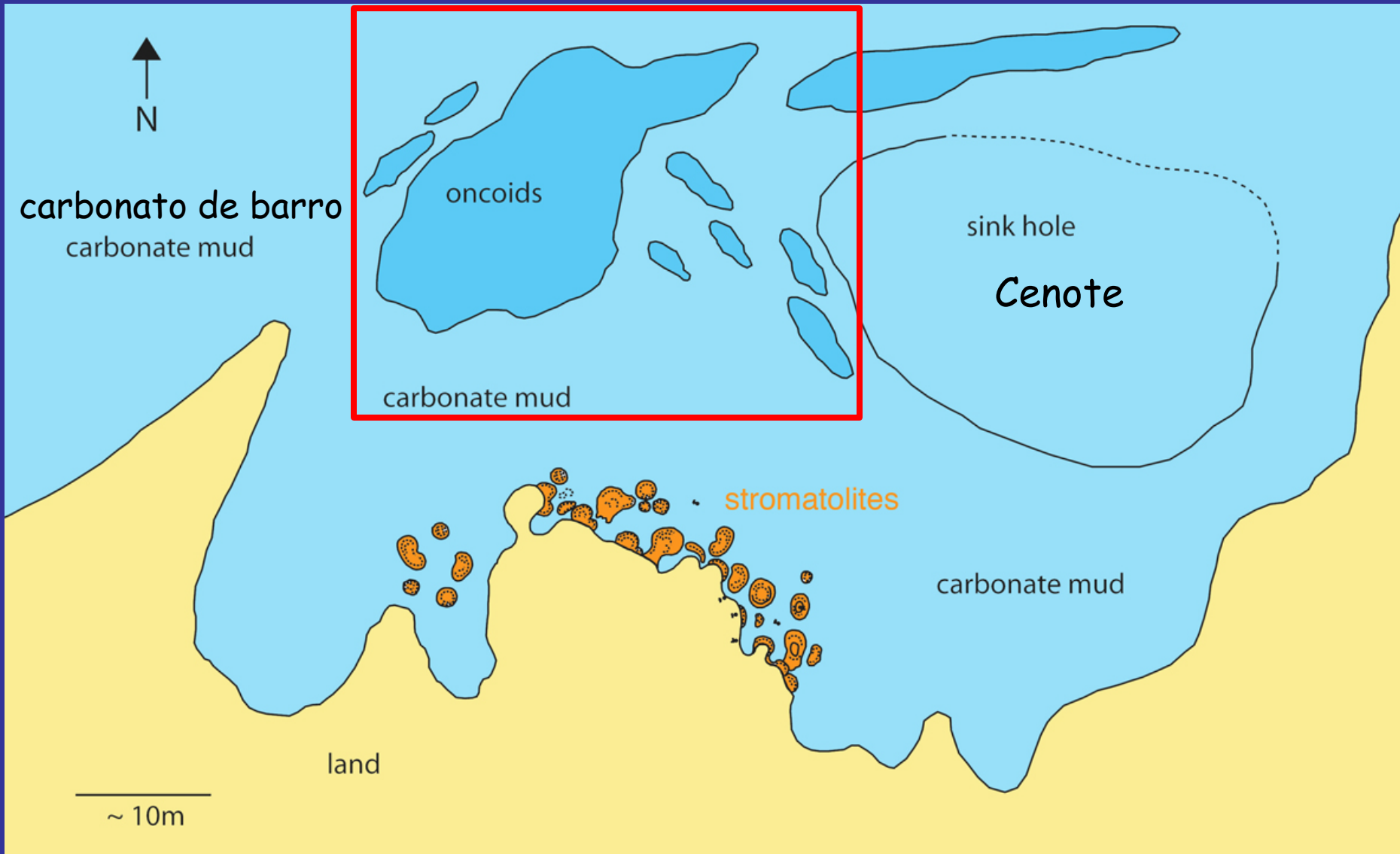
View Underwater



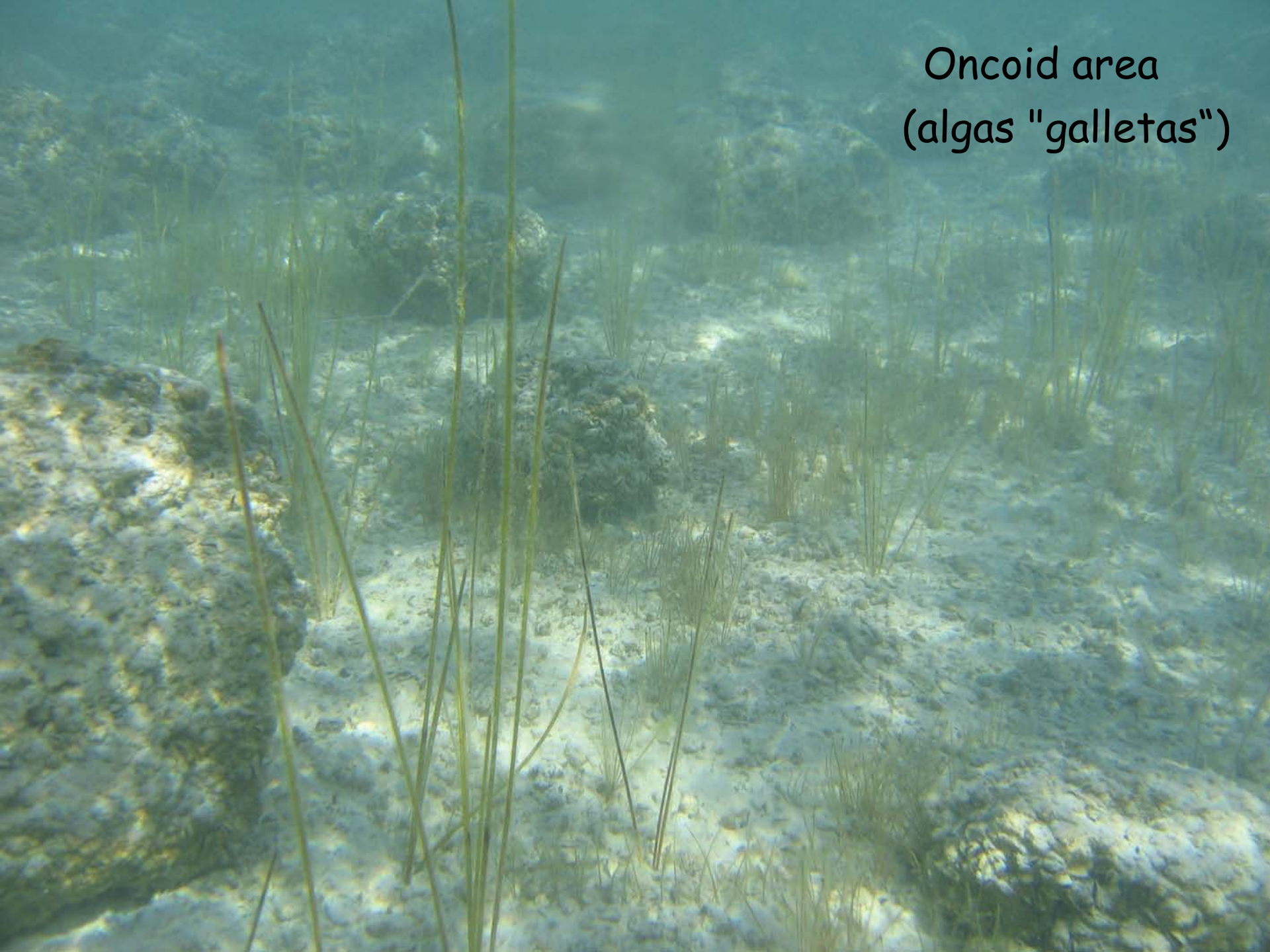
Invasive (?) Dreissinid Mussel Encrustation
Mytilopsis sallei

(Invasoras (?) Incrustaciones de Mejillones
Mytilopsis sallei)

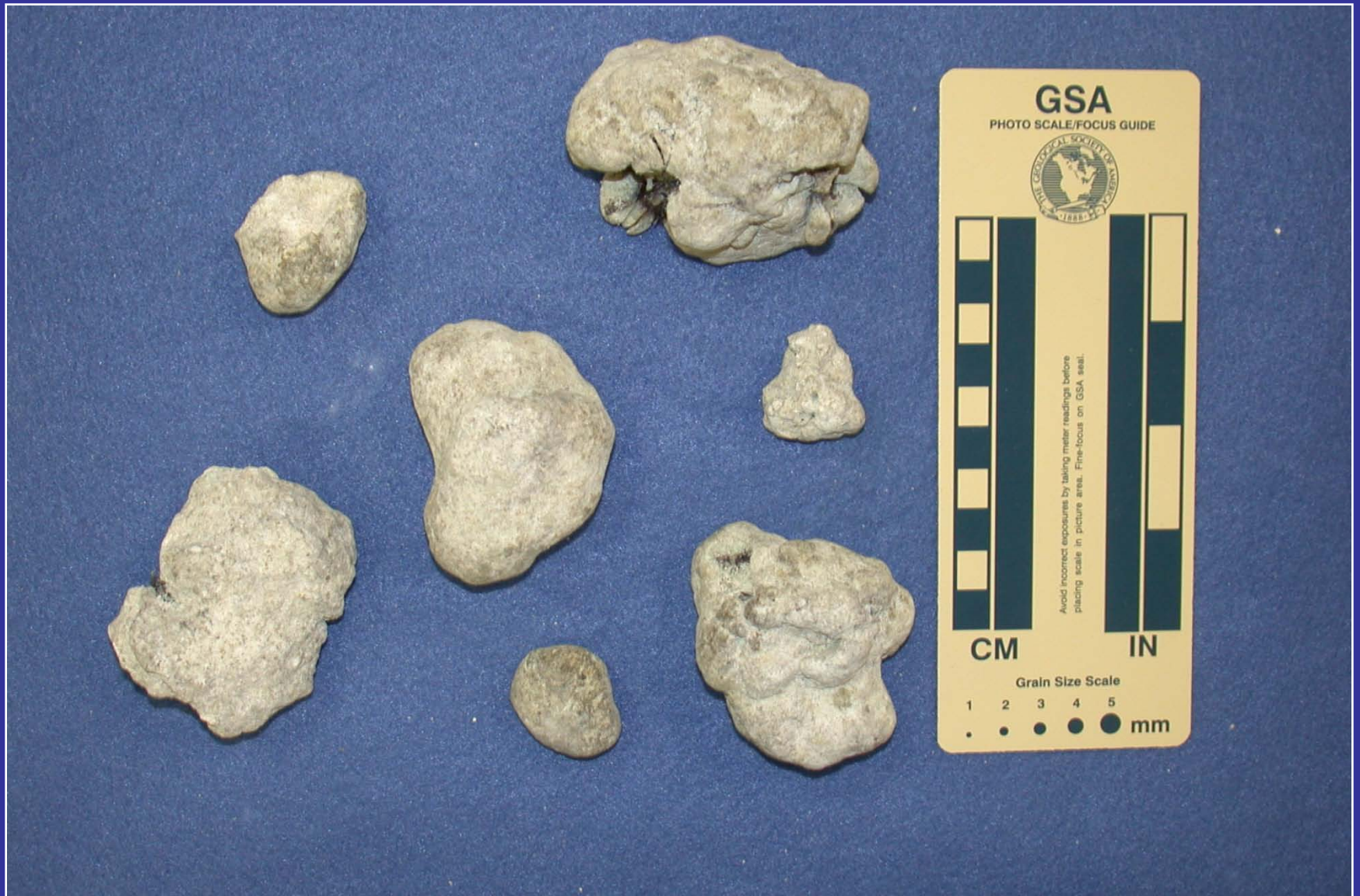
Map of Location 2 (Coccolitos)



Oncoid area
(algas "galletas")



Oncoids - algal "biscuits"



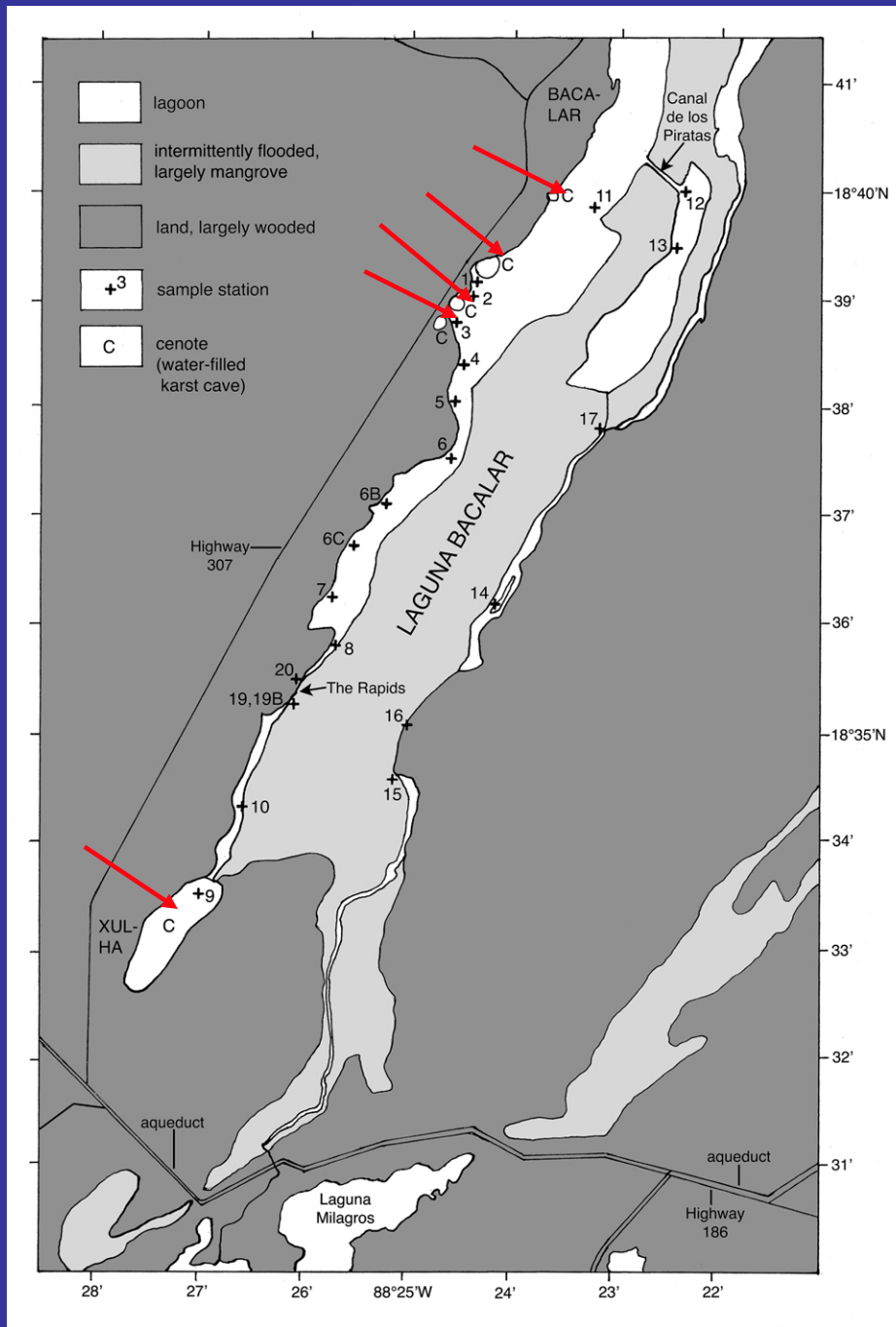
Oncoid grown on a gastropod (*Pomacea* sp.)
(Oncoid crecido en un gastrópodo - *Pomacea* sp.)



Avoid incorrect exposures by taking meter readings before placing scale in picture area. Fine-focus on GSA seal.



Cenotes →
 crucial influence
 on current regime
 (influencia crucial
 on el régimen actual)



Sampling:

- sediment
- microbial mats
- surface water

(Toma de muestras:

- Sedimentos
- Tapetes microbianos
- Las aguas superficiales)

N

core locations

4°

~2m



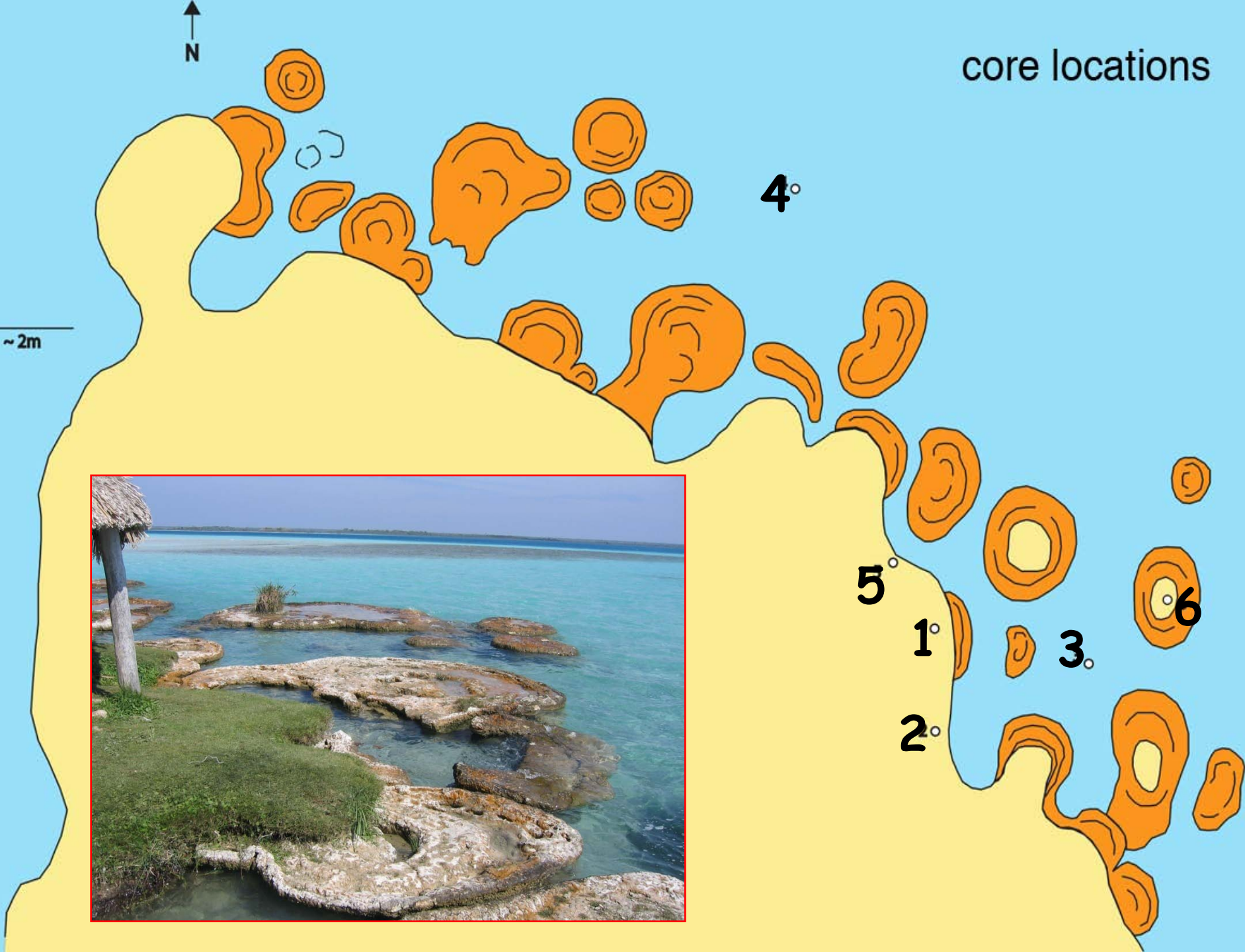
5°

1°

2°

3°

6



"Push Coring" - So much effort...

("Push Coring" - Por lo tanto, mucho esfuerzo ...)

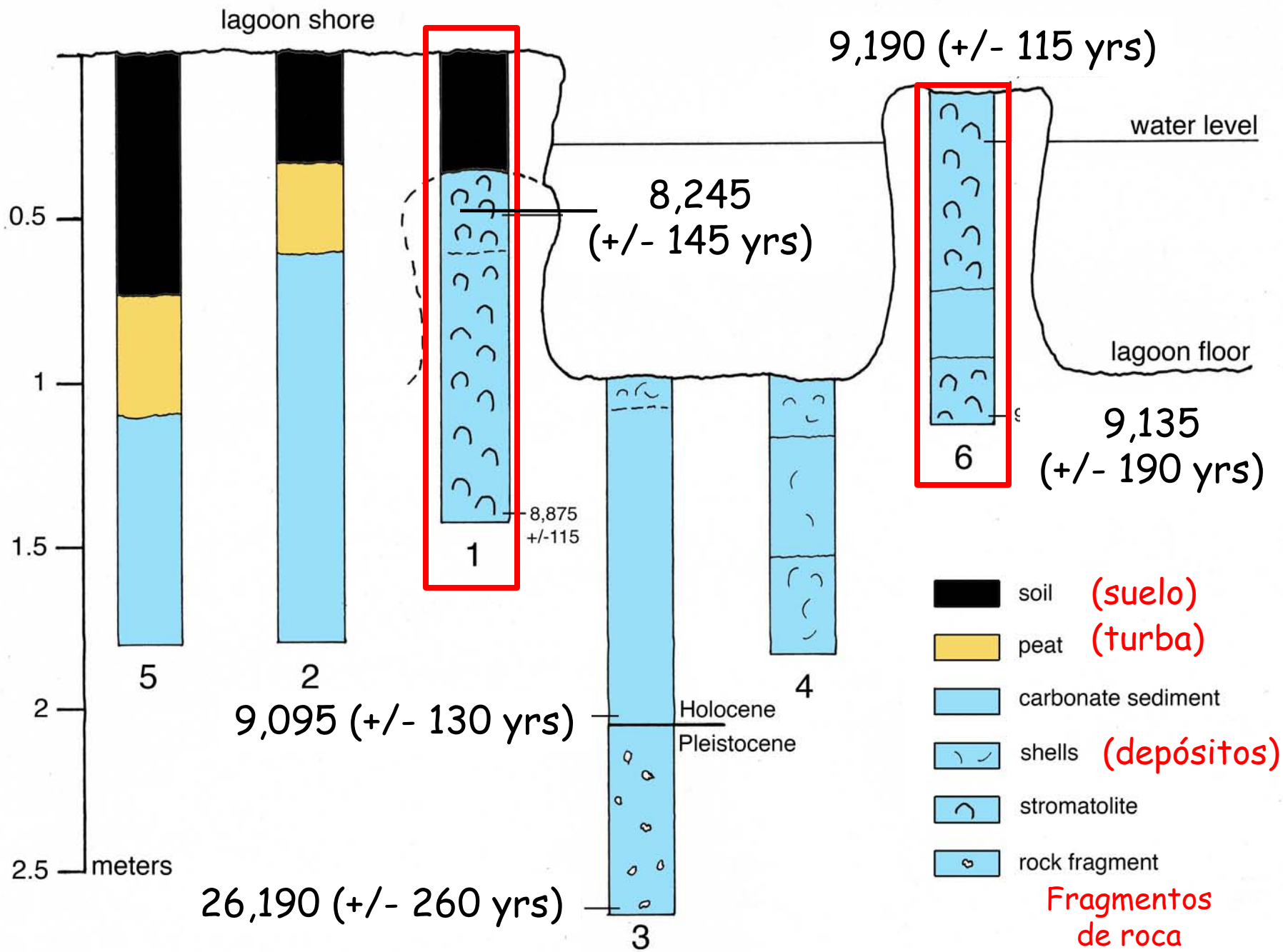


...so little return!
(... Tan poco rendimiento!)



Cores 1 & 6





Associated fauna:

(La fauna asociada)

Pomacea sp. (apple snail)

Mytilopsis sallei (BlackBanded Zebra Mussel)



Dating:

^{14}C -ages of modern shells range from 7-8 kyrs BP

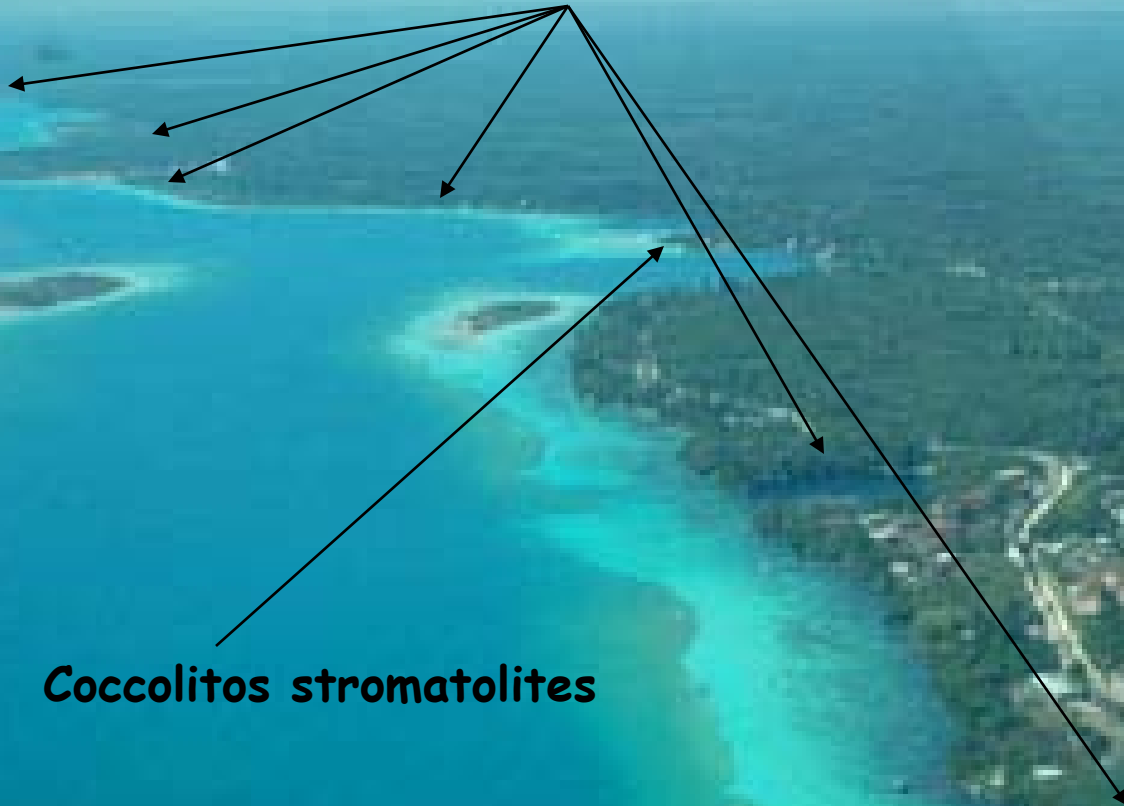
^{14}C ages of core samples range from 9-7 kyrs BP

---> *strong hard water effect!*

(El fuerte efecto de agua dura!)

Stromatolite búsqueda de nuevos sitios en los alrededores de Bacalar y lagunas (patrones espaciales?)

Other sites???



Coccolitos stromatolites

Search for additional stromatolite sites in Bacalar & nearby lagoons (spatial patterns?)

Followed Western Lagoon South (Seguido Occidental Laguna Sur)

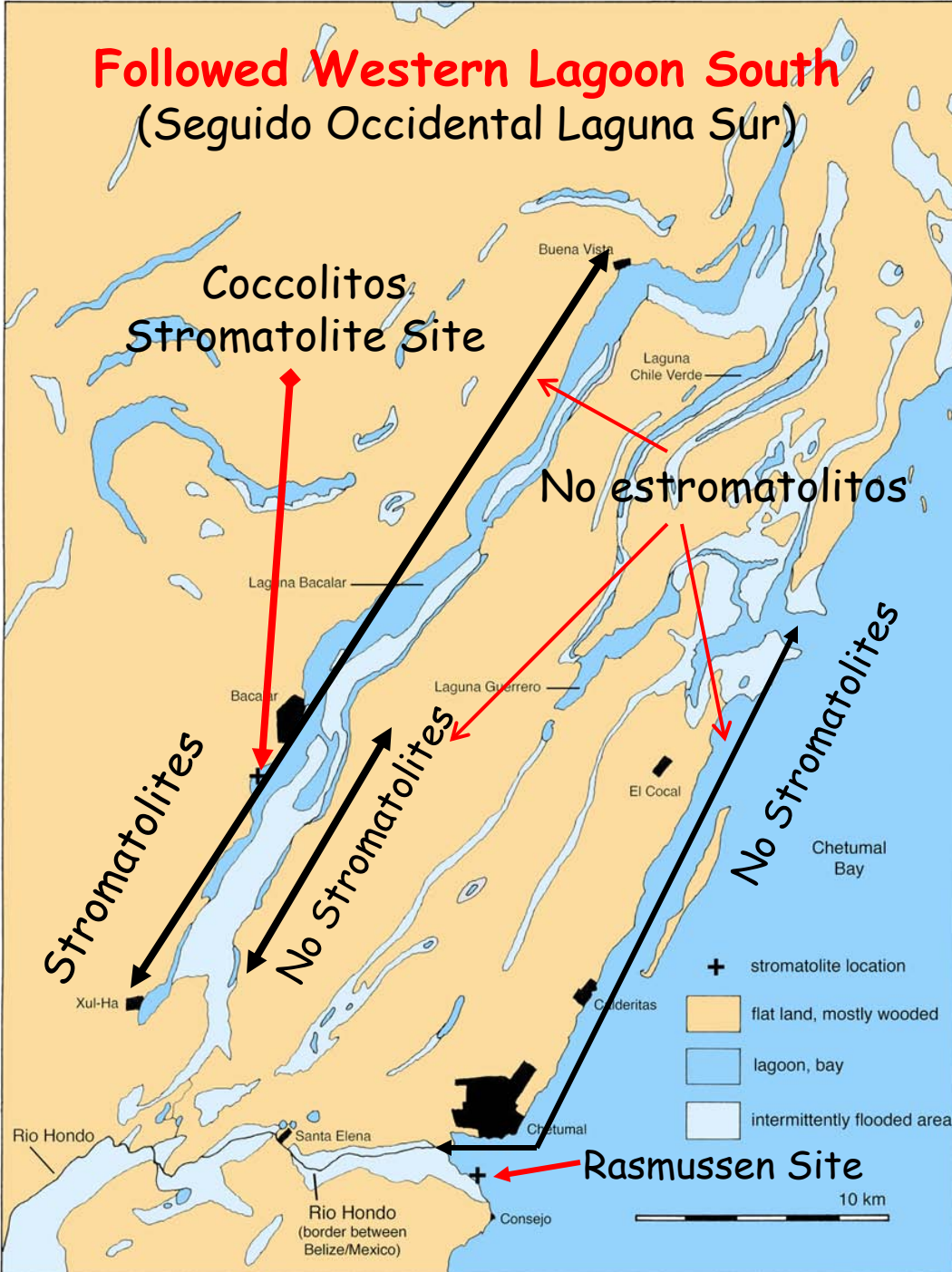
2006 - checked other areas!
(Siguiendo comprobado otros
ámbitos!)

Observations:

1. **Geographic extent:**
 - > 10 linear km of stromatolites
 - Eliminated 3 areas
2. **Obtain additional cores:**
 - 22 new sites
 - 8 new cores
 - 3 new cenotes
 - 22 water samples

Observaciones:

1. **Extensión geográfica:**
 - > 10 km lineales de stromatolitos
 - Eliminado 3 áreas
2. **Obtener núcleos:**
 - 22 nuevos sitios
 - 8 nuevos núcleos
 - 3 nuevos cenotes
 - 2 muestras de agua



Observations:

3. Define variation in morphology

- 2 new variations
- Zonation evident

4. Determine origin

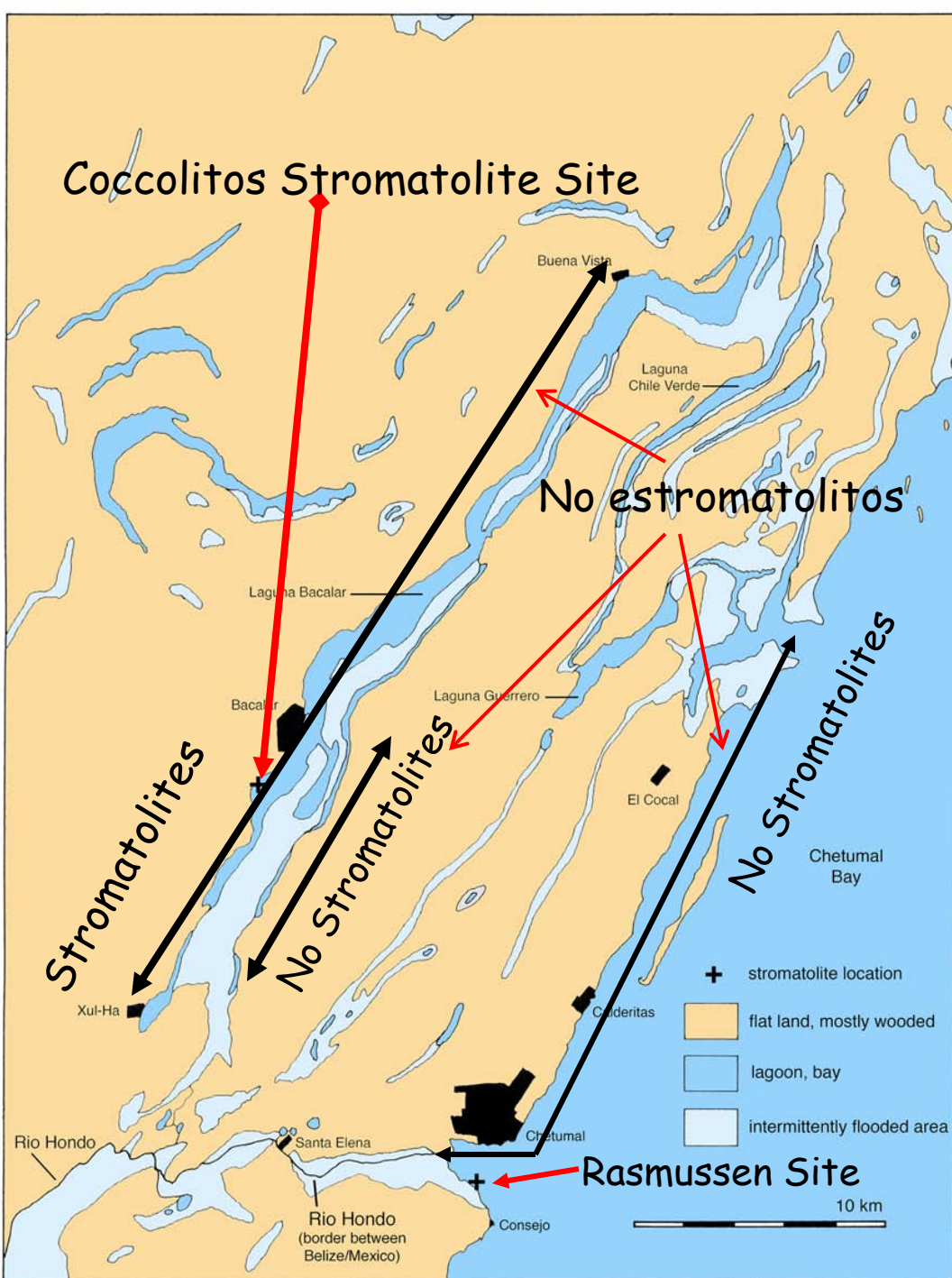
- Possibly related to largest cenote & paleodrainage

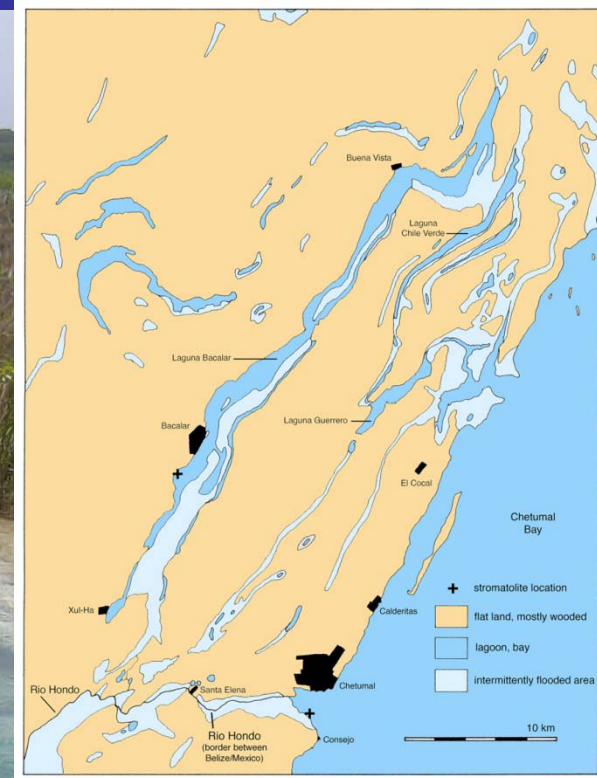
3. Definir la variación en la morfología

- 2 nuevas variaciones
- Zonación evidente

4. Determinar el origen

- Posiblemente relacionadas con el cenote más grande y paleodrainage





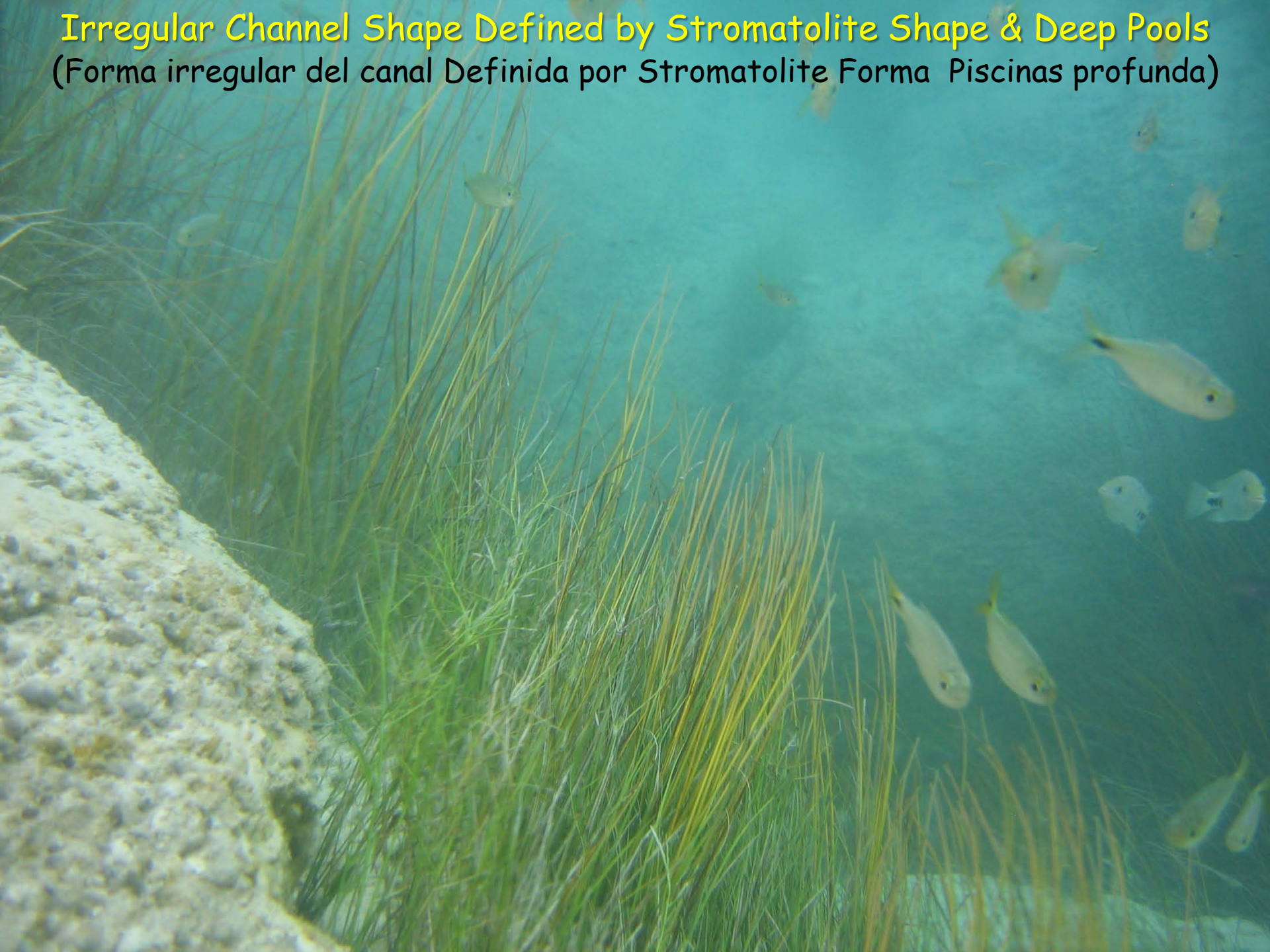
"The Rapids"

Enormous coalesced microbialites including ledges in high currents
(Enorme unieron microbialites incl. repisas en las corrientes de alta)



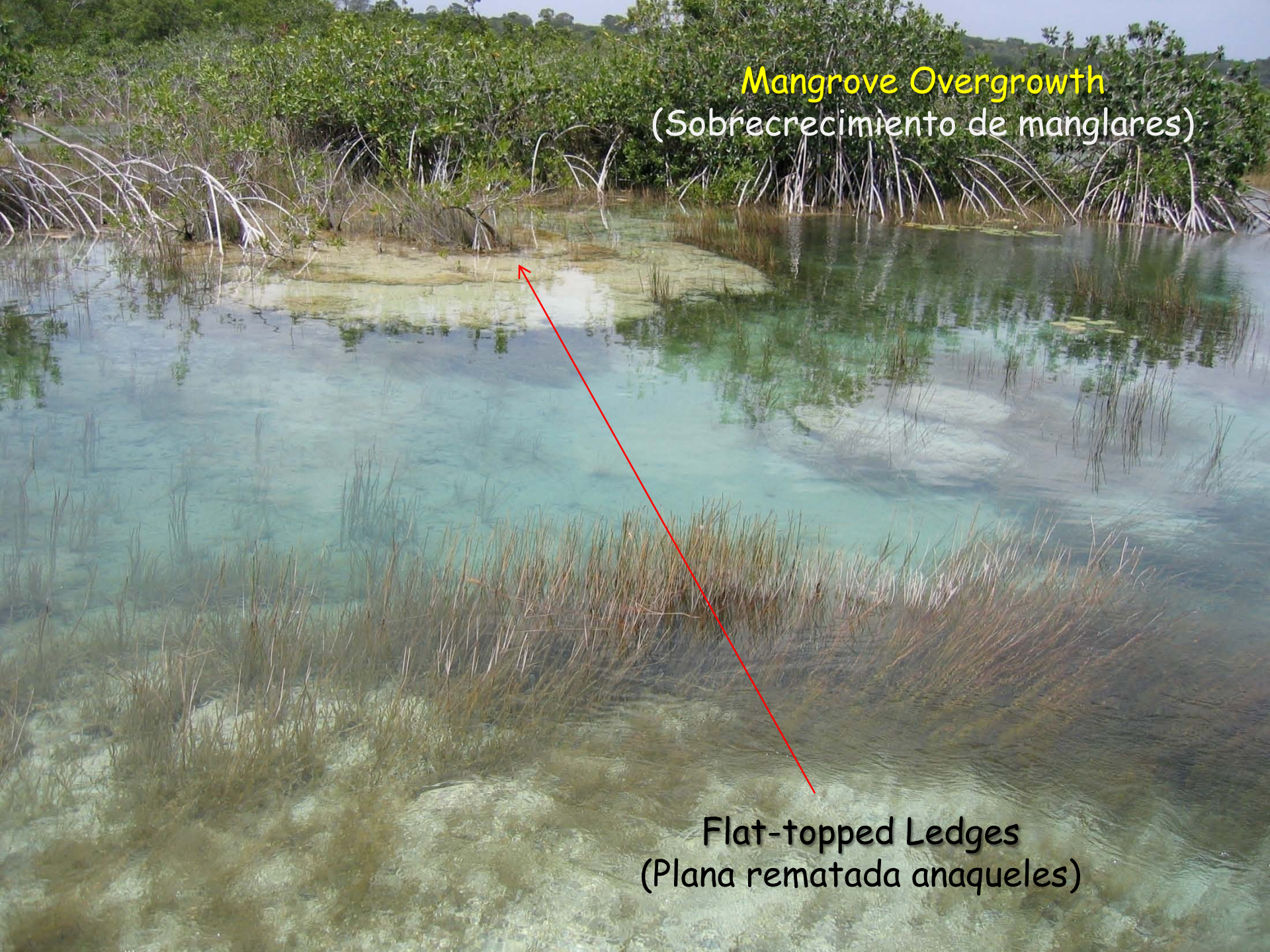
Irregular Channel Shape Defined by Stromatolite Shape & Deep Pools
(Forma irregular del canal Definida por Stromatolite Forma Piscinas profunda)

Irregular Channel Shape Defined by Stromatolite Shape & Deep Pools
(Forma irregular del canal Definida por Stromatolite Forma Piscinas profunda)



Mangrove Overgrowth
(Sobrecrecimiento de manglares)

Flat-topped Ledges
(Plana rematada anaqueles)



Soil Stabilization?
(Estabilización de suelos)

Flat-topped Ledges
(Plana rematada anaqueles)



Location 6: Largely unconsolidated microbialites in low energy environment



(Situación 6: En gran parte no consolidados microbialites bajo consumo de energía en el medio ambiente)



Rapid Growth Rate

(Tasa de crecimiento rápido)

A new form encountered...

crusts...



...but not mounds



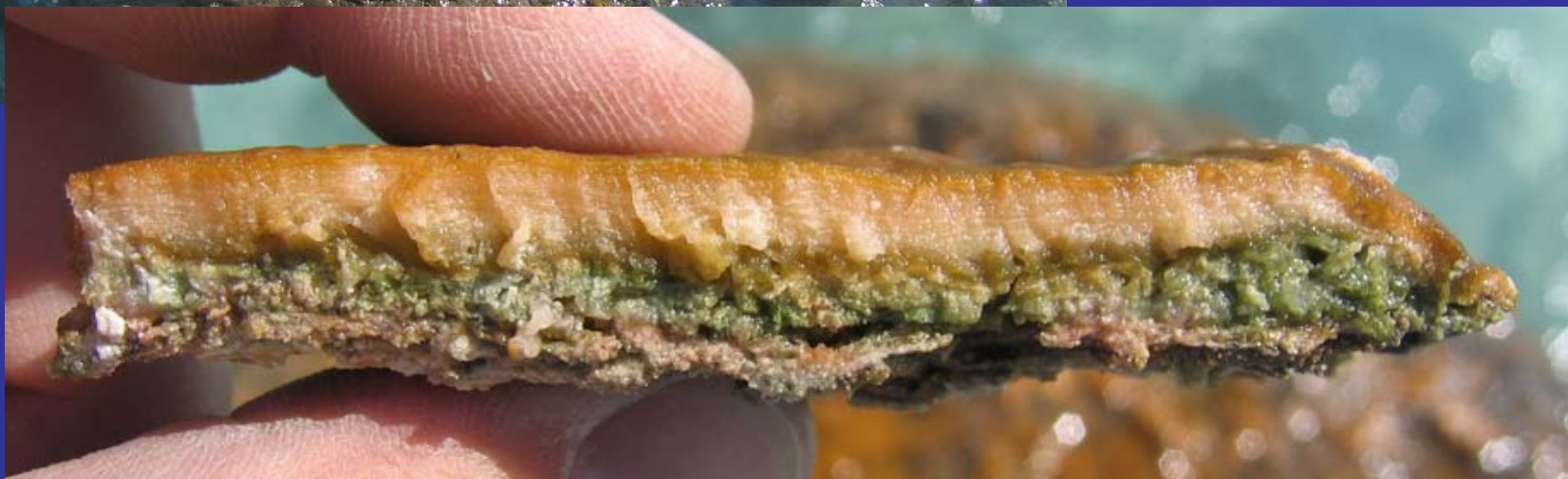
How wide?
Well, still to be determined.
(¿Qué anchura?
Bueno, todavía por determinar.)

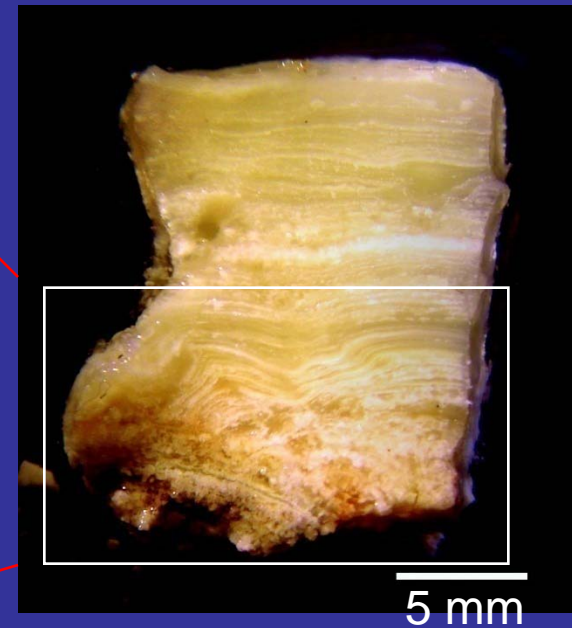
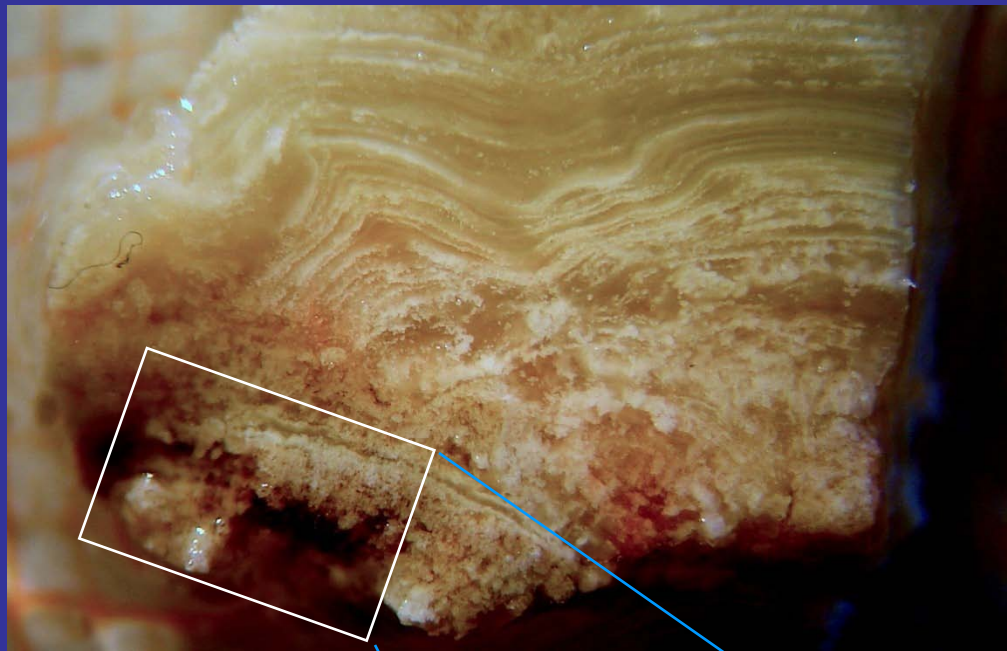




Living Microbial Mats

(Vida
Tapetes microbianos)





Leptolyngbya sp. mat

Dark filaments & several upward diverging, heavily calcified fans, upper right

(oscuro y varios filamentos divergentes al alza, muy calcificadas ventiladores, arriba a la derecha)

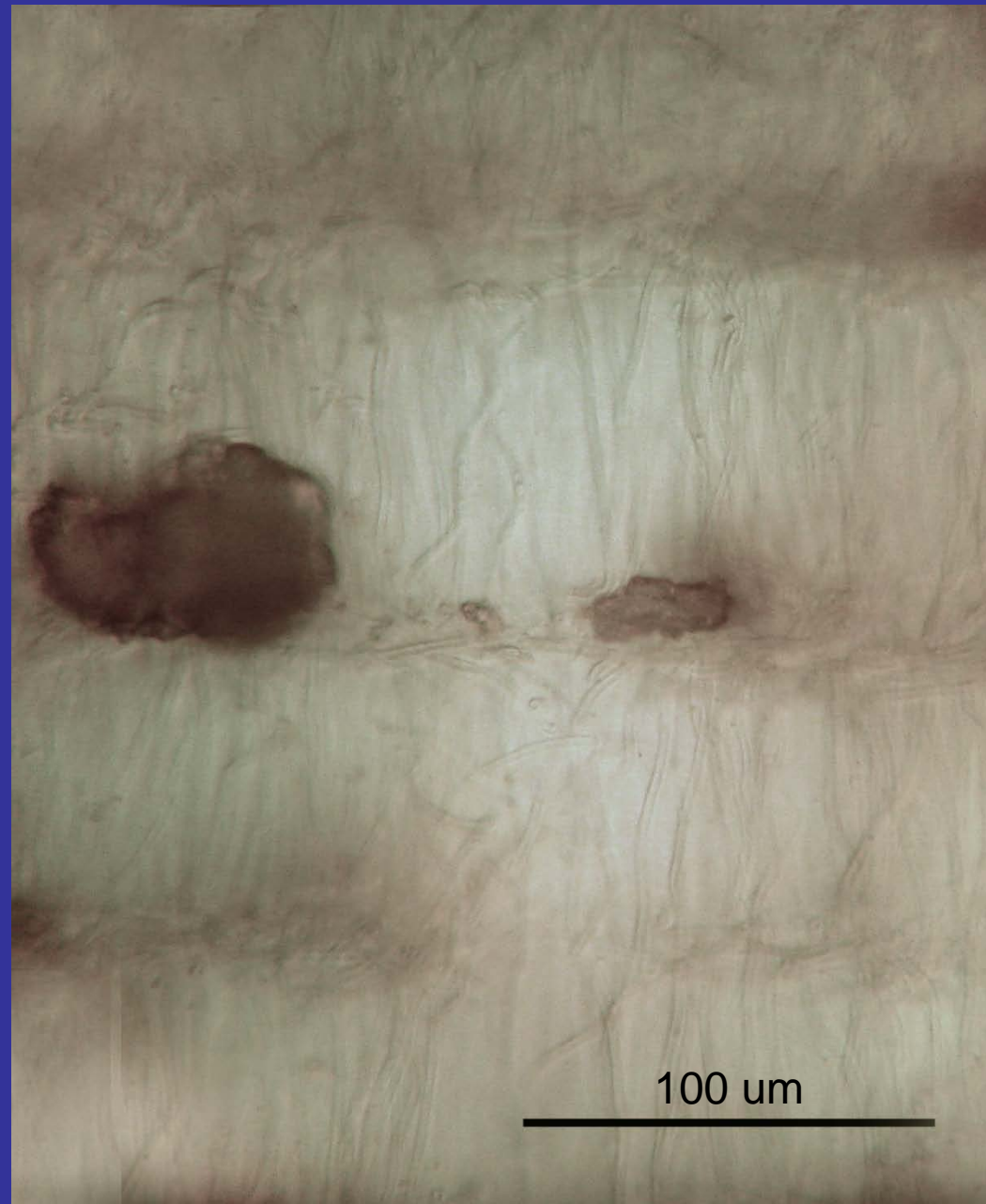


Orientation of filaments changes in rhythmic mode from vertical to horizontal; carbonate grains correlate with prostrate laminae.

Same pattern of lamination produced by filament orientation described for marine cyanobacterium *Phormidium hendersonii* (presently revised as *Leptolyngbya hendersonii*)

(Orientación de los filamentos cambios en el ritmo de modo vertical a la horizontal; correlacionan con los granos de carbonato prosternan láminas.

Mismo patrón de laminación producida por el filamento de orientación descrito para marinos cianobacteria *Phormidium hendersonii* (actualmente revisado como *Leptolyngbya hendersonii*)

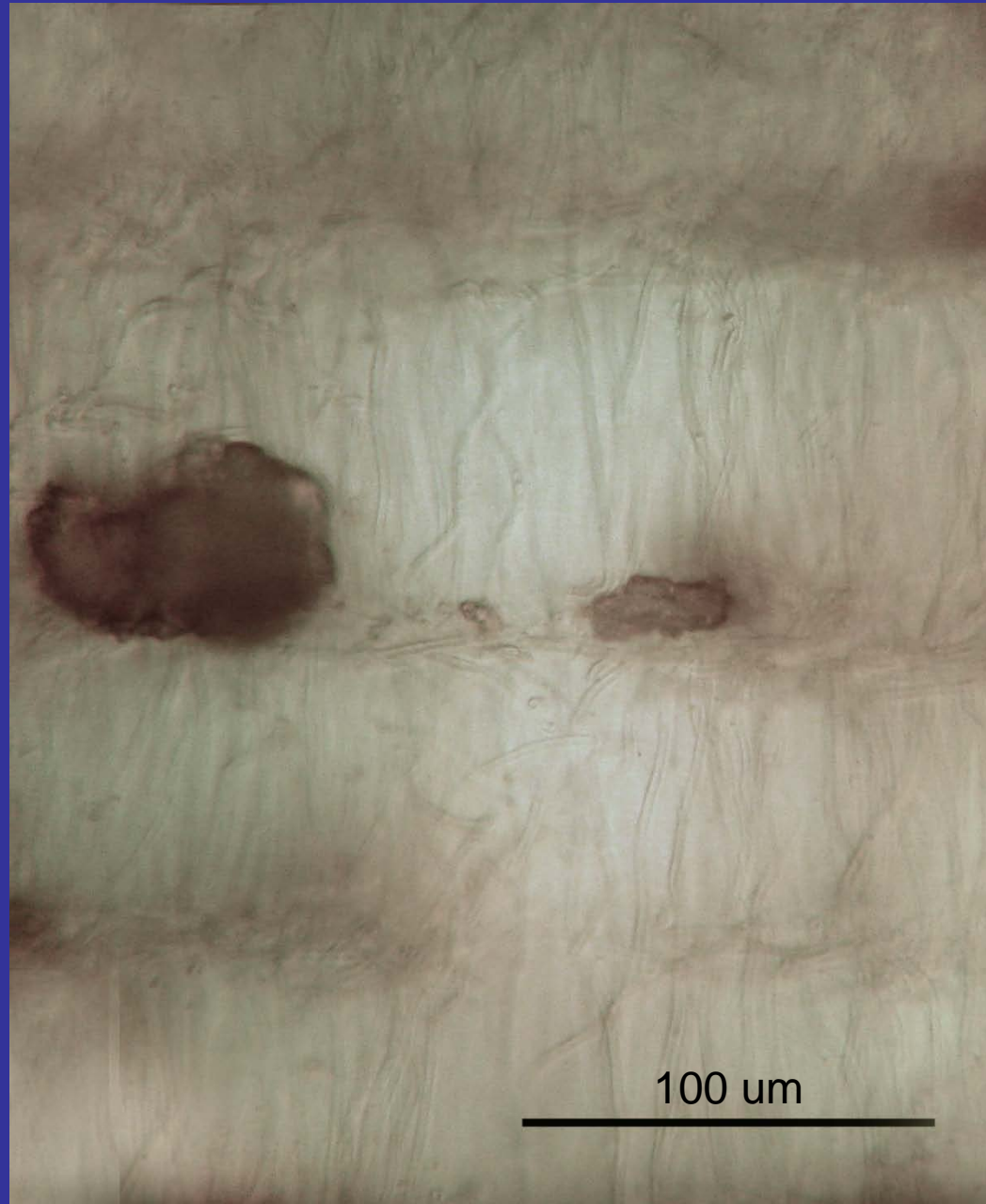


Rhythm established as
nocti-diurnal: upright orientation
is phototactic during the day

1st observation of this type of
lamination in freshwater
microbialites

(Ritmo se ha establecido como
nocti-diurna: orientación vertical
es phototactic durante el día

1 de la observación de este tipo
de laminación de agua dulce en
microbialites)



SEM of living mat (critically point dried)

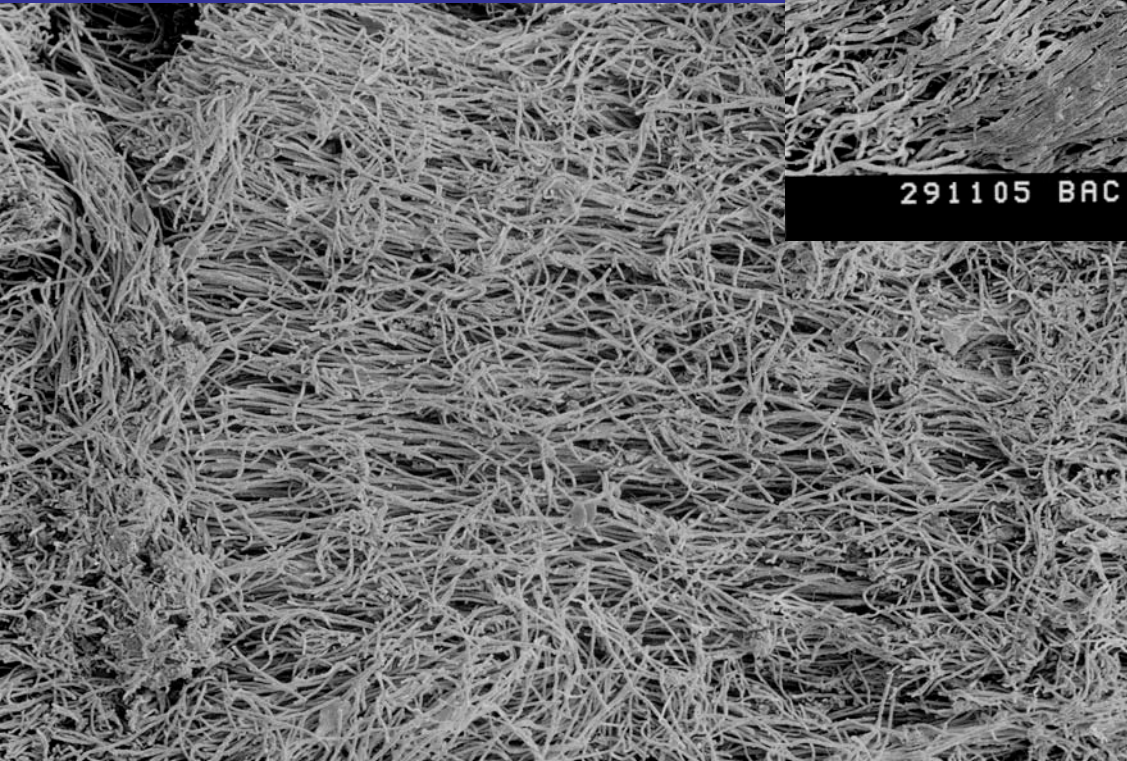
(SEM estera de vida
(punto crítico de secado))



291105 BAC

00012

100µm



291105 BAC

00006

100µm

Mat Surface
(estera de superficie)

Cross-section
(Sección transversal)

Carbonate Formation in Living Mat

"spiked balls" of LMC on filament

(Carbonato de Formación
Vivir en Mat)

"bolas de pinchos" de la LMC en filamento)



86319

3 μ m



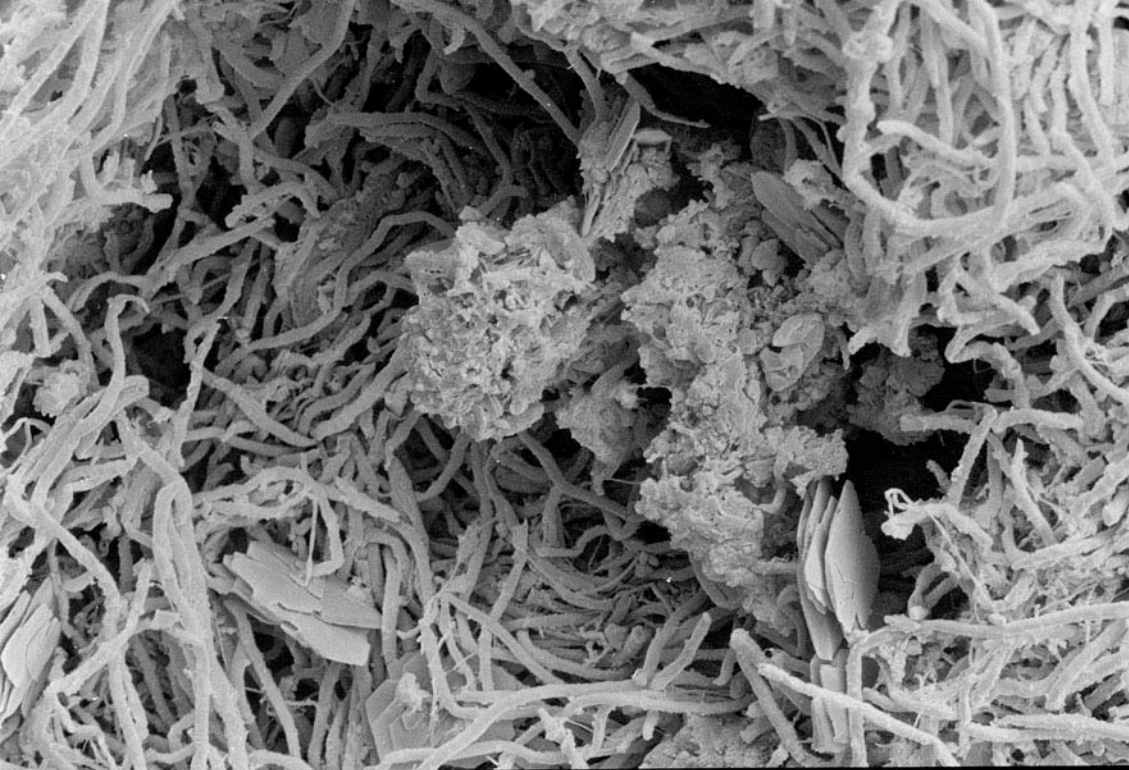
291105 BAC

00010

3 μ m

Nano-crystals of LMC

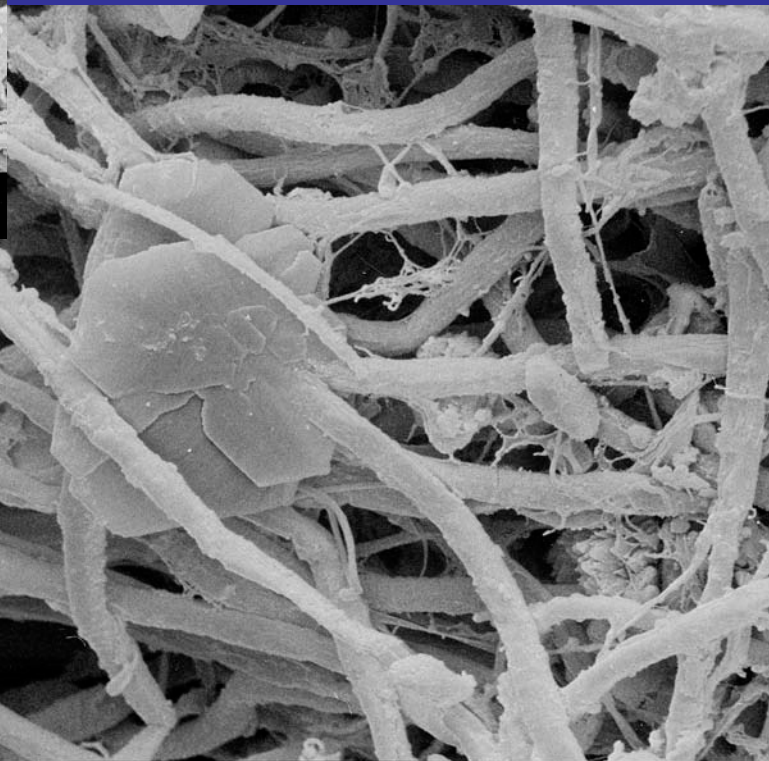
(Nano-cristales de calcita baja Mg)



Detritus
Platelets of LMC

Detritus
Las plaquetas de la LMC

291105 BAC 00001 30µm



Platelets of LMC
Las plaquetas de la LMC

291105 BAC 00004 10µm

Core (from "The Rapids")
shows both thrombotic &
stromatolitic texture
(sample is 15 cm wide)

Core (muestra de "Los Rápidos")
muestra tanto trombolítica y
textura stromatolitic
(la muestra es de 15 cm de ancho)



Core sample from location 9)
thick calcite cement crust
(sample is 3 cm wide)

Muestra la ubicación de 9)
calcita corteza gruesa de
cemento (la muestra es de 3 cm
de ancho)



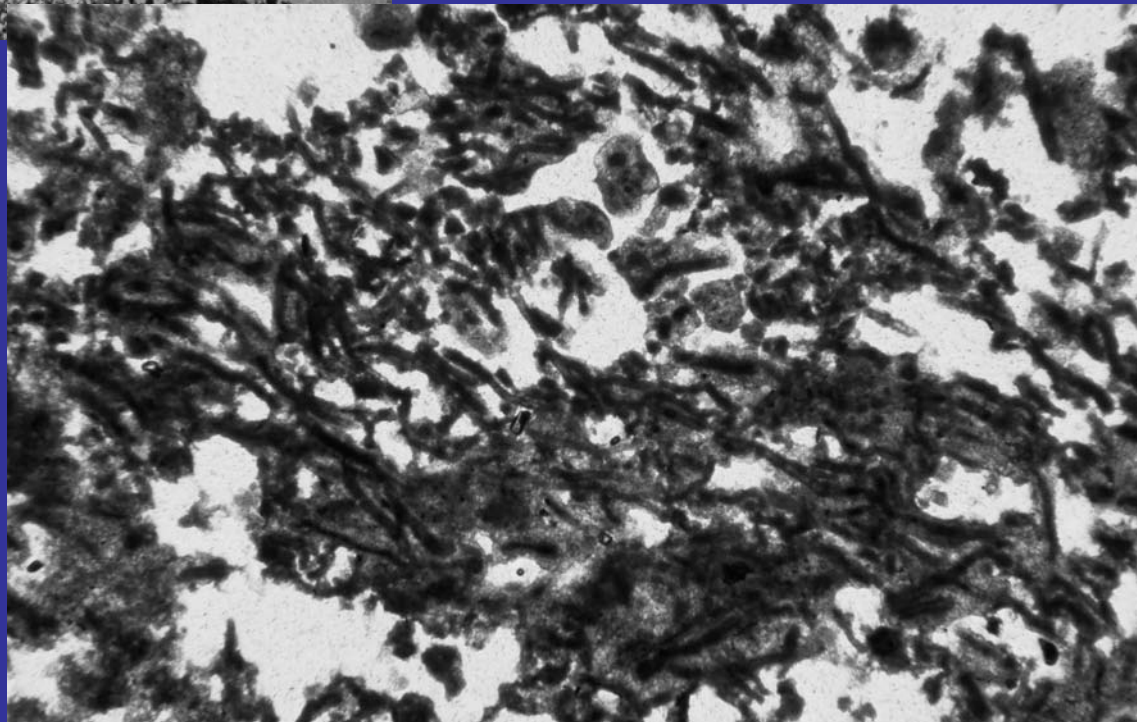
Thin-sections:

Microbialite in core:
radial orientation of
filaments;
note weak lamination
(*diameter 1 cm*)

Microbialite en el núcleo: radial de
la orientación de los filamentos;
nota débil laminación (1 cm de
diámetro)

Close-up of same sample:
filaments surrounded by CO_3
(*diameter 1 mm*)

Close-up de la misma muestra:
rodeado de filamentos CO_3
(diámetro de 1 mm)



Lagoon water

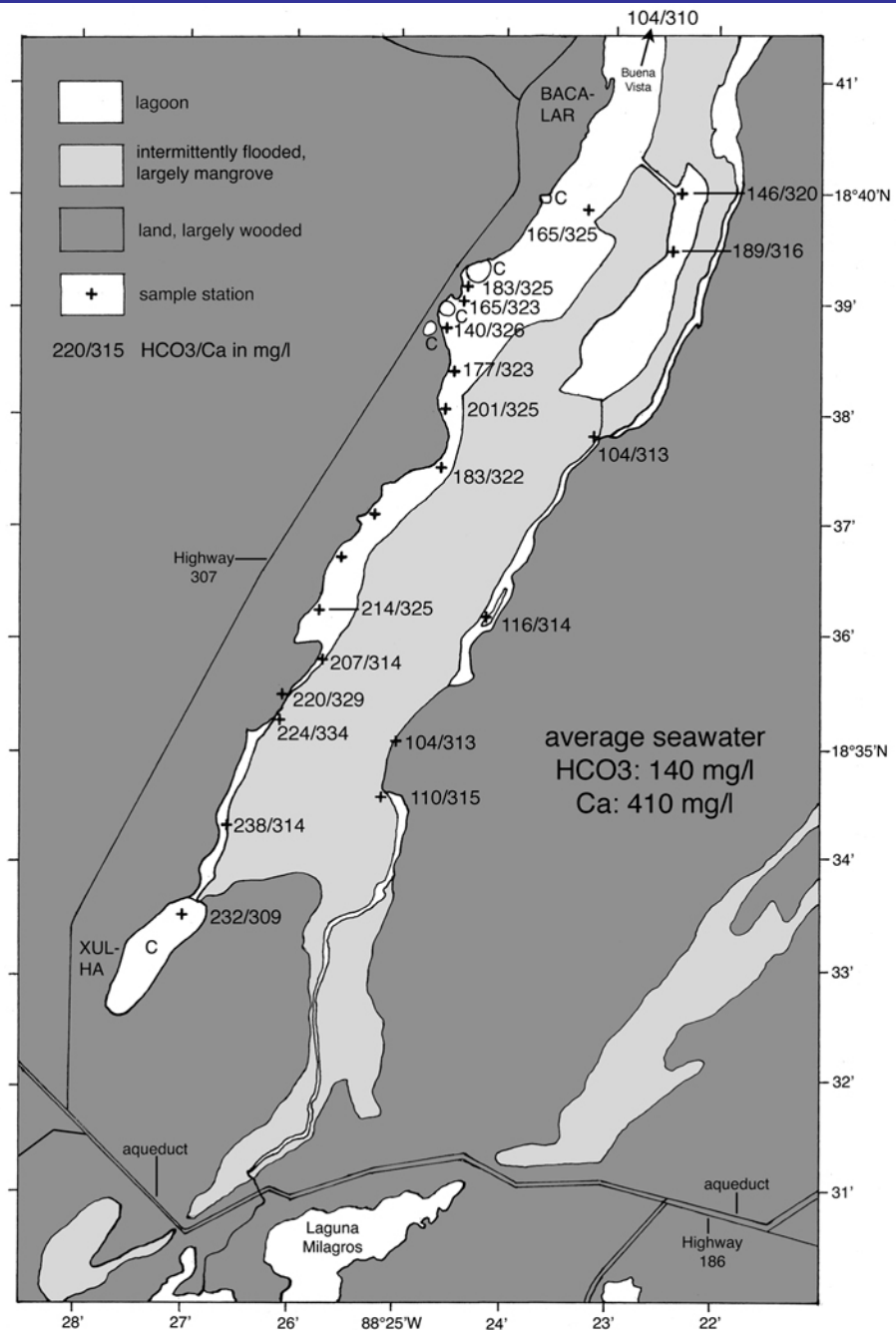
Significance of CO_3 saturation
(higher compared to marine realm)

Microbialites occur only in SW part of lagoon (near cenotes)

Laguna de agua

Importancia del carbonato de saturación (más alto en comparación a marino)

Microbialites ocurrir SW sólo en parte de laguna (cerca de cenotes)





¿Cómo la vista Residentes
de Bacalar
estromatolitos?



Again, the take-home points

- Laguna Bacalar home to rare impressive freshwater microbiolite structures (one of largest in world)
- Great geologic value as paleoenvironmental indicators - need study
- Archives of environmental change - useful!
- Intimately tied to water chemistry geology of area
- Great potential in ecotourism (educational topic unique)
- Bacalar microbialites are already in danger from development of area
- Still much to do to fully understand them



Remember Bob Ginsburg's Points!

What is next...time to submerge!
¿Cuál es la próxima vez ... a sumergirse!



Hello There!

Giant Holocene Freshwater Microbialites, Laguna Bacalar, Quintana Roo, Mexico

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Want to know more...
¿Quieres saber más ...

microbialites gran trombolítica; LMC
la precipitación de CaCO_3
inducida por la retirada de CO_2 :
cianobacterias (y diatomeas);
también: la captura de los detritus
 CO_3 elevado contenido en
ambiente laguna de agua
Rubor crucial

La mayor parte de la formación en el Holoceno tardío (<10 kyrs BP)
¿Por qué formación 9o-8o kyrs BP?
Restringido laguna / lago?
elevados de saturación de carbonato?
exclusión de herbívoros macro?
sedimentación evento?
abundancia de herbívoros no parecen obstaculizar la formación de microbialites
extracción de testigos adicionales, también en las partes más profundas laguna
microbiológicos de trabajo que viven en esteras

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