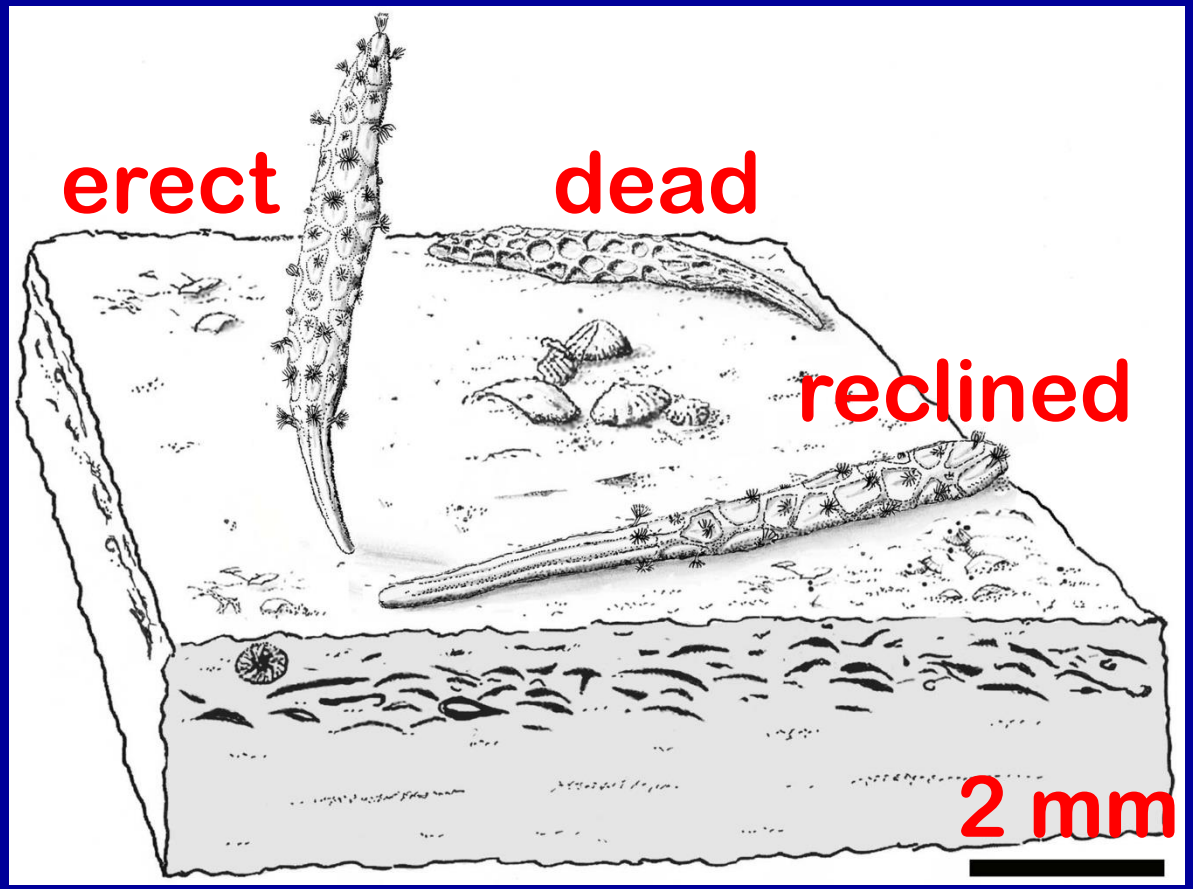
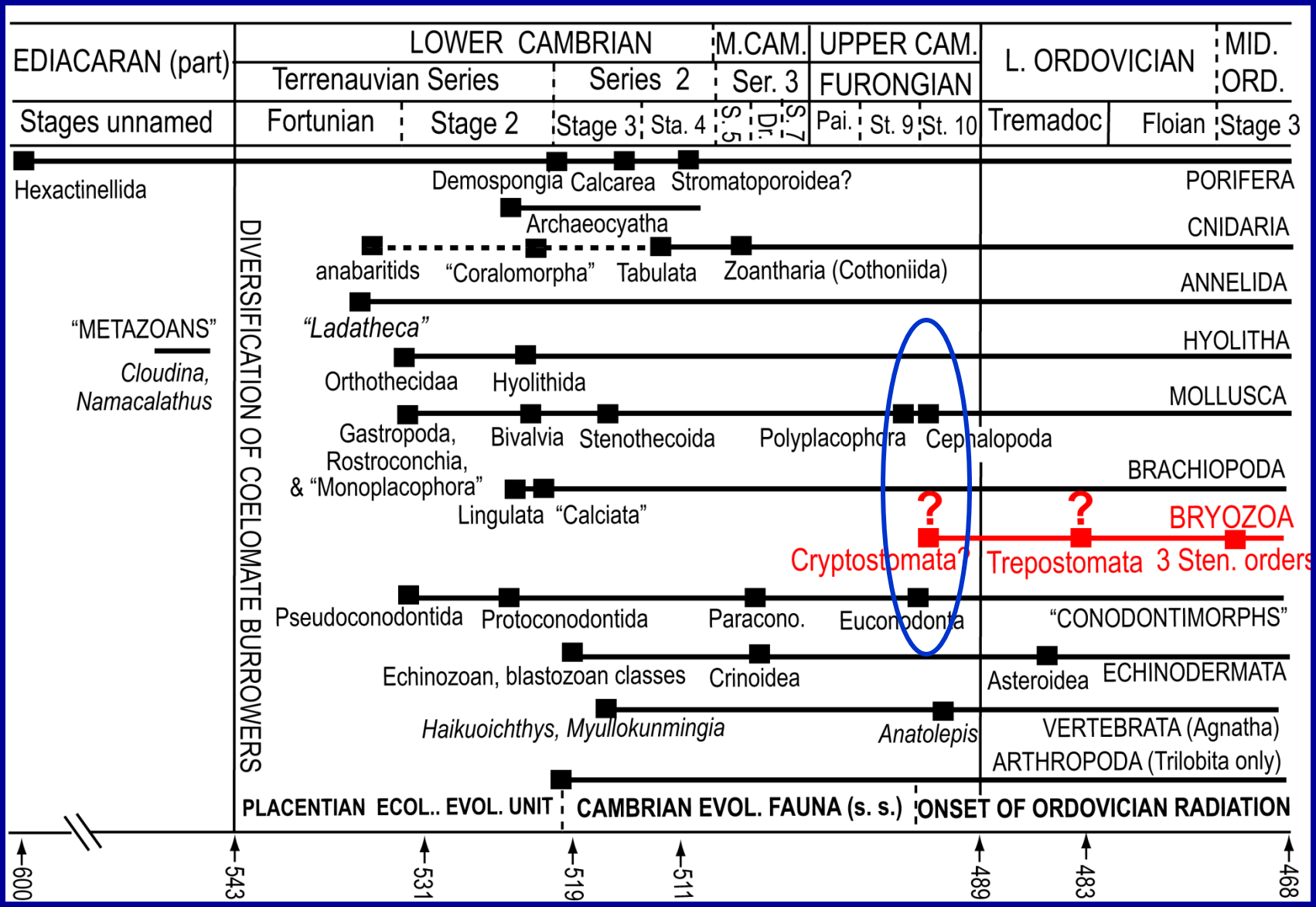
# EARTH'S OLDEST KNOWN BRYOZOAN (*PYWACKIA*, LATE CAMBRIAN) AND THE CAMBRIAN DIVERSIFICATION OF BIOMINERALIZED METAZOANS

E. Landing, J. B. Antcliffe, M. D. Brasier, & A. B. English

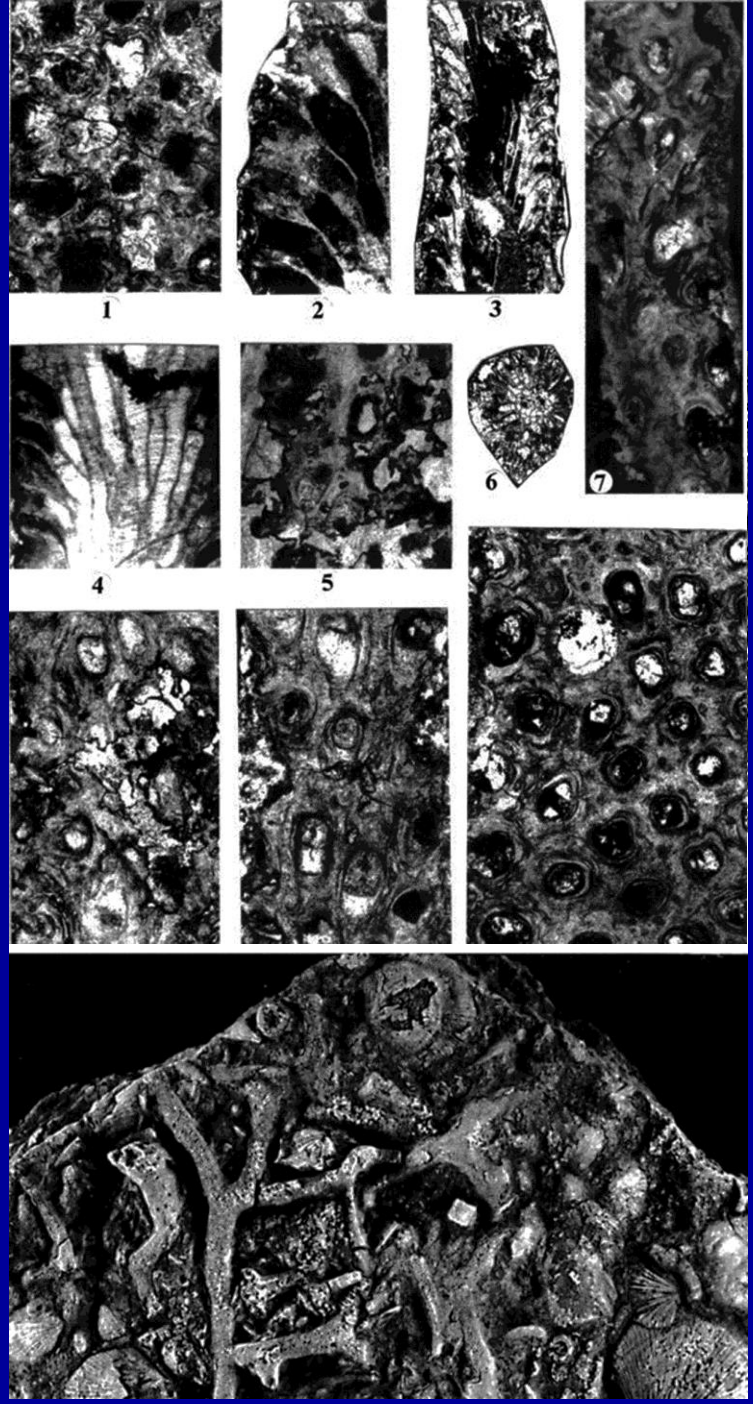



Reconstructed *Pywackia* colonies (zooaria)

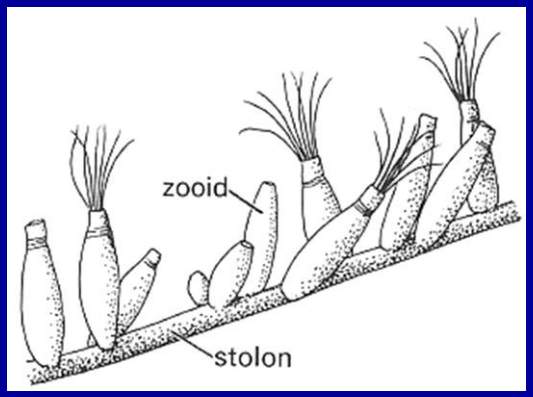
# Did bryozoans miss the Cambrian diversification of biomineralized Metazoa?

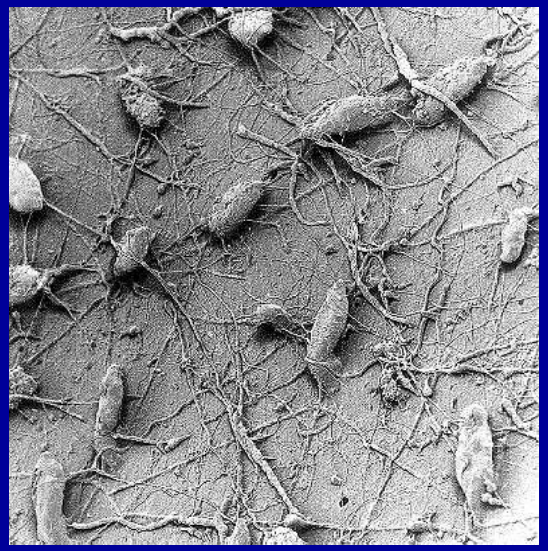



# Oldest known bryozoans: Tremadocian or Late Cambrian?



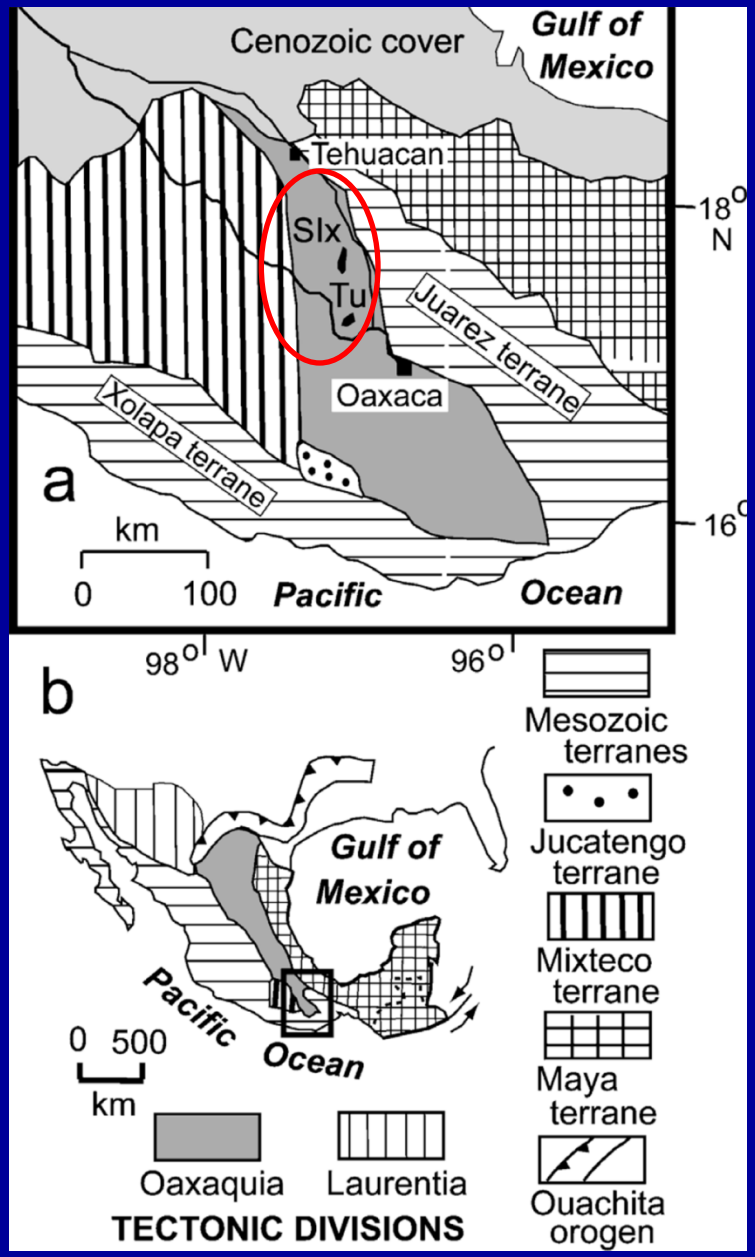

Chinese taxa: 2 orders present, stick- to mound-like forms, styles, extrazooecial tissue

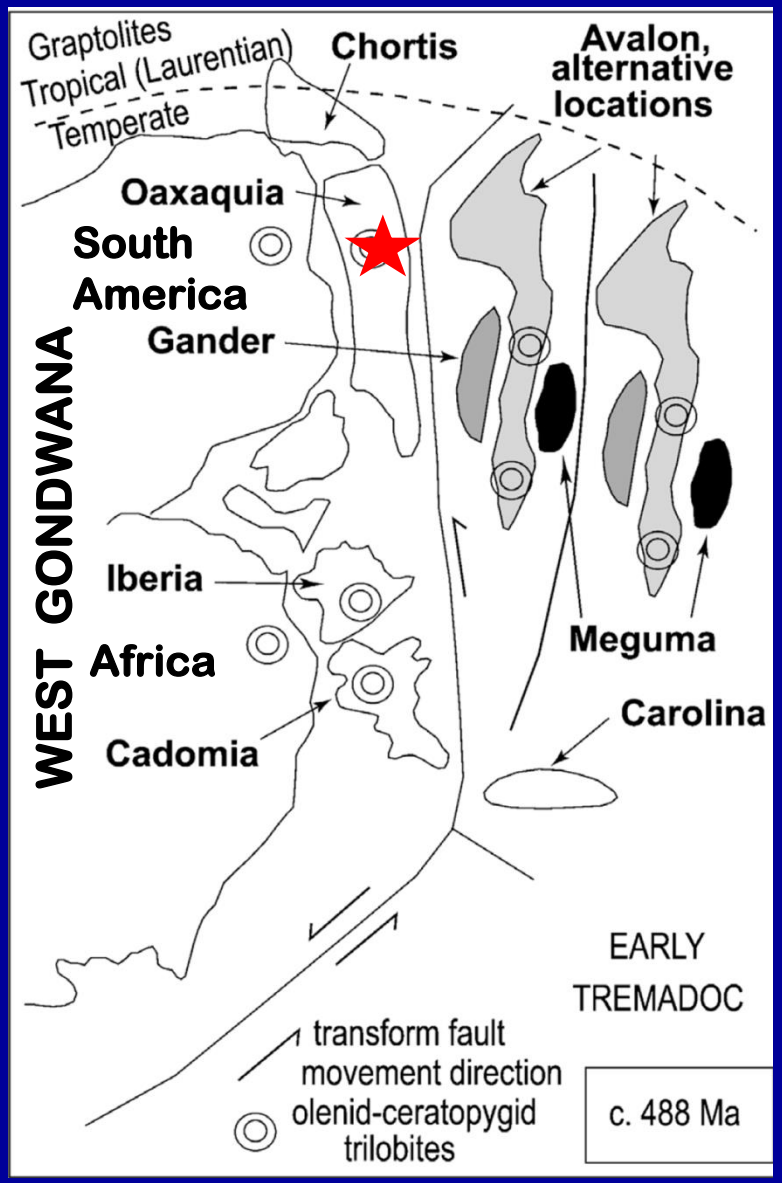


Ctenostome-like ancestors of later bryozoa largely unmineralized, consist of budding stolon & feeding zooids

**The oldest Chinese bryozoans (483 Ma) are derived**

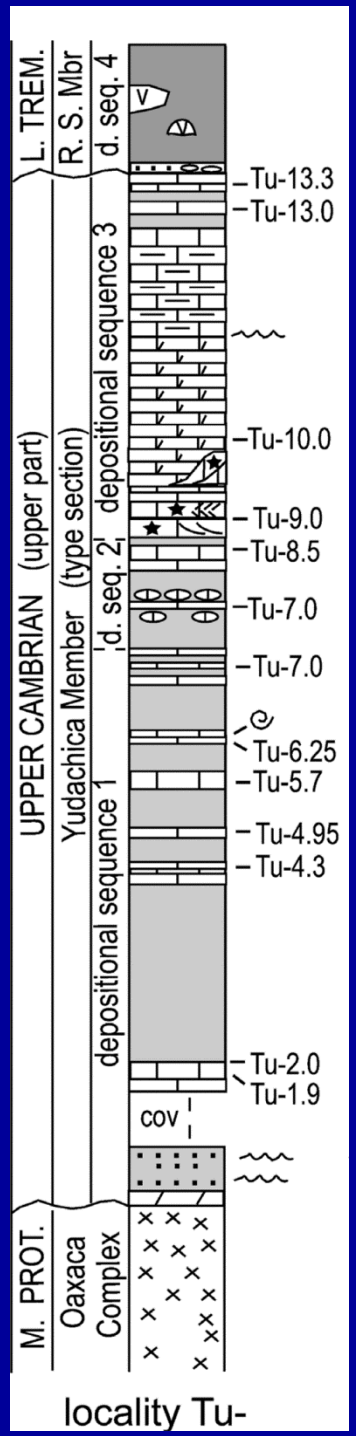



**Localities at Tiñu (shelf) & Santiago Ixtaltepec (slope)**

**Oaxiquia (modern central Mexico)**

**Red star = field area area**




**Storm-dominated shelf lss. of Yudachica Member**

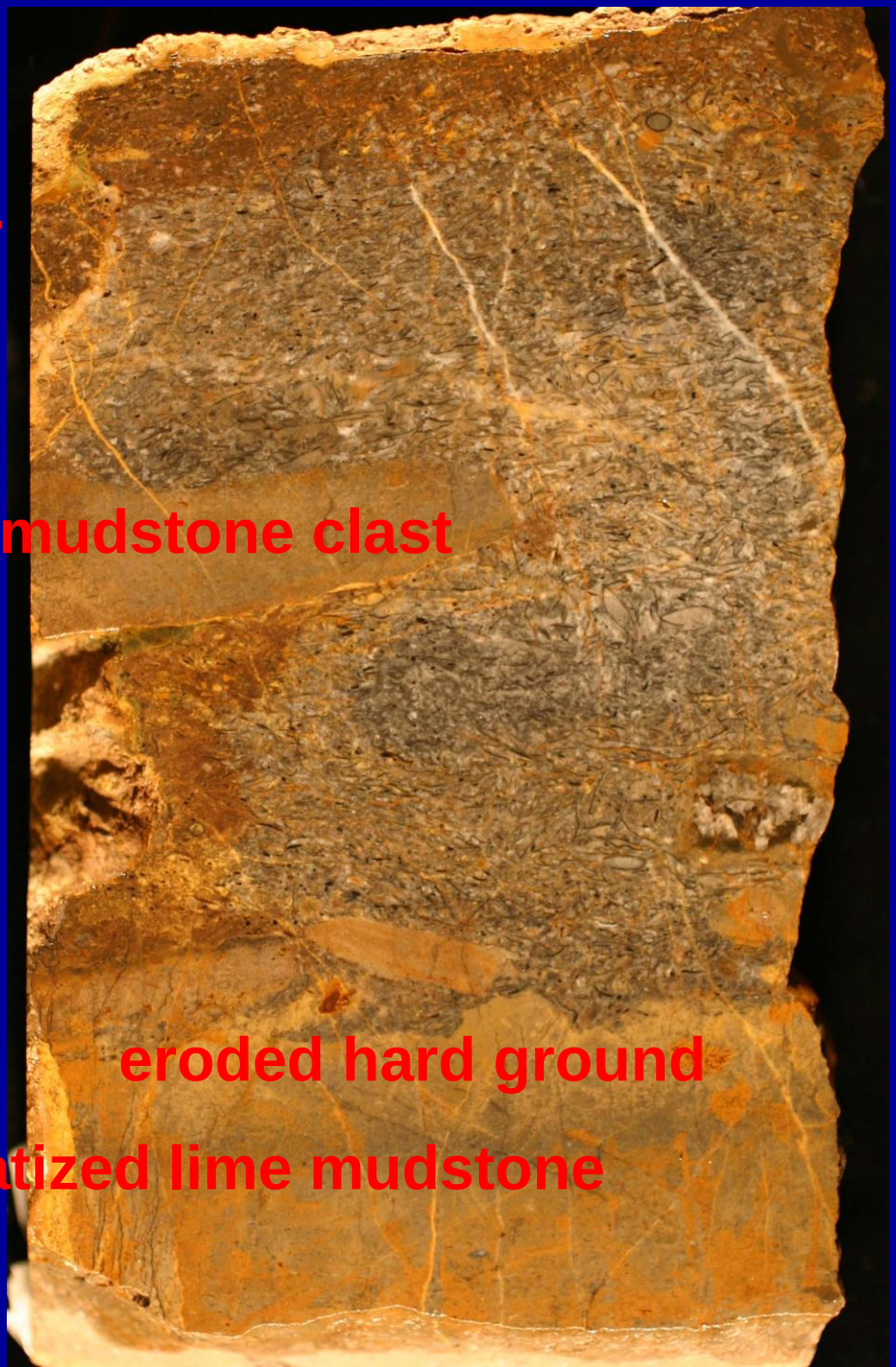
**151 specimens from lower 4.95 m of Yudachica Mbr**

**Diagenetic window of *Pywackia* occurrence**

“pelmatozoan” –trilobite hash- & phosphate granules

phosphatic lm. mudstone clast

**Phosphatic debris, phosphatized limestones & phosphatized fossils only in basal 5.7 m of Tiñu Fm. type section**



eroded hard ground

phosphatized lime mudstone

| Sample numbers (Tu-) | Tu-1.9 | Tu-2.05 | Tu-4.3 | Tu-4.95 | Tu-5.7 | Tu-6.25 | Tu-7.9 | Tu-8.5 | Tu-9.0 | Tu-13.0 | Tu-13.3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Phosphatic sand, polished | X | X | X | X | X | - | - | - | - | - | - |
| Phosphatic cement druse | 5% | 10% | 10% | 9% | 5% | 5% | 1% | 2% | 1% | <1% | <1% |
| Bryozoans | | | | | | | | | | | |
| *Pywackia baileyi* | X | X | X | X | | | | | | | |
| proximal extremity | 0 | 12 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| median stem fragments | 1 | 53 | 26 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| apical ends | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sponges | | | | | | | | | | | |
| phosphatic hexaxons | 3 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chancellorid spicules | | | | | | | | | | | |
| *Archiasterella* | 0 | 2 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gastropods | | | | | | | | | | | |
| phosphat. mold & shell | 1 | 5 | 1 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agnostoid arthropods | | | | | | | | | | | |
| phosphatic molds | 0 | 4 | 10 | 5 | 5 | 0 | 0 | 5 | 0 | 0 | 0 |
| Trilobites | | | | | | | | | | | |
| phosphatic sclerites | 15 | 14 | 10 | 1 | 3 | 0 | 0 | 4 | 1 | 0 | 0 |
| Crinozoan columnals | | | | | | | | | | | |
| phosphatized | 16 | 4 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Protoconodonts | 1 | 0 | 0 | 0 | 3 | 2 | 0 | 4 | 27 | 19 | 28 |
| Euconodonts | 1 | 5 | 3 | 60 | 20 | 39 | 22 | 45 | 88 | 127 | 6 |

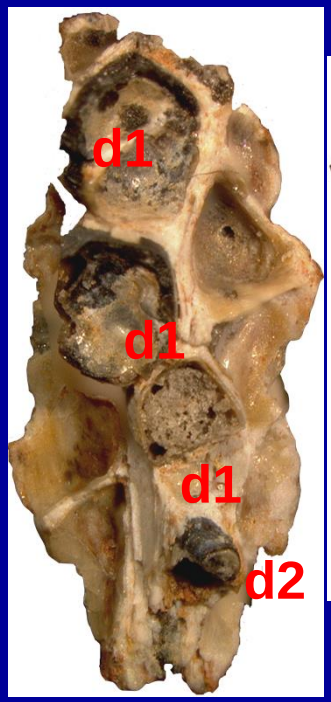
***Pywackia*** **specimens occur only in highly phosphatized limestones & w. phosphatized calcareous & siliceous sclerites**

abraded

distal extremity

unabraded

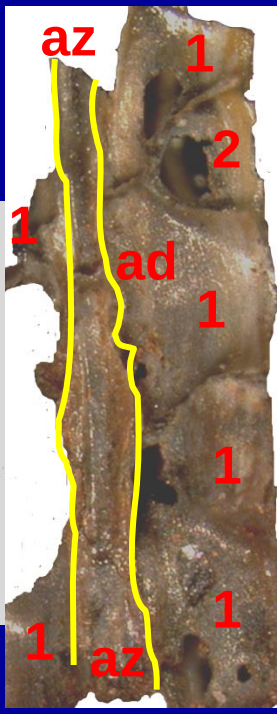
medial stem frags.




autozooid bud (star)

basal extremities w/ diaphragms (d) & hemiphragms

Trans. & long. frags., generations 1 & 2, az = axial zooecium, “ad” = axial diaphragm



nanozooecium

# Cambrian origin of all skeletalized metazoan phyla—Discovery of Earth's oldest bryozoans (Upper Cambrian, southern Mexico)

Ed Landing[1]*, Adam English[2], and John D. Keppie[3]
[1]New York State Museum, 222 Madison Avenue, Albany, New York 12230, USA
[2]Chevron Gulf of Mexico Business Unit, 5750 Johnston Street, Lafayette, Louisiana 70503, USA
[3]Instituto de Geologia, Universidad National Automona de Mexico, Ciudad Universitaria, 04510 Coyoacan, D.F., Mexico

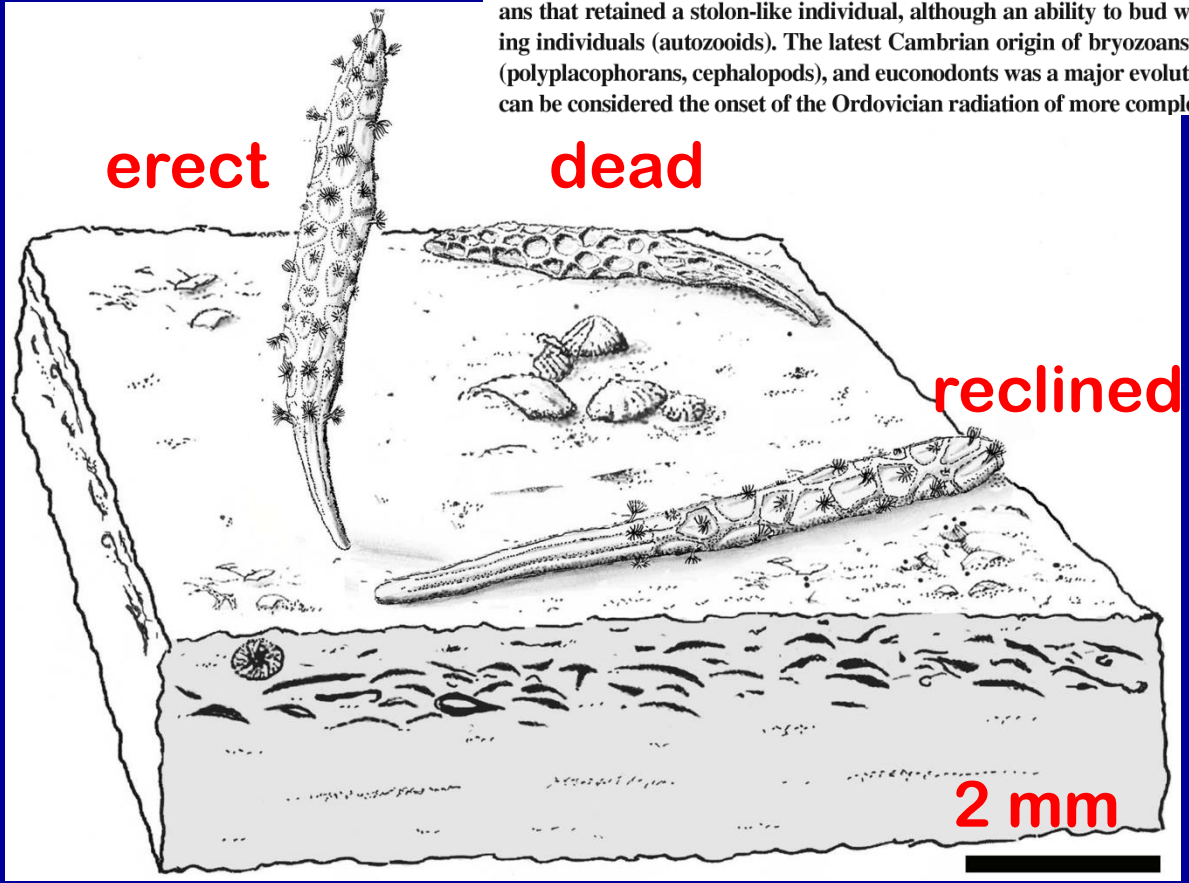
**ABSTRACT**

**Exquisite *Pywackia baileyi* Landing n. gen. and sp. specimens from the lower Tiñu Formation, southern Mexico, extend the bryozoan record into the Upper Cambrian. They are ~8 m.y. older than the purported oldest bryozoans from South China, and show that all skeletalized metazoan phyla appeared in the Cambrian. The new form differs from similar, twig-like cryptostomes by its shallow autozooecia and an elongate axial zooid, which may be homologous to the stolon in nonmineralized ctenostomes. It may morphologically resemble mineralized stem group bryozoans that retained a stolon-like individual, although an ability to bud was acquired by the feeding individuals (autozooids). The latest Cambrian origin of bryozoans, several mollusk classes (polyplacophorans, cephalopods), and euconodonts was a major evolutionary development and can be considered the onset of the Ordovician radiation of more complex marine communities.**

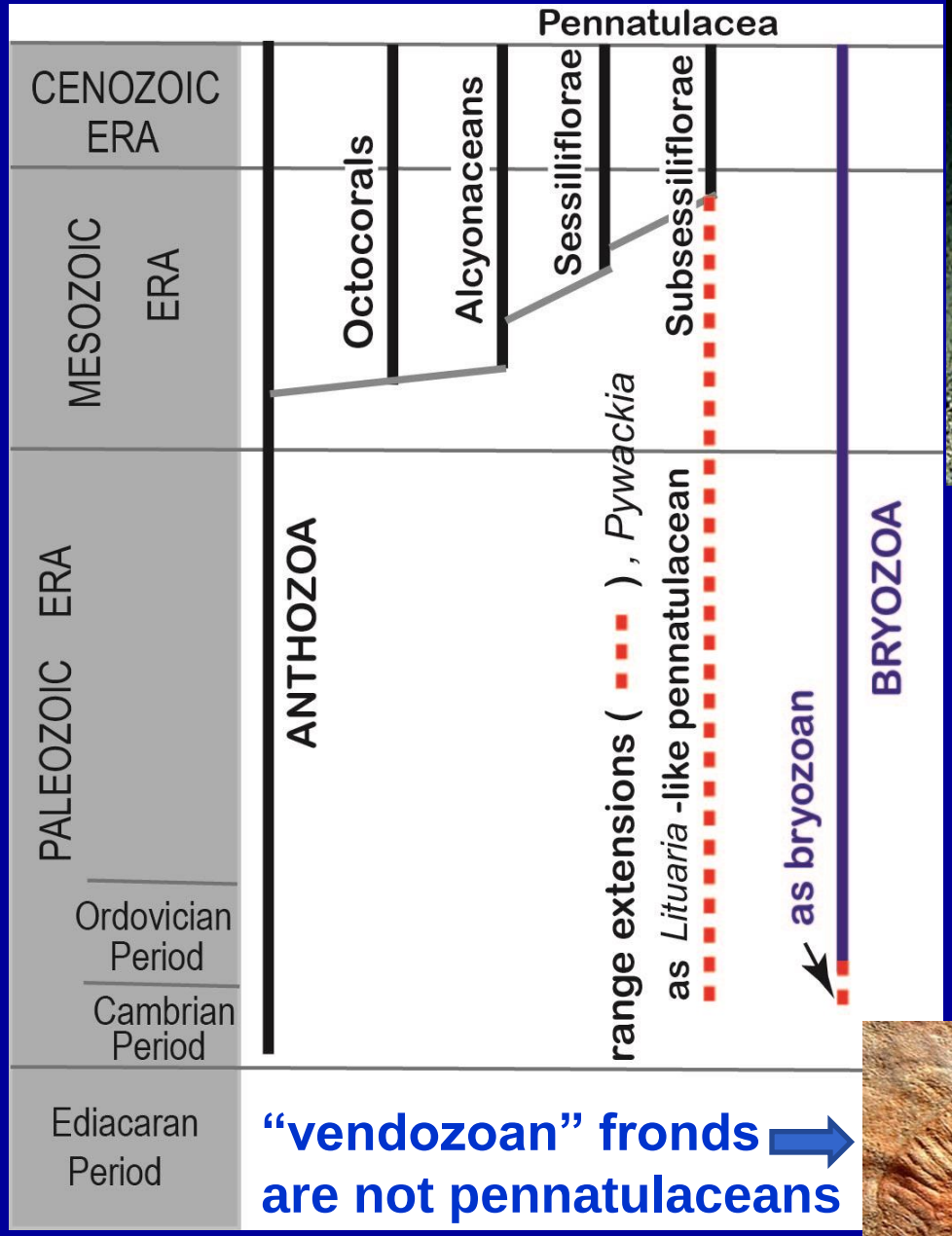
and concluded that the upper Tremadoc
South China has the oldest bryozoans. Xia
al.'s (2007) taxa have complex microstructure
which suggest that these ca. 483 Ma forms (se
Landing et al., 1997) had mineralized ancestor
As discussed below, Late Cambrian bryozoan
are now known, and have features that sugge
they lie near the base of the bryozoan lineage.

**GEOLOGIC SETTING**

Landing et al. (2007a) detailed the paleoen

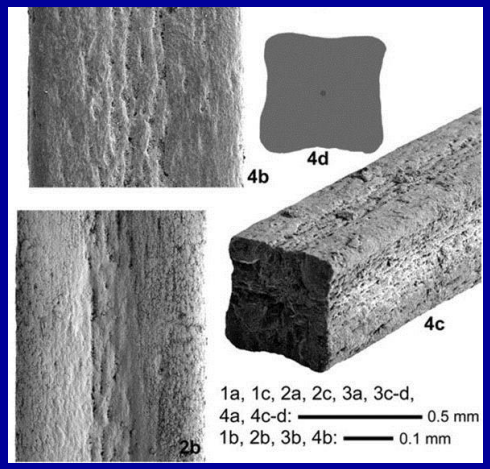


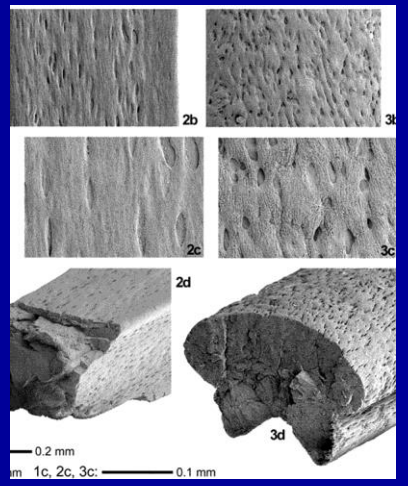

**Reconstruction of *Pywackia* zooaria**




sessillifloraed

subsessilli-floraed




**“vendozoan” fronds are not pennatulaceans**

**High-Mg calcite axial rods w/ “wood fiber” histology**

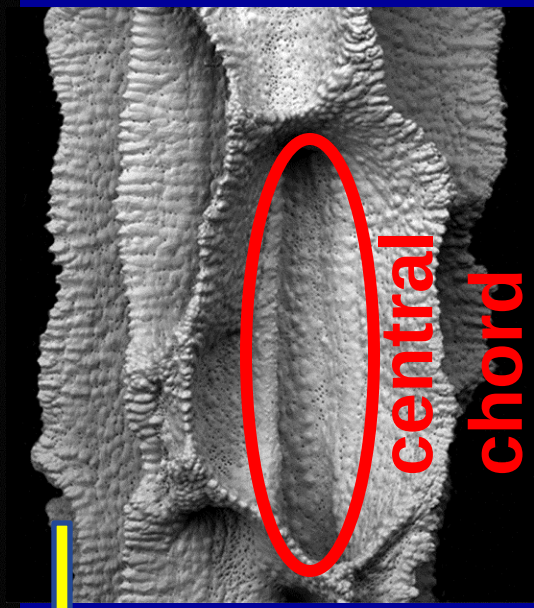
ca. 0.2 mm

**Sealed axial zooid, autozooid budding, granular & granular-prismatic histology**

***Pywackia***
**Cambrian bryozoan**

0.5 cm

***Lituaria***
**Recent pennatulacean**

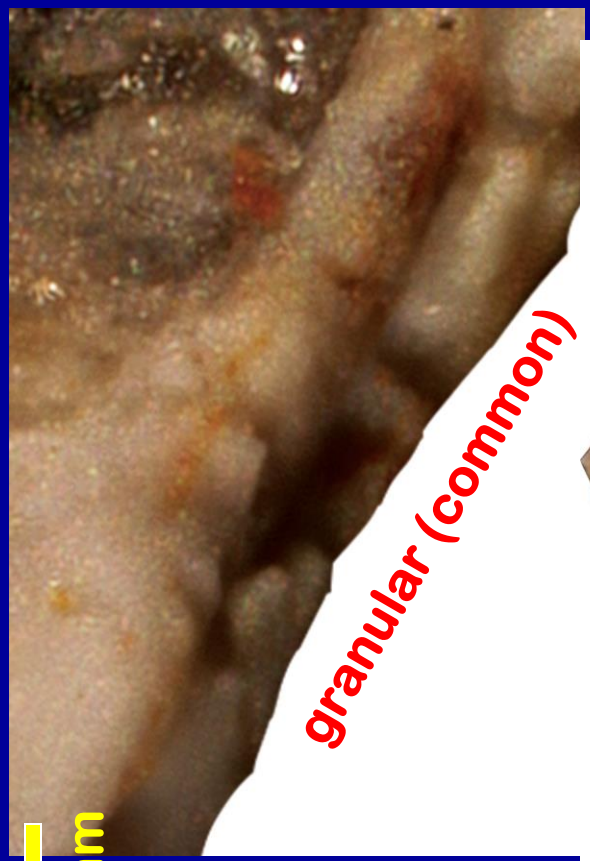



0.5 mm

**Open central chord, no autozooid budding, wood grain histology**

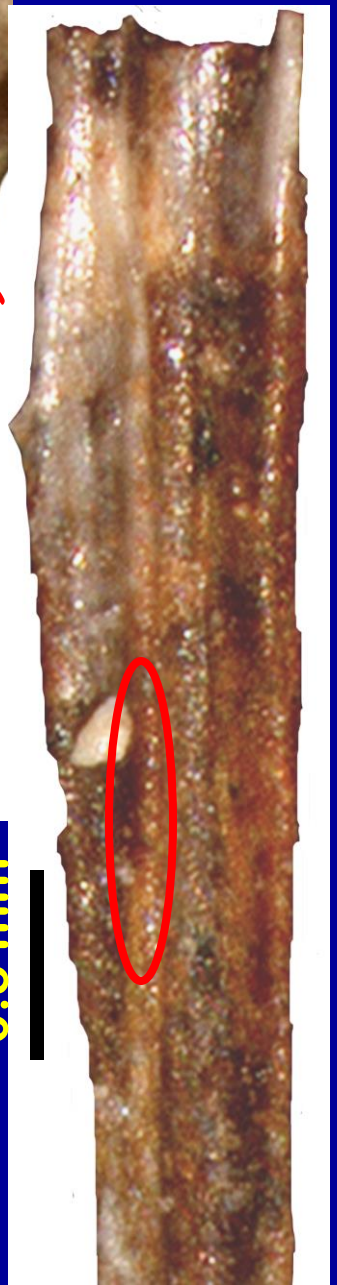
# Histologies of

*Pywackia*



granular (common)

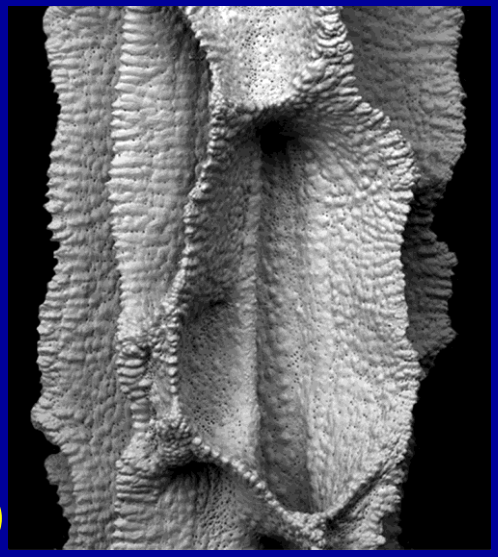
0.05 mm



0.5 mm

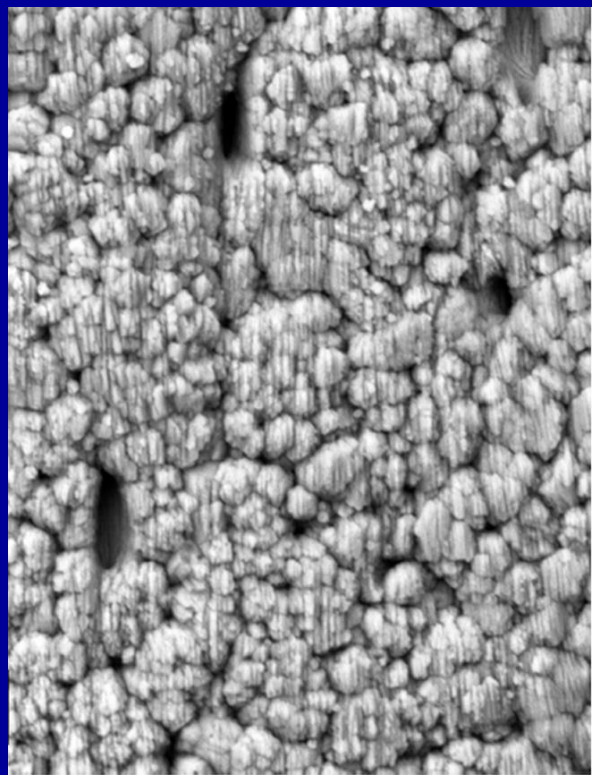
granular prismatic (rare)

*Lituaria*



(pennatulacean)

wood grain



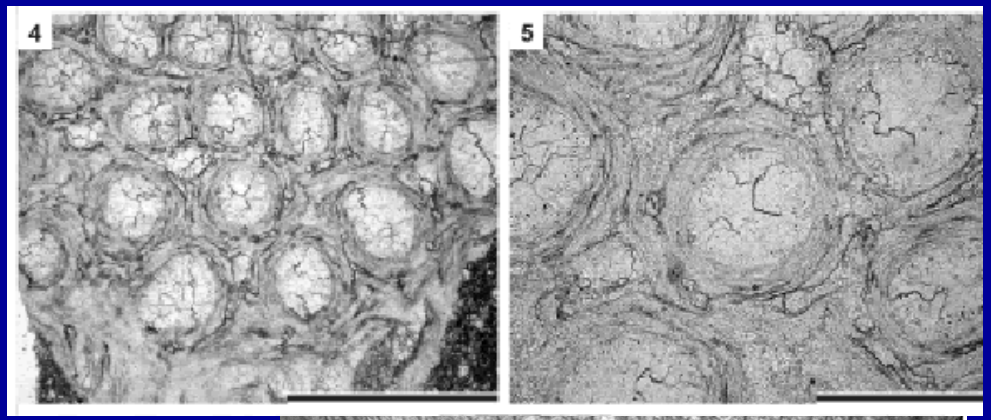
0.05 mm

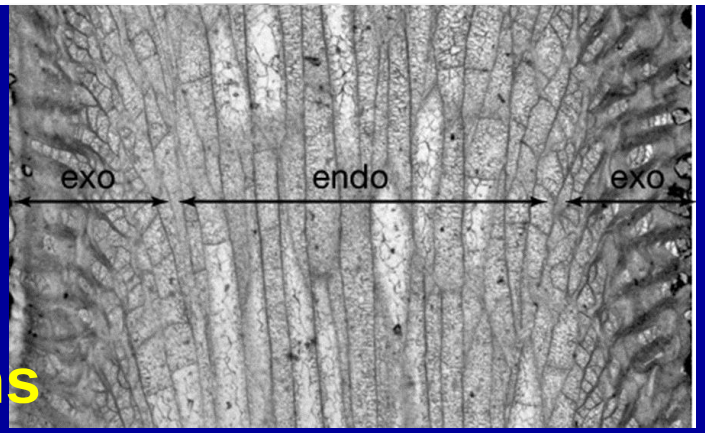
The "problem" of branching and regularity in later bryozoans: "spacers"

extrazooecial tissue

*Pywackia*, fairly "regular"

14-hedron, Beijing Water Cube

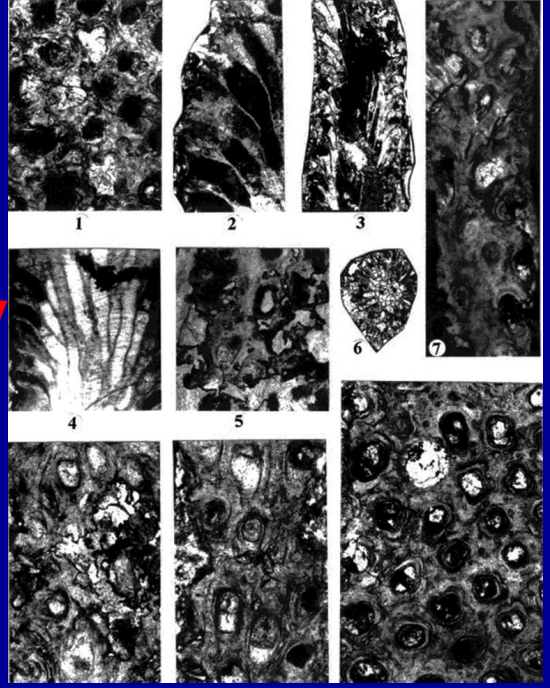



Styles & polymorphs

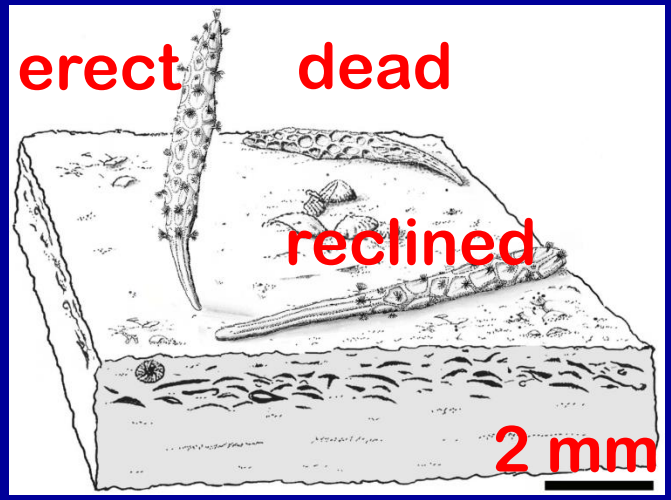
# SUGGESTED EARLY BRYOZOAN HISTORY

2 orders present, stick- to mound-like , styles extrazooecial tissue

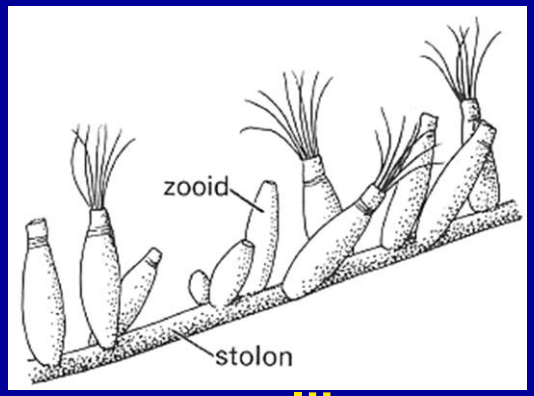



Diverse stenolaemates, by 483 Ma, late Tremadocian

*Pywackia*




Origin stem-group stenolaemates by 491 Ma, Late Cambrian




Origin ctenostome-like bryozoans, as early as late Terreneuvian?, ca. 530 Ma?

Ctenostome-like ancestors largely unmineralized, budding stolon & feeding zooids