Sedimentary structures

Stratification and bedforms – Part II

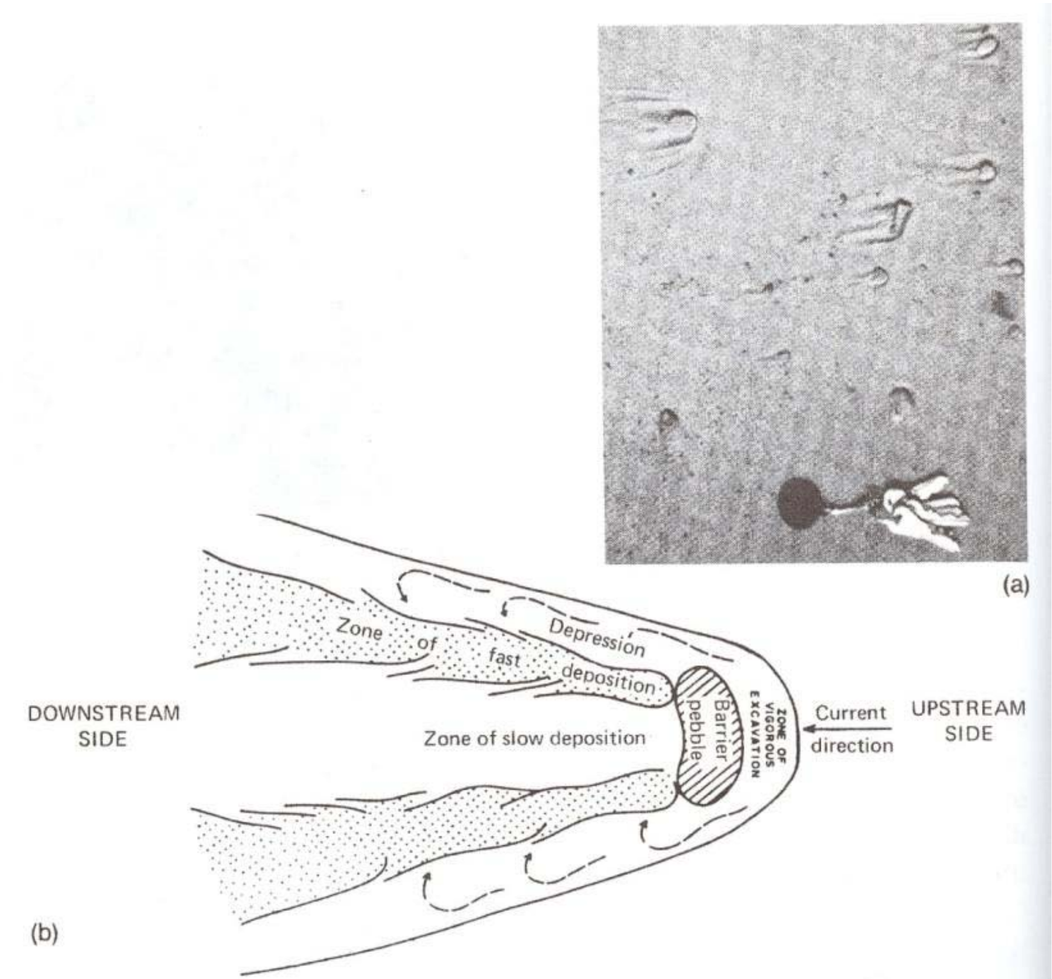
Bedding-plane structures

current-formed and tool-formed structures

Sole marks – Flute casts

Sole marks – groove casts

Surface marks – current crescents

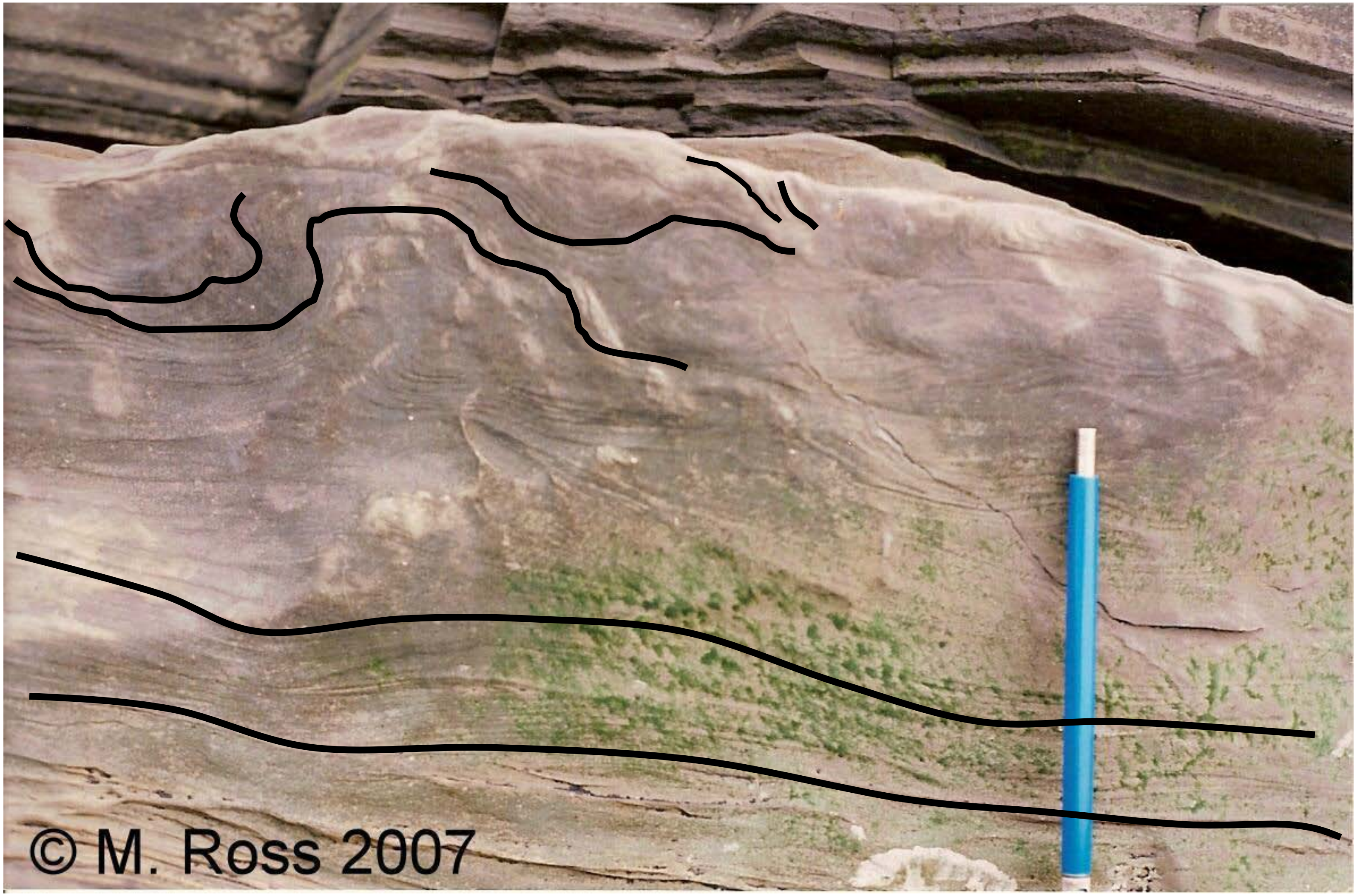


Davis (1992)

Northern Yukon (Porcupine River)

Deformation structures

Convolutes



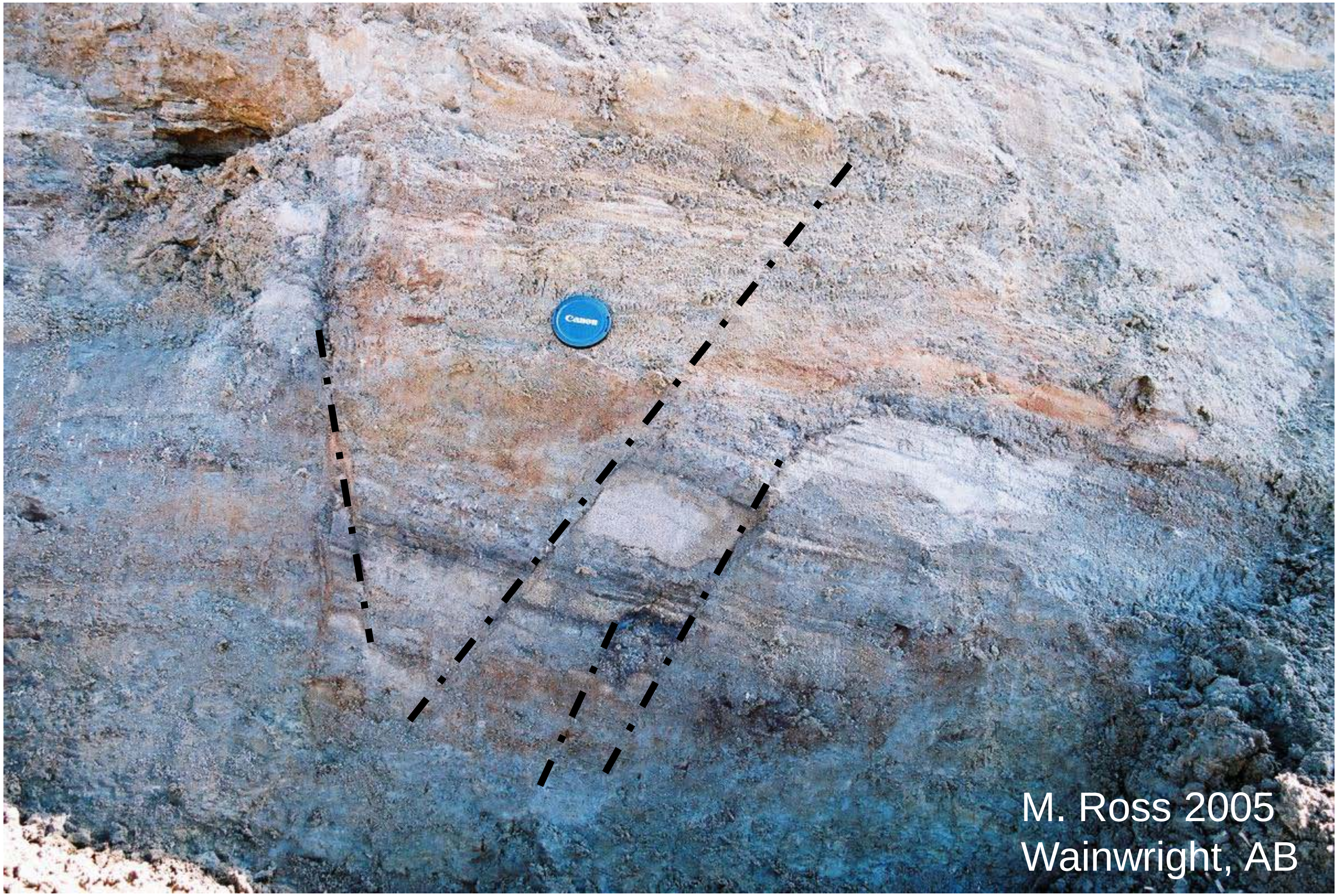
Flame structures

Lower St. Lawrence River , QC

Lower St. Lawrence River , QC

Ball and pillow structures

Syn- to post-sedimentary folds and faults



Syn- to post-sedimentary folds and faults

Conjugate fault pattern

Biogenic structures

Trace fossils and stromatolites

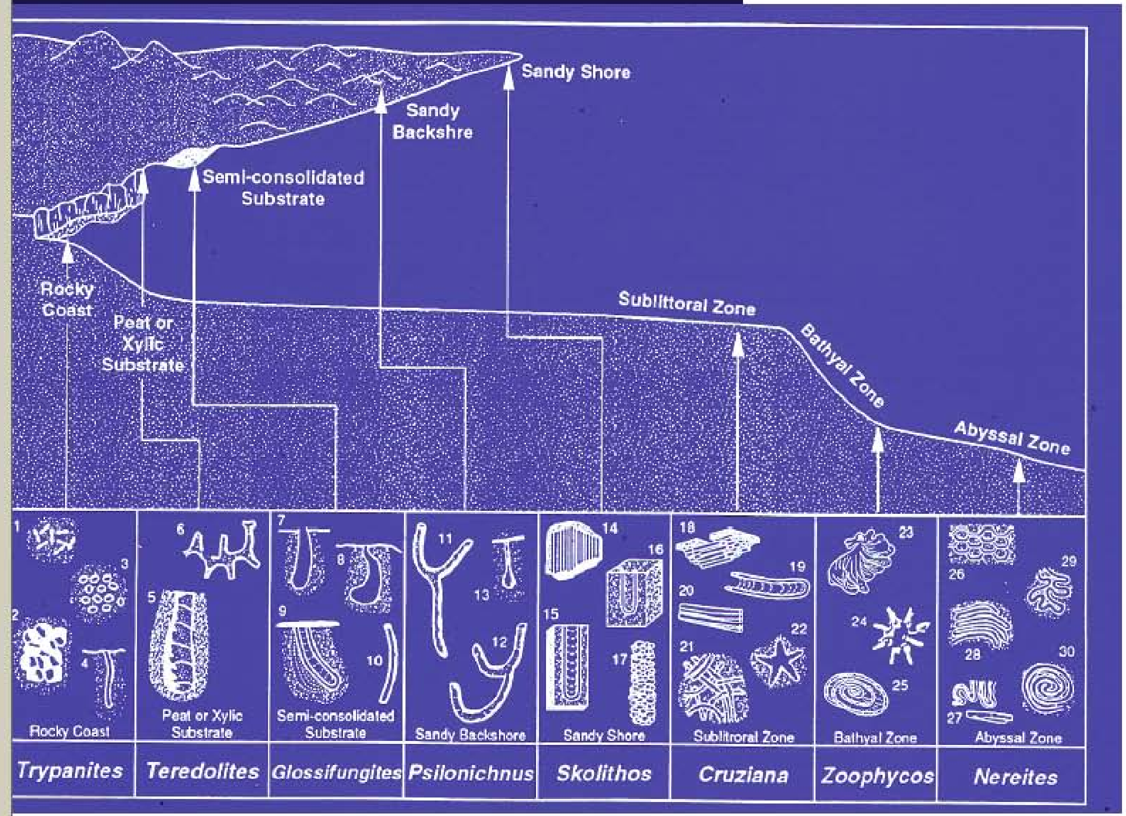
Trace fossils (ichnofossils) and other biogenic structures

- Structures that originated through the activities of organisms
  - Bioturbation
    - Tracks, trails, burrows, root penetration structures
  - Biostratification structures
    - Algal stromatolites
  - Bioerosion structures
    - Involves erosion of a consolidated substrate by an organism (from algae to T-Rex!)
      - Borings, scrapings, toothmarks
  - Excrement
    - Coprolites (fecal pellets)

What are ichnofacies?

- Ichnofacies are spatially and temporally recurring groupings of organism behaviours, as recorded in trace fossil suites
  - Facies models: Theoretical constructs

ICHNOFACIES AND BATHYMETRY



The relationship displayed above is **only as rigid as a generalized proximal-distal trend in sediment calibres** on the bathymetric profile, or to the distribution of primary sedimentary structures!

Frey et al. (1990) published a paper that showed that ichnofacies have a **passive relationship to water depth.**

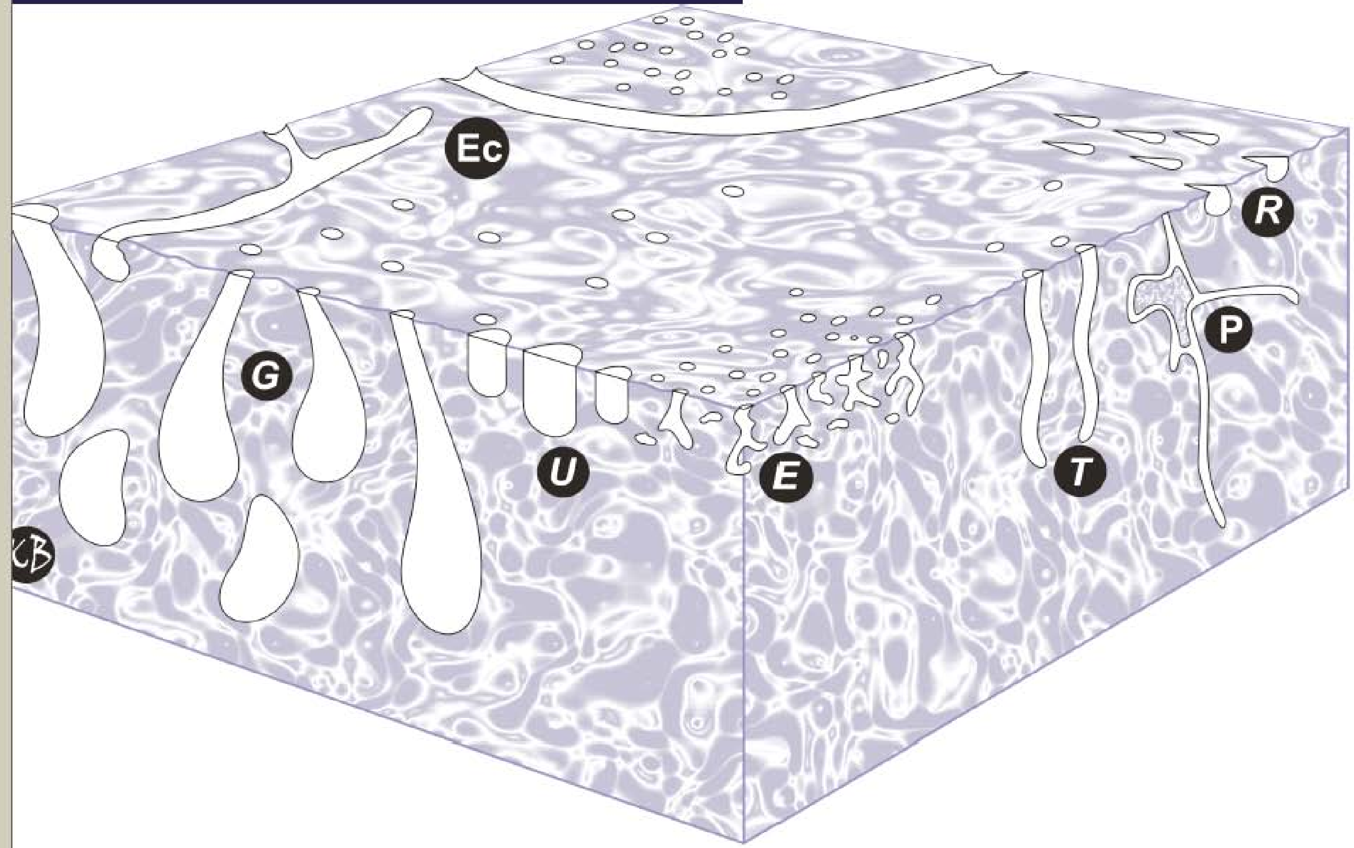
Traces and their distributions are controlled by conditions that *tend* to change with water depth:

- Substrate consistency
- Food resources
- Energy conditions at the bed
- Salinity
- Oxygenation
- Temperature

Slide is from J.A. MacEachern (SFU)

TRYPANITES ICHNOFACIES

Fully cemented substrates **Rocky coasts**



Cylindrical to vase-, tear-, or U-shaped domiciles generated by boring

Borings perpendicular to substrates

Trace makes generally suspension feeders or passive carnivores

Raspings and gnawings of algal grazers

Moderately low diversity; individual borings may be abundant

Common elements include: *Trypanites* (*T*), *Ubiglobites* (U), *Gastrochaenolites* (G), *Entobia* (E), *Rogerella* (*R*), Echinoide grooves (Ec), and Polychaete borings (P).

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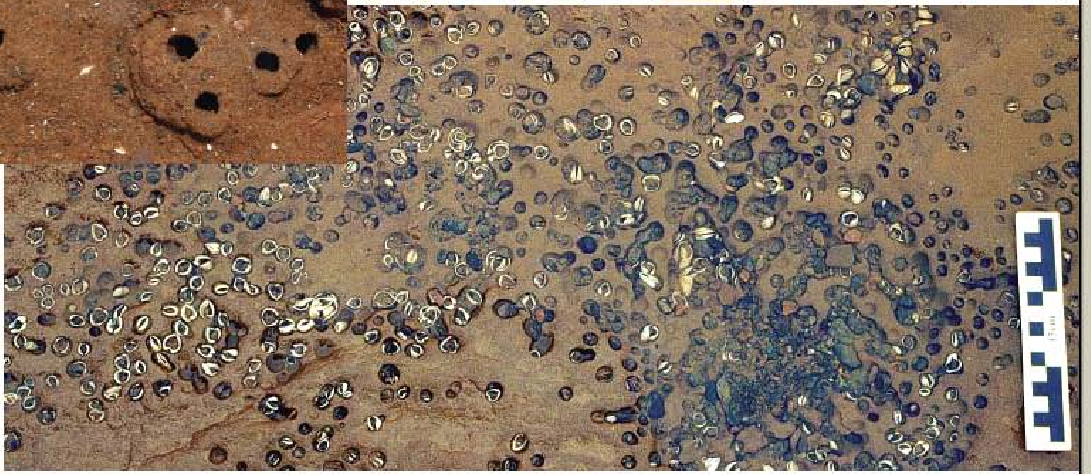
TRYPANITES ICHNOFACIES



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TEREDOLITES ICHNOFACIES

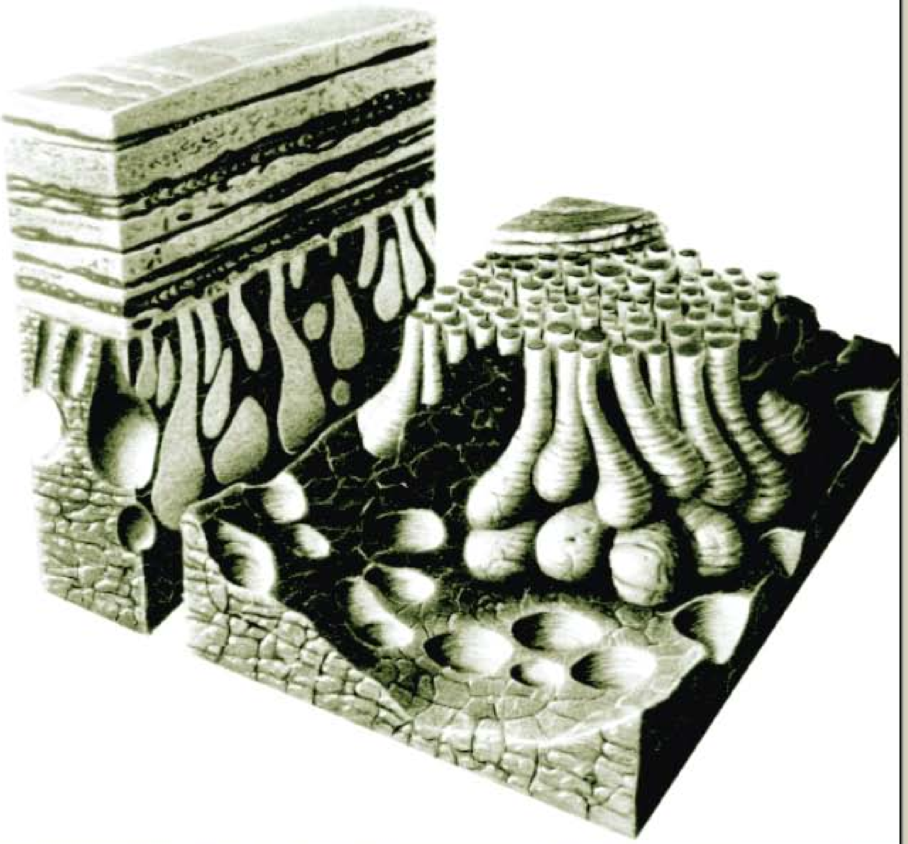
Woodground Substrates

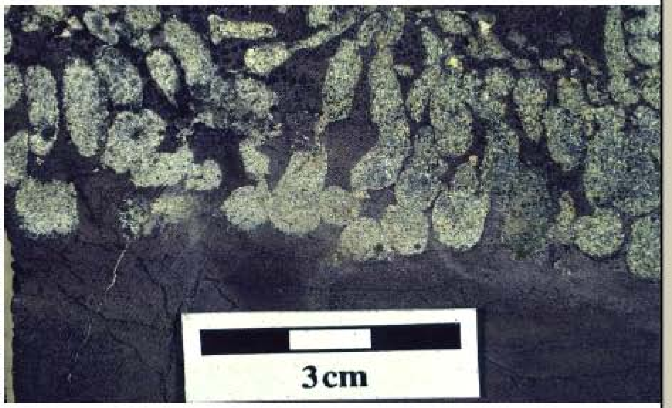
Sparse to profuse clavate-shaped borings into wood or coal

Dense excavations, but without interpenetrating borings

Walls ornamented with the texture of the host substrate

Elongate sub-cylindrical, excavations in marine settings





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GLOSSIFUNGITES ICHNOFACIES

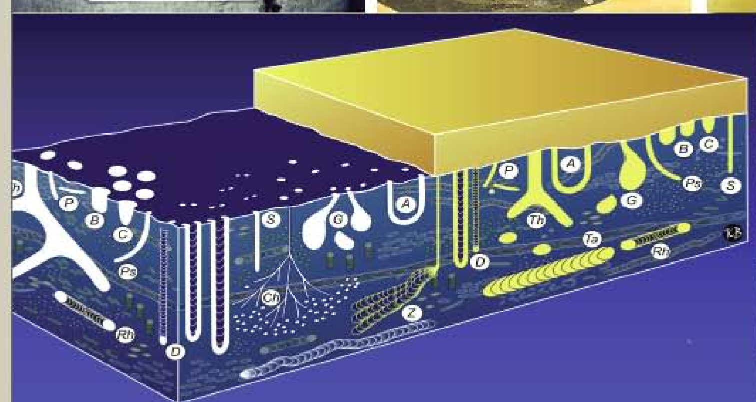
Cohesive/Compacted (Firm) Substrates

Vertical, cylindrical, U- or tear-" shaped dwellings as "pseudo-borings

Suspension feeders or animals that leave the burrow to feed

Low diversity but individual structures may be abundant

Burrow walls are unlined, sharp and may display scratch marks



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PSILONICHNUS ICHNOFACIES

Low diversity and abundance.

Dominated by J-, Y-, and U- shaped dwelling burrows made by crabs (*Psilonichnus*).

Vertical shafts of insects and spiders (*Macanopsis*).

Horizontal trails of crawling and foraging insects and tetrapods.

Ephemeral tracks, trails, and fecal pellets of insects, reptiles, birds, and mammals.

Roots are common.

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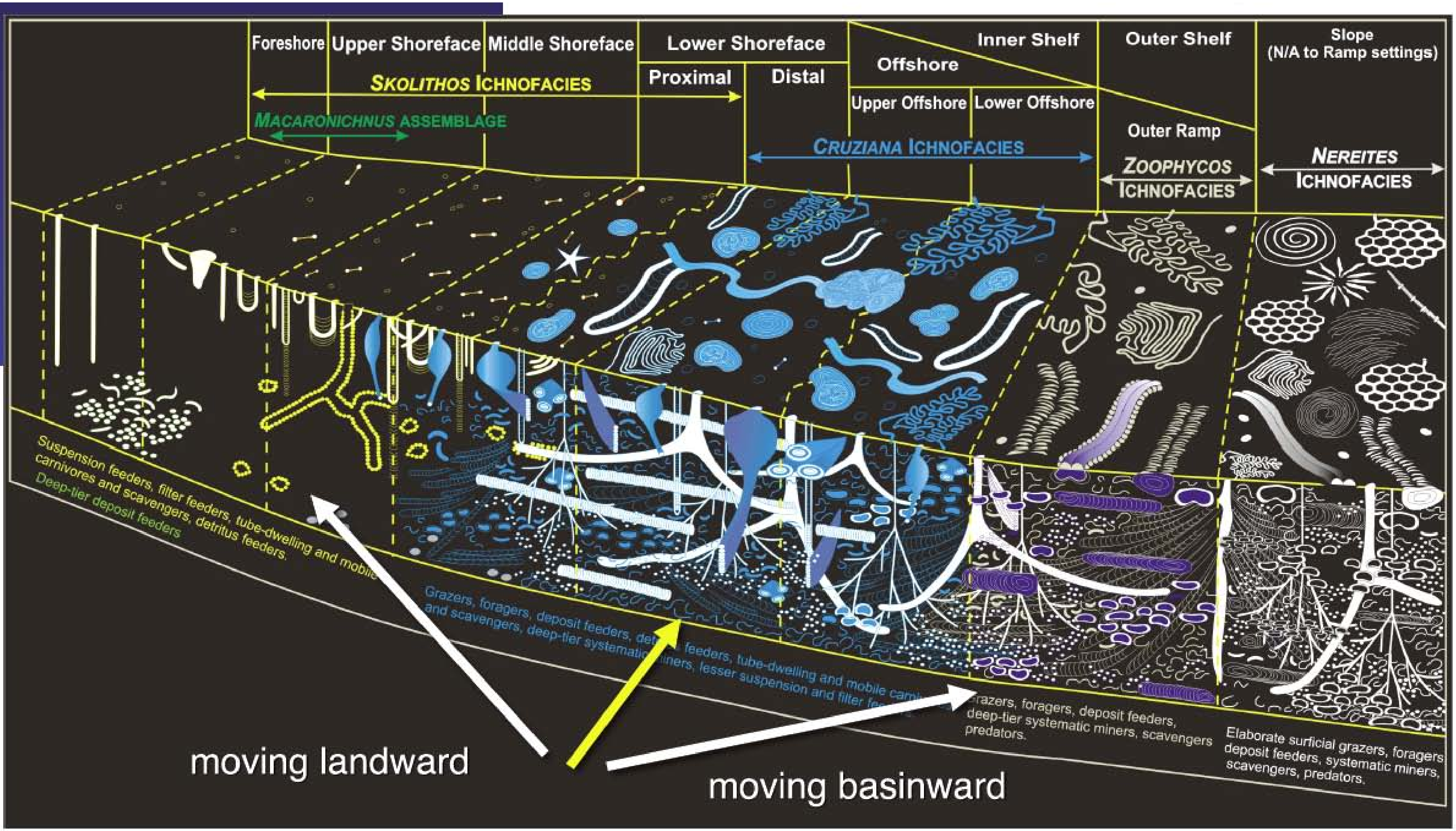
Beach to outer shelf and continental slope



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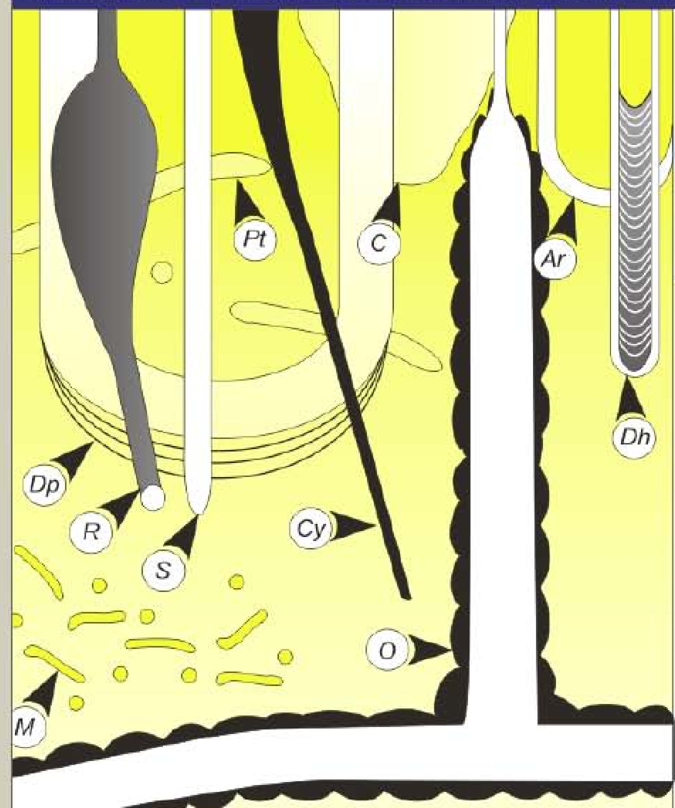
Skolithos Ichnofacies



- Dominated by **dwelling** and **equilibrium-adjustment structures** largely produced by **suspension feeders**.
- Some **passive carnivore dwellings.**
- Subordinate **deposit-feeding** and **grazing** structures.
- Marks **well-oxygenated settings** with **particulate, non-cohesive** (shifting) sandy **substrates,** such as **shoreface** and **high energy shallow marine** or **marginal marine** settings.

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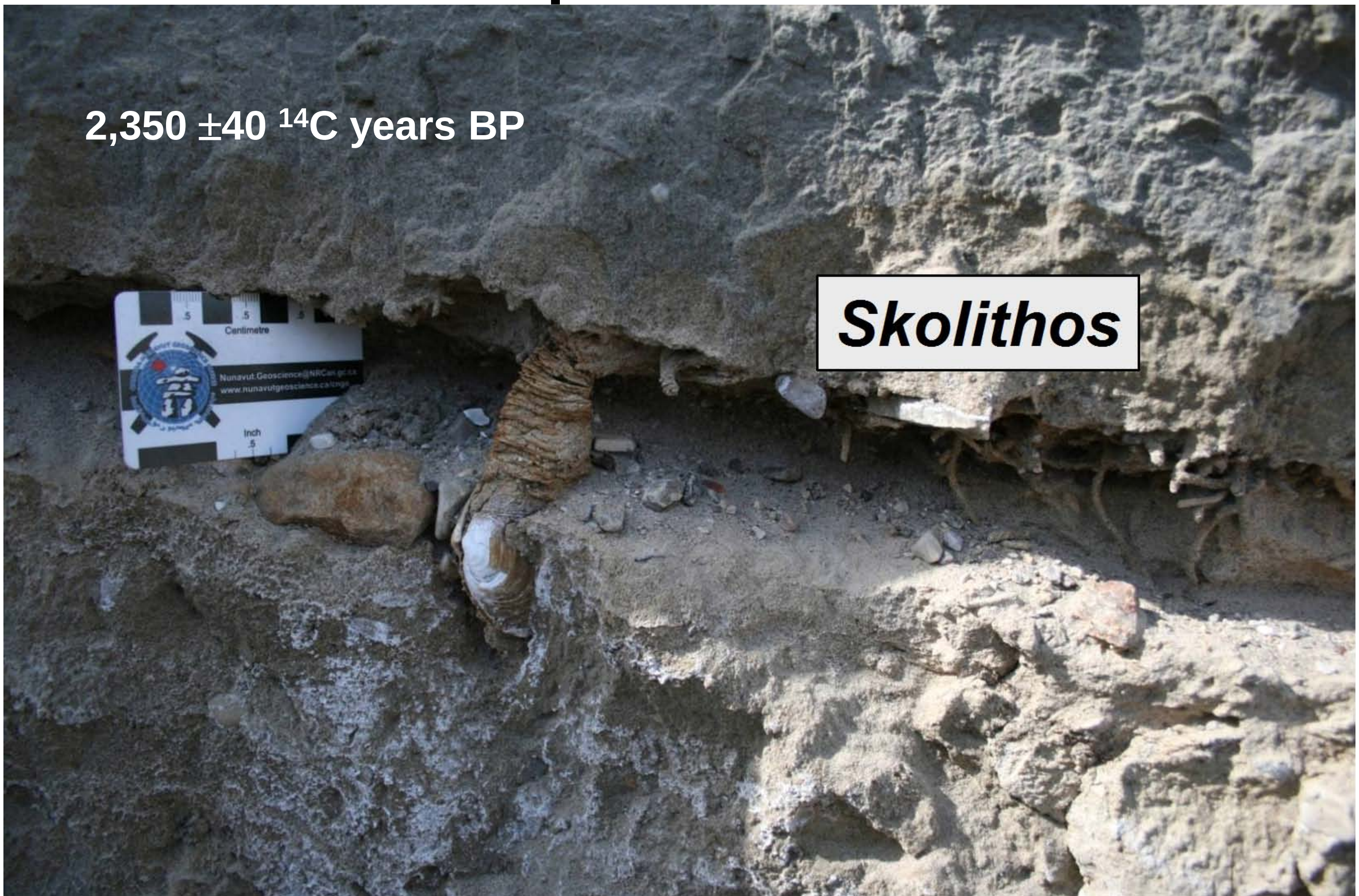
An example from the recent past…



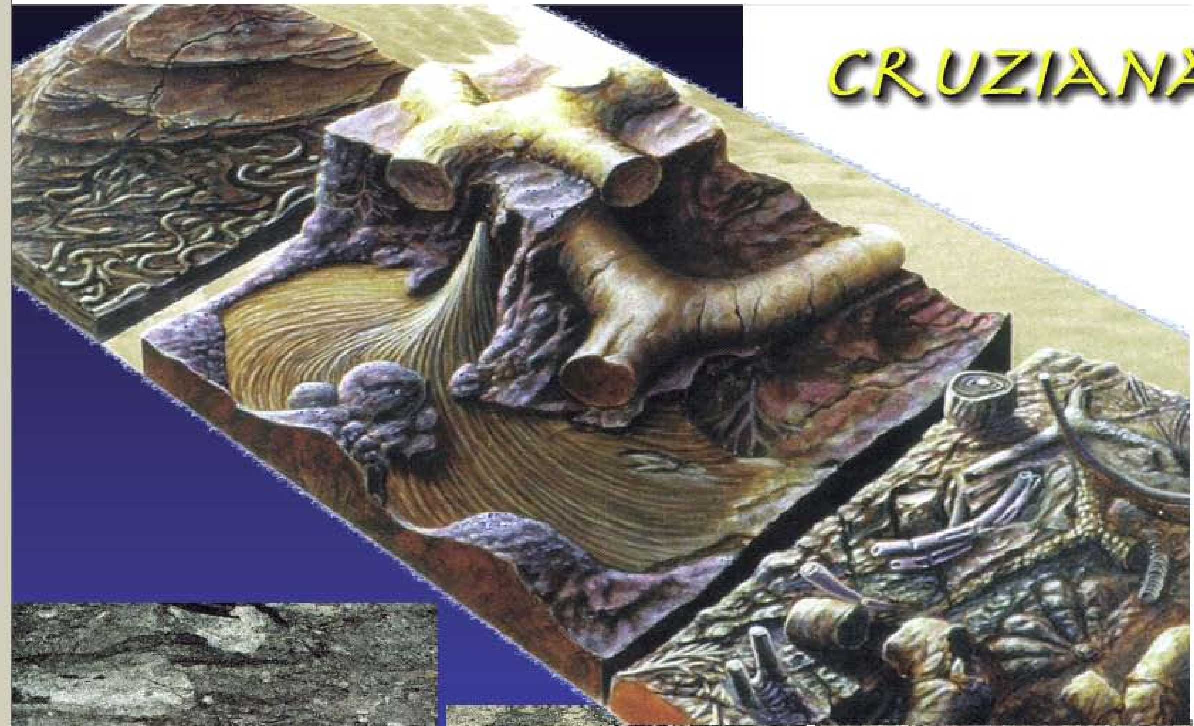
Southampton Island, Nunavut

Combining observations at different scales: facies, deposit, context

Sandy deposit + foreset beds + fossil assemblages: Shallow delta front environment with prograding beach ridges

Raised delta and beach ridges

CRUZIANA ICHNOFACIES



- Dominated by deposit-feeding structures
- Subordinate grazing structures
- Rare, small diameter, silt-lined passive carnivore dwellings
- Variable, though very rare, dwelling structures of suspension feeders
- Common to the Offshore and distal Lower Shoreface.

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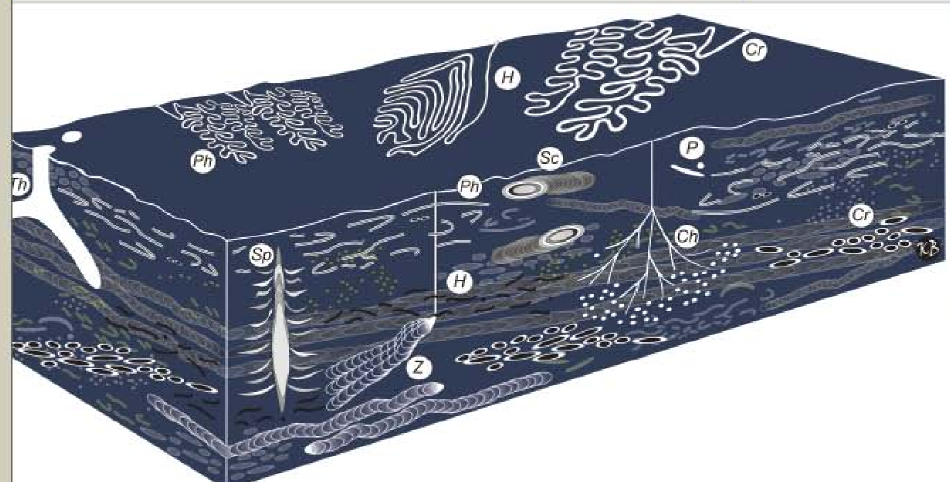
ZOOPHYCOS ICHNOFACIES



Dominated by grazing structures

Subordinate diminutive deposit feeding structures

Very rare, small diameter, silt-lined passive carnivore dwellings

Typical of soft, muddy substrates in quiet-water Shelf or Lower Offshore settings.

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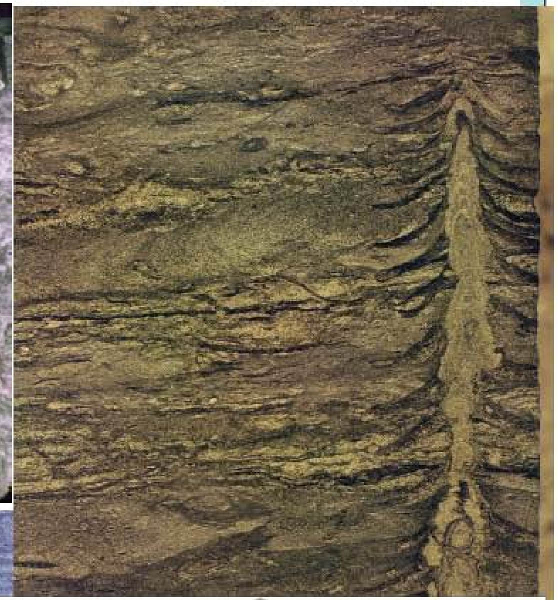
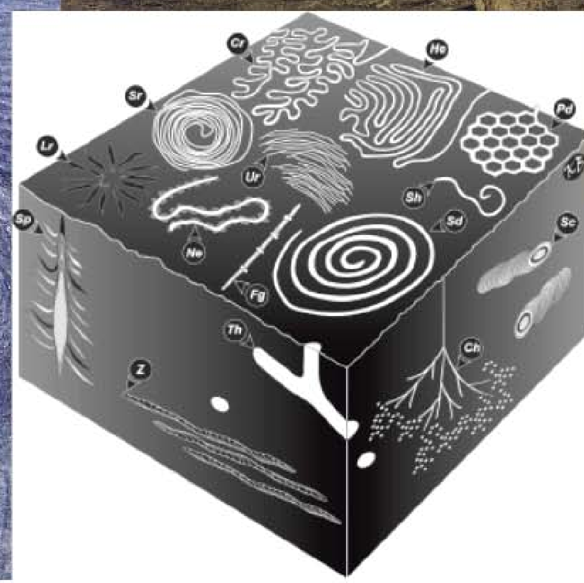
NEREITES ICHNOFACIES





- High diversity but low abundance.
- Complex horizontal grazing traces and patterned feeding/dwelling structures reflecting highly organized efficient behavior.
- Numerous crawling and/or grazing traces and sinuous fecal castings (*Helminthoida*) that are intrastratal.
- Structures associated with trapping and farming microbes within permanent open domiciles (*Paleodictyon*).

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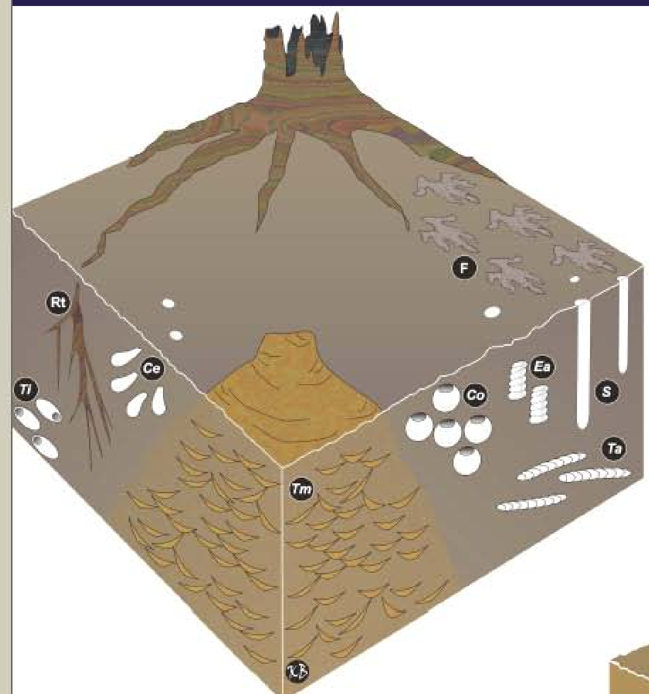
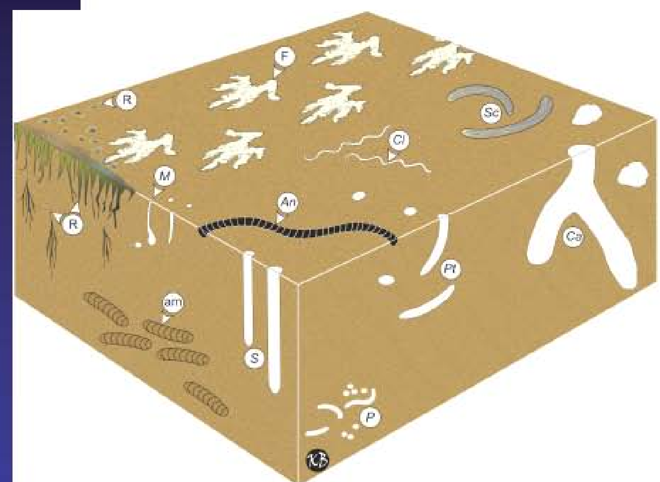
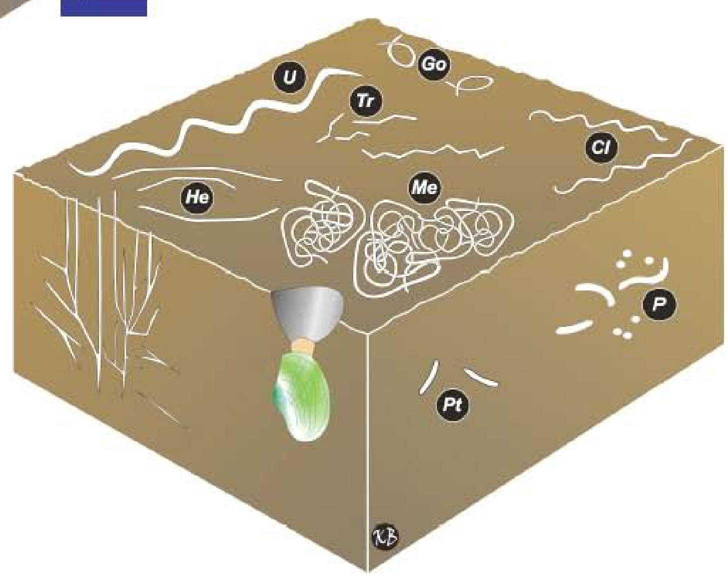
THE CONTINENTAL ICHNOFACIES



Coprinisphaera Ichnofacies



Scoyenia Ichnofacies



Mermia Ichnofacies

Three continental ichnofacies have been formally defined.

They are in their early stages of refinement and show some sense of recurrence.

The continental realm is strongly affected by evolutionary and taphonomic variations.

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Significance of ichnofossils

- Paleoenvironmental indicators
- Indicators of relative SR
- Erosional breaks
- Behavior patterns of extinct organisms
- Top and bottom orientation of beds
- Bio- chronostratigraphic significance
  - Bounding discontinuities

Stromatolites

Ancient examples

Organosedimentary structures formed by the trapping and binding activities of blue-green algae (cyanobacteria)

Organic precipitation of calcium carbonate

- Photosynthesis

$$6H_2O + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6O_2$$

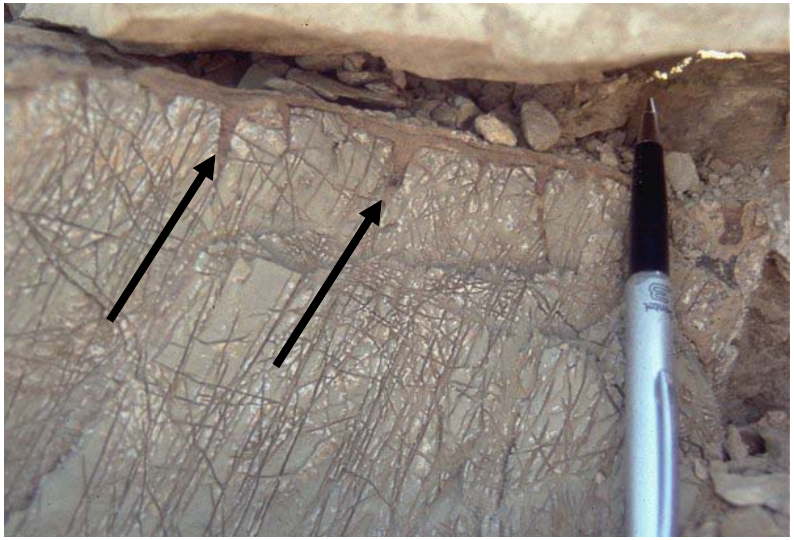
Any process that removes carbon dioxide from water facilitates carbonate precipitation by increasing the pH.

Climate-related structures

Some examples…

Mudcracks

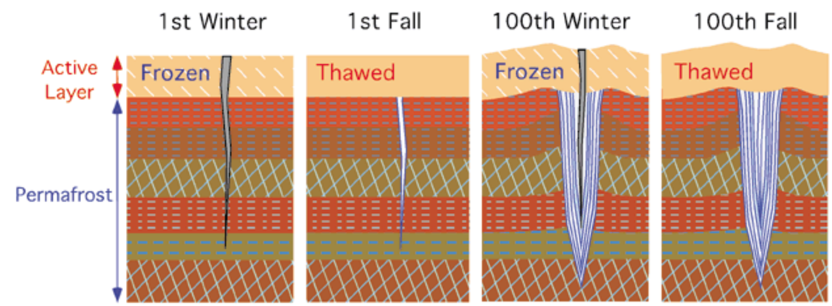
- V-shaped fractures
- Polygonal pattern
  - Estuarine
  - Lagoonal
  - Tidal-flat
  - River floodplain
  - Playa lake
  - Etc.



Raindrop imprints

Ice-wedge polygons and ice-wedge casts

http://www.physicalgeography.net/fundamentals/10ag.html



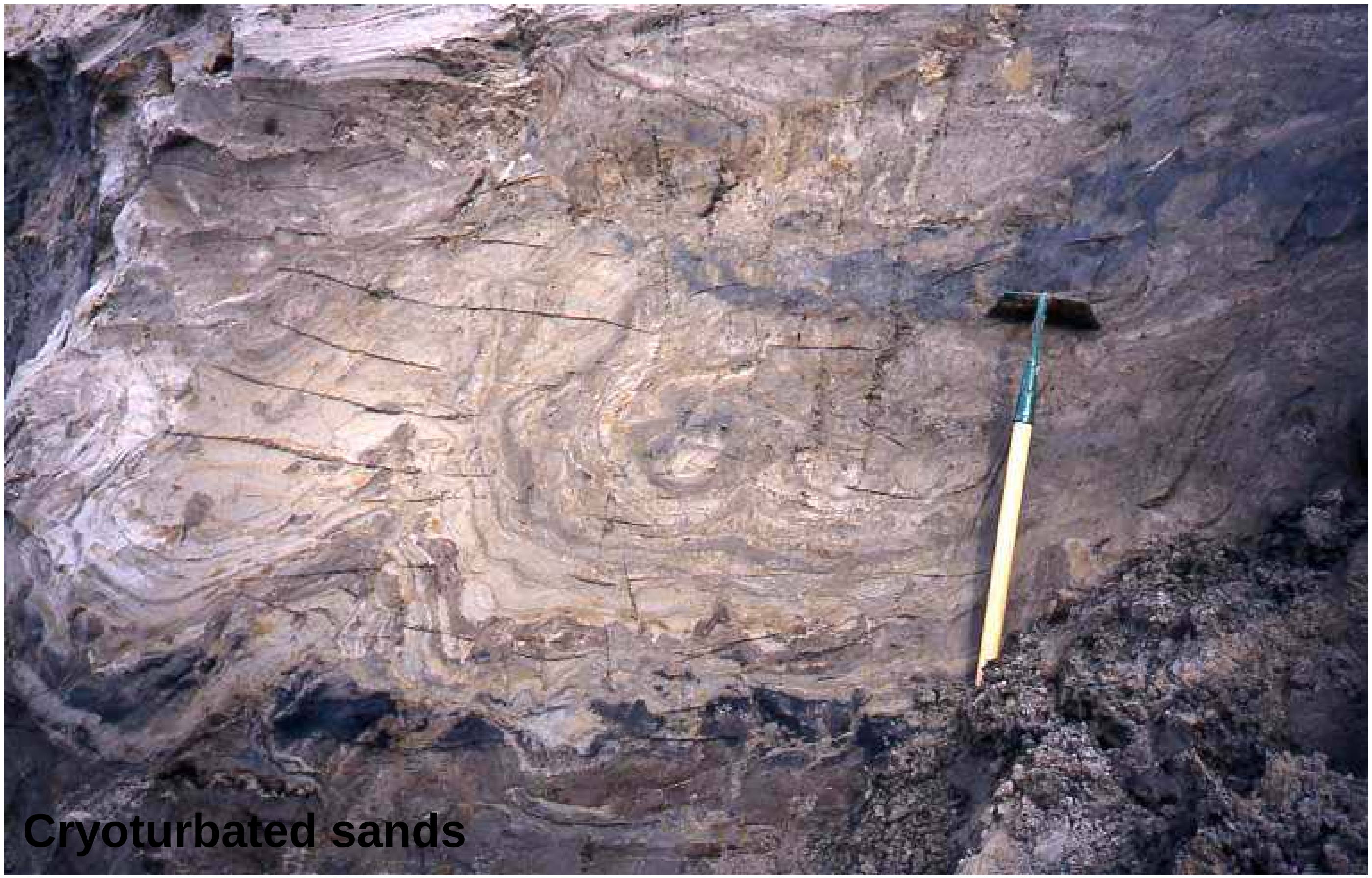
Ice-wedge cast

http://www.hi.is/~oi/siberia_photos.htm

Ice wedge formation

- In dry sands and gravels,
  - organic cover is slight
  - moisture content low
    - well-drained active zone
    - the liquid limit of the sediment is very high;
  - the thawed zone is stable enough to perpetuate seasonal growth of vertical ice wedges that are expressed at the surface as frost cracks.

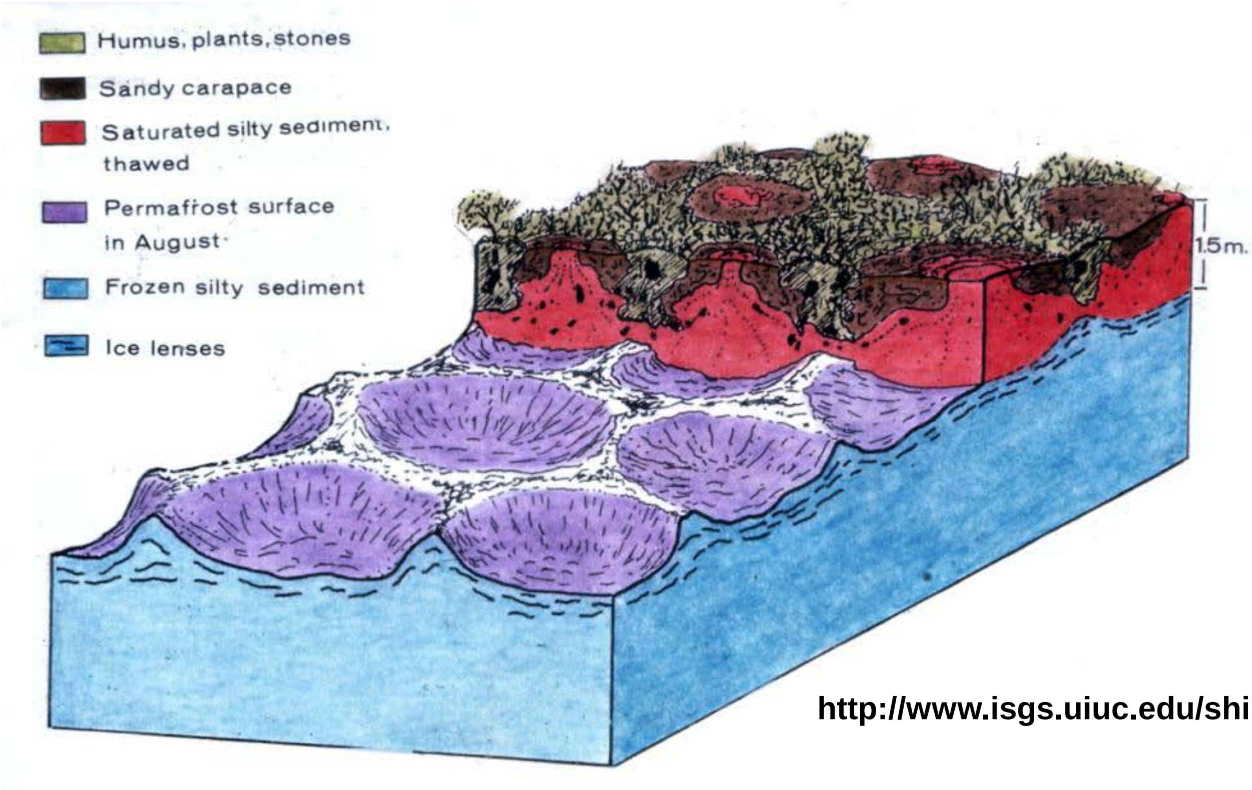
Cryoturbation



“Mudboils” in permafrost terrains

Soft-sediment deformation features, representing small-scale diapiric structures formed during the thaw season

Mudboil formation



http://www.isgs.uiuc.edu/shilts/wwshilts.shtml

Mudboils are formed on poorly-sorted surficial sediment with low liquid limits* (<20%) and significant amounts of silt and clay

In order for mudboils to form, diamicton in a plastic or liquid state must be confined between a rigid surface soil layer and the frost table

***The liquid limit (LL) is the water content where a soil changes from plastic to liquid behavior.**

The liquid mud phase is under hydrostatic pressure and mud can be mobilized by differential loading stresses related to density differences among various sediment components

Geologist trapped in liquefied mud of subaqueous mudboil 1

Location: Island in Kaminak Lake, Nunavut, Canada; NTS 55L; Long. 95 13' W; Lat. 62 18.5' N. (approximately)

Date taken: August 7, 1973
Photo ID: 0063
High resolution image available
Useage statement

Aaron Villakazie, a student assistant funded by the Canadian International Development Agency (C.I.D.A.), was probing a subaqueous mudboil adjacent to an island in Kaminak Lake with a pointed steel bar, when his foot became trapped in till as he attempted to pull the bar out of the bottom. As he struggled to free himself, his left foot sank further and further, until he was waste-deep in water that had been a few inches deep at the start of the incident. Several people, flown in to the island in our helicopter, worked more than two hours, without success, to free him. The cause of his predicament was that, as his foot sank in the saturated mud, his weight, transferred to the mud at the sole of his leather boot, increased the pore water pressure in the mud, causing it to pass above its liquid limit (12.4% water by weight), liquefying it. As his foot descended, the mud above his foot, because of the limited plasticity index of the till in this area (<1%) set to cement-like hardness, preventing him from moving his foot. Even though his colleagues attempted to excavate the material around his leg, it was not possible to keep the excavated mud from flowing back into the depression around his leg, and setting up solidly again. This is the same characteristic of mudboil soils in this region illustrated graphically in images 0065, 0095, and 0096 and described in the caption for image 0240 and in Shilts, 1974. Despite the efforts of seven men, Aaron sank almost to the frost table and was extricated only after the rigid sediment around his leg was excavated hydraulically using a portable, high-discharge water pump (see

http://www.isgs.uiuc.edu/shilts/wwshilts.shtml