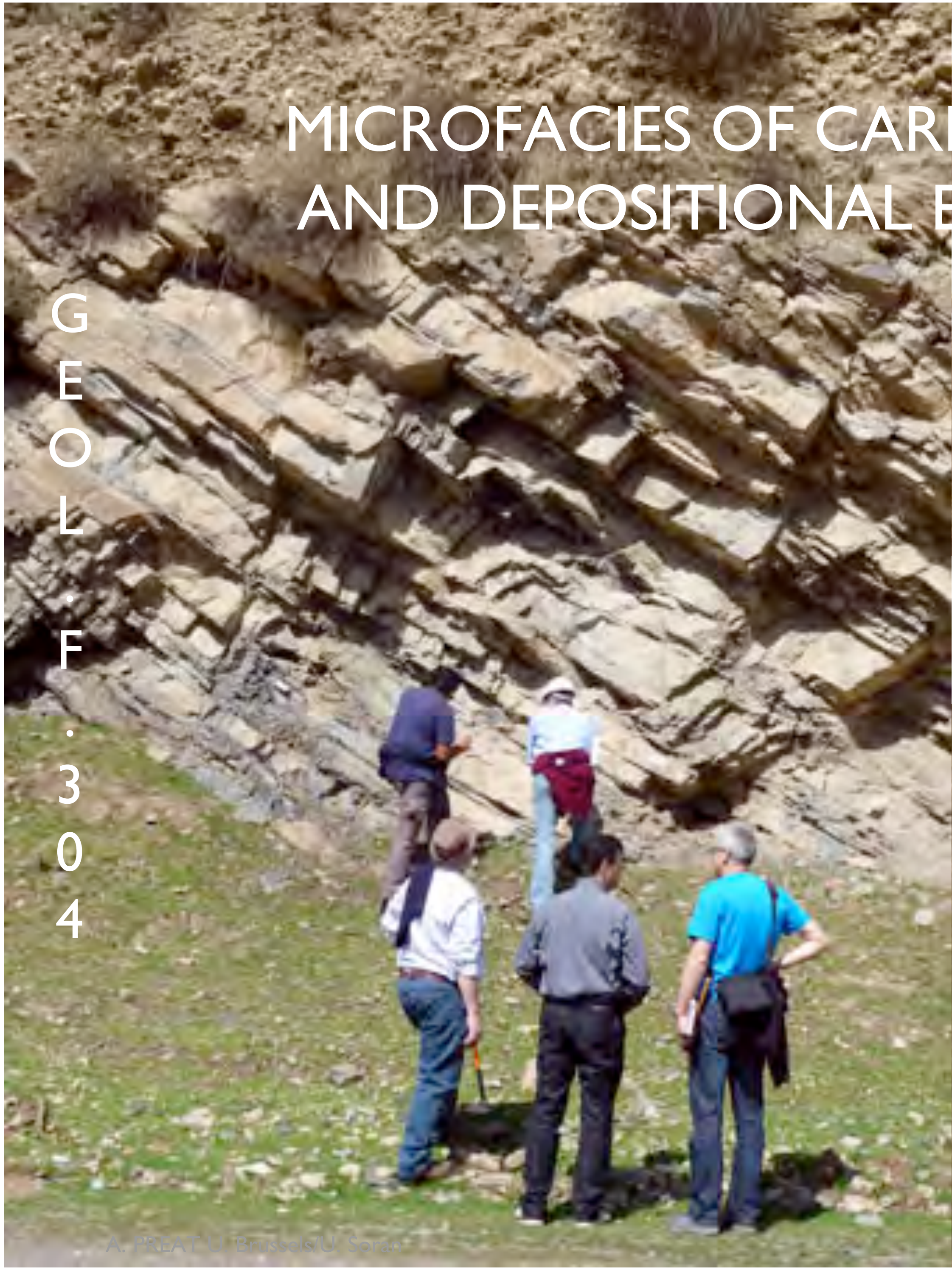
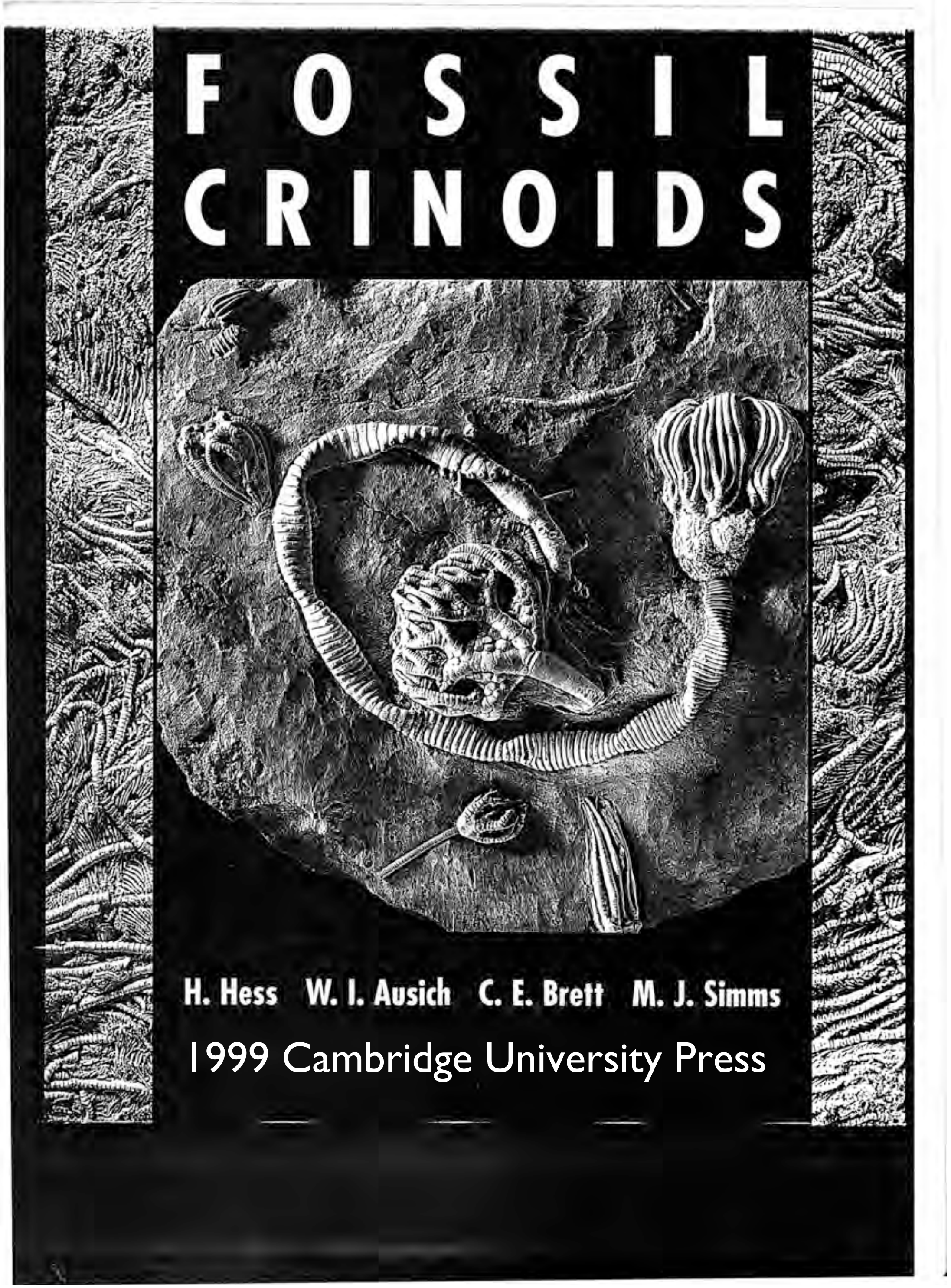
MICROFACIES OF CARBONATE ROCKS AND DEPOSITIONAL ENVIRONMENTS

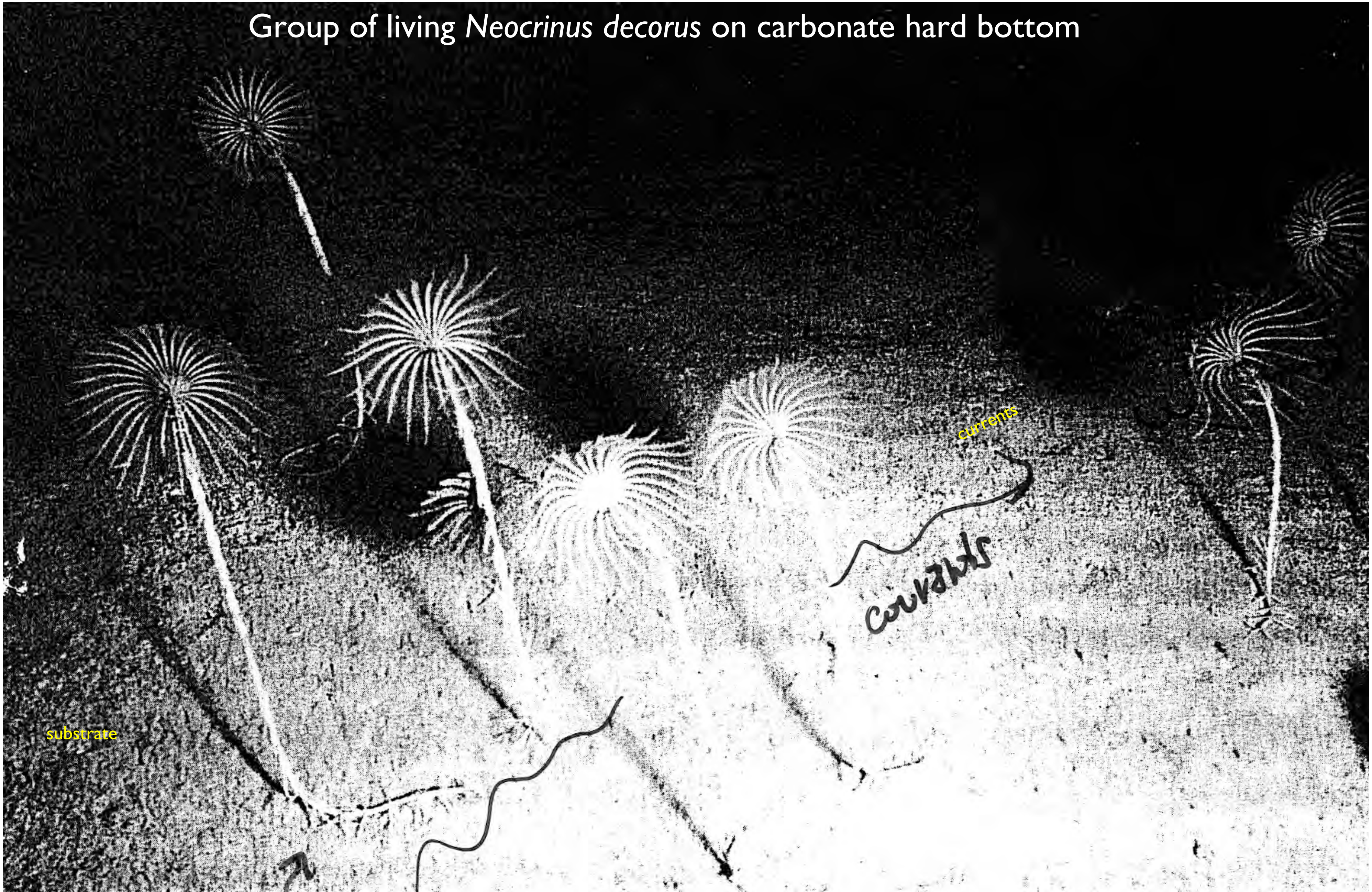
GEOL.F.304



Prof. Alain Préat
Free University of Brussels


FOSSIL CRINOIDS
H. Hess W. I. Ausich C. E. Brett M. J. Simms
1999 Cambridge University Press

Group of living *Neocrinus decorus* on carbonate hard bottom

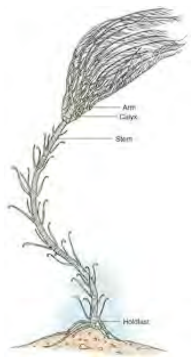


Density of population?
Ecologic niche
Current = Nutrition

In situ fossilization
Fragmentation SWT and/or SWWB

ECHINODERMS

- ★ Exclusively open marine
- ★ Worldwide distribution from the Cambrian to the Recent with an important development during the Ordovician (also apparition of the first shelly facies)
- ★ Composed of 10^2-10^3 of individual plates of LMC (sometimes > one thin section) attached by ligaments or organic fibers
  - => stereomic microstructure = 50% of microporosity
  - => skeletons rapidly disarticulate after the death
  - => plates are scattered … [nb 1dm^3/yr/m^2!...]
- ★ Unable to cement fragments (≠ algae), easily broken, cannot form reefs
  - => **peri-reefal communities**
- ★ two major groups
  - => PELMATOZOANS (attached) = Crinoids-Blastoids-Cystoids
  - => ELEUTHEROZOANS (free) = Echinoids, Asteroids, Holothurians, Ophiuroids




ECHINODERMS

HOLOTHURIANS or 'SEA CUCUMBERS' do not have skeletal plates, and consist of isolated, microscopic, single-crystal calcite pieces (50µm-1mm) = **<u>SCLERITES</u>**. The pieces are named after the object they resemble and include forms such as 'anchors, hooks, wheels, tables, baskets, rods…. disks, plates and rosettes'. They are rare in thin sections, and are often recovered from washed samples and occasionally from insoluble residues.

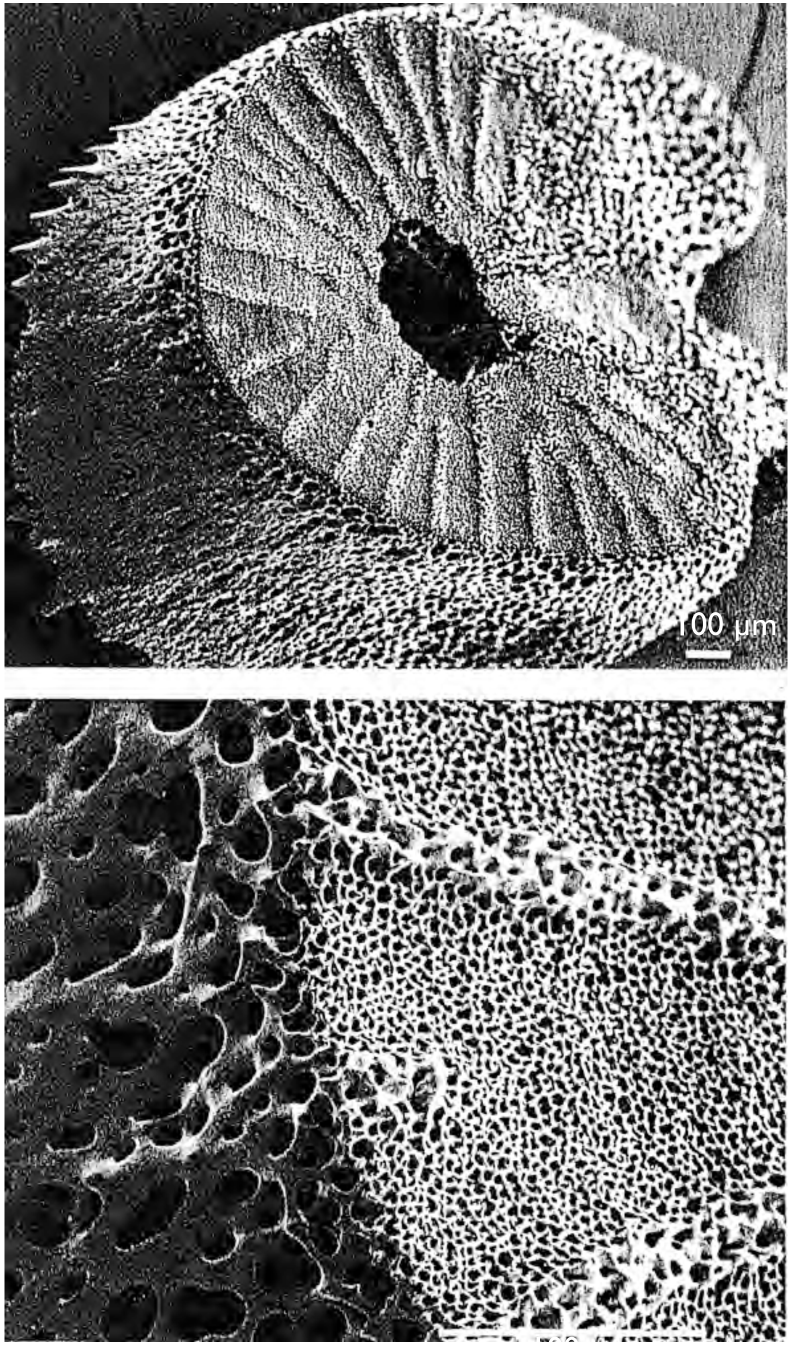
ECHINOIDS = SEA URCHINS, HEART URCHINS (= spatangoids), SAND DOLLARS are readily distinguished by the occurrence of SPINES and sometimes by plates. They can be abundant in chalky limestones and in chalks (ex. in the European Cretaceous).



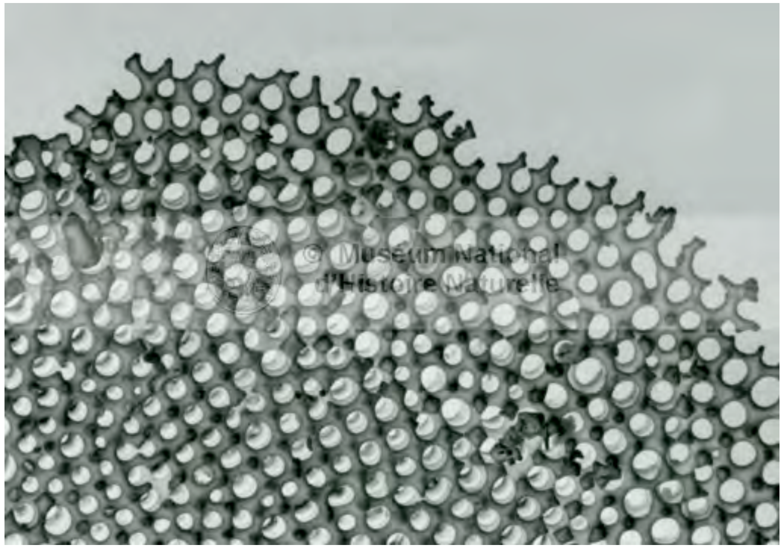

A. PREAT U. Brussels/U. Soran

STEREOMIC MICROSTRUCTURE

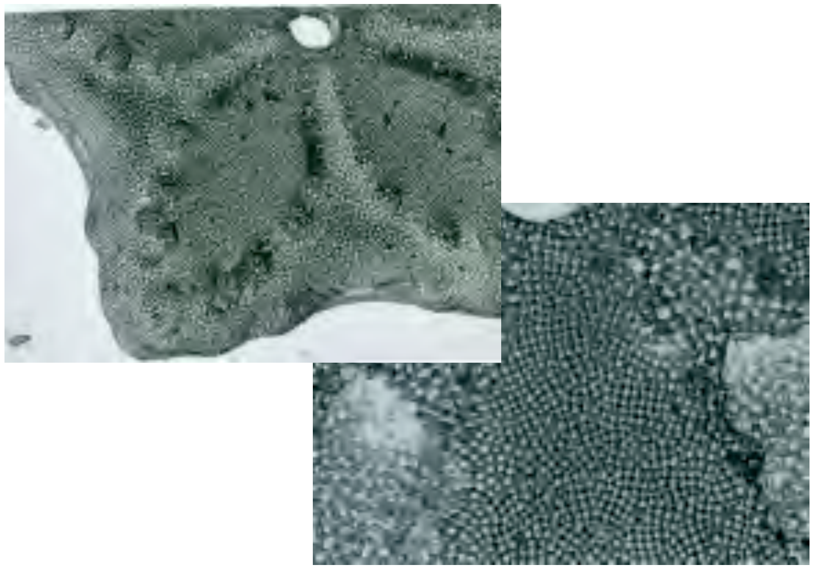
high microporosity (50%) => diagenesis…



SEM photomicrographs of a brachial plate from *Promachocrinus kerguelensis* (Recent, Antarctica)



Muséum national d'Histoire Naturelle, Paris



Crinoid and ostracod succession within the Early–Middle Frasnian interval in the Wietrznia quarry, Holy Cross Mountains, Poland

EDWARD GŁUCHOWSKI, JEAN-GEORGES CASIER, and EWA OLEMPSKA

Głuchowski, E., Casier, J.-G., and Olempska, E. 2006. Crinoid and ostracod succession within the Early–Middle Frasnian interval in the Wietrznia quarry, Holy Cross Mountains, Poland. *Acta Palaeontologica Polonica* 51 (4): 695–706.

Early–Middle Frasnian ostracods and crinoids from Wietrznia in the Northern Kielce subregion of the Holy Cross area were analyzed. Twenty three ostracod species assigned to thirteen named genera, as well as eighteen crinoid species including the representatives of fifteen stem-based taxa were distinguished. For most of the species open nomenclature is applied. The composition of ostracod assemblage changes from moderately diverse in the lower part of the *Palmatolepis transitans* Zone to poorly diverse in its higher part. Lack of ostracods in the uppermost part of the *Pa. transitans* Zone and in the *Palmatolepis punctata* Zone is noted. The crinoid distribution pattern comprises the interval of relatively high diversity, interrupted in the uppermost part of the *Pa. transitans* Zone, and the interval of temporary recovery in the lower *Pa. punctata* Zone. Such distribution patterns point to deterioration of environmental conditions across the Early–Middle Frasnian transition, coinciding with a large-scale C-isotopic perturbation superimposed on intermittent, two-step eustatic sea level rise. On the other hand, impoverished, surviving crinoid faunas and absence of ostracods in the *Pa. punctata* Zone indicate the overall long-term deterioration of life conditions through the major C-isotope anomaly time span. However, this may also result from synsedimentary tectonic pulses, causing block movements and large-scale resedimentation phenomena on the northern slope of the Dyminy Reef during the basal Middle Frasnian sea level rise.

Key words: Crinoidea, Ostracoda, Frasnian, Holy Cross Mountains, Poland.

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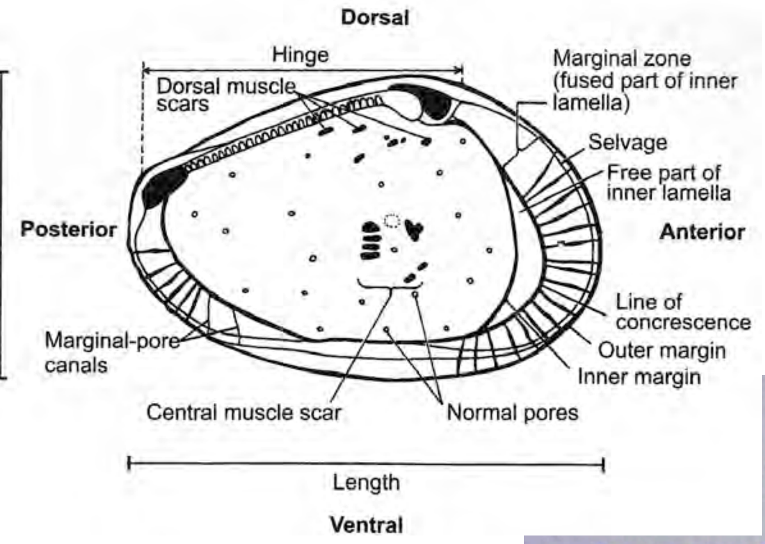
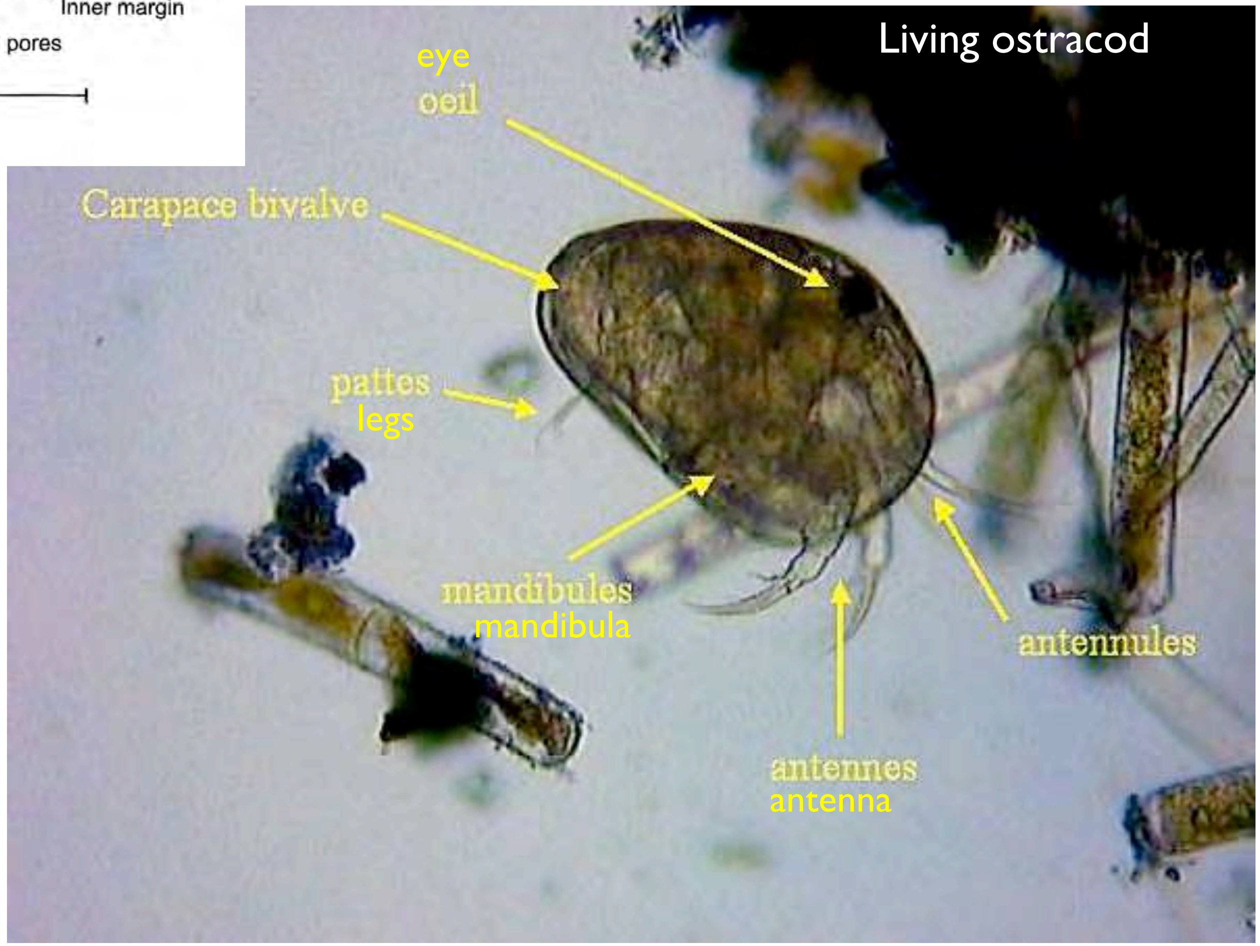
Ostracods: most diverse group of living crustaceans (arthropods) 0.5-3mm L [max 3cm]
> 50,000 living and fossils species
Widely used in biostratigraphy, paleoenvironments, paleoclimates from the Ordovician

van Morkohoven 1963





http://micromegas.over-blog.com/article-35258857.html

Early-Middle Frasnian (Late Devonian, Poland)

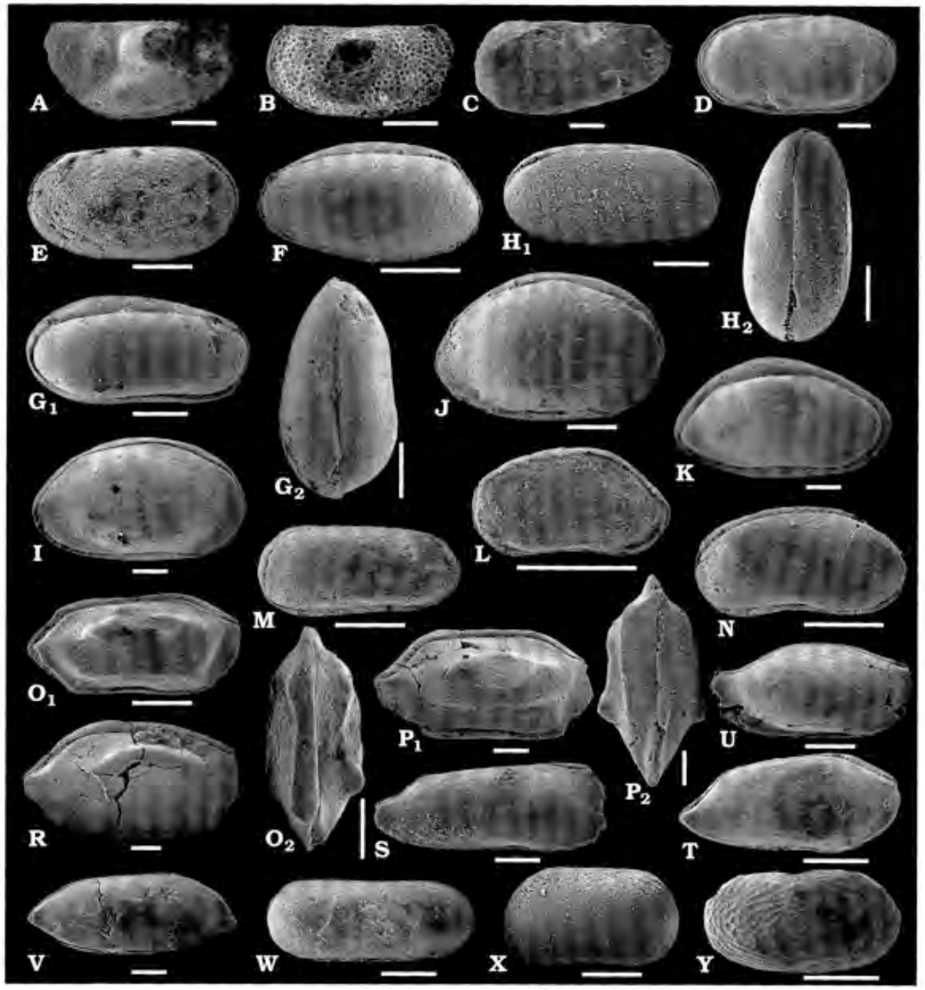


Fig. 2. Early Frasnian (*Palmatolepis transitans* Zone) ostracods from the Wietrznia Id-W section, Holy Cross Mountains. **A**. *Hollinella* sp., ZPAL O.57/1, sample Id-W-29, in left valve in lateral view. **B**. *Amphissites* sp. aff. *A. parvulus* (Paeckelmann, 1913), ZPAL O.57/2, sample Id-W-9, right valve in lateral view. **C**. Palaeocopida indet., ZPAL O.57/3, sample Id-W-39, left valve in lateral view. **D**. *Uchtovia* sp., ZPAL O.57/4, sample Id-W-31, carapace in left lateral view. **E**. Paraparchitidae? sp. indet., ZPAL O.57/5, sample Id-W-31, carapace in right lateral view. **F**. *Micronewsomites* sp., ZPAL O.57/6, sample Id-W-9, carapace in right lateral view. **G**. *Microcheilinella* sp. A., ZPAL O.57/7, sample Id-W-17, carapace in right lateral (G_1) and dorsal (G_2) views. **H**. *Microcheilinella* sp. B, ZPAL O.57/8, sample Id-W-39, carapace in right lateral (H_1) and dorsal (H_2) views. **I**. *Bairdiocypris* sp. A, ZPAL O.57/9, sample Id-W-31, carapace in right lateral view. **J**. *Bairdiocypris* sp. B, ZPAL O.57/10, sample Id-W-31, carapace in right lateral view. **K**. *Bairdiocypris* sp. C, ZPAL O.57/11, sample Id-W-31, carapace in right lateral view. **L**. *Healdianella* cf. *alba* Lethiers, 1981, ZPAL O.57/12, sample Id-W-17, carapace in right lateral view. **M**. *Cytherellina*? sp., ZPAL O.57/13, sample Id-W-31, carapace in right lateral view. **N**. *Bairdiacypris* sp. A, ZPAL O.57/14, sample Id-W-9, carapace in right lateral view. **O, P**. *Bairdia* (*Rectobairdia*) sp. nov. A. **O**. ZPAL O. 57/15, sample Id-W-31, carapace in right lateral (O_1) and dorsal (O_2) views. →

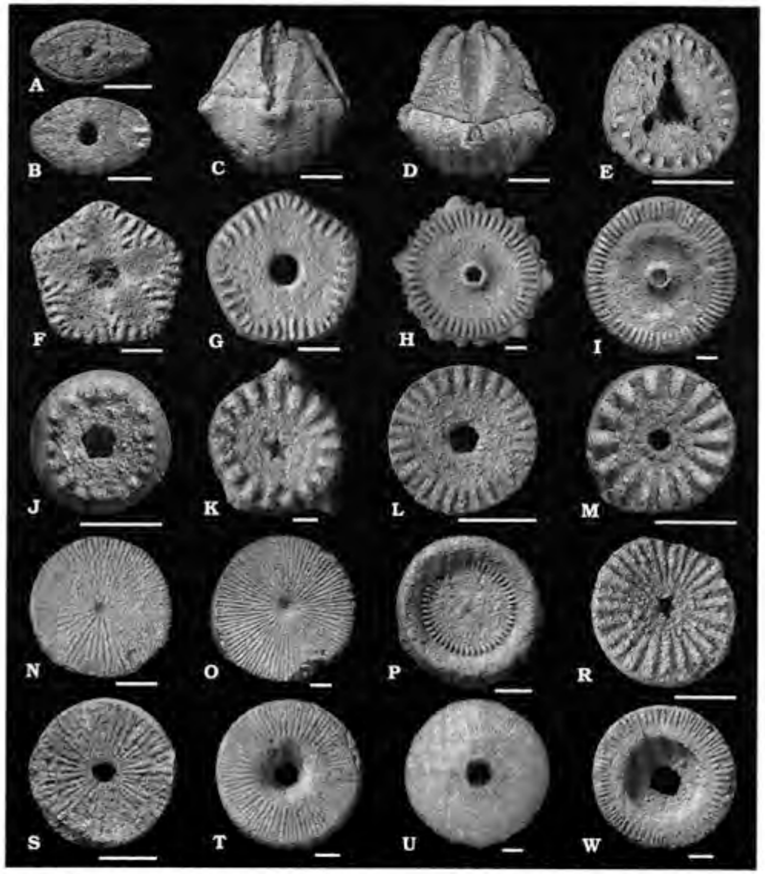
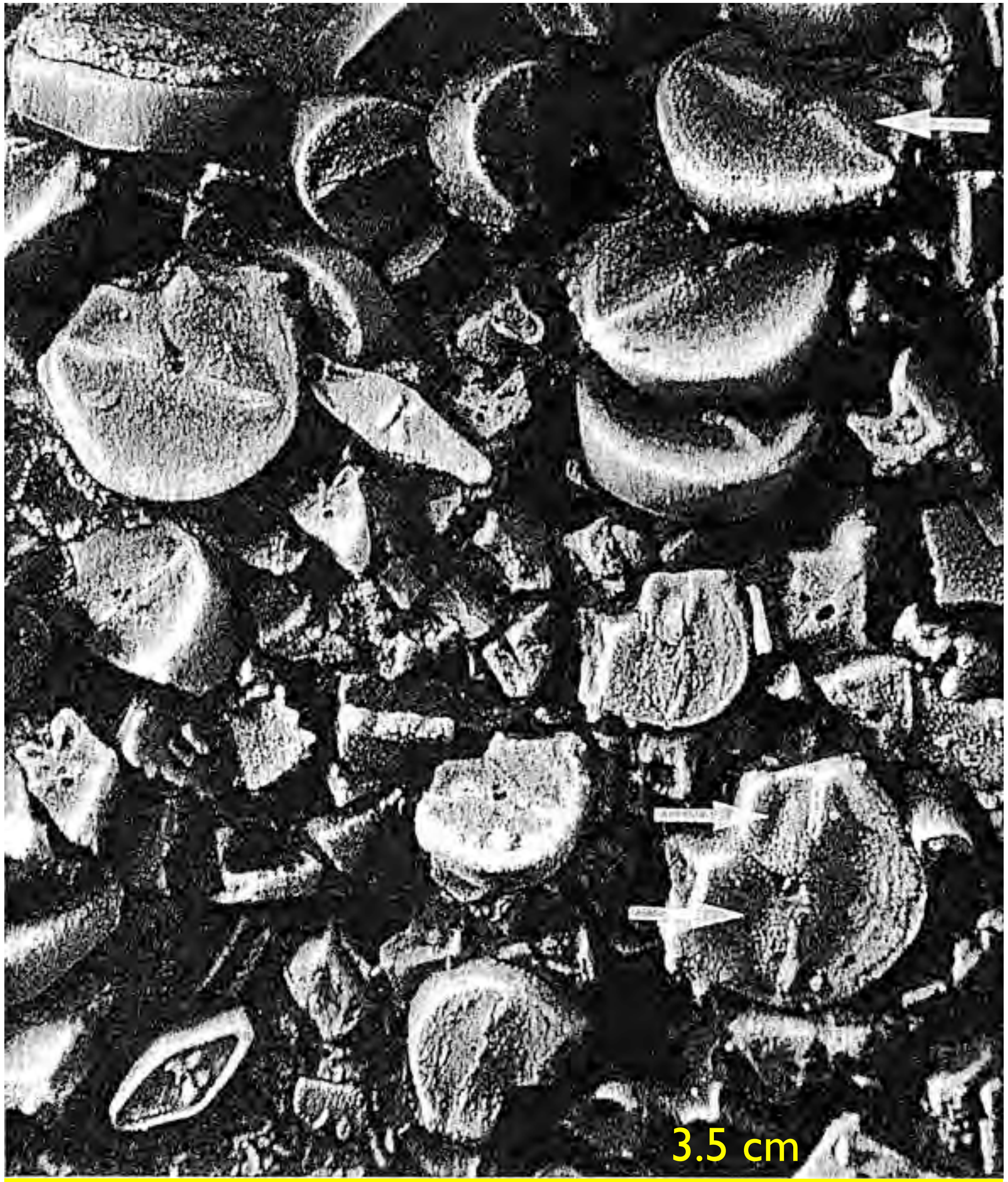


Fig. 3. Early–Middle Frasnian crinoids from the Wietrznia Ie section, Holy Cross Mountains. **A, B**. *Platycrinites* sp. **A**. GIUS 4-404/2, sample Ie-66, articular facet with very weakly developed fulcrum. **B**. GIUS-4-404/3, sample Ie-66, articular facet with marginal culmina. **C, D**. *Haplocrinites* sp. **C**. GIUS-4-404/5, sample Ie-48, theca from A-ray side. **D**. GIUS-4-404/6, sample Ie-48, theca from E-ray side. **E**. *Cupressocrinites* sp., GIUS-4-404/8, sample Ie-19. **F**. *Floricrinus* sp., GIUS-4-404/6, sample Ie-66. **G**. *Anthinocrinus wenjukowi* Yeltyschewa in Yeltyschewa and Stukalina, 1977, GIUS-4-404/15, sample Ie-34. **H**. *Marettocrinus kartzevae* (Yeltyschewa and Dubatolova in Dubatolova and Yeltyschewa, 1961), GIUS-4-404/10, sample Ie-19. **I**. *Laudonomphalus humilicarinatus* (Yeltyschewa in Dubatolova and Yeltyschewa, 1961), GIUS-4-404/7, sample Ie-19. **J**. *Kstutocrinus* sp., GIUS-4-404/13, sample Ie-66. **K**. *Schyschcatocrinus multiformis* Gluchowski, 1993, GIUS-4-404/16, sample Ie-19. **L**. *Schyschcatocrinus delicatus* Gluchowski, 1993, GIUS-4-404/14, →



Muscular articulation on brachials of *Pentacrinites fossilis*. Small muscular fields (arrows), a rhomboidal cirral is visible at lower left.

Sinemurian, Dorset, UK (Simms 1989)

stems : **sometimes >20m** in length!

ECHINODERMS
today ≈ 7000 sp.

THIN SECTION : accumulation of plates or single crystals (some with articulation –sea urchins also with echinoid spines) and ossicles (crinoids) with a central canal.

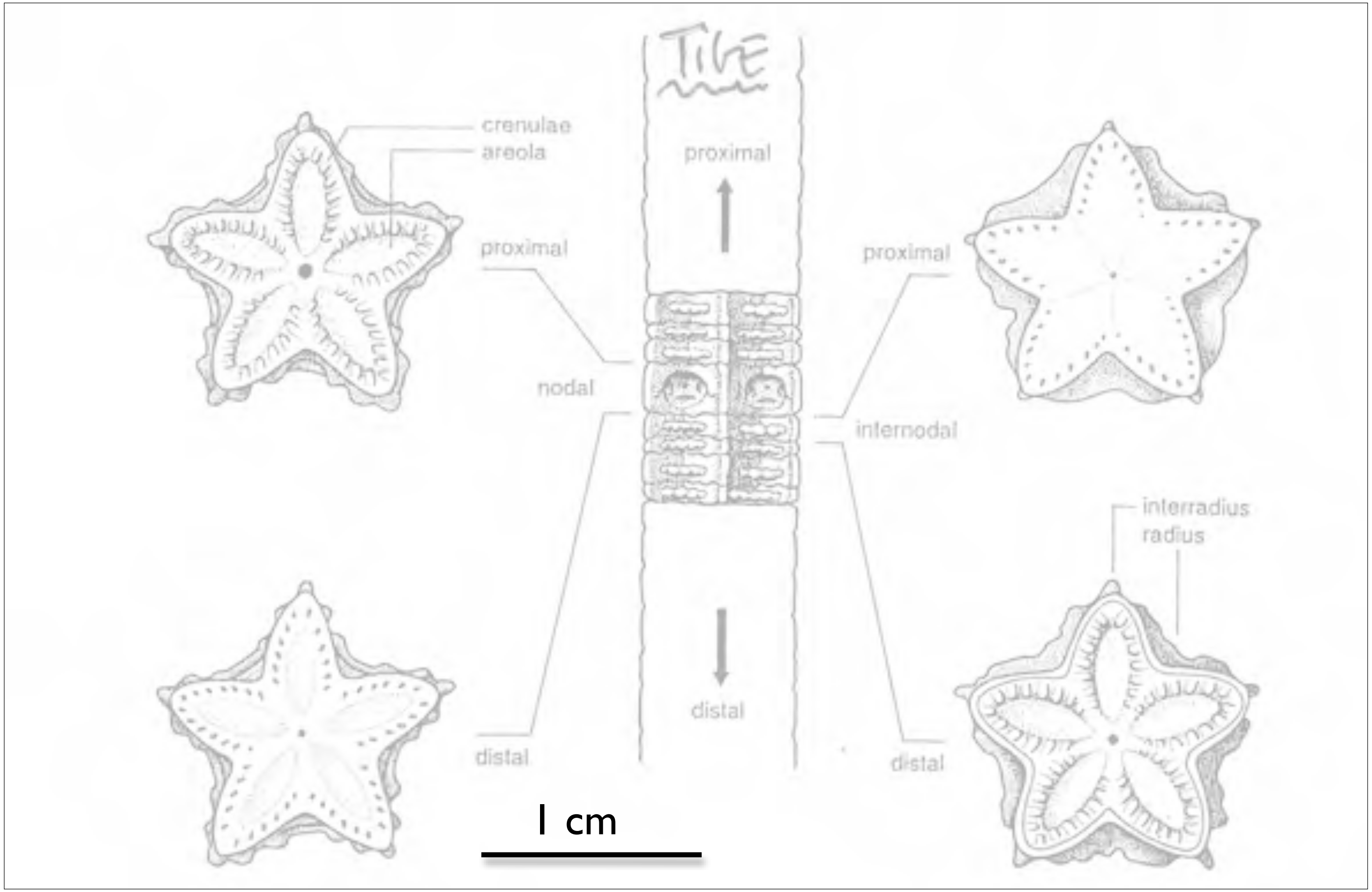
CRINOIDAL MEADOWS

- 0.6 individual/m^2, stem dm'-m or >10m!, plates mm-cm
- **slightly agitated environment** below FWWB : i.e. ±20m for the upper limit and 30-40m for the lower limit
- SWB and tempestites (very common)
- exclude any other form of life (except bryozoa)

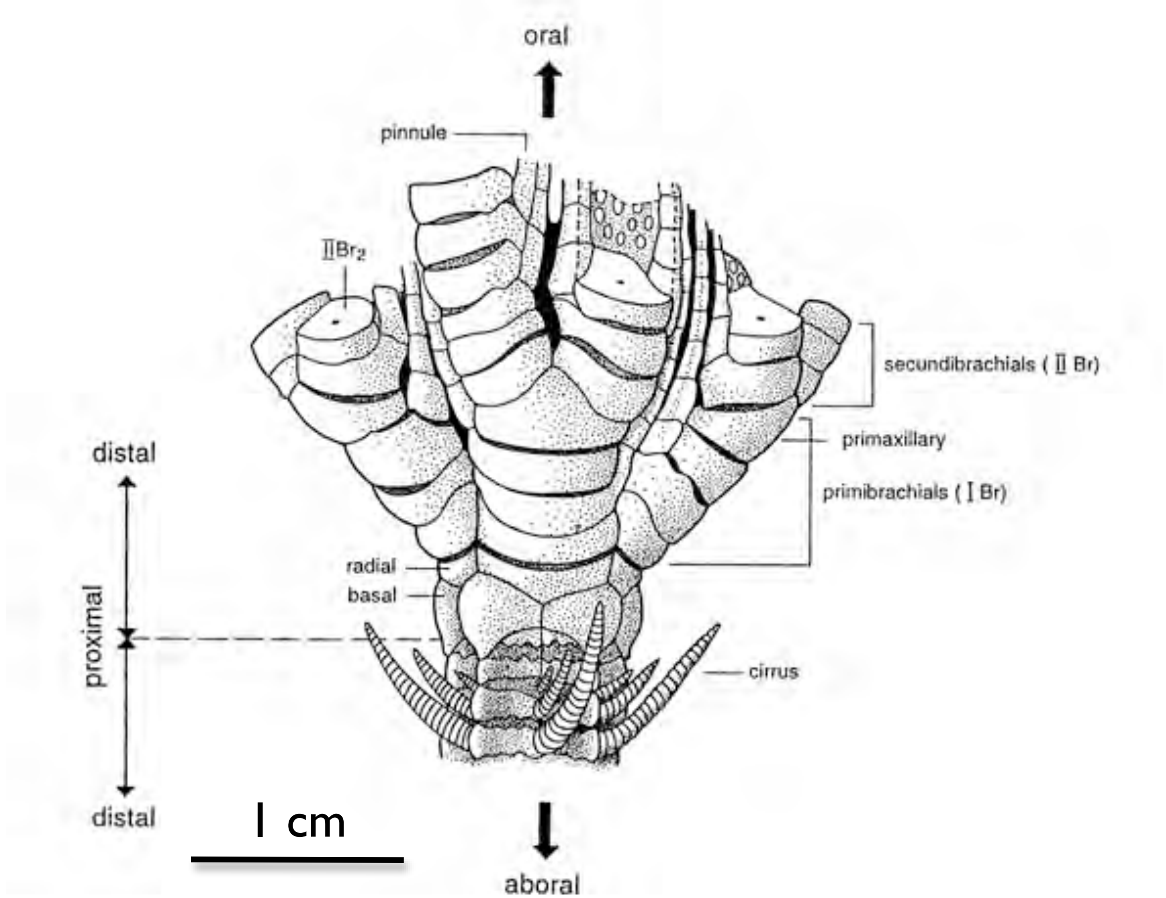
ROCKS : 'encrinites' or crinoidal limestones in the Paleozoic, 'calcaires à entroques' in the Mesozoic (France), echinodermal or pelmatozoan limestones (with cystoids and blastoids in the Ordovician)

ABUNDANCE : very abundant in Upper Paleozoic (Devonian-Carboniferous-Permian)
± 13000 fossil species through geologic times

STEM

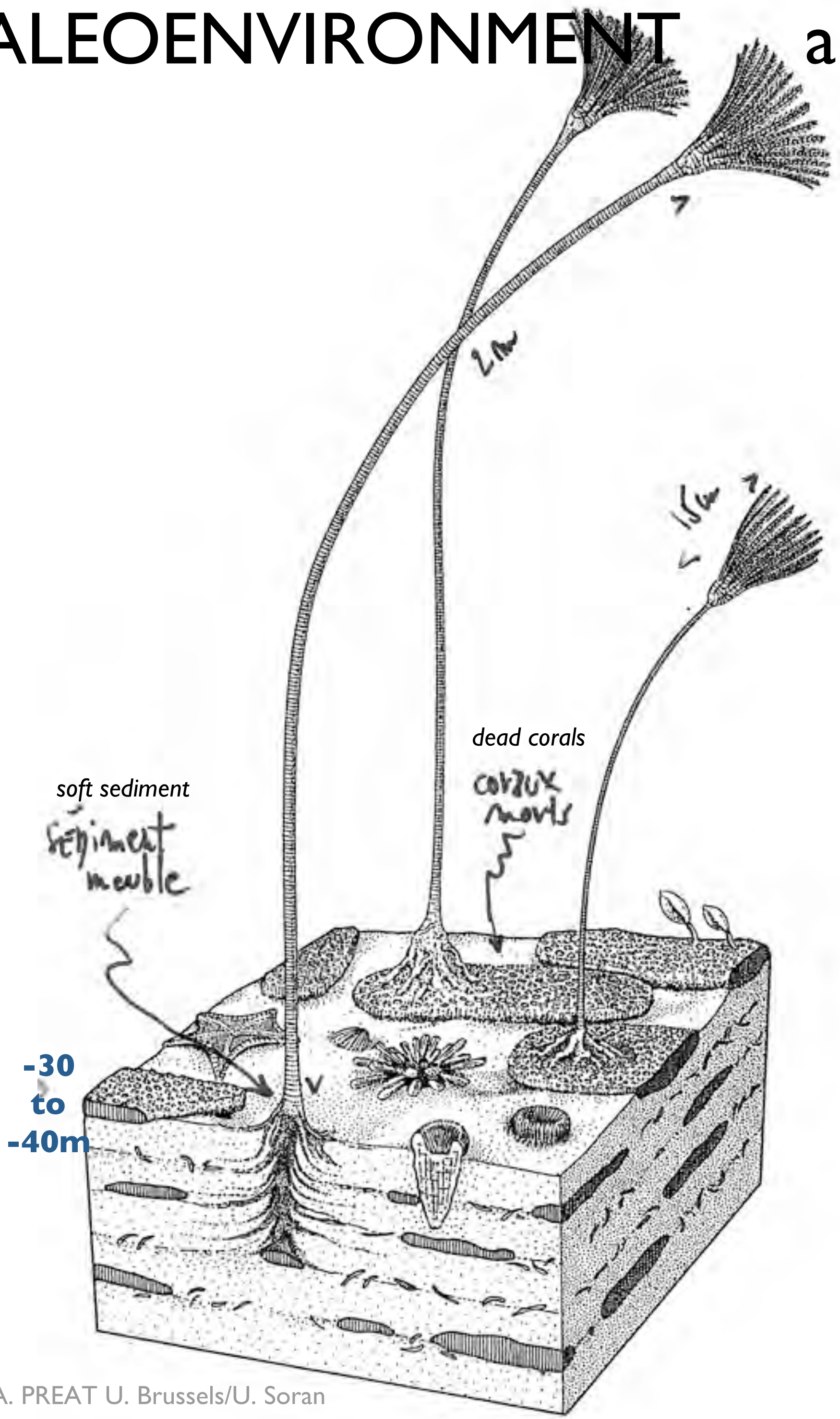


Part of the stem of the isocrinid *Metacrinus angulatus,* with nodal and internodals, showing the different articulations (Carpenter, 1883)



Proximal stem, cup and base of arms of *Metacrinus angulatus* (Carpenter 1884).

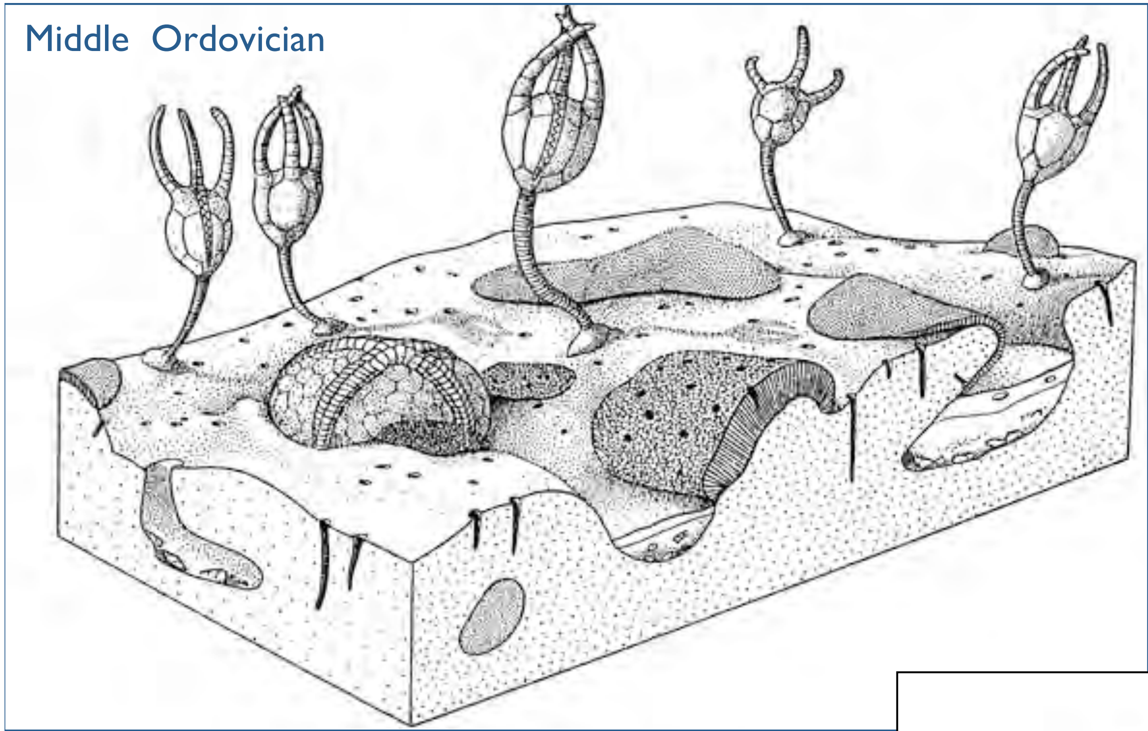
PALEOENVIRONMENT and PALEOECOLOGY



Reconstruction of the Jurassic sea lily *Liliocrionus munsterianus.*
This environment is comparable to today's lagoon southeast of Nouméa (New Caledonia), where flat corals lie loose on a muddy bottom in -35 to -40m deep water (Hottinger, 1996).

The crinoid was fixed to hard substrates by a massive root, alternatively, it was anchored in the soft bottom by roots that become quite long, growing in step with accumulating sediment.

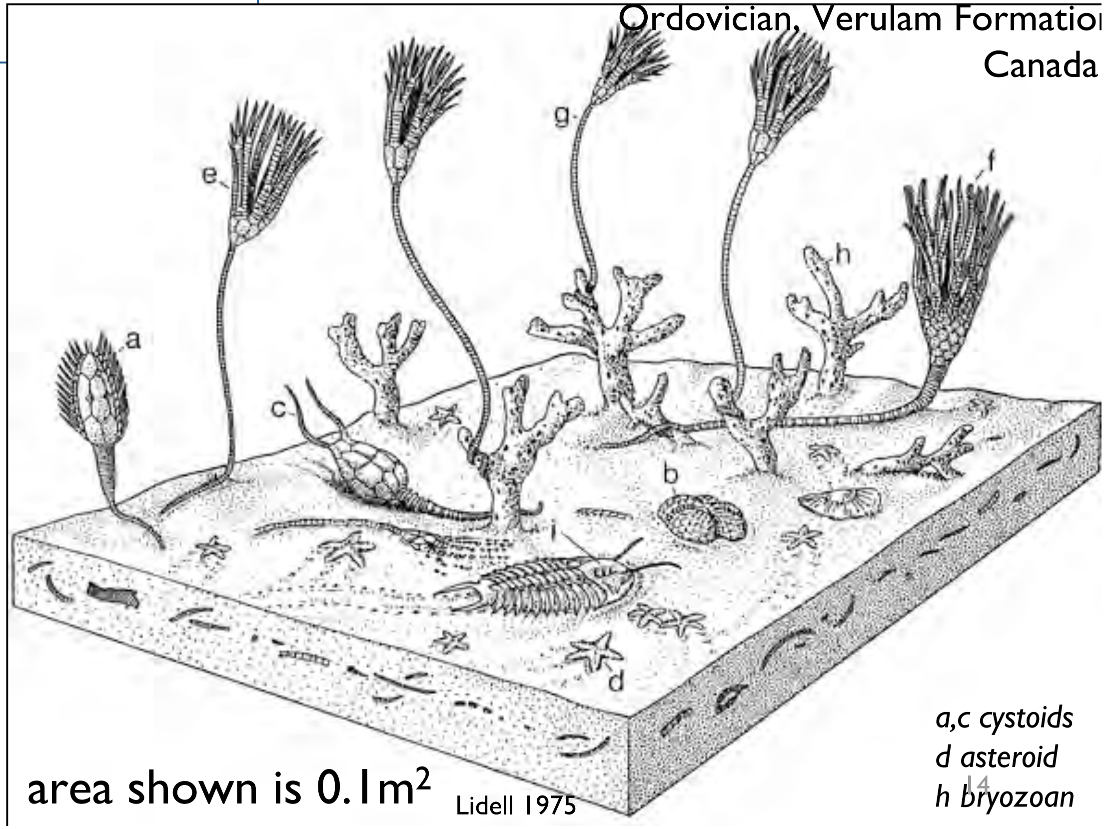
Other parts of fauna consist of the echinoid *Paracidaris florigemma,* the asteroid *Tylasteria,* a pectinid bivalve and two terebratulids (brachiopods), the solitary coral *Montlivaltia* (dead specimens) is partly embedded in the mud.



PALEOENVIRONMENT PALEOECOLOGY

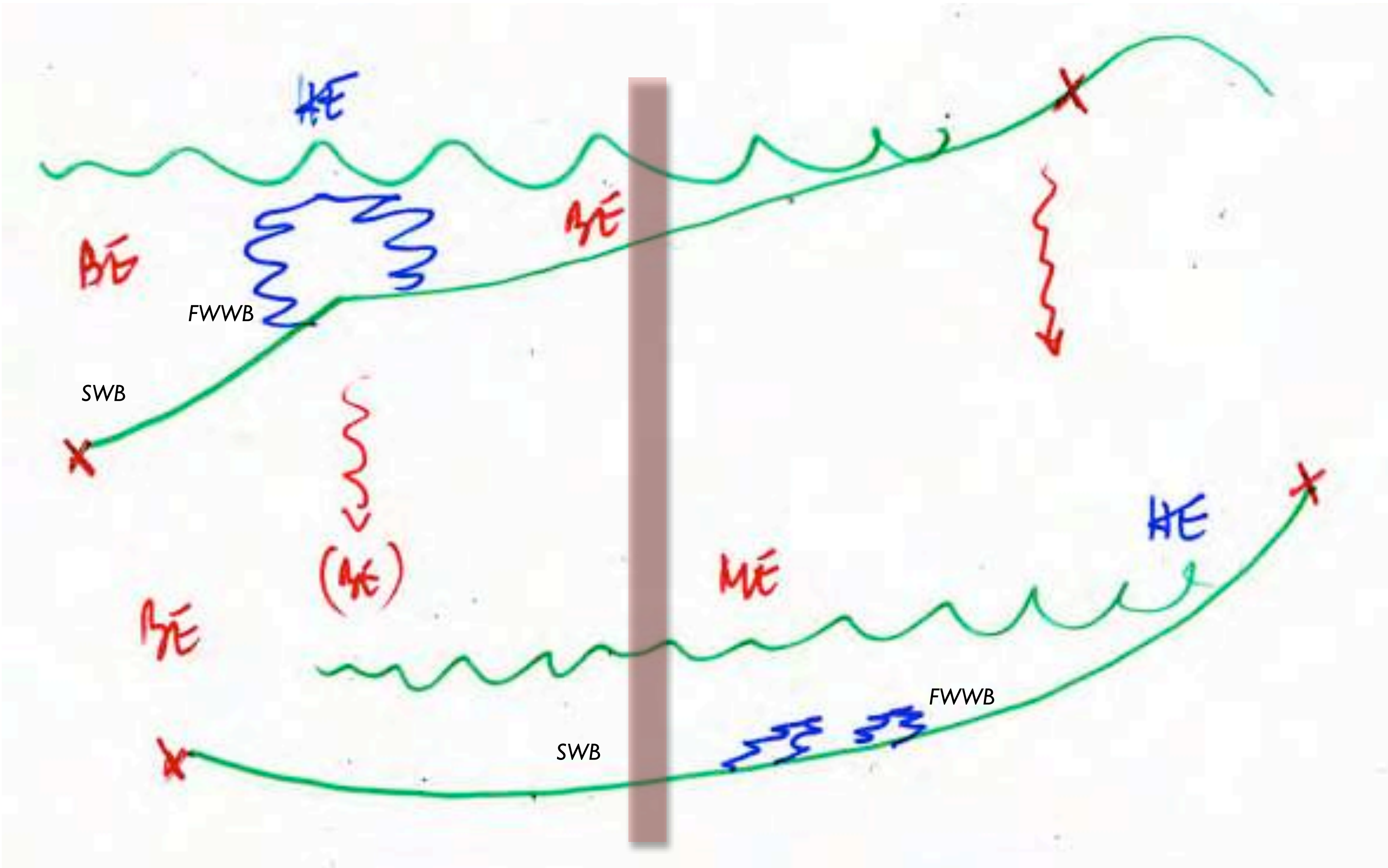
Middle Ordovician hardground community.
Irregular topography, abundant *Trypanites* borings and encrusting bryozoa. Echnioderms include the small, short-stemmed hybocrinid *Hybocystes eldonensis* and the edrioasteroid *Edrioaster bigsbyi* (left foreground) (Brett & Lidell 1978).

nb *Trypanites* = probably sipunculid worm



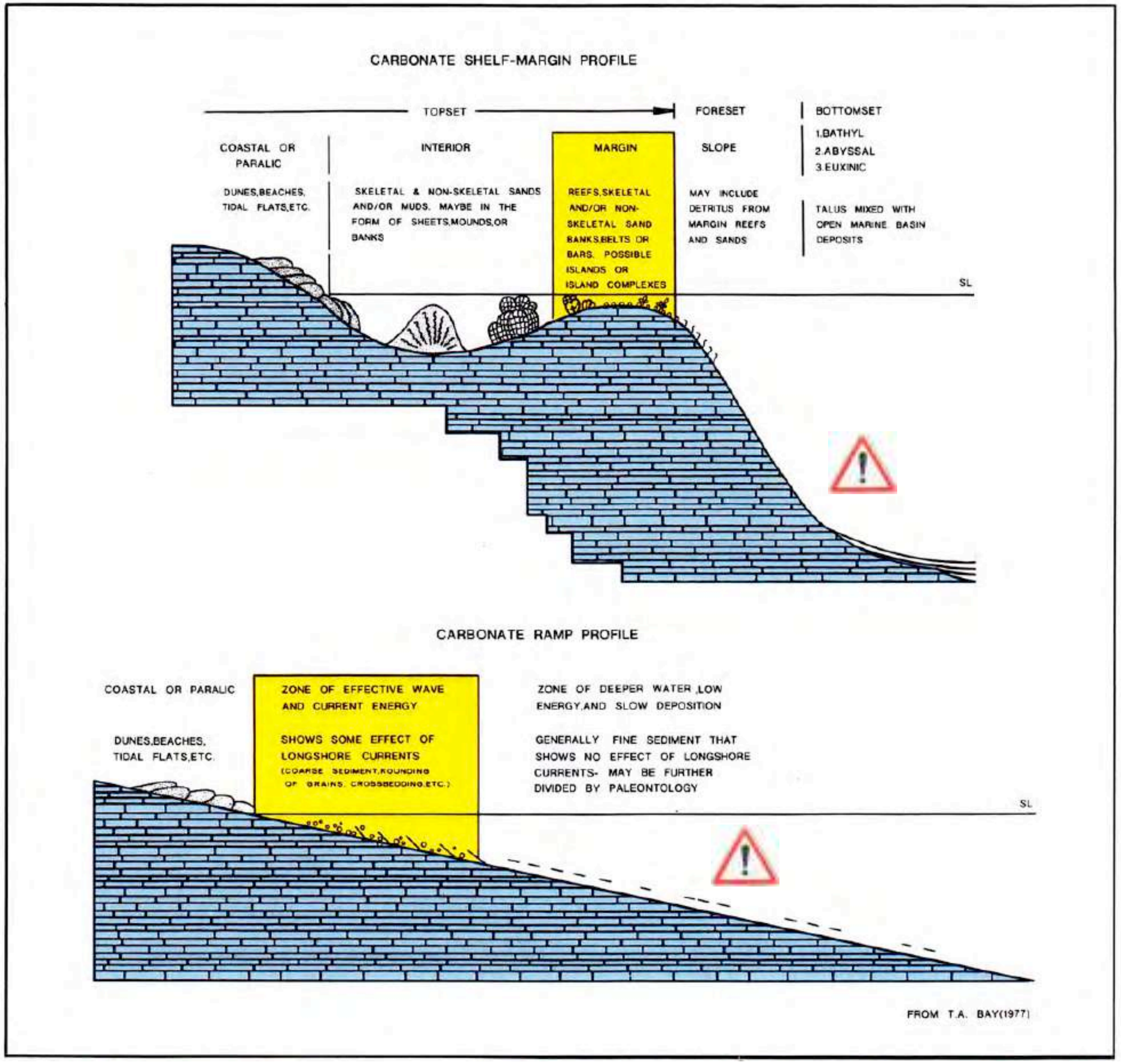
SHELVES

PLATFORM vs RAMP SYSTEMS (MODELS)



BE = low energy
ME = mid energy
HE = high energy
+ FWWB and SWB
ex: Bahamas vs Persian Gulf ...

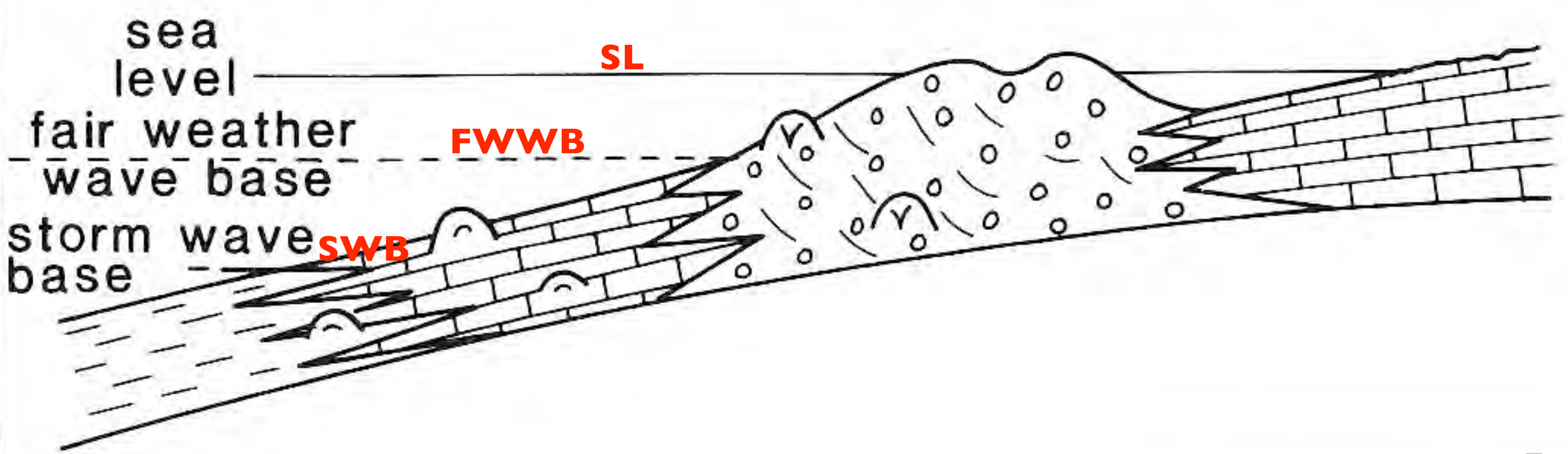
CARBONATE PLATFORM - RAMP MODELS



SLOPES VERY EXAGGERATED

The carbonate ramp depositional model

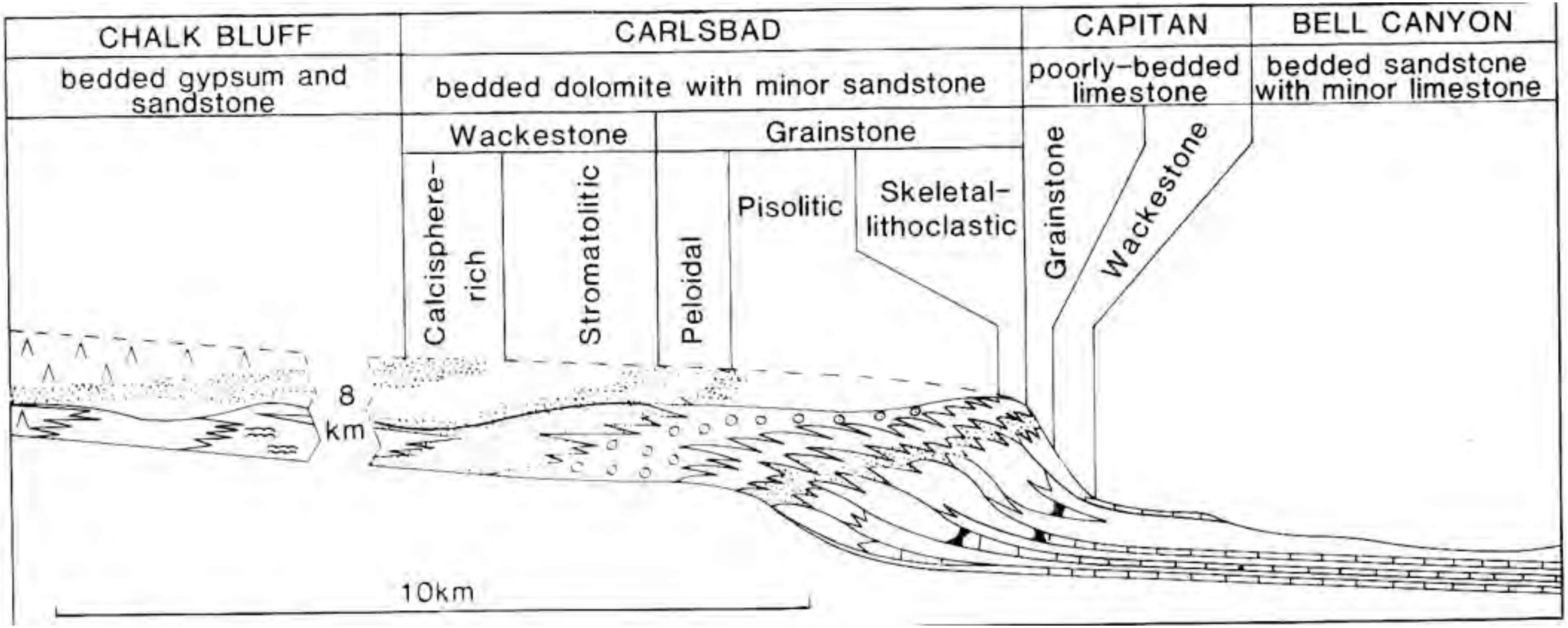
BASIN	CARBONATE RAMP deep ramp	CARBONATE RAMP shallow ramp	CARBONATE RAMP back ramp
below fair weather wave base		wave dominated	absent or very limited protected/subaerial
shale/ pelagic limestone	thin bedded limestones storm deposits ± mud mounds	beach/barrier/ strand plain/ shoals ± patch reefs	lagoonal–tidal flat– supratidal carbonates, ± evaporites paleosols, paleokarsts

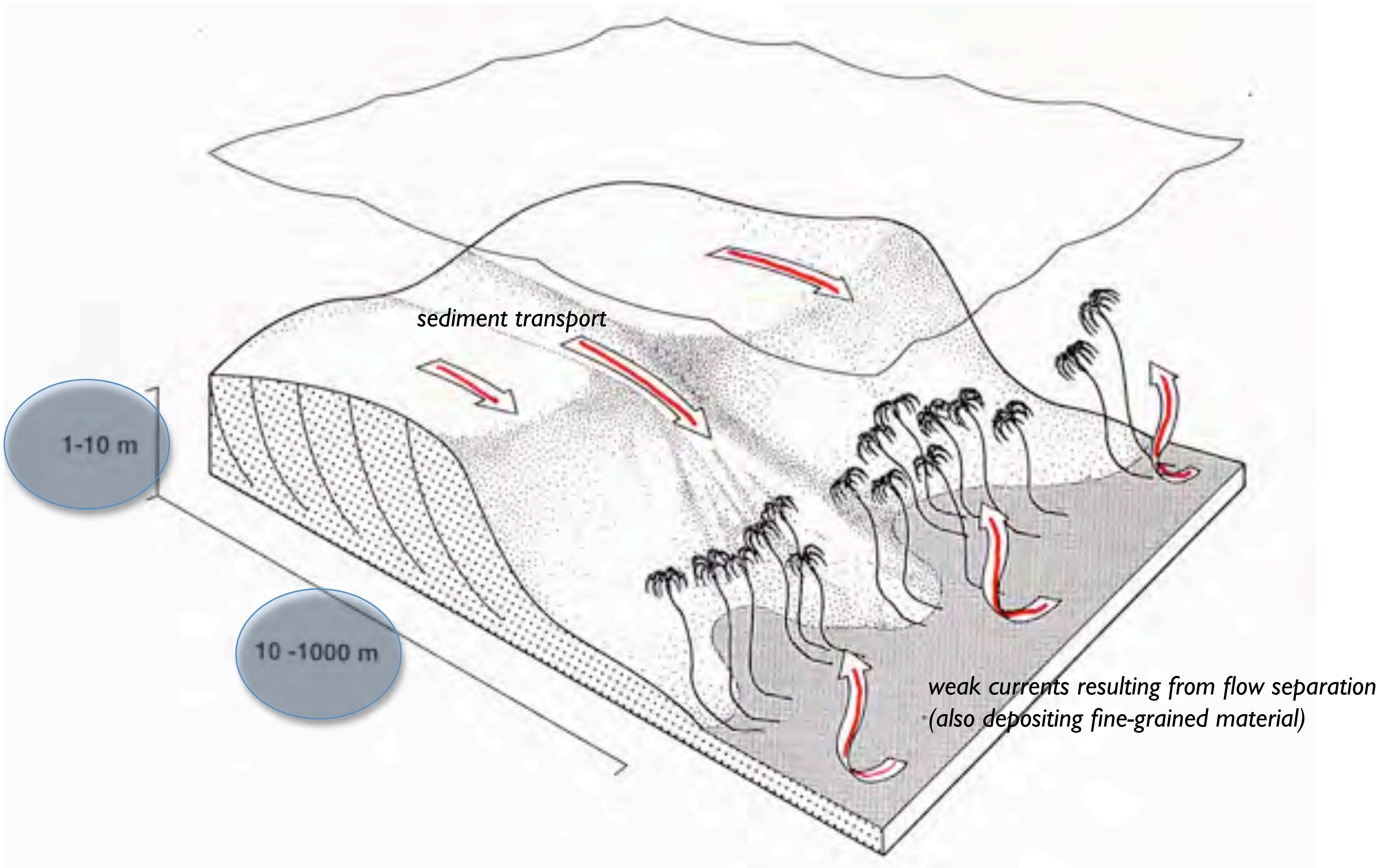


in Tucker & Wright 1990

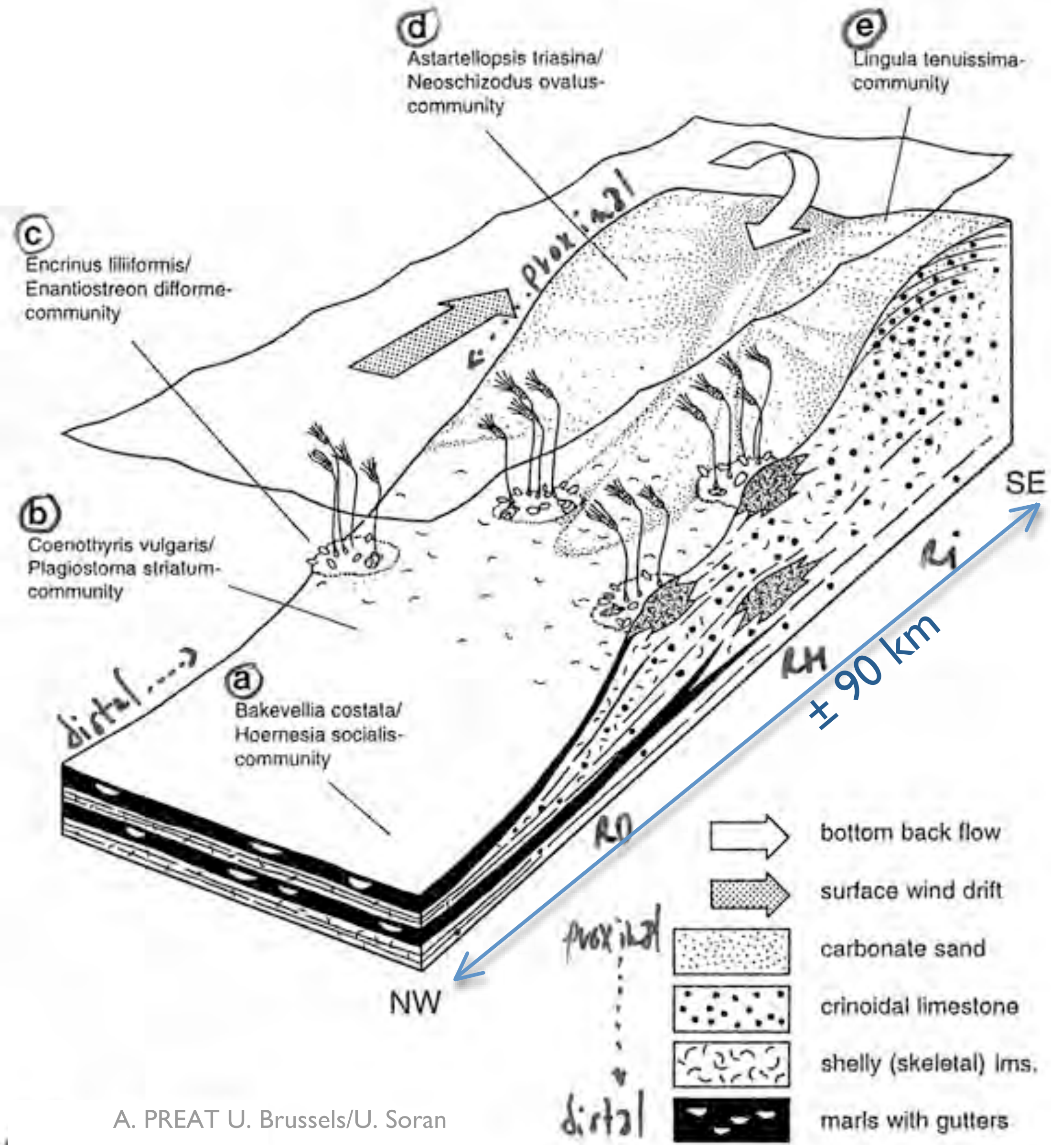
The carbonate platform depositional model

Permian, W Texas- New Mexico (Matthews, 1984)





Model of a sand wave with *Chariocrinus andreae* colonies on the leeward side. Crinoidal colonies will be displaced to similar new positions by movement of the sand wave. Size of crinoids exaggerated, from Gonzalez 1993.

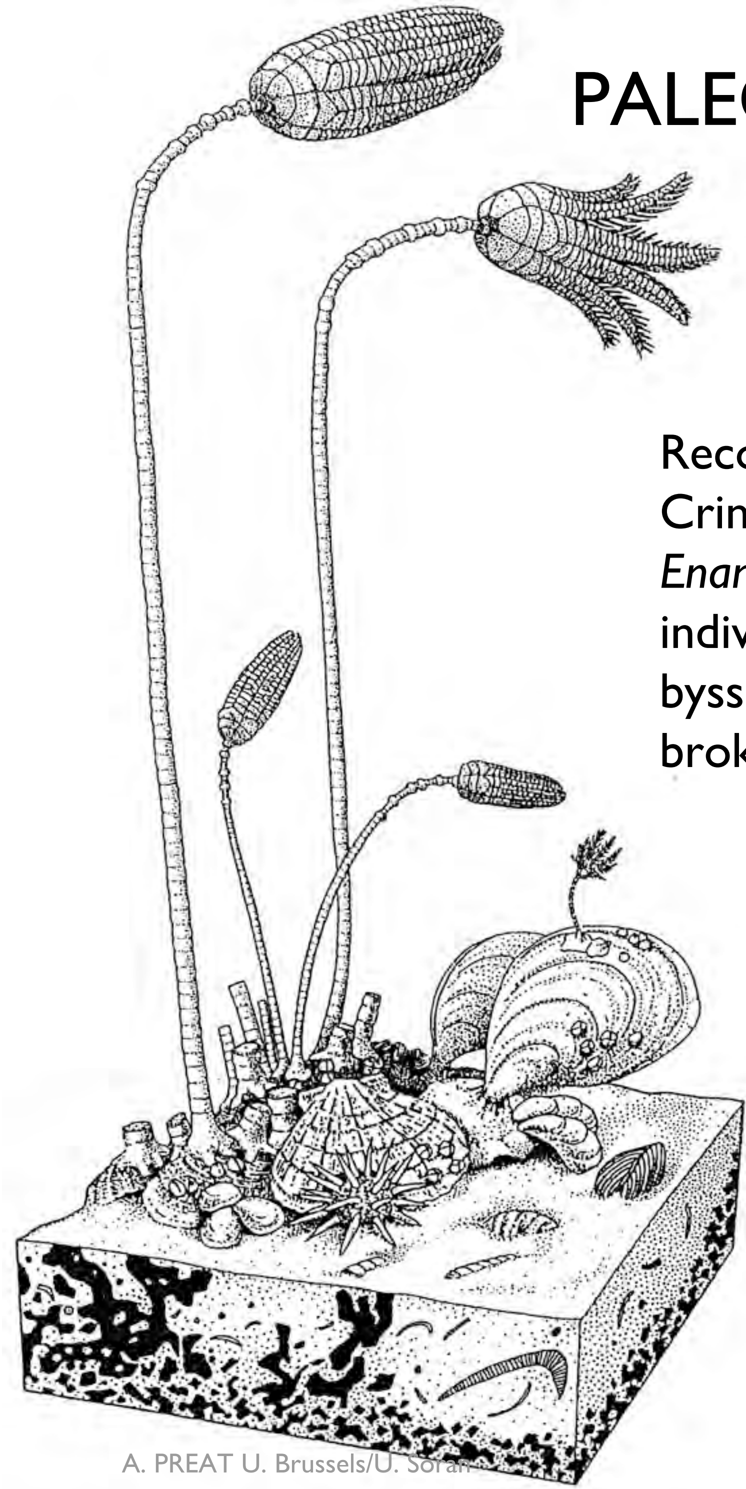


CARBONATE RAMP

Facies model and fossil community zonation on the SW German Trochitenkalk carbonate ramp with crinoid bioherms.

Hydrodynamic model : fair-weather alongshore currents (SW-NE) provided NUTRIENTS. Storm-induced wind-drift currents of surface water piled up skeletal debris that was continuously reworked in shallow water. Bottom backflows were responsible for the smoothering of habitats in deeper water (Hagdorn 1991).

PALEOENVIRONMENT- PALEOECOLOGY



Reconstruction *of Encrinus liliiformis* on an encrinid BIOHERM. Crinoids of different age are attached to oyster-like terquemids *Enantiostreon* and *Newaagia* (left) with holdfasts, juvenile individuals are attached to the mussel *Myalina* (right, fixed by byssus threads to a *Newaagia* shell. Large stems of *Encrinus* are broken near the base (Hagdorn 1991).

IN BELGIUM : famous and well-known 'PETIT GRANIT'

⇒ sidewalks and facades of buildings/houses/monuments… in Brussels and Belgium

⇒ Upper Tournaisian, (micro)facies is a grainstone or packstone with 60% of crinoidal plates and 40 % of voids (intergranular porosity)

⇒ = => syntaxial cementation tight rock (grainstone)

INTEREST of ECHINODERM IDENTIFICATION

- energy index => indication of transport distance
  = => if each plate extinct optically at a single position under crossed nicols
  = <u>weak or no transport</u>
  = => if 'pitting' and ?micritization = transport

- all crystals are twinned => weakness zone = = > the bioclasts are more and more ANGULAR with the transport (opposite for the quartz grains!)

- if encrustation by microstromatolites and/or ferruginization … (Fe-Mn)
  = => relation with condensed series and/or hardgrounds = outer shelf and (hemi)pelagic settings. Quiet environments with stagnant conditions.

- CONCLUSION
  Paleoenvironmental indicator : SWB, FWWB, condensation….sedimentary models.

  Modification of the ecologic niche from Paleozoic to Mesozoic.

- BIOSTRATIGRAPHY only by specialists

ECHINODERMS

MICROSTRUCTURE : ‘monocrystalline’, each individual plate acts OPTICALLY as a single crystal of calcite => each plate will extinct optically at a single position under crossed nicols in a polarizing microscope

- these single crystals commonly serve as nucleation sites for CALCITE CEMENT
- calcite is added in optical continuity to the echinoderm plates = SYNTAXIAL CEMENTATION in carbonate rocks

1. Proteinic network with a 5-symmetry => HMC epitaxy = BIOMINERALIZATION

2. ‘Crinoid’ = a single clear crystal with regular cleavages

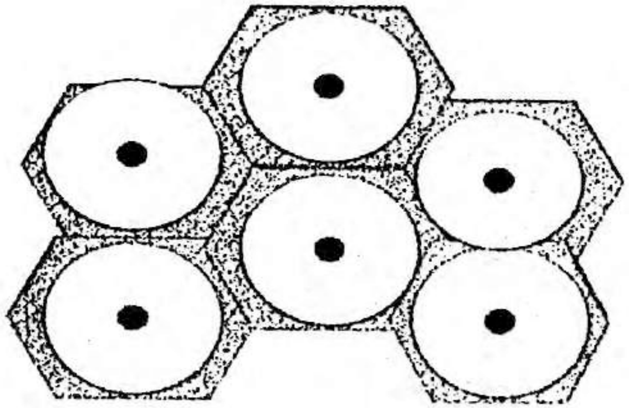
3. Syntaxial cementation OR alteration (partly or total) => micritization [loss of the single extinction]

3’. Pyritization and (microbial or …) bioperforations in stagnant environments (cf redox potential)

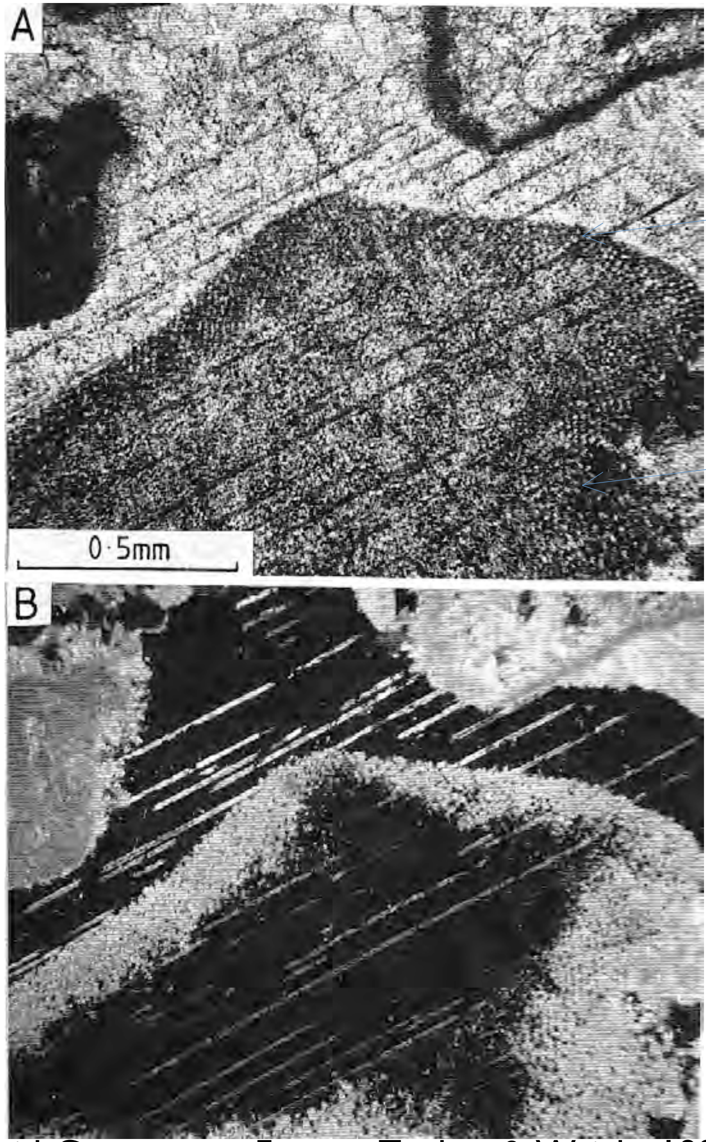
….

SYNTAXIAL CALCITE SPAR OVERGROWTH on an echinoderm fragment

‘Petit Granit’ : grainstone



plan polarized light



optical continuity

micritization
pitting
(pyritization)

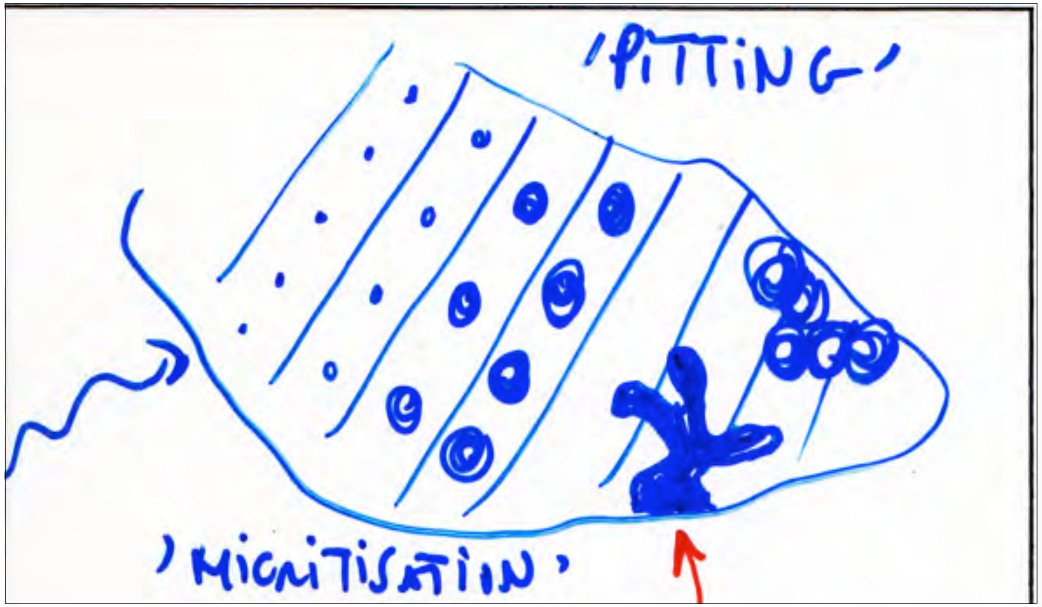
crossed polars

mid-Cretaceous, France, Tucker & Wright 1990

ECHINODERMS

an echinodermal grain may tells us a (very) long story….

weak transport
(small holes)



bioperforation
≠ transport
(Fe, Mn, HG….)

in condensed hemi-pelagic series

Fe-(Mn) microstromatolites + bioperforations (‘colonized by iron-bacteria)

Coumiac (France)
Frasnian/Famennian
Préat et al 1998

ECHINODERMS

COMPARISON Echinoderm fragments can be confused with

• sponge spicules, alcyonarian coral spicules, (plates of sclerites of holothurians)

• algae (but these latter do not exhibit calcite cleavage and same extinction type)

Anti-Atlas, Morocco, blastoids and asteroids

Préat 2004